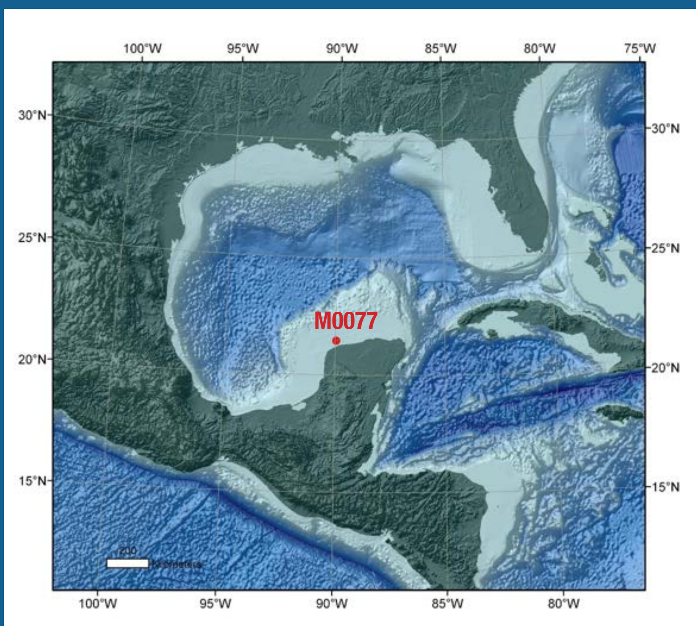
# Chicxulub K-Pg Impact Crater Expedition

In April 2016, the *L/B Myrtle* sailed from Progreso, Mexico, with 14 scientists from Expedition 364 onboard to begin coring and logging operations at one site located over the intact Chicxulub "peak ring" - a ring of mountains located within the larger crater, protruding through the crater floor and mantled by impact melt rock and breccia, and rarely found on Earth. Led by Joanna Morgan, Department of Earth Science and Engineering, Imperial College London, UK, and Sean Gulick, Institute for Geophysics, University of Texas at Austin, USA, the offshore Science Party and ESO staff spent 54 days coring at 1 site (M0077).

Dates: 5 April - 31 May 2016
Platform: Jack-up platform *L/B Myrtle*
Maximum water depth: 19.8 m
Number of boreholes: 1
Number of cores: 303
Core recovery: 839.51 m (101.27%)
http://www.ecord.org/expedition364




The Chicxulub impact crater in Mexico is unique. It is the only known terrestrial impact structure that has been directly linked to a mass extinction event and the only terrestrial impact with a global ejecta layer. Of the three largest impact structures on Earth, Chicxulub is the best preserved. Chicxulub is also the only known terrestrial impact structure with an intact, unequivocal topographic peak ring. Chicxulub's role in the Cretaceous/Paleogene (K-Pg) mass extinction and its exceptional state of preservation make it an important natural laboratory for the study of both large impact crater formation on Earth and other planets and the effects of large impacts on Earth's environment and ecology.

## Scientific goals

International Ocean Discovery Program (IODP) - International Continental Scientific Drilling Program (ICDP) Expedition 364 cored through the peak ring of the Chicxulub impact crater to investigate:

- the nature and formational mechanism of peak rings,
- how rocks are weakened during large impacts,
- the nature and extent of post-impact hydrothermal circulation,
- the deep biosphere and habitability of the peak ring,
- the recovery of life in a sterile zone.

*L/B Myrtle*

Of additional interest is the transition through a rare mid-latitude record of the Paleocene/Eocene Thermal Maximum (PETM); the composition and character of impact breccias, melt rocks, and peak-ring rocks; the sedimentology and stratigraphy of the Cenozoic sequence; and any observations from the core that would help us constrain the volume of dust and climatically active gases released into the stratosphere by this impact. Petrophysical property measurements on the core and wireline logs are being used to calibrate geophysical models, including seismic reflection data.

