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**Title:** The Geology of the Oquossoc 15' Quadrangle, West Central Maine

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## Introduction

This report is based on three summers of field work during the years 1962-64. The northwest corner of the area mapped lies in Cambro-Ordovician strata on the axis of the Boundary Mountains Anticlinorium as located by Green and Guidotti (1968). The southeast corner lies in the Silurian rocks of the northwest limb of the Merrimack Synclinorium. The work of Milton (1961) in the Old Speck Mountain quadrangle (just south of the Oquossoc quadrangle) dealt with Ordovician and younger strata but due to abundant intrusives the stratigraphic interrelationships could not be established rigorously. However, by extrapolating along strike from Milton's work and taking into account the work of Green (1960) in the Errol quadrangle it seemed likely that the stratigraphic relations among the Cambro-Ordovician and younger units could be investigated in the Oquossoc quadrangle.

Unfortunately, because most of the quadrangle is underlain by Ordovician and Lower Devonian igneous rocks observations in the Oquossoc area have shed little further light on the details of the Lower Paleozoic stratigraphic section between the Boundary Mountains Anticlinorium and Merrimack Synclinorium. Fortunately, however, the work of Moench (1971) has provided this information.

In the Oquossoc quadrangle one can recognize clearly several Cambro-Ordovician units in the western, and northern parts of the area. These include: the Aziscohos, Albee, and Dixville Formations. In the southeastern part of the area several members of the Silurian Rangeley Formation occur in large roof pendants. Because of the limited areas underlain by these several units and the nature of their areal distribution it has not been possible (from observations within the Oquossoc area) to contribute significantly even to the several stratigraphic problems within the Cambro-Ordovician sequence that occupies the core of the Boundary Mountains Anticlinorium. Essentially one is able to fit the Oquossoc units into any of the several stratigraphic models proposed by various workers for the whole of northern New Hampshire plus western Maine but without providing any light on which models are better. For an elaboration of regional correlation models the reader is referred to Green and Guidotti (1968), Harwood et al (1970), Harwood (1973), Boone et al (1970), Osberg et al (1968), Moench and Boudette (1970), and Moench and Zartman (1976). In this report, I will concentrate on description and discussion of the local units.

## Acknowledgements

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## Stratigraphy

Cambro-Ordovician Sequence In the Oquossoc quadrangle this sequence consists of the Aziscohos, Albee, and Dixville formations (plus possibly some of the Ammonoosuc Volcanics) but each of these have two mappable members. This usage of formation names and age sequence is consistent with that of Green (1964) and Harwood (1973). An alternative proposal of names and sequence following Boone et al (1970) will be discussed briefly below.

Aziscohos Formation: This Formation has two members and was named by Green (1964) from the good exposures in the vicinity of Aziscohos Lake in the Errol and Oquossoc quadrangle. In the latter region it is restricted to the northwest and north-central parts of the area. In most places it is only slightly metamorphosed but the southern-most outcrops are commonly metamorphosed to sillimanite grade.

The lower member of the Aziscohos Formation consists of black, graphitic phyllites to schists depending upon the metamorphic grade. Pyrite is common in this member and thus weathered surfaces are usually rust-colored. In contrast with the upper member, the foliation is relatively undisturbed by crenulations and very small folds. However, in some outcrops that have abundant lenticular quartz pods (0.5 to 1.5 cm thick) the foliation is very contorted. As much as 5 percent of this member consists of greenstone beds up to 20 meters thick. Also present, are a very few, scattered, thin dark quartzite beds. In most cases foliation and bedding appear to be parallel except on the noses of obvious minor folds.

The most extensive outcrops of the lower member of the Aziscohos Formation occur as a northeast trending band, just to the northwest of the Adamstown Granite. Other good exposures of the lower member are present on the shores of Aziscohos Lake. In these exposures, dragfolds and graded beds in outcrops containing the contact between the lower and upper members of the Formation, show clearly that the black phyllites are structurally and stratigraphically the lower unit. This observation clearly supports the suggestion of Green (1964).

The upper member of the Aziscohos Formation is easily distinguished from the lower one by virtue of its highly contorted green phyllites with abundant thin, quartz pods (0.5 to 1.5 cm thick) which in some cases have been pulled apart to form distinct rod or mullion structures. Minor folding and crinkling are very common in this unit. In many cases it is evident that the minor folds are very tight suggesting that isoclinal folding is probably present throughout much of the region. Moreover, from such examples, it would seem that the foliation is generally parallel to axial planes of folds. In accordance with this supposition, bedding and foliation are usually parallel.

However, especially in the north-central part of the area, a later slip cleavage (NIOE, vertical) has strongly affected this member (and to a lesser extent the lower member also) and produced a prominent, almost vertical crinkling or crenulation. In some outcrops this late cleavage is so well developed that it partially obliterates the earlier foliation which is related to the deformation that produced the large, northeast-trending folds.

A particularly common feature of the phyllites of the upper member of the Aziscohos Formation is the presence on weathered surfaces of 1-2 mm magnetite euhedra and in a few cases pyrite cubes also. Greenstone beds up to 30 meters thick are scattered throughout this member.

