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Helium isotopes distribution in groundwater and thermal waters of Tunisia: relationship to tectonics and geology

E. Fourré (1), P. Jean-Baptiste (1), P. Allard (2), F. Parello (3), S. Calabrese (3), E. Gaubi (4) and A. Ben Mamou (4)

(1) Laboratoire des Sciences du Climat et de l'Environnement, CEA-CNRS-UVSQ-IPSL, Gif-sur-Yvette, France (elise.fourre@cea.fr), (2) Laboratoire Pierre Süe, CNRS-CEA, Gif-sur-Yvette, France, (3) CFTA, Università di Palermo, Palermo, Italy, (4) Laboratoire des Ressources Minérales et Environnement, Université de Tunis El-Mamar, Tunisia.

From North to South, Tunisia comprises numerous thermo-mineral manifestations and hot water wells, many of which are currently used for thermal baths (hammam) or water supply for drinking water and/or agriculture. Thirty-two sites (both natural springs and production wells) were sampled for helium isotope geochemistry, in order to map the spatial distribution of the $^{3}He/^{4}He$ ratio. In addition to water samples, gas samples were also collected whenever gas bubbles were present. At each sites, samples were also taken for chemical analysis and stable isotope geochemistry (C, O, H).

The data set reveals helium-4 (^{4}He) concentrations ranging from 8 to 4700 (10^{-8} $cm^{3}STP/g$). $^{3}He/^{4}He$ isotopic ratios range from 0.021 to 2.4 Ra, indicating a mixing pattern between crustal helium ($^{3}He/^{4}He < 0.05$ Ra, where Ra = air $^{3}He/^{4}He$ ratio) and a mantle-derived component ($^{3}He/^{4}He \sim 8$ Ra). When gas and water were sampled simultaneously, we observe a good agreement between their respective $^{3}He/^{4}He$ ratio.

The lowest $^{3}He/^{4}He$ values, close to the crustal production ratio of 0.02-0.05 Ra, are found in southern Tunisia, in deep waters from the gigantic "Continental Intercalaire" Saharian aquifer tapped by deep wells. These waters are also the most enriched in helium-4, in good agreement with their very long residence time ($\geq$16-500 ka, according to recent ^{36}Cl dating). Increasing $^{3}He/^{4}He$ ratios in the central to northern

part of the country, with all values but one between 0.2 and 0.6 Ra, point to an input of mantle-derived helium. However, this component is extensively diluted by radiogenic ^{4}He. The only sample with a higher ^{3}He/^{4}He ratio than in air is a CO_2 rich mineral spring (Ain Garci) located some 30 km south of the city of Zaghouan. Both its high ^{3}He/^{4}He ratio (2.4 Ra) and CO_2 content demonstrate a substantial input of mantle volatiles that may be put in relation with an active local fault and the nearby volcanic outcrops of Djebel Fadeloun and Djebel Abid.

A detailed discussion of the helium data set, as well as of water geochemical and isotopic composition, will be presented and the results will be examined in relation to the geological and tectonic framework of Tunisia.