DESCRIPTIVE NOTES

INTRODUCTION

The Savant Lake greenstone belt forms the north-central part of the Wabigoon Subprovince (Blackburn et al., 1991) of the Superior Province, northwestern Ontario (Fig. 1). This belt has had no mineral production to date, but contains lithologic units, structures and alteration assemblages which indicate potential for base and precious metal mineralization. To better assess this potential, the stratigraphic units and structural geology of this area were examined (Sanborn-Barrie, 1989, 1990) to reconstruct its tectonic history and to assess the manner and degree to which deformation has modified stratigraphic units and controlled, or affected, volcanogenic massive sulphide and precious metal mineralization in the belt. This, in turn, has provided a stronger geologic data base with which to compare styles of deformation, alteration and mineralization in the Savant Lake belt with those in the Sturgeon Lake greenstone belt to the south (Sanborn-Barrie et al., 1998; Sanborn-Barrie and Skulski, 1998), where both gold and base metal mining operations have made an important contribution to the regional economy.

PREVIOUS WORK

Early geological reconnaissance of the Savant Lake area was conducted by Collins (1910), Moore (1910, 1928), Rittenhouse (1936) and Skinner (1969). A program of detailed mapping (1:31 680) was initiated in the Savant Lake area in the early 1970's by the Ontario Division of Mines (Bond, 1977, 1979, 1980; Trowell, 1981; Trusler, 1982) following the development of the Mattabi Mine on nearby Sturgeon Lake in 1968. A study of sedimentary rocks in the Savant - Sturgeon lakes area was carried out by Shegelski (1978). A regional overview of the Savant Lake area by Trowell (1986) is based on compilation of previous work, supplemented by additional mapping and extensive sampling of volcanic rocks for geochemical analyses.

Mapping of predominantly granitoid rocks northwest of the belt was conducted by Hudec (1965) and Breaks et al. (1979) and incorporated into a compilation map of the central Wabigoon Subprovince area (Breaks, 1980). Available geochronological constraints on stratigraphic elements of the Savant Lake belt are presented on the accompanying map and discussed below.

LITHOLOGICAL UNITS

The stratigraphy of the Savant Lake greenstone belt has been subdivided by previous workers into informal groups and formations on the basis of lithology and geographic distribution (Figure 1). In the following descriptions, a revised version of the stratigraphic nomenclature of Trowell (1986) is used.

SUBSTRATE (UNIT 1)

The oldest supracrustal rocks recognized in the belt form a ca. 100 m thick sequence on northeast Savant Lake. These comprise, from base to top, ultramafic schist, rhyodacitic lapilli tuff, and fuchsitic siltstone ± chert, capped by ultramafic-derived siltstone/ash (Sanborn-Barrie and Skulski, 1999). A maximum age of the rhyodacite tuff is 2881 ± 2 Ma, (T. Skulski, unpublished data, 1999; inverted triangle symbol #2 on Map). Uppermost layered rocks of the substrate unit are in contact with basal conglomerate of the Jutten sedimentary sequence (described below). An unconformable relationship between the Mesoarchean supracrustal substrate and Jutten sedimentary sequence is indicated by the presence of clasts of all substrate units within the latter. An angular unconformity is suggested by the presence of previously deformed clasts of substrate units within conglomerates of the Jutten sedimentary sequence (see figures 3b and 6d in Sanborn-Barrie and Skulski, 1999).

JUTTEN GROUP

The Jutten Group forms an extensive sequence of tholeiitic basalt exposed in the east and northwest parts of the belt. Mafic volcanic rocks dominate, however, the lowermost part of the group consists of clastic sedimentary rocks. Minor ultramafic, chemical metasedimentary and intermediate to felsic volcanic rocks occur throughout the group.

Clastic Sedimentary Rocks

A sequence of quartzose wacke and conglomerate (unit 2) is interpreted to form the lowermost Jutten Group in the northeast part of Savant Lake. This distinctive clastic sequence, designated the Jutten sedimentary sequence by Cortis et al. (1988) consists of 1) angular quartz grit supporting boulder-size clasts of trondhjemite, which may be basal to the sequence; 2) feldspathic wacke conglomerate with clasts of substrate granodiorite, ultramafic rock and vein quartz; 3) quartzose wacke and quartzose wacke conglomerate with clasts of ultramafic rock, green mica-rich (fuchsite?) rock, crenulated fine-grained sericite schist, and vein quartz. This clastic sequence is quartz-rich and thus chemically mature, yet is texturally immature. These attributes, and its low stratigraphic position suggest that this clastic sequence may represent the weathered products of an adjacent granitoid terrain. A sample of quartzose wacke/quartz arenite (inverted triangle symbol #3 on Map) yielded detrital zircons of which two were concordant at 2948 ± 3 Ma and 3199 ± 3 Ma and two were discordant with 207Pb/206Pb ages of 3258 ± 3 Ma and 3297 ± 6 Ma (Davis and Moore, 1991). These ages indicate a Mesoarchean-age source for the sequence and provide a maximum depositional age of ca. 2950 Ma for the Jutten sedimentary sequence and mafic volcanic rocks of the overlying Jutten group.

