Stratigraphic succession and U-Pb geochronology from the Teslin suture zone, south-central Yukon

Douglas H. Oliver[1] and James K. Mortensen[2]
[1] Department of Geological Sciences, Southern Methodist University
Dallas, TX, USA 75275, e-mail: oliver@mail.smu.edu
[2] Department of Earth and Ocean Sciences, University of British Columbia
Vancouver, BC, Canada V6C 1Z4, e-mail: jmortens@eos.ubc.ca

Oliver, Douglas H. and Mortensen, James 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, Indian and Northern Affairs Canada, p.69-75.

Abstract

A lithologic succession is recognized in tectonites of the eastern Teslin suture zone in south-central Yukon. Metagraywacke and quartzite, marble, mafic metavolcanics, and interbedded metagraywacke and argillite outcrop on both limbs of an upright northwest-trending syncline at Little Salmon Lake. A body of equigranular granodiorite intrudes the basal stratigraphic units. The granodiorite and its host sediments were penetratively deformed during top-to-the-SW shearing and greenschist facies metamorphism. The granodiorite gives a Devono-Mississippian U-Pb zircon age (353 +1.3/-1.4 Ma) which is interpreted as the minimum age of crystallization. This provides a minimum depositional age for these suture zone protoliths. Based on the sedimentary succession and the age constraints, the eastern suture zone protoliths show a clear genetic link to other pericratonic terranes in the northern Cordillera.

Résumé

Une succession lithologique a été identifiée dans les tectonites de la partie orientale de la suture de Teslin, dans le centre-sud du Yukon. À Little Salmon Lake, des métagrauwackes et des quartzites, des marbres, des métavolcanites mafiques ainsi que des métagrauwackes et des argilites interstratifiées affleurent sur les deux flancs d'un synclinal debout de direction nord-ouest. Un massif de granodiorite équigranulaire pénètre les unités stratigraphiques de base. La granodiorite et les sédiments encaissants ont été déformés de manière pénétrative au cours d'épisodes de cisaillement allant du sommet vers le sud-ouest et de métamorphisme du faciès des schistes verts. La datation à l'U-Pb de zircons de la granodiorite a fourni un âge dévono-mississippien (353 +1.3/-1.4 Ma), que l'on interprète comme l'âge minimum de cristallisation. Cette datation fournit également un âge minimal de dépôt de ces protolithes de la partie orientale de la suture de Teslin.

INTRODUCTION

The Teslin suture zone is a belt of complexly deformed tectonites that outcrop across south-central Yukon (Fig. 1). Despite an abundance of new structural, geochemical and thermochronometric data, the origin and tectonic significance of the Teslin suture zone remains controversial (e.g., Hansen, 1989, 1992; Stevens and Erdmer, 1996; Creaser et al., 1997). In part, this is a function of the polyphase deformational history of this crustal feature. Different study areas often record dissimilar tectonic events, cooling histories, and/or resided at different crustal levels at the time of deformation. However, data sets that would allow for the testing of the various tectonic models — specifically, constraints on the age and source of the protoliths, and the timing and duration of deformation — are only beginning to be developed.

Geologic investigations at Little Salmon Lake have focused on: 1) the nature and sequence of deformation events along this segment of the Teslin suture zone, 2) the thermochronometric history of this area, and 3) P-T conditions at the time of deformation. However, an effort was also made to constrain the age and origin of the protoliths through identification of conodont microfossils from relatively undeformed carbonate units and zircon separation from an orthogneiss body. Although penetrative deformation precluded fossil preservation, U-Pb zircon methods dated the metaplutonic body thus providing a minimum age of deposition for the host rocks. In addition, a lithologic succession is recognized in the eastern part of the study area. The U-Pb crystallization age and the lithologic succession allow new correlations between the study area and other lithologic assemblages in southern Yukon.

