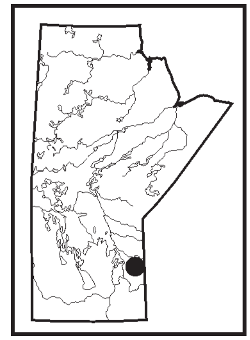
GS-20 Preliminary results and economic significance of geological mapping and structural analysis in the Rice Lake area, central Rice Lake greenstone belt, Manitoba (NTS 52M4 and 52L13)

by S.D. Anderson



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Summary

In 2004, the focus of the Rice Lake gold metallogeny project shifted to the economically important Rice Lake area in the central Rice Lake greenstone belt. A new threefold subdivision is proposed for the Bidou assemblage north and east of Rice Lake, which includes three distinct lithostratigraphic associations that are informally termed the Rainy Lake Road, Townsite and Round Lake sections. The medial unit of the Rainy Lake Road section, which appears to record a transition from subaerial felsic volcanism to subaqueous mafic volcanism, includes a heterolithic rhyolite debris flow that contains clasts of solid sulphide (pyrrhotite-chalcopyrite), suggesting coeval base-metal exhalative activity. The lithostratigraphy of the Rainy Lake Road section indicates a possible correlation with the Manigotagan River Formation southeast of the Ross River Pluton, and thus the potential for an unrecognized base-metal metallotect in the Rice Lake belt. Mesoscopic overprinting relationships, coupled with inferences drawn from macroscopic map patterns, indicate six distinct generations (D_1–D_6) of ductile and ductile-brittle deformation structures in the Rice Lake area. Newly recognized outcrop-scale examples of 'San Antonio–type' vein systems on surface north of Bissett will be examined in the context of this structural framework, to further constrain the relative timing, tectonic setting, and orogenic significance of lode-gold mineralization in the Rice Lake belt.

Introduction

With historic gold production of approximately 1.73 million ounces from several past-producing mines, including 1.42 million ounces from the San Antonio mine at Bissett, the Rice Lake greenstone belt is the most significant lode-gold district in Manitoba. The Rice Lake gold metallogeny project was initiated in 2002 by the Manitoba Geological Survey with the objective of updating the understanding of the stratigraphy, structure and tectonic evolution of selected portions of the Rice Lake belt, with particular emphasis on gold metallogeny. This multiyear project involves 1:20 000-scale mapping, structural analysis, lithogeochemistry and U-Pb geochronology, with the goal of providing an improved predictive framework for gold deposits in the Rice Lake belt. The results of fieldwork completed in years one and two of this project, which focused on the Garner Lake area in the southeast portion of the belt, have been summarized by Anderson (2002, 2003a, 2003b).

In 2004, the focus of the project shifted to the economically important Rice Lake area in the central Rice Lake belt (Figure GS-20-1). Previous mapping at regional (Stockwell, 1945; Davies, 1963) and local (Stockwell, 1938; Davies, 1953) scales provides an excellent geological base in this area. More recent studies, mostly completed under the auspices of Canada-Manitoba Mineral Development agreements (1984–1994) and the Western Superior NATMAP project, provide important insights into the geology, geochemistry, geochronology, structure, hydrothermal alteration and gold mineralization of the Rice Lake area (e.g., Poulsen et al., 1986, 1994; Tirschmann, 1986; Ames, 1988; Lau, 1988; Turek et al., 1989; Ames et al., 1991; Theyer, 1994; Bailes, 1998, 1999), and much of this work has been incorporated into regional metallogenic (Poulsen et al., 1996) and tectonostratigraphic (Bailes et al., 2003) syntheses of the belt.

Nevertheless, several fundamental aspects of the geology and metallogeny of the Rice Lake area remain unresolved. For example, although the Neoarchean stratigraphy is well established in the southeast Rice Lake belt (e.g., Campbell, 1971; Brommecker, 1996), a lack of younging criteria and geochronological constraints, coupled with structural complexities, have frustrated attempts to unravel the stratigraphy of similar-age rocks in the central and western portions of the belt (e.g., Bailes, 1998, 1999). In addition, despite the fact that the Rice Lake area has been the focus of numerous studies concerned with the structural setting of lode-gold mineralization (e.g., Stockwell, 1938; Davies, 1953, 1963; Skerl, 1955; Poulsen et al., 1986; Lau, 1988), the relative and absolute timing of regional and mine-scale structures, their relationships to gold mineralization and their tectonic significance remain poorly understood.

In light of these problems, a roughly 80 km^2 area centred on Rice Lake was mapped at a scale of 1:20 000 during the 2004 field season (Figure GS-20-2), with particular emphasis on new bedrock exposures created during construction of the tailings impoundment and trailer park north of Bissett, and new logging roads northwest of Horseshoe Lake and east of Rice Lake. The area under investigation includes that mapped at 1:10 000 scale by D. Ames, A. Galley and

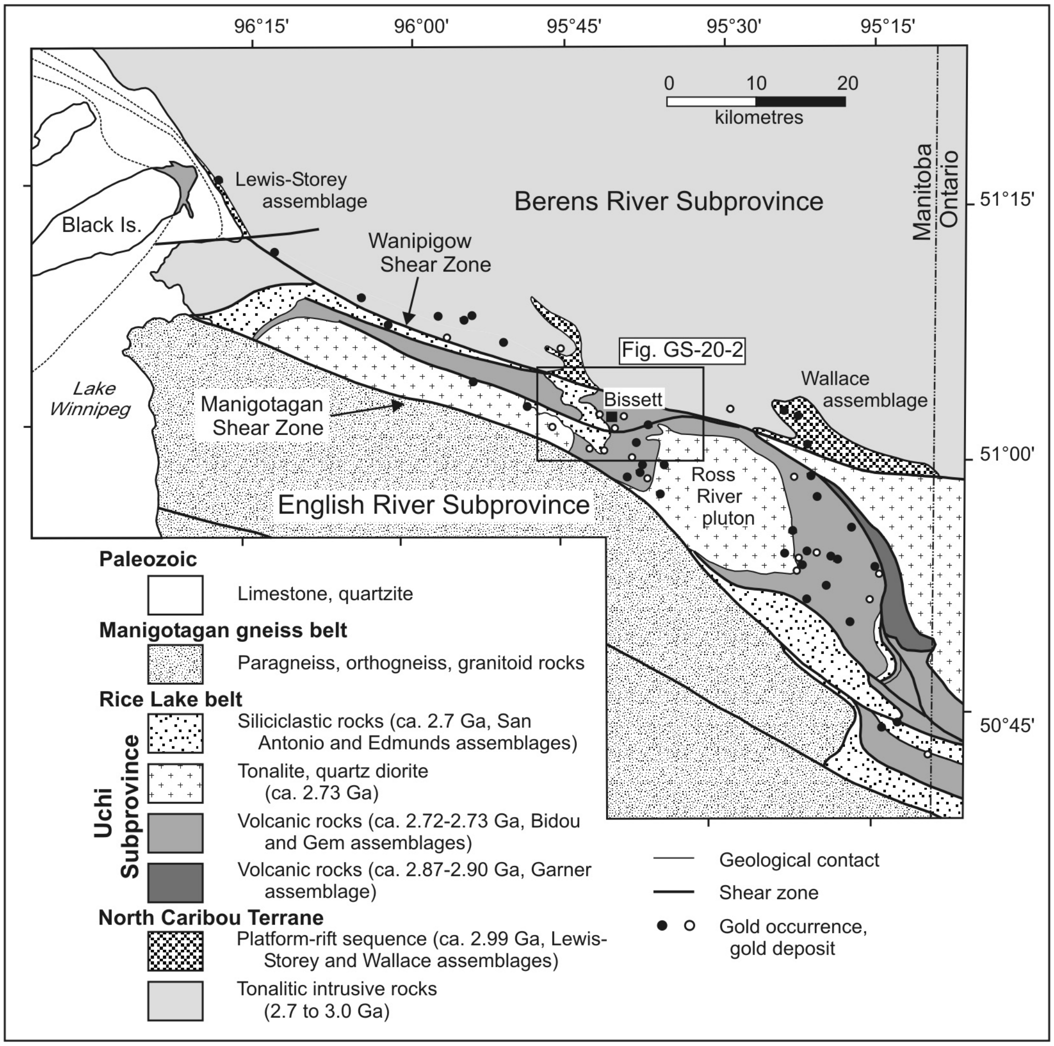


Figure GS-20-1: *Simplified geology of the Rice Lake belt, showing the location of Figure GS-20-2.*

H. Poulsen in 1985, as described by Poulsen et al. (1986). During the 2004 fieldwork, a suite of 17 least altered rock samples was collected and will be analyzed by high-precision instrumental neutron activation analysis (INAA) and inductively coupled plasma–mass spectrometry (ICP-MS) methods to provide trace and rare earth element data to complement that obtained by Bailes (1998, 1999). Two 20 kg samples of felsic volcanic rock were collected for thermal ionization mass spectrometry (TIMS) to provide U-Pb (zircon) ages for volcanism in the Rice Lake area.

