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Genesis of Ultra-High Pressure Garnet Pyroxenite in Orogenic Peridotites and its bearing on the Isotopic Chemical Heterogeneity in the Mantle Source of Oceanic Basalts

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The genesis of ultra-high pressure (UHP) garnet pyroxenites in orogenic peridotite massifs and its implications on the formation of chemical heterogeneities in the mantle and on basalt petrogenesis are still not fully understood. Some UHP (diamond-bearing) garnet pyroxenites have isotopic, and major and trace element compositions similar to the recycled oceanic crustal component observed in oceanic basalts [1–6]. These pyroxenites hence provide an exceptional opportunity to investigate *in situ* the nature and scale of the Earth's mantle chemical heterogeneities.

Here, we present an integrated geochemical study of UHP garnet pyroxenites from the Ronda (Betic Belt, S. Spain) and Beni Bousera (Rif Belt, N. Morocco) peridotite massifs. This investigation encompasses, in the same sample, bulk rock major and trace elements, as well as Sr-Nd-Pb-Hf isotopic analyses. According to their Al_2O_3 content, we classify UHP garnet pyroxenites into three groups that have distinct trace elements and Sr-Nd-Pb-Hf isotopic signatures. *Group A pyroxenites* (Al_2O_3: 15 – 17.5 wt. %) are characterized by low initial $^{87}Sr/^{86}Sr$, relatively high $^{143}Nd/^{144}Nd$, $^{206}Pb/^{204}Pb$ and $^{176}Hf/^{177}Hf$ ratios, and highly variable $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ ratios. *Group B pyroxenites* (Al_2O_3 < 14 wt. %) have isotopic signatures characterized by relatively high initial $^{87}Sr/^{86}Sr$ and low $^{143}Nd/^{144}Nd$, $^{206}Pb/^{204}Pb$ and $^{176}Hf/^{177}Hf$ ratios. *Group C pyroxenites* (Al_2O_3 ~ 15 wt. %) display relatively low initial $^{87}Sr/^{86}Sr$ and $^{206}Pb/^{204}Pb$ ratios, high $^{143}Nd/^{144}Nd$ and $^{176}Hf/^{177}Hf$ ratios, and $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ ratios similar to Group B pyroxenites.

The major and trace element, and isotopic compositions of the studied Ronda and Beni Bousera UHP garnet pyroxenites lend support to the "Marble Cake Mantle" model [7] for the genesis of these pyroxenites. This model envisions the mantle source of oceanic basalts as a mélange of subducted, ancient oceanic crust —-represented by garnet pyroxenites in orogenic peridotites—- intimately mixed with peridotites by mantle convection. The present study reveals, however, that besides this exotic component of ancient recycled oceanic crust, the genesis of these pyroxenites requires a previously unnoticed component of recycled lower continental crust akin to the lower crustal section of the lithosphere where these UHP garnet pyroxenites now reside in. The results of this study provide a new recipe for the marble cake hypothesis for the genesis of UHP garnet pyroxenites in orogenic peridotites. Furthermore, it establishes a connection between the genesis of UHP pyroxenites, the composition of the continental crust and the generation of Earth's mantle heterogeneities.

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