Upper Montney Geochemistry: Insights into Sedimentary Provenance

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Summary

This study uses tectonic discriminant diagrams, REE (Rare Earth Elements) and multi-element plots, to determine the magmatic affinities of sediments in the upper Montney Formation in the Groundbirch region, NE BC. Whole rock geochemistry, specifically REE and immobile elements, are particularly useful for classifying a rock's tectonic origin. Tectonic discriminant diagrams illustrate that the upper Montney Formation has granitic/andesitic-rhyodacitic geochemical affinities; and multi-element and REE plots, display that the upper Montney Formation has negative Ce and Eu anomalies, when standardized to chondrite and primitive mantle. Previous work suggests the Montney was deposited on a west-facing marine ramp/shelf setting, during the Triassic where the western margin of the Laurentian continent was a passive margin, and sediments from the east were being deposited from the craton and into the Western Canada Sedimentary Basin (WCSB). Alternatively, to the west during this time, it is thought volcanic arcs existed, staging a back-arc-basin depositional type environment, where these Triassic sediments were accumulating. Utilizing immobile element geochemistry, this study elaborates on these two directionally opposing tectonic sources.

Introduction

Previous studies (Davies, et al., 1997) have classified much of the lower Triassic Montney Formation, as the accumulation of wind blown sediments from the craton to the east. More recent studies (Zonneveld, et al, 2010) suggest the low diversity of indigenous infauna, support dysoxic depositional conditions sourced by local ephermeral deltas. Provenance studies by Ross et al., (1997), Beranek et al., (2009) suggest Triassic sediments are linked to reworked Devonian sediments of the Ellesmerian clastic wedge. This study evaluates whole rock geochemical analyses and more specifically immobile element chemistry of four cores from the Groundbirch area, NE BC, to attest their magmatic signatures to further evaluate and develop a potential source.

Theory and/or Method

Trace elements were used to validate the specific source of the upper Montney Formation, particularly the high field strength elements, Y, Th, U, Zr, Ti, Nb, Ta, since these elements are considered the most immobile, both in seawater and rock dominated processes (Jenner, 1996). The volcanic geochemical discriminant diagrams after Winchester and Floyd (1977) (Figure 1), plots the upper Montney Formation in the rhyodacite/dacite field. These plots were specifically utilized to illustrate how magmatic rock types can be distinguished from metamorphosed/altered volcanic rocks.

Similarly, tectonic discriminant diagrams after Pearce (1983) show these same samples plotting within the volcanic arc granite compositions as well as syncollisional granites (Figure 2).

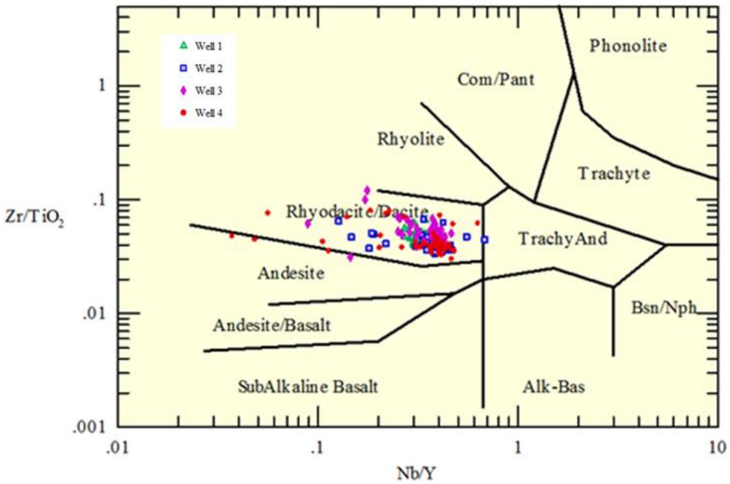

Figure 1: Geochemical discriminant diagrams using immobile elements to determine how different magma series can be determined in altered/metamorphosed volcanic rocks, modified from Winchester and Floyd (1977).

