SEARCHING FOR CONTEMPORARY SUPERNOVA DUST IN DEEP-SEA SEDIMENTS R. C. Ogliore[1], M. Cohen[1], K. Wang[2], H. Chen[2], N. Liu[1]. [1]Department of Physics, Washington University in St. Louis, St. Louis, MO 63130, USA, [2]Department of Earth and Planetary Sciences, Washington University in St. Louis, St. Louis, MO 63130, USA.

Introduction: Excess ^{60}Fe measured in ferromanganese deep-sea crusts [1] was interpreted as a signature of dust from a nearby supernova because ^{60}Fe ($t_{1/2}$ = 2.6 Myr) is not produced efficiently by other mechanisms (e.g. cosmic-ray spallation). The ^{60}Fe excess (^{60}Fe/Fe=1–10 $\times 10^{-15}$) was recently found to be global and present in two different epochs (1.7–3.2 and 6.5–8.7 Myr ago) [2, 3]. Additionally, measurements of ^{60}Fe well above background (^{60}Fe/Fe=3.6$\times 10^{-15}$) in Apollo 12 soils [4] provide strong evidence that supernova grains arrived at the Earth-Moon system $\sim$2 Myr ago. The likely origin of these grains are supernovae from $\sim$9M$_\odot$ stars within a moving group, whose surviving members are now in the Scorpius–Centaurus stellar association (90–100 parsecs from the Sun) [5].

The solar wind and interplanetary magnetic field would have effectively shielded the Solar System from gas and plasma ejected from a nearby supernova, so it was likely supernova dust grains that carried the ^{60}Fe signature to Earth and Moon [6]. Most of this dust likely vaporized upon atmospheric entry [6]. However, if any supernova dust survived, it would represent an extremely valuable sample of contemporary supernova dust that can be compared with well-studied presolar (>4.6 Gyr old) supernova dust [7].

If supernova grains impacting the Moon had very high speed, the vaporized impactor material would exceed the Moon's escape velocity and be lost to space. However, [4] measured a similar concentration of ^{60}Fe as that seen on Earth [2]. Conservatively, the speed of the impacting grain must have been lower than about 10 km/s to account for the measured ^{60}Fe in lunar soils. The peak atmospheric heating temperature of such a grain can be calculated [8]. Grains less than 2 μm will not be heated above 1500° C. Therefore, refractory supernova grains, such as SiC (2730° C) and graphite ($\sim$4000° C) should easily survive atmospheric entry and can likely be found intact within $\sim$2-Myr-old deep-sea sediments.

The concentration of 1 μm contemporary SiC and graphite supernova grains in 2-Myr-old deep-sea sediments can be calculated by using the ^{60}Fe/Fe measurements of [2], the estimated ^{60}Fe/Fe in freshly synthesized supernova material [9], the atom fraction of Fe in presolar supernova grains, the fraction of presolar supernova grains that are SiC, and other considerations. Again using conservative estimates, we estimate there are 50–500 1-μm contemporary supernova SiC grains per 100 g of 2-Myr-old deep-sea sediment. This is similar to the concentration of presolar supernova grains in the sediments, hosted by micrometeorites. However, it would be possible to distinguish contemporary supernova dust from ancient dust by the presence of freshly synthesize, live ^{26}Al ($t_{1/2} = 705,000$ years) in contemporary dust.

Here we describe our effort to identify contemporary supernova grains in deep-sea sediments. Previous efforts to search for corundum, hibonite, and spinel among grains filtered from an ice core from the Qinghai-Tibetan plateau in China yielded no positivie identifications [10], though this study focused on more recent time periods (2–72 kyr ago).

Methods: We were allocated 200 grams of deep-sea sediments from the Antarctic Marine Geology Research Facility. These sediments were collected by the ELTANIN expeditions, sampled from cores measured by [2] and at similar depths: E49-53 ($\sim$385 cm depth) and E45-21 ($\sim$753 cm). The sediments resembled dried mud macroscopically. Backscattered electron imaging (Figure 1) and EDX of the soils revealed they were primarily composed of calcium carbonate in the form of calcareous fossils like coccoliths (several μm in size). Cosmic spherules and barite (released by calcareous microorganisms [9]) are also present in the sediments.

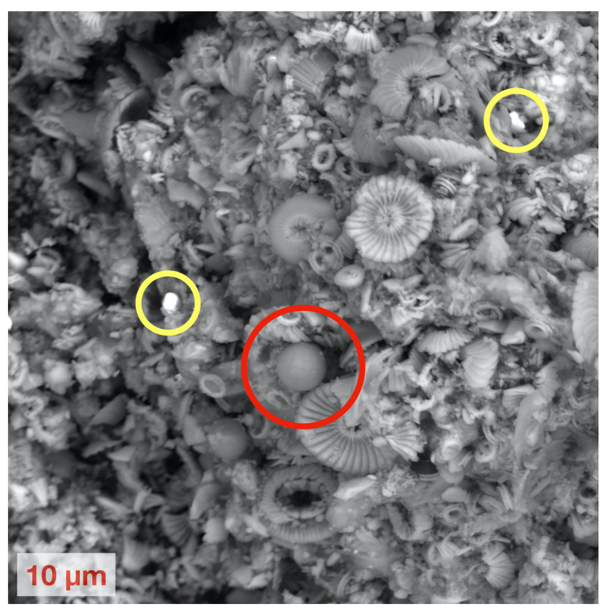

Figure 1: Backscattered electron image of sea sediment showing barite (circled in yellow) and a cosmic spherule (circled in red) embedded in calcareous fossils.

