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Supernova Isotopic Signatures in Carbonaceous Chondrites: Implications for Chur Parameters

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Ed Anders compared the procedures of isolating presolar grains in primitive meteorites to “burning down the haystack to find the needle”. The “haystack” contains important complimentary information about the origin of our solar system that we can not learn from the “needle” alone.

We have recently reported Mo (N-TIMS) isotopic anomalies in acid dissolvable fractions of bulk carbonaceous chondrites (the haystack) as well as CAIs from Allende (Yin et al., 2000). The Mo isotopic results for Allende and Murchison are shown in Figure 1a and compared with a typical Mo isotopic composition of mainstream silicon carbide grains (Figure 1b, Nicolussi et al., 1998; Pellin et al., 1999). Acid dissolution procedures are not expected to attack and dissolve presolar grains, such as SiC and diamond. The acid dissolvable fraction of both Allende and Murchison exhibits *r*- and *p*-process enhancements (Figure 1a) and are in general complimentary to that of mainstream SiC grains in (Figure 1b). Using the abundance of the mainstream SiC grains (Huss, 1997) in Murchison, the Mo concentrations in SiC (Amari et al., 1995; Bernatowicz et al., 1996) and in our bulk sample, we may derive “zero epsilon”; or “solar average” Mo isotopic composition for Murchison. However, Allende contains very little SiC (Huss, 1990), and yet it’s isotopic composition shows the same *r*- and *p*-process enhancements as Murchison. This is strong evidence for unidentified silicates with supernova (*r*- and *p*-process) isotopic signature. Another bulk Allende sample shows an *s*-process enhancement, indicating that the *s*-process carrier is not limited to SiC grains.

Mo isotope results obtained for CAI “A44A” exhibit an *r*-process enhanced pattern, broadly similar to that of X-grains of supernova origin (Pellin et al., 1999). However, they differ in detail. The largest *r*-process excess would be expected in the pure *r*-process isotope, ^{100}Mo, which is clearly the case in A44A, but not in the two X-grains analyzed so far (Pellin et al., 1999). The largest enrichments for X-grains are in ^{95}Mo and ^{97}Mo. Thus the Mo isotopic signature of the X-grains is quite different from the solar system *r*-process mixture. The origin of X grain Mo anomalies have been successfully accounted for by the neutron burst model (Meyer et al., 2000), which also produces the Xe-H bearing component of presolar microdiamonds. We also note that A44A and X-grains show no enhancement in *p*-process ^{94}Mo, in contrast to bulk Allende and Murchison. This points to a component with strong enhancements in *p*-only nuclides, suggesting decoupled carrier phases for *p*- and *r*-process signature. The *p*-only component has not yet been observed for Mo, but it was observed for ^{144}Sm in CAI “C-1” (McCulloch and Wasserburg, 1978).

The Mo isotopic anomalies observed in the bulk carbonaceous chondrites and CAIs clearly indicate *r*- and *p*-process enhancement, corresponding to the theoretically expected nucleosynthetic components in supernova processes, but points to several distinct sources. It complements the *s*-process patterns observed in main stream SiC thought to be primarily of AGB star origin. These results are comparable with the *r*-process residuals after *s*-process subtraction from the solar abundance in classical stellar models (Käppeler et al., 1989).

Similar effects also exist in Zr (in particular ^{96}Zr) as well as Ba and Nd isotopes. The primary interest in measuring ^{96}Zr is that the ^{96}Zr abundance is a very sensitive indicator for the source and density of neutrons in the stellar source due to the branching at ^{95}Zr (64d) (Gallino et al., 1998).

The CHUR (*CH*ondritic *U*niform *R*eservoir) parameters used for various isotopic systems should not be based solely on data from carbonaceous chondrites, as they may be anomalous. For example, the Hf-W isotopic constraint on the time scale of core formation is currently based on reference values from carbonaceous chondrites. Therefore, the Hf-W time scale for core formation in the Earth may be in need of revision.

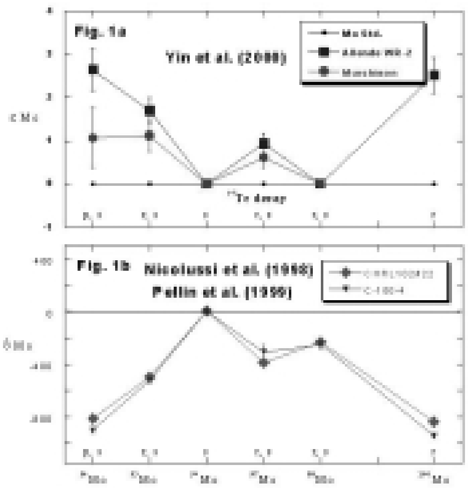

Figure 1: Mo isotopic anomalies in acid dissolvable fractions (the “haystack”) of bulk carbonaceous chondrites Allende and Murchison (Fig.1a), showing typical r-process enrichment pattern. Fig.1b compares typical Mo isotopic composition of mainstream silicon carbide grains. The patterns are complimentary.

Yin Q-Z, Yamashita K, & Jacobsen SB, *LPSC XXXI*, **CD-ROM**, Abstract#1920 and references there in, (2000).
Meyer BS, Clayton DD, & The L-S, *LPSC XXXI*, **CD-ROM**, Abstract#1458, (2000).