New stratigraphic and provenance studies of Triassic sedimentary rocks in Yukon and northern British Columbia

Luke P. Beranek and James K. Mortensen[1]
Department of Earth and Ocean Sciences, University of British Columbia

Beranek, L.P. and Mortensen, J.K., 2008. New stratigraphic and provenance studies of Triassic sedimentary rocks in Yukon and northern British Columbia. *In:* Yukon Exploration and Geology 2007, D.S. Emond, L.R. Blackburn, R.P. Hill and L.H. Weston (eds.), Yukon Geological Survey, p. 115-124.

ABSTRACT

New fieldwork investigating the provenance and stratigraphic setting of Triassic sedimentary rocks in the northern Cordillera focused on previously documented, but largely unstudied, exposures overlying the Yukon-Tanana, Slide Mountain and Cassiar terranes. We report on the lithologies observed and samples collected from the Sheldon Lake, Quiet Lake and Glenlyon map areas of Yukon, and McDame map area of northern British Columbia. Our research goal is to characterize sediment source regions in the Triassic and constrain early Mesozoic basin development in the northern Cordillera. We interpret the Triassic sedimentary evolution in Yukon and northern British Columbia to be intimately tied to collision of the Yukon-Tanana terrane with the ancient Pacific margin by closing of the Slide Mountain ocean. Our new samples collected from Middle to Late Triassic strata will further constrain that collisional event and add to the database that consists mainly of Early to Middle Triassic miogeoclinal rocks.

RÉSUMÉ

De nouvelles études ont été menées sur le terrain pour connaître l'origine et le cadre stratigraphique des roches sédimentaires triasiques du nord de la Cordillère. Elles étaient axées sur des affleurements reposant sur les terranes de Yukon-Tanana, de Slide Mountain et de Cassiar, affleurements qui ont été précédemment répertoriés mais peu étudiés. Le présent rapport a pour objet les lithologies observées et les échantillons prélevés dans les zones cartographiques du lac Sheldon, du lac Quiet et de Glenlyon, au Yukon, ainsi que dans celle de McDame, dans le nord de la Colombie-Britannique. Nos travaux de recherche visent à caractériser les régions d'origine des sédiments triasiques et à délimiter la formation de bassin pendant le Mésozoïque précoce, dans le nord de la Cordillère. Notre interprétation suppose que l'évolution sédimentaire triasique au Yukon et dans le nord de la Colombie-Britannique est intimement liée à la collision survenue entre le terrane de Yukon Tanana et l'ancienne marge du Pacifique pendant la fermeture de l'océan de Slide Mountain. Les nouveaux échantillons que nous avons prélevés dans des strates datant du Trias moyen à tardif permettront de mieux délimiter cette collision et d'alimenter la base de données portant surtout sur des roches miogéoclinales datant du Trias précoce à moyen.

[1]*jmortens@eos.ubc.ca*

INTRODUCTION

In Yukon, Triassic sedimentary rocks occur both as miogeoclinal strata in depositional contact with the North American autochthon (and parautochthonous Cassiar terrane) and as disparate sections in depositional, structural, or ambiguous contact with rocks of the Yukon-Tanana (YTT) and Slide Mountain (SMT) terranes (*e.g.,* Gordey and Anderson, 1993; Roots *et al.*, 2002; Colpron *et al.*, 2005, 2006a). Traditionally, Triassic rocks assigned to the Yukon miogeocline are interpreted to be part of the Western Canada Sedimentary Basin, a westward-thickening package of mixed siliciclastic-carbonate strata that bridge late Paleozoic passive margin sedimentation and Jurassic collisional tectonism in the northern Cordillera (Davies, 1997; Monger and Price, 2002). However, field studies and provenance analyses on Triassic sedimentary rocks since summer 2005 suggest that these strata have a partial source from the YTT and SMT, which lie to the west of the Selwyn basin (Beranek and Mortensen, 2006, 2007). In these earlier reports, we interpreted YTT-derived detritus in the Selwyn basin to indicate mid- to Late Permian partial or full closure of the Slide Mountain ocean, a backarc basin that separated the YTT from the western margin of North America (Colpron *et al.*, 2006a). Subsequently, Permo-Triassic collision between the YTT and Cordilleran margin and emplacement of the YTT onto North America loaded the margin, providing accommodation space in the form of a peripheral foreland basin. This collisional basin was probably active until Middle Triassic time, when it transitioned into an overlap assemblage, blanketing the YTT, SMT and North American margin.

