Structure of the Burntside Lake Fault from a Horseshoe-shaped Lake South of Kahshahpiwi Lake to Hurlburt Lake, Quetico Provincial Park, Ontario

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Introduction

Kahshahpiwi Lake lies roughly in the center of the Hunter Island area of Ontario's Quetico Provincial Park. The topography of the area is dominated by glacially sculpted rock of low but steep relief rising above abundant lakes and swamps; regolith above the water level is usually thin or absent, leaving outcrop generally covered by only lichen and moss. Outcrops are generally accessible by canoe or short traverse.

In our study area the Burntside Lake fault cuts through the Quetico subprovince, an area characterized by metasedimentary rocks and intrusive granitic units (Card, 1990). The Wawa subprovince lies about five kilometers to the south and east of the study area; that unit is characterized generally by metabasalts but has several intrusive and schistose layers proximal to its junction with the Quetico belt, a juncture that lies close and roughly parallel to the Burntside Lake fault (Figure 1). The primary goals of this study were to locate the Burntside Lake fault northeast of where it had been previously mapped, and to describe some of its deformational effects on several of the rock types which it cuts in the Kahshahpiwi Lake area.

Previous Work on the Burntside Lake Fault

All previous work on the Burntside Lake fault has been to the southwest, where the fault is considerably more pronounced. In an extensive study of the several fault systems of northeastern Minnesota, Sims (1976) proposed a series of structural events that would explain the Burntside Lake fault as a boundary fault between the Quetico and Wawa belts. He found that the fault separated the Vermilion Massif - a major element of the Quetico terrane - from the lower grade supracrustal rocks of the Wawa terrane. He described the surficial evidence as primarily cataclastic zones as much as 500 meters wide with associated retrograde minerals. He proposed a dip-slip displacement of 1-2 kilometers. Sims (1976) acknowledged that the fault diverges from the junction of the terranes in the Basswood Lake region, entering entirely into the Quetico belt. His genetic explanation of the fault, or at least its dip-slip nature, was that the batholith continued to rise buoyantly after its southern boundary had solidified.

Sims (1976) describes the Vermilion fault, a major east-west fault across northern Minnesota, and associated faults as later events that clearly displaced and are therefore younger than the Burntside Lake fault/Quetico-Wawa junction. Further work in northeastern Minnesota has proceeded largely on the presumption that, whether genetically related or not, the Burntside Lake fault is roughly aligned with the junction of the Quetico and Wawa terranes. Huddleston et al. (1987) described the major deformation in the Wawa belt – principally the Vermilion and related faults – as being the effects of dextral transpression: oblique compression of the Wawa belt between the more rigid lithospheric blocks of the Quetico belt to the north and the Giants Range to the south. They repeat the presumption that the Burntside Lake fault is associated with the junction of the Quetico and Wawa terranes and is not related to the Vermilion events (Huddleston et al. 1987).

