Provenance and source rock weathering of the 2.7 Ga shallow- and deep-facies black shales from Pilbara, Western Australia

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Large perturbation in carbon cycle and rapid growth of continental crust have been recognized as the major characteristics of the Earth's surface environment 2.7 Ga ago. Under a high pCO_2 atmosphere in the Neoarchean, chemical weathering of evolving continental crust must have been extensive. In order to quantify the degree of chemical weatheirng and chemical compositions of source rocks, we explored major and rare earth element geochemistry of the 2.7 Ga shallow- and deep-facies black shales (drillcores RHDH2A and WRL1, respectively) from Pilbara, Western Australia. Those samples belong to the Fortescue Group, and their facies-dependent geochemical differences are useful in understanding their sedimentological features.

CIW (Chemical Index of Weathering; Harnois et al., 1988) values of the shallow-facies samples are mostly 85~90 (Ave.±1σ = 86±13; n = 29), while those of the deep-facies samples are mostly 95~99 (Ave.±1σ = 89±10; n = 24). Such difference is consistent with the basinal geometry, or facies-dependent residence times of detritus in the ocean (deep-facies particles took longer time before sedimentation and subject to prolonged wethering).

Normalized REE patterns (against PAAS; Post-Archean Australian average Shales) of the deep-facies shales exhibit stratigraphic/temporal changes; the lowest tuffaceous layers show basaltic (LREE-depleted) patterns with positive Ce anomary, the middle layers show more granitic (flat) patterns, and the upper layers show basaltic patterns. Those of the shallow-facies shales show PAAS-like flat patterns. These results are not consistent with a conventaional view that a deep-water environment is more stable (less subject to changes) than shallow-water environment.

Estimated source-rock compositions of the shales based on their La, Th, and Yb contents (e.g., Wronkiewicz and Condie, 1989) suggest that, in stratigraphic upward succession, continental (graniitc) component decreased in the deep-facies shales but increased in the shallow-facies shales.

These results coherently suggest deepening (subsidence) of the sedimentary basin, which is also consistent with associated changes in geochemical cycling of Fe, S, C, N, P, and Mo and microbial metabolism reported elsewhere.