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Hydrogeological Investigation of Karakaya and Ilicakoy (Ankara) Hotwaters

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ABSTRACT

In this study, the geological, hydrogeological, hydrochemical and isotope hydrology studies were conducted in an area of 236.2 km^2 within Ayas (Ankara) county and vicinity. Within the framework of the study, geological, hydrogeological maps and geological and hydrogeological cross sections of 1/100 000 scaled were prepared. Geological and hydrogeological properties of the reservoir rock were determined; the relationship of hot waters and the cold waters, the recharge area and residence time of the waters were examined and a conceptual hydrothermal model of the studied area was proposed. In the hydrogeological studies, hydrogeological units in the studied area were identified. The Bilecik Limestone and the alluvium constitute the main permeable units in the studied area. Karakaya Complex is defined as impermeable, while the Hancili formation, Tekke volcanics and the Bozkir formation are stated as semipermeable. The evaluation of hydrochemical data indicates that both hot and cold waters existing in the studied area are type of Na-Mg-HCO_3. Hot waters (20^{0}C -31^{0}C) are recharged from Bilecik limestone and Tekke volcanic rocks and conglomerate levels of the Hancili formation. Hot and cold waters were found to be supersaturated with respect to mineral species such as, calcite, dolomite and quartz. Environmental isotope data point out that hot waters have relatively long residence time which represents a deep groundwater circulation system in this studied area.

1. INTRODUCTION

To explain the hydrogeochemical properties of the studied area, it is necessary to study the geological structure, origin of the geothermal waters, relationship among geothermal water, groundwater, reservoir rock, properties of the reservoir rock and the feeding and circulation system.

The studied area is located in approximately 60 km W of Ankara. The drainage area of the studied field is 236,2 km^2. The previous studies realized by Akyürek et.al (1984), Canik (1970) and Sahinci (1970) before drilling in Ayas. Ayas region is under the effect of terrestrial climate. The annual average outside temperature is 10,6°C and the annual average precipitation amount is 438,35 mm.

2. GEOLOGY

There are respectively from older to young units in the studied area. These are Triassic, Upper Cretecaous, Neogen and Tertiary aged units giving outcrops. These consist of respectively from metamorphics rocks, volcanics and sedimentary units.

These formations named as Karakaya Complex (Tk), Bilecik Limestone (Jkb), Tekke Volcanics (Tt), Hancili Formation (Th), Bozkir Formation (Tbo), Terrace (Qt) and Alluvim (Qal) (Akyürek et al., 1982 and 1984).

The tectonic lines are mostly developed in mainly NE-SW and E-W directions (Figure 1).

3. HYDROGEOLOGY

Permeable lithologic units consist mainly of Upper Jurassic - Lower Cretaceous aged Bilecik Limestone and Quaternary aged alluvium and terrace . Also, Miocene aged Hancili Formation, Upper Miocene aged Bozkir Formation and Tekke volcanics are considered semi permeable units. Triassic Karakaya Complex is defined as impermeable (Figure 1).

Hot waters placed in the area:

Ilicakoy spring: Ilicakoy spring discharges from the intersection point of right strike slip fault, E-W direction and normal fault, NW-SE direction (Figure 1). It is quantified that temperature is 20^{0}C, flow rate is 0,3 and pH is 7,5, used for washing clothes by peasants.

Karakaya hot spring: Although Karakaya hot spring where point of discharge point isn't shown due to intensive settlement, it has been transmitted to Ayas Spa. It is measured that temperature of spa's water is 30^{0}C.

Hotwater wells: Due to increasing necessity for balneological applications, Ak1 (31^{0}C, 5 l/s), Ak2 and Ak3 wells were drilled. Depths of these wells varies from 127-251 meter. But, it is determined that AK1 well had been working and its flow rate was measured as 5 l/s. during in the field studies. Flow rate of others wells (Ak2 and Ak3) could not be measured, because they have not been worked. Due to low temperature, the hot water which is obtained from these wells has been used while transmitting along heat exchanger temperature increasing to 38^{0}C.

