

## Hydrogeochemical Properties of Haymana (Ankara) Geothermal Field

Nilgun H. Bakir\* and Sakir Simsek\*\*

\* ORME Jeotermal Inc., Hosdere cad. 190/7-8-12, 06550 Cankaya/Ankara,

\*\* Hacettepe University, Eng. Fac.Geological (Hydrogeological) Eng. Department, Beytepe, Ankara

[orme-f@tr.net](mailto:orme-f@tr.net), [ssimsek@hacettepe.edu.tr](mailto:ssimsek@hacettepe.edu.tr)

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### ABSTRACT

Haymana City is located in Central Anatolia and is the district of the capital City Ankara of Turkey.

Haymana shows a suitable structure for social and economic development and is famous with its balneological utilization applications.

This study contains the hydrogeological, hydrogeochemical and isotope hydrology studies in Haymana City. According to the hydrogeological studies, the permeable formations (reservoir rocks) are karstic Mollaresul, Caldag, Yesilyurt formations, alluvium and travertines.

Faults are developed mainly in E-W, NE-SW and NW-SE directions. The flow rate of the hot springs in Haymana geothermal field was totally 12 l/s with a temperature 34 - 44 °C. Their flow was decreased and stopped with the production of the geothermal wells in 1986.

Haymana karstic hot waters are produced mainly from the MTA-4 (45 °C, 52 l/s) and KH-1 (31,4 °C) wells for balneological utilization in the thermal facilities (Seyran Hamami, Merkez Kaplica, Termal Otel, Uyuz Hamami). These waters are low mineralized (1137- 1171 mg/l), hyperthermal (45 °C), Ca, Mg, HCO<sub>3</sub>, heated groundwaters. According to the isotopic analyses results, the cold and hot waters in Haymana area are of meteoric origin.

Due to the tritium analyses of the waters produced from the wells, the circulation duration is more than 50 years. The SiO<sub>2</sub> geothermometers results are 43 - 57 °C temperature interval, which appear to be more realistic if compared to the cation geothermometers which give rather very high results and also the production temperatures are 44 - 45 °C.

### 1. INTRODUCTION

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

The water supply area in the field is 180 km<sup>2</sup>. Haymana city is under the effect of terrestrial climate. The annual average outside temperature is 10,2 °C and the annual average precipitation amount is 415,09 mm.

With a population of 10900, Haymana city has a property as an emigration city.

### 2. GEOLOGY

Sediments beginning with Upper Jurassic-Lower Cretaceous age are giving outcrops in the study area (Figure 1).

In the study area, Upper Jurassic/Lower Cretaceous - Quaternary aged 11 units are giving outcrops (Unalan, G., Yuksel, V., 1985) (Figure: 2).

These formations are named as Temirozu (Tkt), Mollaresul (Jkm), Derekoy (Kd), Haymana (Kh), Beyobasi (Kb), Caldag (Tc), Yesilyurt (Ty), Kirkkavak (Tki), Ilginlikdere (Ti), Eskipolatli (Te), Cayraz (Tca), Neogene (n,nv), Quaternary (Qal) and Travertine (Qtr).

#### 2.1 Structural Geology

The large fold orogenic units covering the Ankara region are Anatolian, Central Anatolian and Western Taurus belts from north to south.

The tectonic lines are mostly developed in SW-NE and NW-SE directions.

The Anatolian Folds and Middle Anatolian Folds are the main large scale folds affecting the Haymana region. But the E - W extended and symmetric Haymana Anticline with an observable 18 km length and the E - W extended Caldag Fold are the main two fold systems important in the Haymana geothermal field.

In the study area, mostly normal and overlap faults exist. Derekoy overlap fault, Uyuzhamami, Spa, Haymana-1 and Haymana-2 faults are the main faults existing in the Haymana geothermal field.

Haymana is located in the 4<sup>th</sup> Earthquake Zone, which means that perceptible but not hazardous earthquakes are expected in Haymana City (Gencoglu et al., 1990).

