Geophysical Research Abstracts
Vol. 16, EGU2014-2152-1, 2014
EGU General Assembly 2014

Controls on the Flow Regime and Thermal Structure of the Subduction Zone Mantle Wedge: A Systematic 2-D and 3-D Investigation

Giuseppe Le Voci (1), Rhodri Davies (2), Saskia Goes (3), Stephan Kramer (4), and Cian Wilson (5)

(1) Department of Earth Science and Engineering, Imperial College, London, UK (g.le-voci09@imperial.ac.uk), (2) Research School of Earth Sciences, The Australian National University, Canberra, Australia (rhodri.davies@anu.edu.au), (3) Department of Earth Science and Engineering, Imperial College, London, UK (s.goes@imperial.ac.uk), (4) Department of Earth Science and Engineering, Imperial College, London, UK (s.kramer@imperial.ac.uk), (5) Lamont-Doherty Earth Observatory, Columbia University, Palisades, New York, USA (cwilson@ldeo.columbia.edu)

Arc volcanism at subduction zones is likely regulated by the mantle wedge's flow regime and thermal structure and, hence, numerous studies have attempted to quantify the principal controls on mantle wedge conditions. Here, we build on these previous studies by undertaking the first systematic 2-D and 3-D numerical investigation, across a wide parameter-space, into how hydration and thermal buoyancy influence the wedge's flow regime and associated thermal structure, above a kinematically driven subducting plate. We find that small-scale convection (SSC), resulting from Rayleigh-Taylor instabilities, or drips, off the base of the overriding lithosphere, is a typical occurrence, if: (i) viscosities are $< 5\times10^{18}$ Pa s; and (ii) hydrous weakening of wedge rheology extends at least 100-150 km from the trench. In 2-D models, instabilities generally take the form of 'drips'. Although along-strike averages of wedge velocities and temperature in 3-D structure are consistent with those in 2-D, fluctuations are larger in 3-D. Furthermore, in 3-D, two separate, but interacting, longitudinal Richter roll systems form (with their axes aligned perpendicular to the trench), the first below the arc region and the second below the back-arc region. These instabilities result in transient and spatial temperature fluctuations of 100-150K, which are sufficient to influence melting, the stability of hydrous minerals and the dehydration of crustal material. Furthermore, they are efficient at eroding the overriding lithosphere, particularly in 3-D and, thus, provide a means to explain observations of high heat flow and thin back-arc lithosphere at many subduction zones, if back-arc mantle is hydrated.