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GEOTHERMAL RESERVOIR CHARACTERISTICS (T AND DEPTH) OF AYUB PEIGHAMBAR AND SHAFA HOT SPRINGS USING GEOTHERMOMETERS AND ENVIRONMENTAL ^{2}H AND ^{18}O ISOTOPES

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Abstract: Hot springs are evidence of geothermal filed, where the internal thermal of the earth, resulted from volcanic activities and from geochemical reactions, is transferring to the land surface. Ayub Peighambar and Shafa hot springs, with temperature of about 40 ^{o}C and CaSO4 water type, are located in Northeast of Iran. These springs due to have high temperature than other adjacent springs and are using for balneotherapy purposes, are very important. According to geotermometery and stable isotope (^{18}O and ^{2}H) studies, depth of Ayub Peighambar hot spring geothermal reservoir is about 4-5 kilometer and its temperature is less than 150 ^{o}C.

1. INTRODUCTION

Several factors can generate hot springs including: 1- volcanic activities; 2- geothermal gradient with deep circulation of water; 3- radioactive material (long-lived radioactive isotope) and decay process that produced heat; 4- tectonic and fault movement/earthquake; and 5-physicochemical reaction [1-6]. To estimate the temperature and the depth of geothermal reservoir, the geothermometers tools (minerals, element and chemical composition) can be applied [7].

2. METHODS

Samples were collected, each in polyethylene 25 ml bottle, from Ayub Peighambar and Shafa hot springs. All samples were filtered using 0.45µm membrane and the cation samples were acidified with concentrated HNO_3 acid. Samples were sent to Ottawa University Geochemistry and G.G Hatch stable isotope laboratories for measuring anions, cations and stable isotope (^{18}O and ^{2}H) compositions. During field observation and sampling period, the field parameters (T, EC, TDS, Ph, Eh and DO) were measured. In this paper, the temperature and the depth of geothermal reservoir of Ayub Peighambar and Shafa hot springs were estimated using Na-K geothermometer, methods developed Giggenbach [8] and by Mohammadi [9], and stable isotope techniques.

3. RESULTS

Based on chemical composition, the temperature and depth of geothermal reservoir for Ayub Peighambar and Shafa hot springs were calculated and the results were tabulated in Table 1.

The $\delta^{18}O$ and $\delta^{2}H$ contents of samples from Ayub Peighambar and Shafa hot springs indicate origin of geothermal and meteoric waters (Figure 1). The average $\delta^{2}H$ values of hot springs is about -73 ‰, therefore, the source of temperature/heat for Ayub Peighambar and Shafa hot springs can't be related to volcanic activities (with $\delta^{2}H$ values of -20 ‰ to -30 ‰). The

temperature/heat source and the origin of water for both hot springs are geothermal gradient and meteoric waters. Meteoric water, by penetrating to the depth through existence deep faults/fractures in the study area, get the heat of the earth and altering to geothermal waters, then rising to the land surface. The depth of water circulation in Ayub Peighambar hot spring calculated using isotopic composition and the results are tabulated in Table 2.

Table 1: Temperatures and depths of hydrothermal reservoir for Ayub Peighambar and Shafa hot springs.

	Ayub Peighambar hot spring					Shafa hot spring	
	Sp8.1	**Sp8.2**	**Sp8.3**	**Sp8.4**	**Sp8.5**	**Sp10.1**	**Sp10.2**
Using Aq.QA hydrogeochemistry software							
Temperature (Na-K)	150 >	150 >	150 >	150 >	150 >	150 >	150 >
Depth (km)*	5 >	5 >	5 >	5 >	5 >	5 >	5 >
Depth (km)**	4.65	4.65	4.65	4.65	4.65	4.65	4.65
Using Mohammadi method's [9]							
Temperature (Na-K)	113	114	114.50	109.80	111	100.90	100.90
Depth (km)*	3.76	3.80	3.82	3.66	3.70	3.36	3.36
Depth (km)**	3.42	3.45	3.47	3.31	3.35	3.02	3.02
Using Giggenbach method's [8]							
Temperature (Na-K)	157	157	158	154	155	146.50	146.50
Depth (km)*	5.20	5.20	5.26	5.10	5.16	4.80	4.80
Depth (km)**	4.89	4.89	4.92	4.79	4.82	4.54	4.54

Note: *General law (0.03 ^{o}C/m) and ** Using Marques et al., method [10].

