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Hindered silicate weathering by rapid erosion in continental arc: case study in the Cretaceous Xigaze forearc basin in southern Tibet, China

HEHE JIANG[1], JIANGANG WANG[1], WEI AN[2], GAOYUAN SUN[3] AND ZIYI GE[1,4]

[1]Institute of Geology and Geophysics, Chinese Academy of Sciences
[2]Hefei University of Technology
[3]Hohai University
[4]University of Chinese Academy of Sciences

Presenting Author: hehe.jiang@outlook.com

Continental arcs represent prominent topographic highs developed due to magmatic orogeny, often serving as one of the major erosion “hotspots” that supply voluminous terrestrial clastic materials into the ocean. Therefore, the development of continental arcs plays an important role in regulating the oceanic alkaline budget, further influencing the carbon cycle and climate. Recently, progress and debates on the interplay between physical denudation and chemical weathering in mountainous regions have arisen. One observation is that silicate weathering can be “hindered” by fast denudation rate and/or runoff, due to a lack of reaction time in the weathering column. However, the exact relation between physical erosion and silicate weathering, particularly under what condition the near-linear relationship between the two breaks down, and how it would affect the weathering flux, is still not clear.

We conducted a case study in the Xigaze forearc basin in southern Tibet, China, which represents a simple-provenance catchment developed at mid-low latitude under a hot-house climate. The forearc basin was developed mostly during the Late Cretaceous, following a major magmatic flare-up in the Gangdese magmatic arc adjacent to its north, which contributed most of the detritus deposited in the basin. We sampled fine-grained components (mudstone, shale and siltstone) along a continuous stratigraphic column approximately 4 km thick and analyzed the major and trace element content in their silicate proportions. The results indicate that throughout the stratigraphic column, proxies for silicate weathering, such as the chemical index of alteration (CIA), mobile/immobile element ratios (K/Al, Ca/Ti, etc.), suggesting an overall moderate silicate weathering intensity during the Late Cretaceous (i.e. CIA = 60-80). The variations in these proxies also display long-wavelength cyclicities, with the lows often correlating with increased proportion of coarse-grained components (i.e. sandstones, conglomerates and/or local slumps) in the stratigraphic column. Since the proportion of coarse-grained component is indicative of the provenance sediment supply rate, we propose that the first-order variation in the chemical weathering intensity in the studied Xigaze forearc section is most likely driven by the variation in the erosion rate in the Gangdese arc, which are ultimately controlled by the tectonic and magmatic dynamics during Neo-Tethyan subduction.