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CLAY MINERALOGY AND HYDROTHERMAL ALTERATION STUDIES OF THE IZMIR-BALCOVA GEOTHERMAL FIELD, TURKEY

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Abstract

The Balçova geothermal field is located approximately 10 km west of Izmir in West Turkey. The geological units seen in the field, from oldest to youngest, are the Upper Cretaceous Izmir flysch; Pliocene agglomerate-tuff, andesites, and rhyolites; and Quaternary alluvium and debris flows. The main faults trend in NE-SW (Agamemnon-II), NW-SE and E-W (Agamemnon-I) directions. Hot water flows along the Agamemnon-I fault.

X-ray Diffraction studies were carried out in order to determine the distribution and occumnce of clay minerals using cutting samples taken from five production wells. This investigation indicates that the clay minerals occur in three zones:

Zone I: kaolinite + montmorillonite	(90-98°C)
Zone II: illite + montmorillonite + vermiculite	(100-180°C)
Zone 111: illite + chlorite	(180-230°C)

The formation temperature of these clay minerals and the geochemical thermometers are comparable but in the production wells, the measured temperatures are lower than the calculated temperatures; this demonstrates that the geothermal system is cooling.

There are nine heat-exchanger wells in this field. These have the capacity to produce 4,400,000 kcal/h heat which is being used for space heating, swimming pools and health purposes.

Introduction

The Balçova geothermal field is located approximately 10 km west of Izmir and south of the Izmir-Çesme road (Fig. 1). Geological studies were carried out by Akatuna (1962), Samilgil (1964), and Yilmazer (1989); geophysical investigations were completed by Tezcan (1963), Ekingen (1970), and Ercan et al. (1981).

The aim of this study is to learn about the distribution of clay minerals in the area. Cutting samples were taken from five shallow (<150 m deep) drill holes (Table 1). The cuttings were washed to remove drilling mud and described with the aid of a binocular microscope. Clays were mechanically separated by crushing, ultrasonic vibration, and sedimentation and were studied by classical methods of X-ray Diffractometry. The Occurrence of hydrothermal alteration minerals and their relationship with depth and temperature are reported in Table 1.

Geological Setting

The Balçova geothermal field is covered by the Upper Cretaceous Izmir flysch but the basement was not seen in the area studied. The Izmir flysch consists of metasandstone, phyllite, limestone, serpentinite and diabase. This formation is overlain at an angular unconformity by the Yenikoy formation which consists of Miocene conglomerates, sandstones and siltstones. The upper pan of the Yenikoy foxmation overlies the Pliocene Cumaovasi volcanics which include andesite, agglomerate, tuff, and rhyolites (Fig. 2). The main faults extend in NE-SW (Agamemnon-11), NW-SE and E-W (Agamemnon-I) directions. Field observations and resistivity studies indicate that the hot water is carried by the Agamemnon-I fault (Fig. 3).

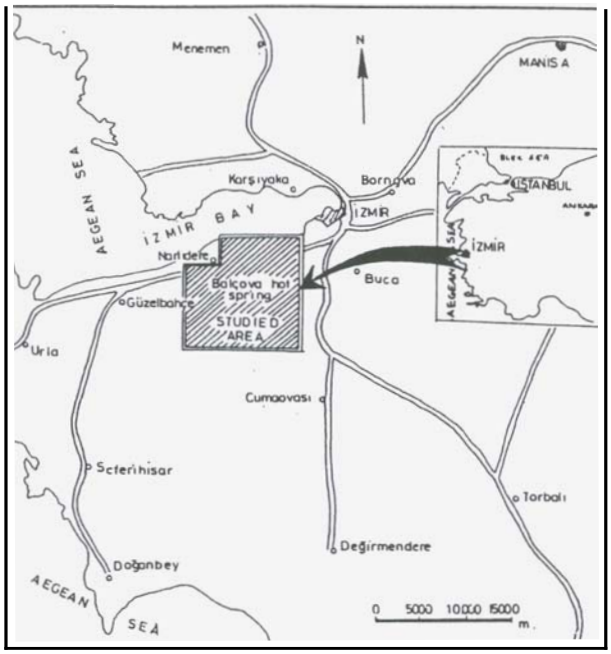


Fig. 1. Location of area studied.

Hydrothermal Alteration

Distribution of hydrothermal minerals

Two groups of diagenetic and alteration minerals were observed in the studied wells:

(a) pore-filling cement; quartz, calcite, dolomite and pyrite.
(b) detrital and diagenetic clay minerals formed by dehydration and reaction with detrital kaolinite, montmorillonite, illite, vermiculite and chlorite.

