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Abstract

Title: *Deep Water Cycling and 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 supercontinent 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 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. Parameterized models of whole mantle convection have previously been used to study deep water recycling over the history of the Earth [1,4]. These models provide valuable insight on the gross hydrological evolution of an Earth-like planet, but are unable to capture changes on ~ 10^1-10^2 Ma time scales; time scales which can represent drastic variations in the tectonic setting.

Modeling studies of subduction water fluxes suggest that the amount of water that can reach the deep mantle is well correlated with the age and velocity of the subducting plate [3], and that the rate of water outgassed from the mantle at ridges is proportional to the spreading rate [2]. We use plate motion history reconstructions [5] to obtain these highly time-dependent tectonic parameters that are important for deep water recycling, and explore various parameterizations of regassing in terms of their dependence on slab age and plate velocity. This provides a better understanding of the interaction between tectonics and deep water cycling, and allows us to study in more detail the exchange of water between Earth's oceans and the mantle over the last 230 Ma.

We find that cyclic changes in tectonic rates can induce cyclic changes in sea level because they affect regassing rates differently than degassing rates, and that the magnitude of these changes may be comparable in to other sea level changing mechanisms over the last supercontinent cycle.

References

[1] Crowley, John W; Gérault, Mélanie, and O'Connell, Richard J. On the relative influence of heat and water transport on planetary dynamics. Earth and Planetary Science Letters, 310(3):380–388, 2011.

[2] Li, Mingming; Black, Benjamin; Zhong, Shijie; Manga, Michael; Rudolph, Maxwell L, and Olson, Peter. Quantifying melt production and degassing rate at mid-ocean ridges from global mantle convection models with plate motion history. Geochemistry, Geophysics, Geosystems, 17(7):2884–2904, 2016.

[3] Magni, Valentina; Bouilhol, Pierre, and van Hunen, Jeroen. Deep water recycling through time. Geochemistry, Geophysics, Geosystems, 15(11):4203–4216, 2014.

[4] McGovern, Patrick J and Schubert, Gerald. Thermal evolution of the earth: effects of volatile exchange between atmosphere and interior. Earth and planetary science letters, 96(1-2):27–37, 1989.

[5] Müller, R Dietmar; Seton, Maria; Zahirovic, Sabin; Williams, Simon E; Matthews, Kara J;Wright, Nicky M; Shephard, Grace E; Maloney, Kayla T; Barnett-Moore, Nicholas; Hosseinpour, Maral, and others, . Ocean basin evolution and global-scale plate reorganization events since pangea breakup. Annual Review of Earth and Planetary Sciences, 44:107–138, 2016.