DISCOVERY OF AN IN-SITU PRESOLAR SILICATE GRAIN WITH GEMS-LIKE COMPOSITION IN THE BISHUNPUR MATRIX. S. Mostefaoui, K. K. Marhas, and P. Hoppe, Max-Planck-Institute for Chemistry (Otto-Hahn-Institut), Becherweg 27, D-55128 Mainz, Germany (smail@mpch-mainz.mpg.de).

Introduction: The study of acid-resistant residues in meteorites revealed that the most abundant mineral among presolar O-rich dust is spinel (>1 ppm), followed by corundum (200 ppb) [1]. This contrasts with expectations from ISO observations which revealed that silicates are the major oxide phases around young stars and in outflows from evolved red giant stars [2]. Interplanetary dust particles (IDPs), on the other hand, are found to contain presolar silicates [3]. Messenger and co-workers [3] estimated the abundance of presolar silicates in IDPs to be about 5500 ppm, which is considerably higher than the abundances of any other presolar mineral type in meteorites.

We recently reported the discovery of in-situ O-isotopic anomalies associated with two O- and Si-rich grains in Semarkona (LL3.0) and Bishunpur (LL3.1) [4]. Their O/Si ratios are within the olivine/pyroxene range, suggesting that these grains are presolar silicates. Together they represent an abundance of about 20 ppm in the matrix of Semarkona and Bishunpur. This indicates that the abundance of presolar silicates is far below that in IDPs. Many IDPs are attributed to be of cometary origin. They thus represent very primitive matter that escaped high temperature events, providing best prerequisites for the survival of presolar silicates. The comparatively lower abundance of presolar silicates in ordinary chondrites implies that they may have been partly destroyed in the meteorite parent bodies. Alternatively, presolar silicates might not have been homogenously distributed in the solar nebula or might have been preferentially destroyed in certain regions of the solar nebula.

Here, we report on continued in-situ NanoSIMS searches for presolar O-rich dust (oxides and silicates) in Bishunpur, taking full profit of the high spatial resolution of the NanoSIMS for the detection of submicrometer-sized presolar O-rich dust.

Procedure: Our procedure we used to search for in-situ presolar O-rich grains in meteorites consisted of five steps: (1) Selection of the meteorite which should have experienced no or only little alteration by secondary events such as metamorphism and aqueous activity. (2) Identification and documentation of the fine-grained matrix, the preferential site for hosting presolar grains. (3) Acquisition of ion images of the oxygen isotopes with the NanoSIMS. (4) Identification of isotopically anomalous objects in O-isotopic ratio images. (5) Determination of the chemical composition and mineralogy of presolar grains and mineralogical characterization of their environment by SEM/EDX.

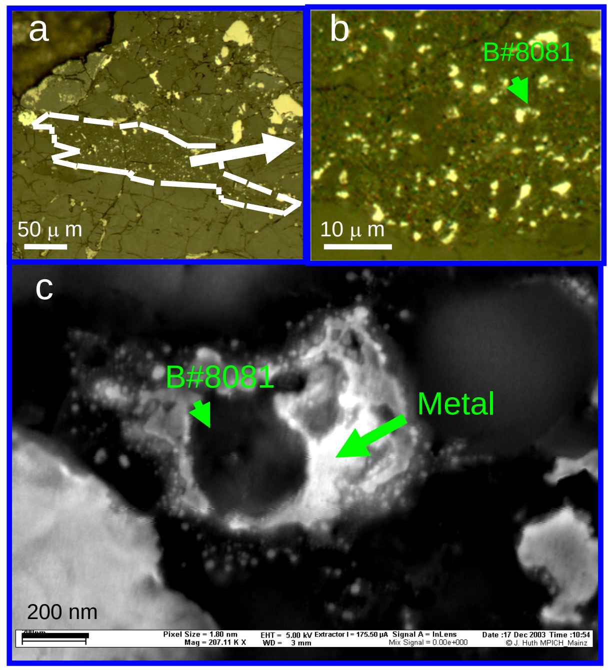

Fig. 1: (a) Optical microscope images of a portion of matrix in Bishunpur, (b) higher magnification image of a part of region (a) where the presolar silicate grain B#8081 was found, and (c) SEM image of grain B#8081.

Sample: In a previous investigation [4] we examined both Semarkona and Bishunpur. Here, although Semarkona is slightly more primitive than Bishunpur, we continued our studies on Bishunpur because its material is known to have escaped significant aqueous alteration, giving a better chance of finding presolar O-rich dust. A polished thin section of Bishunpur was then examined with optical microscope and SEM, where fresh matrix regions were selected (Fig. 1).

O-isotopic measurements: The selected matrix regions in Bishunpur were searched for presolar O-rich dust using the NanoSIMS 50 ion microprobe at the MPI for Chemistry. A focussed Cs^+ ion beam (<100 nm) of ~0.5 pA was rastered over areas of 9x9 µm^2. Negative secondary ions of the three O-isotopes, ^{28}Si and $^{27}Al^{16}O$ were simultaneously measured in multi-collection and 256x256 pixel image sequences (total integration time of ~30 min to ~1 hour per image set) were acquired on different locations.

