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Deep Water Recycling and Cyclic Sea Level Change on a Supercontinental Time Scale

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First-order variations in sea level exhibit amplitudes of ∼200 m over periods that coincide with those of supercontinental cycles (∼200-300 Myr). Proposed mechanisms for this sea level change include processes that change ocean basin container volume (changes to the volumes of spreading ridges, and the emplacement or removal of sedimentary and volcanic materials) and the thermal elevation of supercontinents due to trapping of heat beneath them. Here we investigate deep water recycling as an alternative mechanism: if the amount of water that enters the mantle at subduction zones (regassing) is not balanced by the water released at mid-ocean ridges (degassing), the volume of water in the oceans may change, affecting global sea level. Previous modeling studies of subduction water fluxes suggest that the amount of water that can reach the deep mantle is well explained by a linear combination of subduction velocity and age of the subducting plate, while the rate of water degassing from the mantle and ridges is believed to be proportional to the spreading rate. We explore the relative importance of each factor by first developing a parameterized model for an idealized deep water recycling system. We find that cyclic changes in tectonic rates can induce cyclic changes in sea level because they affect regassing rates differently than degassing rates. The amplitude of the sea level change produced depends on the period and amplitude of the tectonic variations, and on the efficiency of degassing and regassing. Next, we used subducting plate velocities and ages from tectonic reconstructions to compute rates of degassing and regassing, and associated sea level change, for the last supercontinental cycle. We find that deep water recycling may be comparable in magnitude to other sea level changing mechanisms over the last supercontinent cycle, and therefore may be an important component of the sea level budget. Our model can be used to gain a more complete picture of the dynamics of sea level on a supercontinental time scale, and for understanding water cycling within the deeper mantle.