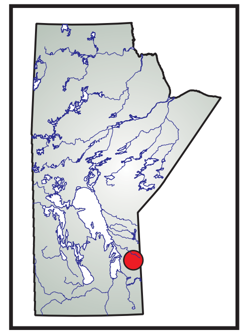
GS-10 Detailed geological mapping of the Rice Lake mine trend, southeastern Manitoba (part of NTS 52M4): stratigraphic setting of gold mineralization

by S.D. Anderson



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Summary

The Rice Lake mine trend is located at Bissett, Manitoba, in the central portion of the Archean Rice Lake greenstone belt of the western Superior Province. This trend includes several gold deposits with a collective gold endowment of approximately 5 million ounces (reserves, resources and past production), making it the most significant lode-gold camp discovered to date in Manitoba. Within the trend, auriferous quartz-vein systems are hosted by a north-younging stratigraphic succession of ca. 2.72 Ga volcaniclastic, effusive, synvolcanic intrusive and derived epiclastic rocks.

Detailed (1:5000 scale) geological and structural mapping of the Rice Lake mine trend was completed during four weeks of fieldwork in August 2011. The purpose of this mapping was to address the need for a single, comprehensive and up-to-date geological map of the mine trend at a scale suitable for modelling the distribution and geometry of the contained gold deposits and the controls on mineralization. This report presents the preliminary results of this mapping as they pertain to the lithology, stratigraphy and depositional setting of the hostrocks. These data represent a significant upgrade to the existing geological map and serve to emphasize the important role of hostrock composition, competency and primary strength-anisotropy in the localization of vein-hosted gold mineralization in the Rice Lake mine trend.

Introduction

The Rice Lake mine trend is located 155 km northeast of Winnipeg, Manitoba, in the central portion of the Archean Rice Lake greenstone belt of the western Superior Province. The trend is hosted by a north-younging stratigraphic succession of ca. 2.72 Ga volcaniclastic, effusive volcanic, subvolcanic intrusive and derived epiclastic rocks of the Neoarchean (ca. 2.745–2.715 Ga) Bidou assemblage, and includes several significant gold deposits, the largest of which is the Rice Lake (a.k.a. San Antonio) deposit at Bissett. Within the trend, auriferous quartz veins are associated with brittle-ductile shear zones and cogenetic arrays of shear and tensile fractures that preferentially formed within chemically favourable or competent rock types, or along strength-anisotropies, during regional compressional deformation. With total production of nearly 1.6 million ounces of gold, and current reserves and resources of 3.4 million ounces in six deposits (George, 2010), the Rice Lake mine trend is the most significant lode-gold camp in Manitoba and is currently the focus of intensive exploration and mining activity by San Gold Corporation.

Early geological investigations of the Rice Lake area were conducted by Moore (1914), Dresser (1917), Cooke (1922), De Lury (1927), Wright (1932), Stockwell (1938, 1940) and Davies (1950, 1963). Of these, Stockwell (1938) provided the most comprehensive and detailed description of the mine trend; the map that accompanies his report covers an area of 40 km^2 surrounding Rice Lake and was published at a scale of 1:6000 (1 inch to 500 feet). In 1985, the mine trend was remapped at 1:10 000 scale by the Geological Survey of Canada (GSC) in support of detailed studies of the Rice Lake deposit and its hostrocks (Tirschmann, 1986; Ames, 1988; Lau, 1988; Ames et al., 1991; Lau and Brisbin, 1996), which took place under the auspices of the 1984–1989 Canada-Manitoba Mineral Development Agreement (MDA). Aspects of this work were summarized by Poulsen et al. (1986, 1996) and Poulsen (1987, 1989). Concurrent with the MDA, Manitoba Energy and Mines documented the area's mineral occurrences (Schmidtke, 1984; Theyer, 1994). Studies that focused specifically on the Rice Lake deposit include those of Reid (1931), Bragg (1943), Gibson and Stockwell (1948), Whiting (1989) and Rhys (2001). Most recently, the Rice Lake area was remapped at 1:20 000 scale under the auspices of the Rice Lake metallogeny project (Anderson, 2004, 2005), with the intent of resolving problems identified by previous workers and providing an updated geological map for ongoing exploration. Results of this mapping and concurrent structural, lithogeochemical, Sm-Nd isotope and U-Pb geochronological studies were described in detail by Anderson (2008).

Despite considerable geoscientific and economic interest in the Rice Lake area, there was no single published map prior to the present study that displayed the entire mine trend at a scale suitable for detailed modelling of the contained gold occurrences. On the map of Stockwell (1938), for example, the mine trend extends across portions of four separate sheets and is truncated at its eastern end by the mapping limit. Although the entire mine trend appears to have been included in the area mapped at 1:10 000 scale by the GSC (*see* Poulsen et al., 1986, Figure 24.1), the resulting map was not published.

A portion of this map, at 1:5000 scale, is included in the M.Sc. thesis of Ames (1988, Figure 2a) but displays only the southern portion of the mine trend, which extends through Rice Lake and has traditionally been considered most prospective. However, recent exploration results demonstrate that the prospective hostrocks extend well to the north and northeast of Rice Lake.

In order to address the need for a single comprehensive map of the Rice Lake mine trend, the geology and structure of a roughly 6 km^2 area north and northeast of Rice Lake were mapped in detail (1:5000 scale) during a four-week campaign in August 2011. This paper summarizes the preliminary results of this work, with emphasis on the lithology and stratigraphy of Neoarchean hostrocks to gold mineralization within the trend. The paper and accompanying preliminary map (Anderson, 2011) incorporate data collected during the 2011 mapping campaign, as well as data collected by the author in 2004 and 2005 during the Rice Lake metallogeny project. Results pertaining to the structural geology of the mine trend and contained quartz-vein systems are described in a separate report (Anderson, GS-11, this volume).

Regional setting

The Rice Lake greenstone belt comprises Neoarchean and Mesoarchean supracrustal rocks and associated intrusions that define the westernmost segment of the volcano-plutonic Uchi Subprovince (Card and Ciesielski, 1986; Stott and Corfu, 1991) of the western Superior Province (Figure GS-10-1). In Manitoba, the Uchi Subprovince is flanked to the north by the metaplutonic Berens River Subprovince and to the south by metasedimentary rocks and derived gneiss, migmatite and granitoid plutonic rocks of the English River Subprovince (Card and Ciesielski, 1986). The Berens River Subprovince and the Mesoarchean portions of the Uchi Subprovince constitute the continental 'North Caribou Terrane' (NCT), which is regarded as the protocratonic nucleus of the western Superior Province (e.g., Stott and Corfu, 1991; Thurston et al., 1991; Percival et al., 2006a, b). In this context, the Rice Lake belt is interpreted to record back-arc, arc and arc-rift magmatism and synorogenic sedimentation within a north-verging subduction-accretion complex that developed over a span of roughly 50 m.y. along the NCT margin (e.g., Stott and Corfu, 1991; Poulsen et al., 1996;

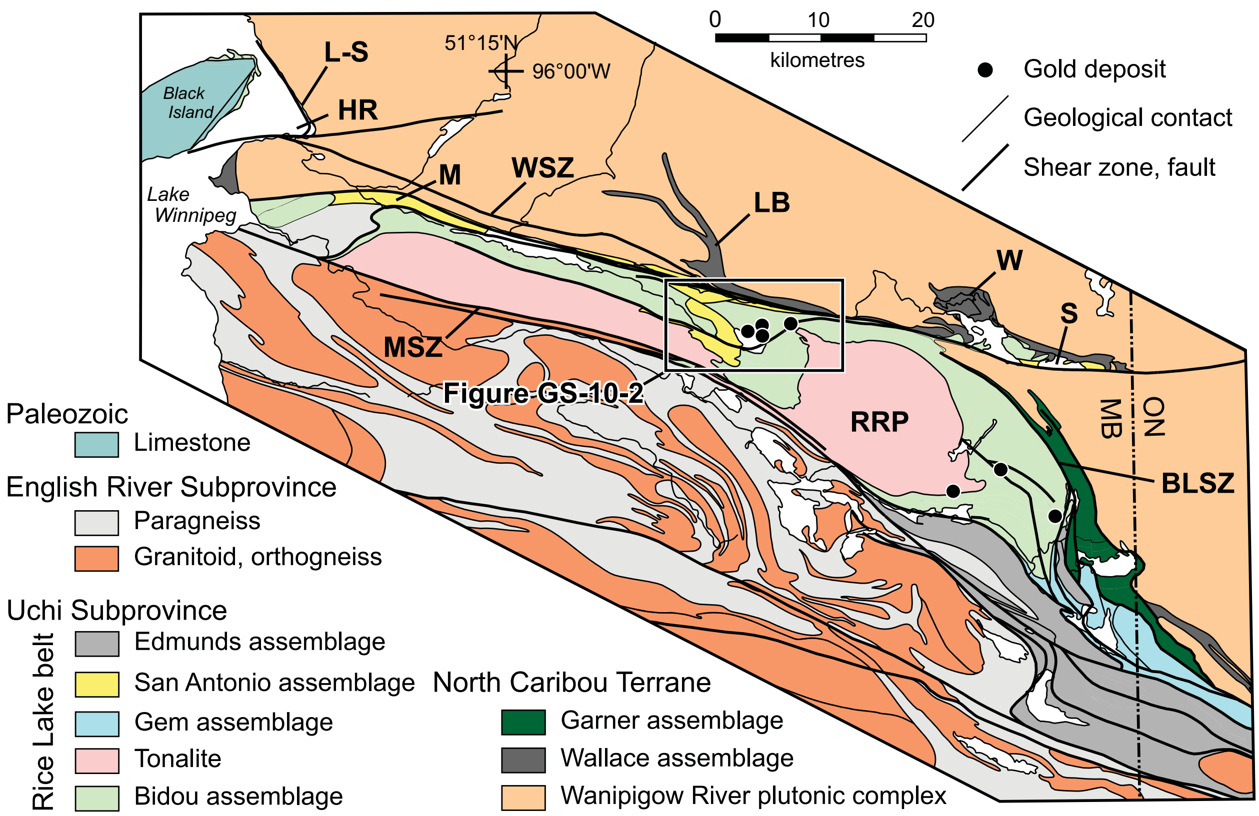

Figure GS-10-1: *Simplified geology of the Rice Lake belt, showing the principal lithotectonic assemblages, major gold deposits and location of the study area. Abbreviations: BLSZ, Beresford Lake Shear Zone; HR, Hole River assemblage; LB, Little Beaver assemblage; L-S, Lewis-Storey assemblage; M, Manigotagan assemblage; MSZ, Manigotagan Shear Zone; RRP, Ross River pluton; S, Siderock assemblage; W, Wallace assemblage; WSZ, Wanipigow Shear Zone*

Percival et al., 2006a, b; Anderson, 2008). The greenstone belt is structurally bounded to the north and south by regional-scale shear zones (Figure GS-10-1).

