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FISH CREEK PHACOLITH, NORTHWESTERN NEW YORK

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ABSTRACT. The Fish Creek intrusive mass is located in the Brier Hill quadrangle, northwestern New York. The mass, of an outcrop area of approximately 12 square miles, occupies a steeply plunging, nearly isoclinally folded syncline. The outcrop surface is a cross-section nearly perpendicular to the axis of the fold. The main part of the mass is a fine-grained, pink alaskite gneiss. Medium-grained, gray-green trondhjemite, which is regarded as a portion of the alaskite magma contaminated by impure marble, forms a discontinuous border facies. All intrusive contacts observed are with highly metamorphosed Precambrian Grenville series marble. The mass is considered to be a phacolith because: (1) it is generally concordant; (2) it occupies the trough of a syncline; (3) it has a general lenticular cross-section; and (4) it appears to have resulted from the consolidation of magma that was intruded syntectonically. Phacolithic emplacement is inferred because of marked thickening on the plunging nose of the mass and the presence of sheetlike inclusions within the alaskite. The lack within the Fish Creek mass of a systematic spatial arrangement of alaskite that is apparently undeformed, of alaskite that has a marked cataclastic texture, and of alaskite that has been recrystallized completely is thought to be corroborative because this arrangement appears to be explained more readily as a result of deformation during the consolidation of the magma than by subsequent deformation of the solid rock.

INTRODUCTION

Buddington (1929) presented the idea, then novel in American geology, that 14 Precambrian alaskitic bodies in the northwestern Adirondacks are phacoliths. He described five of the masses in detail and suggested that the other nine masses may be phacoliths on the basis of their petrography and outcrop pattern. The Fish Creek mass, one of the latter masses, has been investigated and described in detail by the writer (Dietrich, to be published). The main features of the mass and additional genetic considerations are presented here.

The mass is composed chiefly of alaskite gneiss, has a discontinuous trondhjemite border facies, and has local concentrations of sheetlike gneissic pyroxene-plagioclase inclusions. The body has been called the Macomb granite and considered to be a portion of the Alexandria batholith by Cushing (1916, p. 18); it was named the Fish Creek phacolith by Buddington (1929, p. 52). "Fish Creek" is used in this report because the mass is on Fish Creek, whereas only a part of it is in the town of Macomb and its southernmost part is more than five miles northeast of the village of Macomb.

The Fish Creek alaskite mass is considered to be a phacolith because it is a generally concordant, lenticular body that occupies the trough of a syncline and because evidence suggests that the alaskite owes its origin to consolidation of a magma that gained its present position by syntectonic intrusion. These fill the qualifications established for the phacolith concept (see especially Harker, 1909, p. 77-78; Vogt, 1927, p. 136-185, 249-260; Buddington,

1929, p. 51-81; Stenzel, 1936). i.e., syntectonic (synkinematic) intrusion of magma along crests and/or troughs of folds in country rocks. They eliminate other types of igneous intrusive masses that would be most difficult to distinguish from phacoliths—folded laccoliths or sills and igneous masses that have intruded previously folded sediments.

GENERAL FEATURES

The Fish Creek mass has a total outcrop area of approximately 12 square miles. It has a U-shaped outcrop pattern and data from wells located between the arms of the U, i.e., wells that go through 80 to 115 feet of Potsdam sandstone into marble, show that this apparent shape is a true expression of the shape of the mass and not the result of a fortuitous erosion of overlapping sandstone. The outcrop surface is a cross-section nearly perpendicular to the axis of the mass. The mass occupies a syncline¹ that plunges steeply toward the northeast and has its axial plane dipping steeply toward the southeast (fig. 2).

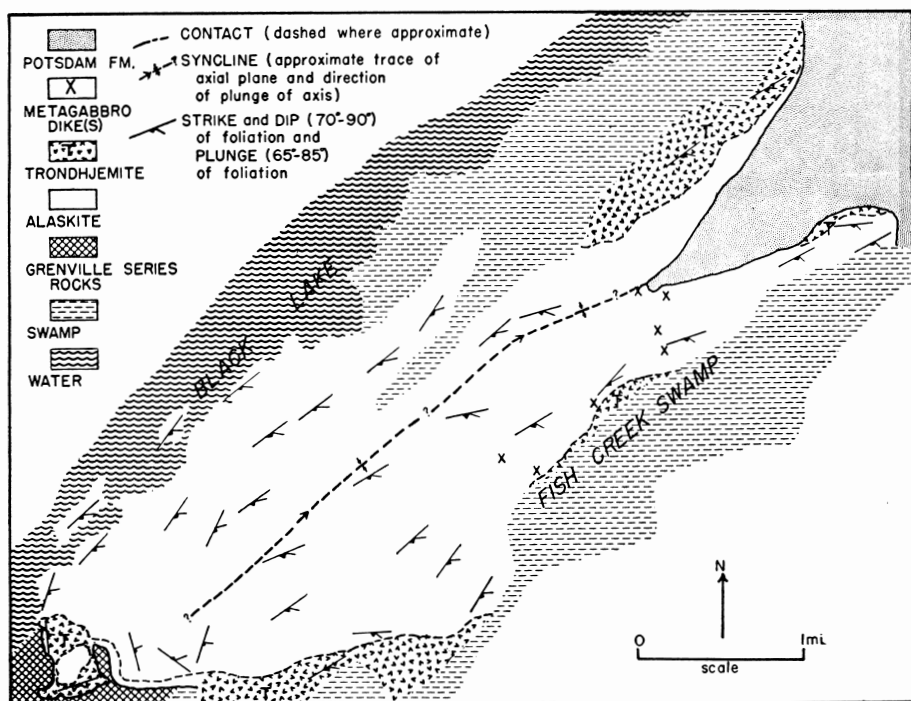


Fig. 1. Generalized map of the Fish Creek phacolith.

