DESCRIPTIVE NOTES

PREVIOUS MAPPING

The area (NTS 76D/10, Koala) lies in the central part of the Slave structural province, 315 km NNE of Yellowknife. Folinsbee previously mapped the area on a regional scale in 1949 (GSC 1" to 4 mile scale map #977A).

DESCRIPTION OF MAP UNITS

All map units recognized are either Archean metasedimentary and granitoid rocks or younger intrusives (diabase, kimberlite). The geology of 76D/10 is dominated by a central granitoid batholith. Co-magmatic rock types observed (in decreasing order of abundance) in the Koala batholith include: biotite granodiorite, hornblende-biotite tonalite, quartz diorite and diorite. The Koala batholith intrudes flanking metasedimentary rocks (of variable grade), and itself is cut by a two mica granite along its eastern margin. Evidence for basement to the above-mentioned units in the map area is problematic. Small pods and lenses (1 - 10 m scale; not indicated on the map) of highly deformed rocks of intermediate composition observed in the metasediments along the north shore of Lac de Gras may possibly represent basement olistrosomes. Lithologic units in the map legend are described below in inferred stratigraphic order.

Metasedimentary rocks **(Agw)**

A variety of metamorphosed sedimentary rocks ('greywackes' consisting of interbedded psammite/pelite) are present in the map area. Grey-green weathering, graded psammite - pelite assemblages of low metamorphic grade (spotted slates and phyllites) predominate in the northwestern portion of the map sheet as well as in a narrow belt along the north shore of Lac de Gras. In these rocks thin, bedding parallel-quartz veins are common. Adjacent to the northwestern margin of the Koala batholith, the slates/phyllites are highly silicified and quartz net-veined. South of the Koala batholith, green-brown to rusty brown weathering pelite/psammite assemblages are dominanted by cordierite + andalusite schists. Rare sillimanite (1 - 3 cm porphyroblasts) schists outcrop along the northwest shore of Lac de Gras.

Based on criteria from studies of greywackes in the Contwoyto-Itchen Lakes area of the central Slave province, Bostock (1980) subdivided the metasediments into the Contwoyto and Itchen Formations. Recent work by King et al. (1991) has provided additional observations on rocks of these two formations. In the Koala map sheet, greywackes spatially associated with two-mica granite along the eastern margin of the map area are similar to those in the Paul Lake map sheet to the east (Kjarsgaard and Wyllie, 1993, 1994) and are interpreted to be an extension of the Paul Lake greywacke belt. These rocks characteristically contain mats of fibrolite plus minor acicular sillimanite needles plus partial melt. No graphite-bearing assemblages, banded iron formation or volcaniclastic sediments are found associated with greywackes in the Paul Lake belt. These characteristics, along with 1 to 10 cm scale thick beds suggests these greywackes have affinities with the Itchen Formation (as defined by Bostock, 1980). In contrast, the two large areas of metasediments flanking the Koala batholith are notable for thinner bedding, dominantly millimeter to 10 cm scale (although thicker beds to 50 cm occur) and minor occurrences of graphite-bearing metasediments and beds of mafic and intermediate volcaniclastic rocks. These rock types can only be traced along strike for 10's of metres and their distribution is thus not shown on the map. Although banded iron formation was not observed in 76D/10, it occurs to the northeast in sheet 76D/16 (along strike from the greywacke belt north of the Koala batholith). These characteristics suggest the greywackes have affinities with the Contwoyto Formation (as defined by Bostock, 1980).

Granitoid intrusive rocks

Rocks from the Koala batholith have been subdivided into mappable units (diorite/quartz diorite; quartz diorite/hornblende-biotite tonalite; hornblende-biotite tonalite and biotite granodiorite/hornblende-biotite tonalite) on the basis of mineralogy, presence or absence of cognate xenoliths and variation in fabric development. They are tentatively correlated with the Concession plutonic suite (Bostock, 1980; King et al., 1992; Davis, 1994) in the Contwoyto-Nose Lakes map area to the north.

Diorite/quartz diorite (Ad/Aqd)

One small pluton consisting of variably deformed (massive to foliated), coarse- to medium-grained diorite and quartz diorite occurs within the eastern portion of the Koala batholith. These rocks define a weak magnetic anomaly on the regional (800 m) airborne magnetic survey map (GSC map #7200G). Mineralogy of these rocks is dominated by plagioclase and hornblende, with small, but variable amounts of biotite schlieren, pyroxene, magnetite, quartz and pyrite. Hornblendite and microdiorite cognate cumulate xenoliths are relatively common. No intrusive relationships were observed.

