GEOLOGICAL FIELDWORK

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)

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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.

ABSTRACT

We present new field and whole-rock geochemical data from the type section of the Triassic Jones Lake Formation (JLF) located along the Yukon-Northwest Territories border in the Nahanni map area (NTS 105I/13). The type section is the first location of a regional-scale study that investigates the nature of Triassic siliciclastic rocks, and tests the presence of an overlap assemblage linking pericratonic terranes with North America by the Triassic, instead of Early to Middle Jurassic. The JLF is composed of carbonaceous shale and ripple cross-laminated calcareous sandstone thought to be associated with the Cordilleran miogeocline, and is devoid of sediment sourced from terranes to the west. Whole-rock shale geochemistry has provided evidence that the JLF is distinguishable from the underlying Mount Christie Formation and has trace and rare earth element concentrations that are most similar to old continental crust. However, the JLF does contain geochemical signatures suggestive of a minor mafic component.

RESUMÉ

Nous présentons ici de nouvelles données de terrain et de géochimie pour les roches du stratotype de la Formation de Jones Lake (FJL) du Trias le long de la limite entre le Yukon et les Territoires du Nord-Ouest dans la région de la rivière Nahanni sur la carte Mount Wilson (SNRC 105I/13). Le stratotype est le premier endroit visité dans le cadre d'une étude régionale sur la nature des roches siliciclastiques du Trias et don't le but est d'établir si ces roches représentent un assemblage liant les terranes péricratoniques à l'Amérique du Nord au Trias plutôt qu'au Jurassique précoce à moyen. La FJL se compose de shale carboné et de grès calcaire à stratification entrecroisée qui serait associé à la marge continentale de la Cordillère et dépourvu de sédiments provenant des terranes à l'ouest. La géochimie du shale a fourni des indications à l'effet que la FJL peut être distinguée de la sous-jacente Formation de Mount Christie et renferme des concentrations d'éléments traces et de terres rares des plus similaires à celles présentes dans la croûte continentale ancienne. Cependant, la FJL présente des signatures géochimiques suggérant l'existence d'une composante mafique mineure.

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INTRODUCTION

Triassic siliciclastic strata of the northern Canadian Cordillera are traditionally considered to be associated with the Western Canada Sedimentary Basin, a westward-thickening succession of sedimentary rocks deposited along the western edge of Laurentia (e.g., Gibson and Barclay, 1989). Sedimentary loading from the deposition of siliciclastic and carbonate strata, along with tectonic subsidence related to the adjacent Panthalassic ocean basin, provided accommodation space for sediments from the Late Proterozoic to middle Mesozoic. Siliciclastic sediments were derived from the Canadian Shield to the east, the Franklinian and Ellesmerian orogenic belts in Arctic Canada, local block uplifts to the west, and cannibalization of the miogeocline itself (Gordey and Anderson, 1993; Ross *et al.*, 1997; Patchett *et al.*, 1999).

Although the patterns of Phanerozoic sedimentation in Yukon appear similar to other locations in the northern Cordillera, the precise age, compositional variation, and relationship of Triassic siliciclastic rocks to pericratonic (margin-fringing) Yukon-Tanana Terrane (YTT), Slide Mountain Terrane (SMT), and autochthonous North America remain unresolved. Several characteristics of the Triassic rocks in Yukon are problematic and suggest that these strata may record a somewhat different depositional setting and provenance than age-equivalent formations in the Western Canada Sedimentary Basin: (1) coarse-grained siliciclastic sedimentary rocks containing late Paleozoic detrital zircon, along with metamorphic (serpentinite, garnet amphibolite, quartz-mica schist, phyllite, quartzite) and igneous (basalt, granitic gneiss) clasts, unconformably overlie YTT in several locations, suggesting western-derived sediment overlapped YTT and SMT by the early Mesozoic (Roots *et al.*, 2002; Pigage, 2004; Colpron *et al.*, 2005); (2) the Triassic basin architecture is unclear due to early(?) Mesozoic accretion of YTT and subsequent late Mesozoic contractional deformation, resulting in discontinuous outcrop exposure; (3) conodont biostratigraphic and early Mesozoic regional stratigraphic correlation is unresolved as the type Triassic section in the Selwyn Basin (Jones Lake Formation) has an Early Triassic age (Smithian; ~245 Ma) whereas Late Triassic ages (Carnian, Norian; ~220 Ma) dominate most other exposures in the YTT, SMT and Cassiar Platform.

In this study we are investigating the possibility that Triassic strata in Yukon comprise an overlap assemblage that links YTT and SMT with autochthonous North America. This would suggest that terrane accretion in the northern Cordillera began by the Early Mesozoic, much earlier than has previously been believed (e.g., Gabrielse and Yorath, 1991) and would require substantial revisions to current models for the tectonic evolution of the Cordillera. This paper presents new data from fieldwork carried out in the summer of 2005 on the type sections of the Triassic Jones Lake Formation and immediately underlying Mississippian-Permian Mount Christie Formation, which were first described by Gordey and Anderson (1993). The goal of this study is to understand the age, stratigraphic position, and provenance of these units in order to test whether Triassic strata of westernmost North America received siliciclastic input from outboard YTT and SMT assemblages. Our approach was to investigate the lithologic and compositional characteristics of the Mount Christie and Jones Lake formations, noting any changes in time between them, and then compare those data to known rock units along the ancient Pacific margin.

If the Jones Lake Formation is an overlap assemblage linking North America with YTT, rather than simply an offshore component of the North American miogeocline, this calls for dramatic revisions as to the timing and style of pericratonic terrane accretion in the northern Cordillera. Additionally, this would require that the basin in which the Jones Lake Formation was deposited was not simply part of the Cordilleran miogeocline, but rather was a flexural or foreland basin generated by the tectonic loading caused by accreting pericratonic terranes to the west.

