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Ferruginous seawater facilitates the transformation of glauconite to chamosite: An example from the Mesoproterozoic Xiamaling Formation of North China

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Abstract

Berthierine and chamosite are iron-rich clay minerals that share similar chemical compositions. Berthierine forms at low temperature (25–45 °C) during early diagenesis and may transfer to chamosite at temperatures of ≥70 °C. Because the formation of berthierine and chamosite requires significant amount of Fe^{2+} supply, their presence in marine sediments is often used as a mineral proxy for ferruginous conditions in porewater. Recent studies reveal that the Precambrian oceans were characterized by pervasive ferruginous water-column conditions that may favor the formation of iron-rich clay minerals like berthierine and chamosite. To evaluate if ferruginous water-column conditions in the Precambrian ocean played a role on iron-rich clay mineral formation, we conducted an integrated petrographic, mineralogical, and geochemical study on the chamosite- and glauconite-bearing strata of the Mesoproterozoic Xiamaling Formation (~1.40–1.35 Ga) in North China. Petrographic, XRD, SEM, and EDS analyses show that the chamosites of the Xiamaling Formation was transferred from glauconite, with berthierine as an intermediate mineral phase during early diagenesis. Geochemical analyses indicate that a complete transformation from glauconite-dominated to chamosite-dominated end-members (samples) requires an addition of a large amount of Fe (16.9 wt%), Mg (2.4 wt%), and a small amount of Al (1.4 wt%), but a simultaneous release of Si (11.8 wt%) and K (6.0 wt%). Considering that the glauconite- and chamosite-bearing strata are devoid of iron-rich detrital minerals (e.g., biotite and iron oxides) and lack evidence of hydrothermal alteration, the required Fe^{2+} for glauconite-berthierine-chamosite transformation was most likely from Fe^{2+}-rich (ferruginous) seawater, which may have promoted glauconite-berthierine transformation at the very early diagenetic stage when Fe^{2+} exchange between porewater and seawater was still available. This interpretation is consistent with the high Fe_{HR}/Fe_T (but low Fe_{py}/Fe_{HR}), Fe/Al, and V/Al ratios from the hosting strata that support ferruginous depositional environments. Because most Precambrian strata have passed the oil window temperature (>50–150 °C), the preservation of berthierine would be rare and chamosite should be the representative iron-rich clay mineral. Thus, the abundance of chamosite in fine-grained, marine siliciclastic sediments may be used as a mineral indicator of ferruginous water-column conditions.

Keywords: Glauconite, berthierine, chamosite, seawater redox conditions, Mesoproterozoic, Xiamaling formation