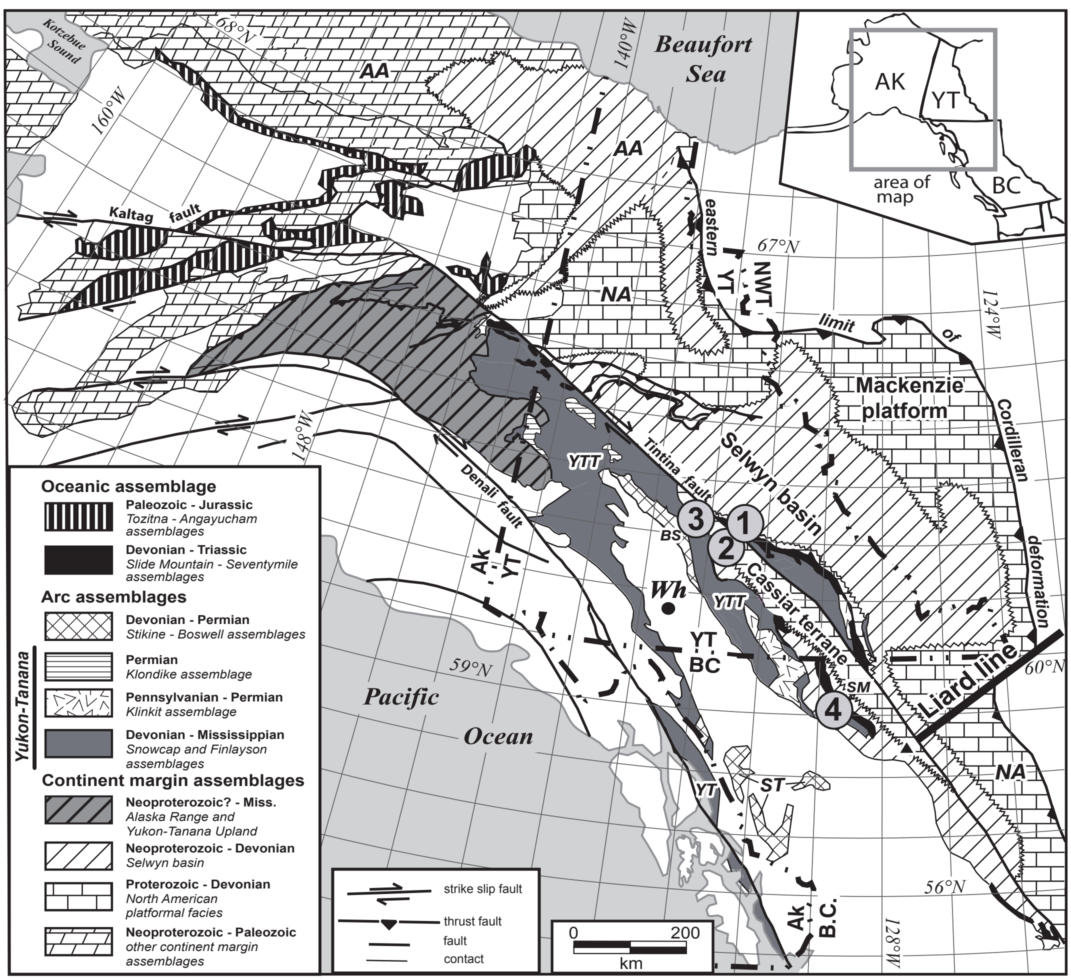


Figure 1. *Early Paleozoic to early Mesozoic tectonic assemblages of the northern Canadian and Alaskan Cordillera. YT = Yukon Territory; BC = British Columbia; NWT = Northwest Territories; Ak. = Alaska; Wh. = Whitehorse; YTT = Yukon-Tanana terrane; SM = Slide Mountain terrane; BS = Boswell assemblage; ST = Stikine assemblage; NA = North American miogeocline; AA = Arctic Alaska. Modified from Colpron et al. (2006a).*

In this report, we document new stratigraphic observations and provenance sampling studies conducted in summer 2007, the final stage of our three-year project investigating Triassic sedimentary rocks of the northern Cordillera. Our new collections add to a suite of Triassic samples from the Selwyn basin and Cassiar terrane (Beranek and Mortensen, 2006, 2007). Research in summer 2007 focused on Late Triassic exposures of the YTT, SMT and Cassiar terrane, complementing our database from 2005 and 2006 that mainly sampled Early to Middle Triassic strata.

TRIASSIC SAMPLE LOCALITIES

SHELDON LAKE MAP AREA

In the southwestern Sheldon Lake (NTS 105J) map area, northeast of the Tintina fault, Triassic sedimentary rocks lie in fault contact with the Cretaceous South Fork volcanics and the early Paleozoic Road River and Earn groups (Gordey and Irwin, 1987). We visited one locality approximately 50 km northeast of Ross River and 10 km south of Tay Lake (location 1 on Fig. 1; Fig. 2). Exposure of Triassic and older strata in this area is limited due to vegetation, and restricted to the south side of a east-trending drainage south of the Connolly caldera (Fig. 3a).

Triassic rocks at this location are predominantly light grey-weathering, grey, thickly bedded, parallel to wavy- to ripple cross-laminated, silty to sandy to bioclastic limestone (Figs. 3b and c). Minor recessive shale and siltstone can also be observed from subcrop. Conodont collections from these limestones are Late Triassic (Carnian-Norian; Orchard, 2006; compilation by S. Gordey, pers. comm.).

Two samples were collected from outcrops of Late Triassic sandy limestone for detrital zircon geochronology. To aid in our understanding of sedimentary provenance in this region, a detrital zircon sample from a coarse-grained, poorly sorted, chert lithic sandstone of the underlying Devono-Mississippian Prevost Formation, which comprises the upper part of the Earn Group in eastern Yukon, was also collected.

QUIET LAKE MAP AREA

In the Quiet Lake (NTS 105F) map area, two sections of Triassic sedimentary rocks of the parautochthonous Cassiar terrane, south of the Tintina fault, were examined. First, rocks of the Triassic Hoole Formation in the core of the Ketza syncline, occurring within the upper plate of an unnamed thrust fault, were sampled (Tempelman-Kluit, 1977). These strata are well exposed immediately north of Mount Green, approximately 25 km due south of Ross River (location 2 on Fig. 1; Figs. 4 and 5a) and underlain by Devonian-Mississippian chert and shale. Orchard (2006) reported Late Triassic conodont ages from rocks of this area. Generally, these strata are light grey to tan-