Structural relationships between the alaskite and surrounding Precambrian Grenville rocks cannot be determined definitely in many places because most of the contact is covered. However, similar orientation of minor struc-

¹ Syncline is generally defined as a fold with the younger rocks toward the center of the curvature. Because age relationships of different strata of the Grenville series are unknown, syncline is used here in its geometrical sense, i.e., a fold that is concave upwards.

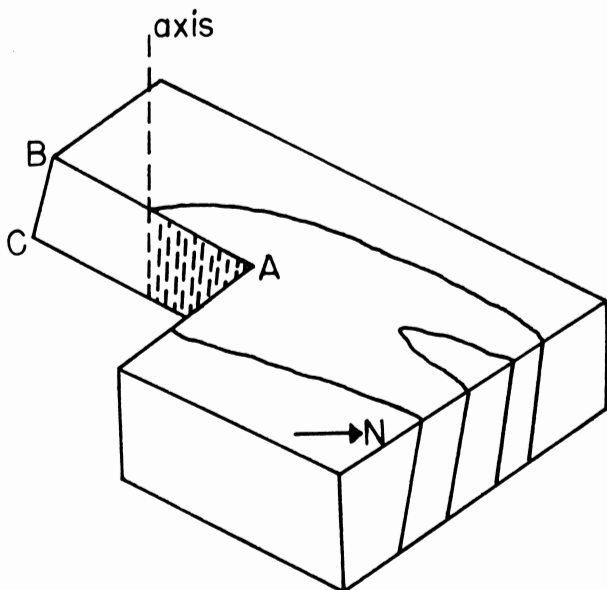


Fig. 2. Generalized block diagram of the Fish Creek mass. (ABC plane is foliation plane; dashed lines on this plane indicate lineation.)

tural features in the alaskite and in the Grenville rocks and the relationships between the two units at observable contacts suggest that the mass is generally concordant. Axes of nearly all minor folds in adjacent Grenville series rocks and of folded sheetlike inclusions within the alaskite gneiss are parallel to the lineation of the alaskite. Axial planes of most of these minor folds are parallel to the trend of the foliation of the alaskite. Where the contact of the alaskite gneiss with the Grenville series rocks can be observed, e.g., locally along the southern border of the mass, the marble is, except for minor divergences, concordant to the contact. The arrangement of tabular inclusions in the massive trondhjemite border facies and the overall shape of the mass corroborate the general concordancy.

The synclinal structure of the body itself is indicated by foliations and lineations of the alaskite and by parameters of the sheetlike melanocratic inclusions within the alaskite. The foliation, marked by parallel orientation of blebs of magnetite and grains of leaf quartz in the alaskite, is perceptible at all outcrops of the Fish Creek mass, with the exception of those of the trondhjemite border facies. Although the trend of foliation of the alaskite is nearly constant over the whole body, locally the strikes and dips of the planar elements differ within short distances. Most of the abrupt local changes occur near folded and fractured xenoliths where the foliation of the alaskite commonly deviates from the areal trend and is more nearly parallel to crenulations and broken edges of the inclusions. The general foliation in the alaskite apparently represents an axial plane foliation and is believed to have been formed in response to tectonic stresses. The foliation parallel to the *sides and* edges of folded and fractured inclusions is thought to be the result of effects

associated with magmatic flowage. Lineation, which is nearly constant over the whole mass, is in the plane of the foliation. It is expressed by parallel arrangement of grains of leaf quartz and by intersections between foliation planes and folded inclusions. The folded inclusions, most of which are in a zone that nearly bisects the mass, typically have their axes parallel to the lineation of the alaskite and their axial planes parallel to the foliation trend of the alaskite. On the basis of the attitude of the foliations and lineations, the body is interpreted to occupy a nearly isoclinal syncline that plunges steeply to the northeast and has its axial plane, which is marked by a zone of highly folded inclusions, dipping at a high angle to the southeast. The structure of the mass is, of course, more complicated than indicated on the schematic diagram (fig. 2) and the generalized map (fig. 1). Possible complications are described in another paper by the writer (to be published).

PETROGRAPHY

Alaskite that makes up the main part of the Fish Creek mass is a fine-grained, pink, hololeucocratic gneiss. Preferred orientation of leaf quartz, present at most outcrops, gives both planar and linear fabrics to the rock. Sporadic blebs of magnetite and plates of biotite are the only accessory minerals megascopically visible. Where present, they accent the gneissosity.

Thin-section investigations show that the mineral composition and fabric of the alaskite gneiss are different from place to place. Because there is an apparent relationship between fabric and mineral composition, the differences in mineral composition are believed to be manifestations of the relative amounts of cataclasis versus recrystallization that the alaskite has undergone. That the different types grade imperceptibly into each other and that the compositional differences, as indicated by their modes, are strictly mineralogic within nearly constant chemical composition are corroborative.

Modal analyses are given in table 1 of two of the heteromorphic variants of the alaskite that appear to be nearly end members in mineral composition.

TABLE 1
Modes of Two Heteromorphic Variants of Alaskite Gneiss from
the Fish Creek Mass

(Numbers indicate volumes in percentages.)

	I	II
quartz	48	50
microcline	} 5	19
albite (An_{0-5})		26
antiperthite ($Ab_{58}Mi_{42}$)	47	
accessory minerals*	trace	trace

* The accessory minerals, which are completely lacking in some specimens, are biotite, sphene, apatite, and opaque minerals (magnetite and possibly a trace of ilmenite). Anatase, chlorite, kaolin, and sericite are sporadic alteration products.