Distribution of clay minerals

The distribution of clay minerals in the wells are shown in Fig. 4. There is a relationship between the abundance of clay minerals and deep temperature in the wells investigated.

B-4 well: Kaolinite and illite are present at 70 m depth (Fig. 4a). The amount of illite present increases with decreasing depth. Kaolinite disappears but vermiculite and chlorite appear at 102 m; below this point the main clay minerals are illite and chlorite.

B-5 well: The clay mineralogy is the same as in well B-4, except for the appearance of montmorillonite at 83 m, and illite and chlorite at 103 m (Fig. 4b).

B-2 well: The sample taken from 35 m depth includes high amounts of illite and lesser kaolinite and montmorillonite. With increasing depth and temperature, montmorillonite abundance increases but the amount of kaolinite present decreases down to 74 m (Fig. 4c).

B-7 well: Abundant montmorillonite and lesser illite and chlorite occur at 80 m depth. The amount of illite and chlorite increases but montmorillonite decreases down to 98 m. At this depth vermiculite also appears but below, the amount of illite and chlorite decreases as montmorillonite increases to 118 m (Fig. 4d).

Table 1. List of exploration wells in Balçova geothermal field

Well No.	Depth (m)	Bottom Temp.(°C)	Sample Depth (m)	Sample Temp (°C)
B-1	104	115	44	
			46	
			96	
B-2	150	113	35	94
			41	96
			73	102
B-3	160	112		
B-4	125	112	70	117
			102	118
			125	118
B-5	108.5	114	63	123
			83	115
			103	
B-6	150	93	115	87
			130	89
			148	93
B-7	120	115		
B-8	250	93		
B-9	48.5	122		

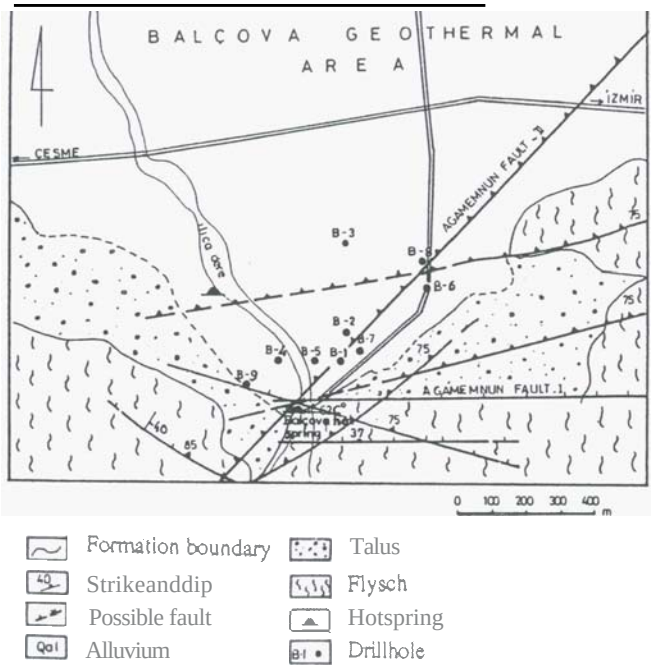


Fig. 3. Geology of Balçova and nearby springs

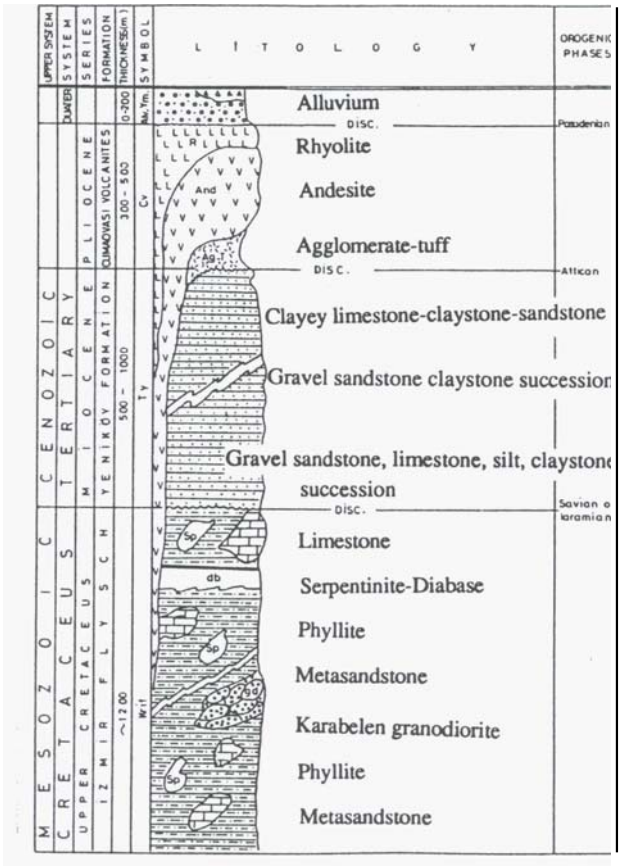


Fig. 2. Generalised cross-section of the study area.

