DESCRIPTIVE NOTES

INTRODUCTION the Superior Province, northwestern Ontario (Fig. 1). This belt has had no mineral production to date, but contain 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 t 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.

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 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 peochronological 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.

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, ultramatic schist, rhyodacitic lapilli tuff, and fuchsitic siltstone ±chert, capped by nafic-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 ndicated 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).

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.

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 b Cortis et al. (1988) consists of 1) angular quartz grit supporting boulder-size clasts of trondhjemite, which may be asal to the sequence; 2) feldspathic wacke conglomerate with clasts of substrate granodiorite, ultramafic rock an rein 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 plastic sequence may represent the weathered products of an adjacent granitoid terrain. A sample of quartzo acke/quartz arenite (inverted triangle symbol #3 on Map) yielded detrital zircons of which two were concordant 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 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

Mafic Volcanic Rocks The Jutten Group is dominated by pillowed to massive mafic flows (unit 3) of tholeiitic composition. The flows are nterpreted 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 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 to 3 mm long. A transition from massive flow to breccia (interpreted as flow top breccia) occurs at several localitie 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 of the Jutten Group (unit 4a) mainly occur in the northwest part of the map area at Armit Lake, western gama Lake and Dickson Lake. In the Armit Lake area, they consist of fine- to medium-grained, massive to terpreted as intrusive sills of komatiitic composition (Trowell, 1986). A 1 m wide unit of fine-grained, strong crenulated, magnetic ultramafic rock on southern Armit Lake is in contact with mafic flows and may represent a extrusive unit. On western Kashaweogama Lake, coarse-grained ultramafic rock with an assemblage of talce-magnetite + tremolite + chlorite is exposed near the narrows with Fairchild Lake where it forms extensi outcrops which are cut locally by pegmatitic phases of the Fairchild Lake intrusion and by a plagioclase-porphyriti 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 oliated and lineated, pale-green weathering, fine-grained rocks whose weathered surface is highly pitted due to vasive 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, nedium-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

t crystals up to 6 mm, and the lack of spinifex texture are consistent with an intrusive origin for these rock

Similarly textured ultramafic rock cuts fuchsitic substrate (described above) and here an intrusive origin is indicated by

interpreted as a subvolcanic quartz porphyry (Breaks et al. 1979) and were designated the Kashaweogama Lake

Intermediate to Felsic Volcanic Rocks Restricted exposures of intermediate to felsic volcanic rocks (unit 5) are spatially associated with matic flows of the itten Group, however, it remains to be established whether these are cogenetic and representative of the upper ten Group. In central Savant Lake, intermediate and felsic volcanic rocks are exposed on two small islands, o 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 now square to rectangular sections, and 5% lithic fragments (< 4 mm) set in a quartzo-feldspathic groundmass 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 Arm e is highly folded and transected by abundant quartz veins. On the north shore of central Kashaweogama Lake nediate to felsic volcanic units are infolded with mafic flows. These felsic to intermediate rocks were previous

a 10 cm wide, finer-grained contact zone which is interpreted to be a chilled margin.

Calc-alkaline volcanic rocks of the Handy Lake Group (units 6.7.8) have been the focus of base metal exploration sin 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, roclastic 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 Co 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 etasedimentary rocks comprise predominantly feldspathic and lithic wacke with subordinate chemical sedimenta s consisting of laminated to thinly bedded magnetite ironstone, chert and silicate-facies ironstone. The young 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 he basal member of the former Evans Lake formation comprises massive to pillowed high-magnesian thole 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 ern 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

bedded volcanogenic metasedimentary rocks occur in the upper part of the formation, south and east of Evans 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 dspar and quartz-feldspar porphyritic sills (unit 9) with a U-Pb age of 2733 ± 1.0 Ma (Davis, 1996; inverted triangle nbol #5 on Map). These sills are interpreted to be subvolcanic to the Conant Lake formation. The Conant usion (Fig. 1) is spatially associated with the Handy Lake porphyritic sills and is a sill-like body of granodioritic to comagnatic volcanic pile (Bond 1979). Intermediate and felsic volcanic rocks (inverted triangle symbol #6 on Mar I at 2704±2 Ma (Davis, 1996) which are interbedded with clastic and chemical sedimentary rocks are now

ystallization age of 2745 + 1.9/-1.8 Ma (Davis and Trowell 1982). The coarsest pyroclastic rocks occur north an est of Evans Lake and accordingly, this region is interpreted as the possible site of a volcanic vent (Trowell 1986).

ne upper member of the Evans Lake formation consists of mafic metavolcanic flows and minor pyroclastic rocks

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.