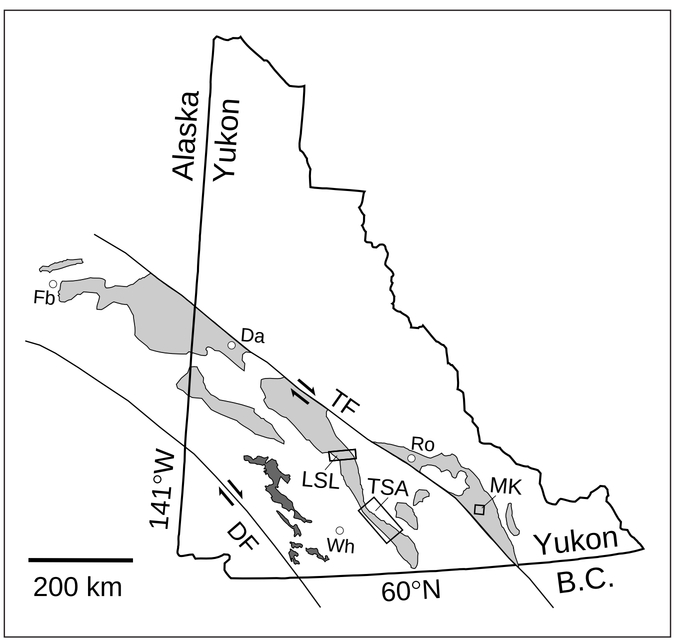

Figure 1. *Distribution of rocks broadly correlative with those of the Yukon-Tanana Terrane and Teslin suture zone in light gray. Nisling terrane and equivalent rocks in dark gray. LSL - Little Salmon Lake study area, TSA - Teslin study area of Stevens et al. (1996), MK - Money Klippe, Wh - Whitehorse, Da - Dawson City, Ro - Ross River, Fb - Fairbanks, TF - Tintina Fault, DF - Denali Fault.*

REGIONAL GEOLOGY

The Teslin suture zone is a prong of the Yukon-Tanana terrane which extends across southeastern Yukon. The suture zone marks a fundamental crustal discontinuity that separates rocks of autochthonous North America from the accreted terranes to the west (Tempelman-Kluit, 1979). Tectonites within the suture zone are defined by a pervasive, penetrative ductile fabric with the sedimentary, volcaniclastic and igneous protoliths commonly metamorphosed to greenschist or amphibolite facies (Hansen, 1989; Stevens and Erdmer, 1996).

Little Salmon Lake is located 170 km north-northeast of Whitehorse and 65 km west of Faro. Access is provided by the Robert Campbell Highway which transects the area of interest. Good exposures on both the north and south shores of Little Salmon Lake and in road-cuts allow for a nearly continuous transect across the Teslin suture zone before it enters the lowlands to the northwest.

The Teslin suture zone at Little Salmon Lake is 25 to 30 km wide and is bounded on the east and west by the d'Abaddie and Big Salmon faults, respectively (Campbell, 1967). Lithologies of North American affinity occur northeast of the d'Abaddie Fault (Fig. 2). The suture zone tectonites commonly display both a mylonitic foliation and an elongation lineation (Oliver, 1996). Foliation strikes N40W with both southwest and northeast dips. A series of 5 to 20 km wavelength folds are the most conspicuous structural feature at Little Salmon Lake. These NW-trending folds — close to tight, steeply inclined to upright, and gently plunging — increase in amplitude to the northeast. Axial planar cleavage is infrequently observed except within the core of the eastern syncline. The orientation of the steeply-dipping cleavage is compatible with development during broad-scale folding.

In addition to a mylonitic foliation, most Little Salmon Lake tectonites also display a mineral elongation lineation consisting of sheared mica or rodded quartz. Lineation trends are dominantly either parallel or perpendicular to strike and form several spatially-distinct domains. Kinematic analysis through microshear-sense indicators and quartz c -axis analysis reveals a complex structural history (Oliver and Goodge, 1996). From oldest to youngest, the deformation events include: 1. Top-to-the-SW and top-to-the-NE dip-slip shear within the structurally low tectonites, 2. Partial overprinting of the dip-slip fabrics during top-to-the-NW shearing in the structurally high tectonites, and 3. Folding of the tectonite assemblage after the cessation of penetrative deformation (Oliver, 1996).

