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Hydrothermal Alteration Minerals of the Balçova Geothermal Field

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ABSTRACT

Balçova Geothermal Field, being located 10 km from the western part of İzmir, Turkey, is one of the most prominent geothermal fields of the country. The lithology in the field, from oldest to youngest, is consisted to be classified as the Upper Cretaceous İzmir Flysch, Miocene aged Yeniköy Formation, Pliocene aged Cumaovası Volcanites, Quaternary alluvium and debris flows. By examining the structural, hydrogeological, and geochemical properties of the Balçova Geothermal Field, the relationship between these and the geothermal potential of the field has been searched. Hot water samples have been taken from the deep wells present in the Balçova Geothermal Field. The analysis of the samples have been subjected to the computer program, Aquachem 3.70 and classified by the diagrams obtained. After examining the well-logs of several deep wells, cutting samples and well-cores have been taken from the appropriate levels and studied by the means of petrology and hydrothermal alterations. As a result; three zones have been determined in the field. These are the following: montmorillonite + kaolinite zone (100^0C - 200^0C), transition zone (150^0C - 200^0C) and chlorite + illite zone (200^0C - 250^0C), in accordance with the former shallow well alteration studies. By applying chemical geothermometers to the samples,a maximum temperature of 240 ^{0}C is obtained. In consideration of all these studies, the possible geothermal boundary, maximum temperature, and extension of the geothermal field have been interpreted.

1. INTRODUCTION

The Balçova geothermal field is located 10 km on the western side of Izmir city center and is hosted on the Alpine-Himalayas tectonic Zone (Figure 1). There are numerous cold and hot water points in the field as indicated by shallow and deep wells. Temperature values from the production and reinjection wells range from 80^0C to 139^0C. Various studies regarding this field has been carried out by general directorate of mineral research and exploration (MTA), where studies have been performed continuously.