In the Rice Lake area (Figure GS-10-2), the southern margin of the NCT is occupied by Mesoarchean supracrustal rocks of the Little Beaver assemblage, which consists mostly of interlayered psammitic and semipelitic schist, with minor iron formation and gabbro, and is thought to represent a relatively distal marine portion of a ca. 2.98–2.92 Ga (Percival et al., 2006a) continental-platform succession (Anderson, 2008). These rocks are intruded to the north by Meso- and Neoarchean tonalite and granodiorite of the Wanipigow River plutonic complex and, to the south, are juxtaposed with Neoarchean supracrustal and intrusive rocks of the Uchi Subprovince across the Wanipigow Shear Zone (WSZ). This shear zone can be traced east-southeast along strike for more than 170 km to Red Lake, Ontario, and is interpreted to represent a long-lived crustal-scale structure of the type associated with major orogenic gold districts in other Archean greenstone belts. In the Rice Lake area, major subsidiary structures to the WSZ include the Gold Creek, Normandy Creek and Red Rice Lake shear zones.

South of the WSZ in the Rice Lake area, the Rice Lake greenstone belt of the Uchi Subprovince comprises two distinct supracrustal successions. The Bidou assemblage consists of an upright homoclinal succession of subaqueously deposited, ca. 2.745–2.715 Ga, intermediate to felsic volcaniclastic and epiclastic rocks, subordinate mafic flows and volcaniclastic rocks, and associated subvolcanic intrusive rocks. This assemblage dips moderately to the north and is intruded in its lower portions by synvolcanic tonalite–granodiorite plutons of the ca. 2.725–2.715 Ga Ross River plutonic suite. All of these rocks are unconformably overlain by terrestrial and marine siliciclastic rocks of the San Antonio assemblage, which has a maximum depositional age of ca. 2.705 Ga (Percival et al., 2006a) and was deposited shortly after cessation of major volcanism.

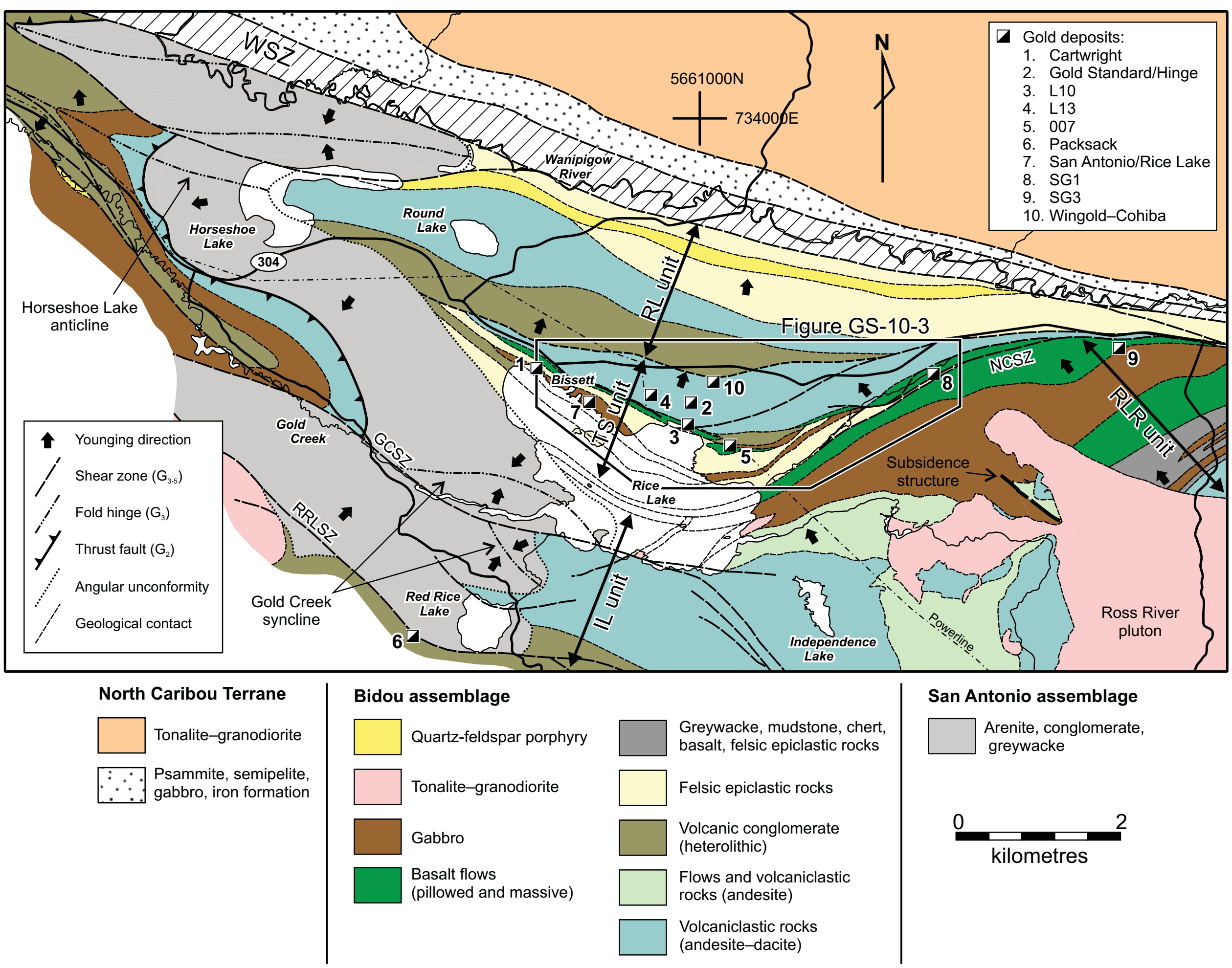

Figure GS-10-2: *Simplified geology of the Rice Lake area, showing the locations of the Independence Lake (IL), Rainy Lake road (RLR), Townsite (TS) and Round Lake (RL) units of the Bidou assemblage, and the major gold deposits. Abbreviations: GCSZ, Gold Creek Shear Zone; NCSZ, Normandy Creek Shear Zone; RRLSZ, Red Rice Lake Shear Zone; WSZ, Wanipigow Shear Zone (indicated by hachured pattern).*

Bidou assemblage

Following the terminology of Anderson (2008), the Bidou assemblage in the Rice Lake area is divided for descriptive purposes into four lithostratigraphic units, each of which is characterized by distinctive associations of rock types, U-Pb zircon ages and geochemical signatures. These units trend generally west, dip consistently to the north and are informally termed, from south to north, the Independence Lake (IL), Rainy Lake road (RLR), Townsite (TS) and Round Lake (RL) units (Figure GS-10-2). Contact relationships and younging criteria indicate that these units define a north-younging stratigraphic succession.

The IL unit is exposed south of Rice Lake, beyond the limits of the present map area, and is at least 2.5 km thick. It consists of aphyric to coarsely plagioclase-phyric, intermediate volcanic and volcaniclastic rocks, with thick intervals of heterolithic volcanic conglomerate and minor effusions or cryptodomes of basalt and andesite. Northeast-trending dikes of Fe-tholeiitic gabbro with mid-ocean-ridge basalt (MORB)–like trace-element signatures crosscut these rocks and are interpreted to represent feeders to chemically similar flows and intrusions in the overlying RLR unit. The contact between these units is conformable at Rice Lake. To the east, this contact is obscured by younger intrusions but is interpreted from map patterns and facies associations to represent a highly discordant synvolcanic subsidence structure (Anderson, 2008).

The RLR unit ranges up to at least 2.5 km thick in the hangingwall of the subsidence structure and comprises three distinct lithostratigraphic sections that dip moderately to the northwest and are intruded by voluminous gabbro sills. Aphyric to coarsely plagioclase-phyric felsic volcaniclastic rocks constitute the lower section of the RLR unit and may, in part, be equivalent to similar rocks along strike to the west in the IL unit. The medial section of the RLR unit is dominated by thin-bedded greywacke-mudstone turbidites, with minor intervals of heterolithic volcanic conglomerate, felsic volcaniclastic rocks, pillowed basalt flows and laminated chert. This section is interpreted to record deposition in a relatively short lived, restricted marine basin that formed in the hangingwall of the subsidence structure. The upper section of the RLR unit overlaps this structure and consists of pillowed and massive basalt flows, voluminous dikes and sills of gabbro, and a very prominent laccolith of gabbro that appears to be rooted to the south in the subsidence structure (Figure GS-10-2). Iron-tholeiitic basalt and gabbro in the RLR unit display MORB-like trace-element signatures and are comparable in most respects to basalt erupted in modern back-arc–basin settings. Detrital zircons from a heterolithic debris flow at the top of the medial section indicate a maximum age of ca. 2727 Ma for the later increments of basin infilling (Anderson, 2008).

The TS unit is the major host to gold mineralization in the Rice Lake area and largely defines the Rice Lake mine trend. It varies from moderately northwest dipping in the east to moderately northeast dipping in the west, and ranges up to 1.3 km in thickness. Felsic volcanic sandstone and heterolithic volcanic conglomerate at the base of the TS unit are locally interstratified with mafic to intermediate flows and associated volcaniclastic rocks, and are overlain to the north by a thick interval of coarsely plagioclase-phyric intermediate to felsic volcaniclastic rocks. Using the local mine terminology, these units correspond, respectively, to the ‘Hares Island formation’, ‘Shoreline basalt’ and ‘Townsite dacite’ (e.g., Poulsen et al., 1996). Epiclastic rocks at the base of the unit contain unimodal populations of ca. 2.724 Ga detrital zircons (Anderson, 2008) and are intruded by several gabbro sills and slightly discordant dikes, the thickest of which hosts the Rice Lake deposit and is informally referred to as the ‘SAM unit’. In contrast to the underlying RLR unit, basalt and gabbro in the TS unit are of transitional tholeiitic-calcalkalic geochemical affinity, with trace-element signatures that are indicative of volcanic-arc magmatism.