Regional setting

The Rice Lake greenstone belt is situated in the western Uchi Subprovince of the Archean Superior Province. In Manitoba, the volcanoplutonic Uchi Subprovince is flanked to the north by the North Caribou continental terrane (Berens River Subprovince) and to the south by the metasedimentary Manigotagan gneiss belt of the English River Subprovince (Figure GS-20-1). The North Caribou Terrane (Thurston et al., 1991) comprises a ca. 3.0 Ga, dominantly tonalitic basement complex that is nonconformably overlain by ca. 2.99 Ga platform-rift sequences, and intruded by predominantly ca. 2.92 and 2.73 Ga granitoid plutons. The platform-rift sequences, as represented by the Lewis-Storey and Wallace assemblages, consist of basal quartz-rich clastic rocks overlain by intercalated iron formation and komatiite flows, and are thought to record continental rifting and plume-related magmatism along the south margin of the North Caribou Terrane (Percival et al., 2002). To the south, the North Caribou Terrane is bounded by the regional-scale Wanipigow Shear Zone (WSZ). The English River Subprovince, which is bounded to the north by the Manigotagan Shear Zone, consists of ca. 2.69 Ga paragneiss, orthogneiss and granitoid plutons that formed during high-T–low-P

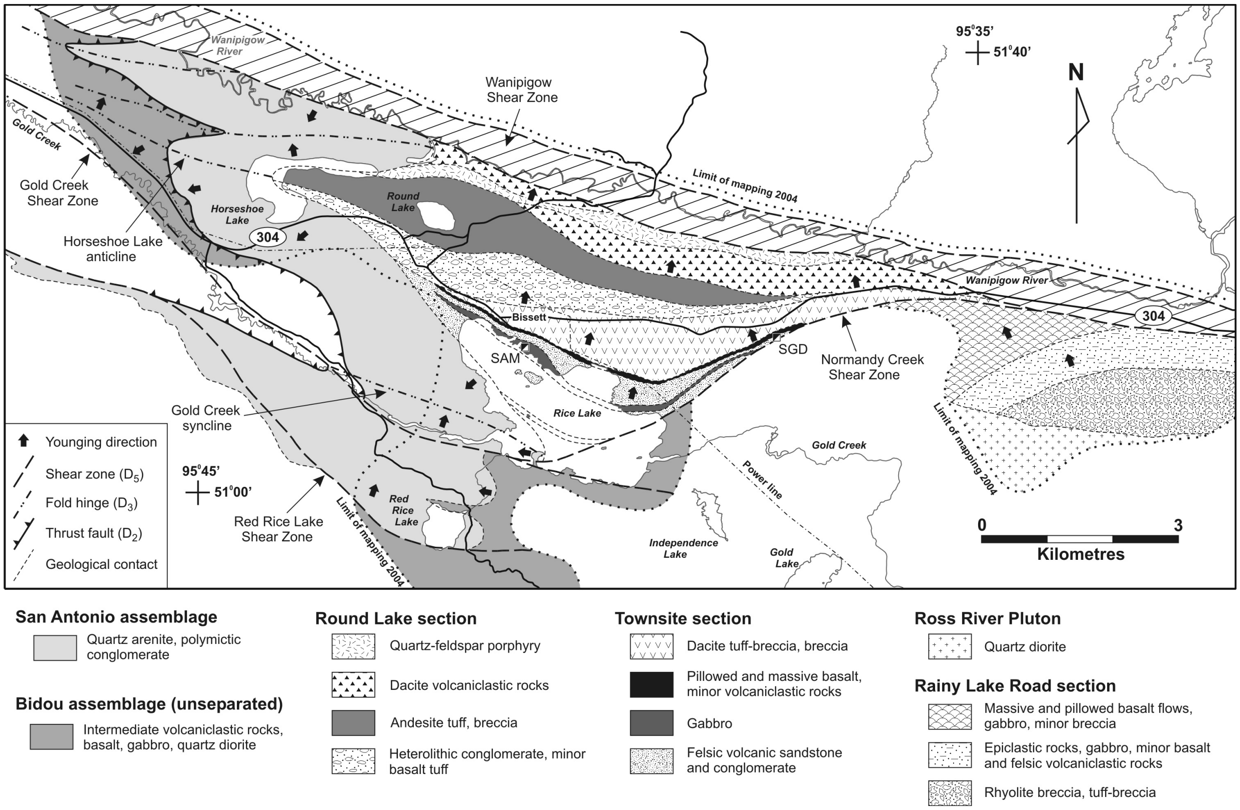


Figure GS-20-2: *Simplified geology of the Rice Lake area (*see *Figure GS-20-1 for location). The map pattern of the San Antonio assemblage is based on mapping by the author, and that of Stockwell (1938) and Davies (1963) in those areas not covered in 2004. Abbreviations: SAM, San Antonio mine; SGD, San Gold deposit.*

regional metamorphism of ca. 2.7 Ga metasedimentary rocks (Corfu et al., 1995). Lower grade equivalents of these rocks, known as the Edmunds assemblage, overlap the Rice Lake belt to the south (e.g., Bailes et al., 2003).

The Rice Lake greenstone belt, which defines the Uchi Subprovince in Manitoba, consists mainly of tholeiitic and calcalkaline volcanic rocks of oceanic affinity, which range in composition from basalt to rhyolite and are intercalated with synvolcanic mafic sills and derived epiclastic sedimentary rocks. In the eastern Rice Lake belt, these rocks are presently subdivided into the Neoarchean (ca. 2.72–2.73 Ga) Bidou and Gem assemblages, and the Mesoarchean (ca. 2.87–2.90 Ga) Garner assemblage, which includes a thick succession of komatiite flows (e.g., Poulsen et al., 1996; Anderson, 2003a; Bailes et al., 2003). These rocks are intruded by tonalite, quartz diorite and granodiorite plutons, which include the ca. 2.73 Ga (Turek et al., 1989) Ross River pluton in the central portion of the belt (Figure GS-20-1). Fluvial and alluvial siliciclastic rocks of the San Antonio assemblage unconformably overlie these rocks and contain detrital zircons as young as 2.704 Ga (Percival et al., 2002). These rocks likely represent the proximal equivalents to the more distal Edmunds assemblage.

