

EVOLUTION OF OCEAN CIRCULATION DURING THE CENOZOIC

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Today the surface circulation in the oceans is dominated by tropical-subtropical anticyclonic gyres in the northern and southern hemispheres, separated from cyclonic gyres in the polar regions by subtropical and polar fronts. The deep circulation acts as a conveyor, with surface water sinking to the depths in the Arctic and Norwegian-Greenland Sea, flowing southward in the interior of the Atlantic, then eastward through the Southern Ocean and turning northward through the depths of the Pacific. The loss of surface water from the Norwegian-Greenland Sea and Arctic is compensated by flow from the Pacific to the Indian Ocean, around Africa to the South Atlantic, across the equator to the North Atlantic and then across the Greenland-Scotland Ridge into the polar seas. The distribution of Paleogene calcareous plankton indicates that the circulation then was very different and that there were no subtropical or polar fronts. The modern circulation developed in response to the opening of passages between Antarctica and Australia-Tasmania and South America, formation and subsidence of the Greenland-Scotland Ridge, and closure of the Tethys and Panamanian Isthmus. Each of these events changed ocean circulation, initially by redirecting the flows of currents as passages opened, and later by creating salinity differences between the oceans as connections closed. These changes in ocean circulation also had a profound effect on the evolution of the global climate during the Cenozoic.