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Hydrogeological, hydrogeochemical and isotope geochemical features of geothermal waters in Tekkehamam and environs, western Anatolia, Turkey

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Abstract

From Early to Middle Miocene, the continental rift zones of the Büyük Menderes, the Küçük Menderes and the Gediz were formed by extensional tectonic features, which generally strike E-W and are represented by a great number of geothermal waters, epithermal Hg, Sb and Au mineralizations, and volcanic rocks of Middle Miocene to recent age. The geothermal waters and epithermal mineralizations are related to faults, which strike preferentially NW-SE and NE-SW and are located transversely to the general strike of the rift zones. These faults are probably generated by compressional tectonic stress, which leads to the deformation of uplift between two extensional rift zones. One of these continental rift zones is the rıft zone of the Büyük Menderes which is ascribed to a great number of geothermal waters such as those issuing in very important locations of Kızıldere, Tekkehamam, Salavatlı, Germencik and others with a geothermal capacity of 860 MWe in the next future. The geothermal waters of Tekkehamam and surroundings are identified to belong to the Na+K>Ca>Na and HCO_3>SO_4>CI facies. According to the Cl-SO_4-HCO_3 diagram the geothermal waters might be heated by a magmatic source due to the high content of sulfate and boron in geothermal waters. Geochemical thermometers were applied to the collected samples in the region. According to the Na-K-Mg diagram (1), part of the geothermal waters can be considered as equilibrated geothermal waters. According to the results of geochemical thermometers, the reservoir temperatures of geothermal waters range from 160 to 250°C. The δ^2H values of geothermal waters are between -61.9 to -51.8, while $\delta^{18}O$ values range from -9.23 to -5.84. The tritium contents of geothermal waters are between 0.7 to 3.3 TU. These results show that there is no mixing with cold groundwaters.

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Keywords: Western Anatolia; Tekkehamam; the rift zone of the Büyük Menderes; geothermal waters; hydrogeolological modelling

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1. Introduction

The Tekkehamam geothermal field is located in the southern part of the continental rift zone of the Büyük Menderes, within the Menderes Massive of Western Anatolia, and forms the one of the important geothermal areas (Fig. 1). The aim of this study is (i) to update the geological setting of Tekkehamam and surroundings, (ii) to describe fluid-rock interaction in the study area, (iii) to investigate the formation and development of the geothermal waters by hydrogeological, hydrogeochemical and isotopic methods, and (iv) to develop an hydrogeological modelling of the geothermal waters in the investigated area.

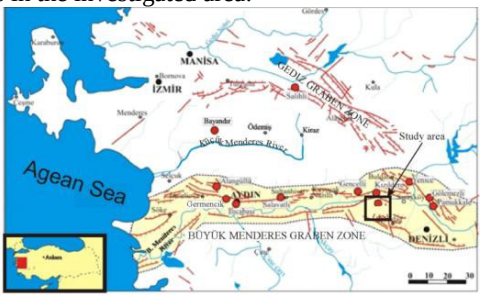

Fig 1. Location map of the geothermal waters of Tekkehamam and surroundings, in the rift zone of the Büyük Menderes within the Menderes Massif, Western Anatolia, Turkey (Adapted from[2]).

2. Geological setting

The Tekkehamam geothermal field and surroundings consist of Precambrian to Cambrian metamorphic rocks and Pliocene sedimentary rocks. As basement rocks, metamorphic rocks of the Menderes Massive are composed of gneiss, mica schists and the Iğdecik formation with altered mica schists, quartzites and marbles[1,2]. Neogene sediments consisting of Kızılburun, Sazak, Kolonkaya and Tosunlar formations overlie the metamorphic rocks discordantly which were overlaid by alluvium and travertines during Quaternary. In the İğdecik formation**,** the thick marble sequence is in the upper parts of mica schists and forms an alternation with schists and quartzites. Marbles are dark grey with light in colors, largely crystallized, good developed joints and thin to moderate clear layers (3). The metamorphic rocks are also overlain by Pliocene sedimentary rocks considered as four lithological rock members. The Kızılburun formation overlies the metamorphic rocks of the Menderes Massive discordantly. The thickness of this formation is about 300 m in which there are different lithological features. In the upper part of this formation, the grain size decreases as the carbonate contents increases. In the deeper part the Kızılburun formation consists of thick and red-brown gravels, and continues with sandstones, siltstones and clay stone rocks. The Kızılburun formation can be considered as a good geological formation for geothermal waters/exploitation, due to high contents of clay minerals.

At the bottom, the Sazak formation is composed by the alternation of clay stones, sandstones and conglomerates, silicified marls, white and yellowish marls and lacustrine limestones. An alternation of clay stones, sandstones and conglomerates outcrop in a narrow area. The Sazak formation has been generated in a lacustrine area with high carbonate sediments and low energy. The Sazak formation is ascribed to a shallow geothermal reservoir in the Kızıldere geothermal area, with a depth of 800 m and a temperature of 198°C due to the tectonic structure with faults and fissures. An age of Late Miocene to Pliocene was indicated by[4] for the Sazak formation.

The Kolonkaya formation consists of marls, siltstones, sands with gravels and weak cemented sands which display the features of a typical fan delta. There are a great number of soft-sediment deformation structures, mainly composed by medium grained, weak cemented sands, silts and marls. In this formation, load prints, drop structures, fire structures, debris intrusions, disrupted layers, slump structures and synsedimentary faults can be observed.

The Tosunlar formation is widespread in the western part of the study area and consists of multicolored red conglomerates, sandstones and fossiliferous clay stones. Components of conglomerates are gneiss, several schists, quartzites, marbles, Mesozoic limestones and gravels and blocks of the Sazak formation and