Ultramafic rock occurs at several localities proximal to the quartz-rich clastic rocks (unit 4). Rather than a potential source of ultramafic clasts within the conglomerate, field relations suggest that they postdate the sedimentary sequence and are intrusive into it.

Mafic Volcanic Rocks

The Jutten Group is dominated by pillowed to massive mafic flows (unit 3) of tholeiitic composition. The flows are interpreted to conformably (or disconformably) overlie quartz-rich clastic rocks, described above, since pillowed flows face away from same-facing clastic units; a fault or high strain zone is not recognized at the contact; and gabbroic dykes interpreted to be feeder dykes to the basaltic flows cut underlying clastic rocks at several localities. In general, pillowed flows dominate over massive flows and constitute up to 85% of the group. Pillowed mafic flows rarely possess varioles or amygdules.

Massive flows are locally observed to be plagioclase phyric with up to 20% euhedral plagioclase phenocrysts, up to 3 mm long. A transition from massive flow to breccia (interpreted as flow top breccia) occurs at several localities. Oxide-facies ironstone with minor jasper forms marker horizons within the Jutten Group. Units of chert ± magnetite, several metres wide, occur on the northwest shore of Kashaweogama Lake.

Ultramafic Rocks

Ultramafic rocks of the Jutten Group (unit 4a) mainly occur in the northwest part of the map area at Armit Lake, western Kashaweogama Lake and Dickson Lake. In the Armit Lake area, they consist of fine- to medium-grained, massive to foliated tabular units, up to 120 m thick, which are reported to grade transitionally from peridotite to pyroxenite and are interpreted as intrusive sills of komatiitic composition (Trowell, 1986). A 1 m wide unit of fine-grained, strongly crenulated, magnetic ultramafic rock on southern Armit Lake is in contact with mafic flows and may represent an extrusive unit. On western Kashaweogama Lake, coarse-grained ultramafic rock with an assemblage of talc-serpentine-magnetite ± tremolite ± chlorite is exposed near the narrows with Fairchild Lake where it forms extensive outcrops which are cut locally by pegmatitic phases of the Fairchild Lake intrusion and by a plagioclase-porphyritic diabase dyke. These variably magnetic rocks display a mottled, rubbly texture on their weathered surface due to the presence of 2 to 3 cm size, subrounded grains, each rimmed by a 2 to 4 mm wide, rusty-weathering corona. One km east, ultramafic rocks (formerly Northern Dynasty's Chromite-Mica Trench property) are highly altered, strongly foliated and lineated, pale-green weathering, fine-grained rocks whose weathered surface is highly pitted due to pervasive iron-carbonate alteration. Talc is visible in hand samples and forms netted vein textures. On southern Dickson Lake, adjacent to the contact of the Dickson Lake stock, light grey-green weathering, strongly magnetic, medium-grained, moderately foliated ultramafic rock is transected by mm- to cm-scale, white to pale green weathering, tightly folded talcose veins.

On northeastern Savant Lake, ultramafic rocks occur in close proximity to quartzose wacke and conglomerate of the Jutten sedimentary sequence. These are white-weathering, homogeneous, moderately to strongly magnetic rocks, with a dark black-green fresh surface. The uniform texture of the weathered surface, except for local zones with relict crystals up to 6 mm, and the lack of spinifex texture are consistent with an intrusive origin for these rocks. Similarly textured ultramafic rock cuts fuchsitic substrate (described above) and here an intrusive origin is indicated by a 10 cm wide, finer-grained contact zone which is interpreted to be a chilled margin.

Intermediate to Felsic Volcanic Rocks

Restricted exposures of intermediate to felsic volcanic rocks (unit 5) are spatially associated with mafic flows of the Jutten Group, however, it remains to be established whether these are cogenetic and representative of the upper Jutten Group. In central Savant Lake, intermediate and felsic volcanic rocks are exposed on two small islands, off the northwest shore of Girard Island. These buff weathering tuffs of dacitic to rhyodacitic composition are generally unsorted and unbedded. They contain 20% feldspar, 10% quartz grains (< 5 mm) which are subangular and may show square to rectangular sections, and 5% lithic fragments (< 4 mm) set in a quartzo-feldspathic groundmass containing up to 12% sericite.

In the Dickson Lake-Winsome Lake area, grey-green weathering intermediate flows with colour index generally < 20 are interbedded with mafic flows. A similar unit of grey-buff weathering intermediate rock on southern Armit Lake is highly folded and transected by abundant quartz veins. On the north shore of central Kashaweogama Lake, intermediate to felsic volcanic units are infolded with mafic flows. These felsic to intermediate rocks were previously interpreted as a subvolcanic quartz porphyry (Breaks et al. 1979) and were designated the Kashaweogama Lake intrusion (Trowell 1986).