Polymictic conglomerate of the Narrows Formation (unit 11) extends from Schist Lake in the far western part of the belt, rough Fairchild-Kashaweogama lakes, to the Neverfreeze-Elwood lakes area in the northwest, as island exposures hrough 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 the conglomerate vary along its strike and reflect the rock types of immediately underlying strata. In the Schis ake area, pebble- to boulder-size clasts are dominantly plagioclase porphyritic tonalite similar to the Fairchild Lake. ntrusion to the immediate north. In central Savant Lake, pebble- to cobble-size clasts of mafic volcanic rock nterflow 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 riangle symbol #9 on Map) yielded a U-Pb zircon age of 2704 \pm 1.2 Ma from three zircon fractions (Davis et al. 1988 e conglomerate in this area. A clast of blue quartz-bearing tonalite collected a few metres from the medium Polymictic conglomerate of the Narrows Formation generally grades transitionally into finer-grained clastic limentary units of the Savant Group, except west of central Savant Lake, where it appears to be interstratified with termediate 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 units, though highly folded, are typically well-bedded and well-graded, except at the base of the group where po bedded, well-graded character of feldspathic wacke which regularly alternates with silt-size lithic wacke, and th 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 he youngest detrital zircon analysed. Detritus contributed to this group may reflect far-field orogenic activit elsewhere in the western Superior Province, however the well-preserved sedimentary features and interbedde chemical sediments which characterize this group indicate that these rocks were deposited under local low-ener onditions in advance of orogenic activity ($ec{ extsf{D}}_i, \ ec{ extsf{D}}_i$) which subsequently affected all supracrustal elements of this

Felsic to intermediate volcanic rocks (unit 15) occur in west-central Savant Lake near Whimbrel Lake. These

age of ca. 2703 Ma. They consist mainly of pyroclastic deposits, although intermediate to mafic porphyritic and nygdaloidal flows and associated fragmental rocks are exposed on Whimbrel Lake. Dacite tuff and lapilli tuff are terbedded with clastic and chemical metasedimentary rocks of the Savant Group on islands in central Savant Lake. roic (unit 13) and feldspar porphyritic (unit 14) sills that cut the Savant Group are likely intrusive phases of the Near the North Arm of Savant Lake, small shoreline and island exposures of intermediate to felsic volcanic rock 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 hly 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 tonalit-gneiss, exposed 4 km northwest of the greenstone belt. These gneissic rocks, dated at 2970 ± 7 Ma (T. Skulski blished GSC II SHRIMP data, 1999; inverted triangle symbol #1 on Map), are interpreted as Mesoarchea 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 ths to the east and southwest of the belt, respectively. A marginal phase of the Lewis Lake batholith yields oreliminary U-Pb zircon age of ca. 2735 Ma (McNicoll and Whalen, 1999, unpublished data), supporting felsic Dutonism coeval with Handy Lake volcanism and with volcanogenic massive sulphide mineralization in the Sturgeon Several felsic to intermediate plutons intrude supracrustal rocks of the Savant Lake belt (Fig. 1). Deformed and orphosed intrusions include porphyritic stocks (units 9, 14) exposed on Elwood and Seldom lakes, ca. 2733 Ma ritic 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 low post-tectonic intrusions (unit 17) include the Grebe Lake stock, Wiggle Creek stock, Dickson Lake stock and North

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 and supracrustal substrate) and deposition of undated submarine tholeiites of the Jutten Group. Evidence 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 anitoid rocks (eg. ca. 2970 Ma tonalite immediately northwest of the belt) were an important source component for

