American Mineralogist, Volume 98, pages 879–887, 2013

New insights into the formation of diagenetic illite from TEM studies

TAO CHEN,[1,2,*] HEJING WANG,[3] TING LI,[3] AND NAN ZHENG[3]

[1]State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Wuhan 430074, China
[2]Institute of Gemology, China University of Geosciences, Wuhan 430074, China
[3]School of Earth and Space Sciences, Peking University, Beijing 100871, China

ABSTRACT

Diagenetic illite from the Proterozoic Chuanlinggou Formation, China, has been investigated using the techniques of transmission electron microscopy (TEM), selected-area electron diffraction (SAED), X-ray diffraction (XRD), scanning electron microscopy (SEM), and energy-dispersive spectrometer (EDS). Polytypes of $1M_d$ and $1M$ illite coexist in the diagenetic illite. The $1M_d$ polymorph is predominant in the <0.2 μm size fraction, which has high Al and low Mg contents and irregular crystal shapes. Lattice-fringe imaging and one-dimensional structural imaging show abundant structure defects. The $1M_d$ illite has both layer and sheet terminations caused by edge dislocations and layer displacements along **c*** caused by screw dislocations. These observations indicate that the disordered $1M_d$ structure of the diagenetic illite resulted from abundant dislocations. The dislocation serves as nucleation sites for the illite nano particles to spontaneously nucleate in the initial stage of illite formation. Such a nucleation process obeys the Ostwald ripening rule. The illite only shows a 1.0 nm thickness for each layer in high-resolution TEM images, which suggests that the illite crystals have no mixed smectite layer, and the $1M_d$ illites are authigenic and not illitized from smectite or illite/smectite. Heterogeneous nucleation led to directly crystallization of the $1M_d$ illite during the initial growth of illite in shale under a low-temperature and tectonic-stress-free environment. The results have implications for interpreting the distribution of $1M_d$ illite in sedimentary rocks.

Keywords: Diagenetic illite, heterogeneous nucleation, $1M_d$ polymorph, edge dislocation, screw dislocation