

Science AMA Series: We are Drs. Gulick, Morgan and Lowery.  
We're drilling into the Chicxulub impact crater — aka 'ground zero'  
for the asteroid that killed the dinosaurs. AUA!

Chicxulub<sub>Crater</sub><sup>1</sup>*andr/ScienceAMAs*<sup>1</sup>

<sup>1</sup>Affiliation not available

April 17, 2023

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# Science AMA Series: We are Drs. Gulick, Morgan and Lowery. We're drilling into the Chicxulub impact crater — aka 'ground zero' for the asteroid that killed the dinosaurs. AUA!

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After the impact, how quickly (or slowly) did it kill the dinosaurs?

How did it kill them (most interested about those that didn't die quickly)?

What other animal and plant life was lost?

How big of a percentage of animal and plant life was lost?

Edit: Woa! The answers I got are amazing. Thanks to everyone.

[3eg](#)

Depends where they were. Within about 1500 km from Chicxulub dinosaurs would have been killed instantaneously by thermal radiation, as this impact behaved a bit like a very very large atomic bomb. On the other side of the Earth it could have taken months, following the destruction of much of the primary food source due to fires, as well as dark and cold conditions. 90 % of the near-surface plankton in the oceans, ammonites... about 75% of life in total (Jo)

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[3eg](#)

All three of us are on the same login, so I think we're going to try to identify ourselves when we post. I'm Chris.

To answer your question, there are some competing ideas about how exactly the dinosaurs died from this impact (what we call the “kill mechanism”), and it’s something we hope that our research might help address. I’m familiar with the hypothesis explained in the Radiolab story that’s linked there, and I like it because it’s cool. Basically the idea is that the impact blasted a huge amount of material out of the crater and all the way into space. We know these were blasted into space because 1- we see this layer all over the world, and 2- glass beads from the boundary layer have bubbles inside of them that are a vacuum, which can only be formed if they were still molten when they left the atmosphere and cooled in space. Anyway, the idea is that when all these millions/billions/whatever bits reentered the atmosphere they collectively heated the earth to the point that it ignited forest fires across the world and boiled the blood of the dinosaurs. Unfortunately, this is probably too awesome to actually be true; models have suggested that this rain of debris would only have been sufficiently hot enough to trigger forest fires in places close to the impact like North America. There probably was a heat flash over most of the earth, but I don’t know if it would have been enough to cause the extinction by itself. More likely, I think, is that major environmental changes in the months and years after the impact are what really drove the extinctions at the end of the Cretaceous. In this hypothesis, the type of rocks that the asteroid hit matter, and the Yucatan was a particularly unfortunate place (for the dinosaurs) because it contains a lot of evaporite minerals that are rich in sulfur. According to this hypothesis, this sulfur was vaporized and blasted into the upper atmosphere, where it did what sulfur always does in the upper atmosphere, which is block sunlight and cause cooling. These two things combined would have caused a breakdown of the food chain as primary producers had trouble photosynthesizing, and so the things that eat them would have struggled, etc. Basically, the dinosaurs were baked then frozen and starved. It was a rough couple years. To answer your other questions, about 75% of all life on earth went extinct at the KPg Boundary, including non-avian dinosaurs, marine reptiles like mosasaurs and plesiosaurs, and ammonites.

Your expedition seems to be an expensive proposition and was sure to be one of the biggest obstacles you had to overcome. Can you tell us about your sponsors and is there any advice you'd give others about funding?

[loganallenwolf](#)

This is an excellent question, because I think that the thing that's been lost in a lot of the "Scientists drill into Chicxulub Crater" news stories that have come out is that this project is part of the Integrated Ocean Discovery Program (IODP), the latest name for nearly 50 years of scientific ocean drilling that started with Project MoHole (which is the best name for any scientific project that I have ever heard) in the early 60s and has basically been going ever since. The IODP is Big Science; it's geoscience's version of the Hubble telescope or the Large Hadron Collider. It's how we get samples from places we would never otherwise be able to sample (like the middle of the Chicxulub Crater) and is basically responsible for the vast majority about what we know of the history of the oceans, the age of the seafloor, high-resolution climate records going back to the Jurassic, etc. In 1968-69, Leg 3 of the Deep Sea Drilling Project (as it was called at the time), tested the concept of seafloor spreading, which helped prove the Theory of Plate Tectonics, which was still controversial at the time. 47 years later we're now on Expedition 364.

<https://www.iodp.org/>

(Chris)

How sure are you this was their extinction event and what's the science behind it?

[crumbbelly](#)

We are very sure that this impact caused the KPg mass extinction, which killed ~75% of all species on the planet, including non-avian dinosaurs, marine reptiles like mosasaurs and plesiosaurs, and other unique marine groups like ammonites. As thattopicishot mentioned a little while ago, we know this because of the unique layer of clay found at the top of Cretaceous sediments worldwide, which contains iridium (very rare on earth; very common in asteroids) and minerals that are formed in impacts like shocked quartz and glass spherules that were blasted out of the crater. We know that this clay comes from the Chicxulub crater very simply because this layer gets thicker the closer you get to the crater. In sites very far away (Europe, Japan, Australia) it's just a thin layer of clay with iridium; as you get closer (North Atlantic) it gets thicker, with a clear layer of spherules and shocked quartz below a clay layer with iridium; in the Gulf of Mexico this boundary layer can be hundreds of meters thick, and large chunks of rock that were blasted from the crater, meters-thick layers of sand deposited by tsunamis that washed back and forth across the basin, and thin a clay layer with iridium on top.

More generally, we are so confident that this impact was the cause of the mass extinction because we clearly see all these groups range right up to the boundary.

