DISTRIBUTION OF SIDEROPHILE AND OTHER TRACE ELEMENTS IN MELT ROCK AT THE CHICXULUB IMPACT STRUCTURE;

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Recent isotopic and mineralogical studies [1-4] have demonstrated a temporal and chemical link between the Chicxulub multiring impact basin [5] and ejecta at the Cretaceous-Tertiary boundary. A fundamental problem yet to be resolved, however, is identification of the projectile responsible for this cataclysmic event. Drill core samples of impact melt rock from the Chicxulub structure contain Ir and Os abundances and Re-Os isotopic ratios indicating the presence of up to ~3% meteoritic material [2,6,7]. We have used a technique involving microdrilling and high sensitivity instrumental neutron activation analysis (INAA) [8] in conjunction with electron microprobe analysis to characterize further the distribution of siderophile and other trace elements among phases within the C1-N10 melt rock.

Initial studies of whole rock INAA for eleven melt rock fragments reported Ir abundances ranging from <1.5 ppb to 13.5 ± 0.9 ppb [2,6]. Furthermore, variations in Ir concentration (~2×) between splits (≤100 mg) of finely-ground powder from single fragments (~1 g) suggest that the Ir is concentrated in a trace phase that is not uniformly disseminated in the melt rock. Because sulfides, ranging in size from 10 to 300 μm, were observed in thin section as heterogeneously distributed trace phases (<1%), and because significant siderophile element enrichments have been found in association with sulfide particles at other impact structures [9-11], these sulfides, variably enriched in Co and Ni (e.g. Fig. 1a), were considered potential carrier phases for the Ir [6]. The principal objective of this study was to test that hypothesis.

Microcores of four pyrite grains (e.g. Fig. 1b) were obtained from a thin section of C1-N10. Chalcopyrite, though present, was not sampled because of the elevated background expected from high Cu concentrations. Samples of pyroxene, plagioclase, magnetite, and mesostasis were also drilled to investigate trace element partitioning among the more abundant phases of the melt rock. Because the cores (40 to 400 μm dia. × 50 μm thick) are too small to weigh accurately, their masses have been estimated by calibrating the Fe concentration determined by INAA with the FeO content obtained by microprobe analyses prior to removal from the thin section. Comparison of INAA values for Na_2O, K_2O, CaO, and relevant minor elements to corresponding microprobe analyses indicate that, in most cases, the cores are of reasonable purity with respect to the phase of interest. Two of the pyrite cores were known to contain significant (melt?) inclusions and/or adhering silicate material, and their analyses are compromised by relatively high concentrations of alkali and rare earth elements.

Analyses of the two relatively pure pyrite cores are compared to C1-N10 whole rock abundances in Figure 2. These results confirm the elevated concentrations and variable distribution of Co and Ni, and show analogous variations for Au and As. However, no measurable Ir was found in either sample, and 2σ upper limits of <50 ppb and <34 ppb place severe constraints on the feasibility of pyrite as a significant sink for the Ir. Considering average Co concentrations of 4720 ppm for pyrite and 15 ppm for the whole rock limits the maximum pyrite abundance to ~0.3%, whereas at least 25% would be required to account for the whole rock Ir abundance even if one assumed an Ir concentration for pyrite to lie between the noted upper limits. Cobalt concentrations of 40 ppm in pyroxene suggest that the pyrite abundance is probably much lower than 0.3%. Based on these results, the hypothesis that sulfides are a carrier phase for Ir must be rejected. We note, however, that these samples constitute only four of the 125 sulfide grains observed in the thin section, and it is possible that a sulfide phase other than pyrite and chalcopyrite (e.g. Irarsite, Iridarsenite, etc.) is among that population. Nevertheless, it is clear that alternative hypotheses for the Ir carrier phase should be explored. There are numerous submicron particles with high backscatter electron intensity scattered throughout the melt matrix yet to be characterized.