Graphitic phyllites east of the d'Abaddie fault contain dip-slip lineations that are parallel to those in the adjacent suture zone tectonites. However, the graphitic phyllites differ in protolith, are of a lower metamorphic grade and lack kinematic indicators. The relationship of these tectonites to those of the suture zone and the relative timing of fabric development is unconstrained.

STRATIGRAPHIC SECTION

Siliciclastic sediments constitute the primary protoliths at Little Salmon Lake with lesser amounts of pelites, marls/limestones, volcaniclastics, mafic flows, and intermediate intrusives. Attempts to establish a stratigraphy in the western part of the suture zone were unsuccessful. Although the lithologic successions are not chaotic, neither are they systematic and a high degree a compositional heterogeneity characterizes many outcrops. The absence of distinctive, wide-ranging markers is an impediment to stratigraphic correlation and the pronounced mylonitic foliation obscures lithologic contacts, either depositional or tectonic.

In contrast, field investigations in the eastern third of the Little Salmon Lake study area indicate that a sedimentary succession is preserved within the eastern syncline. Tectonites in this area display strong L-S fabrics and record dominantly top-to-the-SW dip-slip shear giving way to top-to-the-NW shear in the core of the syncline. The protoliths have been metamorphosed to the greenschist facies.

A metagraywacke and quartzite unit is exposed at the lowest structural/stratigraphic level (Fig. 3). The metagraywackes are composed primarily of quartz, muscovite, plagioclase, chlorite and biotite and are weakly graphitic. Thin interbeds include relatively clean quartzite, chloritic phyllite and minor stretched-pebble conglomerate. The units show a pronounced mylonitic foliation and primary bedding is not observed. Quartz within the metagraywacke and quartzite are commonly sheared into ribbons that remain unannealed.

A ~10 m thick layer of fine-grained sugary white quartzite is exposed on the south shore of Little Salmon Lake (SS-27). This unit contains up to 10% disseminate pyrite and is extensively stained with jarosite and possibly scorodite. Because of the pervasive ductile shearing, the primary relationship of this unit to the surrounding metagraywacke and quartzite remains equivocal although it could be syngenetic and exhalative.

