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A Case Study for a Geothermal Field Formed by Magmatic Processes; Caglayik Geothermal Field, Central Anatolia, Ankara/Turkey

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ABSTRACT

The study area is situated west of the Pontides Tectonic Zone, at the Middle Sakarya Sections, approximately 60 km southwest of Ankara. This area is in the Central Anatolia Plains District, which is the one of the five Neotectonic Districts of Turkey (Şengör, 1980). Generally, the area around the study area is not very important for geothermal energy. In the study area there are some geothermal manifestations such as a hot springs with temperatures of 38 ^{o}C.

Granitoid of Maastrichtian-Danian age is widespread in the area. This unit is unconformably overlain by the Middle Miocene Bozkır Formation which consists of conglomerates, sandstone, shales, interstratified pyroclastics, claystone, clayey limestone and gypsum beds. Alluvium of Quaternary age is the uppermost (Figure 1, Figure 2). Basic rocks in the granitoid pluton have the same age as the pluton and have signs of the cooling model, crystal-liquid fraction, and magma mingling. Some segments are graded at the granite-basic rocks contact, and some segments are sharp. Graded contacts act like faults for geothermal fluid. At the area some discharges are seen at this contact.

Radioactivity in granitic areas is the most important factor for heating, which is the most important parameter for geothermal systems in studied area. After the geological and hydrogeochemical investigation of the field was performed, a geophysical investigation of field was performed. In this investigation geophysical measurements were taken by resistivity (VES) and SP methods at specified stations. However, morphology was not suitable to gather data about geothermal anomalies. According to geological evidence at the end of the investigation, a drill location was determined. According to hydrogeochemical results, we concluded that only a little more warmth from the heat of the spring (38 ^{0}C) can obtain the SiO_2 (chalcedony) and Na-K-Ca geothermometer of the hot water samples gathered; reservoir rock temperatures ranging from 33 ^{0}C to 44 ^{0}C have been calculated. A well was drilled to a depth of 236 m and hot fluid (43°C) was taken out at a flow rate of about 17 l/s.

1. INTRODUCTION

The Central Anatolia "Ova" Province is characterized as an extensional basin called "Ova" Central Anatolia Plains Disrict and is one of the Neotectonic realms of Turkey (Şengör et al, 1985). The study area is in the Central Anatolia Plains District and situated west of the Pontides Tectonic Zone at the Middle Sakarya Sections, approximately 60 km wouthwest of Ankara (Figure 1).

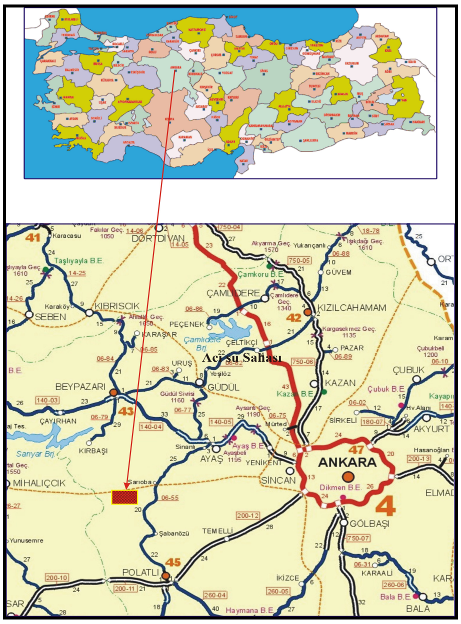

Figure 1-Location of Caglayık area

Generally, the area around the study area is not very important for geothermal energy. Granites and Neocene aged sediments are widespread in the area. A granitoid pluton represents the beginning of the magmatic processes and yields K/Ar ages of 69.1±2.7 ma (from hornblende 71.1±2.7 ma). The cooling model of the magma chamber has a very important role on a geothermal system. In this area, the geothermal system was formed by magmatic processes.

2. STRATIGRAPHY

2.1. Granitoid (Mkpg)

In regional geology a granitoid is represented by alkali feldspar granite, granodiorite, granite, diorite with andesite apophyses and veins (Açıkgöz et all, 1996, Açıkgöz et all, 2007, Helvacı et all, 1992 and Zoroğlu, 2004). This formation is exposed around and the west of Çaglayık geothermal area.

A granitoid pluton represents the beginning of the magmatic processes and yields K/Ar ages 69.1±2.7-60.3±2.5 ma (from hornblende 71.1±2.7ma) (Açıkgöz et al, 2007). As the magma solidifies, especially during convective cooling processes including convective cells of different velocities, heat may develop in a magma chamber.