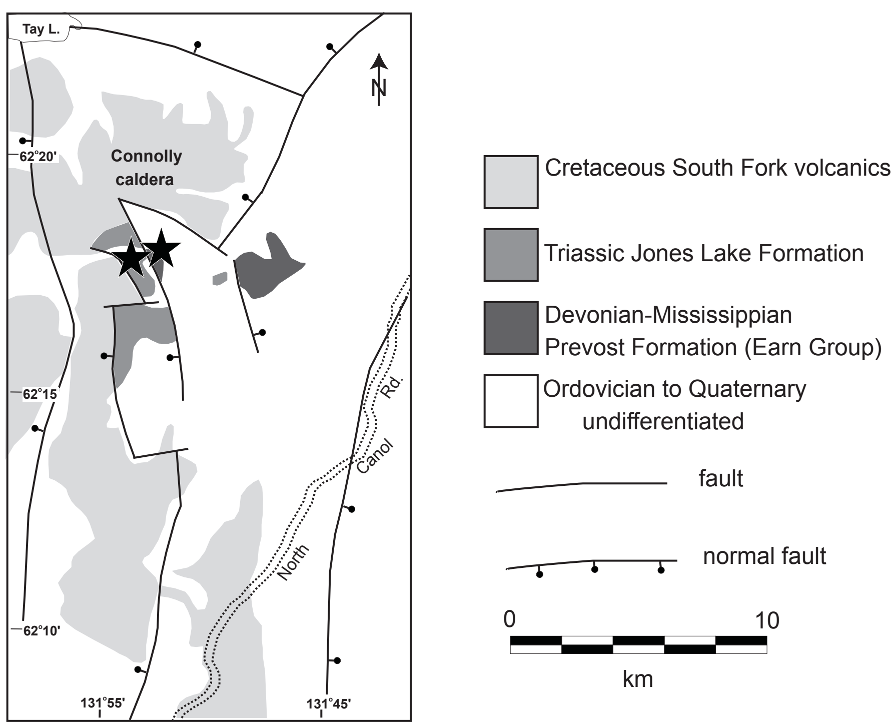


Figure 2. *Simplified geologic map of the Connolly caldera region, Sheldon Lake map area, modified from Gordey and Irwin (1987). Black stars indicate sample locations.*

weathering, grey to dark grey, thin to thickly bedded, parallel to wavy-laminated, silty limestone and limy siltstone to medium- to coarse-grained (quartz) sandy limestone (Fig. 5b). To constrain the provenance of siliciclastic input into this carbonate section, two samples of sandy limestone were collected for detrital zircon analyses.

The second location visited in the Quiet Lake map area was just west of the South Canol road and Lapie River, on the southeast side of Mount Ross, approximately 20 km southwest of Ross River (Fig. 4). As with the previously described section, these Triassic rocks are assigned to the Hoole Formation, occurring structurally above the St. Cyr thrust fault, and are constrained as Late Triassic in age by conodonts (Tempelman-Kluit, 1977; Orchard, 2006).

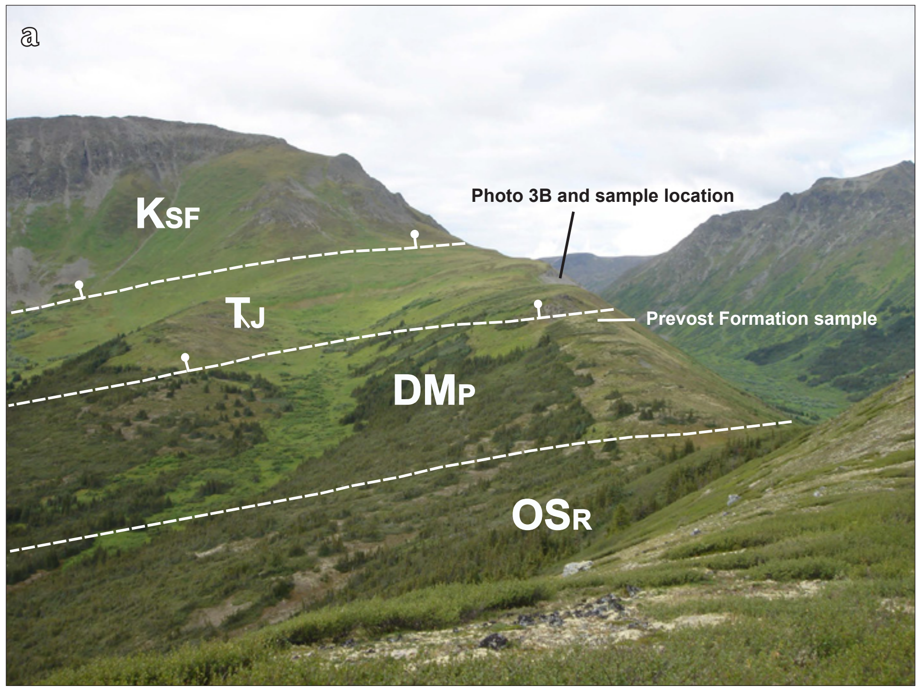


Figure 3. *Field photos of Triassic strata in the Connolly caldera region, north of Ross River, Sheldon Lake map area.* ***(a)*** *View to west of Triassic Jones Lake Formation (ŦJ) and older sedimentary section (DMP, OSR) in fault contact with Cretaceous South Fork volcanics (KSF). DMP = Devonian-Mississippian Prevost Formation (upper Earn Group); OSR = Ordovician to Silurian Road River Group.* ***(b)*** *Outcrop view of thickly bedded, silty to sandy limestone; hammer for scale.* ***(c)*** *Typical view of wavy- and ripple cross-laminated silty to sandy limestone; hammer handle at right for scale.*

These strata are tan- to buff-weathering, light to medium grey, thin- to medium-bedded, parallel (thin to thickly) to wavy-laminated, calcareous in part, muscovite-bearing in part, siltstone to fine-grained sandstone (Figs. 6a and b). Two samples from these strata were collected for detrital zircon geochronology.

