HGS Bulletin

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Houston Geological Society

MARCH 2025

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In Every Issue

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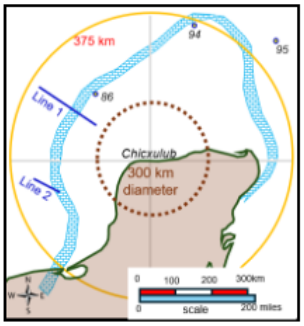
About the Cover: Cover image is from Alamy, showing a rendition of the Chicxulub asteroid about to make impact on the present Yucatán peninsula

Technical Meetings

Features



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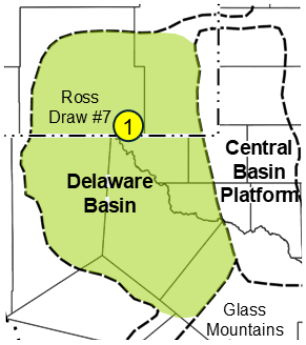

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Penny Patterson, HGS President 2024-25
pennyp70@att.net

It's Time to Explore in Our Houston Area

March has arrived in Houston, Texas, with mostly warm, pleasant temperatures prevailing and a few Arctic cold blasts reminding us of winter's lingering presence. This is the perfect time to plan activities to get outside and explore the many scientific wonders that Houston and our south Texas coast area have to offer.

SPRINGTIME GEOSCIENCE ACTIVITIES

Numerous outdoor activities are occurring this spring that are particularly interesting to our young scientists. HGS's Educational Outreach Committee has several events lined up for this month. On March 1, 2025, the 21st Annual Nature Fest will be held at Jesse Jones Nature Center. At this event, HGS will host two booths that introduce concepts of river deposits, which can be observed at the park, and also present concepts on flooding events that impact our area. On March 5, 2025, the HISD school system is hosting a Geoscience Challenge entitled "Current and Future Water Usage in our Community: A Tale of Two Sources – Surface versus Groundwater". This challenge is for high school students working virtually in teams of 3 to 4 members. HGS volunteers will assist with this event, providing information and insights on the challenges Houston and many cities face in our need for potable water. On March 10 - 14, 2025, EOG Resources will organize the "Success Skill Center" Event at Discovery Green Park, Houston Texas. HGS will have tents at this event, which will help with learning about careers in energy and present training on leadership and communication skills. For details of these events, please get in touch with Educational Outreach Committee Chair Phil Caggiano.

The Houston Museum of Natural Science (HMNS) is a must-visit museum for rainy-day activities. There are several awe-inspiring exhibits, including the Cullen Hall of Gems and Minerals, which is my favorite; the Moran Paleontology Hall, which is truly impressive; and the newly renovated Weiss Energy Hall, which is a "must-see" exhibit for all Houston geoscientists. HGS Co-Chairs for HMNS, Inda Immega, and Janet Combes, can help you with additional information.

This spring explore and grow "taller" in your understanding of our geoscience wonders in Houston

Interested in venturing outside the city? There are numerous options available to explore our geological wonders. On March 2, 2025, AAPG is hosting a "Galveston Field Trip" led by Erik Scott. The field trip will examine Texas coastal processes along the Brazos River and Galveston Island. Another fun and informative adventure is seeing Texas' dinosaur tracks at Dinosaur Valley State Part in Glen Rose, Texas. Additional dinosaur tracks can be observed at the Heritage Museum of the Texas Hill Country in Canyon Lake and Government Canyon State Natural Area.

UPCOMING TECHNICAL EVENTS

On March 10, 2025 Dr. Kevin Bohacs, Chief Scientist, at KMBohacs GEOconsulting LLC, will present his work with the Mars Scientific Laboratory (MSL) at HGS's Dinner Meeting in the Norris Conference Center. The title of Dr. Bohacs' talk is "The path to Gale and Jezero craters—the role of terrestrial fieldwork in selecting landing sites on Mars and interpreting the resulting observations." Dr. Bohacs has been working with MSL for several years, and his and his colleagues' research is exciting and extraterrestrial!

On March 11-13, 2025, the Carbon Capture Utilization and Storage (CCUS) Conference hosted by AAPG, SPE, and SEG will be held at the George R. Brown Convention Center, in Houston, Texas. The conference is now in its fourth year and continues to highlight innovative technologies and research advancements in CCUS projects.

On April 6 – 8, 2025, the GeoGulf2025 Conference will be held in Nacogdoches, Texas. This year's conference will cover a wide range of topics, including Regional Gulf Coast Geological Studies and Facies Analyses, Critical Mineral Explorations, CCUS, Water Resources and Environmental Geology, and Unconventional Plays.

Please visit the HGS website for more information on these and additional upcoming events.

From the President *continued on page 8*

Ted Godo, HGS editor 2024-25
editor@hgs.org

Continuing with the Theme of Critically Thinking and Avoiding Dogmas

Greetings, fellow HGS members. As the days grow warmer, the typically foggy and humid conditions allow us ample opportunities to clean the remaining leaves and mold and mildew from outdoor furniture and the house. Meanwhile, it seems the writers and editors are all aboard the Chicxulub train this month. Our Bulletin cover was a "must have" from Alamy to highlight the editor's "feature article" and celebrate the excellent dinner talk on Sponsorship Night by Andrew Madoff and Cody Miller of Chevron. Plus, I just received my February AAPG Explorer magazine, and what is featured on page 38 is an article on Chicxulub! Obviously, these three presentations were not coordinated as each has a different specific focus, but something must "be in the air" …. no groaning.

In researching the feature article this month, I read that some authors referred to an "asteroid impact," while others used the phrase "bolide impact." So, what's the difference, you might say? Basically, there is no apparent difference, just in imagination. Let me explain. The main difference between a "bolide impact" and an "asteroid impact" is that an asteroid impact is less descriptive. It seems that we geologists invent different words for a similar thing, but then again, we tend to be "right-brained," which contributes to artistry in our science. By definition, a "bolide impact" is characterized by a flamboyant type of asteroid appearing as a bright fireball that ignites/explodes in the atmosphere before impacting the Earth. No one was around at the time to characterize this flamboyant expression, but it was undoubtedly impressive.

we geologists invent different words for a similar thing, but then again, we tend to be "right-brained," contributing to the artistry of our science

Besides being an incredible event to write about, I wanted to continue focusing on a theme this year, which, for example, is always to ask how we think. Do we ask new questions and avoid dogmas by talking and listening to others' opinions? In the feature article, I titled it, "The Discovery Road to Chicxulub and the Creation of a World Class Breccia Reservoir." How did I choose this title? In 1981, a young geoscientist felt he had discovered a shallow buried impact crater that was previously thought to be a volcano. PEMEX had just drilled and found an impressively thick and porous breccia at Cantarell, with its first production in 1979. Their model of deposition was a debris flow off the nearby Cretaceous margin. Despite ongoing drilling efforts and finding breccia within the KMZ field complex, numerous wells were cored without any modifications to the existing depositional model. PEMEX did not acknowledge that the breccia originated from Chicxulub until 2000. That's 20 years of drilling and production. So, I asked myself a few specific questions after learning about the exploration and development of the field complex.