Rocks of intermediate compositions are common in the mass. Specimens con-

taining perthite² and quartz have one of two distinct fabrics—typically, they are mainly cataclastic with or without some grains of recrystallized quartz; perthite and quartz in one section, however, show no evident cataclasis nor recrystallization. Specimens having discrete grains of albite and microcline with quartz are believed to represent a complete reorganization of the type containing microperthite and quartz; it is suggested that the discrete grains of albite and microcline represent a complete unmixing of the perthite and segregation of the components and that the quartz, present as leaves, has been completely recrystallized. Specimens of intermediate compositions have what

PLATE 1



A. Dimensions of inclusions. Horizontal surface.



B. Plunge of the mass. Horizontal surface showing folded inclusions that have been weathered more than the alaskite host, leaving that host in relief; viewer was facing eastward.

² Perthitic feldspars in the Fish Creek mass have a range of composition between albite, 45 to 58 percent and potassium feldspar, 55 to 42 percent. *Perthite* is used here for both the antiperthites and the perthites.

appear to be intermediate fabrics. The following represent a few of the diverse types from the mass (pls. 3, 4, 5):

(1) Panallotriomorphic quartz and perthite with some of the grains showing a tendency to be amoeboid; small, rounded grains of quartz occur in larger grains of the perthite and small, rounded grains of the perthite occur in larger grains of quartz; albite rims are present on the grains of perthite along quartz-perthite and perthite-perthite borders but in general are lacking along perthite-albite borders. The perthite is made up of albite approximately 58 percent and potassium feldspar approximately 42 percent.

(2) Cataclastic perthite and quartz with minor albite; this rock tends to have a mortar fabric.

(3) Cataclastic perthite and quartz with some recrystallized quartz.

(4) Differentially granulated perthite and completely recrystallized quartz; porphyroclastic augen of perthite occur within a matrix of granulated perthite and recrystallized leaf quartz. Some thin sections have many such augen of perthite; others have only a few.

(5) A mosaic of albite and microcline with large quartz leaves; a trace of perthite is present locally.

MAGMATIC ORIGIN OF THE ALASKITE

No glass of alaskitic composition has been found to occur associated with the Fish Creek mass, so it cannot be stated unequivocally that the alaskite ever existed as a magma. Different ideas concerning the origin of the alaskite can be resolved into two main hypotheses: a) the body resulted through transformation, in the solid state, of pre-existing rocks—granitization; or b) the body resulted from consolidation of mobile rock matter that consisted in part of a liquid phase with the composition of a silicate melt—a magmatic origin.

Some of the more notable features that must be explained by any hypothesis of origin for the alaskite are:

(1) The ratio of the thickness of the nose to the thicknesses of the limbs of the alaskite mass is greater than the ratio of the same parameters of folds involving adjacent Grenville rocks.

(2) Structural features shown in plate 2-B could result only from movements involving an extremely mobile material.

(3) The foliation of the alaskite wraps around some of the inclusions within it.

(4) Tabular inclusions within the alaskite typically are oriented parallel to the foliation of their alaskite host.

(5) Strikes and dips of linear and planar elements of the alaskite gneiss differ within short distances locally.

(6) Threadlike fingers of alaskite material penetrate a few inclusions along their foliation planes.

(7) In some places, tabular inclusions that are highly folded lie between those that are relatively uncontorted.

(8) Some inclusions lie with their foliation athwart the foliation of the alaskite.

(9) A few inclusions do not have their foliation parallel to either their own borders or to the foliation of the host alaskite.

(10) Most inclusions have angular shapes.

(11) Most contacts between inclusions and the alaskite host are "knife edge" in sharpness; this is evident in both hand specimens and thin sections.

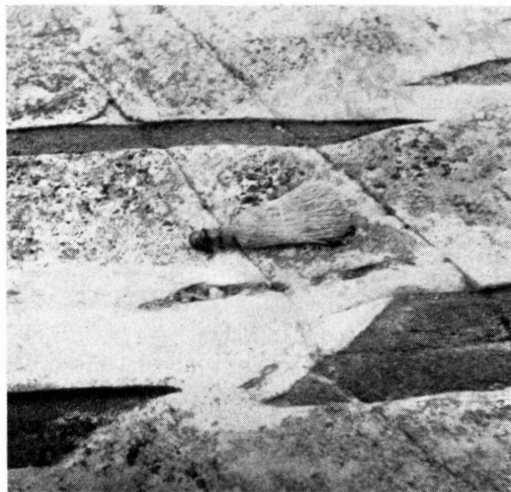
(12) Alaskite that is apparently undeformed, alaskite that has a marked cataclastic texture, alaskite that has been recrystallized, and alaskites with intermediate textures occur with no apparent systematic spatial arrangement within the mass.

PLATE 2

Some structural relationships of the inclusions.



A. Folded and fractured inclusions.



B. Fractured inclusions.

(13) The alaskite contains a notable percentage of perthite composed of nearly equal amounts of potassium and sodium feldspars (K-feldspar—55 to 42 percent; Na-feldspar—45 to 58 percent) and/or discrete grains of albite and microcline.

(14) Metamorphism of the contact type occurs spatially associated with the mass.

(15) The alaskite mass has some crosscutting relationships at its contact.

(16) Pegmatite and aplite bodies show a peripheral association with the alaskite mass.

(17) At least 14 bodies of this type, i.e., bodies composed of alaskite and structurally restricted to the crests or troughs of folds, are present in this region.

