Maine Geological Survey
DEPARTMENT OF CONSERVATION
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OPEN-FILE NO. 79-25

Title: Report on Field Mapping in the Sherbrooke 2 degree Quadrangle, Northwestern Maine.

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Date: 1979

Financial Support: Preparation of this report was supported by funds furnished by the Nuclear Regulatory Commission, Contract No. AT (49-24)-0291.

This report is preliminary and has not been edited or reviewed for conformity with Maine Geological Survey standards.

Contents: 8 page report and 1 map

INTRODUCTION

A preliminary Bedrock and Brittle Fracture Map of the Sherbrooke 2-degree Quadrangle (U.S. portion) has recently been compiled by Boone (1978). The dominant geologic structure in this area is the Boundary Mountain Anticlinorium, which is, at least in part, of Precambrian age (Naylor, R.S., et al., 1973). The core of the anticlinorium has been mapped by various workers and is reported to consist primarily of gneiss, serpentinite, metapyroxenite, and gabbroic and granitic rocks (Boone, 1978). The bedrock and brittle fracture mapping around the southwestern and southeastern sides of the structure has been compiled by Boone (1978) in some detail. Albee and Boudette (1972) present a detailed map of the northern boundary of this structure in the Attean Quadrangle, showing the contact between the Attean Quartz Monzonite within the Boundary Mountain Anticlinorium and the Devonian slates (Seboomook Formation) exposed to the north. In addition, they indicate the existence of two "slivers" of Silurian limestone occuring between the two previously mentioned units. The structural geology of this northwestern boundary of the anticlinorium is the focus of this report.

There is considerable disagreement among previous workers as to the nature of the northwestern boundary of the Boundary Mountain Anticlinorium. It has been suggested to be a southeast-dipping thrust fault (Rodgers, 1970; Boone, 1978*), a northwest-dipping thrust fault (Boone, G.M., et al., 1970), and both a depositional unconformity and a northwest-dipping thrust fault (Albee and Boudette, 1972). St. Julien and Hubert (1975) indicate in cross-section the presence of 14 steeply dipping normal faults located in the Eastern Townships northwest of the Boundary Mountain Anticlinorium and presumedly parallel to that structure. This author considers the contact to be a normal fault dipping steeply to the northwest.

FIELD MAPPING AND PURPOSE

Four weeks were spent in the field during June and July, 1978, mapping the contact between the Seboomook Formation and the rocks of the Boundary Mountain Anticlinorium in the western portion of the Attean (15') Quadrangle, and in the Skinner Northeast (7.5'), Skinner (7.5') and Boundary Pond (7.5') Quadrangles, a distance of about 20 km (Figure 1). Two hundred and fifty-six outcrop locations were visited; and lithologic data, fold and cleavage data, and brittle fracture data were collected. The purposes of the investigation were to: (1) accurately locate the contact; (2) determine the nature of the contact; and (3) search for evidence to indicate the most recent faulting activity along the contact.

