A NANOSIMS STUDY OF TWO NEW PRESOLAR SPINEL GRAINS FROM THE BISHUNPUR ORDINARY CHONDRITE. N. Krestina and P. Hoppe, Max-Planck-Institute for Chemistry, Cosmochemistry Department, P.O. Box 3060, D-55020 Mainz, Germany (krestina@mpch-mainz.mpg.de).

Introduction: Presolar oxide grains are rare in meteorites. Only some 190 grains [1-5], ~1µm to ~5µm in size, were found before the St. Louis group started to search for submicrometer-sized presolar oxides in meteoritic residues using the imaging technique with the NanoSIMS ion microprobe [6, 7]. These studies led to the discovery of a large number of additional presolar oxide grains. Out of ~75,000 submicron-sized grains, 317 grains with anomalous O-isotopic compositions were identified. While 88% of these presolar oxide grains are spinel, only 4 presolar spinels grains (out of ~190) were found among the micron-sized grains [1, 2, 4]. The vast majority of presolar spinel is apparently submicron in size and these grains make up at least 1 ppm of primitive meteorite matter, making spinel one of the most abundant presolar mineral phases in meteorites [6]. The small size of most presolar spinels, however, limits the number of elements for which isotopic compositions can be measured. On micron-sized grains, on the other hand, much more isotopic information can be obtained, making these grains indispensable for the study of presolar matter. Here we report on the discovery of two spinel grains, one of which is several µm in size and one with very extreme O-isotopic composition, from the Bishunpur ordinary chondrite.

Experimental: The acid- resistant Bishunpur residue was provided by G. Huss. Thousands of grains were dispersed on an ultra-clean gold foil. Prior to ion imaging the sample was analyzed with the Caltech SEM scanning system in order to determine the mineralogy of the grains [8]. Presolar oxide candidate grains were found by low-mass resolution secondary ion imaging with the modified Cameca IMS 3f ion microprobe at MPI for Chemistry, Mainz [9]. The ion imaging system consists of a Photometrics series 300 CCD camera attached to the MCP/FS detector. A defocused Cs^+ primary ion beam (~150 µm, ~5 nA) was used to acquire ion images of $^{16}O^-$, $^{18}O^-$, and $^{27}Al^{16}O^-$. Subsequent data processing resulted in the identification of two grains (out of ~6,000 Al-rich grains) whose $^{18}O/^{16}O$ ratios differ by more than 3σ from the solar value (Fig. 1).

These two grains were subsequently re-located in the NanoSIMS 50 ion microprobe at MPI for Chemistry and precise oxygen isotopic compositions were measured. Negative secondary ion images of ^{16}O, ^{17}O, ^{18}O, $^{24}Mg^{16}O$, and $^{27}Al^{16}O$, produced by rastering a focused (~100 nm) Cs^+ primary ion beam of <1 pA over the grains, were acquired in a multi-detection mode at a mass resolution sufficient to separate all relevant isobaric interferences. Measured $^{17}O/^{16}O$ and $^{18}O/^{16}O$ ratios were normalized to those obtained for spinels of solar composition from the meteoritic residue.

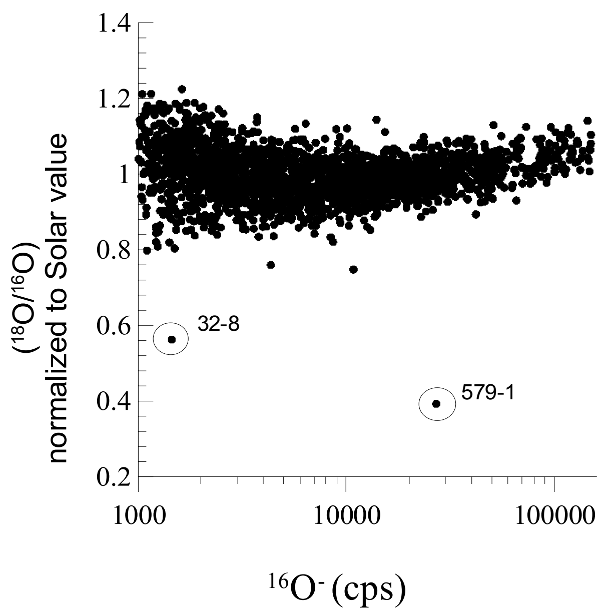

Fig. 1. $^{18}O/^{16}O$ ratios normalized to solar vs. $^{16}O^-$ count rate of Al-rich oxide grains from a Bishunpur residue measured by low-mass resolution ion imaging.

Results and Discussion: The NanoSIMS O-isotopic measurement confirmed the presolar nature of the two spinel grains identified by low- mass resolution ion imaging. The first spinel grain, Bish-579-1, is exceptionally large (6 x 4 µm) (Fig. 2 A). This grain is highly enriched in ^{17}O and highly depleted in ^{18}O relative to solar isotopic abundances ($^{17}O/^{16}O$ = 2.8 x solar and $^{18}O/^{16}O$ = 0.32 x solar, respectively). The other spinel grain, Bish-32-8, is relatively small (400 x 300 nm) (Fig. 2 B, left grain). The second grain to the right on the same image is an oxide grain with solar oxygen isotopic composition. Bish-32-8 is highly enriched in ^{17}O ($^{17}O/^{16}O$ = 2.9 x solar), as similarly seen in Bish-

579-1, and extremely depleted in ^{18}O ($^{18}O/^{16}O$ = 0.08 x solar). The $^{18}O/^{16}O$ ratio of this grain represents one of the most extreme ratios found so far for presolar oxide grains (see Fig. 3). Both grains belong to the group 2 of presolar oxide grains (^{17}O excess and large ^{18}O depletion) [1].