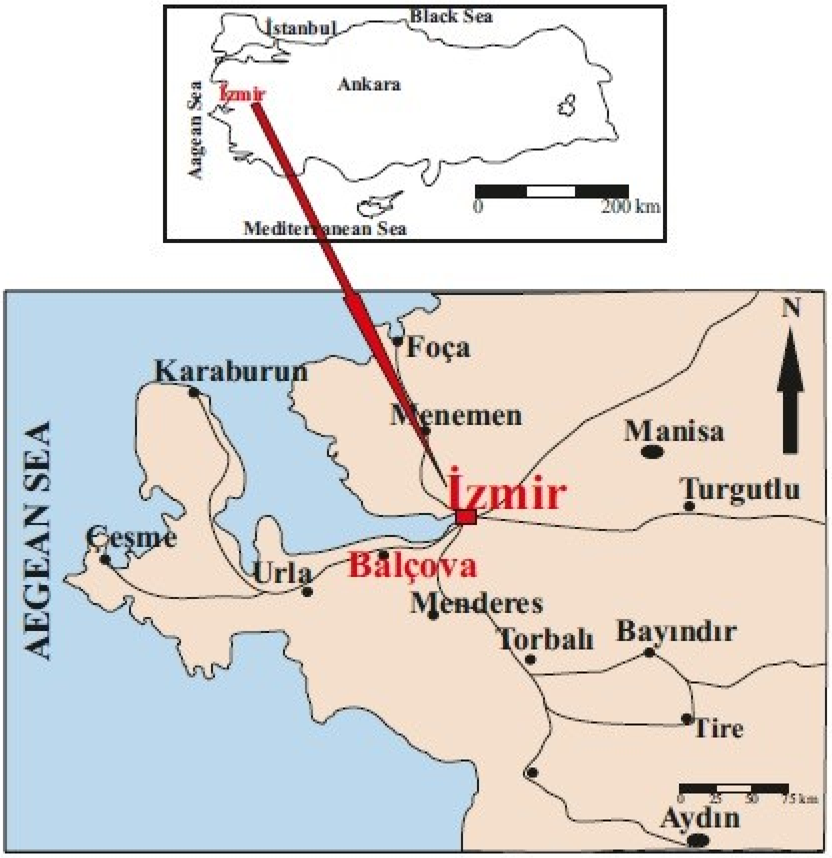

Figure 1: Location map

2. GEOLOGICAL SETTING

The region where Balçova geothermal field is located shows a horst-graben structure which is a result of the N-S extensional forces due to the effect of West Anatolian Neotectonic (Kaya, 1979; Emre, 1996; Yılmaz et al., 2000; Emre et al., 2005; Akyol et al., 2006; Sözbilir et al., 2008). The stratigraphic lithology determined in the field, from oldest to youngest, consists of the Upper Cretaceous İzmir Flysch, Miocene aged Yeniköy Formation, Pliocene aged Cumaovası Volcanites, Quaternary alluvium, alluvial fan and debris flows, where the metamorphics units of Menderes Massif are regarded as the basement of all these (Yılmazer et al., 1977; Tansuğ et al., 1983; Sözbilir et al., 2008). The boundaries between these units are unconformable and the extension tectonics result in several faults such as Agamemnon-1, Agamemnon-2 and Agamemnon-3, along with some other possible faults. The assumed basement of the flysch unit cannot be observed in the area (Erdoğan, 1990).

3. HYDROGEOCHEMICAL STUDIES

Cold and hot water samples from the field (BD_-1, BD-4 and BD-6) were collected and analyzed. The water sample taken from BD-1 had a sum of anions of 15.1525 meq/l and cations of 14.4423 meq/l. On the other hand, BD-4 had a sum of anions equal to 19.7952 meq/l and cations equal to 19.5819 meq/l. In addition, BD-6 represented a sum of anions of 20.7087 meq/l and cations of 20.9492 meq/l. The hardness of the samples of BD-1, BD-4 and BD-6 are 5.71, 4.61 and 3.06 ^{0}F, respectively. Moreover, the water type is Na-HCO_3-Cl. The geothermal water has a tendency to scale and is not suitable for irrigation (Figure 2).