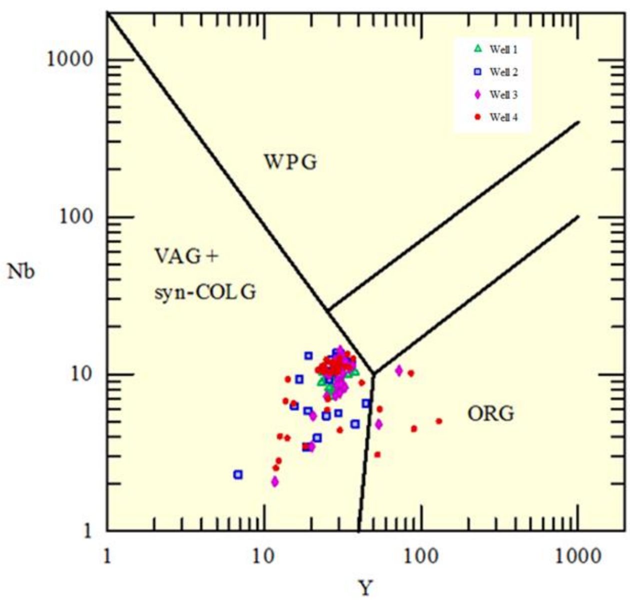

Figure 2: Geochemical discriminant diagram after Pearce (1983), plotting upper Montney Formation in volcanic arc granites and syncollisional granites field.

Multi-element diagrams (Figure 3) show significant U, K, Pb, Sr, Sm, and Hf anomalies, and a plateau from Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, and Lu, when standardized to primitive mantle (Sun and McDonough, 1989). REE plots standardized to the Post Archean Australian Shales (Taylor and McLennan, 1985), show minor negative anomalies in Ce (Figure 4). Plots standardized to chondrites (Sun and McDonough, 1989) show a negative Ce and Eu anomaly (Figure 5).

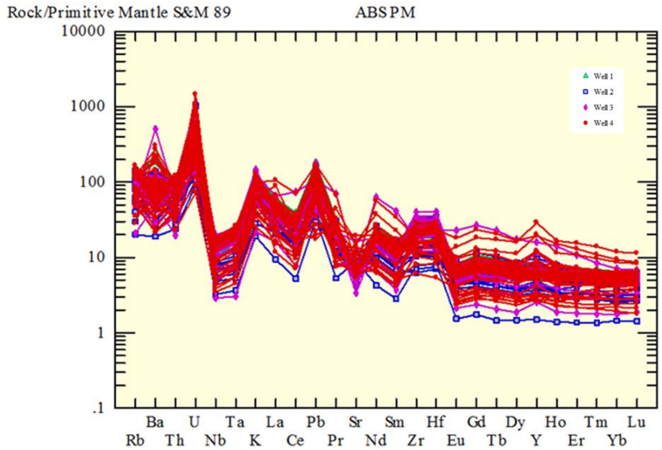

Figure 3: Multi-element diagram after Sun and Mcdonough (1989), illustrating how the upper Montney Formation deviates from a primitive mantle standard.

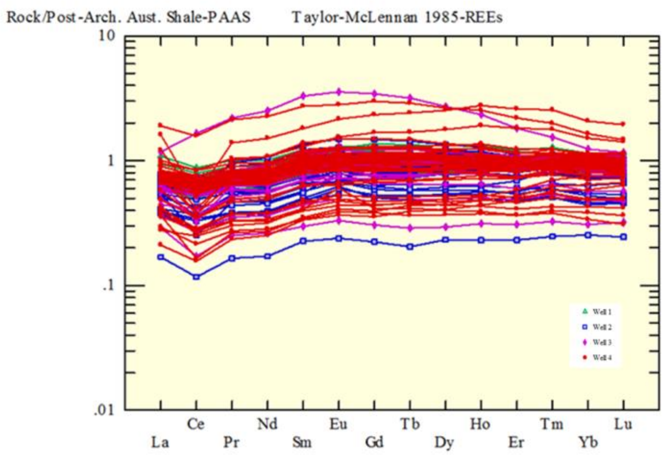

Figure 4: REE diagram after Taylor and McLennan (1985), illustrating how the upper Montney Formation deviates from the Post Archean Australian Shale.