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-D₁, 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 ing to the northwest, indicating that Jutten strata strike northeast in this region. These are in contact with eratic rocks of dominantly mafic volcanic provenance, as well as boulder-size clasts of ferruginous chert minor jasper pebbles. The (folded) volcanic/conglomerate contact trends 115°, at a high angle (80°) to the strike of itten strata in this region. An unconformable relationship is also apparent in the Fairchild - Kashaweogama lakes a 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 lded with conglomerate. These wacke beds strike eastward, slightly discordant to the strong foliation in 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

METAMORPHISM AND ALTERATION In general, the belt has been metamorphosed to greenschist and almandine amphibolite facies. In the Evans Lake ence of staurolite, andalusite, kyanite, cordierite and sillimanite. The peraluminous nature of altered rock Handy Lake Group is similar to that observed in footwall rocks beneath the Mattabi massive sulphide deposit klin 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 vol amphibolitic material which occurs as linear lenses and bands, diffuse matic clots, and fracture filling 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 dominantly hornblende with minor actinolite and chlorite. A more sodic variety of amphibole with a distinctive green birefringence was also noted. Anthophyllite is reported from several localities, roughly 2 km northeast and

Moderate to intense ferroan-carbonate alteration is pervasive throughout much of western and central ashaweogama Lake with lesser degrees of silicification and sericitization. A green, chromium (?) mica, likel 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 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

he most significant of the base metal occurrences in the Handy Lake Group is the Sabin occurrence (also know as the Marchington Road sulphide zone). This is a small Zn-Cu-Ag-Pb zone located on Highway 516, roughly 1.5 k 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 sphale galena with minor chalcopyrite, pyrite and pyrrhotite hosted in felsic to intermediate volcanic flows. Other mineralize avolcanics near Evans Lake, sphalerite-bearing felsic tuff, and pyrite-pyrrhotite stringers in sericitic felsic schis Highly tectonized and altered rocks within the Kashaweogama Lake shear zone have been the focus of exploration mineralization. The best gold values come from highly tectonized and altered rocks of the Jutten group wh 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 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 synaxial planar cleavage, see Map). More difficult to document are faults/thrusts between, and within, units. Fo ance, the fault (suture) postulated between the Jutten and Handy Lake groups (Sanborn-Barrie and Skulski, 1999 nterpreted 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.

events and localized shearing. In general, bedding strikes northwest and northeast.

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

f, folds are identified primarily by reversals in structural facing of volcanic and sedimentary rocks (c.f. Borradaile, 176). Traces of F, folds are parallel to bedding and are generally northwest-striking (Fig. 2 and Map), prior to modification by F₂ folds, shear zones and faults. Macroscopic F₁ folds have bedding-parallel axial surfaces and steepened during subsequent D₂ folding. Firstly, several shallow-plunging F, folds are observed in the Handy Lak Group, where an axial planar S, foliation is best preserved. Secondly, a shallow plunge to F, structures is consister with bedding-parallel S, axial planar cleavage. Thirdly, their shallow plunge would account for the scarcity of majo nges, a difficulty in identification of these folds which has been overcome by the use of opposing structural facing s to locate their axial traces.

 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 F₂ folds strike northeast to east and dip steeply (65° to 85°) south with a mean at 073/82 (Fig. 2). F₂ axes dominantl blunge moderately to steeply to the east, with a mean trend of 082° and a mean plunge of 60° and display S-, Z-, and 1000nmetry. Locally, they plunge moderately to steeply to the west-southwest. In hinge zones of major F_z folds, mino is are typically tight to isoclinal and limbless due to transposition parallel to the axial planar S_z cleavage. Specific features of several major F, folds are as follows. 1) The Jutten sedimentary sequence in northeast Savant Lake defines a northeast-striking, southwest-closing schistosity in this area strikes 055° to 060°, and is axial planar to F2. These structures indicate that Jutten mafic metavolcanic and clastic rocks are not simply a northwest-facing, homoclinal sequence as interpreted by previous 2) A series of F2 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 Armi 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.

