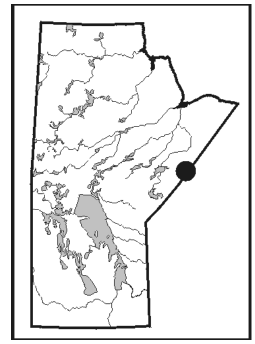
GEOLOGY OF THE LITTLE STULL LAKE AREA (PART OF NTS 63K/10 AND 7)



by M.T. Corkery and T. Skulski[1]

Corkery, M.T. and Skulski, T. 1998: Geology of the Little Stull Lake area (part of NTS 63K/10 and 7); **in** Manitoba Energy and Mines, Geological Services, Report of Activities, 1998, p. 111-118.

SUMMARY

The results of new mapping and geochemical and geochronological investigations based on mapping and sampling in 1997 are reported here. Information reported includes: 1) the description of a broad south-southeast-trending alteration zone that cuts Hayes River Group basalt and gabbro rocks to the southeast of the gold occurrences on Little Stull Lake, 2) report of geochronological results for the aphyric felsic volcanic sequence of the Oxford Lake Group - volcanic subgroup, and 3) discussion of geochemical results from analyses from Hayes River Group and Oxford Lake Group rocks.

INTRODUCTION

This report is a brief update on a project in progress (Corkery, et al. 1997b; Preliminary Map 1997S-1). This year a joint Ontario Geological Survey (OGS) - Manitoba Geological Services Branch field program, based in Little Stull Lake, expanded the mapping in Manitoba to the southern margin of the Stull Lake greenstone belt. The previous preliminary map has been updated and is re-released this year (Corkery, 1998; Preliminary Map 1998S-2). A 1:50 000 scale map is planned for simultaneous release with the OGS in January 1999.

Reissue of the Little Stull Lake Preliminary map (1998 S-2) is important because of the newly documented large alteration zone in the Hayes River Group basalt south of Ken Bay and the distribution of anomalous values for numerous elements in this area, reported in the multimedia survey by Fedikow and Nielsen (1998).

The Little Stull Lake map area represents a moderately well exposed extension of the northern segment of the Stull Lake greenstone belt in Ontario. The belt extends from Ontario through the Rorke - Little Stull lakes area, northwest to the Edmund Lake area (Fig. GS-22-1). It is on strike with the Gods Lake greenstone belt to the west.

Previous mapping in the region at 1:250 000 coverage is out-of-date, (Downie, 1936).

REGIONAL SETTING

Supracrustal rocks in the Little Stull Lake area were originally subdivided into Hayes River group (HRG) and Oxford group. This original subdivision was based on the distinction between a predominantly volcanic sequence of rocks (HRG) that range from basaltic through rhyolitic compositions with minor intercalated sedimentary rocks, and a younger, unconformably overlying sequence dominated by sedimentary rocks and marked at the base by polymictic conglomerate, the Oxford group. In the 1970's a major mapping program in the greenstone belts to the west, in the Gods, Knee, Oxford lakes area reevaluated the supracrustal sequences. Hubregtse (1985), redefined the Oxford group, and separated it into a lower metavolcanic and volcaniclastic subgroup and an overlying metasedimentary subgroup. These subgroups were then included in the new Oxford Lake Group (OLG).

In reporting on the Little Stull Lake area Corkery et al. (1997b) provided a table that placed local names for supracrustal sequences into the existing regional framework and indicated that the old stratigraphic nomenclature was no longer adequate. The HRG and OLG nomenclature has been retained for this report.

SUPRACRUSTAL ROCKS

The belt was subdivided into four panels (Corkery et al., 1997b) of distinct supracrustal sequences with contacts defined by deformation zones (Fig. GS-22-2). From south to north the panels are: panel 1) basalt and associated gabbro intrusions; panel 2) subareal sandstone and conglomerate; panel 3) a diverse series of intermediate to felsic volcanic tuff and breccia, and associated volcaniclastic rocks, and epiclastic sedimentary rocks all deposited in a marine setting; and panel 4) basalt, minor sedimentary rock, and iron formation.

Panels 1 and 4 are dominated by mafic volcanic flows and synvolcanic intrusives interpreted to belong to the Hayes River Group. Panel 2 consists of subareal sedimentary rocks equivalent to the sedimentary subgroup of the Oxford Lake Group. Panel 3 has been interpreted as belonging to the volcanic subgroup of the Oxford Lake Group.

Hayes River Group

Rapson Bay mafic complex

To the south of the "Wolf Bay" shear zone in panel 1 (Fig. GS-22-1), a northeast- trending sequence of variably, but generally highly, strained basalt and gabbro form the southern element of the supracrustal belt (panel 1). This package can be traced directly from Rapson Bay on northern Stull Lake (in Ontario), through Little Stull Lake, and west to Edmund Lake. The thickest and best preserved portions of this sequence occur in the Rapson Bay area (Stone and Pufahl, 1995) where they are described as north facing, pillowed mafic volcanic flows and minor sandstone. In the Little Stull Lake area, the basalt typically includes aphyric pillowed and massive flows. The sequence is characterized by up to 50% gabbroic sills of variable thickness.

