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Types of the scaling in hyper saline geothermal system in northwest Turkey

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ABSTRACT

Tuzla is an active geothermal area located in northwestern Turkey, 80 km south of the city of Canakkale and 5 km from the Aegean Coast. The geothermal brine from this area, which is dominated by NaCl, has a typical temperature of 173 °C. Rapid withdrawal of fluid to ambient surface conditions during sampling causes precipitation of various compounds known as scaling. Scaling is one of the important problems in Tuzla geothermal system that reduces the efficiency of the geothermal power plant and causes economical loss. The aim of this study was to determine the type of scaling as a first step towards preventing its formation. The scales formed in the geothermal system were divided into two groups according to location: the ones that formed in downhole and the ones that accumulated along the surface pipeline. Both scales were examined in terms of their elemental composition, structure and morphology using XRF, XRD, and SEM, respectively. The former was found to be mainly composed of PbS (Galena) and $CaCO_3$ (aragonite or calcite). In contrast, the latter was heterogeneous in nature and consisted of mainly saponite like amorphous structure along with submicrometer-sized amorphous silica particles, layered double magnesium and iron hydroxide, and NaCl.

1. Introduction

Geothermal fluids are saturated with silica and are typically close to saturation with calcite, calcium sulphate, calcium fluoride, magnesium silicate, aluminium-silicates, opaline silica, iron–magnesium-silicates, and metal sulfide (Gunnlaugsson, 1989; Kristmannsdóttir, 1989; Honegger et al., 1989; Ölçenoğlu, 1986; Patzay et al., 2003). The reduction of temperature and pressure during production lowers the solubility and causes prodigious precipitation known as scaling. Literally tens of different types of scales have been reported. Depending upon the reservoir temperature and the chosen brine production and utilization processes, four major types of scale are encountered: (1) Carbonates such as calcium and strontium carbonates. (2) Silica and other siliceous materials. (3) Heavy metal sulfides. (4) Various types of exotic chlorides. However, calcite and silica deposits are the most frequent scale formation materials. Scale formation is a common problem in many geothermal energy exploitations (Juranek et al., 1987; Arnorsson, 1989; Gill, 1998; Potapov et al., 2001; Gallup, 2002). The most troublesome scaling deposits usually occur in the well casing at the level of first boiling (bubble point) (Patzay et al., 2003). They can be defined as hard adherent mineral deposits that precipitate from brines. The amount and location of scale depend on different factors, such as the degree of supersaturation, kinetics, solution pH and composition, CO_2 content, temperature, and pressure (Garcia et al., 2005). The most extreme cases are due to precipitation of calcium carbonate in brackish water and occur both in downhole pumps and surface installations. Silica scaling in waste water is a general problem in most sites (Kristmannsdóttir, 1989). Scaling in several Turkish wells caused scale of 3 cm thickness, leading to a 50% reduction in cross-section without flow problems at the wellhead (Ölçenoğlu, 1986; Şimşek et al., 2005). Well production and injection capacities undergo serious decline due to scaling therefore resulting serious damage to utilization systems and consequent economic loss. Scale prevention is, therefore, the most important action that must be taken at the sites. Accordingly, the chemical identification and description of the scale formed during production are of primary importance.

Geothermal fluids have been utilized for energy production in Tuzla geothermal field (TGF), which is located in northwestern Turkey, 80 km south of the city of Canakkale and 5 km from the Aegean Sea (Fig. 1). An Organic Rankine Cycle (ORC) binary plant has been selected and constructed by Ormat Company. The two phase geothermal fluid coming from the production wells is segregated at wellhead separators to steam and brine. While steam flows to the power plant naturally, brine is pumped to the power plant by

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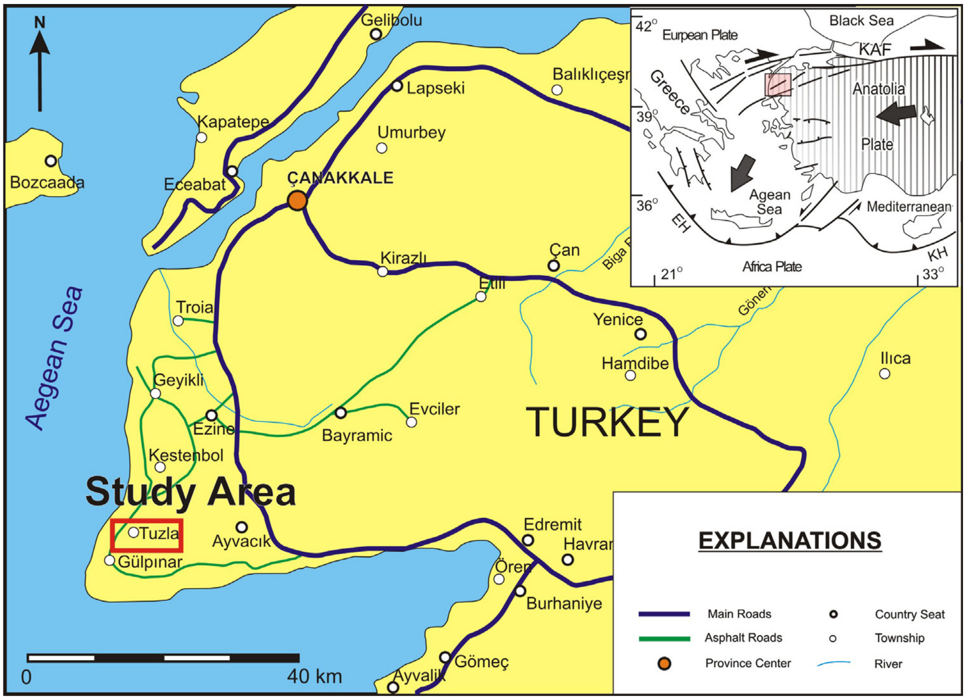