(Chris)

Will you take full responsibility if you awaken an ancient godlike monstrosity from beyond the stars from its timeless slumber?

And on a more serious note, what are you hoping to discover from this impact site? Why is it unique from others?

[Iron\\_Cobra](#)

Full responsibility taken. We want to know: how large craters are formed, is there a deep biosphere, how did life recover in the ocean above the crater? It is the most intact large crater on Earth, the only crater with a peak ring, the only impact linked to a mass extinction and the only crater with a global ejecta layer (Jo)

Hi there!

Thank you so much for this AMA! Also thanks to the mods for cross-posting to [/r/Geology!](#)

A few questions:

- How is the drilling going and how far do you believe you currently are from the K-T horizon; when do you expect to get there?
- How far under the K-T horizon are you planning to drill once you've reached it?
- Is there any suggestion, perhaps from geophysics, perhaps from surprises in the core, that there might be a melt sheet associated with the crater?
- Do you have any specific hypotheses you are putting to the test with this project, or is there anything specific you personally hope to see?

Thank you for your time! The sound of a spinning drill is a happy song! Best of luck!

[Gargatua13013](#)

We reached the K-Pg boundary at 620 m and are now at 840 m. We hope to get down to 1500 m. We are testing models for peak ring and large crater formation, we think peak rings are formed by rocks that were pushed down 20-30 km, then rebounded upwards above the Earth surface, and collapsed

downwards and outwards about 40 km. We are also taking microbiological samples to see if there is a living a deep biosphere, and looking to see how life recovers after the impact in the ocean above the crater? (Jo)

How deep do you plan to drill, and at what level of depth do you anticipate finding evidence or remnants of the meteor?

[outof\\_zone](#)

We hope to go to 1500 m and are currently at 840 m. About 95% of the meteor was vaporized on impact, and ejected all around the Earth in the expanding vapor plume. That's how we discovered the impact occurred in the first place - we found the meteoritic material in the K-Pg boundary layer all around the Earth.

Do you expect to find fragments of the impactor, or are you mainly interested in an analysis of the crater and subsequent layers?

[Timothy\\_Riches](#)

About 95% of the meteor was vaporized on impact, and ejected all around the Earth in the expanding vapor plume. That's how we discovered the impact occurred in the first place - we found the meteoritic material in the K-Pg boundary layer all around the Earth. We are mainly interested in other things, how are large craters formed, is there a deep biosphere, how did life recover in the ocean above the crater? (Jo)

I have several Questions:

- What is the magnitude of seismicity associated with the impact?
- Everyone is very interested in the impact's effects on life and the K-Pg mass extinction, but what about tectonics?, I am interested what effect an impact of this size would have on plate kinematics, and if the impact caused plate motions to change, or far field changes in deformation styles along plate boundaries.
- How deep is the Crater, and by using paired thermochronometers is it possible to reconstruct the thermal/cooling history of the impact site? or will they likely be reset by later burial?
- How is the age of impact constrained? I assume mostly by stratigraphic dating of the Iridium layer found around the world, But do you have any plans to directly date the Impact? is it possible to use zircons quenched during impact? also would those zircons/other minerals produced during impact have a distinct geochemical/isotopic signature?
- (This one is for [Sean](#)) When and where can I see your next Jousting match?

Thanks so much, I hope the rest of the cruise and drilling goes well, and I am excited to see the results of all your efforts. This is a major scientific advancement and will undoubtedly change our understanding of processes associated with an impact of this size and the biologic response to this cataclysmic event.

[bill-merrly](#)

Great questions: -Magnitude 12 or even 13 have been estimated such that all the continental shelves

around the Gulf of Mexico collapsed due to the seismic energy -So its not thought that the impact changed anything in terms of tectonics over the long term, but the amount of energy released might have induced some seismicity on tectonic boundaries. -The crater when it initially formed was 100 km wide and ~30 km deep but it rapidly (within minutes) rebounded and collapsed such that the final crater floor of the much larger final crater(~200 km) was only ~1-1.5 km deep. We are definitely looking to use thermochronometers to study the history of the thermal effects and cooling. -Age of the impact is constrained through magnetic stratigraphy, biostratigraphy, and most recently thermochronology. In fact it defines the boundary in the geologic timescale between Mesozoic and Cenozoic. -Jousting in June in Indiana and in July in Germany :-)

Sean

Thanks for taking time to answer questions.

Can you explain why you drill the crater rim, and how you intend to compare/contrast results from the rim with other regions of the crater.

[Wrathchilde](#)

We are actually drilling the crater's peak ring, which is an internal ring of hills within the crater basin. Other holes have been drilled inside the peak ring and into the central impact melt sheet, and there are also holes outside the peak ring and crater rim. We have seismic reflection and other geophysical data that allows us to construct models of crater structure between the drill holes. (Jo)

That sounds so cool!

Down to business:

- I was told that we have limited public knowledge of the crater/Yucatan area because there's oil there and because Pemex (maybe it was another oil company?) drilled and mapped the area and these documents are private property. Are these available now or how did you get access/permission to drill?
- Do we know or is it still up for debate whether the crater triggered the Siberian traps?
- From your post it sounds like you're looking for life recovery near the crater. Wouldn't life recover more readily somewhere that had been affected less (i.e midpoints between the two cataclysmic events)? Or does even the presence of even a little life make it harder to determine repopulation?
- Did you learn Spanish for the trip?

Welcome back to shore!!

[MirimeVene](#)

Answering these in order: We have had two different seismic studies over the crater that led to the hypotheses which we are testing now by drilling. There is no oil in the crater simply due to the fact all the organic matter that would have been buried here was vaporized or ejected by the impact and hence no source material within the crater to later form oil.