Kistigan Lake Basalt

In panel 4 the Kistigan Lake basalt arc eastward from the south shore of Kistigan Lake into north central Rorke Lake (Fig. GS-22-2). The sequence is dominated by pillowed and massive basalt flows and associated gabbro intrusions that is similar to the Rapson Bay mafic complex. Oxide facies iron formation is sporadically interbedded with the basalt. Panel 4 is flanked on the south by a deformation zone and on the north is intruded by the Kistigan tonalite.

Geochemistry

Volcanic rocks of the Hayes River Group are dominated by tholeiitic basalt showing pronounced enrichment in Fe (Fig. GS-22-3) and Ti. Trace element profiles normalized to primitive mantle reveal three groups of Hayes River Group basalt that likely reflect chemical differences in their respective source regions (Fig. GS-22-4a). Two samples of basalt from northern Stull Lake (Rapson Bay mafic complex) and Rorke Lake are enriched in light rare earth elements (LREE) and have relative enrichment of La>Th>Nb and Ta (Fig. GS-22-4a). Hayes River Group basalt in the Kistigan and Rorke lakes area include basalt with flat heavy rare earth element (HREE) and middle rare earth profiles, that are depleted in primitive mantle normalized Nb and Ta relative to Th and La (Fig. GS-22-4b). In contrast, Hayes River Group basalt in the Stull Lake area and two basalts from the Rorke Lake area in the north (Fig. GS-22-2), have LREE and large ion lithophile (LIL) depleted trace element profiles with relatively flat abundances of HREE and Y (Fig. GS-22-4c).

The LREE, LIL depleted geochemical type includes a high-Mg basalt (11.3 % MgO, 650 ppm Cr and 300 ppm Ni) from southern Stull Lake (Richardson Arm) that has low overall abundances of incompatible trace elements. A liquid of this composition is too Fe-rich (in equilibrium with Fo_{87} olivine assuming $XFe^{3+}=0$ and $(Fe/Mg)_{OL}/(Fe/Mg)_{liq}=0.3$ (Roeder and Emslie,1970)) to have been derived by melting of a model pyrolite mantle (i.e., containing Fo_{89} olivine). Liquids of this composition could have been related to primary mantle-derived melts by small amounts of olivine fractionation. The trace element geochemistry of the

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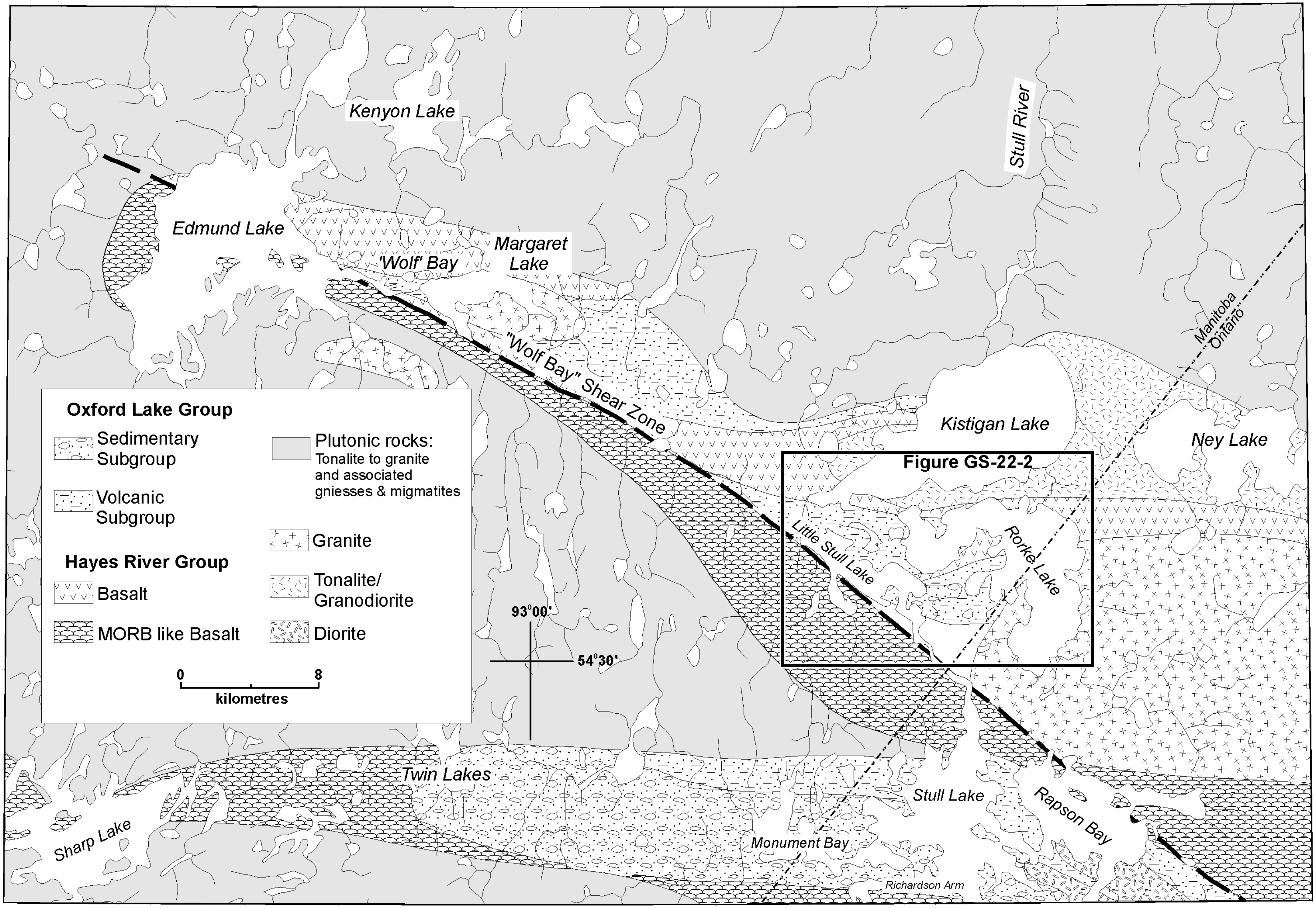

