Geology at the contact between Yukon-Tanana and Cassiar terranes, southeast of Little Salmon Lake (105L/1), south-central Yukon

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ABSTRACT

Paleozoic platformal and basinal strata of Cassiar Terrane are separated from rocks of Yukon-Tanana Terrane to the west by an unexposed fault in southeast Glenlyon map area.

Quartzite, marble, phyllite, and amphibolite are grouped in Cassiar Terrane, and no rocks of Slide Mountain Terrane are recognized. The mid-Cretaceous Glenlyon batholith contains pendants of Cassiar Terrane and is intruded by at least five andesite dykes. West of the fault, the Yukon-Tanana Terrane includes: (1) mafic volcaniclastic rocks with preserved primary textures; (2) coarse-grained quartz-feldspar grit; and (3) metasiltstone and semi-pelitic schist. The grit is intruded by foliated hornblende granodiorite, likely of early Mississippian age. Small outcrops of tectonized serpentinite were tectonically emplaced into Yukon-Tanana Terrane, and a positive magnetic anomaly parallel to the fault suggests an unexposed extension to the southwest.

Two mylonite localities and evidence of brittle cataclasis up to 1 km on either side of the presumed buried fault suggest a complex structural history along this terrane boundary.

RÉSUMÉ

Les roches de marge continentale d’âge Paléozoïque du terrane de Cassiar sont séparées des roches du terrane de Yukon-Tanana (à l’ouest) par une faille dissimulée dans le secteur sud-est de la carte de Glenlyon.

Le terrane de Cassiar consiste de quartzite, de marbre, de phyllade, et d’amphibolite; aucune de ces roche est apparentée au terrane de Slide Mountain (tel que suggéré au préalable). Le batholite de Glenlyon, datant du Crétacé moyen, contient des enclaves du terrane de Cassiar et est recoupé par au moins cinq dykes d’andésite. À l’ouest de la faille, le terrane de Yukon-Tanana comprend : (1) des roches volcaniclastiques mafiques dont les textures primaires sont intactes; (2) un grès grossier à quartz et feldspath; et (3) du méta-siltstone et du schiste argilleux. Le grès est recoupé par un granodiorite à hornblende folié, dont l’âge est vraisemblablement du Mississippien précoce. De petits affleurements de serpentinite tectonisée sont présents au sein du terrane de Yukon-Tanana; une anomalie magnétique positive qui parallèle la faille suggère que la serpentinite se continue vers le sud-ouest.

Deux affleurements de mylonite et des indications de structures cataclastiques cassantes sur près d’un kilomètre de distance de l’emplacement présumé de la faille suggère une évolution structurale complexe le long de ce contact entre les deux terranes.

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INTRODUCTION

A northwest-trending fault system regionally separates Paleozoic platformal and basinal strata of Cassiar Terrane to the east from crystalline rocks of Yukon-Tanana Terrane to the west (Fig. 1). In eastern Laberge map area (NTS 105E), the southern part of this fault system corresponds to the d'Abbadie Fault (Tempelman-Kluit, 1979). It was originally interpreted by Tempelman-Kluit (1979) as a thrust fault that emplaced Yukon-Tanana Terrane over Cassiar Terrane in pre-Cretaceous time. It was later interpreted by Hansen (1989) as a strike-slip fault which formed the eastern boundary of a north-trending Jurassic transpressional shear zone. Harvey et al. (1997) estimated right-lateral strike-slip displacement of 4 km along the fault and demonstrated that d'Abbadie Fault is intruded by the synkinematic Last Peak granite, dated at 98 Ma (Brown et al., 1998). More recently, d'Abbadie Fault has been interpreted as a mid-Cretaceous brittle normal fault that cuts an older thrust fault that emplaced Yukon-Tanana Terrane onto Cassiar Terrane (de Keijzer et al., 1999).