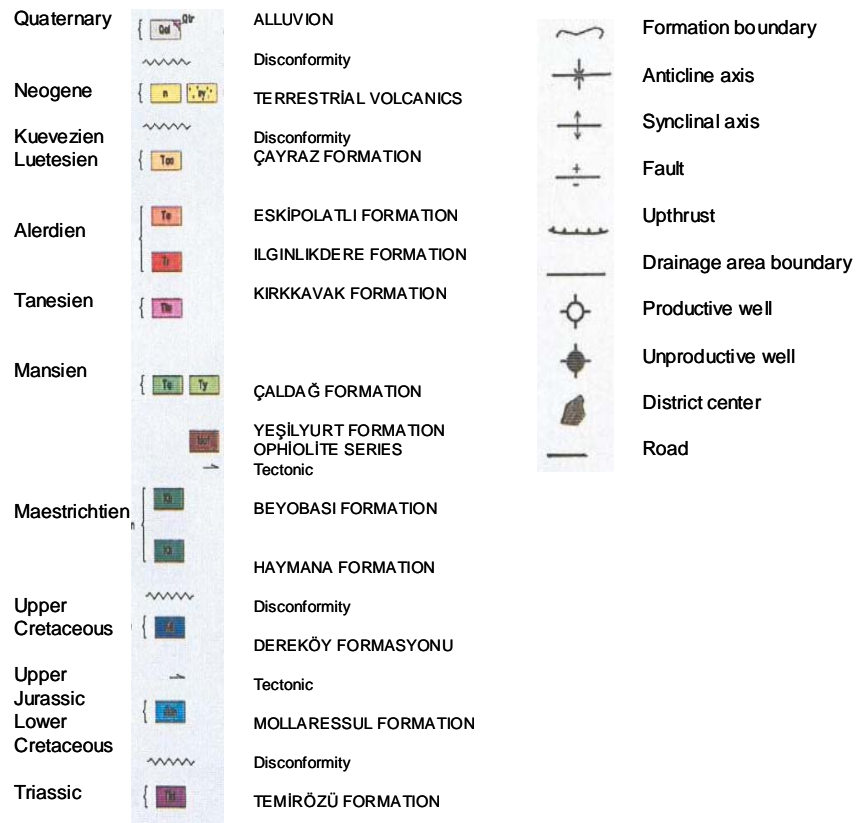
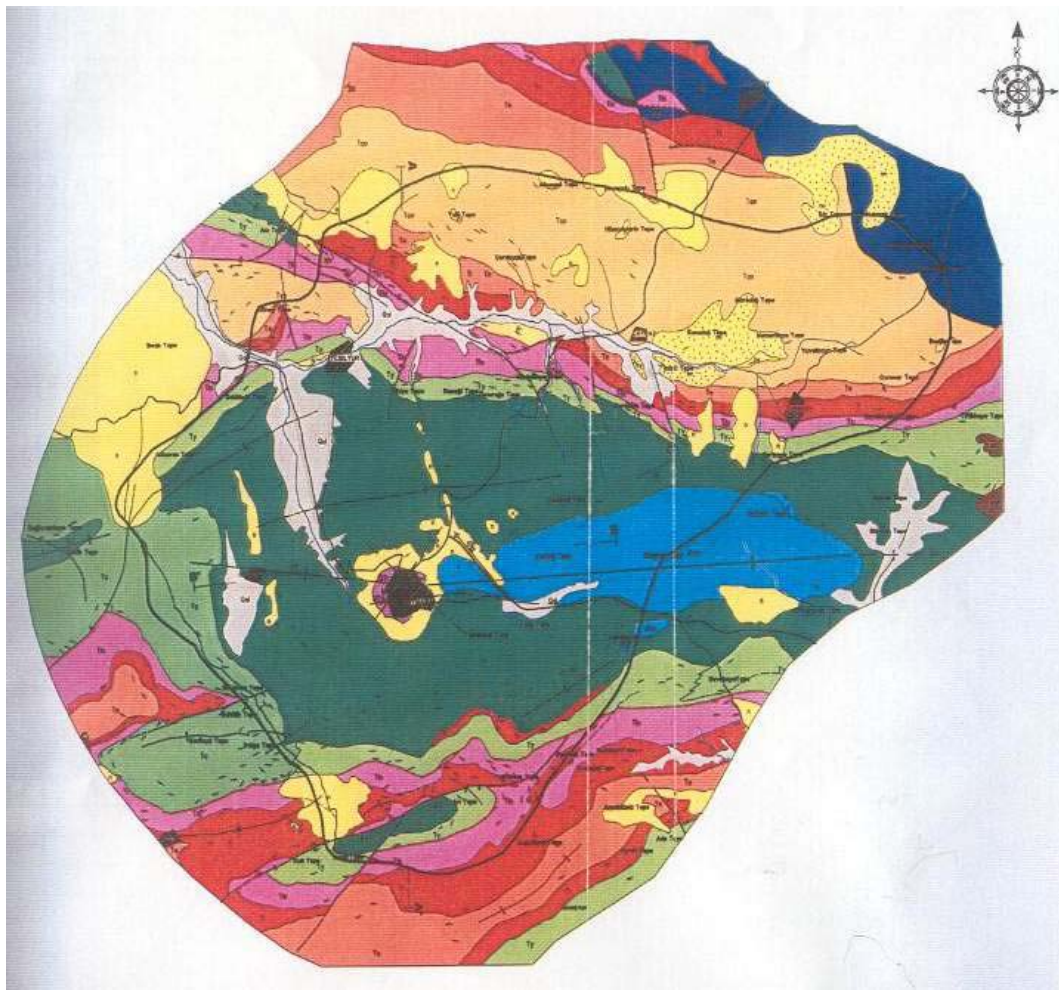
