Proceedings World Geothermal Congress 2015
Melbourne, Australia, 19-25 April 2015

Hydrogeological Survey of Karaagac Geothermal Field (Usak, Turkey)

[1]Aysegul CETIN, [2]Fikri OZTURK, [3]Kemal AKPINAR, [4]Zehra Ozgur CENGIZ

[1]aysegulcetin32@gmail.com [2]ugurezgi@yahoo.com [3]akpinar_kemal@hotmail.com [4]czozgur@gmail.com

1-2 Iller Bank Co.Inc., 3 Jeoson Ltd., 4 Ankara University

Keywords: Karaagac (Usak) Turkey, Hydrogeology, Geothermal

ABSTRACT

In this study, mainly geothermal hydrogeological studies were conducted in an area of Karaagac (Usak) and vicinity. Within the framework of the study, geology, hydrogeology, water chemistry, geothermal alteration and isotope hydrology studies have been carried out and geological, hydrogeological cross sections and maps were prepared. In exploration area, the basement rock is schist Paleozoic aged, respectively others which are Permien aged marble units. Miocene units consist of mainly conglomerate, sandstone, claystone and volcanics which are agglomera, andesite and tuffs. In the hydrogeological studies, hydrogeological units in the studied area were identified. The main permeable rock (reservoir) is fractured schists. There are 4 drilling wells. Thermal water temperatures are 48-51 ^{o}C, depths are 182 m and 550 m. Chemical properties of hot water based on ion characteristics of hot waters vary between Na+K>Ca>Mg and HCO_3+CO_3>SO_4>Cl, These are grouped as sodium-bicarbonated waters. As a result of these studies a hydrothermal conceptual model is proposed.

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 10 km W of Usak city center. The previous studies realized by Ercan et.al (1977) before drilling in Karaagac. This region is under the effect of terrestrial climate. The annual average outside maximum temperature in summer is 30,6 °C and minimum is -1,2 in winter, the annual average precipitation amount is between 430 and 700 mm.

2. GEOLOGY

There are respectively from older to young units in the studied area. These are Paleozoic, Miocene and Pliocene aged units giving outcrops. These consist of respectively from metamorphics rocks, volcanics and sedimentary units. These formations named as Esme Formation (Pzse), Musadagi Marble (Ptrm), Yenikoy Formation (Thy), Karaboldere volcanics (Thkv), Ahmetler Formation (Tia), Beydagi volcanics (Tib), Ulubey Formatin (Tiu) and Asartepe Formation (Qat) and Alluvim (Qy, Qe) (Ercan, 1977). The tectonic lines are mostly developed in mainly NE-SW and E-W directions (Figure 1-2). Studied area is located between Usak-Gure Basin and Selendi Basin (Bozkurt, 2001).

3. HYDROGEOLOGY

Permeable lithologic units consist mainly of Paleozoic aged fractured marble of Esme Formation and Miocene aged andesite levels. Also, it is considered that Miocene aged lacustrine limestone of Ulubey formation and Quaternery aged alluvium are cold water aquifer. Miocene aged tuffs and marn of Asartepe Formation levels are defined as impermeable (Figure 1).

There isn’t any hotwater spring in the area. There are drilling wells which were opened by Usak Municipality and private sector. In spite of the fact that well logs data couldn’t have been obtained except B1, B2, B3, B4 and B5 drilled by Municipality (Akgoz, 2014), water samples were taken from the all wells and their hydrogeochemical analysis were made. Hotwater wells placed in the area (Table 1):

Table 1 Geothermal properties of hot water wells in studied area.

	Number of Well	Coordinates(UTM-ED50)		Depth (m)	Temperature (^{0}C)	Yield (l/s)
		Y	X			
Private wells	O1	0699000	4279555	105	44,1	2
	O2	0701254	4279250	150	30	2
	O3	0700805	4279315	80	37	3
MTA Wells	M1	0706740	4284275	-	23,2	-
	M2	0706718	4284246	-	21,3	-
Municipality wells	B1	0699305	4279515	210	51	220 (Artesien)
	B2	0699315	4279186	468	51	57 (Artesien)
	B3	0699585	4279255	750	47	50
	B4	0699300	4279515	auxilary		
	B5	0703181	4279924	800	72,5	In progress