The first seven listed features indicate that the alaskite was very mobile during at least one period of its formation. This mobility could be accounted for by a magma or by the granitization of a previously highly plastic rock. The fact that the ratio of the thickness of the nose to the thicknesses of the limbs is greater for the folded alaskite body than the ratio of these parameters of folds involving nearby marble (1), however, would necessitate the granitization of a rock that was even more plastic than Grenville marble. No rocks of the Grenville series that appear to have been more mobile under deforming forces than the marble have been found to occur within this general region. A magma probably would have had the requisite mobility to account for this feature.

Relationships between the alaskite and its inclusions can be discerned rather easily because both horizontal and vertical exposures are abundant. The inclusions are thin sheets that are typically parallel to the foliation of the alaskite and generally have an internal gneissosity parallel to their margins. The sheets range from less than an inch to a few feet in thickness, are up to many rods in length, and appear to have extensions in depth comparable to their lengths along the strike. Most of the sheets have sharp contacts with the alaskite, although locally they are partially assimilated. The alaskite immediately adjacent to those with sharp borders is identical in composition to that of nearby alaskite that contains no inclusions; xenocrysts of hornblende and/or pyroxene are commonly present in the alaskite near assimilated inclusions. Only sporadic inclusions maintain their integrity for more than a few feet. Typically, the inclusions are broken, and alaskite, commonly pegmatitic, fills the intervening spaces. Although some broken ends show evidences of corrosion, most are unaltered fracture surfaces. Most of the fractured inclusions lose their apparent identity within short distances; some, however, because they are members of distinctive sequences, can be traced for great distances along their strikes, even where they have been broken and separated.

At some outcrops, individual highly contorted sheetlike inclusions occur between other sheetlike inclusions that are nearly straight or only slightly bent. Both types are typically fractured. Locally the foliation of the alaskite wraps around the fractured ends of the inclusions. The presence of the highly contorted sheets that are also fractured suggests that the relative rigidity of the inclusions differed temporally. The presence of contorted sheets between rela-

tively unfolded sheets suggests notable freedom of movement among the different inclusions. Other structural relationships, such as those shown in plate 2-B also indicate that there was great freedom of movement among the different inclusions and that even restricted zones were affected by distinctly different movements that were out of harmony with each other. As is apparent in this photograph, shortening was the result of the relative movements involving the thinner inclusion after it was fractured and its parts initially separated, whereas lengthening was the result of the relative movements involving the thicker inclusion after it was fractured. The movements indicated by the field evidence appear to have been similar to those found in flowing fluids.

The inclusions in the axial plane zone of the syncline are of special interest. Although there is a parallelism between the axial planes of the folded inclusions and the general foliation of the alaskite and a general parallelism between the axes of the folded inclusions and the lineation of the alaskite, many inclusions in this zone have their foliation athwart that of the alaskite and locally adjacent inclusions do not approach parallelism either of their shapes or of their internal foliations. Also, a notable number of the inclusions of this zone do not have their foliation parallel to their long dimensions. The presence of inclusions that lie with their foliation athwart the foliation of the

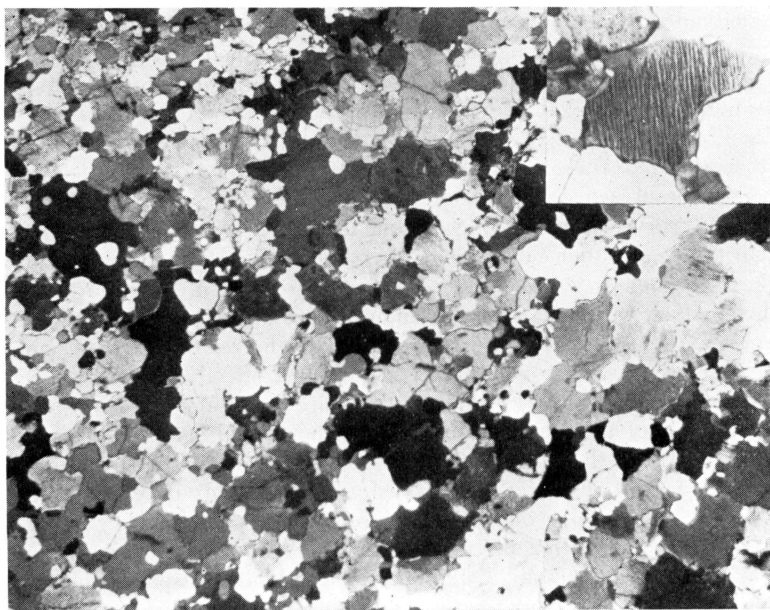


PLATE 3

Panallotriomorphic quartz and micropertthite (x 8). Inset, upper right, shows relationships within the individual perthite grains more highly magnified (x 30).

alaskite imposes the necessity for at least two periods of foliation formation; this could be accounted for under the magmatic hypothesis by intrusion of a magma, that solidified to a gneissic rock, into a foliated sequence of rocks.

If, however, the alaskite had been formed by granitization, at least two periods of metamorphism would be necessitated, the latter of which would have had to have been strong enough to initiate a new or different foliation in one member and yet not strong enough to efface a previously formed foliation in the other member. It might be suggested that this set of conditions is not necessary because the inclusions might represent dismembered sills and dikes rather than foliated metasedimentary rocks; if this were true, however, the foliations in the inclusions would represent relict flow foliation and typically would be parallel to the borders of the tabular sheets; the presence of inclusions having their foliation at an angle to their margins and also at an angle to the foliation of the alaskite precludes this origin for at least some of the inclusions, and thus some relationships are present that would require at least the two periods of metamorphism. This especially complicates any suggestion that the mass resulted from granitization because it is the alaskite that has an axial plane foliation whereas the foliations of the included pyroxene-amphibole-plagioclase rocks commonly deviate from this trend. Consideration of the present degree of preferred orientation of constituent minerals in the host alaskite and in the included rocks suggests that the included rocks are more susceptible to induced foliation than the alaskite is.

