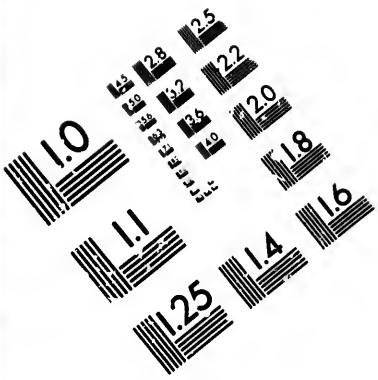

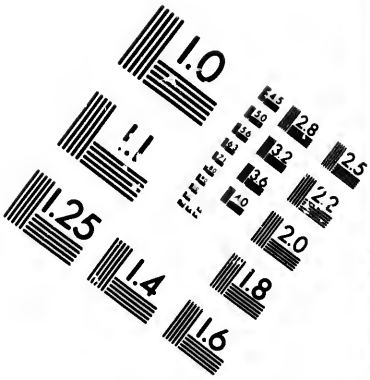

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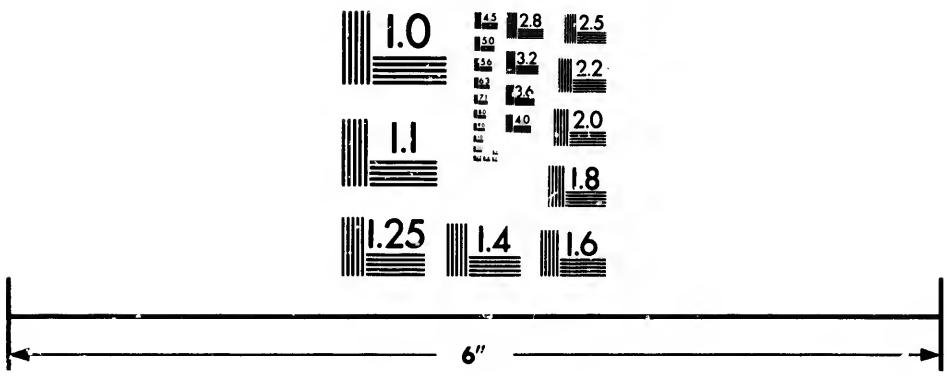

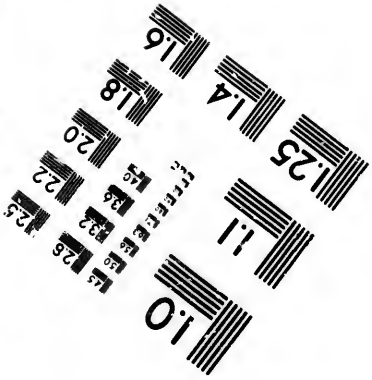

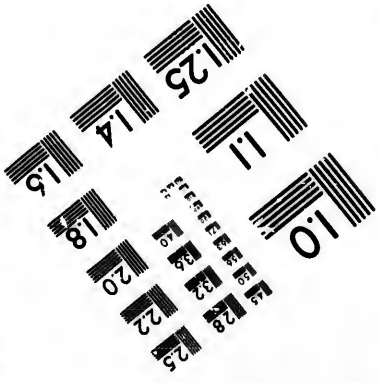

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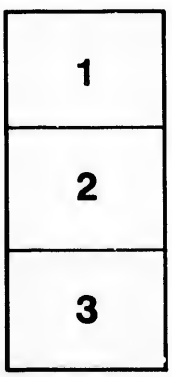

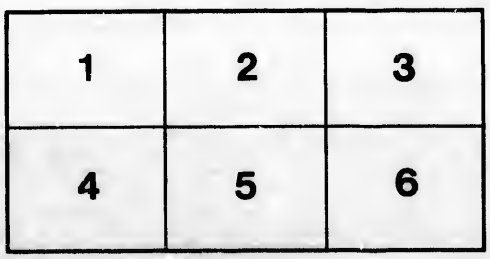

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NOTES

ON SOME

DIABASE DYKES

OF THE

RAINY LAKE REGION.

