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Subduction-induced deep water cycling from integrated thermodynamic and thermomechanical modeling

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Water transport from the surface to Earth's deep interior and its circulation plays significant roles in understanding the dynamics of the planet, while the subduction process is a critical way to bring water to the mantle. It remains widely debated about how and how much water could be carried to the deeper mantle, e.g. the mantle transition zone or even the lower mantle. On the other hand, it is still unclear whether and how the recycled water interacts with the overriding craton and modifies its thermo-rheological properties as well as chemical compositions. In order to investigate the aqueous fluid/melt activities in the subduction zones, systematic numerical models are constructed, which integrate the thermomechanical models with petrological thermodynamic datasets of water solubility down to the lower mantle depth, i.e. 0-30 GPa. The models reveal that the amount of water carried by oceanic crust to the mantle transition zone is rather limited. A significant amount of water can be carried by the hydrated mantle rocks to the transition zone, which requires a relatively thicker hydrous mantle layer and faster subduction in order to pass through the 'choke point' in the phase diagram. The aqueous fluid in the high pressure hydrous phases may be stable in the mantle transition zone for a certain time, which will be released with the increased temperature and then go upward, passing through the big mantle wedge and then interacting with the overriding craton. The modification of the overriding craton generally occurs in the lower part of the lithosphere due to the hydration and partial processes, which may finally lead to the significant weakening and thinning of the cratonic lithosphere and extensive magmatism.