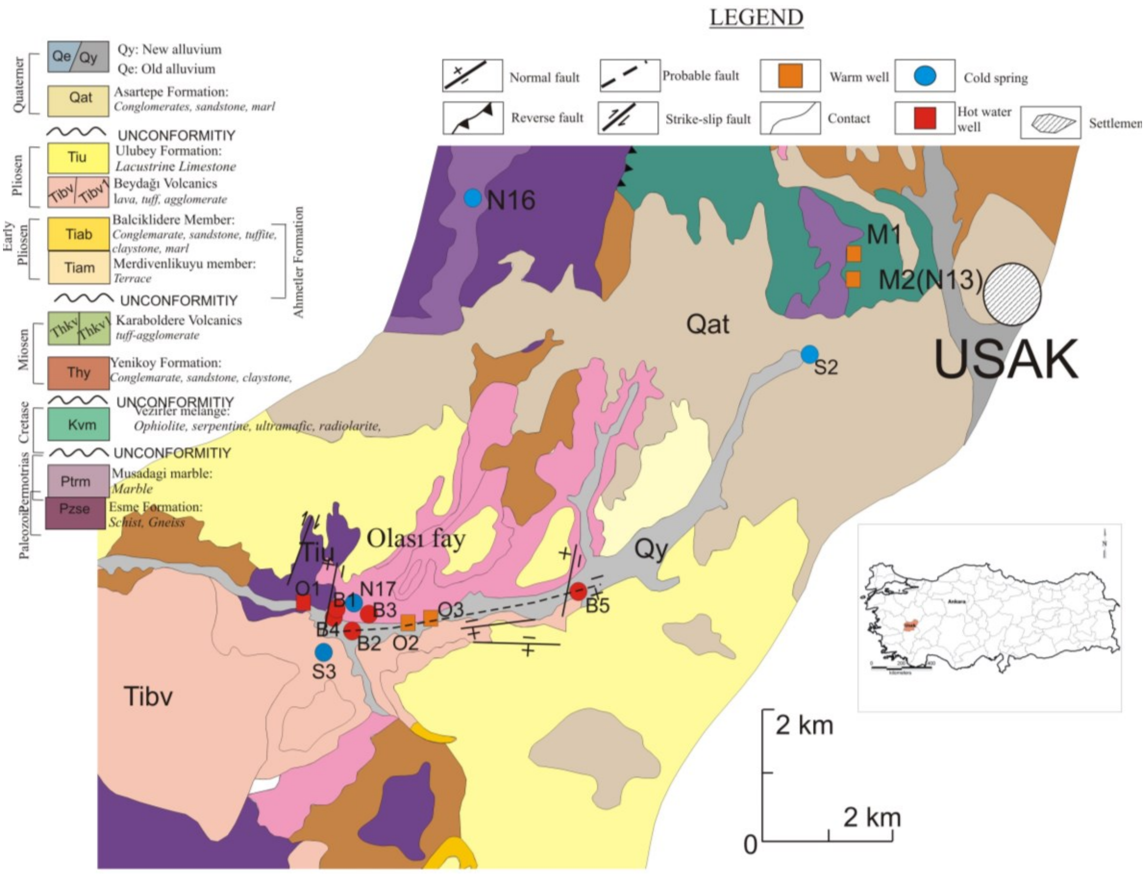

Figure 1. Geological map of studied area.

The geothermal field studies carried out in 2010 summer 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 are Na+K>Ca>Mg and HCO_3+CO_3>SO_4>Cl, these are grouped as Sodium-Bicarbonated waters in Piper Diagram. Cold waters' ion characteristics are Ca>Na+K>Mg and HCO_3+CO_3>SO_4>Cl (Piper, 1944) (Figure 2). Samples from water point of S1,S2,S3 and S4 which seem in the Table 2 were analysed for $\delta^{18}O$, ^2H and ^3H.

Table 2- Chemical and stable isotopic analyses results of hot and cold waters of the studied area (June, 2010).