The earliest foliation recognized, designated S₁, is axial planar to F, folds (Figs. 2, 3a). S₁ is not the dominant planar fabric throughout the belt, but is well displayed throughout the Handy Lake Group. It typically occurs as a beddingparallel, spaced cleavage of variable attitude (Fig. 3a), due to subsequent folding.

S_a is the dominant foliation throughout the greenstone belt and is a penetrative, moderately to strongly develop histosity which is characterized by a gently curvilinear east- to northeast- strike and a uniformly steep dip (Fig. 3b; n 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 recognized in that the spaced S₁ cleavage is crenulated by a pervasive, east-striking schistosity (S₂). In the eastern half of the area, a single, well-developed, steeply-dipping schistosity which strikes northeast (040° to recognized throughout the supracrustal rocks, except in zones of higher strain intensity where fabrics typicall not recognized here because: 1) the penetrative schistosity throughout the eastern area is subparallel to isity in the Handy Lake area, where both S_1 and S_2 are recognized; 2) this foliation is not bedding parallel, ibute which is diagnostic of S, and 3) mineral lineations on this fabric plunge moderately to steeply to the east. terly extension characterizes the $S_{\scriptscriptstyle 2}$ foliation in the south-central area.

In general, mineral and shape lineations in supracrustal rocks plunge moderately to steeply. They vary in trend but dominant trend toward the east, with no significant distinction in the attitude of lineations on S, and S, rast, mineral lineations in foliated to gneissic granitoid rocks in the eastern part of the area plunge moderately to

DEFORMATION ZONES ne 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 (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 teeply (65° to 88°) parallel to the direction of maximum finite extension. In the western part of the shear zone, these ions dominantly plunge steeply west; while in eastern Kashaweogama Lake and near Whimbrel Lake, lineatio llunge steeply east. These fabric elements are interpreted to reflect subvertical, oblique-slip movement on the K 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 phyllonite shear foliations, plunge shallowly, and are interpreted to have formed orthogonal to

the displacement direction. Conjugate kink bands are also common.

/ariably 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

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 kely 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 nably 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 the greenstone belt. The Jutten sedimentary sequence appears to be conformably overlain by submarine tholei basalts of the Jutten Group, since these mafic volcanic rocks face away from similar-facing clastic rocks. The Jutten up is believed to be Mesoarchean (ca. 2850 Ma) in age, but may correlate with ca. 2775 Ma (Davis et al., 1985) noleiites 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 a is interpreted to have taken place in an oceanic environment (Sanborn-Barrie and Skulski, 1999), because these nean rocks show no petrologic or isotopic evidence of contamination by, or interaction with, continental crust ulski et al., 1999). Late to postvolcanic clastic rocks of the Savant Group everywhere separate the Jutten Grou 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 onglomerate 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 Collision-related regional-scale D, deformation initiated at ca. 2703 Ma resulted in folding of all supracrustal units about shallow-plunging, northwest-striking F, folds and widespread development of bedding-parallel foliation (S,) and egional-scale D_z deformation involved refolding of F_1 folds, and penetrative development of a 45°- to 60°- striking, steeply dipping schistosity which overprints and crenulates S₁. Extension lineations on S₂ are moderately to steeply east-plunging. D₂ 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 d style of deformation within these contiguous belts. Regional-scale structural studies across subprovinces in ne 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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S₂ DATA Intrabelt intrusions Conant & Handy Lake intrusion Patterson I ake porphyry Elwood Lake intrusion D Dickson Lake stock G Grebe Lake stock He Heron Lake pluton Lewis Lake Batholith Ho Hough Lake stock North Arm pluton Tersha Lake stock Wiggle Creek stock Figure 1. Regional geology of the Savant Lake greenstone belt showing volcanic stratigraphy and granitoid rocks internal and external to the belt. Modified from Bond (1977, 1979, 1980) and Trowell (1986). Former divisions of the Handy Lake Group, E, - Evans Lake formation, C₁ - Conant Lake formation are indicated. Macroscopic F₁ folds overturned antiform, synform Figure 3. Planar tectonic fabric data. a) first generation planar foliation, S₁, showing contours of poles to planes, and trajectories of S1 (blue lines) which are axial Axial surface trace of F₂ planar to F₁ folds (Fig. 2). b) second generation planar foliation, S₂, showing anticline, syncline overturned antiform, synform contours of poles to planes with a mean pole of 343/8, corresponding to a mean orientation of 073/82 for S2, and trajectories of S2 (red lines) which are axial planar to F2 folds (Fig. 2). D₂ shear zone Macroscopic F₂ folds Figure 2. Axial surface trace of major F1 and F2 folds and shear zones of the Savant Lake greenstone belt. Stereoplots display orientation data for macroscopic F, and F2 folds, shown on map. Regional faults shown are the Kashaweogama Lake shear zone (KLSZ; discussed in text) and the Miniss River fault zone (MRFZ; Hudec 1965, Breaks et al. 1979).