Local geology and stratigraphy

The Rice Lake area has been mapped in considerable detail (e.g., Stockwell, 1938, 1945; Davies, 1953, 1963; Poulsen et al., 1986; Tirschmann, 1986; Ames, 1988). Between the south shore of Rice Lake and the WSZ, previous authors have described an upright, homoclinal succession of predominantly intermediate to felsic volcaniclastic rocks that dips moderately north. Poulsen et al. (1996) subdivided these rocks, from south to north, into a series of informal map units, which include the Hare's Island, Shoreline, Townsite and Round Lake volcanic units. The Hare's Island unit yielded a U-Pb zircon age of 2729 ±3 Ma, which overlaps the 2731 ±3 Ma age obtained from the Bidou assemblage in the southeast portion of the belt (Turek et al., 1989). The Hare's Island unit is intruded by several tholeiitic gabbro sills (Ames, 1988), including the San Antonio sill that hosts the ca. 1.5 million ounce San Antonio gold deposit. In the area extending from south of Rice Lake to the Manigotagan Shear Zone, Stockwell (1938) and Davies (1953) mapped a thick section of heterolithic felsic to intermediate volcaniclastic rocks that are presumed to be of Bidou affinity, although the geology in this area remains poorly understood (e.g., Bailes, 1998). These rocks are intruded to the east by porphyritic quartz diorite of the Ross River pluton. To the west, the San Antonio assemblage forms a 2–3 km thick, broadly S-shaped map unit that trends across the regional strike of the Rice Lake belt (Figure GS-20-2).

The 2004 mapping has not resulted in significant changes to the overall map patterns defined by previous workers. On the basis of this mapping, however, a new threefold subdivision is proposed for the Bidou assemblage north and east of Rice Lake, which includes three distinct lithostratigraphic associations that are informally termed the Rainy Lake Road (RLR), Townsite, and Round Lake sections (Figure GS-20-2). These sections are described in detail below, in order of decreasing apparent age. The Bidou assemblage south of Rice Lake and west of Horseshoe Lake was only briefly examined in 2004 and is not described in this report. Metamorphic mineral assemblages in the map area indicate low to middle greenschist facies regional metamorphism; in the interest of brevity, however, the prefix 'meta' is omitted from the rock descriptions.

Bidou assemblage

Rainy Lake Road (RLR) section

The RLR section is best exposed in a series of clean outcrops along the recently constructed Rainy Lake logging road, which branches to the south off Provincial Road 304 approximately 7.5 km east of Bissett. The section is at least 2.6 km thick and comprises three southwest-trending, northwest-younging units that appear to record a transition from subaerial, felsic-dominated volcanism to subaqueous, mafic-dominated volcanism in the Bidou assemblage. The Normandy Creek Shear Zone (NCSZ), which dips steeply northwest, separates the RLR section from the Townsite section to the northwest (Figure GS-20-2). To the south, the section is intruded by quartz diorite of the Ross River pluton, which characteristically contains euhedral phenocrysts of plagioclase and hornblende that range in size up to 1.5 cm. Dikes and sills of porphyritic quartz diorite, which range up to 15 m in thickness, are abundant in the RLR section and are not observed northwest of the NCSZ. This, together with the fact that bedding on either side of the NCSZ consistently faces in opposite directions on the regional, west-northwest–trending cleavage, suggest that the upper contact of the RLR section is tectonic. Despite its proximity to the regional-scale WSZ, the RLR section is characterized by an anomalously low state of strain, and thus contains remarkably well preserved primary features.

Rhyolitic volcaniclastic rocks

The base of the RLR section consists of rhyolitic volcaniclastic rocks that are at least 1 km thick. The rhyolite is light grey or white on weathered surfaces, and dark grey to black on fresh surfaces. In the upper 300 m of the unit, the rhyolite is generally aphyric or sparsely quartz phyric, whereas that in the lower portion is distinctly plagioclase phyric and contains 10–20%, plagioclase crystals. These crystals range in size up to 10 mm and are evenly distributed in a siliceous, dark grey or black, aphanitic matrix. The rhyolite typically exhibits coarse fragmental textures, and consists predominantly of intercalated breccia and tuff-breccia, with minor lapilli tuff. The breccia units are typically monolithic, matrix supported and unsorted, and contain angular to well-rounded fragments up to 50 cm across. The fragments range from equant to tabular, and locally exhibit distinctly finer grained, almost vitreous margins and a delicate, shard-like morphology that are suggestive of pyroclastic or hyaloclastic fragmentation. The breccia units contain rare intercalations, up to 5 m thick, of well-bedded tuffaceous sandstone and siltstone, with minor chert. Individual beds range up to 10 cm thick and locally exhibit normal grading. The overall characteristics of this unit suggest minor subaerial reworking of primary pyroclastic material, with final deposition in a subaqueous environment, likely via debris-flow mechanisms. These rocks are intruded by dikes and sills of fine-grained, weakly pyroxene-phyric gabbro, which range up to 3.0 m thick and have well-developed chilled margins.

Epiclastic rocks

The rhyolitic volcaniclastic rocks are overlain to the north by a complex, approximately 450 m thick unit that marks the transition from subaerial felsic volcanism to subaqueous mafic volcanism, and consists mainly of epiclastic sedimentary rocks, intercalated with minor massive to pillowed basalt flows, flow breccias and felsic pyroclastic rocks. Sills and dikes of fine- to medium-grained, typically pyroxene-phyric gabbro account for at least 40% of this unit, and locally range up to 80 m thick. On the Rainy Lake road, the base of the unit is marked by a layer of mafic breccia that is at least 5 m thick. The breccia is unsorted and clast supported, and consists of angular, blocky fragments of weakly pyroxene-phyric basalt that range up to 50 cm across. Significantly, the fragments locally exhibit chilled margins, and the breccia is crosscut by texturally similar, pyroxene-phyric gabbro dikes with thick (5–15 cm) chilled margins, which is suggestive of a subvolcanic feeder relationship between the dikes and the breccia. Angular fragments of aphyric rhyolite constitute up to 5% of the breccia.

The epiclastic rocks consist of interbedded mudstone, chert, siltstone and medium- to coarse-grained, pebbly feldspathic wacke. These rocks are characterized by well-developed planar beds that are typically 2–10 cm thick, but locally range up to 50 cm. Bedding in these rocks generally dips at moderate angles to the northwest, and normal-graded beds, load casts and local crossbeds indicate that the rocks are upright. The wacke beds commonly contain tabular rip-up clasts of mudstone and chert. These features, together with the common presence of partial Bouma sequences, indicate subaqueous deposition via downslope sediment gravity flows.

The epiclastic unit contains subordinate (<10%) intercalations of pillowed basalt and subaqueously deposited felsic pyroclastic, and secondary pyroclastic, material. The pillowed basalt is exposed in one location, and occurs as a 5 m thick flow within a package of thick-bedded feldspathic wacke. The basalt is light green to grey, aphyric and nonamygdaloidal, and forms bun-shaped pillows up to 50 cm across. Interpillow material accounts for up to 5% of the rock and consists of laminated cherty mudstone, with minor chloritic hyaloclastite. In another location, thin (<10 cm) beds of massive aphyric tuff are rhythmically interlayered with black chert. The tuff beds locally contain up to 5%, angular to subrounded, slightly vesicular lapilli that are concentrated in discrete zones in the middle to upper portions of otherwise massive beds, and are interpreted as pumice fragments. A massive layer of heterolithic lapilli tuff is exposed immediately below the upper contact of the epiclastic unit. This layer is 3 m thick, and contains 20–50%, angular to subrounded lapilli, up to 5 cm across, that are supported in a matrix of crystal-lithic tuff. The dominant lapilli type is dark grey rhyolite, which ranges from aphyric to coarsely plagioclase and quartz phyric. Also present are highly elongate, wispy fragments of dark grey or brown, aphanitic siliceous material, which appear to represent welded pumice. Lithic fragments include chert and laminated mudstone, with minor amygdaloidal basalt. Significantly, this bed also contains up to 2% subangular to subrounded pebbles of solid sulphide (pyrrhotite-chalcopyrite) that range up to 3 cm across (Figure GS-20-3). This bed likely represents a subaqueous debris flow, composed of primary or early secondary pyroclastic material that was shed off the flanks of a nearby felsic volcanic centre. The solid sulphide clasts indicate coeval base-metal exhalative activity. This unit was sampled for U-Pb (zircon) geochronological analysis.

