EXTREME CHROMIUM ISOTOPE ANOMALIES IN ORGUEIL NANO-OXIDES: PRESOLAR TYPE IA SUPERNOVA CONDENSATES?

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Introduction: Tiny (<100 nm) ^{54}Cr-rich oxide nanoparticles found in acid residues of the Orgueil meteorite [1,2] likely originated in supernovae (SN) and have been suggested to be the carriers of ^{54}Cr variations observed at bulk meteorite scales. However, these presolar grains are still poorly characterized, largely due to their small size and the relatively poor spatial resolution (~400-800 nm) of the duoplasmatron O^- ion source used for the prior NanoSIMS studies. Whereas the maximum previously observed ^{54}Cr enrichment was ~2.5×solar, simulations suggested that the true enrichments in the grains were up to ~50×solar [1]. Here we report high-resolution (100 nm) Cr-isotopic measurements of an Orgueil residue made with a new O^- NanoSIMS source. We have confirmed the presence of extreme ^{54}Cr anomalies of up to 57×solar. An origin in Type Ia SNe is preferred over Type II SNe, adding these to the list of stellar sources of presolar grains in the early Solar System.

Methods: We used the Carnegie NanoSIMS 50L equipped with a new Hyperion RF plasma O source (Oregon Physics, LLC) to map 195 15×15 µm areas of the same Orgueil acid residue mount studied by [1]. A 2-pA, ~100-nm-diameter O^- primary ion beam was used to produce secondary images of the four Cr isotopes as well as ^{48}Ti (to correct for the ^{50}Ti interference on ^{50}Cr) and ^{56,57}Fe (to correct ^{54}Cr for ^{54}Fe and search for Fe-isotope anomalies). Isotopic ratios were internally normalized to the average values in each image. Anomalous grains were identified both manually by examining isotopic ratio images and by automatic image segmentation. Typical uncertainties for individual ~100-nm grains were 14%, 10%, and 20% for ^{50}Cr/^{52}Cr, ^{53}Cr/^{52}Cr, and ^{54}Cr/^{52}Cr, respectively.

Results and Discussion: Out of about 60,000 Cr-rich grains identified in the images, we identified 42 grains with >10% ^{54}Cr enrichments (3σ) and three additional grains with normal ^{54}Cr but moderate anomalies in other Cr isotopes (Fig.). ^{54}Cr/^{52}Cr ratios range from 1.1 to 57 times solar. SEM analysis of five of the most ^{54}Cr-rich grains indicates that after analysis most are smaller than 80 nm in diameter. The ^{54}Cr-rich grains all have close-to-solar ^{53}Cr/^{52}Cr ratios, but the most anomalous grain (2_37) also has a large enrichment at mass 50; smaller mass 50 excesses are seen in the other grains with ^{54}Cr/^{52}Cr>0.1 (3.5×solar) We cannot yet determine whether these anomalies are in ^{50}Ti or ^{50}Cr; inferred δ^{50}Ti values are shown in parenthesis on the Fig. The predicted Cr-isotopic compositions [3] of O-rich zones of Type II SNe do not agree well with the data (Fig.), in particular the ~solar ^{53}Cr/^{52}Cr ratios seen in the grains. In contrast, predictions [4] for high-density Type Ia SNe are in good agreement with the grain data if the measured excesses at mass 50 are due to enhanced ^{50}Ti/^{48}Ti ratios in the grains. This supports a SNIa origin for the grains, though how Cr-oxides could form in these environments is a puzzle. Fe-isotope measurements also revealed one grain with excesses in ^{57}Fe (δ^{57}Fe=400±85‰) and at mass 54, corresponding to either δ^{54}Cr or δ^{54}Fe~300‰; a RIMS measurement could in principle identify which element carries the anomaly.

References: [1] Qin L., et al. (2011) *Geochimica Cosmochimica Acta, 75:* 629-644. [2] Dauphas N., et al. (2010) *Astrophysical Journal,* 720*:* 1577-1591. [3] Woosley S. E. and Heger A. (2007) *Physics Reports*, 442: 269-283, [4] Woosley S. E. (1997) *Astrophysical Journal,* 476:801-810.