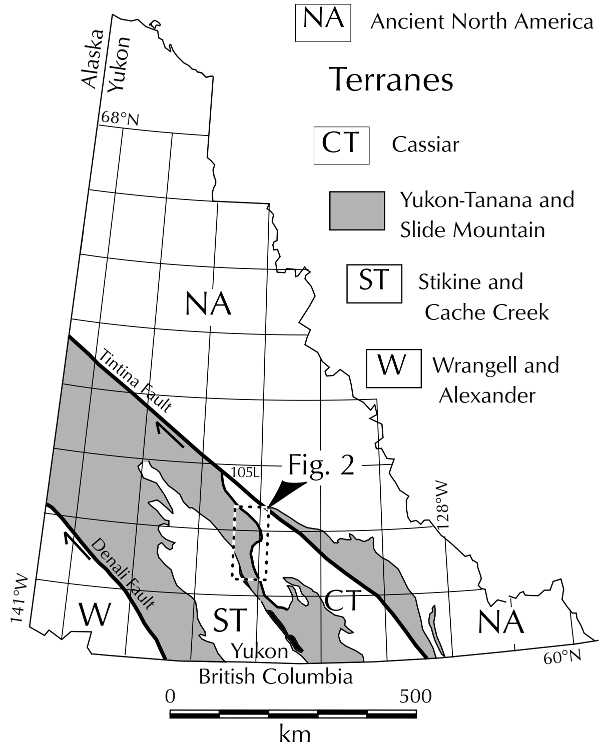

Figure 1. *The study area is located in the southeast corner of Glenlyon map area (NTS 105L), along d'Abbadie Fault. Simplified tectonic boundaries are modified after Wheeler and McFeely (1991).*

When traced northward, d'Abbadie Fault takes a sharp northeast-trending bend in the northeast corner of Laberge map area (105E; Fig. 2). Its northern extent is less certain. In southeastern Glenlyon map area (105L), the contact between Yukon-Tanana and Cassiar terranes is once again defined by a steep, northwest-trending fault system (Campbell, 1967) that has been correlated with the d'Abbadie Fault (Gordey and Makepeace, 2000). It is currently unclear whether the fault system mapped in southeastern Glenlyon map area shares the same deformation history as the d'Abbadie Fault mapped in eastern Laberge map area. Furthermore, the fault system in southeastern Glenlyon map area is displayed, in part, on recent geological compilations to separate Yukon-Tanana Terrane, to the west, from Slide Mountain Terrane to the east (Gordey and Makepeace, 1999, 2000). An objective of the current study is to clarify these relations.

Recent paleomagnetic studies from Late Cretaceous volcanic rocks (Carmacks Group), which disconformably overlie the Yukon-Tanana Terrane immediately west of the d'Abbadie Fault, suggest that these rocks were 2000 km south of their present location during deposition (Johnston et al., 2001). This is consistent with the findings of earlier paleomagnetic work in central Yukon (Johnston et al., 1996; Wynne et al., 1998). However, a maximum of 450 km of Cretaceous or younger dextral strike-slip displacement can be accommodated by the strike-slip faults east of Solitary Mountain (Gabrielse, 1985; Roddick, 1967). If the paleolatitude implied by these rocks is correct, a major Late Cretaceous-Early Tertiary structure northeast of Solitary Mountain must have accommodated large-scale northward translation of Yukon-Tanana Terrane. This study aims to provide further constraints on the nature of the contact between Yukon-Tanana Terrane and Cassiar Terrane in Glenlyon map area.

The study area was previously mapped by Campbell (1967) at a scale of 1:250 000, from fieldwork carried out in the 1950s. Limited exploration work was completed in the 1980s and 1990s in connection with mineral prospects peripheral to mid-Cretaceous intrusions (Yukon MINFILE, 1997, 105L 001). More recently, Colpron (1999, 2000) has mapped Yukon-Tanana Terrane in the areas north and southwest of Little Salmon Lake at a scale of 1:50 000.

