Geophysical Research Abstracts
Vol. 21, EGU2019-9408, 2019
EGU General Assembly 2019

Is mantle upwelling required to produce intraplate magma ? – The counterexample of petit-spot volcanoes.

Sebastien Pilet (1) and Naoto Hirano (2)

(1) University of Lausanne, Institut des Sciences de la Terre, Lausanne, Switzerland (sebastien.pilet@unil.ch), (2) Center for NE-Asian Studies,Tohoku University, Sendai, Japan (nhirano@tohoku.ac.jp)

Mantle upwelling is considered as the key mechanism to produce melt below intraplate volcanoes. However, the discovery of petit-spot volcanoes in front of Japan calls this concept into question. These small volcanoes are observed on the top of the downgoing Pacific plate where the plate starts to bend in front of subduction zone (Hirano et al., 2006). As no mantle upwelling is expected in this zone, the formation of these petit-spot volcanoes has been interpreted as the extraction of pre-existing melts present at the base of the lithosphere.

Geophysical studies support the presence of low-degree melt at the base of the lithosphere to explain the properties of the low velocity zone (Kawakatsu et al., 2009), but the composition of such melt is still debated. Gaillard et al., (2008) and Hirschmann (2010) suggested the presence of carbonatitic melt. However, the basaltic composition of petit-spot lavas rules out this hypothesis. The melting of peridotite in presence of CO_2 could produce basaltic melt, but the significantly lower CaO content observed in petit-spot lavas compared to predictions from melting experiments seems to exclude a direct extraction of such low degree peridotitic melt from the base of the lithosphere. Buchs et al. (2013) suggest that petit-spot melts could be produced by the interaction of magma rising from the base of the lithosphere with metasomatic veins, veins produced earlier by the asthenospheric magmas which fail to reach the surface, but cool and crystallize within the lithosphere producing hydrous phases. Such a hypothesis is supported by two observations. First, multiple saturation experiments performed on petit-spot lava (Machida et al., 2017) suggest that these liquids were last equilibrated with peridotite at lithospheric pressure (1.8 GPa) supporting melt percolation within the base of the lithosphere before their extraction. Second, mantle xenoliths sampled by petit-spot lavas show clinopyroxene compositions typical for metasomatized phlogopite–bearing peridotites (Pilet et al., 2016). Our favored model for petit-spot volcanism suggests a tectonic control of volatiles-rich melt extraction from the base of the lithosphere following with melt-peridotite interaction in the ductile part of the lithosphere. One fundamental question is now: is this model applicable to larger intraplate volcanoes associated to tectonic stress?

Buchs et al. (2013). Low-volume intraplate volcanism in the Early/Middle Jurassic Pacific basin documented by accreted sequences in Costa Rica. Geochemistry Geophysics Geosystems 14, 1552-1568.
Gaillard et al. (2008). Carbonatite Melts and Electrical Conductivity in the Asthenosphere. Science 322, 1363-1365.
Hirano et al. (2006). Volcanism in response to plate flexure. Science 313, 1426-1428.
Hirschmann (2010). Partial melt in the oceanic low velocity zone. Physics of the Earth and Planetary Interiors 179, 60-71.
Kawakatsu et al. (2009). Seismic evidence for sharp lithosphereasthenosphere boundaries of oceanic plates. Science 324, 499-502.
Machida et al. (2017). Petit-spot as definitive evidence for partial melting in the asthenosphere caused by CO_2. Nature Communications 8, 14302.
Pilet et al. (2016). Pre-subduction metasomatic enrichment of the oceanic lithosphere induced by plate flexure. Nature Geoscience 9, 898-903.