Do we listen to others' interpretations, such as the original observation/idea that an anomalous feature did not look like a volcano but rather an impact structure?

From the Editor *continued on page 8*

WELCOME TO NEW MEMBERS, EFFECTIVE FEBRUARY 2025

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HGS MONTHLY BULLETIN

Would you like to share your groundbreaking research and insights with the Houston area geoscience community?

If so, submit your article to the HGS Bulletin, a high-quality journal published monthly by the Houston Geological Society.

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From the President continued from page 5

HGS FEBRUARY EVENTS

February was a stellar month for HGS for recognizing and supporting our geoscience students on their academic excellence. On February 10, 2025, HGS hosted Scholarship Night, which Fang Lin and Allison Barbato co-chaired. The highlight of Scholarship Night was the presentation of Calvert Fund scholarship awards to 17 graduate students and the presentation of HGS Undergraduate Fund awards to five undergraduate students. HGS received a record $56,185 in scholarship contributions in support of both these scholarship funds. HGS sincerely thanks everyone for their contributions. In addition, HGS extends sincere thanks to the event co-chairs, as well as Jeff Lund, Chair of the Calvert Fund Committee, and Joe Lynch, Chair of the HGS Undergraduate Fund.

On February 15, 2025, the Science and Engineering Fair of Houston (SEFH) was held at the EpiCenter, Rosenberg, Texas. Dorene West, HGS Chair for SEFH, deftly organized ten HGS volunteers to judge earth and environmental science projects completed by elementary and high school students. The HGS judges awarded first, second, and honorable mention certificates to students in these two grade levels from the many thorough and well-thought-out science projects. In addition, three students were awarded summer internships at the Houston Museum of Natural Science. HGS sincerely thanks Dorene West for making this such a successful event for HGS and our Houston area students.

HGS BOARD NOMINATIONS

The HGS Nominations Committee has assembled an outstanding slate of candidates for the 2025 – 2026 HGS fiscal year. The candidates are currently working diligently on their brief biographies and statements of interest in serving on HGS's board, both documents of which will be published in the April issue of the HGS Bulletin. Voting will begin on April 10, 2025 and extend through midnight May 10, 2025. I encourage everyone to meet our candidates at upcoming HGS events.

I close my letter with a quote from Henry David Thoreau: "I took a walk in the woods and came out taller than the trees." I encourage everyone to take "a walk in the woods" this spring to explore and grow "taller" in your understanding of our geoscience wonders in Houston and the south Texas area. ■

I look forward to seeing you out exploring this spring!

From the Editor continued from page 6

Do we occasionally call the idea names like "Glen's sky rock"?

Do we sometimes become dogmatic in our models, like when we discovered a world-class, 300-meter-thick breccia and decided that our model of a talus debris flow could only be the right one?

Did we not look at the core in detail for possible impact-related debris?

Could development have happened differently if we had realized this breccia had a much more widespread and continuous permeability across all fields?

I also want to thank Wayne Camp for his thought-provoking technical article this month, "A Proposal to Reinstate the Wolfcamp Formation as a Formal Lithostratigraphic Unit, Delaware Basin, New Mexico and Texas." His article complements the current theme, which addresses questions like, "Are we avoiding dogmatic models, or are we continuing to think critically and seek input from others on our questions?"

As a final reminder to all, please consider submitting technical or feature articles to the Bulletin. I could use your help for the April issue. Thank you and enjoy the coming Spring. ■

We Are The HGS

Asiya Kudarova, HGS member since December 2024

Asiya, originally from St. Petersburg, Russia, where she pursued her MSc in Applied Mechanics, making a practical choice given her interest in technical disciplines and the versatility they offer. While many of her peers excelled in both technical subjects and the arts, Asiya's studies laid a solid foundation for a future in a wide range of fields. Eager to delve deeper, she joined the Applied Geophysics department at Delft University of Technology in the Netherlands, where she pursued a Ph.D. in Geophysics. Asiya's transition into geophysics was seamless, with her prior knowledge in the mechanics of elastic wave propagation aligning well with the study of seismic waves and poroelasticity, she connected her background with the geoscience world, where she began to explore how mechanical concepts could apply to subsurface phenomena.

Asiya looks forward to building connections in the Houston area and contributing to the geological community

By the time Asiya was finishing her Ph.D., she realized she needed more practical experience in geology, geophysics, and petrophysics, as her studies had focused largely on theoretical concepts. In 2015, she joined Shell's graduate program, where she was introduced to real-world challenges. "I started to learn about reservoir monitoring and 4D seismic and shortly after I joined… I also attended my very first geology field trip!" she recalls, marking a pivotal moment in her transition from theory to practice.

In her current role as a Geoscience Projects Manager at ThinkOnward, a Shell portfolio company, Asiya is at the forefront of digital transformation in geophysics. She is involved in the development and application of deep learning algorithms for seismic data: "We are still trying to understand how to make life of seismic interpreters easier and what AI can do for subsurface," she explains. While digital tools are revolutionizing the field, Asiya emphasizes the ongoing challenge of integrating these technologies with traditional workflows. Outside of work, she is passionate about hiking and opera singing, even seeking out the perfect acoustics in canyons and outcrops. ■

Ali Stagner, HGS member since August 2024

Ali's career as a geologist has taken her on a dynamic journey, blending a love for science with a deep connection to both her Canadian roots and Georgia, where she spent much of her youth. Originally from British Columbia, Canada, Ali's family moved to the U.S. when she was young, settling in Georgia. While her childhood aspirations were more about adventure—climbing trees and biking—her path eventually led her to geology, inspired by a passionate professor who made science come alive and sparked a love for carbonate geology.

