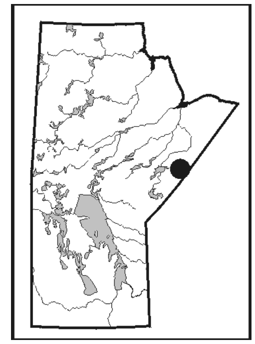
GS-23 A PRELIMINARY STRUCTURAL ANALYSIS OF THE EDMUND LAKE - LITTLE STULL LAKE AREA, NORTHWESTERN SUPERIOR PROVINCE, MANITOBA (PART OF NTS 63K/10, 11 AND 7)

by D. Jiang[1] and M.T. Corkery



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SUMMARY

The Edmund Lake and Little Stull Lake map areas in the Stull Lake greenstone belt are transected by the "Wolf Bay" shear zone, dividing the area into two domains. The domain south of the shear zone consists of pillowed basalt and related gabbro of MORB affinity considered to belong to the Hayes River Group. North of the shear zone, and at the bottom part of the supracrustal sequence, similar mafic rocks are exposed. Tectonically above the mafic complex diverse volcanic and volcanogenic sedimentary rocks of possible arc affinity are exposed. Preliminary structural analysis reveals four generations of deformation. D_1 is only recognized in the mafic complex and is possibly low angle ductile shear zone deformation, and $D_{2\text{-}4}$ affect all rock units. The map pattern in the Little Stull Lake area is controlled mainly by D_2 structures modified by D_3. The "Wolf Bay" shear zone formed during D_3 dextral transpression, and small scale shear zones kinematically similar to the "Wolf Bay" shear zone are commonly observed in the area. D_4 structures are interpreted to result from north side up thrusting.

INTRODUCTION

A multi-disciplinary study of the Edmund Lake - Little Stull Lake area has been carried out since 1996 (Corkery 1996a, Corkery, et al., 1997b) following earlier work (Downie, 1937; Satterley, 1937; Corkery, 1981). It is one of Manitoba's Northern Superior projects and is a contribution to the Western Superior NATMAP Project, aimed at characterizing the volcanic, structural and tectonic evolution of greenstone belts of the Western Superior Province in particular and advancing our understanding of greenstone belts in general. Previous mapping in the Edmund Lake - Little Stull Lake area (Corkery, 1996b; Corkery, et al., 1997a) identified a regional high-strain zone, the "Wolf Bay" shear zone, that contains several gold occurrences within and near the zone on Little Stull Lake. The structural geometry of the supracrustal belts in the area, the role this geometry plays in controlling the map pattern, and its possible genetic relationship with the "Wolf Bay" shear zone have been poorly understood. Such information is, however, of critical importance in understanding the geological history of the area including better constraints on the structural setting for gold mineralization. In the summer of 1998 a structural analysis of the area was conducted and some preliminary results of this work are presented below.

LITHOTECTONIC UNITS

The Edmund Lake - Little Stull Lake map area is situated in the Stull Lake greenstone belt, that extends from Ontario northwestward through the Rorke Lake and Little Stull Lake area to the Edmund Lake (Fig. GS-23-1). The belt is on strike with the Gods Lake greenstone belt to the west (Corkery, 1996a). A regional shear zone, the "Wolf Bay" shear zone, trending approximately 120º, divides the area into two domains. Supracrustal rocks in the southern domain consist mainly of basalt of MORB affinity (Corkery and Skulski, GS 22 this volume) and associated gabbro, considered to belong to the Hayes River Group (Corkery, et al., 1997b and references therein). These rocks are ca. 2830 Ma at Knee Lake (D. Davis, 1986 cited in Syme et al., 1997). Supracrustal rocks in the domain north of the shear zone are diverse and can be divided into four lithotectonic units.

Oxford Lake Group (Little Stull Lake Arkosic sedimentary rocks and Rorke Lake assemblage)

Little Stull Lake fluvial - alluvial sequence (ca. 2709 Ma)

The Little Stull Lake arkosic sedimentary rocks (Corkery, et al., 1997) are exposed at the east end of the Little Stull Lake (Fig. GS-23-2), and are composed of fluvial-alluvial sandstone and conglomerate. The sequence is folded in an isoclinal anticline with arkosic sandstone at the core and conglomerate on the limbs.

Minnow Bay volcanic sequence (ca. 2717 Ma)

These units form the northern part of "the Rorke Lake assemblage" in panel 3 of Corkery, et al. (1997b). They consist of feldspar phyric intermediate to felsic tuff and breccia and derived volcanogenic sedimentary rocks. The unit is interpreted to be folded in an isoclinal anticline, bounded to the north by highly deformed basalt and to the south by a fault contact with the Lodge Bay - Sickle Bay sequence (Fig. GS-23-2).

