

The alteration mechanism of ilmenite to rutile: An electron microscopy study.

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Ilmenite is the major raw material for the production of TiO₂, used in pigment industries. Natural ilmenite contains impurity elements that cause a range of problems in TiO₂ production. The production process typically involves acid treatment, which oxidises and removes the Fe and impurities, leaving behind a TiO₂-rich phase (generally rutile). The kinetics of ilmenite leaching in acid solutions has been well studied (van Dyk et al. 2001). However detailed information of the ilmenite alteration mechanism is still not available. For naturally weathered ilmenite, Grey and Reid (1975) first proposed a two-stage alteration mechanism that is currently the generally accepted model. In the first stage ilmenite undergoes weathering through oxidation and removal of Fe to form an apparently continuous series of compositions from ilmenite to pseudorutile (ideally Fe₂Ti₃O₉) as a transitional phase. The Fe is assumed to diffuse out through the unaltered oxygen lattice. In the second stage, pseudorutile undergoes incongruent dissolution, resulting in the formation of rutile, hematite, and goethite (Schroeder et al. 2002).

We have carried out an experimental study of ilmenite alteration with 0.1 molar hydrochloric and sulphuric acid at 150 °C for 31 days in Teflon[®]-lined autoclaves. The resulting products were studied by electron microprobe, scanning and transmission electron microscopy.

The alteration begins at the original ilmenite crystal surface and has also taken place along fractures in the ilmenite. However, the fracture pattern that did not exist before the reaction may itself have been generated by the reaction. Element distribution maps and chemical analyses of the reaction product within the fractures show marked depletion in Fe and Mn and a relative enrichment of Ti. Chemical analyses however, do not correspond to any stoichiometric composition, and may represent mixtures of TiO₂ and Fe₂O₃. Transmission electron microscopy is used to clarify the nature of these product phases. The fracturing is possibly driven by volume changes associated with dissolution of ilmenite and instantaneous reprecipitation of the product phases, including rutile, from an interfacial solution along an inward moving dissolution-reprecipitation front.

References

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