BY

ANDREW C. LAWSON, M.A.,

GEOLOGIST TO GEOLOGICAL SURVEY OF CANADA.

Extract from Proc. Can. Institute 1887

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1888.

NOTES ON SOME DIABASE DYKES

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The most recent of the crystalline rocks of the Rainy Lake region are comprised in a series of strong dykes of comparatively fresh diabase which are observed to cut, at different localities, the various members of the Archæan complex of formations. These dykes are not infrequent throughout the country lying between the eastern confines of the first prairie steppe, which forms the basin of the Red River of the north, and the western border of the area of Animikie and later formations of the Lake Superior basin. Their occurrence and some of their characters are briefly referred to in my report on the Lake of the Woods region.* As there observed, the occurence of these dykes cutting the older folded rocks, which in their eastward geographical continuation, pass under the flat-lying Animikie and Keweenawan formations, is suggestive of their possible connection with the bedded traps that form so large a part of the two latter geological series. With the question of the possible identity of character and age of these dykes with the traps of the Animikie or Keweenawan, or of both, is associated the equally interesting one of the extent of the earth's surface, over which, in early geological times, were in simultaneous operation, those particular volcanic forces which appear to have had their focus in the Lake Superior basin.

The more notable field characters of these dykes are : their common strike throughout the region from N.W. and S.E. to N.N.W and S.S.E. ; the sharp, well defined nature of the gash or fissure which they fill, no matter what may be the character of the country rock ; the absence of inclusions of the country rock, or of apophyses of the dyke running into it, except in very occasional instances ; their generally uniform width under different conditions of occurrence in different localities, the limits being as a rule 60 and 150 feet ; their continuity for one or several miles where exposures permit them to

* Geological and Natural History Survey of Canada, Annual Report, 1885, p. 41 CC., p. 47 CC.

be traced; their passage from a very compact, aphanitic, black rock at the immediate contact with the dyke walls, by insensible gradations to a very coarse-grained, mottled, dark gray rock in the middle of the dyke; an occasionally observed peculiar pitting of the weathered surface, arranged in straight, more or less uniformly spaced lines transverse to the strike of the dyke; their prominent, steeply rounded, or domed, glaciated surfaces in contrast to the more gently inclined *roches moutonnées* of the schists and gneisses; their assumption of brownish tints on surfaces aerially weathered; (surfaces beneath high water mark of the lakes are generally quite fresh and black).

These dykes have as yet only received a preliminary study, and it will require a much more extended examination of the country in which they occur and a much more elaborate investigation of their petrographical characters before a comprehensive statement of their geological relations can be formulated. A few notes regarding the microscopic features of these dykes, taken together with what has been said of their field occurrence, may however, be of interest, and will serve as a report of progress of what is being done in this line of investigation in the field west of Lake Superior.*

One of the most characteristic of these dykes is one that traverses the coarse granitoid gneiss of the west arm of Jackfish Lake, which lies to the north-west of Rainy Lake. Its width is 135 feet and its contact with the country rock is well exposed as a sharp line. From a macroscopic examination the gneiss does not appear to have been altered perceptibly towards the contact. Specimens for microscopic examination were taken from different parts of the dyke, viz., at 60 feet, 20 feet, and 6 feet from the contact, and at the contact. At 60 feet from the contact, the rock is a coarse-grained mottled gray rock in which dirty white feldspar and black pyroxene are the prominent constituents. Under the microscope it presents the characters of a coarse-grained, comparatively fresh diabase. Augite of a pale mauve tinted gray colour is abundant and often occurs in masses that fill the field of the microscope when low powers are used. Sometimes these plates of augite are individual crystals. For the most part however,

* These rocks were studied microscopically in the laboratory of the Johns Hopkins University, Baltimore, under the guidance of Prof. G. H. Williams, for whose kind advice and assistance the writer desires to express his grateful acknowledgments.