The RL unit defines the top of the Bidou assemblage at Rice Lake and consists of a basal heterolithic volcanic conglomerate, overlain to the north by a thick succession of volcaniclastic and epiclastic rocks that exhibits increasingly felsic bulk compositions, from andesitic through dacitic to rhyolitic. This unit ranges up to 1.7 km thick and is truncated to the north by the WSZ. The basal conglomerate includes a 10–15 m thick layer of basaltic tuff that is chemically similar to gabbro dikes in the underlying RLR and TS units. These rocks are of calcalkalic geochemical affinity and display distinctive ‘sanukitoid-like’ trace-element signatures that are indicative of highly evolved volcanic-arc magmas (Anderson, 2008). Near the top of this unit, a slightly discordant body of rhyolitic quartz-feldspar porphyry, which is interpreted to represent a hypabyssal intrusion, returned a U-Pb zircon age of 2715 ±2 Ma and thus provides a minimum age for the Bidou assemblage (Anderson, 2008).

Ross River plutonic suite

Both the RLR and IL units are intruded from the south by tonalite and granodiorite plutons of the Ross River plutonic suite, which crop out southwest and southeast of Rice Lake, outside the present study area (Figure GS-10-2). The western pluton consists of a homogeneous, possibly sheet-like intrusion of ca. 2.72 Ga (Anderson, unpub. data, 2008) tonalite that was emplaced into the IL unit and is unconformably overlain to the north by the San Antonio assemblage. The eastern pluton, known as the Ross River pluton, intrudes the IL and RLR units, and consists of a roughly elliptical intrusion that dominates the central portion of the Rice Lake belt. Aeromagnetic data and reconnaissance mapping indicate the presence of two nested stocks within the pluton, each of which appears to be zoned outward from a granodioritic core to a tonalitic margin. Igneous zircons from the granodioritic core of the western stock yielded a U-Pb age of ca. 2724 Ma (Anderson, 2008), which is taken as the best estimate of the emplacement age. Prominent apophyses of heterogeneous tonalite extend outwards toward the northwest and southeast, and impart a sigmoidal shape to the pluton (Figure GS-10-1).

San Antonio assemblage

The San Antonio assemblage (<2.705 Ga; Percival et al., 2006a) consists mainly of pebbly crossbedded arenite and wacke, with subordinate intervals of polymictic conglomerate, quartz wacke and planar-bedded greywacke and mudstone, which were likely deposited in a fault-bounded fluvial-alluvial basin. These rocks define a 1.2 km thick succession that trends across the regional strike of the Rice Lake belt (Figure GS-10-2) and overlies the Bidou assemblage along a pronounced angular unconformity. In marked contrast to the Bidou assemblage, no intrusions are known to cut the San Antonio assemblage and detrital zircon populations include a significant number of Mesoarchean (3.0–2.9 Ga) grains, which points to the uplifted NCT margin as a major source of detritus. Bedding in the San Antonio assemblage consistently faces west on the main regional foliation, which is axial planar to the macroscopic Horseshoe Lake anticline and Gold Creek syncline (Figure GS-10-2). To the west, the San Antonio assemblage is structurally overlain by west-facing rocks of the Bidou assemblage, and this contact is inferred to represent a thrust fault that formed prior to regional folding.

Description of units

The area mapped in 2011 encompasses all known exposures of the TS unit, and also includes the northernmost portion of the RLR unit south of the SG1 deposit, as well as the immediately overlying rocks at the base of the RL unit north of Rice Lake (Figure GS-10-2). Unit codes in this report correspond to those on PMAP2011-3 (Anderson, 2011); a simplified version of this map is included herein as Figure GS-10-3.

Metamorphic-mineral assemblages throughout the map area indicate low to middle greenschist-facies regional metamorphism. In the interest of brevity, however, the prefix ‘meta’ is not utilized in this report and the rocks are described in terms of known or inferred protolith.

Rainy Lake Road (RLR) unit

Gabbro (unit 1)

Several outcrops were examined along the northern margin of the laccolithic gabbro in the RLR unit south of the SG1 deposit, in the footwall of the Normandy Creek Shear Zone (NCSZ). In these outcrops, the gabbro is fairly homogeneous and melanocratic, with a buff to reddish-brown weathered surface and a dark green fresh surface. It is typically characterized by a fine- to medium-grained subophitic texture defined by closely packed subhedral crystals (0.5–2.0 mm) of amphibole (after pyroxene) and plagioclase. Some specimens contain 1–3% deep blue quartz ‘eyes’. Although most specimens are equigranular, a local glomeroporphyritic texture is defined by euhedral to subhedral, blocky phenocrysts or aggregates of actinolite, which range from 2 to 7 mm across and impart a spotted appearance to the rock. The gabbro is cut by dikes of plagioclase-phyric or plagioclase-quartz-hornblende–phyric diorite or quartz diorite, and varies from massive to weakly foliated.

Basalt flows (unit 2)

Pillowed basalt flows, with minor intercalations of massive basalt, brecciated basalt and heterolithic epiclastic rocks, define two major flow complexes in the upper section of the RLR unit. A portion of the upper flow complex was examined in detail over a strike length of approximately 1.3 km in the immediate footwall of the SG1 deposit. Here, the basalt everywhere contains a moderate to strong planar fabric defined by foliated chlorite and amphibole, and strongly flattened pillows. The contact with overlying felsic volcanic sandstone of the TS unit is exposed in two locations and is sharp and strongly sheared.

The basalt is fine grained and aphyric, with a brownish-green or rusty brown weathered surface and dark green fresh surface. Most specimens are nonamygdaloidal, although some contain rare (<2%) carbonate or quartz amygdules up to 1.0 cm across, which tend to be concentrated in pillow margins. Pillowed flows (subunit 2a) consist of strongly flattened bun-shaped to amoeboid pillows that are typically 0.3–1 m across but locally range up to 2 m. Pillow selvages are less than 2 cm thick and are strongly chloritized. Interpillow material (generally carbonate) accounts for less than 5% of the flows. In several localities, the pillowed flows are intruded by irregular branching swarms of fine-grained basalt dikes (subunit 2b). Buff to light grey-green–weathering diorite and quartz diorite occur as straight-walled dikes that crosscut the basalt and gabbro, and vary from aphyric to plagioclase (±quartz±hornblende) phyric. In an outcrop located approximately 200 m south of the SG1 vent raise, one of the porphyritic dikes is boudinaged and overprinted by tight to isoclinal, steeply plunging ptygmatic folds.

Townsite (TS) unit

Felsic volcanic sandstone (unit 3)

Felsic volcanic sandstone, with minor pebble to cobble volcanic conglomerate and mudstone, defines three

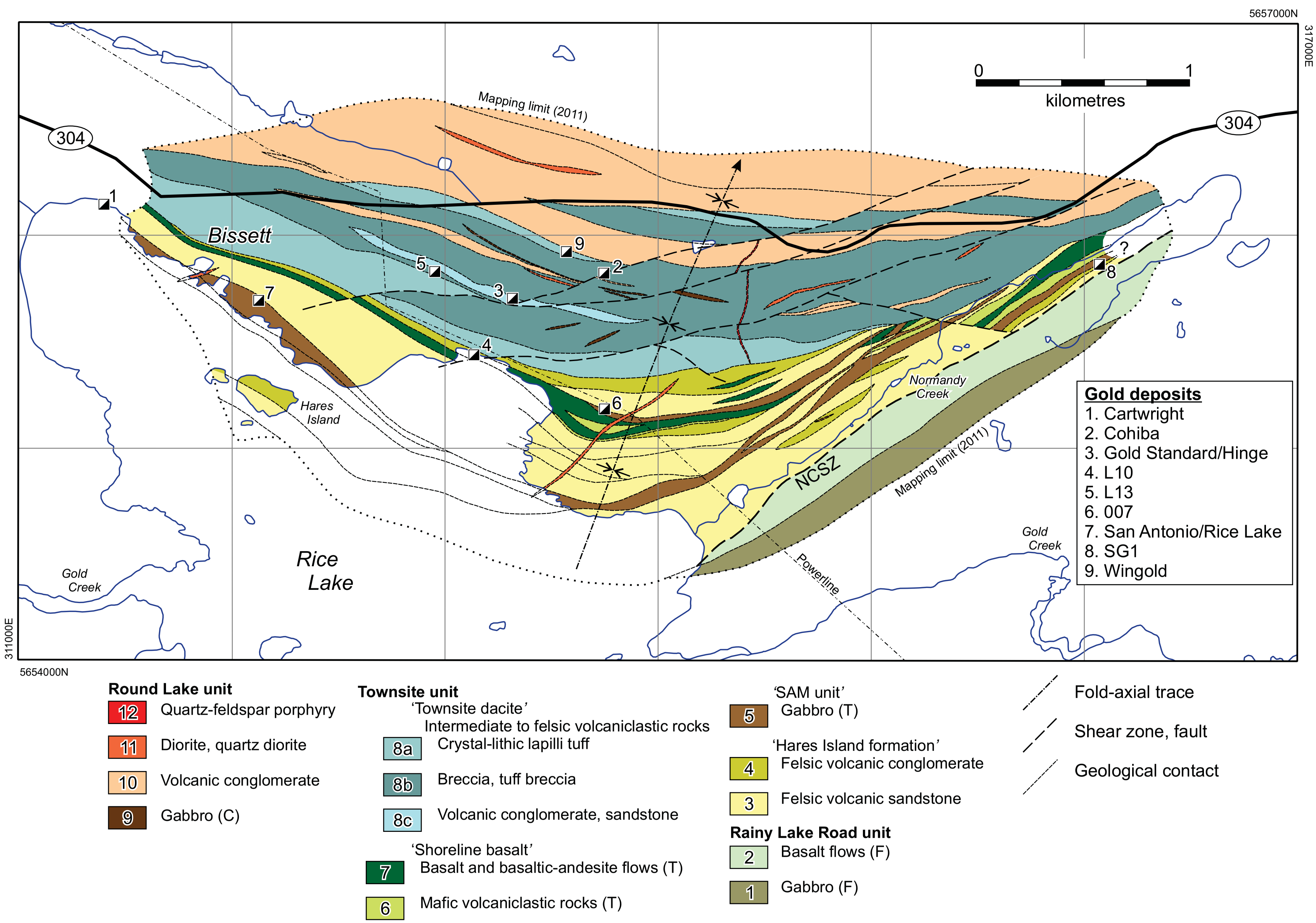

Figure GS-10-3: *Geology of the Rice Lake mine trend, simplified from PMAP2011-3 (Anderson, 2011). Major gold deposits are shown in the approximate locations of their up-dip projections to surface. Abbreviations: C, calcalkalic; F, Fe-tholeiitic; NCSZ, Normandy Creek Shear Zone; T, transitional tholeiitic-calcalkalic.*

major map units in the lower portion of the TS unit (Figure GS-10-3). These rocks were described as tuff and arkose by Stockwell (1938) and as lithic arenite by Tirschmann (1986); the latter study includes detailed petrographic descriptions. The lower unit is at least 150 m thick and is best exposed on the small islands south of Hares Island on Rice Lake; it is also exposed in several locations along the NCSZ, where it defines the immediate footwall to gold mineralization in the SG1 deposit. The medial unit is well exposed along the eastern shoreline of the lake, where it is approximately 300 m thick, and tapers out along strike to both the east and west. This lenticular sandstone unit is bounded to the south by the SAM unit and to the north by the Shoreline basalt. The upper unit overlies the Shoreline basalt east of Rice Lake and also defines a lens-like body that ranges up to approximately 100 m thick. This unit defines the immediate hangingwall to gold mineralization in the 007 deposit and is exposed along strike to the east in several small outcrops north and south of the SG1 haul road, where it includes two lenticular basalt flows of map unit 7. As described below, each of the sandstone units is capped by heterolithic volcanic conglomerate (unit 4), thus defining three distinct coarsening-upward cycles that are suggestive of proximal suprafan-lobe and channel-fill deposits in a progradational submarine fan.