Figure GS-22-1: Regional geologic setting and major subdivisions in the Stull-Edmund- Margaret lakes region.

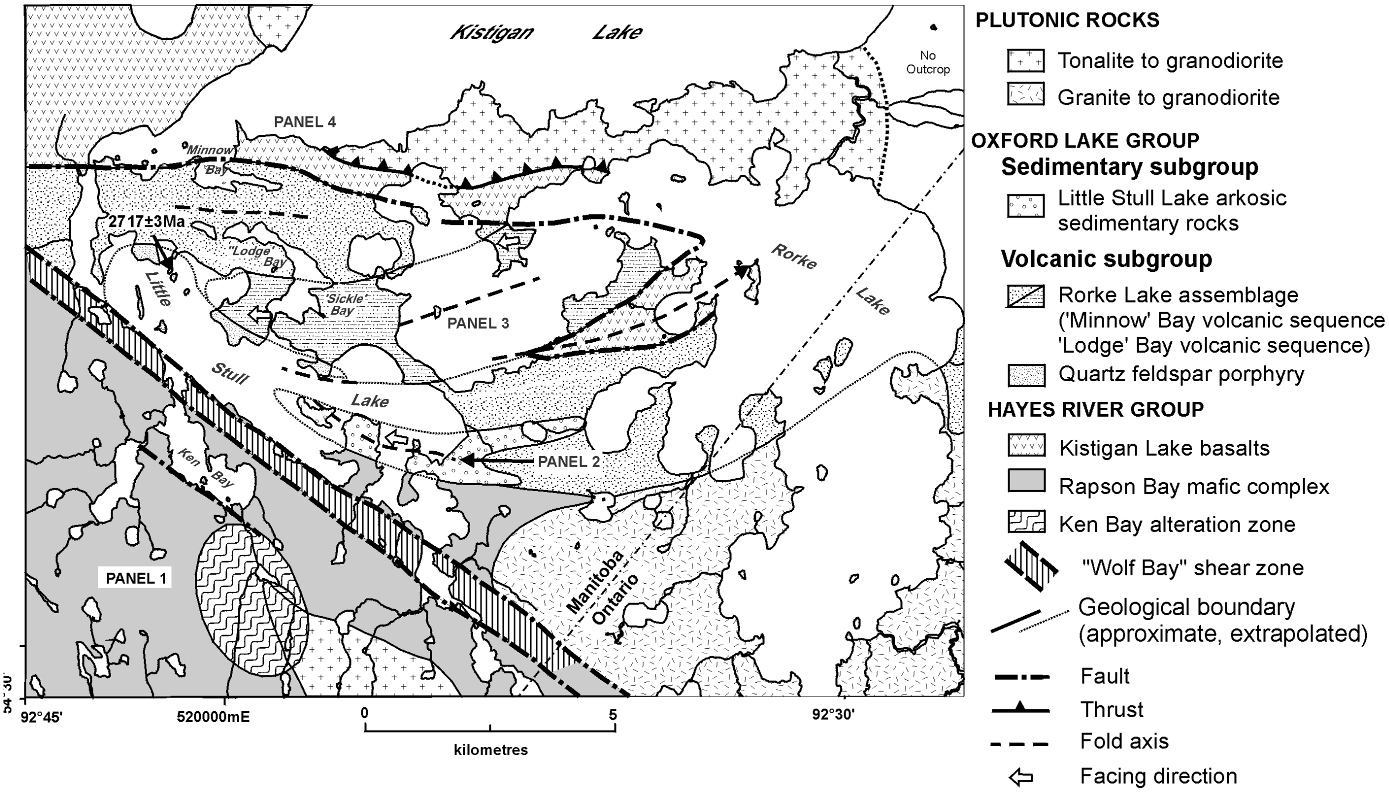

Figure GS-22-2: General geology of the Little Stull, Rorke, Kistigan lakes area.