Ali admires an approach that encourages broad scientific thinking and increasing one's skill set

After earning her BSc from the University of West Georgia, Ali worked at SEI Environmental, making a practical choice as a single mother looking to support her family. However, her thirst for knowledge led her to pursue a master's degree at the University of Oklahoma, where she found a mentor in Dr. Lynn Soreghan. Following her master's studies, Ali worked for ConocoPhillips for 7 years, an experience that further solidified her love for carbonate geology, where she had the freedom to explore various research projects and develop her expertise. "They let me do everything I wanted—worked carbonates, spent time in the field, and developed research projects that suited precise business needs," Ali shares. In 2016, she returned to Canada for her PhD at Queen's University, studying under Dr. Noel James, which was a meaningful return to her roots.

Today, Ali's career has taken a new turn at ExxonMobil, where she's diving into lithium exploration—an entirely new and exciting challenge for her. The transition from a smaller company like Denbury to a global energy leader has brought fresh opportunities and a chance to grow in new directions. Despite the shifts in her professional focus, Ali's love for the outdoors remains a constant, whether she's hiking, playing cribbage with her spouse, or enjoying family breakfasts. Through it all, she remains dedicated to scientific discovery and contributing to the broader energy landscape, always with a sense of adventure and purpose. ■

We Are The HGS is a series that highlights the careers and contributions of HGS members with the intention of building community. Would you like to be featured in We Are The HGS? Send a note to editor@hgs.org.

The Discovery Road to Chicxulub and the Creation of a World-Class Breccia Reservoir

By Ted Godo

When asked about the likely cause of the extinction of the dinosaurs at the K/T boundary, many people refer to a giant asteroid that struck the Earth. Some will even detail that it landed in Mexico (Yucatan). Others will name or attempt to name the specific crater left by this asteroid: the Chicxulub crater (cheek-shoo-LOOB). People may forget or maybe never been taught this extinction theory before 1980 or even in the early 1980s. Before then, it was thought that dinosaurs and other species went extinct not because of an apocalyptic event but because of gradualism. "Gradualism" or Darwinism was used to explain natural and resource changes. It caused animals who were more suited to exploit these changes to adapt to them, whereas others who did not, declined in their population to extinction.

HISTORY OF DISCOVERING THE CHICXULUB IMPACT

The asteroid impact theory was introduced in the late 1970s but was not published until 1980. This theory was based on a distinctive dark clay, enriched in iridium and found at many locations at the boundary of Cretaceous and Tertiary sediments. It was described as a "thing" in many areas of the earth. Walter Alvarez proposed the theory that the iridium-rich layer was caused by some unknown massive impact from outer space and left in its wake was the iridium-rich layer (Alvarez, 1980). However, this new idea was without any evidence of a K-T-aged crater left by such an impact, and scientists did not heartily accept the idea of an iridium-rich layer at the K-T boundary.

The Discovery Road to Chicxulub *continued on page 11*

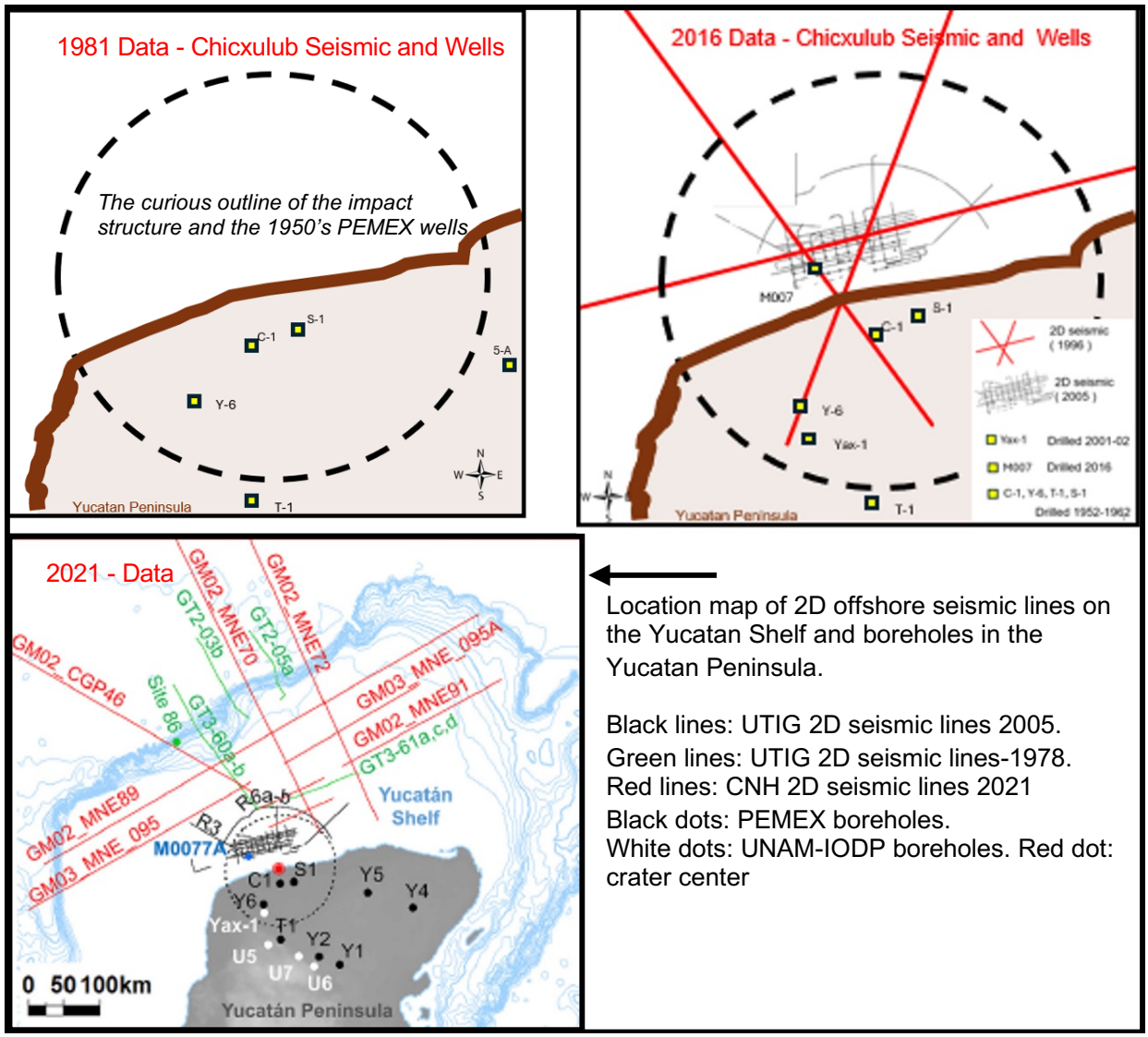

Figure 1. *Three "snapshots" in time of data available over the Chicxulub impact. The upper left is the 1981 view, which shows Penfield's outline of the magnetic and gravity anomaly that he interpreted as an impact structure, not a volcano. In the upper right box is a 2016 view with two more drilled wellbores and seismic acquired in 1996 and 2005. The lower left box shows the current data set (seismic and wells)*