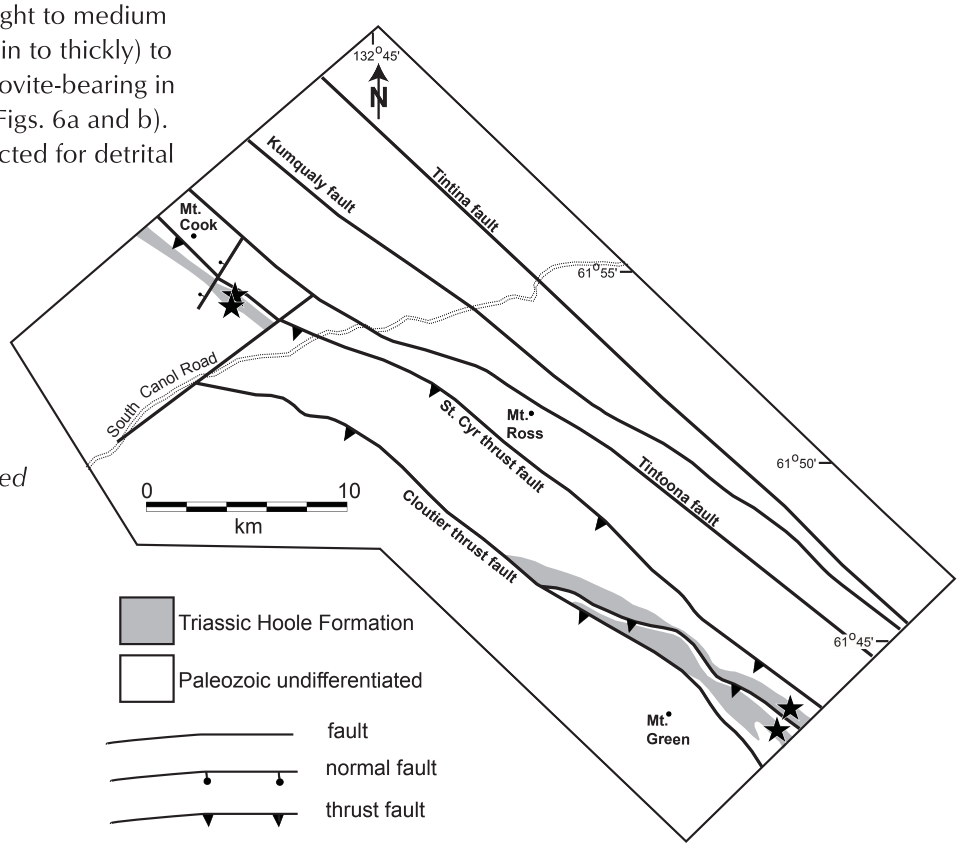


Figure 4. *Simplified geologic map of the northeastern Quiet Lake map area, modified from Templeman-Kluit (1977). Black stars indicate sample locations.*

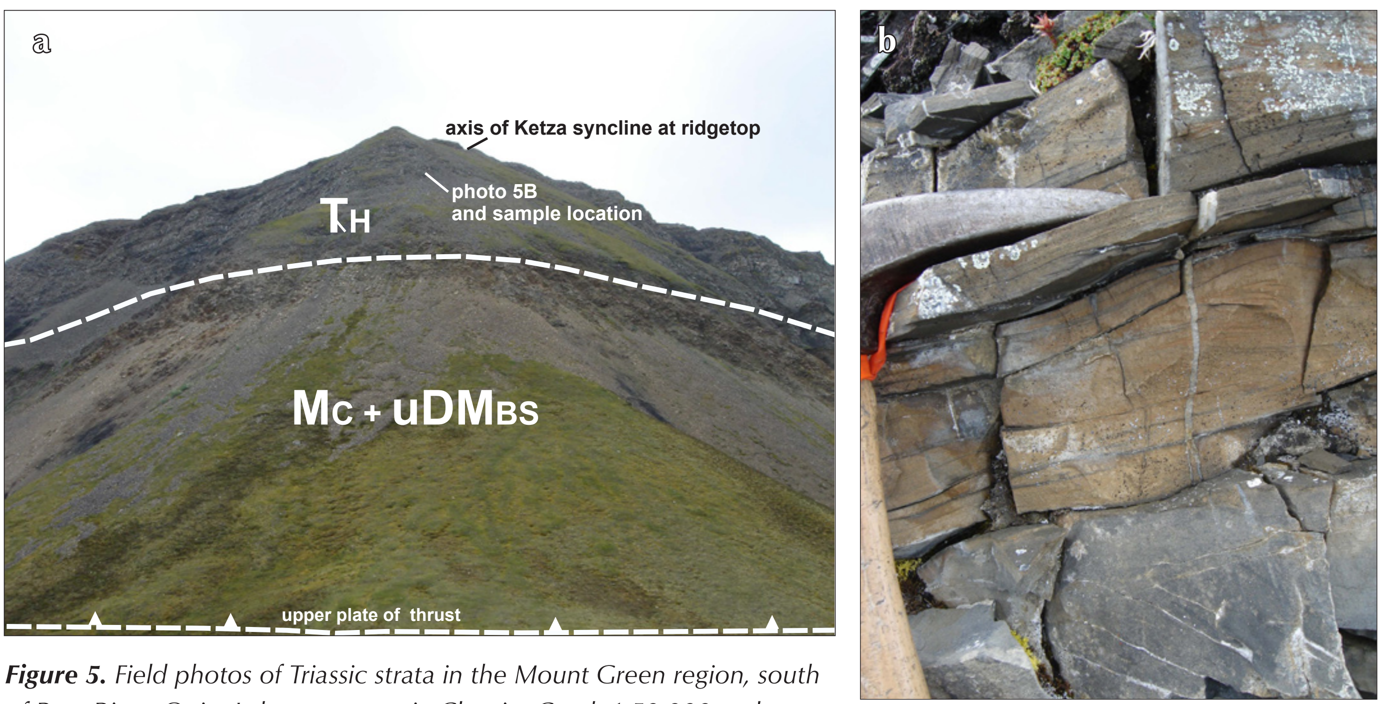


Figure 5. *Field photos of Triassic strata in the Mount Green region, south of Ross River, Quiet Lake map area, in Cloutier Creek 1:50 000-scale sheet.* ***(a)*** *View to south of Triassic (TRH) and older sedimentary section (Mc +uDMBS) within upper plate of St. Cyr thrust.* ***(b)*** *Typical outcrop view of parallel to wavy-laminated calcareous siltstone to sandy limestone; hammer at left for scale. TRH = Triassic Hoole Formation; Mc = Mississippian Chert Tuff Formation; uDMBS = Upper Devonian and Mississippian Black Slate Formation.*

