Fe isotopes: A clue to chondrule formation ?

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Two main categories of models are proposed to explain the diversity of chondrule compositions. One category relies on differentiated chondrule precursors formed from incomplete condensation of the nebular gas to solids [e.g. 1] or to liquids [2], while the other group of models relies on open-system behavior during the formation of chondrules from undifferentiated nebular (possibly in part interstellar) solids involving evaporation and recondensation [3]. Based on Ni and P concentration in metal inside and at the surface of Renazzo (CR2) chondrules, [4] argued that massive loss of Fe from the internal metal and its subsequent recondensation involved oxidation in order for Fe to be carried to the surface of the chondrule through the silicate melt. The Fe isotopic composition of the metal and silicates should accordingly be governed by redox exchange and evaporation from the silicate melt whereas in the processes advocated by [1,2], the Fe-isotope signature should be controlled by partial condensation.

[5] reported that Fe in olivine was systematically lighter than in the adjoining metal in extraterrestrial samples including Allende chondrules and suggested [6] that Fe isotopes had fractionated before or during chondrule formation. To check whether such signatures could have been established during chondrule formation involving evaporation, we are performing laboratory simulations at various fO_2, T, total pressure and for various lengths of time (in order to vary the amount of volatile loss), starting with an isotopically homogenous material. Terrestrial fayalite mixed with albite was melted at 1540°C and IW-1 for different heating times (10 min to several hours) in a graphite crucible. Metallic iron was formed through the reduction of FeO in the melt, in quantities increasing with the heating time. Metal and silicate from the charges will be separated and their Fe isotopes will be analysed by MC-ICPMS to see if the processes involved could have generated the isotopic shift between silicates and metal observed by [5].

References

[1]Wasson, J. T. (1993) Meteoritics **28**, 14-28.
[2]Krot A.N. et al. (2001) Science 291, 1776-1779.
[3]Sears D. W. G. et al. (1996) In *Chondrules and the Protoplanetary Disk* pp. 221-232, CUP.
[4]Zanda B. et al. (2002) Lunar Planet. Sci. XXXIII 1852.pdf.
[5]O'Nions R.K. Pers. Comm.
[6]Zhu X.K. et al. (2001) Nature 412, 311-313

Carbon content, C and O isotope compositions of minor carbonates in metasilicate rocks from the Dabie-Sulu orogen in eastern China

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Minor amounts of carbonates occur in silicate rocks of different metamorphic grades and thus record a history of geochemical processes that operate in crustal rocks, where carbon is an active geologic agent. However, difficulty in the analytical technique has hampered the practical study of their C contents and isotopic ratios. We have developed an extraction line for this purpose in which dolomite and calcite can both be analyzed. This has allowed us to analyze the C contents, δ^{13}C and δ^{18}O values of minor carbonates in HP and UHP metasilicate rocks from the Dabie-Sulu orogen in eastern China.

Our results show large variations from <10 to 2500 ppm in C content, from −33 to 0‰ in δ^{13}C value, and from −15 to 28‰ in δ^{18}O values. Most of the metasilicate rocks display disequilibrium C- and O-isotope fractionations between dolomite and calcite, and disequilibrium O-isotope fractionation between carbonate and host silicate. These suggest low-T hydrothermal overprinting over the high-T rocks after amphibolite-facies metamorphism.

Three possible sources may have contributed to the carbon in the HP/UHP metasilicate rocks: (1) sedimentary carbonate, which was either precipitated synchronously with the protolith of metasedimentary rocks or derived from external sedimentary carbonate by fluid-rock interaction. The minor carbonate from this source is characterized by high carbon concentrations (>600 ppm) and high δ^{13}C values (ranging between −4‰ and 0‰); (2) magmatic carbonate inherited from igneous protolith, which is manifested by medium carbon concentrations (200 to 600 ppm) and the normal mantle C and O isotopic ratios (δ^{13}C of −5±2‰ and δ^{18}O of 7±2‰); (3) sedimentary-organic carbon, which is characterized by very low carbon concentrations (less than 100 ppm) and low C isotopic ratios ($\delta^{13}C < -12$‰) and thus may be formed by the oxidization of organic carbon in the metasilicate rocks during prograde metamorphism at depth and/or isotope-exchange reaction during exhumation at the Earth's surface. Preservation of both sedimentary carbonate and sedimentary-organic carbon, revealed by C concentrations and C- and O-isotope compositions of minor carbonates in the HP/UHP metasilicates of continental protoliths, indicates that the sediments in the upper crust were subducted into great depths, and may have an impact on the C budget of the mantle. Survival of carbonates from metamorphic devolatilization in subduction zones may shed light on the C cycling among the Earth's C reservoirs.