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Detrital zircon geochronology and the evolution of clastic source areas, Liard Basin, Northeast British Columbia.

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Summary

New U-Pb detrital zircon ages from Lower Cambrian to Cretaceous (Cenomanian) samples of the Liard Basin show how their source areas evolved over time.

Introduction

The Liard Basin, a sub-basin of the Western Canada Sedimentary Basin, is characterized by anomalously thick Upper Paleozoic and mid-Cretaceous sections. The Basin, bounded on the east by the deep-seated Bovie Lake Structure (Figure 1), occupies an important reentrant in the main Cordilleran deformation front (Wright et al. 1993). In BC this has allowed over 5000 m of gently deformed Upper Devonian to Campanian clastic strata to be preserved west of the Bovie Lake Structure. Formation of the Liard Basin began in the Pennsylvanian and Permian as a result of differential motion and erosion across the Bovie Lake Structure (McLean and Morrow, 2004) and its formation had no effect on the depositional facies and thicknesses of important Upper Devonian shale gas units. In contrast, syn-depositonal west-side-down movement on the Bovie Lake Structure in the Cretaceous appears to have influenced potential Lower Cretaceous unconventional targets (see Ferri et al., 2015).

In general terms the succession in the Liard Basin area consists of the following. 1) Mesoproterozoic clastic and carbonate strata deposited in shelf environments after Mesoproterozoic rifting. These were weakly deformed prior to deposition of 2) unconformably overlying clastic-dominated Uppermost Proterozoic-Cambrian strata which were deposited after latest Neoproterozoic rifting and local Middle Cambrian extension. 3) An unconformably overlying carbonate-dominated, shelf-platform succession that persisted through Middle Devonian and removed the lower Paleozoic succession from most of the area. 4) A clastic-dominated Upper Devonian to Pennsylvanian succession of basinal shale overlain by deltaic deposits that records renewed subsidence initiated either by extension and rifting (e.g. Gordey et al., 1987) or orogeny to the west (Antler Orogeny (e.g. Richards et al., 1993; Root, 2001). 5) Unconformably overlying Permian sandstone, carbonate and chert that form relatively thin disconformity bounded units and record widespread block faulting and extension. 6) Triassic clastic and younger carbonate strata that form a shallowing upward succession and record another episode of renewed subsidence. Recently these strata have been interpreted as deposits in the foreland of the late Permian Klondike Orogeny (Golding, 2014). 7) Unconformably overlying Albian to Campanian shale-dominated Cordilleran foreland basin deposits overlie a major regional unconformity that downcuts progressively north and eastward so that no Jurassic or lower Cretaceous is preserved in the Liard area and only a little of the Triassic package remains along the northeastern edge of the basin.