Sample No	Sample Name	pH	EC	T	Ca	Mg	Na	K	Cl	SO_4	HCO_3	CO_3	SiO2	B	$\delta^{18}O$	^2H	^3H (TU)
			µS/cm	(°C)	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm			(‰)	(‰)	
O1	Balta Orient well	6,7	4490	41,5	142,4	42,7	785,8	94,8	132,2	562,5	2178,6	0	171,6	10,3	-8,54	-65,9	
O3	Ozdemirler2 well	7,4	834	37	102,3	30,1	13	4,1	10,2	175,9	299,2	0	47,6	6	-7,57	-55,02	
M1	MTA 1 well	7,2	1340	23,2	192,2	49,5	14	3,1	18,3	431,5	275,9	0	40,4	0			
B1	İUJ1 well	6,46	4255	51	202,6	45,5	783,4	110	61,4	37,7	2316,8	0			-7,95	-65,46	-0,30
B2	İUJ2 well	6,76	4180	51	226,8	54,4	773,1	120,4	85,3	503,9	2157	0			-	-	0,63
N13	Gokcesme spring	6,5	250	18,9	22,4	6,2	11,4	2,0	5,5	14,6	113,4	0	48,7	0	-	-	-
N16	Cuhadarlar spring	8,4	592	21	73,3	25,1	25,4	4	23,2	14,4	333,3	0	20,3	1,5	-	-	-
N17	Himmet spring	7,1	652	20,6	82,9	36,7	16	2,1	9	18,2	401,7	0	37,2	1,6	-	-	-
S1	Koy hizm.well	-	-	-	-	-	-	-	-	-	-	-	-		-7,56	-52,85	
S2	Koy hizm. well	-	-	-	-	-	-	-	-	-	-	-	-	-	-7,04	-50,62	0,50
S3	Kayaagil fountain	-	-	-	-	-	-	-	-	-	-	-	-	-	-8,72	-58,50	
S4	Rain water	-	-	-	-	-	-	-	-	-	-	-	-	-	-9,90	-64,76	

Hydrogeochemical analyzes evaluated by using Piper, Schoeller, Giggenbach and World Meteoric Line Diagrams (Figure 2 and 3).

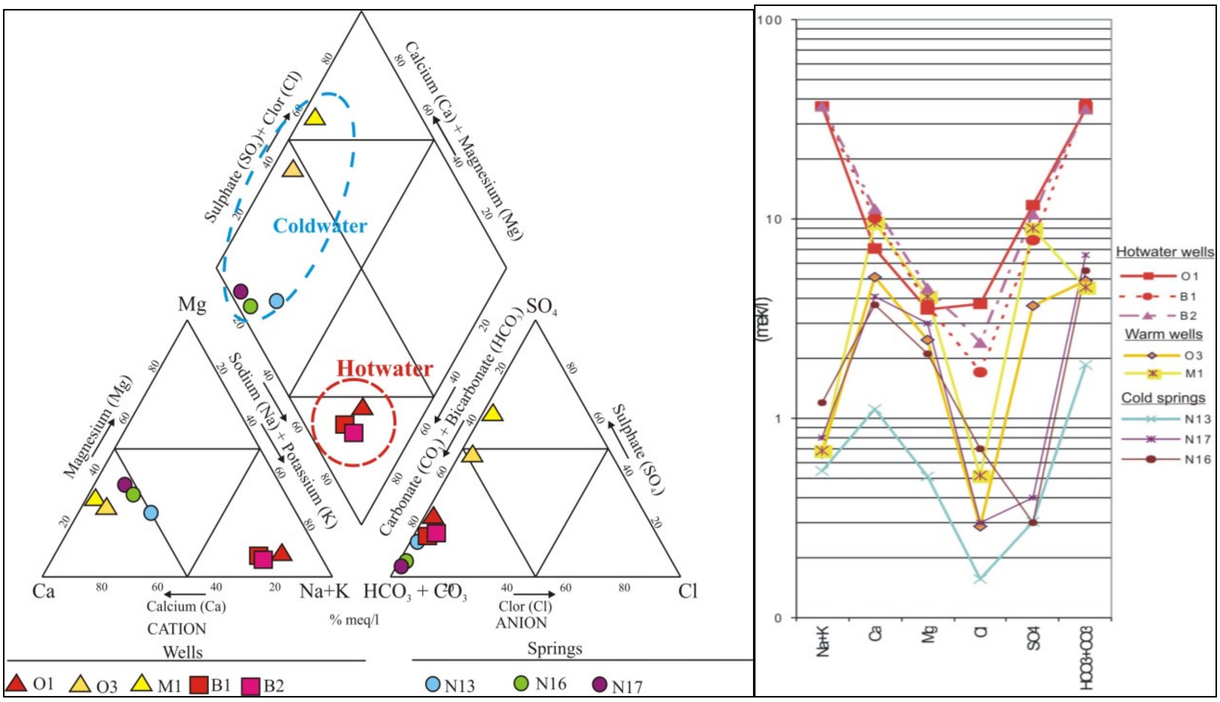

Figure 2. Piper (1944) (left) and Schoeller (1977) (right) diagram evaluation of water samples which are collected from the studied area.

