# Mineralogical origins of Wild 2 comet particles collected by the Stardust spacecraft

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## Mineralogy

The return of samples from comet Wild 2 by the NASA Stardust spacecraft in February 2004 has provided the first opportunity to directly study in the laboratory unambiguous materials from the edge of the Solar System. Using conventional TEM and SEM methods, we have examined more than 30 individual fragments > ~10 µm that were lodged along tracks in aerogel tiles from 15 impacting comet grains. Results from preliminary examination are reported in [1]. Detailed study of the captured particles has shown that they consist of a diverse range of single minerals and/or mineral assemblages including olivine, low-Ca pyroxene, high-Ca pyroxene, pyrrhotite, pentlandite, kamacite and spinel. In two tracks, fayalite+tridymite and roedderite+enstatite+richterite+glass assemblages are mineralogically similar to chondrules from chondritic meteorites [2, 3]. A unique Stardust track – named Inti - contains numerous > 5 um particles composed of spinel ($MgAl_2O_4$), anorthite, gehlenite, fassaite, diopside, kamacite, PGE's and osbornite, an assemblage nearly identical to refractory calcium aluminum inclusions (CAIs) found in many chondritic meteorite types.

## Origin of Wild 2 Grains

The presence of high temperature µm-size crystalline minerals along with a general paucity of amorphous materials indicates that the grains that accreted to form comet Wild 2 were not formed in the cold outer regions of the protoplanetary disk nor were they derived from the interstellar medium which is dominated by submicron amorphous materials such as glassy silicates and carbonaceous grains. It appears that many of the grains in comet Wild 2 originated in the hot inner region of the solar nebula, were transported to the Kuiper belt region, and accreted into comet Wild 2.

[1] Zolensky *et. al.* (2006) *Science* **315**, 1735-1739. [2] Krot, A.N. & Wasso, J.T. (1994) *Meteoritics* **29**, 707-718. [3] Wood, J.A. & Holmberg, B.B. (1994) *Icarus* **108**, 309-324.

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# Fractionation of copper isotopes in plants

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The fractionation of copper isotopes in the environment is a topic of debate. The isotopic fractionation associated with plants activity in soils has not yet been documented. Fractionation of iron isotopes by plants has been recognized [1]. Iron isotope fractionation measured by Guelke *et al.* [1] stronly depends on the plants iron uptake strategy. During uptake, strategy I plants (reduction of Fe(III) in the soil), induce, a depletion of heavy isotope ($^{56}Fe$) in the plant by up to -1,6‰ compared to Fe in the soil while strategy II plants (exudation of chelating agents: phytosiderophores), generate a small enrichment of heavy iron (0,2‰).

Phytosiderophores exudated by strategy II plants can also complex copper and other metals [2]. Tests were made with strategy II plants (wheat) grown on Cu contaminated soils. Cu isotopic composition was measured in roots and shoots and measurements in the soils and seeds are currently ongoing. A depletion of heavy isotopes from roots to shoots of -0,41‰ ±0,07 is measured. New experiments in a phytotron with nutritive solutions are in progress to compare the Cu isotopic fractionation of strategy I (tomato) and strategy II (wheat) plants.

[1] Guelke M. & Von Blackburg F. (2007) *Environ. Sci. Technol.*, **41**, 1896-1901. [2] Chaignon *et al.* (2002) *New Phyt*, **154**, 121-130.