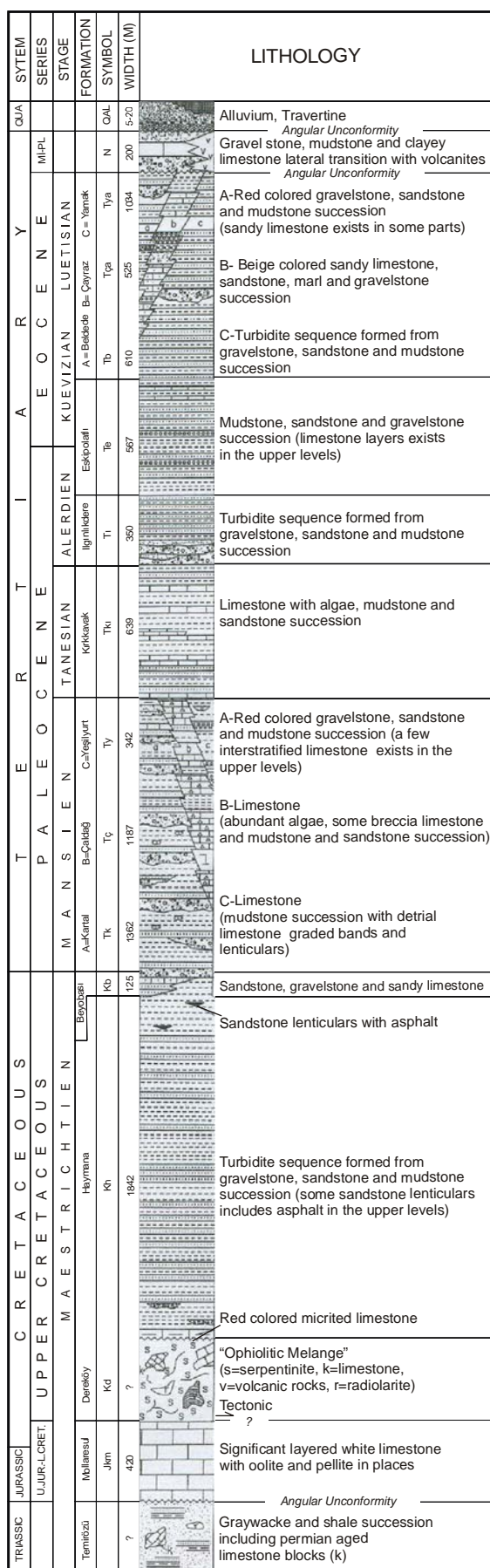


