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A preliminary synthesis of structural, stratigraphic, and magnetic data from part of the northwest Adirondacks, New York

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Abstract

Synthesis of recent work in the NW Adirondacks, New York allows the development of a coherent geologic picture. Mapping of the Precambrian rock units enables the recognition of four major units which are, from bottom to top, 1) Granitic Gneiss (alaskite), 2) Lower Marble, 3) Major Gneiss, and 4) Upper Marble. Additionally, lenses of amphibolite and granite occur as intrusives within this succession. These rock units have been complexly deformed by three major folding episodes, and by two distinctly different styles of faulting. The result has been to produce large northeast-southwest trending dome and basin structures. Patterns of magnetic intensity closely parallel distribution of rock units and provide additional information for a structural and stratigraphic synthesis.

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Introduction

Within the NW Adirondacks, New York, a striking correlation exists between patterns of magnetic anomalies and the distribution of Precambrian bedrock units. This close association is evident at all scales, but is most impressive at larger scales, in areas where detailed geology is known. In the following discussion, the structures and stratigraphy of a reasonably well mapped east-west trending strip across the NW Adirondacks (Fig. 1) will be synthesized

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Figure 1 near here.

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and a comparison made of geology and the associated magnetic patterns. This analysis of a small, fairly well known area provides the basis for later speculations about the regional geology of much of the NW Adirondack lowlands.

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Figure 1. Location of the mapped areas which provide the basis for this geologic synthesis.

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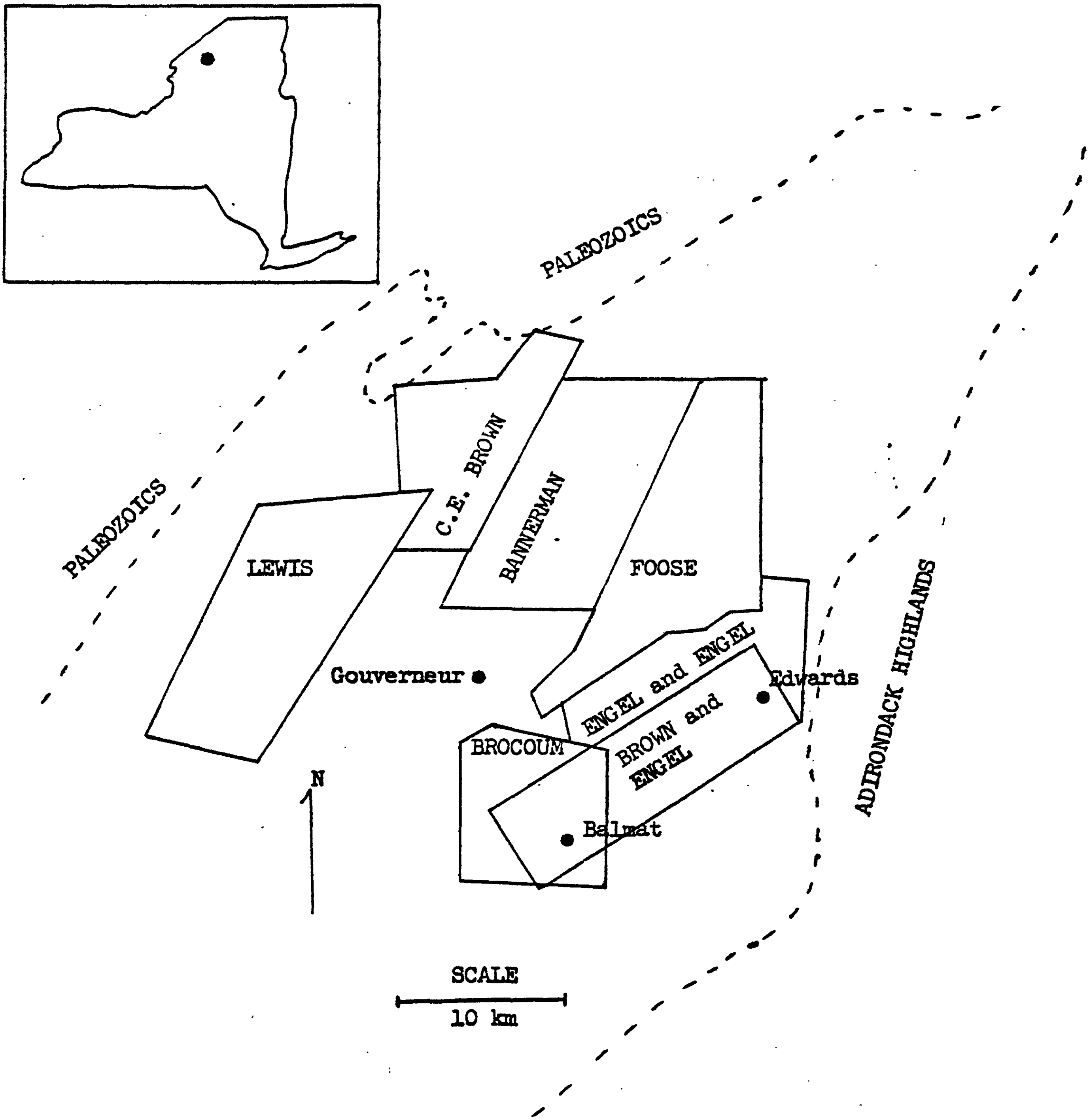

