HSE ABUNDANCES AND Re-Os MODEL AGE OF A METALLIC VEIN IN CANYON DIABLO GRAPHITE. C.D. Hilton[1], K.R. Bermingham[1], R.D. Ash[1], P.M. Piccoli[1], D.A. Kring[2], T.J. McCoy[3], and R.J. Walker[1] [1]Department of Geology, University of Maryland, College Park, Maryland, 20742, USA [2]Lunar and Planetary Institute, USRA, Houston, TX, 77058, USA [3]Department of Mineral Sciences, National Museum of Natural History, Smithsonian Institution, Washington, DC, 20560, USA (chilton@umd.edu).

Introduction: The origin of metallic veins penetrating graphite nodules in the Canyon Diablo (CD) IAB iron meteorite is unresolved. There are two leading models describing metallic vein formation. One possibility is that shock melting of CD resulted in melt intrusion into the graphite nodules, followed by rapid cooling [1]. This model is supported by trends of highly siderophile element (HSE: Re, Os, Ir, Ru, Pt, Rh, Pd) abundances in the vein compared to bulk CD material. Alternatively, metallic veins were a product of a more moderate thermal event than suggested by [1]. This alternate model is supported by sub-mm chemical heterogeneity within the veins and noble gas data obtained from CD graphite, which has been implied to suggest that graphite nodules were not heated above 500-600 °C [2-3].

To further constrain the origin of metallic veins in CD, we report the presence of cohenite, kamacite, and taenite in the vein, mineral compositional data, and HSE abundances in vein kamacite relative to CD bulk kamacite.

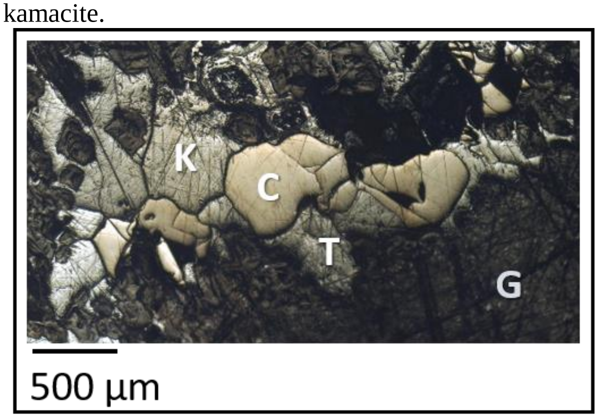

Figure 1. Reflected light photograph of a metallic vein within a graphite nodule in CD. Minerals are labeled as G (graphite), C (cohenite), K (kamacite), and T (taenite).

Methods: A 6.52 g sample of CD consisting of a graphite nodule with cross-cutting metallic veins (Fig. 1) was obtained from the Smithsonian Institution (SI), Department of Mineral Sciences, National Museum of Natural History. A piece of CD, which was devoid of graphite and metallic veins and also obtained from the SI, was examined for comparison. Both samples were analyzed using a *JEOL JXA-8900* electron probe microanalyzer (EMPA) at the University of Maryland (UMd). Phases from each sample were analyzed for Mg, Al, Si, S, Cl, Ti, Cr, Mn, Fe, Co, Ni, and Cu. Two-sigma uncertainties for the analyses of the major elements were determined from counting statistics and range from 1.4-4.5% for Ni, 0.64-0.66% for Fe and 6.7-24.6% for Co. Phases from each sample were also analyzed for HSE abundances by laser-ablation using a *Thermo Finnigan Element 2* Inductively Coupled Plasma Mass Spectrometer (LA-ICPMS) at UMd. A 7 Hz, 55 µm laser spot size was used, and absolute HSE concentrations were obtained from comparison with iron meteorites Hoba, North Chile, and SRM 1263a, using Fe as the element of reference. Concentrations for the HSEs were averaged for each mineral and errors are reported using 2SE. Three homogenized bulk fractions of the vein were digested and purified for Os and HSEs using methods described in [4]. $^{187}Os/^{188}Os$ ratios were determined using a *Thermo-Fisher Triton* Thermal Ionization Mass Spectrometer (TIMS) at UMd. Isotope dilution measurements of other HSEs were made using ICP-MS.

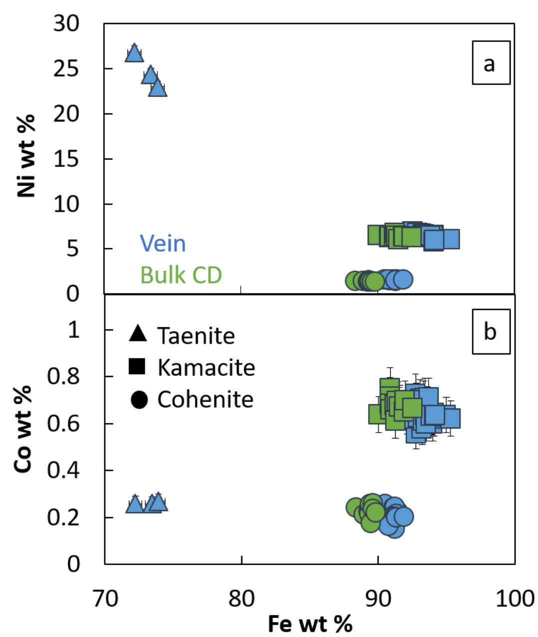

Figure 2. Iron (wt %) vs. (a) Ni (wt %) and (b) Co (wt %). These elemental abundances were used to identify the presence of cohenite, kamacite, and taenite in the samples. 2σ error bars are smaller than some symbols. Blue shapes represent the metallic vein and green shapes represent bulk CD material.

