# Mantle flow in subduction zones and implications for material transport and mixing in the mantle

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The character of the mantle flow field in subduction systems and the dynamic interaction between slabs and the ambient mantle remain poorly understood, despite their importance for our understanding of subduction processes and of the geometry and dynamics of mantle convection. In order to identify subduction processes that make first-order contributions to the global pattern of mantle flow in subduction zones, we have compiled shear wave splitting measurements from subduction zones worldwide. We have estimated average splitting parameters for the wedge and sub-slab region and compared them to other subduction parameters. We tested for relationships between sub-slab and wedge splitting and other parameters such as trench migration velocity, convergence velocity, and the age, dip, and morphology of the subducting slab. The global splitting dataset supports a model in which the mantle beneath subducting slabs is dominated by three-dimensional flow induced by trench migration, while in the wedge there is an interaction between the two-dimensional corner flow induced by the downdip motion of the slab and the three-dimensional flow field associated with the migration of the trench. Our model suggests that downgoing slabs entrain little, if any, of the surrounding ambient mantle when (or if) they penetrate the transition zone and enter the lower mantle; this has significant implications for the material flux between the upper and lower mantle reservoirs and the extent of mantle mixing. In the wedge, our model implies that trench-parallel flow is important in many (though not all) mantle wedge systems with significant implications for melt generation and material transport in the wedge.

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# Better lighting through geochem-history

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In describing subsurface processes, Paul Johnson of the University of Arizona famously observed: ‘It’s dark down there.’ This ‘darkness’ is a central challenge for contaminant geochemists as they study the complexity of subsurface systems, environments in which numerous and interrelated process control the mobility, toxicity and overall character of contaminants. Characterization, via solid and fluid samples collected from boreholes and using geophysical methods, dimly illuminate isolated portions of the subsurface for observation but leave many unanswered questions. Thus, geochemists use other strategies to assist in identifying key transformation and transport processes and in quantifying these processes to support environmental management decisions. Historically, a central front for lighting up the subsurface has been a stepwise process: carefully controlled laboratory studies of isolated individual reactions followed by thermodynamic/kinetic geochemical models to composite the many contributing bits and build up a virtual world. The Department of Energy Office of Science – Biological and Environmental Research Divison – recently advocated supplementing the traditional ‘bottom-up’ paradigm described above with research that approaches subsurface challenges from a ‘top-down’ or complex systems perspective. Simple historical examples from real-world sites illustrate the potential usefulness of a systems approach in which site history is synergistically combined with intermediate- and field-scale observation of physical conditions, emergent biogeochemical impacts, and temporal changes. In particular, some stark geochemical lessons can be identified by comparing and contrasting the various attempts to establish facilities for high-level nuclear waste disposal around the world. The journey from shallow groundwater, to Yucca Mountain, to the Boom Clay suggests that supplementing the standard paradigm with the emerging systems approach will be both a challenge and an opportunity. Geochemists who embrace the challenge will have a more diverse and powerful toolbox to illuminate the subsurface and to improve the future of environmental management.