The Discovery Road to Chicxulub continued from page 10

A 1975 new professional named Glen Penfield graduated from Oberlin College in Ohio and is credited with originally discovering and naming the Chicxulub Impact crater. It took some time, however, before others thought it was credible. The story goes that upon graduation from Oberlin, Penfield began studies of volcanoes in Guatemala for a few years but then began an assignment with PEMEX as a quality-control geophysicist. He flew across all of Mexico to acquire more modern magnetic data (Penfield, 2019). While acquiring newer magnetic data over the Yucatan Peninsula, weakly magnetic but high-frequency (shallow) anomalies were "mapped" into a circular pattern. However, this circular-shaped structure has a magnetic field different from any known volcanic terrain. Penfield and PEMEX geophysicist Antonio Carmargo-Zanoguera strongly felt that this feature was not a volcano but probably an impact crater. In 1981, Penfield joined with fellow teammate Antonio Camargo and submitted an abstract on this discovery at the SEG international convention in Los Angeles (Penfield, 1981). It was not seriously received and dismissed by some as "Glens Sky Rock" (Penfield, 2019). It was known that PEMEX had drilled some exploratory wells in this "anomalous area," and Penfield felt that re-examining the rocks might lead to some supporting data. (**Figure 1**). Penfield had more work to overcome these established "blind spots." Looking back at other data that might corroborate the "impact crater" theory, Penfield looked for information from old well data. PEMEX had drilled several wells in the area starting in 1952, which included drilling the Chicxulub-1 borehole and eight other boreholes in the area (Urrutia-Fucugauchi, 2011). Reports in the 1970s from these wells by well-established geologists described some lithologies as andesite igneous rocks from volcanic activity called the "Merida Volcanics" (Lopez-Ramos, 1975). Penfield wanted to look at the well cores himself, but he was told the warehouse in Mexico that stored the core samples had burned down, so they could not look for corroborating evidence.

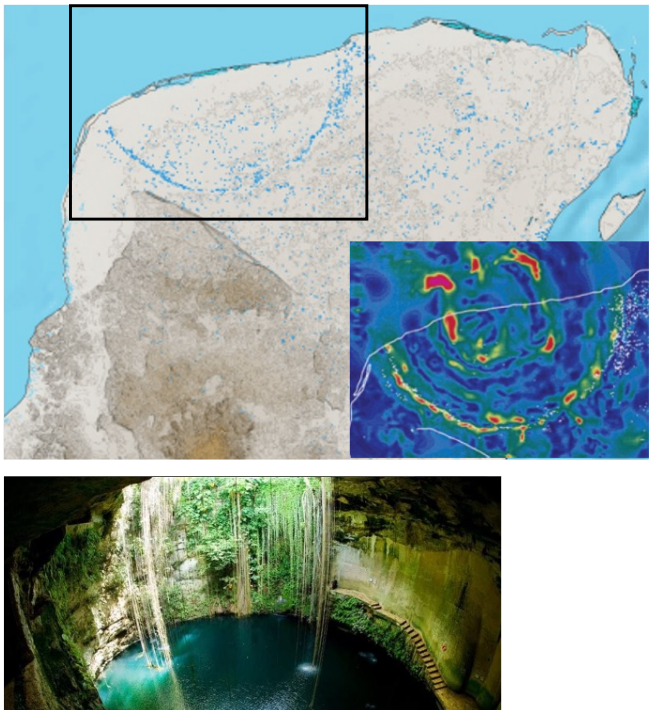

Figure 2. *Upper figure - In light blue dots are the surface sinkhole (cenotes) that outline the features of the impact ring. NASA/ JPL, 2000, SRTM Mexico Images. Shuttle Radar Topography Mission (Feb 2000) Jet Propulsion Laboratory, NASA. https:// sites.northwestern.edu/monroyrios/ring-of-cenotes/ . Inset map corresponding to the black outline around the Cenote map is a gravity map from Urrutia-Fucugauchi, (2011)*

Lower picture – A Cenote or sinkhole filled with blue water. The local people call these sinkholes "cenotes" (pronounced say-no-tays) in a word tied to the Maya language (ts'ono'ot), meaning "a hole filled with water".

Later, in 1990, another graduate student, Alan Hildebrandt, from the University of Arizona, contacted Glen and had heard through the "academic grapevine" that some core samples from these old PEMEX wells were not all destroyed in the Mexican warehouse fire but in 1965, they had been re-warehoused at the University of New Orleans. Apparently, not everyone knew. Hildebrandt identified shock-metamorphosed quartz grains as being supportive of impact metamorphism. Hildebrandt, Glen, and his wife Erendira named the crater Chicxulub after the onshore community of Chicxulub Pueblo. In that same year (1990), Houston Chronicle reporter Carlos Byars wrote a news story highlighting the possibility of a large impact crater, "Chicxulub," discovered by Glen Penfield and Antonio Camargo. Byars' article helped to popularize the idea of the Chicxulub crater as a significant impact site and its connection to the dinosaur extinction event.

