THE RECOVERY OF LIFE IN THE CHICXULUB CRATER FOLLOWING THE END CRETACEOUS MASS EXTINCTION.

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Introduction: The end Cretaceous mass extinction, when approximately 75% of all species on earth went extinct, is widely agreed to have been caused by the bolide impact that formed the Chicxulub Crater on Mexico's Yucatan Platform 66 million years ago [1]. The rapidity of the KPg extinction is unique in geologic history, with all other mass extinctions driven by processes that operated on the timescale of hundreds of thousands or millions of years like massive volcanism or continental reconfiguration. Life recovered relatively quickly, with blooms of specific groups of survivor taxa that were able to thrive in the decimated ecosystem reappearing years after the impact [2]. Paleontological evidence shows that Cretaceous survivors began to diversify into new species within 30,000 years of the impact, although it took approximately 10 million years for marine groups like planktic foraminifera to return to levels of diversity equal to that of the Late Cretaceous [3].

In the spring of 2016, International Ocean Discovery Program Expedition 364 recovered ~829 m of core materal from the Chicxulub Crater, including a complete record of sediments that filled in the crater in the millions of years immediately following the impact. This unique record of the immediate aftermath of the impact allows us to address some intriguing questions, including: 1) what kill mechanisms drove the mass extinction, and did the persistence of these mechanisms slow the recovery of life? 2) How did life recover within the crater? Did lingering toxicity or hydrothermal flow within the crater create a sterile zone for a period of time, or did life return immediately? Here we present the first record of the recovery of life from within a large impact crater.

Methods: Thin sections and disaggregated sediment samples were examined for marine microfossils, including foraminifera and calcareous nannoplankton. By examining the assemblage of microfossils in marine sediments, in which thousands of individuals might be present in a single sample, we can observe changes in the entire population through time. This can serve as a proxy for the entire marine community. Additionally, by correlating the occurrence of certain marker species with global records we can generate an age model for the post impact sediments.

Results: The earliest Paleocene post-impact section is relatively expanded at Site M0077 relative to most KPg boundary sections. Syn-impact suevite breccia is immediately overlain by a dark brown calcareous siltstone between 616.58-617.33 meters below seafloor (mbsf). This unit contains a suite of reworked Maastrichtian microfossils well known from the KPg boundary in the Gulf of Mexico, termed the KPg Boundary Cocktail [4]. The top of this unit is enriched in Ni and Cr and is immediately overlain by limestones that contain the planktic foraminifer *Parvularugoglobigerina eugubina*, the first new planktic species to evolve in the Danian, less than 30 kyr post-impact. This horizon is also characterized by a bloom of the photosynthesizing nannoplankton *Braarudosphaera bigelowii* and the calcareous dinoflagellate *Thoracosphaera* spp. The latter fossils represent resting cysts that can lay dormant for years, and *Thoracosphaera* are most common in the modern ocean in regions with low nutrient concentrations [5].

Zone Pα, which is defined by the occurrence of *P. eugubina*, is approximately 32 cm thick, although it covers less than 200 kyr of time and is therefore relatively expanded compared to most deep sea sites. Above this, a condensed record of the rest of the early Paleocene, ranging from planktic foraminifer Zones P1a to P3b (65.72 to 60.73 Ma) occurs in the limestones ranging from 608.02 to 617.33 mbsf. Planktic foraminifera appear relatively normal, and show a normal succession of species originations. Calcareous nannoplankton, meanwhile, are clearly stressed, as indicated by the continued dominance of disaster bloom taxa and the absence of common early Paleocene species. Benthic foraminifera are also generally rare and lack diversity, suggesting seafloor conditions which were not conducive to benthic life. Thus, the limestone records a divergent story about how local conditions during the recovery impacted different trophic levels, with phytoplankton are generally stressed and slow to recover, and zooplankton diversifying at the expected rate.

Conclusions: Overall, life returned fairly quickly at ground zero of the Chicxulub impact, but conditions in the immediate aftermath of the mass extinction favored certain groups of organisms over others. These included r-selected (i.e., organisms that reproduce quickly and favor uncompetitive ecological niches) zoo- and phytoplankton, with very few benthic organisms present. However, while planktic foraminifera evolved and diversified to re-occupy ecological niches in the millions of years following the impact, the calcareous nannoplankton population were dominated by the same disaster taxa. This indicates some persistent environmental stress that preferentially affected marine phytoplankton.

References: [1]Schulte, P. et al. (2010) *Science 237*, 1214-1218. [2] D'Hondt. S., Donaghay, P., Zachos, J.C., Luttenberg, D., and Lindinger, M. (1998) *Science 282*, 276-289. [3] Coxall, H.K., D'Hondt, S.D., and Zachos, J.C. (2006) *Geology 34*, 297-300. [4] Bralower, T.J., Paull, C.K., Leckie, R.M. (1998) *Geology* v. 26, p. 331-334. [5] Kohn, M., and Zonneveld, K.A.F. (2010) *Deep Sea Research I, 57*, 1543-1560.

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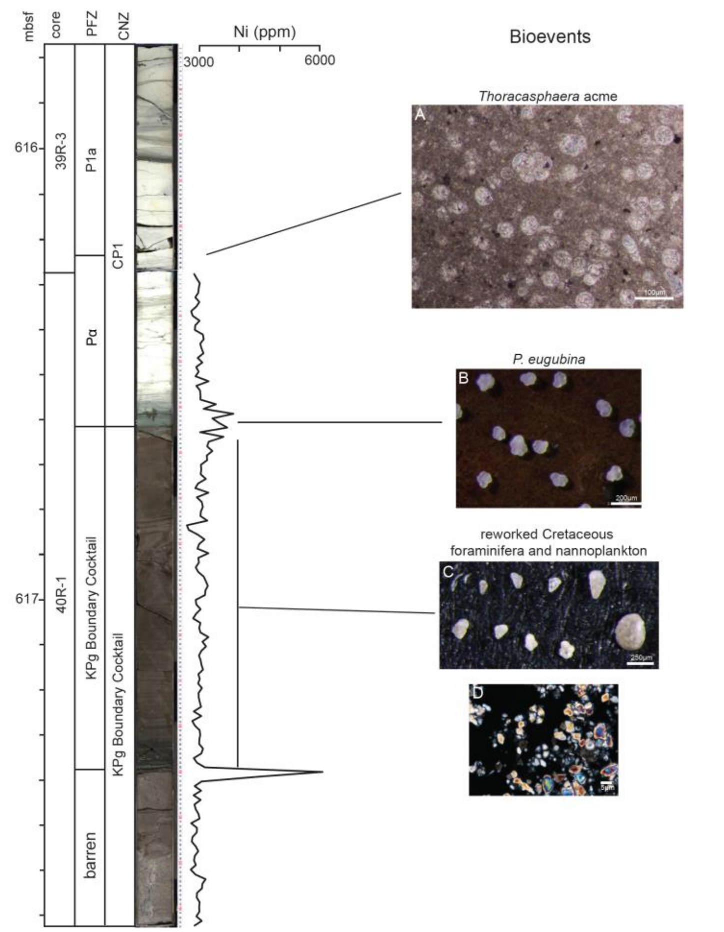

Figure 1. Occurrence of specific bioevents in section 1 of core 40 from IODP Site M0077.