Petrochemistry of Mafic Rocks Within the Northern Cache Creek Terrane, NW British Columbia, Canada

ABSTRACT

The Cache Creek terrane is a belt of oceanic rocks that extend the length of the Cordillera in British Columbia. Fossil fauna in this belt are exotic with respect to the remainder of the Canadian Cordillera, as they are of equatorial Tethyan affinity, contrasting with coeval faunas in adjacent terranes that show closer linkages with ancestral North America. The Cache Creek terrane is typified by tectonically imbricated slices of chert, argillite, limestone, wacke and volcaniclastic rocks, as well as mafic and ultramafic rocks. These lithologies are believed to represent two separate litotectonic elements: Middle Triassic to Lower Jurassic, subductionrelated accretionary complexes, and dismembered basement assemblages emplaced during the closure of an ocean basin in the Middle Jurassic. Petrochemical analysis revealed four distinct mafic igneous assemblages that include: magmatic 'knockers' of the Nimbus serpentinite mélange, basaltic tuffs of 'Blackcaps' Mountain, augite-phyric breccias of 'Laughing Moose' Creek, and volcanic pediments to the reef-forming carbonates of the Horsefeed Formation. Major and trace element analysis classifies the 'Laughing Moose' breccias and the carbonate-associated volcanics as alkaline in nature, whereas the rest are subalkaline. Tectonic discrimination diagrams show that the alkaline rocks are of within-plate affinity, while the 'Blackcaps' basalts and 'knockers' from within the mélange typically straddle the island-arc tholeiite and the mid-ocean ridge boundaries. However, primitive mantle normalised multi-element plots indicate that these subalkaline rocks have pronounced negative Nb anomalies, a characteristic arc signature. The spatial association of alkaline volcanic rocks with extensive carbonate domains points to the existence of seamounts within the Cache Creek ocean. However, the precise origin of the 'Laughing Moose' breccias remains somewhat uncertain and may be related to a subsequent rifting event. To conclude, preliminary data from the Nakina region show it to be dominated by two different petrogenetic components: alkaline volcanic rocks of within-plate affinity, and primitive arc-related, subalkaline mafic rocks. An accretionary complex/ oceanic arc origin may provide a mechanism to explain the lithological diversity within the Nakina area.