4. HYDROGEOCHEMISTRY

The geothermal field studies started in 2001 and in-situ EC, pH, temperature and TDS measurements have been taken with cold water and hot water probes. Chemical compositions of thermal water samples taken from the studied area are given in Table 1.

Since the ion characteristics of hot water and cold water are Na>Mg>K and HCO_3+CO_3> SO_4>Cl, these are grouped as Sodium-Magnesium Carbonated waters in Piper Diagram (Piper, 1944) (Figure 2).

It is supposed that hot and cold waters have same recharge areas, based on the parallelism they show in the Schoeller (1977) diagram (Figure 3).

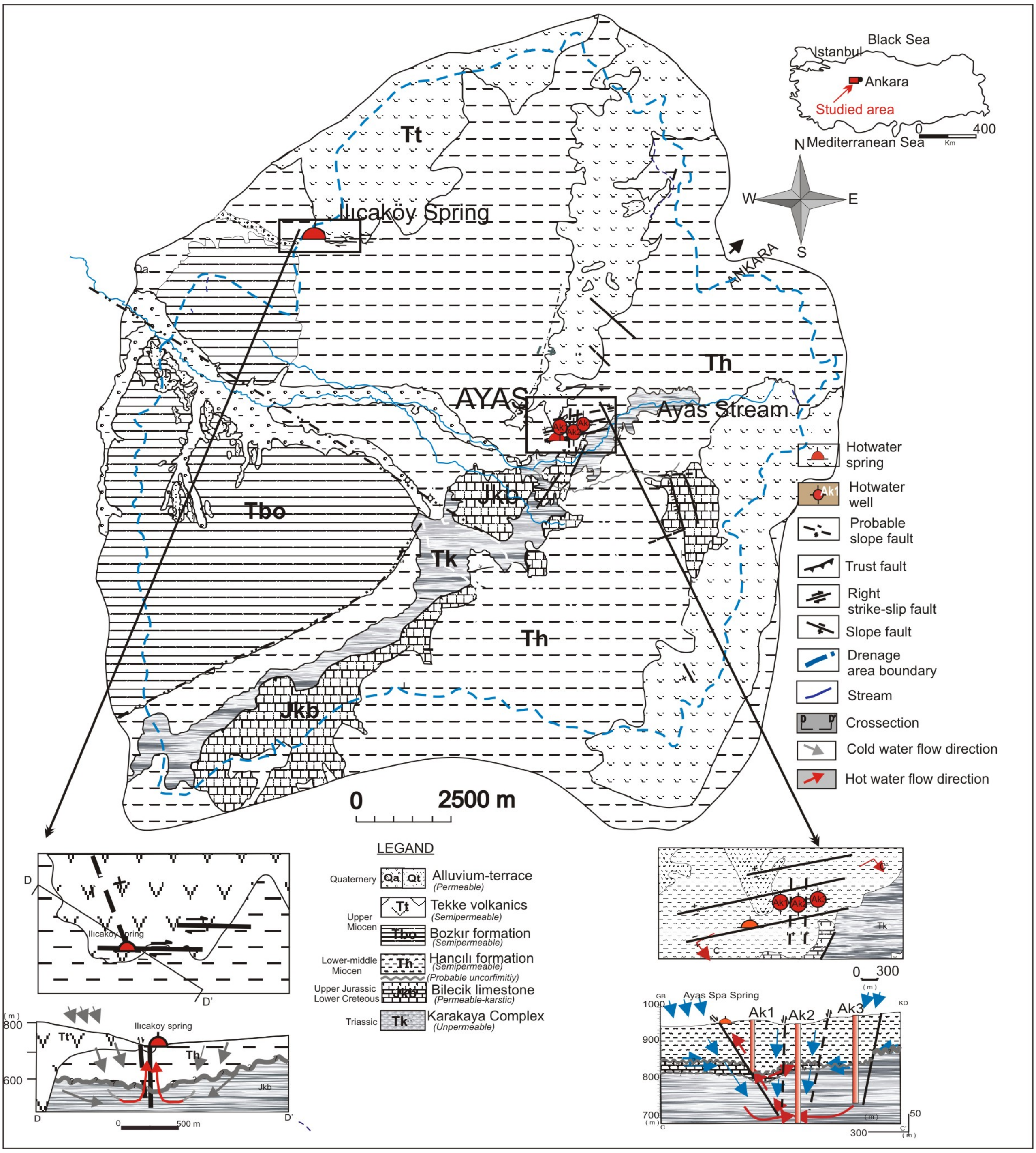

Figure 1: Hydrogeological map and its cross sections of the studied area.