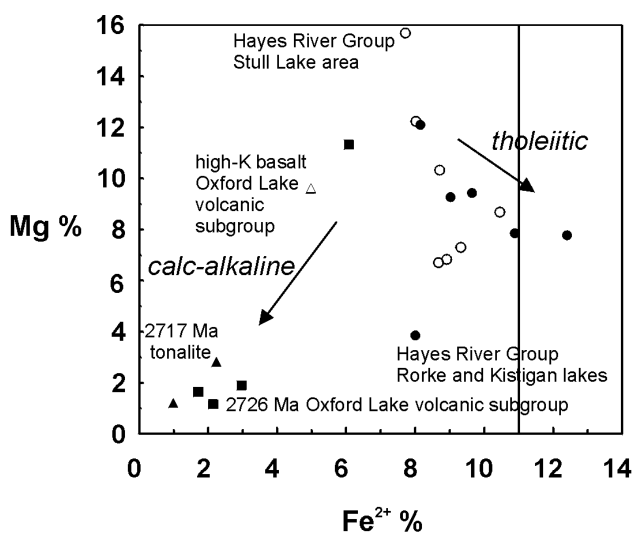

Figure GS-22-3: Fe-Mg diagram in cation % units (all iron as Fe^{2+}) showing tholeiitic (Fe-enrichment) and calc-alkaline (Fe-depletion) trends of volcanic and plutonic rocks in the study area. Symbols are as follows: Hayes River Group basalt in the Stull Lake area (open circles), Hayes River Group basalt on Rorke and Kistigan lakes (filled circles), diverse ca. 2726 Ma volcanic and subvolcanic intrusive rocks of the Oxford Lake Group (filled squares), 2717 Ma porphyritic tonalite on Little Stull Lake (filled triangles), and high-K basalt of the Oxford Lake Group, Stull Lake (open triangle).

depleted basalt (Fig. GS-22-4c) indicates that the mantle source of the parental melts was refractory and had sustained earlier melt extraction events, similar to the source of modern MORB.

Enrichment of LIL and LREE relative to Nb and Ta characteristic of submarine basalts that predominate in the northern part of the map area (Fig. GS-22-4a and 4b) is a geochemical feature of both Phanerozoic marine basaltic volcanism in suprasubduction zone environments (arc and back arc),but has also been recognized in some tholeiitic provinces at continental margins. Combined whole rock and Nd isotopic analysis of Hayes River Group basalt should resolve whether this volcanic suite recycled continental crust and, therefore, better constrain its tectonic setting.

Oxford Lake Group - volcanic subgroup - Rorke Lake Diverse Suite

Outcrops on the north shore of Little Stull Lake and central Rorke Lake (panel 3) consist of a series of intermediate to felsic volcanic tuff and breccia and associated volcaniclastic and epiclastic sedimentary rocks deposited in a marine setting. They can be grouped into four distinct associations: 1) aphyric intermediate to felsic tuff and breccia; 2) greywacke turbidites, argillite, and oxide iron formation; 3) feldspar phyric intermediate to felsic tuff and breccia, and derived volcanogenic sediments and associated epiclastic derivatives; and 4) generally hornblende phyric mafic breccia and derived volcanicalastic rocks.

A marine environment for deposition of the subgroup is indicated by the partial Bouma sequences (graded bedding, parallel laminate and 'E' division argillite) observed in the greywacke sandstones, iron formations and laminated argillites. However, the well rounded nature of the clasts in most of the conglomerates indicates subareal erosion. The environment of deposition is interpreted to be islands dominated by intermediate to felsic volcanism, shedding a limited variety of rock types into a marine basin.