The felsic volcanic sandstone weathers white to light brown or grey and is medium to very coarse grained. It contains coarse grains and granules (0.5–4.0 mm) of feldspar (10–40%; euhedral to subhedral) and quartz (1–10%, up to 25% locally; angular to rounded), the quartz distinguishing it from superficially similar sandstone beds higher in the stratigraphy. Subunit 3a consists of well-bedded felsic volcanic sandstone, with minor interbeds of pebble to cobble volcanic conglomerate and volcanic mudstone. Beds in these intervals are planar and massive to normally graded (Figure GS-10-4a), ranging up to 1.0 m thick; crossbedding is absent. In the context of the submarine-fan model of Walker (1978), these sandstone

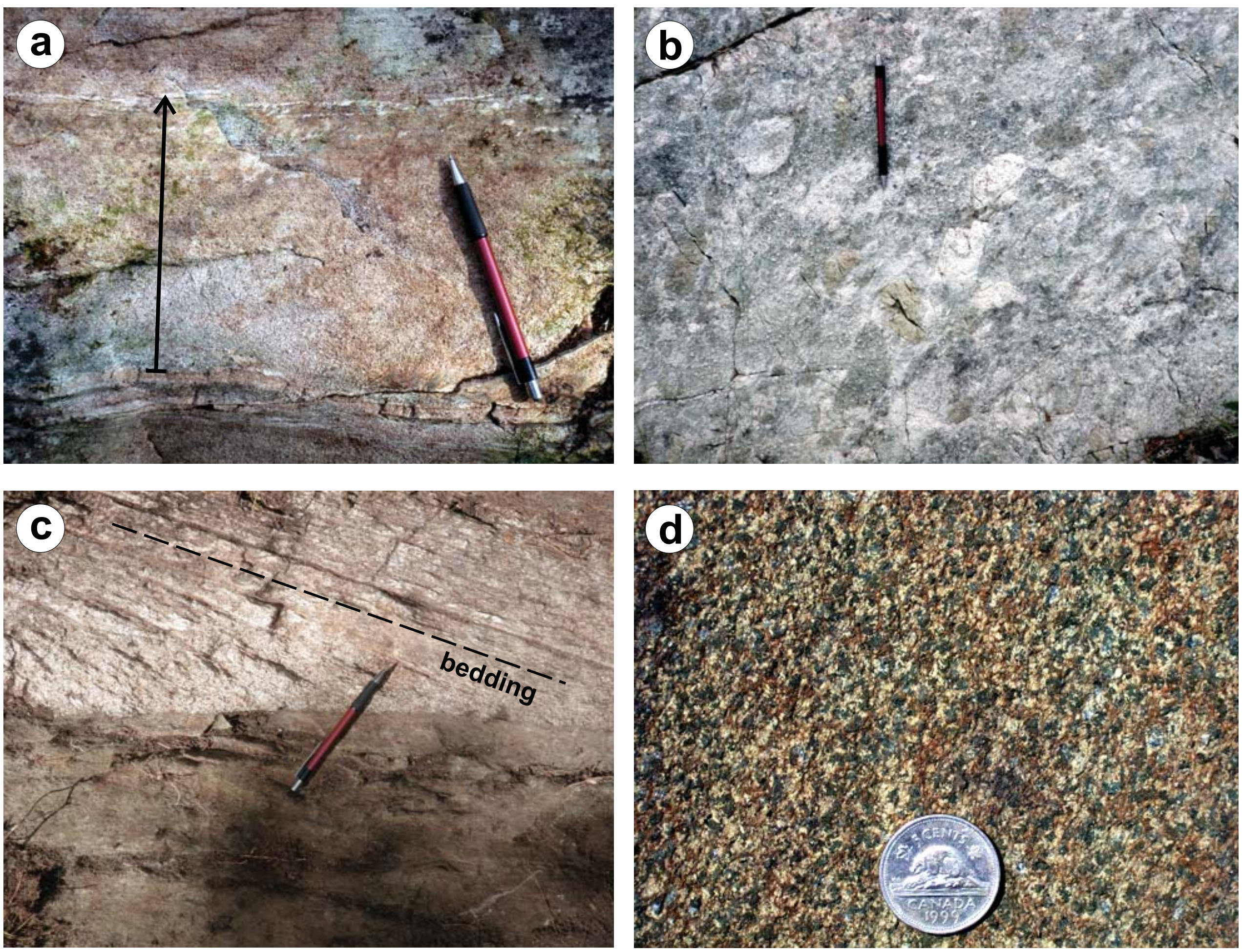

Figure GS-10-4: *Outcrop photographs of rock types in units 3, 4 and 5:* ***a)*** *bedded felsic volcanic sandstone (subunit 3a), east of Rice Lake; normally graded beds (arrow) in this location indicate tops to the north (indicated by pencil);* ***b)*** *heterolithic volcanic conglomerate (unit 4), east of Rice Lake; note the abundant clasts of pale green epidotized basalt;* ***c)*** *sharp, planar hangingwall contact of a mesocratic gabbro dike (subunit 5b), east of Rice Lake; note angular discordance to bedding (indicated by dashed line) in the adjacent felsic volcanic sandstone (subunit 3a);* ***d)*** *mesocratic gabbro (subunit 5b), east of Rice Lake.*

beds likely represent proximal suprafan-lobe deposits. Consistent normal size-grading and local scours indicate tops to the north. Subunit 3b consists of massive to very faintly stratified felsic volcanic sandstone, which tends to be very coarse grained and pebbly, and is best developed in the thickest portion of the medial unit, where it forms homogeneous intervals up to several tens of metres thick. Subangular to rounded pebbles of pink-white, quartz- and/or feldspar-phyric rhyolite account for up 25% of these layers. In the context of a submarine-fan model, the massive sandstone units likely represent mid-fan channel-fill deposits.

Felsic volcanic conglomerate (unit 4)

As described above, discontinuous units of heterolithic volcanic conglomerate (unit 4) cap each of the felsic volcanic sandstone units. The lower conglomerate unit is best exposed on the north side of Hares Island in Rice Lake, where it is homogeneous and massive, and ranges up to 190 m thick. The medial unit is approximately 40 m thick in the immediate footwall of the Shoreline basalt where it is crossed by the powerline, and appears to taper out along strike in both directions. Recently stripped outcrops along the haul road to the SG1 deposit provide the best exposures of the upper unit, which also has a pronounced lenticular shape, and ranges up to 60 m thick within a strike length of 1.6 km. In the context of a submarine-fan model, these conglomerate units most likely represent upper-fan channel-fill deposits.

The conglomerate is typically clast supported and poorly sorted, and varies from crudely stratified (subunit 4a) to massive (subunit 4b). It consists of subangular to well-rounded clasts of intermediate and felsic volcanic rock types that range up to 50 cm across (typically <30 cm). The matrix consists of medium- to coarse-grained, pebbly volcanic sandstone that contains up to 20% feldspar and quartz crystals. The northern map unit contains a significant population of subangular to very angular clasts of variably epidotized amygdaloidal basalt (Figure GS-10-4b), and is intruded by dikes and sills of texturally similar basalt. This heterolithic conglomerate was likely deposited as high-density debris flows.

Gabbro (unit 5)

Epiclastic rocks at the base of the TS unit host two laterally extensive intrusions of gabbro, the southern of which hosts the bulk of the gold mineralization in the San Antonio/Rice Lake and Cartwright deposits and is informally referred to as the 'SAM unit'. This unit is traced over a strike length of 5 km on surface, and has been traced by drilling for an additional 700–800 m to the northwest of Rice Lake. In the mine, this unit has been traced more than 2 km down dip and remains open at depth. The western segment of the unit ranges up to 120 m thick, dips moderately to the northeast and appears to cut slightly downsection toward the east, whereas the eastern segment ranges up to 80 m thick, dips steeply to the northwest, and cuts significantly upsection toward the east into immediate footwall of the Shoreline basalt (Figure GS-10-3). The contacts are well exposed in several locations and are typically sharp, planar and significantly discordant to bedding in the country rock (Figure GS-10-4c). Large rafts and roof pendants of felsic volcanic sandstone within the SAM unit clearly indicate its intrusive nature. The northern gabbro intrusion ranges up to 50 m thick and is discontinuously exposed over a strike length of 2.0 km in the hangingwall of the Shoreline basalt. Each of these map units is intruded by sills and dikes of sparsely amygdaloidal basalt or fine-grained gabbro, which typically have well-developed chilled margins and are interpreted as feeders to the basaltic volcaniclastic rocks and flows of map units 6 and 7.

The gabbro of unit 5 is fine to medium grained and equigranular, with a subophitic texture. Although homogeneous on the scale of individual outcrops, it is divided into three subunits on the basis plagioclase content. Melanocratic gabbro (subunit 5a) contains less than 20% plagioclase and is dark green to rusty brown on weathered surfaces. This subunit is only abundant in the central segment of the southern intrusion, where it is strongly foliated and carbonate altered. Mesocratic gabbro (subunit 5b) contains 20–60% plagioclase and weathers medium green or brown (Figure GS-10-4d); this subunit accounts for most of the gabbro intrusions. Leucocratic gabbro (subunit 5c) contains more than 60% plagioclase and weathers light greenish-grey to buff, and is slightly coarser grained than the other subunits. Typically, the leucocratic gabbro also contains 2–5% magnetite and is thus strongly magnetic. This subunit is most extensive near the top of the thick western segment of the SAM unit, where it ranges up to 90 m thick and is interpreted to result from in situ magmatic differentiation. The leucogabbro also forms planar to irregular dikes up to 50 cm thick that crosscut melanocratic and mesocratic gabbro. An outcrop of layered gabbro on a small island in Rice Lake consists of irregular wisps, clots and discontinuous contorted layers (2–10 cm thick) of leucogabbro in melagabbro, and perhaps represents the interface between these subunits. In at least the upper levels of the San Antonio/Rice Lake deposit, auriferous quartz-carbonate veins are preferentially developed in the leucogabbro.

