Polybaric critical melting with high melt retention explains the compositions of Barberton komatiites

Christophe Robin (1), Nicholas Arndt (1), Catherine Chauvel (1), Gary Byerly (2), Alexander Sobolev (1), and Allan Wilson (3)
(1) University of Grenoble (France), (2) Louisiana State University, (3) University of Witwatersrand (Johannesburg, South Africa)

Komatiites are highly magnesian volcanic rocks characteristic of the Archean. They are divided into three types: Al-depleted, which have low Al/Ti, relatively high concentrations of incompatible elements and depleted HREE; Al-undepleted komatiites, with chondritic Al/Ti and slightly depleted LREE; and Al-enriched komatiites, with high Al/Ti, low concentrations of incompatible elements and extremely depleted LREE. The oldest well-preserved examples are found in the Barberton greenstone belt in South Africa (3.5-3.3 Ga). All three komatiite types are found in the belt, commonly within the same stratigraphic unit. Based on a comprehensive petrological and geochemical study, we propose a new melting model for their formation. The basis of the model is the observation, from published experimental studies, that at great depths (~13 GPa), the density of komatiitic liquid is similar to that of solid peridotite. Under such conditions the komatiite liquid does not escape from the source. As the source (probably a mantle plume) ascends through the mantle, the pressure decreases and the density difference increases, making the escape possible. We modelled the formation of komatiite assuming a progressive decrease of the proportion of liquid retained in the source. The Al-depleted komatiites form first at about 13 GPa at conditions close to equilibrium melting when a large proportion of liquid (30%) was retained in the source and where the residue contained a high proportion of garnet (20%). Al-undepleted komatiite forms at intermediate depth after exhaustion of residual garnet and after most of the liquid had escaped the source. Al-enriched komatiite forms at shallow depths and pressure (5-10 GPa) from the highly refractory source left after extraction of up to x% liquid. This model reproduces the chemical characteristics of all komatiite types in the Barberton belt and can probably be applied to komatiites in other parts of the world.