Nanocalcite as a model for biogenic, geological calcite

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Many geological systems, including chalk, limestone, and calcareous sandstone, contain sub-μm (nano), biogenic calcite formed by organisms long ago. These systems are intimately linked to environmental and economic interests (e.g. aquifers and petroleum reservoirs). Many geochemical research studies seek to understand the transformation (e.g. growth/dissolution) and reactive influence of calcite on pore fluids. For model system calcite, studies typically use commercial samples or calcite synthesized from super-saturated solutions of Ca^{2+} and CO_3^{2-}. The particle size of these types is generally much larger than biogenic calcite, and industrial calcite often contains trace amounts of the chemicals used during the manufacturing process or for ensuring good storage properties.

We explored an alternative method for synthesizing nanocalcite by carbonating a $Ca(OH)_2$ slurry using gaseous CO_2. This method has been used for industrial product improvement, but the use of nanocalcite as a model research system with high purity and surface area has not been explored.

Surface- and bulk-sensitive techniques, including X-ray photoelectron spectroscopy (XPS), infrared spectroscopy (IR), and X-ray diffraction (XRD), indicate negligible contamination from unreacted hydroxyl or trace metals. Further, there was no evidence of other $CaCO_3$ polymorphs, vaterite or aragonite. SEM showed agglomerations of nanostructured particles and the BET method quantified specific surface area in the range from 13-16 m^2/g. IR spectra of industrial calcite, geological calcite (chalk) and nanocalcite displayed distinctly different peak widths, in the order of nanocalcite < chalk < industrial calcite. This indicates that nanocalcite has a relatively high degree of crystallinity and few defects.

This study shows that nanocalcite might improve research results in studies that seek to understand processes in ultrafine geological calcite. Ongoing work will use nanocalcite to more effectively analyze recrystallization rates and surface reaction/adsorption phenomena that are important to aquifer and oil reservoir applications.

Timing of early solar system homogenization from p-process ^{180}W heterogeneities

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Introduction

Collapse and subsequent formation of the solar system may have been triggered by a nearby supernova. This can explain the injection of freshly synthesized short-lived radionuclides into the young solar system and can also account for the presence of nucleosynthetic isotope anomalies in meteorites. In order to trace the mixing history of nuclides in the early solar system, we performed the first analyses of one of the rarest isotopes in the solar system, p-process ^{180}W (ca. 0.1 % relative abundance).

Methods and Results

Measurements were conducted using a Neptune ICP-MS, equipped with high sensitivity 10^{12} Ohm resistors. For most analyzed iron meteorites, clearly resolvable ^{180}W excesses (up to +7 $\varepsilon^{180}W$-units) were measured, whereas metals from chondrites and IAB iron meteorites overlap with the terrestrial value. There are distinct ^{180}W abundance variations between different groups of iron meteorites.

Discussion and Conclusion

Our first data provide clear evidence for an increasing homogenization of the early solar system by decreasing ^{180}W anomalies with decreasing age, suggesting mixing-timescales in the order of several million years. As most asteroidal parent bodies accreted and differentiated during this time span parent nuclides of short lived decay systems may not have been homogeneously distributed in the early solar system.

Because the production of ^{180}W requires distinct stellar environments, multiple supernovae explosions may have affected the early solar system, thus further weakening the astrophysical view that protostars have formed in relative isolation from their molecular cloud neighbours [1].

[1] L.W. Looney, J.J. Tobin, B.D. Fields (2006) *APJ* **652**, 1755.