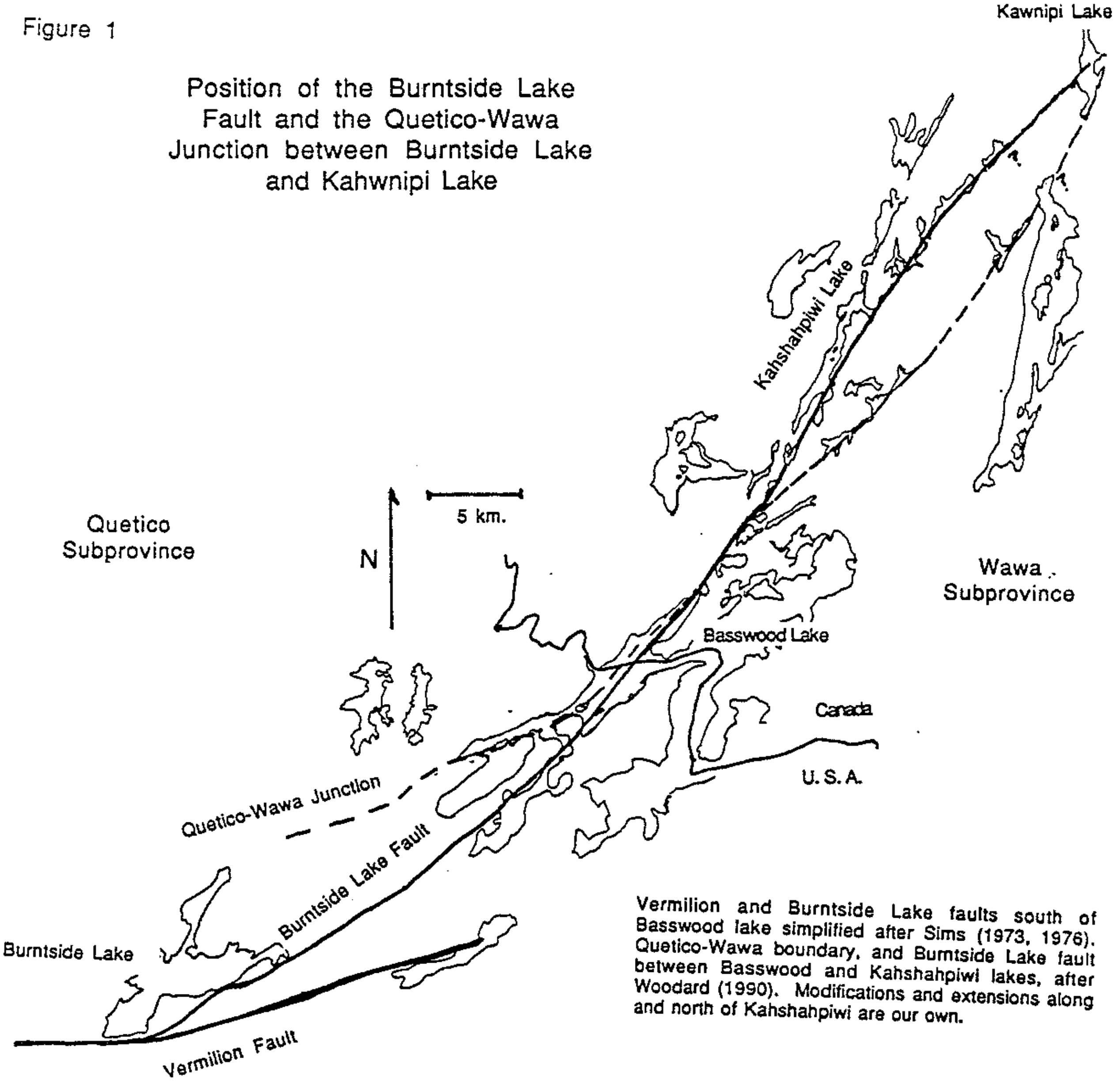
Detailed mapping of the Basswood Lake region (Woodard and Weaver, 1990) has shown the Burntside Lake fault to be unrelated to the junction; age relationships establish the Burntside Lake fault as younger than the Quetico-Wawa junction. Hodgson (1990) reported that both brittle and ductile deformation exist in the fault zone and that these represent distinct periods of deformation. The fault trace that was mapped as the Burntside Lake fault at Basswood Lake by the Keck party clearly refutes the theory that the Burntside Lake fault is genetically related to the Quetico-Wawa junction. The natural working assumption is that the Burntside Lake fault north of Basswood Lake, including our study area, is genetically associated with the Vermilion fault system. This assumption is in contradiction to the hypothesis of Sims (1976).

Methods

In the field, we traveled by canoe for the most part, making traverses on foot when necessary, in search of evidence of the Burntside Lake fault. The traverses were made perpendicular to what we assumed to be the trace of the fault. We took measurements of the fault surfaces and slickensides when exposed, taking note of the sense of shear. We also took measurements of the foliation where prominent. Other evidence that we looked for included brecciation and hydrothermal alteration, and we noted how these varied with respect to proximity to the fault trace. We also noted the changes in lithology as we traced the fault. The bearing and plunge of the slickensides and the strikes and dips of planes of fracture were plotted on mylar overlays of aerial photographs.

Figure 1

Position of the Burntside Lake Fault and the Quetico-Wawa Junction between Burntside Lake and Kahwnipi Lake



Vermilion and Burntside Lake faults south of Basswood lake simplified after Sims (1973, 1976). Quetico-Wawa boundary, and Burntside Lake fault between Basswood and Kahshahpiwi lakes, after Woodard (1990). Modifications and extensions along and north of Kahshahpiwi are our own.

In the laboratory we examined thin sections from samples collected along the fault trace. We also examined specimens in hand sample, taking note of the intensity of brecciation and alteration. By grouping rocks into categories that we thought to have been similar before Burntside Lake fault deformation, and by taking proximity to the fault trace into account, we were able to assess the impact of the fault on several lithologies. We selected structural data believed to be associated with the Burntside Lake fault and plotted it using *Stereonet 3.75* (a program for the Macintosh); using great circles, we found average values for movement planes and lineations. We used the structural data, together with the lithologic data and interpretations of maps and aerial photos, to attempt to define the location and the nature of the fault.