Quartz diorite/hornblende-biotite tonalite (Aqd/Ahbt)

A large pluton consisting of multiple intrusions of equigranular, medium-grained rocks dominated by quartz diorite with lesser amounts of hornblende-biotite tonalite occurs in the northeastern part of the Koala batholith. These rocks intrude adjacent metasedimentary rocks. Inclusions of cognate microdiorite or hornblendite xenoliths are rare or absent in this pluton, in contrast to their occurrence in the diorite/quartz diorite pluton to the southwest. Rocks in this pluton are weakly deformed, appearing slightly recrystallized with poor to non-existent foliation development. Samples from the adjacent Paul Lake sheet to the east contain mineral assemblages consisting principally of plagioclase and hornblende with biotite + quartz + pyrite ± epidote ± interstitial K feldspar. The biotite and epidote are thought to be of magmatic origin. Hornblende + biotite tonalite is distinguished in the field from quartz diorite on the basis of lower modal hornblende, higher quartz + biotite contents and the presence of minor K-feldspar.

Hornblende-biotite tonalite (Ahbt)

Deformed ($S_1 \pm L_1$ fabric) hornblende-biotite tonalite occurs south of the massive quartz diorite/hornblende-biotite tonalite pluton. Thin (10 cm - 10 m scale) greywacke septae of variable length (10's - 100's of m) commonly occur in this body, with garnet observed in tonalite adjacent to the metasediments. This unit also typically contains hornblende-rich microdiorite enclaves. The enclaves are boudinaged, with long axes lying parallel to S_1. These rocks extend east into the Paul lake sheet, north of Eagle lake; the southwestern extent of this unit is uncertain due to poor exposure, however, development of the anastomosing biotite plane foliation weakens and more massive rocks are observed to the south in the vicinity of the southwest/northeast oriented metasedimentary panel.

Biotite granodiorite/hornblende-biotite tonalite (Abgd/Ahbt)

Granodiorites of the Koala batholith are dominantly massive, consisting of plagioclase, K-feldspar, quartz, biotite and ubiquitous accessory pyrite. Texturally distinct phases (e.g. orbicular biotite granodiorite) occuring within the batholoith are observed in a variety of cross-cutting relationships. Subordinate hornblende-biotite tonalite (massive) also occurs within the area, consistent with the Koala batholith being a multiple intrusive. Poor exposure limited attempts to outline individual plutons within the batholith and understand intrusive relationships with the flanking metasedimentary rocks. Lit par lit intrusive relationships with greywacke was observed in one area along the southern contact and at four areas along the northern contact of the batholith. Based on limited evidence, the southern batholith contact is suggested to be intrusive, however, well developed $S_1 \pm S_2$ foliation(s) are observed along the northern contact, suggesting tectonic overprinting subsequent to intrusion. Cleavage development weakens to the south away from this contact; rocks are generally massive one km from the northern margin of the batholith.

Two mica granite (A2mg)

A distinctive white to light grey weathered surface and abundant primary muscovite characterizes these granites. Rocks typically consist of equal proportions of quartz, plagioclase and K-feldspar, with 5 - 10% of both muscovite and biotite. Aquamarine apatite and tourmaline are common accessories. Garnet, cordierite and sillimanite are also observed, but the latter is invariably found only in association with greywacke inclusions. The two mica granite body in the southeast part of map sheet is a composite intrusion, consisting dominantly of medium- to coarse-grained rocks; less common are fine grained, very coarse grained and porphyritic variants. Fabric development consists of one (variably developed) cleavage. This foliation in general persists weakly, displaying localized strain partitioning throughout the pluton. The two mica granite in contact with tonalite has a massive, equigranular fabric. In contrast, a well developed S_1 fabric is observed in the two mica granite where it is in contact with greywacke.

Diabase dykes

Three swarms of Proterozoic diabase dykes (<1 to 50 m in width) are observed. The dykes cut all Archean units. Rocks from separate dyke swarms are distinguished on the basis of orientation, texture, mineralogy and magnetic characteristics. Dykes have been correlated with known swarms in the Slave Province (Fahrig and West, 1986; LeCheminant, 1994).

