PLATINUM GROUP ELEMENTS ANALYSIS OF IMPACTITES FROM THE ICDP CHICXULUB DRILL CORE YAX-1: ARE THERE TRACES OF THE IMPACTOR?

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Introduction: The nature of the Chicxulub impactor is still not fully understood. Attempts to identify the traces of the impactor from chemical analyses of impactites within the crater are extremely controversial. Ir analyses of samples from the Chicxulub-1 and Yucatan-6 drill cores lead to different results. Nuggets of platinum group elements (PGE) and Ir concentration of more than 1000pg/g were reported [1]. Analyses of samples from the same core made by other authors did not show any Ir enrichment [2,3]. Os isotopes studies of one impact melt sample from the Chicxulub-1 core indicate a probable presence of an extraterrestrial component [4]. Results from K/T sites show an unequivocal picture. K/T sites all over the world are enriched in PGE. These enrichments are interpreted as resulting from the impacting bolide. The PGE ratios in those sites are mostly highly disturbed because of post depositional fractionation [5]. Based on Cr-isotope studies of two K/T sites a carbonaceous chondrite was proposed as source for the PGE anomaly [6]. This theory is supported by a fragment of a small meteorite found in the K/T layer at the DSDP Hole 567. This piece of meteorite was interpreted as a fragment of the Chicxulub impactor and shows a texture that resembles a carbonaceous chondrite [7].

Samples: The aim of our study is to characterize the Chicxulub impactor by means of analyzing PGE and siderophile elements of impact melt rocks. The samples were taken from the ICDP Yax-1 drill core as well as from Yucatan 6 drill core. The Yax-1-samples represent various types of melt-rich suevite-type polymict breccias as defined in a companion abstract [8].

Methods: Mayor and some trace elements were analyzed by XRF. The PGE concentrations were determined using ICP-MS in combination with nickel sulfide fire assay pre-concentrations after the method of [9]. The fire assay pre-concentration method provides good precision down to concentration of around 90pg/g Ru, 20pg/g Rh, 190pg/g Pd, 60pg/g Ir, 70pg/g Pt and 130pg/g Au. It is thus ideal to detect even minute meteoritic contamination. PGE tend to concentrate in small nuggets, that can not be homogenized within the sample. This may results in a poor reproducibility of the data if the amount of sample is of only some mg. The nickel sulfide fire assay procedure allowed to concentrate PGE from a relatively large mass of sample powder up to 70g. The sample mass used per analysis was between 20 and 40g. (Table 1) Samples (Yax-1 824.01m and Yax-1 838.29m) were analyzed twice. The variation of the results is minor (see also Fig. 1). The other samples are analyzed once, because of the good reproducibility no significant changes were expected by duplicating these analyses.

Tab. 1. PGE and Au concentration of the Chicxulub Yax-1 suevite samples. Detection limit (blank +3* std. dev.). Concentration for the continental crust [10], Rh and Au values from [11]. The sample mass used per analysis is given in the right column. Y6-N19: melt rock sample from Pemex core Y6

conc. [pg/g]	Ir	Ru	Pt	Rh	Pd	Au	[g]
detection limit	40	60	40	13	130	90	
YAX-1 (800.25m)	<60	255	384	52	513	541	40
YAX-1 (824.01m)	<40	<60	335	21	1102	1191	20
YAX-1 (824.01m)	<40	<60	421	43	1045	854	34
YAX-1 (838.29m)	<40	<60	572	24	1941	3124	20
YAX-1 (838.29m)	<40	<60	526	32	1838	2160	40
YAX-1 (852.8m)	99	682	837	63	1700	1820	30
YAX-1 (865.01m)	<40	662	472	33	1006	2334	20
Y6-N19	62	<60	447	15	262	569	31
continental crust	31	210	510	60	520	2500	

