Geological Investigations of the Basement of Quesnellia in southern British Columbia: Progress Report

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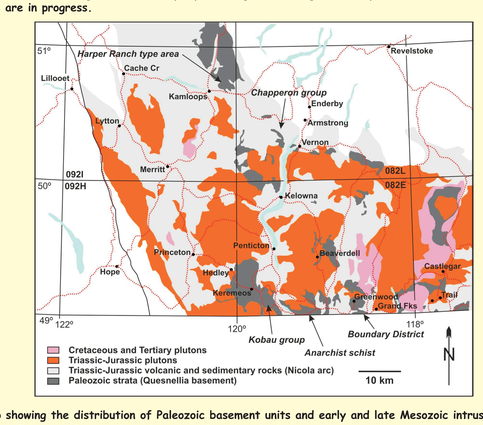
Introduction

The nature and origin of Paleozoic oceanic rock assemblages that form the basement of Early Mesozoic arc rocks in the Quesnellia terrane in southern BC are generally poorly understood. We have undertaken a reconnaissance level study of these Paleozoic units in the Keremeos - Osoyoos area, focusing particularly on the Apex Mountain complex and the Kobau Group. Existing geological mapping of these areas is mainly of 1930-40 vintage (Bostock, 1940, 1941), although some portions of the area were subsequently remapped in more detail (e.g., Okulitch, 1969; Milford, 1984; Ray and Dawson, 1994). Similar rock units in the Greenwood area to the east have seen more recent geological mapping and related studies (e.g., Fyles, 1990; Massey and Duffy, 2008). In addition there have been several biochronological studies in the area by F. Cordey, M. Orchard, T. Danner, and others.

The main goals of the study are: 1) to evaluate the current subdivision of lithotectonic assemblages in the region; 2) to determine the ages of the various assemblages; and 3) to assess the structural and possible stratigraphic relationships between the various assemblages. We are employing a variety of techniques, including micro- and macrofossil biochronology, U-Pb zircon dating, major, trace and rare earth element geochemistry, and detrital zircon dating. We spent approximately three weeks in July 2010, examining and sampling the Paleozoic rock units in the Keremeos and Osoyoos areas. We also spent several days in the Greenwood area with N. Massey, who has recently completed a geological mapping, geochronological and lithogeochemical study, and carried out additional sampling of Paleozoic rock units there (Knob Hill complex, Attwood formation and Anarchist Schist) for geochemical analyses and detrital zircon dating to complement our work farther to the west. In a parallel study we sampled Mesozoic intrusive rocks in vicinity of the Hedley gold district and adjoining areas to the east, for detailed U-Pb zircon dating and Pb isotopic studies.

Including samples collected in October 2009, during a preliminary visit to the area, we now have a suite of 52 representative samples of basalts and related intrusive rocks for lithogeochemical study, 55 samples of clastic sedimentary rocks for detrital zircon dating, 6 samples of carbonate rocks for conodont dating, and a large number of samples of chert for radiolarian dating. Most of the lithogeochemical analyses are complete, and most radiolarian samples have been processed. Detrital zircon dating, conodont sample processing, and dating and isotopic work on the intrusive rock units are in progress.

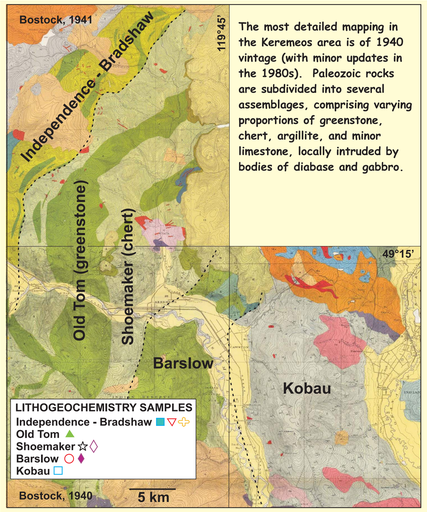


Map showing the distribution of Paleozoic basement units and early and late Mesozoic intrusions in Quesnellia in southern and south-central British Columbia.