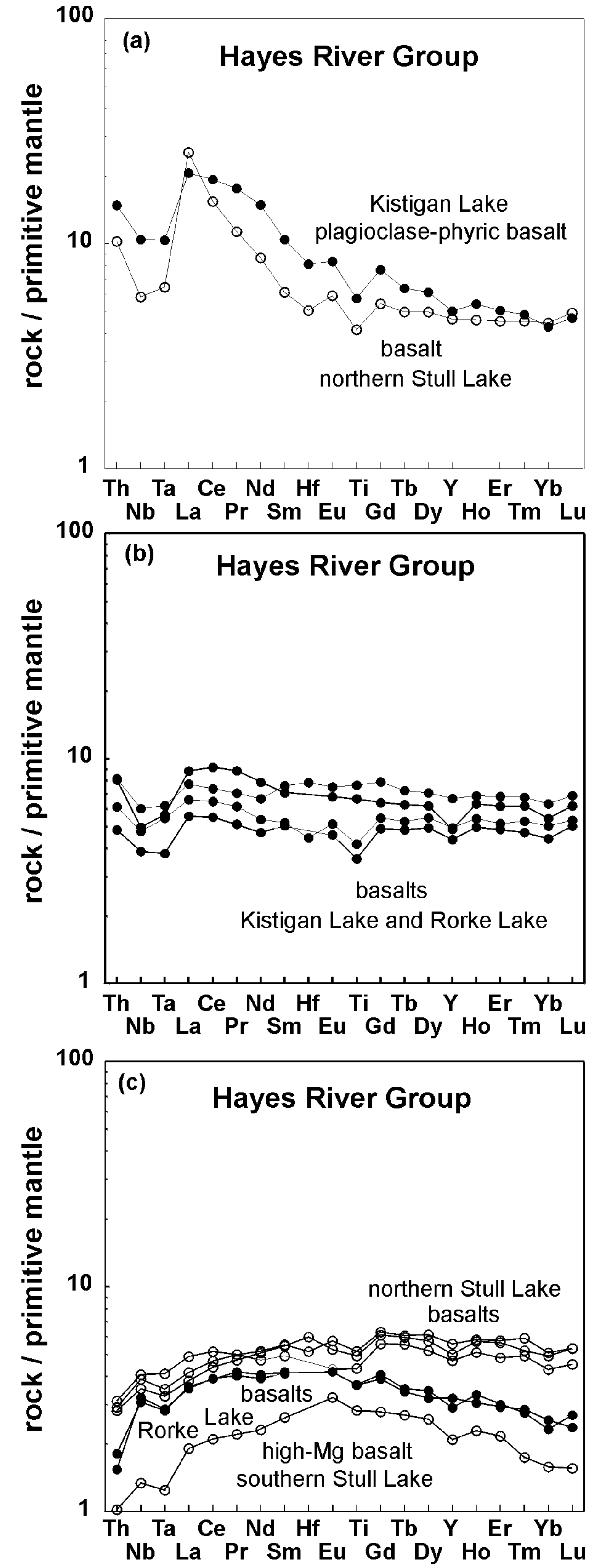

Figure GS-22-4: Primitive mantle normalized trace element profiles of Hayes River Group basalt (normalization factors from Sun and McDonough, 1989). a) LREE-enriched basalt from Kistigan Lake (filled circles) and northern Stull Lake (open circles). b) basalt with flat REE profiles from Kistigan and Rorke lakes (filled circles). c) LREE-depleted basalt from northern Stull Lake (open circles) and Rorke Lake (filled circles).

The aphyric intermediate to felsic volcanic rocks are typically interbedded with argillite and iron formation and, on a larger scale, greywacke turbidites. Bed thickness ranges from 5 cm (tuff and lapilli tuff) up to 1.5 m (in breccia with block, lapilli and ash size fragments; (Fig. GS-22-5)). A sample from location 36-97-1G (Fig. GS-22-2) taken from a thick, block dominated debris flow deposit was collected for U-Pb zircon geochronology and the results discussed in this report. These deposits are interpreted to be primary; however, variable amounts of reworking are to be expected in marine- deposited debris flows.

Feldspar- and quartz- feldspar phyric andesite to rhyolite and associated sedimentary rocks are in contact to the north and northwest of "Sickle Bay". They are interpreted to be in fault contact with the aphyric sequence. This abrupt change to porphyritic volcanic rocks and derived sedimentary rocks provides a distinctive characteristic for the upper portion of this sequence.

Age of the Oxford Lake Group - volcanic subgroup

A sample from the aphyric sequence of dacitic tuff intercalated with fine grained reworked volcanogenic sediments was collected for U/Pb dating (see Skulski et al. 1996 for analytical details) from the diverse suite of the OLG volcanic subgroup on the shores of north central Little Stull Lake (54°34'19.2"N, 92°41'8.4"W). Four single, abraded zircon fractions yield concordant results with $^{207}Pb/^{206}Pb$ ages that range from 2751 ± 2 Ma to 2726 ± 2 Ma (Fig. GS-22-6). Because the spread of these ages likely reflects either incorporation of xenocrysts or detrital zircons, the youngest fraction at 2726 ± 2 Ma provides a maximum age of crystallization of the volcanic clasts. The age of the diverse suite on Little Stull Lake is bracketed between this age and the 2717±1 Ma (Davis and Moore, 1991) age of a crosscutting porphyritic tonalite, and is similar in timing and setting to the 2730 Ma Gunpoint Group in the Cross Lake greenstone belt to the west (Corkery et al., 1992).

Geochemistry of the Oxford Lake Group - volcanic subgroup and syn- to late-volcanic plutons

The OLG volcanic subgroup at Little Stull Lake comprises an earlier, diverse sequence, the Rorke Lake assemblage, of calc-alkaline (Fig. GS-22-3) extrusive and likely subvolcanic intrusive rocks with a maximum age of 2726 ± 2 Ma (this paper), and a younger sequence of undated, high-K basalt that underlie fluvial-clastic sedimentary rocks that include the Little Stull Lake arkosic sedimentary rocks. The 2726 Ma sequence is cut by a 2717 ± 3 Ma, calc-alkaline porphyritic tonalite plug exposed on Little Stull Lake. Trace element analyses of basaltic andesite, rhyodacite tuff, diorite and tonalite of the diverse suite have primitive mantle normalized profiles that show enrichment in Th>La>>Nb and Ta, and depletion in Ti (Fig. GS-22-7c), similar to modern arc lavas. Rhyodacite and tonalite have lower overall trace element contents, greater depletion in HREE and Y relative to LREE, and higher Th/Nb values relative to more mafic basaltic andesite and diorite samples that were analysed. A similar pattern of variations is seen between leucotonalite (70.5% SiO_2) and tonalite (64.3 % SiO_2) in the 2717 Ma Little Stull Lake pluton. Fractional crystallization of accessory minerals including apatite and zircon, can explain the lower overall trace element abundances in the felsic relative to mafic rocks in the diverse suite and younger porphyritic pluton, and depletion in HREE in felsic magmas in particular. A positive correlation between SiO_2 (an index of differentiation) and Th/Nb values in the diverse suite may reflect progressive contamination by continental crust (enriched in Th relative to Nb; Taylor and McLennan, 1985), although this awaits further testing with Nd isotopic data.