This paper presents the preliminary results of detailed 1:50 000-scale mapping of a northwest-trending, 200-km^2 area straddling the boundary between Yukon-Tanana, Slide Mountain and Cassiar terranes in southeast Glenlyon map area. Access to the study area was by

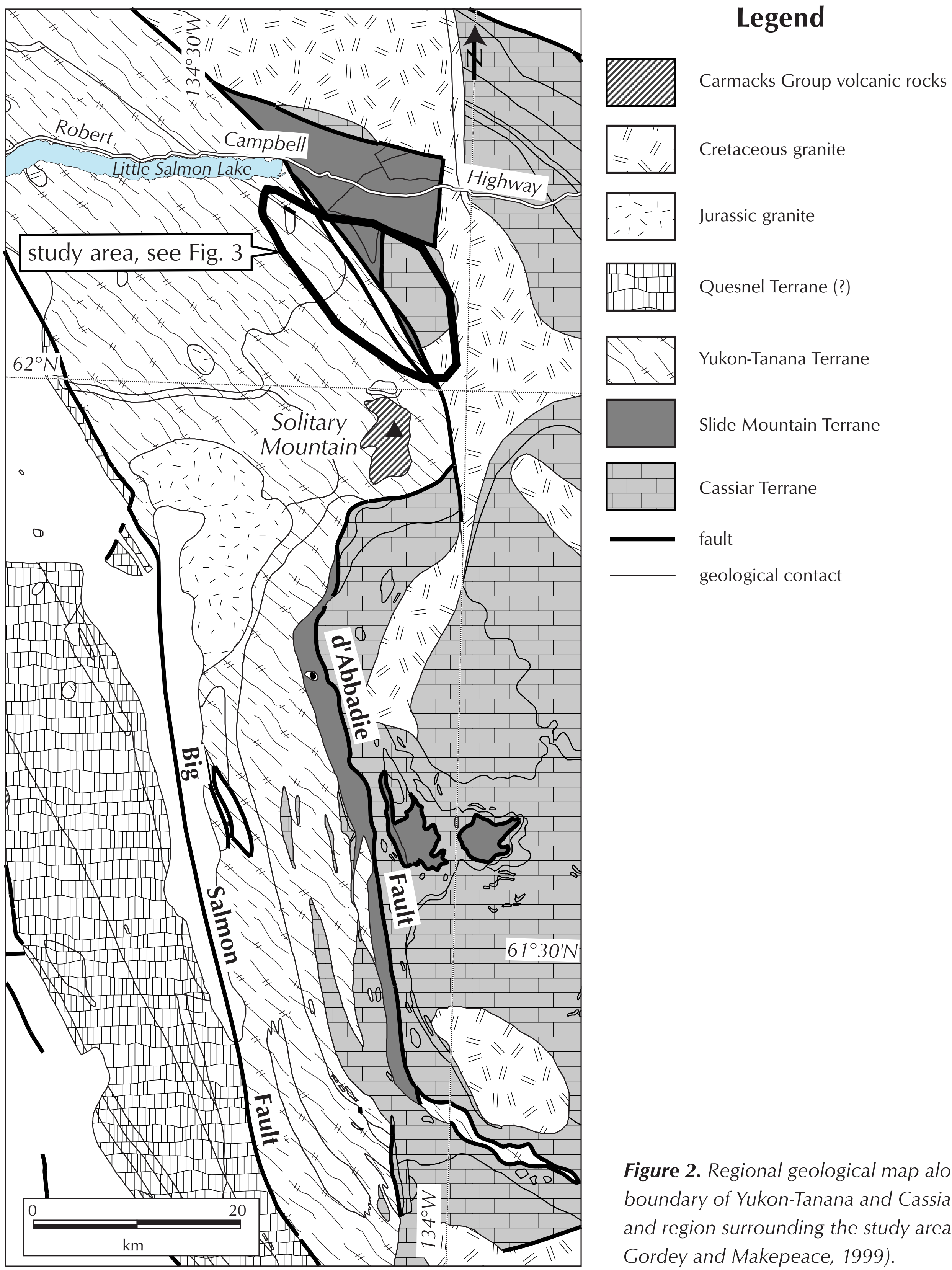

Figure 2. *Regional geological map along the boundary of Yukon-Tanana and Cassiar terranes, and region surrounding the study area (from Gordey and Makepeace, 1999).*

helicopter. The eastern side of the d'Abbadie Fault is predominantly alpine with good outcrop exposure, in contrast to the low-lying areas to the west (Yukon-Tanana Terrane), which have poor outcrop exposure.

