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Coherent He-Sr-O isotope variation in Italian Plio-Quaternary basalts demonstrate recycling of crustal-radiogenic He

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In the prevailing models of global He isotope systematics the mantle ^{3}He/^{4}He evolves by degassing of primordial He and ingrowth from U- and Th-decay. The high diffusion rate of He in crustal minerals is considered to exclude recycling of crustal-radiogenic He into the mantle. Plio-Quaternary subduction-related volcanism of the Italian arc displays chemical and isotopic signatures indicate that the mantle wedge has been strongly influenced by crust and is a prime candidate for testing the veracity of prevailing models. He-Sr-O isotopes have been measured on over 40 basalts from the length of the arc. The ^{3}He/^{4}He of olivine phenocrysts increase northwards, from 7-6 R_a at Etna and Ustica, to 0.44 R_a in Tuscany. ^{3}He/^{4}He (and ^{87}Sr/^{86}Sr) does not correlate with whole rock MgO ruling out significant crustal contamination. This implies that the radiogenic He is inherent to the mantle source. The near-linear ^{3}He/^{4}He-^{87}Sr/^{86}Sr co-variation ($R^2 > 0.92$) is consistent with a mix between asthenosphere (with young HIMU affinities) and metasomatically-enriched mantle (EM), and rules out the direct addition of subducted sediments. The He-Sr relationship requires that radiogenic He in the EM source mantle is derived directly from subducted crustal rocks with only a minor contribution from post-subduction ingrowth in a U-rich mantle wedge. Better constraints on the volume of subducted He is can be placed by considering He-O isotope correlaions. Olivine and pyroxene phenocrysts δ^{18}O vary

coherently with $^{3}He/^{4}He$, consistent with a strongly hyperbolic mixing relationship. We calculate that the radiogenic ^{4}He in the metasomatised mantle wedge beneath Italy is 10-100 times higher than in the HIMU mantle. This has implications for global He isotope systematics that will be considered.