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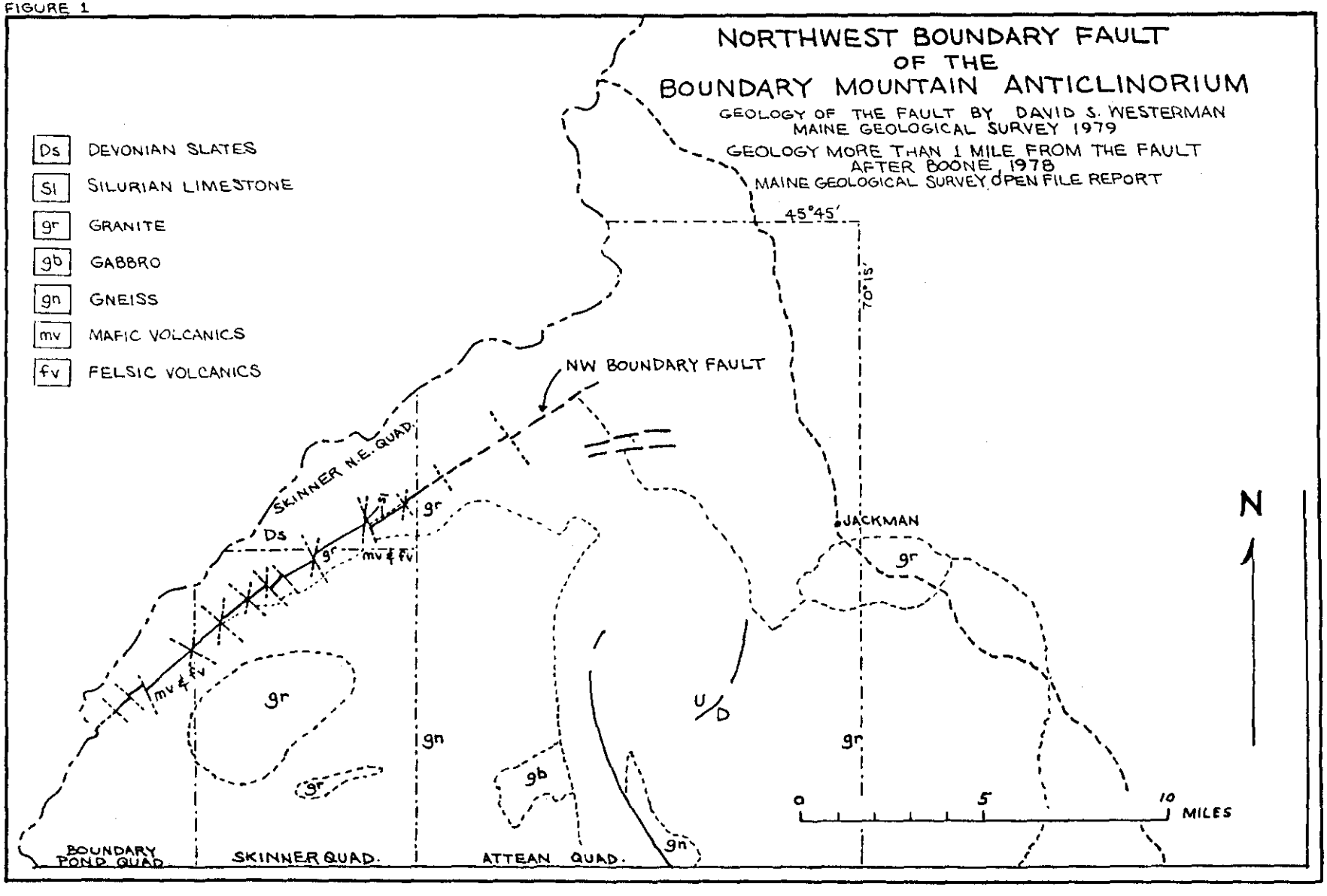
*Boone (July, 1978, personal communication) considers the boundary to be a northwest-dipping thrust fault, pointing out an error in the preparation of the 1978 map.

FIGURE 1


NORTHWEST BOUNDARY FAULT
OF THE
BOUNDARY MOUNTAIN ANTICLINORIUM
GEOLOGY OF THE FAULT BY DAVID S. WESTERMAN
MAINE GEOLOGICAL SURVEY 1979
GEOLOGY MORE THAN 1 MILE FROM THE FAULT
AFTER BOONE, 1978
MAINE GEOLOGICAL SURVEY OPEN FILE REPORT
Ds DEVONIAN SLATES
Sl SILURIAN LIMESTONE
gr GRANITE
gb GABBRO
gn GNEISS
mv MAFIC VOLCANICS
fv FELSIC VOLCANICS
45°45'
70°15'
NW BOUNDARY FAULT
SKINNER N.E. QUAD.
JACKMAN
N
U/D
0
5
10
MILES
BOUNDARY POND QUAD.
SKINNER QUAD.
ATTEAN QUAD.

BEDROCK GEOLOGY

The rocks on opposite sides of the northwest contact of the Boundary Mountain Anticlinorium have been previously separated into two groups on the basis of their ages (Albee and Boudette, 1972). The rocks on the southern side are considered to be pre-Upper Silurian in age and include the Attean Quartz Monzonite in the eastern and central portion of the map area, and mafic and felsic metavolcanic units in the western portion (Figure 2 and 3). The rocks on the northern side of the contact include slivers of Upper Silurian limestone and, predominately, phyllitic Devonian slates of the Seboomook and Frontenac Formations.