GEOLOGY OF SOUTHEASTERN GLENLYON MAP AREA

A north-northwest-trending fault system bisects the study area (Fig. 3). The northeast side of the fault is underlain by a low-grade (greenschist facies) metamorphosed package of sedimentary rocks, including: (1) marble; (2) phyllite; (3) calc-silicate rocks; (4) amphibolite; and (5) pure and impure quartzite. Quartzite and marble are the most common lithologies. The quartzite commonly has a light green colour, is locally calcareous, and contains minor black, locally graphitic, phyllite. The thickness of the quartzite unit is unconstrained but is probably greater than 1 km. The quartzite unit underlies a marble unit which also includes minor amphibolite, quartzite and calc-silicate rocks. A thinly (centimetre-scale) interbedded gradational contact between the quartzite and marble was observed in several locations. Both quartzite and marble units are deformed by a steep foliation defined by mica growth that is axial planar to folds of lithological contacts. Open to closed folds on scales of tens to hundreds of metres have horizontal axes that are parallel

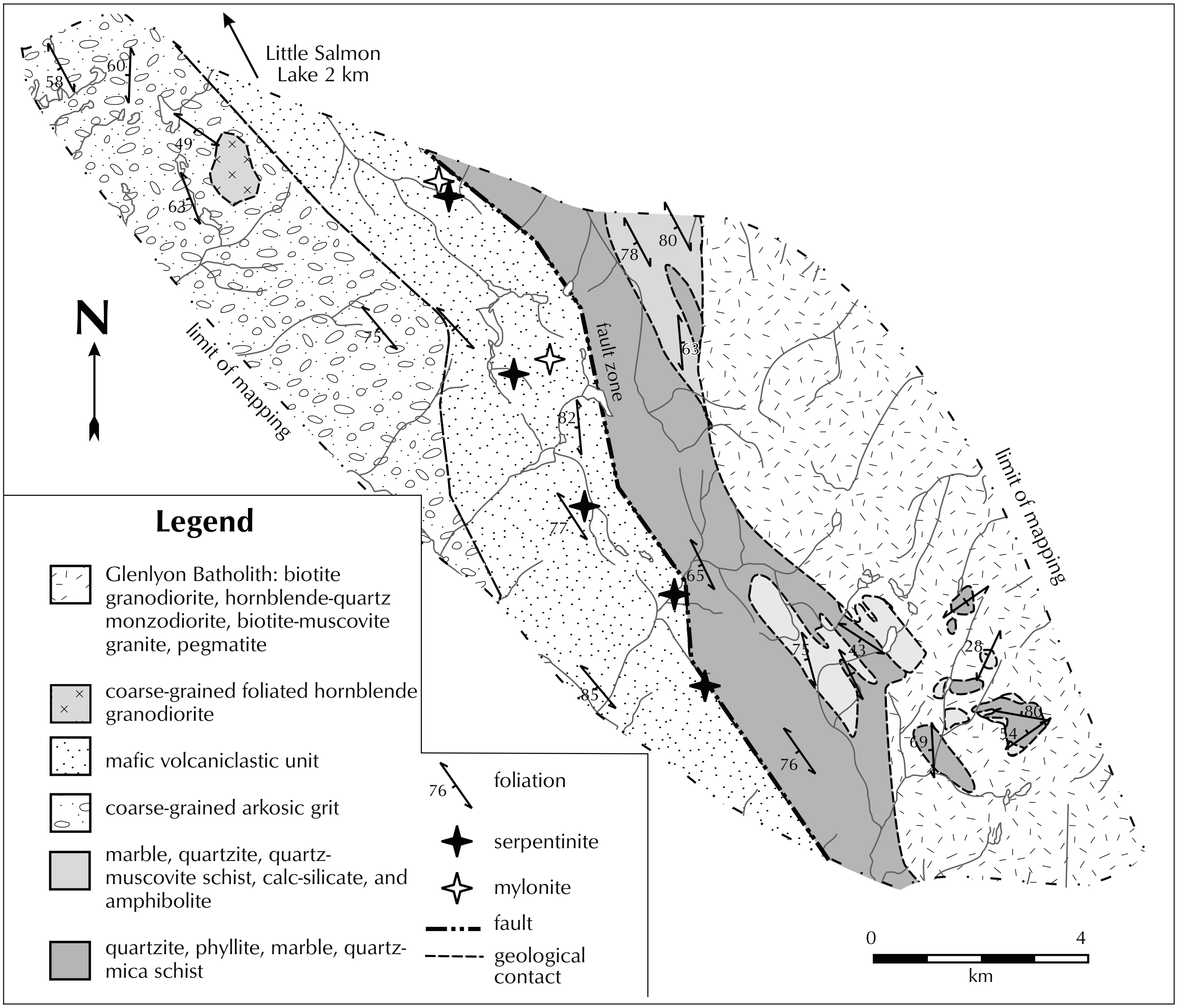

Figure 3. *Preliminary geological map of study area based on mapping completed in the 2001 field season.*