HANDY LAKE GROUP

Calc-alkaline volcanic rocks of the Handy Lake Group (units 6,7,8) have been the focus of base metal exploration since the early 1970's following the discovery of the Mattabi and Lyon Lake copper-zinc massive sulphide deposits in felsic volcanic rocks of the Sturgeon Lake greenstone belt to the south. The Handy Lake Group consists primarily of flows, pyroclastic rocks and volcanogenic metasedimentary rocks of mafic, intermediate and felsic composition.

The Handy Lake Group was formerly subdivided into the lowermost Evans Lake formation and uppermost Conant Lake formation (see former subdivisions in Fig. 1) by Trowell (1986), on account of a 1 km wide metasedimentary unit that occurs midway through the interpreted thickness of the group (Bond 1977, 1979, 1980; Trowell 1986). These metasedimentary rocks comprise predominantly feldspathic and lithic wacke with subordinate chemical sedimentary rocks consisting of laminated to thinly bedded magnetite ironstone, chert and silicate-facies ironstone. The youngest dated detrital zircon from a wacke northeast of Evans Lake (inverted triangle #7 on Map) is 2703 ± 1 Ma (Davis, 1996). Post- 2703 Ma old deposition for this metasedimentary panel suggests that it likely represents infolded clastic rocks of the Savant Group (described below) rather than intra-Handy Lake Group rocks. Accordingly, it remains to be established whether former subdivisions of the group reflect real differences in age (see below) and/or chemistry.

The basal member of the former Evans Lake formation comprises massive to pillowed high-magnesian tholeiitic basalt flows, porphyritic flows and fragmental zones of mafic composition (Bond 1977, 1979, 1980; Trowell 1986). This unit is exposed west of Harris Lake in the eastern part of the belt, and between Lewis Lake and Farrington Lake in the western part of the belt. Between these two localities, the mafic metavolcanic unit is interrupted by the Lewis Lake batholith which intrudes it. Overlying the mafic sequence are flows and pyroclastic rocks of felsic and intermediate composition. A dacitic tuff located about 1 km southwest of Evans Lake (inverted triangle symbol #4 on Map) has a crystallization age of 2745 +1.9/-1.8 Ma (Davis and Trowell 1982). The coarsest pyroclastic rocks occur north and west of Evans Lake and accordingly, this region is interpreted as the possible site of a volcanic vent (Trowell 1986). The upper member of the Evans Lake formation consists of mafic metavolcanic flows and minor pyroclastic rocks. Interbedded volcanogenic metasedimentary rocks occur in the upper part of the formation, south and east of Evans Lake.

The former Conant Lake formation (Fig. 1) comprises predominantly felsic and intermediate pyroclastic rocks, including tuff, lapilli-tuff and tuff-breccia. Near Handy Lake, this sequence is intruded by felsic to intermediate feldspar and quartz-feldspar porphyritic sills (unit 9) with a U-Pb age of 2733 ± 1.0 Ma (Davis, 1996; inverted triangle symbol #5 on Map). These sills are interpreted to be subvolcanic to the Conant Lake formation. The Conant Lake intrusion (Fig. 1) is spatially associated with the Handy Lake porphyritic sills and is a sill-like body of granodioritic to tonalitic composition. This pluton is similarly interpreted as a subvolcanic intrusion emplaced within its associated comagmatic volcanic pile (Bond 1979). Intermediate and felsic volcanic rocks (inverted triangle symbol #6 on Map) dated at 2704 ± 2 Ma (Davis, 1996) which are interbedded with clastic and chemical sedimentary rocks are now believed to be part of the Whimbrel Lake Formation (described below).

SAVANT GROUP

Late to post-volcanic clastic rocks exposed in the central part of the Savant Lake greenstone belt (Fig. 1) dominate the Savant Group. These include basal polymictic conglomerate of the Narrows Formation and overlying turbiditic wacke and oxide-facies ironstone, herein designated the West Shore Formation. Compositionally diverse volcanic rocks of the Whimbrel Lake Formation represent a minor component of this group.

Narrows Formation

Polymictic conglomerate of the Narrows Formation (unit 11) extends from Schist Lake in the far western part of the belt, through Fairchild-Kashaweogama lakes, to the Neverfreeze-Elwood lakes area in the northwest, as island exposures through central Savant Lake, to South Arm (Fig. 1). This extensive unit marks a fundamental, belt-scale angular unconformity between the Jutten Group and turbiditic wacke of the West Shore Formation (described below). Clasts within the conglomerate vary along its strike and reflect the rock types of immediately underlying strata. In the Schist Lake area, pebble- to boulder-size clasts are dominantly plagioclase porphyritic tonalite similar to the Fairchild Lake intrusion to the immediate north. In central Savant Lake, pebble- to cobble-size clasts of mafic volcanic rock ± interflow chemical sedimentary rocks are prevalent. The unit may contain sandy beds which similarly reflect felsic plutonic vs mafic volcanic sources.