PRE-UPPER SILURIAN ROCKS

Mafic and Felsic Metavolcanics

A wide variety of mafic and felsic metavolcanic rocks occur in the western half of the map area along the southern side of the contact between the pre- and post-Upper Silurian rocks. Many of these same rocks occur to the east, separated in most places from the contact by 1.6-2.4 km of Attean Quartz Monzonite. Although individual units can in some cases be mapped over distances as great as 3.2 km, the extent of field mapping away from the contact was not sufficient to allow a detailed presentation of the distribution of these units. Many of the individual rock types within this metavolcanic group can be easily recognized as the same specific unit occurring in several widely separated locations. The potential for detailed mapping would at first appear high, but exposures are severely limited and individual units appear to be relatively thin and discontinuous.

The mafic metavolcanics are characteristically dark green, often having a purplish tint. They vary in grain size from very fine grained to medium grained, and their textures range from strongly schistose to massive. Individual rock types include metamorphosed crystal tuff with euhedral feldspar and minor quartz, metabasalt and metadiabase (both greenstones), pyroxene-plagioclase granofels, albite-chlorite-quartz schists, and fine-grained feldspar-chlorite-biotite-quartz gneisses. These names, as is the case with all the lithologic names in this report, are based on hand specimen identification in the field.

The felsic metavolcanics generally have been distinguished from their mafic counterparts on the basis of their pale colors. This group of rocks includes whitish gray chert, pale yellow siliceous metavolcanics, quartz-limonite-muscovite schist, brown quartz-feldspar schist, pale pink siliceous muscovite schist, brownish gray feldspathic granofels, pale greenish gray siliceous schist, and yellowish pink quartz-porphyry latite. Grain sizes are generally very fine to fine, and rarely medium. Most of these rocks have well-developed schistosity parallel to the brittle fractures, although some of the units are massive (i.e. chert).

Attean Quartz Monzonite

The Attean Quartz Monzonite occurs along the southern side of the contact in the Attean and Skinner Northeast Quadrangles, and in most of the Skinner

Quadrangle. It is an extensively mylonitized, two-feldspar granite in most locations, commonly porphyritic with varying amounts of recognizable potassium feldspar phenocrysts. The percentage of quartz appears to range from as low as 20% up to 35%, but mylonitization makes these estimates difficult.

The texture of this unit varies with proximity to the contact, becoming finer grained to the northwest where the extent of mylonitization is greater. The rocks commonly contain oriented chlorite, producing a foliation and a pale green color on fresh surfaces. Outcrops in the Attean Quadrangle were observed to contain secondary calcite as well as chlorite. The weathered surfaces of the Attean Quartz Monzonite are typically whitish gray, irrespective of the extent of shearing and recrystallization.

POST-UPPER SILURIAN ROCKS

Silurian Limestone

As was noted by Albee and Boudette (1972), thin slivers of Silurian limestone are found in the Attean Quadrangle along the contact between the pre-Upper Silurian rocks and the Devonian slates. One such sliver is well exposed in the Skinner Northeast Quadrangle east of East Branch Gulf Stream. The rocks are exposed over a distance of 610 m with a map width ranging from 61 m at the west end to 92 m at the east end of the outcrop belt.

These limestones are typically gray on fresh surfaces, weathering to brown. The most common texture of the limestone is massive, but exposures of thinly laminated (1 mm) limestone were also observed. One outcrop exhibited a swirled texture of very fine-grained gray limestone and brownish weathering coarser limestone with disseminated black angular fragments. Mylonitzed breccias of limestone and Attean Quartz Monzonite occur along the southern margin of the outcrop belt.

West of the limestone sliver discussed above, two occurrences of limestone were observed. The first is in East Branch Gulf Stream where large angular boulders of pale purple, laminated limestone occur, the lamination being seen as discontinous layers of very fine-grained and medium-grained (1-2 mm) limestone. Square and circular particles can be seen in the coarser layers with the circular fragments having darker cores. These particles are thought to be crinoid stem fragments. The only other limestone occurrence in the map area is in the Skinner Quadrangle, between the Devonian slate and the Attean Quartz Monzonite, at the crest of the first major hill west of West Branch Gulf Stream. The limestone at this locality is fine grained and has a brownish gray color, appearing to be very similar to the major sliver described above.

Devonian Phyllitic Slates

Dark gray phyllitic slates are exposed on the northern side of nearly the entire extent of the contact between the pre- and post-Upper Silurian rocks. In those areas where Silurian limestones constitute the boundary, the Devonian slates are exposed immediately to the north of the limestone.

