# THE SIGNIFICANCE OF NI-RICH MAGNETITES FOR THE STUDY OF THE K-T BOUNDARY EVENT.

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The question of the origin of the K/T boundary event is still a subject of debate: an asteroid-impact theory (1-5) and a long term volcanic crisis (6-9) are competing. Although Ir may be released during volcanic eruptions (10-12), the occurrence of an Ir anomaly at many K/T sites (13,14), together with shocked minerals (15,16) and Ni-rich magnetites (17-21), are strong arguments in favor of an extraterrestrial origin. However, the stratigraphical extent of the Ir distribution indicates a long duration event ($10^5$-$10^6$ yrs) starting well before the boundary and finishing well after (14,22-25). Then, the key question is: does the over-all extent of the Ir distribution represent the actual duration of the event?

Taking into account the local sedimentation rates, one can note that the apparent event duration varies from one site to the other: 1 Ma at Hole 761C, a core recovered in the Indian Ocean (21), 400 ka at the site of Gubbio, Italy (22-24), and 50 ka at the site of Caravaca, Spain (14). In fact, the Ir anomaly has a nearly symmetrical extent with respect to the boundary, that always spans a total thickness of 1-2 m. This argues in favor of a postdepositional diffusion process. The main Ir enhancement is characterized by a sharp rise in coincidence with the planktonic crisis, followed by a gradually decreasing tail. It represents a duration ranging from 10 to 50 ka. Although the tail may be partially explained by reworking, other reasons may be involved: actual duration, residence in the oceanic reservoir, and other delayed deposition. Therefore, considering that Ir and probably other geochemical elements are not reliable indicators of the event duration, we have searched for solid markers which are specific of the K/T boundary and which can only be affected by reworking.

Two such tracers can be considered: Ni-rich magnetites and shocked minerals. We have discarded shocked minerals because they are far from being uniformly distributed around the earth: their abundance, as well as their maximum size, rapidly decrease away from sites in North America (16). Conversally, Ni-rich magnetites (17,20,21), also named spinels (18), and magnesioferrite (19), are more uniformly distributed. They have been found in abundance in very distant sites: in spanish (19,20), italian (17,18,20) and New Zealander (19) emerged sections and in deep sea sites in Pacific (17-19), Atlantic (18) and Indian (21) oceans. They are usually clustered in lenses or flattened spheroids (17,20,21), the relics of their original host bodies, whose sizes lie in the range 30-300 microns. The most common types show dendritic, skeletal and cruciform structures (17-19), which are characteristic of primary component rapidly crystallized at high temperatures, and octahedral morphologies (19-21). Smit and Kyte (17) were the first to notice that their particular composition, with very high NiO (always higher than 1% with a mean value of about 5%) and relatively low $TiO_2$ (<1%) content and variable amount of MgO (0-25%), $Al_2O_3$ (0-15%) and $Cr_2O_3$ (0-15%), is quite unusual for terrestrial magnetites. The most common terrestrial magnetites are pure magnetites and titanomagnetites. Solid solutions of magnesian, aluminian and chromian titanomagnetites, as well as solid solutions of magnesian and aluminian chromites, exist in ultramafic igneous rocks but both are distinguishable on the basis of their much higher $TiO_2$ (>1%) or $Cr_2O_3$ (>20%) content and their much lower NiO content

(<1%, see ref. 26). Some very rare magnetite-rich spinels in metamorphosed ultramafic rocks may have some chemical similarities (27) but they are easily recognizable by their structure and, again, their relatively lower NiO content (<1%). In fact, Ni-rich magnetites of the type considered here have never been reported in any volcanic or usual sedimentary terrestrial rocks.

At the opposite, they are quite common in extraterrestrial objects of nearly chondritic composition which have been melted and oxidized in the Earth's atmosphere. They are found in the fusion crust of meteorites (28) and micrometeorites (29,30), in chondritic extraterrestrial spherules collected from deep sea sediments (31,32) and polar ices (29, 33) and in various cosmic debris such as the well-preserved particles discovered in a lower-middle Jurassic hardground (34). In all cases, they display dendritic, skeletal, cruciform and octahedral morphologies and have the same compositional range in NiO, $Cr_2O_3$, $Al_2O_3$, MgO and $TiO_2$. With their size and composition the Ni-rich magnetites of the K/T boundary look very much like those found in the Jurassic particles which are believed to originate from molten silicate droplets produced by ablation in the atmosphere of a chondritic object (34).

As a general result, Ni-rich magnetites represent a unique and specific marker which, if found together with Ir, are evidence of an extraterrestrial infall. Therefore, the presence of these two components at many K/T sites permit to ascertain that an extraterrestrial event did occur at the end of the Cretaceous. The narrow distribution of the Ni-rich magnetites at the boundary of Caravaca (Spain) and Hole 761C (ODP leg 122, Indian Ocean) compared with the wide Ir dispersion, (Robin et al., submitted) confirms that Ir diffuses around the boundary and demonstrates that Ni-rich magnetites are a more reliable indicator of the event duration. The stratigraphic distribution of Ni-rich magnetites at these two distant sites are markedly different but are easily explained in term of bioturbation of a brief event (<2000 years).

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