PREVIOUS WORK

The type sections of the Mississippian-Permian Mount Christie Formation and Triassic Jones Lake Formation are exposed in the western limb of the Wilson Syncline, located along the Yukon-Northwest Territories border, approximately 9 km south of Mount Wilson in the Nahanni map area (NTS 105I/13) (Fig. 1). Gordey and Anderson (1993) measured, described, interpreted and obtained depositional ages for these two formations in the composite ~1500-m-thick section of dominantly fine-grained, offshore to shoreface siliciclastic sedimentary rocks. They were interpreted to be the youngest preserved strata of the Selwyn Basin.

The age of the Mount Christie Formation, which unconformably overlies the Mississippian Tsichu formation in its type section, is constrained by four conodont collections. The lower shale member of the

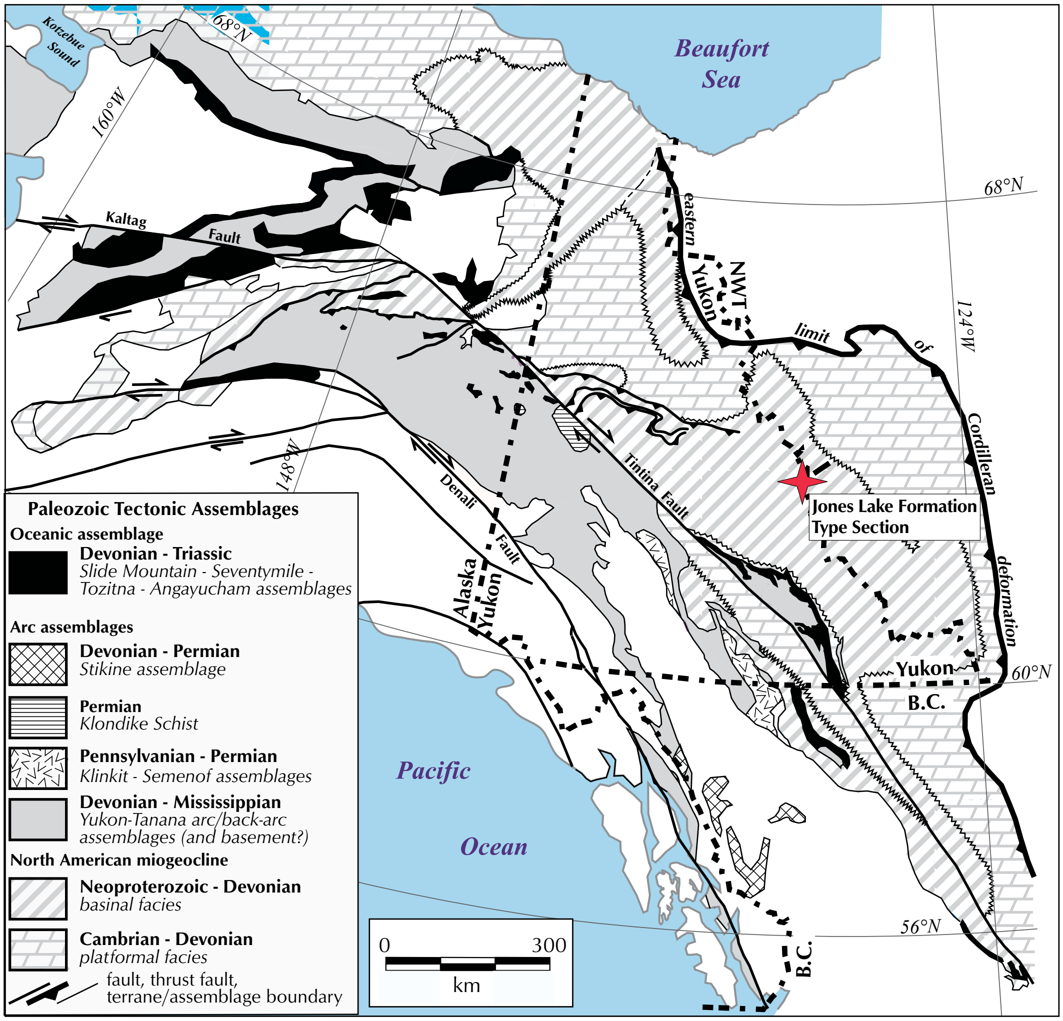

Figure 1. *Regional view of northern Canadian Cordillera highlighting pericratonic terranes and adjacent facies belts of North America. Jones Lake Formation type section indicated by star symbol along Yukon-NWT border. Modified from Colpron et al. (2003).*

Mount Christie Formation is thought to be Late Mississippian from a sample in the Niddery Lake map area (NTS 105O), whereas three conodont samples from the upper chert unit from the type section suggest an Early Permian (Late Wolfcampian to Leonardian) age (Gordey and Anderson, 1993). The Mount Christie Formation is thus thought to be age-equivalent to the Kindle and Fantasque formations of British Columbia and Alberta.

Gordey and Anderson (1993) suggested that the covered contact between the Mount Christie and Jones Lake formations in their type sections is unconformable, because the Triassic is observed to sit on lower portions of the Paleozoic section in other parts of the region. A single conodont collection from the type section approximately 300 m above the base of the Jones Lake Formation yielded a Smithian (Early Triassic) age (Gordey and Anderson, 1993). The age of the rest of the Jones Lake Formation in its type section is unconstrained. The Jones Lake Formation is thought to be correlative with the Toad and Liard formations and Spray River Group to the south.

