Implications of Subduction Rehydration for Earth's Deep Water Cycle

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The presence of liquid water is the principle difference between our Earth and other planets in the solar system. The global ocean is the obvious surface expression of this. The 'standard model' for the genesis of the oceans is that they are exhalations from Earth's deep interior continually rinsed through surface rocks by the global hydrologic cycle. The question of how much water resides within the Earth's deep interior remains unresolved and is a matter of vigorous ongoing scientific debate. We have addressed the question of water distribution between the exosphere and the mantle throughout Earth's history with simple mass balance considerations. In our model, water is outgassed from the mantle into the exosphere (atmosphere + continental crust) during pressure-release melting at mid-ocean ridges and hotspots. Plate subduction may transport water back from the surface into the deeper mantle thereby 'closing' the global geologic water cycle. In series of some 5000 model runs we have thoroughly explored the mutual effect of model parameters. All models correctly predict the formation of the present-day oceans but differ in their predicted sea-level changes through time and in the amount of water in the present-day mantle. To distinguish which model runs are the most realistic we use geochemical constraints and observed sealevel changes during the Phanerozoic. Recently Dixon et al. [2002] estimated water concentrations for some of the major mantle components and concluded that the most primitive (FOZO) are significantly wetter than the recycling associated EM or HIMU mantle components and the even drier depleted mantle source that melts to form MORB. Sealevel changes over hundreds of million of years are notoriously bad constrained. But a maximum drop in sealevel of 400-600m appears to be an upper bound. We find that only those model runs are consistent with these constraints in which deep water subduction is limited and in which the present-day mantle is relatively dry containing much less water than the exosphere. We therefore suggest a global water cycle model in which the oceans have formed by efficient outgassing of the mantle. Deep water recycling is limited and the present-day depleted mantle will contain a small volume fraction of more primitive wet mantle in addition to drier recycling related enriched components. This scenario is consistent with the observation that hotspots with a FOZO-component in their source will make wetter basalts than hotspots whose mantle sources contain a larger fraction of EM and HIMU components.

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