Sickle Bay - Lodge Bay sequence (ca. 2728 Ma)

These units form the southern part of "the Rorke Lake assemblage" in panel 3 of Corkery, et al. (1997b). The youngest unit of this sequence is exposed at Lodge Bay (Fig. GS-23-2) where it comprises intermediate to felsic tuff and lapilli tuff (Corkery, et al., 1997b). The middle part of the sequence, exposed at Sickle Bay, comprises brown to light brown weathering greywacke to feldspathic greywacke. The lower part of the sequence is composed of mafic to intermediate volcaniclastic rocks called "the Isthmus volcanic sequence" (Corkery et al., 1997).

Raspon Bay mafic complex (basalts and gabbros, Hayes River group ca. 2830 Ma)

Supracrustal rocks exposed south of the "Wolf Bay" shear zone consist of deformed and metamorphosed basalt of MORB affinity (Corkery and Skulski, GS-22 this volume) and associated gabbro that can be traced from Raspon Bay in Ontario westward through Little Stull Lake to Edmund Lake (Stone and Pufahl, 1995; Stone and Halle, 1997; Corkery, et al., 1997b). In the Little Stull Lake area, the basalt includes pillowed and massive aphyric flows. Up to 50% of the complex consists of medium grained gabbro. On the shoreline of Ken Bay in Little Stull Lake, the gabbro exhibits various degrees of deformation, from massive and equigranular, through layers composed of weakly deformed gabbro alternating with strongly deformed gabbros, to completely mylonitized gabbro. In the domain north of the "Wolf Bay" shear zone, similar mafic assemblages are widely exposed in Wolf Bay, Margaret Lake, and at Little Stull Lake, Kistigan Lake and Rorke Lake.

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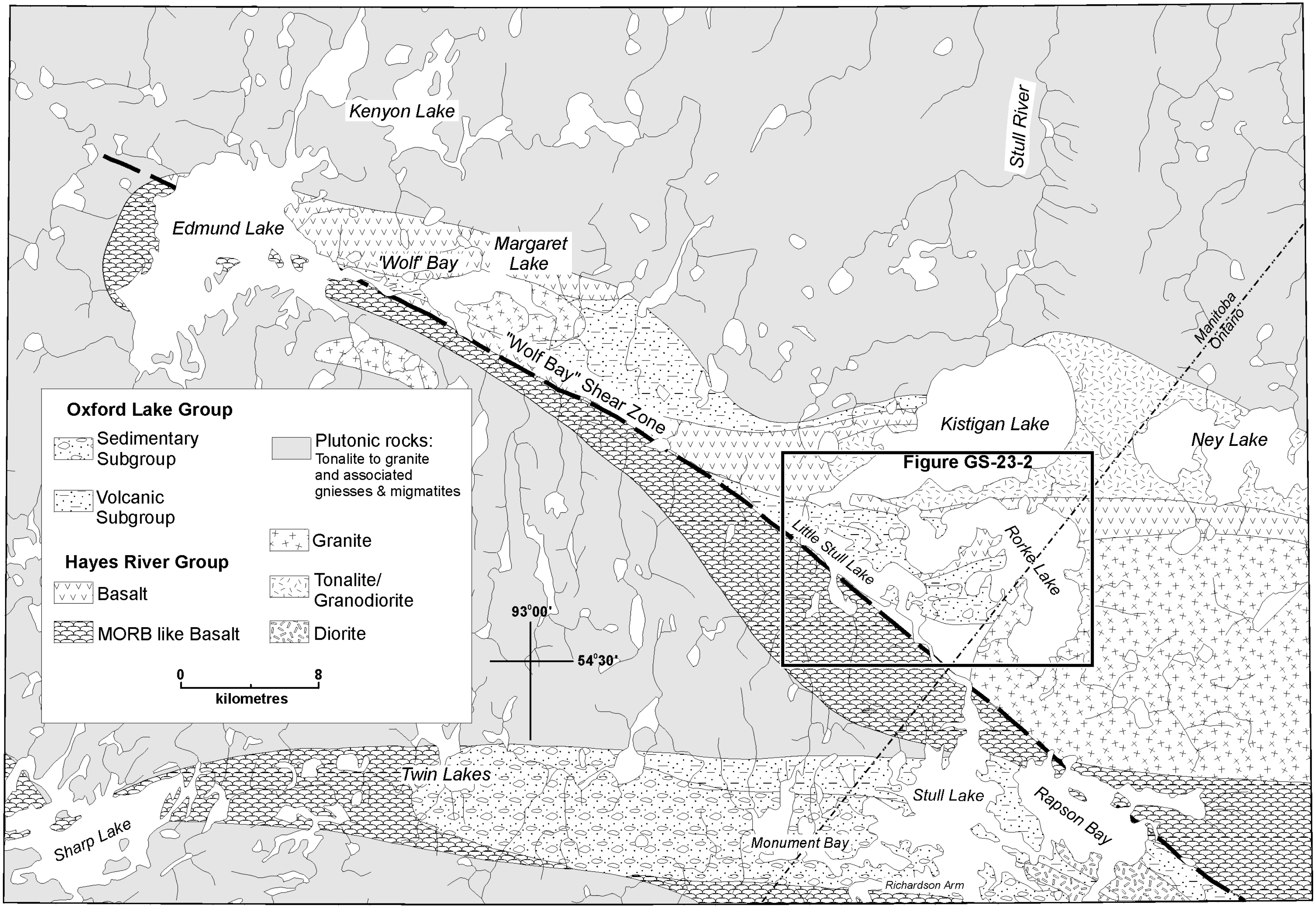