they are not single individuals. When examined between crossed nicols the plate of augite is seen at once to be resolved into an intimately interlocking mosaic of irregularly shaped grains of diverse optical orientation. In ordinary light the boundaries between the different members of these "polysomatic"* masses of augite are traceable only with difficulty and uncertainty. There is no interstitial matter whatever, the different grains being as intimately associated as in the case of interpenetration twins of feldspar. That they are not twins is shown by the fact that there are often as many as half-a-dozen grains all of different orientation thus combined in the same mass. The cleavage, by its lack of continuity over the field of course indicates a difference of orientation in different parts of it, but the cleavage traces are not strongly marked, and attention is only directed to the discordance of the cleavage after the polysomatic character of the mass has been rendered prominent by the analyser of the microscope. This polysomatic structure of augite does not appear to be common. Rosenbusch does not mention it in his last comprehensive summary of the present state of petrographical knowledge.† The nearest approach to this structure that is at all well known is the polysomatic character of some chondri of olivine in certain meteorites such as are figured by Tschermak‡ and Wadsworth.§ Olivine in a similiar condition in terrestrial rocks has recently been described and figured by Renard in specimens from Kerguelen Island in the Indian Ocean.‖ The polysomatic structure in augite is not so well known. Renard notes that the augites of the feldspathic basalt of Heard Island, Indian Ocean, are grouped together at certain points,** and again in the same rocks in Marion Island that the augite is characterized by a tendency to form groups of individuals having their vertical axes parallel.†† Teall mentions "Granular Aggregates" of augite in the Hett and the High Green dykes in the north of England.‡‡ Some of these appear from the figures given to

* Adapted from Tschermak's use of this word as applied to a similar structure in the olivine of certain meteorites.—V. Die Mikr. Beschaff. der meteor. Stuttgart, 1885.

† Mikr. Phys. der Mineralien und Gesteine Stuttgart, 1886.

‡ Die Mikr. Beschaff. der Meteor. Stuttgart, 1885, Taf. xv. Fig. 1 and 2.

§ Lithological Studies, Mem. Mus. Comp. Zöol. Harvard, Vol. x., pl. 1.

‖ Notice sur la geologie de l' ile de Kergueien, Bul. Mus. Roy. Hist. Nat. Belgique, Tome IV. No. 4., p. 233, fig. 1, pl. v.

** Notice sur les roche de l' ile Heard. Bull. Mus. Roy. Hist. Nat. Belgique, 1886, 3 p. 260.

†† Notice sur les roches de l' ile Marion. Ibid. p. 250.

‡‡ Petrographical Notes on some north of England Dykes, Q. J. G. S., 1884, 158. p. 229 and 242.

be aggregates of grains of augite not in close juxtaposition with an interstitial base, although that figured in Plate XII, Fig. 5, would seem to be a polysomatic augite, and if so is the only strictly parallel instance that I can find of this structure so common in this dyke and in others of the region.

The augite is generally altered to hornblende at its periphery and occasionally the latter mineral entirely replaces the former. The process of alteration does not appear to proceed along the almost or quite imperceptible lines of demarkation between the different individuals of the polysomatic augite, but extends from the periphery of the mass as a whole in towards its centre.

The plagioclase appears in two general forms a rather stout or tabular form which is the larger and usually the more cloudy with decomposition products, and a small long lath shaped feldspar which appears quite fresh and in which the polysynthetic lamellae are much more distinct than in the former.

Magnetite occurs in irregularly bounded masses or is disseminated, often quite thickly, through the augite as inclusions of dusty or finely granular aspect. Pyrite also occurs and is discernable macroscopically. Apatite is seen in occasionally colorless hexagonal sections and in slender prisms with rounded terminations. Water-clear quartz, with inclusions of apatite microlites and liquid inclusions with dancing bubbles, forms a considerable proportion of the mineral constituents of the rock and is characterised by having a common orientation for isolated sections over a wide area of the microscopic field, as in the micropegmatite structure. A few colorless garnets are also present. The rock, such being its characters, may be classed as a uralitic quartz diabase.

