PETROGRAPHIC AND STRUCTURAL INTERPRETATION OF DISPLACEMENT ALONG THE BURNTSIDE LAKE FAULT ZONE BASSWOOD LAKE AREA, NORTHERN MINNESOTA

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INTRODUCTION

The Burntside Lake fault is one of the major splay faults which extends from the great Vermilion fault in northeastern Minnesota. The portion of the fault zone examined in this study trends roughly N30°E and lies along a ten-mile stretch of Basswood Lake, which straddles the international boundary between the United States and Canada. Two separate areas along the southeast side of the fault comprise the primary focus of the study (fig. 1). These are named the Back Bay region and the White Island region (fig. 4). The goal of the project was to determine the degree and nature of the displacement which has occurred. Two main strategies were focused upon to accomplish this task. The first involved gathering structural data on slickensides and fracture orientations which occur throughout both regions.

The second strategy entailed a thorough mapping of the lithologies of the Archean units. This part of the study served two purposes. First, it allowed the determination of amount and direction of drag on units cut by the fault. Second, it enabled recognition of an increasing grade of metamorphism (chlorite to amphibolite) that occurs as one proceeds northeastward along the fault zone. One of the hypotheses that this paper intends to address is whether this difference in metamorphic grade can be used as an indicator of uplift in the block southeast of the fault.

STRUCTURAL INFORMATION

An initial survey revealed that the fault was exposed in two separate areas in the Back Bay region (fig. 4B). The effects of fault drag in this region are easily observed in the lithologic units which contain discernable bedding. One of the best areas to see this relationship is in a thin unit of chloritized metasediments (Ms on fig. 2 and 4B) in the Back Bay region. Exposures located farthest from the fault zone strike N80°E and dip 80°SE. This orientation remains reasonably constant along the trend of the unit until one comes within a half mile of the fault trace. Here, the strike of the bedding begins a clockwise rotation and passes through E-W, reaching a maximum deflection of N80°W. This drag implies right-lateral displacement.

The relative age relationships among the units listed in figure 4 were determined by examining crosscutting relationships, vague and irregular occurrences of graded bedding in the Metasedimentary (Ms) unit, and rough interpretations of stratigraphic up using moderately distorted and metamorphosed pillow basalts in the Chlorite Schist (Cs).

A linear zone of migmitization cutting through the central portion of the Back Bay region was the first evidence of the existence of an overturned syncline, here called the Back Bay syncline. This structure is not particularly obvious because of its isoclinal form. Two measurements taken near a swamp in the northeastern section of Back Bay mark the axis of the fold, and suggest that the hinge line trends S55°W and plunges 65°SW. Several other minor folds within the adjacent units appear to be in strong agreement with this trend and have plunges ranging from 50°SW to 73°SW. This orientation of the hinge line strongly correlates with measurements taken on the eastern side of United States Point by Shaver (1970), whose data record a trend and plunge of S44°W and 52°SW, respectively. Strike and dip measurements of bedding taken along the limbs of the fold also support these values for trend and plunge.

The White Island region of Canada (fig. 4A) is structurally and petrologically simple when compared to the Back Bay region. Originally, it was expected that the Burntside Lake fault trace would pass through the southeast part of this region. However, it soon became apparent that the main trace actually lies farther to the north. As mapping progressed northward in search of the location of the fault zone, it was noted that the structural data demonstrated the presence of a gently plunging anticline, here called the Queens Lake anticline. Orientations of several small-scale fold axes confirmed this conclusion. The data gathered with respect to this structure were obtained from the unit called Biotite Schist-rich Migmatite (Mb on figs. 2 and 4A). The Hornblende Granite Gneiss (Hg) unit is probably equally affected by this fold structure, but this is impossible to prove because no primary layering exists in the unit. The hinge line trends N50°E and plunges 14°NE. Data collected by individuals studying adjacent areas to the southwest show evidence for fault drag of the axis where it is cut by the main trace of the Burntside Lake fault (see the Mb unit in fig.

2). This distortion, and slickenside measurements taken near the fault trace in the White Island region again indicate a right-lateral displacement.

Because the alignment of the adjacent hinge axes of the Queens Lake anticline and the Back Bay syncline are nearly parallel (fig. 3), but the plunges of the folds are in opposite directions, a rotation of the southeast block is also suggested. This structural evidence demonstrates an uplift of the White Island region relative to the Back Bay region.

