Mantle heterogeneity as evidenced by Raobazhai peridotite, North Dabieshan, China

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The peridotite bodies occurred near Raobazhai, in north Dabieshan trends northwestwards extending more than 10Km. The peridotite body consists mainly of harzbergite and dunite, with a few lherzulite mostly amphibolized due to amphibolite facies metamorphism. All of them are highly serpentinized. Major mineral paragenesis of the peridotites are Ol+Opx+Spl and Ol+Spl. The peridotite bodies are highly deformed and are mylonitized. REE distribution pattern and trace element geochemistry evidenced the chemical heterogeneity of these mantle-derived rocks.

There are a number of garnet pyroxenite enclaves scattered within the peridotite body as small pods, decimeters in size, enclosed in the serpentinized peridotites. Major mineral components of the garnet pyroxenite are: garnet (Prp_{25-35}), sodium augite(Jd_{10-25}) with a small amount of ilmenite. There are two stages of retro- metamorphism: the retrogressive granulite facies superimposed by amphibolite facies. On the basis of garnet–clinopyroxene geothermometry Kd=4.06–5.28;T=793–919℃, P=1.5 Gpa are estimated for the garnet pyroxenite.

It is inferred that the peridotites are mantle rocks about 60Km in depth. During the exhumation of the orogenic belt it was tectonically emplaced into the lower crust in solid state and then uplifted to shallow depth. The REE distribution pattern and the Ni-Co-Sc diagram reveal that they are chemically equivalent respectively to the basaltic melt and ultramafic residua. Incomplete removing of mantle melting products from source area could be a possible mechanism for the mantle heterogeneity.

Si and Mg isotopic constraints on the astrophysics of CAI formation in the early solar system

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Silicon and magnesium isotope ratios can be used to constrain the pressure (P_{H_2}) and duration of melting of calcium-aluminum-rich inclusions (CAIs) in the early solar system. Recent results (Shahar and Young 2007) show that these primitive protoplanetary objects most likely melted for integrated timescales of tens of days at $P_{H_2} < 10^{-6}$ bar. Here we show that the isotopic compositions of CAIs further require that they formed not only at lower pressures than the more abundant chondrules with which they are found, but also at orders of magnitude lower number densities, constituting an important constraint on the astrophysical setting of CAI formation.

The substantial Si and Mg isotope fractionation in CAIs suggests that their number densities were too low to permit an overall elevation in background partial pressure of Mg and SiO that would have prevented fractionation. We quantify this effect by estimating the pressure of gas molecules or atoms i produced by a population of evaporating CAIs:

$$P_i^{\text{vac}} = \frac{3 J_i r_\circ^2 t\, N_{\text{CAI}}}{(D_i^{\text{gas}} t)^{3/2}} kT \quad (1)$$

where N_{CAI} is the number of CAIs within a sphere defined by a radius equal to the characteristic length scale for diffusion in the gas $(D_{igas}t)^{1/2}$ and J_i is the flux of an element i (e.g., Mg or SiO) from a single CAI. Modification of J_i by $(1+P_i/P_{i,eq})$ to account for deviations from vacuum and approaches to equilibrium vapor pressures results in the expression

$$\frac{P_i}{P_{i,\text{eq}}} = \frac{P_i^{\text{vac}} / P_{i,\text{eq}}}{1 + P_i^{\text{vac}} / P_{i,\text{eq}}} \quad (2)$$

For typical conditions indicated by Si and Mg isotope fractionation, including T = 1673 to 1873 K, $P_{H2} = 10^{-9}$ to 10^{-4} bar, equations (1) and (2) yield a maximum number density of CAIs during their melting of 1×10^{-3} to 2.0 m^{-3}, or a linear spacing of > 0.8 to 8 meters. This number density is four orders of magnitude lower than that for chondrules (Young and Galy 2004; Cuzzi and Alexander 2006).

References

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