Figure GS-23-1: Regional geologic setting and major subdivisions in the Edmund- Margaret- Stull lakes region.

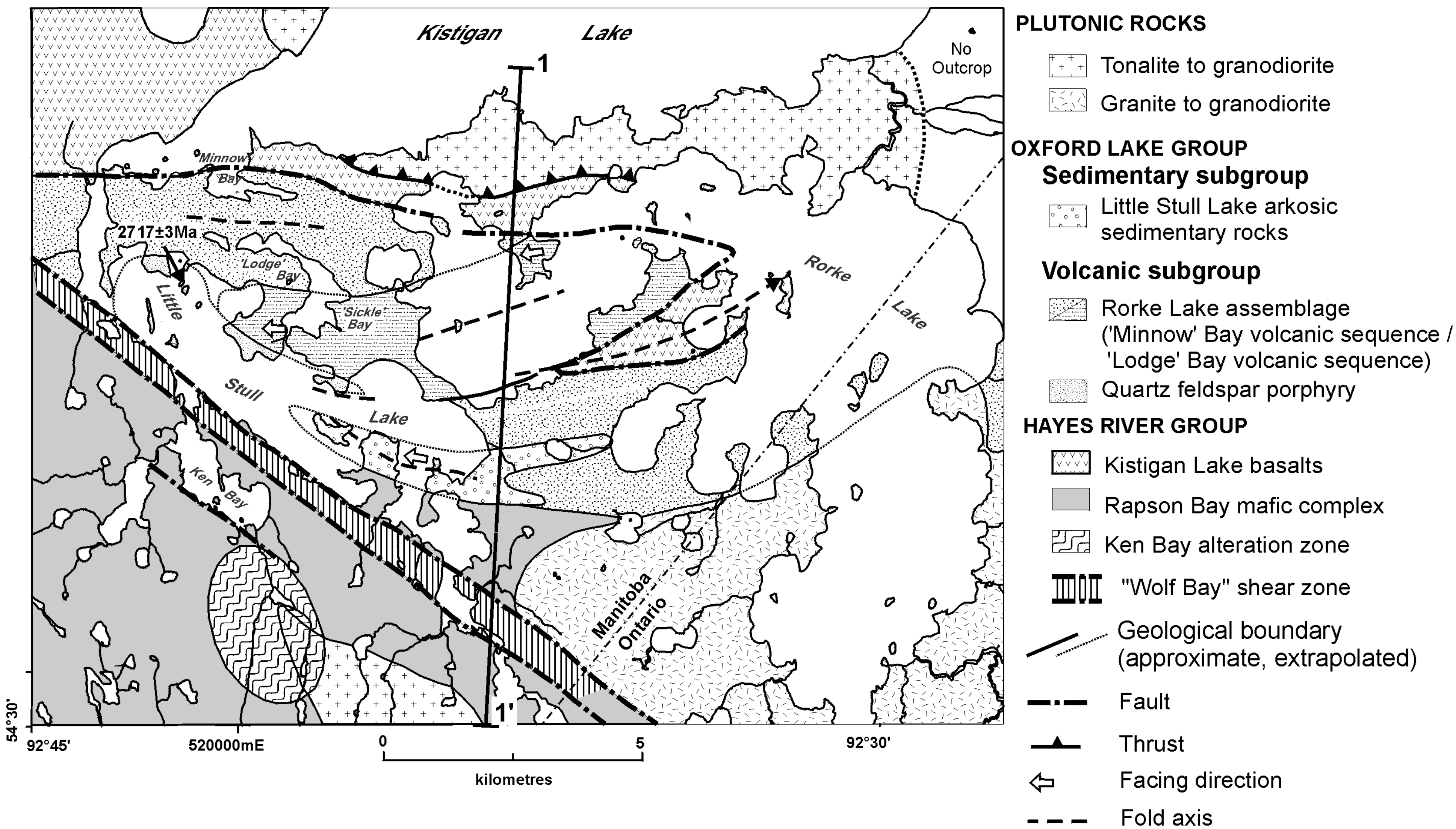

Figure GS-23-2: General geology of the Little Stull, Rorke, Kistigan Lakes area.