Fig. 1. Tuzla geothermal field.

booster pumps. Steam and brine transfer their thermal energy to *n*-pentane that is circulating in the electromechanical equipment in the plant, while passing through heat exchangers called vaporizers and preheaters. Later, the geothermal fluid is re-injected back into the reservoir. Two reservoir wells (T9E and T16E) have been used to produce fluid (Fig. 2). The wellhead pressure of T9E and T16E is 3.6 bar and 3.72 bar, respectively. These wells are artesian flow. No pumps have been used in these wells.

In the Tuzla geothermal system, silicate-based scaling, which is the most difficult scaling to remove, is readily observed. Therefore,

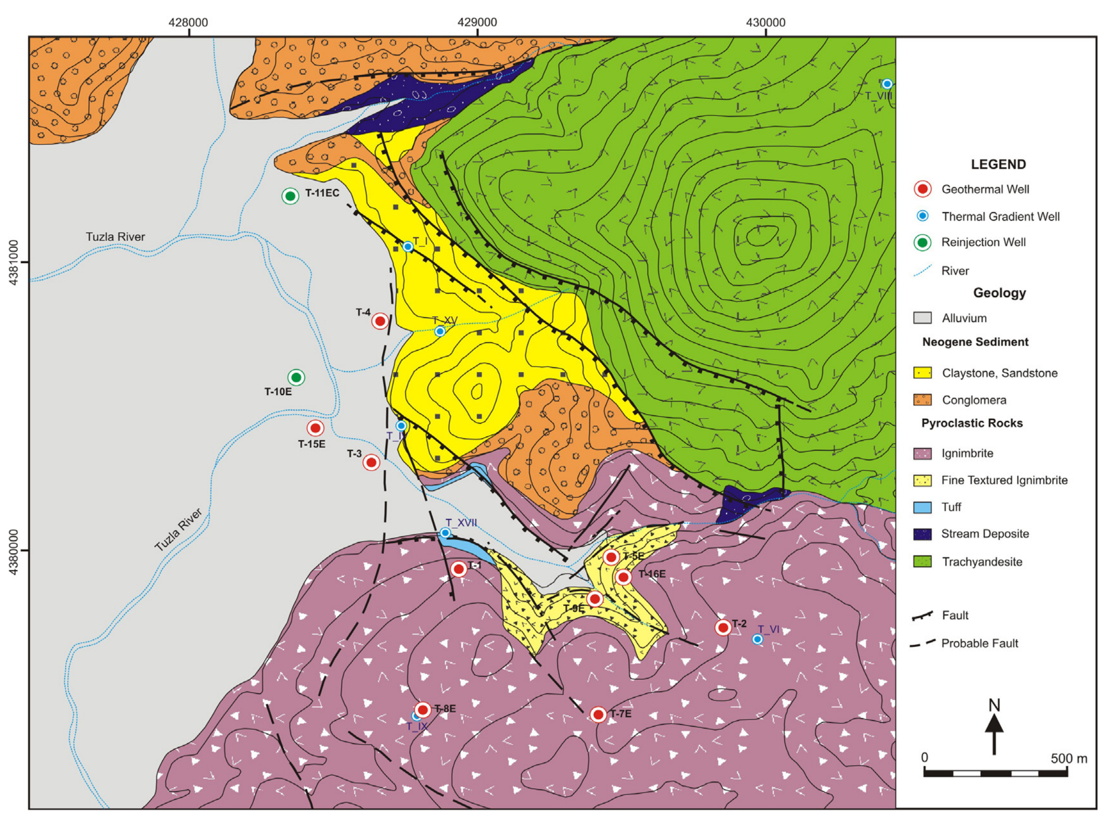

Fig. 2. Geological map of study area.

Modified from WES JEC (2006) and HU (2008a,b).