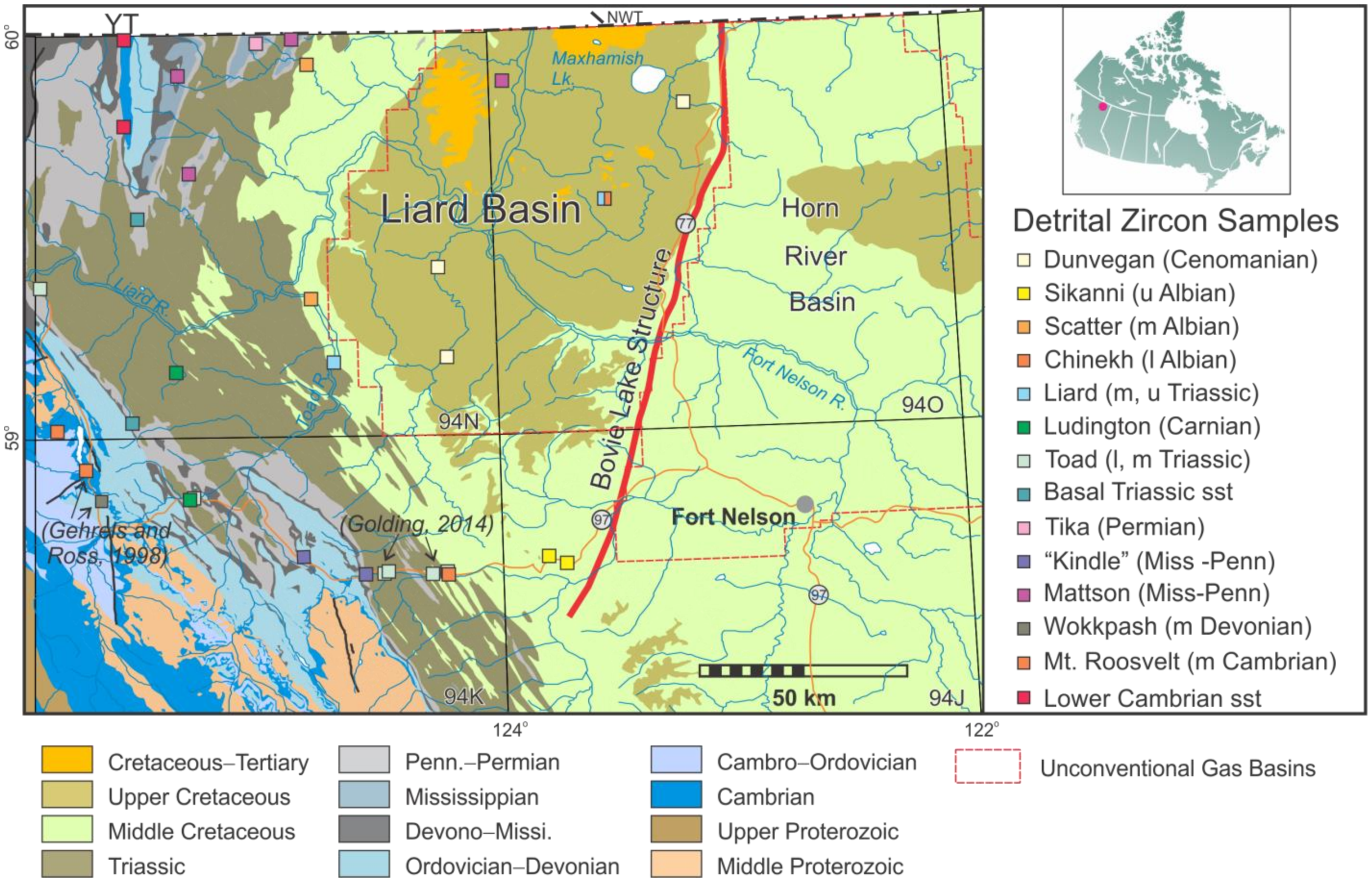

Figure 1. Location of new detrital zircon samples, BC Liard Basin

In the Liard area the provenance of most coarser clastic units has been inferred from thickness, distribution, paleocurrents and clast types. Limited detrital zircon work by Gehrels and Ross (1998; 2 samples) indicated Cambrian sandstones were derived from basement rocks exposed to the east and northeast, whereas Devonian sandstone was derived from the vicinity of the Peace River Arch. Samples of the Middle Triassic siltstone and sandstone collected along the Alaska Highway west of Fort Nelson (Golding, 2014, 6 Toad Formation samples) indicate the majority of sediment was reworked from North American or Arctic (Innuitian) sources. In contrast Middle Triassic sandstone collected less than 100 km north of the BC Yukon border contain a significant compenent of west derived zircon (Beranek and Mortenson, 2011). Reconnaissance Sm-Nd isotopic system work for northeastern BC indicated Cambrian and older shales were derived from Canadian Shield sources, whereas Upper Devonian to Triassic shales are thought to have been sourced from the Innuitian orogen in the Arctic (Garizione et al., 1997; Ross et al. 1997).