Do you expect to find any structural evidence of the intensity of the impact (for example, shatter cones) or are you looking specifically for mineral content (iridium, pseudotachylite, among others)?

Also do you have any evidence or suspicion that the impact is related to the beginning of the formation of the Deccan Traps (e.g. through shockwaves destabilizing the crust) or do you think the crater and the traps are unrelated and coincidentally occur during the same relative time?

[HippieTrippie](#)

We are looking for evidence for the intensity of impact, for example we will be using shocked quartz to estimate maximum shock pressures.

I have no suspicion that the Deccan and impact are linked. The impact occurred in the middle of the Deccan eruptions (Jo)

Do you expect to find any structural evidence of the intensity of the impact (for example, shatter cones) or are you looking specifically for mineral content (iridium, pseudotachylite, among others)?

Also do you have any evidence or suspicion that the impact is related to the beginning of the formation of the Deccan Traps (e.g. through shockwaves destabilizing the crust) or do you think the crater and the traps are unrelated and coincidentally occur during the same relative time?

[HippieTrippie](#)

So, Deccan volcanism began well before the KPg boundary (with the onset of the main eruptive phase ~400-600 kyr before the boundary) and continued several hundred thousand years into the Paleogene. If these eruptions drove the mass extinction, we'd expect to see a staggered extinction event over a long period of time. What we see instead is an instantaneous extinction all at the same level, right below a boundary clay layer with iridium and other elements from the fallout of the asteroid impact. A recent paper suggested that the impact may have invigorated Deccan volcanism, which, maybe? I think more work needs to be done there. But it's actually kind of hard to imagine how these flood basalts could have caused the extinction. This kind of volcanism doesn't really release a lot of CO<sub>2</sub> (compared to explosive volcanoes), nor does it release a lot of volatile organic compounds. The Siberian Traps (which we think caused the Permo-Triassic Mass Extinction) came up through a massively thick interval of coal and other organic rich rocks that contributed lots of sulfur, etc. into the atmosphere, which we think was critical in that extinction (the sulfur-rich evaporites that the make up the target rocks at Chicxulub likely had a similar effect), but the Deccan Traps didn't come up through anything nasty like that.

Also, if the extinction was controlled by volcanic outgassing, we'd expect to see a strong impact on life in the deep oceans. The ocean has a mixing time of about 1000 years, so atmospheric inputs that are slower than 1000 years (like the eruption of the Deccan Traps) effect life at all levels of the ocean, and things that are much faster than 1000 years only impact life near the surface. At the KPg, things that live on the seafloor or in deep waters barely even noticed, and had virtually no extinctions, while things that lived near the surface suffered severe extinctions (planktic foraminifera, which I study, lost more than 90% of their diversity). This all suggests that things happened much more quickly than could be possible with flood basalt volcanism.

(Chris)

I'm curious about what the physical makeup of the crater will inform you how life on earth recovered after the event. Are you hoping to learn details about the size and composition of the asteroid? How will this let you predict it's effect on recovery?

[Cleverpenguins](#)

We will see how life recovered in the ocean above the crater, by looking at fossils in the sediments that filled the crater, and undertaking geochemical analyses, to see how long the ocean took to return to normal. This is interesting because the ocean was probably quite toxic due to hydrothermal venting, and conditions would have been similar to the Early earth when life originated (Jo)

I'm a science educator. This expedition has a huge potential of grabbing attention from the school world. The topic is on all science book and curricula of every school of the world. It would be a waste of motivation and interest not having a wide and strong educational project. Several IODP project have implemented amazing Educational and Public Outreach projects, including embedding science teachers in scientific team. What plans do you have for matching this crucial need?

[matteocattadori](#)

We agree how important it is to use the expedition for science education. Onboard right now in fact is Kevin Kurz who is a science educator and children's book author and has been doing direct Zoom sessions with schools around the US. We plan to also make models of the best cores for use in museums and continue our outreach efforts long after the cores have been acquired. -Sean

In terms of fossilized microbial life, is there anything in particular you expect to find? Would any life found be different from microbes that exist today?

[GreatGreenNorth](#)

Not my area of expertise, but we might see something exotic, for example chemosynthetic life, since the fluids circulating through the rocks were hot and thought to be carrying trace metals - nutrients for such life (Jo)

Is there geophysical evidence that fragments of the bolide survived the impact? In very large impacts often the bolide is completely vaporized...so i am wondering if anything is even still there. Since the bolide is most likely chondritic (~97% of material that falls to Earth is chondritic), if there are any remnants, they may show up in geophysical data due to their density contrast to the basaltic ocean floor (perhaps it is sed. there).

[GraveNunatak](#)

As you say, most of the asteroid is vaporized, and now forms part of the K-Pg boundary clay layer that can be found all around the globe. People used to think the asteroid would be buried in the middle of the crater. The Barringer family spent a fortune drilling Meteor crater in Arizona - and failed.

Hi team, thanks for doing this ama, sounds like an amazing project!

My question is: since the crater has been there for 66 million years, what made you suddenly decide to probe it now?

Thanks and good luck!

[OverGold](#)

Well, for the first 65,999,953 years we didn't have a scientific ocean drilling program, so really we got here as quickly as we could. (Chris)

What tech toys are you using in the crater? Laser 3D mapping? Ground-penetrating radar (GPR)? Etc.

[Punkfarter](#)

I have a pen and a notebook. I did use full-waveform inversion to obtain a high-resolution model of p-wave velocity - that we used to locate the drill hole. We have acquired geophysical data using wireline logs, a multi sensor core logger and a VSP (Jo).