STRATIGRAPHIC COLUMN

During July, 2005, the type sections of the Mount Christie and Jones Lake formations were measured with a Jacob staff and sampled for palynomorph and conodont biochronology, detrital zircon and mica geochronology, and whole-rock geochemistry. Gordey and Anderson (1993) reported formation thicknesses and described lithofacies present in the section; however, we re-measured their type section in order to develop our own interpretations of sedimentary environments and lithofacies, and to apply a systematic sampling strategy that will be followed for the coming field seasons for all Triassic assemblages.

The stratigraphic column for the type sections are presented in Figure 2. A panoramic view of the composite column with highlighted features is shown in Figure 3.

Mount Christie Formation

The base of the Mount Christie Formation unconformably overlies the uppermost fine- to medium-grained, tan quartz arenite of the Tsichu formation. This contact serves as our base datum (0 m) of the composite Mount Christie-Jones Lake section. We followed Gordey and Anderson (1993) in subdividing the Mount Christie Formation into two informal members, a lower shale member (550 m) and an upper chert and shale member (200 m).

The lower member comprises dark grey, greenish grey and reddish brown, thin- to wavy-laminated, cleaved, siliceous shale and siltstone which typically breaks into elongate pencil structures that commonly produce significant scree piles on the southwest-facing ridge (Fig. 4). Detrital mica appears variably along bedding planes in the lower shale member. At 400 m, near the top of the lower shale member, a resistant bed of very fine-grained sandstone contains nodules of barite. Barite nodules in the Mount Christie Formation vary from sand- to boulder-sized (Fig. 5). The origin of the locally abundant and characteristic barite nodules in the Mount Christie Formation is uncertain. Goodfellow *et al.* (1995) suggested that high barite concentrations in underlying middle Paleozoic units were ultimately derived from the reworking of lower Paleozoic alkalic and potassic volcanic rocks in the northern Cordilleran miogeocline.

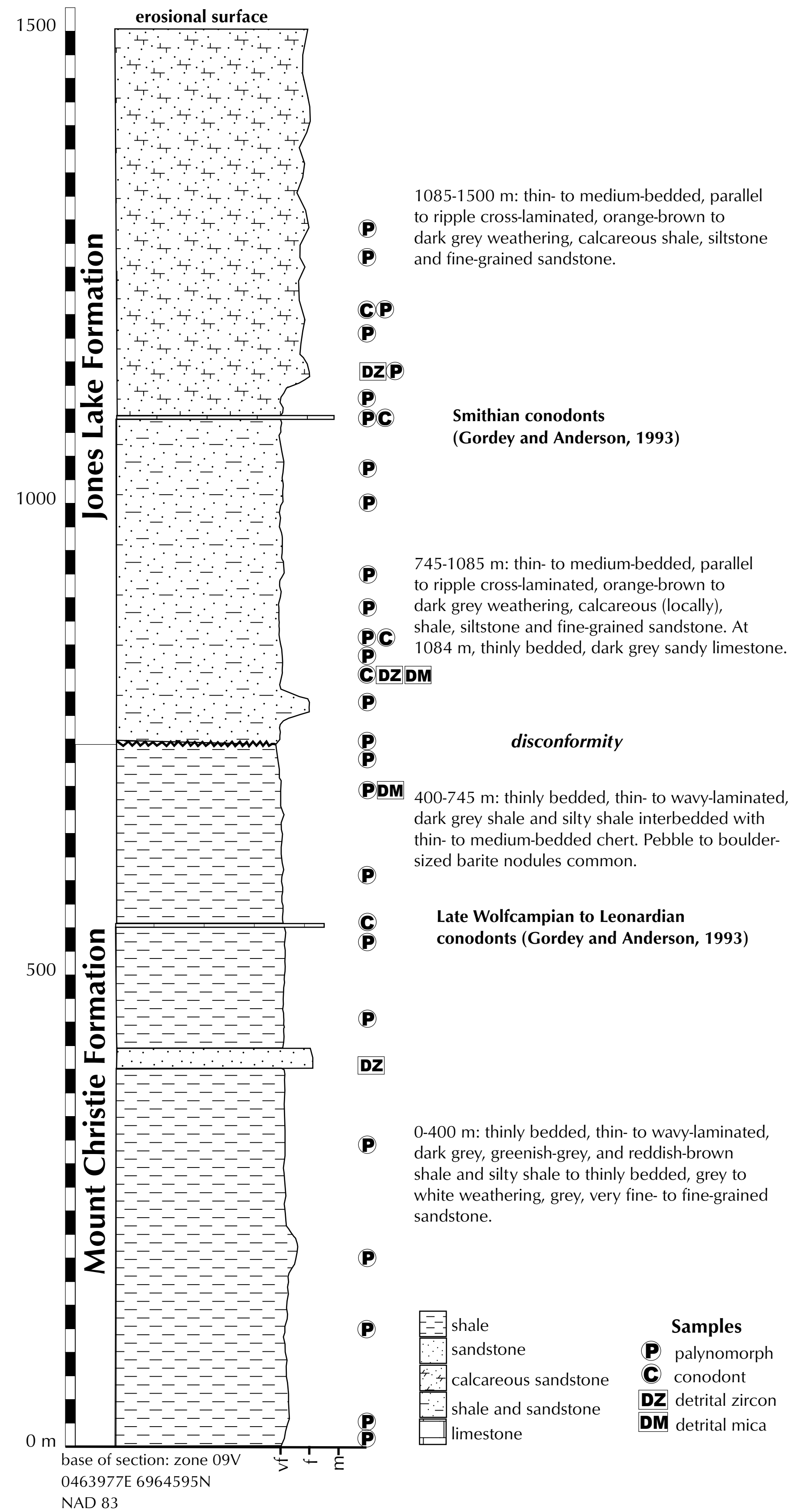

***Figure 2.** Measured stratigraphic column of composite Mount Christie and Jones Lake type section. Unit thickness and sample locations above 1200 m are estimated.*