A clast of medium-grained tonalite collected from conglomerate from central Kashaweogama Lake (inverted triangle symbol #9 on Map) yielded a U-Pb zircon age of 2704 ± 1.2 Ma from three zircon fractions (Davis et al. 1988). This represents the age of magmatic emplacement of the source of the clast and is a maximum age for the deposition of the conglomerate in this area. A clast of blue quartz-bearing tonalite collected a few metres from the medium-grained tonalite clast (inverted triangle symbol #10 on Map), gives a 207Pb/206Pb age of 2723 ± 2 Ma.

Polymictic conglomerate of the Narrows Formation generally grades transitionally into finer-grained clastic sedimentary units of the Savant Group, except west of central Savant Lake, where it appears to be interstratified with intermediate pyroclastic rocks and flows of the Whimbrel Lake Formation (Fig. 1).

West Shore Formation

The West Shore Formation (unit 12) of the Savant Group comprises medium to fine sand-size feldspathic wacke, fine to silt-size lithic wacke, and interbeds of very thinly bedded to thickly laminated magnetite-chert ironstone. The wacke units, though highly folded, are typically well-bedded and well-graded, except at the base of the group where poorly graded wacke occurs as isolated interbeds (< 40 cm wide) within conglomeratic rocks of the Narrows Formation. The well-bedded, well-graded character of feldspathic wacke which regularly alternates with silt-size lithic wacke, and the prevalence of delicately laminated magnetite-chert ironstone are interpreted to reflect turbiditic deposition in deep-water conditions, with intermittent quiescence and precipitation from iron- and silica-rich waters. Detrital zircon ages from feldspathic wacke (inverted triangle symbol #8 on Map) show a range: the youngest dated zircons are 2704 Ma, with apparent age clusters at ca. 3060 Ma, ca. 2950-2920 Ma and ca. 2790-2770 Ma (Davis, 1996). This data indicates that a large age spectrum of source materials contributed to this clastic sequence which was deposited after 2703 Ma, the youngest detrital zircon analysed. Detritus contributed to this group may reflect far-field orogenic activity elsewhere in the western Superior Province, however, the well-preserved sedimentary features and interbedded chemical sediments which characterize this group indicate that these rocks were deposited under local low-energy conditions in advance of orogenic activity (D_1, D_2) which subsequently affected all supracrustal elements of this greenstone belt (discussed below).

Whimbrel Lake Formation

Felsic to intermediate volcanic rocks (unit 15) occur in west-central Savant Lake near Whimbrel Lake. These conformably overlie polymictic conglomerate of the Narrows Formation and, as such, have a maximum depositional age of ca. 2703 Ma. They consist mainly of pyroclastic deposits, although intermediate to mafic porphyritic and amygdaloidal flows and associated fragmental rocks are exposed on Whimbrel Lake. Dacite tuff and lapilli tuff are interbedded with clastic and chemical metasedimentary rocks of the Savant Group on islands in central Savant Lake. Gabbroic (unit 13) and feldspar porphyritic (unit 14) sills that cut the Savant Group are likely intrusive phases of the Whimbrel Lake Formation.

Near the North Arm of Savant Lake, small shoreline and island exposures of intermediate to felsic volcanic rocks include massive flows, lapilli tuff and pyroclastic breccia. The latter is composed of subangular blocks (10 cm by 4 cm) of mainly dacitic composition in a feldspar crystal tuff groundmass. The fragments are texturally diverse and include highly vesiculated fragments and plagioclase-phyric fragments. Minor fragment types include 2% highly attenuated mafic volcanics (or collapsed pumice) and 3% accidental fragments of chert. The variety of clast types suggests that this unit may represent a volcanic debris flow, shed from a volcanic edifice of dominantly dacitic composition.

INTRUSIVE ROCKS

Foliated and gneissic granitoid rocks external to the greenstone belt (unit 16) exhibit a variety of textures and structures and represent a range of ages of magmatic activity. The oldest plutonic rock recognized is biotite tonalite gneiss, exposed 4 km northwest of the greenstone belt. These gneissic rocks, dated at 2970 ± 7 Ma (T. Skulski, unpublished GSC II SHRIMP data, 1999; inverted triangle symbol #1 on Map), are interpreted as Mesoarchean basement to the Jutten Group. Plutonic complexes of probable syn-volcanic age include massive to foliated, granodioritic to tonalitic rocks of the Fairchild Lake intrusion northwest of the belt, and the Jutten Lake and Lewis Lake batholiths to the east and southwest of the belt, respectively. A marginal phase of the Lewis Lake batholith yields a preliminary U-Pb zircon age of ca. 2735 Ma (McNicoll and Whalen, 1999, unpublished data), supporting felsic plutonism coeval with Handy Lake volcanism and with volcanogenic massive sulphide mineralization in the Sturgeon Lake greenstone belt to the south.

