Chemical weathering response of Northern New Guinea to orbital-scale climate variability

Yifan Du[1,2], Peter D. Clift[1,2]

1. Department of Earth Sciences, University College London, London, WC1E 6BT, UK
2. Department of Geology and Geophysics, Louisiana State University, Baton Rouge, LA, 70803,USA

This presentation participates in OSPP

Outstanding Student & PhD candidate Presentation contest

Overview

Silicate weathering is recognized as being critical in removing greenhouse CO_2 gas from the atmosphere. Although initial attempts to understand how mountain building during the Cenozoic may have affected global cooling since the Eocene mostly invoked erosion of the Himalaya and Tibetan Plateau, it has become increasingly clear that weathering fluxes in South Asia have been largely constant or even decreased during the Neogene as global average temperatures reduced.

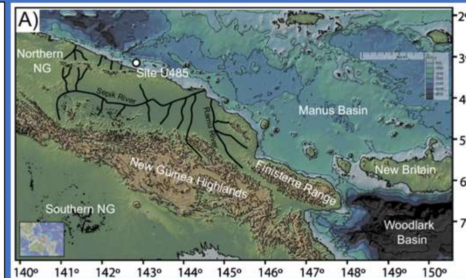
We test the idea that tropical, mafic-dominated islands are major CO_2 sinks by investigating the weathering history of New Guinea, which spans ~2600 km in length and has experienced significant tectonically driven rock uplift, especially in the last 300 k.y. Despite this potential the weathering flux from New Guinea has yet to be estimated. We look at the history of chemical weathering using marine records sampled by the International Ocean Discovery Program (IODP) Expedition 363, Site U1485.

Sampling and Methods

246 samples of muddy siltstone were taken from cores recovered at IODP Site U1485, located ~200 km west of the mouth of the Sepik River, ~19 km offshore the northern coast of Papua New Guinea and 1145 m below sea level (mbsl). Age control is based on a matrix of nannofossil and foraminifer assemblages. The samples were analyzed for grain size, major and trace element geochemistry, Sr and Nd isotope composition and clay mineralogy to define the provenance and changing character and intensity of chemical alteration of sediment sources.

Results

Although grain size is not a good proxy for erosion or chemical weathering, the size of sediment particles is an important control over the chemistry and especially the degree of chemical alteration that a sediment particle may experience.



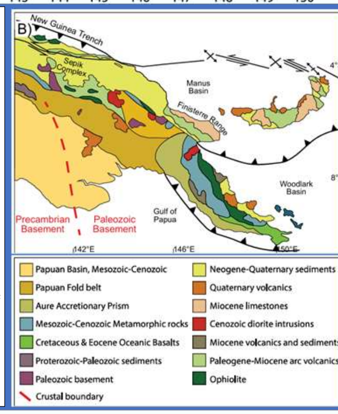


Fig. 1 Bathymetric, topographic and geologic maps of eastern New Guinea and related surrounding regions.

Base map generated by GeoMapApp (https://www.geomapapp.org); Bedrock map modified from Davies (2012).

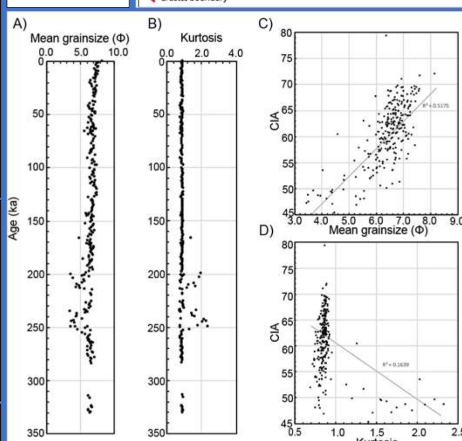


Fig. 2 Temporal evolution in mean grain size and kurtosis and cross plot of the Chemical Index of Alteration versus mean grain size and kurtosis.