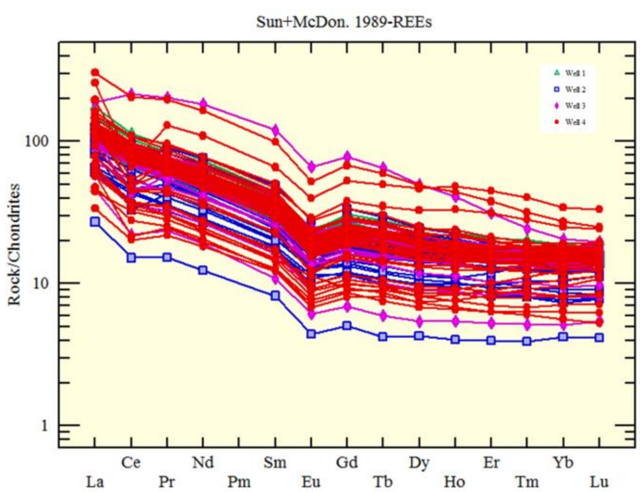

Figure 5: REE diagram after Sun and McDonough (1989), illustrating negative Ce and Eu anomalies.

Conclusions

The geochemical trends of immobile and REE's suggest the upper Montney sediments were sourced from either granitic/andesitic-rhyodactie magmatics. The abundant samples with a negative Eu anomaly, suggests a large proportion of these sediments were sourced from the Laurentian continent to the east from a highly differentiated craton, however samples that do not exhibit the Eu anomaly could be considered products of western volcanic arcs that were not subject to differentiation. Further geochemical studies need to be employed, such as Sm-Nd isotopes, to further develop the magmatic source of these rocks and build on the previous provenance studies of Ross et al., (1997) and Beranek et al., (2009).

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References

Beranek, L.P., J.K. Mortensen, M.J. Orchard, and T. Ullrich, 2010, Provenance of North American Triassic strata from west-central and southeastern Yukon: correlations with coeval strat in the Western Canadian Sedimentary Basin and Canadian Arctic Islands, Canadian Journal of Earth Sciences, vol.47, p.53-73.

Davies, G.R., T.F. Moslow, and M.D. Sherwin, 1997, The Lower Triassic Montney Formation, west-central Alberta, Bulletin of Canadian Petroleum Geology, vol. 45, no.4, p.474-505.

Jenner, G.A. 1996, Trace element geochemistry of igneous rocks: geochemical nomenclature and analytical geochemistry, in Wyman, D.A., ed., Trace Element Geochemistry of Volcanic Rocks: Applications For Massive Sulphide Exploration: Geological Association of Canada, Short Course Notes, v.12, p.51-77.

Pearce, J. A., 1983, Role of the sub-continental lithosphere in magma genesis at active continental margins, *in* Hawkesworth, C. J. and M. J. Norry, eds., Continental basalts and mantle xenoliths, Nantwich, Cheshire, Shiva Publications, p. 230-249.

Ross, G.M., G.E. Gehrels, and P.J. Patchett, 1997, Provenance of Triassic strata in the Cordilleran miogeocline, western Canada, Bulletin of Canadian Petroleum Geology, vol. 45, no.4, p.461-473

Sun, S. and W. F. McDonough, 1989, Chemical and isotopic systematics of oceanic basalts: implications for mantle composition and processes, Geological Society, London, Special Publications, vol. 42, no. 1, p. 313-345.

Taylor, S. R. and S. M. McLennan, 1985, The continental crust: Its composition and evolution, Palo Alto, CA, Blackwell Scientific Publishing, p.328.

Winchester, J. A. and P. A. Floyd, 1977, Geochemical magma type discrimination: application to altered and metamorphosed basic igneous rocks, Earth and Planetary Science Letters, vol. 28, no. 3, p. 459-469.

Zonneveld, J.P., R.B MacNaughton, J.U. Utting, T.W. Beatty, S.G. Pemberton, and C.M. Henderson, 2010, Sedimentology and ichonology of the Lower Triassic Montney Formation in the Pedigree-Ring/Border-Kahntah River area, northwestern Alberta and northeastern British Columbia, Bulletin of Canadian Petroleum Geology, vol. 58, no.2, p.115-140.