Rethinking mantle geochemical heterogeneity: New insights into mantle geology

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Classical statistical data analysis constrains the upper mantle geochemical and mineralogical complexity introducing the concept of Mantle Resevoirses. This concept is based on the underlying assumption that the mean composition of wide mantle volumes may be attained by significantly smaller representative samples. We argument that this underlying hypothesis needs to be checked and non-linear methods are able to reveal how mantle compositional heterogeneity cannot be conceived as a deviation from a mean value.Non-linear analysis methods reveal that the mutual distribution of isotope and immobile trace element of Ocean Island Basalt mantle sources mirrors the intrinsic spatial organization of the mantle revealing the systematic occurrence of strange attractors in the geochemical signals. This supports the evidence for a chaotic mantle, bridging the discrepancy between geochemical and geophysical views of mantle composition, and overcomes the impasse of the twenty years-old theories on mantle reservoirs. Our results confirm that the vertical scale of mantle heterogeneity is similar to its horizontal organization, as revealed by MORB sampled at ridge axes, and reinforces the conclusion that this structure is inherited from an ancient convection regime, probably affecting the whole mantle scale.

PTt path of rising magmas. An ascent rate meter recorded in lava volatile contents

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Experimental and theoretical investigations prove that the triggers of volcanic eruptions are related to the ascent rates at depth, which control the exolution and expansion of volatile components. Volatile loss (mainly H20 and CO2) has in turn cascade affects on a variety of parameters (crystallinity, viscosity, volume, composition) all able to strongly affect the dynamic of the ascent rate. The complex feedbacks of ascent rate and volatile content may be recorded at shallow levels by the composition of melt inclusions and at depth, by early liquidus phases which are sensible to pressure, temperatue and volatile content.

Among these, pyroxene has been identified as a valid tracef of the PT path of ascent of magma providing dP/dT estimates that may be related to dZ/dt (Z=depth) trough kinetic consideratios on crystal growth and nucleation. The recent introduction of a clinopyroxene hygrometer now opens the possibility to relate the water content to pressure and temperature, extending at considerable depths our record of P,T.t, Xi .

Since degassing of non ideal CO2-H2O mixtures is strongly non-linearly dependent on pressure, the volatile contents of lavas, as revealed by the mineralogical and melt inclusion record, can be matched by a unique PTt path that is coherent with the thermodynamic modelling of gas exsolution.

This new tool to define the PTt path of magmas is here applied to some recent eruptions of Mt Etna.

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