STRUCTURE

Four generations of deformation are recognized.

D_1: Possible low-angle ductile shear zones

The earliest deformation event, best observed along the west shoreline of Edmund Lake, produced a shallowly-dipping foliation (S_1) and shallowly-plunging stretching lineation (L_1) (Fig. GS-23-3 and 4). S_1 is defined by a shape fabric in deformed gabbro and a compositional layering of mylonitized gabbro and basalt; L_1 is defined by alignment of plagioclase on the S_1 foliation surface (Fig. GS-23-3). The S_1-parallel compositional layering of alternating gabbro layers and basalt layers along the west shoreline of Edmund Lake is tectonic in origin and represents the C- foliation in ductile shear zones, not the original gabbro sills. S_1 is overprinted regionally by isoclinal D_2 folding, dextral transpressional D_3 shear and possibly north side up D_4 overthrusting.

The dominant foliation in the mafic complex outside the "Wolf Bay" shear zone is interpreted to be S_1. It is overprinted by F_2 with a well developed S_2 foliation. In areas strongly affected by subsequent deformations, it is very difficult to identify the L_1 lineations.

D_1 deformation occurred in a ductile shear zone environment, but it is difficult to evaluate the initial orientation and sense of shear of D_1 shear zones. This deformation is likely to have been dominated by low angle shear zones leading to regional tectonic transposition in the basalt-gabbro sequence near the contact between the granitoid and the supracrustal sequence. D_1 deformation is only recognized in the mafic complex.

D_2: Regional isoclinal folding

This generation of deformation is characterized by regional isoclinal folding. Map-scale F_2 folds, well developed in the Little Stull Lake area (Fig. GS-23-2), have gentle plunges and include: an anticline in the Little Stull Lake fluvial - alluvial sequence, an anticline in the Minnow Bay sequence and a syncline and anticline in the Sickle Bay - Lodge Bay sequence (Fig. GS 23-2).

The anticline in the Sickle Bay - Lodge Bay sequence, recognized during this investigation, is cored by Rapson Bay mafic complex of the Hayes River Group. The isoclinal nature of the fold has caused the mafic complex in the core of the fold to be so strongly deformed that it was previously interpreted as a ductile shear zone (Corkery, et al., 1997a, 1997b). However, a clear S_1/S_2 overprinting relationship occurs along the shoreline of Rorke Lake northeast of the portage to Little Stull Lake, where S_2 is a crenulation cleavage. Locally S_1/S_2 may resemble an S/C relationship, but unlike an S/C relationship in a ductile shear zone, the sense of shear that S_1/S_2 reflects varies spatially from one limb of the fold to the other.

Possibly the best example of overprinting of S_2 on S_1 and outcrop scale F_2 folds occurs on a burnt island near the southwest shoreline of Margaret Lake (Fig. GS-23-5). There, S_1 (defined by compositional layering) is folded by F_2 with an axial plane cleavage S_2 (a differentiated crenulation cleavage; Fig. GS-23-5).

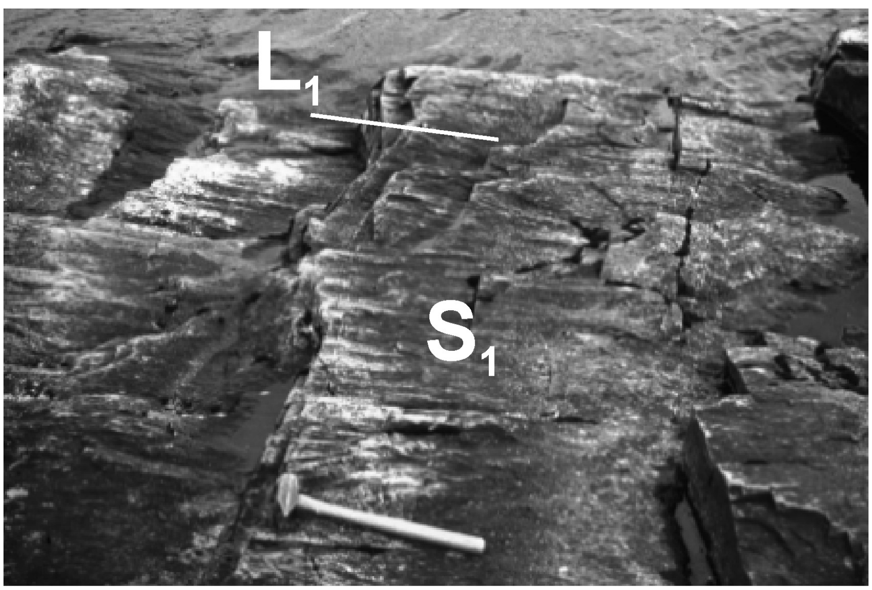

Figure GS-23-3: Shallowly-dipping S_1 foliation and stretching lineation (L_1) commonly observed along the western shoreline of Edmund Lake. They suggest that D_1 might have been low-angle shear zone deformation.