Results: We analyzed 69 areas in various matrix regions in Bishunpur with the NanoSIMS covering a total area of 5590 µm^2. O-isotopic ratio images were calculated for each area. Selection criteria for a grain to be considered presolar were as follows: (i) an anomaly of >3σ should exist in at least one O-isotopic ratio, extending over at least 4 pixels, and (ii) the anomaly should be present in at least two subsequent images of the same area. Using the above criteria we successfully identified one presolar O-rich grain (B#8081, Fig. 2). The grain is enriched in both ^{17}O and ^{18}O, with $\delta^{17}O = 294 \pm 85$ ‰ and $\delta^{18}O = 711 \pm 43$ ‰. Grain B#8081 is about 300 nm in size and embedded in Fe-metal which contains significant amounts of oxygen (Fig.1c). Quantitative SEM-EDX investigation was carried out at 5 kV in order to minimize X-ray contributions from the surrounding material. These analyses showed that the grain is O- and Si-rich containing significant amounts of Al, Fe, and Mg (atom percent, O=66%, Mg=5%, Al=7%, Si=16%, Fe=7%). The abundance of Fe was estimated from the L-line in the EDX spectrum. A check at 15 and 20 kV indicates that other possible constituents, such as Ca, are low.

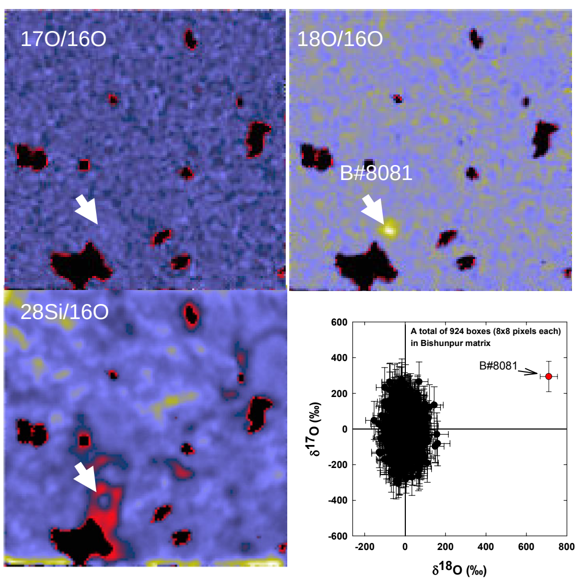

Fig. 2: O-isotopic and $^{28}Si/^{16}O$ ratio images of the 9x9 μm^2 area in the Bishunpur matrix where the presolar silicate grain B#8081 was found. The diagram shows oxygen isotopic ratios of 8x8 pixels sub-areas (~300 x 300 nm^2). Grain B#8081 with its large excesses in ^{17}O and ^{18}O is clearly separated from the bulk of the grains.

Discussion: Grain B#8081 is the second presolar O-rich grain we found in-situ in Bishunpur. In contrast to the two grains we found previously in Bishunpur and Semarkona [4], which belong to group 1 of presolar oxide grains, the O-isotopic signature of grain B#8081 is within the range of the rare group 4 presolar oxide grains [5]. The origin of the isotopic anomalies of group 4 is not well understood, but possible sources could be AGB stars experiencing dredge-up of ^{18}O during early pulses, low mass AGB stars of unusually high metallicity, or type II supernovae [5,6].

The textural setting of grain B#8081 is certainly of particular importance. The O-isotopic composition of the oxygen contained in the Fe-metal surrounding grain B#8081 is apparently normal. This suggests that grain B#8081 may have served as a condensation nuclei for the Fe-metal envelope in the solar nebula. Another possibility is that the Fe is primary, i.e., a stellar condensation product and that the oxygen contained in the Fe-metal is of secondary origin.

Grain B#8081 is larger than the two presolar grains we previously found (S#34-35, 100 nm; B#5-6, 200 nm) [4]. Taken together, the three grains represent an abundance of about 15 ppm in these two meteorites. This is higher by one order of magnitude compared to the abundance given by [1] for presolar oxides in CM meteorites but clearly lower than the abundance of 5500 ppm reported for presolar silicates in IDPs [3].

The major constituents of grain B#8081 are O and Si, i.e. it is a silicate. The low (Mg+Fe)/Si atomic ratio of 0.75 and the presence of Al in B#8081 excludes the possibility that it is olivine. Also, the atomic O/(Mg+Al+Si+Fe) ratio of 2 seems to rule out pyroxene (where this ratio is 1.5). On the other hand, the composition of grain B#8081 falls within the range of those of GEMS (glass with embedded metal and sulfides) previously described in IDPs [7]. Two of the presolar silicates identified in IDPs (out of three for which the mineralogy is known) [3] were shown to be GEMS. The non stoichiometric nature and O-excess, which are characteristics of GEMS [7], are visible in B#8081, suggesting that also grain B#8081 is a GEM.

Isotopic measurements of other elements in B#8081 (e.g. Mg-Al) are eminent for a better understanding of the stellar origin of the rare group 4 presolar O-rich grains. We plan to do such measurements in the near future.

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References: [1] Zinner E. et al. (2003) *GCA*, 67, 5083. [2] Waters E. B. F. M. et al. (1996) *A&A, 315*, L361. [3] Messenger S. et al. (2003) *Science, 300,* 105. [4] Mostefaoui S. et al. (2003) MAPS, 38, A99. [5] Nittler L. R. et al. (1997) *ApJ, 483*, 475. [6] Choi B. G. et al. (1998) Science, 282, 1284. [7] Bradley J. P. (1994) *Science*, 265, 925.