Several felsic to intermediate plutons intrude supracrustal rocks of the Savant Lake belt (Fig. 1). Deformed and metamorphosed intrusions include porphyritic stocks (units 9, 14) exposed on Elwood and Seldom lakes, ca. 2733 Ma porphyritic sills of the Handy Lake Group, the Conant Lake intrusion, and the tonalitic to granodioritic Hough Lake and Heron Lake stocks. Tonalite of the Heron Lake stock (inverted triangle symbol #11 on Map) yielded discordant single zircons with 207Pb/206Pb ages of 2675 ± 3 Ma and a discordant single grain wih 2854 ± 3 Ma (Davis et al. 1988). The younger ages are interpreted to reflect the age of emplacement of stock (i.e., ca. 2703 Ma when forced through a lower intercept of 600 Ma), whereas the older age is interpreted as a xenocrystic component (Davis et al. 1988). Late- to post-tectonic intrusions (unit 17) include the Grebe Lake stock, Wiggle Creek stock, Dickson Lake stock and North Arm pluton.

UNCONFORMABLE CONTACTS

Two unconformities are recognized in the stratigraphic record of this area. The oldest is represented by the Jutten sedimentary sequence which marks a period of erosion and deposition between Mesoarchean magmatism (tonalite gneiss and supracrustal substrate) and deposition of undated submarine tholeiites of the Jutten Group. Evidence for this unconformity is twofold. Firstly, conglomeratic units of the Jutten sedimentary sequence can be demonstrated, by younging relationships, to occur at the base of the Jutten Group, indicating that the clastic rocks represent some of the earliest formed rocks in the belt. Secondly, the dominant clast types in conglomerate at most localities are fine- to medium-grained, equigranular granitoid clasts and vein-quartz clasts, hosted in a chemically mature quartzose matrix, which at most localities is texturally immature. These features indicate that proximal, felsic, quartz-bearing granitoid rocks (eg. ca. 2970 Ma tonalite immediately northwest of the belt) were an important source component for this clastic sequence.

A post-2704 Ma belt-scale unconformity is represented by polymictic conglomerate of the Narrows Formation, which unconformably overlies the Jutten Group. An angular unconformity between Jutten volcanics and the Narrows Formation can be demonstrated at several localities, suggesting that a pre-D_1, low-strain tilting of the Jutten Group took place prior to ca. 2704 Ma. In the South Arm area of Savant Lake, well-preserved, pillowed mafic metavolcanics young to the northwest, indicating that Jutten strata strike northeast in this region. These are in contact with conglomeratic rocks of dominantly mafic volcanic provenance, as well as boulder-size clasts of ferruginous chert and minor jasper pebbles. The (folded) volcanic/conglomerate contact trends 115°, at a high angle (80°) to the strike of Jutten strata in this region. An unconformable relationship is also apparent in the Fairchild - Kashaweogama lakes area where polymictic conglomerate of the Narrows Formation contains both volcanic and plutonic clasts whose composition directly reflects in situ strata to the north. Angular relationships between bedding of the Jutten group and that in the Narrows Formation is commonly obscured on Kashaweogama Lake due to the highly strained nature of the basal conglomerate, which rarely allows recognition of bedding attitudes and younging directions in this area. However, at two localities on Fairchild Lake, relatively continuous beds of medium-grained feldspathic wacke are interbedded with conglomerate. These wacke beds strike eastward, slightly discordant to the strong foliation in this area. If the attitude of bedding at these localities reflects primary bedding attitudes within the conglomerate, an angular relationship is demonstrated whereby bedding in the Jutten is about 45° clockwise to that in the Narrows Formation.

METAMORPHISM AND ALTERATION

In general, the belt has been metamorphosed to greenschist and almandine amphibolite facies. In the Evans Lake area, however, rocks of the Handy Lake Group are characterised by alumina enrichment and alkali depletion, reflected by the presence of staurolite, andalusite, kyanite, cordierite and sillimanite. The peraluminous nature of altered rocks of the Handy Lake Group is similar to that observed in footwall rocks beneath the Mattabi massive sulphide deposit (Franklin et al. 1975) in the Sturgeon Lake greenstone belt to the south.

Felsic to intermediate volcanic units in the Evans Lake area also commonly contain 3% to 80% (by volume) of amphibolitic material which occurs as linear lenses and bands, diffuse mafic clots, and fracture filling. Field relationships generally reveal that these zones are the result of pre-metamorphic Mg alteration, likely due to interaction of the volcanic rocks with seawater. The amphibole minerals were identified by Bond (1980) as predominantly hornblende with minor actinolite and chlorite. A more sodic variety of amphibole with a distinctive blue-green birefringence was also noted. Anthophyllite is reported from several localities, roughly 2 km northeast and east of Evans Lake (Trowell 1981).

Moderate to intense ferroan-carbonate alteration is pervasive throughout much of western and central Kashaweogama Lake with lesser degrees of silicification and sericitization. A green, chromium (?) mica, likely fuchsite, is sporadically observed. Alteration is spatially associated with the Kashaweogama Lake shear zone. Tectonized rocks south of Kashaweogama Lake and northwest of Hough Lake also possess strong Fe-carbonate alteration (c.f. Bond, 1980).