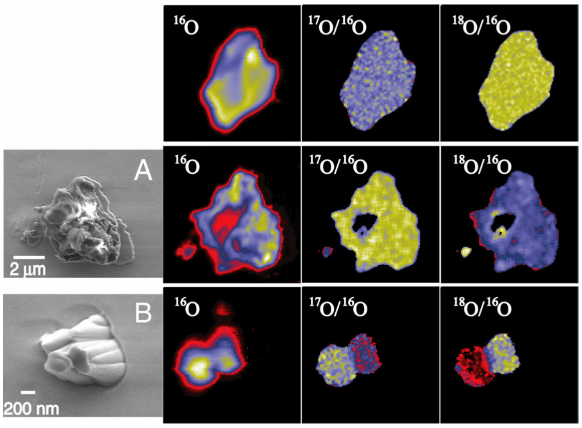

Fig. 2. NanoSIMS ^{16}O, $^{17}O/^{16}O$, and $^{18}O/^{16}O$ ion images of an isotopically normal spinel grain (top) and two new presolar spinel grains, Bish-579-1 (A) and Bish- 32-8 (B, left grain). The size of the ion images is 5 x 5 µm^2 (solar spinel), 9 x 9 µm^2 (Bish-579-1), and 1.5 x 1.5 µm^2 (Bish-32-8), respectively. The anomalous O-isotopic compositions of Bish-579-1 and Bish-32-8 can be seen from the different colors compared to the solar spinels.

It is well established that presolar oxide grains formed in red giant (RG) and asymptotic giant branch (AGB) stars [1]. In the envelope of such stars O-isotopic ratios are affected by core H burning followed by first and second dredge-up events [10]. Shell H and He burning and the third dredge-up events in AGB stars affect the envelope O-isotopic ratios only marginally. But cool bottom processing (CBP) in low-mass (< 3 $M_\odot$) AGB stars [11, 12] as well as hot bottom burning (HBB) in intermediate mass (4- 7 $M_\odot$) AGB stars [13] can strongly reduce $^{18}O/^{16}O$ ratios. Both spinel grains of this study plot near O- isotopic evolution lines that are calculated for CBP (see Fig.3), suggestive of formation in low- mass AGB stars with solar metallicities that experienced considerable CBP. Predictions for O-isotopic compositions resulting from HBB are more extreme than those observed in our two spinel grains. However, Nittler and co-workers [15, 16] have recently reported on a presolar spinel grain of similar O-isotopic composition as Bish-32-8 and with large Mg-isotopic anomalies which were attributed to HBB. Measurement of the Mg-isotopic composition in Bish-32-8 may thus help to get more insight into the nucleosynthetic history of the parent star.

The measurements of the isotopic compositions of other elements are in progress now. Of particular importance in this respect will be Mg-Al in both grains and, because of its very large size, Ti and other astrophysically diagnostic trace elements in Bish-579-1.

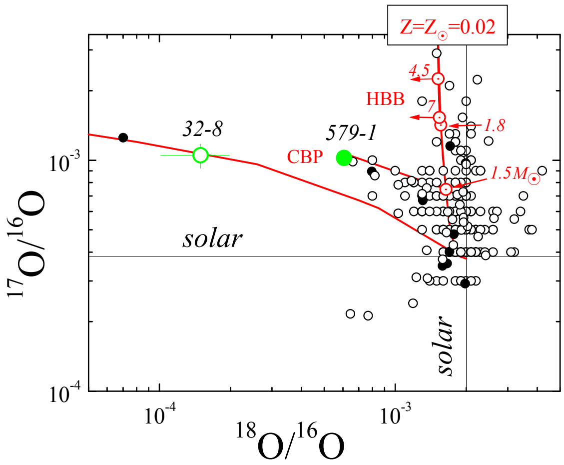

Fig. 3. Oxygen isotopic compositions of presolar spinel grains identified in this study (green circles) as well as previously measured presolar spinel grains (black circles) are shown along with model calculations [10, 14]. Filled circles represent micron-sized grains, open circles submicron-sized grains.

Acknowledgements: We thank Joachim Huth for the support in the SEM Lab and E. Gröner for technical assistance on the ion microprobes.

References: [1] Nittler L. R. et al. (1997) ApJ, 483, 475. [2] Choi B. et al. (1999) ApJ, 522, L133. [3] Krestina N. et al. (2002) LPSC, 33, #1425. [4] Strebel R. et al. (1997) MAPS, 32, A125. [5] Huss G. R. et al. (1994) ApJ, 430, L81. [6] Zinner E. et al. (2003) GCA, 67, 5083. [7] Nguyen A. et al. (2003) Public. of Astr. Soc. of Australia, 20, 382. [8] Heinrich M. et al. (1998) LPSC, 29, abst. #1715. [9] Besmehn A. et al. (2001) MAPS, 36, A20. [10] Boothroyd A. & Sackmann I. (1999) ApJ, 510, 232. [11] Wasserburg G. J. et al. (1995) ApJ, 447, L37. [12] Nollett K. M. et al. (2003) ApJ, 442, L21. [13] Boothroyd A. et al. (1995) ApJ, 442, L21. [14] Boothroyd A. et al. (1994) ApJ, 430, L77. [15] Nittler L. R. et al. (2000) LPSC, 30, abst. #2041. [16] Nittler L. R. et al. (2003) LPSC, 34, abst. #1703.