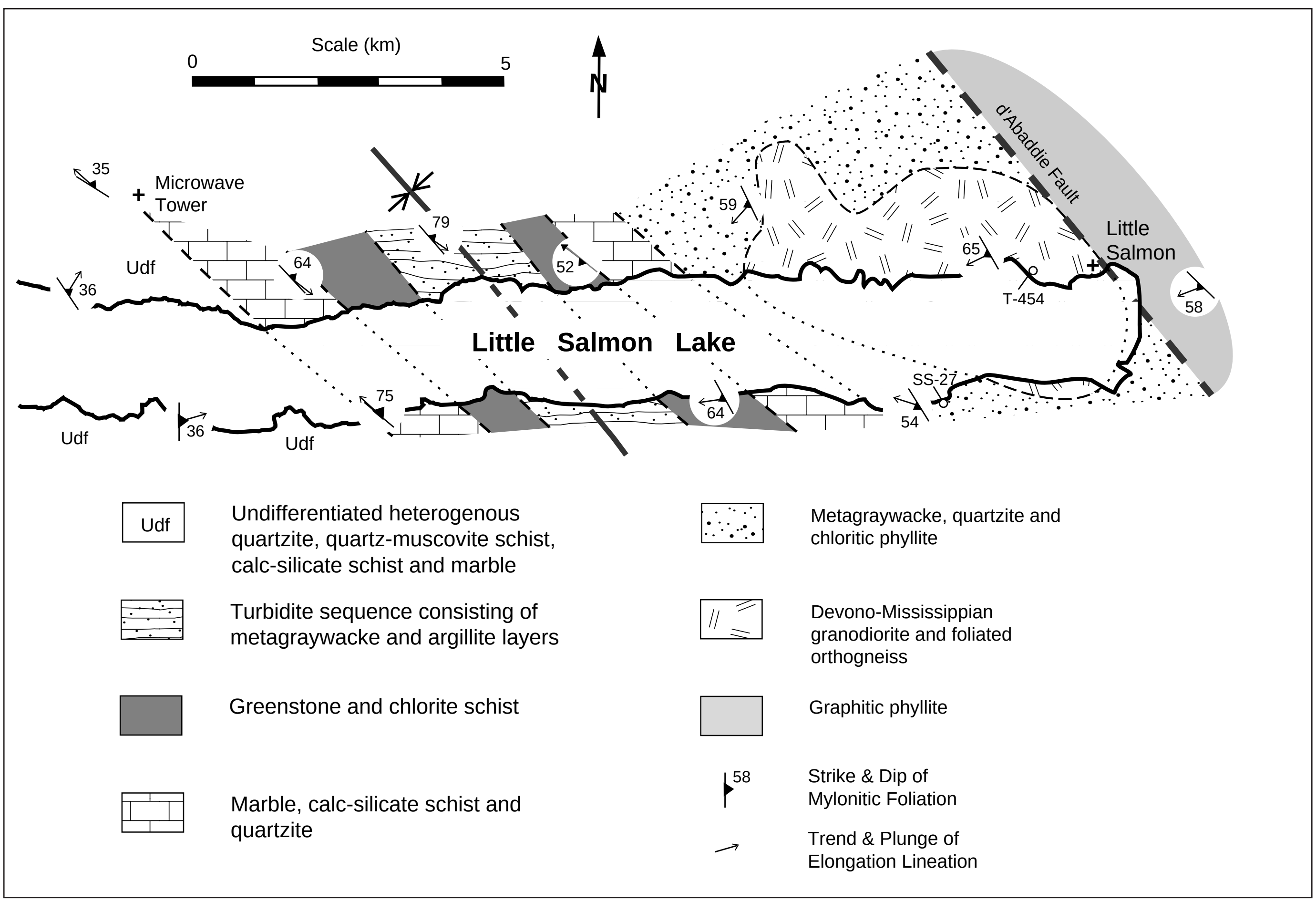

Figure 2. *Geology of the eastern Little Salmon Lake study area.*

However, geochemical analyses revealed only background amounts of Au, Ag and As.

The base of the metagraywacke/quartzite unit is not exposed although it has a thickness of at least 1.5 km. It appears to fine upward into chloritic phyllite and may have a gradational contact with the overlying unit.

Marble and calc-silicate schist form a distinctive unit on both limbs of the eastern syncline. The marbles are strongly recrystallized and occasionally contain disseminated dolomite rhombs. Epidote, clinozoisite and minor titanite are commonly observed in both the calc-silicate schists and in quartzite layers within the marbles. The marbles are intensely contorted with fold axes parallel to the eastern syncline. The marble and calc-silicate schist unit has a thickness of approximately 500 m.

Greenstone and intercalated chlorite schist overlie the marble and calc-silicate schist although the contact is covered. The greenstones are often massive and lack both foliation and lineations. The greenstone and chlorite schist appears to have been derived from mafic volcanics although no primary textures are preserved. They have an approximate thickness of 500 m.

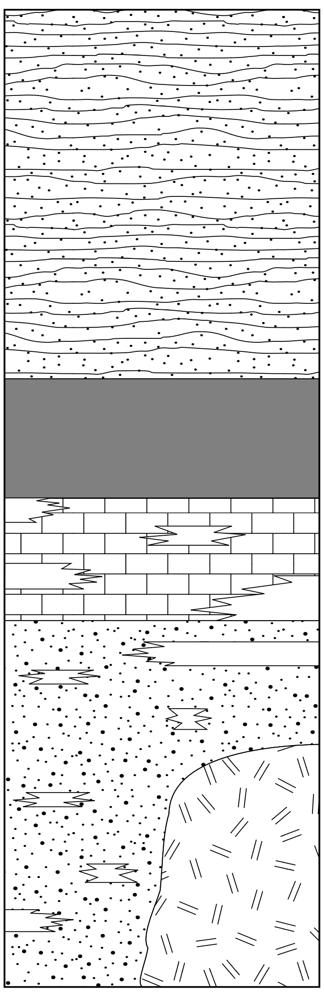

Figure 3. *Stratigraphy of the eastern Teslin suture zone at Little Salmon Lake.*