Method

Detrital zircons from 13 different stratigraphic units ranging in age from lowest Cambrian to Cenomanian (Figure 1, 2) are being used to systematically constrain changes in provenance and the evolution of source areas for the BC Liard Basin. Zircons were obtained from the rock samples by conventional density and magnetic separation techniques. At each step in the separation process care was taken to avoid introducing biases with the potential to distort the measured DZ age spectra. Approximately 100 zircons from each sample were analysed using an ASI RESOlution™ 193nm laser ablation system coupled to an Agilent 7700 ICPMS at either the new CPATT lab at the University of Calgary or Apatite to Zircon Inc. in

Idaho. Albation occured in a Laurin Technic™ M-50, dual volume ablation cell. Data was corrected for instrumental mass fractionation, drift and laser induced elemental fractionation using Iolite™ (Paton et al., 2010) employing the VisualAge data reduction scheme (Petrus and Kamber, 2012). Zircon reference FC-1 from the Duluth Anorthosite was used as a primary standard (Paces and Miller, 1993). Secondary references 91500, Temora-2 and an internal GSC reference zircon 1242 were used to assess the accuracy of the dataset and to determine excess errors (Weidenbeck et al., 1995; Black et al., 2003). The calculated ages of all secondary references were within 2% of the accepted $^{206}Pb/^{238}U$ and $^{207}Pb/^{206}Pb$ ages determined by ID-TIMS. U-Pb detrital zircon age distributions for each sample were qualitatively compared with zircon ages from potential source rocks in other areas and with detrital zircon age distributions from time equivalent stratigraphic units preserved elsewhere.