MacKay (080°)

Two MacKay dyke were observed. These dykes are strongly plagioclase phyric. The dyke in the southern part of the map sheet is 35 to 45 metres wide and is intermittently exposed across the greywacke belt and two mica granite body on the north shore of Lac de Gras. While this dyke trends at approximately 080°, there are a number of segments which trend at approximately 045°. Two outcrops of a MacKay dyke occur in the central part of the map sheet and range from 1 - 10 m wide, trending approximately 080°. It is unknown if these thin dykes represent splays or satellite dykes from a wider (i.e. 30 - 50 m), but unobserved, MacKay dyke nearby. U-Pb baddeleyite studies on a MacKay dyke yielded an age of 2.21 Ga (LeCheminant and van Breemen, 1994).

Lac de Gras (010°)

Two Lac de Gras dykes, 30 - 50 m wide, trending approximately 010°, outcrop intermittently in the map area. They are distinguished from other dykes by their well-developed ophitic texture. U-Pb baddeleyite studies yielded ages of 2.03 to 2.02 Ga (LeCheminant and van Breemen, 1994), correlative with the Booth River intrusive suite 300 km to the NNE.

Mackenzie (335°)

Segments of at least five dykes of the Mackenzie swarm, with trends of 330°- 340° and up to 50 m wide, were observed in the map area. Previous U-Pb baddeleyite studies on dykes from the Mackenzie swarm yielded an age of 1.27 Ga (LeCheminant and Heaman, 1989).

Kimberlite **(k)**

Several kimberlite pipes occur in the area. The Panda, Koala, Leslie, Grizzly and Fox pipes (BHP/DiaMet joint venture), along with pipe #DI-2 (DHK/Kennecott joint venture) are shown on the map. Note that all of these kimberlites lie under lakes, therefore pipe outlines as indicated on the map are schematic only and do not indicate the actual size (this remains proprietary information). Exact locations of other pipes on this map sheet remain proprietary information at this time. A Rb/Sr three point isochron yielded an Eocene age of 52 ± 1.2 Ma (Northern Miner, 1993), however the exact location of the specific kimberlite dated (other than being in the BHP/DiaMet claim block) is unknown. Kimberlite-derived mudstones with Cretaceous to Paleocene dinoflagellate, pollen and spores (Northern Miner, 1993) potentially suggest more than one period of kimberlite emplacement. A U-Pb perovskite age of 86 ± 2 Ma (C.M.H. Jennings, quoted in Pell, 1994) from another kimberlite in the Lac de Gras area (locality unspecified) supports this idea.

ARCHEAN INTRUSIVE RELATIONSHIPS & AGE CORRELATIONS

U-Pb geochronology (in progress) is presently not available for Archean rocks in the Koala map sheet. Relative ages (based on intrusive relationships) are considered to be metagreywacke > diorite ≈ quartz diorite ≈ hornblende-biotite tonalite ≈ biotite granodiorite > two mica granite. On the basis of mineralogy, preliminary geochemistry and relative degree of deformation, all granitoid rocks in the map area are considered correlatives of the 'younger Slave granitoid suite' (King et al., 1992; Davis, 1994), intruded at *ca.* 2625 - 2580 Ma (van Breemen et al., 1992). Specifically, the diorite - granodiorite suite in the map sheet appears to be equivalent to the Concession suite granitoids found to the north in the Contwoyto-Nose Lakes sheets, dated at 2608 +5/-4 Ma (Davis, 1994). Previous age determinations on two mica granites from the Contwoyto-Nose Lakes sheets are in the range 2599 ± 5 Ma to 2585 ± 4 Ma (summarized in Davis, 1994). Detrital zircon studies on a metagraywacke sample from the Paul Lake sheet to the east of the map area give a preliminary maximum deposition age of 2.67 Ga (M.E. Villeneuve, pers. comm., 1994).

STRUCTURAL GEOLOGY

Fabric elements

S_0 is bedding in metasediments and is defined by textural and mineralogical variation at the outcrop scale. Primary sedimentological features observed include graded turbititic beds and scour and fill, ball and pillow and flame structures.

S_1 is the dominant regional cleavage, axial planar to F_1. In metasediments it is defined mainly by biotite alignment, plus parallel first generation quartz stringers.

