FERROUS MINERALS AND IMPACTITE MINERALIZATION AT MISSOURI'S CROOKED CREEK AND DECATURVILLE IMPACT CRATERS. R. E. Beauford[1], [1]Arkansas Center for Space and Planetary Sciences, MUSE 202, University of Arkansas, Fayetteville, AR, 72701, USA. rbeaufor@uark.edu

A sample of iron from the Crooked Creek crater and a sample of iron oxide from the Decaturville crater were subjected to XRF major oxide analysis in order to identify possible gross indicators of impactor metal contribution and constrain future directions of inquiry. While a positive result was not anticipated for the Crooked Creek sample, its analysis could not be neglected due to its unusual character (figure 1) and setting. This sample showed no suggestive nickel or other enrichment and may result from early 19th century iron mining within the crater.

A significant quantity of ferrous minerals, often as crystalline masses of up to a kilogram or more, are found amidst indurated lithic breccias near the central region of the Decaturville crater. Cutting and physical examination suggests that these are limonitic pseudomorphs after iron sulfide (figure 3). Upon speculation that these could represent the in-situ decay or hydrothermal concentration of impact related iron, a mass was subjected to preliminary analysis via X-Ray Fluorescence. The result suggests that the mass originated during post-impact mineralization of the structure via groundwater, and shows no unusual enrichment.

Both of these findings are consistent with the known history of the region, which has been a major source of metal ores for well over 100 years. If an impactor is to be identified at either of these sites, it will, in all likelihood, be via trace element analysis as summarized by Tagle and Hecht (2006) [1].

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Figure 1. Unoxidized iron, originally mistaken for magnetite due to a covering scale of oxide, revealed a surprising interior when cut. A 2+ kilogram mass was found as a float cobble during field work at Crooked Creek Crater, Missouri.

Introduction: The Crooked Creek (7 km) and Decaturville (5.5 to 6 km) impact craters are both principally located in Ordovician to Carboniferous dolostone and sandstone in central Missouri. Both craters were originally documented and explored, long before they were identified as impact structures, by geologists seeking lead, zinc and iron ores. Missouri has historically been one of the world's leading producers of both lead and zinc. Lead, coal, iron, and barium were all mined in limited quantities at small excavations within the bounds of the Crooked Creek crater during the early 1900s and late 1800s [2]. Substantial exploratory core drilling, surface prospecting, and some small scale mining was done at the Decaturville site as well [3], including the economic exploitation of iron sulfide bearing breccias on the central uplift.

Timing of Mineralization at Decaturville and Crooked Creek: Epigenetic hydrothermal mineralization accompanied Paleozoic dolomitization of carbonates at a regional scale in the Ozarks [4], and is attributed to hot, mineralized brines that flowing from the Arkoma Basin to the south and possibly from the Illinois Basin to the East [5]. Mining, for a wide range of metals, has been going on in southern and central Missouri since the mid 19th century or earlier. Kiilsgaard et al., 1962 [6], found evidence that mineralization occurred subsequent to the Crooked Creek impact. Hendriks, 1954 [2], and others have suggested that not only the mineralization, but the faulting with which it is associated post dates the crater.

The presence of mineralization associated with impact related faults at the Decaturville site suggests that the impact occurred prior to or during regional mineralization of this region as well, but it is also possible that the impact itself drove temporary localized hydrothermal mineralization along the flanks of the crater's central uplift. Since the faults associated with both structure reach to the igneous basement of the region, previously isolated brines overlying the regional basement may have been mobilized by impact induced failure of subsurface hydrological barriers. Both interpretations are consistent with the poorly constrained crater age and with the timing range for mineralizing episodes in Missouri's history.

Timing of dolomitization and Mississippi Valley-Type mineralization of the Ozarks varies regionally with the geophysical evolution of the landscape [7]. Earliest and most prolonged mineralization is recorded in SE Missouri, from the Cambrian to early Mississippian, while central Missouri, with less data published, shows mineralization in the Pennsylvanian [8].

Figure 2. **F**errous mineral mass from the weathered surface of breccias on the south side of the central uplift region of the Decaturville Crater, Missouri.

Figure 3. Interior of the mass shown in figure 3. Limonite/Hematite pseudomorphs preserve pyrite crystal structure. Less altered masses of iron-sulfide were mined from a pit closer to the crater's center [3].

Discussion - The Crooked Creek Metal: The iron mass (figure 1) found as float within the Crooked Creek Crater was analyzed for major oxides by XRF at Activation Laboratories, Ltd., in Ontario, Canada. Despite the metal's unusual context, a lack of nickel or other substantial impurities suggests that this material is the result of metal ore mining. If this interpretation is correct, the same challenges that make interpretation of sedimentary impactites difficult might be seen here to affect the normally simple process of recognizing refining slag. Since the sample was recovered as float and showed no evidence of unusual origin, the analysis proves little use beyond saving future researchers a waste of time in duplicating analysis.

Discussion: Impactors and Impactor Identification at large impact structures:

Impactor Survival over geological time

Prior discoveries suggest that original, unaltered iron may occasionally be found from early impacts. The 110 million year old Lake Murray, Cretaceous aged iron is an example [9]. Whether deteriorated equivalents can be recognized as in-situ masses of iron oxide or iron sulfide minerals is unknown, as is the extent to which nickel or other indicators of meteoritic origin for such a mass may evade mobilization away from the site of a decayed mass.

Large Impact Event Survival

Before an impactor can survive post-impact chemical decay, it must survive the impact itself. [10] Pierazzo and Melosh, 2000 suggest that a substantial portion of some impacting masses may survive, even for very large impacts. Evidence seems to agree [11][12].

Impactor Identification

Regardless of impact survival, the preservation of impactor remnants over geological time requires extraordinarily fortuitous circumstances. Though remotely possible, it is not a good bet, and relying on trace element ratios in contaminated impactites from chemical traces dispersed during impactor obliteration has been far more productive. The identification of impactors at large impact structures has been achieved through several avenues of trace element chemical analysis at over two dozen craters [1], and may provide an achievable route forward in attempts to identify the impactor at both of these crater locations.

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