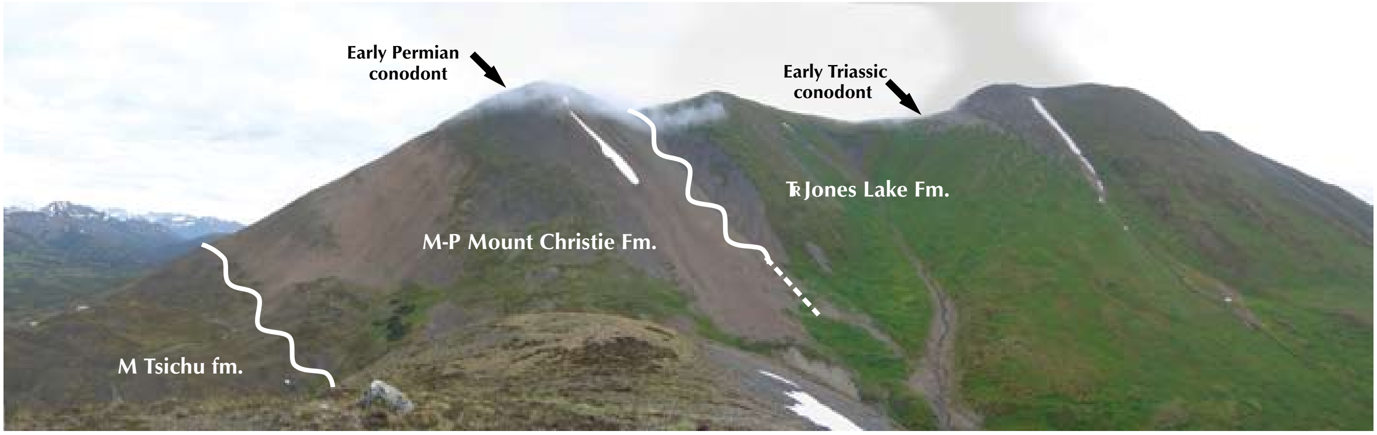

Figure 3. *View to the northwest of composite Mount Christie-Jones Lake type section. M = Mississippian, P = Permian, Tr = Triassic, Fm = Formation*

Separating the lower and upper members of the Mount Christie Formation is a discontinuous, red-weathering crystalline limestone that yielded a Late Wolfcampian to Leonardian (Early Permian) age (Gordey and Anderson, 1993).

The upper member of the Mount Christie Formation is characterized by dark grey splintery shale similar to that in the lower member, intercalated with thin- to medium-bedded grey and black chert. Local concentrations of barite nodules occur throughout the upper member. As with the lower member, detrital mica occurs locally in shaley and sandy horizons. The top of the upper member and base of the overlying Jones Lake Formation was chosen by Gordey and Anderson (1993) to be at the last

Figure 4. *Typical splintery shale and siltstone of the Mount Christie Formation. Image is taken at the 223-m level in section.*

Figure 5. *Barite nodules from the upper Mount Christie Formation at 600 m.* ***(a)*** *Typical pebble to cobble-sized accumulations in siltstone.* ***(b)*** *Boulder-sized (up to 0.3 m in diameter) crystalline barite.*

occurrence of chert. However, it is noteworthy that the lowermost Jones Lake Formation contains shale and siltstone that is lithologically similar to that of the uppermost Mount Christie Formation. The contact, presumed to be unconformable, is covered by vegetation and scree at this locality.

Considering the fine sediment size and cherty nature of these deposits, Gordey and Anderson (1993) interpreted the depositional environment for the Mount Christie Formation to be below wave-base, in an off-shelf setting. Sand and limestone occurrences within the section require sporadic clastic sediment inputs and regional shoaling events. Due to the fine-grained nature of these deposits and scree cover, no paleocurrent determinations were possible.

Jones Lake Formation

The core of the Wilson Syncline comprises distinctive orange-tan weathering shale, siltstone and sandstone of the Jones Lake Formation. Above the contact with the Mount Christie Formation, the Jones Lake Formation is typified by shale and siltstone to sandstone couplets of varying thicknesses, most commonly around 0.5 to 1 m. Contacts between lithofacies are commonly sharp and bedforms are planar to hummocky. Shale and siltstone beds commonly display 1-2 mm mud and silt laminations, and parallel to ripple cross-laminated fine quartzose sandstone is abundant. Paleocurrent indicators are not unidirectional but mainly indicate flow towards the southeast (Fig. 6). Siltstones commonly show tangential, mud-draped, stoss-side laminae that locally grade into hummocky and swaley laminations (Fig. 6). Laminated siltstones in local float contain what is thought to be Cruziana ichnofacies (trace fossils). Detrital mica is present, especially along shaley bedding planes.

Approximately 130 m above the contact with the Mount Christie Formation, the Jones Lake beds display open to tight folding, which make our thickness measurements a maximum value. Triassic strata exposed on the ridge returns to the typical northeasterly dip above this narrow zone of minor folding. Approximately 200 m of dark grey splintery carbonaceous shale and tan-weathering, medium grey, wavy-laminated fine calcareous sandstone make up the majority of the section. A coarse sandy limestone unit that yielded a Smithian conodont age (Gordey and Anderson, 1993) is located at 1084 m. This age is crucial because this limy bed is 300 m above the contact with the underlying Mount Christie Formation. If the conodont elements are primary and not from a reworked source, the bulk of the Jones Lake Formation in its type section has a maximum age of Early Triassic and theoretically could extend down into the Permian.

