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RESPONSE OF LATE ORDOVICIAN GLOBAL OCEAN CIRCULATION AND OCEAN TEMPERATURE TO CHANGES IN SEA LEVEL, CONTINENTAL DRIFT, AND ATMOSPHERIC PCO_2

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We performed sensitivity experiments using an ocean general circulation model at two stages of the Late Ordovician (Caradocian, ~454 Ma; Ashgillian, ~446 Ma) under a range of atmospheric pCO_2 values (8-18x pre-industrial atmospheric level) in two different modes - with high and low sea levels.

Changes in paleogeography during the two time slices have only a minor effect on the surface circulation pattern. The most significant change occurred in the Iapetus Ocean. The northward movement of Baltica in the Ashgillian narrowed the Iapetus Ocean, which in turn, narrowed and slowed down the Iapetus Current. Changes in atmospheric pCO_2 have almost no effect on the global ocean circulation pattern. Sea level change is the most important factor that affects Late Ordovician ocean circulation. The further restriction of the Iapetus Ocean with the exposed shelf areas at low sea level narrowed and intensified the Iapetus Current.

Our results also show that the long-term global cooling trend during the Late Ordovician and the cool-water carbonates of North America, which was situated close to the equator, can be explained by progressive cooling of the global ocean in response to lower levels of atmospheric pCO_2 coupled with sea level and paleogeographic changes. Atmospheric pCO_2 has the strongest effect on surface and deep water temperatures. This is consistent with the interpretation that global cooling during the Late Ordovician could have been the result of a drawdown of pCO_2 due to the deposition of organic matter or by increased silicate weathering.

Furthermore, we show that meridional overturning was the main mechanism of poleward ocean heat transport. The response of the meridional overturning to changes in paleogeography, atmospheric pCO_2, and sea level is stronger than the response of the surface circulation to these perturbations. In all simulations, a drop in sea level led to a reduction in poleward ocean heat transport. This indicates a possible positive feedback that could have led to enhanced global cooling in response to a pre-glaciation sea level drop.

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