Structural Analysis of Waste Material from Mafic Rock Quarries Used for CO_2 Sequestration

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Sequestration of carbon dioxide by *ex situ* mineral carbonation has the potential to safely store CO_2 as carbonate minerals, which are stable over geological time scales. This method could become more economically viable by using solid wastes rich in Ca^{2+}, Mg^{2+} and Fe^{2+}, generated from quarrying processes. In the present study, the structural characteristics of a representative sample of waste material, obtained from a mafic rock quarry is investigated using Transmission Electron Microscopy (TEM) methods. The waste material was subjected to the ball milling process, in order to produce a nanostructured material with enhanced CO_2 adsorption capacity.

TEM experiments were carried out in both the unmilled and the ball-milled sample with the highest CO_2 uptake. A comparison of TEM images from the quarry waste before and after the ball milling process, shown in Fig. 1(a) and (b), confirms the significant reduction of particle size due to mechanical activation: the unmilled sample is predominantly composed of particles with sizes larger than 600 nm, whereas the majority of the particle sizes after ball milling is in the 30-50 nm range. Furthermore, TEM revealed that in the ball-milled sample a great percentage of particles are highly disordered or even, amorphous, implying that ball milling not only leads to nanoscale particle size reduction, but also to crystal structure amorphization of the constituent minerals. Energy dispersive X-ray spectroscopy (EDS) confirmed that the dominant mineral phases are chlorite (clinochlore, cc), actinolite (ac), albite, augite, anorthite, quartz (q) and magnetite. Such structural modifications in the crystal structure of the constituent silicate minerals are considered to be the most significant factor towards the enhancement of the CO_2 uptake of the quarry waste under study.

Although the sizes of the primary augite crystals are quite small, ranging between 8 and 40 nm, they are still highly crystalline as proved by selected area diffraction (SAD) and HRTEM experiments. The fact that these particles retain their crystallinity even after extensive ball milling, demonstrates their high resistance to mechanical activation. Having in mind that augite is an anhydrous Ca-, Mg-, Fe-bearing silicate mineral, it is suggested that the presence of augite nanocrystals in the milled quarry waste is closely linked to the high CO_2 adsorption capacity of this material. Specifically, it is considered that augite nanocrystals comprise a significant number of surface sites that promote the carbonation process.

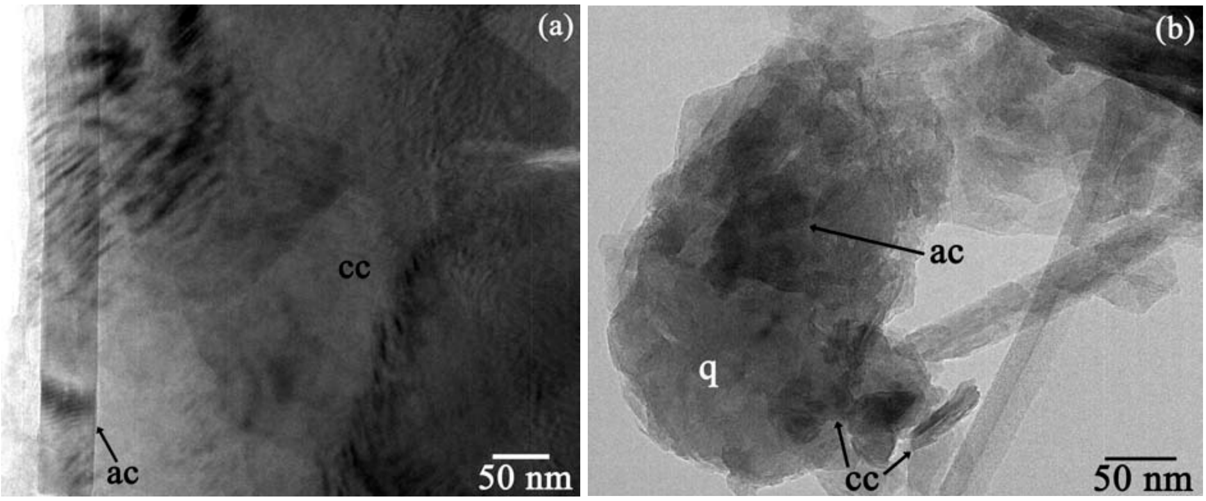

Fig. 1: TEM images of quarry waste material (a) before and (b) after ball milling.