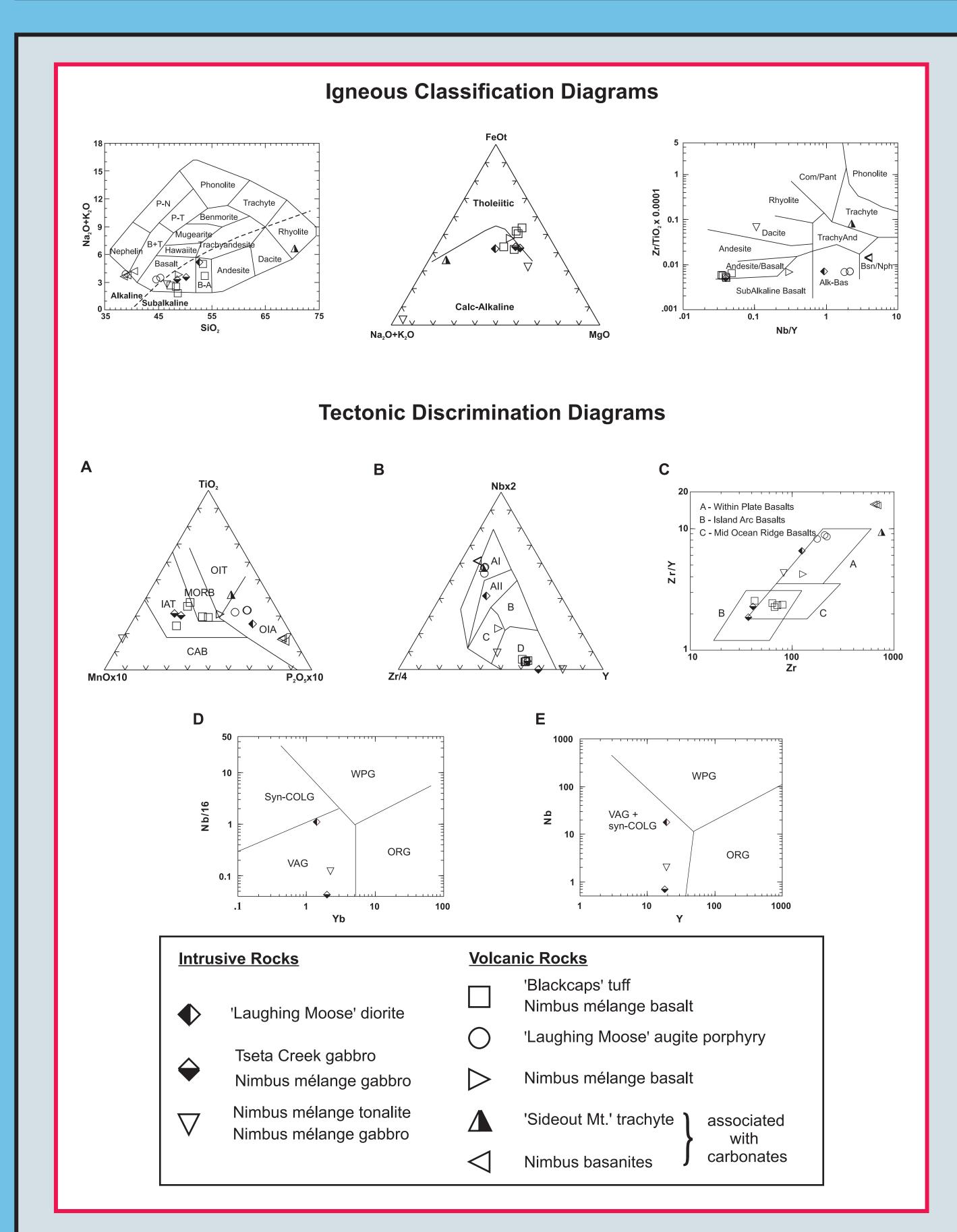


Figure 3: Igneous classification and tectonic discrimination diagrams for mafic rocks within the Nakina map-area. Volcanic rocks associated with extensive Carboniferous-Permian Tethyan carbonate domains are alkaline in nature, consistent with formation in a ocean island/plateau environment. The 'Laughing Moose' volcanic and intrusive rocks are also alkaline in chemistry, but their age and origin remains poorly constrained. The 'Blackcaps' basaltic tuffs and the intrusive rocks within the serpentinite mélange are subalkaline in composition

Diagram B: AI - within-plate alkali basalts; AII - within-plate alkali basalts and within-plate tholeiites; B - E-type MORB; C - within-plate tholeiites and volcanic arc basalts; D - N-type MORB and volcanic arc basalts.

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(Mihalynuk and Cordev. 1997)

'Mihalynuk and Cordev, 1997)

(Childe and Thompson, 1997)

What is

accreted?

IAT: <u>primitive oceanic</u>

(Tethyan) carbonates

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Figure 1: Location map of north-western British Columbia showing the Atlin Targeted Geoscience Initiative study area (1:250 000 sheet 104N), and the Nakina regional mapping project area (1:50 000 sheets 104N1, 2, 3). Distribution of Cache Creek terrane in BC and