PETROLOGICAL INFORMATION

The major purpose of the petrographic analysis of the rocks was to identify any change in the metamorphic character of the lithologic units. Generally, the grade of metamorphism in the southeast block seems to progress from a chlorite schist unit in the southwest to hornblende-bearing rocks located to the northeast. Locations of metamorphic isograds are difficult to define because of different original lithologies and late stage regression of higher metamorphic grade material. Nevertheless, the suggestion of increasing metamorphic grades toward the northwest may imply that the southeast block has been rotated, with the southwest portion of the block moving down relative to the northeast. This deduction, drawn from petrological data, agrees with the results obtained in the structural analysis.

CONCLUSIONS

Measurable effects of fault drag located in the Metasedimentary (Ms) unit in the Back Bay region and the Biotite Schist-rich Migmatite in the White Island region show strong evidence that the displacement along the fault has been right-lateral. Strike and dip measurements of bedding and orientations of hinge axes of small folds provide evidence that a syncline exists within the Back Bay region and that an adjacent and parallel anticline is present in the White Island region.

The increase in metamorphic grade to the northeast and the opposing plunges of the anticline and syncline suggest a vertical component of movement. This motion is believed to be an upward rotation of the higher grade metamorphic units (the White Island region) and an opposing downward shift in those of lower grade. These apparent displacements could have been accomplished by a single oblique motion of the southeast block or multiple motions of differing character through time.

REFERENCES

Shaver, K. C., 1970, The bedrock geology of United States Point, on Basswood Lake, in northern Minnesota: unpublished undergraduate research report, Beloit College.

