# Clumped isotope calibration of modern deep sea corals and implications for vital effects

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Deep-sea corals are a unique archive in paleoceanography. They have large banded skeletons that allow for high resolution records and have a high uranium content allowing for accurate calendar ages independent of radiocarbon age measurements. However, their use as a paleoceanographic archive is complicated by the fact that the bulk isotope and trace-metal compositions of their skeletons are generally out of isotopic equilibrium with co-existing seawater. We explore the mechanisms of this 'vital' effect through 'clumped isotope' analyses of $CO_2$ evolved by acid digestion of natural deep-sea corals.

Carbonate clumped isotope thermometry is a temperature proxy based on the extent to which $^{13}C$ and $^{18}O$ atoms are ordered into bonds with each other in the same carbonate ion in a carbonate mineral lattice. Unlike other paleothermometers, this thermometer is independent of the $\delta^{18}O$ of the water and the $\delta^{13}C$ of the DIC from which the carbonate grew.

Our calibration is based on 10 specimens of three species of deep-sea corals and one species of a surface coral spanning a temperature range of 2-25°C. Analytical precision for measurements made over the course of this study was typically in the range 1-2°C (1σ). We find that skeletal carbonate from deep-see corals shows the same relationship of $\Delta_{47}$ (the index of $^{13}C$-$^{18}O$ ordering) to temperature as does inorganic calcite. In contrast, the $\delta^{18}O$ values of these carbonates (measured simultaneously with $\Delta_{47}$ for every sample) differ markedly from equilibrium with seawater; i.e., these samples exhibit pronounced 'vital effects' in their bulk isotopic compositions. We explore several reasons why the clumped isotope compositions of deep-sea coral skeletons exhibit no evidence of a vital effect despite having large conventional isotopic vital effects. Our results also indicate that clumped isotope measurements in deep sea corals can be used to reconstruct deep ocean paleotemperatures.

# Chemical weathering during rapid erosion and subtropical climate: A case study from Taiwan

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The relationship between chemical weathering and physical erosion in rapidly exhuming mountain ranges is still a matter of debate. Subtropical climate with mean annual precipitation of 2-3m/yr within the rapidly uplifting Central Range of Taiwan provides an environment for high rates of erosion, which can be compared to rates of chemical weathering. Seven drainage basins along the eastern slopes of the Central Range have been studied with U-series isotopes in order to constrain average basin-wide chemical weathering rates. Isotopes ($^{238}U$-$^{234}U$-$^{230}Th$, $^{235}U$-$^{231}Pa$) have been analyzed from both dissolved and suspended load (>0.2μm). Preliminary results yield remarkably high $^{234}U/^{238}U$ activity ratios (1.3-3.0) in both dissolved load, and suspended load (1.07-1.19). Furthermore our data indicate $^{230}Th$ excess (1.08-1.36) in suspended particles. Although both activity ratio of the suspended load above 1 suggests a complex chemical weathering process, the high activity ratio of the dissolved load indicate extremely high mobilization of $^{234}U$ considering the humid climate. We compare this weathering measure to physical erosion rates obtained from detrital zircon fission-track (dZFT) age distributions of modern sand sediments of 6 basins in the same region. The dZFT indicate high basin-wide erosion rates with ≥ 98% of the detrital grains defining a population with a mean age of 1.1 Ma, corresponding to an average erosion rate of >4km/Myr. Taken together, this suggests a correlation between physical erosion and weathering, though a one-to-one correspondence cannot yet be demonstrated and previous published models do not account for Taiwan.