Along the north and northwest contacts of the Adamstown granite the upper member of the Aziscohos Formation was metamorphosed to a hornfels but subsequently retrograded back to greenschist facies by Acadian metamorphism. The effects of this hornfels development are reflected in the dense hardness of rocks from this zone and the distinctive pitted weathering surfaces. Moreover, the original thinly laminated aspect of the green phyllites appears now as a pin-striping which closely simulates that of the quartzites in the Albee Formation. However, thin sections clearly show that most of these rocks are not particularly quartz-rich. In regions such as the south end of Aziscohos Lake, the phyllites have more recently been metamorphosed to staurolite to sillimanite grade and there the hornfels has been largely obliterated.

Possibly associated with or indirectly resulting from the metamorphic event associated with emplacement of the Adamstown Granite is a faint green mottling in some of the green phyllites. The mottles (up to 0.5 cm across) consist of tabular aggregate of very fine grained chlorite which may be pseudomorphs after some higher temperature mineral such as cordierite (?).

Some "tops" evidence on the east slopes of Deer Mountain (North-central border of the quadrangle) and especially the results of the work by Harwood (1965, 1973) in the Cupsuptic quadrangle would seem to put the Aziscohos Formation as mapped in this study below the Albee Formation--much as suggested by Green (1964) in the Errol quadrangle. Here reference to the Albee means those strata which contains 10-50 percent of the distinctive pinstriped quartzites.

Green (1964) estimated that the total thickness of the Aziscohos Formation is 7000 feet (2130 meters). Harwood (1973) has estimated that the upper member of the Aziscohos Formation is 4000 feet (1220 meters) thick in the Cupsuptic quadrangle.

Albee Formation:

According to Harwood (1966) a combination of map pattern, "tops" evidence, and structural interpretation in the region along the mutual boundary of the Oquossoc and Cupsuptic quadrangles suggest some Albee "types" underly Aziscohos "types." In particular, green phyllites with

10 to 50 percent of interbedded 10-30 cm thick pin-striped quartzites seems to underly green phyllites that are lithologically identical with the upper member of the Aziscohos Formation. Indeed, on the basis of detailed mapping Harwood (1973) has shown the Albee subdivided into several members. For the purpose of this report, only two members are important: the Portage Brook Member and the Deer Mountain Member.

The Portage Brook Member is more typical of what various workers have mapped as Albee Formation in other parts of northern New England. At comparable metamorphic grades it is very similar to the green phyllite member of the Aziscohos Formation in virtually every respect except for the presence of 10 to 50 percent of the above mentioned pin-striped quartzites. Commonly the quartzites are somewhat more resistant than the enclosing phyllites and tend to stand out on weathered surfaces. By a decrease in the percent of the pin striped quartzites in the Portage Brook Member, it grades downward into the upper member of the Aziscohos Formation. This member of the Albee is also similar to the Aziscohos in that greenstone beds up to 30 meters thick are scattered through the unit.

Harwood (1973, p. 11) estimates that the Portage Brook Member in the Cupsuptic Quadrangle is about 6000 feet (1830 meters) thick. This Member outcrops along the northern border of the quadrangle where it is only at greenschist grade. It also occurs in a broad belt of high grade rocks in the south central part of the area and as a few roof pendants in the central regions.

Some of the Deer Mountain Member occurs along the northern boundary of the quadrangle on Deer Mtn. However, the most extensive area underlain by this unit is a northwest trending belt along the east side of Cupsuptic Lake. As mentioned previously, it is lithologically identical with the upper member of the Aziscohos Formation. It is mapped as a member of the Albee Formation only on the basis of relationships described by Harwood (1973) in the Cupsuptic Quadrangle.

In the northern two-thirds of the belt of Deer Mtn. Member outcropping along the east side of Cupsuptic Lake, the metamorphic grade is only greenschist facies. However, to the south of Bald Mtn. the grade rises steeply to the lower sillimanite zone.

The Deer Mountain Member is about 2500 feet (760 meters) in the southern part of the Cupsuptic area, Harwood (1973). In the northeastern part of the Oquossoc area it grades upward by an increase in the number of interbedded greenstones into the volcanic member of the Dixville Formation.

Dixville Formation: The northwest-trending greenstones and black slates in the northeastern part of the area are designated as Dixville Formation purely on the basis of following the suggestions of Green and Guidotti (1968), Harwood et.al. (1970), and Harwood (1973). Below an alternative model will also be considered.

In the Oquossoc area the Dixville Formation can readily be divided into a lower greenstone member and an upper carbonaceous fissle, slate member.

The lower member consists of medium grained, foliated to massive greenstones. Most of it lies within the greenschist grade of metamorphism and most specimens contain the assemblage quartz + albite + chlorite + epidote ± actinolite ± calcite ± pyrite. The more massive greenstones commonly retain a vesicular texture, the vesicule now being filled with quartz and/or calcite. Some outcrops have epidote-rich pods and blebs up to 15 cm in diameter which suggest volcanic bombs among the original deposits. Possibly some remnant pillow structures are also present.

In some of the well foliated beds the presence of remnant feldspar clasts up to 0.5 cm in diameter suggest a pyroclastic origin. This is also suggested by a few thin, light colored beds which in thin section show remnant shards.

The individual massive and foliated beds of the lower member range from 3 to 15 meters thick. The weathering surfaces of both types are usually a punky, dark brown color and readily crumble into fragments. Fresh pieces of rock, however, have the typical green color of basaltic rocks metamorphosed to the greenschist facies. Where the metamorphic grade reaches lower sillimanite zone (near the south side of Bald Mtn.), the metavolcanics occur as dark, well foliated amphibolites.