By 1991, Hildebrand, along with William Boynton and David Kring at the University of Arizona, further worked on the same well samples from the crater and confirmed that Chicxulub was an impact crater using additional petrologic analysis. For example, they described these "volcanic andesites" as having characteristics that were not consistent with normal volcanic andesites (Kring, 1991). In 1995, UNAM (Universidad Nacional Autonoma de Mexico) drilled nine boreholes up to 700m deep (#U-1-U9) targeting eject blanket near the crater rim (Urrutia-Fucugauchi, 2011). Pope (1996) made additional observations based on geomorphic, soil, and topographic analyses using regional satellite images. Pope and others mapped distinct surface expressions of a series of concentric features, including an outer trough and ridge crest corresponding to buried ring faults and the topographic rim of the crater. The most prominent is a ring of sinkholes (aka Cenote) marking the outer edge of the crater floor (**Figure 2**). Using the Cenote rings and subtle surface expressions of ridges and troughs, Pope suggested a crater diameter of 180km that could potentially range up to 260km (Pope, 1996). Also in

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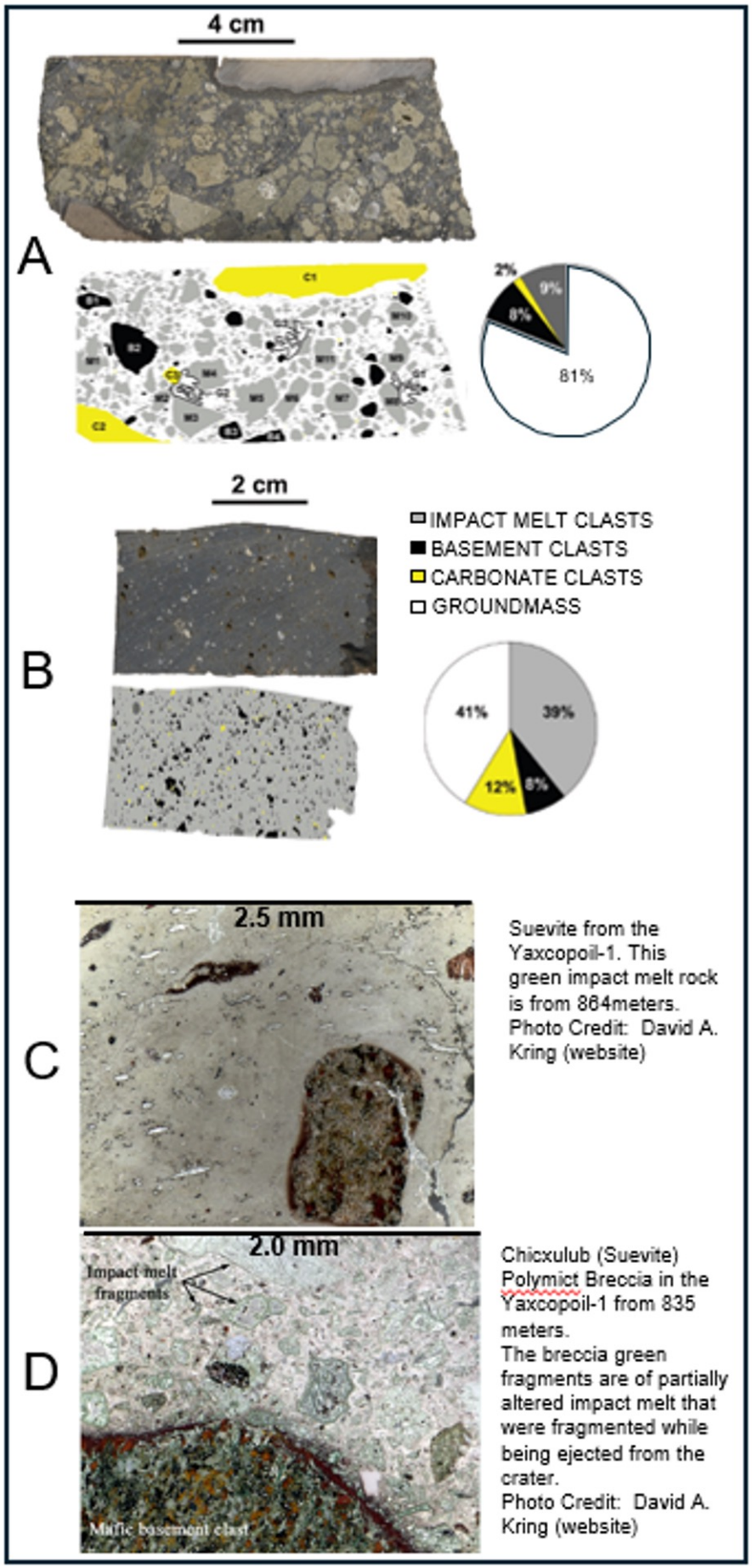

1996, the British Institutions Reflection Profiling Syndicate (BIRPS) acquired 650 km of marine seismic reflection profiles across the crater, recorded to 18 s two-way travel-time (TWTT) (**Figure 3**) (Morgan, 1997; Bell, 2004). Sharpton (1996) presents evidence for an approximate 300km diameter crater by integrating data from subsurface wells. Jablow (1998) added that this feature had to be a crater if, for no other reason, it displayed a "most un-volcano-like symmetry and is ten times the size of any volcano."

By 2001, the Chicxulub Scientific Drilling Project (CSDP), supported by the International Continental Scientific Drilling Program (ICDP), drilled a wellbore and collected a continuous core to study the Chicxulub crater. This well/borehole is named Yaxcopoil-1 (aka Yax-1) and was drilled ~60 km south-southwest of the crater center within the impact basin and inside a ring of cenotes (surface sinkholes) (Stöffler et al., 2004; Urrutia-Fucugauchi et al., 2004). The location of Yax-1 was chosen to drill between ridges of the impact crater at the outer part of an annular trough. Hence, the well was expected to penetrate several hundred meters of suevite overlying a coherent impact melt sheet (Dressler, 2003). Suevite is a commonly found rock type in impact structures. It is a polymict, of allochthonous fragments of target (pre-impact) rock in a "melt', or a melt breccia (Schulte, 2021) (**Figure 4**). The results found suevite but thinner than expected at about 100 meters (794-894m), deposited on top of a brecciated melt rock. Below the melt rock, a fault was crossed, and drilling continued to total depth in fault-rotated Cretaceous limestone, dolomite, and anhydrite (894-1495m) (**Figure 5**). One of the shallower interesting sequences

Figure 3 *A and B are two examples of melt breccias photographed in normal light. Below each is an elemental digital mapping showing the components. C and D are suevite thin sections (modified from Kring website (thin sections) and Kaskes, 2021 for digital mapping)*