Above the Smithian conodont locality, our measurement was discontinued due to steep exposures and locally pervasive deformation in the Jones Lake strata. We continued to sample and describe the sedimentary rocks in this upper section but have opted to use the stratigraphic thickness estimates of Gordey and Anderson

Figure 6. *Images of Jones Lake Formation laminated siltstone to sandstone around 800 m. Both photos are taken towards east-northeast.* ***(a)*** *Ripple cross-laminated siltstone, with flow from left to right. Note concave-down laminae near top of image.* ***(b)*** *Cross-laminated siltstone that grades up into concave up and then concave-down laminae, consistent with hummocky and swaley geometry.*

(1993) for the uppermost portions of the exposed Jones Lake Formation.

Gordey and Anderson (1993) interpreted that the ripple cross-laminated calcareous sandstone of the Jones Lake Formation indicates deposition in a shallow marine setting that was affected by both traction and suspension sedimentation. We agree with this interpretation and expand on it by noting shoreface ichnofacies and possible storm-induced features, indicated by Cruziana and hummocky bedform geometry. Gordey and Anderson (1993) did not report any paleocurrent information and assumed an easterly source for sediment. Our paleocurrent analyses from the Jones Lake Formation, and from other preliminary studies of Triassic sections in southeast Yukon, mainly indicate flow directions parallel to the North American margin (south-southeasterly).

CONODONT AND PALYNOMORPH BIOCHRONOLOGY

One main focus of this project is to tighten chrono–stratigraphic controls on Triassic sequences that appear to be spatially associated with pericratonic terranes in Yukon. To date, age determinations have been made using conodonts. Here, we apply the tool of palynomorph biochronology to the pre-existing conodont biostratigraphic framework for the Mount Christie-Jones Lake section. Palynomorphs can be recovered from calcareous and non-calcareous rocks and they may be particularly important in dating Triassic units, which are typically only weakly to moderately calcareous. As such, it is hoped that the biostratigraphic resolution afforded by conodonts can be enhanced by palynomorphs. The use of two independent biochronological methods will permit a greater chronostratigraphic resolution and, hopefully, more robust age determinations.

Twenty-five palynology and four conodont samples were collected from the composite Mount Christie and Jones Lake section (shown in Fig. 2). Fifteen palynology samples were processed during fall, 2005, and palynology slides were generated by Global Geolabs Ltd. These slides are currently being evaluated by J. Utting of the Geological Survey of Canada in Calgary. Preliminary results are mixed; initial examination indicates that palynomorphs are present but were highly altered during diagenesis. Palynomorphs from these samples are dark coloured, reflecting a high thermal maturity. This alteration is consistent with high conodont colour alteration index (CAI) values of 4-5 for this region reported by Gordey and Anderson (1993). If palynomorphs are found to be a useful tool for the Jones Lake section, other samples collected from Triassic exposures in the MacNeil Lake, Frances Lake and Clinton Creek areas will be processed. New conodont samples from the Early Permian and Early Triassic localities in the section are currently being processed at the Geological Survey of Canada in Vancouver, along with two other new samples from the Jones Lake Formation (see Fig. 2). Age determinations on these samples are being carried out by M.J. Orchard.

WHOLE-ROCK GEOCHEMISTRY

Whole-rock geochemistry and isotopic data are useful for determining the bulk provenance of clastic sedimentary rocks, especially those containing monotonous, fine-grained siliciclastic sediments where ultimate source rock information is not available and petrographic methods (e.g., Gazzi-Dickinson) are not applicable (Heller and Frost, 1988; McLennan *et al.*, 1993). Specifically, trace elements such as high field strength (HFSE) and rare earth elements (REE) are not significantly diminished during weathering, transportation or diagenetic processes, and faithfully record their source rock composition (McLennan *et al.*, 1993).

We have obtained whole-rock major, trace and rare earth element data for 14 samples of shale and silty shale from the Mount Christie and Jones Lake type sections. Analyses were done by ALS Chemex in North Vancouver and consisted of XRF analyses of major elements and a combination of ICP-MS and ICP-AES analyses for minor and trace element concentrations. Our focus is to characterize the Mount Christie and Jones Lake sections independently and then document compositional changes or similarities between the two. We then compare our data to published data from other rock units and assemblages that could have been reservoirs that supplied sediment to Permian and Triassic depocentres.

MOUNT CHRISTIE FORMATION

Five shale to siltstone samples collected between 23 and 745 m in the Mount Christie type section yield similar whole-rock major and trace element signatures. Major element data will not be discussed in detail, however, it is noteworthy that SiO_2 values are elevated (68-78 wt.%) compared to the average for continental crust (Wedepohl, 1995) and continentally derived shale (Mason, 1982). In the field, Mount Christie Formation shales appear to be highly siliceous, and this diagenetic or hydrothermal overprint may be responsible for the low quality of palynomorph preservation.

Chondrite-normalized REE and trace element data for the Mount Christie Formation samples are shown in Figures 7a and b. The Mount Christie Formation contains an enrichment of light rare earth elements (LREE) relative to a flat heavy rare earth element (HREE) pattern. This is shown by high (~7.0-8.5) La_N/Yb_N ratios, and Gd_N/Yb_N ratios from 1.0-1.5. LREE enrichment commonly occurs during igneous differentiation processes and is a feature observed in old upper continental crust (McLennan *et al.*, 1993). A significant negative Eu anomaly exists for the Mount Christie Formation, and Eu/Eu* values range from 0.6-0.7, both suggesting derivation from evolved continental crust. First-cycle volcanic detritus, as would be associated in the outboard YTT and SMT assemblages, would not be expected to have a Eu anomaly because plagioclase would likely be present. Mount Christie Formation shales are enriched in Ba (up to 4900 ppm), presumably reflecting the presence of fine-grained disseminated barite. REE concentrations and trends in the Mount Christie Formation compare favourably with Cambrian-Devonian deposits of the northern miogeocline (Garzione *et al.*, 1997; Patchett *et al.*, 1999).