Mafic volcaniclastic rocks (unit 6)

Mafic volcaniclastic rocks of map unit 6 appear to be confined to a relatively restricted stratigraphic interval at the base of the uppermost of the three suprafan-lobe successions described above (Figure GS-10-3). These rocks are spatially associated with basalt and basaltic andesite flows of unit 7 (see below), to which they appear to be genetically related, and thus collectively define the 'Shoreline basalt'. The mafic volcaniclastic rocks range up to 50 m thick and, in places, contain minor interlayers of felsic volcanic sandstone and conglomerate. At the type locality, which is located approximately 100 m east of Rice Lake in the immediate footwall of the 007 deposit, this unit is situated at the contact between felsic-volcanic sandstone of unit 3 (south) and massive basalt of unit 7 (north). This unit is also exposed in several locations along strike to the northeast, in the hangingwall of the NCSZ, where it likewise defines the immediate stratigraphic footwall to unit 7.

The mafic volcaniclastic rocks weather light brown or green and are dark green on fresh surfaces. They consist of monolithic tuff, lapilli tuff, lapillistone, tuff breccia and breccia, which were derived from aphyric to very sparsely plagioclase-phyric basalt and basaltic andesite. The clasts typically contain sparse (<10%) quartz or carbonate amygdules up to 1.5 cm across. In most localities, a high proportion of the clasts exhibit very wispy, shard-like or cuspate shapes and show evidence of formerly glassy margins (Figure GS-10-5a). These features are indicative of primary hyaloclastite deposits. The clasts are variably epidotized, likely as a result of syneruptive hydrothermal alteration (Figure GS-10-5b).

Subunit 6a defines the base of the unit in most locations and consists of laminated to thin-bedded tuff and lapilli tuff, with minor interbeds of felsic-volcanic sandstone up to 20 cm thick. In the western portion of unit 6, this subunit is well exposed in three locations over a strike length of approximately 700 m and varies from 2.5 to 10 m thick. Normally graded beds and scours in these locations indicate tops to the north. Massive to crudely stratified intervals of monolithic lapilli tuff and lapillistone (subunit 6b) locally overlie these rocks and range up to 15 m thick. These rock types are characterized by closely packed, angular to subangular lapilli with delicate shard-like or cuspate shapes. Subunit 6b is interlayered with, or overlain by, massive layers of clast-supported monolithic breccia and tuff breccia (subunit 6c), which contain very

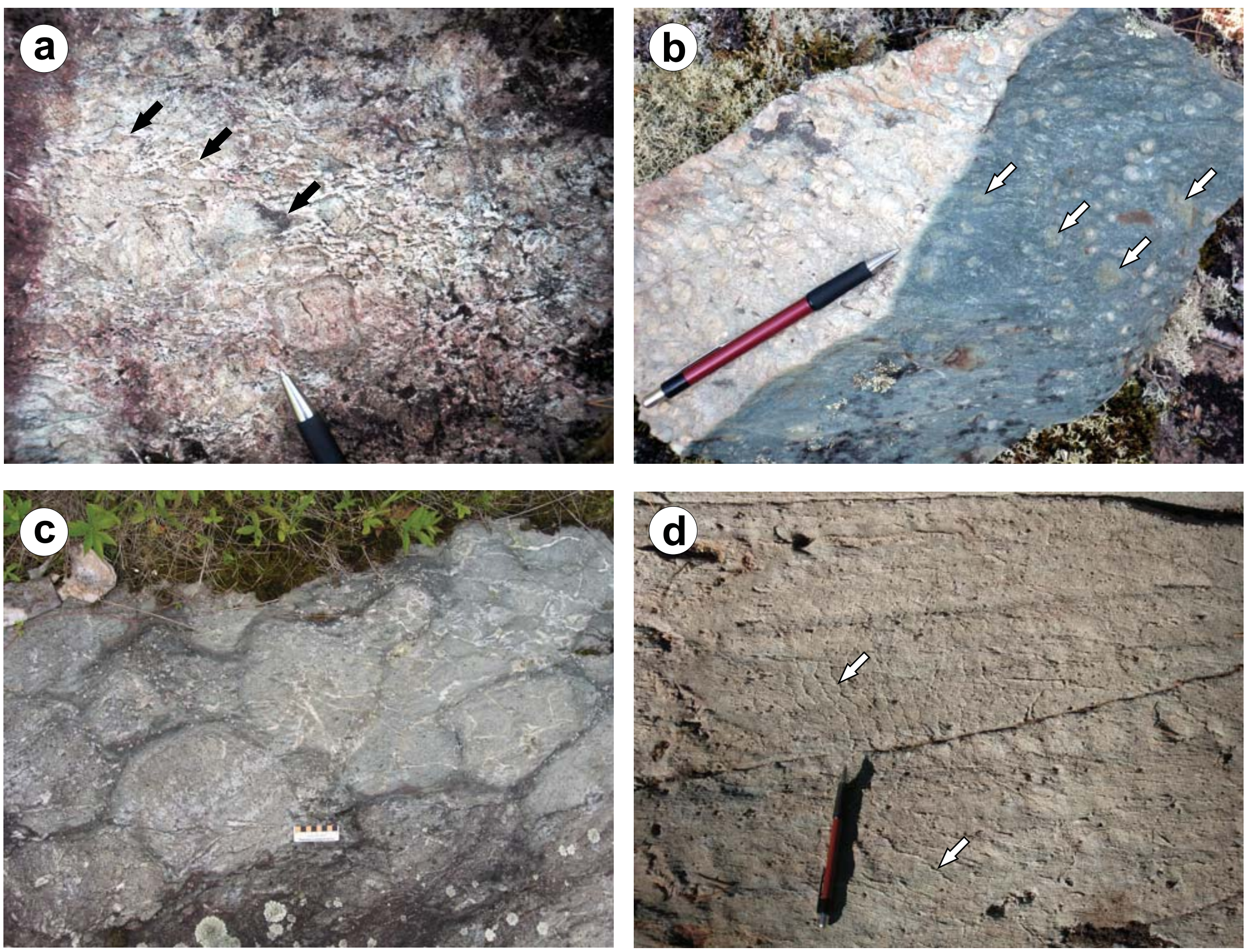

Figure GS-10-5: *Outcrop photographs of rock types in units 6 and 7:* ***a)*** *basaltic lapilli tuff (subunit 6a) from the type locality of unit 6, east of Rice Lake; note shard-like cuspate lapilli (indicated by arrows) and possible quenched (fine-grained, dark green) margins on the large lapillus above the pencil tip;* ***b)*** *basaltic lapilli tuff (subunit 6b), east of Rice Lake; strongly epidotized lapilli indicated by arrows;* ***c)*** *pillowed basalt flow (subunit 7b), north shoreline of Rice Lake;* ***d)*** *basalt flow (subunit 7a), east of Rice Lake; note the recessively weathered amygdules (dark pits) and quartz-filled thermal contraction fractures (indicated by arrows).*

angular to subangular basaltic clasts up to 30 cm across. At the type locality, the three subunits define a coarsening upward sequence in the footwall of a massive flow of texturally similar basalt. Here, the sequence is interpreted to record a distal to proximal facies transition within an apron of resedimented and in situ hyaloclastite, which was likely deposited in front of the advancing flow and was subsequently overridden.

Basalt and basaltic andesite flows (unit 7)

Basalt and basaltic andesite flows of map unit 7 are confined to a relatively restricted stratigraphic interval at or just above the base of the uppermost of the three suprafan-lobe successions (Figure GS-10-3). This unit comprises several discrete lenticular flows that range up to 100 m thick locally and are interstratified on a variety of scales with mafic volcaniclastic rocks (unit 6) and minor felsic epiclastic rocks (units 3 and 4). Unit 7 is best exposed in shoreline outcrops in the northeastern portion of Rice Lake, but is also well exposed in scattered outcrops along strike to the northeast. The northern contact of this unit is the locus for significant shear-hosted mineralization in the L10 and 007 deposits, whereas the southern contact appears to host the SG1 deposit. As described by Stockwell (1938), this unit was traced northwest by drilling beneath the covered area north of the Rice Lake mine, and is exposed at two locations in Bissett.

The basalt (and basaltic andesite) weather light green to reddish-brown and are dark green on fresh surfaces. They are typically aphyric with a very fine grained intergranular texture. Sparsely porphyritic basalt contains 2–10% euhedral to subhedral plagioclase laths that are 1–3 mm in length. Most specimens are moderately to strongly altered, such that the primary mineral assemblage is completely replaced by secondary chlorite, epidote and carbonate. The basalt contains 1–5% finely disseminated magnetite and is typically weakly to moderately magnetic. Flow types identified in outcrop include massive (subunit 7a), pillowed (subunit 7b) and brecciated (subunit 7c). All three flow types are locally observed in single outcrops; however, the exposure is generally insufficient to determine the internal flow organization. In one location approximately 1.5 km east of Rice Lake, the unit consists of a series of 1–5 m thick, pillowed, massive and brecciated flows with a cumulative thickness of 45 m.

Massive flows of subunit 7a range up to at least 4 m thick and are generally fine grained, aphyric and sparsely amygdaloidal. Flow contacts are sharp, chilled and planar to wavy. In two locations, these flows appear to grade upward over several metres into pillowed or brecciated basalt. Pillowed flows of subunit 7b consist of bun-shaped pillows 20–50 cm across (Figure GS-10-5c), with subordinate amoeboid pillows up to 1.5 m in length. Pillow cores are sparsely amygdaloidal, moderately to strongly epidotized and locally plagioclase phyric. Amygdules are round and less than 5 mm in diameter, and variably contain epidote, quartz, calcite and/or hematite. Quartz-filled thermal contraction cracks are preserved in one location near the base of a flow that appears to consist of very large (>2 m) pillows or lobate flows (Figure GS-10-5d). Pillow selvages are 0.5–1.5 cm thick and strongly chloritized. Composite flows are indicated by abrupt changes in pillow morphology and thin (<1 m) layers of pillow-fragment breccia or hyaloclastite. Interpillow hyaloclastic tuff and lapilli tuff account for not more than 5% of the pillowed flows and are well preserved in places. Brecciated flows of subunit 7c consist of blocky to very irregular to wispy fragments of fine-grained amygdaloidal basalt, some of which show evidence of chilled margins. These flows range up to 10 m thick and tend to be strongly epidotized and deformed.