In the Skinner Northeast Quadrangle, in the eastern portion of the map area, slates are typically laminated on a scale of 1 to 2 mm with black metapelite beds and dark gray metasiltstone beds nearly parallel to a phyllitic slaty cleavage. Discontinuous 1-cm thick lenses of metasandstone occur commonly in places but rarely in most localities.

Dark gray phyllitic slates are common in the western portion of the map area, but they are rarely laminated. The grain size of these rocks is generally somewhat coarser (metasiltstone) than is that of the slates to the east, and phyllitic texture commonly is absent. The color of these rocks varies from black to gray, and weathered surfaces typically are brown and rusty.

Breccias

A wide variety of breccias are exposed in various locations along the length of the contact between pre- and post-Upper Silurian rocks, as well as in rocks immediately adjacent to that contact. In the eastern portion of the map area, near the Silurian limestone sliver, breccias of limestone-in-Attean Quartz Monzonite matrix, Attean Quartz Monzonite-in-limestone matrix, limestone-in-Devonian slate (schistose) matrix, and Devonian slate-in-limestone matrix have been observed. Clast sizes commonly reach 10 cm in their long dimension and rarely reach 20 cm. These breccias have angular, elongated clasts showing internal deformation, contained in a schistose matrix. The breccias generally are found at the lithologic contacts, but one limestone-in-black schist breccia occurs within the limestone outcrop belt.

A breccia containing clasts of Attean Quartz Monzonite, limestone, and black schist is exposed on the west shore of Gulf Stream at the contact. This rock is intensely sheared with a well-developed schistose texture and a dark green color.

Near the western outcrop limit of the Attean Quartz Monzonite, two exposures of breccia occur on opposite sides of an unnamed stream west of Gulf Stream. Both of these breccias consist of very angular, white cherty volcanic(?) fragments up to 10 cm in length contained in a granitic matrix. Abundant coarse quartz is present in the matrix along with small angular fragments of the banded cherty volcanic(?) rock. The western exposure of this breccia is approximately 30 m south of typical Devonian slate.

Farther to the west, near the west side of Little Gulf Stream, a breccia of angular white, cherty volcanic(?) fragments in a fine-grained, felsic schistose matrix is exposed. This breccia is very similar to rocks at another exposure located farther to the west, north of the summit of Clear Pond Mountain in the Boundary Pond Quadrangle.

All of the breccias share the characteristics of having clasts elongated parallel to the regional fracture foliation (N20-40°E, 55-80°W) and having extensive phyllosilicate mineralization on their sheared surfaces. These surfaces are commonly lineated, but no movement directions were obtained.

STRUCTURAL GEOLOGY

STRUCTURAL FEATURES IN PRE-UPPER SILURIAN ROCKS

Well-developed, closely-spaced intersecting brittle fractures with superimposed joint sets are the dominant structural features in the pre-Upper Silurian rocks. No faults or folds were observed within the units of this group, but the lack of planar features would make the recognition of such structures unlikely.

The orientations of the closely-spaced brittle fractures are shown on Figure 2. There is a clearly consistent trend in the orientation of the resulting foliation, typically at a shallow angle to the northern boundary of these rocks. These fractures generally occur either in sets that intersect at angles of 10 to 20° or in a single set, producing in each case what is hereafter referred to as a fracture foliation. The spacing between fractures is generally less than 1 cm. Several fine-grained rock types in both the mafic and felsic metavolcanic groups commonly have a schistosity that parallels or replaces the fracture foliation. Both the fracture foliation and the schistosity tend to increase in their degree of development as one approaches the northern contact of these older rocks. Fracture foliation is commonly very well developed in the Attean Quartz Monzonite, where it is associated with observable mylonitization. Both quartz and feldspar generally exhibit the results of a mechanical reduction in size.

Many outcrops exhibit slickensides and mineral lineations on the steeply dipping fracture foliation surfaces. The direction of movement is almost directly down dip (normal), that is north side down, in nearly all cases. Occasionally lineations occur plunging at an angle less than the dip of the fracture surface, and very rarely, slickensides indicate a high angle reverse sense of motion.

Joints in the pre-Upper Silurian rocks are generally well-developed, nearly vertical sets (Figure 3). They are typically planar and smooth, and their spacing is highly variable but usually consistent at the outcrop scale (1 cm to 2 m). Most joints are devoid of mineralization on their surfaces, but quartz-filled joints are abundant in places. This is particularly true at closest proximities to the northern contact of these units. Rarely, quartz veining roughly parallel to the joint sets accounts for as much as 40% of an outcrop by volume.

