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Subducted Sediments and Mantle Regassing – How Life Impacts the Earth's Geodynamics

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Subduction is an important process on Earth. Through the subducting slab the oceanic lithosphere, including volatiles and sediments, is recycled back into the mantle. While metamorphic processes in great depth are the subject of many studies, the dewatering of the subducting oceanic crust in very shallow depth is often neglected. We show that a low permeability sedimentary layer, formed by eroded continental crust, can suppress dewatering in this region, resulting in larger amounts of volatiles available at greater depth. This in turn increases the amount of newly produced continental crust and the rate of mantle water regassing. We present a global evolution model that includes (i) mantle convection, (ii) mantle water vapor degassing at mid-ocean ridges and regassing at subduction zones, and (iii) continental crust formation and erosion. The mantle viscosity of our model depends on the mantle water concentration, and boundary layer theory is used to parameterize mantle convection. We use present day parameters of the Earth to explore a phase plane spanned by the total continental area and the total mantle water content. We show that present day continental area and mantle water content represent a stable fixed point in the phase plane, which has a large zone of attraction if we assume the present day, biogeochemically enhanced weathering rate. However, a system with a reduced weathering rate – which would be a likely scenario for an abiotic Earth – tends to reach an alternative stable fixed point with a reduced mantle water content and a slightly reduced continental area. Therefore we argue that the biosphere helps the Earth to develop continents and to keep a wet mantle, which in turn enhances the geodynamic activity of our planet.