REFRACTORY METAL NUGGETS WITHIN PRESOLAR GRAPHITE.

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Introduction: We report the discovery of OsRu-rich metal grains within a ^{13}C-rich low-density graphite from the Orgueil meteorite. The metal grains are compositionally similar to those found previously within 2 Murchison KFC1 graphites [1] and to the refractory metal nuggets (RMNs) found within primitive meteorites that are believed to be first condensates from the solar nebula [2]. Since the metal grains are found encapsulated in presolar graphite, they are probably first condensates from a ^{13}C-enriched and s-process-enriched circumstellar environment.

Procedure: C, N, O, Si, Al-Mg, K, Ca, and Ti isotopes were measured with the NanoSIMS on graphite d3m-7 from the Orgueil OR1d density-size separate (1.75-1.92 g cm^{-3}, >1 μm) [3,4]. D3m-7 was then ultramicrotomed and studied in TEM [5].

Results and Discussion: A ~20 nm grain of composition $Ru_{34}Os_{24}Mo_{23}Fe_{17}Ni_2$ was found within a ^{13}C-rich graphite (^{12}C/^{13}C=11.4 +/- 0.1). Multiple electron diffraction patterns show a hcp (a~2.8, c~4.4) solid solution of metallic Ru and Os. The grain was not closely associated with sulfides or oxides (as with some RMNs), but internal SiCs (~4.4 BCC) and low-Ni kamacites (~3.0Å BCC) and peripheral chromites were found within this graphite. Isolated metal grains with compositions $Os_{82}Ru_9Mo_6Fe_2Cr_1$ and $Os_{48}Ru_{36}Cr_{12}Fe_4$ and same crystal structure were found previously in two separate Murchison KFC1 graphites (isotopic compositions unmeasured), but no associated phases were found [1]. Numerous RuFe-rich metal grains (hcp with a~2.8Å, c~4.5Å; Ru_xFe_{1-x} w/ x=0.57-0.87 and no Os) were also found along with s-process enriched carbides in various turbostratic KFC1 graphites [6]. The RuFe metal grains were found with disproportionate frequency among ^{13}C-rich graphites. The absence of abundant noble metals seen in RMNs (e.g. Ir, Pt, Rh) may result from their limited solubility in the hcp phase (only Os, Ru, Re form hcp phase). The large s-process element enrichments (e.g. Ru, Mo) in the metal grains, as well as the association with s-process enriched carbides in some cases, indicate that CH stars or Sakurai's object are plausible stellar source types for the ^{13}C-rich graphites, as was the case for s-process enriched SiC A+B grains [7]. However, the range of metal grain compositions could also be a result of final equilibration with the gas (prior to encapsulation) over a range of temperatures. A study of isolated RMNs by [8] showed a similar compositional range to our metal grains, namely Os-dominated alloys that became progressively richer in Mo, Ru and with simultaneous increase in Fe, Ni content. These RMN compositions agree with results of condensation calculations from a gas of solar composition as the temperature of final equilibration is lowered from 1616K to ~1450K [8].

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