Mafic volcanic rocks

The upper unit of the RLR section is at least 1.2 km thick, and consists of massive and pillowed basalt flows, gabbro sills and minor mafic breccia. The basalt is generally fine grained and aphyric, with a light grey or pale green weathered surface and dark green fresh surface. Pillowed basalt predominates, and consists of slightly elongate to bun-shaped to amoeboid pillows up to 1.5 m across. In several locations, molar-shaped pillows indicate that this unit youngs to the northwest. The pillow selvages are generally less than 2 cm thick and strongly chloritized. Interpillow material accounts for 2–5% of the rock, and includes well-preserved examples of hyaloclastite. The pillows contain round quartz- or calcite-filled amygdules that range up to 1 cm across and locally appear to be preferentially concentrated along the northwest margins of individual pillows. The gabbro is typically massive, with a slightly coarser grain size than the basalt and a well-developed subophitic texture. It contains up to 10% plagioclase phenocrysts (<2.0 cm) and is crosscut by thin, irregular basalt dikes with well-developed chilled margins. The gabbro locally grades into pillowed basalt, indicating that at least some of these rocks are probably massive basalt flows.

Figure GS-20-3: *Heterolithic lapilli tuff with solid sulphide clasts (indicated by arrows) near the upper contact of the epiclastic unit in the RLR section, 50 m south of kilometre one on the Rainy Lake logging road.*

Townsite section

The Townsite section trends northwest, dips moderately northeast or north and is at least 1.7 km thick. The section consists of felsic epiclastic rocks, overlain to the north by mafic volcanic rocks and a thick package of volcaniclastic dacite. From south to north, respectively, these units correspond with the Hare's Island, Shoreline and Townsite volcanic units of Poulsen et al. (1996), portions of which have been described in detail by previous workers (e.g., Tirschmann, 1986; Ames, 1988). The Townsite section is truncated to the southeast by the NCSZ and unconformably overlain to the southwest by an overturned, southwest-younging section of the San Antonio assemblage (Figure GS-20-2). As described below, the northern contact of the Townsite section may represent an important disconformity within the Bidou assemblage.

Felsic epiclastic rocks

The base of the Townsite section consists of a thick (>1.0 km) succession of immature volcanic sandstone and conglomerate, with minor thin-bedded intervals of siltstone, sandstone and chert. These rocks are best observed on island and shoreline exposures on Rice Lake. Massive to faintly layered, medium- to coarse-grained volcanic sandstone, which weathers distinctively white or pale grey, is the dominant rock type and contains up to 25% angular to well-rounded quartz crystals (<5 mm). Subangular to rounded lithic clasts, up to 1 cm across, account for up to 5% of this rock and consist mainly of aphyric and quartz-phyric rhyolite. Well-developed bed forms are present locally, and include partial Bouma sequences, indicative of subaqueous deposition via downslope sediment gravity flows. Bedding dips moderately north, and graded beds and a scour in one location indicate tops to the north. The sandstone is intercalated with heterolithic volcanic conglomerate that is typically clast supported and unsorted, and forms massive layers that are locally more than 40 m thick. Clasts in the conglomerate are generally equant, angular to well rounded and up to 25 cm across (typically 2–5 cm). Weakly plagioclase- and/or quartz-phyric rhyolite are the predominant clast types. The conglomerate is best exposed on Hare's Island, and appears to become coarser and more heterolithic toward the north. As described by Tirschmann (1986), these rocks locally contain brownish wispy fragments, up to 5 cm long, that may represent flattened pumice. These rocks are intruded by several tholeiitic gabbro sills, which are compositionally similar to the overlying Shoreline volcanic unit (Ames, 1988), perhaps indicating a synvolcanic relationship. The largest example, the San Antonio sill, locally ranges up to 195 m thick and is weakly differentiated from a melagabbro base to a leucogabbro top (Ames, 1988).

Mafic volcanic rocks

The Shoreline volcanic unit (Poulsen et al., 1996) is best exposed along the northeast shoreline of Rice Lake, where the unit is 50–100 m thick and composed of massive and pillowed basalt, with minor pillow breccia, gabbro and derived epiclastic sedimentary rocks. The basalt weathers light to dark brown or green, has a dark green fresh surface, and is typically aphyric to weakly plagioclase phyric. The basalt forms bun-shaped or locally amoeboid pillows, up to 50 cm across, that locally exhibit strongly epidotized cores. In some locations, the pillows contain 5–10% round, epidote-filled amygdules up to 0.5 cm across. Interpillow hyaloclastite is locally preserved and generally accounts for less than 5% of the rock. Pillow cusps in two locations indicate tops to north. Along the power line east of Rice Lake, this unit includes a 5 m thick section of mafic epiclastic rocks, which consists of well-bedded, fine- to medium-grained volcanic sandstone, with minor pebble conglomerate, siltstone and chert. Bedding dips north, and fining-upward cycles, up to 1 m thick, indicate that these rocks are likely upright.

The upper contact of the Shoreline volcanic unit is well exposed 50 m north of the main San Gold deposit (Figure GS-20-2). In this outcrop, epidotized pillowed basalt and pillow breccia with wisps of laminated interpillow sedimentary material are overlain to the north by massive plagioclase-phyric dacite. Separating these units is a 2.0 m thick interval of interlayered crystal-rich tuffaceous sandstone, pillow breccia and thinly bedded, fine-grained epiclastic rocks, including minor chert. Bedding dips steeply northwest, and the sandstone beds typically fine to the north and contain angular rip-up clasts of the underlying basalt (Figure GS-20-4). This contact appears conformable, perhaps with a minor depositional hiatus, as indicated by the presence of bedded chert.

Dacitic volcaniclastic rocks

The uppermost unit in the Townsite section ranges up to 600 m thick, and consists of dacitic volcaniclastic rocks that are well exposed in the large ridge extending east from Bissett. The dacite weathers pale green-grey and is dark green on fresh surfaces. Coarse, plagioclase-phyric textures dominate, and the dacite characteristically contains 25–50% euhedral

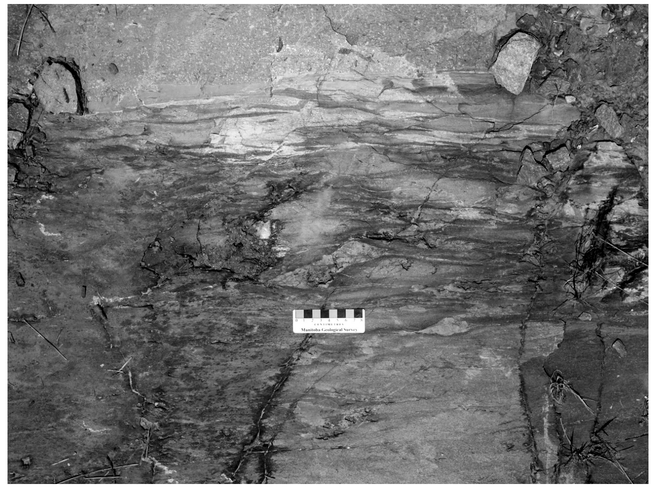


Figure GS-20-4: *Upper contact of the Shoreline volcanic unit of the Townsite section, showing pillow breccia overlain by bedded, crystal-rich tuffaceous sandstone, 50 m north of the main San Gold deposit. Note the angular rip-up clasts of basalt.*

to subhedral plagioclase crystals that range up to 1 cm and are evenly distributed in an aphanitic to fine-grained, weakly chloritic matrix. Locally, the dacite also contains 1–2% anhedral blue-quartz crystals up to 5 mm across. Very angular, broken fragments of plagioclase locally account for up to 10% of the rock. The dacite mainly exhibits coarse fragmental textures, and consists predominantly of intercalated monolithic tuff-breccia and breccia, with thick intervals of massive crystal tuff. The breccia is typically matrix supported and unsorted, and contains angular to subrounded fragments that range in size up to 1.0 m (generally 20–40 cm). The fragment shapes tend to be equant, although highly irregular, blocky fragments are locally observed. Typically, the fragments are more coarsely and/or densely plagioclase phyric than the matrix, and often exhibit diffuse margins that are suggestive of in situ disaggregation. In several locations, these fragments are closely associated with rounded clasts of texturally identical material (Figure GS-20-5), suggesting minor subaerial or shallow subaqueous reworking of a weakly lithified precursor. The breccias contain rare intercalations, up to 5 m thick, of well-bedded tuffaceous sandstone. Individual beds range up to 30 cm thick and locally exhibit normal and reverse grading. The beds dip moderately north, and scours in two locations indicate that these rocks are upright. As proposed by Tirschmann (1986), the overall characteristics of these rocks are most consistent with subaqueously deposited pyroclastic and secondary pyroclastic material.

