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Separating silicate weathering effect from grain size and source rock effects on sediment composition of Yangtze River

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Silicate chemical weathering plays a critical role on the long-term carbon cycle and stabilizing atmospheric pCO_2 by so-called Walker feedback (a negative feedback) through neutralizing carbonic acid by dissolving Ca and Mg silicate minerals and re-precipitated as carbonates and chert (SiO_2). Consequently, it is important to quantitatively evaluate past intensity of silicate weathering. There are several proxies proposed for silicate weathering intensity based on chemical and/or mineral composition of bulk sediments. However, it becomes increasingly apparent that chemical and mineral composition of bulk sediments is significantly influenced by the difference in grain size as well as the difference in source rocks. However, none of previously proposed proxies takes into account of both the grain size effect and source rock effect simultaneously.

We selected Yangtze River because it is one of the largest river in the world with over 250 gauge stations, the large variation in bed rock geology among branches, and large ranges in topographic relief and climate. Thus we expect large ranges in chemical weathering intensity and source rock types.

In this study, we used 21 river bed sediment samples and 42 suspended particulate matter (SPM) samples collected from major branches and throughout the main stream of the Yangtze River. We conducted grain size separation of bulk river bed sediment samples into 3 fractions ($<4\mu$m, 4-16μm, 16-63μm). As to SPM samples, we did not conduct grain size separation because their median diameters range from 3.5 to 10.6 μm and more than 98% of SPM is less than 100μm. We analyzed major element composition and mineral composition of these samples by XRF and/or ICP-AES and XRD, respectively. We compare chemical and mineral compositions of the 3 size fractions of the same samples to evaluate the grain size effect on chemistry and mineralogy. We found sediments and SPM are basically composed of 3 components; one is Si, Na, Ti, Mn (quartz)-rich component representing coarser grains, another is Al, K, and Fe (clay minerals)-rich component representing finer grains, and the other is Ca and Mg (carbonate)-rich component representing dolostone and limestone fragments. Sediments from the uppermost reaches and their branches where chemical weathering is minimal, K/Al and Fe/Al of the 3 different size fractions tend to show similar values suggesting Al, Fe, and K are contained in the same component with the same composition that are diluted by the coarser fraction that are dominantly composed of quartz. However, K/Al of fine fraction relative to K/Al of coarse fraction decreases downstream with the increase in temperature and precipitation, suggesting the ration $(K/Al)_f/(K/Al)_c$ ratio may reflect the intensity of chemical weathering.

We will discuss the possibility of $(K/Al)_f/(K/Al)_c$ ratio as a quantitative indicator of silicate weathering.

Keywords: chemical weathering, sediments, chemical composition, grain size effect, source rock effect, Yangtze River