Petrogenesis of Bohemian Massif metabasites

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During the early Palaeozoic the Cadomian continental basement of the northern margin of Gondwana underwent extensive rifting with the formation of various independent crustal blocks, such as Avalonia and the Armorican Terrane Assemblage (ATA). The ATA encompassed a collage of small units that became separated by oceanic crust – the Saxothurigian seaway. In the Bohemian Massif region of the ATA, attenuation of the Cadomian continental lithosphere was accompanied by the initial emplacement of anatectic granites (c.500 Ma) and extensive mafic-dominated bimodal magmatism (late Cambrian-early Ordovician). The mafic components often featured basalts with a chemistry akin to those typical of ocean floor and thus, constitute the Saxothurigian seaway. During the later Variscan orogeny these Lower Palaeozoic oceanic basalts were subsequently metamorphosed to various amphibolites, greenschists and blueschists (collectively metabasites) and often extensively sheared and deformed.

Within the Bohemian Massif two broad associations can be identified: (a) intrusive metabasites in deep crustal segments associated with granitic orthogneisses, and (b) extrusive submarine basaltic lavas at higher levels associated with both pelagic and basinal sediments, as well as shallower water sandstones. The metabasites from both associations have many chemical features in common and suggest that the deeper level intrusives were probably the feeders to the higher level lavas.

The metabasites, as a whole, show a wide range of chemical characteristics, but are dominated by variably enriched tholeiites. Most of the Variscan crustal blocks in the Bohemian Massif show the presence of three main chemical groups of metabasites: (a) low-Ti tholeiitic metabasalts, (b) Main Series or high-Ti tholeiitic metabasalts, and (c) alkalic metabasalts. They differ in the degree of incompatible element enrichment (depleted to highly enriched normalized patterns), in selected LIL to HFS element ratios, and abundances of HFS elements and their ratios.

In terms of petrogenesis and their tectonic environment, three features require explanation: (a) the wide range of chemical composition displayed by the metabasites, (b) the common enrichment factor of light REE-Th-Nb-Ta shown by the metatholeiites, and (c) high Th values (or more specifically Th/Ta ratios) and associated low E_{Nd} values especially displayed by the low-Ti tholeiitic metabasalts. In the light of the ocean floor chemistry of many of the metabasites, it is suggested that the chemical features could be the consequence of spreading ridge-plume interaction and differential mantle source composition. Apart from variable fractionation and differential partial melting, the range of chemistry exhibited is a consequence of the involvement of: (a) a lithospheric source contaminated by a sediment component (which generated the Low-Ti tholeiites), and (b) a high-level asthenospheric MORB-type source that mixed with a plume component (which generated the range of enriched Main Series tholeiites and the alkali basalts respectively). In this model, high Th values reflect sediment contamination in the mantle source rather than at crustal levels, although this latter feature cannot be ruled out entirely.

It is considered that a plume played an important role in the generation of both early granites and the enriched MORB-type compositions in the metabasites.

The Saxothurigian seaway is envisaged as starting as a continental rift initially dominated by lithospheric melts. On further development, oceanic crust, derived by asthenospheric melting, was generated and which came under the variable influence of a plume or plumes. In a sense the spreading ridge was partially hijacked by the plume(s) and controlled the composition of the melts produced. Its significance for the initial fragmentation of Gondwana is unknown, but a plume presence may have facilitated deep continental crust melting and the fracturing into small crustal blocks.