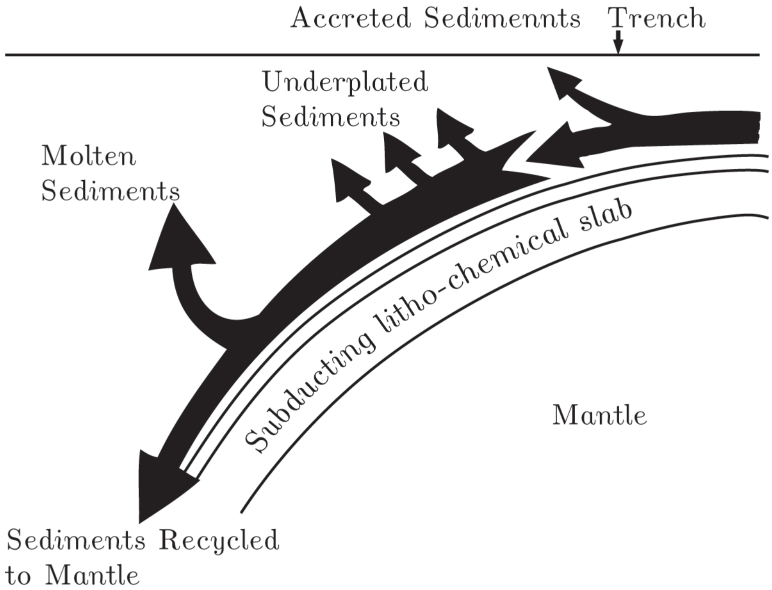
The fate of subducted sediments at convergent plate boundaries

Zurab Chemia, Susanne Buiter
Centre for Geodynamics, Geological Survey of Norway (NGU)
Leiv Eirikssons vei 39, 7491 Trondheim, Norway (Zurab.Chemia@ngu.no)

The dynamic evolution of subducted material is of primary importance for understanding the chemical and thermal evolution of the Earth, as differentiated material is transported from the surface to the interior of our planet and back. Subduction organizes mantle flow and results in volatile transport from the surface to the mantle, part of which is released in volcanic arcs, causing secondary crustal differentiation (Fyfe, 1997; Plank and van Keken, 2008). Sediment subduction and subduction erosion are the main processes that transfer material from continental crust and island arcs to the mantle, which in turn results in the generation of "light" alkaline basalts in arc volcanism. The quantification of these processes and understanding the factors that control them are thus essential for determining the overall mass balance of continental and arc crust. Sediment subduction is hence important to continental growth (von Huene and Scholl, 1991; Condie, 2002) and the long-term chemical evolution of the mantle (Plank and Langmuir, 1998). Global estimates of sediment fluxes indicate that considerable amounts of sediments can be transported into the mantle along with subducting lithosphere (Coats, 1962; Scholl et al., 1980). However, reliable calculations of sediment subduction rates are only available from a small number of subduction zones (von Huene and Scholl, 1991; Bourgois et al., 1996; Clift and MacLeod, 1999).

The purpose of our work is to investigate general aspects of sediment transport in a subduction zone, such as: (i) To what depth can sediments be subducted? (ii) Which parameters govern deep sediment subduction? (iii) What is the influence of potential deep sediment subduction on volatile transport into the mantle? (iv) Under which circumstances do sediments melt during subduction and release geochemical tracers into the overlying mantle wedge and ultimately into arc volcanism? (v) What is the influence of metamorphic reactions in the slab (both the sediments and the basalt) on the thermal state of subduction zones?

While fully dynamic models are needed to improve our understanding of sediment dynamics at convergent plate boundaries, such models are computationally expensive, because resolving sediment subduction on a large scale requires a high numerical grid resolution. An alternative approach is to use models that prescribe the kinematics of the slab. We first focus on such simple models in order to obtain a useful framework for better quantification of sediment fluxes into the mantle as these could play a central role in understanding geochemical aspects of subduction zone processes. Our first models are on the scale of the mantle wedge and provide quantitative estimates of sediment fluxes into the mantle wedge and the deeper mantle.



Schematic illustrations of four possible scenarios for sediment transfer at convergent plate boundaries.

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