FIGURE 1: Location of the mapped areas which provide the basis for this geologic synthesis.

Geology

Introduction

The NW Adirondacks is a region underlain predominantly by complexly deformed metasedimentary rocks which characteristically yield radiometric ages of approximately 1.1 by. These series of metasediments form an elongate, northeast-southwest trending belt that is bounded to the east by the predominantly metaigneous Adirondack Highlands, and to the north, west, and south by unconformably overlying Paleozoic rocks. The recent mapping of Brown and Engel (1956), Engel and Engel (1953b, 1958), Lea and Dill (1968), Brown (1969), Lewis (1969), Brocoum (1971), Bannerman (1972), and Foose (1974) has covered much of a 25 km long 5-15 km wide, roughly rectangular, east-west trending area that extends across the strike of much of this belt (Fig. 1). The following is an attempt to synthesize the geology of this strip. A preliminary geologic map, structural map, and schematic structural section are presented in Plates 1, 2, and 3; a description of the stratigraphic units is also included in Plate 1.

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Approach to the geologic synthesis

Any attempt to synthesize NW Adirondack geology encounters considerable difficulties. Problems related to folding, faulting, and stratigraphic facies changes are inherent to each area and reflect the complex geologic character of the region. Other problems, however, result from differences in detail and approach taken by different workers in mapping rock units and geologic structures. Often, there is no clear way to separate these two types of problems. Although these difficulties generate some ambiguities, we feel that sufficient data are available for this region to present a synthesis that is reasonably accurate in its major features, if not in all of its details.

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The development of this synthesis proceeded along the following lines. Mapping by Foose (1974) and Brown (1969, and unpublished data) in two separate areas (Fig. 1) revealed strikingly similar stratigraphic sections and structures. Importantly, it was also noted that similar topographic and outcrop patterns developed in areas affected by similar structures. In the regions peripheral to these two areas, the rock units and structures were less well known. However, along strike continuity into similar rock units and the presence of similar outcrop patterns strongly suggested that the same general stratigraphy and structures were present. Interpretation of the marbles near Balmat and Edwards, which is perhaps the most controversial aspect of this synthesis, followed a similar approach. Although no direct correlation of rock units has yet been possible, relationships in the eastern part of the area mapped by Foose (1974) shows that these marbles have the same general stratigraphic position as the marbles further west, near Gouverneur.

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Discussion

At the scale (1:62,500) of this compilation (Plate 1), only the major stratigraphic units can be shown, and for much of the area, there appears to be a well established, consistent stratigraphic sequence. The lowermost unit recognized is a distinctive granitic gneiss (alaskite) which crops out throughout the region as dome or hook-shaped bodies. Recently, Carl and Van Diver (1975) have described the chemical character of this alaskite and concluded that it most probably represents a large outpouring of rhyolitic ash. Commonly this gneiss is overlain by a distinctive sillimanitic gneiss, which in turn is overlain by a carbonate rich sequence (the Lower Marble) that contains mostly marbles, but also calcareous quartzites, calcareous gneisses, and some biotitic and granitic gneisses. Many of these thinner units appear to be recognizable over large areas (Plate 1).

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Overlying this sequence is the Major Gneiss, a complex of biotitic gneisses and porphyroblastic granitic gneisses, the latter containing some interlayered marbles. The mineralogy and chemical character of this gneissic sequence has been described in detail by Engel and Engel (1953a, 1953b, 1958, 1960) and has been termed by them "the Major Paragneiss." Engel and Engel interpreted the relationship between the two types of gneiss to be a metasomatic one. Enrichment in potassium was thought to have transformed the biotitic gneiss into the porphyroblastic granitic gneiss. Recent mapping, however, reveals that regional metasomatic alterations have not occurred and that these units form part of a well defined, normal stratigraphic sequence. Further, where mapped in detail, the contact of the Major Gneiss and the Lower Marble appears to be a structural one. It is not known whether this discontinuity developed during folding (tectonic slide) or if it represents a pre-folding structure (overthrust).

