Structure of the Side Lake shear zone in the southern Kahshahpiwi Lake area, Quetico Provincial Park, Ontario, Canada

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Introduction

As sophomore researchers in the 1992 Keck Geology Consortium project in the Quetico Provincial Park of southern Ontario, Canada, we contributed to the continuing research being done by Prof. Henry Woodard on structural and lithologic characteristics of the Quetico and Wawa structural belts and their junction. The rocks present in the Quetico and Wawa belts are two differing Archean terranes; the Quetico is characterized by metasedimentary rocks, metavolcanics, quartz monzonite sills and granitic intrusions, whereas the Wawa is composed of a series of biotite schists overlain by metavolcaniclastic rocks and underlain by metapillow basalts. Thick sills of tonalite to quartz diorite rock were injected into the metavolcaniclastic rocks and the entire sequence was folded around northeast-trending axes (Woodard and Weaver, 1990). These structural subprovinces are cut by several major faults. The purpose of our project was to map the southern portion of a northeast-trending fault zone within the Quetico belt known as the Side Lake shear zone. Woodard and Weaver (1990) briefly described the shear zone, although they gave it no name. It was described as an intense zone of shearing within the Quetico belt in which fault surfaces dip 25°-30° NW and on which gently plunging slickensides are present on almost all the shear surfaces. They did not understand what genetic relationship existed between it and the Burntside Lake fault, or the Quetico-Wawa belt junction. From our mapping we attempted to establish the boundaries of the shear zone both along its length and width and its possible origin. In addition, we attempted to establish its relationship to the nearby Burntside Lake fault which occurs to the east of the Side Lake shear zone.

Our research area was located southwest of our base camp on the southeast arm of Kahshahpiwi Lake (fig.1). An intense zone of shearing within the Side Lake shear zone was found along the west shore of Kahshahpiwi Lake. Further research confirmed that this zone extended south into the Side Lake area. To determine the westward extent of the Side Lake shear zone we made two transects, one into lake "A" and and a second along the northeast shores of Sarah Lake. We also studied the two lakes east of Side Lake in an effort to determine the nature of the shear zone eastward.

Geologic Setting

Bounded on the north by the Wabigoon subprovince and to the south by the Wawa subprovince, the Quetico subprovince extends for 1200 km. in the Superior Province of the Canadian shield. Percival (1989) describes the Wabigoon subprovince as being composed of at least two granite-greenstone cycles, while the Wawa is made up of mafic to felsic volcanics and gneissic to massive granitoids. Regionally, the Quetico subprovince is a metasedimentary belt consisting of marginal metagreywacke that grades to axial migmatite and granitic plutons.

Four mappable Quetico belt rock units were described in our study area by Woodard (1992). They are from oldest to youngest: (1) Mb- a biotite schist-rich migmatite with less than 50% of granitic leucosome present. Trondhjemite, selectively replaced by K-feldspar, is the chief granitic material; (2) Mg- a granitic-rich migmatite with more than 50% granitic leucosome present. Biotite-rich rafts define fold structures and are oriented within the Mg; (3) Ha- a hornblende quartz monzonite gneiss composed predominantly of microcline phenocrysts in which igneous-type zoning is common, with smaller amounts of interstitial plagioclase, quartz, hornblende, and small amounts of biotite and chlorite; (4) Lg- a leucocratic sugary to pegmatitic granite composed of microcline, plagioclase, quartz, and less than 5% biotite. Lg occurs as late dikes and sills in the sequence and sometimes grades into Mg with increasing biotite content and biotite schist rafts. Burgy and Peck (1992) have most recently described a unit of muscovite-bearing migmatite, Mm, located northwest from Kahshapiwi Lake.

The Burntside Lake fault occurs around the southwest end of the Vermilion Batholith. The steeply dipping fault was described by Woodard and Weaver (1990) and followed a distance of 50 km. from Pipestone Bay to Kahshapiwi Lake, striking between N 30°-N 50 ° E. The fault forms a hydrothermally altered, highly brecciated zone. It was found to be younger than the Quetico and Wawa belts because where the fault crosses the belt junction the rocks within the belts are brecciated and displaced. Kambhu and

Russin (1992) have traced the fault to the northeast of Kahshahpiwi Lake as far as Hurlburt Lake and have found consistent right-lateral movement, strikes varying from N10°-N45°E, and steep dip directions. The relationship of the Side Lake shear zone to the Burntside Lake fault is still not fully understood.