Structural Data

Large-scale structural evidence in the form of slickenside-movement planes has been rare in the Burntside Lake fault zone (H. H. Woodard, personal communication); therefore, in our collection of field data we have relied on topographic features and lithologic observations to place the fault, and we have taken note of prominent fracture planes that show some polishing due to movement. Great circle analysis of the stereographic plottings of the Burntside Lake fault zone data gives the plane of movement an average strike of N10°E and and average dip of

70°W; analysis also gives the slickenline lineations an average bearing of S30°W and an average plunge of 15°. These values confirm the previous assumptions about the fault; however, there is considerable variation in strike values as the fault is traced northward. The strike of the fault, from lineament observation and from slickenside data, trends towards the east, reaching about N30°E in Trant and Hurlburt lakes (see figure 2). In that area, both topographic features and movement planes indicate that the fault may be trending even further to the east, but because of the abundance of later faulting that cuts the Burntside in that area, any observations are speculative.

Topographically, the trace of the Burntside Lake fault is dramatic. It generally follows lakebottoms, and even when it is not underwater, transects to find the fault usually end disappointingly in swamps. At any rate, almost all data collected has been from the very edges of the fault zone or beyond into peripheral areas, because outcrop is very rare within the fault trace. The lineament becomes less pronounced towards the north, but this may be caused by a series of N30°W faults that cross-cut the Burntside Lake fault.

As indicated on figure 2 we have located the trace of the Burntside Lake fault as far north as the center of Hurlburt Lake; from there further north the lineament continues northeast fifteen kilometers, until Kawnipi Lake, where it intersects the lineament of the Quetico-Wawa junction. The lineaments of both the fault and the junction are fairly pronounced and we can say with confidence that the fault and the junction intersect.