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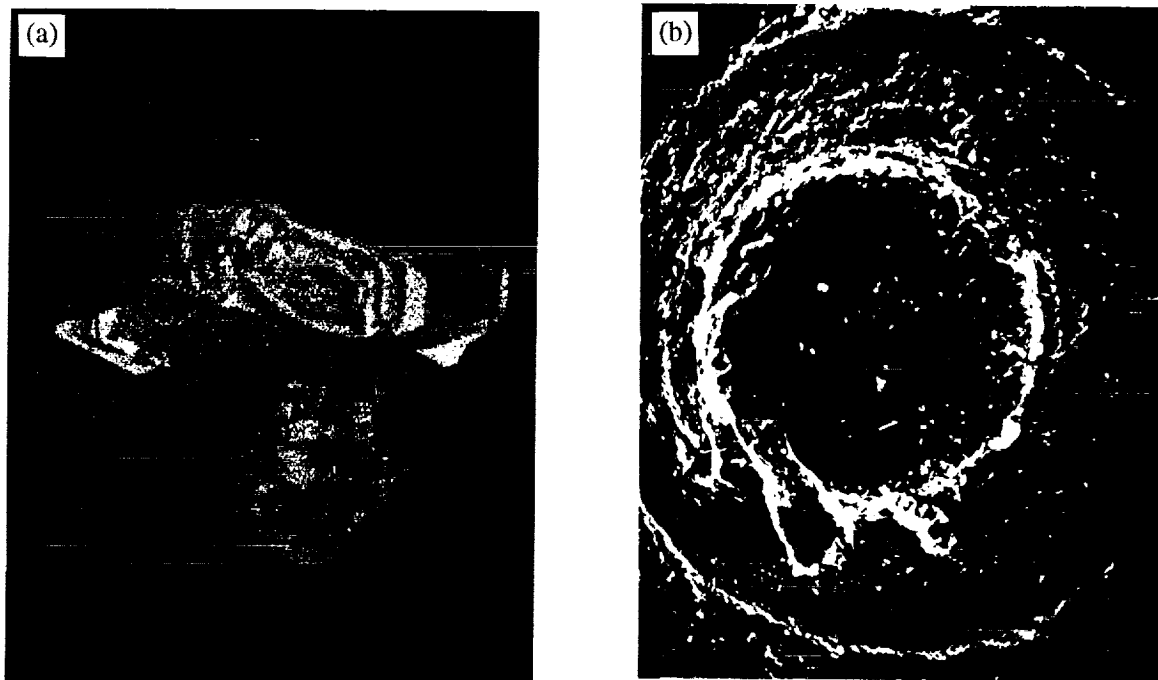

Figure 1. Thin section photomicrographs of pyrite C1-N10 S85. (a) X-ray map showing oscillatory zoning of Co. (b) SEM image of microcore volume.
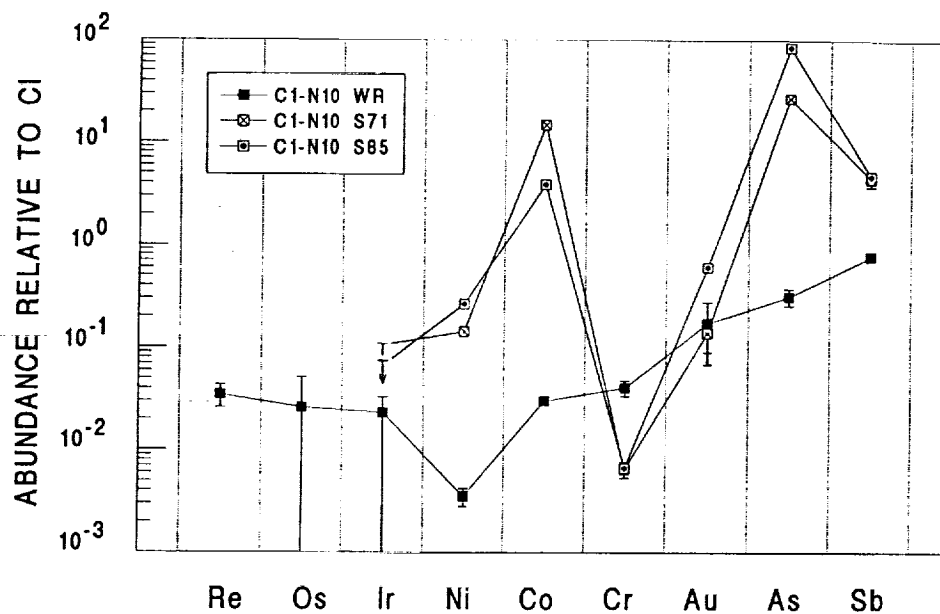

Figure 2. Siderophile and chromium abundance ratios in C1-N10 whole rock (WR) and pyrite cores (S71 and S85) relative to CI chondrites [12]. 2σ upper limits for Ir are shown for the pyrite cores. Rhenium and Os data for C1-N10 WR from [7].