Constraining tropical climate sensitivity: the need for improved Mg/Ca calibrations

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Abstract

One way to estimate how Earth's average surface temperature will increase with rising greenhouse gas concentrations (Earth system climate sensitivity) is to compare contemporaneous temperature and greenhouse gas concentration data from paleoclimate records. Since numerical models indicate that the tropical climate sensitivity is lower and more tightly constrained than global or high-latitude climate sensitivity, measurements of tropical climate sensitivity can be considered as a lower bound for global climate sensitivity estimates. Here we measure Mg/Ca of surface foraminifera *G. ruber* from ODP Site 871 from the past 800 kyr in the western Pacific warm pool to estimate tropical Pacific equilibrium climate sensitivity to a doubling of greenhouse gas concentrations to be ~4ºC. This tropical SST sensitivity to greenhouse gas forcing is ~1-2 Cº higher than that predicted by climate models of past glacial periods or future warming for the tropical Pacific.

Further, this record of past sea-surface temperature (SST) makes use of the relationship between the Mg/Ca ratio of surface foraminifera and mean annual temperature to estimate past SST. Since high-Mg calcite in modern core-top material preferentially dissolves at water depths as shallow as 1.6 km, well above the lysocline, a correction for such dissolution is necessary. Here we present a new type of dissolution correction for Mg/Ca-based paleotemperature estimation based on a regional core-top calibration from the tropical Pacific [data from 1]. We correct the Mg/Ca data for the loss due to dissolution and then apply the corrected value to the accepted Anand equation [2], since dissolution directly affects the Mg/Ca content of the tests. When applied to existing SST records the new correction decreases the observed glacial-interglacial range of SST. Such a depth-based dissolution equation is especially important for estimating the sensitivity of surface temperatures to changes in radiative forcing, such as atmospheric greenhouse gas concentrations. We recommend such a dissolution correction for all Mg/Ca-based temperature records from open ocean, low productivity sites.

[1] Dekens (2002) *G3*, **3**. [2] Anand (2003) *Paleoceanography*, **18**.

New U-series isotope data from the Andean backarc indicate shallow melting in the Payún Matrú complex

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Essential differences between magmas in subduction zones and magmas in intraplate or MORB type settings have become apparent with an increasing number of ^{238}U-^{230}Th disequilibria data on recent volcanic rocks. Mid-ocean ridge and ocean island magmas are characterized by enrichment of thorium relative to uranium, whereas magmas related to subduction zones have been shown to vary from ^{230}Th-excess to ^{238}U-excess. In fact, radioactive equilibrium of ^{238}U and ^{230}Th (activity ratios = 1) seems to be a typical feature of many arc magmas, particular in continental arcs. We investigate three volcanic centers located in the main Andean arc and into the backarc system in order to constrain the influence induced by fluids in subduction zones.

The new U-series disequilibria analyses from the Andean backarc system support the OIB-character of the Payún Matru volcano, and the more fluid influenced arc-like character of the Infernillo volcano. Results from Maipo show radioactive equilibrium. For all samples the ($^{234}U/^{238}U$) ratios are within 1% of secular equilibrium, supporting evidence for the samples being unaffected by significant alteration.

The Infernillo samples plot beneath the equiline with 5-10% excess of ^{238}U. This feature is characteristic of those arcs deviating from equilibrium and is best ascribed a slab-derived fluid enrichment of the mantle source beneath Infernillo. The excess of ^{238}U also requires that the fluid addition occurred within the last 300 ka. In contrast data from the Payún Matru volcano show 5% excess of ^{230}Th, and plot within the ocean island basalt field as defined by literature data. In the case of OIB, partial melting is the main process fractionating Th/U and thus producing the $^{230}Th/^{238}U$ disequilibria. Analyzed samples are of Holocene age and the relatively low disequilibrium could indicate that melting induced fractionation between U and Th was limited due to shallow melting above the garnet stability field. This is supported by evidence from trace elements (e.g. low Dy/Yb).