Tosudite in very low-grade metamorphic graywackes from the Málaga area (Betic Cordilleras, Spain)

MARIA DOLORES RUIZ CRUZ and BARTOLOMÉ ANDREO

Departamento de Química Inorgánica, Cristalográfía y Mineralogía, Facultad de Ciencias, Universidad de Málaga, E-29071 Malaga, Spain

Abstract: The regularly interstratified dioctahedra1 chlorite/smectite, tosudite, has been identified in Carboniferous graywackes from the Málaga region (southern Spain). It mainly occurs replacing large phyllosilicate grains, frequently intergrown with muscovite and dickite. X-ray diffraction data reveal a basal spacing of 29.2 Å that shifts at 31 Å after ethylene-glycol treatment and contracts at 23.2 Å after heating at 500°C. Transmission electron microscopy confirms the nature of a regular 1:1 interstratification and shows sequences resulting in 24 Å periodicity, due to chlorite (14 Å) and collapsed smectite (10 Å). Chemical data (AEM) indicate high Si content and about 0.60 atoms of Fe + Mg in the octahedral sheets.

The Málaga tosudite can be included within the very low-grade metamorphic association determined in the Malaguide complex (Betic Cordilleras), and ascribed to the Alpine orogeny. Minimum P–T conditions of tosudite stability are estimated around 150–170°C and 2–4 kbar on the basis of chlorite geothermometry and phengite geobarometry.

Key-words: kaolinite, mixed-layer minerals, tosudite, very low-grade metamorphism, Spain.

Introduction

Regularly interstratified dioctahedral and di,triocahedral chlorite/montmorillonite were first described in hydrothermally altered tuffs, respectively by Sudo et al. (1954) and Sudo & Kodama (1957), and the dioctahedral interstratification was named tosudite by Frank-Kamenetskii et al. (1965). At present the name tosudite is used for a 1:1 regular interstratification of chlorite and smectite that is, on average, dioctahedral (Bailey, 1982). This includes the possible interstratifications dioctahedral chlorite/dioctahedral smectite, dioctahedral chlorite/trioctahedral smectite and di,triocahedral chlorite/dioctahedral smectite. This mineral, mainly considered as hydrothermal in origin, has been reported occasionally in deeply buried sequences (Kulke, 1969; Wilson, 1971; Morrison & Parry, 1986; Daniels & Altaner, 1990; Garvie, 1992). In most cases tosudite appears in sandstones from the Paleozoic to Permo-Triassic age, which contain illite, chlorite and kaolinite as main clay minerals. The development of tosudite is related either to the action of hydrothermal fluids permeating the sandstones (Morrison & Parry, 1986) or to the transformation of preexisting minerals, mainly kaolinite or smectite, during deep burial (Kulke, 1969). The temperature at which tosudite formed appears to range from 100 to 350°C (Morrison & Parry, 1986; Ichikawa & Shimoda, 1976) although the stability field of this mixed-layer mineral is still poorly known.

In the present paper we describe a 1:1 regular interstratification of dioctahedral chlorite and dioctahedral smectite, developed in Carboniferous graywackes from the Málaga region (Betic Cordilleras, southern Spain). Since tosudite had not been previously described in metamorphic conditions, this work provides new data about the origin and evolution of dioctahedral minerals dur-