

The first phase of protoplanetary dust growth: The bouncing barrier

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The initial growth phase of protoplanetary dust into larger agglomerates is still very enigmatic. Although the very first step – the fractal growth regime – is well understood, the further growth – due to collisions between macroscopic (>100 μm), non fractal aggregates with velocities in the cm s^{-1} to m s^{-1} range – seems to be complicated. The collisional outcomes for these collisions are very diverse and depend on many parameters, like, e.g., the (relative) aggregate sizes, collision velocities, aggregate porosities, and surface roughness [1]. In this work, we classify numerous collision experiments into nine classes of collisional outcomes: four types of sticking, two types of bouncing, and three types of fragmentation. Depending on the collisional parameters, we are able to distinguish, which of these outcomes occurs in a collision.

We implemented the collisional physics into the Monte Carlo dust-evolution code described by Zsom & Dullemond [2] and computed the growth in the midplane of a protoplanetary disk. We find that in the first 10,000 years, most collision types play a role and aggregates grow continuously, but after that time bouncing with compaction of the collision partners [3] dominates the collisional outcome (Fig. 1). After 10,000 years, the system is in an almost steady state and growth is inhibited. It is the first time that bouncing has been included in a growth model and it turned out to be an extremely important process.

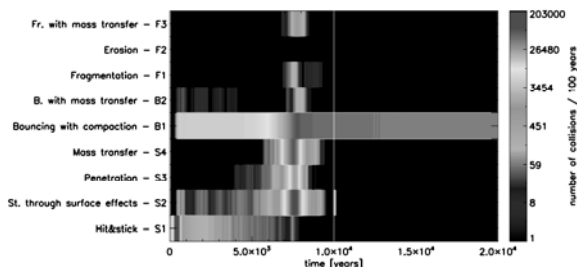


Figure 1: The collision frequency of different interaction regimes including sticking, bouncing, and fragmentation.

[1] Blum & Wurm (2008) *ARAA* **46**, 21-56. [2] Zsom & Dullemond (2008) *A&A* **489**, 931-941. [3] Weidling *et al.* (2009) *ApJ*, accepted.

Investigating the dissolution behaviour of fayalite (Fe_2SiO_4) by *in situ* X-ray absorption spectroscopy

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A large body of research exists dealing with dissolution kinetics of Mg-rich olivine (close to forsteritic composition), but only a few experiments were dedicated to the Fe end-member (fayalite). Determining the major rate-controlling parameters of fayalite dissolution is however crucial to derive robust dissolution rate laws of olivine solid solutions, and to model the iron release from olivine in various contexts and its persistence in planetary environments [1].

Our methodology was based on *in situ* synchrotron X-ray absorption spectroscopy (XAS) at the iron K-edge. For that purpose, we used a high-pressure/high-temperature cell [2] that allows, in the same run, the determinations of both iron molality and iron speciation in the fluid in contact with a mm-sized fragment of synthetic fayalite.

The dissolution of fayalite was investigated as a function of time between 50°C and 100°C, either in non-buffered HCl solutions with different initial pH, or in sodium acetate/acetic acid buffered solutions. A regression algorithm was coupled together with a geochemical code to fit the measured iron release as a function of time in the non-buffered experiments, and thus to determine the exponent n describing the pH-dependence of the rate at acidic pH ($n=0.74 \pm 0.08$), as well as the activation energy of the reaction ($E_a=45.6 \pm 4 \text{ kJ.mol}^{-1}$). In the case of acetate solutions, a strong positive correlation was observed between the dissolution rate of fayalite and the concentration of acetate ligands.

Current research is ongoing for determining the nature of the Fe^{II} complexes in HCl and acetate solutions; these complexes are thought to resemble that of the corresponding activated surface complexes [3] and could in turn explain the differences in the measured dissolution rates.

[1] Olsen & Rimstidt (2007) *Am. Min.* **92**, 598-602.

[2] Testemale, D. *et al.* (2005), *Rev. Sci. Instrum.*, **76**, 043905.

[3] Ludwig, Casey & Rock (1995) *Nature* **375**, 45.