A sample of hornblende-phyric, amygdaloidal basaltic breccia that underlay fluvial-clastic sedimentary rocks on Stull Lake is characterized by high K contents (49.2 % SiO_2, 2.45% K_2O, 0.76 K_2O/Na_2O). This high-K basalt is enriched in Th and LREE relative to other volcanic rocks analyzed in the map area (Fig. GS-22-7a). The basalt shows pronounced enrichment in Th and La relative to Nb and Ta. Although the K_2O/Na_2O values are less than 1, the high abundances of LIL and LREE in general are similar to shoshonite series lavas. Volcanic rocks described as belonging to the shoshonite series at Oxford Lake also have K_2O/Na_2O values less than 1, likely as a result of LIL remobilization during metamorphism (Brooks et al., 1982).

Late-stage shoshonites and high-K basalt have now been recognized across the northern Superior Province from Cross Lake in the west (<2710 Ma Cross Lake Group; Corkery et al., 1992), at Oxford Lake (2706 Ma Oxford Lake Group, D. Davis, cited in Syme et al., 1997), Knee Lake (Syme et al., 1997) and in the Stull Lake area to the

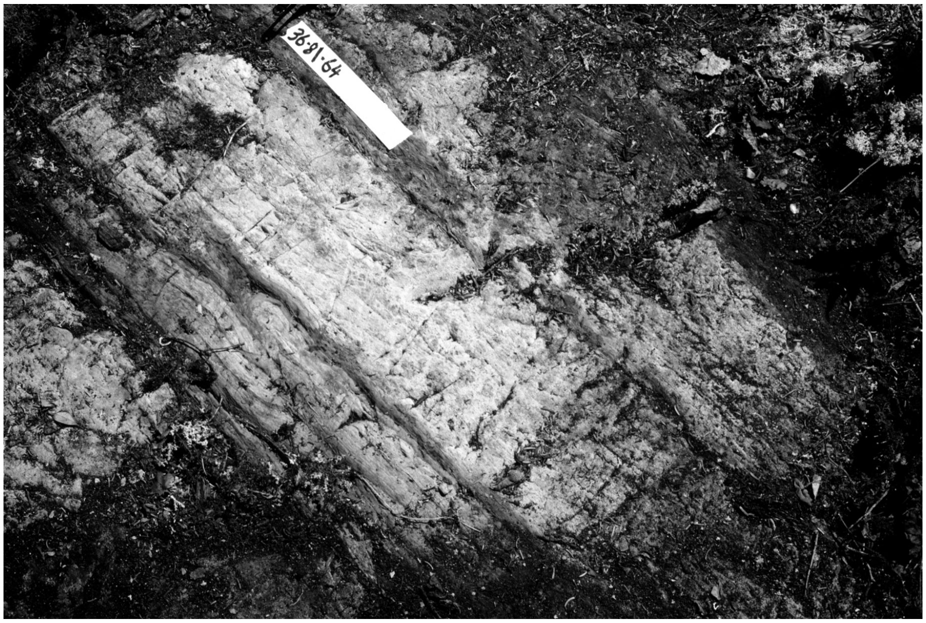

Figure GS-22-5: Photograph of the aphyric rhyolitic debris flow deposits and interbedded oxide facies iron formation at the location sampled for U-Pb geochronology.

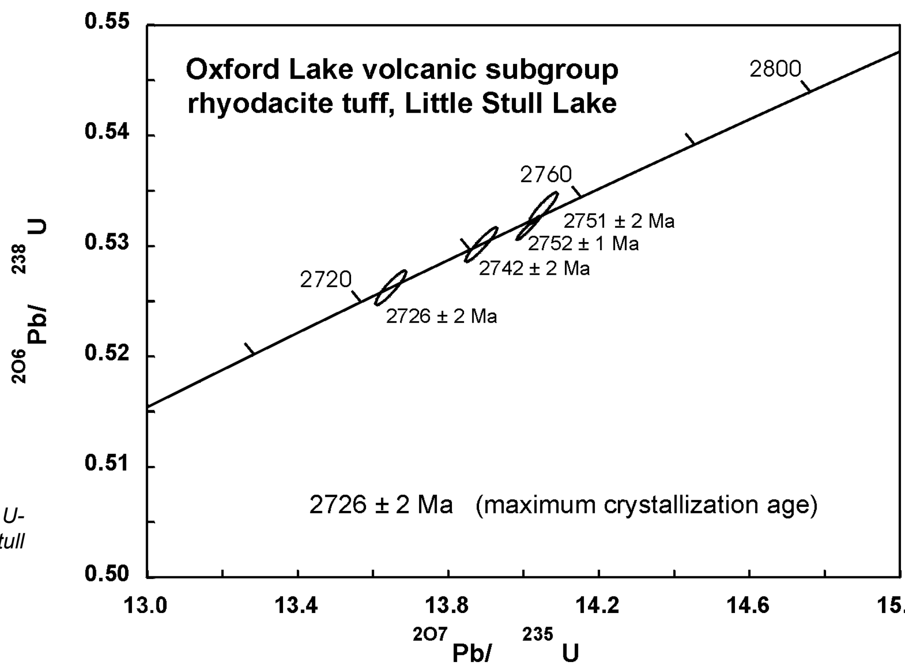

Figure GS-22-6 Concordia diagram showing U-Pb zircon data from a rhyodacite tuff, Little Stull Lake.

east. At Stull Lake, overlying fluvial conglomerate contains previously deformed clasts, indicating that late-stage sedimentation (and likely volcanism) followed an earlier episode of uplift and crustal shortening. At Cross Lake to the west, shoshonitic rocks overlie fluvial clastic sedimentary rocks that contain detrital zircons as old as 3547 Ma, and are separated by an angular unconformity from underlying strata. It is possible that in the northern Superior Province, shoshonitic rocks were extruded on a previously thickened, sialic crust. Ongoing field, geochronological and geochemical studies are aimed in part at determining whether the shoshonites acquired their characteristic signature of LIL enrichment and high field strength depletion in a subduction zone setting, or in an orogenic setting above ancient subduction-modified mantle.

