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Lithospheric delamination in Northern Apennines as revealed by modelling of He, CO2 isotopes and heat flow data

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$^{3}He/^{4}He$ ratios measured in twelve CO_2-dominated gas seeps from the Tuscany-Roman Volcanic Provinces in Italy range between 0.07 and ~1.7 R_a; in agreement with previous studies [1]. He [2, 3] and $d^{13}CO_2$ [3] isotopes systematics indicate a dominant crustal source (up to 95%) and a variable but significantly lower contribution from the mantle. The CO_2 mainly originates from the decarbonation of limestone, and this requires melting of carbonates at high temperature and pressure met in the mantle; and correlates with the presence of crustal carbonate melts in the low velocity mantle wedge [4].

Low He (0.6 – 1.6 R_a) and high Sr ($^{87}Sr/^{86}Sr$ = 0.709514 – 0.710595) isotopes systematics of olivine and pyroxene mantle phenocrysts of the same region have been previously interpreted to be related to the addition of a crustal signature into a HIMU-type magma in the mantle by subduction of the continental crust fluids/ rocks [5], thus explaining the much lower $^{3}He/^{4}He$ compared to typical oceanic subduction (average= 5.37 ± *1.82;* [6]).

Here we explore a model in which the crustal contamination expresses the delamination of the continental lithosphere of the (previously subducted) Adria microplate, as inferred from geophysics (e.g: [7]) and mechanical modelling [8]. We present a thermal and helium isotope modelling that accounts for radiogenic heat and ^{4}He production in the U, Th and K – rich delaminated continental crust and in the variably (SCLM age and He residence time - dependant) ^{4}He-rich sub-continental lithospheric mantle. Our model supports a tectonic scenario in which the unusually low $^{3}He/^{4}He$ values, and heat flow data are reproduced by the delamination of a ≈15km – thick continental crust in the mantle.

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