Overlying the Major Gneiss is a second series of carbonate rich metasediments. The Upper Marble apparently occurs only in the western part of the mapped strip (Plate 1) and appears to be made up of a large number of discontinuous carbonate and gneiss units (Lewis, 1969; Brown, unpublished data). A regionally coherent internal stratigraphy, if present, has not been recognized.

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In addition to these four major rock units, several other rock types occur throughout the NW Adirondacks. Amphibolites, probably of intrusive origin, are found either as large masses with roughly circular outcrop patterns or as smaller bodies which occur as concordant lenses. Small granite bodies, many having the form of concordant sheets, occur most abundantly in the area mapped by Brown (Fig. 1). Although the relationship between these granites is not well known, evidence suggests that at least two different generations are present. Undeformed mafic dikes, of probable late Precambrian age, occur sporadically throughout this region. The largest of these dikes (Plate 1) has been mapped by Brown and is over 15 m in width and 11 km in length (Brown, 1975). Finally, patches of middle Cambrian Potsdam Sandstone are frequently found unconformably overlying the Precambrian rock units.

It is evident that this generalized stratigraphic sequence is essentially identical to that proposed by Engel and Engel (1953b) and Lewis (1969). The chief difference between the current interpretation and these earlier ones is in the distribution and relationship of these rock types. Most importantly, because of relationships mapped by Foose (1974), the marbles that outcrop in the vicinity of Balmat and Edwards are interpreted here as part of the Lower Marble. Further, this interpretation implies that the synform, in which these marbles are folded, is actually part of a large overturned anticlinal structure. Second, the recognition of a major structural dislocation at the contact between the Lower Marble and the Major Gneiss is important as it explains a number of apparently anomalous stratigraphic relationships in the NW Adirondacks, Despite the detailed mapping, the nature of the structures occurring in this east-west trending strip are still incompletely known. However, it has been possible to recognize several major structural elements which combine to develop basic structural patterns that are repeated throughout this area. Basically the region is a multiply folded terrain in which three episodes of deformation can be recognized and, superimposed upon this folding, are the effects of two distinctly different types of faulting. Some of the major structural elements are shown on Plate 2.

Detailed study of NW Adirondack fold structures has been carried out in only small areas (Brocoum, 1971; Foose, 1974). However, the repeated occurrence of similar map patterns throughout the NW Adirondacks indicates that similar fold elements occur throughout the region. Basically three different large fold sets may be recognized. First generation folds may vary from tight to isoclinal and are refolded by open to isoclinal second generation folds to produce hook or crescent shaped interference patterns. Whereas both first and second period folds have axial surfaces which trend NE-SW, third generation folds strike NW-SE. These cross-folds act to gently warp the axial surfaces of the earlier structures while markedly reorienting the earlier fold axes. The relationship of these three fold sets is shown schematically in figure 2.

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Figure 2.--Schematic illustration of the multiple folding elements found in the NW Adirondacks.