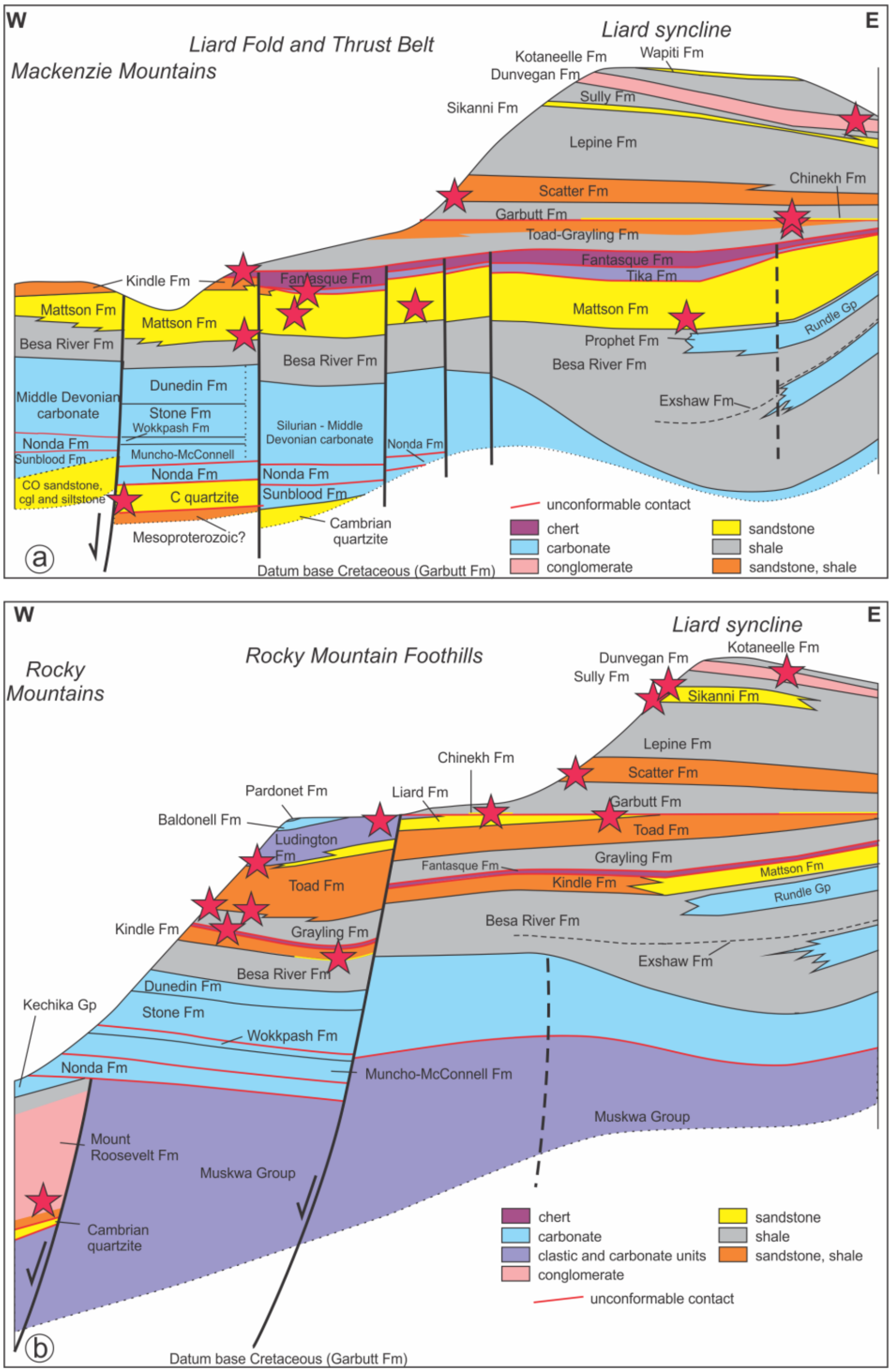

Figure 2. Stratigraphic relationships of new detrital zircon samples BC Liard Basin.

Results and Conclusions

Laser ablation mass spectrometry U-Pb detrital zircon age distributions for Lower Cambrian to Cretaceous (Cenomanian) samples from the Liard Basin show how their source areas evolved with time. Samples from Cambrian quartzites are dominated by detrital zircon ages of ca.1500–3000 Ma and are consistent with derivation from Laurentian basement rocks. A minor component of ca. 620–680 Ma detrital zircon found in Middle Cambrian graben-fill sediments suggests some west-derived material reached the basin at that time. Mississippian-Pennsylvanian sandstones have detrital zircon ages from ca. 350–3000 Ma with relatively few grains between ca. 500–900 Ma and ca.1900-2500 Ma. The abundance of ages around 450 Ma and 1000–1800 Ma indicate input from a new source area or areas. Not surprisingly the Permian sandstone detrital signatures are similar to those of the underlying Mississippian-Pennsylvanian sandstones. Uppermost Albian sandstones known to be west-derived, based on thickness and facies relationships, contain remarkably few detrital zircon grains young enough to be first-cycle detritus from the west. This suggests the bulk of the zircons in these samples have been recycled. Cenomanian sandstone and conglomerate is dominated by Cretaceous detrital zircons sourced from the Cordillera to the west.

Acknowledgements

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References

Beranek, L.P. and Mortensen, J.K., 2011. The timing and provenance record of the Late Permian Klondike orogeny in northwestern Canada and arc-continent collision along western North America. Tectonics, **30**, 1-23.

Garzione, C.N., Patchett, P.J., Ross, G.M. and Nelson, J.L., 1997. Provenance of Paleozoic sedimentary rocks in the Canadian Cordilleran miogeocline: a Nd isotopic study. Canadian Journal of Earth Sciences, **34**, 1603-1618.

Gehrels, G.E. and Ross, G.M., 1998. Detrital zircon geochronology of Neoproterozoic to Permian miogeoclinal strata in British Columbia and Alberta. Canadian Journal of Earth Sciences, **35**, 1380-1401.

Gordey, S.P., Abott, J.G., Tempelman-Kluit, D.J. and Gabrielse, H. 1987, “Antler” clastics in the Canadian Cordillera. Geology, **15,** 103-107.

Richards, B. C., Bamber, E. W., Higgins, A. C. and Utting, J. 1993. Carboniferous (Chapter 4: Stratigraphy). *In* Sedimentary Cover of the Craton in Canada; Stott, D. F. and Aitken, J. D. (ed.); Geological Survey of Canada, Geology of Canada Series no. 5, 272-293.

Root, K.G. 2001. Devonian Antler fold and thrust belt and foreland basin development in the southern Canadian Cordillera; implications for the Western Canada Sedimentary Basin. Bulletin of Candian Petroleum Geology, **49**, 7-36.

Ross, G.M., Gehrels, G.E. and Patchett, P.J., 1997. Provenance of Triassic strata in the Cordilleran miogeocline, western Canada. Bulletin of Canadian Petroleum Geology, **45**, 461-473.