Near the base of this member of the Dixville Formation it is readily possible to find 3 to 15 meter beds of green phyllite. With increase in the amount of phyllite, the greenstones grade conformably down into the Deer Mtn. Member of the Albee Formation. In the upper part of the greenstones, a few 4 to 10 meter beds of dark slates are present but generally the contact with the upper member of the Dixiville Formation is fairly sharp in the Oquossoc area. Based on observations by Moench (1971) in the Rangeley area, some parts of this contact may be in a faulted relationship. Nonetheless, on some parts of the contact between the two members the greenstone is sharply conformable below the slates (e.g. at the good exposures on Rte 16 about one mile east of Oquossoc village).

The upper member of the Dixville Formation consists mainly of very fissle, dark, sulfide-bearing slates. Late Middle Ordovician graptolites have been found in this unit (Harwood, 1966) approximately two miles north of the Oquossoc area. Also present in this unit are a few thin beds of light volcanics, thin dark quartzites, and also a few beds of grits. The upper part of the slate unit has a greater amount of the thin quartzite beds and hence becomes flaggy bedded.

There appears to be no direct evidence in the Oquossoc area that the Dixville Formation is stratigraphically above the Deer Mtn. Member of the Albee Formation. It is clearly structurally higher. Consideration of the lithologic sequence involved and comparison with the well known sequence of lithologies in the Albee, Ammonoosuc, and Partridge Formations to the southwest in New Hampshire suggest that a correlation can be made and thus the Dixville would be stratigraphically above the Albee.

According to Harwood (1973) the lower member of the Dixville Formation near the Cupsuptic-Oquossoc boundary may be up to 7500 feet thick (2500 meters) and the upper member up to 1200 feet in thickness (4000 meters).

Quimby Formation: A small area along the eastern border of the quadrangle is shown as underlain by the Quimby Formation although no exposures are present. Nonetheless the map pattern shown by Moench (1971) for Rangeley quadrangle strongly suggests that some of this unit occurs in the Oquossoc area. (See Moench (1971) for a description of this unit).

Other Pre-Silurian Strata:

The only other strata of presumably Ordovician age is the narrow belt of dark green amphibolites sandwiched between the Albee Formation in the west-central part of the quadrangle and the Umbagog granodiorite in the southwest corner of the area. Because of the lithology, association with the Albee Formation and the fact that Milton (1961) assigned similar rocks to the Ammonoosuc Volcanics just a short distance to the south in the Old Speck Mountain area, one can tentatively suggest that these strata are part of the Ammonoosuc Volcanics.

Silurian Sequence:

Although Moench (1971) has been able to establish an extensive sequence of Silurian units in the Rangeley area which lies just east of the Oquossoc quadrangle, only one, the Rangeley Formation, crosses the quadrangle boundary. This situation results from a change in the strike of the units near the quadrangle boundary plus the great abundance of adamellite intrusives in the southeastern part of the Oquossoc area. Indeed, most of the Rangeley Formation in the Oquossoc area occurs as large roof pendants. As a result, all outcrops are at the sillimanite grade of metamorphism.

The most abundant rock-type of the Rangeley Formation in the Oquossoc area is well bedded meta-shale with abundant thin sandy, interbeds. Bedding is on a 2-10 cm scale and some beds are graded. Small amounts of pyrrhotite are present in most specimens and as a result weathering surfaces are usually moderately rusty. Moreover, due to the abundance of coarse (0.5 to 1 cm) metamorphic minerals like staurolite, garnet, etc., the weathering surfaces commonly have a rough, nubbly aspect. The summit of Bemis Mtn. and west slopes of Elephant Mtn. are largely underlain by these meta-shales.

On the summit and middle of the west slope of Elephant Mtn. there are two belts of coarse polymictic conglomerate, coarse quartz-sandstones and quartz-pebble conglomerates. Abundant graded beds in these rocks near their contacts with the meta-shale indicate that the two belts are on the limbs of a tight syncline.

One small area of coarse, arkosic sandstone also occurs in the Rangeley Formation of the Oquossoc quadrangle. Because it is largely composed of quartz and feldspar it is a rather poorly foliated rock.

Moreover, the bedding tends to be indistinct--possibly due to the thickness of individual beds--up to 10 meters.

## Regional Corration of Stratified Rocks

(1) Cambro-Ordovician Units:

Because the black slates of the Dixville Formation in the southeast part of the Cupsuptic quadrangle contain Late Middle Ordovician graptolite, Harwood and Berry (1967) their age is well established. The underlying volcanic member of the Dixville and the Albee Formation are probably Lower or Middle Ordovician. The still lower Aziscohos Formation is probably Cambrian or Lower Ordovician. These suggested ages follow the proposals of Green and Guidotti (1968) and Harwood et al (1970).

On the other hand, Boone et al (1970) questioned whether the type Dixville and the black slates plus metavolcanics in the northeast part of the Oquossoc area are stratigraphically equivalent. In essence, based on "tops" evidence they have proposed that the roughly northeast trending belts of Pre-Silurian strata in the core of the Boundary Mtns. Anticlinorium become progressively younger to the southeast. Moreover, because the Dixville Formation in its type locality has been correlated with the Partridge and Ammonoosuc Formations by Green (1964), they then question whether the classical Albee, Ammonoosuc, Partridge sequence of New Hampshire is applicable in a straight-forward fashion in the Boundary Mtns. Anticlinorium.