Concerning the fabrics of the alaskite (10), none has a fabric that can be called unequivocally protoclastic. However, the presence of the different fabrics with no obvious systematic spatial arrangement within the mass may suggest that the deformation took place during consolidation of an at least partly mobile material. Under this interpretation, the cataclastic rocks might represent the results of deformation of consolidated portions of the magma; the recrystallized rocks, consolidated portions of the magma that were deformed in the presence of fluids or while hot, the fluids or higher temperature promoting recrystallization; the alaskite having a panallotriomorphic fabric without traces of either cataclasis or recrystallization, a portion of the magma that consolidated in zones sheltered from deformation, or a portion of the magma that consolidated after the main deformation; and the rocks having intermediate textures, intermediate conditions. The relative time of consolidation of the magma with respect to the period of effective deformation would have been the only control, and it is therefore necessary only to assume that different parts of the magma consolidated and cooled at different times from other parts. If, on the other hand, the fabrics are considered to represent deformation of solid rock, very localized forces of notably different magnitudes would be necessary to account for the differences.

If it is supposed that the perthite in the Fish Creek alaskite was formed by unmixing of an originally homogeneous alkali feldspar rather than by replacement or some other process(es), then the presence of perthite consisting of nearly equal amounts of potassium feldspar and sodium feldspar (13) indicates that the alaskite consolidated at a temperature of at least 650°C. (Bowen and Tuttle, 1950, p. 501-502, 510-511; Tuttle, 1952, p. 112). The extremely low calcium content of the alaskite (Tuttle, 1952, p. 117-119), comparison of the features of the perthites in the alaskite with features commonly shown by structures known to have formed by unmixing from origin-

ally homogeneous solids (e.g., pearlitic structures in some alloys), and consideration of previous discussion (Perrin and Roubault, 1953; Tuttle, 1953) warrant this supposition in the opinion of the writer. The alaskite made up of discrete grains of microcline and albite is interpreted as the result of unmixing carried to its ultimate limit, i.e., complete elimination of one feldspar from the other. This unmixing of a once homogeneous alkali feldspar into perthite and locally into discrete grains of albite and microcline may have been promoted by prolonged heating below the temperature of stability of the homogeneous feldspar (Bowen and Tuttle, 1950; Tuttle, 1952), by stress (Phemister, 1926, p. 25; Larsen, 1938; Buddington, 1939, p. 329; Chayes, 1952), by slow cooling (Chayes, 1952, p. 293), or possibly by a combination of processes. It appears likely in the light of the suggested mode of emplacement of the mass and of post-emplacement events that the alaskite was in a zone where prolonged heating or slow cooling would have obtained and also that it was affected by tectonic stress(es) both during and after emplacement. That the feldspar was at or near 650°C. at one time in its evolution and that actual rocks and synthetically prepared mixtures similar in composition to the Fish Creek alaskite begin to melt at 655°C. and 4000 bars water vapor pressure (Tuttle, 1953) are strong evidence in favor of a magmatic origin for the Fish Creek alaskite.

The shapes and contacts of the inclusions, the metamorphism spatially associated with the mass (14), the local crosscutting relationships (15), and the peripheral arrangement of pegmatites and aplites (16) are suggestive of an igneous origin for this mass, in the opinion of the writer. However, these same features have been denied such a significance many times by proponents of granitization and are offered here only as features that must be explained. The presence in the region of many alaskitic bodies that are restricted to crests and troughs of folds (17) and the general lack of alaskite on the limbs of the folds could be accounted for by either hypothesis; either the movement of granitizing agents or the intrusion of magma would be facilitated in such zones of low pressure developed during folding.

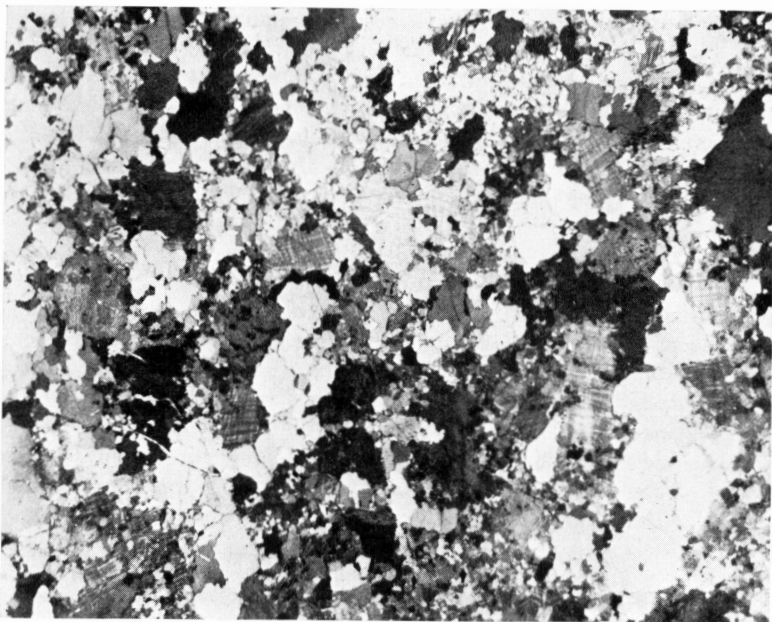
The balance of evidence, though much of it is admittedly only permissive, suggests that the alaskite body resulted from the consolidation of a magma rather than by the transformation of solid rock. Further, no known evidence is at odds with this interpretation.