STRUCTURAL FEATURES IN POST-UPPER SILURIAN ROCKS

The dominant structural feature in the Silurian and Devonian rocks is a well-developed slaty cleavage, commonly exhibiting a phyllitic sheen. Where bedding is observable, the cleavage is typically parallel or very nearly parallel to the bedding. The shallow angles of intersection (rarely greater than 10°) produce a nearly horizontal lineation on the cleavage surface. There is no consistent angular relationship between cleavage and bedding, but the cleavage is more frequently at a steeper angle. Occasionally, a second cleavage occurs, in varying orientations, associated with kink folding of the initial cleavage surface. These kinks consistently illustrate a down

dip movement on their axial plane surfaces, either to the north or southeast. A well-developed slaty cleavage occurs in the Silurian limestone although many outcrops of this unit are massive and have poor cleavage.

Joints in the post-Upper Silurian rocks are well-developed, planar, and smooth, typically occurring as one or two sets. The occurrence of quartz in the joints is most common near the southern contact of these rocks.

FAULTING

No faults were directly observed in the map area, but considerable evidence exists to infer their presence. The contact between the pre- and post-Upper Silurian rocks has been located with tight control in most parts of the map area, frequently within 18 m and rarely within 9 m. The map pattern of this contact shows that it exists in straight segments which vary in orientation from N38°E to N58°E (average N53°E). These segments are occasionally offset as much as 915 m.

Breccias showing extensive crushing and shearing commonly occur along the contact. The occurrence of younger rocks as clasts in a matrix of sheared older rock could be explained by theories of rip-up conglomerates in a matrix of eroded basement, but the close proximity of the opposite arrangement makes that unlikely. It seems more likely that the breccias resulted from faulting.

The contact is a major unconformity with intense internal deformation in the adjacent rocks. The orientation of the fracture foliation is consistently within 30° of the contact and it dips steeply to the northwest. The surfaces of these fractures almost invariably exhibit a normal sense of movement when it can be detected.

SUMMARY

Detailed mapping has accurately established the location of the northern boundary of the Boundary Mountain Anticlinorium over the distance from the U.S. - Canadian border to the Attean Quadrangle, Maine. The contact defines a slightly arcuate pattern made up of straight segments in varying orientations. This contact is thought to be a normal fault dipping steeply to the northwest, which varies in orientation as a result of high angle faults trending N10°E and N35°W. No evidence of post-Acadian deformation was observed.