Although the proposal of Boone et al (1970) has major implications for the broad scale interpretations of the Pre-Silurian stratigraphy of the Boundary Mtns. Anticlinorium it does not affect the sequence of ages proposed for the units exposed in the Oquossoc area. The main importance of their proposal for this report is whether or not to use the name

Dixville for the greenstones and black slates in the northeastern part of the quadrangle.

With regard to the applicability of the classical Albee, Ammonoosuc, Partridge sequence in the Boundary Mtns. Anticlinorium, it is evident that the questions raised by Boone et. al. depend considerably on whether the Dixville in its type locality truly correlates with the Ammonoosuc and Partridge to the southwest in New Hampshire. Assuming such a correlation were invalid, then the sequence of units in the northeastern part of the Oquossoc quadrangle could still be correlated with the classical New Hampshire sequence of Ordovician units. In this context it is well to note that Milton (1961) in the Old Speck Mtn. area was able to extend the Albee, Ammonoosuc, Partridge sequence well into Maine on the northeast nose of the Bronson Hill Anticline. Moreover, Ammonoosuc-like amphibolites and Albee types in the south central part of the Oquossoc area are just on the other side of the Umbagog granodiorite from the Albee and Ammonoosuc mapped by Milton in the northern part of the Old Speck Mtn. quadrangle. Hence, it seems premature to discount completely the possibility of the classical New Hampshire sequence of Ordovician strata also occurring in the Boundary Mtns. Anticlinorium.

(2) Silurian Units: Boone et al (1970, p. 14) state: "The Rangeley Formation is considered to be Early Silurian (?) in age, but fossiliferous rocks in the Kennebago Lake quadrangle, with which the Rangeley is correlated, are Early Silurian in age..."

## Igneous Rocks:

(1) Adamstown Granite: The Adamstown granite underlies a large area in the north-central part of the Oquossoc quadrangle and also occurs as a

large lens-shaped body on Bald Mtn. just to the east of Mooselookmeguntic Lake. Along most exposed contacts it cuts sharply the Aziscohos and Albee Formations and in some cases a thin chill zone is evident. Moreover, in some localities dikes and sills of this granite are found intruding the Cambro-Ordovician strata at some distance from the main body. On the other hand, in several places the Adamstown granite is found as inclusions in the adamellites of Devonian age.

The Adamstown granite was metamorphosed during the Acadian event. It is a coarse-grained rock that approximates mineralogically a true granite or granodiorite. The exact mineralogic composition is partially obscured by the great deformation and granulation that have affected the body. In most outcrops a strong foliation and 1 to 2 cm megacrysts of white or pink microcline are the most notable features of this rock. The white colored microcline seems to be more prominent in those parts of the body which have recrystallized at higher grades of metamorphism. In hand specimen the deformation is readily apparent from the lenticular and granular nature of the quartz and plagioclase of the matrix. The lenticules of quartz are commonly cracked perpendicular to the foliation planes--the latter being evidenced largely by concentrations of platy minerals. In thin section the granulated texture is shown by a mortar structure of quartz and plagioclase grain boundaries.

The large megacrysts of microcline are seen to be only somewhat fractured and have a small amount of granulation around their rims. Nonetheless, considering the degree of granulation of the rest of the rock, the microcline is remarkably well preserved. X-ray and probe work on these microclines shows that they are structurally maximum microcline and almost pure potassium end member compositions. Albite exsolution lamellae are common and evident even in hand specimen. These lamellae of albite are (like the cracks in quartz) oriented perpendicular to the foliation.

The mineralogy of the Adamstown granite varies from locality to locality depending upon the metamorphic grade of the adjacent pelitic rocks (see the isograd distribution on the geologic map of the area). Where the intruded pelitic rocks are now in the greenschist facies the granite contains quartz + albite + microcline + chlorite + muscovite + epidote. Where the adjacent pelites are in the sillimanite zone the granite contains quartz + plagioclase + muscovite + microcline + biotite. Moreover it seems that the size of the microcline megacrysts is smaller where the granite has recrystallized at higher grade.

Clearly the Adamstown granite is no older than Cambro-Ordovician. A pre-Siluro-Devonian age is suggested by the fact that it is cut by Devonian granitic rocks, highly deformed, and metamorphosed. Thus, it would appear to pre-date the Lower Devonian Acadian event. Moreover, lithologic similarity to granites of the Ordovician Highlandcroft Magma Series (Billings, 1956) suggests a similar age for the Adamstown granite.

(2) <u>Umbagog Granodiorite</u>: The Umbagog granodiorite underlies the southwest corner of the Oquossoc quadrangle. In general, it is not well exposed. According to Green (1964) it is a biotite, hornblende granodiorite and although it could be of Acadian age, it most likely was intruded during the Ordovician. At the very least, it predates the Devonian adamellites because it is cut by them.

(3) <u>Two-Mica Adamellites</u>: These adamellites underlie a large part of the Oquossoc area as small to large plutons which cross-cut all of the other lithologies in the region. The Mooselookmeguntic Pluton of Moench (1971) is clearly the largest of the adamellite bodies but even it is

probably formed by coalescence of smaller bodies.

The adamellites are light-colored, medium to coarse grained rocks and although some variation occurs in their mineralogy, the excess of plagioclase over K-feldspar in most specimens requires that they be called an adamellite or quartz-monzonite. They clearly belong to the Acadian age, New Hampshire Magma Series (Billings, 1956) and like many plutons in this series, they are sufficiently Aℓ-rich to have present muscovite and even some almandine garnet.