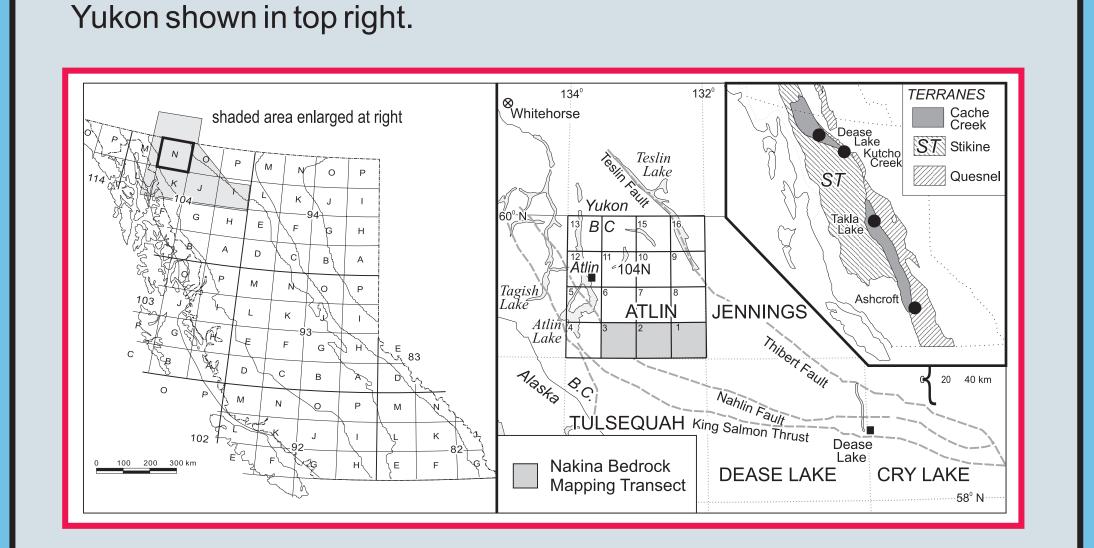
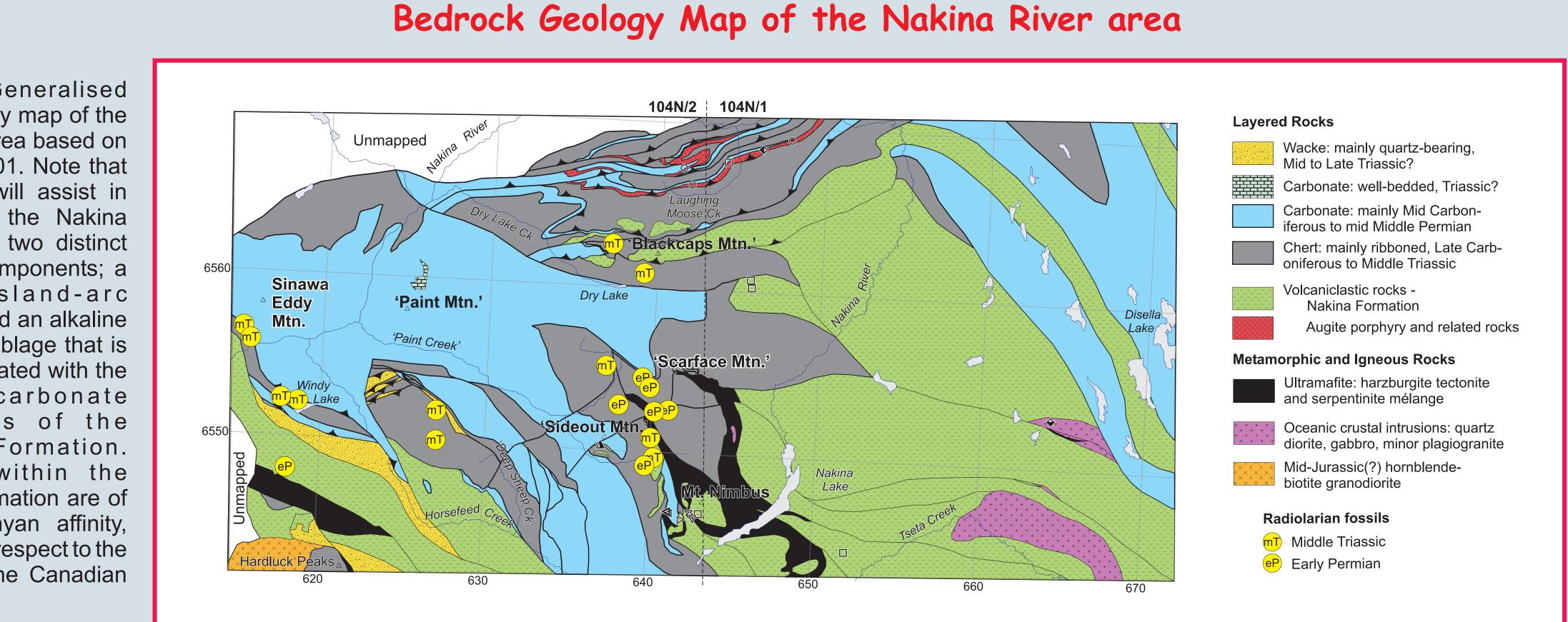