MINERAL OCCURRENCES

Mineral exploration in the Savant Lake area has been ongoing since the turn of the century in the search for gold, iron, and massive sulphide mineralization; however, there has been no mineral production to date. Descriptions of past mineral exploration can be found in Bond (1977, 1979, 1980) and Trowell (1986). A few select mineral occurrences and/or showings that have received considerable interest through the years are described briefly below.

The most significant of the base metal occurrences in the Handy Lake Group is the Sabin occurrence (also known as the Marchington Road sulphide zone). This is a small Zn-Cu-Ag-Pb zone located on Highway 516, roughly 1.5 km west of Highway 599. Geologic- and drill-inferred tonnage is estimated at 216 000 tons grading 0.76 percent Cu, 3.19 percent Zn, 1.54 percent Pb and 1.81 ounces per ton Ag (Umex Inc, personal communication, 1989). The Handy Lake Group also hosts the Hadley Zn-Pb-Cu-(Cd)-(Au) occurrence, a lenticular pod (4.5 m by 1m) of massive sphalerite and galena with minor chalcopyrite, pyrite and pyrrhotite hosted in felsic to intermediate volcanic flows. Other mineralized showings include a silicified sericitic-pyritic showing at Sue Lake, anomalous Cu and Zn values in Na-depleted felsic metavolcanics near Evans Lake, sphalerite-bearing felsic tuff, and pyrite-pyrrhotite stringers in sericitic felsic schist.

Highly tectonized and altered rocks within the Kashaweogama Lake shear zone have been the focus of exploration for gold mineralization. The best gold values come from highly tectonized and altered rocks of the Jutten group where Au occurs in ferroan carbonate-quartz veins (± galena, pyrite, chalcopyrite and arsenopyrite) and pyritized shear zones. Alteration includes Fe- and Ca- carbonatization, sericitization, silicification and the development of talc and chromium mica.

STRUCTURAL ELEMENTS

The Savant Lake greenstone belt is polydeformed with two recognizable generations of structures interpreted to have been imposed following deposition of the youngest sedimentary rocks at ca. 2.703 Ga. Two sets of folds related to syn-2.7 Ga deformation (F_1 and F_2) are established by opposing younging and structural facing (younging in the direction of F_2 axial planar cleavage, see Map). More difficult to document are faults/thrusts between, and within, units. For instance, the fault (suture) postulated between the Jutten and Handy Lake groups (Sanborn-Barrie and Skulski, 1999) is interpreted to be obscured by the Savant Group (overlap foredeep assemblage), while faults/thrusts internal to the Handy Lake Group are difficult to establish due to exposure constraints at the scale of mapping. The dominance of folds relative to faults within the Savant Lake greenstone belt may be real, or a consequence of these constraints.

BEDDING

Present attitudes of bedding throughout the Savant Lake greenstone belt are variable due to two regional-scale folding events and localized shearing. In general, bedding strikes northwest and northeast.

FOLDS

Two episodes of folding have affected much of the greenstone belt; including the Jutten Group, which historically has been interpreted as a northwest-facing sequence more than 10,000 m thick. Evidence of two folding events is provided by 1) opposing structural facing directions throughout the supracrustal sequences; 2) outcrop-scale, refolded fold patterns; and 3) folds with axial surfaces and respective axial planar cleavages which are orthogonal, striking northward and eastward. Planar fabrics throughout the belt are generally associated with these two folding events, except in areas of increased strain intensity related to shearing.

F_1

F_1 folds are identified primarily by reversals in structural facing of volcanic and sedimentary rocks (c.f. Borradaile, 1976). Traces of F_1 folds are parallel to bedding and are generally northwest-striking (Fig. 2 and Map), prior to modification by F_2 folds, shear zones and faults. Macroscopic F_1 folds have bedding-parallel axial surfaces and variably oriented fold axes. Three lines of evidence suggest that F_1 folds were originally shallowly plunging and were steepened during subsequent D_2 folding. Firstly, several shallow-plunging F_1 folds are observed in the Handy Lake Group, where an axial planar S_1 foliation is best preserved. Secondly, a shallow plunge to F_1 structures is consistent with bedding-parallel S_1 axial planar cleavage. Thirdly, their shallow plunge would account for the scarcity of major F_1 hinges, a difficulty in identification of these folds which has been overcome by the use of opposing structural facing directions to locate their axial traces.

F_2

F_2 folds are readily recognized in the field, primarily by reversals in younging and fold closures. They are pervasively developed throughout the Savant and Handy Lake groups and less commonly affect the Jutten Group. Axial surfaces of F_2 folds strike northeast to east and dip steeply (65° to 85°) south with a mean at 073/82 (Fig. 2). F_2 axes dominantly plunge moderately to steeply to the east, with a mean trend of 082° and a mean plunge of 60° and display S-, Z-, and W-symmetry. Locally, they plunge moderately to steeply to the west-southwest. In hinge zones of major F_2 folds, minor folds are typically tight to isoclinal and limbless due to transposition parallel to the axial planar S_2 cleavage. Specific features of several major F_2 folds are as follows.