The contact relations of the adamellite plutons vary on an areal basis. In the northwest part of the area where the plutons occur as circular, small, isolated bodies the contacts are steep and sharp and very well developed chill margins are present. In the west-central part of the area where the metamorphic grade is upper sillimanite zone, the contact relations are much less sharp and there is considerable intermingling and interfingering of the adamellite and metamorphic rocks. In the southeast part of the region the contacts are fairly sharp but many of the bodies appear to be cross-cutting low-dipping sheets. It seems likely that this is a reflection of the very well developed low dipping slip cleavage that is present in the metamorphic rocks of that local area. As discussed below, this cleavage is a fairly early feature and was already present when the adamellites were intruded. As developed by Moench and Zartman (1976) the larger bodies like the Mooselookmeguntic pluton are probably broadly arched, subhorizontal sheets only a few kilometers thick.

Moench and Zartman (1976) report a number of Rb/Sr ages for the Mooselookmeguntic Pluton that give an isochron age of 379 $\pm$ 6 m.y. Hence, the Acadian age for the adamellites suggested on geological grounds is fully supported by the radiometric age dating.

## Structure

(1) Cambro-Ordovician Structural Relationships:

To a considerable extent recognition of the larger structure in the Cambro-Ordovician rocks of the Oquossoc area depends on the structural interpretations of Green (1964) in the Errol quadrangle and Harwood (1966, 1973) in the Cupsuptic quadrangle. This dependency is largely the result of the small amount of area in the Oquossoc quadrangle which is underlain by Cambro-Ordovician strata. The structural model developed below is based upon minor structures, attitudes of bedding, "tops" evidence (graded beds, cross bedding, and drag folds), and map pattern.

Foliations and Bedding: As mentioned previously, bedding and foliation tend to be parallel in the Cambro-Ordovician strata except on the noses of the tight, isoclinal, minor folds. In most of the northwest corner of area bedding tends to be steep (70-80°) with trends near N 15° E. Possibly there is some preponderance of eastward dips. Near the northwestern contact with the Adamstown granite the beds are still steeply dipping but tend to swing into parallelism with the granite contact and even become east-west along the north-central boundary of the quadrangle. Moreover, the bedding attitudes closely reflect the trend of the band of lower Aziscohos Formation which parallels the northwest border of the Adamstown granite. In the northeastern part of the quadrangle most attitudes of bedding trend northwesterly, more or less parallel to the stratigraphic contacts. Dips are uniformly 50° to 70° to the northeast.

Minor Folds and Lineations:

Two prominent styles of minor structures occur in the Cambro-Ordovician strata of the Oquossoc quadrangle. First there is the earliest type which consists of isoclinal minor folds, crinkles, drag folds, and quartz rodding. These generally trend NE-SW and plunge in either direction at angles up to 45°. Such structures are especially common in the upper member of the Aziscohos Formation and the Portage Brk Member of the Albee Formation. Except in the northeast part of the area, the axial planes of minor folds are close to vertical and in all areas the minor folds tend to be isoclinal. In the northeastern section (east of Cupsuptic and Mooselookmeguntic Lakes) of the quadrangle the minor folds commonly have axial planes dipping 35°-65° to the NE (nearly the same as the dip of the bedding) and plunge ENE about 20°-30°. There is a general tendency for the first generation minor structures in the N and NW parts of the region to plunge in a northerly direction but only on the east shore of Aziscohos Lake have minor folds been useful in determining the plunge of larger folds and in determining the stratigraphic relations.

The second generation of minor structures consists solely of crinkles and crenulations produced by the intersection of a steep cleavage which varies from a microscopic spacing up to a 5 cm spacing. This slip cleavage is especially well developed in the Cambro-Ordovician strata of the north central part of the quadrangle. It strikes about N 15°E and is nearly vertical. The resulting crenulations plunge very steeply to the north and south. The second generation of minor structures clearly cuts the first generation structures and does not seem to be related to any of the major folds as outlined by map pattern. In contrast, the first generation minor structures do seem to be spacially related to the larger folds outlined by map patterns of the units.

## Major Folds

The geologic map which accompanies this report shows the major folds in the Cambro-Ordovician rocks of the Oquossoc area. To a large extent these fold axes are based upon extension of fold axes mapped by Harwood (1973) in the Cupsuptic area. The Deer Mtn. syncline, which plunges to the NE in the Oquossoc quadrangle, is clearly the major structural feature. The strata in the northeast part of the quadrangle form a NE dipping homocline but Harwood (1966, 1973) has suggested that they form the west limb of a major syncline. Moench (1971) shows such a structure. In the south central part of the quadrangle the area underlain by Albee Formation is structurally ambiguous but it is presumed that an open, SW plunging syncline is present. This suggestion is based primarily upon extension of the structures mapped by Green (1964) in the Errol quadrangle.

According to Harwood (1973), the NE trending folds so evident in the pre-Silurian rocks are the result of Acadian deformation. However, he also describes evidence for NW trending Taconic Age folds in the pre-Silurian strata.

## Tectonic Events

From the preceding discussion it would appear that the pre-Silurian strata in the Oquossoc area may have been subjected to three deformational events.

(1) Taconic Folding

(2) Acadian Folding to form the northeast trending major and minor folds.

(3) A still later deformation to form the NNE trending slip cleavage. Green and Guidotti (1968) speculate that it is Acadian and resulted from the Adamstown pluton acting as a solid buttress during the Acadian orogenic movement.

Faults: Several breccia zones have been found but these seem to be associated with only small scale faulting. None of the contact relations among stratified or intrusive rocks require postulating large faults.