Results: The identification of kamacite and taenite in the metallic vein were made from electron microprobe analyses, as they are easily identifiable from Fe and Ni concentrations (Fig. 2). Importantly, cohenite was identified in the metallic vein, making this the first reported occurrence of cohenite in a CD metallic vein. Cohenite was identified by comparison with Ni and Co concentrations reported by [5].

Abundances of HSEs for kamacite in the vein compared to kamacite in the CD bulk sample are shown in Fig. 3. The HSE concentrations in the vein correlate with ionic radius, as observed by [1]. A similar trend is observed if this ratio is plotted by partition coefficients between taenite (γ) and liquid Fe-Ni metal, D (γ/liq. met.) [6].

$^{187}Os/^{188}Os$ ratios for the vein are noticeably more radiogenic (0.13517-0.13868) than the $^{187}Os/^{188}Os$ value obtained by [7] for a bulk sample of CD (0.12723). Data collection for a Re-Os model age calculation and HSE concentrations of homogenized vein samples are underway.

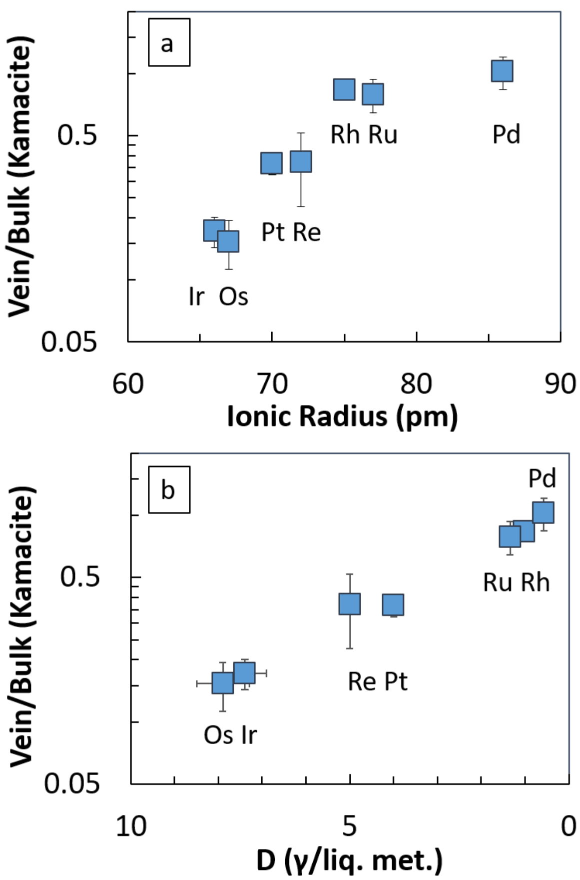

Figure 3. HSE concentrations in kamacite from the vein normalized to kamacite in the bulk CD sample. Blue squares are average concentrations of the HSEs in the samples and error bars represent 2SE, although they may be smaller than the symbols. (3a) There is an increase in concentration of HSEs with larger ionic radii in kamacite in the vein, similar to the trend reported by [1]. (3b) There is an increase in concentration for HSEs in kamacite in the vein that correlates with D (γ/liq. met.) [6].

Discussion: The presence of cohenite in the vein indicates that the vein formed at temperatures above 600 °C, based on published data for the Fe-Ni-C system [8,9]. Additionally, the trend observed in Fig. 3a supports the conclusion that the vein represents melt from the CD bulk material; larger ions are typically less compatible and will preferentially go into a melt. For example, kamacite in the vein is enriched in HSEs with larger ionic radii, suggesting that the bulk CD material was partially melted and formed metallic veins enriched in more incompatible HSEs. This trend is better observed in Fig. 3b, where D (γ/liq. met.) is used in place of ionic radius [6]. This trend shows that incompatibility generally correlates with ionic radius for the HSEs.

The $^{187}Os/^{188}Os$ values obtained for the homogenized vein are more radiogenic than the bulk CD material. A Re-Os model age for the vein, relative to the bulk metal may provide insight into when the veins formed once Re data are available.

Conclusion: The identification of cohenite in a CD metallic vein is evidence that the vein reached temperatures above 600 °C. The HSE data for kamacite in the vein compared to a bulk sample of CD suggests that the vein is a melt product of CD. Additionally, the different $^{187}Os/^{188}Os$ values obtained for the vein compared to bulk CD material is promising for Re-Os chronometry.

References: [1] Hirata T. and Nesbitt R.W. (1997) *EPSL*, *147*, 11-24. [2] Kurat G. et al. (2000) *LPS XXXI*, Abstract #1666. [3] Matsuda J. et al. (2005) *MAPS*, *40*, 431-443. [4] Walker, R.J. (2012) *EPSL*, *351-352*, 36-44. [5] Scott E.R.D. and Goldstein J.I. (2012) *LPS XLIII*, Abstract #2671. [6] Corrigan C.M. et al. (2009) *Geochim. Cosmochim. Acta*, *73*, 2674-2691. [7] Worsham, E.A. et al. (2016) *Geochim. Cosmochim. Acta*, *188*, 261-283. [8] Brett R. (1966) *Sci.*, *153*, 60-62. [9] Brett, R. (1967) *Geochim. Cosmochim. Acta*, *31*, 143-159.