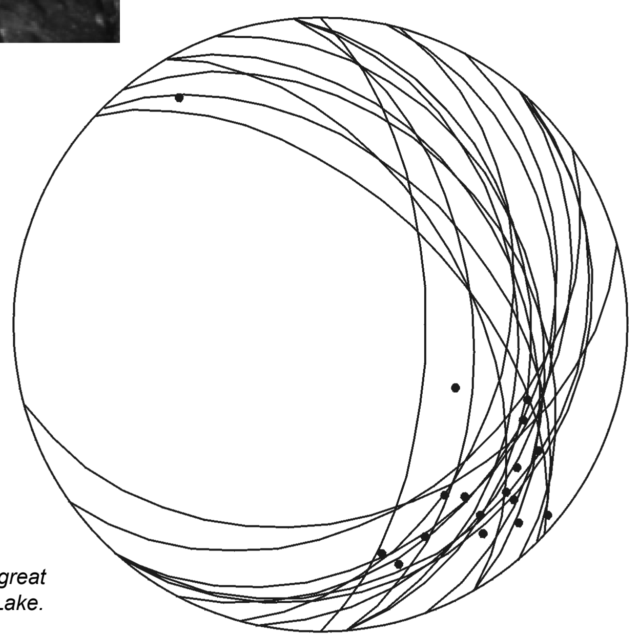

Figure GS-23-4: Lower hemisphere stenographic projections of S_1 (great girdles) and L_1 (dots) measured along the western shoreline of Edmund Lake.

Outcrop scale parasitic F_2 folds are not found in units other than the mafic complex. There are two possible explanations for this observation. One is that S_1 was not well developed in those units (i.e., D_1 shear zones were sporadically developed in these units or not developed at all), which would materially not favour development of small scale folds. The other is that the lack of markers in those units combined with limited outcrop make it difficult to identify F_2 folds in them.

The map pattern in the Little Stull Lake area is primarily controlled by F_2 folds. Fig. GS-23-6 is a schematic cross section showing the overall structure.

D_3: Dextral transpression

D_3 deformation is most likely a continuation of D_2, with an evolution in the kinematic framework from compression-dominated folding to more non-coaxial dextral transpression. The regional "Wolf Bay" shear zone formed during D_3. Smaller scale shear zones kinematically similar to the "Wolf Bay" shear zone are widely developed in the mafic complex south of the "Wolf Bay" shear zone in the Edmund Lake area (Fig. GS-23-7). The "Wolf Bay" shear zone and small scale shear zones typically strike 110~130º with well developed S/C fabrics and other kinematic indicators, that collectively suggest a dextral sense

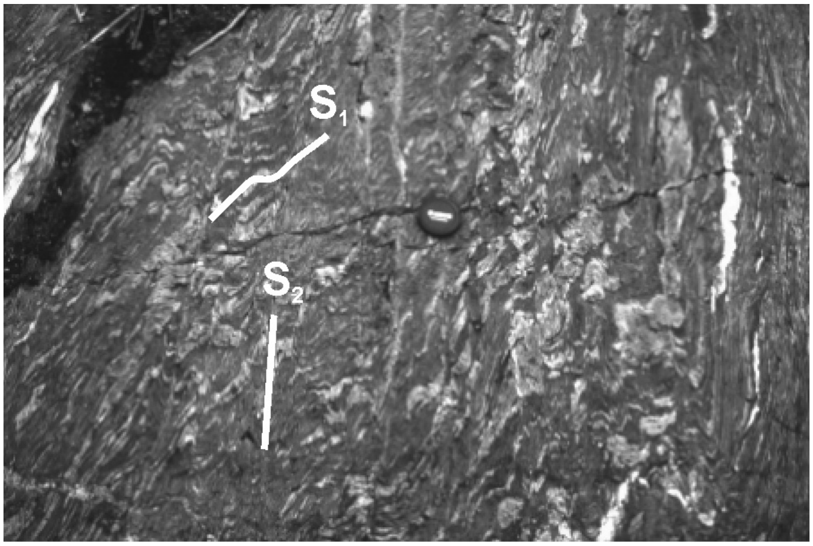

Figure GS-23-5: Overprinting of S_2 on S_1. S_2 is a differentiated crenulation cleavage. (Margaret Lake; scale - 6 cm diameter lens cap).