Intermediate to felsic volcaniclastic rocks (unit 8)

Intermediate to felsic volcaniclastic rocks of map unit 8 define the top of the TS unit and host significant gold mineralization in the Cohiba, L13, Gold Standard/Hinge and Wingold deposits (Figure GS-10-3). This unit is well exposed in the large outcrop ridge that extends east from Bissett and is informally referred to as the ‘Townsite dacite’. It is exposed for just over 5.0 km along strike and ranges up to 500 m thick north of Rice Lake. To the east, the unit thins considerably toward the confluence of the WSZ and the NCSZ, and is less than 100 m thick in the hangingwall of the SG1 deposit. To the west, the unit appears to be truncated by a deep erosional scour at the base of the RL unit. Similar rocks are also exposed in several widely spaced outcrops between 100 and 300 m north of the main body, and are interpreted to define an approximately 150 m thick map unit that is interstratified with volcanic conglomerate of unit 10 (Figure GS-10-3). Three distinct subunits are recognized in unit 8 on the basis of primary textures and structures. As described below, primary lithological variations in this unit may have significantly influenced the localization of gold mineralization. In particular, the most significant deposits discovered to date in this unit are restricted to its upper portion, in intervals that contain a well-developed primary anisotropy in the form of discrete layers of thin-bedded volcanic sandstone.

Subunit 8a consists of massive to very crudely stratified crystal-lithic lapilli tuff, which has a bulk composition varying between dacite and high-silica andesite. This rock type defines the base of unit 8 in its western and central portions, where it ranges up to 190 m thick, and is also locally present in the upper and eastern portions of the unit, where it appears to define diffuse layers up to several tens of metres thick. The crystal-lithic lapilli tuff weathers pale green-grey and is dark green on fresh surfaces. It tends to be very homogeneous, with a seriate-porphyritic texture defined by euhedral to subhedral plagioclase crystals (<1 cm; 20–45%) in an aphanitic to fine-grained matrix of feldspar, quartz and phyllosilicate minerals. The crystals vary from euhedral (tabular) to angular (broken) to subrounded, and commonly display oscillatory zoning. In some specimens, the crystal component also includes trace to 2% blue quartz (<5 mm) and black amphibole (<3 mm). Subtle variations in the size and proportion of crystals or lithic clasts define a crude stratification in some outcrops. The lithic component consists of subrounded to angular clasts (<10 cm) of crystal tuff, aphyric andesite, amygdaloidal basalt or sulphidic mudstone (Figure GS-10-6a), and includes possible examples of felsic pumice. The latter three clast types commonly have angular wispy shapes, which preclude the possibility of significant transport or reworking. The proportion of clasts is typically <5%, but ranges up to 20% in some specimens. As described by Anderson (2008), the preferred depositional model for the crystal-lithic lapilli tuff involves 1) initial fragmentation by explosive eruption of crystal-rich magma; 2) syneruptive elutriation of the fine fraction to produce high concentrations of coarse plagioclase crystals; 3) final deposition in a shallow subaqueous, or locally subaerial, setting as primary pyroclastic or resedimented grain-flow deposits.

Breccia and tuff breccia of subunit 8b are the dominant rock types in the upper and eastern portions of unit 8, and host significant mineralization in the Cohiba deposit. These rocks are generally monolithic, matrix supported and poorly sorted, and vary from massive to crudely stratified. They consist of very angular to subrounded blocks of crystal-lithic lapilli tuff that range in size up to 1.0 m (generally 5–40 cm). These blocks are typically more coarsely and densely plagioclase phyric than the matrix (Figure GS-10-6b), although the clasts and matrix in some localities are texturally similar and indistinct. Some outcrops consist of very angular interlocking clasts with less than 5% matrix material. Clast margins vary from sharp to diffuse, perhaps as a consequence of in situ disaggregation of weakly indurated material. Rare examples of angular, joint-bounded clasts of crystal-lithic lapilli tuff indicate at least local derivation from well-indurated material (Figure GS-10-6c). Aphyric basalt and andesite clasts form a minor component of some outcrops, and locally exhibit wispy lenticular shapes, ragged terminations and vesicular textures that are suggestive of juvenile vitriclasts. Near the base, subunit 8b includes widely spaced, discontinuous layers (<1 m thick) of thin-bedded volcanic sandstone and pebble conglomerate. Normal size-grading, low-angle crossbeds and scours provide reliable younging criteria in these layers. Subunit 8b is interpreted to represent secondary mass-flow deposits generated by gravitational instability of partially indurated primary pyroclastic or syneruptive sedimentary deposits (subunit 8a).

Subunit 8c consists of interlayered volcanic conglomerate and volcanic sandstone that define a well-stratified, lenticular unit near the interface between subunits 8a and 8b in the central portion of unit 8. This subunit ranges up to 50 m thick and is traced along strike for approximately 1.5 km. The trace of this unit in outcrop coincides with the surface projection of the Gold Standard/Hinge deposit, and possibly also the L13 deposit, suggesting that it may be a significant host to gold mineralization. The conglomerate layers range up to 15 m thick and are poorly sorted, matrix supported and unstratified (Figure GS-10-6d). They consist of angular to subrounded clasts of crystal-lithic lapilli tuff that range up to 80 cm in maximum dimension. Subordinate clast types include aphyric andesite, epidotized basalt and rare melagabbro. Most layers are massive, with thin (<50 cm) reversely graded bases and normally graded tops, whereas others show diffuse normal or reverse size-grading throughout; basal contacts are sharp and scoured (Figure GS-10-6e). These features indicate deposition as high-density debris flows. Some layers also contain thin (<5 cm) diffuse beds of volcanic sandstone, indicating that they represent more than one debris-flow unit.

In the type locality of the subunit, located 150 m west of the Gold Standard/Hinge deposit (Figure GS-10-3), the volcanic conglomerate contains six discrete interlayers of volcanic sandstone (Figure GS-10-7), which vary from 0.3 to 1.0 m thick. Individual layers consist of a relatively thick (15–30 cm), normally graded bed of pebbly volcanic sandstone at the base. The tops of these layers are characterized by thin (<10 cm) planar beds of medium- to coarse-grained volcanic sandstone (Figure GS-10-6f). These beds have sharp scoured bases and normally graded tops; some beds are also reversely graded at the base. Some of these layers contain low-angle crossbeds. These features are indicative of sedimentation from high-density turbidity currents. Collectively, the volcanic conglomerate and sandstone of subunit 8c are interpreted to record an influx of more strongly reworked detritus during a transition from grain-flow–dominated (subunit 8a) to mass-flow–dominated (subunit 8b) sedimentation, likely in a shallow submarine fan.

Round Lake (RL) unit

Gabbro (unit 9)

Intermediate to felsic volcaniclastic rocks of unit 8 are crosscut by abundant narrow dikes and sill-like intrusions of gabbro, which are here assigned to unit 9. Although somewhat similar in terms of field characteristics to gabbro of unit 5, these intrusions are assigned to a separate map unit on the basis of their distinctive geochemical signatures. In particular, the available data indicate that gabbro intrusions in the lower portion of the TS unit (unit 5) are of transitional tholeiitic-calcalkalic affinity, whereas those in the upper portion are of highly evolved calcalkalic (sanukitoid) affinity (Anderson, 2008). Dikes and sills of the latter type have been identified using

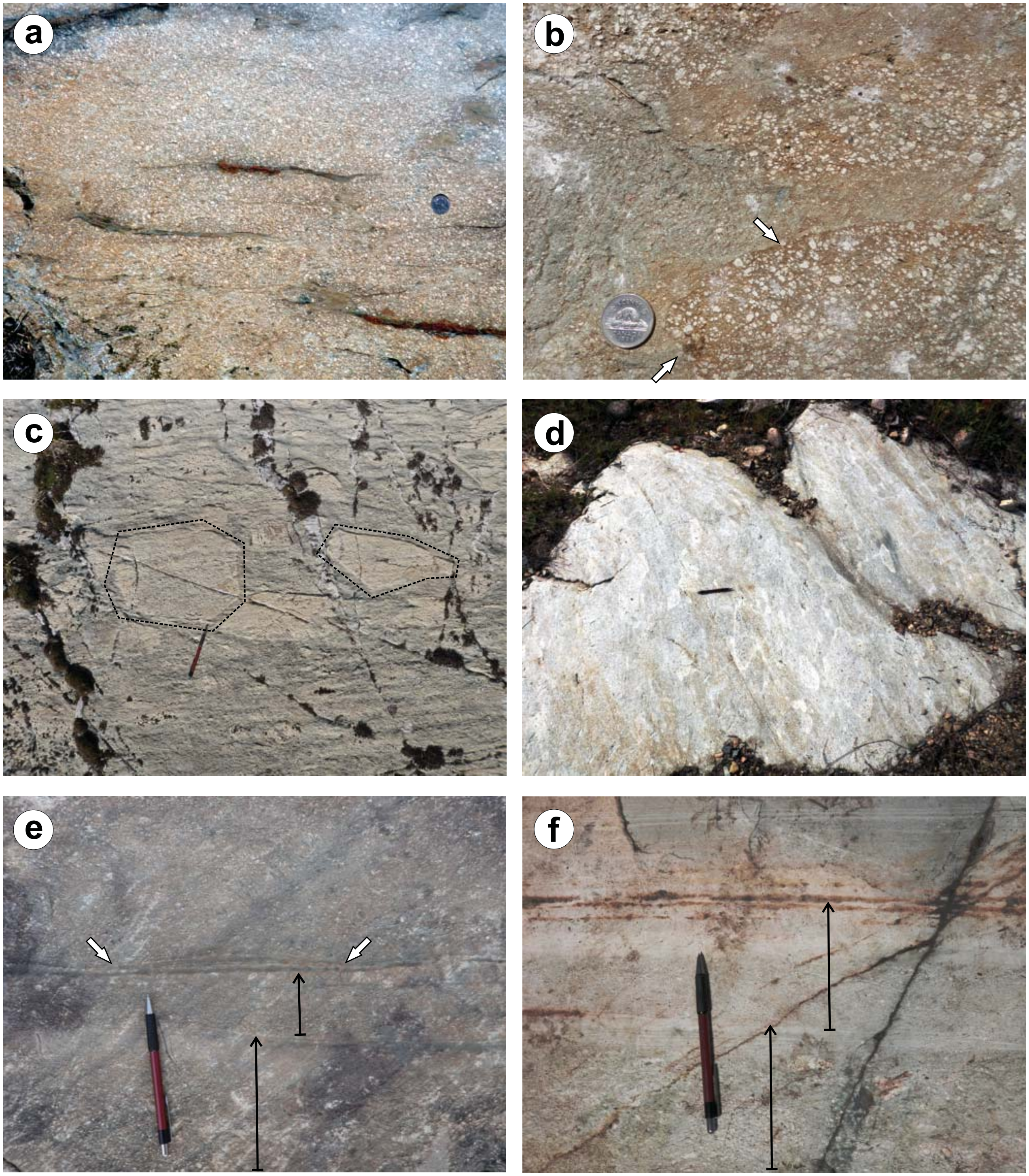

Figure GS-10-6: *Outcrop photographs of rock types in unit 8:* ***a)*** *massive crystal-lithic lapilli tuff (subunit 8a), north of Rice Lake; note wispy rip-up clasts of sulphidic mudstone;* ***b)*** *brecciated crystal-lithic lapilli tuff (subunit 8b), north of Rice Lake; lower clast has sharp margins, with locally protruding plagioclase crystals (indicated by arrows), whereas upper clast has gradational margins;* ***c)*** *joint-bounded blocks (outlined) of crystal-lithic lapilli tuff in crudely stratified tuff breccia (subunit 8b), northeast of Rice Lake;* ***d)*** *volcanic conglomerate of subunit 8c, in type locality north of Rice Lake;* ***e)*** *slightly undulating, scoured contact (indicated by white arrows) between volcanic sandstone (bottom) and volcanic conglomerate (top) of subunit 8c; volcanic sandstone beds are normally graded (indicated by black arrows), whereas base of volcanic conglomerate is reversely graded;* ***f)*** *fine- to coarse-grained, normally graded beds of volcanic sandstone (subunit 8c), north of Rice Lake.*

