Causes and impacts of tropical Pacific climate change during the early Pliocene warm period

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During the Pliocene warm period (ca. 5-3 Ma), global temperature was 2-3˚C warmer than present. Since solar forcing and atmospheric CO_2 were similar to today, the causes of Pliocene warmth must be related to oceanic and climatic factors. As such, the Pliocene can be used to study these factors and to validate climate models. The Ocean Drilling Program has recovered Pliocene sediments in critical regions allowing for an evaluation of the role of the tropics in Pliocene warmth. We present a synthesis of paleoceanographic data from the Indo-Pacific tropics including sea surface temperature (SST) and sub-surface temperature data, derived from analyses of alkenone saturation of organic matter in sediments, and of oxygen isotopic and elemental ratios of planktonic foraminifera. The SST data indicate a permanent El Niño-like state (referred to as 'El Padre') and an inferred reduction in Walker circulation. Eolian grain size data from these cores are used as a means to reconstruct past atmospheric circulation including the position of the Intertropical Convergence Zone. The sub-surface temperature data indicate a warmer and/or deeper thermocline, suggesting that the thermocline, whose conditions are determined at higher latitudes, plays a role in tropical climate change.

The possible explanations for, and extratropical impacts of, 'El Padre' conditions are explored by considering them in a global context. Theory and models of the processes that control the thermocline suggests that changes in the oceanic heat budget and enhanced ocean heat transport, relative to today, could explain observed Pliocene tropical temperature patterns. Observational and modeling studies indicate that these patterns could have impacted extratropical climate conditions in turn, via atmospheric teleconnections. Although much progress has been made studying the processes responsible for observed Pliocene conditions, coupled climate models cannot reproduce tropical oceanic conditions in the warm Pliocene. Solving this problem will take close interactions between modelers and the geologist that produce the paleoclimate data.

Andaman inner arc volcanoes: An evaluation of arc geochemistry and role of sediments in arc lavas

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The seismically active Andaman arc (~1100 km) is seismically very active, is one of the poorly explored double chain arc-trench systems worldwide. Along the Andaman-Nicobar subduction zone, the Indian Ocean crust and the overlying sediments are obliquely subducted beneath the Burmese plate, resulting in two inner arc volcanoes, Barren (currently active) and Narcondam (dormant). Preliminary published geochemical studies reveal that Barren island mostly erupts tholeiite to Andesitic lava while acidic and intermediate lavas are common for Narcondam island. The calculated $Si_{6.0}$ and $Ca_{6.0}$ [1] of Barren lavas are 2.98 and 10.5 respectively similar to Java volcanoes (3 and 10.1). High $Ba_{6.0}$ and $Th_{6.0}$ values (70 and 1) of arc basalts suggest substantial sediments input or source enrichment. The linear mixing as shown by Pb-Pb isotopic ratios suggest Barren lavas must have formed between two component mixing of depleted mantle (or N- MORB mantle) and oceanic sediments. Uniform ε_{Nd} and $^{87}Sr/^{86}Sr$ ratios further suggest homogeneity of subducting slab. The role of sediments in arc volcanism is also evident in incompatible trace element ratios. The Barren lavas show strongly increasing Ba/Th (i.e. indices of fluid addition) with decreasing Th/Nb (indices of sediment addition), and a maximum Ba/Th of about 100. Ba/Th and Nb/Ta co variations are comparatively weak and the lowest Ba/Th samples (~47) note the highest Nb/Ta value (14).

The tholeiitic basalts at Barren suggest its generation from subarc mantle at relatively high pressure and at low degrees of melting vis-à-vis Narcondam volcanics which display strong evidences of magma mixing.

[1] Plank & Langmuir (1988) *Earth Planet Sci Lett* **90**, 349-370.