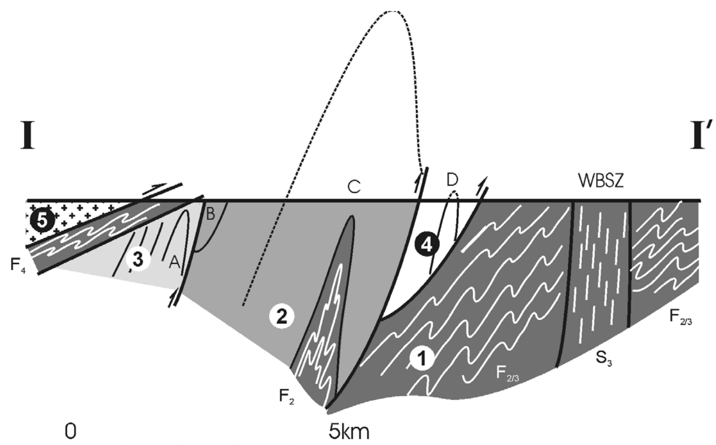

Figure GS-23-6: Cross section of the Little Stull Lake area showing the overall structural geometry. 1: Rapson Bay mafic complex; 2: Sickle Bay - Lodge Bay sequence; 3: Minnow Bay volcanic sequence; 4: Little Stull Lake fluvial - alluvial sequence; 5: granite. WBSZ = "Wolf Bay" shear zone. A: anticline in the Minnow Bay sequence; B and C: syncline and anticline in the Sickle Bay - Lodge Bay sequence; D: anticline in the fluvial- alluvial sequence. See text for detail.

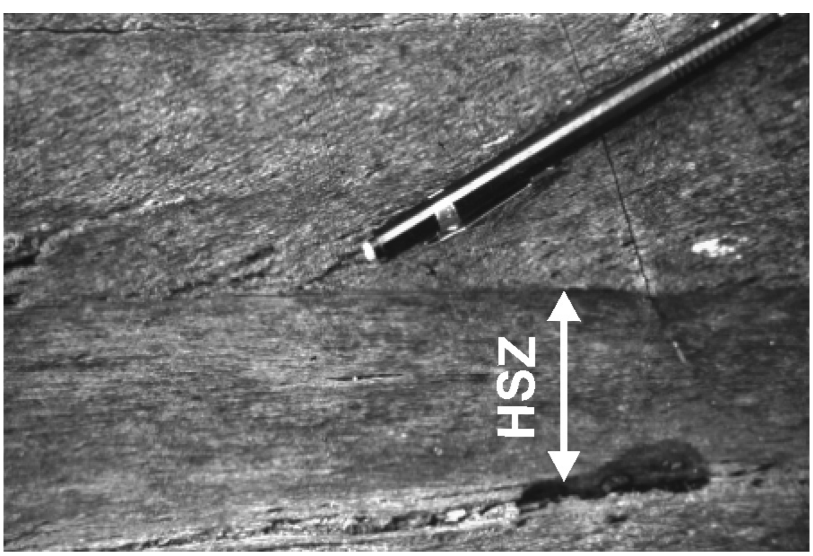

Figure GS-23-7: An outcrop scale D3 shear zone parallel to and have the same kinematics as the "Wolf Bay" shear zone in the mafic complex south of the "Wolf Bay" shear zone in Edmund Lake area. The pencil is parallel to the shape fabric. HSZ = high-strain zone.

of shear (Fig. GS 23-8 and 9). Outside the shear zones, the rocks exhibit a variable degree of strain, and primary features such as pillow structures in basalt are preserved. The S/C relationship is observed on different scales from hand sample to a whole outcrop where flattened pillows define the shape foliation and cm-wide high-strain zones define the C-foliation. Lineations in the "Wolf Bay" shear zone are subhorizontal (Fig. GS-23-9), as are lineations in most outcrop scale shear zones parallel to the Wolf Bay shear zone. Lineations in less deformed wall rocks are steeper and more variable and thus suggest deformation path partitioning during transpression (Lin, et al., 1998; Jiang and Williams, 1998).

D_3 deformation is responsible for the curvature of the D_2 structural trend toward parallelism with the "Wolf Bay" shear zone near the zone boundaries (Fig. GS-23-2).