Other local fault zones occur in the Quetico, and one was especially obvious in our research. In the area of Sarah Lake we mapped several fault surfaces striking N60°W and dipping steeply to the northeast. Sanchez and Troolin (1992) also noted the presence of this direction of faulting farther to the north in the areas of Kahshahpiwi and Keefer Lakes. These fault surfaces cut the Side Lake shear zone indicating that they are younger. Sanchez and Troolin also described a fault direction striking N30°W in the northern part of Kahshahpiwi Lake. We found no evidence of this fault to the south.

Geology of the Side Lake shear zone

Methods. The majority of our research was done south of our base camp on Kahshahpiwi Lake. The lakeside outcrops showed fault surfaces of the Side Lake shear zone to advantage, so most measurements were taken from our canoe. Other times it was necessary to do traverses, mapping the outcrops we found along the way. At each station we measured structures on slickensided surfaces and noted lithologies.

Data. We collected data from 83 stations and recorded measurements of 200 fault surfaces and slickenlines. We examined an area roughly 7 km. in length (N-S) and 6 km. in width (E-W). The Side Lake shear zone consists of fault surfaces striking N15°-46°E and dipping 10°-56°NW, averaging N25°E 36°NW (fig.2 a.). Slickenlines in these planes plunge S5°-60°W at 0°-45°, averaging S45°W at 10° (fig.2 b.). Faults that did not have this geometry are considered unrelated to the Side Lake shear zone. Fault surfaces associated with the Side Lake shear zone demonstrate senses of displacement which suggest that the upper block consistently moved down the fault surface to the southwest. This movement was subparallel to strike with plunges of slickenlines ranging from 0° to 45°. Along the well-developed length of the shear zone between Kashahpiwi and Side Lake, the shearing is visible as closely spaced fault planes--on the order of 5 mm in thickness. Westward, the spacing of the shear planes broadens to the order of meters, but individual fault planes are highly developed.

Slickenlines and fault surface orientations along the southwest arm of Kahshahpiwi Lake are typical of the Side Lake shear zone, with fault surfaces striking N17°-46°E and dipping 20°-56° NW. Slickenlines plunge 5°-15° at S30°-55°W. In order to establish a western boundary of the Side Lake shear zone, we portaged into two unnamed lakes, informally designated as lakes "B" and "C", immediately west of Kahshahpiwi Lake. Lg type rocks dominated the area, appearing massive with no rafts. The westernmost evidence of the Side Lake shear zone in lake "C" occurred on the northwest bank to the east of lake "B". Further to the west on lake "B" no evidence of the shear zone was found. However, later research showed that Side Lake shear zone structures were present in lake "A" which lies to the west of lake "B". Fault surfaces in outcrops on lake "A" are sparse but well developed where they occur. At one station on the far west side of the same lake the fault surfaces differed, appearing closely spaced but not well developed.

To the south of Kahshahpiwi Lake, we mapped the rocks around the unnamed lake that lies directly north of Side Lake, hereafter referred to as lake "D". Outcrops of Mg contained faults with Side Lake shear zone orientations, with fault surfaces striking N10°-56°E and dipping 17°-44°NW, and slickenline lineations bearing S35°-53°W and plunging 3°-23°. Further south in Side Lake we found abundant evidence of Side Lake shear zone structures in Mg terranes. The rocks are marked by large quartz veins and pegmatites void of muscovite. Working east from Side Lake, we mapped the outcrops in the area of lake "E". The rocks on the west shore of southern lake "E" are sheared to near mylonitization (cleavage spaced about 2 mm). The east shore is a mylonite, but insufficient study was made to determine the origin of the deformation. The lake lying directly to the south, lake "F", did not display any mylonization, but fault planes of the Side Lake shear zone were found to be spaced closely together.

Another area of observation was along the northeast shore of southern Sarah Lake. It was here that we found the westernmost evidence of the Side Lake shear zone. Fault surfaces were very broadly spaced, but well developed. We also found a local fault trending N65°W. According to Woodard (1992: unpublished data) faults of this same orientation reoccur further north in Kahshahpiwi Lake and cut the Burntside Lake Fault. Thus, the faults are younger than the Burntside Lake fault. Root (1992: unplublished data) states that these faults also cut the Side Lake shear zone. Deviations from the typical geometry of Side Lake shear zone occur to the west of the central zone of shearing. The areas of western Sarah Lake and of lake "A" show fault surfaces that dip greater than 60°. These are steeper than those found to the east. In whole, the shear zone demonstrates a width of approximately 6 km in our area of study, with most intensive shearing occurring in an area of one km in width along the west shore of Kahshahpiwi Lake, lake "D", and Side Lake.