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FIGURE 2

CLEAVAGE AND FRACTURE FOLIATION MAP

Northern Boundary of the Boundary Mountain Anticlinorium

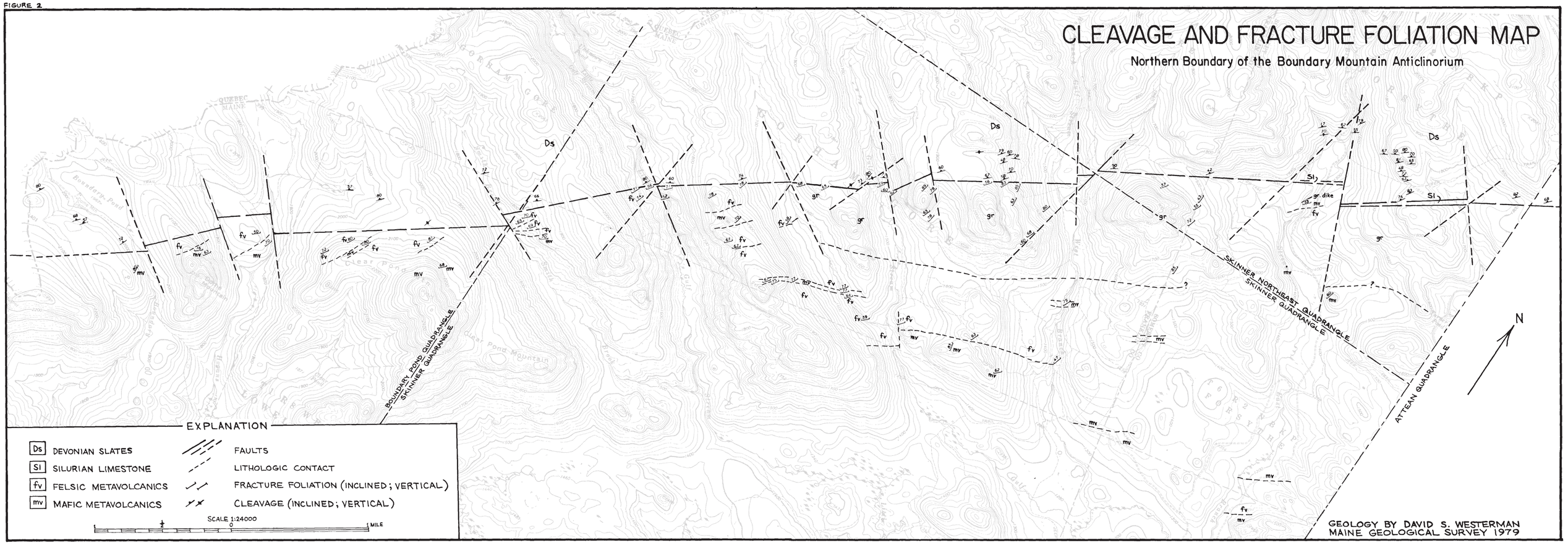

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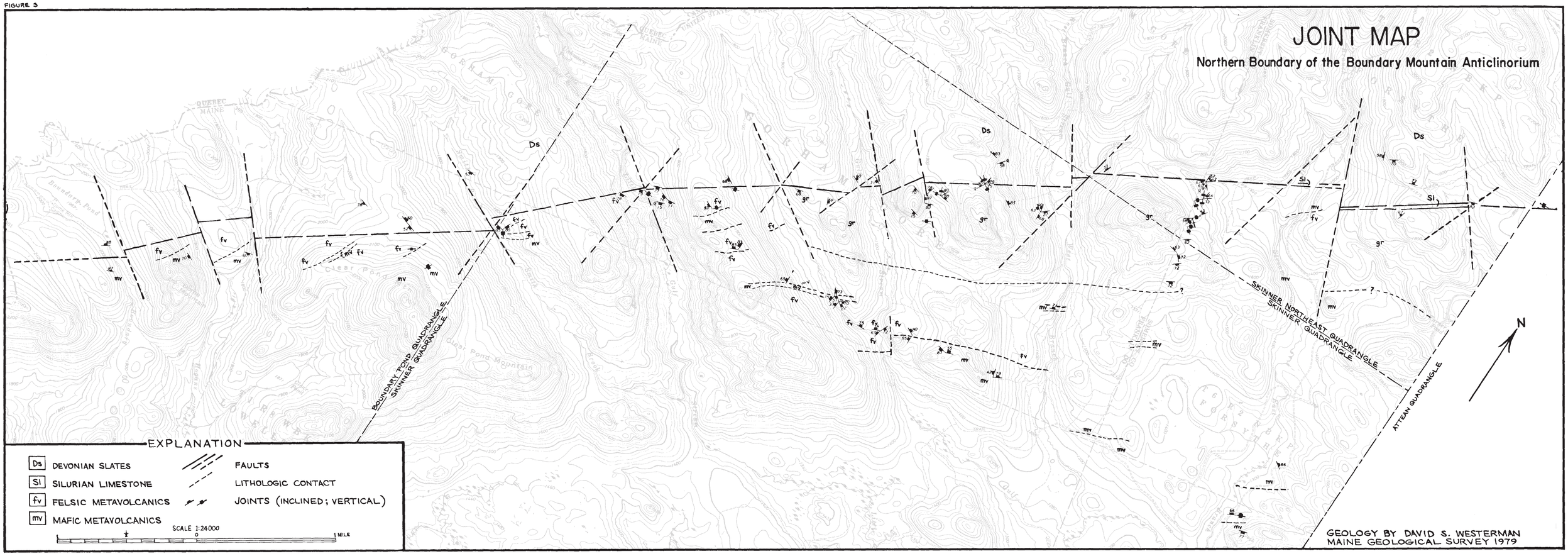
FIGURE 3

JOINT MAP

Northern Boundary of the Boundary Mountain Anticlinorium



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Preparation of this map was supported by funds furnished by the Nuclear Regulatory Commission Grant No. AT (49-24)-0291 and the Maine Geological Survey.