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The Mineralogy of the K-Pg Transition on the Peak Ring of the Chicxulub Impact Crater in Drill Cores of IODP-ICDP Expedition 364

Axel Wittmann[1] and Expedition 364 Scientists[2].

[1] LeRoy Eyring Center for Solid State Science, Arizona State University, Tempe, USA.
[2] Chicxulub Drilling Expedition 364 Scientists: S. Gulick (US), J. V. Morgan (UK), E. Chenot (F), G. Christeson (US), P. Claeys (B), C. Cockell (UK), M. J. L. Coolen (AUS), L. Ferrière (AU), C. Gebhardt (D), K. Goto (J), H. Jones (US), D. A. Kring (US), J. Lofi (F), C. Lowery (US), C. Mellett (UK), R. Ocampo-Torres (F), L. Perez-Cruz (MEX), A. Pickersgill (UK), M. Poelchau (D), A. Rae (UK), C. Rasmussen (US), M. Rebolledo-Vieyra (MEX), U. Riller (D), H. Sato (J), J. Smit (NL), S. Tikoo-Schantz (US), N. Tomioka (J), J. Urrutia-Fucugauchi (MEX), M. Whalen (US), A. Wittmann (US), L. Xiao (C), K. E. Yamaguchi (J), and W. Zylberman (F).

In 2016, International Ocean Discovery Project-International Scientific Drilling Program (IODP-ICDP) Expedition 364 drilled into the peak ring of the ~200 km Ø Cretaceous-Paleogene (K-Pg) Chicxulub impact crater [1], the only known impact that caused a mass extinction [2]. Initial results from drill core petrography, geochemistry, and micropaleontology [1; 3–7] suggest a continuous transition from peak ring impactites (sorted suevite rocks) to post-impact sedimentation of carbonate rocks. The 75 cm thick siltstone unit (616.58–617.33 mbsf; Fig. 1) has been interpreted as a settling deposit capping massive tsunami deposits in the crater because the NE crater wall had collapsed during the impact [8]. This brown carbonate siltstone lithology is characterized by thin intercalations of green sand and dispersed sulfide minerals, a mixture or pre- and post-impact microfossils, and an enrichment of Ba, Sr, Pb, and Ni near its basal contact with sorted suevite of the upper peak ring [3; 7].

We used optical microscopy and the field emission electron microprobe at Arizona State University to analyze a thin section from the transition interval at 616.95 mbsf (Fig. 1). Our sample is composed of <10 to 50 µm calcite grains that contain 1 to 3 mm lenticular pockets of Fe (Mg, K)-rich clay minerals. Calcite occasionally contains a few wt% MgO and typically 1 to 2 wt% MnO. Sulfide minerals occur dispersed as <10 to ~100 µm rounded to euhedral crystals. Euhedral sulfide crystals are mostly stoichiometric pyrite (FeS_2) and typically do not contain inclusions. Rounded pyrite grains are typically zoned with a center of stoichiometric, nickelous pyrite with up to 3 wt% Ni (Fig. 2). Larger pyrite crystals are concentrated in the clay domains, while smaller sulfide crystals tend to occur dispersed in the carbonate siltstone. Less common than pyrite are chalcopyrite ($CuFeS_2$) crystals. They occur as up to ~200 µm aggregates of ~10 µm euhedral grains that are typically intergrown with nickelous pyrite and rarely with calcite rhombs. Locally, chalcopyrite grains contain a few wt% Ni that can be concentrated to 25 wt% in <1 µm thick lamella. Such grains tend to have ~5 µm rims that are more strongly enriched in Ni (up to 30 wt%) and these rims also contain substantial Co. More rare than $CuFe(Ni,Co)S_2$ grains are euhedral to subhedral, up to 40 µm ZnS crystals that contain <1 to 5 wt% Fe ± Cd.