Segregation by thermogravitational forces constitutes two zones with different temperature and density compositions in the magma chamber; these zones constitute the different convection currents and solidify (Figure 3). According to this cooling model mafic and felsic rocks appear together. At the study area, in the magma chamber double-diffusive convective layering apophyses that main magmatic intrusive mass and vein rocks are seen. At the study area andesite (68.6±2.7 ma) and dacite (69.1±2.6 ma) in the granitoid pluton have the same ages as the pluton and have signs of the cooling model, crystal-liquid fraction, and magma mingling (Figure 4).

There is no definite evidence about the thickness of this formation.

In the study area, three rock-stratigraphic units are exposed. These are granitoid, Bozkır Formation, and alluvium. Granitoid of Maastrichtian-Danian age is widespread in the area. This unit is unconformably overlain by the Middle Miocene Bozkır Formation which consists of conglomerates, sandstone, shales, interstratified pyroclastics, claystone, clayey limestone and gypsum beds. Alluvium of Quaternernary age is the uppermost (Figure 1, Figure 2).

2.2. Bozkır Formation (Smb)

The Bozkir formation was firstly named by Birgili et al. (1975) and is widespread in and around the study area, including in outcrops around and east of Çağlayık farm (Figure 2).

This unit is represented by conglomerate, sandstone, shales, claystone, clayey limestone and gypsum beds with pyroclastic intercalations.

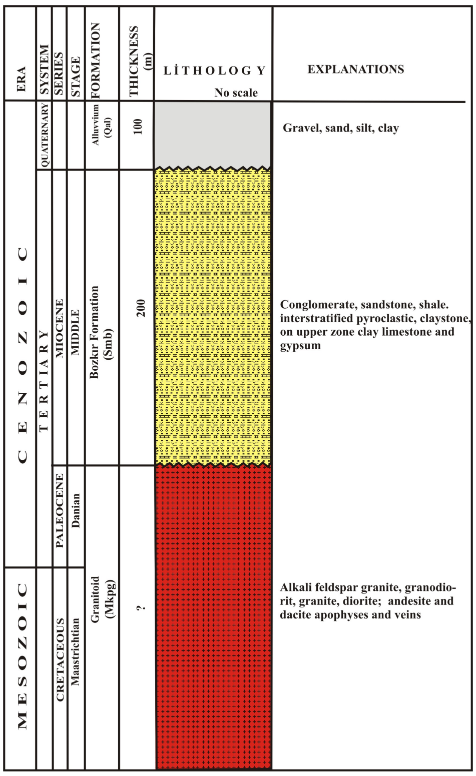

Figure 2-Generalized stratigraphic Section of study area.

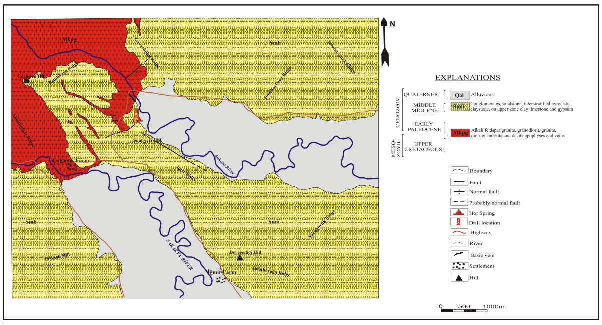

Figure 3-Geological Map of Study area

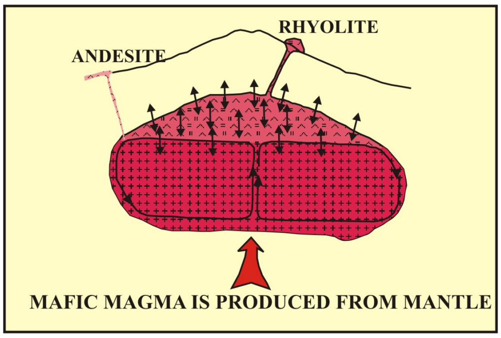

Figure 4-Magma Chamber with Two zones (Boztuğ, 2001).

It unconformably overlies the granitoid in the study area. Near the basin, it is represented by delta deposits. Lithological and stratigraphical characteristics of the Bozkır formation all suggest a depositional setting of fresh water lake and river facies. Also gypsum beds give a clue about the environment of sedimentation. The thickness of this formation is about 200 m. Akgun et al. (2002) mention that the age of the Bozkır formation is of the Middle Miocene based on fossil content.

2.3. Alluvium (Qal)

The alluvium is composed of gravel, sand, clay and silt and is seen near rivers and plains. Generally, the thickness of this formation is about 100 m in the plains.

3. GEOTHERMAL SYSTEM

In the Caglayık geothermal field there is a hot spring with a temperature of 38 ^{0}C and flow rate of about 1 l/sec. There is no surface manifestation anymore in the field.