S_1 is generally oriented parallel or sub-parallel to S_0 in the metasediments, but is strongly refracted across pelitic and psammitic S_0 beds.. S_1 is defined in the diorite/quartz diorite/tonalite/granodiorite suite by mildly ansatomosing biotite planes ñ aligned microdiorite boudins. A local S_1 fabric in two mica granite is defined by a biotite/muscovite + equidimensional quartz/feldspar foliation.

S_2 is a locally observed cleavage axial planar to F_2. S_2 in the greywackes is defined by biotite, muscovite and a second generation of quartz veins. Cleavage development is best observed in pelitic beds. An S_2 pressure solution cleavage is also locally developed, but is seen only in the porphyroblastic greywackes.

F_1 folds are isoclinal, but are rarely seen. However, when observed, S_0 is transposed parallel to S_1, yielding isolated F_1 fold closures with attenuated and sheared off limbs. Mesoscopic and and layer-scale F_1 isoclines are determined by frequent changes of S_0 younging directions and bedding/cleavage (S_0/S_1) relationships.

F_2 are asymmetric folds; Z folds predominate, S folds are quite rare.

L_1 mineral lineations (quartz, biotite) observed in metasedimentary rocks are related to flattening across S1.

L_2 intersection lineations, defined by biotite, muscovite and quartz are observed where both S_1 and S_2 are developed.

Rarely observed slicken striae are shallowly plunging. Joint surfaces in all rock types are dominantly steeply dipping. Sub-horizontal joints (not measured) in granitoid rocks are interpreted to be cracks developed during pluton cooling.

Structural development

Tectonic fabrics exhibit varying degrees of development and orientation. The deformational history in the map area consists of two phases, D_1 and D_2. Note that in adjacent map areas in the central Slave province (e.g. King et al., 1992, Thompson et al., 1994) which contain the 'older' Slave granitoid suite an earlier deformation event and associated cleavage is observed (S_1) and the main or regional cleavage in these areas is the second cleavage (S_2). The main or regional cleavage in the 76D/10 map area is S_1, an earlier cleavage has not been observed.

S_0 is dominantly steeply dipping. However, moderately dipping beds are locally observed. The main cleavage (S_1) is associated with isoclinal folds (F_1), related to D_1. S_1 forms a discrete, spaced cleavage in the greywackes and is oriented sub-parallel to S_0. The locally developed S_2 cleavage is associated with asymmetric F_2 Z folds (rarely S folds) related to D_2. In the map area, D_2 is inferred to be genetically related to two different tectonic features. One locality is associated with a high strain zone at the northern margin of the Koala granodiorite batholith where it is in contact with greywacke. The other area is associated with the tectonic juxtaposition of low grade biotite spotted slates/phyllites against medium/high grade cordierite + andalusite schists near the north shore of Lac de Gras.

Porphyroblast development is complex, suggestive of mineral growth pre-, syn- and post-D_1. At least two generations of cordierite are present. Large, idioblastic porphyroblasts of cordierite and andalusite overgrow S_0 and are wrapped by S_1 (biotite) suggesting that D_1 deformation is preceded by static porphyroblastesis. However, cordierite and andalusite porphyroblasts are also observed to contain dextrally rotated non-planar inclusion trails (syn-D_1). Cordierite is also seen overgrowing S_0, S_1 and a biotite mineral lineation as well as being wrapped or cut by S_2 (post-D_1, pre- to syn-D_2) Both cordierite and sillimanite are observed to overgrow andalusite; S_2 wraps sillimanite and F_2 crenulates fibrolite, suggesting sillimanite is also post-D_1, pre- to syn-D_2. Isograds are discordant to the main regional cleavage (S_1). Cleavage development in the Koala batholith is consistent with emplacement syn-D_1 and pre-D_2. Two mica granites (with local cleavage development) are interpreted to have been emplaced late- to post-D_1.

High strain zones

Localized areas of high strain were noted during mapping. In metasediments and two mica granite, these are related to D_1. Strain partitioning related to D_2 was observed along the northern margin of the Koala batholith; here F_2 Z folds and related S_2 cleavage are locally well developed along the contact in both granodiorites and metasediments.