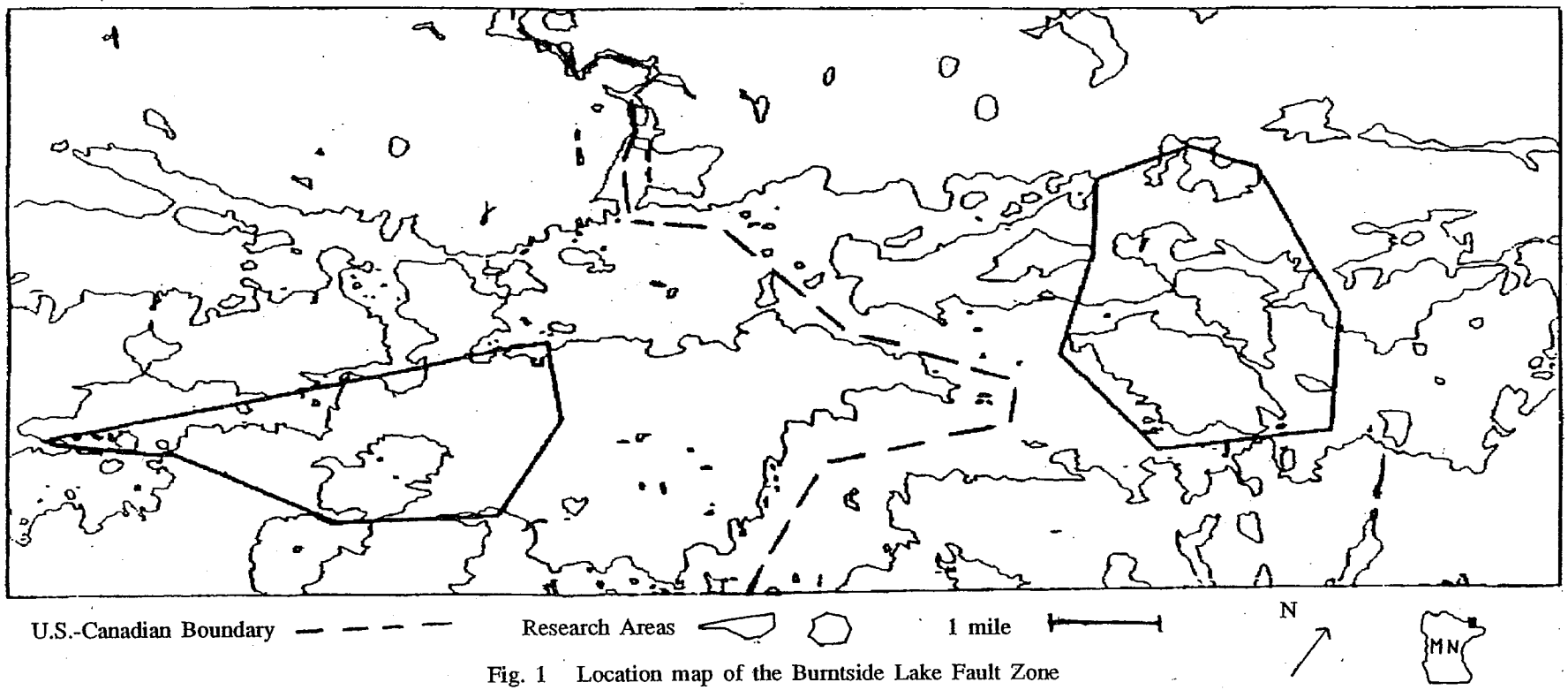

Fig. 1 Location map of the Burntside Lake Fault Zone

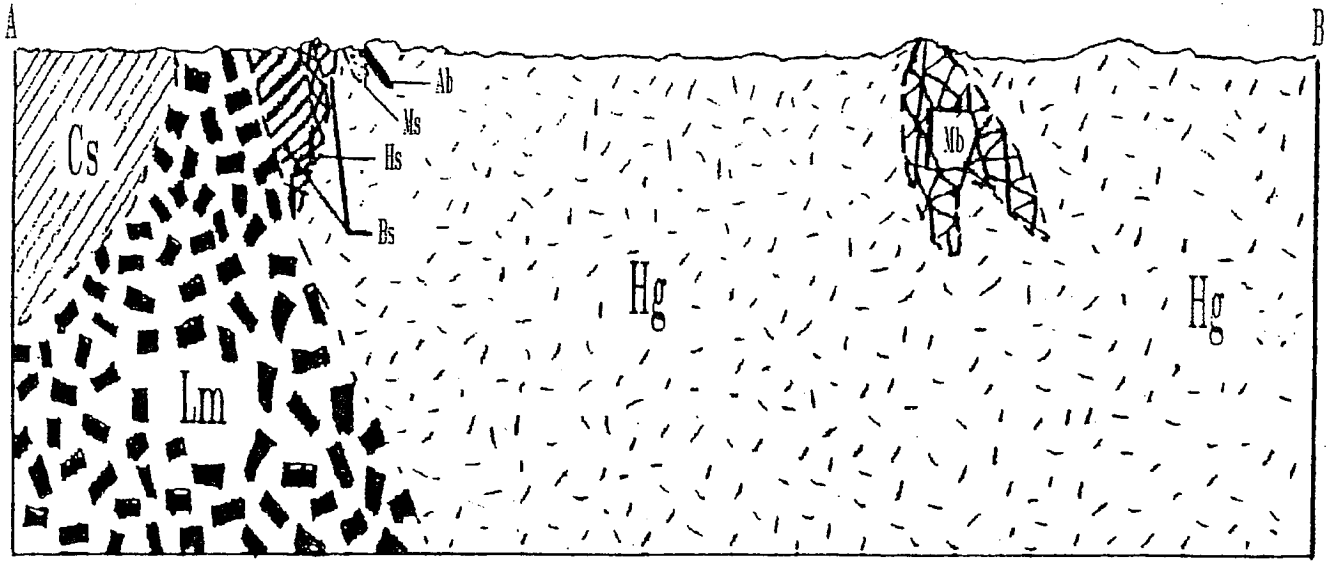

Fig. 2 Interpretational cross section in the southeast wall of the fault trace. See fig. 3 for location. See the legend in fig. 4 for age relationships.

