Goldschmidt 2000
September 3rd–8th, 2000
Oxford, UK.

Journal of Conference Abstracts
Volume 5(2), 1127

Models of Haline-Thermal Mode Switching in Palaeo Oceans

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We show that models of ocean circulation configured with topographies are very different from today's, such as that of the late Permian, can support thermohaline circulation driven by evaporation from the subtropics (haline mode) or polar sinking circulation driven by heat loss at the poles (thermal mode). General circulation model studies show that the haline mode is inherently unstable and is periodically (every few thousand years) flushed by a switch to polar thermal convection of the thermal mode.

Here we explore and understand the essential mechanism of the haline-thermal mode switching using an idealised box model. The period of the switching increases with the amplitude of surface freshwater flux and decreases with ocean vertical mixing rate. When the amplitude of surface freshwater flux exceeds a certain threshold the haline mode stabilizes.

The haline-thermal mode switching has important implications for bio-geochemical cycles in the ocean. During the haline mode the deep ocean is highly stratified and stagnant, and experiments with bio-geochemical models shows that it can gradually become very depleted in dissolved oxygen. On switching to the transient flushing thermal mode the deep ocean is replenished with oxygen due to strong ventilation from the surface. In this way oscillations between thermohaline modes could be imprinted in the deep-sea sedimentary records with a cycle of the order of a few thousands of years. The period of the oscillations in our simple model determines whether, and for how long, deep-sea anoxia might persist.