BIOCHRONOLOGY

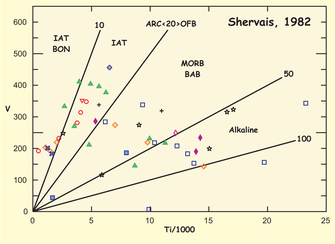
Although the ages of the Mesozoic strata in the region (Nicola Group in the west and Brooklyn Formation in the Greenwood area) are well established from detailed conodont dating, available age constraints from the Paleozoic assemblages were limited prior to this study. A small number of radiolarian, conodont and macrofossil ages from the Apex Mountain complex in the Keremeos area range from Middle Devonian to Carboniferous; however, conodonts and some macrofossils from rare carbonate units within the complex include both much older (Ordovician) and younger (Late Triassic) ages. Reconciling all of the seemingly contradictory fossil ages in the study area will allow us to better evaluate the stratigraphic and structural relationships between and within the various lithotectonic assemblages.

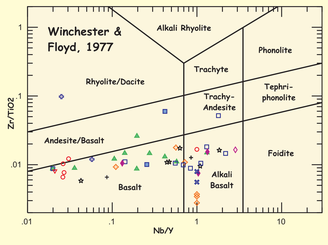
Radiolarian chert is a widespread and abundant lithology within the Paleozoic assemblages in the study area; however, microfossils in these units are commonly too recrystallized to permit precise age assignments. New ages determined from radiolarian in cherts (determined by F. Cordey), together with conodont ages from some of the cherts and from rare carbonate units in the area (determined by M. Orchard), confirm that the main age range for the Paleozoic units in the area is from Late (locally Middle) Devonian to Carboniferous. This is the same age range that has been established by N. Massey for the Knob Hill and Attwood assemblages in the Greenwood area. Older (Ordovician) carbonate blocks preserved west of Olalla appear to be either olistoliths from presently unknown sources that were incorporated during deposition, or exotic blocks that were structurally interleaved into the complex. Similarly, Late Triassic carbonate bodies on Shoemaker Creek west of Keremeos appear to have been structurally sandwiched between older panels of Paleozoic rocks.

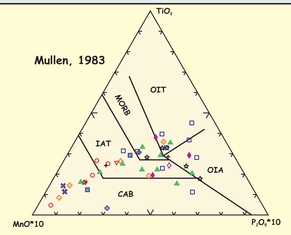


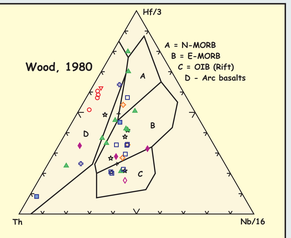
The most detailed mapping in the Keremeos area is of 1940 vintage (with minor updates in the 1980s). Paleozoic rocks are subdivided into several assemblages, comprising varying proportions of greenstone, chert, argillite, and minor limestone, locally intruded by bodies of diabase and gabbro.

A: Panorama view to north across Similkameen R valley, looking towards exposures of Barslow assemblage clastic rocks with interlayered basalt; B: Top of Mt. Kobau; C; Sheared greenstone in the Kobau Gp near top of Mt. Kobau; D: Sheared Barslow assemblage mafic volcaniclastic rocks near Cawston; E; Vein of granophyre in large body of gabbro in Barslow assemblage on S side of Similkameen R east of Keremeos; F: Bedded radiolarion chert (prob. Late Devonian age) in talus block west of Keremeos; G: Thin-bedded sandstone and sandy limestone in road cut above Keremeos dumpsite; H: "Broken formation" near locality "G".









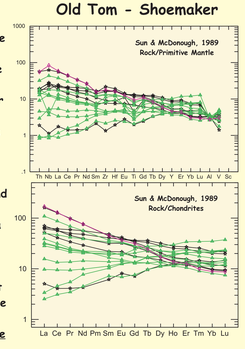
LITHOGEOCHEMISTRY

A total of 49 samples of mafic volcanic and intrusive rocks from all of the lithotectonic assemblages in the study area have been analyzed for major, trace and rare earth element compositions. The majority of the samples fall in the basalt field with a smaller number in the alkali basalt field and a few samples plotting as andesites or trachy-andesites. The data show considerable scatter on various immobile element plots, suggesting generation in several different paleotectonic settings. Tectonic discriminant plots indicate that both arc settings and non-arc settings are represented.

