Hf-W evidence for rapid accretion and core formation in protoplanets

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Introduction

Several Hf-W studies [e.g. 1] showed that the parent bodies of magmatic iron meteorites formed very early, about contemporaneously to Ca-Al-rich inclusions (CAI). Cosmic-ray induced neutron capture reactions can, however, modify the W isotope budgets of iron meteorites [2] but no accurate method is yet available for correcting these effects [3, 4]. Consequently, the exact timing and duration of core formation in these bodies remain uncertain.

Approach

Cosmogenic noble gas abundances can help to select iron meteorite samples whose W isotope budgets likely remained unaffected by cosmic rays. Nevertheless, quantitative corrections of cosmic-ray induced shifts in W isotopes using a direct neutron dose monitor like ^{113}Cd [see e.g. 5] are desirable [2]. We here report results from a combined noble gas and W isotope study on different groups of magmatic irons. Complementing Cd isotope analyses on the same samples are currently on going.

Results

Cosmogenic noble gas concentrations in most of the analyzed samples are at the lowermost end of the range observed in iron meteorites [6]. Samples with the lowest cosmogenic noble gas abundances have ε^{182}W values (10^4 deviations from the terrestrial value) ranging from -3.3 to -3.2, indistinguishable from the CAI initial of -3.28±0.12 [7].

Implications

The (weighted) mean ε^{182}W of the weakly irradiated irons analyzed in this study is -3.25±0.05. Unlike in previous W isotope studies, this average value is higher than the CAI initial, not lower, demonstrating that ε^{182}W values lower than the CAI initial reflect cosmic-ray induced effects. Our W isotope data indicate that different iron meteorite parent bodies segregated their cores within a brief interval of less than 1 Myr. The average core formation age of the samples investigated here is $0.3^{+1.3}/_{-1.1}$ Myr after Solar System formation.

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Sorption properties of supercritical carbon dioxide in nano-porous synthetic rocks

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Carbon dioxide (CO_2) generated in fossil-fuel powered plants is a concern due to its potential contributions to global warming. Large-scale carbon capture and sequestration (CCS) can help to slow the rise of atmospheric CO_2 levels. In this process, CO_2 is stripped from the plant emissions, compressed and injected into subsurface reservoirs. Directly after injection, the dominant processes to contain the supercritical CO_2 in the reservoir are sorption and capillary trapping. Quantification and understanding of these processes is needed to estimate reservoir capacities and model long-term storage security. In this study, gravimetric sorption experiments were conducted from 0-200 bars and 35-50°C, using mesoporous silica, a synthetic proxy for quartz-rich rock. The CO_2 excess sorption isotherms were measured for samples with different pore sizes and morphologies. Strong adsorption of CO_2 to silica was found at low pressure, with the formation of a maximum in the excess sorption isotherm. The excess sorption is small or negative at high pressure. An inverse temperature dependence of the sorption strength was found in the adsorption region at low pressure, while the excess sorption showed little temperature dependence at high pressure. Our data suggest the existence of an optimum pressure, between 75–100 bars depending on temperature and pore size, for carbon storage in dry quartz-rich rocks.

We also studied the sorption of supercritical CO_2 to Na-montmorillonite clay, a proxy for cap rock materials. Limited amounts of CO_2 adsorbed to this clay mineral.