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The influence of mantle flow on the interaction between arc and back-arc melts

Valentina Magni
University of Oslo - CEED, The Centre for Earth Evolution and Dynamics, Oslo, Norway (valentina.magni@geo.uio.no)

Volcanic arcs are one of the most common features of subduction zones. However, they are not the only type of volcanism related to subduction. Volcanoes can form along STEP faults, at the edge of slabs, due to mantle upwellings. Moreover, if the back-arc region is under extension, rifting and eventually seafloor spreading can occur. Although these different types of volcanism are fairly well known, the way they interact with each other is poorly understood. In this study, I use three-dimensional numerical models of oceanic and continental subduction to investigate how melt production evolves in different regions of a subduction zone. Particular focus is put on tracking the mantle flow to understand where the mantle material that is the source of melting at the arc and back-arc comes from. I vary the initial geometry and composition of the subducting plate to obtain different mantle flow patterns.

My results show that at the initial stage of back-arc basin formation the melting zones beneath the arc and the back-arc are connected to each other. Thus, back-arc melts are a combination of adiabatic decompression melting of ascending primitive mantle and hydrous mantle wedge melting. As the slab keeps retreating, the two melting zones get further apart. Interestingly, at this stage, the mantle that flows beneath the arc comes from the back-arc region where it has been already partially depleted. Therefore, for $\sim$10 Myrs, during the spreading phase at the back-arc, arc magmatism is reduced and has a more depleted source. Eventually the arc and back-arc spreading regions get so far apart that the mantle flow gets back to the more classic corner flow advection cell that does not sample any depleted mantle source before reaching the mantle wedge. These models can help explaining the spatial and temporal geochemical variations of lavas along the arc.