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Mineral saturation and scaling tendencies of waters discharged from wells (>150 °C) in geothermal areas of Turkey

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Abstract

Aqueous species distribution was calculated from the chemical composition of water discharges from 27 selected production wells, with reservoir temperatures >150 °C, in seven geothermal areas including Kızıldere, Salavatlı, Germencik, Kavaklıdere-Sazdere, Salihli-Caferbeyli, Simav, and Tuzla. Twenty-five of the water compositions are relatively dilute with electro-conductivity values of 1826 to 7200 μS/cm and are dominated by Na (410 to 2027 mg/kg), Cl (45 to 1882 mg/kg), and alkalinity-CO_2 (491 to 2312 mg/kg). Two water samples from Tuzla are highly saline connate waters with Cl of 35 273 to 44 140 mg/kg and Na of 18 200 to 22 250 mg/kg.

Mineral equilibrium modeling indicates that the aquifer waters in these selected geothermal wells, with some exceptions, are oversaturated with respect to calcite, aragonite, and celestite, but undersaturated with respect to gypsum, anhydrite, fluorite, Ca-montmorillonite, anorthite, albite-low, gibbsite, illite, kaolinite, and K-feldspar. The waters are at near saturation with respect to chalcedony, quartz, amorphous silica, dolomite, and strontianite. Calculation of mineral saturation states, geochemical studies, and field observations show that carbonate minerals (calcite, aragonite, and dolomite), amorphous silica, and sulfate minerals (celestite and anhydrite) are most likely to be precipitated as scales in geothermal wells. Assessment of calcite and amorphous silica scaling tendencies for selected well waters indicates that hot injection is favorable for Tuzla well T-2 (~50–170 °C) and for Kızıldere wells R-1 and KD-6 (around 100 °C). For the other wells, cold injection (<50 °C) is favored if calcite and amorphous silica accumulation is to be avoided in injection wells.

Keywords: Turkey; aquifer geochemistry; mineral saturation; scaling; geothermal system

1. Introduction

There are eight explored and exploited liquid-dominated geothermal systems in Turkey, with aquifer temperatures ranging from 150 to 242 °C. All these are linked to the Neogene graben systems within the western Anatolian active tectonic massif, called the Menderes Massif, in western Turkey (Fig. 1). From south to north, the geothermal systems include Denizli Kızıldere, Aydın Germencik, and Aydın

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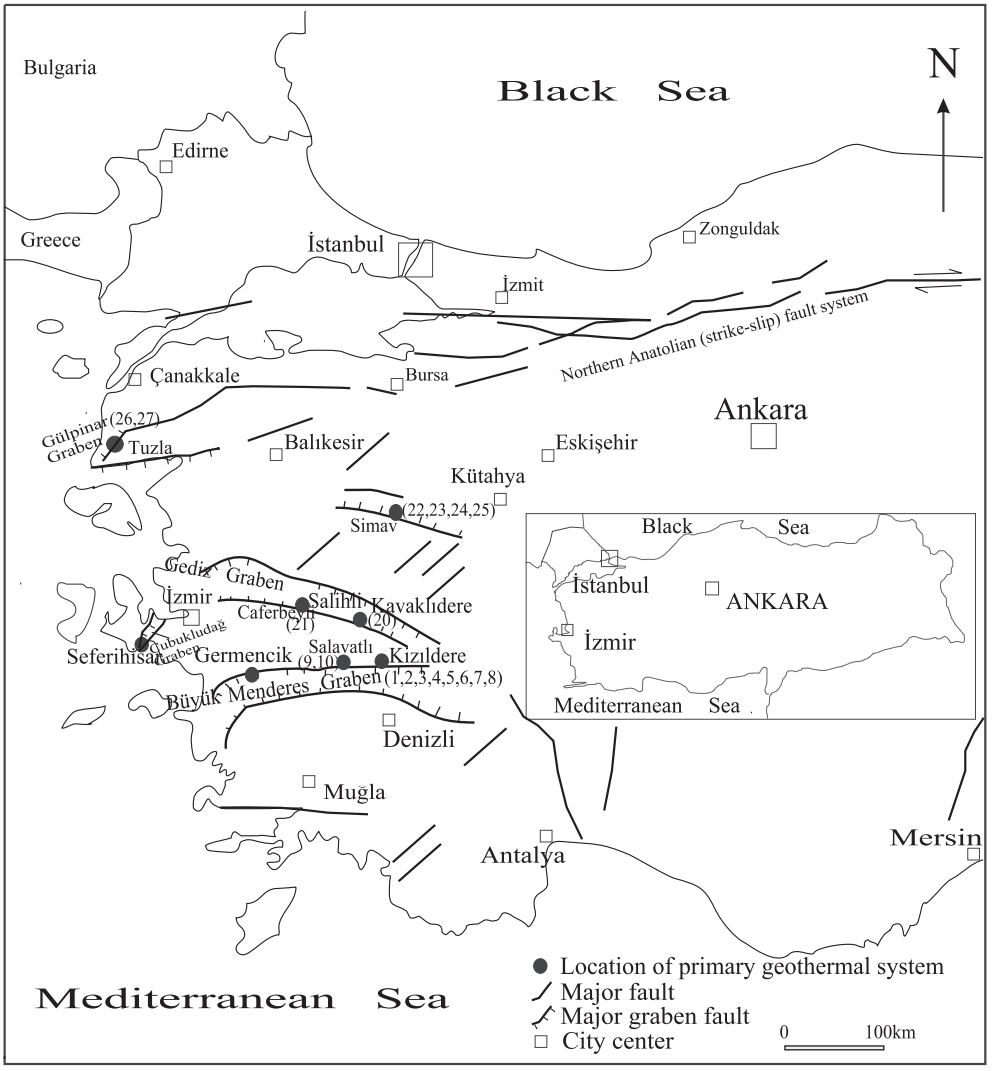

Fig. 1. Location of the primary geothermal areas and wells in Turkey. The numbers in parentheses correspond to sample locality number of wells. Geological structures are modified from Şimşek and Yıldırım (2000), Yılmaz and Karacık (2001), and Bozkurt (2001).

Salavatlı geothermal systems within the Büyük Menderes Graben; İzmir-Seferihisar within the Çubukludağ Graben; Kavaklıdere-Sazdere and Salihli-Caferbeyli within the Gediz Graben; Kütahya Simav within the Simav Graben; and Çanakkale Tuzla in the Gülpınar Graben. The basement in the aforementioned geothermal systems consists of Precambrian to Paleocene (Dora et al., 1997) Menderes Massif rocks, composed of high- to low-grade metamorphics (phyllites, quartz schists, mica schists, gneiss, marbles, dolomitic marbles) and granodiorite. Menderes Massif rocks are unconformably overlain by Neogene terrestrial sediments consisting of interbedded conglomerate, sandstone, claystone, siltstone, marl, and limestone. Neogene volcanics cover the Menderes Massif rocks and Neogene sediments in some areas. Quaternary alluvium, made up of unconsolidated granular sediments, is also observed in all the areas. Table 1 summarizes the number of wells drilled, minimum and maximum drilled depths, measured down hole temperature ranges, total discharge rate, reservoir and cap rocks, present use, and