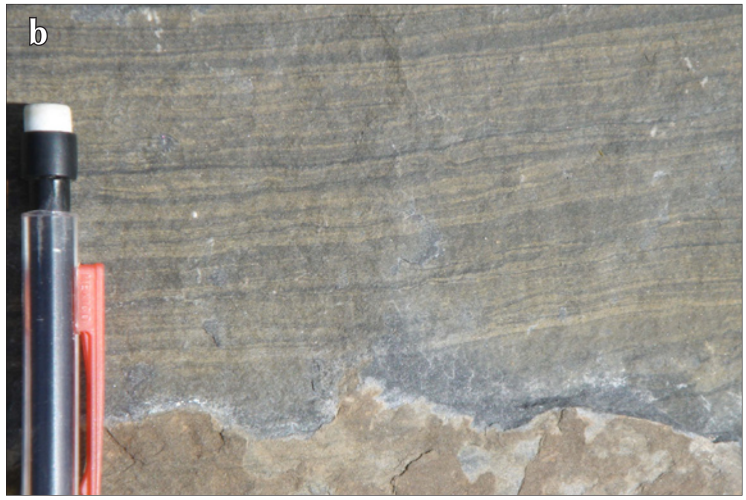


Figure 6. *Field photos of Triassic strata southeast of Mount Ross, west of the Lapie River and South Canol road, Quiet Lake map area, in Ram Creek 1:50 000-scale sheet.* ***(a)*** *Typical outcrop view of thin- to medium-bedded, parallel to wavy-laminated, micaceous in part, siltstone and fine-grained sandstone; hammer for scale.* ***(b)*** *Close-up view of thin to thick laminations (parallel to wavy) within fine-grained sandstone; pencil for scale.*