CONTACT METAMORPHISM

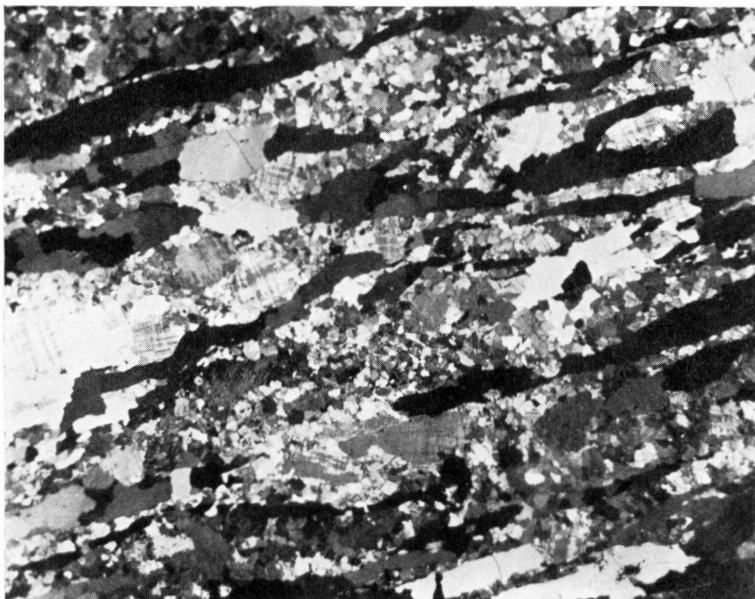
As mentioned above, metamorphic effects spatially associated with the Fish Creek mass were not given as criteria of magmatic origin for the mass because similar associations have been denied as having such a significance many times by proponents of granitization. However, since the mass has been shown to be of probable magmatic origin by using other criteria, a brief description of the metamorphic effects is in order. The following is a summary of the contact metamorphism as described and interpreted by the writer in another report, to be published.

Both exomorphic and endomorphic effects are present near the contact of the Fish Creek mass. The Grenville series rocks show evidences of reconstitution and introduction of material; the Fish Creek mass itself is notably

PLATE 4



A. Cataclastic perthite and quartz with some recrystallized quartz and minor amounts of albite (x 8).



B. Large cataclastic augen of perthite; granulated perthite; recrystallized quartz (x 8).

different in grain size and composition along parts of its contact.

There is no regularly zoned aureole around this mass. The exomorphism associated with the Fish Creek mass is similar to that associated with the granitic masses in the nearby Oxbow district as described by Agar (1923). Contact metamorphic minerals occur: 1) disseminated through large volumes of marble; 2) as irregular pockets both near the contact and at considerable distances from any visible intrusive contact; and 3) in completely altered bands that may represent former impure or dolomitic layers in the marble unit. Minerals found to occur within the contact zone are actinolite, albite, apatite, biotite, bowlingite (?), calcite, chondrodite, clinozoisite, cordierite (?), garnet (chiefly almandine), graphite, hornblende, leucoxene, microcline, micropertite, myrmekite, periclase (?), phlogopite, pyrrhotite, pyroxene (both augite and hedenbergite-diopside), quartz, scapolite (mizzonite-dipyre), serpentine, sillimanite, sphene, spinel (both green and colorless varieties), and tourmaline (both blue and brown varieties). The hedenbergite-diopside, scapolite, sphene, chondrodite, quartz, and different feldspars are the most common minerals other than calcite. Two especially common mineral associations are colorless spinel and chondrodite, and sphene, pyroxene (of the hedenbergite-diopside series), and scapolite. Locally, the spinel-bearing chondrodite marbles are now opicalcites because of serpentinization of the chondrodite.

This contact metamorphism probably represents an addition of elements from the magma as well as recrystallization and rearrangement of elements to form the calcium and magnesium silicates. Among the elements probably added are boron, fluorine, chlorine, and phosphorus, represented respectively by the minerals tourmaline, chondrodite, scapolite, and apatite.

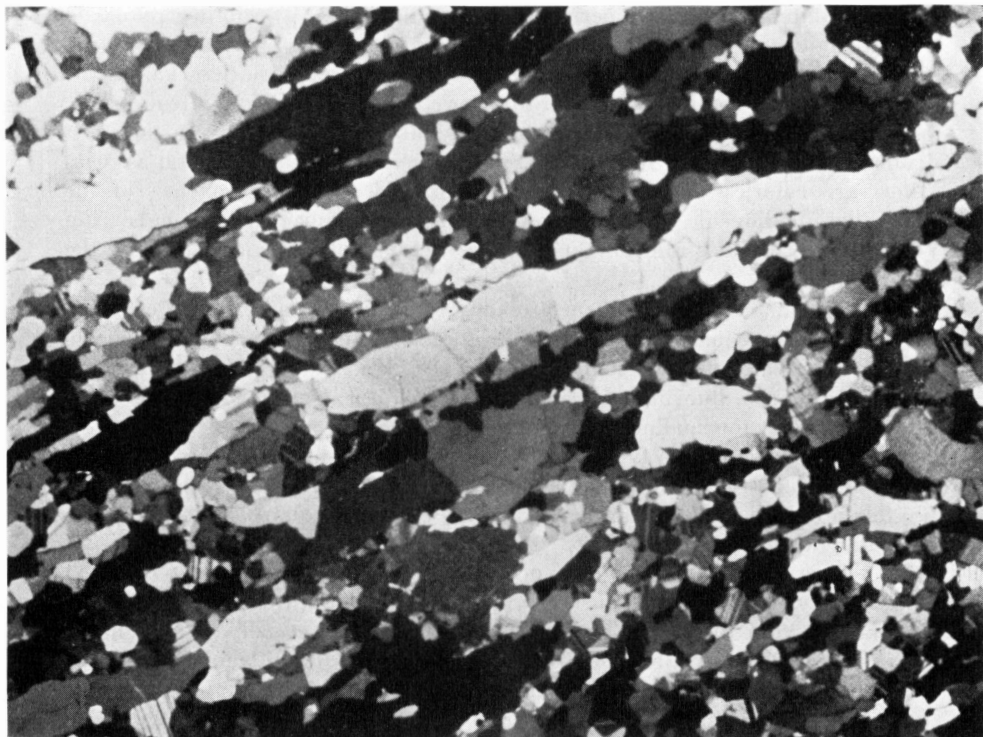
Other petrographic types associated with the Fish Creek mass that have been attributed to exomorphism associated with similar alaskite gneiss bodies in this province are garnet gneiss, "amphibolites," and quartz-oligoclase rocks (Buddington, 1939, p. 169-172).