Metagraywacke and argillite form the core of the eastern syncline. This metagraywacke is similar in composition to that seen in the metagraywacke/quartzite unit but differs by its lack of a well-developed tectonite fabric. Bedding relations in the upper metagraywacke unit consist of grits fining upward into graphitic argillite followed by an abrupt contact with the next overlying grit layer. The grit/argillite pairs range in thickness from 0.5 to 4 m and resemble upright turbidite sequences. An axial planar cleavage is well-developed in the argillite layers, particularly in the core of the syncline. Although the top of the upper metagraywacke is not exposed, the unit is estimated to have a minimum thickness of about 1.5 km.

Orthogneiss outcrops immediately west of the d'Abaddie fault and is the only deformed plutonic body at Little Salmon Lake. Massive, medium-grained equigranular granodiorite is exposed at sample station T-454 and consists of plagioclase, quartz and chlorite after amphibole with minor biotite. The intrusive becomes increasingly mylonitized away from the undeformed core. In most outcrops the orthogneiss displays a pronounced foliation including discrete bands of ultramylonite. Quartz grains within the orthogneiss are sheared into ribbons and the feldspar porphyroblasts are comminuted with σ-tails. The orthogneiss is surrounded by the metagraywacke/quartzite unit on the south, west and north. Because the metagraywacke has a bulk mineralogy similar to the orthogneiss, they are often indistinguishable after deformation and the contact relationship between them remains obscure. The limits of the orthogneiss are poorly constrained although it has a minimum surface area of ~8 km^2.

U-Pb RESULTS

A sample from the undeformed core of the orthogneiss body was chosen for U-Pb zircon dating. Sample T-454 was collected on the north side of the Robert Campbell Highway and consists of unfoliated granodiorite. Care was taken to exclude the mafic xenoliths that are locally contained within the pluton. The analytical results are shown in a conventional U-Pb concordia plot (Fig. 4).

Three fractions of zircon from sample T-454 were analyzed (Table 1). All the fractions are discordant but a regression line through the three analyses (MSWD = 0.3) gives lower and upper intercept ages of 353 +1.3/-1.4 Ma and 3.12 ±0.35 Ga, respectively. The data array indicates the presence of a small inherited zircon component in all the fractions. The lower intercept age is interpreted as the minimum crystallization age of the granodiorite.

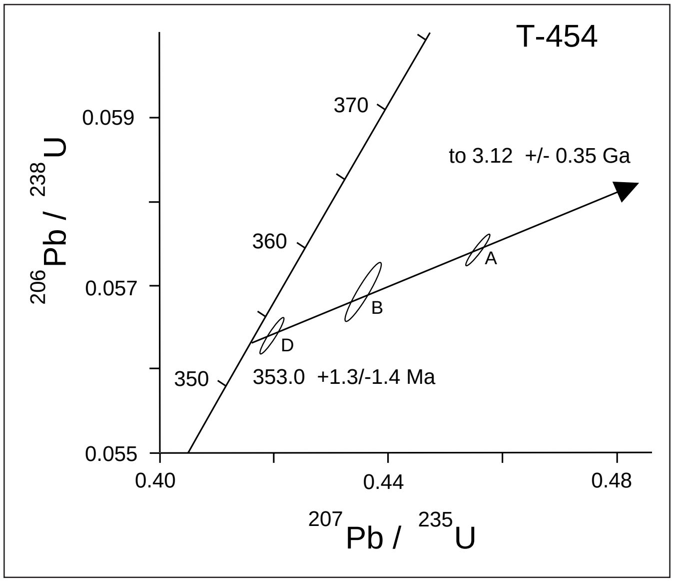

Figure 4. *U-Pb concordia diagram for granodiorite sample.*

DISCUSSION

U-Pb zircon dating at Little Salmon Lake establishes that at least the basal portion of the sedimentary succession in the eastern study area is pre-Mississippian. The distinctive sedimentary succession — coupled with Devono-Mississippian magmatism — allows for possible correlations with other lithotectonic terranes in the northern Cordillera.