ECONOMIC CONSIDERATIONS

The Ken Bay alteration zone forms a broad, south-southeast-trending alteration zone that cuts Hayes River Group basalt and gabbro south of Ken Bay (Fig. GS-22-2). The extensive fracture controlled alteration system affects the rocks over a band four km long by at least 1 km wide. Three types of alteration are documented:

(1) bleaching of basalt and gabbro to a pale cream- gray weathering rock composed dominantly of white amphibole (tremolite?) and feldspar is the most extensive type of alteration;

(2) fracture controlled, white weathering zone, silicification with patchy, pyrite- rich gossans. These zones form a linear 340º to 350º trend in the core of the Ken Bay alteration zone;

(3) irregular, black- weathering magnesian alteration zones within the bleached basalt-gabbro.

Sulphide- bearing gossan zones are most abundant in northwest-trending high strain phylonite zones. An anastamosing network of quartz-diorite to tonalite veins occur in the core of the Ken Bay alteration zone and may represent the northwest culmination of the intrusion to the south east (Fig. GS-22-2). Weak, fracture- related mineralization was observed in the form of molybdenum in sheared metasedimentary rocks south west of the alteration zone (Fig. GS-22-2)

Within and surrounding the Ken Bay alteration zone, Fedikow and Nielsen (1998) report a distinctive pattern of multi-element enrichment,

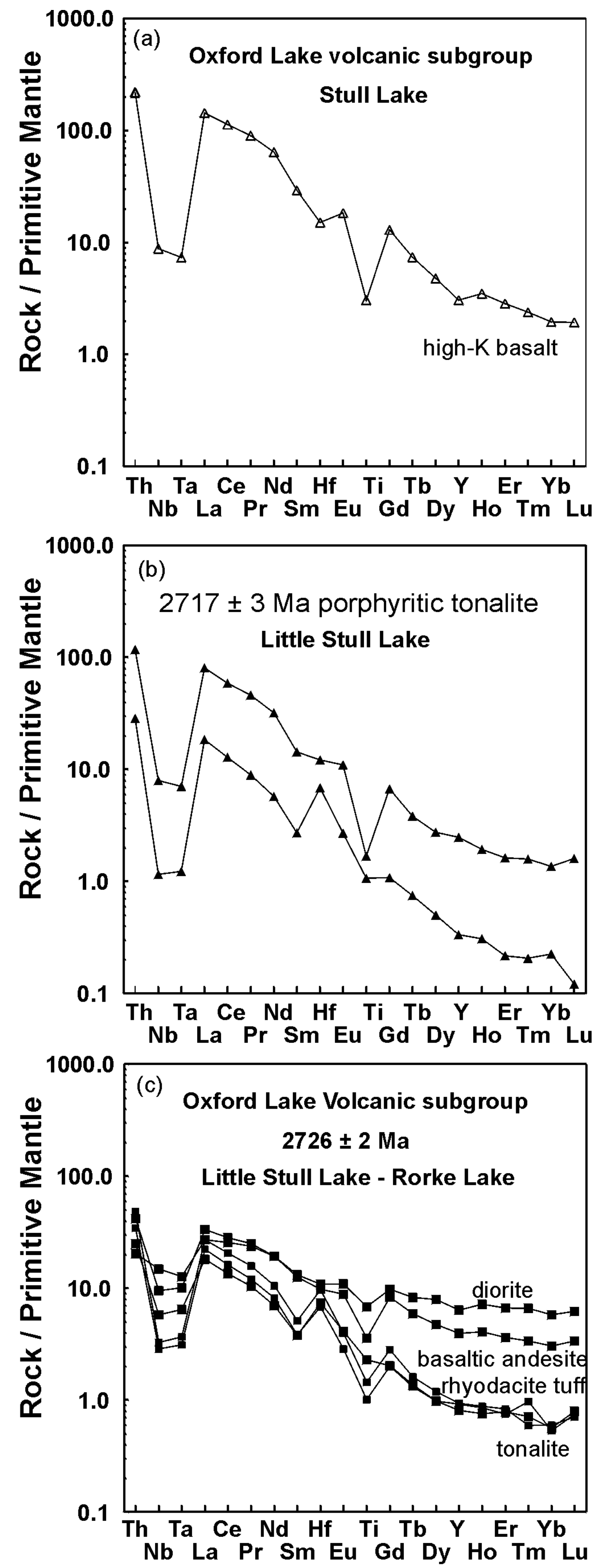

Figure GS-22-7: Primitive mantle normalized trace element profiles of volcanic subvolcanic rocks of the Oxford Lake Group. a) high-K basalt from Stull Lake (open triangle). b) 2717 Ma LREE-enriched porphyritic tonalite from Little Stull Lake (filled triangles). c) LREE-enriched volcanic and subvolcanic rocks of the 2726 Ma diverse suite on Little Stull Lake and Rorke Lake (filled squares).

from several of the media analysed in their regional geochemical program. The most noteworthy values reported are on the southeast and northwest corners of the alteration zone (Fig GS-22-8). Coincidentally the Little Stull Lake gold occurrences and Ken Bay showing are at the northwest tip of this zone. Corkery (1997b) described similar patterns for the alteration and mineralization near one of the gold occurrences on the south shore of Little Stull Lake.