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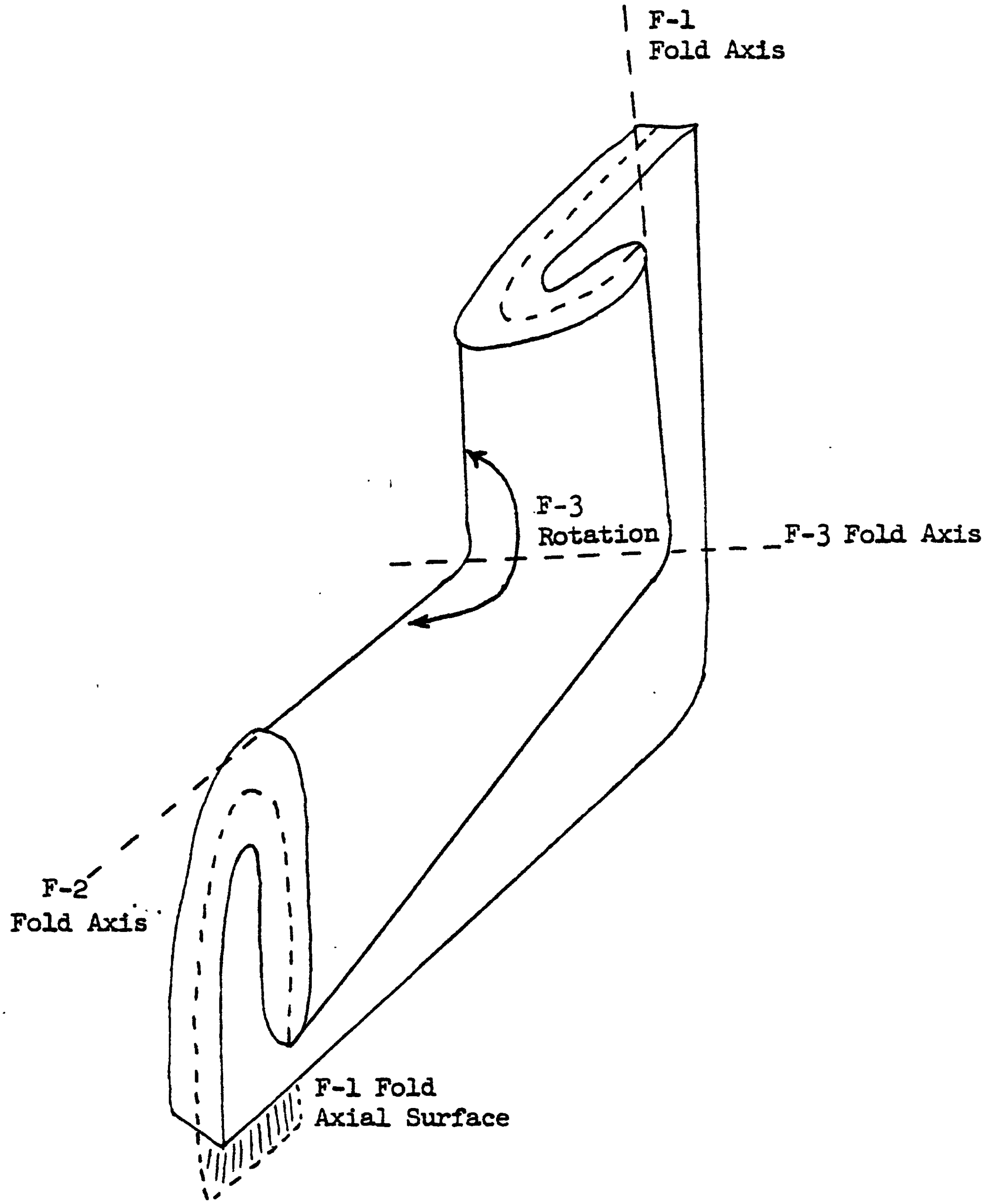

Figure 2: Schematic illustration of the multiple folding elements found in the NW Adirondacks. Isoclinal first generation (F-1) folds are refolded by second generation (F-2) folds to produce hook-shaped interference patterns. Third generation (F-3) folds vary in intensity and may rotate earlier fold axes as much as 100 degrees, while only gently warping the preexisting fold axial surfaces.

As a result of the interference of two or more of these fold elements, individual rock units are exposed with a variety of outcrop patterns. Most prominent, on a regional scale, are exposures of the basal granitic gneiss. These domal exposures assume elliptical, hooked, or crescent shapes depending on the relationship between the three folding elements.

In addition, two distinctly different types of major faults may be recognized. Most important is a prominent discontinuity that is observed to separate the Lower Marble from the overlying Major Gneiss. The detailed mapping of Foose (1974) and Brown (unpublished data) clearly indicate that rock units are progressively thinned and ultimately sheared out along this zone. Thus, this discontinuity represents a major structural feature and is not the result of a preexisting unconformity. However, it is not known whether this structure initially developed during folding (tectonic slide) or if it existed prior to folding (thrust). Because the fault truncates first generation folds near Moss Ridge, it is apparent that parts of the fault were reactivated during the second period of folding. As a result of folding, dips on the fault surface vary from flat to steep.

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Recognition of this fault is important in the development of a regional structural and stratigraphic synthesis. Because of this structure, large sections of the underlying Lower Marble and overlying Major Gneiss may be cut out and, as a result, apparently anomalous stratigraphic sequences developed. For example, it is suggested that this fault is responsible for the close juxtaposition of the basal granitic gneiss unit (alaskite) outcropping at the Clark Pond and California alaskite with the overlying Major Gneiss Formation. A similar close juxtaposition, resulting from this fault structure, has been demonstrated along the east edge of Moss Ridge (Foose, 1974) (Plate 1).