Intermediate composition plutonic bodies with Devono-Mississippian crystallization ages have previously been reported from within the Teslin suture zone (Stevens et al., 1993). Analyses of three bodies of quartz-diorite orthogneiss in the Teslin map area yielded U-Pb zircon crystallization ages ranging from 341 to 351 Ma. Because of the intrusive relationship between the orthogneiss and the siliceous schists of the Nisutlin assemblage, Stevens et al. (1996) argue the Nisutlin assemblage was a coherent lithotectonic unit by Mississippian time. Consequently, the Nisutlin assemblage could not be the product of Permian to Early Jurassic subduction/accretion as has been suggested (e.g., Tempelman-Kluit, 1979; Hansen, 1989). Because ε_{Nd} values of the sedimentary protoliths in the Teslin map area indicate two sources of sediment supply — one of continental affinity and a second from a more primitive source-Creaser et al. (1997) conclude that the Nisutlin assemblage represents the outermost margin of ancestral North America.

However, plutons yielding comparable crystallization ages are found in a number of lithotectonic terranes. Hornblende-bearing Devono-Mississippian plutons are found in the eastern Alaska Range (Nokleberg and Aleinikoff, 1985), north of the Tintina fault in the Finlayson Lake area (Mortensen and Jilson, 1985; Grant et al., 1996), and the in Tracy Arm assemblage in the Coast Ranges (Karl et al., 1996). Devono-Mississippian plutons with peraluminous compositions are reported from the orthogneiss assemblage of the Yukon-Tanana Terrane of east-central Alaska (Dusel-Bacon and Aleinikoff, 1985; Aleinikoff et al., 1986), the Nisling terrane (Mortensen, 1992; Johnston et al., 1996), and the Cassiar terrane in the Laberge-Quiet Lake area east of the d'Abaddie fault (Hansen et al., 1989).

Similarly, the primitive to evolved ε_{Nd} signature of the Nisutlin sediments has also been reported from quartz-rich schists of the Nisling terrane (Jackson et al., 1991), the Tracy Arm and related assemblages of the Coast Ranges (Samson et al., 1991), and the "lower unit" strata beneath the Money klippe north of the Tintina Fault (Grant et al., 1996). Consequently, neither the Devono-Mississippian plutons nor the ε_{Nd} signature of the sedimentary host rocks allow for an unambiguous correlation between the suture zone tectonites and other pericratonic terranes in the northern Cordillera.

The lithologic succession observed at Little Salmon Lake offers an alternative means of identifying prospective correlative lithotectonic units. A similar stratigraphy is observed in the Finlayson Lake area (Mortensen and Jilson, 1985; Hunt, 1997). There the "lower unit" consists of pre-Late Devonian micaceous

Description[1]	Wt (mg)	U (ppm)	Pb[2] (ppm)	$^{206}Pb/^{204}Pb$ (meas.)[3]	total common Pb (pg)	% ^{208}Pb[2]	$^{206}Pb/^{238}U$[4] (±% 1σ)	$^{207}Pb/^{235}U$[4] (±% 1σ)	$^{207}Pb/^{206}Pb$[4] (±% 1σ)	$^{206}Pb/^{238}U$ age (Ma, ±%2σ)	$^{207}Pb/^{206}Pb$ age (Ma, ±%2σ)
Sample T-454, undeformed granodiorite (62°11.99'N; 134°26.79'W)											
A: N2, >134	0.255	319	18.6	10090	29	10.3	0.05741(0.17)	0.4558(0.23)	0.05758(0.10)	359.9(1.2)	513.8(4.3)
B: N2, >134	0.180	247	14.2	2314	69	10.1	0.05692(0.31)	0.4357(0.36)	0.05552(0.13)	356.8(2.1)	433.2(6.0)
D: N2, 104-134	0.118	254	14.4	9454	11	9.8	0.05639(0.19)	0.4197(0.25)	0.05398(0.10)	353.6(1.3)	370.3(4.7)

