



## Using geochemical and isotopic techniques for exploration of geothermal energy in Southern Sabalan geothermal field, NW Iran

Rahim Masoumi

Iran, Islamic Republic Of (rahimmasumi@gmail.com)

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Rahim Masoumi<sup>1,\*</sup>, Ali Asghar Calagari<sup>1</sup>, Kamal Siahcheshm<sup>1</sup>

<sup>1</sup> Department of Earth Sciences, Faculty of Natural Sciences, University of Tabriz, Iran

\*Corresponding author. Email address:

Rah\_masoumi@tabrizu.ac.ir

Rahimmasumi@gmail.com

From a hydrogeochemical point of view the geothermal fluids in the study area can be divided into two categories, (1) Na-Cl and (2) Na-Ca-HCO<sub>3</sub>. In the study area, the hot water samples depict temperature and pH ranges of 22 °C to 77 °C and 6.4 to 7.3, respectively. The total dissolved solids vary from 456 mg/L to 7006 mg/L. The concentration of rare metallic and non-metallic elements such as Li, Rb, B, Ba, Sr, CS, Se, Al, As, Hg in cold and hot spring waters in the Bushdi area were also analyzed. The utmost concentration belongs to Se which ranges from 135 mg/L to 273 mg/L. Boron also shows notable concentration values, in most samples it exceeds 20 mg/L, and in certain samples it ranges from 28 mg/L to 33.5 mg/L. The concentration value of arsenic ranges from 3 mg/L to 4 mg/L. The maximum concentration value of mercury is 0.01 mg/L. The  $\delta^{18}\text{O}$  values of these samples vary from -12.4 ‰ to -7.5 ‰ and the  $\delta\text{D}$  values range from -78.6 ‰ to -70.6 ‰. Plotting  $\delta^{18}\text{O}$  versus  $\delta\text{D}$  demonstrates that the data points are clustered close to both, the global meteoric water line (GMWL) with the equation  $\delta\text{D} = 8 \delta^{18}\text{O} + 10$  and, the national meteoric water line (NMWL) with the equation  $\delta\text{D} = 6.89 \delta^{18}\text{O} + 6.57$ . As can be observed, the geothermal fluids in the Bushdi area show relatively slight increase in  $\delta^{18}\text{O}$  values that may be caused by interaction of hot fluids with host volcanic rocks. In fact, this relatively slight increment in  $\delta^{18}\text{O}$  values may indicate the low to moderate temperature of the geothermal system. The  $\delta\text{D}$  values, in general, do not show notable variation because of very low hydrogen content of the host rocks. The slight increase in  $\delta\text{D}$ , however, may be in conjunction with vaporization and isotopic interaction with the host rocks. The  $^3\text{H}$  content of the cold and hot waters in the Bushdi area is relatively high and varies from 0.65 TU to 41.4 TU. This may be caused either by mixing with meteoric sources or rapid fluid flow within the system in a shorter time than the  $\beta$ -disintegration of the isotope  $^3\text{H}$ . The  $\delta^{18}\text{O}$  versus  $\delta\text{D}$  diagram demonstrates that the data for the Bushdi area is plotted in three distinct domains, a, b, c. In a, the  $^3\text{H}$  content is > 10 TU indicating these waters being modern waters. Domain b belongs to samples whose  $^3\text{H}$  values are within the range of 1 TU to 10 TU being temporally categorized as sub-modern waters. The water samples in c possess  $^3\text{H}$  values < 1 TU indicating the oldest waters within the geothermal system in the study area.

Key words: Geothermal fluids, Stable isotopes, Tracemetals, Sabalan volcano.