Crystal chemistry of the zeolites erionite and offretite

E. PASSAGLIA,1 G. ARTIOLI,2,* AND A. GUALTIERI1

1 Dipartimento di Scienze della Terra, Università di Modena, via S. Eufemia 19, I-41100 Modena, Italy
2 Dipartimento di Scienze della Terra, Università di Milano, via Botticelli 23, I-20133 Milano, Italy

ABSTRACT

Many known occurrences of the zeolites erionite and offretite have been characterized by electron probe microanalysis, X-ray powder diffraction, and optical microscopy. For the first time, a substantial amount of experimentally consistent and homogeneous chemical and crystallographic data have been evaluated for these natural zeolites. Systematic analysis of the data, performed by statistical multivariate analysis, leads to the following conclusions: (1) the two zeolites have well-defined compositional fields in the chemical space describing the extraframework cation content, best illustrated in a Mg-Ca(+Na)-K(+Sr+Ba) diagram; (2) no discrimination is possible on the basis of the framework Si/Al ratio because of the extensive compositional overlap between the two species, however the Si-Al content in the framework tetrahedra is the major control on the unit-cell volume dimensions, particularly in erionite; (3) the crystal chemistry of the Mg cations is a major factor in controlling the crystallization of the mineral species; (4) cation compositions at the boundary of the recognized compositional fields might be due to chemical averaging of two-phase intergrowths, although these mixed-phase occurrences are much less common than previously thought; (5) the sign of optical elongation is not a distinctive character of the two phases, it is related to the Si/Al ratio in the framework tetrahedra of each zeolite type and cannot be used for identification purposes; (6) the zeolite mineral species epitaxially overgrown on levyne in all cases is identified as erionite; in a few cases offretite was found to be overgrown on chabazite; (7) erionite samples epitaxially overgrown on levyne are substantially more Al-rich and Mg-poor than the erionite samples associated with other zeolites.

INTRODUCTION

Erionite and offretite are natural zeolites having different topologies ([ERI]- and [OFF]-topological codes following Meier and Olson 1992). Both zeolites are found in vugs of volcanic massive rocks, and available literature descriptions include: one-phase occurrences and epitaxial intergrowths of the two species (Pongiluppi 1976; Rinaldi 1976; Wise and Tschernich 1976; Hentschel and Schricke 1976; Betz and Hentschel 1978; Rychly et al. 1982), epitaxial overgrowth of both erionite and offretite on levyne (Shimazu and Mizota 1972; Passaglia et al. 1974; Sheppard et al. 1974; Wise and Tschernich 1976; England and Ostwald 1979; Birch 1989; Kile and Modreski 1988), and epitaxial overgrowth of offretite on chabazite (Passaglia and Tagliavini 1994; Passaglia et al. 1996). Only erionite is also found as an authigenic mineral in volcanoclastic silicic layers and tuffs diagenetically altered in continental (Staples and Gard 1959; Sheppard and Gude 1969; Sheppard et al. 1965; Gude and Sheppard 1981; Boles and Surdam 1979; Surdam and Eugster 1976) and marine (Shameshima 1978) environments. Given the wider range for conditions of formation, erionite is the more common of the two mineral zeolites, whereas offretite occurrences are scarce. Typical occurrences, morphological and optical features, and earlier crystal chemical studies are well described in the literature (Sheppard and Gude 1969; Wise and Tschernich 1976; Gottardi and Galli 1985; Tschernich 1992). The present study stems from two major problems commonly encountered in the characterization of erionite-offretite mineral samples: (1) The identification of mineral species is troublesome, due to the structural and crystal chemical similarities of the two zeolites; and (2) the literature descriptions available to date do not provide clear discriminatory parameters for the definition and the distinction of the two minerals, unless a complete structural study is performed.

The first point is readily justified: In the literature it is possible to find several cases where the minerals were misidentified by simple routine mineralogical analysis. An example is the sample from Beech Creek, Oregon, which was originally identified as an offretite overgrowth on levyne on the basis of optical elongation sign and X-ray powder diffraction data (Sheppard et al. 1974), but was subsequently redefined as erionite on levyne on the basis of thorough X-ray and electron diffraction analysis and adsorption capacity measurements (Bennett and Grose...