Garnet gneiss was found to occur in four places in and near the Fish Creek body. It occurs as thin layers in the marble south of the mass and as xenoliths within the mass. The gneiss is composed essentially of almandine, sillimanite, micropertite, andesine, quartz, and biotite with minor amounts of green spinel, sphene, myrmekite, zircon, apatite, sericite, and opaque minerals. Locally, sillimanite is absent. The origin of similar garnet gneiss in this general region has been a subject of great interest since Martin's discussion (1916, p. 24-40) of different possible origins for it in the Canton quadrangle. He concluded that the garnet gneiss resulted from metamorphism of siliceous-aluminous sediments. Buddington (1929, p. 96-105) reviewed objective data concerning the gneiss and concluded that it originated as a consequence of interaction between a portion of granitic magma enriched in hyperfusibles and/or thermal solutions and an earlier-formed amphibolitic facies (which was formed by prior contact metasomatism of marble). The writer favors the idea that the garnet gneiss spatially associated with the Fish Creek mass was derived essentially by simple reconstitution of *aluminous-siliceous sedimentites*.

Many petrographic types are included in the term "amphibolite" as that term has been used by former workers in this general region. Included are various plagioclase foliates that contain biotite and/or hornblende and/or pyroxenes (clino- and/or ortho-). Gneissic hornblendic pyroxene-plagioclase rocks predominate in the Fish Creek mass. Most of the rocks of this type appear to have had essentially their present character before intrusion of the alaskite magma.

The quartz-oligoclase rock—trondhjemite—along part of the periphery of the alaskite body is believed to represent endomorphism rather than exomorphism. The rock is typically dark gray or greenish gray, medium grained,

PLATE 5



Large leaves of recrystallized quartz; albite and microcline (x 19).

and massive and is composed of zoned, antiperthitic plagioclase feldspar (An_{27-32}), 45 to 65 percent; strained quartz, 20 to 40 percent; and minor amounts of biotite, apatite, zircon, and ilmenite (with included magnetite lamellae) plus or minus hornblende, diopside-hedenbergite, myrmekitized microcline-micropertthite, pyrite, and epidote. The trondhjemite grades imperceptibly into the alaskite of the main mass and it contains inclusions identical in composition to those in the main mass. Its chemistry and mineralogy suggest that it represents a portion of the alaskite magma that was contaminated by the calcareous country rock.

EMPLACEMENT

The source of the alaskite magma is not known. It could represent part of a primitive magma, a fraction of a differentiated magma, or a magma derived by partial or complete fusion of pre-existing rock. Data available in this area apparently do not preclude any of these possibilities. The widespread distribution in the region of alaskite like that in this mass (Buddington, 1939, pl. 23—the alaskite is equivalent to his “Alexandria Type” granite), the fact that it cuts all other major pre-Potsdam rock units in the region, its occurrences in many phacoliths and a major batholith, and its highly silicic composition are data that, in conjunction with the features already mentioned, must be considered.

The writer favors the possibility that the alaskite magma was derived by partial or complete remelting of pre-existing rock and that the phacoliths represent portions of the magma, so formed, that moved away from the main mass. Many features are in accord with any suggestion that would place the phacoliths in a critical zone where conditions favoring fusion and refusion obtained. It is considered not impossible that the alaskite represents an easily fusible portion of the basement upon which the Grenville Series rocks were deposited.

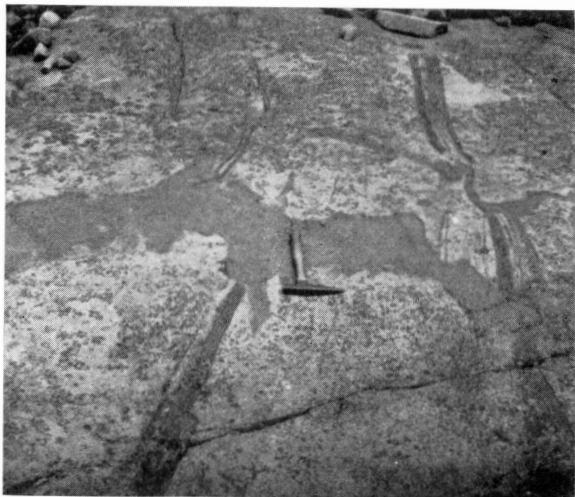
No matter what the source of the alaskite magma, all evidence suggests that the portion of it that solidified to form the Fish Creek mass came to occupy its position mainly by permissive intrusion. (Permissive intrusion was defined by Pirsson (1914, p. 299) as intrusion in which magma is emplaced by flowing into space that opened for it, the openings being formed mainly by some force other than one exerted by the invading magma.) In the case of the Fish Creek mass, the magma is believed to have flowed into potential cavities created by tectonic stress at the trough of a fold.

