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Hydrogeological, hydrogeochemical and isotope geochemical features of Geothermal waters in Simav and environs, Western Anatolia, Turkey

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Abstract

Simav geothermal field is located in Simav graben within the Menderes Massif in Western Anatolia, Turkey. The geothermal waters in marbles, limestones and basalts can be classified as Na-HCO_3-SO4 type exchange waters with the dominant cations in increasing order of Na+K>Ca>Mg while the anions are HCO_3>SO_4>Cl. The Cl-SO_4-HCO_3 ternary diagram shows that the waters are peripheral/immature and more likely related to groundwaters heated by steam from deeper reservoirs. Quartz, aragonite, calcite and chalcedony are oversaturated at discharge temperatures while at a recomputed temperature according to the reservoir composition, only quartz, dolomite and chalcedony are oversaturated. The silica thermometer shows reservoir temperatures between 83 and 182^{0}C. The Na-K-Ca-Mg correction cation thermometers give reservoir temperatures close to the measured reservoir temperature on site in Eynal which is between 148 and 163 ^{0}C. The waters plot along the meteoric water line suggesting the source from local meteoric water and are rich in $\delta^{18}O$. This situation points to the existence of water-rock interaction in the system and/or boiling due to the high temperatures in the reservoir.

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Keywords: Turkey; Western Anatolia; Menderes Massif, Simav, geothermal system, geothermal model

1. Introduction

Simav geothermal field, one of Turkey's most important fields, is located in Simav graben within the Menderes Massif in Western Anatolia, Turkey (Fig. 1). This is on the eastern part of the graben and approximately 4 km north of Simav town and on the NE edge of the Simav plain, which is separated from the mountain by a high and steep escarpment. The purpose of this study is to understand the formation and development history of the geothermal

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waters by hydrogeological, hydrogeochemical and isotope geochemical methods and to determine the water types in the geothermal area.

2. Geologic setting

The stratigraphic sequence of the formations in Simav and environs region is given in[1]. Paleozoic metamorphic rocks are located at the base of the rock strata in the area. The rocks form the mountains that border the graben on both sides, and outcrop frequently in these mountains. These rocks are overlain by volcanic rocks and lake sediments of Miocene that were deposited in the graben along a NNE-SSW axis and formed in relation to those grabens. These formations appear on the Simav horst to the south of the graben as well as on ridges of the arm to the north of the graben, which has risen to a lower altitude. These are followed by younger formations which formed together with the Simav graben. These are spread out over the graben interior areas, which have been downthrown significantly compared with the horsts on both sides of the graben. The coarse-grained terrestrial sediments, basaltic lava deposits and thick alluvium have created a layer in the graben that is hundreds of meters thick. Based on the existing wells drilled in the area, the fractured reservoir rocks producing hot fluids in the field largely consist of Naşa Basalt, Simav metamorphics and Mesozoic limestones, while the cap rock consists of Tertiary strata of volcano-sedimentary rock. The Simav detachment, formed later, reactivated the Eocene Cyclades-Menderes thrust and its initial movement was synchronous with the intrusion of Eğrigöz granites. After Miocene, western Anatolia underwent the extensional regime that helped build the actual form. This process produced the Simav graben, which has an asymmetric structure. The southern part of the graben is limited by the Simav fault, which is roughly extended in west-east direction for more than 80 km and separates Simav Mountain from Simav plain.

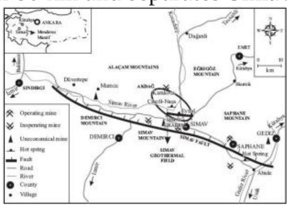

Fig. 1. Location map of the study area[1].

3. Hydrogeology, hydrogeochemistry and isotope geochemistry

3.1 Hydrogeology

Joints and faults resulting from neotectonic activity caused the developments of secondary porosity and high permeability in limestone and marble. In the study area, 3 (three) reservoir rocks and 3 (three) cap rocks were determined[1].

I. Reservoir rocks: The Nasa basalt pinching out in quaternary unit is the shallow reservoir rock. The Nasa basalt and the Toklargölü formation cover an area of 84 km^2 in the study area. The Nasa basalt covered by alluvium and Eynal formation, geothermal fluid production is active in 6 wells. In addition, hot water has been produced from the first reservoir rocks in some of the other boreholes.

II. Reservoir rocks: The Budagan limestone and the Arıkaya formation having secondary porosity and permeability are the second reservoir rocks. These formations crop out in an area of 25 km^2. These formations have longer lateral extension and are located deeper than first reservoir rocks. Therefore higher temperatures were obtained.

III. Reservoir rocks: The Balıkbası formation crops out in an area of 6 km^2 in the study area. It comprises of secondary porous and permeable marble and underlines the Sarıcasu formation having cover rock characteristics.

I. Cap rocks: The Eynal formation over the Nasa basalt contains impermeable clayey level in places. In wells around the Nasa and Citgöl thermal springs, after alluvium, impermeable levels of formations were cut. This shows that it has characteristics of cap rock. It crops out in an area of 2 km^2 in the study area.

II. Cap rocks: The Akdag volcanic rocks, the Civanadag tuffs and the Kızılbük formation form a thick cap rock. All these units cover an area of 140 km^2 in the study area.

III. Cap rock: The Sarıcasu formation has lateral and vertical transition with the third reservoir rocks. It crops out in an area of 19 km^2 in the study area.