How controversial is the Chicxulub impact theory in your field? Or is it generally uncontested and accepted as a fact?

I think it's a very plausible theory (and the best theory I've heard so far), taking into account for example the iridium deposits etc. But I'm barely a layman in your field (theoretical computer science, yay). It would be interesting to hear how unanimous paleontologists and geologists are with regard to that singular event.

[Saivo](#)

Good question on our certainty! In the geological community the impact hypotheses is by far the most supported and with the best evidence amongst the theories. It explains the truly sudden nature of the event and direct evidence is present in terms of the iridium anomaly precisely at the extinction event. If I had to put a number on it greater than 95% of our community is convinced of the scientific evidence that the Chicxulub impact was the cause of the end Cretaceous mass extinction event. If you know scientists then that is saying something! We would like use the word Theory to now describe this conclusion. -Sean

How controversial is the Chicxulub impact theory in your field? Or is it generally uncontested and accepted as a fact?

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[Saivo](#)

I think it's pretty widely accepted. There's a (vocal) group that has been flying the flag for various alternate hypotheses for a while, but most of the community is on board with the impact theory. This paper does a pretty good job explaining the evidence and why competing theories are probably wrong. I think it's written at a pretty generalist level, but I have a PhD in this and so I'm probably not the best judge.

<http://eesc.columbia.edu/courses/w4937/Readings/Schulte.etal.2010.pdf>

(Chris)

Did you have a falsifiable hypothesis before you started? I'd like to hear what research methods you used to decide where to drill and why including expected results vs. actual.

[ProudTurtle](#)

We are testing models for peak ring and large crater formation, we think peak rings are formed by rocks that were pushed down 20-30 km, then rebounded upwards above the Earth's surface, and collapsed downwards and outwards about 40 km. Our numerical simulations of peak ring formation predict: depth of origin of the rocks that form the peak ring, maximum shock pressures they have been subjected to, and the reduction in density due to shock metamorphism and fracturing due to the impact. We have drilled the peak ring to test this. We have some initial results on the mineralogy, shock pressures, and density of the rocks - which I can't share with you (Jo)

Is the meteor expected to be mostly whole, or would the impact have pulverized it? How will you know if your samples are from the meteor itself?

[xupleprechaun](#)

Yeah, like the people below have already pointed out, we expect the asteroid was completely obliterated on impact. In fact, we find tiny bits of the asteroid all over the world in the KPg Boundary clay; tiny bits of that space rock the source of the iridium enrichment that first suggested to geologists that there was a major impact at the end of the Cretaceous.

(Chris)

As I understand it, the impact caused semicircular rings of underground water to form, that are seen as cenotes on the surface. Do you know how well connected this system is, and how deep it goes? Is it possible you will find caves that run unusually deep beneath the earth there, with novel forms of life?

[Wikiwnt](#)

The ring of cenotes onshore formed only in the last 10,000 years or so, whereas the impact occurred 66 million years ago. However, the cenotes and underground water system that flows through them in a ring are connected to the fact that there are crustal scale faults that form rings around the impact. The inner ring faults come close to the surface and in the last 10000 years surface water has used these faults to filter down and form caverns in the limestone in a ring around the center of the impact. - Sean (who keeps forgetting to sign his name!)

thank you for doing this ama!

how crazy for a planet that has essentially 70% of its surface covered by oceans, for this asteroid(?) to still manage to hit land & be a catalyst for such altering changes. my question isn't as interesting as some, but if this particular event happened again, but impact was in any of the oceans, near or far from any landmass, would the effects be as devastating?

[babybabayaga](#)

We do think that a sedimentary target full of carbon and sulfur made this impact much more devastating than it might have otherwise been. So a deep marine impact would have certainly had a deleterious effect but perhaps not have reached the 75% extinction level. -Sean

What proof links it to the event?

[albinocobra](#)

Copied from above:

we know this because of the unique layer of clay found at the top of Cretaceous sediments worldwide, which contains iridium (very rare on earth; very common in asteroids) and minerals that are formed in impacts like shocked quartz and glass spherules that were blasted out of the crater. We know that this clay comes from the Chicxulub crater very simply because this layer gets thicker the closer you get to the crater. In sites very far away (Europe, Japan, Australia) it's just a thin layer of clay with iridium; as you get closer (North Atlantic) it gets thicker, with a clear layer of spherules and shocked quartz below a clay layer with iridium; in the Gulf of Mexico this boundary layer can be hundreds of meters thick, and large chunks of rock that were blasted from the crater, meters-thick layers of sand deposited by tsunamis that washed back and forth across the basin, and thin a clay layer with iridium on top.

(Chris)

What is the current consensus about the role of the asteroid and the effects from the Deccan Traps in the extinction event?

[ghostsarememories](#)

That the impact drove the extinction and Deccan Volcanism did not.

Basically, the way that everything went extinct (i.e., very, very quickly, all at the same time) and the groups that went extinct (large land animals, things that lived in the shallow parts of the oceans) point to a quick event like an asteroid impact and not the slow outgassing of flood basalt volcanism.

A good summary can be found here:

<http://eesc.columbia.edu/courses/w4937/Readings/Schulte.etal.2010.pdf>

(Chris)

How many locations will you drill at, and what determines those locations?

Find anything fun that won't make it to your scientific report?

Will you be going back out for more sampling if you find something significant?

[someoneiswrongonline](#)

-We only had enough funding for one hole, and so we decided to drill the peak ring because it gives us the best chance to answer the most questions about the impact.