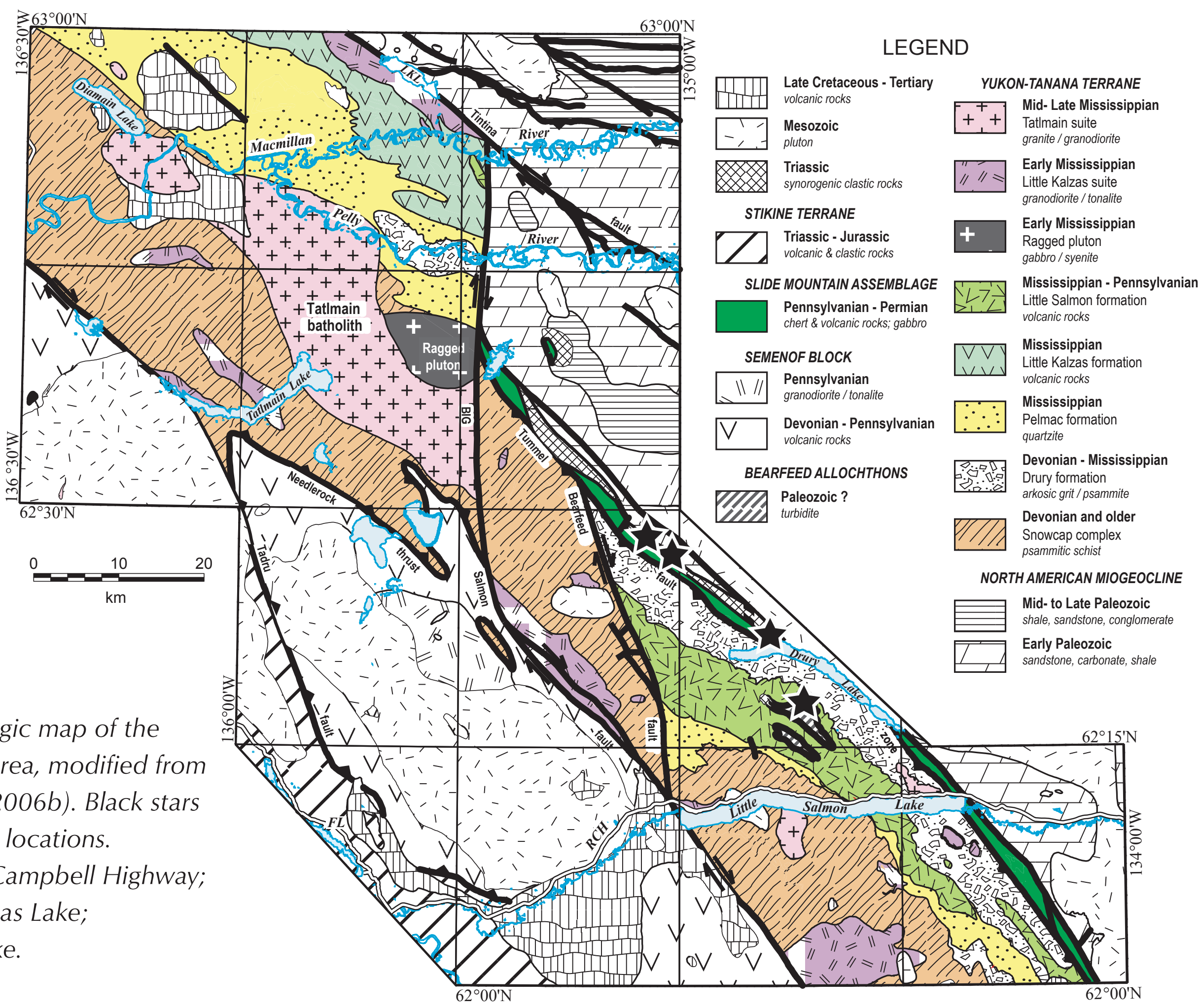


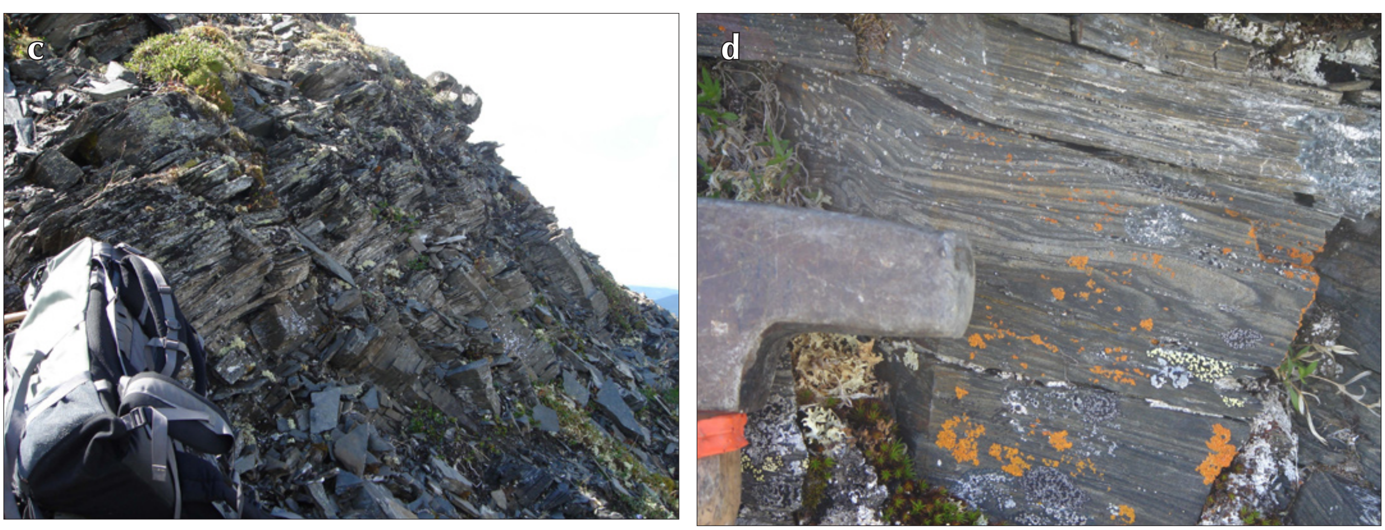
Figure 7. *Geologic map of the Glenlyon map area, modified from Colpron et al. (2006b). Black stars indicate sample locations. RCH = Robert Campbell Highway; LKL = Little Kalzas Lake; FL = Frances Lake.*

GLENLYON MAP AREA

Approximately 30 km north of Little Salmon Lake, east of the Big Salmon fault, Triassic sedimentary rocks in the Glenlyon map area (NTS 105L) occur in the Tummel fault zone, a structural zone that juxtaposes Yukon-Tanana and Slide Mountain rocks with the parautochthonous Cassiar terrane (location 3 on Fig. 1; Fig. 7; Colpron *et al.*, 2005, 2006). In this region, we sampled variably deformed, monomictic to polymictic (chert, shale, felsic volcanic?), muscovite-bearing, pebble conglomerate (Figs. 8a and b) and micaceous feldspathic sandstone for detrital zircon and detrital muscovite geochronology. These strata are similar to, and in one locality include, rocks of the Bearfeed klippe, immediately north of Little Salmon Lake (Fig. 7). Colpron *et al.* (2005) analysed detrital zircons from conglomerate of the Bearfeed klippe, and interpreted Paleozoic ages therein to indicate recycling of the Semenof block (see location on Fig. 7) and Yukon-Tanana terrane.

One section of Triassic strata containing Middle Triassic conodonts (Orchard, 2006) overlying Pennsylvanian-Permian chert of the Slide Mountain terrane was examined (Figs. 8c and d). These strata are well exposed near the northwest end of Drury Lake and comprise brown- to tan-weathering, brown-tan, thin- to medium-bedded, fine- to medium-grained, thickly laminated,

Figure 8. *Field photos from the Glenlyon map area, north of Little Salmon Lake.* ***(a)*** *Close-up view of sheared polymictic conglomerate; hammer for scale.* ***(b)*** *Typical outcrop view of sheared conglomerate and lithic and feldspathic sandstone; hammer for scale.* ***(c)*** *Outcrop view of thin- to medium-bedded siltstone and sandstone that overlies chert of Slide Mountain terrane; backpack for scale.* ***(d)*** *Close-up view of thickly laminated siltstone, showing soft sediment deformation; hammer for scale.*



calcareous shale and sandstone. Samples from this locality were collected for detrital zircon and detrital muscovite geochronology.

MCDAME MAP AREA, NORTHERN BRITISH COLUMBIA

Triassic sedimentary rocks of the Table Mountain Formation within the Sylvester allochthon, at the Cusac gold property (104P 070, BC MINFILE, 2007), near Cassiar, British Columbia, were also examined (location 4 on Fig. 1; Fig. 9). Middle to Late Triassic strata of the Sylvester allochthon were assigned to Division II (Slide Mountain assemblage) by Nelson (1993), and resemble the basal Takla and Slocan groups of Quesnellia in southern British Columbia and Triassic rocks of the Cassiar terrane in Yukon. Triassic strata, exposed in disparate, structurally imbricated sections at Table Mountain, occur as grey- to tan-weathering, grey, fine-grained, siltstone to sandstone and grey- and orange-weathering, dark grey, argillite and phyllite (Fig. 10a), with abundant muscovite along bedding planes. Sedimentary structures such as ripple marks and wavy-laminations are ubiquitous (Fig. 10b). A total of five detrital zircon and two detrital mica samples from Table Mountain were collected. At the Plaza pit (Fig. 10c), we observed pinkish-grey micaceous sandstone that resembles a sandstone unit we sampled in the McNeil klippe area of the Cassiar terrane in southeastern Yukon (Beranek and Mortensen, 2007).