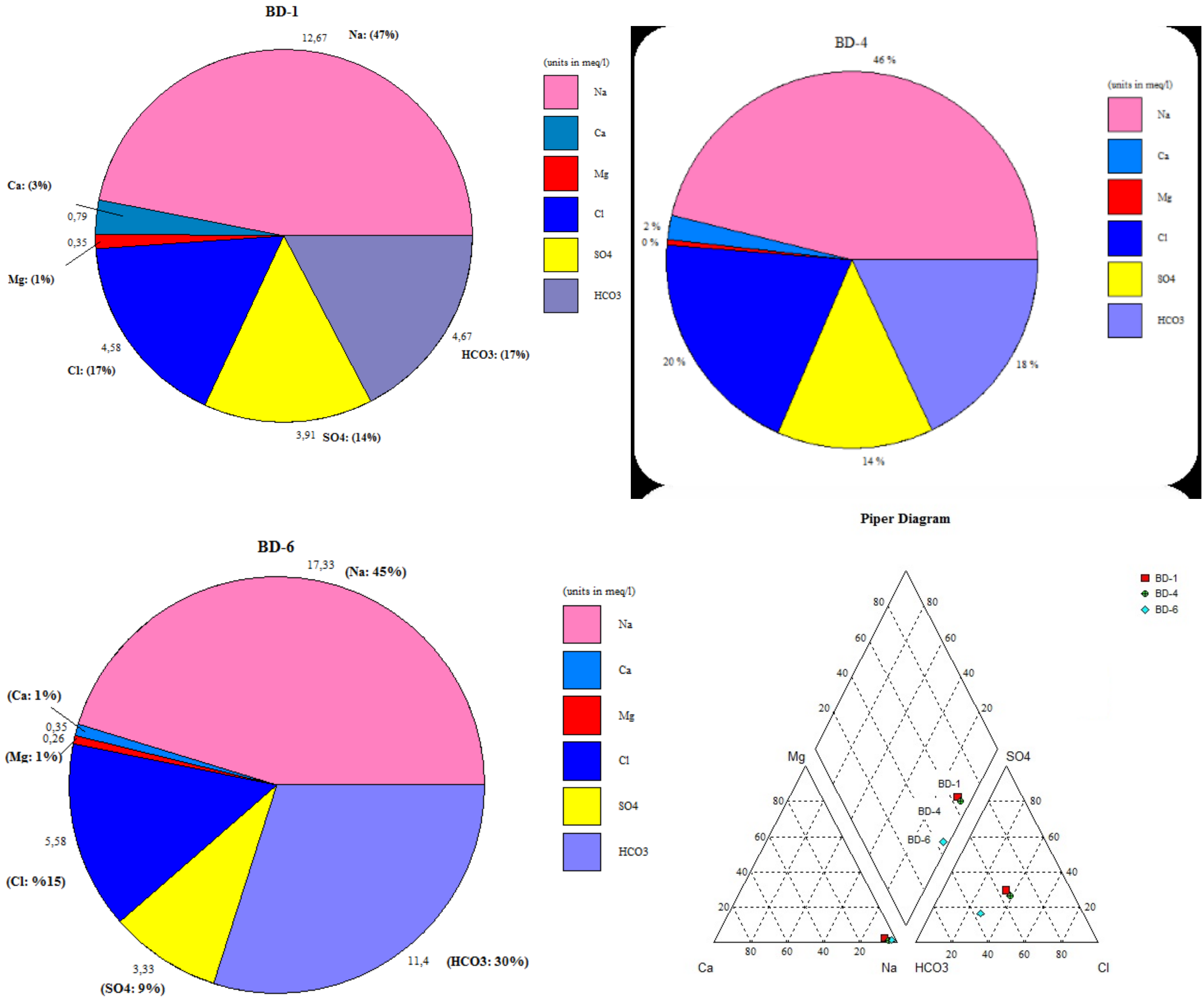

Figure 2: Pie and Piper diagrams of the samples referring to BD-1, BD-4, and BD-6

4. ALTERATION STUDIES

Hydrothermal alteration mineral studies are very heplful in geothermal explorations from the point of the physical and chemical conditions of the geothermal fields (Browne, 1970; Browne, 2002; Yang et al., 2001). Here, core cuttings selected from appropriate levels of BD-6, BD-8, BD-9 and BD-10 were studied petrographically and the x-ray diffraction method was used to determine the hydrothermal alteration minerals (Alacalı, 2006; Alacalı, 2012). The main minerals found were: quartz, kaolinite, illite/mica, chlorite, calcite and feldspar dolomite and eastonite (mica) (Figure 3). These minerals were then correlated with the depths the cutting samples chosen and the temperature values were obtained from the well logs. Three alteration zones were determined: montmorillonite + kaolinite zone (100^0C - 200^0C), transition zone (150^0C – 200^0C), and chlorite + illite zone (200^0C - 250^0C), in accordance with the former shallow well alteration studies.

Table 1. Alteration minerals from the samples of BD-6, BD-8 and BD-10 in Balçova geothermal field determined using the x-ray diffraction method

Sample Location	Depth (m)	Sample depth (m)	Determined minerals
BD–6	606	340-360	Quartz, Kaolinite, Muscovite, Illite, Siderite
		530-550	Quartz, Siderite, Illite, Kaolinite, Dolomite (ferroan)
BD–8	630	139-140	Quartz, Illite/mica, Siderite, Feldspar, Chlorite, Kaolinite
		321-322	Quartz, Illite/mica, Kaolinite, Feldspar, Siderite, Dolomite
		415-416	Quartz, Illite/mica, Siderite, Kaolinite, Dolomite, Feldspar?
		454-456	Quartz, Illite/mica, Siderite, Kaolinite, Feldspar? Dolomite
		498-500	Quartz, Kaolinite, Illite/mica, Chlorite, Calcite, Dolomite
		530-532	Quartz, Kaolinite, Illite/mica, Dolomite, Feldspar? Siderite?
		535-536	Quartz, Illite/mica, Kaolinite, Feldspar? Chlorite, Dolomite, Siderite
		539-540	Quartz, Kaolinite, Illite/mica, Feldspar? Dolomite?
		541	Quartz, Kaolinite, Illite/mica, Feldspar? Dolomite?
BD–10	750	75	Kaolinite, Quartz, Siderite, Calcite
		80	Quartz, Siderite, Dolomite, Kaolinite, Eastonite (mica)
		125	Kaolinite, Siderite, Quartz, Illite, Calcite
		219	Muscovite, Quartz, Kaolinite
		220	Muscovite, Quartz, Kaolinite

5. CONCLUSIONS

The first district heating application in Turkey, Balçova geothermal field, does not have a certain reservoir rock but the flysch unit, with its fractures and fault zones, behaves like a reservoir. Meteoric water descends through these zones and is heated at high depts. with the effect of magma. Then, this ascends via the fractures and fault zones to the surface. There are three alteration zones determined regarding the geothermal field. More and detailed studies for the extension of the geothermal field may be helpful for the future studies.

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