Analyses done at the Geochronology Laboratory, University of British Columbia, methods as described in Mortensen et al., 1995
[1] N2 = non-magnetic at one degree side slope on Frantz isodynamic magnetic separator, grain size given in microns
[2] radiogenic Pb; corrected for blank, initial common Pb, and spike
[3] corrected for spike and fractionation
[4] corrected for blank Pb and U, and common Pb

Table 1. *U-Pb analytical data.*

quartzite, marble, limy argillite and greenstone, and carbonaceous quartzose rocks. Devono-Mississippian augen gneiss also occurs at the base of the section. Similarly, descriptions of the Aishihik metamorphic suite from the Nisling terrane indicate that quartzofeldspathic mica schist is overlain by metabasite, marble and carbonaceous quartzite (Johnston et al., 1996). However, the metabasite largely lies under the primary marble unit. Two-mica granite orthogneiss contained within the Aishihik metamorphic suite also gives an Early Mississippian U-Pb crystallization age. Finally, quartzose schists with metaigneous rocks and marble are recognized in the Coast Range (Wheeler and McFeely, 1991).

Because of the Teslin suture zone's location, the Nisling terrane and ancestral North America are considered the most likely potential source terranes for the tectonites of the eastern study area. Although it remains ambiguous which provides the best match, the similarities between the eastern tectonites and other terranes with North American affinities is an important constraint in the evolution of the Teslin suture zone. The processes that tectonized these pericratonic fragments and resulted in their distribution are inherently linked to the larger issues of terrane distribution and tectonic history in the northern Cordillera.

However, it is emphasized that these results should not be extrapolated across the entire suture zone at Little Salmon Lake. Tectonites in the western part of the study area differ from those to the east in protolith, shear sense and cooling history (Oliver and Hansen, 1997). Although age constraints for these western tectonites are lacking, lithologic associations suggest a diverse source of sediments and multiple depositional environments. Given its heterogeneous nature, it is possible that the Teslin suture zone juxtaposes constituents with spatially and temporally distinct tectonic histories.

ACKNOWLEDGMENTS

This paper summarizes results that form part of a Ph.D. dissertation (Oliver, 1996). Oliver was supported by National Science Foundation grant EAR-9103531 to Vicki L. Hansen. We thank the staff of the UBC Geochronology Laboratory for assistance in producing the analytical data.

REFERENCES

Aleinikoff, J.N., Dusel-Bacon, C., and Foster, H.L., 1986. Geochronology of augen gneiss and related rocks, Yukon-Tanana terrane, east-central Alaska. Geological Society of America Bulletin, v. 97, p. 626-637.

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

Creaser, R.A., Erdmer, P., Stevens, R.A., and Grant, S.L., 1997. Tectonic affinity of Nisutlin and Anvil strata from the Teslin tectonic zone, northern Canadian Cordillera: Constraints from neodymium isotope and geochemical evidence. Tectonics, v. 16, p. 107-121.

Dusel-Bacon, C., and Aleinikoff, J.N., 1985. Petrology and tectonic significance of augen gneiss from a belt of Mississippian granitoids in the Yukon-Tanana terrane, east- central Alaska. Geological Society of America, Bulletin, v. 96, p. 411-425.

Grant, S., Creaser, R., and Erdmer, P., 1996. Isotopic, geochemical and kinematic studies of the Yukon Tanana terrane in the Money Klippe, SE Yukon. *In:* F. Cook and P. Erdmer (eds.), Slave-Northern Cordillera Lithospheric Evolution (SNORCLE) Transect and Cordilleran Tectonics Workshop Meeting 1996, University of Calgary. Lithoprobe Report No. 50, p. 27-30.

Hansen, V.L., 1989. Structural and kinematic evolution of the Teslin suture zone, Yukon: Record of an ancient transpressional margin. Journal of Structural Geology, v. 11, p. 717-733.

Hansen, V.L., 1992. P-T evolution of the Teslin suture zone and Cassiar tectonites, Yukon, Canada: Evidence for A- and B-type subduction. Journal of Metamorphic Geology, v. 10, p. 239-263.

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, v. 26, p. 2224-2235.