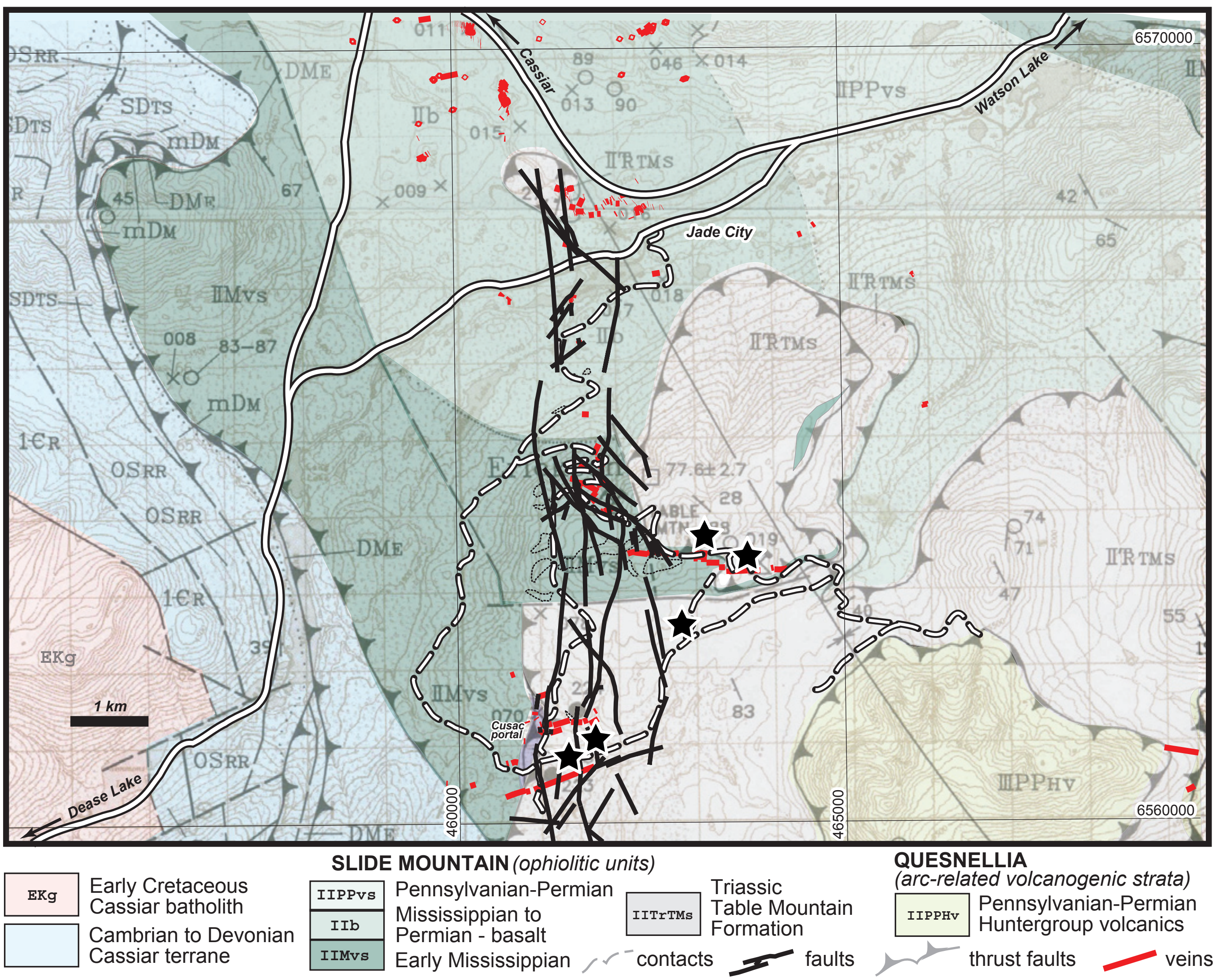


Figure 9. *Geologic map of the Table Mountain area, modified from Colpron et al. (2007). Black stars indicate sample locations.*

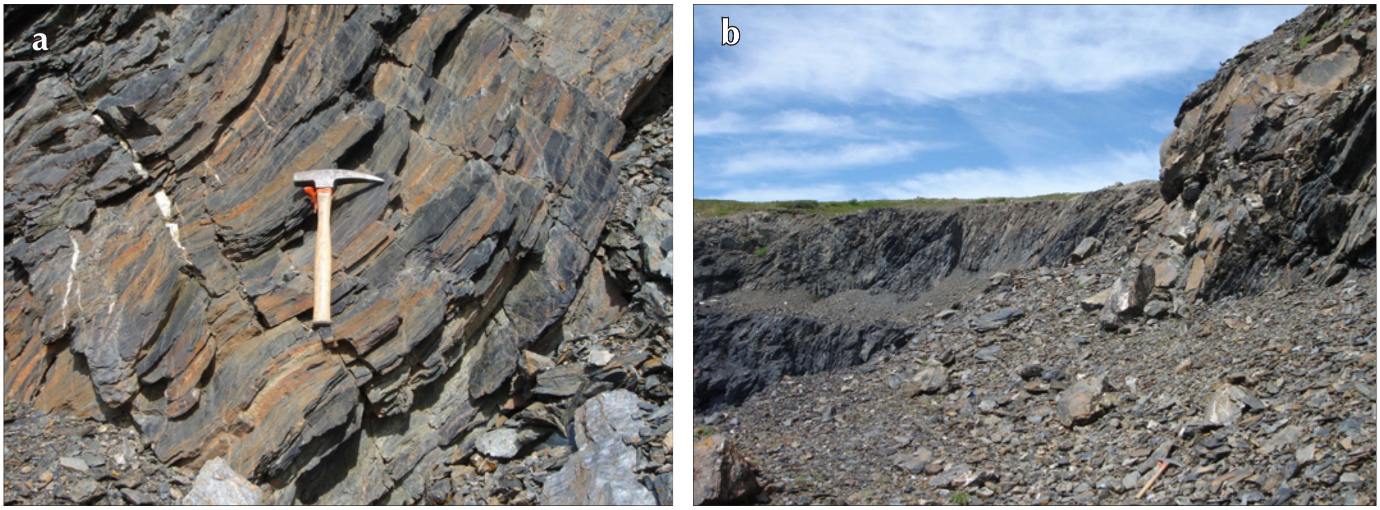


Figure 10. *Field photos from Sylvester allochthon at Table Mountain, Cusac gold property, near Cassiar, BC, McDame map area.* ***(a)*** *Typical outcrop view of grey- and orange-weathering argillite to phyllite at the Plaza pit; hammer for scale.* ***(b)*** *View to south of the Plaza pit at Table Mountain; area to the right is outcrop of pinkish-grey micaceous quartzite, back left is argillite and phyllite, portions of which are an overlying thrust plate.* ***(c)*** *Close-up view of ripple marks in tan-weathering micaceous siltstone; hammer for scale.*

SUMMARY

Triassic sedimentary rocks with ages constrained by conodonts were collected for provenance analysis. These new collections will complement an existing database that provides evidence for latest Permian closure of the Slide Mountain ocean and emplacement of the YTT onto the Cordilleran margin. Fieldwork from summer 2007 focused on previously documented, but largely unstudied, exposures of Triassic strata in east-central Yukon. Along with fieldwork carried out in 2005 and 2006, we have now examined and sampled most Triassic outcrop belts within the Selwyn basin, Yukon-Tanana, Slide Mountain and Cassiar terranes. Stratigraphic and provenance analyses from these strata will further constrain the age signatures of detrital mineral populations that have been observed in Triassic miogeoclinal rocks and yield insights into early Mesozoic basin evolution in the northern Cordillera.