to the terrane-bounding fault. Small, centimetre- to metre-scale chevron folds were observed locally, and are thought to be contemporaneous with the larger-scale folds. These rocks were likely deposited in a continental margin setting and are probably part of Cassiar Terrane.

This metasedimentary succession is intruded by the mid-Cretaceous Glenlyon batholith (Gordey and Makepeace, 2000; Figs. 3, 4). The batholith is characterized by an early phase of hornblende-quartz monzodiorite, a voluminous phase of biotite granodiorite, and a late phase of two-mica granite and pegmatite. The two-mica granite is locally plagioclase-megacrystic. These rocks are unfoliated, but are locally cut by north-northwest-trending brittle faults. These faults are defined by chloritized fracture planes with slickenlines. Where present, release steps indicate dextral motion.

Large xenoliths of quartz + muscovite ± biotite ± garnet schist, marble, garnet + diopside calc-silicate rock, and amphibolite are common near the margin of the batholith and best exposed on hilltops. They range in size from one metre to hundreds of metres. The Glenlyon batholith imposes a contact metamorphic aureole on the metasedimentary rocks. The contact aureole extends 1-1.5 km from the southwestern margin of the batholith, with garnet-grade metamorphism at the batholith margin giving way to biotite- and chlorite-grade rocks farther to the southwest.

Figure 4. *Coarse-grained granite of Glenlyon batholith intruding laminated marble of Cassiar Terrane. Rock hammer for scale.*

Five porphyritic andesite dykes, trending south-southeast to north-northwest, were observed in the Glenlyon batholith. The dykes are sub-vertical, 0.3 to 1.5 m wide, with chilled margins and small wall-rock xenoliths. Clinopyroxene and plagioclase phenocrysts are common. No dykes were observed in Yukon-Tanana Terrane to the west.

Southwest of the fault, the Yukon-Tanana Terrane is dominated by siliciclastic and mafic volcaniclastic rocks. Coarse-grained arkosic grit in the northwestern part of the study area (Fig. 3) is intruded by a coarse-grained, foliated hornblende granodiorite. This association of arkosic grit and foliated granodiorite is similar to that described by Colpron and Reinecke (2000) from the north shore of Little Salmon Lake. There, the arkosic grit is intruded by a hornblende granodiorite which has yielded two discordant early Mississippian preliminary U-Pb zircon dates (Oliver and Mortensen, 1998; Colpron and Reinecke, 2000). The granodiorite mapped in the study area (Fig. 3) is of similar composition and is possibly of early Mississippian age.

West of the volcaniclastic unit, and south of the grit, several outcrops of meta-siltstone and a single exposure of quartz-feldspar-sericite-chlorite schist are exposed. The schist could represent a deformed grit or an intermediate volcanic protolith. It is therefore uncertain whether these rocks are associated with the grit unit or the volcaniclastic unit.

Mafic volcaniclastic rocks occur in a 3-km-wide, northwest-trending belt that separates the grit unit from the fault system (Fig. 3). Primary porphyritic texture is commonly preserved in the basaltic lithic clasts. Epidote and chlorite development indicate greenschist facies regional metamorphism. Foliation, defined by an alignment of chlorite, dips steeply to the west. An interpreted disconformity, along which the volcaniclastic rocks overlie siliciclastic rocks to the north and west, is constrained to within 100 m at one location. Both the volcaniclastic rocks and the grit unit are interpreted to be part of the Yukon-Tanana Terrane.

