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Ophiolite obduction in the Precambrian

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Vogt, K. and Gerya, T. (2014). Deep plate serpentinization triggers skinning of subducting slabs. Geology, 42, 723-726.

Gerya, T.V. and Yuen, D.A., (2003) Characteristics-based marker-in-cell method with conservative finite-differences schemes for modeling geological flows with strongly variable transport properties. Phys. Earth Planet. Interiors, 140, 293-318

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Lithos, 116, 209-229

abstract

Ophiolites (former oceanic crust) are and not recognized in the geological record before 1 Ga and only become abundant after 800 Ma. Hence, different hypothesis have been put forward to explain this major shift in plate tectonics.

obduction in modern times:

In a recent study on modern subduction zones Vogt and Gerya (2014) have proposed that serpentinized mantle may provide a mechanically weak horizon along which basal detachment of oceanic crust is feasible.

It has been suggested that deformation of this serpentinized layer may lead to decoupling and separation of oceanic crust from the downgoing slab. Subsequently, the oceanic crust is broken and obducted on top of continental crust.

no obduction in the Precambrian:

However, conditions for subduction were different in the past. The oceanic crust has been thicker and mantle temperatures have been higher. Therefore, the resulting oceanic lithosphere was more likely to resist subduction. Thus, bending-related fractures may have been less common for water to be transmitted downwards.

In a series of experiments using a 2D petrological–thermomechanical numerical model of oceanic subduction (Gerya and Yuen, 2003) we have systematically investigated the dependence of ophiolite obduction along serpentinized fracture zones in relation to upper-mantle temperatures and oceanic-crust thickness. First results indicate that detachment of oceanic crust from the downgoing slab becomes less likely with increasing temperaturesand increasing crustal thickness.

initial setup:

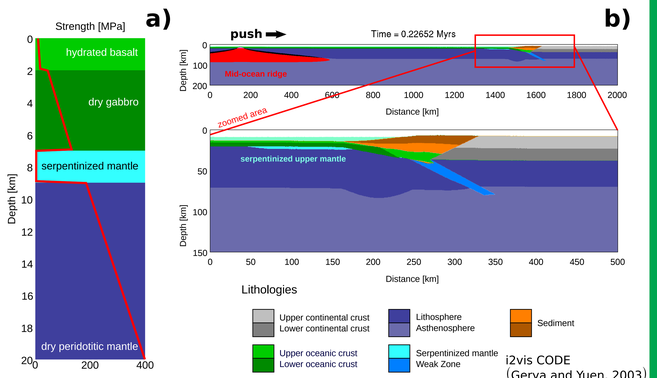

Fig. 1a) Strength profile of the oceanic crust and uppermost mantle for constant strain rate of ε = 1 × 10 –13 . Serpentinized mantle provides mechanically weak subcrustal horizonwithin which basal detachment of the oceanic crust is feasible
Fig. 1b) Thermomechanical model. Compositional map

reference model:

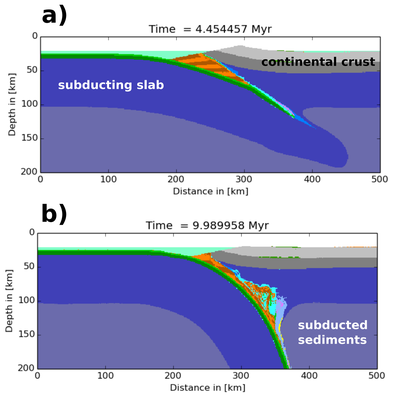

Fig.2)Compositional map of a model performed at present day mantle temperature. No serpentinization along fracture zones

sperpentinization:

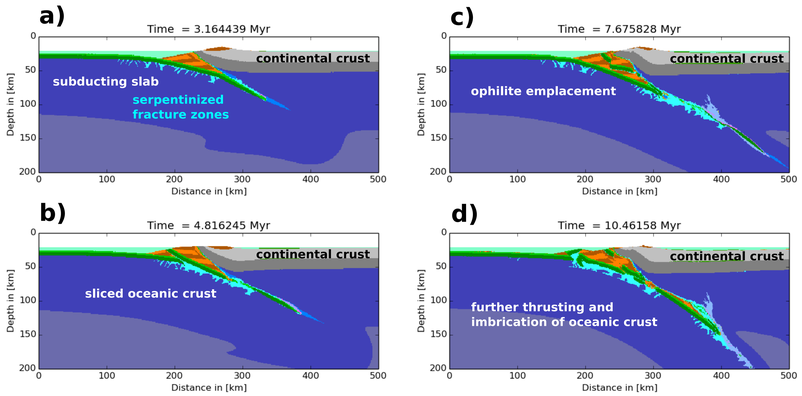

Fig. 3) Compositional map of a model performed at present day mantle temperature. Bending related faulting in the outer rise region forms serpentinized fracture zones

Oceanic crust detaches along the weak serpentinized horizon, breaks, and is incorporated into the accretionary wedge. *Skinned* lithospheric part of the subducting slab sinks into mantle.

Precambrian:

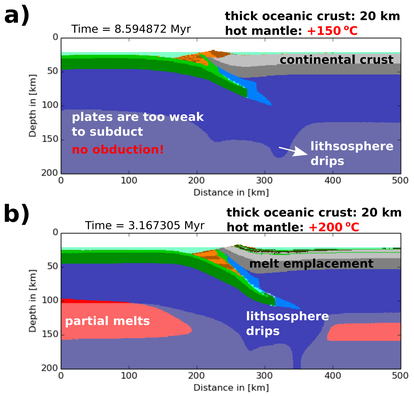

Fig.2)Compositional map of a model performed at Precambrian conditions. The uppermost mantle is too hot to permit serpentinization along fracture zones and too weak to subduct (Sizova et al., 2010)