Table 2: Maximum depth of circulation of hot water in study area

Average amount in cold spring (‰)		Average amount in hot spring (‰)		Difference (‰)		Maximum depth of circulation of water (‰)	
$\delta^{18}O$	**$\delta^{2}H$**	**$\delta^{18}O$**	**$\delta^{2}H$**	**$\delta^{18}O$**	**$\delta^{2}H$**	**$\delta^{18}O$**	**$\delta^{2}H$**
-9.29	-66.47	-9.97	-73	-0.68	-6.53	4.16	3.66

4. CONCLUSIONS

According to geological, hydrogeochemical and stable isotope studies of Ayub Peighambar hot spring area, the main source for fairly high temperature of water (38 ^{o}C) in this spring is the geothermal gradient and may be the underground alteration and partial melting (new deep situated material). The origin of water is meteoric water which is penetrated to the depth through existence deep fault in highly tectonized study area. According to geothermometry and stable isotope studies, depth of Ayub Peighambar hot spring geothermal reservoir is about 4-5 kilometer and its temperature is less than 150 $^{\circ}$C.

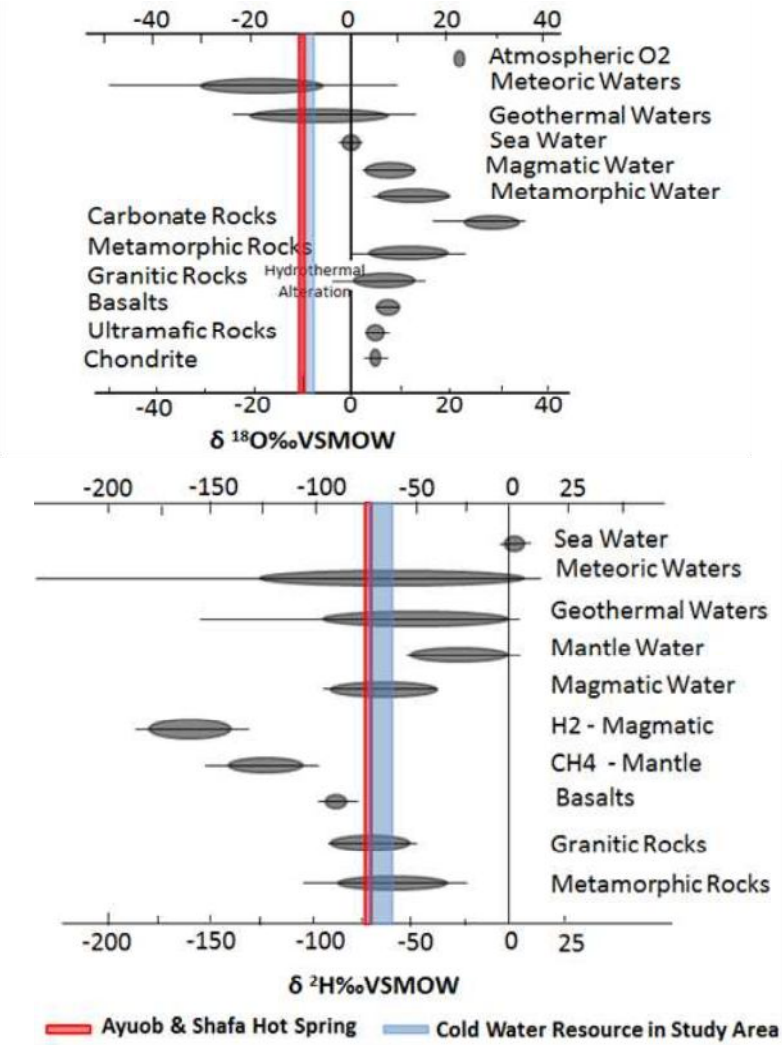

Figure 1: The range of $\delta^{18}O$ and $\delta^{2}H$ in various crustal rock and water type [11] and in Ayub Peighambar hot spring and other cold water resources in the study area.

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