Round Lake section

The Round Lake section consists of a basal heterolithic conglomerate unit, overlain to the north by a succession of volcanic and volcaniclastic rocks that appears to progress up section from andesite through dacite to rhyolite. Unlike the underlying RLR and Townsite sections, mafic intrusions are apparently absent in the Round Lake section, and the constituent volcanic rocks are, in places, distinctly hornblende phyric. The Round Lake section trends west, dips moderately north and ranges up to 2.5 km thick. This section is truncated to the north and east by the WSZ, and to the west is unconformably overlain by the west-younging San Antonio assemblage. Apparent finite strain generally increases

Figure GS-20-5: *Well-rounded clasts (left) and disaggregated fragments (lower right) of plagioclase-phyric dacite in tuff-breccia near the top of the Townsite section, 1.0 km east of the San Antonio mine.*

toward the east in this section, and the aspect ratios of deformed clasts in horizontal outcrop surfaces near the confluence of the NCSZ and WSZ locally exceed 100:1. This fact may explain the progressive eastward decrease in thickness, and local pinching out, of the map units in the Round Lake section (Figure GS-20-2).

Heterolithic volcanic conglomerate

The heterolithic volcanic conglomerate at the base of the Round Lake section ranges from 350 to 850 m thick. This conglomerate is typically massive, matrix supported and unsorted, and contains very well rounded to subangular clasts that range up to 2.5 m across (typically 20–50 cm). The high degree of rounding, coupled with the common presence of narrow (<2 cm) bleached margins on the clasts, suggest significant subaerial transport and weathering, probably in a braided stream or alluvial environment. The clast population is mainly representative of the underlying Townsite section. The matrix consists of light grey to brown, fine- to coarse-grained feldspathic wacke that generally lacks coarse detrital quartz. Crudely layered intervals, defined by subtle changes in the proportion of clasts and matrix on a 1–10 m scale, are observed near the base of this unit and include minor interbeds of medium- to coarse-grained sandstone up to 50 cm thick. The conglomerate locally contains distinct, 1–3 m thick layers in which hornblende-phyric andesite constitutes up to 90% of the clast population.

The contact with the underlying Townsite section is well exposed in several large outcrops immediately north of the new trailer park in Bissett, and is clearly depositional. Here, the top of the Townsite section is marked by 2–3 m of variably reworked porphyritic dacite breccia, overlain to the north by a 35–40 m thick unit of heterolithic conglomerate in which the proportion of porphyritic dacite clasts decreases northward from 90% to less than 20%. In this location, the porphyritic dacite is crosscut by several dikes of fine-grained, sparsely plagioclase- and pyroxene-phyric basalt that range up to 2.5 m thick and have well-developed chilled margins. These dikes were not observed north of the contact. Instead, the conglomerate contains texturally similar fragments of dark green basalt that locally constitute up to 80% of the clast population. These fragments, which range up to 20 cm across, are commonly very angular, and many exhibit delicate cuspate shapes (Figure GS-20-6). Several fragments have distinctly finer grained, dark green rims, suggestive of chilled margins. In one location, approximately 35 m above the basal contact, the conglomerate also contains a 10 m thick layer of massive mafic tuff that contains angular to wispy lapilli of aphanitic black basalt (Figure GS-20-7). The lower contact of this layer is exposed in one location, and is very sharp. These features indicate coeval mafic volcanism and high-energy, subaerial sedimentation at the base of the Round Lake section, perhaps indicative of an arc-rift depositional setting. The geochemical signatures of the mafic dikes and tuff will be examined to evaluate the merits of this hypothesis.

Andesitic volcaniclastic rocks

The medial portion of the Round Lake section contains a poorly exposed unit of andesitic volcaniclastic rock that ranges up to 1.2 km thick. The andesite weathers pale green-grey to buff-brown, and is dark green or grey on fresh surfaces. The dominant rock type is a massive to moderately well layered crystal tuff that contains euhedral plagioclase (10–20%) and hornblende (3–10%, rarely up to 30%) crystals that range in size up to 1 cm. Anhedral quartz crystals (<2 mm) are locally observed, but do not exceed 2% of the rock. In many outcrops, subtle variations in the proportion

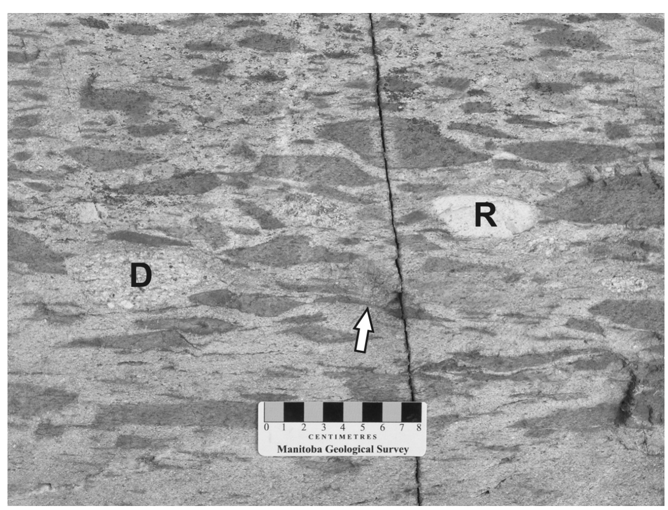


Figure GS-20-6: *Angular basalt fragments in heterolithic volcanic conglomerate at the base of the Round Lake section, north of the new trailer park in Bissett. Note the cuspate basalt fragment (indicated by arrow) and the contrast with the rounded clasts of aphyric rhyolite (R) and plagioclase-phyric dacite (D).*

Figure GS-20-7: *Mafic tuff containing minor, angular basalt lapilli near the base of the Round Lake section, 30 m north of the town soccer pitch in Bissett.*

and size of these crystals define diffuse, laterally continuous layers up to 50 cm thick. In other locations, massive crystal tuff forms distinct, 50 cm thick layers intercalated with massive andesite breccia and tuff-breccia. The breccia layers are unsorted, matrix or clast supported and typically monolithic, although heterolithic breccia is common near the base of the unit. The subangular to subrounded fragments, which range up to 40 cm across, are typically texturally similar to the crystal tuff, although often more densely plagioclase phyric.

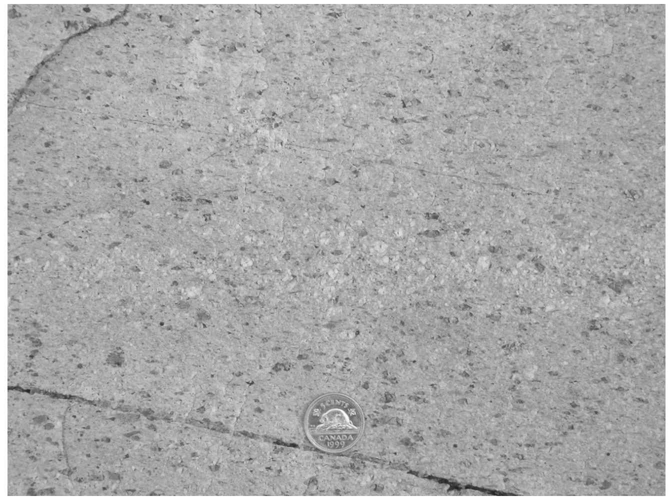
Dacitic volcaniclastic rocks

The andesite is overlain to the north by variably reworked dacitic volcaniclastic rocks that define a very heterogeneous, 400–450 m thick succession of intercalated breccia, tuff-breccia and lapilli tuff, including thick intervals of well-layered volcanic conglomerate, sandstone and siltstone. In the field, the contact with the underlying andesite is generally gradational over 30–50 m, and was defined on the basis of the first appearance of significant (>2%) coarse detrital quartz, as well as clasts of light grey, quartz-phyric dacite. These rocks typically weather buff to light grey, and are grey or green on fresh surface. In general, the breccia layers are more massive, unsorted and monolithic than the conglomerate layers, and contain a higher proportion of angular to subangular clasts. The conglomerate layers locally contain well-rounded boulders up to more than 1 m across, and typically fine upward or downward into thin-bedded (<30 cm thick) intervals of dark grey, fine- to medium-grained, pebbly volcanic sandstone. Normal-graded beds and scours are common in these intervals, and consistently indicate tops to the north. Light grey, quartz- and/or plagioclase-phyric dacite is the dominant clast type throughout this unit, and contains up to 10% quartz eyes and up to 15% subhedral plagioclase crystals that typically do not exceed 3 mm. The quartz-crystal content of the dacite clasts appears to generally increase toward the north in this unit.