Input from mafic and ultramafic sources associated with Slide Mountain Terrane do not appear to be present as our samples are low in Cr and Ni (Fig. 8a).

JONES LAKE FORMATION

Nine samples spanning the entire thickness of the Jones Lake Formation in its type section were analysed. Major element analyses show that the Jones Lake Formation is slightly different than the underlying Mount Christie Formation, and can be differentiated from it by alumina and titanium oxide contents (Fig. 9). The Jones Lake Formation contains less SiO_2 (48-68 wt.%) but more MgO (1-2.4 wt.%), and nearly double TiO_2 (avg. ~1 wt.%) and K_2O (average ~4 wt.%) than the Mount Christie Formation. A change up-section in these oxides may suggest a change in provenance but they appear to match the range of values observed in Paleozoic deposits of the northern miogeocline (e.g., Garzione *et al.*, 1997).

Trace element patterns in the Jones Lake Formation are similar to the Mount Christie Formation, however, the former is commonly enriched relative to the latter (Fig. 7). Like the Mount Christie Formation, the Jones Lake Formation has high La_N/Yb_N ratios (average ~9.4), low Gd_N/Yb_N ratios (1.2-1.7), and a significant negative Eu anomaly, where Eu/Eu* values are around 0.6. These data suggest that a significant source component feeding the Jones Lake basin was evolved and granitic in nature.

Although the Jones Lake Formation in its type section does not show an overwhelming signature consistent with a significant ultramafic or ophiolitic input, it does contain higher values of Cr and Ni than the Mount Christie Formation (Fig. 8a). Although used primarily for igneous rock classification, Figure 8b shows that the Jones Lake Formation samples plot largely within the mid-oceanic

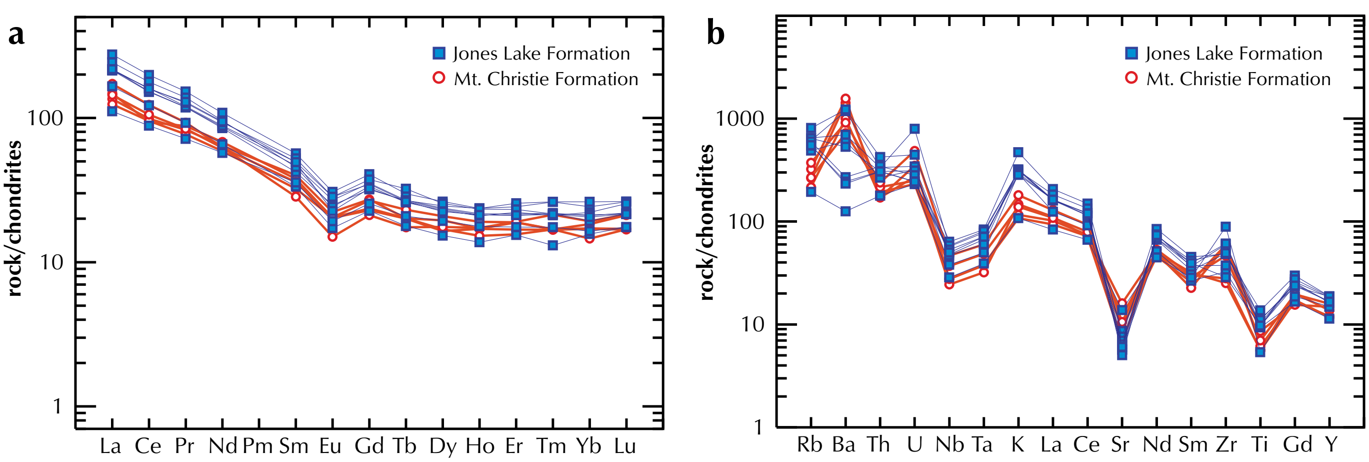

Figure 7. *Multi-element plots of the Mount Christie and Jones Lake formations.* ***(a)*** *REE plot normalized to chondrite (Sun and McDonough, 1989).* ***(b)*** *Trace element plot normalized to chondrite (Sun, 1980). Calculated Eu/Eu*, La_N/Yb_N and Gd_N/Yb_N determined from chondrite of Sun and McDonough (1995).*