Five outcrops of serpentinite, 50-200 m long, have been found within the volcaniclastic unit, 50-500 m west of the contact between Yukon-Tanana and Cassiar terranes (Fig. 3). Lineations on facoid surfaces in two of the outcrops plunge shallowly to the south. In thin section, magnetite surrounded by felty masses of chlorite, can be seen. This association probably represents pseudomorphs of spinel with plagioclase coronae, which would suggest that the rock was changed from the spinel to the plagioclase stability field as it was exhumed. This association therefore implies tectonic emplacement of the ultramafic rocks, rather than an intrusive origin (D. Canil, pers. com., 2001). A strong positive magnetic anomaly spatially associated with these outcrops suggests a larger mass may lie further southwest in an area where there is no outcrop exposure (Gordey and Makepeace, 1999).

Due to limited outcrop exposure in some areas, the exact trace of the fault cannot be precisely located, but has been constrained to an area 50 to 150 m wide. A cataclastic texture was observed in some quartzite outcrops of Cassiar Terrane. A similar texture was noted in several exposures of volcaniclastic rocks southwest of the fault. This brittle fabric was generally observed within about 1 km of the presumed fault location, although it was less apparent in the volcaniclastic unit.

Outcrops of mylonitic rocks occur at intervals along strike from the ultramafic rocks (Fig. 3). The mylonitic fabric is complexly folded at one locality, but the authors are uncertain whether this deformation of the mylonitic fabric is in response to a later event, or to progressive localized deformation. Another outcrop of mylonitic rocks occurs 50 m north of the northernmost outcrop of serpentinite (Fig. 3). At this locality, the mylonitic fabric strikes parallel to the adjacent serpentinite cliff face and dips steeply southwest beneath it. The spatial association and similar orientation suggests that the fabric may have formed during ductile deformation associated with tectonic emplacement of the serpentinite.

DISCUSSION AND NEW INTERPRETATIONS

Platformal metasedimentary rocks and granitic intrusive rocks of Cassiar Terrane on the east side of the study area contrast with arkosic grit, quartz-muscovite schist, foliated granodiorite and mafic volcaniclastic rocks of Yukon-Tanana Terrane to the west. The contact between the terranes has been spatially constrained to a narrow (100- to 500-m-wide), north-northwest-trending zone coincident with the presumed location of the d'Abbadie Fault. Occurrences of serpentinite and mylonitic rocks near this contact, and the local presence of late, brittle structures, suggest that the terrane boundary has experienced a complex structural history.

The boundaries of lithological units in Cassiar Terrane, previously shown as faulted contacts (Campbell, 1967), are explained by observed folding patterns and contact metamorphism (Figs. 2, 3). Therefore, these metasedimentary rocks (northeast of the fault) are grouped as quartzite and marble units of the Cassiar Terrane. Rocks that were formerly assigned to Slide Mountain Terrane (Fig. 2) were observed by the authors to be lithologically and structurally similar to the Cassiar Terrane rocks to the south, and are therefore shown herein as Cassiar Terrane. The authors also note that the Glenlyon batholith extends 5 km farther to the northwest than previously mapped (compare Figs. 2 and 3). A large portion of the area previously mapped as Cassiar Terrane (Fig. 2; unit 2a of Campbell, 1967) corresponds to a series of large xenoliths at the western margin of the batholith (Fig. 3).

The 2002 field season will build upon the geological map produced this season, focusing on the nature of the contact between Yukon-Tanana and Cassiar terranes and its relation to the d'Abbadie Fault, as defined to the south in Laberge map area.

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REFERENCES

Brown, R.L., de Keijzer, M., Carr, S.D., Williams, P.F. and Gallagher, C.S., 1998. Structure of the Teslin zone, Yukon, Canada. *In:* Slave-Northern Cordillera Lithospheric Evolution (SNORCLE) and Cordilleran Tectonics Workshop, F. Cook and P. Erdmer, (eds.), Lithoprobe Report no. 64, p. 152-157.

Campbell, R.B., 1967. Geology of Glenlyon map area, Yukon Territory (105L). Geological Survey of Canada, Memoir 352, 92 p.

Colpron, M., 1999. Glenlyon Project: Preliminary stratigraphy and structure of Yukon-Tanana Terrane, Little Kalzas Lake area, central Yukon (105L/13). *In:* Yukon Exploration and Geology 1998, C.F. Roots and D.S. Emond (eds.), Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada, p. 63-72.