Significant exploration including geophysics and drilling have outlined significant resources on Little Stull Lake, however, the large zone to the south and east has not been explored.

ACKNOWLEDGMENTS

We gratefully acknowledge the assistance of Denver Stone, Jesse Halle and the rest of the OGS mapping crew for help traversing in plus 30° C sunshine over the scorched southeast corner of the supracrustal belt. Assistance by Guy Desharnais always kept the field work up to date as well as spirits up in general. Eddie and Stella Cull of Red Sucker Lake Air Service Ltd. are thanked for extensive logistical support.

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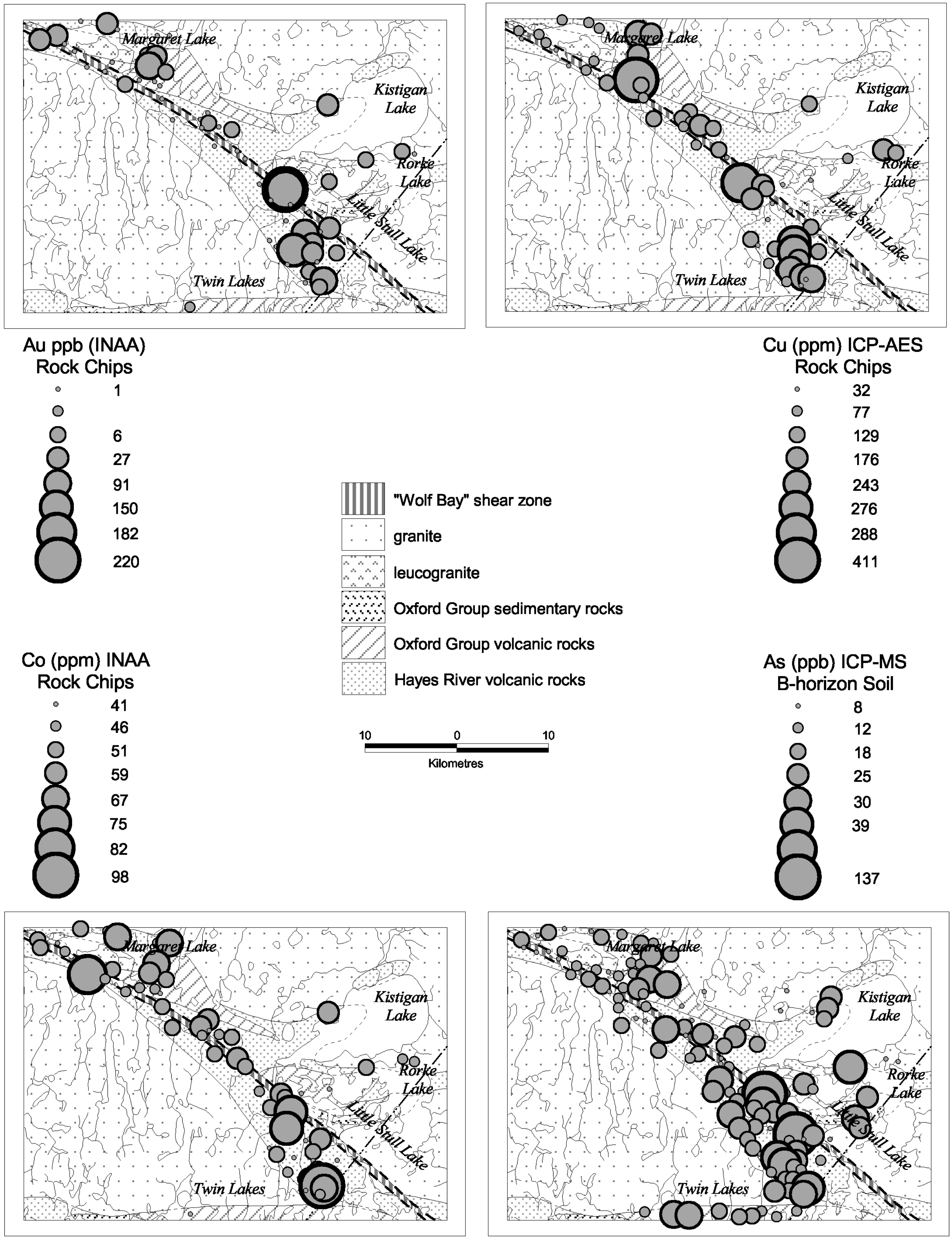

Figure GS-22-8: Percentile bubble plots for selected metal and minor element distribution in the Ken Bay alteration zone and surrounding area. Data from Fedikow and Nielsen (1998).

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