NanoSIMS search for interstellar silicate dust in chondritic samples

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Introduction

Our solar system formed in a molecular cloud made of gas and dust 4.6 Ga ago. Some fraction of this initial dust was inherited from dying stars (stardust) [e.g., 1], but models on interstellar dust evolution predict that the majority of this dust could have formed in the interstellar medium (ISM) itself [2]. The most abundant type of ISM dust are amorphous silicates, and "glass with embedded metal and sulfides" (GEMS) found in interplanetary dust particles (IDPs) might represent these interstellar silicates [3]. First results of analyses of solar wind samples from the GENESIS mission point towards an O-isotopic composition close to that of CAIs [4]. Since the sun should have inherited its O-isotopic signature from the parental molecular cloud, one might expect to find interstellar silicates with this O-isotopic signature, i.e., with $\delta^{17}O$ and $\delta^{18}O$ both ~ -50‰. The goal of this study was therefore to search for ISM silicates with such $^{17,18}O$-depleted compositions in the unaltered chondrite Acfer 094 and microtome sections of IDPs U2071J2 and U2071C9.

Experimental

We scanned matrix areas in Acfer 094 (~489 μm^2) and in slices of IDPs U2071J2/C9 (~4×8/~6×9 μm^2) with the Mainz NanoSIMS in multicollection ($^{16,17,18}O$, ^{28}Si, $^{27}Al^{16}O$). Analysis time for each scan was long enough to gain relative counting statistical errors on 0.2–1 µm grains of 20–45‰ ($^{17}O/^{16}O$) and 10–20‰ ($^{18}O/^{16}O$), sufficient to resolve anomalies in the -50‰ range, at least for ^{18}O.

Results and Discussion

No grains could be located within all analyzed areas that show the predicted isotopic composition and lie well outside the background scatter by more than 3σ. As the astrophysical models predict ISM silicates to be much more abundant than silicate stardust, this should not be explained by too little analyzed material. The most straightforward explanations are (i) that ISM silicates have $\delta^{17,18}O$ values within about ±30‰, i.e., not resolvable with our approach and clearly different than those of CAIs and probably the sun today [4], (ii) that ISM silicates are not more abundant than silicate stardust, which implies that larger areas have to be scanned, or (iii) that ISM silicates are too small (<100 nm) to be detected even by the NanoSIMS.

[1] Hoppe (2008), *Space Sci. Rev.* **138**, 43–57 [2] Zhukovska, Gail & Trieloff (2008), *A&A* **479(2)**, 453–480. [3] Bradley *et al*. (1999), *Science* **285**, 1716–1718. [4] McKeegan *et al*. (2009), *LPSC* **40**, abstr.#2494.

Kinetics of neutrophilic iron oxidation by *Leptothrix cholodnii*

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At neutrophilic conditions, competition with abiotic Fe(II) oxidation poses a challenge for iron oxidizing bacteria. As most neutrophilic iron bacteria are found at niches with low oxygen concentrations, it has been proposed that microbial iron oxidation is in particular favored at low oxygen levels. This might be due to different rate dependencies of the biotic and abiotic pathways on oxygen concentration. The rate law for abiotic Fe(II) oxidation is well established but little is known about the oxygen dependency of bacterial iron oxidation. In this study, Fe(II) oxidation rates of two *Leptothrix cholodnii* strains were determined in batch experiments at pH 7 at varying oxygen concentrations.

It turned out that the rates of microbial iron oxidation and the dependency on oxygen concentration are also affected by the growth state and the pretreatment of the bacteria. A delay of the reaction initiation was observed, when bacteria were harvested from Fe(II) free medium. Interestingly, abiotic oxidation was not observed during this delay phase, implying that microbes could be able to inhibit abiotic reaction by absorption/uptake or by releasing a Fe(II) complexing ligand. Once microbial iron oxidation started, the oxidation rates were lower or equal compared to abiotic rates at the investigated oxygen levels between 63 and 109µmol/l.

Using *Leptothrix* suspensions with freshly formed iron oxides, induction times decreased and oxidation rates increased compared to experiments with bacteria without oxides. Microbial oxidation rates were similar compared to abiotic rates. These results suggest that longer induction time is required for *Leptothrix* to express Fe(II) oxidizing capability. However, the observed increase in oxidation rates in the presence of oxides could also be caused by the contribution of abiotic, surface catalyzed oxidation.