

⁶⁰Fe in the cosmic blender

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Central to the significance of ⁶⁰Fe ($t_{1/2}=1.49$ Myr) in cosmochemistry are the questions of its abundance and distribution in the protoplanetary disk [1-5]. Significant advances have been made recently in estimating the initial ⁶⁰Fe/⁵⁶Fe ratio in meteoritic materials [4-7]. The best estimate of the ⁶⁰Fe/⁵⁶Fe ratio at the time of CAI formation is 5 to 10×10⁻⁷. Several studies have suggested that ⁶⁰Fe was heterogeneously distributed in the disk [8-10]. In order to address the question of ⁶⁰Fe distribution, we have analyzed the Ni and Fe isotopic compositions of meteorites already analyzed for Ni by [11]. After internal normalization to constant ⁶²Ni/⁵⁸Ni and ⁵⁷Fe/⁵⁴Fe ratios, meteoritic metal has terrestrial isotopic composition [12]. This result agrees with previous studies but with significantly improved precision [11, 13-15]. We report the most precise measurements of the low abundance neutron-rich isotopes ⁵⁸Fe and ⁶⁴Ni ($\pm 0.3 \epsilon$ and $\pm 0.1 \epsilon$, respectively). These isotopes are produced together with ⁶⁰Fe in cc-SN and AGB stars by neutron-capture reactions. Based on the lack of anomalies on $\epsilon^{58}\text{Fe}$, $\epsilon^{60}\text{Ni}$, and $\epsilon^{64}\text{Ni}$ and on comparison with model predictions for collateral isotope effects, we conclude that ⁶⁰Fe must have been injected into the protosolar nebula and mixed to less than 10 % heterogeneity before formation of planetary bodies.

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Combining experimental studies and kinetic modelling to investigate the carbonation of Ca-bearing silicates

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Among the different ways considered to store CO₂, the safest one involves its conversion into a geologically stable form: carbonate. If the corresponding carbonation process is thermodynamically favoured for (ultra)basic minerals, only a few data are available for its kinetics. As wollastonite carbonation is thought to be a relevant model to study the kinetics and mechanisms involved during the carbonation process, it was investigated in batch reactors, at realistic pressure and temperature conditions of injection.

The micro-textural features of the neo-formed phases are found to be dependent on the reactions conditions. A silica layer always surrounds the remaining wollastonite grains. Calcites form either packed and continuous coatings of small crystals on (and even interlayered with) this layer if the reaction takes place in supercritical CO₂ or in aqueous fluid with circum-neutral pH, or big and isolated crystals in more acidic fluid. The experimental carbonation rate in the aqueous phase, which is faster than in supercritical CO₂, was compared with kinetic modelling performed with a geochemical code. At acidic pH, comparison of the experimental data with the model shows that the rate-limiting step of the reaction is wollastonite dissolution, and that the passivating effect of the silica layer remains weak. At circum-neutral pH, the experimental data are consistent with an inhibitor effect of the dense calcite coating, which reduces the reactive surface of the wollastonite.

Finally, because the dissolution step is rate-limiting of the carbonation of Ca-bearing silicates, the accuracy of the kinetic modelling strongly depends on the features of the dissolution kinetic rate law implemented in the code. We thus cast doubt on the relevance of the use of classical codes in which reaction rates and chemical affinity are linked by the transition state theory (TST). We have developed an alternative kinetic module which allows the test of more recent mathematical relations than that established using the TST. This shows that the use of TST can be the source of dramatic overestimations of carbonation rates.