ORIGIN OF THE HIGH BORON CONTENTS IN THE THERMAL WATERS OF THE RIFT ZONES OF THE MENDERES MASSIF, WESTERN ANATOLIA, TURKEY

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ABSTRACT

The thermal waters of Kızıldere and environs in the Büyük Menderes rift zone are marked by boron concentrations up to 32 mg/l and flows with rates of about 250 l/s into the Büyük Menderes River, thus increasing the boron contents of the river water up to 4.4 mg/l (e.g., in 1992), for a river-water flow rate of 2 m³/s. These high boron concentrations poison plants, particularly citrus fruits, in irrigated agricultural areas of the rift zone.

High boron contents in the thermal waters can be attributed to (i) unstable boron-bearing mineral phases (e.g., feldspars, micas, tourmalines, amphiboles and biotites) in the metamorphic rocks, proven by the experimental leaching tests in various rocks, and (ii) geochemical input, caused by leaching of silicic acid, and (iii) 11B/10B isotope ratio in boiling thermal waters, respectively. Therefore, high boron concentrations in the water reservoirs must be ruled out because the boron contents of the groundwaters from the Büyük Menderes in the northern part of the study area are below detection limits (0.1 mg/l). There is no single reason for the high boron concentrations measured in the thermal waters of Kızıldere and environs, rather, a concurrence of several natural factors is likely.

1 Introduction

High temperature thermal waters in the rift zones of the Menderes Massif are distinguished by boron concentrations up to 35 mg/l. Due to toxic effects of boron the economic utilization of the thermal waters is less favorable in the area as long as the geothermal waters are not remediated in the near- and mid-term. Therefore, high boron concentrations in this value poison some parts in the thermal zones of the Büyük Menderes and Gezik, i.e. citrus fruits. The waste waters from the geothermal power plant of Kızıldere flows with a flow rate of 500 l/s to the river of Büyük Menderes.

In order to give a reply to the origin of these high boron contents in the thermal waters in the Menderes Massif, we have decided to investigate the thermal field of Kızıldere and its environs in the rift zone of Büyük Menderes in combination with the origin and evolution of the thermal waters.

A research scheme carried out from 1994 to 1996, divided in two main fields: (i) geological and geochemical investigations on detailed geological mapping and rock sampling (i) and (c) comprehensive hydrogeological and hydrogeochemical investigations with sampling of groundwaters, thermal waters and river waters of the Büyük Menderes.

2 Geological setting

The investigated area is located in the northern flank of the eastern part of the rift zone of the Büyük Menderes (Fig. 1). In this area, the metamorphic basement build up by Paleozoic and Mesozoic sediments is overlain discordantly by Pliocene-Pleistocene clastic sediments. These sediments show fluvial and lacustrine characters and consist of (i) conglomerates, sandstones, siltstones, and claystones; (ii) the Maçka complex, showing felsic to intermediate rocks; (iii) the Komurca formation in a range of thickness from 30 m to 500 m, which contains yellowish green marls, silstones, and sandstones; and (iv) the Pliocene-thick Tosek formation showing alternation of conglomerate, sandstone, and mudstones with fossiliferous clay units (Fig. 2). The geosyncline is distinguished by the mineral phases of quartz, feldspar, white and black mica, tourmaline and accessory minerals. In comparison, the mica schists contain garnets additionally.

The studied field is regionally controlled by E-W trending faults. Locally, NW-SE or NE-SW trending faults are active in the field (Özgür et al., 1998a, b). The development of these faults lead to a compression, which was generated by the extension during the formation of the rift zone of Büyük Menderes (Özgür et al., 1997; Özgür, 1998).

In the studied field of Kızıldere, the metamorphic and sedimentary rocks are distinguished by intensive hydrothermal alteration which is represented by phyllitic, argillic, and silicic alteration zones. The carbonatization must be considered as a new type alteration in the thermal field of Kızıldere additionally.

3 Thermal Geochemistry

In order to investigate the origin of the high boron concentrations in thermal waters, 200 rock samples within the investigation area were collected. Boron contents in rocks, groundwaters, thermal waters, and river waters were analyzed by photometry (Robert Reit, P.E. 210) using reagents of calibrating standards, spectrophotom 140/10, and curcumin. The Precambrian to Cambrian metamorphic rocks differ from the Phanerozoic sedimentary rocks by their high boron contents (Fig. 3). The Gneissos show boron contents in a range from 6 to 28.151 ppm and a background value of 19 ppm. For comparison, the feldspar formations, which are composed of mica schists, quartzites and marbles, has a range of boron from 6 to 241 ppm and a background value of 166 ppm. The background values are 5 ppm in Kızıldere formation (range: 9 ppm to 79 ppm), 16 ppm in Sarıkız formation (range: 4 ppm to 24 ppm), 15 ppm in Kalkokaya formation (range: 2 to 681 ppm) and 48 ppm in Tosel formation (range: 15 ppm to 65 ppm). Recent mineral precipitations in the thermal waters of Kızıldere and its environs show a background value of 56 ppm in a range of 5 ppm to 2.846 ppm. The plot of B versus SO₄ and Al₂O₃ (Fig. 4) indicates a close positive correlation between boron contents and rock-forming mineral phases of quartz, feldspar and micas in the study area of Kızıldere, which can be confirmed by plot of B versus Na₂O and K₂O (Fig. 5). Boron may be incorporated in the crystal lattice of Si and Al (Christ, 1965), besides, the size of lattice depends on Al³⁺ and B⁴⁺ in 1A° and 1.48 A° in ion radius respectively.

4 Geochemical Analysis

The geochemical investigations in Kızıldere and environs show a background value of 56 ppm in a range from 5 ppm to 2.846 ppm. Recent mineral precipitations in the thermal waters of Kızıldere and its environs can be corroborated by the isotope ratios of 11B/10B (Giese, 1997; Özgür, 1998) and the values of δ⁰⁺ and δ³⁴S in thermal waters (Özgür, 1998; Özgür et al., 2001a, b). The boron deposits in depth, which occur in connection with young volcanism in the northeastern part of Turkey, i.e. the deposits of Bilecik and of Kutahya in Eskisehir, have to be taken into consideration in boron occurrence as long as the constancy of existence of such deposits has not been established.

Finally, it can be concluded, that not one single reason is the cause for the high boron concentrations measured in the thermal waters of the rift zones of the Menderes Massif, but a concurrence of several natural factors is likely.

5 References