Quartz-feldspar porphyry

The dacitic volcaniclastic rocks in the Round Lake section contain a distinctive unit of massive quartz-feldspar porphyry, which ranges from 100 to 250 m thick, and has been variously described as intrusive (Stockwell, 1945; Davies, 1963), intrusive and extrusive (Poulsen et al., 1986), or extrusive (Bailes, 1998). The porphyry weathers buff or light grey and typically contains coarse phenocrysts of plagioclase (20–30%) and quartz (5–10%), which range in size up to 10 mm and are evenly distributed in aphanitic to very fine grained, feldspathic matrix. Locally, this rock also contains up to 2% euhedral hornblende crystals. The plagioclase is typically euhedral and blocky, whereas the quartz, which is often slightly blue-grey, ranges from euhedral to anhedral and locally exhibits very angular, shard-like shapes. Larger quartz crystals tend toward more rounded shapes. Although generally very massive and homogeneous, variations in the proportion of quartz and/or plagioclase crystals locally define subtle layers that are concordant with the trend of the unit (Figure GS-20-8). In places, the layered intervals contain up to 5% subangular to subrounded clasts of green-grey aphanitic andesite that range up to 5 cm across. In the eastern portion of the Round Lake section, the southern contact of the porphyry unit is exposed in one location, and appears to be gradational over 2–3 m into the underlying dacitic volcaniclastic rocks. Toward the west, however, the porphyry appears to cut discordantly across section, and is overlain to the north by a well-layered section of dacitic volcaniclastic rocks. As suggested by Poulsen et al. (1986), this unit most likely represents a very high level subvolcanic intrusion. A sample of this unit, which is presently thought to record the

Figure GS-20-8: Diffuse layer, defined by plagioclase phenocrysts, in the quartz-feldspar porphyry unit of the upper Round Lake section, northeast of Round Lake.



youngest Neoarchean volcanism in the study area, was collected for U-Pb geochronological analysis.

San Antonio assemblage

The San Antonio assemblage (<2.704 Ga; Percival et al., 2002) constitutes a 1.5–2.0 km thick succession of fluvial-alluvial quartz arenite and minor polymictic conglomerate that is well exposed west of Bissett, between Red Rice Lake and Horseshoe Lake (Figure GS-20-2). The arenite typically consists of medium- to coarse-grained quartz greywacke and protoquartzite that contain very well developed planar and trough crossbeds. Pebbles of quartz and lithic material constitute up to 10% of these rocks, and are commonly concentrated in discrete, planar lag deposits (Figure GS-20-9). North of Horseshoe Lake, the arenite includes thick intervals of massive to thick-bedded orthoquartzite and arkose, with subordinate, thin-bedded, greywacke-mudstone turbidite. In this area, the upper portion of the San Antonio assemblage contains a distinct unit of hematitic, clast-supported, polymictic cobble conglomerate that ranges up to 200 m thick. A distinctive unit of monolithic, clast-supported conglomerate is also well exposed on the south shore of Red Rice Lake, and is composed almost exclusively of well-rounded to subangular tonalite boulders up to several metres across, with almost no matrix material (<10%), suggesting a high-energy depositional environment, proximal to a tonalite source area.

As described by Stockwell (1938), the basal unconformity of the San Antonio assemblage is well exposed approximately 600 m northeast of Red Rice Lake. Here, trough crossbedded protoquartzite lies in very sharp contact to the east with a 0.5–1.5 m thick layer of reworked intermediate volcanic material that contains rare, well-rounded quartz pebbles up to 1.5 cm across. To the east, this unit grades into thickly layered andesitic volcaniclastic rocks of the Bidou assemblage, which are crosscut by a 1.5 m thick dike of plagioclase-porphyritic andesite. The reworked unit at the base of the San Antonio assemblage is also exposed on the prominent point on the south shore of Rice Lake (Figure GS-20-2). In this location, the unit is at least 50 m thick and consists of several 5–10 m thick layers that fine toward the west

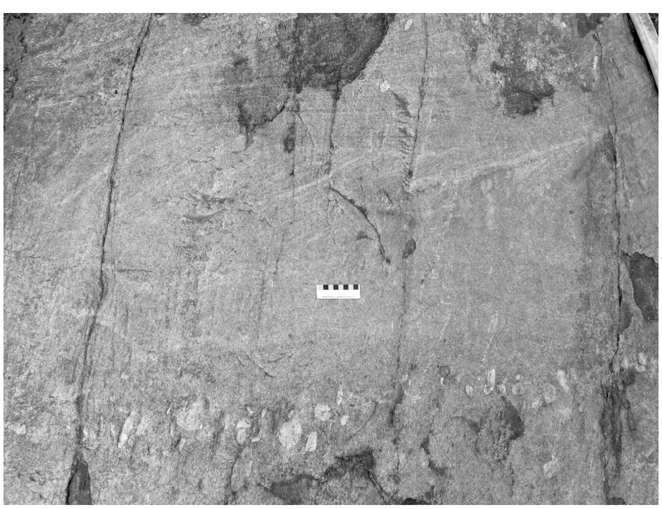


Figure GS-20-9: Pebble lag in crossbedded protoquartzite of the San Antonio assemblage, west of Horseshoe Lake. Note that the pebbles are elongate orthogonal to bedding.

from heterolithic cobble conglomerate to pebbly coarse-grained sandstone. These rocks contain up to 5% well-rounded quartz pebbles. Although Bailes (1998) and Bailes et al. (2003) described clasts of previously foliated rock in the basal conglomerate of the San Antonio assemblage, no convincing examples of such clasts were observed by the author.

Structural geology and deformation history

One of the primary goals of the 2004 mapping program was to gain a better understanding of the structural geology and deformation history of the north-central Rice Lake belt. Toward this end, mesoscopic deformation structures throughout the Rice Lake area have been examined in detail, with particular emphasis on overprinting relationships. Overall, this work has resulted in a significantly improved understanding of the deformation history of the Rice Lake area, and indicates a significantly more complex sequence of deformation that had previously been contemplated. In this report, ductile and ductile-brittle deformation structures are subdivided into six generations (D_1–D_6; Table GS-20-1) on the basis of mesoscopic overprinting relationships and inferences drawn from macroscopic map patterns, as described below.

Table GS-20-1: Provisional summary of ductile and ductile-brittle deformation in the Rice Lake area.