At 20 feet from the contact the rock is very similiar to that at 60 feet but is much less coarse in texture. It differs from the latter in mineralogical composition in the fact that there is present an abundance of white or colorless garnets, all perfectly isotropic. They have a well defined border indicative of a high index of refraction and a perceptibly rough surface. Their shape is for the most part rounded, or, when rectilinear outlines are observable, they are hexagonal sections of the rhombic dodecahedron. The larger grains have a curved parting which may be demarkation lines between different individuals. The treatment of the slide with

hydrochloric acid cold or hot, leaves them unaffected. The occurrence of garnets in basic dykes is by no means unique. They are however regarded as a product of contact metamorphism within the dyke. Speaking of the "Iron District of Lake Superior," Wadsworth says, "Most of the "diorites" (uralitic diabases) here (at Republic Mt.) contain garnets, this mineral being found principally along the edge of the intrusion while the centre was nearly if not entirely free from it. The schist in like manner near the "diorite" frequently contains garnets both rocks appearing to have mutually reacted upon each other." * The garnets in the Jack Fish Lake dyke do not appear to be a product of contact metamorphism since they are found in the middle of the dyke and very much more abundantly at 20 feet from the contact than at 6 feet from it, or immediately at the contact, where their presence has not been detected. Beyond the abundance of garnets, the dyke at 20 feet has the same characters as at 60 feet. The polysomatic structure of the augite is pronounced.

At 6 feet from the contact the rock is fine grained and the ophitic structure of typical diabase is much more characteristically developed than in the coarser grained parts of the dyke. In this part of the dyke there is first observed a differentiation of the rock into constituents of different periods of crystalization, the order being first plagioclase in more or less idiomorphic† lath-shaped individuals lying in all positions, then augite generally allotriomorphic,† sometimes hypidiomorphic† and finally a base or matrix of both these minerals in a very much more finely crystalline state together with magnetite. The structure of the base is rather obscure, the chloritic substance usually present in diabase rocks being more prominent here than in the coarser grained part of the dyke when it is almost or perhaps entirely wanting. Quartz is present but in smaller quantities than in the coarser grained portions of the dyke. The augite occurs both in simple individuals and in polysomatic masses. The uralitization of the augite, which is generally observable, is much more pronounced in the irregularly bounded polysomatic masses than in the simple allotriomorphic development of the same mineral. A few garnets are present as inclusions in the feldspar but were not identified with

* Notes on the Geol. of the Iron and Copper Districts of Lake Superior. Bull. Mus. Comp. Zöel. Harvard, 1880, pp. 45, 46, 47.

† Terms introduced by Rosenbusch. Cf. op. cit. p. 11.

certainty. In this respect this portion of the dyke differs markedly from the more central portions examined. The most interesting constituent of this portion of the dyke remains, however, to be mentioned. It is the non-pleochroic colorless rhombic pyroxene, enstatite; it occurs in idiomorphic development showing the characteristic obtuse domes in some of the sections. It shows regular cleavage parallel to ∞ P (110), upon which the angle of extinction is zero, and characteristic cross parting along which partial alteration of the mineral to bastite or serpentine is apparent. This enstatite is not abundant and plays the role of an accessory mineral. Its occurrence in a rock of well marked diabase structure is interesting. Rosenbusch remarks that it is present in only a few diabases which have a gabbro-like structure,* and Teall has recorded the occurrence of the allied rhombic pyroxene bronzite in the Whin-Sill of the north of England as an accessory.† Enstatite also occurs in a variety of the allied rock diabase porphyrite from Schaumberge, which has been described by Laspeyres and Streng under the name Palatinite. This enstatite was not observed in the coarser parts of the dyke but occurs, as will be noted, in the still finer grained diabase at the contact.