The second type of fault occurs as steeply dipping, straight to gently curved structures, some of which may be traced for tens of kilometers. These faults are best developed in the western part of the map area (Plate 2) near Beaver Creek and Pleasant Lake, but a similar structure (the Balmat fault) occurs in the east. In the west, these faults separate the area into panels of stratigraphically and structurally distinct geology (Brown, 1973). However, despite these breaks, the overall general stratigraphy and structural style described above can be recognized throughout this region.

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The basic structural and stratigraphic elements described above are combined in the schematic structural section shown in Plate 3. Although this section is a preliminary one and lacks good control, it does serve to illustrate basic regional relationships. First and second period folds interfere to produce prominent hook-shaped structures, while faults cut out large sections of the stratigraphy. Because this section is drawn parallel to the axial surface of third period folds, the effects of these structures is not shown.

Throughout the mapped strip, major second generation fold structures exhibit an interesting and important regional relationship (Plate 1, 2; Fig. 3) which supports this interpretive structure section. The difference in asymmetries of the second generation structures located near Halls Corner and at Moss Ridge indicate that a major fold (an antiform) lies between these two areas. Similarly, the difference in asymmetries between the structures at Moss Ridge and those located near Edwards, to the southeast, indicates that a large synformal structure exists in the belt of intervening Major Gneiss.

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Figure 3.--Relationships between regional second generation folds .

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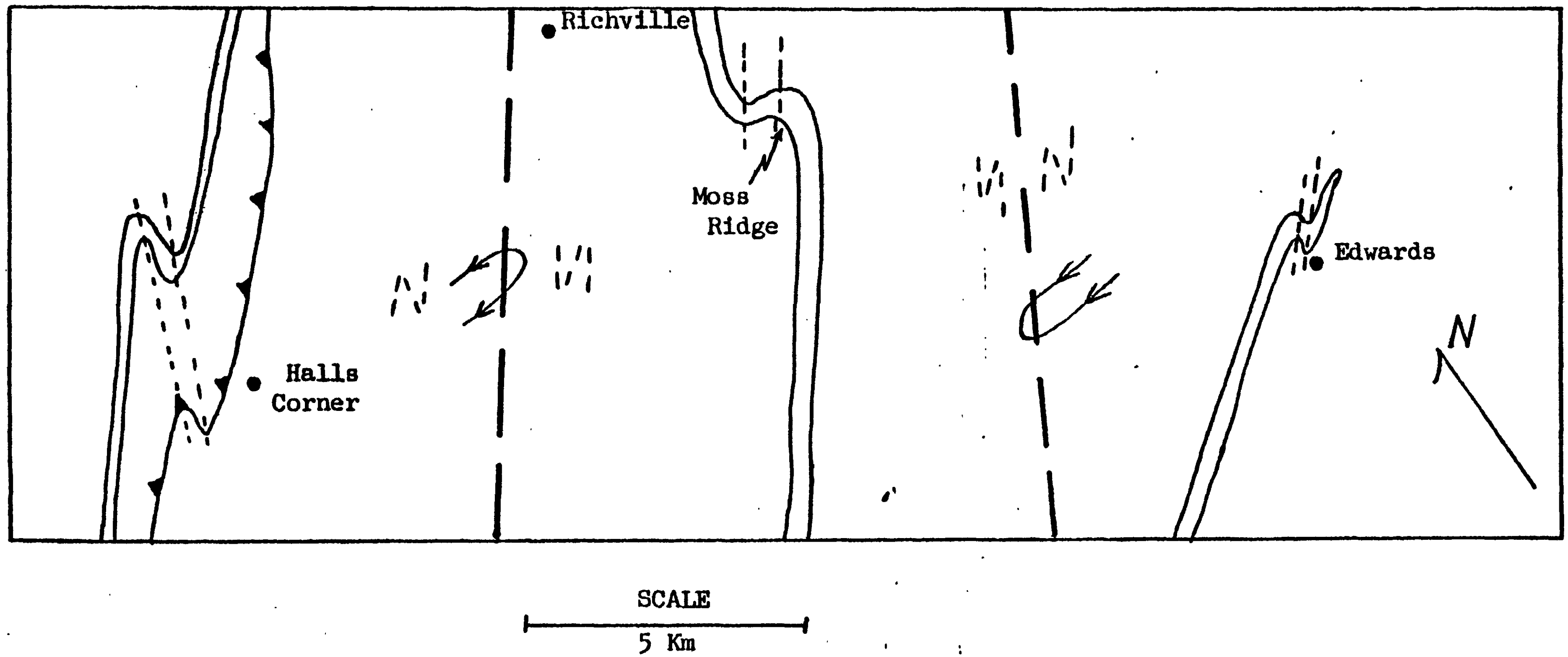

FIGURE 3: Relationships between regional second generation folds (the figure is simplified from Plate 1). Asymmetries of second generation folds near Halls Corner (Z folds) and on Moss Ridge (S fold) suggest the presence of an intervening anticlinorium. Between the Moss Ridge (S) fold and the Edwards (Z) fold is a synclinorium. These regional fold asymmetries therefore support the stratigraphic and structural interpretation presented for this area.