-I don't think our Initial Reports volume will have a chapter on FishCam, which is a shame:

<https://www.facebook.com/ESO-outreach-305621560212/>

(Chris)

Very envious of the great work! What's it like working on this? How can I get more involved with palaeontology?

[islamicporkchop](#)

Oh man it is so much fun. Exactly the reason I go into geology. I'm a micropaleontologist, so when I was offshore my job was to look at a sample from each new 3 m core as it came on deck to use the microfossils present figure out what age rock we were in, so we could know how close we were to the

boundary. Doing that in real time was very exciting, and I had a real sense of discovery every new core. It made it hard to go to bed when my shift was over. More broadly it's very cool to be part of a team all working toward the same goal, and working with great people is part of the reason this kind of big research is so much fun.

In the broader "what was it like" category, we've been keeping a blog mostly about shipboard life, which you can find here: <https://esoexpedition364chicxulubimpactcrater.wordpress.com/>

As for how can you get more into paleo: are you in school? Take some classes and try to get a research project with a professor. Or volunteer at a museum.

(Chris)

Very envious of the great work! What's it like working on this? How can I get more involved with palaeontology?

[islamicporkchop](#)

Fossil hunting is fun. In the UK I go to Lyme Regis

What do you expect to see in these cores, and what can you learn from them?

The first thing I anticipate would be high concentration of iridium. This would associate the impact with the iridium layer at the K-Pg boundary. I also expect lots of metamorphic rock at and below the impact layer. Can we learn more about the impactor from looking at these cores? Will we be able to get a better estimate of its size and composition? What about how much energy was released? From these things would it be possible to better characterize the impactor? Could it have been a near-earth asteroid, or something else? What will you be looking for in layers above the impact? What clues will tell you about the climate's recovery afterwards?

[GregariousWolf](#)

From other KPg sections in the Gulf of Mexico we have a pretty good idea of what we'll see as we get into the impact sediments. Probably there will be an iridium layer at the top, followed by thick tsunami deposits with a group of microfossils from different parts of the entire Cretaceous that were redeposited after the rocks they're normally found in were displaced by the impact/shockwave/tsunami. By the way, this was a massive event in the Gulf of Mexico; it released a huge amount of energy (magnitude >11 earthquake), and there are big tsunami deposits all around the region. Below that we should find thicker and thicker clasts of angular rocks that were deposited by "ground flow" in the crater. Below that, well, that's why we're drilling this hole. We don't expect to see much (or any, really) of the impactor itself, though, since it would have been vaporized on impact. In fact, this is why we see the iridium layer all over the world: it's all tiny bits of the asteroid. I'm just a simple micropaleontologist, so I don't know what the elemental makeup of this space rock might tell us, but maybe Sean or Jo can chime in.

(Chris)

If I were watching a (very) high speed video of the crater from the moment of impact to now, what would I see?

[Daddingly](#)

Initially the impact which hit at 20 km/s which is around 76000 mph formed a transient crater 100 km across and 30 km deep. It basically hit with enough energy (roughly equivalent to 100 million atomic bombs) to cause the rocks to flow like a viscous fluid. Then like throwing a rock in a pond the Earth rebounded with an upward rising center to the impact that rose above the Earth's surface by kilometers and then collapsed downwards and outwards. At the same time the sides of the transient crater collapsed inwards widening the rim and forming the rings to reach a final diameter of 200 km or so. The collapsing center overturned and formed a ring of mountains called the peak ring and that is what we have targeted with this drilling. All of this was in the first 5 minutes. -Sean

Will there be any open hole logging done in addition to core recovery, and will this data be made publicly available?

[newdecade1986](#)

Yes we are open hole logging each interval that is exposed before we then case and move on to greater depths. All of our data collected out here will be publicly available through the International Ocean Discovery Program after the moratorium ends. - Sean

Will there be any open hole logging done in addition to core recovery, and will this data be made publicly available?

[newdecade1986](#)

Yeah, the whole thing will be logged. After the end of the moratorium period (which will start a year from the time we finish with the onshore phase in Bremen this fall), it will all be published in the IODP Initial Reports volume for Exp. 364.

(Chris)

How certain are you of the size of the crater? What I mean is that 65 million years of weathering has occurred. Is it possible that the crater was significantly larger originally?

[fr33andcl34r](#)

Reasonably certain. The crater is not badly eroded. It was formed on a carbonate platform in a tectonically quiet area. So it has just been gradually buried for 66 Ma and is now a few hundred meters below surface. We have high quality seismic reflection data across the crater. You can see reflective Cretaceous sediments outside the crater, that get increasingly faulted and eventually disappear at about 45 km from the crater center. This tells us the amount of material that has been excavated, and the diameter of the excavation cavity scales with crater size (Jo)

What is something other researchers have hypothesized you might find there that would be surprising to you if it were validated, and why do you not expect those other theories to be confirmed?

[shaggorama](#)

Other researchers have postulated that peak rings are formed from an impact breccia that floated on top of the impact melt sheet. We didn't think that model was correct since the melt sheet in the middle of the crater has a high p-wave velocity and density, whereas the rocks that form this peak ring have a low density and velocity. Jo

How come we cannot see the crater on Google Maps or something like that? I understand that it's hidden, but wouldn't it still show a little bit?

[kgriffen](#)

Good question! Its entirely buried by the 66 million years of sediments (mostly limestones) that infilled it since it formed. For us this is good news because it perfectly preserved it making it a unique opportunity to study how large impact craters are formed. You can see the ring of cenotes that line the inner rim of the crater. -Sean

Do you expect to learn how the ring of cenotes formed?