Deformation phase	Shortening direction	Deformation structures	Regional structure	Tectonic significance
D_1	?	None observed	Tilting of Bidou assemblage	Intraoceanic accretion?
D_2	?	Local, weak, layer-parallel S_2 foliation	Thrust fault placing Bidou assemblage over San Antonio assemblage	Collisional tectonics; basin inversion; early Kenoran Orogeny
D_3	NNE-SSW	Regional NW- to WNW-trending S_3; L_3 stretching lineation; upright F_3 folds	Macroscopic folds; Gold Creek syncline and Horseshoe Lake anticline	Collisional tectonics; crustal thickening; main-stage Kenoran Orogeny
D_4	NW-SE	Regional SW- to WSW-trending S_4; L^3_4 intersection lineation; Z-asymmetric F_4 folds	?	Early dextral transpression?
D_5	NNW-SSE	S_5 mylonite in WNW- to NNW-trending, ductile, high-strain zones; L_5 lineation; F_5 folds; S_5 shear-band cleavage (regional)	Dextral transcurrent shear zones (GCSZ, MSZ, NCSZ, RRLSZ, WSZ)	Orogen-scale dextral transpression; terminal collision?
D_6	E-W	Open, north-trending F_6 crenulations	Open folding of the Bidou assemblage at Rice Lake	?

Abbreviations: GCSZ, Gold Creek Shear Zone; MSZ, Manigotagan Shear Zone; NCSZ, Normandy Creek Shear Zone; RRLSZ, Red Rice Lake Shear Zone; WSZ, Wanipigow Shear Zone

The existence and nature of two early deformation episodes (D_1 and D_2) are inferred from the map patterns of the San Antonio and Bidou assemblages in the Horseshoe Lake area, where bedding in the San Antonio assemblage defines a tight, macroscopic fold closure (Stockwell, 1938) that is herein referred to as the Horseshoe Lake anticline (Figure GS-20-2). This fold is upright, plunges steeply to the northwest and is overturned to the southwest. To the east however, younging criteria in the underlying Townsite and Round Lake sections indicate that the older rocks in the core of the anticline consistently young to the north, and thus contain no evidence of the macroscopic fold closure. As described by Bailes (1998), this relationship is best explained in the context of a pronounced angular unconformity at the base of the San Antonio assemblage, which must have been configured such that the maximum principal stress during folding was oriented subparallel to the primary anisotropy (i.e., bedding) in the San Antonio assemblage, but suborthogonal to that in the underlying Townsite and Round Lake sections. Hence, the younger San Antonio assemblage accommodated the regional shortening by buckling and folding, whereas the older Bidou assemblage experienced layer-subparallel flattening without buckling. Implicit in this model is the regional-scale rotation of the Townsite and Round Lake sections into a near-vertical orientation prior to deposition of the San Antonio assemblage. This rotation is attributed to D_1 deformation.

West of Horseshoe Lake, intermediate volcanic and volcaniclastic rocks that are comparable to those of the Bidou assemblage at Rice Lake (e.g., Bailes, 1999) locally contain well-preserved bedding-cleavage relationships that clearly delineate the westward continuation of the Horseshoe Lake anticline (Figure GS-20-2). The observed bedforms also indicate that these rocks are largely concordant with the structurally underlying San Antonio assemblage, and likewise young to the west along the hinge of the fold. Along the western contact of the San Antonio assemblage, flattened clasts and fine-grained, foliated sericite and chlorite locally define a weak, bedding-parallel planar fabric that predates the axial-planar fabric associated with the Horseshoe Lake anticline, and is the earliest fabric element observed in the Rice Lake area. This contact is inferred to be a D_2 thrust fault, which imbricated the Bidou and San Antonio assemblages, and likely records inversion of the San Antonio basin and regional shortening of the Rice Lake belt during an early collisional phase of the Kenoran orogeny.

In the Rice Lake area, the mesoscopic deformation structure is dominated by three regionally pervasive generations of planar fabric, which are attributed to D_3, D_4 and D_5 deformation. Figure GS-20-10 provides a representative example of these fabrics, and clearly illustrates their mutual overprinting relationships. It is important to note that the S_3 fabric is well developed in the San Antonio assemblage, indicating that penetrative regional deformation in the Rice Lake area postdates the maximum depositional age of these rocks (i.e., 2.704 Ga; Percival et al., 2002).

The earliest regionally pervasive fabric element is a penetrative, finely spaced cleavage that, in coarse fragmental rocks, typically parallels the long axes of moderately to strongly flattened clasts. This fabric, which is attributed to D_3 deformation, generally trends west-northwest and dips steeply to moderately north. The flattened clasts are often elongate and thus define a locally pronounced L_3 stretching lineation that typically plunges moderately to the northeast. In the Townsite and Round Lake sections, the S_3 cleavage is consistently oriented at a very shallow, counter-clockwise angle to bedding (which thus faces east on S_3), and mesoscopic examples of F_3 folds are very rare. Across the NCSZ in the RLR section, S_3 is consistently oriented clockwise to bedding (which thus faces west on S_3), and is axial planar to open to tight, S-asymmetric folds that plunge shallowly northwest. In both of these areas, S_3 generally dips more steeply than bedding. West of Rice Lake, the S_3 cleavage passes continuously into the San Antonio assemblage, where it is most prominently defined by highly elongate pebbles (Figure GS-20-9). This fabric is axial planar to mesoscopic and macroscopic F_3 folds, the most prominent examples of which are the Horseshoe Lake anticline and Gold Creek syncline (Figure GS-20-2). Bedding-cleavage relationships and younging criteria indicate that the F_3 folds are tight, upright structures that plunge northwest and are overturned to the southwest. In the area northwest of Horseshoe Lake, these criteria have been utilized to define two additional F_3 folds in the San Antonio assemblage that considerably simplify the complex map pattern in this area. Overall, the geometry of the D_3 structures indicate north-northeast–south-southwest shortening (present coordinates) and regional folding of the Rice Lake belt, possibly during crustal thickening and collisional tectonics associated with the main stage of the Kenoran orogeny in the Uchi Subprovince.

Throughout the mapped area, the S_3 cleavage is consistently overprinted at a shallow counter-clockwise angle by a penetrative to finely spaced crenulation cleavage that is attributed to D_4 deformation. The S_4 cleavage trends southwest or west-southwest, dips steeply northwest and is often best preserved within the flattened clasts that define the regional S_3 fabric. In many cases, the S_4 fabric is truncated along the margins of the clasts, suggesting post-D_4 reactivation of S_3. The S_4 fabric clearly transects the major northwest-plunging F_3 folds in the Rice Lake area, and intersects S_3 in a very prominent, pervasive L^3_4 intersection lineation that generally plunges at moderate angles to the north. In several

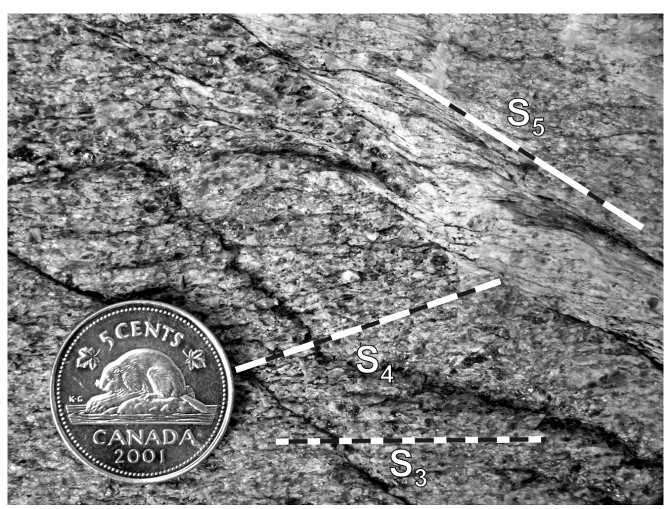


Figure GS-20-10: *S_3-S_4-S_5 fabric relationships in coarse-grained arkose of the San Antonio assemblage, north of Horseshoe Lake (top of photograph is north): S_3 is defined by elongate quartz grains and parallels the long edge of the photo; S_4 is a finely spaced crenulation cleavage that is best developed to the upper right of the coin; and S_5 is a spaced shear-band cleavage that clearly overprints both S_3 and S_4 in the upper right portion of the photograph.*

locations, the L^3_4 lineation clearly overprints the L_3 stretching lineation. The S_4 fabric is axial planar to rare, open to tight, Z-asymmetric folds that plunge moderately north. No regional-scale F_4 folds have been delineated in the Rice Lake area, and the D_4 structures appear to have accommodated weak northwest-southeast shortening of the Rice Lake belt, perhaps during the early increments of regional dextral transpression (*see* below).