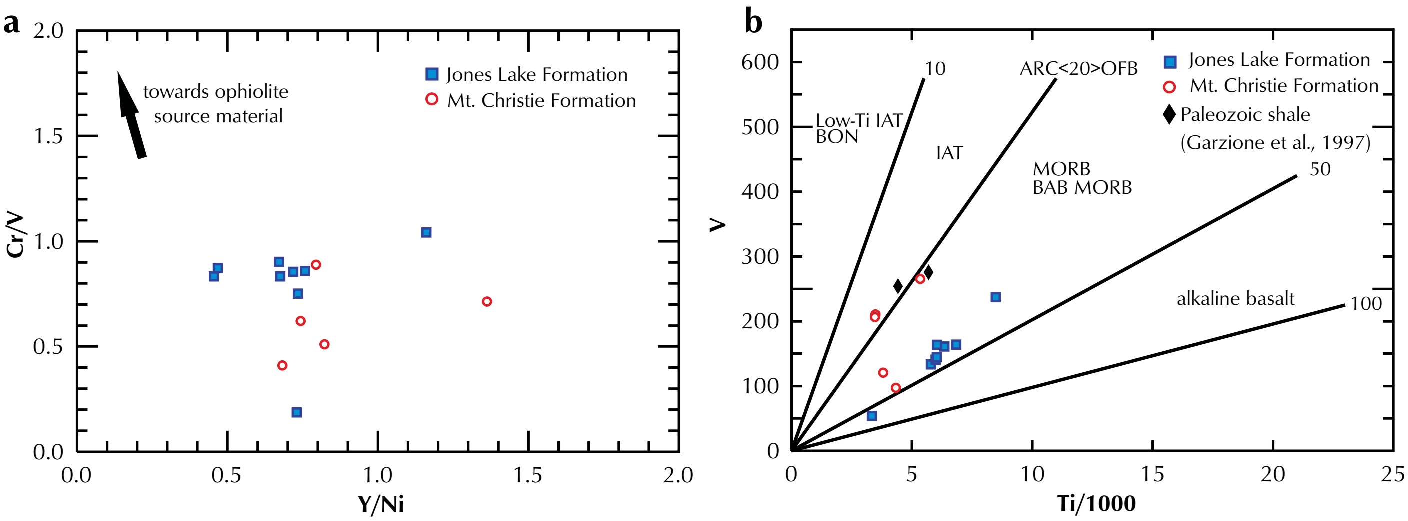

Figure 8. *Bivariate diagrams that determine possible mafic input to the Mount Christie-Jones Lake section.* ***(a)*** *Cr/V versus Y/Ni plot after McLennan et al. (1993).* ***(b)*** *V versus Ti/1000 tectonomagmatic diagram after Shervais (1982). Paleozoic shale data from Garzione et al. (1997). BON = boninite, IAT = island-arc tholeiite, MORB = mid-oceanic ridge basalt, BAB = back-arc basin.*

ridge basalt (MORB) field. This is quite different from the Mount Christie Formation and Paleozoic shale of the Cordilleran miogeocline of Garzione *et al.* (1997), which plot closer to, or in, the island-arc field (IAT). This could be consistent with the Mount Christie Formation being fed by the craton to east, which mainly comprises Proterozoic and Archean arc terranes, whereas detritus eroded from uplifted oceanic crust of the now-closed(?) marginal back-arc basin (Slide Mountain Ocean) could be present within the Jones Lake Formation.

It is noteworthy that the Ba enrichment that is so prevalent in the Mount Christie Formation persists in the Jones Lake Formation until 1114 m, which is 30 m above the Smithian conodont collection. From the base at 750 m to 1114 m, Ba values range from 1600-4000 ppm, while up-section of that they range from 390-870 ppm, which is possibly noting a change in local-scale provenance.

ND ISOTOPE GEOCHEMISTRY

Recent Sm-Nd isotopic studies of Paleozoic sedimentary strata within the northern Cordilleran miogeocline concluded that these units record an influx of juvenile material derived from early to middle Paleozoic rock units in Arctic Canada (Boghossian *et al.*, 1996; Garzione *et al.*, 1997; Patchett *et al.*, 1999). Although trace element concentrations showed relatively little variation amongst the Paleozoic strata, the Nd isotopic signature was shown to display a significant shift from lower Paleozoic samples with continental affinity ($\varepsilon_{Nd(T)}$ of -10 to -21) to middle Paleozoic and Mesozoic samples which yielded a mixture of continental values and a juvenile component with younger mantle extraction ages ($\varepsilon_{Nd(T)}$ of -5 to -15).

Garzione *et al.* (1997) obtained an $\varepsilon_{Nd(T)}$ value of -8.3 for a sample of the Mount Christie Formation collected along the Dempster Highway in northern Yukon. As no sources with that signature exist in western Canada, Garzione *et al.* (1997) suggested a mixture of evolved and juvenile sources. Patchett *et al.* (1999) traced the source of the juvenile signature to the Franklinian mobile belt of Arctic Canada. In addition, Boghossian *et al.* (1996) indicated Triassic Spray River Group shale and sandstone in southern Cordillera to have $\varepsilon_{Nd(T)}$ of -9 to -10, Creaser and Harms (1998) received $\varepsilon_{Nd(T)}$ values of -9 to -11 for Triassic rocks of the upper Klinkit assemblage in northern British Columbia (Teh clastic unit of Roots *et al.*, 2002), and Ross *et al.* (1997) reported $\varepsilon_{Nd(T)}$ of -6 to -10 for the Triassic Toad and Liard formations in northern Alberta.

We plan to carry out Nd isotopic analyses for a suite of samples from the Mount Christie and Jones Lake type formations over the next several months. Although the Mount Christie and Jones Lake formations show mainly continental signatures in terms of their trace element concentrations, the more sensitive Sm-Nd system may reveal a juvenile component sourcing these sediments, as

Garzione *et al.* (1997) and Patchett *et al.* (1999) have shown. Interestingly, Piercey *et al.* (2004) noted that mafic assemblages of Yukon-Tanana and Slide Mountain terranes contain juvenile signatures similar to those coming from Arctic Canada, suggesting that a large portion of juvenile input to the miogeocline could be from proximal outboard terranes to the west.