Hunt, J., 1997. Massive sulphide deposits in the Yukon-Tanana and adjacent terranes. *In:* Yukon Exploration and Geology 1996; Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 35-45.

Jackson, J.L., Gehrels, G.E., Patchett, P.J., and Mihalynuk, M.G., 1991. Stratigraphic and isotopic link between northern Stikine terrane and an ancient continental margin assemblage, Canadian Cordillera. Geology, v. 19, p. 1177-1180.

Johnston, S.T., Mortensen, J.K., and Erdmer, P., 1996. Igneous and metaigneous age constraints for the Aishihik metamorphic suite, southwest Yukon. Canadian Journal of Earth Sciences, v. 33, p. 1543-1555.

Karl, S.M., Hammarstrom, J.M., Kunk, M., Himmelberg, G.R., Brew, D.A., Kimbrough, D., and Bradshaw, J.Y., 1996. Tracy Arm transect: Further constraints on the uplift history of the Coast plutonic complex, southeastern Alaska. Geological Society of America Abstracts with Programs, v. 28, p. A-312.

Mortensen, J.K., 1992. Pre-mid-Mesozoic tectonic evolution of the Yukon-Tanana terrane, Yukon and Alaska. Tectonics, v. 11, p. 836-853.

Mortensen, J.K., Ghosh, D., and Ferri, F., 1995. U-Pb geochronology of intrusive rocks associated with copper-gold porphyry deposits in the Canadian Cordillera. *In:* T.G. Schroeter (ed.), Porphyry deposits of the northwestern Cordillera of North America, CIM Special Volume 46, p. 142-160.

Mortensen, J.K., and Jilson, G.A., 1985. Evolution of the Yukon-Tanana terrane: evidence from southeastern Yukon Territory. Geology, v. 13, p. 806-810.

Nokleberg, W.J., and Aleinikoff, J.N., 1985. Summary of stratigraphy, structure, and metamorphism of Devonian igneous-arc terranes, northeastern Mount Hayes quadrangle, eastern Alaska Range, Alaska. United States Geological Survey Circular 967, p. 66-71.

Oliver, D.H., 1996. Structural, kinematic, and thermochronologic studies of the Teslin suture zone, south-central Yukon Territory. Ph.D. thesis, Southern Methodist University, Dallas, 231 p.

Oliver, D.H., and Goodge, J.W., 1996. Leucoxene fish as a micro-kinematic indicator. Journal of Structural Geology, v. 18, p. 1493-1497.

Oliver, D.H., and Hansen, V.L., 1997. Devono-Mississippian crustal fragments within an early Jurassic suture zone assemblage, central Yukon. Geological Society of America, Abstracts with Programs, v. 26, p. A-465.

Samson, S.D., Patchett, P.J., McClelland, W.C., and Gehrels, G.E., 1991. Nd isotopic characterization of metamorphic rocks in the Coast Mountains, Alaskan and Canadian Cordillera: Ancient crust bounded by juvenile terranes. Tectonics, v. 10, p. 770-780.

Stevens, R.A., and Erdmer, P., 1996. Structural divergence and transpression in the Teslin tectonic zone, southern Yukon Territory. Tectonics, v. 15, p. 1342-1363.

Stevens, R.A., Erdmer, P., Creaser, R.A., and Grant, S.L., 1996. Mississippian assembly of the Nisutlin assemblage: Evidence from primary contact relationships and Mississippian magmatism in the Teslin tectonic zone, part of the Yukon-Tanana terrane of south-central Yukon. Canadian Journal of Earth Sciences, v. 33, p. 103-116.

Stevens, R.A., Mortensen, J.K., and Hunt, P.A., 1993. U-Pb and ^{40}Ar-^{39}Ar geochronology of plutonic rocks from the Teslin suture zone, Yukon Territory. Geological Survey of Canada, Paper 93-2, p. 83-90.

Tempelman-Kluit, D.J., 1979. Transported cataclasite, ophiolite and granodiorite in Yukon: Evidence of arc-continent collision. Geological Survey of Canada, Paper 79-14, p. 1-27.

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, scale 1:2 000 000.