1) The Jutten sedimentary sequence in northeast Savant Lake defines a northeast-striking, southwest-closing, F_2 antiform which plunges steeply to the southwest and which is superposed on a NW-striking F_1 anticline. The regional schistosity in this area strikes 055° to 060°, and is axial planar to F_2. These structures indicate that Jutten mafic metavolcanic and clastic rocks are not simply a northwest-facing, homoclinal sequence as interpreted by previous workers.

2) A series of F_2 folds affecting the West Shore Formation possess 045°-striking axial surfaces. This interpretation is consistent with younging criteria and the 045° strike of axial planar cleavage throughout this region. These observations depart from those of Bond (1977) who suggested that axial surfaces of folds in this group strike 035°: oblique to the local foliation but parallel to the proposed Savant Lake fault, whose presence could not be corroborated in this study (see Deformation Zones).

3) The structural style of the Narrows Formation on the west shore of central Savant Lake and in the South Arm is one of tight to isoclinal folding and a high degree of transposition about a strongly developed, 030° to 050° axial planar cleavage. Previous workers interpreted bedding within this unit as parallel to the tectonic direction, rather than at a high angle to it, as revealed by enveloping surfaces to the folded strata.

FOLIATION

S_1

The earliest foliation recognized, designated S_1, is axial planar to F_1 folds (Figs. 2, 3a). S_1 is not the dominant planar fabric throughout the belt, but is well displayed throughout the Handy Lake Group. It typically occurs as a bedding-parallel, spaced cleavage of variable attitude (Fig. 3a), due to subsequent folding.

S_2

S_2 is the dominant foliation throughout the greenstone belt and is a penetrative, moderately to strongly developed schistosity which is characterized by a gently curvilinear east- to northeast- strike and a uniformly steep dip (Fig. 3b). In the south-central part of the study area, both S_1 and S_2 occur together in outcrop. The overprinting nature of S_2 is readily recognized in that the spaced S_1 cleavage is crenulated by a pervasive, east-striking schistosity (S_2).

In the eastern half of the area, a single, well-developed, steeply-dipping schistosity which strikes northeast (040° to 060°) is recognized throughout the supracrustal rocks, except in zones of higher strain intensity where fabrics typically trend 065° to 085° (see Deformation Zones). This dominant fabric is interpreted as S_2, although an earlier S_1 cleavage is not recognized here because: 1) the penetrative schistosity throughout the eastern area is subparallel to S_2 schistosity in the Handy Lake area, where both S_1 and S_2 are recognized; 2) this foliation is not bedding parallel, an attribute which is diagnostic of S_1 and 3) mineral lineations on this fabric plunge moderately to steeply to the east. Steep easterly extension characterizes the S_2 foliation in the south-central area.

LINEATIONS

In general, mineral and shape lineations in supracrustal rocks plunge moderately to steeply. They vary in trend but show a dominant trend toward the east, with no significant distinction in the attitude of lineations on S_1 and S_2 In contrast, mineral lineations in foliated to gneissic granitoid rocks in the eastern part of the area plunge moderately to steeply (20° to 75°) to the west.

DEFORMATION ZONES

The greenstone belt is transected by a number of steeply-dipping, east-striking shear zones. The most prominent and continuous of these is the Kashaweogama Lake shear zone (KLSZ), a 1 to 3 km wide zone of strongly deformed and altered rocks which extends at least 45 km along strike from Schist Lake in the west, to the west-central shore of Savant Lake. Within the KLSZ, ductilely deformed rocks possess an intensely developed shear foliation, or C-(cisaillement) fabric, which strikes 250° to 260°, parallel to the strike of the shear zone, and dips steeply north and south. Mineral and stretch lineations, the latter represented mainly by ellipsoidal clasts in conglomerate, plunge steeply (65° to 88°) parallel to the direction of maximum finite extension. In the western part of the shear zone, these lineations dominantly plunge steeply west; while in eastern Kashaweogama Lake and near Whimbrel Lake, lineations plunge steeply east. These fabric elements are interpreted to reflect subvertical, oblique-slip movement on the KLSZ rather than a dominant strike-slip component as previously interpreted by other workers. Shear sense indicators are rare in these fine-grained rocks but indicate south-side-down, dip-slip movement (Cote, 1990). Throughout the western part of the KLSZ (between Schist Lake and central Kashaweogama Lake), steep, west-plunging lineations, steeply plunging, asymmetric Z-folds and composite S and C-type fabrics on horizontal exposures are consistent with a minor component of dextral displacement. Crenulation lineations are well-developed throughout the zone. These microfolds developed in phyllonitc shear foliations, plunge shallowly, and are interpreted to have formed orthogonal to the displacement direction. Conjugate kink bands are also common.

Variably tectonized and altered (ferroan carbonate) rocks are observed at numerous other localities throughout the greenstone belt, including the Hough Lake and Stillar Bay - Southeast Bay areas.

Fabric evidence supporting the presence of 035° striking fault zone through the long axis of Savant Lake, historically referred to as the Savant Lake fault (Moore,1910, 1928; Rittenhouse, 1936; Bond, 1979), could not be established.