The clay minerals occur in three zones which are distinguished as follows:

Zone I: kaolinite + montmorillonite	(90-98°C)
Zone II: illite + montmorillonite + vermiculite	(100-180°C)
Zone III: illite + chlorite	(180-230°C)

The facies map of the wells studied (Fig. 5) also shows the reservoir properties and isotherms.

Geothermal Utilisation

So far nine heat-exchanger wells have been drilled in the Balçova geothermal field. Surface cold waters are circulated through these heat exchangers rather than the deep reservoir fluid because of scaling problems associated with mineralised fluids. These nine wells have produced 4,405,000 kcal/h heat equivalent to the heat capacity of 1103 kg/h lignite or 459 kg/h fuel-oil. This heat is being used for space heating, swimming pools and health purposes.

Discussion and Summary

Browne (1978) listed six of the main factors affecting the formation of hydrothermal minerals as:

a. temperature
b. pressure
c. rock type
d. permeability
e. fluid composition
f. duration of activity

Browne (1978, 1984). Elders et al. (1979) and Cathelineau et al. (1985) observed that montmorillonite, illite and chlorite occur at 140°C, 220°C and 250°C respectively in active geothermal fields. However, the temperature of the studied wells range from 93-122°C; this indicates that the Balpva geothermal field has been cooling since the clay minerals formed. This study also indicates that examination of cutting samples with respect to their clay content make it possible to predict temperatures in the wells and will aid in locating new well sites.