Table 1: Chemical and stable isotopic analyses results of hot and cold waters of the studied area (May, 2005).

Sample No	Sample Name	pH	EC	T	Ca	Mg	Na	K	Cl	SO_4	HCO_3	CO_3	$\delta^{18}O$ (‰)	^2H (‰)	^3H (TU)
			µS/cm	(°C)	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm			
A(1)	Ayas Stream	7.9	764	16	70.1	52.4	12.1	4.5	4.6	96.0	312.4	24.1	-9.6	-65.3	8.8
A(2)	Yayla Spring	7.3	600	16	68.6	30.1	11.5	1.7	2.7	15.9	355.3	0.0	-10.4	-69.3	8.8
A(3)	Sihmuhittin Spring	7.2	910	17	102.5	46.2	24.6	2.6	5.1	42.5	465.6	0.0			
A(4)	Atsinek spring	7.1	690	17	70.2	31.3	29.8	2.5	4.6	24.1	361.4	0.0			
A(5)	Ilica Spring	7.3	485	17	60.9	20.6	10.6	1.0	4.4	39.7	238.9	0.0			
A(6)	Sinanli Spring	7.4	775	16	51.8	50.8	46.4	4.4	4.5	47.9	440.9	0.0			
A(7)	Ayas Stream	8.3	1030	18	75.1	46.9	55.5	16.6	30.7	96.1	398.2	33.2	-9.3	-65.6	6..5
A(8)	Kirucu Spring	7.6	660	16	70.4	32.4	20.4	4.1	5.5	13.5	373.6	0.0			
A(9)	Ilicakoy hotwater Spring	7.5	540	20	33.9	29.8	42.8	7.6	13.4	25.4	284.7	0.0	-9.1	-63.7	0..9
A(10)	Karadere Spring	7.6	505	19	24.4	26.1	42.7	10.5	13.7	22.9	269.4	0.0			
A(11)	Camasirhane Spring	6.6	250	16	24.7	8.5	10.7	4.3	11.5	34.8	67.5	0.0			
A(12)	İbrahim Aktas spring	7.4	6550	17	497.6	1,063.7	158.4	25.7	32.4	5,081.7	349.5	0.0			
A(13)	Ayas Stream	7.8	2130	19	211.8	175.8	85.0	15.2	34.6	845.6	511.3	0.0			
A(14)	Maslaktepe Spring	7.4	227	15	24.6	6.9	9.3.5	1.2	11.8	17.9	73.6	0.0	-10.1	-68.6	7.8
A(15)	Ak1 hotwater well	7.7	685	30	43.6	22.1	78.2	5.3	13.6	43.4	355.3	0.0	-10.4	-72.2	0.5
A(16)	Ak2 hotwater well	7.1	645	30	37.4	18.6	76.7	3.4	12.8	48.3	351.1	0.0			
A(17)	Ak3 hotwater well	7.2	680	29	37.6	18.4	76.4	3.4	13.2	47.8	351.1	0.0			
A(18)	Ayas Karakaya	7.1	667	30	39.9	18.1	78.2	3.7	12.7	47.5	351.1	0.0			
A(19)	Ayas Stream	7.5	4650	18	356.4	333.3	491.2	25.9	468.4	2,423.6	532.4	0.0			
A(20)	İlhan Stream	7.8	850	22	68.6	28.6	46.5	7.3	19.4	124.6	345.7	0.0			

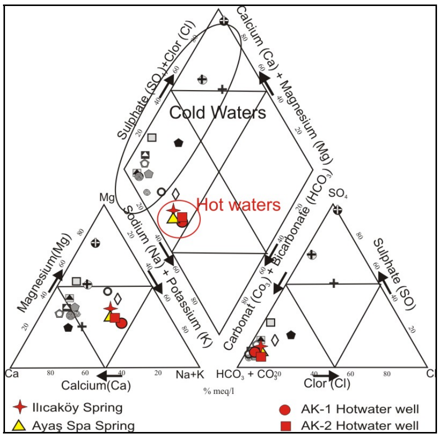

Figure 2: Piper (1944) diagram evaluation of water samples which are collected from the studied area.