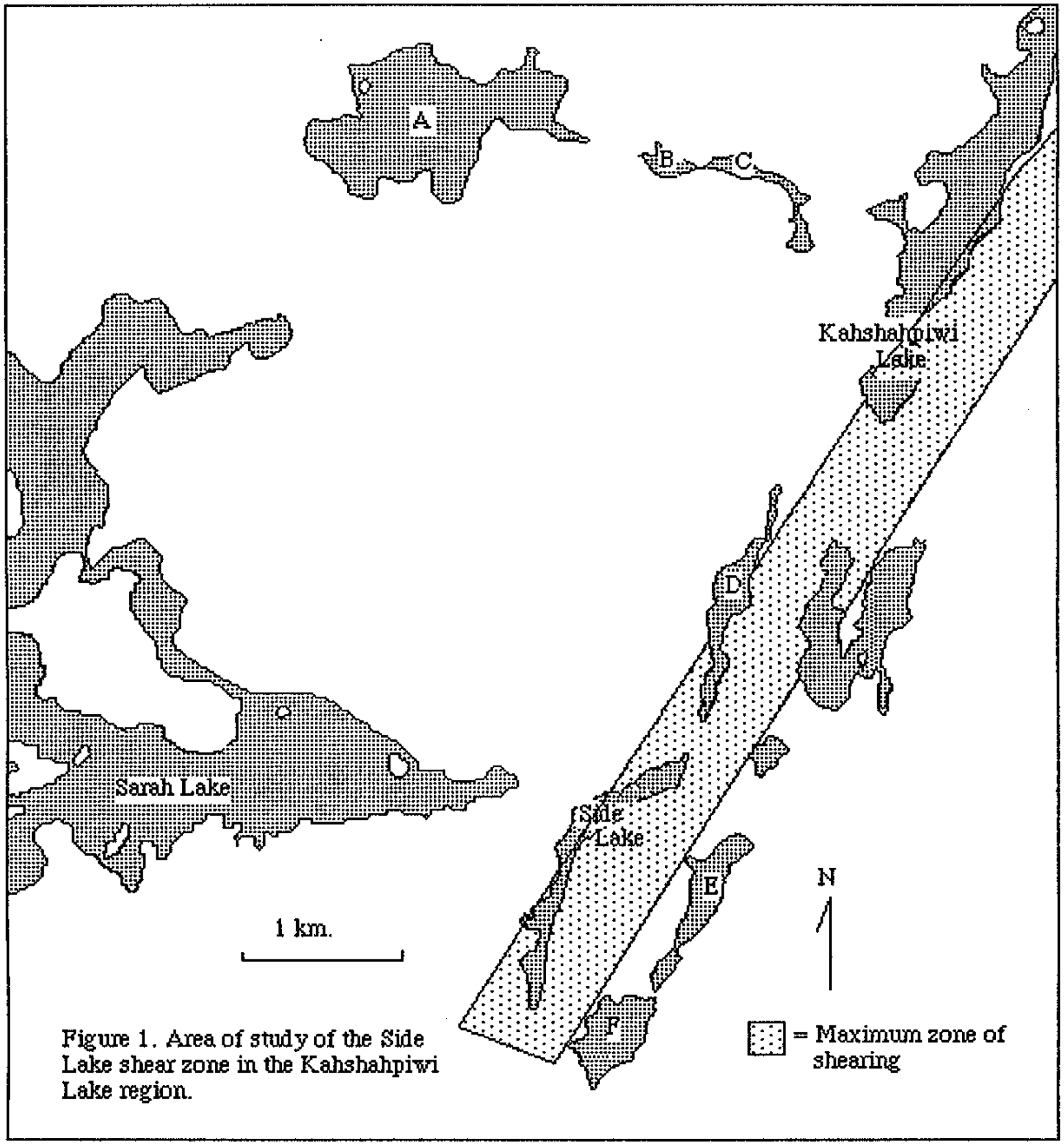

Figure 1. Area of study of the Side Lake shear zone in the Kahshahpiwi Lake region.

