



A conceptual model for groundwater flow and geochemical evolution of thermal fluids at the Kızılcahamam geothermal area, Galatian volcanic Province



Suzan Pasvanoğlu^{a,*}, Mehmet Çelik^b

^a *Yahya Kaptan Mah, C-14, Daire no 21 Kocaali-İzmit, Turkey*

^b *Ankara University, Geological Eng. Dept. 06830 Gölbaşı, Ankara, Turkey*

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ABSTRACT

Kızılcahamam geothermal area is one of the most important geothermal fields in the Galatian Volcanic Province northern Central Anatolia of Turkey. Kızılcahamam geothermal field is liquid-dominated system that have been developed in the rugged terrain, and usually consists of a geothermal systems that occur commonly associated with terrestrial volcanism. This field is characterized by thermal and mineralized springs, travertine, with wide alteration zones. Thermal waters are issue through the faults and fracture zones of the volcanics. The temperatures of the wells in the Kızılcahamam town center varies between 42 and 81 °C, whereas the temperature of thermal and mineralized water springs in the area of Acısu Stream and Seyhamam varies between 23 and 43 °C. Electrical conductivity values for thermal waters are between 1029 and 3700 μS/cm. Thermal waters in Kızılcahamam area are mainly Na-HCO₃-Cl and Na-Ca-HCO₃ type, with high salinity, while cold groundwater is mostly of Ca (Na, Mg)-HCO₃ type, with lower salinity. Both waters of Kızılcahamam town center and Acısu Stream appear to be derived from a deeper reservoir fluid, whereas Seyhamam thermal waters are compatible with shallow cold waters heated by steam absorbing high temperatures. High contents of some minor elements in thermal waters, such as F, B, Li, Rb, Sr and Cs probably derive from enhanced water–rock interaction.

The isotopic values of thermal water ($\delta^{18}\text{O}$, $\delta^2\text{H}$, $\delta^3\text{H}$) indicates their deep-circulating meteoric origin and allow estimation of infiltration altitude ranging between 1350 and 1750 m.a.s.l. This datum, supported by structural data, suggests the Işıkdag and Aluçdag Mountains as the recharge area of the system. As frequently observed in many geothermal systems positive ^{18}O shifts of Kızılcahamam thermal waters relative to the local meteoric line were considered to be primarily due to interaction with host rocks at elevated temperature ($T > 150\text{ }^\circ\text{C}$) and from CO₂ exsolution of thermal and mineral springs. In this system, geothermal waters are heating by an intrusive-cupola and geothermal gradient, followed by the waters rising to the surface along faults and fractures that act as hydrothermal conduits. A conceptual hydrogeochemical model was developed for a hydrogeological flow system in the Kızılcahamam Region.

1. Introduction

Located, in Central Anatolia GVP, one of the four main Neogene and Quaternary volcanic fields of Turkey, comprises a number of composite volcanic province intimately associated with development of a series of sedimentary basins (Milch, 1903; Toprak et al., 1996; Wilson et al., 1997; Kazancı, 2012; Fig. 1). The northern margin of the GVP is bordered by the Northern Anatolian Fault Zone. The active Kızılcahamam geothermal field is located 75 km NW of Ankara (Central Anatolia, Turkey) and hosted in the Tertiary GVP (Fig. 1-A). The Kızılcahamam area is the first official geopark of Turkey on a small part of

the GVP with the name “Kızılcahamam–Çamlıdere Geopark” and it was registered by the national authorized institutions in 2011 (Kazancı, 2012). The town Kızılcahamam is placed geographically on a transition zone between the semi-arid Central Anatolian plateau and the mountainous and wet northern Anatolia; therefore, plant cover and morphology change from bushes to pine forest, and from large plains to deep valleys–high summits with altitudes of 2000 m, respectively. The maximum elevation in the Kızılcahamam area is Işıkdagı Mountain (Mt.) with 2000 m. Işıkdagı Mt. is interpreted as a stratovolcano based only on morphology (Türkecan et al., 1991). Active tectonics and young volcanoes in the Kızılcahamam region have led to the formation of

* Corresponding author.

E-mail address: spasvanoglu@hotmail.com (S. Pasvanoğlu).

