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Organic carbon and red-bed deposition - alternations in the state of the ocean?

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Climate model simulations of the warm Cretaceous indicate that, without polar ice, seasonal reversals of the atmospheric pressure systems occur at the poles. This is in contrast to the present situation where polar ice forces year-round polar highs. The present polar highs are responsible for stabilizing the wind systems, with polar Easterlies, mid-latitude Westerlies, and tropical Easterlies. Although there are seasonal variations in the boundaries between these wind systems, particularly the polar Easterlies and the Westerlies, they are integrated by the ocean into a relatively stable circulation system. The winds generate tropical-subtropical anticyclonic gyres and high-latitude cyclonic gyres. Between these gyres are frontal systems that form beneath the maxima of the Westerlies. The region of sinking water stretches across about 5˚ of latitude and bounded equatorward by the subtropical front and poleward by the polar front. The water sinking along these frontal systems forms the ocean thermocline which extends equatorward and forms a floor beneath the anticyclonic gyres. The polar cyclonic gyres convect from the ocean surface to bottom and directly communicate with the ocean interior beneath the thermocline. The convecting polar water supplies oxygen to the ocean interior favoring deposition of oxidized red clays and preventing any widespread development of anoxic conditions.

If reversals of the polar atmospheric pressure systems occur, the winds at mid- and high-latitudes become unstable. Westerlies are developed only during winter, and during the remainder of the year winds are light and variable, and may even reverse. The result is that the gyral systems would be replaced by mesoscale eddies. Without constant Westerly wind forcing the frontal systems would not develop, and there would be no thermal or haline pycnocline. Without well developed cyclonic circulation in the

polar regions there would be no steady supply of oxygen to the ocean interior. Mixing in the ocean would be controlled by the eddies, with anticyclonic eddies pumping water downward, and cyclonic eddies pumping water upward. Motion of the eddies would be under the control of ocean bathymetry. Without a steady supply of oxygen to the deep sea, but frequent open-ocean upwelling by cyclonic eddies, the deep sea would be prone to become anoxic.

The stability of the present ocean circulation system depends on steady Westerly winds which in turn require ice-forced high pressure at the poles. The critical factor permitting reversal of atmospheric pressure systems and unstable wind systems was absence of ice at the poles during the summer. When there was no ice, the northern pole was water, whereas the southern pole was land probably covered by coniferous vegetation. Water at the north pole would be warmer than the surrounding land during winter and cooler during summer, and opposite conditions would prevail at the southern pole.