numbers in parentheses are drill core depths

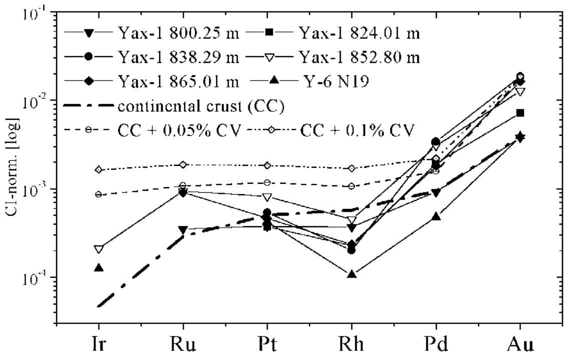

Fig. 1. CI-normalized PGE and Au concentration of the Chicxulub impactites (Yax-1-suevites and Y6-N19 impact melt rock) compared to the continental crust. CC with no contamination, with 0.05% and 0.1% contamination of a CV carb. chondrite (see text for expl.)

Results: The concentrations of Ir in most of the samples are extremely low, some even below the detection limit of the analytical method. Not only the low amount of PGE in the samples but also the element patterns for all the Chicxulub samples resemble the pattern for the PGE and Au of the continental crust. In addition, the data show a homogeneous distribution of the PGE pattern in all of the analyzed samples. Also, the PGE concentrations for Yax-1 and Y6 samples are similar. In conclusion, there is no indication of any meteoritic contamination of the samples. A syn-and post-impact modification of the PGE pattern from meteoritic towards a continental crust pattern is very unlikely. PGE in impact melts from different craters always showed little to no fractionation of the impactor pattern [12,13,14]. Moreover, a relative depletion of the more refractory PGE, like Ir and Ru, by hydrothermal alteration can be ruled out, since these elements are the least mobile PGE. The interpretation of the samples as pure mixtures of target rocks dominated by crystalline basement rocks (which is also compatible with the results of petrographic and geochemical studies [8]) and the lack of any impactor signature can be confirmed by artificially mixing small amounts of C-chondrite material to the continental crust (Fig.1). Admixture of only 0.05% and 0.1% carbonaceous chondrite (CV Ir = 825 ng/g [15]) to the continental crust produces a distinct “chondritic” pattern. The model sample with 0.05 wt.% of a carbonaceous chondrite, rises the Ir concentration by about one order of magnitude (Fig. 1).

The average amount of meteoritic material in impactites (impact melt and melt rich breccias) from different craters is <1 wt.% [15]. In extreme cases it may go up to a few wt.%, e.g. at Clearwater and Morokweng [12,13]. The extremely low PGE concentrations in the rocks from the Chicxulub impactites (Table 1) indicate that if there would be any contamination by PGE rich extraterrestrial material its fraction must be <<0.05 wt.%.

Conclusions: It must be concluded from the present results and from [2,3] that the allochthonous impactites (suevitic breccias and melt rocks) exposed at the drill cores Yax-1 and Y6 are not contaminated in any measurable amount with the Chicxulub impactor material. These drill sites are located inside the annular trough and outside of the peak ring and central basin of the Chicxulub impact structure. On the other hand, the globally distributed fall out material at the K/T boundary has high PGE concentrations indicating that the Chicxulub impactor was most probably a C-chondritic asteroid.

If we exclude the extremely implausible assumption that the K/T boundary is not related to the Chicxulub impact event, we have very interesting data in support of a non-homogeneous spatial distribution of impactor material between the proximal and distal impact formations of a terrestrial multi-ring basin. If we take the results of three-dimensional numerical simulations of the Chicxulub event into account [17, 18] we may draw the following conclusions from the observations presented here:

1. The main fraction of the vaporized and shock fused impactor is ejected within the central part of the ejecta plume far beyond the stratosphere [17, 18], distributed globally, and deposited in the K/T boundary clay.
2. A minor fraction of vaporized impactor remains within the downward moving target rock melt which fills the central basin of Chicxulub as indicated by the results from the C1 drill core [4].
3. The impact melt (component of suevite and coherent melt rock) deposited within the annular ring basin of Chicxulub at Yax-1 and Y6 is derived from a region of the ejecta plume which is not contaminated by impactor material in agreement with modeling results [17, 18].

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