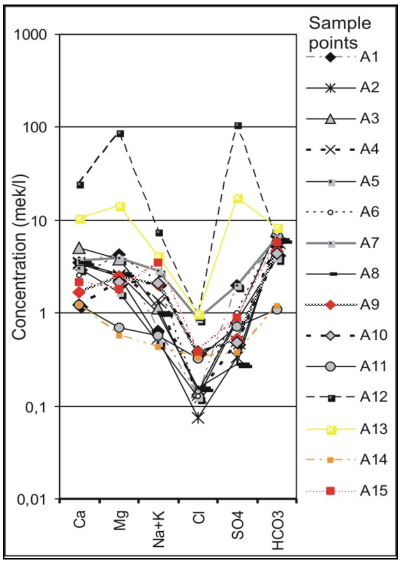

Figure 3: Schoeller (1977) diagram evaluation of water samples which are collected from the studied area.

Calculating the mineral saturation indicates were made with values of pH, temperatures which are taken from the studied field and from the interpretations of chemical analysis.

4.1 Geothermometers

Because of the Ayas geothermal waters are located in the immature zone of the Giggenbach Diagram (Giggenbach 1991), only the silica geothermometers have been applied (Figure 4). Silica geothermometers which give more reliable results than cation geothermometers (Fournier, 1991) give a result as 63°C – 69°C.

4.2. Isotopes

Ayas hot water samples are located in Ankara Meteoric Water Line and the World Meteoric Water Line (Figure 5). Based on the contents of stable envitonmental isotopes, the hotwaters have been determined to be meteoric origin.

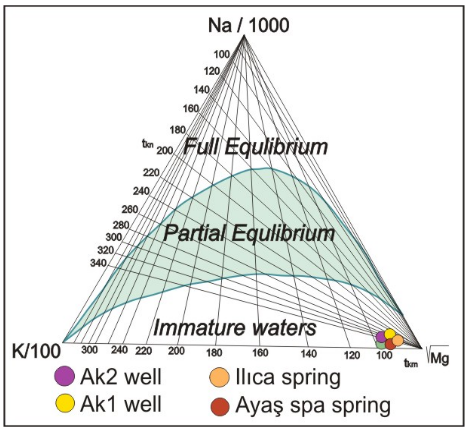

Figure 4: Piper (1944) diagram evaluation of water samples which are collected from the studied area.

From the tritium analyses, it is observed that the tritium amount is zero. According to this, duration of the circulation of the geothermal waters is more than 50 years. For this reason, it can be said that the geothermal waters have a deeper circulation compared to cold waters.

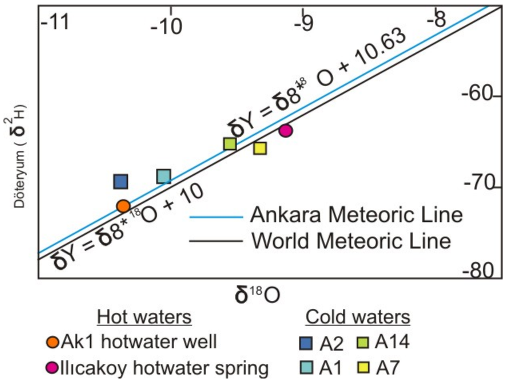

Figure 5: δ^{2}H and δ^{18}O diagram of the thermal and cold waters of the studied area

5. CONCEPTUAL HYDROTERMAL MODEL

Natural mixture of groundwaters and geothermal waters exist in the Ayas geothermal field. The geothermal waters mostly have meteoric origin and are fed by normal groundwaters. The groundwater gets mineralized by dissolving the elements from the rocks due to rock-water interaction and it is heated by the geothermal gradient. The heated and mineralized water moves to the surface by means of these faults. These waters are collected mainly in Bilecik Limestones and also in conglomerate zones of Hancili formation and fractured zones of Karakaya Complex. The geothermal water is produced from the karstic Bilecik formation formed by white limestones. Although the gradient exist as the heat source in the hydrothermal system, the mixture of cold water and non adequate existence of cap rocks/impermeable formations, prevent the formation of hotter geothermal fluids (Figure 6).

