ON THE EXISTENCE OF SEVERAL IRIDIUM-ENRICHED LAYERS AT THE K-T BOUNDARY AND IN A JURASSIC SEQUENCE.

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Analysing two Italian K-T sections, Crocket et al. (1) found significant Ir enrichments over background level in several clay layers extending over a thickness of several meters. Other measurements by Asaro (2) indicate a similar behaviour though with slightly different values. However, some discrepancies about distant levels raised doubts as to the validity of the Crocket et al. results and related interpretations concerning the origin of the K-T event. This was the subject of passionate discussions at recent topical conferences (AGU 1988, Snowbird 1988) and it appeared that, independantly of any interpretation, it would be worth having these analyses carried out by a third independant group. We have therefore sampled the Botaccione section, close to Gubbio (Umbria), over a thickness of more than 4 meters, from 1.8 m below to 2.8 m above the boundary. Besides the K-T boundary layer itself,which is not the subject of this paper, we have identified fourteen millimetric clay-rich levels containing between 25 and 60 % of insoluble residue. To avoid distorsions due to chemical treatments we have carried out analyses by instrumental neutron activation on bulk samples only. After irradiation for a few hours in the $2\ 10^{14}$ n cm^{-2} s^{-1} neutron beam of the Osiris reactor (laboratoire Pierre Sue, Saclay), iridium was measured with a γ-γ spectrometer detecting the 316-468 keV γ-ray cascade produced by the decay of ^{192}Ir to ^{192}Pt. The measurement accuracy lies around 20 $pg.g^{-1}$. The carbonate fraction was measured independantly with the energy dispersive X-ray spectrometer associated with our scanning electron microscope. Table shows the most significant results obtained on half of the samples. A significant enrichment over background can be noticed in five of them, the distance between the extreme ones being 2.7 meters. Although systematically lower, our measurements are qualitatively consistent with the results reported by Crocket et al.. There is no strong evidence for a secondary maximum around -1.8 m. It remains that the iridium anomaly is not limited to the boundary clay layer but that the distribution extends on both sides over several meters. Our results are also consistent with the Asaro measurements. A straightforward estimate with a sedimentation rate of 1 cm kyr^{-1} would therefore suggest a duration of several 10^5 years for the iridium event.

What kind of explanation can we propose for these levels? Some other K-T sections show a complex structure (3,4,5,6,7) but their interpretation is rather uncertain. Perhaps, it is more pertinent to look for possible explanations in other sedimentary records.

Multiple Ir anomalies in a Jurassic sequence. Complex features have been observed in a lower-upper Jurassic sequence (8,9). Starting from the base, this sequence, which outcrops in the Southern Alps, consists in a yellow limestone ("Giallo di Mori" Formation) whose upper part represents the Toarcian and possibly a part of the Aalenian. On top of that, we find a brown ferriferous hardground crust covered with 30 cm of pink Bajocian-Bathonian sediments. The upper part of the sequence is of upper Jurassic age. The iridium distribution shows six anomalies. a) Three enriched levels (0.1-0.2 $ng.g^{-1}$) in centimetric pink layers interbedded in the "Giallo di Mori" Formation. b) A rather strong peak (1-3 $ng.g^{-1}$) in the 3 to 5 mm thick hardground. c) A plateau around 0.1 $ng.g^{-1}$ in the 30 cm thick Bajocian-Bathonian layer. d) a small spike of about 0.3 $ng.g^{-1}$ in a millimetric clay layer located 7 cm above the hardground.

In this Jurassic sequence, paleontological and stratigraphical data give clear indications about the origin of all these features. The three levels a) located 0.7, 1.5 and 2 m below the hardground are sedimentary seams from the Bajocian-Bathonian unit. This is demonstrated by the presence of characteristic fossils, the color of the sediments and the iridium concentration which is the same as in the Baj-Bat unit. Transport was probably done through vertical fissures partly visible in the section (10). The plateau c) observed in the Baj-Bat ("Amonitico rosso inf." Formation) unit is likely the consequence of a low sedimentation rate. The hardground itself b)is the result of the halt in the carbonate productivity. This level contains the relics of cosmic particles (steady flux + exceptional infall) accumulated during the time of its formation (9). Finally, anomaly d) appears to be a dissolution level: carbonate free fractions in this layer and in adjacent levels have the same composition. In short, from the six identified anomalies, four are the consequence of post depositional processes: only two are likely to be original ones.

Coming back to the Gubbio sites, we must first note that the Botaccione and Contessa sections are (like the Jurassic section) highly fractured and tectonised: for a fine stratigraphic study, they may not be the most suitable. As far as the different Ir enriched clay layers are concerned, they are obviously not hardgrounds. The existence of sedimentary seams in the sections could explain the Ir enrichment peaks below the K-T boundary but does not account so easily for the Ir peaks observed above the boundary. Therefore, this explanation must probably be rejected. Dissolution levels appear to be more appropriate: this is consistent with the Crocket et al. results (1) which show that, on a carbonate free basis, the clay layers and limestone adjacent levels have comparable iridium concentrations. They have also the same clay composition (essentially illite and kaolinite). Our Ir measurements are not yet completed but it is clear that, if they confirm these previous measurements of Crocket et al. (1), the extension over several meters of the Ir anomaly in carbonate rich samples is more intriguing than the existence of secondary Ir peaks resulting from post-depositional carbonate dissolution. From this point of view, the Gubbio section would not be unique: in many K-T sections the Ir distributions show complex features (3,4,5,6,7) which, in our opinion, have not received sufficient attention, especially, regarding their connection with paleontological data (11).

Table.

Sample position. (m)	Ir (bulk). ($ng.g^{-1}$)	Carbonate fraction. (%)	Ir (Carbonate free) ($ng.g^{-1}$)
+1.65	0.11	63	0.31
+1.1	0.08	75	0.3
+0.35	0.26	71	0.89
-0.4	0.34	52	0.71
-1.	0.20	44	0.35
-1.75	0.12	77	0.51
-1.8	0.06	53	0.12

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