DEGRADATION OF ANTIGORITE UNDER DRY GRINDING

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Introduction

Grinding is a common treatment for layer-silicates in industrial operations, research laboratories and in studies related to soil genesis. The processes involved during grinding have been widely studied, especially for kaolinite and montmorillonite. Nevertheless, little is known of the behaviour of serpentine to grinding. The aim of this communication is to clarify the mechanically induced crystal-structure distortion of antigorite to a quasi-amorphous state using a vibration grinder. The material used in this paper is a serpentine rock from the Mulhacén group of Sierra Nevada Complex in the Betic Cordillera (SE Spain) consisting in antigorite as the major serpentine mineral with small amounts of chrysotile and bertherine. The major impurities were olivine and magnetite (both 5%). The material was ground in amounts of 100 g for 1, 10, 60 and 120 min and examined by X-ray diffraction (XRD), infrared spectroscopy (IR), thermal analyses (TG), grain-size distribution and transmission and analytical electron microscopy (TEM/AEM).

Results and discussion

The mechanism involved in the degradation of the Mulhacén antigorite by vibration grinder can be described as a series of parallel changes in the crystal structure and chemistry of the mineral. At 1 min grinding, all the infrared transmittance values increase and become better defined as a result of a decrease of particle size. When grinding was prolonged, it was observed that the OH stretching vibration band at 3673 cm⁻¹ decreased and the bands at 622 and 563 cm⁻¹ attributed, respectively, to the OH deformation and to the MgO out of plane vibrations have completely disappeared. On the other hand, the transmittance bands at 985 cm⁻¹ and 447 cm⁻¹ attributed, respectively, to the Si-O vibrations in the basal plane and to the Si-O vibrations, were well defined even after 120 min. All these results suggest that grinding affects the tetrahedral sheet to a lesser extent than the octahedral one. The AEM data support the results of the IR spectra: Mg decreased at 10 min grinding in the semi-crystalline particles, Si increased relatively and Al remained constant. At the end of grinding the composition of the resulting amorphous material is similar to that of the fresh antigorite. This suggests that at first grinding causes the expulsion of Mg by preferential destruction of the octahedral sheet. At the end of grinding, the resulting matrix consisted in amorphous material with some relics of tetrahedral and octahedral sheets weakly bound into the system.

The TG analyses showed that between 1 and 120 min grinding the temperature corresponding to the maximum loss of structural OH decreased from 748 °C to 662 °C and its weight loss also decreased. In contrast, the weight loss of the adsorbed water increased as well as the temperature
corresponding to the maximum loss. Therefore, a narrow relationship would exist between the increasing adsorbed water and the decreasing structural OH. After 120 min grinding, the OH groups remained in the system bound either in the form of water molecules, adsorbed on the degraded matrix or linked by unsaturated broken bonds.

The most significant reflections, at 7.22, 3.61Å as basal reflections and those at 2.52 and 2.16 Å as (hkl) reflections, were examined. The greatest change was observed in the (00l) reflections, which decreased even in the first minute of grinding and disappeared entirely after 120 min grinding. The peak area of the (hkl) reflections behaved otherwise: the reflection at 2.52 Å increased until 10 min of grinding and then declined to below the initial value but was still well defined even at 120 min grinding, whereas the reflection at 2.16 Å showed an intermediate behaviour between the (00l) reflections and that at 2.52 Å. Therefore, it can be inferred from the X-ray diffraction study that grinding in a vibration grinder disturbs the unit-cell along the c-axis more than along the ab-plane.

TEM and grain-size distribution studies showed that dispersion and fracturation of the coarser particles give place to smaller but more numerous ones that act on the IR spectra to produce high transmittance band intensities. With continued grinding, the ultrafine particles tend to adhere to each other due to the increased surface energy, the action of the amorphous and probably to the water adsorbed in the matrix formed by grinding. Larger agglomerates are formed and yield decreasing transmittance intensity values for the IR spectra and X-ray powder diffraction.

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