(2) Siluro-Devonian Structural Relationships:

Although the Silurian Rangeley Formation occurs in the Oquossoc area only as large roof pendants, structural coherency is maintained among the pendants. Hence, continuous structures can be mapped from one pendant to the next. Indeed, this coherency is the strongest argument that even the large Mooselookmeguntic pluton is made up of a multitude of smaller plutons. Emplacement of a single, large body would surely have disrupted the structural coherency of roof pendants--as argued by Milton (1961) for similar observations in the Old Speck Mtn. area.

Foliations and Bedding: Bedding and the earliest foliation are essentially parallel. Due to the high metamorphic grade affecting the Rangeley Formation in the Oquossoc area, this foliation is recrystallized to form a distinct schistosity. The attitudes of bedding are always steep, commonly vertical and swing progressively from about N10W near the southern end of the pendants to about N20E near the northern most exposures. Invariably the attitudes of bedding and stratigraphic contacts appear to be parallel.

A second foliation is also present in the form of a low NE dipping ($\sim 5°$) slip cleavage which like the above described foliation has also been recrystallized to form a schistosity. In many cases, this second foliation is more pronounced than the first one. Generally it appears as 1-5 mm spaced shears at high angles to the first foliation and produces "wavy" patterns in the muscovite-rich layers of the first foliation.

However, due to later metamorphic recrystallization none of the individual mica plates are now bent.

Minor Folds and Lineations:

Minor folds generally have steep axial planes and tightly folded limbs. The majority of them plunge 20°-40° to the north or northeast depending upon whether the fold is present in the southern or northern end of the series of roof pendants. However, numerous southerly plunges are also present. Some lineations due to mineral streaking and stretching of conglomerate pebbles is also present. Inasmuch as most of metamorphic recrystallization described below is post tectonic, this stretching of conglomerate pebbles must have occurred during the initial, large scale fold development.

By far the most common minor structures are small crinkles or crenulations resulting from the intersection of the low-dipping second foliation with the steep-dipping early foliation. Because of the spatial relationship of the two foliation planes, the resulting crenulations have low plunges to the north and south.

Major Folds: Only one major syncline is present in the Rangeley Formation in the southeastern part of the Oquossoc area. It is a tight, isoclinal structure which is defined largely by the two belts of conglomerate shown on the geologic map. This structure appears to be a straightforward extension of the Mountain Pond syncline of Moench (1971). This again emphasizes the structural coherency of the roof pendants. However, the bend of the synclinal axis from the NE trend so prominent for the folds in the Rangeley quadrangle to about N10W suggests that at least some significant deformation followed the formation of the NE trending folds.

Tectonic Events: Based on observations over an extensive portion of western Maine, Moench and Zartman (1976) have developed a rather detailed picture of the deformational history of the Siluro-Devonian rocks in the region. The reader is referred to this paper.

From observations only in the Oquossoc area the writer can recognize the following sequence of tectonic events:

(1) Deformation to produce the NE trending folds.

(2) Development of the slip cleavage.

(3) Bending of the NE trending synclinal axis to a N10W trend in the vicinity of Elephant Mtn. Possibly the slip cleavage also formed at this time.

That intrusion of the adamellite post-dated all of these deformational events is suggested by the fact that the metamorphic recrystallization which is spatially related to the adamellites is completely post-tectonic (see below).

(3) Relation of Geologic Map and Aeromagnetic Map

A particularly good correlation exists between the map pattern of lithologies present in the Oquossoc area and the pattern of aeromagnetic highs and lows shown by Boynton and Gilbert (1964). Clearly this correlation supports the map pattern developed by the writer.

Of particular note is the fact that the upper member of the Aziscohos Formation and the Albee Formation (both of which contain magnetite euhedra) form belts of aeromagnetic highs. In contrast, the other stratigraphic units--(especially the Rangeley Formation)--form aeromagnetic lows. The areas underlain by the Adamstown granite and the plutons of adamellite form broad regions of low, uniform magnetic intensity.

## Metamorphism

Some of the Cambro-Ordovician strata have been contact metamorphosed in a narrow zone (1000 m) around the Adamstown granite. However, the same Acadian metamorphism which affects the Rangeley Formation in the southeastern part of the region, has also been superimposed on the pre-Silurian strata, including those contact metamorphosed rocks adjacent to the Adamstown granite. The Acadian age isograds shown on the geologic map in the pre-Silurian rocks are based upon a moderate amount of petrography by the writer and use of the work by Green (1964) in the Errol quadrangle and Al-Mishwt (1972) on the contact aureole around the adamellite located just east of Aziscohos Lake. The work of Al-Mishwt (1972) describes a number of textural relationships that clearly suggest some polymetamorphism. The isograd shown in the Rangeley Formation is based upon detailed petrography by Guidotti (1970A).

Of particular interest in the pre-Silurian rocks is the fact that the isograds cross the Adamstown granite. These isograds are of course, extensions of the isograds defined in the pelitic rocks. However, the mineralogy and textures in the granite reflect a change in grade from low to high as implied by the isograds (see previous description of the Adamstown granite).

In the west and northwest part of the area the pre-Silurian strata have been subjected to a wide spectrum of degrees of intensity. In the west central portions the grade is well up in the upper sillimanite zone and migmatites are well developed. To the north the grade drops down possibly to chlorite zone. However, around the small adamellite plutons narrow contact aureoles have developed, some of which contain cordierite-bearing assemblages. Of particular interest is that the gradient from N to S not only suggests an increase in temperature but also an increase in pressure, the latter implying a progressive increase in depth at which recrystallization occurred.