[shaggorama](#)

We have a pretty strong current theory for that one that the cenotes that surround crater are formed by surface waters using the ring faults to focus their dissolution of the subsurface limestones around the impact basin. Our drilling is well inboard of the cenotes as we are drilling on the peak ring that surrounds the crater center. -Sean

Specifically, how does drilling help us learn things about the asteroid? Didn't it completely obliterate on impact?

Also, y'all make me proud to be a UT student! Hook 'em!

[Maxnwil](#)

Hook em! We are actually less focussed on the asteroid itself and more on specifically what large impacts due to planets. The asteroid is largely spread over the entire planet as you suggest! -Sean

I don't suppose you'll be using that drill invented by Frank H. Pabodie. I understand that it's "unique and radical in its lightness, portability, and capacity ... to cope quickly with strata of varying hardness."

[photolouis](#)

No not that drill :- ) - Sean

I am sure it is accepted in the scientific community but I feel there is still a lack of general awareness on whether it was indeed Chicxulub (and comets / asteroids more generally) that caused the dinosaurs to go extinct.

What are the compelling 2-3 reasons (without using scientific jargon) you can give me as evidence this caused the end of the dinosaurs?

[extremedonkey](#)

The dinosaur record is poor - so we cannot use dinosaur fossils to answer this. The marine record is excellent - and it is very clear that the oceans are productive and healthy right up to the point the asteroid hit (the K-Pg boundary) and the extinctions are geologically instantaneous at this boundary. On land the K-Pg layer contains a fern spike and lots and lots of soot from fires - showing a massive

worldwide loss of flora at the same time as the marine extinctions. So it is likely that the dinosaurs were also adversely affected. Jo

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What are the compelling 2-3 reasons (without using scientific jargon) you can give me as evidence this caused the end of the dinosaurs?

[extremedonkey](#)

- 1) Everything that went extinct at the end of the Cretaceous went extinct at exactly the same time, which is consistent with a rapid event like an impact.
- 2) The pattern of extinction (which groups went extinct and where) is consistent with a very rapid environmental change like an impact; if volcanism drove the extinction we would expect to see a different pattern (for example, more extinctions in the deep sea)
- 3) We find a distinct layer of impact related sediments at the Cretaceous-Paleogene Boundary all over the world.

(Chris)

This explainer article from Berkeley (Oct 2015) says the dinosaur (KT) extinction had two main mechanisms.

.....

"Berkeley geologists have uncovered compelling evidence that an asteroid impact on Earth 66 million years ago accelerated the eruptions of volcanoes in India for hundreds of thousands of years, and that together these planet-wide catastrophes caused the extinction of many land and marine animals, including the dinosaurs."

.....

Asteroid impact, volcanism were one-two punch for dinosaurs

.....

<http://news.berkeley.edu/2015/10/01/asteroid-impact-volcanism-were-one-two-punch-for-dinosaurs/>

.....

This explainer article from Yale (April 2016) says volcanism was not the cause of the KT (dinosaur) extinction.

.....

<http://news.yale.edu/2016/04/25/dinosaur-die-not-result-volcanoes-study-says>

.....

This explainer article from Bristol U (April 2016) claims the dinosaurs were already dying off before the asteroid impact consequences.

.....

"Dinosaurs were already in an evolutionary decline tens of millions of years before the meteorite impact that finally finished them off, new research has found."

....

<http://bristol.ac.uk/news/2016/april/dinosaur-decline.html>

.....

In light of the all the evidence, how can you claim the asteroid is the cause of the KT extinction? "asteroid that killed the dinosaurs".

[DarthHarper](#)

So these are two different sets of studies being quoted here. On the issue of the decline of the dinosaurs, the statistics on the relatively rare fossils of dinosaurs will never be as precise as the statistics on the larger numbered organisms that lived at the same times. For instance tree leaves (see Kirk Johnson's work) show a very healthy ecosystem right up the the impact and then the mass extinction. Similar, plankton fossils show no evidence of degradation before the extinction then had extinction rates over 90%. There also were two recent studies trying to examine the timing of large eruptions from the Deccan traps but neither found a direct correlation with the extinction event or explain the suddenness of the extinction in the statistically clear parts of the fossil record. -Sean

What non-earth substances have you found?

[ninja\\_at\\_law](#)

Too early to say - we need to take the samples home to our labs (Jo)

Does this project satisfy more of a biological curiosity for you guys, or has the drive always been geology-based?

Is Texas the place to be for geological grad school?

[man\\_cub](#)

I was eating tacos during the first part of the AMA, so I can definitely say that yes, UT is a good place to be a geologist.

The cool thing about this project is that it addresses both biological questions and geophysical/structural ones. We're working with a pretty diverse team of experts to answer a number of questions. I was out there as a micropaleontologist, and when I left (because there were no more fossils to look at) I was replaced by an impact petrologist. The multidisciplinary nature of IODP research is a pretty cool feature of the program, I think.

(Chris)

Does this project satisfy more of a biological curiosity for you guys, or has the drive always been geology-based?

Is Texas the place to be for geological grad school?

[man\\_cub](#)

Both Sean and I are geophysicists. We like being able to get high-res images of the subsurface. Which is how we imaged the Chicxulub crater.

Imperial, London is better for geology grad school (Jo)

Do you have any estimate as to how deep the meteor affected the Earth's crust at the impact site? If not, is this something you're hoping to discover?

[\\_sarahphim](#)

This is one of the basic things we're hoping to answer with this drilling. Sean or Jo probably already mentioned that we're drilling the peak ring to study how it's formed (and that it's the crater on earth with this feature preserved); whether the rocks that make up the peak ring come from shallow or deep in the crust is a question that's been modeled, but when we get rock samples from it we will know for sure. This is really kind of basic science: we have a hypothesis, and we're drilling a big hole to test it. It's really cool.

