Berthierine from the Lower Cretaceous Clearwater Formation, Alberta, Canada

Edward R. C. Hornibrook and Frederick J. Longstaffe

Department of Earth Sciences, University of Western Ontario, London, Ontario, Canada N6A 5B7

Abstract: Berthierine occurs as pore-linings of well crystallized laths of variable thickness in oil-sands of the Clearwater Formation, Alberta, Canada. Berthierine crystallized early in diagenesis within portions of a deltaic/estuarine complex dominated by brackish to fresh water.

Separates prepared using high gradient magnetic separation contain approximately equal amounts of monoclinic and orthohexagonal berthierine. Minor, but variable, quantities of inseparable, iron-rich impurities mainly consist of chamosite Ib and IIb, and Fe-rich smectitic clays.

Clearwater Formation berthierine has a range of chemical compositions that differ from those reported for most other berthierines. The SiO_2 (27 – 35 wt%), Fe_2O_3 (5 – 8 wt%) and Al_2O_3 (16 – 18 wt%) contents for Clearwater Formation berthierine fall between values normally reported for berthierine and odinite. The average structural formula of five samples studied in detail is $(Fe^{2+}_{1.01}Al_{0.82}Mg_{0.46}Fe^{3+}_{0.28}Mn_{<0.01}\square_{0.43})(Si_{1.74}Al_{0.26})O_5(OH)_4$, where $\square$ represents vacancies in the octahedral sheet. The large number of vacancies in the octahedral sheet implies a di-trioctahedral character for this clay. Our results also suggest that a series of compositions can occur between ideal berthierine and odinite end-members.

Berthierine has been preserved within the Clearwater Formation because temperatures during diagenesis did not exceed 70 °C, and perhaps also because hydrocarbon emplacement limited subsequent transformation of berthierine to other phases, such as chamosite. Intense, early diagenetic, microbial activity and/or the strongly reducing environment created by later emplacement of hydrocarbons may be responsible for the Fe^{2+}/Fe^{3+} ratio of the berthierine. Because of these conditions, this ratio may have changed since initial clay crystallization. The Clearwater Formation occurrence of grain-coating Fe-rich clays provides valuable insights into possible relationships between the Fe-serpentine minerals, odinite and berthierine, and supports an important role for these phases as precursors to the grain-coating and pore-lining Fe-chlorite (chamosite) that is so common in ancient sandstones, including many hydrocarbon reservoirs.

Key Words: Berthierine • Chamosite • Diagenesis • Neoformation • Odinite • Oil Sands

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