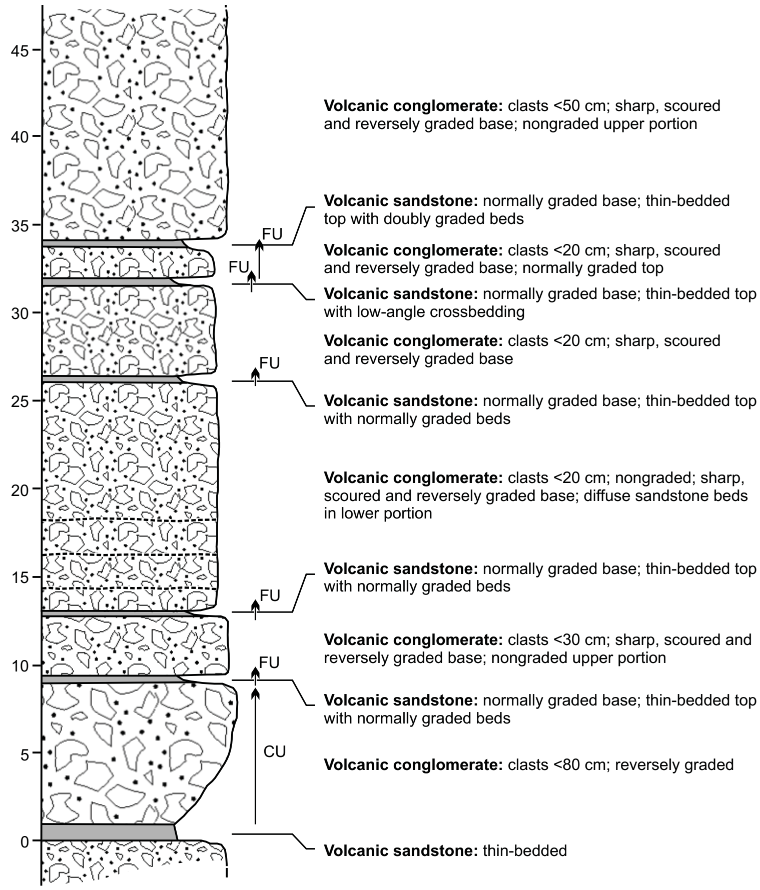

Figure GS-10-7: *Measured section of subunit 8c at the type locality, 100 m west of the Gold Standard/Hinge deposit. The volcanic conglomerate layers are heterolithic, matrix supported and poorly sorted, and are internally unstratified except where indicated. The volcanic sandstone layers are planar bedded, medium to coarse grained and pebbly. Arrows indicate coarsening upward (CU) and fining-upward (FU) trends within individual layers. Vertical scale is metres. The pronounced primary anisotropy in this unit may have influenced the distribution and geometry of the auriferous quartz-vein system in the Gold Standard/Hinge deposit.*

geochemistry in the RLR unit and the upper portion of the TS unit, and are therefore likely to be present in the lower portion of the TS unit as well. For the sake of simplicity, however, all of the gabbro intrusions cutting units 3 and 4 are assigned to unit 5, whereas all those cutting unit 8 are assigned to unit 9. On the maps of Stockwell (1938), all of these intrusions are shown as 'meta-diabase' and are not otherwise distinguished.

Most of these intrusions are less than 5 m thick and are therefore not mappable at 1:5000 scale; several of them range up to 20 m thick locally, and are indicated on PMAP2011-3 (Anderson, 2011). The gabbro generally weathers medium to light green or buff and is dark green on fresh surfaces. In most outcrops, it is characterized by an equigranular subophitic texture. Thinner intrusions tend to be fine grained or very fine grained (subunit 9a), whereas thicker intrusions are medium grained (subunit 9b), particularly in their central portions (Figure GS-10-8a), and locally contain sparse plagioclase phenocrysts (<5%; 2–4 mm). These intrusions contain patchy epidotization, quartz-chlorite-carbonate veins and scattered euhedral pyrite crystals, the pyrite ranging up to 5 cm in one location. Contacts are planar and sharp, with well-developed chilled margins up to 10 cm thick. Dike-in-dike relationships are common (Figure GS-10-8b), and locally indicate several stages of emplacement. Other dikes, particularly near the upper contact of unit 8, are highly irregular and amoeboid, suggesting emplacement into unconsolidated volcaniclastic material; these dikes are not observed north of this contact.

Volcanic conglomerate (unit 10)

Heterolithic volcanic conglomerate of map unit 10 defines the base of the RL unit and is exposed in scattered outcrops along the northern margin of the map area; the best exposures are found along the south side of the new tailings impoundment northeast of Bissett. This unit is exposed for just over 5.0 km along strike and is at least 550 m thick; it is not known to contain significant gold mineralization but does contain quartz-vein systems of similar orientation and style to those in the known deposits (Anderson, 2004). Heterolithic conglomerate is

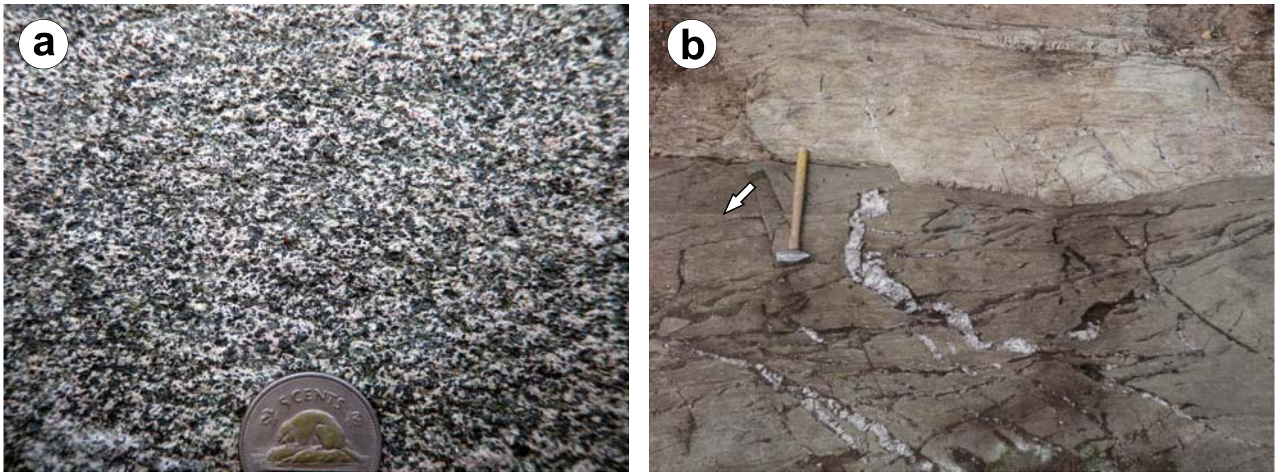

Figure GS-10-8: *Outcrop photographs of rock types in unit 9:* ***a)*** *medium-grained gabbro (subunit 9b), northeast of Rice Lake;* ***b)*** *compound gabbro dike, northeast of Rice Lake; sharp contact between early medium-grained gabbro (bottom) and later fine-grained gabbro (top) is indicated by arrow; external contact of dike is sharp and planar.*

locally interstratified with unit 8 and defines lenticular map units in the upper portion of this unit, the largest of which ranges up to 40 m thick and is traced continuously along strike for 1.3 km (Figure GS-10-3). Contacts with underlying volcaniclastic rocks of unit 8 are exposed in several locations and are clearly erosional. Differences in clast populations are used to define five subunits; most of these rocks are described as 'trachyte breccia' by Stockwell (1938).

Volcanic conglomerate of unit 10 is typically crudely stratified, matrix supported and poorly sorted, and contains very well rounded to subangular clasts that range up to 2.5 m across (typically 0.5–30 cm). Individual clasts range in shape from blocky to nearly spherical, with the latter indicative of significant subaerial transport. Resedimented clasts are common. The matrix consists of green-grey, fine- to coarse-grained, pebbly feldspathic sandstone that generally lacks coarse detrital quartz. Conglomerate of subunit 10a dominates the southern portion of this unit and contains clasts of buff to light grey, fine-grained, aphyric to very sparsely plagioclase-phyric andesite. Crudely stratified intervals, defined by subtle changes in the size and proportion of clasts on a 1–10 m scale, characterize the base of this unit and include minor layers of thin-bedded sandstone up to 50 cm thick (Figure GS-10-9a). Immediately north of contacts with volcaniclastic rocks of unit 8, this conglomerate contains abundant clasts of crystal-lithic lapilli tuff (subunit 10b; Figure GS-10-9b), which decrease in size and abundance upsection (to the north) away from the contacts over distances of between 3 and 40 m.