As the magma solidifies the convective cooling processes may result in convective cells of different velocities and temperatures may develop in the magma chamber. Thermogravitational forces will segregate the magma chamber into two zones with different heat and density compositions and eventually solidify. According to this cooling model it is possible for mafic and felsic rocks to appear together. At the study area, in the magma chamber double-diffusive convective layering apophyses that main magmatic intrusive mass and vein rocks are seen. At the study area basic rocks in the granitoid pluton have the same ages as the pluton and have signs of the cooling model, crystal-liquid fraction, and magma mingling. Some segments are graded at the granite-basic rocks contact, and some segments are sharp. Graded contacts act like faults for geothermal fluid. At the area some discharges are seen at this contact (Figure 5, 6, 7, 8).

Figure 5-Relation between granite and andesite.

Figure 6-Contact of Granite and andesite

Figure 7-Hot spring on transition andesite.

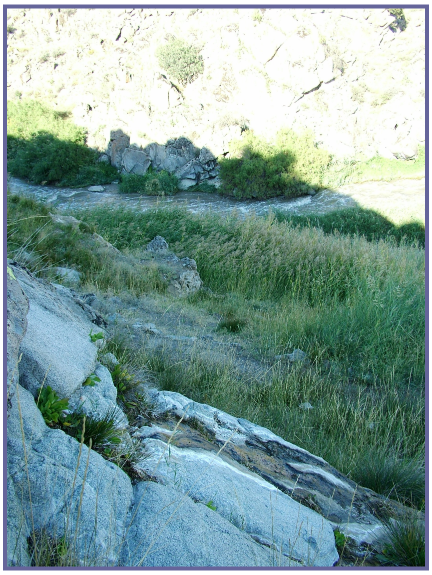

Figure 8-Hot spring and travertine.

Figure 9-Travertine from ancient hot springs

One important source of the thermal energy in earth's crust is the heat supplied by radioactive decay of elements in the crust. Specific isotopes with long half lives (such as U^{235}, U^{238}, Th^{232}, K^{40}) are sources for thermal energy from the origin of the earth to the present. Radioactivity is common in granitic rocks, and is the most important heat source for geothermal systems. The geothermal study area is supplied with heat from radioactivite decay of elements in the granite.

Geophysical measurements could not be taken about geothermal system because the morphology was not suitable to collect information about geothermal anomalies. According to geological evidence, we followed the graded contact between granite-basic rocks underground. In this way, a well location was determined and drilled to a depth of 236 m and hot fluid (43 ^{0}C) is recovered at a flow rate of 17 l/sec (Figure 10).

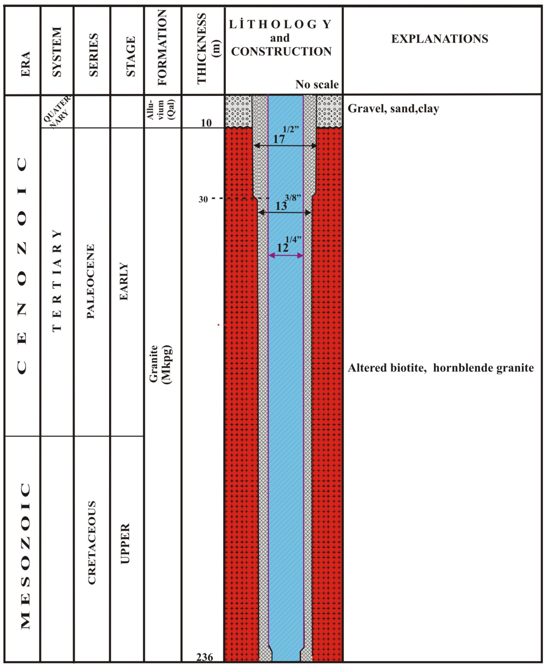

Figure 10-Log of Eell

4. CONCLUSION

In the study area geological, hydrogeochemical, and geophysical investigations were performed. Geophysical measurements were taken by resistivity (VES) and SP methods at specified stations, however morphology of the site was not suitable to collect information about geothermal anomalies. The geothermal study area is supplied with heat from radioactivite decay of elements in the granite. At the study area basic rocks in the granitoid pluton have the same ages as the pluton and have signs of the cooling model, crystal-liquid fraction, and magma mingling. Some segments are graded at the granite-basic rocks contact, and some segments are sharp. Graded contacts act like faults for geothermal fluid. At the area some discharges are seen at this contact. e have followed to graded contact between granite-basic rocks under the cover. Based upon geological evidence and the cooling model of the magma chamber, a well location was determined and drilled to a depth of 236 m and hot fluid (43 0C) is recovered at a flow rate of 17 l/sec. Hydrochemical characterization of the thermal water shows that it is Na-$SO_{4,}$ Cl with B type.

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