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Metasomatic Enrichment of the Lithosphere and its Potential Implications for the Formation of Oceanic and Continental Alkaline Magmas

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The generation of oceanic and continental intra-plate magmas implied that the source of these magmas was enriched regarding the primitive mantle [1]. However, the nature and origin of the mantle components that melt below oceanic islands are still in debate. A hypothesis proposed that the enriched components which melt below oceanic islands correspond to recycled oceanic crust [2]. Alternatives suggest that these components could correspond to metasomatized continental or oceanic lithosphere [3-5]. However, if these two hypotheses are frequently presented as mutually exclusive, we suggest that theses hypotheses could be complementary.

The fact that oceanic crust produces silica-saturated partial melts seems in agrement with the implication of this material in the generation of tholeiitic (i.e., *hy*- and *qtz*- normative) magmas from large oceanic islands and continental lava flows as proposed by [6]; however this fact makes it difficult to envision oceanic crust as a major component in the generation of alkaline (i.e., *ne*-normative) magmas. Experiments on metasomatic veins (hornblendites) and their dehydrated equivalents demonstrate that high-degree melting of these veins followed by variable amounts of interaction of the liquid with surrounding mantle can reproduce key features of the major- and trace-element compositions of alkaline magmas [7]. We suggest two scenarios for the production of alkaline magmas by melting metasomatized lithosphere: (i) the metasomatized lithosphere experiences a thermal perturbation or decompression and thereby melts *in situ*; or (ii) the metasomatized lithosphere is recycled into the convecting mantle by subduction or delamination and melts during later upwelling (e.g., in a plume). In continental alkaline magmas, the presence of amphibole xenocrysts compositionally similar to amphibole in metasomatic veins is consistent with the "in situ" hypothesis. While such veins may play a role in alkaline magmas for some oceanic islands and seamounts, long residence times of the metasomatized sources are required to explain the range of isotopic ratios observed in some OIBs. The recycling scenario could isolate metasomatic veins for times sufficient for ingrowth of extreme isotopic ratios such as those observed in alkaline OIBs from Polynesia.

Since our hypothesis implies that alkaline magmas are typically produced by high degrees of melting of the metasomatic veins, the process responsible for the metasomatic enrichment of the lithosphere is an important component of our model. The metasomatic veins are generally interpreted as cumulates formed during the ascent and differentiation of low-degree melts derived from volatile-rich peridotite within the lithosphere. To evaluate whether hydrous cumulates are suitable as sources for alkaline magmas, we did Monte Carlo simulations of metasomatic vein formation. These simulations indicate that (i) hydrous cumulates produced by such processes have trace-element patterns suitable to be potential sources for alkalines magmas observed in continental volcanoes, in oceanic islands, or seamounst; (ii) the trace-element pattern of these model cumulates could account for the trace-element patterns of HIMU to EM magmas simply by varying the proportion of residual metasomatic liquid trapped in the surroundings of the veins (e.g. cryptic metasomatism); and (iii) the model cumulates can account for the range of isotopic composition observed in OIBs if the amph $\pm$ cpx cumulates (with variable amounts of trapped residual liquid) are isolated for 1.5 to 2 Ga. Thus, we suggest that melting of metasomatized lithosphere is a viable hypothesis for the formation of alkaline OIBs [7] and that the recycled components in the sources of islands characterized by tholeiitic magmas [6] differ from those where *ne*-normative compositions are dominant.

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