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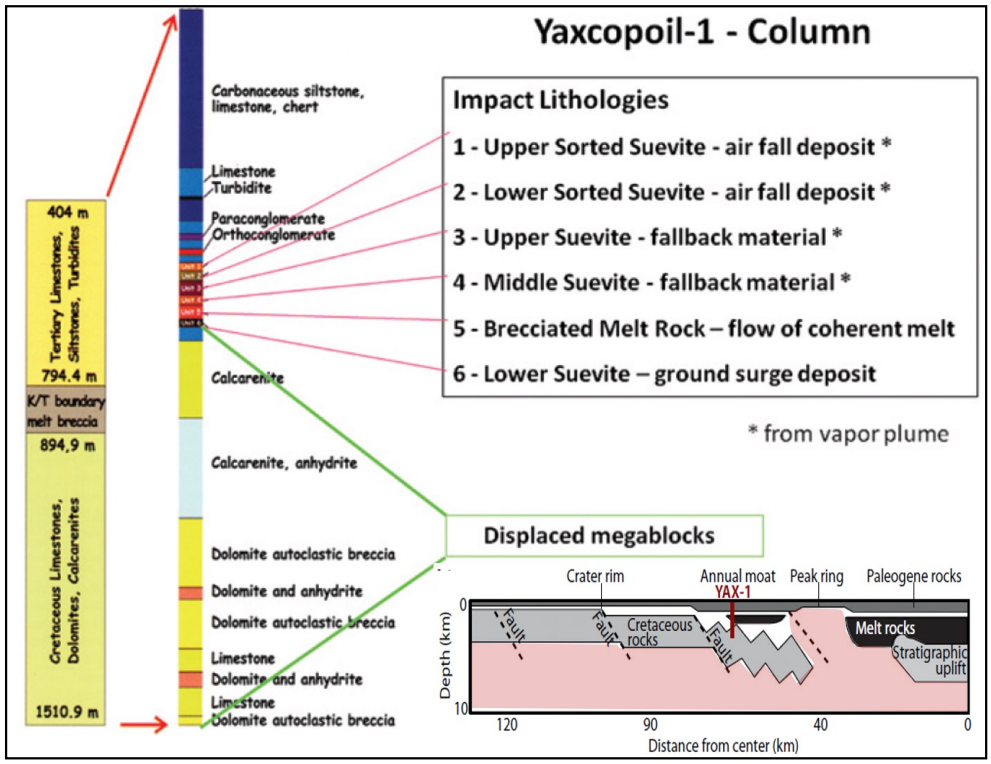

Figure 4 *Modified from Urrutia-Fucugauchi 2011- Left is a schematic column for the Yaxcopoil-1, showing the main lithological divisions. The impactite sequence is ~100 m thick and is formed by six distinct breccia units (Stoeffler et al., 2004; Kring et al., 2004).*

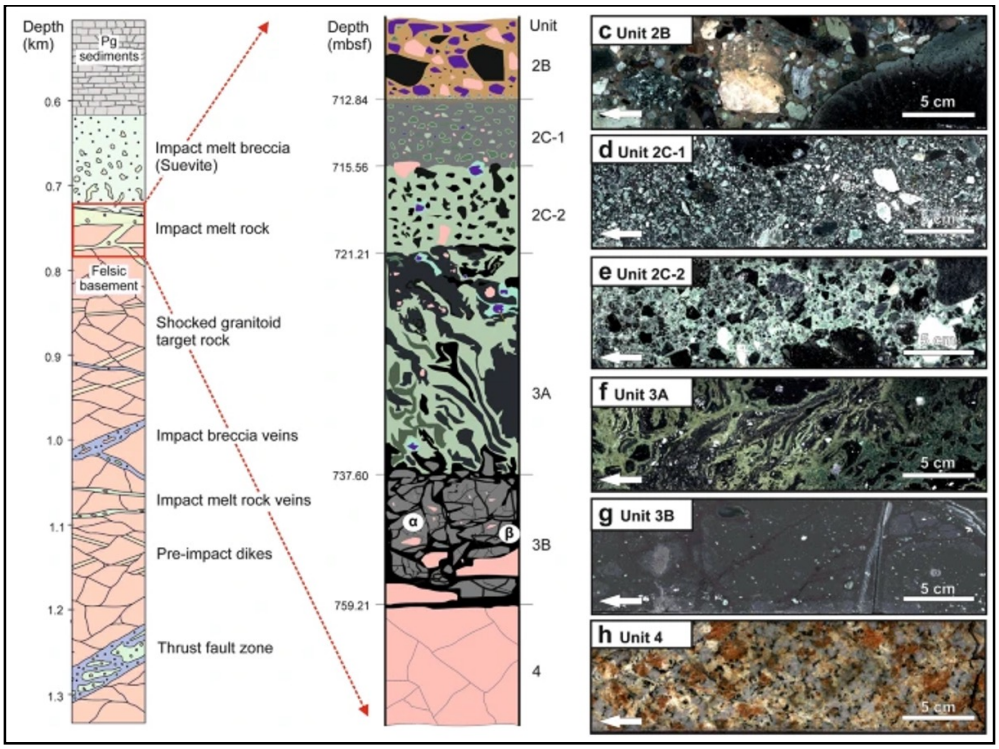

Figure 5 *Modified from Schulte 2021- Petrographic, microstructural and chemical examination of the impact melt rock sequence offshore borehole M0077. The borehole found two physically and chemically different impact silicate melt rock phases, colored black and green. The black silicate melt rock is trachyandesitic in composition and agrees with impact melt rock compositions from other sites in Chicxulub. The green silicate phase consists chiefly of clay minerals and sparitic calcite, interpreted as secondary mineral phases that pervasively replaced a water–rock debris mixture under hydrothermal conditions*