IODP INTERNATIONAL OCEAN DISCOVERY PROGRAM

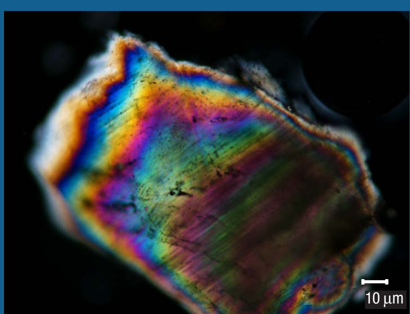
icdp

ECORD EUROPEAN CONSORTIUM FOR OCEAN RESEARCH DRILLING

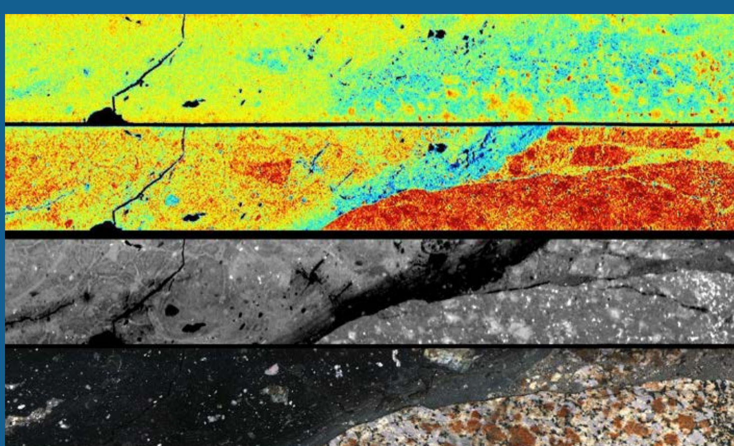
## Scientific results

During the 57-day long offshore phase (54 days on location), and the Onshore Science Party held at the IODP Bremen Core Repository from 21 September to 15 October 2016, an international team of 32 scientists analysed the cores to gain a deeper understanding of impact structures and the effects of impactors on Earth's environment and biodiversity.

Open-hole drilling occurred from the seabed to ~500 m mbsf, and core was recovered between 505.70 and 1334.69 metres below sea level (mbsf). Core recovered through the peak ring was found to comprise shocked, fractured granitoid basement *(below)* intruded by pre-impact dikes, suevite, and impact melt rock overlain by impact melt rock and suevite. The fact that the peak ring is formed from uplifted, shocked, fractured granitic rocks that overlie Mesozoic sedimentary rocks (as observed in seismic reflection data) demonstrates that the dynamic collapse model for peak-ring formation is substantially correct *(Morgan et al., 2016)*. Deformation of the peak-ring rocks includes brittle fractures, cataclasites, and pervasive shearing with striations that often crosscut each other. These observations will be used to address the kinematics of peak-ring formation and the weakening mechanism that governs impact crater formation in large impacts. The physical properties of these rocks demonstrate that the impact process reduces the density and velocity of target rocks and greatly enhances porosity.




*Shocked quartz from the granitoid basement.*



*Core photo and CT images of transition from impact melt rock to granitoid basement.*

*The Expedition Team at the Onshore Science Party in Bremen.*

The Post-Impact Sedimentary Rocks interval *(right)* comprises a mix of lithologies, including marlstones, claystones, limestones, siltstones, and black shales, constrained biostratigraphically to be deposited between ~49 and 66 Ma *(right)*. The lower Paleocene is relatively condensed but complete, with fossils indicative of planktic foraminifer Biozones P$\alpha$ to P4. These initial results suggest that the expedition will be able to address questions about the recovery of life in the ocean basin and directly compare the recovery with the evolving ocean chemistry through further analyses. Nannofossil biostratigraphy indicates that the PETM *(right)* is present and bracketed by unconformities, and the Eocene section above is relatively thick.

In terms of the deep biosphere within the impact crater, cell counts and DNA in the peak-ring rocks indicate the presence of modern microbial life, suggesting suevites provide an ecological niche. This possibility is now being confirmed with additional tests. Hydrothermal minerals are commonly observed in the peak-ring rocks, demonstrating that hydrothermal processes were active after the impact.

The nearly 100% core recovery, high quality of the recovered core, completeness of the early Paleocene, and successful wireline logging campaign represent a great success. As with all new data, it will take time for the teams from around the world to understand the full implications of the insights gained. However, the scientists are confident that the data acquired during Expedition 364 will accomplish the goals of the expedition and go a significant way toward answering the many questions posed about the impact crater, the end-Cretaceous mass extinction, and the effects of impacts on the deep biosphere.


*Post-Impact Sedimentary Rock interval: 1 PETM black shales, 2 Paleocene limestones, 3 fine-grained, earliest Paleocene unit.*

*March 2018 - credits: ECORD/IODP and Volker Diekamp, MARUM)*

## For further reading


- Gulick S, Morgan J, Mellett CL and the Expedition 364 Scientists, 2017. Expedition 364 Preliminary Report: Chicxulub: Drilling the K-Pg Impact Crater. International Ocean Discovery Program. http://dx.doi.org/10.14379/iodp.pr.364.2017
- Morgan J, Gulick S, Mellett CL, Green SL and the Expedition 364 Scientists, 2017. Chicxulub: Drilling the K-Pg Impact Crater. Proceedings of the International Ocean Discovery Program, 364: College Station, TX (International Ocean Discovery Program). https://doi.org/10.14379/iodp.proc.364.2017
- Morgan JV, Gulick SPS, Bralower T, Chenot E, Christeson G, Claeys P, Cockell C, Collins GS, Coolen MJL, Ferrière L, Gebhardt C, Goto K, Jones H, Kring DA, Le Ber E, Lofi J, Long X, Lowery C, Mellett C, Ocampo-Torres R, Osinski GR, Perez-Cruz L, Pickersgill A, Poelchau M, Rae A, Rasmussen C, Rebolledo-Vieyra M, Riller U, Sato H, Schmitt DR, Smit J, Tikoo S, Tomioka N, Urrutia-Fucugauchi J, Whalen M, Wittman A, Yamaguchi KE and Zylberman W, 2016. The formation of peak rings in large impact craters. Science. http://dx.doi.org/10.1126/science.aah6561