ELECTRON MICROPROBE ANALYSIS OF COHENITE AND HAXONITE PRECIPITATES IN THE CANYON DIABLO (IAB-MG) AND COLONIA OBRERA (IIIE) IRON METEORITES AND QEQERTARSUAQ (DISKO ISLAND), GREENLAND, ROCKS. Axel Wittmann[1] and Laurence A. J. Garvie[2], [1]Eyring Materials Center, Arizona State University, Tempe, AZ 85287-1704, axel.wittmann@asu.edu, [2]Center for Meteorite Studies, School of Earth and Space Exploration, Arizona State University, 781 East Terrace Rd., Tempe, AZ 85287-6004, lgarvie@asu.edu.

Introduction: Cohenite (aka cementite) $(Fe,Ni,Co)_3C$ and haxonite $(Fe,Ni)_{23}C_6$ are carbide minerals that occur in meteorites [1–6]. Cohenite also occurs in lunar rocks [7] and a few places on Earth, e.g., [8]. Iron carbide is postulated to be a component of Earth's core [9–11].

Because carbon is typically difficult to analyze with the electron microprobe, its content in cohenite and haxonite in meteorites has been calculated by difference [3,8]. Here we demonstrate the analysis of carbon in meteoritic and terrestrial carbides by wavelength dispersive electron microprobe analysis.

Samples and Methods: For calibration, we used pure metal standards, schreibersite, troilite and cementite grains in carburized pure iron (European Commission – Joint Research Centre Institute for Reference Materials and Measurements certified reference material IRMM-471 with 6.69±0.27 wt% C in cementite; [12]).

The meteoritic specimens are shocked and unshocked pieces of the Canyon Diablo IAB (#34.66.165), and Colonia Obrera IIIE, which are both coarse octahedrites. In addition, we analyzed a piece of native metal with cohenite intergrowths from Qeqertarsuaq (Disko Island, Greenland).

All samples and standards were polished and rinsed with deionized water and plasma cleaned for 20 minutes immediately prior to insertion into the electron microprobe. Samples and standards were analyzed without the typical amorphous carbon coat.

To measure the elements Fe, Ni, Cr, Co, S, P, and C, we used the Jeol JXA-8530F field emission electron microprobe at the Eyring Materials Center of Arizona State University. Utilizing an accelerating voltage of 20 kV, a beam current of 20 nA, and a beam diameter of 1 µm, Fe and Ni were measured with the LIF crystal, Cr and Co with the LIFH crystal, S and P with the PETJ crystal, and C with a LDE2 Ni/C crystal. Counting times on peaks and backgrounds were 60 seconds for Fe, Ni, Cr, Co, S, P, and 130 seconds for C, which yielded detection limits of 0.03 wt% for C, Fe, and Ni, 0.02 wt% for Co, P, and S, and 0.01 wt% for Cr. We applied a peak overlap correction for the Fe-Kβ X-ray line interference with the Co-Kα X-ray line. For the ZAF-correction, we used the model of [13] as implemented in the Probe for EPMA software.

Results: To gauge the degree to which hydrocarbon contamination in our electron microprobe adds C during the analyses [14], we compared 13 analysis spots on nominally C-free schreibersite, 11 of which were taken on the same location (Fig. 1). Carbon-buildup due to beam irradiation in our electron microprobe that operates with oil-free vacuum pumps only becomes an issue after about 10 minutes of beam irradiation on the same spot, with the 6th measurement on the same location. Thus, carbon buildup during analysis did not affect the cohenite and haxonite analyses.

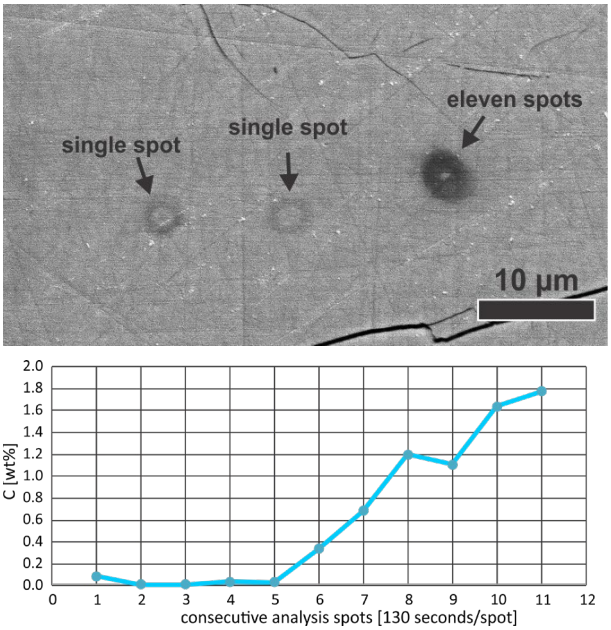

Fig. 1. Carbon deposition by electron microprobe. Secondary electron image of dark carbon halos deposited during spot analyses on schreibersite (top), chart for successive carbon buildup during the eleven spot analyses (below).