Conglomerate of subunit 10c is exposed near the base of unit 10 in the northwestern portion of the map area and also defines a discrete lenticular unit in the east-central

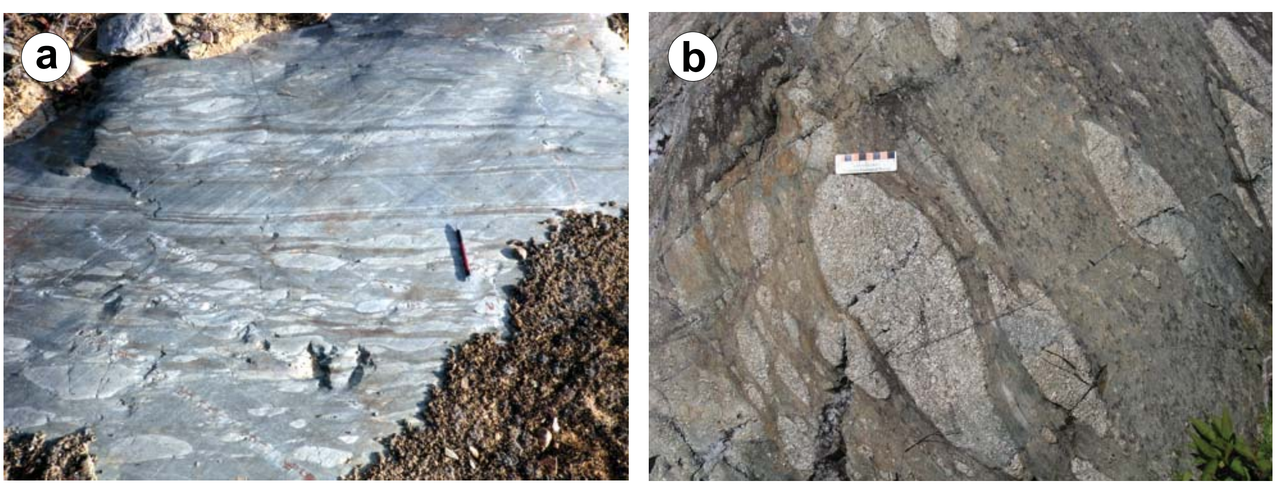

Figure GS-10-9: *Outcrop photographs of rock types in unit 10:* ***a)*** *heterolithic volcanic conglomerate (subunit 10a) with thin-bedded layer of volcanic sandstone, north of Rice Lake;* ***b)*** *angular to subrounded clasts of crystal-lithic lapilli tuff in heterolithic volcanic conglomerate of subunit 10b, just above the base of the 40 m thick interlayer of heterolithic volcanic conglomerate in unit 8, north of Rice Lake.*

portion of unit 8. It is characterized by a large proportion of very angular to rounded clasts of pale green aphyric basalt, which range up to 20 cm across. In the northwestern locality, some of these clasts have delicate cuspate shapes indicative of proximal derivation. Here, the conglomerate is associated with a discrete layer of basaltic lapilli tuff, which is assigned to subunit 10d. This layer is massive, 10–15 m thick and occurs approximately 35 m above the basal contact of the conglomerate. The lapilli tuff weathers pale green and is dark green on fresh surfaces. It consists of closely packed, shard-like to wispy lapilli of aphanitic basalt that have ragged terminations and are interpreted to represent collapsed and recrystallized scoria (Anderson, 2008). The lapilli tuff is chemically similar to dikes of highly evolved calcalkalic (sanukitoid) gabbro (unit 9) in the immediately underlying rocks of unit 8, and is interpreted to represent a scoria-fall deposit that accompanied emplacement of dikes and local effusions of basalt. Conglomerate of subunit 10e dominates the northern portion of this unit and is similar in most respects to subunit 10a, with the exception that clasts and matrix contain ubiquitous, though minor, phenocrysts (or possibly porphyroblasts) of green amphibole up to 5 mm in length.

Intrusive rocks

Diorite, quartz diorite (unit 11)

Diorite and quartz diorite of map unit 11 form dikes and sill-like intrusions that crosscut all map units in the study area, with the possible exception of the quartz-feldspar porphyry of unit 12. These intrusions are particularly abundant south of the Wingold deposit in unit 8, where they define a diffuse swarm that trends south-southwest, slightly counterclockwise to bedding (Figure GS-10-10a). Similarly oriented dikes of diorite and quartz diorite cut counterclockwise across the SAM unit in the Rice Lake mine and likely represent the southwesterly continuation of this swarm. The largest dike in the swarm ranges up to 15 m thick and is traced along strike for approximately 700 m in the area east of Rice Lake, south of the SG1 haul road. Most of these intrusions are less than 5 m thick and are therefore not mappable at 1:5000 scale; those that exceed 10 m in thickness are indicated on PMAP2011-3 (Anderson, 2011). The thickest of these is at least 25 m thick in one locality and defines a laterally continuous sill-like body that intrudes unit 10 along the south side of the tailings impoundment north of Rice Lake. This intrusion is traced for approximately 600 m along strike.

The diorite (and quartz diorite) generally weather to a light greyish-green or buff colour and are medium to light green on fresh surfaces. In most outcrops, this diorite is aphanitic to very fine grained and aphyric (subunit 11a). Most specimens contain dark green chlorite wisps (<5%) that range up to 10 mm in length and may represent a strongly deformed and recrystallized mafic phenocryst phase (in this regard, the diorite is similar in appearance to clasts of amphibole-bearing andesite in the heterolithic volcanic conglomerate of subunit 10e). Porphyritic diorite of subunit 11b contains sparse (<5%) euhedral to subhedral phenocrysts of plagioclase up to 3 mm in length and locally appears to be gradational with the aphyric diorite. Coarsely porphyritic diorite or quartz diorite of subunit 11c contains abundant (10–30%) subhedral plagioclase crystals up to 5 mm in length, with subordinate (<5%) phenocrysts of acicular black amphibole and subhedral quartz in a fine-grained matrix of feldspar, quartz and chlorite. Each of these rock types locally contains quartz-chlorite-carbonate veins as poorly developed stockworks, en échelon gashes or ladder

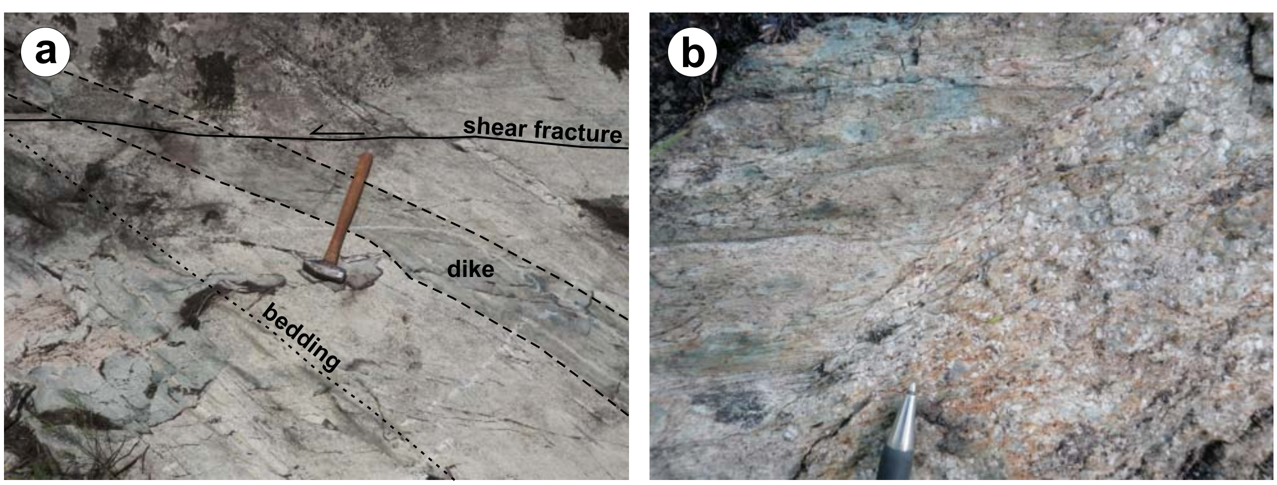

*Figure GS-10-10: Outcrop photographs of rock types in units 11 and 12: **a)** aphyric diorite dike (subunit 11a) cutting at a shallow counterclockwise angle across bedding in an outcrop of crudely stratified breccia (subunit 8b), northeast of Rice Lake; **b)** sharp, planar contact between quartz-feldspar porphyry (right; unit 12) and heterolithic volcanic conglomerate (left; subunit 10a), northeast of Rice Lake; note that the regional foliation in the country rock passes continuously across the contact and is slightly refracted.*

arrays, with localized (patchy) epidotization and scattered euhedral pyrite crystals. Contacts are planar to slightly wavy and very sharp.

Quartz-feldspar porphyry (unit 12)

Intermediate to felsic volcaniclastic rocks of map unit 8 are cut in one location by a quartz-feldspar porphyry dike that trends generally north, ranges between 1 and 3 m in thickness and is traced along strike for approximately 600 m. The northern section of this dike penetrates upward into the base of unit 10 and thus stitches its lower contact. The contacts of the dike are sharp and planar to slightly irregular, and dip steeply to the southwest or northwest, possibly as a result of postemplacement ptygmatic-style folding. The porphyry weathers buff to light grey and is light grey on fresh surfaces, with a seriate-porphyritic texture defined by euhedral to subhedral phenocrysts of feldspar (20–25%) and quartz (2–5%). The phenocrysts range in size from 1 to 5 mm and are evenly distributed in an aphanitic to very fine grained feldspathic matrix. The dike crosscuts mafic dikes of unit 9 and is displaced in a left-lateral sense by a southwest-trending fault. The penetrative regional foliation in the country rock passes continuously across the contacts of the dike (Figure GS-10-10b), indicating that dike emplacement preceded regional deformation. The dike is texturally similar to the hypabyssal quartz-feldspar porphyry intrusion that discordantly cuts felsic epiclastic rocks at the top of the RL unit (Figure GS-10-2).

Economic considerations

Auriferous quartz-vein systems in the Rice Lake mine trend are hosted by discrete brittle-ductile shear zones and kinematically linked arrays of shear and tensile fractures that preferentially formed within chemically favourable or relatively competent rock types, or along strength-anisotropies, during regional compressional deformation. Gold deposits in the mine trend are comparable in this regard to lode-gold deposits in other Archean greenstone belts, which belong to the globally significant 'orogenic' class of synkinematic and synmetamorphic gold deposits associated with accretionary orogenic systems (e.g., Groves et al., 1998). Deposits in this class characteristically exhibit a high degree of structural control. Hence, one of the most important district- to prospect-scale guides to ore is the identification of rheologically favourable rock types or strength-anisotropies in the host succession. In this context, one of the salient results of this study is the recognition of significant primary anisotropy (i.e., stratification) in the upper portion of the Townsite unit, which may have been a factor in the localization of auriferous veins in the Cohiba, L13, Gold Standard/Hinge and Wingold deposits. The preliminary results of this study also provide important new constraints for modelling the distribution, geometry and controls of vein systems throughout the mine trend.

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