Accepted Manuscript

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PII: S0883-2927(16)30478-4

DOI: 10.1016/j.apgeochem.2017.03.019

Reference: AG 3856

To appear in: *Applied Geochemistry*

Received Date: 12 November 2016

Accepted Date: 29 March 2017

Please cite this article as: Amaral, H.I.F., Midões, C., Kipfer, R., Helium evidences for mantle degassing in the groundwater of Madeira Island – Portugal, *Applied Geochemistry* (2017), doi: 10.1016/j.apgeochem.2017.03.019.

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ACCEPTED MANUSCRIPT

HELIUM EVIDENCES FOR MANTLE DEGASSING IN THE GROUNDWATER OF MADEIRA ISLAND – PORTUGAL

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ABSTRACT

The Madeira Island is fed by an active hotspot, but there are no evidences of current volcanism and geothermal activity or, of a heat source at depth, which probably justifies why only low temperature and low TDS groundwater is found in Madeira. Nonetheless, Madeira is a relatively young island (≤ 7 Ma old), and a connection to the upper mantle through geological conduits, is likely to occur. To investigate whether such a connection exists, noble gases and stable isotopes were, so far as we know, for the first time measured in groundwater samples of the main (basal) aquifer of Madeira Is.

Groundwater is the main supply of drinking water in Madeira Is., and the hydrogeology of the island has been well characterized in previous studies. In this study, groundwater was generically divided into 'cold' waters (< 20 °C, near the coast) and 'warm' waters (20-25 °C, central part of the island). This division was based on field temperature, water chemistry and stable isotopic composition. Four 'hot' waters (23-25 °C) showed partly distinct characteristics. A *bubbling* spring was also sampled. Very low tritium values indicate groundwater recharged recently and/or mix with free-tritium waters. Groundwater is fed by rain recharged during autumn as indicated by $\delta^{18}O$ and $\delta^{2}H$ signatures. During infiltration, the waters dissolved soil CO_2 that according to the back-calculated $\delta^{13}C$-CO_2 compositions corresponds mainly to CO_2 of biogenic origin. Nonetheless, a mantle CO_2 component cannot be excluded from samples from the inner part of the island. The noblegas helium was the sole tracer indicating a deep gas contribution to the groundwater. A strong mantle signal was detected in the 'hot' and *bubbling* waters, as indicated by their He-*Ra* values of 8 (being *Ra* the atmospheric $^{3}He/^{4}He$ ratio), typical of the MORB. Thus, even if the last volcanic eruption occurred *ca.* 0,006 Ma, degassing of the upper-mantle was detected in the shallow cold waters of Madeira. The deep gas ascends without heat transport, through dikes and faults that cross, mainly, the central part of the island.

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