The role of mantle flow in subduction-related volcanism

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

Volcanic arcs, back-arc spreading centres, and volcanism along STEP faults are different expressions of magmatism related to subduction. Although they are fairly well known, the way they interact with each other and evolve with changes in subduction dynamics is still poorly understood. In this study, I use three-dimensional numerical models of back-arc basins formation during oceanic 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 back-arc spreading can be responsible for changes in arc activity and magmatic composition. Indeed, for about 10-15 Myrs during back-arc spreading, the mantle that flows beneath the arc comes from the back-arc melting region, where it has been already partially depleted. Therefore, during this phase, arc activity might decrease or stop because its source is highly depleted. Eventually, the more classic corner flow driven by the downgoing slab is restored bringing again fertile mantle beneath the arc. These models are consistent with many present-day subduction zones where a gap in volcanic activity at the arc corresponds to a period of active spreading at the back-arc. Moreover, the models show that the toroidal flow around the edge of a slab that is retreating and rotating has a strong upwelling component that brings fertile mantle to the back-arc and sub-arc melting regions. However, this is not observed when the toroidal flow occurs through a newly formed slab window. In this case, the mantle flows sub-horizontally at >200 km depth and does not take part in melting. These results demonstrate the key role of mantle flow and changes in its pattern in subduction-related magmatic activity and composition.