

The Effect of Gateways on Ocean Circulation Patterns in the Cenozoic

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Both geological data and climate model studies indicate that substantially different patterns of the global ocean circulation have existed throughout the Cenozoic. In particular, the meridional overturning circulation, which refers to the zonally averaged flow in each basin as a function of latitude and depth, depends on the connection of the different ocean basins by gateways at either high or low latitudes. In the modern climate system there is strong deep-water formation in the North Atlantic, while in the Pacific no deep-water formation occurs, often referred to as the ‘Conveyor’ circulation. This asymmetry in the meridional overturning circulation has strong implications for, e.g., the temperate Western European climate because of the associated northward heat-transport. Fully coupled climate model simulations of the late Oligocene and early Miocene have indicated a “northern sinking” type of circulation, with (shallow) deep-water formation in both the North Pacific Ocean and the North Atlantic Ocean. Ocean model studies with idealized continental geometries can help to explain why a certain circulation pattern is found. Here, we study the effect of two types of asymmetry in the continental distribution: (i) the relative northward extent of the Pacific and the Atlantic basin, and (ii) the existence of a circum-global gateway at low latitudes. The more northward extent of the Pacific basin in the Oligocene makes the Conveyor solution less likely and facilitates deep-water formation in the North Pacific compared to the North Atlantic. The low-latitude gateway on the other hand, allows salinity and heat exchange between the two main ocean basins and therefore leads to deep-water formation in both the North Atlantic and the North Pacific.