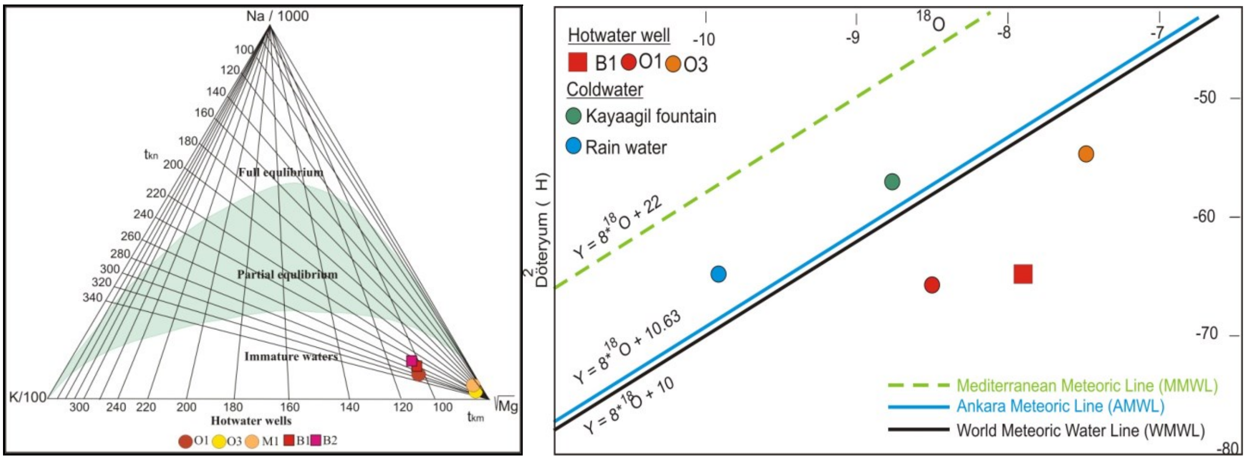

Figure 3: Giggenbach (1991) (left) and δ^2H and δ^{18}O diagram (right) of the thermal and cold waters of the studied area

It is supposed that hot and cold waters have same recharge areas, but based on the limited parallelism due to shallow depth of some wells they show in the Schoeller (1977) diagram (Figure 3).

3.1 Geothermometers

Because of the Karaagac geothermal waters are located in the immature zone of the Giggenbach Diagram (Giggenbach 1991), only the silica geothermometers have been applied (Figure 3). Silica geothermometers which give more reliable results than cation geothermometers (Fournier, 1991) give a result as 84 – 97 °C.

3.2. Isotopes

Karaagac hot water samples are located between Ankara Meteoric Water Line (AMWL) and Mediterrenean Meteoric Water Line (MMWL) (Figure 3). Based on the contents of stable envitonmental isotopes, the hotwaters have been determined to be meteoric origin. 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 explained that the geothermal waters have a deeper circulation compared to cold waters.

4. CONCEPTUAL HYDROTERMAL MODEL

Natural mixture of groundwaters and geothermal waters exist in the Karaagac geothermal field. The geothermal waters mostly have meteoric origin and are fed by 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 fractured zones of schist and andesite. The geothermal water is produced from the schists named as Esme Formation aged Paleozoic. Although, the gradient exist as the heat source in the hydrothermal system, the mixture of cold water comes from Miocene aged lacustrine limestone of Ulubey Formation and non adequate existence of cap rocks/impermeable formations, prevent the formation of hotter geothermal fluids (Figure 4).