Magnetic patterns

Introduction

Comparison of the geologic map (Plate 1) with the map of magnetic intensities (Plate 4) indicates a close correspondence between certain rock types and magnetic patterns. By far the most prominent association is between exposures of the basal granitic gneiss (alaskite) and large positive anomalies (contacts of the granitic gneiss are shown as dotted lines on Plate 4). Less distinct is a correlation between amphibolites and positive anomalies, and carbonates and negative anomalies. Areas underlain by the Major Gneiss are largely magnetically neutral. In a general way, the magnetic patterns observed in the area of well known geology may be extrapolated to predict the general regional distribution of units in poorly known or covered areas.

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Discussion

Large, magnetically positive areas, regions with magnetic intensities greater than 10250 gammas, are found to occur over almost all exposures of the granitic gneiss. In form, these anomalies closely mimic the outcrop pattern of this unit. However, the subsurface distribution of the granitic gneiss also affects the magnetic pattern and causes some distortion in the shape and location of the anomaly. Thus, in the eastern part of the mapped strip, where rock units dip moderately NW, the positive magnetic anomalies are displaced to the west of the outcrop pattern. In the far western part of the area, where dips are nearly vertical, there is an almost perfect correspondence between outcrop location and magnetic intensity. As a further example of subsurface effects, the subsurface join between the granitic gneiss at Reservoir Hill and that near Gouverneur is evident from the magnetic pattern. A small basin structure, shown by lower magnetic intensities, separates the two bodies. Also a prominent anomaly off to the southwest indicates that the Gouverneur body must have a subsurface continuation in that direction.

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Amphibolites and amphibolite-rich rocks are the only other lithology within the mapped strip that exhibit high magnetic intensities. Anomalies are particularly well developed over the amphibolite bodies found near Pleasant Lake (Lewis, 1969) but also occur over a thin amphibolite unit mapped by Brown (1975, unpublished data), a hornblendic porphyroblastic gneiss mapped by Bannerman (1972), and amphibolitic porphyroblastic granitic gneiss mapped by Foose (1974). In general, these anomalies have circular forms and are smaller than the more elongate anomalies produced by the basal granitic gneiss unit.

Areas underlain by carbonates and carbonate rich metasediments characteristically exhibit low magnetic intensities. This correlation is well shown for carbonate rich rocks in the Sylvia Lake area and in the area north of Moss Ridge, but is also evident at a smaller scale for the thin marble belt occurring in Tanner Creek. However, the marbles that are interlayered within the porphyroblastic granitic gneiss appear to be too thin to generate a recognizable anomaly pattern.

The biotitic and granitic gneisses which comprise the Major Gneiss appear to exhibit nearly neutral magnetic intensities. Most intensities vary between 9750 and 1000. However, higher intensities may occur either in amphibolite-rich areas or near outcroppings of the basal granitic gneiss and lower intensities are found near carbonate-rich areas. Thus, there appears to be no distinctive magnetic signature associated with these units.

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The only exposure of granitic gneiss that does not have a pronounced magnetic expression is the Moss Ridge-Battle Hill body (Plate 1). Although a small magnetic high occurs immediately over Battle Hill, most of this body exhibits neutral or low magnetic intensities. Field mapping has shown this to be a continuous, well developed exposure of granitic gneiss that is stratigraphically correlative to the Reservoir Hill body. At this time, the lack of a positive magnetic anomaly over this granitic gneiss cannot be explained.

Additionally, it should be noted that strong positive magnetic patterns are not developed over the thin granitic lenses mapped by Brown east of Beaver Creek or over the large masses of granite exposed off of the mapped strip near Alexandria Bay, New York. The lack of positive magnetic anomalies suggests that these granites are different from the basal granitic gneiss unit. This conclusion has importance because the granite near Alexandria Bay has traditionally been considered the type location for the basal granitic gneiss unit (Buddington, 1939, p. 147).

Regional magnetic patterns

An interpretation of the larger, regional magnetic pattern depends principally on two assumptions. First, the basic stratigraphic succession proposed above must be valid for the entire region and, second, the association of magnetic patterns and rock units determined in the areas of the map (Plate 1) must hold throughout the region. If these assumptions are correct, then regions of high magnetic intensity should represent structurally high areas; conversely areas of low intensity should indicate structural depressions.