ACKNOWLEDGEMENTS

We thank Maurice Colpron and JoAnne Nelson for their time and good nature in the Glenlyon and McDame map areas. Special thanks to Lesley Hunt for her hospitality at the Cusac gold property. Charlie Roots provided unpublished 1:50 000-scale geologic maps from mapping by D. Tempelman-Kluit in the Quiet Lake map area. We thank Steve Gordey for providing a geologic map of the Connolly caldera area, compilation of fossil collections therein, and discussions about Selwyn basin geology. Field logistics and helicopter support for this research were funded by the Yukon Geological Survey. We thank Brian Parsons of Trans North for excellent helicopter support. We appreciate Maurice Colpron for his comments on this manuscript and the use of geologic maps in the Glenlyon and McDame map areas.

REFERENCES

Beranek, L.P. and Mortensen, J.K., 2006. Triassic overlap assemblages in the northern Cordillera: Preliminary results from the type section of the Jones Lake Formation, Yukon and Northwest Territories (NTS 105I/13). *In:* Yukon Exploration and Geology 2005, D.S. Emond, G.D. Bradshaw, L.L. Lewis and L.H. Weston (eds.), Yukon Geological Survey, p. 79-91.

Beranek, L.P. and Mortensen, J.K., 2007. Investigating a Triassic overlap assemblage in Yukon: On-going field studies and preliminary detrital zircon age data. *In:* Yukon Exploration and Geology 2006, D.S. Emond, L.L. Lewis and L.H. Weston (eds.), Yukon Geological Survey, p. 83-92.

Colpron, M., Gladwin, K., Johnston, S.T., Mortensen, J.K. and Gehrels, G.E., 2005. Geology and juxtaposition history of Yukon-Tanana, Slide Mountain and Cassiar terranes in the Glenlyon area of central Yukon. Canadian Journal of Earth Sciences, vol. 42, p. 1431-1448.

Colpron, M., Nelson, J.L. and Murphy, D.C., 2006a. A tectonostratigraphic framework for the pericratonic terranes of the northern Cordillera. *In:* Paleozoic Evolution and Metallogeny of Pericratonic Terranes at the Ancient Pacific Margin of North America, Canadian and Alaskan Cordillera, M. Colpron and J.L. Nelson (eds.), Geological Association of Canada, Special Paper 45, p. 1-23.

Colpron, M., Mortensen, J.K., Gehrels, G.E. and Villeneuve, M., 2006b. Basement complex, Carboniferous magmatism and Paleozoic deformation in Yukon-Tanana terrane of central Yukon: Field, geochemical and geochronological constraints from Glenlyon map area. *In:* Paleozoic Evolution and Metallogeny of Pericratonic Terranes at the Ancient Pacific Margin of North America, Canadian and Alaskan Cordillera, M. Colpron and J.L. Nelson (eds.), Geological Association of Canada, Special Paper 45, p. 131-151.

Colpron, M., Nelson, J.L. and Israel, S., 2007. A transect through the accreted terranes of the northern Canadian Cordillera: from Cassiar, British Columbia to Kluane Lake, Yukon. Yukon Geological Survey, Open File 2007-3.

Davies, G.R., 1997. The Triassic of the Western Canada Sedimentary Basin: tectonic and stratigraphic framework, paleogeography, paleoclimate, and biota. Bulletin of Canadian Petroleum Geology, vol. 45, p. 434-460.

Gordey, S.P. and Irwin, S.E.B., 1987. Geology, Sheldon Lake and Tay River map areas, Yukon Territory. Geological Survey of Canada, Map 19-1987, 1: 250 000 scale.

Gordey, S.P. and Anderson, R.G., 1993. Evolution of the northern Cordilleran miogeocline, Nahanni map area (105I), Yukon and Northwest Territories. Geological Survey of Canada, Memoir 428, 214 p.

Monger, J.W.H. and Price, R., 2002. The Canadian Cordillera: geology and tectonic evolution. Canadian Society of Exploration Geophysicists Recorder, February, p. 17-36.

Nelson, J.L, 1993. The Sylvester Allochthon: upper Paleozoic margin-basin and island-arc terranes in northern British Columbia. Canadian Journal of Earth Sciences, vol. 30, p. 631-643.

Orchard, M.J., 2006. Late Paleozoic and Triassic conodont faunas of Yukon and northern British Columbia and implications for the evolution of the Yukon-Tanana terrane. *In:* Paleozoic Evolution and Metallogeny of Pericratonic Terranes at the Ancient Pacific Margin of North America, Canadian and Alaskan Cordillera, M. Colpron and J.L. Nelson (eds.), Geological Association of Canada, Special Paper 45, p. 229-260.

Roots, C.F., Harms, T.A., Simard, R.-L., Orchard, M.J. and Heamon, L., 2002. Constraints on the age of the Klinkit assemblage east of Teslin Lake, northern British Columbia. Current Research, Part A, Geological Survey of Canada, Paper 2002-A7, p. 1-11.

Tempelman-Kluit, D.J., 1977. Quiet Lake (105F) and Finlayson Lake (105G) map areas, Yukon Territory. Geological Survey of Canada, Open File 486, 1: 250 000 scale.