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Constraining the Conditions Required for the Delamination of Subducting Crust

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It is commonly accepted that the building of the continental crust is linked to subduction zone processes, but the refining mechanism isolating the felsic product from its basaltic counterpart, leading to a stratified crust, remains poorly understood. Delamination of subducting material from the slab, its subsequent melting and segregation, with the felsic part being underplated and added to the overriding crust from below has been suggested to be a viable scenario.

In this study we use thermo-mechanical numerical models of subduction to explore the possibility of delamination of the mafic part of the slab crust and determine the conditions that are required by varying key parameters, such as subduction speed and angle, slab age, crustal thickness and density, overriding plate thickness, mantle temperature, depth of eclogitisation and the rheological properties for crustal and mantle material. We also quantify the extent of the resultant crustal melting, and its composition.

Our preliminary models demonstrate that, for present day mantle potential temperatures and average slab crustal thickness, only the uppermost 2-3km of mafic slab crust may delaminate and only for extreme rheologies (i.e very weak crust) or very slow subduction ($\sim$2cm/yr convergence), making slab mafic crust delamination unlikely. Contrastingly, in an early earth setting (High mantle temperature potential and thicker mafic slab crust) we find that delamination of the subducting mafic crust is a dynamically viable mechanism for a reasonable rheology under a wider range of subduction conditions and that when it does occur, it can be much more extensive, in some cases with the entire crust delaminating from the slab. In these cases, after only $\sim$5 Myrs from the onset of delamination, mafic crust would sit in the hot mantle wedge where it would likely cross its solidus. These melts would readily be segregated from the migmatitic mafic source and contribute to the formation of felsic crust with little interaction with the mantle wedge, explaining part of the geochemical spectrum of the earliest continental crust.