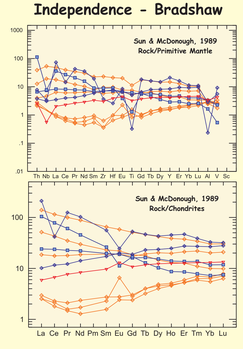
As an initial filter we have sub-divided the data set in terms of the lithotectonic assemblage from which the individual samples were collected. These data are then plotted as ratios to primitive mantle and to chondritic compositions. Results indicate that each assemblage, with the possible exception of the Kobau, includes rocks generated in more than one tectonic setting. Samples in the Old Tom assemblage fall in both arc and non-arc fields on a Shervais-type plot; however, the extended rock/primitive mantle plot suggests that the Old Tom units mainly reflect N-MORB to OIB compositions. Greenstone units within the Shoemaker assemblage yield predominantly E-MORB and OIB compositions. Greenstone units in the Independence-Bradshaw assemblages are compositionally diverse, but appear to be most consistent with non-arc settings. Volcanic rocks in the Barslow assemblage are the only units that yield convincing arc chemistry, although a large gabbro sill contained within this package has a clear within-plate composition. Kobau assemblage greenstones are relatively homogeneous, and give compositions most similar to E-MORB and OIB.

The compositional heterogeneity observed in the Paleozoic mafic igneous rock units in the Keremeos - Osoyoos area may prove valuable for establishing chemostratigraphic correlations within and between the different lithotectonic assemblages, particularly when integrated with existing and new biostratigraphic constraints.

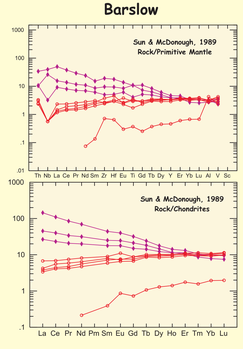
Old Tom - Shoemaker



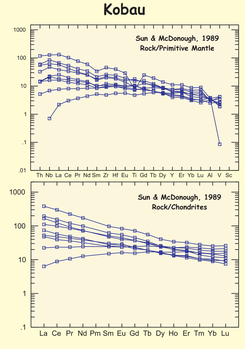
Independence - Bradshaw

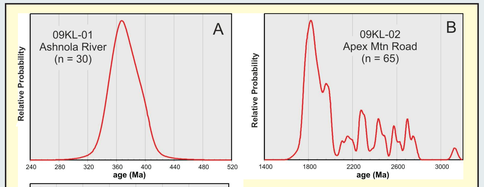


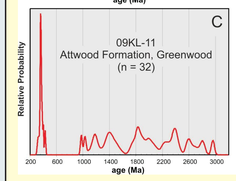
Barslow



Kobau







DETRITAL ZIRCON DATING

Siliciclastic rock units (sandstone and siltstone) make up a minor but widespread component of the Paleozoic assemblages in southern Quesnellia. We will use the detrital zircon age signature of each of the assemblages both to constrain the provenance of the clastic units and to test possible correlations between the different assemblages.

We are presently separating zircons from clastic samples from throughout the study area. Results from three samples that were collected during 2009 are shown above. Two of these were from the Keremeos area (Apex Mountain Road and Ashnola River) and one is from the Attwood Formation in the Greenwood area. Two main observations can be made from the data. First, the Apex Mountain and Attwood samples yield a range of Late Archean to Proterozoic ages. All of the zircons in the Apex Mountain sample are consistent with a NW Laurentian source; however, the 1400-1800 Ma grains in the Attwood sample fall in the "magmatic gap" in NW Laurentia, possibly indicating a non-Laurentian source for these grains. Second, there is a very large component of Devonian-Mississippian zircon grains in both the Ashnola and Attwood samples. This could indicate a stratigraphic link between these two assemblages, and possibly with the Harper Ranch assemblage, which forms the basement to Mesozoic strata in Quesnellia farther to the north, and contains abundant Middle Paleozoic volcaniclastic units.

DISCUSSION AND FUTURE WORK

Our field examinations during 2010 have shown that the Paleozoic assemblages in southern Quesnellia are stratigraphically and possibly structurally more complex than was previously thought. Juxtaposition of rock units of very different age and reflecting quite different tectonic settings in some localities appears to require at least some amount of structural imbrication. Detrital zircon age signatures from all of the assemblages in the region will help determine whether they are at least broadly related to one another, and test possible depositional linkages to North America or possibly other continents. Integration of our chemostratigraphic data with existing and new biostratigraphic age constraints will allow us to determine which, if any, of the assemblages are stratigraphically intact, or whether the Paleozoic assemblages represent an accretionary complex, as was suggested by Milford (1984).

An improved understanding of the nature of the Paleozoic basement on which the Mesozoic arc terranes that define Quesnellia in southern BC were built will provide a framework within which to evaluate possible basement controls on localization of younger mineralization.

ACKNOWLEDGMENTS

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