(Chris)

Do you have any estimate as to how deep the meteor affected the Earth's crust at the impact site? If not, is this something you're hoping to discover?

[\\_sarahphim](#)

We think the Earth's surface was pushed down 20-30 km and then rebounded upwards, forming a 1-km deep impact basin. In seismic data we can see the Moho (base of the crust at 30 km) is uplifted by 1-2 km at the center of the impact crater. This isn't one of the objectives of drilling (Jo)

A ton of research has been done on this impact crater. What do you hope to conclude that hasn't been concluded already?

[NoddingOwl](#)

We hope to directly examine what possible kill mechanisms were involved in the mass extinction, to confirm or deny the existing models of how large impacts fundamentally deform and resurface planetary surfaces, and to search the impacted rocks for evidence of microbial life. -Sean

A ton of research has been done on this impact crater. What do you hope to conclude that hasn't been concluded already?

[NoddingOwl](#)

running out of time - so see our other posts where we have answered this question (Jo)

Bakker thinks it was disease, do you disagree and why?

[moby\\_dick](#)

We have evidence for a cataclysmic event that wiped out 75% of life on Earth with a range of kill mechanisms from incoming fast ejecta, to crash of the food chain, to toxicity. We do not have evidence for a single disease that could somehow jump all species of dinosaurs plus all the marine reptiles and would have to express some doubt that such a single disease would then happen precisely when the extinction of 75% of life in general happened. So path of least astonishment would support the asteroid impact over this idea. -Sean

Bakker thinks it was disease, do you disagree and why?

[moby\\_dick](#)

That would be a heck of a disease, if it killed 70% of life on earth, including groups as diverse as dinosaurs and ammonites and phytoplankton.

(Chris)

Can you explain how you all plan to show how this meteor caused worldwide extinction?

[jc10189](#)

Well, the causal relationship between the KPg mass extinction and the Chicxulub impact has already been proven pretty extensively (see below), but we hope to refine some ideas about how the target rocks contributed to environmental change that caused the extinction (specifically how the amount of sulfur present contributed to global cooling) and also how life recovered in the 10s of thousands of years right after the extinction.

(Chris)

<http://eesc.columbia.edu/courses/w4937/Readings/Schulte.etal.2010.pdf>

Can you explain how you all plan to show how this meteor caused worldwide extinction?

[jc10189](#)

That would be quite a challenge - and isn't one of the objectives of the drilling. Our goals are to better understand large crater formation, determine whether craters provide habitats for life, and see how life returned in the toxic ocean above the crater (Jo)

How accepted is it that this is what killed the dinosaurs?

Furthermore, how does this theory explain the layer of iridium that is close to the layer that most dinosaur fossils are found?

\*\*I'm going off things I've read/heard, feel free to correct me if this iridium layer doesn't actually exist.

[jacobkjones](#)

This remains the prevailing theory with the greatest amount of evidence for what caused the extinction of 75% of life on earth at the end of the Cretaceous including the dinosaurs. The extinction was sudden if you examine records of organisms with large numbers and thus good statistics and is precisely correlated with the iridium layer that came from the Chicxulub asteroid when it vaporized and spread

around the globe. - Sean

Why do people keep propagating the incorrect myth that this asteroid killed the dinosaurs when most species continued to live for hundreds of thousands of years after the event and that it was a multi casual situation instead of this movie fantasy everyone loves?

[igetreallybored](#)

The most recent and best dated global evidence from the fossil record says exactly the opposite of your statement above. -Sean

Good morning all, I hope you're doing well out there in the Gulf.

I have a few small questions I'll list out below, but first I want to say that this is a really exciting study you're doing! Paleontology and dinosaurs were among the first branches of science that made me want to go into STEM as a kid, so this is really exciting for me to see. Anyway, here are my questions:

1. What kind of minerals do you expect to find, and what would be the "smoking gun" of an impactor? Iridium, platinum, other heavy metals? Further, would the composition of this material be able to tell us where the impactor originated?
2. How deep into the crust are you drilling, and at what depths do you think you'll start seeing evidence of the K-Pg boundary?
3. How large are the holes you're drilling? Do you expect to be able to find fossilized remains in them?
4. What (if any) effect could the impact event had on Earth's plate tectonics?

edit: one last question :)

[come\\_in\\_ski](#)

**1 yes correct! Platinum group elements, highly siderophile elements. We so far has three geochemical studies that suggest it was a carbonaceous chondrite.**

**2 1500 m (so a little under a mile). We reach the top of the K-Pg boundary layer at around 620 m which was shallower than we expected and it was formed of lots of breccia and over 100 m thick!**

**3 In order to get to 1500 m we have to kind of telescope the borehole downwards. So we started drilling but not coring with a slightly larger bit (<1 ft) for the first 500 m and then cased off that part of the hole with a metal pipe, we then cored with an oversized mining type bit specially made for this project (<6 in maybe) and at 700 m stepped down to a normal sized mining bit (<5 in) and as we go deeper we have two more even smaller sized bits to use. The fossils in this small core are all microfossils or small shells. The microfossils are largely plankton.**

**4 The impact had enormous effect locally on the crust and set off earthquakes much larger than plate tectonics can generate (magnitude 12 or so) however it did not fundamentally alter tectonics over the long term. Thanks for all the questions! -Sean**

Thank you for doing this AMA! This is incredibly exciting, I wish scientists got the same recognition as athletes and movie stars so you could get more funding.

