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Geochemical water signature in the Bahariya Depression, Western Desert, Egypt

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The Bahariya Oasis is located about 200 km SW of Cairo in the central part of the Western Desert of Egypt. It occupies a sub-elliptic 40 km wide depression stretching NE-SW for approximately 90 km. The Bahariya Oasis has been targeted for numerous geological studies on structural geology, stratigraphy, and iron ore deposits. The oasis was characterized since the Roman times by the presence of natural hydrothermal springs venting water from the relatively shallow Nubia Sandstone formation. Inside the depression are visible numerous circular concentric features that morphologically resemble the hydrothermal vent complexes observed at igneous provinces in other localities of the planet. In order to investigate the origin and the mechanisms of formation of these features, we conducted a fieldwork survey as well as fluids sampling from the available well sites. The aim was to constrain the origin of the fluids that potentially triggered or facilitated the formation of the concentric structures observed on the field.

This study presents the geochemical results of groundwaters and soil gas samples. Ten samples were collected from deep wells present in the area. In particular, 8 warm waters were collected by wells between 800 m and 1200 m deep. The measured temperatures at these sites range from 36.5 °C to 52.3°C, while the coldest wells have temperatures ranging from 27.9 °C to 36.5°C.

For each sample collected from the wells we analyzed the major, minor and trace elements, dissolved gases (He, Ne, H2, O_2, N2, CH4, CO_2, Rn), and relative isotopic values. In the areas around the wells we measured CO_2 and CH4 fluxes as well as radon activity.

Overall, the water showed a high value of dissolved Rn, ranging from 9 to 43 Bq/l, and dissolved CO_2 ranging from 5.9 to 17.4 cc/l. The waters show a radiogenic signature of isotopic helium, highlighting very prolonged interaction with local crust enriched in radiogenic elements.

The isotopic values of δ18O and δD show a clear meteoric component but do not reflect a local type of recharge since they do not lie on the current Egyptian meteoric water line. Indeed, δD ‰ values range from -83.2 ‰ a -76.3 ‰ and δ18O varies from a -11.3 ‰ -10.8 ‰Ȧccordingly, we can infer that the water currently flushed by the wells originates from reservoirs of palaeo-meteoric fluids trapped during colder conditions. The measured temperature range is relatively low suggesting low-enthalpy geothermal system. The estimated geothermal gradients in the Bahariya oasis is 37°C/km.

The exhalation flux values show the presence of low levels of carbon dioxide and methane that are within the normal respiration of the soil indicating no significant emission of deep gas around the artificial wells.

In a parallel study we identify Ba-rich feldspar from breccia samples collected from the paleo-venting sites. This is in agreement with the geochemical signature of the waters enriched in Ba, Fe, and partially in Sr. This could indicate a correlation between the paleowaters and the igneous intrusion , and therefore with the genesis of the circular features probably interpreted as paleo-piercements.