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Evolution of the continental weathering of the South American margin during the Late Cretaceous: a new look upon the tectonic-climate links.

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Continental weathering is a major sink of atmospheric CO_2 over long time scale (> 1Ma) through CO_2 consumption during chemical weathering of silicate minerals. Yet the importance of this process in climate evolution remains debated. The Late Cretaceous period records a pronounced decrease in temperatures at a global scale between 90 and 65 million years, that marks the first step of the progressive climatic decline leading to our modern climate. This cooling is concomitant to a major tectonic uplift of the African and South American continents (Friedrich et al., 2012; Gallagher et al., 1999).

The main objective of this work is to bring new constraints on the links between tectonic, weathering and climate processes, in order to explore the potentially determinant impact of this tectonic uplift on the late Cretaceous long-term cooling. We use here a new proxy of silicate weathering, based on the coupled Lu-Hf and Sm-Nd isotope systems in clays. This proxy has been recently calibrated in modern environments (Bayon et al., 2016) but has only been scarcely applied to deep-time environments. This approach was coupled to clay mineralogy, assessing the evolution of the intensity of physical erosion linked to the uplift. In this study, these coupled weathering and erosion proxies have been applied on clays recovered from DSDP site 356 (Brazil margin).

A change in detrital clay material is recorded at the Santonian-Campanian transition (83.6 Ma), characterized by a decrease in primary clay minerals (illite, chlorite) proportions and an increase of smectite. We interpret this change as reflecting an increase in chemical weathering forming pedogenic smectites, which would have followed an episode of intense mechanical erosion from the Turonian to the Santonian. Enhanced chemical weathering, lasting until the Maastrichtian, was likely associated to locally increased hydrolysing conditions, that would be consistent with the observed decrease in palygorskite proportions, a clay mineral commonly formed in arid conditions.

We interpret the ε_{Nd} decrease observed (at 87 Ma) as reflecting a change of sources with a possibly decreasing contribution of basalts from the Parana-Etendeka traps associated to an increasing contribution of old crustal material. $\Delta\varepsilon_{Hf}$ values, which represents the deviation of the sample's ε_{Hf} compared to the clay array (Bayon et al., 2016), highlight a marked increase in the intensity of chemical weathering at the transition between the Santonian and the Campanian, that is coherent with the concomitant evolution of clay mineral assemblages.

Our new results point to the existence of a relatively arid local climate in the Turonian to Santonian interval, which would have favoured the physical disaggregation of rocks during the uplift of the Brazilian margin. The new relief would thereafter have favoured, from the Campanian onward, locally enhanced precipitations and more hydrolysing conditions, and thus intensified chemical weathering. In the context of the Brazilian margin, the observed chemical weathering increase would then represent the consequence of the active uplift.

Bayon et al. (2016) EPSL 438, p. 25-36.

Friedrich et al. (2012) GSA 40(2), p. 107-110.

Gallagher and Brown (1999) Geol. Soc. Londond Sepc. Pub 153(1), p.41-53