Figure 2: Generalised bedrock geology map of the Nakina River area based on fieldwork in 2001. Note that geochemistry will assist in subdivision of the Nakina Formation into two distinct lithotectonic components; a primitive island-arc assemblage and an alkaline volcanic assemblage that is spatially associated with the extensive carbonate successions of the Horsefeed Formation. Fusulinids within the Horsefeed Formation are of equatorial Tethyan affinity, and exotic with respect to the remainder of the Canadian Cordillera.



▲ N-MORB -ve Nb anomaly Primitive Island **Arc Chemistry** Northern Cache Joe Mountain (Hart and Orchard, 1996) Hall Lake (Mihalynuk and Cordey, 1997) Upper Permian Associated with Teslin Formation Island-arc tholeiites Creek Terrane (Tethyan) carbonates Middle-Triassic Th La Nd Sm Gd Dy Y Lu Peninsula Mtn. (Mihalynuk, 1999) Island-arc tholeiites Th La Nd Sm Gd Dy Y Lu Nb Ce Zr Eu Ti Er Yb Nb Ce Zr Eu Ti Er Yb Middle-Triassic? French Range ▲ N-MORB E-MORB ▲ N-MORB Associated with Teslin Formation 10 [E-MORB or OIB N-MORB? 'Laughing Moose' rocks Th La Nd Sm Gd Dy Y Lu Th La Nd Sm Gd Dy Y Lu OIB or rift? Nb Ce Zr Eu Ti Er Yb Nb Ce Zr Eu Ti Er Yb Nakina River (this study; English et al., 2002) ■ IAT Alkaline volcanic rocks associated with associated with the Horsefeed Formation Nahlin Ultramafic Th La Nd Sm Gd Dy Y Lu (Tethyan) carbonates ~ ~ ~ ~ ~ ~ ~ · · · Primitive island-arc Alkaline volcanic rocks Oceanic seamounts Upper Permian -Carboniferous - Permian Middle Triassic Island-Arc Tholeiites Th La Nd Sm Gd Dy Y Lu (Monger, 1975; Mihalynuk et al., Nb Ce Zr Eu Ti Er Yb Mihalynuk *et al.*, 2003) Alkaline volcanic OIB Figure 5: Comparison of the results of this study with other geochemical data from mafic rocks elsewhere in the northern Cache Creek terrane. Note that island-arc tholeiites rocks associated N-MORB occur exclusively on the western margin of the Cache Creek terrane, with alkaline volcanic rocks occupying more inboard positions. with carbonate successions bearing Tethyan

Figure 4: Multi-element diagrams normalised to primitive mantle (Sun and McDonough, 1989), which compare (a) the 'Blackcaps' tuff, the Tseta Creek gabbro, and some samples from the Nimbus mélange to values for N-MORB (Sun and McDonough, 1989) and IAT (Jenner et al., 1987); (b) 'Laughing Moose' rocks to values for N-MORB and OIB (Sun and McDonough, 1989), and (c) carbonate-associated volcanics and one sample from Mt. Nimbus to values for OIB and E-MORB (Sun and McDonough, 1989).