Tectonic juxtaposition

In the Lac de Gras greywacke belt, low grade slate/psammite or biotite spotted phyllite/psammite are interpreted to have been juxtaposed (dextrally; ± unknown dip-slip component) against medium/high grade cordierite + andalusite schist/psammite. Two lines of evidence were utilized to make this inference. On the south side of the juxtaposition zone, S_2 cleavage development becomes more pronounced in the metasediments northwards; similarly the S_2 cleavage becomes much less significant in the schists further northwards away from the juxtaposition zone. S_2 cleavage development is concentrated along the juxtaposition zone. Metamorphic grade increases slightly northward from the south-central shore of Lac de Gras to the juxtaposition zone (sub-millimetre biotite slates to biotite spotted phyllites). On the north side of the juxtaposition zone the metasediments are monotonous cordierite + andalusite schist/psammite. Presently, it is not possible to determine if metamorphic grade increases to the north or the south in these schists. However, 5 km to the west at the margin of the map area, schists along strike from the juxtaposition zone are observed to be silliminite-bearing, e.g. suggesting metamorphic grade increases to the south. Consistent with this observation is the occurrence of schists on the adjacent southwest shore of Lac de Gras (this study, Folinsbee, 1949).

Faulting

Evidence for faulting in the map area is limited. Although a number of lineaments are apparent on topographic maps and satellite images, no fault gouge was found in surficial exposures, likely a result of subsequent glaciation. However, rare slicken striae were observed. Azimuth measurements of slicken striae coupled with strike measurements on steeply dipping, and often haematized joint sets suggest faulting may be associated with the following trends: ≈050°, ≈080°, ≈115° and ≈335°.

METAMORPHISM

In the metasediments, metamorphic grade is quite variable. Biotite grade spotted slates and phyllites northwest of the Koala granodiorite increase in grade to cordierite + andalusite porphyroblastic schists towards the southwest. Adjacent to the north margin of the Koala batholith, the greywackes are hornfelsed and highly silicified, but no new minerals are observed macroscopically. Metasediments north of Lac de Gras increase in grade northwards from biotite grade slates to biotite spotted phyllites. Metagreywackes south of the Koala granodiorite are cordierite + andalusite schists; the occurrence of sillimanite porphyroblasts in greywackes along the northwest shore of Lac de Gras indicates an increase in metamorphic grade to the southwest; consistent with observations southwest of Lac de Gras. Biotite, cordierite and andalusite porphyroblasts are well developed in the pelitic layers of these schists. Note that sillimanite in these rocks forms large (1 - 3 cm) porphyroblasts. In contrast, metasediments (plus associated partial melt) within two mica granite at the eastern margin of the map area contain silliminite in the form of fibrolite mats plus rare acicular needles. The metamorphic assemblages observed in the metasediments are similar to those observed in other areas of the Slave Province (Thompson, 1978) and are consistent with low-P, high-T metamorphism.

ECONOMIC GEOLOGY

Numerous (> 100) kimberlites have been discovered since the autumn of 1991 in the Lac de Gras area of the central Slave Province. A number of the pipes are diamond-bearing. The following data for pipes from the BHP/DiaMet joint venture within the Koala map sheet is adapted from the DiaMet press release of July 11, 1994. A bulk sample of 230 tonnes from the Panda pipe yielded 270 carats for an average grade of 118c/100t; the diamonds were valued at US$127/carat. A bulk sample of 1572 tonnes from the Fox pipe yielded 360 carats for an average grade of 23c/100t; no information is available on diamond value. For the Koala pipe, which consists of several stacked sub-horizontal phases, the bulk sample was reported as Total sample as well as Upper, Middle, Lower and Deep samples. Koala bulk sample information and derived data are as follows:

Zone	carats	tonnes ore	grade	value US$/c	US$/tonne ore
U	98	≈332	≈ 29.5	88	26
M	468	≈362	≈129	116	150
L	169	≈393	≈ 43	121	52
D	158	≈101	≈157	91	143
Total	893	1193	75	110	82

No data is available for the Leslie and Grizzly pipes. The diamond grade of the DI-2 kimberlite pipe near the north shore of Lac de Gras on the DHK/Kennecott property is unknown; it is thought to be low as it has not been bulk sampled.

The occurrence of metasediments (flanking the Koala batholith), suggested to have affinities with the Contwoyto Formation, coupled with the occurrence of banded iron formation in map area 76D/16 to the northeast (and along strike of metasediments north of the Koala batholith) has potentially important implications for banded iron formation type gold deposits in the map area.

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