We first dissolved carbonates using 6.0N HCl at 20° C for one day, then 6.0N HCl at 150° C for one day. We centrifuged, dried the sample down, then repeated these steps. To dissolve the silicates and organics, we used HF+HNO_3 (3:1 ratio) at 150° C for two days, then concentrated HNO_3 at 150° C for two days, and then we dried down the residue. Next, we used 6.0N HCl at 20° C for one day and centrifuged. After this step, the residue was mostly barite. To dissovle the barite, we used KOH and diethylene triamine penta-acetic acid.

We fabricated Cu half-inch SEM stubs since Al and Au mounts have x-ray lines that interfere with Si, which is especially problematic with high Au or Al and low Si. We added isopropynol and purified water to the residue and deposited a drop onto the SEM stub with a pipette and dried out the liquid under a heat lamp.

We analyzed the residue on the Cu stub using a Tescan FEG-SEM with an EDAX energy-dispersive x-ray analysis system. We wrote custom software in Python, Matlab, and AutoHotKey to synchronize the SEM and x-ray analysis to efficiently analyze thousands of individual grains on the stub. First, we acquired a backscattered electron image with a 200 μm field-of-view. We used Matlab image segmentation routines to identify dark grains (lower atomic number) on the Cu substrate within this image (Figure 2), and wrote a batch x-ray analysis setup file (in XML) that we transfered to the EDAX system. An AutoHotKey script controlled the EDAX system and X-ray spectra were then acquired as spot analyses for each identified grain. These spectra were saved and the process was repeated for the next field-of-view. The entire half-inch stub takes 2-3 weeks to analyze in the SEM.

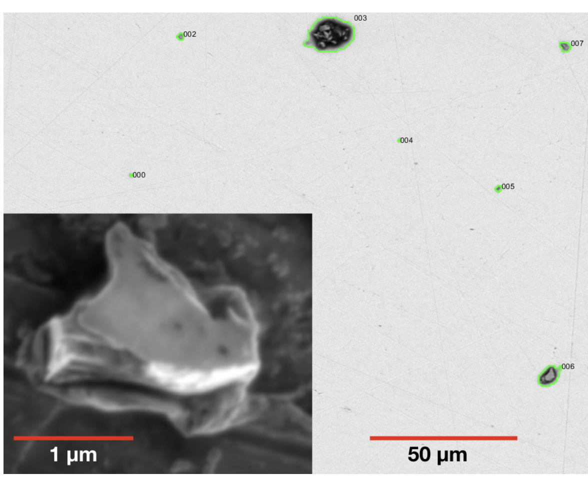

Figure 2: Backscattered electron image of Cu stub with residue particles. Identified grains are outlined in green. Inset: Secondary electron image of a carbon-rich grain identified in this search.

We identified several grains with Si and C contents consistent with either graphite or SiC grains (Figure 3). We located these grains on the SEM stub and analyzed them for C isotopes in the Wash U NanoSIMS 50 using a $\sim$1 pA Cs^+ primary beam focused to $\sim$100 nm.

Results: We have analyzed six grains for C isotopes and found that all were consistent with the terrestrial C isotope ratio ($\sim$10‰ 1σ uncertainties). Therefore, none of these grains are likely to be (contemporary or ancient) supernova grains.

Future Work: We are improving our techniques for: depositing residue on the Cu stubs (to increase the density of particles), more accurately identifying lower-Z grains on the Cu mount (especially sub-micron grains), and batch processing the EDS spectra (to detect sub-micron graphite and SiC grains with higher sensitivity). We are currently analyzing a second SEM stub, and will present these analyses at the conference.

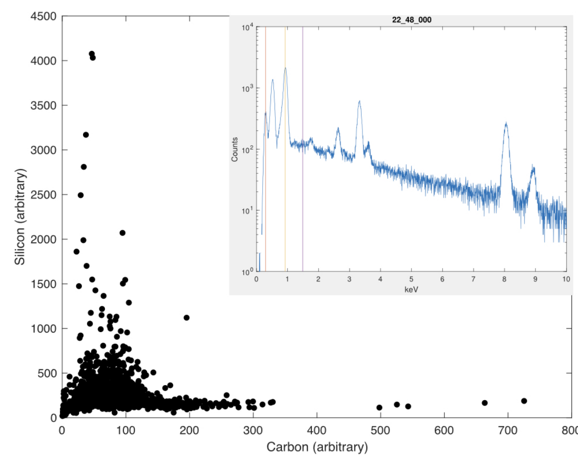

Figure 3: Si vs. C counts for from sediment residue grains. Inset: Example x-ray spectrum.

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