1 mile

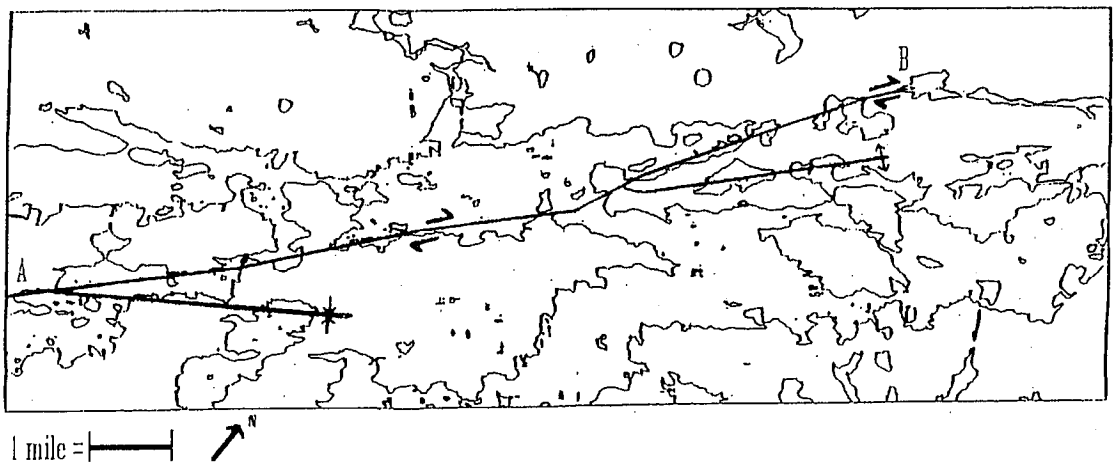

Fig. 3 Structural map of the Burntside Lake Fault Zone

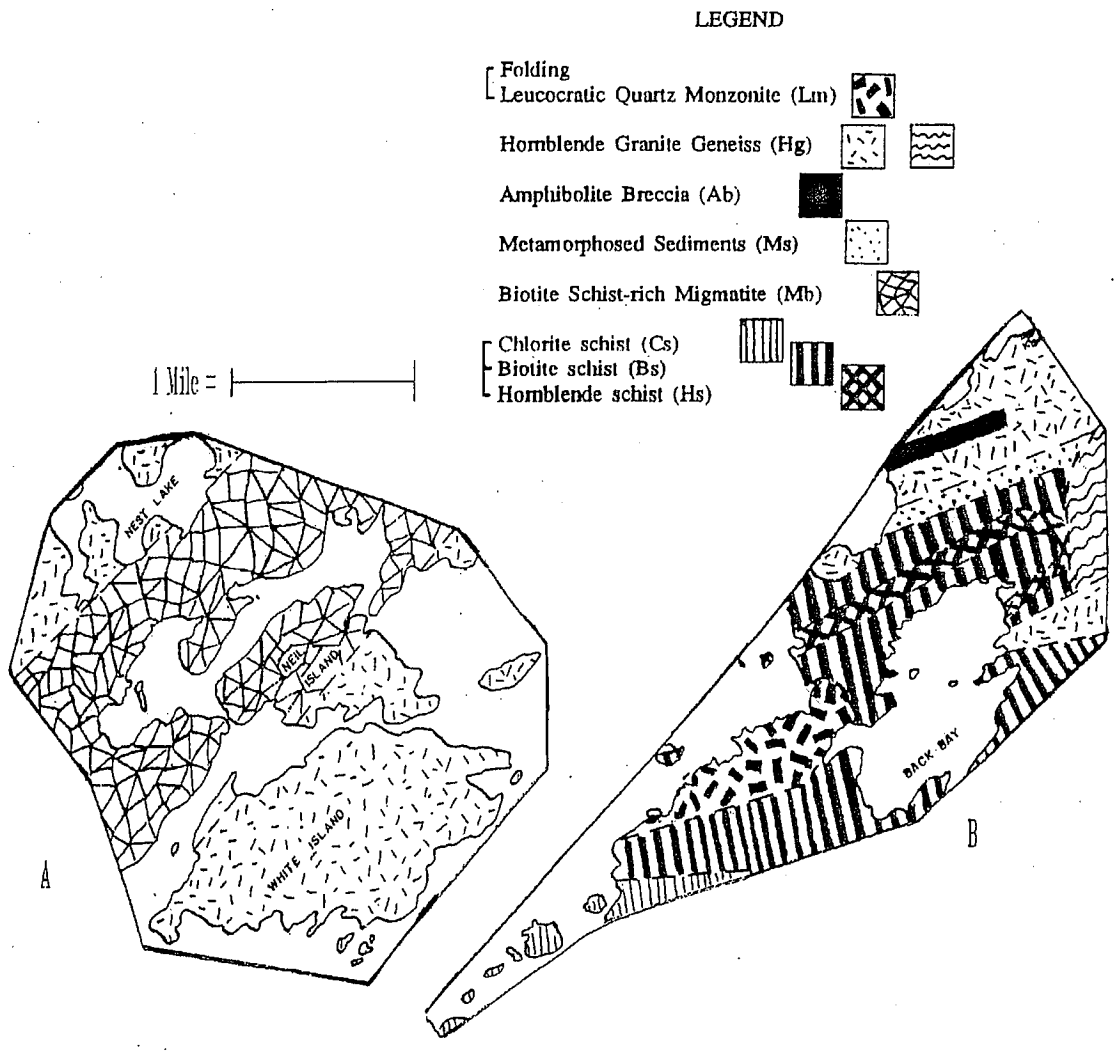

Fig. 4 Figures A and B represent geologic maps of the White Island and Back Bay regions, respectively. North is parallel to the right edge of the paper.