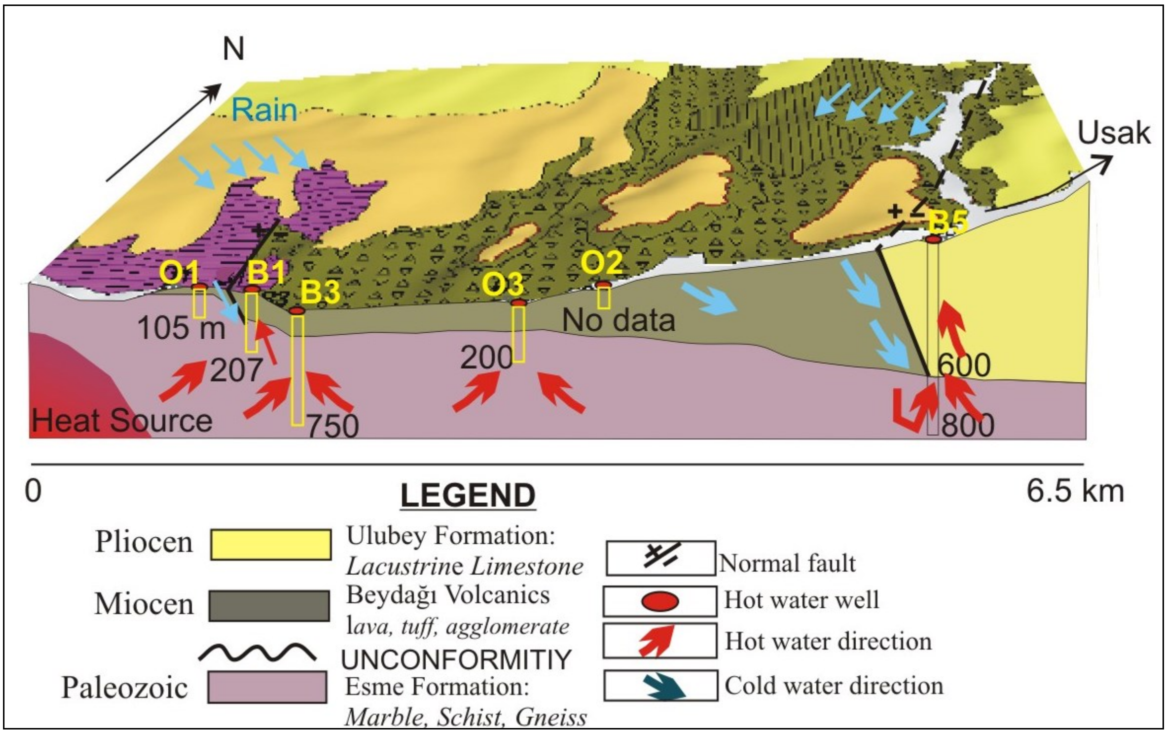

Figure 4: Hydrothermal model of the studied area

5. CONCLUSION

The Karaagac field is suitable for geothermal development. By drilling new geothermal production wells, the geothermal field could be expanded. 78 °C hot water has been obtained from last drilled well but regional heating system would be used in the center of Usak city in case of performing well tests and new drilling wells at eastern part of the studied area in the future. Also 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 Usak 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.

REFERENCES

Akgoz, R., Private contact (2014)

Akkas, B., : Draft Geothermal Report, İller Bank 3. Region Departement, İzmir, Turkey (2009)

Bozkurt, E., : Neotectonics of Turkey-a synthesis, Geodinamica Acta 14, (2001).

Ercan, T., Dincel, A., Gunay, E., Turkecan, A.: Geology of Usak Region and Petrological investigation of Volcanics, MTA Report No: 6454, Ankara, Turkey (1977).

Fournier, R.O.: Water geothermometers applied to geothermal energy and Horne, Application of Geochemistry in Geothermal Reservoir Development, D'amore F. Coord, UNITAR/UNDP, Rome (1991).

Giggenbach, W.F.: Collection and Analysis of Geothermal and Volcanic Water and Gas Discharge, In Application of Geochemistry in Geothermal Reservoir Development (Edited by F. D'amore), Unitar, Rome (1991).

Piper, A.M.: A graphic procedure in the geochemical interpretation of water analysis, Transactions American Geophysical Union (1944).

Schoeller, H.: Geochemistry of groundwaters, In Groundwater Studies and International Research and Practice, UNESCO, Paris (1977).