At the immediate contact the dyke assumes microscopically the characters of a very compact grayish black aphanitic rock in which can be occasionally detected minute glistening facets of porphyritic crystals. With low powers of the microscope the matrix is not resolvable but appears as an uniformly yellowish to greenish gray ground thickly dotted with grains of magnetite. Under the higher powers this is seen to be made up, in addition to magnetite, of a fine felt-work of minute lath-shaped crystals of plagioclase imbedded in hazy, somewhat yellowish green flocculent chlorite substance derived presumably from the alteration of the augite, since that mineral cannot with certainty be identified in the base. The porphyritic character of this part of the dyke is well marked, though the imbedded crystals are small. These are augite in small irregular polysomatic masses, with a hazy margin or fringe of greenish decomposition product, and long lath-shaped plagioclase and occasionally stouter broken fragments. Besides these there are porphyritic crystals of enstatite much more altered and

* Mik. Phys. der Massigen Gestine, 2nd Ed., 1896, p. 188.
† Q. J. G. S., 1884, p. 652.

less plentiful than at 6 feet from the contact. Neither quartz nor garnets are observable in the contact rock.

Considering then the dyke with reference to its variation in structure and mineral composition the points of interest to be noted are: The passage of the coarse grained central portions of the dyke to the compact aphanitic rock at the contact; the absence of porphyritic structure in the middle of the dyke as contrasted with the well marked development of the same as the rock becomes finer grained towards the dyke walls; the absence of the characteristic chloritic substance of diabase in the centre of the dyke and its abundance towards the contact; the presence of quartz in greater quantity in the coarse grained middle portions than at the sides; the presence of garnets in the coarsest parts of the dyke, their abundance in the medium grained parts and their rarity or total absence in the neighborhood of the contact; the presence of the rhombic pyroxene enstatite in typical idiomorphic porphyritic crystals in the fine grained parts near the contact and its absence in the coarser central parts; the diminution in size of the porphyritic crystals near the contact in co-extension with the increasing fineness of the ground mass; and finally the "polysomatic" structure common to the augite throughout the dyke.

Three quarters of a mile from the exposure where the specimens whose characters have just been given were collected, there occurs, on the opposite side of the bay in the line of the strike of the dyke, another exposure of the same dyke. On the islands of the bay which lie intermediate between these two localities the outcrop of the dyke is observable, so that there is no doubt of their both being exposures of the same dyke. The rock here was not studied in so great detail as at the last exposure. The specimens taken were of the same grade of coarseness as those taken at 20 feet from the contact on the north side of the bay. The feldspars are more decomposed and the twinning lamellae often obscure, and the small quantity of quartz which is associated with them appears to be of secondary origin; whereas the origin of the quartz noted in the same dyke on the north side of the bay seemed much more problematic. In the latter case the common micropegmatitic character of the quartz and the occurrence in it of needles of apatite, which in no way differ from those in the feldspar, together with the not

infrequent occurrence of one individual of apatite partially included in quartz and partially in an adjacent feldspar, would argue for the primary character of the quartz. The augite in the dyke on the south side of the bay resembles that already described occurring both in simple individuals and in polysomatic masses. It is largely altered to uralite. Titanic iron with its alteration product leucoxene shows characteristic barred structure of the cleavage traces parallel to the planes of the rhombohedron. The leucoxene is frequently accompanied by a margin more or less extensive, of secondary brown mica. Apatite is present in comparative abundance. Chlorite occurs in vaguely defined masses and the garnets which, as before, are present, are associated with it.

On the south-east shore of Pipestone Lake about a mile west of Stone-dam Portage occurs another of these dykes cutting transversely schists which have a strike of N.E. to E.N.E. The specimen taken from the middle of the dyke has the characters of an uralitic quartz diabase. The feldspar as a rule is remarkably fresh and occurs in the usual lath-shaped twinned crystals of plagioclase. The crystals are commonly observed to be cracked transversely and the cracks filled with a brownish yellow material which shows aggregate polarization. The augite occurs more commonly in polysomatic masses than in simple individuals. The magnetite is often surrounded by rims of secondary brown mica. The quartz is apparently original and has numerous inclusions of an opaque granular character together with fluid inclusions with dancing bubbles, gas pores with black borders and glass inclusions oval and circular.

Fig. 1.

Section of diabase, from Pipestone Lake dyke, showing large polysomatic grain of augite in three granules of diverse orientation *a b c*; *d* uralitic hornblende; *e* magnetite. X 28.

