Plate tectonics and volatiles: the nanorock connexion

Gautier Nicoli and Silvio Ferrero
Universität Potsdam - Institut für Geowissenschaften

The global geological volatile cycle (H, C, N) plays an important role in the long term self-regulation of the Earth system. However, the complex interaction between its deep, solid Earth component (i.e. crust and mantle), Earth's fluid envelope (i.e. atmosphere and hydrosphere) and plate tectonic processes is a subject of ongoing debate. Here, we want to draw attention to how the presence of primary, pristine melt (MI) and fluid (FI) inclusions in high grade metamorphic minerals could help constrain the crustal component of the volatile cycle. We review the distribution of pristine MI and FI throughout Earth's history, from the onset of plate tectonics at ca. 3.0 Ga to the present day. Combined with thermodynamic modelling, our compilation indicates that periods of well-established plate tectonics regimes at 0-1.2 Ga and 1.8-2.0 Ga, might be more prone to the reworking of supracrustal lithologies and the storage of volatiles at lower crustal depths. We then argue that the lower crust might constitute an important, although temporary, volatile storage unit, capable to influence the composition of the surface envelopes through the mean of weathering, crustal thickening, partial melting and crustal assimilation during volcanic activity.

Such hypothesis has implication beyond the scope of metamorphic petrology as it potentially links geodynamic mechanisms to habitable surface conditions. MI and FI in metamorphic rocks is a rich but still relatively uncharted realm. In the near future, a concerted research effort should aim to find and characterize new instances of pristine inclusions in periods of the Earth's history currently underrepresented in the inclusion database, e.g. the Boring Billion. The merging of the messages of thousands of minuscule droplets of fluids trapped in the deepest roots of the continental plates will then eventually provide a truly comprehensive portrait of how the Earth's evolution proceeds through the geological timescale.