Mixing processes in the mantle wedge: insight from ultra-high resolution numerical modelling

Weronika Gorczyk*, Taras V. Gerya*, James A.D. Connolly*, David A.Yuen**.

* Department of Geosciences, Swiss Federal Institute of Technology (ETH - Zürich), Switzerland
** Department of Geology and Geophysics, University of Minnesota, Minneapolis, USA

Mechanisms driving processes in mantle wedges, like dynamics of magma production and transport above the slab are still enigmatic and question of debate between geo-scientists. Recent work (Gerya and Yuen, 2003) suggests that thermal-chemical plumes that originate from subducted slab as a consequence Rayliegh-Taylor instability are a potentially important mechanism for transporting slab and mantle wedge material to volacanic arcs. To test this hypothesis we used high resolution numerical simulations to anticipate the internal structures that are likely to develop in natural plumes beneath volcanic arcs in intraoceanic subduction settings. We have preformed 2D numerical experiment containing 10 billion randomly distributed markers, what allowed for effective resolution of lithological field around 2m. This approach gave an opportunity for detailed studies of plume and chaotic streamline mixing of plume's components. Plumes are composed of partially molten, hydrated peridotite, dry solid mantle and subducted crust, which may comprise up to 12% of the plume. At the initial stage plume is heterogeneous (composed of molten mantle material), with time crustal material is injected in to the plume. As plumes grow and mature these materials mix chaotically resulting in attenuation and duplication of the original layering on scales of 1-1000 m. Comparison (fig.1) of these results with geological observations on Horoman peridotic complex from Japan (Obata and Takazawa, 2004) suggests that mixing and differentiation processes related to development of hydrous thermal-chemical plumes above slabs are responsible for strongly layered lithologically mixed structure of mantle wedges.

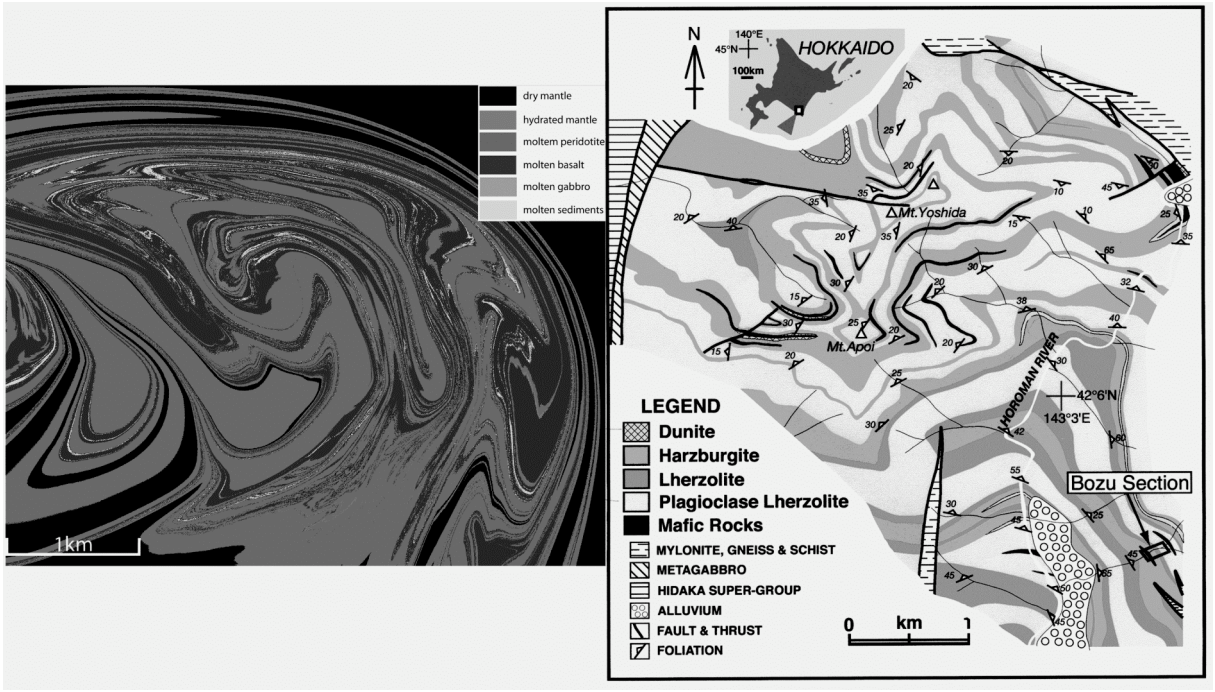

Figure1. Left: Geometry and chemical compositon of part of a plume; Right: geological map of Horoman complex (after (Takazawa et al., 1996));

REFERENCES

Gerya, T.V. and Yuen, D.A., (2003): Rayleigh-Taylor instabilities from hydration and melting propel “cold plumes” at subduction zones: Earth and Planetary Science Letters, 212, 47–62.

Obata, M., and Takazawa, E., (2004): Compositional continuity and discontinuity in the Horoman peridotite, Japan, and its implication for melt extraction processes in partially molten upper mantle: Journal of Petrology, 45, 223-234.

Takazawa, E., Frey, F., Shimizu, N., and Obata, M., (1996), Evolution of the Horoman Peridotite (Hokkaido, Japan): Implications from pyroxene compositions: Chemical Geology, 134, 3-26.