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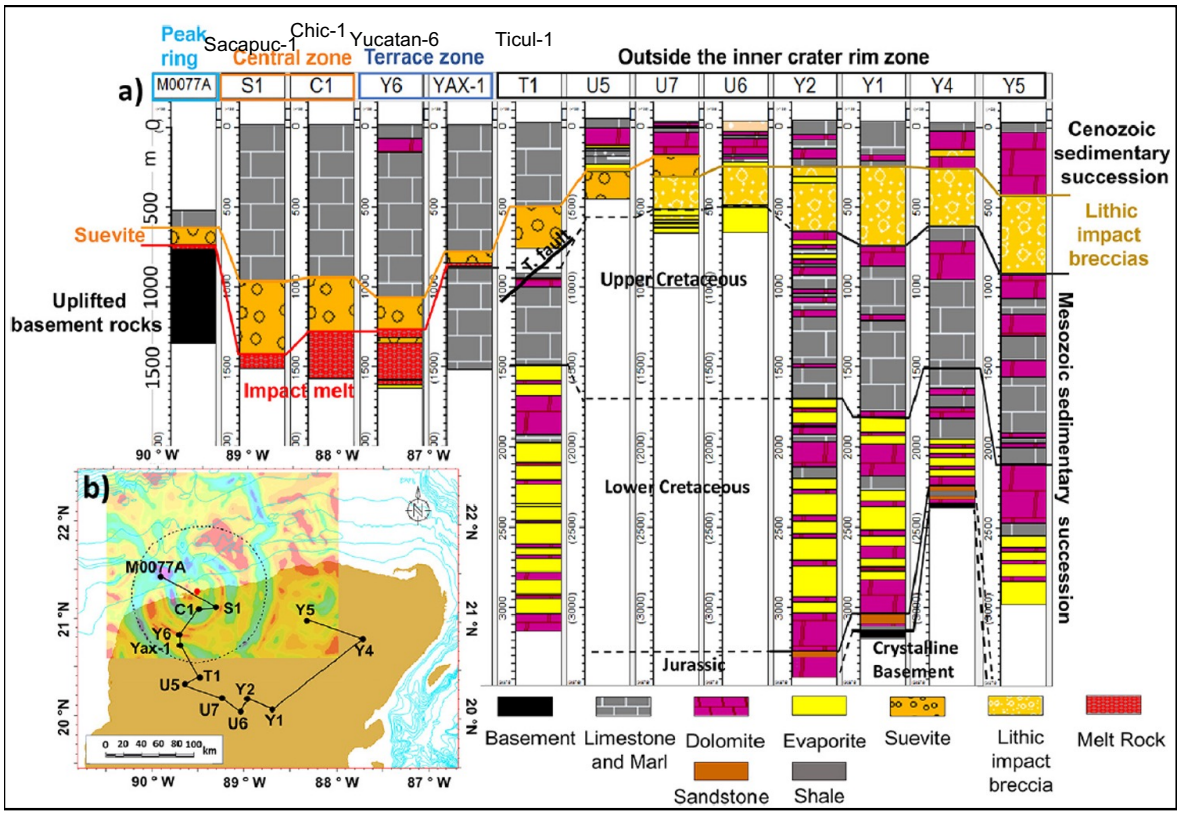

Figure 6 *Modified from Guzman-Hildago, 2021; A cross-section of the wells inside and outside the impact crater. The inset map is a gravity map with the line location*

located just above the suevite breccia is the first carbonate deposited after impact. This carbonate is a dolomitized micrite overlain by a laminated limestone with thin glauconite intervals. Keller (2004) describes in place a diverse fauna that spans the last 160k of the Upper Cretaceous. She uses other interpretations of magnetostratigraphy and carbon isotopes to propose that the impact happened near the end of the Cretaceous. Arz (2004), however, interpreted this carbonate sequence as containing reworked (Albian to Maastrichtian) planktonic foraminifera specimens. Arz interprets this part of the core as representing the water's initial (or backfill) before "normal" Danian sedimentation.

In 2016, a new wellbore was drilled offshore by the joint groups of the International Ocean Discovery Program (IODP) and the International Continental Scientific Drilling Program (ICDP). The well was under the project called Expedition 364, and the specific borehole is called the M0077. The borehole location is ~46 km northwest of the center of the impact structure (Nixon, 2022). It was drilled to a depth of 1,334.69 meters. It recovered an ~829 m core of postimpact sedimentary rocks, impactites, and uplifted basement atop the peak ring of the Chicxulub impact crater (505.7-1334.73m) (Whalen, 2020; Morgan, 2017). A summary description of the cored interval begins in the Post impact sediments of the Paleogene age, crosses the unconformity of the remnant impact section, and drills well into the granitic basement (**Figure 5**) (Morgan, 2016; Kring, 2017; Collins, 2020; Schulte, 2021). The top of the peak ring is at 618 meters. The peak ring is made up of ~130m of breccia, made up of impact melt fragments which then overlies a clast-poor impact melt rock. Below that, the felsic basement begins at 748m and extends to total depth. These felsic basement rocks were intruded by both pre-impact mafic and felsic dikes, as well as dikes of impact-generation. The granite also showed features of shock metamorphism that resulted from the impact including abundant shearing and fracturing (Feignon, 2021). The age of granite gave a Paleozoic (Carboniferous) with U–Pb ages of 326+-5 Ma (Rasmussen, 2019; Zhao, 2020) and 334 +-2.3 Ma (Ross, 2021). The oldest age of the granite is likely to be in the age range of 550-545Ma around Precambrian time based on other basement material further south in this Maya block (Krough, 1993; Kettrup, 2003; Keppie, 2011; Ortega-Gutierrez, 2018). The younger Carboniferous date from the M007 well likely reflects arc magmatism from the subduction of Rheic oceanic crust at northern Gondwana. For a cross-section of wells from inside and outside the crater, including these two most recent wells, see **Figure 6**.

The granite in this peak ring suggests that the Chicxulub asteroid penetrated at least 20km below the pre-impact surface (Kring, 2017; Collins, 2020) (**Figure 7**). The Yucatan basement that the asteroid slammed into is Cretaceous limestone dolomite and anhydrite of three km thickness (Lopez Ramos, 1975; Kring, 2005).