Hydrothermal mineral assemblages have been reported in drill cores from the peak ring section [9] and pipe structures occur near the K-Pg transition layer [7]. The sulfide assemblage (Fig. 2) resembles the mineralogy of high-temperature hydrothermal deposits: Nickelous pyrite has been reported from hot (>300 °C) hydrothermal gold deposits [10], pyrite; ZnS and $CuFeS_2$ are typical assemblages of black smokers [11]. Thus, the sulfide mineral assemblage in the K-Pg transition unit could represent the earliest venting products from the cooling central uplift of the Chicxulub crater; a first record of “black smoker”-like deposits from an impact crater, cf. [12]. This has implications for: (1) the origin of the sulfides from impactor and target rock components; (2) the mobility, and thus, scarcity of platinum-group elements in hydrothermally altered Chicxulub impactites [13]; (3) the potential for ore deposits on top of Chicxulub’s peak ring; (4) a post-impact environment that would favor extremophile organisms; (5) prolonged deposition of the transition layer.

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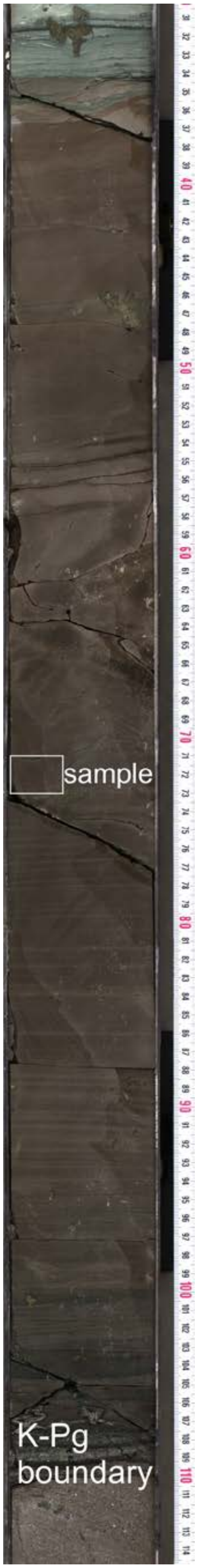

Figure 1. (left) Expedition 364 halfcore photograph 616.54 mbsf (meters below seafloor; top) to 617.38 mbsf (bottom) with the location of our sample at 616. 95 mbsf and the inferred K-Pg boundary at 617.33 mbsf; core diameter is 83 mm.

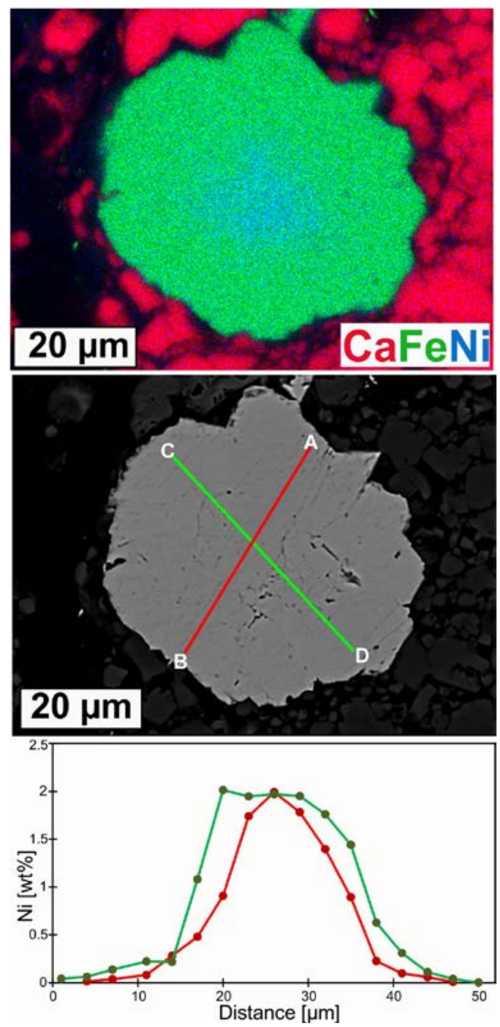

Figure 2. (right) Nickelous pyrite X-ray intensity map (top), back-scattered electron image (center) and nickel concentration along measurement traverses A–B and C–D in center image (bottom).