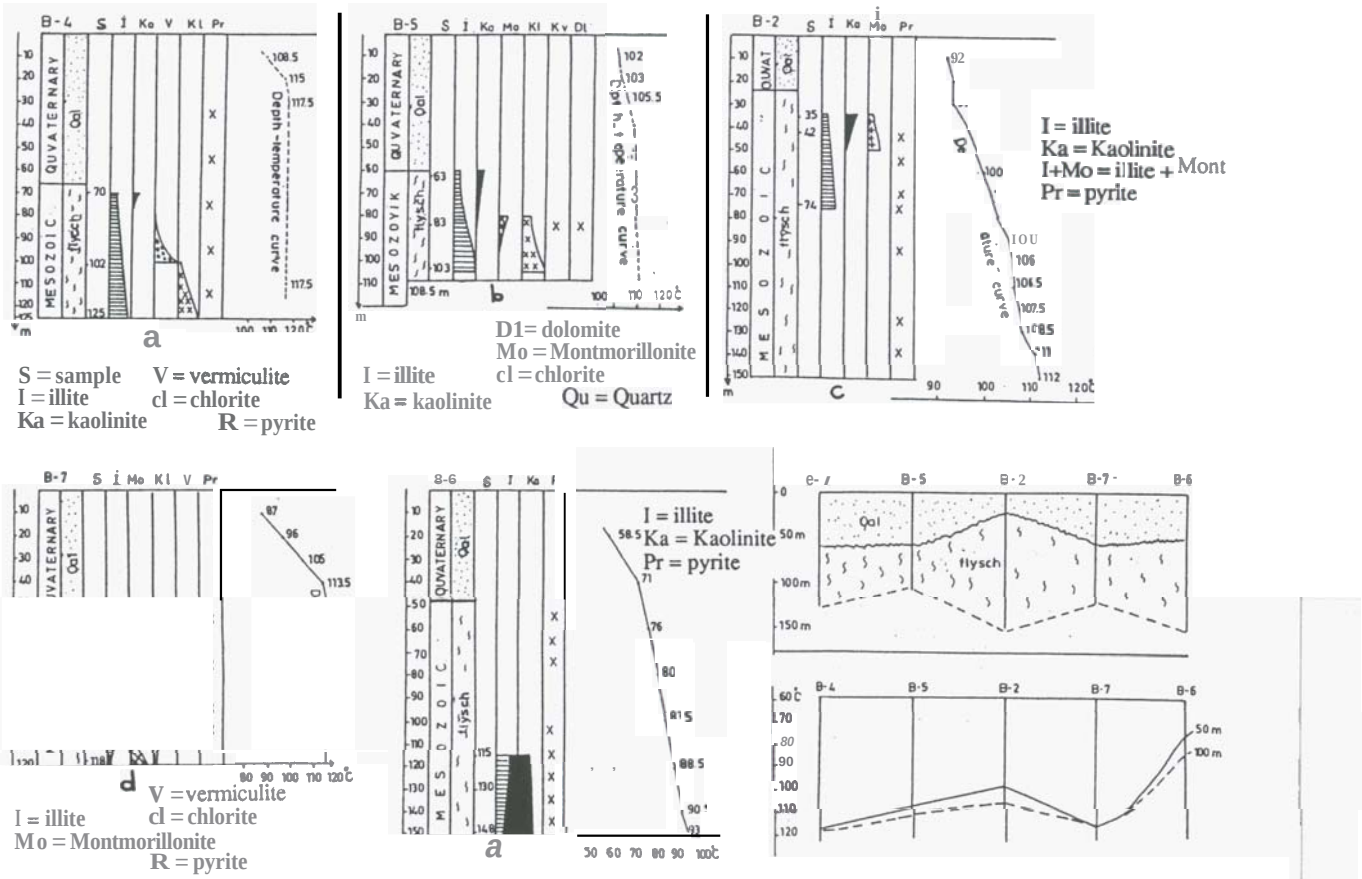


Fig. 4. Relationship between clay minerals and temperature in production wells

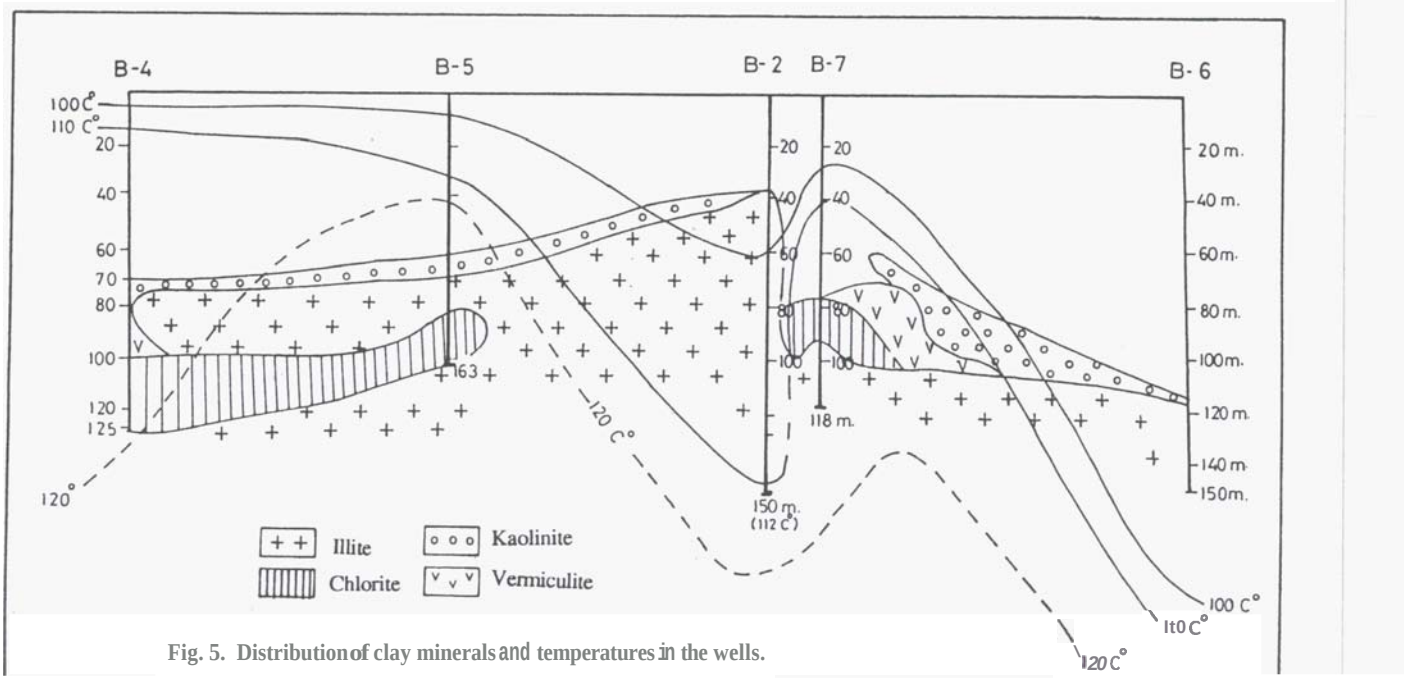


Fig. 5. Distribution of clay minerals and temperatures in the wells.

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