Th La Nd Sm Gd Dy Y Lu

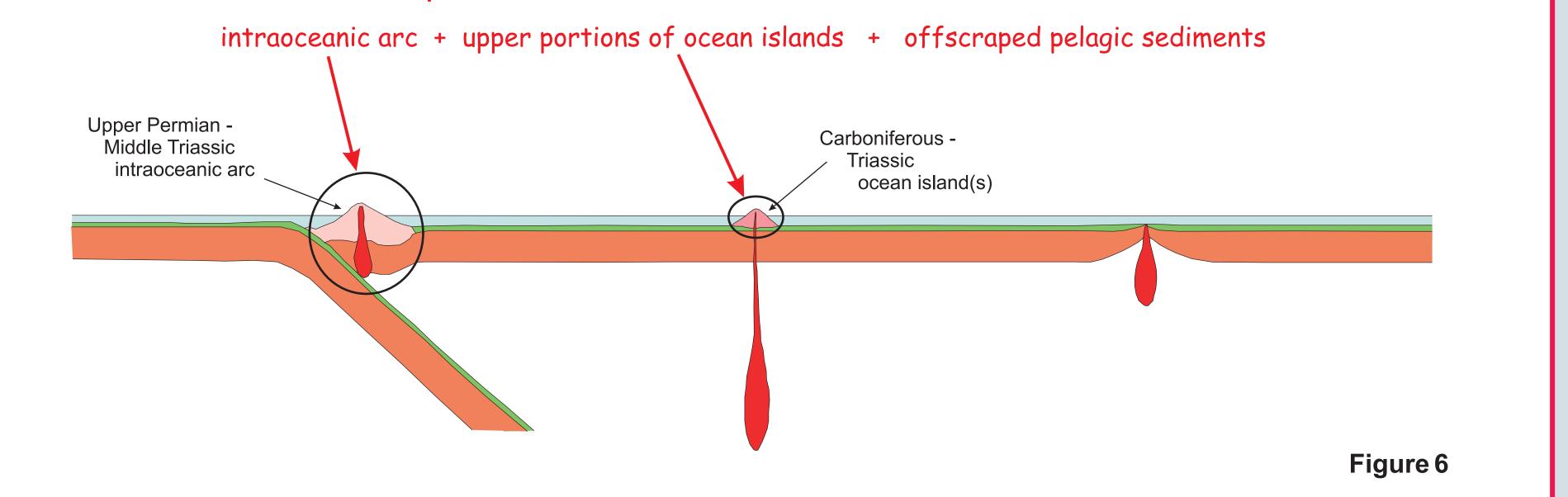
Nb Ce Zr Eu Ti Er Yb

Volcanic seamounts

Carboniferous to

Permian

What is preserved from a Carboniferous - Lower Jurassic ocean basin? Oceanic terrane



Conclusions

- Mafic rocks within the oceanic Cache Creek terrane were formed in a number of disparate tectonic
- The principle components include pelagic sediments and carbonate successions bearing exotic Tethyan fauna, as well as mafic and ultramafic rocks.
- ► Alkaline volcanic rocks are a volumetrically minor component within Carboniferous-Permian carbonate successions, and together they represent the remnants of oceanic seamounts that were 'sliced off' and accreted at a convergent margin. The absence of extensive ocean-island basalts suggests that the volcanic roots to the carbonate atolls were either underplated at greater depth or subducted completely.
- Cherts within the Cache Creek terrane range in age from Carboniferous to Lower Jurassic and record pelagic sedimentation on one or more oceanic plates. N-MORB's appear to be a volumetrically minor component within the Cache Creek terrane, suggesting that the majority of this oceanic lithosphere was subducted.
- Mafic and ultramafic rocks are volumetrically most significant along the western margin of the Cache Creek terrane. Where studied, these rocks display an oceani island-arc affinity. The preservation of all the major components of oceanic lithosphere suggests that these rocks occupied the upper plate at a convergent margin, and hence a suture may occur within the Cache Creek
- Geochemical studies within the oceanic Cache Creek terrane indicate that accretion of island-arcs is the most important mechanism for continental growth. Accretion of thick oceanic seamounts/plateaus may be important locally, although the vast majority of oceanic lithosphere, in the lower plate, is subducted at convergent margins.

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