Paper Number: 5191

Metamorphic evolution and petrogenesis of ultramafic rocks of komatiitic composition from the Central Zone of the Limpopo Belt, South Africa.

Sarkar, T.[1], Mouri, H.[1], Maier, W.D.[2] and Dubinina, E. O.[3]

[1]Department of Geology, University of Johannesburg, Johannesburg 2006, South Africa.

[2]School of Earth and Ocean Sciences, Cardiff University, Cardiff, Wales, CF103AT, United Kingdom.

[3]IGEM, Russian Academy of Sciences, Staromonetnyi per. 35, Moscow, 119017 Russia.

____-
____

Komatiites are MgO rich ultramafic volcanic rocks, mostly interpreted to be essentially anhydrous, and commonly characterized by spinifex texture [1]. They mainly occur in Archean or Proterozoic greenstone belts within cratons. However, in the Central Zone (CZ) of the Limpopo Belt in South Africa, komatiite occurrence was reported for the first time within a high-grade metamorphic terrane [2]. The komatiites occur near Musina within a suite of metamorphosed mafic rocks, pelitic migmatites and associated anatectic granites. The rocks have a dark bluish grey colour on fresh surfaces and form a number of discontinuous semi-round outcrops extending for about 200m. Detailed geochemical study including PGEs revealed that these are Al-undepleted (Munro type) komatiites [2].

The Limpopo komatiites show a medium-grained polygonal texture and are composed mainly of pargasitic amphibole (up to 40 vol.%; X_{Mg} = 0.90), olivine (X_{Mg} = 0.83), orthopyroxene (X_{Mg} = 0.84), Cr-rich spinel and magnetite. The mineralogy is different from that of fresh komatiites, which consist mainly of olivine, clinopyroxene, with or without orthopyroxene, chromite, and plagioclase and in some cases amphibole and quartz. The minerals in the studied rocks represents the peak metamorphic assemblage, which was subjected to minor retrogression and alteration. Thermodynamic calculations and equilibrium assemblage modelling indicate that the komatiites equilibrated at granulite-facies conditions of 820 °C and 8.5 kbar, which is consistent with previously reported conditions in this zone. However, the komatiites lack any evidence of prograde metamorphism (reaction textures etc.) and the mineralogy is unusual for lower crustal metamorphic conditions. Therefore, speculations remain about the source of fluid required to stabilize up to 40 vol.% amphibole under such conditions.

In order to assess the source of fluids, a O and H isotope study was undertaken. The komatiites yield a narrow range of whole rock $\delta^{18}O$ values of +5.4 to +6.3 ‰, unlike $\delta^{18}O$ values from other altered komatiites. However, they generally fall within the range previously reported for ultramafic rocks (+5.5 to +5.9‰) [3] and that modeled for fresh komatiites (+5.4 to +6.0‰) [4]. Amphibole separates yield $\delta^{18}O$ values between +5.5 and +6.1‰, similar to that of the bulk rock, and hydrogen isotopic values (δD) range between -78 and -83‰, which fall within the range of accepted mantle values (-40 to -80‰) and display notable similarities with those of primary amphiboles from other komatiites. The O and H isotope values along with the textural and mineralogical evidence probably indicate that in the komatiites of the Limpopo Belt mantle-derived water played a crucial role in the genesis of amphibole, therefore they represent primary magmatic amphiboles. Based on the existing data, it cannot be said with certainty whether the water was introduced into the magma through partial melting of hydrated mantle or during ascent through hydrous mantle subsequent to their formation. The minerals observed at present most likely crystallized from the melt that intruded into the lower crust and subsequently re-equilibrated in the presence of fluids at the ambient P–T conditions.

References:

[1] Arndt (2008) Komatiites: Cambridge

[2] Mouri et al. (2013) S Afr J Geol 116(1): 55-66

[3] Bindeman (2008) Rev Mineral Geochem 69: 445-478

[4] Beaty and Taylor (1982) In Komatiites: George Allen and Unwin