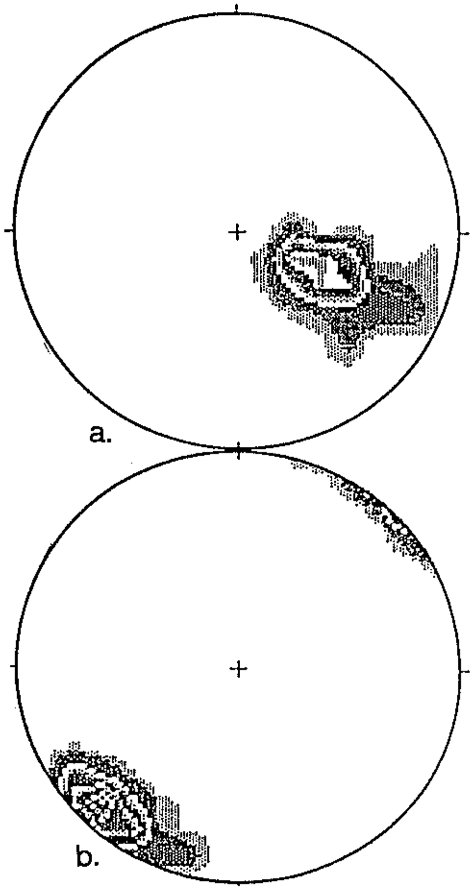

Figure 2. Equal area net plot of Side Lake shear zone data: a.) contour map of poles to fault planes, b.) contour map of slickenlines measured on fault surfaces (C.I.= 2.0%/1.0% area).

Interpretations and Conclusions

It is difficult to classify the Side Lake shear zone, much less interpret its origins. It cannot be described by conventional terms as a normal fault, strike-slip fault, or thrust fault. The Side Lake shear zone demonstrates the geometry of a normal fault with its hanging wall moving downward, but it also displays sub-horizontal displacement on low angle faults. It can be described as a narrow zone of faulting diminishing to the east and west, with mylonites occurring in the most intense areas of shearing. Unfortunately, it is uncertain where the limits of these mylonitic rocks are found.

Two basic models can be applied to try and explain the origin of the zone, and at this point both are equally feasible. The first assumes that the faulting originally occurred in its present orientation. If this is the case and the fault is unrotated, it is difficult to explain the presence of mylonites in the most intensely sheared areas of the zone. These areas are the east shore of lake "E" in our study area, and, as reported by Sanchez and Troolin (1992), the west shore of Keefer Lake to the north. Some intense compressional event must have occurred for these ductile mylonites to have formed. One possible explanation is offered by Root (1992: personal communication). He asserts that a possible metamorphic core complex model could explain the structure. Comparable fault structures to those seen in the Side Lake shear zone occur in the southwestern United States, especially California, and these are interpreted by this model. Detachment faults, normal faults that are gently dipping or sub horizontal, have recently been recognized as features associated with regional extension. Assuming that parallels can be drawn between these two similar structures, one could speculate that the area was one of regional extension at the time of development of the Side Lake shear zone. In detachment faults, the gently dipping fault projects downward across the brittle-ductile transition zone. Movement along the ductile region of the fault produces mylonites (Pridmore and Frost, 1992). This would appear to explain the Side Lake shear zone, and the zone of mylonization that grades outward into more brittle faulting. What must be established for this to be tenable is the presence of metamorphic core complexes in the area. The second model might assume that the fault has been rotated from a steeper thrust position into its current position, perhaps by folding. Supporting this model of thrusting is the presence of the mylonites in some areas, which suggest a compressional event.

In order to resolve these ambiguities, more research is needed. We were unsuccessful in establishing the age relationship between the Side Lake shear zone and the Burntside Lake fault, although one might argue that the Burntside fault, being more brittle in character, is younger. It is necessary that the zones of mylonitization be traced further north and south along the intensive zone of shearing. The Side Lake shear zone itself needs to be traced farther to the north, as Sanchez and Troolin (1992) found strong expression of the shear zone in Keefer Lake and no northern boundary. In the south, the zone appears to dissipate as it approaches the Burntside Lake fault, but this needs to be confirmed. Finally, the possibility of folding and rotation could be resolved by tracing the shear zone farther north and east.

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