The metamorphic grade of the Rangeley Formation strata in the southeastern part of the quadrangle also attained upper sillimanite zone and migmatites are well developed in the outcrops just east of Lower Richardson Lake. The detailed work of Guidotti (1970A, 1970B) has shown that two metamorphisms have affected these rocks. However, both of these events are Acadian as shown by the fact that both events affect Silurian strata and the second event is spatially related to the dated Mooselookmeguntic pluton. The first metamorphism achieved andalusite + staurolite grade and was largely post-tectonic as shown by the fact that both staurolite and andalusite clearly overprint the slip cleavage which reflects the youngest tectonic fabric. The second metamorphism prograded the rocks to the lower and upper sillimanite zone. It involved considerable development of partial pseudomorphs of staurolite and andalusite and was an essentially static event as shown by the fact that the partial pseudomorphs (mainly coarse muscovite plates) are totally free of any directional fabric. Because the isograds developed by this metamorphism in the Rangeley quadrangle (Guidotti, 1974) are spatially related to the Mooselookmeguntic pluton the metamorphism must be the same age as the pluton.

## Conclusions

Several aspects of this report are of importance on a general basis for understanding the regional geology of northern New England.

(1) The mapping reported herein serves to extend our knowledge of the areal distribution of the Lower Paleozoic strata. However, it has not been able to contribute much toward some of the questions existing

about the exact sequence and ages of these strata. Possibly the most important aspect of this work in this respect has been to call attention to the fact that the Albee and Ammonoosuc as mapped by Milton (1961) seem to extend into the south-central part of the Oquossoc area. In turn, this increases the likelyhood that the strata in the northeast part of the quadrangle are indeed Albee, Ammonoosuc, Partridge equivalents.

(2) This work has resulted in recognition of the Adamstown granite as a probable member of the Ordovician Highlandcroft Magma Series. Moreover, from its contact effects it is evident that only weak pre-Silurian regional metamorphism affected the Cambro-Ordovician rocks in this area during the Taconic Orogeny.

(3) All of the high grade metamorphism in this region is Acadian in age. Moreover, this quadrangle lies astride of the transition from the essentially low grade terrain to the north and the uniformly high grade terrain to the south. The northern region involves only high-level plutons with narrow cordierite-bearing contact aureoles thereby indicating shallow depths of intrusion. To the south, the high grade rocks are intimately associated with many large adamellite plutons and the development of migmatites. The rocks of this high grade terrain crystallized at higher pressure ($\sim$4Kb) and hence greater depth than the rocks to the north. Rocks of such high grade continue for several hundred Km to the southwest. Hence, the Oquossoc quadrangle covers the area where a very major change took place in the metamorphic conditions which existed in the Northern Appalachians during the Acadian Orogeny.

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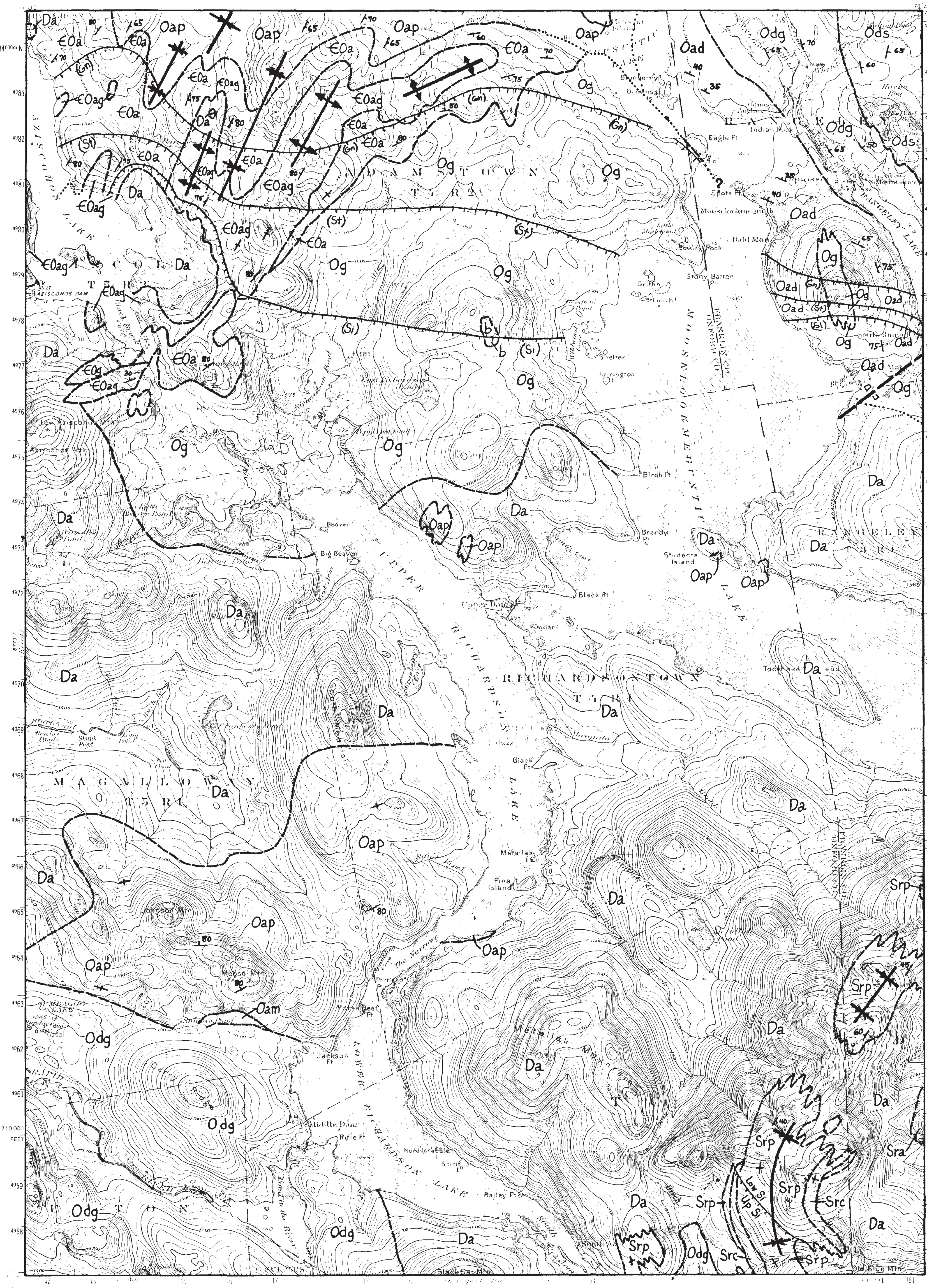