On the south shore of the North-west Bay of Rainy Lake, a similar dyke cuts both the biotite gneiss of the region and the red granite which is intrusive through it. It is an uralitic quartz diabase.

The feldspar is in rather stout crystals in the coarser grained part of the dyke, though usually lath-shaped. It is much decomposed and is partially replaced by quartz and chlorite. The polysomatic character of the augite is not prominent but this may be due to the fact that it is about half altered to hornblende and to chlorite. The augite individuals are often twinned and the cleavage traces are unusually well defined. The magnetite shows a tendency to peripheral arrangement around the altered augite indicative of its secondary origin. Quartz is present which is probably origina besides that which is clearly secondary. Apatite in long slender needles and leucoxene in irregular masses, are the accessory constituents.

In the same dyke, nearer the contact where the texture is fine grained, the rock is much more uralitized, traces of augite being observable only in cores of the compact green hornblende, which has almost entirely replaced it. Apatite appears more abundant, as do also the secondary quartz and chlorite. Garnet of a pale yellowish color occurs sparingly.

g 2.
Plagioclose fr m diabase dyke, Northwest Bay, Rainy Lake, sh'wing effect of pressure of one crystal against another.

At the contact the dyke rock is a compact aphanitic base in which can be detected minute porphyritic crystals. Under the microscope the base is seen to be made up of minute lath-shaped crystals of fresh plagioclase augite grains, magnetite and chloritic substance. The porphyritic crystals are lath-shaped feldspars occasionally broken and showing the lamellae in some instance bent, as the result of pressure of one individual against an angular part of another, and augite generally surrounded with an irregular border of secondary hornblende, which, in turn, has an outer girdle or wreath of granules of magnetite that have separated out in the process of uralitization as in fig. 3.

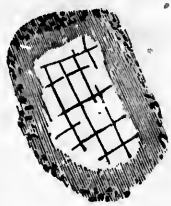

Fig 3.
Augite from diabase dyke, Northwest Bay, Rainy Lake, showing marginal alteration to green compact hornblende with an encircling wreath of secondary magnetite.

In the south part of the Rainy Lake and on the Rainy River a number of these dykes have been observed. One cuts the coarse granitoid gneiss of the river between Couchiching and Fort

Frances on the south side of the river, and another crosses the river at the Manitou rapids. Neither of these have yet been examined microscopically. On the lake near the extremity of Gash Point one of these dykes cuts the schists with a strike of N. W. and S. E. across the whole breadth of the point and traverses the islands on both sides of it. Here it is traceable on the point and on the islands for a distance of a mile. Three miles to the south east in the line of the strike of the dyke, a dyke occurs cutting the schists on the islands off the south shore of the lake which is probably a continuation of that of Gash Point. From this point it is traceable for two miles across the islands to the main shore on the south side of Grassy Narrows. Thus, this dyke has a length of at least six miles and has an extension to the north-west and south-east of the points observed, for a distance that is probably very much greater. A specimen from the central part of this dyke, proved on examination to have the characters of a uralitic quartz diabase. The plagioclase occurs in long, rather stout, lath-shaped crystals, which are generally so cloudy as to obliterate the twinning in most cases. The augite occurs both in simple individuals and in polysomatic masses. It exhibits the usual marginal alteration to hornblende and there is besides a certain amount of chlorite. Original magnetite is frequently surrounded by a margin of secondary biotite. Micropegmatitic quartz is abundant. It is often intimately intergrown with the feldspar, and as the latter is much decomposed, would seem to replace it as a partial pseudomorph, but apatite needles of the same aspect as those which occur as inclusions in feldspar, augite, and quartz, are often seen to be inclosed partly in a feldspar and partly in quartz grain. The primary origin of the quartz in spite of its micropegmatitic character, is however, not beyond doubt. It is to be noted that were the quartz original we would hardly expect to find it in such close association with the feldspar. The plagioclase of these rocks affords unmistakable evidence in its idiomorphic character of its having first crystallized from the magma. The augite crystallized next, enclosing the lath-