TECTONOSTRATIGRAPHIC SUMMARY

The Savant Lake belt is a rare example of an Archean greenstone belt that preserves a record of deposition on Mesoarchean continental crust. This crust is represented by ca. 2.97 Ma tonalite immediately north of the belt, and likely by widespread Mesoarchean plutonic rocks of the Winnipeg River Subprovince (Fig. 1 inset). Evidence for an autochthonous, or parautochthonous, relationship at the base of the supracrustal belt includes the presence of a thin ca. 2880 Ma ultramafic to felsic substrate that shows contamination by continental crust (Skulski et al., 1999) and unconformably overlying, chemically mature, texturally immature quartz-rich clastic rocks with detrital zircons older than 2948 Ma (Davis and Moore, 1991), indicating that Mesoarchean granitoid basement rocks of tonalitic/trondhjemitic to granitic composition were the source of clastic detritus at an early stage in the development of the greenstone belt. The Jutten sedimentary sequence appears to be conformably overlain by submarine tholeiitic basalts of the Jutten Group, since these mafic volcanic rocks face away from similar-facing clastic rocks. The Jutten Group is believed to be Mesoarchean (ca. 2850 Ma) in age, but may correlate with ca. 2775 Ma (Davis et al., 1985) tholeiites of the Fourbay Lake assemblage (Trowell, 1983) in the Sturgeon Lake belt to the south.

Calc-alkalic Handy Lake Group volcanism and associated felsic magmatism (i.e., Lewis Lake batholith) from 2745 Ma is interpreted to have taken place in an oceanic environment (Sanborn-Barrie and Skulski, 1999), because these Neoarchean rocks show no petrologic or isotopic evidence of contamination by, or interaction with, continental crust (Skulski et al., 1999). Late to postvolcanic clastic rocks of the Savant Group everywhere separate the Jutten Group from the Handy Lake Group and are interpreted to have formed in an foredeep setting during arc (Handy Lake) - continent (Jutten Group) collision (Sanborn-Barrie and Skulski, 1999). Deposition < 2704 Ma of basal polymictic conglomerate of the Narrows formation was preceeded, or accompanied by tilting and erosion of Jutten mafic volcanics and plutonic rocks that cut the Jutten, and followed by conformable deposition of fine-grained feldspathic wacke, lithic wacke and magnetite-chert ironstone of the Savant group and volcanic rocks of the areally restricted Whimbrel Lake volcanics.

Collision-related regional-scale D_1 deformation initiated at ca. 2703 Ma resulted in folding of all supracrustal units about shallow-plunging, northwest-striking F_1 folds and widespread development of bedding-parallel foliation (S_1) and extensional lineation (L_1). Fabric elements are consistent with subhorizontal, northeast-directed shortening during D_1. Regional-scale D_2 deformation involved refolding of F_1 folds, and penetrative development of a 45°- to 60°- striking, steeply dipping schistosity which overprints and crenulates S_1. Extension lineations on S_2 are moderately to steeply east-plunging. D_2 fabric elements are less penetrative within rheologically strong mafic volcanic rocks of the Jutten group, and are localized in the 070°-trending Kashaweogama Lake shear zone, a subvertical, south-side-down, oblique-slip, ductile deformation zone.

COMPARISON BETWEEN THE SAVANT AND STURGEON LAKE GREENSTONE BELTS

The Savant Lake area is characterized by high strain, related to at least two major folding events and significant eastward shearing at ca. 2.7 Ga. In contrast, the southern part of the Sturgeon Lake greenstone belt which hosts several significant base-metal deposits is characterized by low strain with well-preserved primary volcanic structures and textures (Groves et al., 1988). However, studies by Dubé et al. (1989) and Koopman (1993) demonstrate the control of folding and faulting on the localization of mineralization at the Lyon Lake deposit, and suggest the potential for stratigraphic repetition by reverse faulting in this part of the greenstone belt.

The location of the Savant Lake greenstone belt at the northern margin of the Wabigoon Subprovince, in contrast to the Sturgeon Lake greenstone belt, in the central part of the subprovince, may account for the difference in intensity and style of deformation within these contiguous belts. Regional-scale structural studies across subprovinces in northwest Ontario have revealed that the complexity and intensity of deformation of greenstone belts increases toward the boundaries of the subprovinces (Stott et al. 1987, Thurston and Stott 1988). Greenstone belts in the margins of subprovinces are characterized by higher total strain; they commonly show evidence of two regional-scale deformation events, and are transected by a higher proportion of ductile shear zones which are discordant to bedding (Stott 1985; Stott 1986; Sanborn-Barrie 1991). In terms of mineral potential, these attributes may be both beneficial and detrimental. Ductile shear zones that transect greenstone belts close to subprovince boundaries are favourable targets for gold mineralization (Colvine et al. 1988); whereas multiple regional-scale deformation events may obscure and complicate alteration and mineralization associated with volcanogenic base-metal deposits.

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