DETRITAL ZIRCON AND MICA GEOCHRONOLOGY

We collected three detrital zircon samples from the Mount Christie and Jones Lake formations' type sections and two from the underlying Tsichu formation. Detrital zircon geochronology has been widely employed in regional tectonic and sedimentary provenance studies in western North America. Previous investigations have documented age patterns for detrital zircons from various portions of the North American miogeocline and have identified significant latitudinal variations (e.g., Ross *et al.*, 1997; Gehrels and Ross, 1998; Gehrels, 2000; Stewart *et al.*, 2001; Ross *et al.*, 2005; Link *et al.*, 2005). Abundant U-Pb zircon geochronology that has been carried out in the pericratonic terranes in the Canadian Cordillera (e.g., Mortensen, 1992; Murphy *et al.*, in press; Colpron *et al.*, in press) will form the basis for recognition of any detrital zircon populations that might have been derived from those terranes. The new detrital zircon dating work will be done using laser ablation inductively coupled plasma mass spectrometer (LA-ICP-MS) methods at the University of British Columbia in Vancouver, BC.

Detrital zircons from the Triassic Liard and Whitehorse formations of Alberta, obtained using conventional thermal ionization mass spectrometry, have been reported by Ross *et al.* (1997). Their samples contained large Proterozoic (*ca.* 1000, 1800 Ma) and Archean (2800, 3500 Ma) populations, all of which are common in the Cordilleran passive margin. Interestingly, they document the presence of two lower Paleozoic grains with ages of 430 and 434 Ma. These ages are not common along the northern Cordilleran margin and were interpreted to have been recycled through early to middle Paleozoic clastic wedge deposits of the Innuitian orogenic belt of Arctic Canada (*cf.*, McNicoll *et al.*, 1995).

Detrital mica is commonly present in the Jones Lake Formation, and locally in the underlying Mount Christie Formation. The source of this mica is problematical, since no obvious source has been identified for many hundreds of kilometres to the east. Micaceous sedimentary rocks of the Mount Christie and Jones Lake formations were sampled for detrital mica geochronology (see Fig. 2). Individual mica grains will be analysed using the laser-equipped noble gas mass spectrometer at the University of British Columbia to constrain their possible provenance.

PRELIMINARY CONCLUSIONS

The Mississippian-Permian Mount Christie Formation and Triassic Jones Lake Formation have similar trace and rare-earth element concentrations, both suggestive of derivation from old continental crust. However, the formations can be differentiated by evaluating barium concentrations versus moderately immobile major

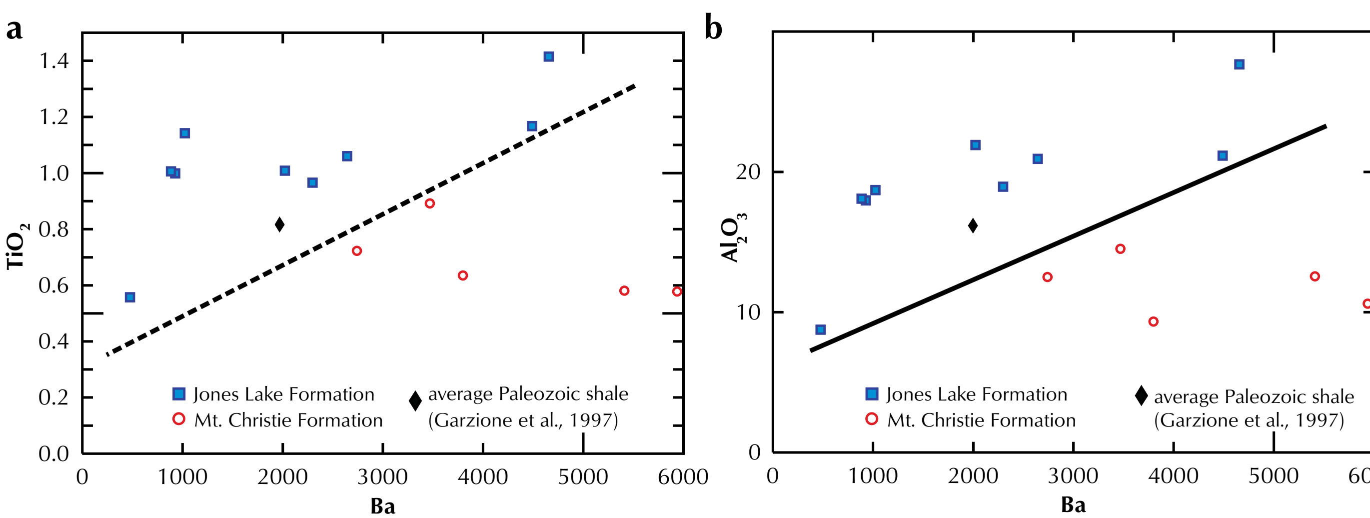

Figure 9. (a) *TiO_2 versus Ba; and* ***(b)*** *Al_2O_3 versus Ba. Lines separate Mount Christie Formation samples from Jones Lake Formation samples. Paleozoic shale data from Garzione et al. (1997).*

element oxides (Fig. 9). This tool could be used for future investigations where contact relationships between these two units are not clear.

The geochemistry of the Jones Lake Formation suggests that the source region included mafic or ultramafic rocks (Fig. 8). Future Nd isotopic analyses may yield more compelling data concerning the nature and possible identity of these juvenile sources.

Paleocurrent indicators in ripple cross-laminated siltstone of the Jones Lake Formation are inconclusive with respect to testing Triassic linkages between outboard pericratonic terranes and autochthonous North America. Paleocurrents predominantly trend to the south-southeast, probably reflecting margin-parallel currents in the distal shoreface.

Forthcoming detrital mineral geochronology and biochronology have a high potential to constrain the position of outboard terranes during the late Paleozoic to early Mesozoic.

ACKNOWLEDGEMENTS

Field work during summer 2005 was funded by the Yukon Geological Survey. Laboratory analyses were funded by a NSERC grant to J.K. Mortensen. We thank Stuart Sutherland for his comments on this manuscript.

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