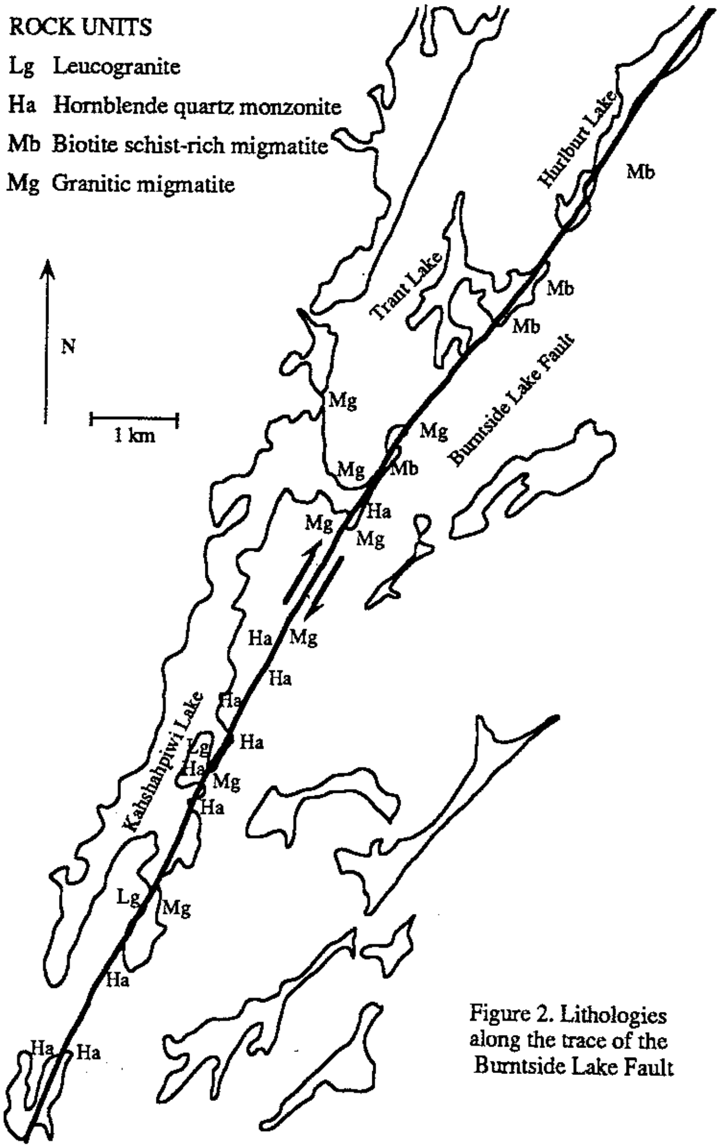


Figure 2. Lithologies along the trace of the Burntside Lake Fault

Lithologic Data

Four main rock types were observed along the presumed main trace of the Burntside Lake fault in the study area (figure 2). A hornblende quartz monzonite (Ha), a granitic migmatite (Mg), a biotite schist-rich migmatite (Mb), and a biotite luecogranite (Lg) were observed and sampled. The hornblende quartz monzonite was pale pink to white in color with large crystals of feldspar occurring often as augen. A finer-grained hornblende quartz monzonite was also observed; these rocks were often extremely brecciated, especially in the southern region of Lake Kahshahpiwi. The finer-grained rock most likely occurs as intrusions into the granitic migmatite and in some cases might have been confused with the luecogranite due to its small amount of mafic material and strong foliation. The hornblende-biotite-chlorite alteration sequence was pronounced and well-defined in the hornblende quartz monzonite as one progressed toward the fault. However, we could not find a coherent pattern of hematite staining in relation to the fault. The hornblende quartz monzonite unit has previous foliation which is roughly aligned (within 20 - 30 degrees) with the Burntside Lake fault. Closer to the fault, the brecciation generally tends to mask the foliation, first cutting and bending folia, then finally obliterating them.

The granitic migmatite, containing less than 50% biotite schist rafts, and the biotite schist-rich migmatite, containing more than 50% biotite schist rafts, both showed alteration to chlorite near the fault. However, the schist varies in mafic composition within the unit, thus complicating direct comparisons. The biotite luecogranite is pink in color and occurs as pegmatitic bodies within the granitic migmatite. The luecogranite shows alteration of the biotite to chlorite and, in places, deep red hematite staining. Tonalite, a minor rock type of the area, occurs as sills and dikes within the granitic migmatite, and shows alteration of plagioclase to epidote in varying degrees. The trace of the fault could be identified by the intensity of epidote alteration with darker shades of green closer to the fault.

Thin sections made from specimens of the luecogranite and hornblende quartz monzonite show evidence of both ductile and brittle deformation. Extensive shattering of crystals resulted in the formation of microbreccias. The luecogranite contains no evidence of chlorite alteration. Undulatory extinction was observed in not only the quartz but also in the feldspar - a result of ductile deformation. Perthite was also observed forming extinction bands in the feldspar, a phenomenon also indicative of ductile deformation.

The hornblende quartz monzonite shows little evidence of hydrothermal alteration but displays strong foliation. The feldspars showed a relict augen structure now difficult to see due to the high degree of brecciation. In thin section, effects of both ductile and brittle deformation were observed. The brittle deformation postdates the ductile deformation as demonstrated by the undulatory extinction in the microbreccia. The microbreccia with the observed flow texture defines a mylonite, a product of cohesive ductile flow, thus confirming that the ductile deformation was followed by brittle deformation. This observation is consistent with the findings of Hodgson (1990), whose study in the Point Lake area found two distinct periods of deformation, first ductile and then brittle, along the Burntside Lake fault.

Conclusions

Lithologic data confirm the observations of Hodgson (1990) that imply that the fault is consistent along strike to the north and represents more that one period of movement. Lithologic evidence was essential in tracing the fault north from Kahshahpiwi Lake through Trant Lake to central Hurlburt Lake. Structural evidence, though rare, is a right-lateral strike-slip, northeast-trending, and steeply dipping fault through the entire length of the study area. Later faults intersecting the Burntside Lake fault fit the description provided by Sims (1976) of small-displacement northwest-trending faults that are probably associated with the Vermilion faulting event; therefore, the Burntside Lake faulting took place no later than the Vermilion fault transpressional event.

The lineament examination to the north reveals that the Burntside Lake fault and the Quetico-Wawa junction join in the vicinity of Kawnipi Lake. Based on the work of Hodgson (1990), and noting the confusion regarding the fault, it seems likely that the junction and fault areas are sites of weakness that have experienced displacement at least twice. The Burntside Lake fault probably followed the weak zone associated with the belt junction. It may have entered entirely into the Quetico belt because of weakness in the rock, possibly along the foliation and layering in the granitic and biotite-schist-rich migmatite units near Trant and Hurlburt lakes, and following the foliation in the hornblende quartz monzonite unit in southern Kahshahpiwi Lake. Regardless of specific conditions, it is clear that the area is one of complex tectonic activity in which younger faulting has occurred along older structures.

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