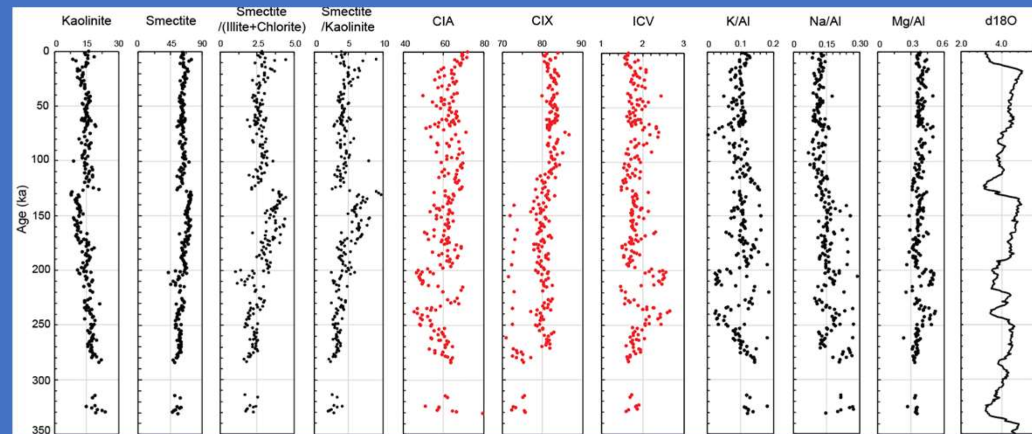


Fig. 3 Temporal evolution in chemical weathering proxies and benthic foraminifer oxygen isotope values from Westerhold et al. (2020) as a proxy for ocean temperature.

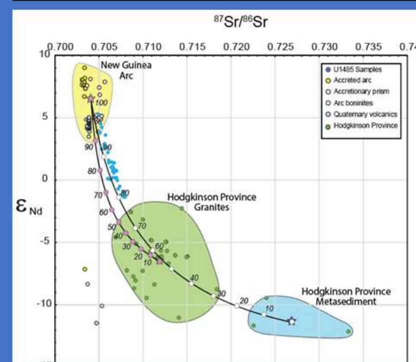


Fig. 4 Cross plot of Nd and Sr isotope compositions for samples together with bedrock analyses from the GEOROC database

Kaolinite is particularly favoured by tropical weathering in hot, humid conditions. Smectite/(illite + chlorite) is a commonly used proxy that shows the intensity of chemical weathering compared to physical weathering and erosion. The ratio between smectite and kaolinite can be used to assess the relative importance of seasonal weathering versus tropical weathering.

By using the compositions of altered sediment relative to fresh source bedrock in terms of the molar ratios of Mg/Al, Ca/Al, Na/Al, and K/Al, it is possible to determine how much CO_2 is removed per unit weight of weathered rock equivalent. A unique major element composition has been measured for each sediment.

In order to record long-term variability in chemical weathering intensity and reduce the impact of outliers, we considered a time-averaged value for ΔCO_2 based on the ages of commonly interpreted seismic reflections that can be used in the future to estimate the total erosion and CO_2 consumption flux.

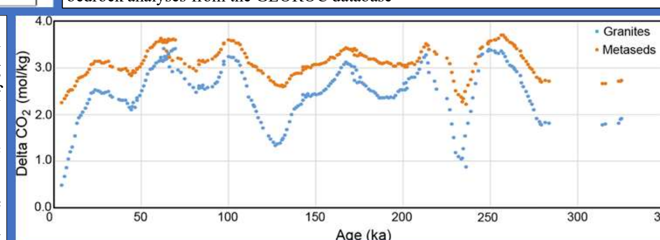


Fig. 5 Estimated development in bedrock reactivity.

Acknowledgments

This work has been submitted to *Geochemistry, Geophysics, Geosystems*. The work was supported by funds from the Charles T McCord Jr Chair in Petroleum Geology at LSU and Wolfson Fellowship at the Royal Society (UK). Samples were provided from the International Ocean Discovery Program. Thanks to Jacqueline Curtis (LSU) for her help in sample processing and analysis.