D_4: North side up thrusting

This deformation is recognized in the Minnow Bay area, where outcrop scale S-folds are well developed (Fig. GS-23-10), and along the south shoreline of Little Stull Lake within the "Wolf Bay" shear zone where the mylonitic foliation (S_3) is folded. F_4 folds in the "Wolf Bay" shear zone, that lack an axial plane cleavage, plunge gently to the northwest, and have Z-asymmetry. Their geometry is inconsistent with D_3 dextral sub-transcurrent transpression. This eliminates the possibility that they are due to progressive D_3 deformation. Similarly, the S-folds at Minnow Bay do not have an axial plane cleavage. Their S-asymmetry shows that they cannot be attributed to either parasitic F_2 fold or D_3 drag folds. Kinematically, F_4 S-folds in the Minnow Bay area and F_4 Z-folds in the "Wolf Bay" shear zone form conjugate pairs, indicating north-south shortening.

In the Minnow Bay area, a shallowly north- dipping ductile shear zone is recognized, within which mylonitic foliation (S_4) is shallowly north-dipping and a stretching lineation (L_4) plunges to the north on the foliation plane. This shear zone separates granite from the mafic complex and thus suggests north side up thrusting (Fig. GS-23-2 and 6). Therefore we suggest that D_4 deformation is dominantly north-south compression.

CONCLUDING REMARKS

Preliminary structural analysis of the Edmund Lake - Little Stull Lake area suggests that the supracrustal rocks of the area underwent four generations of deformation. D_1 is probably represented by low-angle ductile shear zones in the Hayes River Group, near the contact of the greenstone belt with the granitoid terrane. Isoclinal folds, formed during D_2, control the map pattern. D_3 dextral transpression is most likely a continuation of D_2 with an evolution in kinematic framework from compression-dominated folding to more non-coaxial transpression. D_3 modifies D_2 structures and gives rise to an overall Z asymmetry of the map pattern of the Little Stull Lake area. D_4 structures, recognized only in Minnow Bay and along the south shoreline of Little Stull Lake area, arose from possible north side up thrusting of the granite onto the supracrustal rocks, leading to north-south compression of the area.

ACKNOWLEDGMENTS

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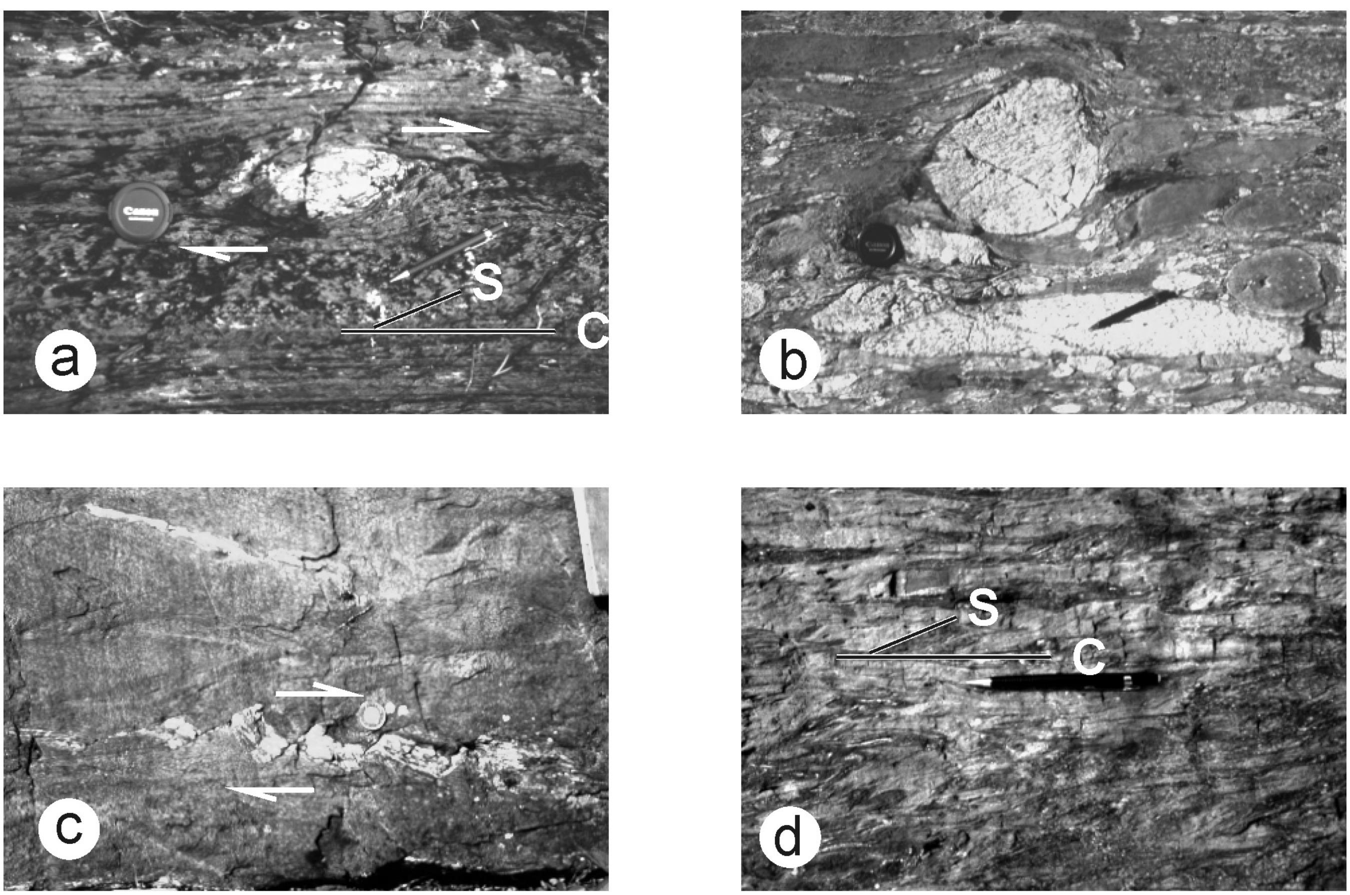