The D_5 deformation produced a network of ductile>brittle, high-strain shear zones that are well developed throughout the map area. Outside of the high-strain zones, the S_5 fabric is typically manifested as a regionally pervasive, spaced, fracture or shear-band cleavage that trends northwest or north-northwest and dips subvertically. The S_3 and S_4 fabrics are transposed in a dextral sense along the margins of the S_5 cleavage planes. On the scale of individual outcrops, this fabric is locally observed to intensify into discrete zones of sericite-chlorite mylonite, which are characterized by shallow-plunging quartz ribbon and mineral lineations, and well-developed dextral kinematic indicators on horizontal outcrop surfaces. In coarsely porphyritic hostrocks, these mylonite zones preserve textural evidence of contemporaneous brittle failure of plagioclase and ductile flow of quartz, suggesting deformation at or near the brittle-ductile transition.

The regional-scale WSZ, which ranges up to more than 1.5 km thick, is the most significant D_5 shear zone in the study area. This shear zone is characterized by a strong, locally anastomosed, mylonitic S_5 foliation that trends west-northwest and dips subvertically. Porphyroclastic textures are common, and the mylonite contains a subhorizontal lineation defined by quartz-filled pressure fringes on porphyroclasts or pyrite cubes, stretched clasts and locally well-developed quartz ribbons. The mylonitic foliation commonly envelops packets of strongly Z-asymmetric, open to tight, upright F_5 folds that exhibit highly variable plunges, from shallowly east to steeply north. Dextral kinematic indicators are very well developed on horizontal outcrop surfaces, and typically include S-C fabrics, shear bands and σ-porphyroclast systems. Conjugate shear bands are common in the WSZ, and are an integral part of the mylonitic foliation, suggesting a significant component of zone-normal shortening.

The ductile-brittle D_5 shear zones are interpreted to have accommodated regional north-northwest–south-southeast shortening of the Rice Lake belt during orogen-scale dextral transpression of the Uchi Subprovince. South of the WSZ, several subsidiary D_5 shear zones have been identified, and are invariably characterized by discrete, laterally extensive zones of moderate to intense hydrothermal alteration (ankerite-chlorite-sericite±pyrite). Subsidiary D_5 shear zones host numerous lode-gold deposits and occurrences in the Rice Lake area, the most prominent example of which is the main San Gold deposit along the NCSZ (Figure GS-20-2). These relationships suggest a temporal and genetic link between lode-gold mineralization, ductile-brittle shear zone development and late-orogenic transpression, as is typical of lode-gold deposits in Archean terranes (e.g., Kerrich and Cassidy, 1994).

The latest ductile deformation, D_6, appears to be associated with the open, north-trending flexure of the Townsite and Round Lake section in the Rice Lake area (Figure GS-20-2). On a mesoscopic scale, this deformation is manifested by open, upright, steeply north-plunging F_6 crenulations and folds of the earlier planar fabrics, and thus appears to have accommodated east-west shortening of the Rice Lake area. The tectonic significance of this deformation is unknown, but may be related to a local strain perturbation in the hangingwall of the Normandy Creek Shear Zone, perhaps in response to a buttressing effect along the northwest margin of the Ross River pluton during the late increments of north-northwest–south-southeast shortening of the belt.

Economic considerations

Evidence of base-metal exhalative activity

The 2004 mapping program has resulted in the identification of a new base-metal occurrence in the north-central portion of the Rice Lake belt. As described previously, this occurrence consists of subangular to subrounded pebbles of solid sulphide up to 3 cm across, which are composed of massive, fine-grained pyrrhotite with up to 5% chalcopyrite. The sulphide pebbles are evenly distributed in a 3 m thick layer of heterolithic lapilli tuff that occurs near the upper contact of the largely epiclastic, medial unit of the RLR section. The lapilli tuff layer is intercalated with turbiditic feldspathic wacke and cherty mudstone, and is interpreted as a subaqueous debris-flow deposit that was shed off the flank of a nearby felsic volcanic centre. No examples of in situ solid sulphide were observed in the RLR section, although stringer-style chlorite alteration is exposed in several small outcrops in the immediate footwall of the epiclastic unit. It is composed of very angular, fractured fragments of aphyric rhyolite (30–40%) in a matrix of fine-grained, dark green to black chlorite (Figure GS-20-11). This style of alteration is common beneath many Archean volcanogenic massive sulphide (VMS) deposits, and is generally considered to be indicative of proximity to a seafloor hydrothermal-discharge site.

As described previously, the RLR section is interpreted to mark a regional transition from subaerial, felsic-dominated

Figure GS-20-11: *Stringer-style chlorite alteration in aphyric rhyolite breccia in the footwall of the epiclastic sedimentary unit of the RLR section, Rainy Lake logging road, 1.5 km south of Provincial Road 304.*

volcanism to subaqueous, mafic-dominated volcanism in the Bidou assemblage. In terms of potential regional correlatives, the association of rock types in the medial portion of the RLR section is remarkably similar to that described by Seneshen and Owens (1985) in the Manigotagan River Formation, which marks the top of the Bidou assemblage in the southeast part of the belt, and is likewise thought to mark a regional transition from subaerial to subaqueous volcanism. In this regard, the potential VMS-hosting strata may prove to be regionally extensive in the Rice Lake belt, and may thus constitute an unrecognized base-metal metallotect. Although the paleotectonic significance of these strata is unknown, arc rifting represents one plausible scenario that is known to have generated significant VMS deposits in other Precambrian greenstone belts (e.g., Flin Flon; Syme et al., 1996). The geochemical signatures of the volcanic rocks in the RLR section will be examined to evaluate this and other possible paleotectonic settings, and further assess the VMS potential of the Rice Lake belt.

Distribution, timing and significance of 'San Antonio–type' vein systems

As described by previous workers, the San Antonio gold deposit is hosted mainly by two distinct types of auriferous quartz vein, which are informally known as the 38- and 16-type veins (e.g., Poulsen et al., 1986; Lau, 1988). In the San Antonio mine, these veins are only developed in the more competent, leucogabbroic portion of the differentiated San Antonio sill (Lau, 1988). The 38-type veins comprise thick, tabular zones of complex stockwork and breccia veining that trend northwest and dip subvertically, whereas the 16-type veins comprise strongly foliated shear veins, which dip steeply northwest and are hosted by discrete, ductile-brittle shear zones that record sinistral-reverse kinematics. The 16-type veins consistently crosscut and displace the 38-type veins in a sinistral sense, thereby indicating two temporally distinct styles of mineralization in the San Antonio deposit (Lau, 1988). In the past, attempts to establish a link between the auriferous vein systems and regional deformation have been frustrated by problems of correlation that result from the marked competency contrast and repeated reactivation of the sill–country rock interface. One of the interesting results of the 2004 fieldwork, however, is the recognition that 'San Antonio–type' vein systems are not restricted to the San Antonio sill and are, in fact, widespread on surface in rocks of widely varying composition and apparent competency (Figure GS-20-12). Particularly good outcrop-scale examples of these veins were observed in clean exposures adjacent to the new tailings impoundment. Aside from the obvious exploration implications, these veins provide an excellent opportunity to establish the relative timing of the 'San Antonio–type' vein systems with respect to the regional deformation history outlined above, and thus address the tectonic setting, orogenic significance, and genesis of the auriferous structures. These veins will be examined in detail during the 2005 field season.

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Figure GS-20-12: *Mesoscopic example of breccia and shear veins exposed on surface north of Bissett, which are identical in terms of style, orientation and relative age to the auriferous 38- and 16-type veins in the San Antonio mine. Pencil points north. Note the sinistral offsets of the comparatively thick, northwest-striking breccia vein (38-type) along a series of southwest-striking, shear-hosted veins (16-type).*

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