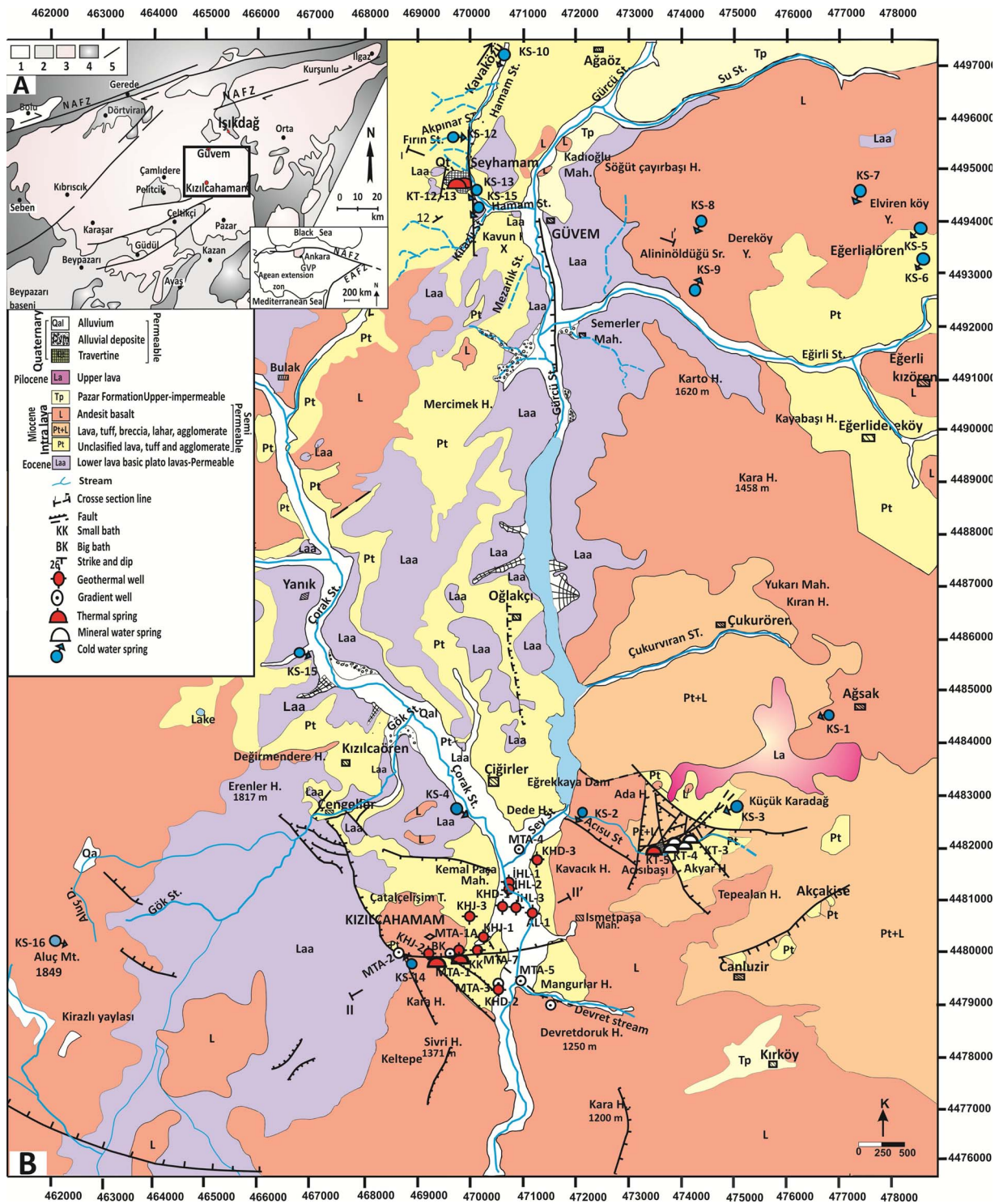


Fig. 1. Location map of the study area. Fig. 1-A. Geological map of the Galatian volcanic Province (GVP) (Yürür et al., 2002). 1) Plio-Quaternary sediments; 2) Continental Neogene sediments; 3) Volcanic and volcano-clastic rocks of GVP; 4) Basement rocks of Early Miocene, 5) Faults. Circule signs indicate the geothermal areas in the region. EAFZ: East Anatolian fault zone. NAFZ: North Anatolian fault zone. Box denotes study area shown in (A). Fig. 1-B. Geological map of Kızılcahamam geothermal field (revised from Erişen and Ünlü 1980; Canik & Pasvanoğlu 1990).

numerous hot and mineral sources.

The thermal and mineral waters in the Kızılcahamam area are located in and around (Acısu stream and Seyhamam Spa) the town of Kızılcahamam and issue through the faults and fracture zones of the volcanic. Using geothermal energy for district heating, greenhouse and for the purpose of bathing and balneology (thermal hotel) is major benefit for the region.

Following the first water analysis published in General Directorate

of Mineral Research and Exploration of Turkey (MTA) journal (Çağlar, 1947), several researchers studied about the chemical composition and possibility use of these thermal and mineral waters. Resulting from these studies several peer-reviewed contributions have been published in the international literature during the last decade (Kurtman and Şamilgil, 1975; 1988; Özbek, 1989; Güleç, 1994; Gevrek, 2000) following some older but comprehensive work (Erol, 1955; Canik, 1972; Keskin, 1974; Tatlı, 1975; Öngür, 1976; Koçak, 1977; Erişen and Ünlü, 1980; Özmutaf

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