Figure 1: Geological Map of the Haymana Geothermal Field



**Figure 2: General Stratigraphic Section of Haymana Region**

### 3. HYDROGEOLOGY

Thermal waters have been used for balneological purposes for decades in Haymana city. With the demand increment for balneological applications, the necessity of drilling production wells was born. Firstly, natural discharges have been used for these purposes. After the wells have been drilled the natural discharges stopped discharge. The 3 natural discharges had a temperature varying from 34 – 44 °C with a total 12 l/sec flowrate (Caglar, 1950)

A total of five geothermal production wells exist in the area, drilled between 1974 and 1986.

**Table 1: Haymana geothermal natural discharges and geothermal wells (N.D.: Natural Discharge, W: Well), (Senturk, N., Ozeke, H., 1987)**

		Temp. (°C)	Flowrate (l/sec.)	Total Mineral. (mg/l)
1968- 1972 (MTA)	Spa N.D	44	4	1209,64
	Seyranhamami N.D	34	4	
	Uyuzhamami N.D	34,5	4	1217,58
	MTA-1W.	44	0,78	1077,42
2001	MTA-3 W.	44	0,94	1137,02
	MTA-4 W.	44,9	52	1171,97
	Uyuzhamami W.	31,4		

Moreover, there are many shallow wells have been drilled in the study area for irrigation and domestic utilization. The depths of these wells are mostly 5-15 m. The production rates in these wells are low where the alluvium is narrow, and the production is good where the alluvium is thick.

### 3.1 Hydrogeological Properties of the Formations

Most of the formations around Haymana geothermal field are not permeable. The permeable formations are Mollaresul, Caldag, Yesilyurt, Aluvial and Travertain formations. Beyobasi formation is a semi permeable formation.

There are two different karstic aquifers determined in the study area. These are Mollaresul formation, aquifer for the geothermal water and Yesilyurt, aquifer for the cold groundwater.

#### 4. HYDROGEOCHEMISTRY

The geothermal field studies have been started in 2001 and cold water and warm water probes and in-situ EC, pH, temperature and TDS measurements have been taken.

The geothermal water produced from the MTA-4 well are produced with pipes to Merkez Spa, Thermal hotel and Seyran hamami and are used for balneological purposes.

It is observed that the ion values are similar to each other in the water samples taken from MTA-3 and MTA-4 wells. The main reason to that is that the wells are not effected too much by the seasonal changes.



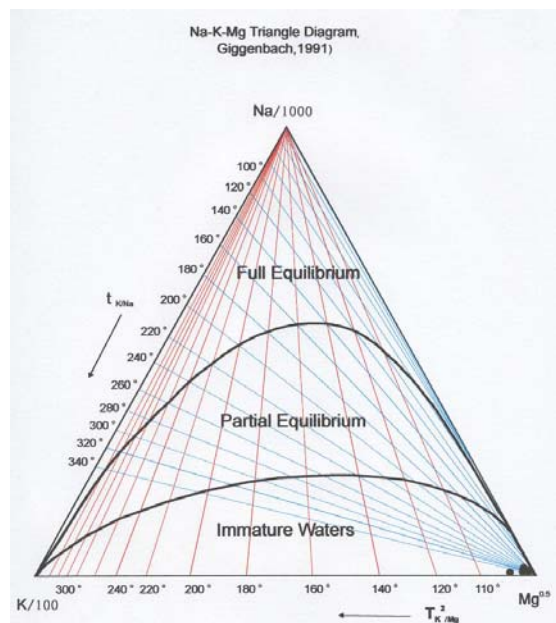
As a result, the geothermal waters in Haymana region are low mineralized, hyperthermal, calcium, magnesium bicarbonated and heated groundwaters.