The detailed magnetic data for the NW Adirondacks region are available in U.S.G.S. Open-File report number 75-526. The details of this report have been greatly simplified to produce a generalized map of regional magnetic intensities (Plate 5). Major areas with high magnetic intensities (overall intensities greater than 10,000 gammas) are shown in black and indicate a series of ridges trending NE-SW in the southern and central part of the map and more easterly in the NE section of the area. Areas in white have lower magnetic intensities and indicate the presence of large, elongate basins. Of particular note on this small scale map are the continuous NE-SW trending structural high in the NW portion of the mapped area, and the large basin structure near Sylvia Lake, west of Edwards. This generalized magnetic map of the entire region thus seems to compliment the structural and stratigraphic data available for smaller, better known areas. Both suggest that the Adirondacks are composed of a complex series of NE-SW to E-W trending dome and basin structures which have developed through a complex sequence of multiple folding and faulting.

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Plate I

Rock unit descriptions

Post Grenville rock units

Єp — Potsdam sandstone.—A middle Cambrian sandstone which unconformably overlies the Precambrian rock units. Often contains angular clasts and may occur within Precambrian marbles as karst fillings.

dk — Mafic dike.—A series of alkalic dikes (varies from analcite bearing diabase to trachytes). Undeformed by folding and faulting. Age is uncertain but probably are latest Precambrian.

Pre Grenville rock units

6 — Amphibolite.—Probably an intrusive amphibolite. Large bodies occur as roughly circular masses; smaller bodies typically have the form of concordant lenses. Rock may be schistose or massive.

5 — Miscellaneous granites.—A series of undifferentiated granites occur abundantly in the western part of the mapped area. Most are roughly concordant sheets, but some are crosscutting. At least two different generations of granites are probably present.

4 — UPPER MARBLE.—An undifferentiated sequence of carbonate rich rocks. Many different lithologies have been recognized, but little along strike continuity appears to exist. Although most of the unit is composed of impure marbles, there are also abundant lenses of calcareous quartzites, quartzites, biotitic gneisses, and granitic gneisses. The formation is recognized only in the northwestern portion of the mapped area.

MAJOR GNEISS

3c — Interlayered marbles.—Thin belts of calcareous or dolomitic marble occur interlayered within the porphyroblastic gneiss. These marbles exhibit great along strike continuity but are generally less than 50 m wide.

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3b **Porphyroblastic gneiss**.--An inequigranular granitic gneiss with porphyroblasts of K-feldspar frequently exceeding 4 cm in length. In the eastern part of the mapped area, the dominant mafic mineral is biotite, while further west hornblende is more abundant.

3a **Biotitic gneiss**.--A layered paragneiss which contains mostly quartz, oligoclase, and biotite, but also small amounts of garnet and sillimanite. Compositional layering is generally well developed, and frequently the rock will display migmatitic segregations.

Structural discontinuity

LOWER MARBLE

2e **Felsic schist**.--A homogeneous felsic rock that is found only in one thin belt in the central portion of the mapped area.

2d **Calcareous gneiss**.--A very heterogeneous series of gneiss. Most are calcareous and contain minor amounts of calcite, tremolite, diopside, and sphene. Some have scapolite.

2c **Diopsidic marble**.--An impure sequence of diopsidic and dolomitic marbles. Large parts of the unit are made up of finely banded sequences of calcareous quartzites.

2b **Pyritic biotitic gneiss**.--A biotitic gneiss of widely variable composition, but usually containing significant amounts of pyrite. Also it may have abundant tourmaline. This unit provides a distinct separation between the two adjacent marbles.

2a **Calcareous marble**.--In the eastern part of the mapped area, this unit has not been subdivided. Dominantly, it is a fairly pure sequence of calcareous marbles with some lenses of biotitic gneiss and layered quartzites. Further west, the unit is divided into three sub-units which are:

2ac 1) A sequence of fairly impure marbles, containing abundant clots of diopside.

2ab 2) A biotitic gneiss which may vary in thickness from 0 to 100 ft. Frequently this unit provides the only clear distinction between the two adjacent marbles.

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2aa 3) A sequence of fairly pure, calcareous marbles.

2 Undifferentiated calcareous marble.--In the region near Balmat and Edwards, N. Y., the calcareous marble has been subdivided into 16 sub-units (Lea and Dill, 1968). At this time, it has not been possible to correlate these sub-units with those further to the west. Thus the marbles in this area are undifferentiated. Two undifferentiated sub-units of gneiss are shown by a stippled pattern.