Table 1 summarizes the electron microprobe data we obtained and Fig. 2 shows representative regions of our samples.

Discussion: Analyzing Fe,Ni carbides with the electron microprobe is a complex problem. Based on repeat analyses on components with C-contents below the EPMA detection limit (kamacite, taenite, schreibersite) [15], we found that the precision with which we can determine the abundance of carbon in natural carbides with the measurement conditions described here

is on the order ±0.15 wt%, which is typical for EMPA of carbon [14].

Our results (Table 1) show the precision of our analytical approach. Element abundances are comparable to typical concentrations reported for cohenite and haxonite in various iron meteorites [16]; however, a dearth of precise electron microprobe data in the literature prevents direct comparison.

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Table 1. Composition of carbide precipitates measured by EPMA.

	[n]	Fe [wt%]	Ni [wt%]	Co [wt%]	C [wt%]	Sum [wt%]
unshocked Canyon Diablo cohenite	15	91.8 ±0.20	1.40 ±0.10	0.10 ±0.01	6.58 ±0.03	99.9 ±0.19
shocked Canyon Diablo cohenite	7	91.6 ±0.28	1.67 ±0.20	0.15 ±0.01	6.55 ±0.06	100.0 ±0.19
Disko Island cohenite	14	92.6 ±0.24	0.53 ±0.02	0.33 ±0.01	6.45 ±0.15	99.9 ±0.23
Disko Island literature‡		92.6	0.60	0.28		
Colonia Obrera haxonite	18	89.1 ±0.28	5.03 ±0.18	0.30 ±0.05	5.28 ±0.06	99.7 ±0.19
Cementite standard	40	93.2 ±0.19	<0.03	<0.02	6.75 ±0.18	100.0 ±0.23

‡[8]; Cr, S, and P were near or below their detection limits.

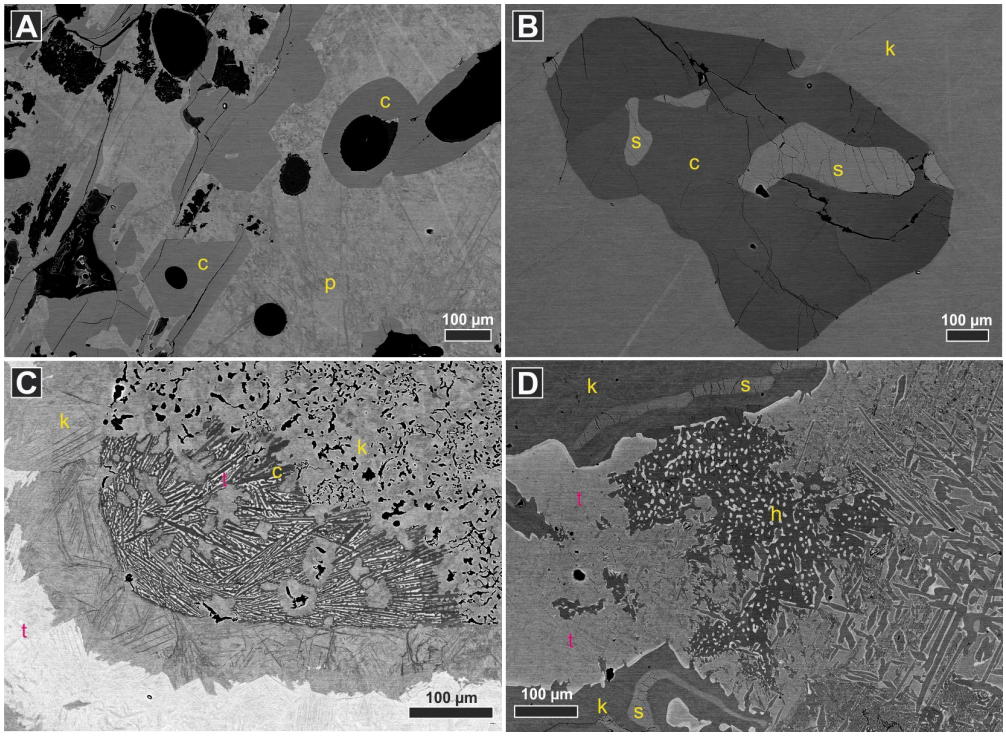

Fig. 2. Carbide precipitates back-scattered electron images. A-Qeqertarsuaq (Disko Island); B-Canyon Diablo unshocked; C-Canyon Diablo shocked; D-Colonia Obrera; s-schreibersite, k-kamacite, t-taenite, p-plessite, c-cohenite, h-haxonite.