Primordial noble gases in OIBs: Primitive mantle or other sources?

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Rocks from oceanic islands (e.g. Hawaii, Iceland) derived from deep mantle plume magmatism, probably originating from the core-mantle boundary (Shen et al., 1998), contain lower excess of radiogenic rare gas isotopes (^{4}He and ^{21}Ne from U and Th, ^{40}Ar from ^{40}K, ^{129}Xe from ^{129}I, $Xe_{fission}$ from ^{238}U and ^{244}Pu) than MORB glasses sampling the shallow upper mantle. This key observation is commonly regarded as the most fundamental geochemical evidence for the existence of a more primitive deep reservoir within the lower mantle that is less degassed and hosts a higher proportion of primordial (solar type and therefore non-recycled) noble gas nuclides. This argument sets stringent limits on mixing within Earth´s mantle, but is difficult to reconcile with increasing geochemical evidence of recycled lithosphere in OIB sources (Hofmann, 1997) and geophysical evidence for whole mantle convection (van der Hilst et al., 1997). An updated estimate of noble gas isotopic composition in mantle plumes (Trieloff et al., 2000) indicates that the radiogenic component in MORB and OIB sources is indistinguishable (Trieloff and Kunz, 2000). This implies that a nearly pure primordial noble gas component was added to OIB reservoirs within the last 2 Ga from an “external” source, for which several possibilities are discussed: Primordial mantle reservoirs such as a deep abyssal layer (Kellogg et al., 1999) with 50% terrestrial U, Th, K require – probable unrealistically high - primordial noble gas abundances (about the same as in the terrestrial atmosphere) to outweigh the considerable radiogenic ingrowth over 4.5 Ga. Another possible source could be subducted sediments containing interplanetary dust with solar He and Ne. In this case radiogenic ingrowth is not as severe, limited to the age of the protolith of probably <1 Ga, but other problems have to be discussed (e.g. the noble gas fraction surviving subduction). Finally, Earth´s core could be a viable “external” source: U, Th, K is low, the OIB flux of primordial nuclides is compatible with noble gas abundances initially partitioning into the core (Matsuda et al., 1993), and significant transfer back into the mantle is possible.

References

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Intrusive komatiites: field evidence from the Kalgoorlie Terrane, Yilgarn Craton, Western Australia

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The Kalgoorlie Terrane of the Norseman-Wiluna Greenstone Belt, Eastern Goldfields Province, Western Australia, is characterised by large volumes of komatiite. Within the Eastern Goldfields Province, including the Kalgoorlie Terrane, komatiites have typically been described as extrusive lava flows primarily associated with basaltic stratigraphy, e.g. Kambalda of the Kalgoorlie Terrane. The Boorara Domain, the northeastern-most subsection of the Kalgoorlie Terrane, provides the best-preserved komatiite textures and contact relationships within the Eastern Goldfields Province and is a key area for the study of primary komatiite-substrate relationships. A reevaluation of the stratigraphy of the region primarily attributes the complexity observed to the associations between the regional komatiite marker horizon and the predominantly felsic substrate.

Two komatiite emplacement styles are recognised in the Boorara Domain. Large volume, dominantly cumulate-textured komatiite bodies that show symmetrically zoned chilled margins together with apophyses and xenoliths on top and basal margins, are interpreted as high-level intrusions. Classical extrusive komatiite lavas are also documented showing asymmetrical zonation within each lava flow, where the top margin shows a fine-grained, chilled margin that grades into a well developed spinifex zone and then to a cumulate zone above a thin basal chilled contact.

Komatiite magmatism/volcanism is interpreted to have been contemporaneous with dacitic magmatism and volcanism. Textures such as irregular, fluidal morphology contacts between the two lithologies, komatiitic apophyses in the dacite and magma mingling, are documented at key localities within the Boorara Domain. These textural features clearly demonstrate an autochthonous relationship between the two lithofacies, which allows for preliminary interpretation into the tectonic regime of the Boorara Domain.