Geology by M. Sanborn-Barrie; K. MacLachlan (1989), OGS; M. Cote (1990), OGS; T. Skulski (1997, 1998, 1999) and C. Hemmingway (1998) Interpretation and digital map compilation by M. Sanborn-Barrie, 1999 Co-ordinated by J. Percival through the auspices of the Western Superior NATMAP Project

Digital cartography by E. Everett, Geoscience Information Division and

L. Kemp, Continental Geoscience Division

STRUCTURAL GEOLOGY SAVANT LAKE GREENSTONE BELT WESTERN SUPERIOR PROVINCE Scale 1:100 000/Échelle 1/100 000

Her Majesty the Queen in Right of Canada, 2000
 Sa Majesté la Reine du chef du Canada, 2000

North American Datum 1927

Système de référence géodésique nord-américain, 1927

OPEN FILE 3947

Any revisions or additional geological information known to the user would be welcomed by the Geological Survey of Canada Digital base map from data compiled by Geomatics Canada, modified by the Geoscience Information Division Some geographical names subject to revision

Mean magnetic declination 2000, 1°46'W, increasing 3.7' annually. Readings

vary from 1°01'W in the SW corner to 2°29'W in the NE corner of the map

2745 +1.9/-1.8 Ma Evans Lake formation 8 <2704 Ma feldspathic wacke, West Shore formation

7 2970±7 Ma tonalite gneiss

Skulski, 1999 unpublished data

Skulski, 1999 unpublished data

<2948±3 Ma quartzose wacke</p>

V Davis and Moore, 1991

Davis and Trowell, 1982

2881 ± 2 Ma rhyodacite tuff (substrate)

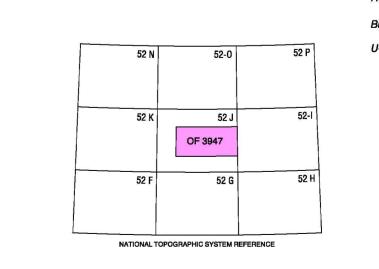
U-Pb (zircon) Ages

Davis et al., 1988

2733±1 Ma porphyritic sill, southwest of Handy Lake 9 2704±1.2 Ma tonalite clast from Narrows formation

2704±2 Ma felsic volcanic, Whimbrel Lake formation 2723±2 Ma blue quartz-bearing tonalite clast from Narrows formation

7 <2703±1 Ma feldspathic wacke, West Shore formation</p>
U ca 2700 Ma Heron Lake stock



b Biotite-hornblende tonalite ± trondhjemite ± quartz diorit

LEGEND

Plagioclase porphyritic diabase dykes, may be vesicular LATE- TO POST-TECTONIC PLUTONIC ROCKS Massive to weakly foliated, relatively unaltered and unrecrystallized 17 a Biotite and amphibole-biotite granodiorite, monzogranite ± quartz

 $monzonite \pm syenogranite$

Canada's National Geoscience Mapping Progran Le Programme national de cartographie géoscientifique du Canada

> d Leucocratic g Pegmatitic RE- TO SYN-TECTONIC PLUTONIC ROCKS Foliated, recrystallized and/or altered granitoid rocks

