

WHEN DID THE ISTHMUS OF PANAMA EMERGE?  
BIOGEOGRAPHIC, PALEOBATHYMETRIC AND EVOLUTIONARY EVIDENCE  
FROM BENTHIC FORAMINIFERA

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In middle Miocene time, a seaway across the present southern Central American isthmus connected tropical Atlantic and Pacific waters. As the isthmus emerged from the sea, it constricted the Caribbean - Eastern Pacific seaway, affecting the evolution of marine organisms, oceanic circulation and global climate. During the late Miocene, southern Central America was a complex island-arc archipelago between Pacific and Caribbean waters with three principal marine corridors connecting Pacific and Caribbean waters: the Panama Isthmus strait in the Panama Canal Basin, the northern Costa Rica/southern Nicaragua strait, and the Atrato strait of northwestern Colombia. This study establishes the timing of the closure of the seaway using biogeographic, ecologic and evolutionary changes in Neogene benthic foraminifera from Panama and Costa Rica, and previous research on benthic foraminifera from the Colombia strait.

Benthic foraminifera of the Gatun Formation, near the Caribbean entrance to the Panama Canal, have a strong Caribbean affinity, which indicates that the southern Central American archipelago had formed an effective biogeographic barrier between Pacific and Caribbean surface waters by 8 Ma. Seventy-eight percent of Gatun taxa have been found in both Caribbean and eastern Pacific Neogene to Recent sediments, but 21 % have never been found in eastern Pacific sediments. Based on ecologic associations of the extant species, Gatun assemblages are from an inner neritic, siliciclastic environment about 25 m deep, which indicates that both the Panama Isthmus and northern Costa Rica straits were closed at this time. However, paleobathymetries previously recorded for the third, Colombia strait were as deep as 750 m, suggesting Caribbean-Pacific surface-water mixing in this area.

Benthic foraminiferal assemblages of the Chagres Formation, Panama Canal area, indicate that by about 6 Ma, the Panama Isthmus strait had reconnected Caribbean and Pacific waters to allow Pacific waters at least 200 m deep to flow into the Caribbean. It follows that the other two principal straits were open to these or greater depths. However, late Miocene to early Pliocene, upper bathyal and neritic benthic foraminifera from localities between the Panama and Costa Rica straits have a strong Caribbean affinity, which suggests that Pacific influence on Caribbean neritic faunas was restricted in lateral extent to the Panama Canal vicinity.

These data demonstrate that an effective biogeographic barrier had formed between tropical Atlantic and Pacific waters by 8 Ma, far earlier than seaway closure estimated at 3-4 Ma. The originations of these taxa also support relatively early evolution. First occurrences indicate increased speciation about 7 Ma and little thereafter. Thus, by the time of the Pacific incursion about 6 Ma, the evolution of Caribbean faunas had advanced to the point that an increased connection of Pacific and Caribbean waters produced no discernible, long-term effect on Caribbean benthic foraminifera.