Figure GS-23-8: Various kinematic indicators observed within or near the "Wolf Bay" shear zone, all consistently indicating dextral sense of shear. a: F-type porphyroclast and S/C fabric (Wolf Bay); b: deformed pebble with internal oblique shape fabric (parallel to pencil, Little Stull Lake); c: clockwise rotated boudins (Margaret Lake); d: S/C fabric in strongly deformed basalt. Flattened pillow selvages are recognizable and are aligned parallel to the C-foliation (Margaret Lake).

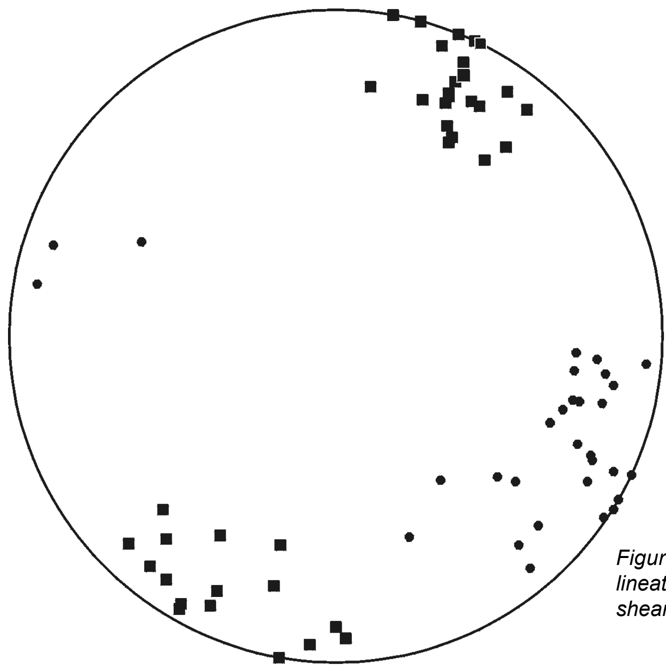

Figure GS-23-9: Lower hemisphere stereographic projections of stretching lineation (solid circles) and poles to foliation (solid squares) from the "Wolf Bay" shear zone.

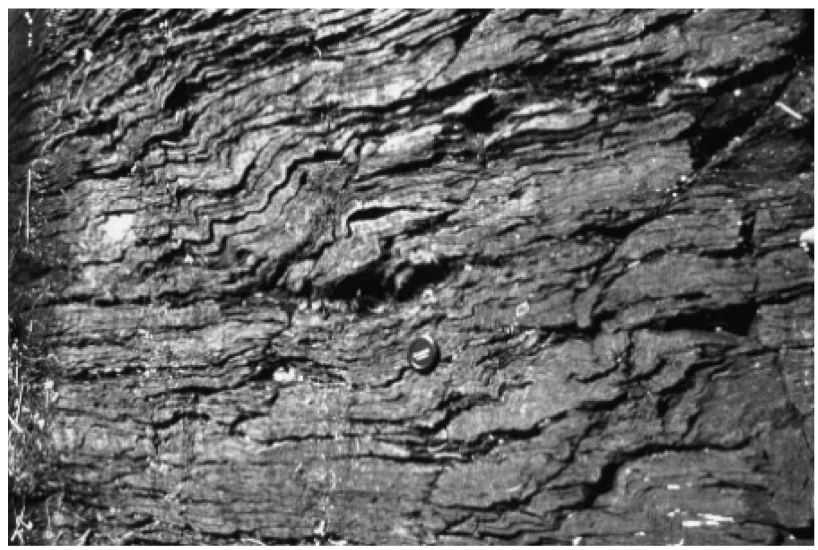

Figure GS-23-10: F_4 S fold at the Minnow Bay.

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