Gateways to Glaciation

Although many people associate plate tectonics with earthquakes and volcanoes, relationships exist between plate tectonics, ocean current circulation, sedimentation, and climatic changes. The reconfiguring of oceans and continents, particularly the opening and closing of oceanic gateways and associated changes in thermohaline circulation and heat transport, play an important role in global climate change. Two recent ODP expeditions addressed these interrelationships, one near Panama and the other near Antarctica.

The Rise of Panama

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The Earth's climate system has experienced large changes during the past few million years. This long-term evolution from extreme warmth with ice-free poles to a globe with bipolar glaciation and massive continental ice sheets can be linked to plate tectonic processes that altered the climate system. The final closure of the Central American Seaway has been a key candidate to cause the transition from pronounced Pliocene warmth to the onset of major ice sheet growth in the Northern Hemisphere between 3.1 and 2.7 million years ago.

Through cores obtained by ocean drilling, scientists found that the gradual shoaling of the Central American Seaway during the Pliocene altered the distribution of freshwater and heat in the global ocean. Surface- and deep-water circulation changes in the Atlantic, Pacific, and Arctic Oceans occurred as a consequence of the restriction of interbasin surface-water exchange by the tectonic closure of the Central American Seaway between about 4.6 and 2.7 million years ago. The altered oceanic circulation patterns increased thermohaline heat and moisture transport from low to high northern latitudes (Haug and Tiedemann, 1998; Haug *et al.,* 2001). The closure of the Central American Seaway initially pushed the climate system toward warmer conditions, the so-called Pliocene Warm Period between 4.6 and 3.1 million years ago. However, the change in physical boundary conditions ultimately preconditioned the global climate system towards major ice sheet growth in the Northern Hemisphere, which started between 3.1 and 2.5 million years ago.

Modern Pacific-Caribbean Sea Surface Salinity Contrast

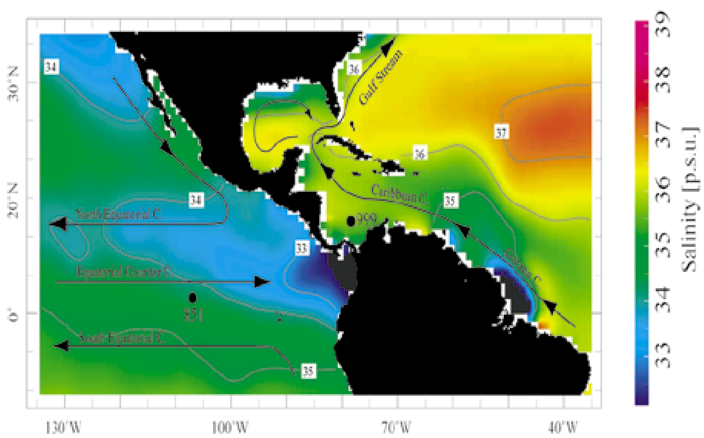

Figure 1. Major surface ocean currents of equatorial west Atlantic-Caribbean Sea and eastern equatorial Pacific and surface ocean salinities in per mil *(colors and small numbers)*. Large circles indicate locations of ODP Sites 999 and 851.

Pacific-Caribbean comparison of planktic $\delta^{18}O$-records

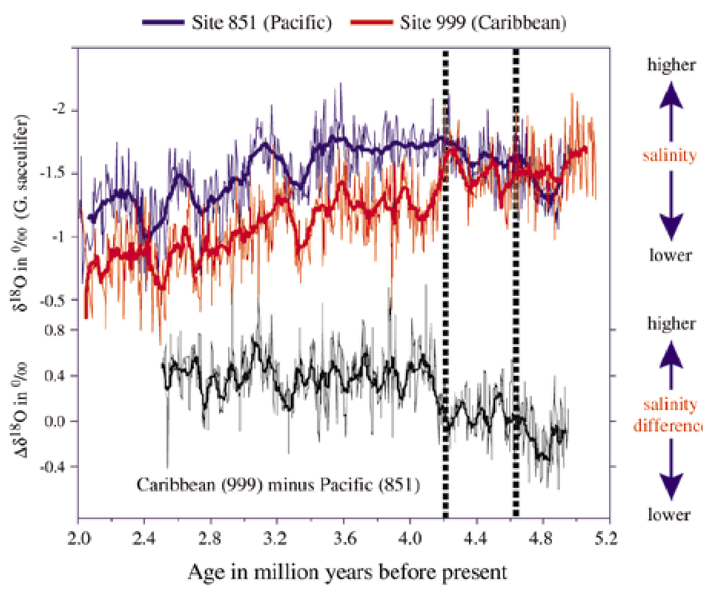

Figure 2. The planktonic foraminifera stable isotope records from ODP Sites 999 (Caribbean Sea) and 851 (equatorial east Pacific) span a time interval 2.2-5.3 million years before present and indicate the evolution of sea surface salinities in the Atlantic/Caribbean and Pacific during the uplift of the Central American Isthmus. The modern salinity contrast developed between 4.7 and 4.2 million years ago.