

## The H-, C-, N-, and O-isotopic compositions of cometary matter returned by STARDUST

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### Introduction

The STARDUST spacecraft collected about 1 mg of dust during a flyby in January 2004 of comet 81P/Wild 2 in two collection media, low-density silica aerogel and Al foil (Brownlee *et al.*, 2004). The dust collector was successfully returned to Earth in January 2006 and the cometary dust was analyzed by an international Preliminary Examination Team. These analyses showed that comet Wild 2 is an unequilibrated mixture of materials that have both solar and presolar origins (Brownlee *et al.*, 2006). Here, I will briefly review the results obtained for H-, C-, N-, and O-isotopic compositions by the Isotope subteam (McKeegan *et al.*, 2006; Stadermann *et al.*, 2007).

### Hydrogen

The H-isotopic composition was measured in five particle fragments. Moderate D enrichments were observed with D/H ratios of up to ~3x the terrestrial value. This is qualitatively consistent with the signature found in IDPs and insoluble organic matter (IOM) from chondrites, although the maximum D enrichments are smaller in the Wild 2 samples.

### Carbon and Nitrogen

C- and N-isotopic compositions were measured in several microtome sections, particle fragments, and crater residues in Al foils. No circumstellar C- or N-rich grains were found. Two hotspots enriched in  $^{13}\text{C}$  and depleted in  $^{15}\text{N}$  were recognized, possibly the signature of labile organic material.  $^{15}\text{N}$  enrichments with  $^{15}\text{N}/^{14}\text{N}$  ratios of up to ~2x the terrestrial value are found in bulk samples and as hotspots as similarly observed for IDPs and IOM from chondrites.

### Oxygen

Most studied samples (crater residues, microtome sections) have O-isotopic compositions compatible with those of bulk chondrites. One circumstellar O-rich grain, about 250 nm in size, was found. The  $^{17}\text{O}/^{16}\text{O}$  ratio of ~2.6x solar and  $^{18}\text{O}/^{16}\text{O}$  ratio of ~0.9x solar suggest an origin from a RGB/AGB star. A CAI-like particle exhibits enrichments in  $^{16}\text{O}$  of ~4% as similarly observed for CAIs from chondrites. The presence of a CAI-like particle among cometary matter is suggestive of large-scale radial mixing in the solar nebula.

### References

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## Mineral-melt trace element equilibria in plutonic rocks studied by Laser Ablation ICP-MS

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Magmatic intrusive systems often yield very complex cumulate rocks, consisting of different solid phases and interstitial residual liquid phases. It is an intrinsic difficulty of cumulate rocks to properly interpret whole rock contents of incompatible trace element data, because the amount of trapped interstitial residual liquid might be the controlling factor. Moreover, as early formed cumulates might have been permeated by later-stage evolved liquids, there is no guarantee that whole rock data represent 'equilibrium' compositions. In the late stages of differentiation accessory minerals often start to crystallize and have an important impact on the behavior of trace elements during differentiation. This raises an important issue since models of fractionation are usually largely based on whole rock geochemical trends.

Equilibria at the micro-scale can be studied in situ in standard, thick polished mounts with LA-ICP-MS. The most promising minerals for the study of REE melt/mineral distributions are clinopyroxenes and plagioclase. However, accurate results require rather meticulous standardisation. Several standard materials have been tested in the present study: the commonly used NIST612 glass, USGS BCR-2 fused glasses, and a natural, very homogeneous obsidian glass from the Krafla volcanic area, Iceland. The equipment consisted of a Cetac200 266 nm UV-light of a NdYAG laser, coupled to a quadrupole based HP4500 ICP-MS. The Krafla obsidian yielded the best analytical results.

Ongoing studies include the analysis of core samples from the oceanic gabbro section of Hole735B drilled during Ocean Drilling Program Legs 118 and 176, and a section from the Tron pluton from the Caledonide Trondheim Nappe Complex, Norway. The accuracy of the LA-ICP-MS could be checked against analysis of separated pure mineral fractions analyzed by other methods. The micro-analytical data allow to calculate the liquid compositions with which clinopyroxene and plagioclase equilibrated, and to estimate the stage of solification at which interstitial liquids were expelled. Mass balances further make it possible to estimate the amount of dispersed trapped late stage residual liquids.