Effects on onset and stability of plate-like behavior in the global mantle water cycle

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In our prevuous study, the rheological properties of hydrous mantle minerals would have the negative thermal feedback (high heat flow across the oceanic lithosphere and colder mantle temperature when the rheological strength of hydrous mantle minerals is strong enough) [Nakagawa et al., 2015]. However, the yield strength in that study was not consistent with that found from deformation experiments [Kohlstedt et al., 1995]. Moreover, the hydrous oceanic crust might occur to the lubrication that could enhance the activity of plate-like behavior caused by mantle volatiles [Crameri et al., 2012; Bercovici, 1998]. Here we examine to find the stable plate tectonics-like behavoir from weak to strong oceanic lithosphere that seems to be consistent with the laboratory experiments in numerical mantle convection simulations with water migration [Nakagawa and Speigeleman, to be submitted]. Two water cycle regime with the stable plate-like behavior would be found as a function of ductile yead strength and friction coefficient of brittle deformation, which would be 'regassng dominated cycle' for weaker oceanic lithosphere and 'balanced water cycle' for stronger oceanic lithosphere because the faster plate velocity cold be expected for the weaker oceanic lithosphere than for the stronger oceanic lithosphere. With the constraint of mantle water content [Hirschmann, 2006; Hirschmann and Kohlstedt, 2012], the balanced water cycle regime would be preferable for reconciling the mantle water cycle. The onset timing of plate-like behavior would be much earlier than the dry mantle convection case with pseudo-plastic yielding rheology.

Keywords: water, mantle convection, plate tectonics, yield strength

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