16 a Biotite and amphibole-biotite granodiorite \pm quartz monzonite b Biotite-hornblende tonalite ± quartz diorite ± trondhjemite d Leucocrati e Xenolithic

g Pegmatitic SAVANT GROUP Whimbrel Lake Formation 15a Rhyolitic to rhyodacitic volcanic rocks

15b Andesitic to dacitic lapilli tuff and tuff breccia, lapillistone and plagioclase-phyric flows Mafic volcanic rocks Feldspar porphyry (may be comagmatic with Whimbrel Lake volcanics)

Medium to thinly bedded, medium sand-size feldspathic wacke typically interbedded

Gabbro, diorite (may be comagmatic with Whimbrel Lake volcanics)

with thinly bedded silt-size lithic wacke and laminated magnetite-chert ironstone Narrows Formation Matrix to locally clast-supported, poorly sorted conglomerate Granitoid and volcanic \pm chemical sedimentary derived Dominantly mafic volcanic derived Dominantly felsic-intermediate volcanic derived d Medium sand-size feldspathic wacke interbeds

West Shore Formation

10 Fine to coarse-grained gabbro, biotite-hornblende diorite (Staunton Lake Stock) Light-weathering, feldspar- quartz (± blue quartz) porphyritic, intrusive/hypabyssal

rocks with 20-30% phenocrysts (Conant, Handy, and Patterson Lake porphyries, possibly also Elwood Lake porphyry), mainly comagmatic with Handy Lake Group Felsic to intermediate volcanic rocks: massive to quartz \pm feldspar-phyric flows, rare Intermediate volcanic rocks: dominantly pyroclastic deposits including tuff, crystal tuff ± hypabyssal intrusive rocks, lapilli tuff, lapillistone, tuff breccia, pyroclastic breccia,

lesser biotite- ± garnet-bearing flows Mafic to intermediate volcanic flows \pm pyroclastic deposits Intermediate to felsic metavolcanic rocks: dominantly pyroclastic tuff and breccia with minor flows ± hypabyssal rocks

Mafic metavolcanic rocks: pillowed flows and fine- to coarse-grained, locally plagioclase-phyric equigranular flows; rare interflow chert beds; gabbro Jutten sedimentary sequence: quartz-rich clastic rocks including quartzose wacke, quartzose wacke pebble to cobble conglomerate, feldspathic wacke conglomerate

Ultramafic schist; rhyodacite tuff; mylonitic fuchsitic siltstone/chert; ultramafic

Bedrock outcrop examined for this study Stratigraphic or intrusive contact (defined, approximate, inferred) Limit of geological mapping

Bedding, top (arrow) from grain gradation (inclined, vertical, overturned) ounging in volcanics, criteria other than pillows (inclined, vertical, overturned) Pillow lava flow, top (arrow) from shape and packing (inclined, vertical, overturned) \sim ounging based on pillow shape compiled from previous workers Structural facing: younging in the direction of axial plane cleavage First foliation (S,) or sole foliation where only one planar fabric observed (inclined, vertical)

Second cleavage (inclined, vertical) Compositional layering (inclined) Ductile shear zone (unknown sense of displacement) Oblique-slip shear zone, solid circle on downthrown side Ductile shear zone (apparent dextral displacement) Ductile shear zone (apparent sinistral displacement) Mineral lineation (1st generation, 2nd generation)

Second foliation (S2) (inclined, vertical)

First cleavage (inclined)

Mineral lineation in shear zone (1st generation, 2nd generation) Minor F, fold with plunge (S-, U-symmetry) . Minor F₂ fold with plunge (Z-, S-, U-, W-symmetry) . Axial plane of macroscopic fold (occurs with fold axis) .

Axial trace of first generation (F₁) syncline (upright; overturned, Axial trace of first generation (F,) anticline (upright; overturned,

Axial trace of second generation (F2) synform (upright; overturned, Axial trace of second generation (F2) antiform (upright; overturned, Regionally extensive high-strain zone, solid circle on downthrown side

U-Pb age determination site

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Whimbrel Lake Formation