# EXPLANATION

b Brecciated area; vuggy quartz pods and silicified Adamstown granite

PLUTONIC ROCKS

Ordovician? Devonian

- **Da** Mooselookmeguntic pluton and related bodies. Primarily a medium-grained, two mica adamellite. Some pegmatite.
- **Og** Adamstown granite. Coarse grained, well foliated to massive, porphyritic granite. Megacrysts of microcline. Pink to white color. Quartz and plagioclase granulated where metamorphosed to greenschist facies.
- **Ogd** Umbagog granodiorite. Coarse grained biotite-rich granodiorite. Some minor hornblende.

METASEDIMENTARY ROCKS

Silurian

- **Sr** Rangeley Formation. Srp - interbedded pelitic schist and feldspathic quartzite with the pelites predominant. Src - polymictic conglomerate, grits, meta-sandstones and minor pelitic schist. Sra - thick bedded arkosic sandstones. Bedding commonly indistinct. Srp usually with rusty weathering surfaces.

Ordovician?

- **Oq** Quimby Formation: no outcrops; map pattern based upon extrapolation from Moench (1971).

Ordovician

- **Od** Dixville Formation: Ods - Upper Member consisting mainly of fissile black slate. Contains Late Middle Ordovician graptolites 2 miles north of this area. Also a few thin beds of light volcanics and thin dark quartzites. Odg - foliated to massive greenstones; amphibolites at high grade.
- **Oam** Ammonoosuc Volcanics: Well foliated, coarse amphibolites; limited to south-central part of the area; probably equivalent with Odg.

Ordovician?

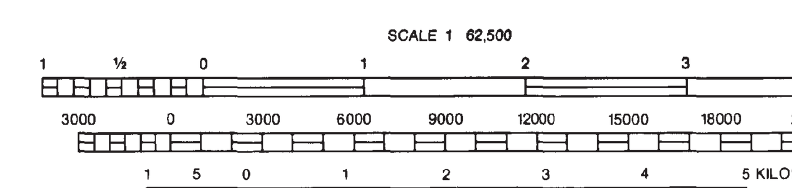
- **Oa** Albee Formation: Oad - Deer Mtn. Member consisting of crinkled, fissile green phyllites with abundant intercalated ½ to 1 cm thick lenticular quartz pods. Commonly shows 1-3 mm magnetite octahedra on weathering surfaces. Some chlorite-rich patches 2-4 mm across. Only minor pinstriped quartzites. Has staurolite and sillimanite at higher grades. Also present are a few 3-15 meter thick greenstone beds, these being most common near the contact with Odg. Oap - Portage Brook Member; very similar to Oad except it also contains 10 to 50% of the 10 to 30 cm thick pinstripe quartzite interbeds.

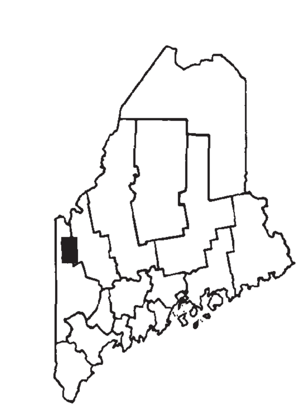
Cambrian to Ordovician?

- **€Oa** Aziscohos Formation: €Oa - Upper Member consisting of lithologies virtually identical with Oad. €Oag - Lower Member consisting of dark, carbonaceous slate to phyllite. Fairly abundant fine grained pyrite along foliation planes. Some lenticular quartz pods, but less than in the Upper Member. As much as 5 percent consists of greenstone beds up to 7 meters thick. Pelites contain staurolite and sillimanite at high grades near the adamellite plutons.

## STRUCTURE SYMBOLS

- Visible lithologic contact
- Covered or inferred lithologic contact
- Fold axes; syncline, anticline.
- Metamorphic isograds; hachures on high grade side.
- U / D Faults



Quadrangle Location

RECONNAISSANCE

# BEDROCK GEOLOGY OF THE OQUOSSOC QUADRANGLE, MAINE

BY

CHARLES W. GUIDOTTI

1977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