Mantle convection from the geochemist point of view

E. Lewin

Laboratoire de Géochimie & Cosmochimie, Institut de Physique du Globe de Paris (Université Paris 7-Denis Diderot et CNRS UMR 1758) boîte 89, 4, place Jussieu, 75252 Paris cedex 05, France

Combination of seismologic tomography with mantle convection modelling has lead geophysics to propose so-called 'mantle circulation models'. These models are based purely on geophysical constraints and thus require us geochemists to reconsider the constraints and information from our measurements.

One critical point is the source of this information. While in geophysics, information about the convective Earth mantle is carried by acoustic waves which record spatial characteristics of the medium through which they propagate, in geochemistry, measurements rely on rock samples, the matter of which has mostly lost the memory of its trajectory throughout the mantle until the outcrops where it has been picked up.

After a short review of a few studies that have tried to extract spatial information from mantle geochemistry sampling, we will focus on the more classical statistical approach, and try to defend this approach as complementary but necessary to mantle convection model studies. In order to do such, the first requirement is to give a precise definition of mantle heterogeneity in this context. Though the classical parameter of statistical dispersion (standard deviation for instance) is well fitted for that, using the variogram technique of the so-called Geostatistics, some sense of the spatial characteristics of mantle heterogeneity can be evaluated.

This evaluation is then proceeded from the available mantle sampling, namely the mid-oceanic ridge basalts collection. One key point is the use of databases for which the different sampling bias can be evaluated and therefore corrected. Indeed, the basalts collection bears only a modified, biased image of the underneath source mantle, the correction of which relies on some assumptions about basalt genesis. For that same reason, only long-lived radiogenic isotope ratios have been used as the describing parameter of the sampled mantle.

The next step goes from the sampled mantle beneath ridges to the whole convective mantle. In order to test the assumption of representativity of the former for the latter, an extremely simplified numerical model of a stirring box with a ridge-subduction-like input-output system stirring passive tracers will be used, thus allowing us to try to relate the dynamic, the spatial and the statistical aspects of such a system. Concerning the dynamics of this system, precisely, another advantage brought by long-lived radiogenic isotopes is their record of the "time dimension", though deciphering it requires a good approach of chemical fractionation under ridges in order to constrain the parent-daughter ratio of the samples' sources. This time-dimension will be approached using the classical geochemical concept of residence time.