LOWER GNEISS

1b Sillimanitic gneiss.--A distinctive gneiss containing sillimanite and garnet is frequently found immediately above the granitic gneiss.

1a Granitic gneiss.--A distinctive and widespread unit, most of alaskite composition. Outcrops frequently display an elliptical or hook-shaped map pattern. The rock is a light, buff colored granite, medium grained, and weakly foliated. Frequently it will contain numerous thin, continuous interlayers of amphibolite.

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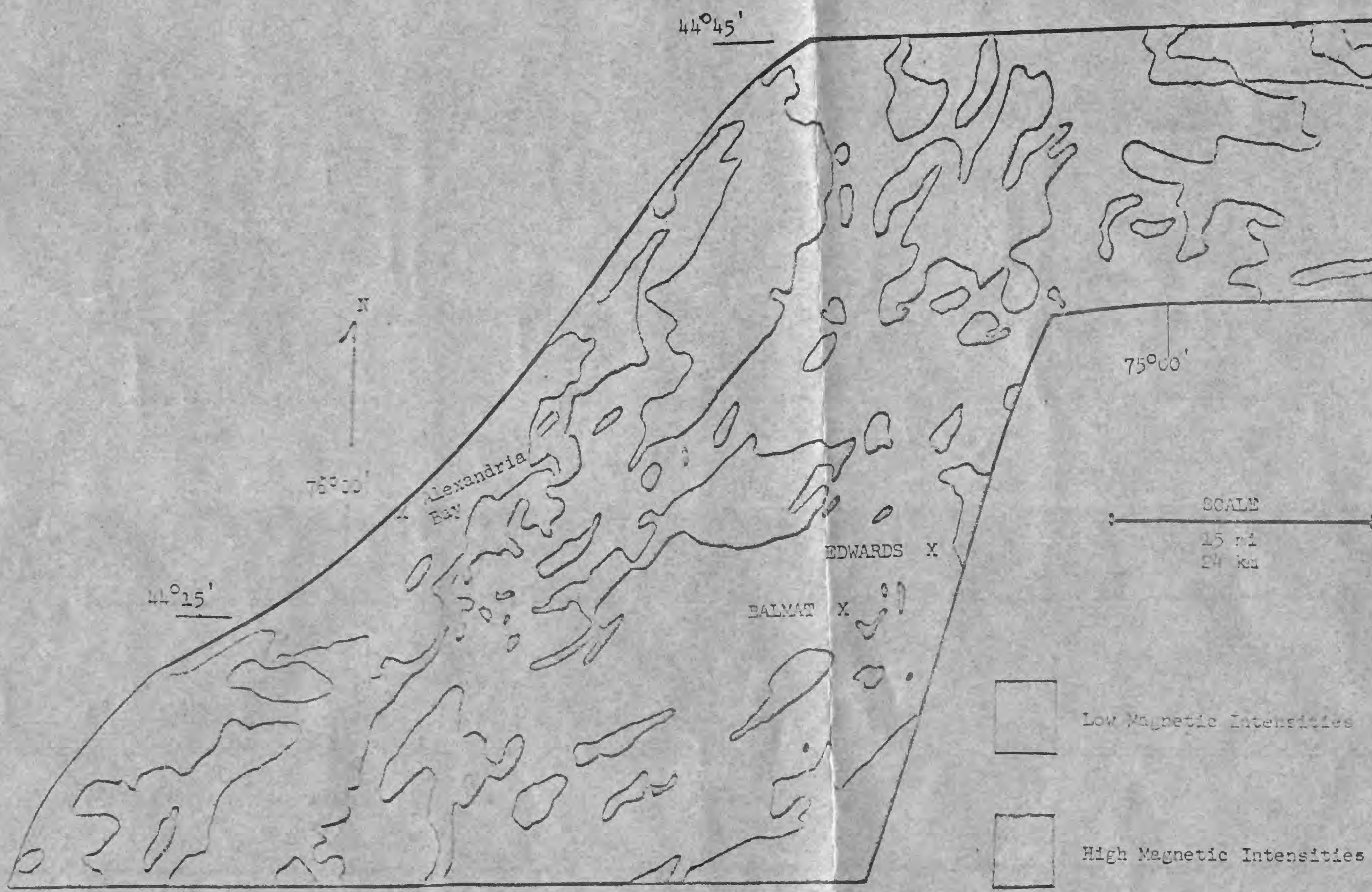

PLATE 5