The general type of injection thought to have been mainly responsible for emplacement of the Fish Creek alaskite may be explained as follows: During folding, crests and troughs of folds become zones of relative weakness and general tension, whereas the flanks of folds become relatively compressed. If the materials being folded have competencies such that they will flow during the folding, folds will be produced that show thickening varying directly with the mobility of the material involved; if on the other hand, the materials involved have competencies such that they will fracture rather than flow under the conditions of the folding, there will be a tendency for openings to form along planes of weakness (e.g., foliation or bedding planes) at the crests and troughs of the folds. If igneous magma were present during such folding, it probably would find its way into the zones of weakness along the crests and troughs of the folds in the more rigid rocks. After the initial permissive introduction of the magma into the potential openings, there might be further enlargement of the interspaces and addition of more magma until the original rock would be dismembered completely and become discrete fragments (xenoliths or inclusions) within the magma. The enlargement of the interspaces between fragments of the country rock might be dependent upon continued folding, simultaneously with addition of more magma, or upon forces exerted by a somewhat aggressive magma. Whichever the case, if enough magma

were supplied, it would finally become the predominant member of the unit, and the unit would then act like a mobile material so long as any notable part of the magma retained its fluidity. Upon consolidation the resulting mass would be a concavo-convex, lenticular-shaped mass containing many sheetlike inclusions or splinters of the injected country rock.

Because this general mode of intrusion appears to explain all features

PLATE 6
Metagabbroid (?) dikes



A. Folded dike.



B. Faulted dike.

associated with the mass, and because no known features associated with the mass preclude this mode of emplacement, it is concluded that the Fish Creek alaskite was so emplaced. Further, no mode of emplacement, except syntectonic, permissive intrusion into the nose of a fold, has been found that is in complete accord with the thickening of the nose of the mass, the orientation and peculiar shapes of inclusions within the alaskite, and the fabric differences in the alaskite.

POST-EMPLACEMENT HISTORY

Subsequent to the emplacement of the phacolith the mass has been intruded by gabbroid (?) magma; intruded by basaltic magma; and uncovered by weathering and erosion at least two times.

A small basaltic dike cuts the mass near its southern margin just south of the marble embayment. The basalt is composed of labradorite, 45 to 60 percent; pyroxene (augite and pigeonite), 30 to 40 percent; olivine, up to 10 percent; and opaques, up to 8 percent. Its texture is diabasic, and although the rock is now holocrystalline, it appears as if it once had a mesostasis of glass. The chilled margins are composed of the same rock with modifications typically associated with rapid consolidation. The dike cuts the foliation of the alaskite, has chilled margins, and is unmetamorphosed.

The present exposure of the Fish Creek phacolith plus the fact that it is overlain locally by Potsdam sandstone shows that the mass has been exposed by weathering and erosion at least two times.

At least 18 gabbroid (?) dikes, ranging from a few inches to nearly two feet in width, cut the foliation of the Fish Creek alaskite gneiss and intersect some of the inclusions within the alaskite. The dikes are of special interest because this is the first mass in the northwest Adirondack province in which they have been recognized and because they may throw new light upon the conditions that prevailed during the late stages of alaskite magmatism. Petrographically, the dikes are now typical amphibolites and are composed of andesine, 45 to 55 percent; hornblende, 35 to 45 percent; magnetite, up to 8 percent; and minor amounts of apatite, titanium-rich biotite, and zircon. No relict igneous textures are apparent in thin section. In the field the thicker dikes may be seen to have fine-grained borders and the thinner ones are fine grained throughout, possibly representing relict chill zones. Subsequent to intrusion, these dikes have been dynamically deformed, reconstituted (?), and have been cut by pegmatitic material.

Two dikes of this type are of particular interest (pl. 6-A and B). Features associated with them suggest that they were intruded before at least the latest period of alaskite mobility: the folded dike, which occurs near the axial plane zone of the phacolith, has its axial plane nearly parallel to the axial plane foliation of the alaskite; the fabric of the alaskite in the area immediately adjacent to the fault that cuts the other dike (pl. 6-B) does not show cataclasis and does not have a fabric different from that of the rest of the alaskite of the same general zone. Foliation in the wider dikes is parallel to the margins of the dikes near the margins and is a compromise between that and that of the Fish Creek alaskite axial plane type in the central part of the dikes;

the dikes are injected locally by pegmatite of the same composition as that of the alaskite.

The origin of the magma that formed these dikes is questionable. Perhaps it represents xenolithic material (inclusions) that sank into a zone where it became at least partially melted and thus gained mobility; perhaps it represents spessartite material or some similar type of late differentiate of the alaskite. In any case the magma apparently came into fractures during the tectonism responsible for injection of the phacolith and during a period when the alaskite was at a critical level or in a critical state, i.e., the alaskite alternated between solid rock that could be fractured and magma or mush that could flow. This interpretation is not unlike that suggested by Sederholm, (1926, p. 22, 39-51) with regard to the inclusions in the granite at W. Bagaskär, Ingå, Finland. Inclusions in the granite there were interpreted to be dismembered mafic fillings of fissures; it was suggested that the fillings were formed by material that exuded from the granitic host and filled fissures in that host while the host was still in a critical state, i.e., it was in such a state of aggregation that fissures could form in it but a portion of it still retained its capacity to flow so it thus had mobility enough to permit the movements that dismembered and floated apart the mafic fissure fillings. Another interpretation that cannot be ruled out completely is that given by Sederholm (1926, p. 39-55) for inclusions in the granite near Pavaskär, Ingå, Finland. He suggested that mafic dikes were injected into a series of rocks that subsequently became mobile because of palingenesis in situ.

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