Colpron, M., 2000. Geological map of Little Salmon Lake (parts of NTS 105L/1, 2 & 7), central Yukon (1:50 000 scale). Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada, Open File 2000-10, 1:50 000 scale.

Colpron, M. and Reinecke, M., 2000. Glenlyon Project: Coherent stratigraphic succession from Little Salmon Range (Yukon-Tanana Terrane), and its potential for volcanic-hosted massive sulphide deposits. *In:* Yukon Exploration and Geology 1999, D.S. Emond and L.H. Weston (eds.), Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada, p. 87-100.

de Keijzer, M., Williams, P.F. and Brown, R.L., 1999. Kilometre-scale folding in the Teslin zone, northern Canadian Cordillera, and its tectonic implications for the accretion of the Yukon-Tanana terrane to North America. Canadian Journal of Earth Sciences, vol. 36, p. 479-494.

Gabrielse, H., 1985. Major dextral transcurrent displacements along the Northern Rocky Mountain Trench and related lineaments in north-central British Columbia. Geological Society of America Bulletin, vol. 96, p. 1-14.

Gordey, S.P. and Makepeace, A.J. (comps.), 1999. Yukon Digital Geology. Geological Survey of Canada Open File D3826, and Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs, Canada, Open File 1999-1 (D), 2 CD-ROMs.

Gordey, S.P. and Makepeace, A.J. (comps.), 2000. Bedrock geology, Yukon Territory. Geological Survey of Canada, Open File 3754, and Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada, Open File 2001-1, 1:1 000 000 scale.

Hansen, V.L., Mortensen, J.K. and Armstrong, R.L., 1989. U-Pb, Rb-Sr, and K-Ar isotopic constraints for ductile deformation and related metamorphism in the Teslin suture zone, Yukon-Tanana terrane, south-central Yukon. Canadian Journal of Earth Sciences, vol. 26, p. 2224-2235.

Harvey, J.L., Carr, S.D., Brown, R.L. and Gallagher, C., 1997. Deformation history and geochronology of plutonic rocks near the d'Abbadie Fault, Big Salmon Range, Yukon. *In:* Slave-Northern Cordillera Lithospheric Evolution (SNORCLE) and Cordilleran Tectonics Workshop, F. Cook and P. Erdmer (eds.), Lithoprobe Report no. 56, p. 103-114.

Johnston, S.T., Wynne, P.J., Francis, D., Hart, C.J.R., Enkin, R.J. and Engebretson, D.C., 1996. Yellowstone in Yukon: The Late Cretaceous Carmacks Group. Geology, vol. 24, p. 997-1000.

Johnston, S.T., Enkin, R., Baker, J., Francis, D., Colpron, M. and Larson, K., 2001. Solitary Mountain, Yukon: Preliminary paleomagnetic results strengthen the correlation with the Carmacks Formation. F. Cook and P. Erdmer (eds.), Lithoprobe SNORCLE – Cordilleran Tectonics Workshop, Victoria, BC, vol. 79, p. 85.

Oliver, D.H. and Mortensen, J.K., 1998. Stratigraphic succession and U-Pb geochronology from the Teslin suture zone, south central Yukon. *In:* Yukon Exploration and Geology 1997, Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada, p. 69-75.

Roddick, J.A., 1967. Tintina Trench. Journal of Geology, vol. 75, p. 23-32.

Tempelman-Kluit, D.J., 1979. Transported cataclasite, ophiolite and granodiorite in Yukon: Evidence of arc-continent collision. Geological Survey of Canada, Paper 79-14, 27 p.

Wheeler, J.O. and McFeely, P., 1991. Tectonic assemblage map of the Canadian Cordillera and adjacent parts of the United States of America. Geological Survey of Canada, Map 1712A, 1:2 000 000 scale.

Wynne, P.J., Enkin, R.J., Baker, J., Johnston, S.T. and Hart, C.J.R., 1998. The Big Flush – Paleomagnetic signature of a 70 Ma regional hydrothermal event in displaced rocks of the northern Canadian Cordillera. Canadian Journal of Earth Sciences, vol. 35, p. 657-671.

Yukon MINFILE, 1997. Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada.