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Geological and hydrogeochemical explorations for geothermal resources in eastern Sabalan, NW Iran.

Roohangiz Masoumi
Iran, Islamic Republic Of (Roohangizmasoomi@yahoo.com)

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Roohangiz Masoumi
No 76, Karoon Street, 5619859863, Ardabil, Iran
Corresponding author. Email address:
Roohangizmasoomi@yahoo.com
Geological considerations in the east of Sabalan volcano indicate that the calc-alkaline volcanic-sedimentary units constitute the great volume of the geothermal reservoir in the study district. The rocks suffered argillic alteration acted as cap rocks for this reservoir. In some localities in the study district siliceous (chalcedony and opal) sinters were developed around the orifice of the hot springs.
The geothermal fluids in the study district, in terms of physico-chemical parameters, have characteristics which differ from other geothermal fields around the Mount Sabalan particularly in the southern and northwestern districts. These differences are: (a) the measured pH values of the geothermal fluids range from approximately 4.5 to 8.8 signifying a variation from acidity to alkalinity; (b) the measured TDS values of these waters, in comparison with the average TDS values for most types of geothermal systems, are low and the minimum values were recorded in the Viladara area; (c) estimation of concentration values of anions and cations in the selected spring water samples indicate that they have chiefly chloride and bicarbonate anions however, samples from the Sardabeh area contain relatively high sulfate (SO42-) content.
The concentration values of rare elements in these waters are noticeable. Selenium has the highest concentration value (170 mg/l) among the rare elements. The maximum concentration values of boron and arsenic were measured to be 7 mg/l and 10 mg/l, respectively. The rest of rare elements have relatively low concentration values in the studied samples.
The calculation of solute-based geothermometry was done on the basis of Na-Li, Na-K, Na-K, Ca, and silica for the water samples. The results of all these procedures for estimation of temperature of the geothermal reservoir in the east of Mount Sabalan were relatively very close to one another. Nevertheless, the temperatures determined by the Na-Li and Na-K geothermometric methods are 225°C and 239°C, respectively while by Na-K-Ca and silica methods are 181°C and 136°C, respectively for the geothermal reservoir.
Consideration of hydrogen and oxygen stable isotopes (δ18O and δD) of the geothermal fluids in the east of Mount Sabalan revealed that their δD and δ18O values vary from -63.37‰ to -80.19‰ and from -9.96‰ to -13.4‰ respectively. The bivariate plot of δ18O versus δD shows that the data points mainly lie between lines GMWL and NMWL indicating that the great portion of these waters have meteoric origin and the role of magmatic waters is almost negligible.
Consideration of unstable isotope of 3H delineated that the average 3H content of these waters is 5.1 TU. Illustration of diagrams of tritium-δ18O and tritium-Cl- showed that most of these waters are categorized as "sub-modern" waters and in respect of depth having shallow circulation.
Key words: Sabalan volcano, geology, hydrogeochemistry, stable isotopes, NW Iran.