Anyway, I'm curious if you've ever come up with a model of what would have happened if the asteroid had exploded in the atmosphere as opposed to impacting. You may be familiar with the airburst theory for the megafaunal extinctions in North America during the Younger Dryas. It claims that an asteroid exploded over north america and caused ice sheets to collapse, along with massive forrest fires thus causing the ice age.

What do you think would've happened if an asteroid of this magnitude had exploded over it's site? How would the world be different in terms of land formations and percentage of animals and plants that survived?

[SilverCross64](#)

Thanks for the post. It would be fantastic if resources were dedicated to the study of the Earth and solar system at even a reasonable fraction of the amount dedicated to sports and movies! But back to reality... An asteroid beyond around 100 m will nearly always be large enough to make it through the atmosphere and impact the Earth's surface. Chicxulub was around 14 km across so it certainly hit the Earth and in fact initially formed a crater 30 km deep!

The Younger Dryas impact hypothesis has been basically disproven it turns out as none the existing samples that were thought to be from a airburst meteor have proven to be meteoritic upon full study. So the Younger Dryas cause is once again being looked at as a potential freshwater pulse into the northern Atlantic since there does not appear to be any kind of extraterrestrial cause. It turns out that we can expect at airburst type impact one every century or so and these have not been shown to cause major effects on our Earth climate, just local effects. The Chebalyesnk (sp?) impact a few years ago was right on cue given the previous known one was Tunguska in Russia in the early 1900s and both caused significant local damage by no lasting climatic effects. -Sean

How long do you think the dinosaurs survived after the asteroid hit?  
Hours? Days? Weeks?

[Zwill711](#)

Probably months to maybe years (long enough for the entire ecosystem to collapse, basically), but no much longer (definitely not 10s of thousands of years).

Thanks for doing the AMA.

I was curious if there was going to be a comparison of samples that are collected from the rim at sea compared to where the rim on the continent is located will occur, if there are samples from the rim located on the peninsula.

Also, if I may will you be looking at the effects of shock metamorphism on certain minerals and compare them to other samples to attempt to get accurate or at least narrow down the range for the temperature and pressure that occurred at impact.

[sawc](#)

There was a drilling project near the rim onshore in 1999 done by the International Continental Drilling Project. That borehole was name Yaxcopoil-1. We are in the offshore drilling the ring of mountains present well inside of the rim (called a peak ring) which forms in every large impact that we know of; yet, we until now have never recovered samples from a peak ring. -Sean

Hi and thanks for this AMA! What are your favourite dinosaurs and why?

[Twatticus](#)

I have always been partial to the Triceratops and in the marine reptiles that lived at the same time as the dinosaurs, the Plesiosaur. -Sean

Thanks for taking the time, this is an intriguing topic to me and my students. The most recent extinction event!

Could you elaborate on the types of tools you'll be using - Magnetometers, sonar, diamond tipped drills and the like? Also, I think someone already asked, but what do you hope to find at the peak ring? Is the inverted terrain as well defined as places like Barringer? Is the lift boat awesome?

That was a lot of questions. Thanks in advance, and good luck out there!

[ITeachFuckingScience](#)

We are using the full suite of drilling and logging tools that we were able to fit onto this small platform. Diamond tipped drill bits definitely, logging downhole and the cores with magnetic, electrical, sonic and gamma ray techniques, and conducting geochemical sampling while looking for microbial life. We will then do more detailed studies onshore in the months to come. Liftboat officers and crew are great as are the drilling team. We are also very well fed out here! We hope to learn from the peak ring rocks what kind of shock pressures they experienced, how peak rings are formed, and fundamentally how impacts can weaken planetary surfaces to allow them to flow like a fluid temporarily. Thanks for the questions. -Sean

What has been the most difficult aspect of drilling so far? And how cooped up do all of the scientists get on the boat in close quarters for that long?

I was part of the recent (ish) ICDP drilling project in New Zealand, and I know you go a little bit crazy after long periods of time (and we were able to "escape" briefly during drilling down time!). when/if you have problems drilling on board, what do you do to pass the time? And what does the crew do to keep up morale?

[gneiss\\_kitty](#)

You are right that the true challenges are during the periods when we are having drilling difficulties. Fortunately those have been infrequent and our core recovery is amazing (almost 100%) and so we can stay busy which equals great morale. It is tight quarters out here though with six of us per cabin as we work 24 hours a day 7 days a week, likely similar your ICDP project in New Zealand. -Sean

This is not -strictly- a science question, but the title says ask anything, so here goes.

Have any of you read [the short story Chicxulub by T. Coraghessan Boyle](#)? (It's linked there for your convenience, it's maybe a fifteen minute read.) First, is his dramatic description of both the Tunguska and Chicxulub impacts accurate, and secondly, what do you think of the story?

[Dear\\_Occupant](#)

I'll put this on my reading list, but I don't have a lot of spare time for reading at the moment, Jo

Is there anything particular you're hoping to find?

[JoshuaRAWR](#)

A tiny T. Rex the size of our core barrel would be awesome.

Also, personally, I'd love to see an expanded interval of the early recovery right above the boundary, so that I can study that interval in detail. Also, identifiable fossils in the clasts of Cretaceous limestone that make up the impact breccia would be awesome, since we could identify what formations make up the target rocks.

Mostly a tiny T. Rex, though.

(Chris)

Other than iridium, shocked quartz, and glass spherules, are there any other types of "exotic" or otherwise interesting minerals or rocks, such as ophiolites, that you have found or expect to find in the impact crater?

[BrakeTime](#)

Interesting question, we do think we will encounter some hydrothermal minerals cause by the "hot springs" that existed at the impact site for 100s of kyr after the impact. We have already found some layers of fully melted rock which implies pressures greater than 50 Gigapascals! - Sean