ZEOLITES AND COEXISTING AUTHIGENIC MINERALS IN MIOCENE TUFTS OF THE ALAÇATI (ÇEŞME) AREA, TURKEY

H. KAÇMAZ1,*, and U. KÖTÜRK2

1 Dokuz Eylül University, Faculty of Engineering, Department of Geological Engineering, Tınaztepe Campus, 35160, Buca-İzmir, Turkey
2 Dokuz Eylül University, Faculty of Engineering, Department of Mining Engineering, Tınaztepe Campus, 35160, Buca-İzmir, Turkey

Abstract—The zeolites and coexisting minerals of the silicic vitric tuffs in the Alaçatı (Çeşme) area, west of İzmir (Turkey), were studied. Mordenite is the most abundant zeolite in tuffs of the Alaçatı area and usually coexists with clinoptilolite-heulandite, smectite and calcite. Opal-CT was identified by means of its crystal morphology and EDX spectrum. Scanning electron microscopy (SEM) revealed the relative age relationships between the zeolites and coexisting minerals, namely mordenite, clinoptilolite-heulandite, smectite, calcite, and, in addition, opal-CT. Smectite consistently crystallized earlier than any of the zeolites, and it occasionally coats the outer walls of some of the vitric material. The zeolites are commonly located on the smectite, although some mordenites were observed to be in direct contact with glass shards that lacked a smectite coating. Clinoptilolite-heulandite formed after smectite and before mordenite. Opal-CT is seen to postdate both smectite and needle-shaped mordenite. Calcite was probably the latest mineral to crystallize in the Alaçatı tuffs. The zeolites in the tuffs of the Alaçatı area formed by dissolution of silicic vitric tuffs by Na- and Ca-rich thermal waters which passed through the fracture zone. The appearance of zeolites together with smectite along this zone may be attributed to a semi-open system which subdivided into smaller closed systems. Small changes in the pH and chemical composition of the thermal waters during alteration produced the corrosion effects observed by SEM. Small amounts of clinoptilolite-heulandite were corroded prior to crystallization of coexisting mordenite. The different compositions of the thermal waters were probably inherited from water that resulted from mixing of thermal and groundwaters.

Key Words—Alaçatı, Calcite, Clinoptilolite-heulandite, Geothermal, Miocene, Mordenite, Turkey, Zeolite.

INTRODUCTION

Zeolites are the common authigenic silicate minerals reported in sedimentary deposits, especially those that originally contained volcanic glass (Hay, 1966). The most common zeolites formed from silicic glass in saline, alkaline environments are phillipsite, clinoptilolite and erionite; less common are chabazite and mordenite (Hay, 1978). There are some cases, in hydrothermal settings, where mordenite was found to be the dominant zeolitic phase as an alteration product (Kitsopoulos, 1997; Pe-Piper, 2000). An example of mordenite formation has been noted by Pe-Piper and Tsolis-Katagas (1991) in the Miocene rhyolitic tuffs at Samos Island, Greece. This mordenite formed by hydrothermal circulation of alkaline lake waters, rich in Ca and K, through the volcanic pile. Mordenite commonly occurs within active geothermal areas as one of the earliest mineral-formed zeolites (Honda and Muffer, 1970; Kristmannsdóttir and Tomasson, 1978). Its formation temperature is known to range from ~60 to 160°C (Mas et al., 2000). Likewise, mordenite and clinoptilolite occur in the lower-T (60–110°C) parts of some active or recently active geothermal systems elsewhere in the Taupo Volcanic Zone. The main fluid in these systems is weakly saline (alkali-chloride) water, heated by geothermal activity. The formation of mordenite and clinoptilolite, reported by Brathwaite (2003), in the Ngakuru area in the Taupo Volcanic Zone (TVZ), originated from reaction of glass-rich tuff with groundwater-diluted, alkali-chloride water of geothermal origin.

The known zeolite deposits of Turkey were deposited in lacustrine environments. All of these deposits are associated with clay minerals, borates, carbonates and soda minerals. They are also found in close association with lignite-bearing lacustrine rocks and evaporate. For example, the zeolite minerals are found with borates, carbonates and clays in the Kirka (Yağımı, 1988), Emet (Yağımı and Gündoğdu, 1987) and Bigadic (Gündoğdu et al., 1989; Helvacı, 1995) areas. In the Gördes (Esenli, 1993) and Yozgat (Yağımı et al., 1997) regions, zeolites coexist with carbonate and clay minerals and they are interbedded with coal horizons. All of these deposits are rich in clinoptilolite or heulandite, while mordenite is almost absent.

The first mordenite occurrence in the Alaçatı tuffs was discovered by Kaçmaz (2001). The mineralogical