**Table 2: Chemical Analyses results of Haymana geothermal waters (in mg/l) (Caglar, 1950).**

	Uyuz Spa	MTA -4	MTA -3	Harlak	Bas-degirmen	Yeni. mah.
T (°C)	31,4	44,9	44	19	19	20
pH	6,93	6,83	6,86	7,69	7,76	7,41
EC (μS/cm)	890	900	900	360	369	830
TDS (mg/l)	783	816	832	310	315	692
Na	23,9	28,9	34,3	4	4	33,5
K	7	7,5	7	4,5	4	10,5
Ca	129,5	123	124	58	58,5	107,5
Mg	23,5	26,5	27	8,5	9	22
HCO <sub>3</sub>	562	599	607	192	195	446
Cl	8,86	8,86	8,86	7,09	7,09	24,82
SO <sub>4</sub>	14,6	8,06	7,9	30,8	33,1	38,3
B	0	0,22	0,24	0,2	0,11	0,46
SiO <sub>2</sub>	13,2	14,3	15,2	4,5	4,7	9

The ion characteristics of the cold and warm waters of Haymana geothermal field are  $\text{Ca}^{+2} + \text{Mg}^{+2} > \text{Na}^{+} + \text{K}^{+}$ ,  $\text{HCO}_3^{-} + \text{CO}_3^{2-} > \text{Cl}^{-} + \text{SO}_4^{2-}$  and are grouped as calcite and carbonated waters.

The geothermal waters are located at the immature zone in the Giggenbach Diagram (Figure 3) (Giggenbach, 1988).



**Figure 3: Giggenbach Diagram of Haymana Geothermal Waters**

#### 4.1 Mineral Saturation of the Waters

The chemical reactions in the groundwaters, gives the opportunity for observing the hydrochemical environment. For this reason, it is important to study the Saturation index of the groundwaters.

The waters in the study area show dolomite saturation. In the geothermal well waters also a small amount of quartz saturation exist.

That the geothermal well waters are showing mostly saturation in dolomite, calcite and aragonite, shows that the feeding area and aquifer lithology is composed of dolomite, dolomite limestones and limestones.

#### 4.2 Geothermometers

Although, the Haymana geothermal waters are located in the immature zone of the Giggenbach Diagram, the geothermometers have been applied as below

##### 4.2.1 Cation Geothermometers

The mixture of cold water, the separation of potassium ion from the system prevents the cation geothermometers to give reliable results.

##### 4.2.2 Silica Geothermometers

Silica geothermometers give a result as 43 – 57 °C which give more reliable results than cation geothermometers. This is confirmed with the maximum temperature produced from the wells is 44.9 °C and there seems not a formation to exist which could be form the aquifer at the depths.

#### 4.3 Isotope Properties

Haymana geothermal water samples are located very close to each other between Ankara Meteoric Line and the General Meteoric Line. The waters are of meteoric origin. From the tritium analyses, it is observed that the tritium amount is zero. So, the circulation duration of the geothermal waters is more that 50 years. For this reason, it can be said that the geothermal waters have a deeper circulation if compared to cold waters.

### 5. GEOTHERMAL SYSTEMS

Natural mixture of groundwaters and geothermal waters exist in the Haymana geothermal field. But this mixture happens in a very limited conditions since most of the formations exist in the geothermal field are non permeable. The geothermal waters are mostly meteoric in origin and are fed by normal groundwaters. The groundwater is getting mineralized by dissolving the elements from the rocks getting in water-rock interaction and are heated by the geothermal gradient. The heated and mineralized water is moving to the surface by means of the faults which goes through to deeper levels. These waters are collected in Mollaresul formation and produced by the geothermal well.

The geothermal water is produced from the karstic Mollaresul formation formed by white limestones and normal faults cutting this formation.

Although the gradient exist as the heat source in the hydrothermal system, the mixture of cold water and non adequate existence of cap rocks/non permeable formations, prevents the formation of hotter geothermal fluids.

## 6. CONCLUSION

The Haymana geothermal field is very 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 district heating and other integrated geothermal applications (thermal tourism, balneology etc.).

The geothermal water could be utilized in district heating by means of floor heating and nearly 7500 people/day could be benefited from geothermal waters by means of balneology. To make use of this potential is very important for the social and economical development of the Haymana City.

The determined prtotection zones shall be taken into account and necessary precautions shall be taken for protecting the geothermal field from pollution.

Another important subject is to prevent the uncontrolled well drillings to safe the geothermal field properties.

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