Fig. 4.
Polysomatic grain of augite—Grassy Narrows dyke Rainy Lake, *a* and *b* are twins —the other granules are of diverse optical orientation. X 28.

shaped plagioclase; and the quartz, which would be the last to crystallise, we would expect to find separate from the plagioclase by the augite, *i.e.*, to fill in the interstices between the augite. Again although single apatites are often found extending from a quartz grain to a feldspar grain, a condition of things favoring the notion of a common primary origin of both the latter minerals, yet such a phenomenon is not incompatable with a secondary origin for the quartz, since the replacement of feldspar by quartz must necessarily be a slow operation and proceed particle by particle. Further, if the quartz were original we should hardly expect to find in it inclusions of crystals of the first generation like apatite, which would be liable to be enclosed for the most part in the earlier secretions like feldspar and augite, rather than in the residual silica of the magma. The non-existence, however, of quartz in some diabases which are very much decomposed and its presence in fresh ones, militates against the theory of the secondary origin of the quartz in these rocks, so that the question of how much of the quartz is primary and how much secondary in an old diabase is a question that as yet does not appear susceptible of definite settlement.

About a mile to the west of this dyke where it crosses Grassy Narrows Island is another nearly parallel dyke converging on the former at a small angle towards the south. The rock is an uralitic quartz diabase and in its coarser portions, near the middle, the texture is more granular than that of typical diabase. The plagioclase is cloudy with decomposition products and quartz is abundant. The augite is entirely replaced by compact green hornblende the only indication of the augite that remains being the light colored character of the central portion of the hornblende and the abundance of magnetite granules that have separated out in the process of alteration. Apatite occurs in slender hexagonal needles mostly in the quartz, but also in the feldspar and hornblende; and a number were observed which were common to both feldspar and quartz. A few zircons showing parallel extinction, deep black border and brilliant polarization colors also occur. A few colorless, rounded, isotropic grains probably garnets were observed. Nearer the contact where the rock is much finer grained the typical diabase structure is much better developed, the feldspar having its usual

lath-shaped character with augite in allotriomorphic structure around it, although the character of the latter is obscured by its extensive alteration into hornblende. The augite so far as it is revealed in the cores of the hornblende occurs both in simple individuals and in polysomatic masses and it is interesting to note that the hornblende derived from a polysomatic aggregate of augite is of uniform orientation throughout. Magnetite or titanic iron with associated leucoxene is generally distributed. The quartz is in small grains proportioned to the finer grained texture of the rock. In the central part of the dyke the quartz is in large grains commensurate with the increased size of the feldspar and augite. In neither case does it occur in the mosaics which are so characteristic of the secondary or vein quartz. In addition to the minerals enumerated in this part of the dyke, there is in prominent porphyritic development an altered rhombic pyroxene. The alteration has proceeded very far and the mineral is now represented only by a mass of yellowish green serpentine with perhaps some of the intermediate alteration product bastite. The cleavage is, however, well defined and the extinction in the several cases noted is sharply parallel to it. These characters together with the traces of the obtuse dome so characteristic of sections of enstatite are sufficient to identify it as that mineral in an altered state. The occurrence of the enstatite in this dyke in its finer grained parts towards the contact is analogous to, and an interesting confirmation of the similar occurrence of the mineral noted in the Jack Fish Lake dyke also in the vicinity of its contact.

To summarise, the main points of interest are, briefly: 1. Post Archæan age of dykes. 2. Their problematic relationship to traps of Animikie and Keeweenawan. 3. Their uniform strike and width. 4. Sharp contact. 5. Passage from coarse texture at centre to aphanitic at sides. 6. Granular character towards centre, porphyritic at sides. 7. Prevalence of quartz and garnets towards centre and absence near contact. 8. Presence of enstatite at sides, absence towards centre. 9. "Chloritic substance" abundant at sides, absent towards centre. 10. Polysomatic character of augite throughout. 11. Uralitization of augite. 12. Very marked contrast of texture of two different parts of a rock mass which solidified under practically the *same pressure* but at *different rates of cooling*.