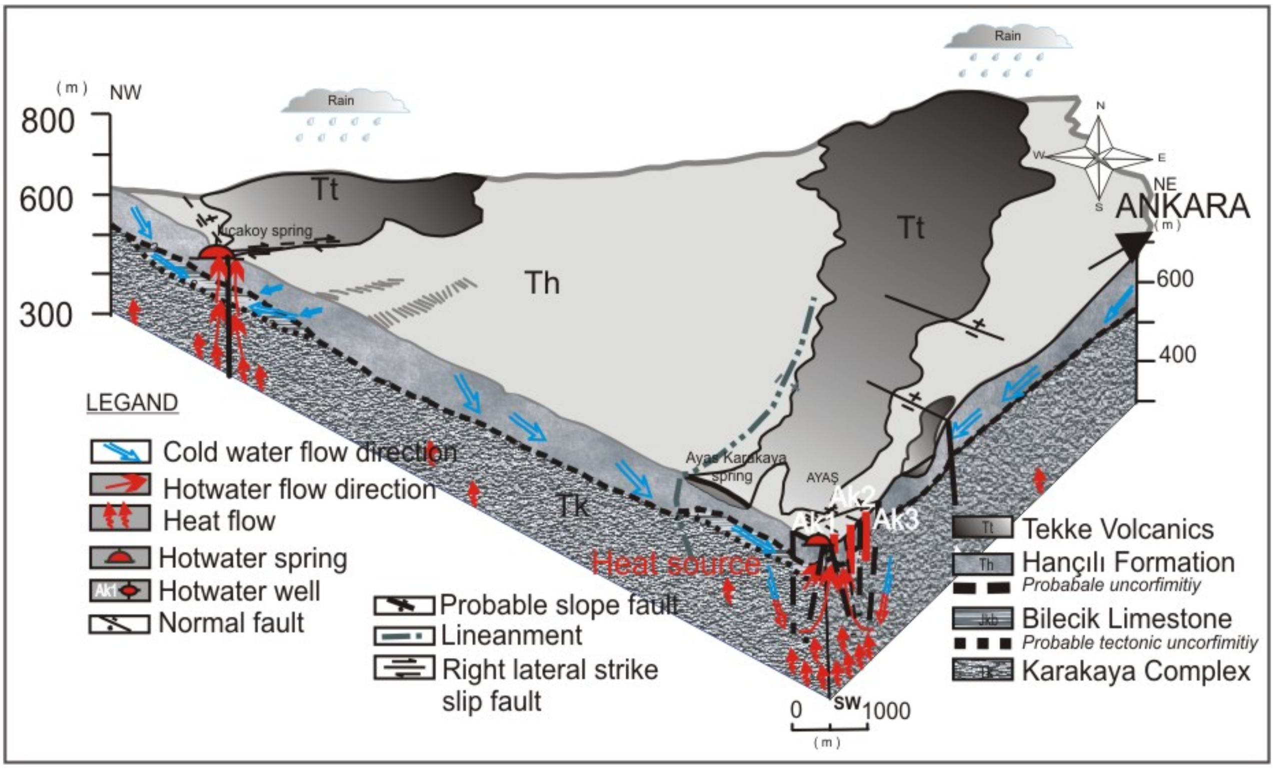

Figure 6: Conceptual hydrothermal model of the study area.

6. CONCLUSION

The Ayas geothermal field is suitable for development. By drilling new geothermal production wells, the geothermal field could be expanded. The geothermal water could be utilized more efficiently and widespread for spas and other integrated geothermal applications (thermal tourism, balneology etc.). It is important to make use of this potential in the social and economical development of the Ayas Municipility. Because of the density of residantal area, improper use of hot water should be prevented in order to protect geothermal field from pollution.

Other important subjects on saving the geothermal reservoir and field properties are restriction of the drillings and controlling the number of wells in the area.

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