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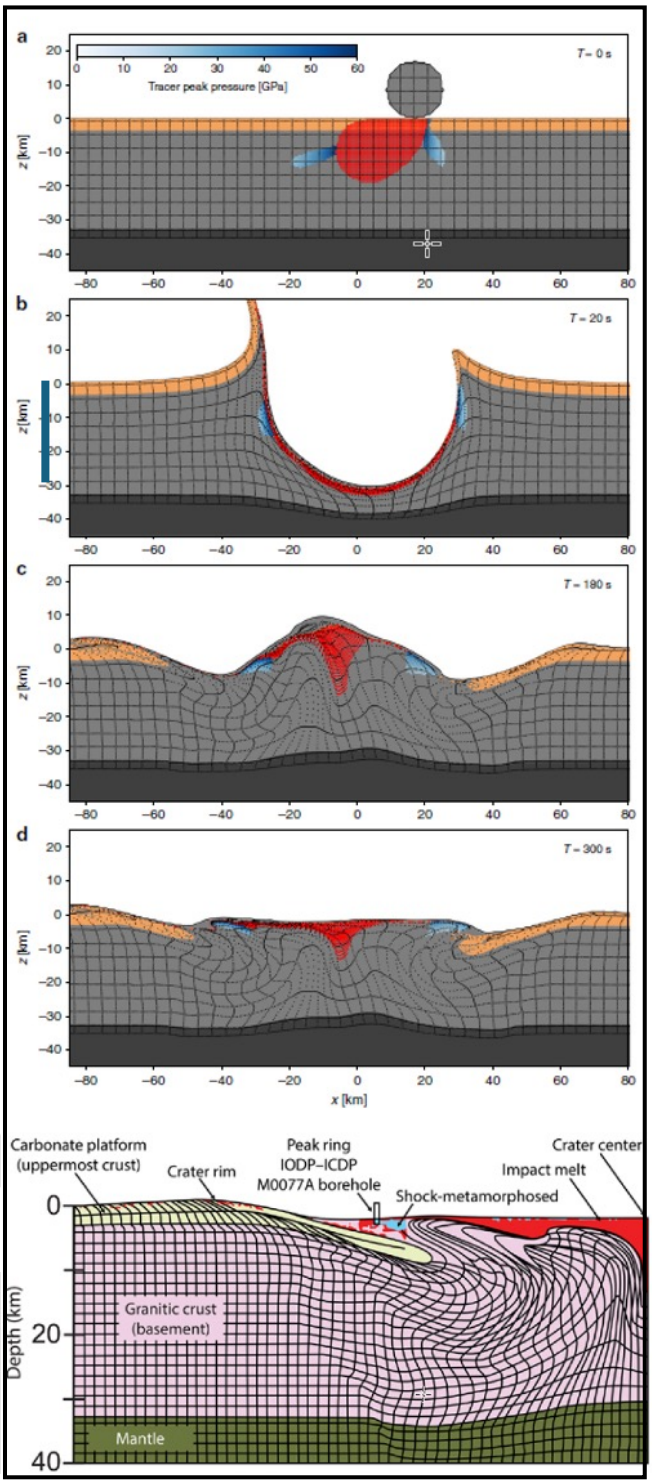

Figure 7 *Modified from Collins, 2020; The development of the Chicxulub crater for a 60 impact. The impact scenario depicted is for a 17-km diameter impactor with a density of 2630 kg m3 and a speed of 12 km/s. Evolution of the crater up to 5 min after impact is depicted. Shown are cross-sections through the numerical simulation along the plane of trajectory, the direction of impact is from right to left. The upper 3 km of the pre-impact target, in sandy brown is the sedimentary rocks. Deformation in the crust (mid-grey) and upper mantle (dark grey) is depicted by a grid of tracer particles (black). The bottom cross section is modified from Kring, 2017 and shows the granite crust (pink) overturned and expressed now as a peak ring close to the M0077 wellbore*

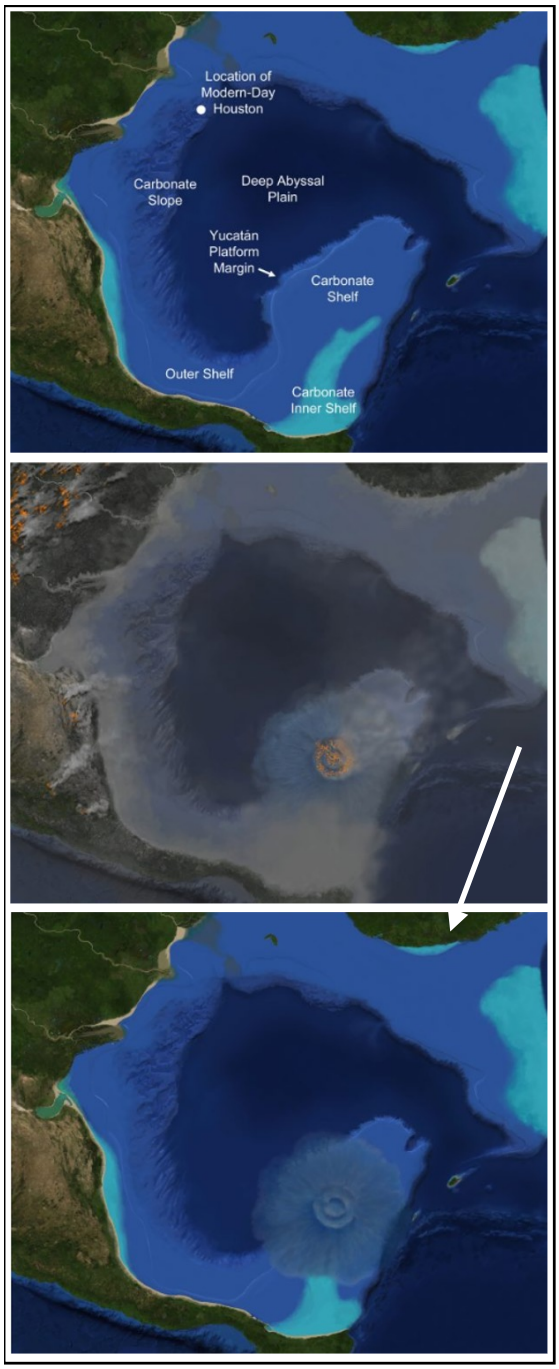

Figure 8 *Taken from Kring 2021; Top panel: Pre-impact paleogeography of the Gulf of Mexico region. Middle panel: The Chicxulub impact crater superimposed on that late Cretaceous paleogeography. The impactor hit the sea, penetrating carbonate shelf sediments, underlying carbonate platform strata that included sulfate-rich anhydrite beds, and crystalline basement rocks. Impact melt fills the crater. The surrounding landmass was affected by an air blast and fire. Coastal seas were turbid with debris. Bottom panel: Post-impact view of the crater. In this view, early Tertiary vegetation covers the land, but the crater has not yet been buried by seafloor sediments. Credit: Pre-impact paleogeographic reconstruction provided by John Snedden, University of Texas-Austin. Other illustration details by the author. Credit: Art by Victor O. Leshyk for the LPI.*

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The trajectory of the asteroid was likely from the northeast. The most likely and accepted angle uses Collins (2020) at 600 but some suggest a lower angle of 300 by Duong (2023). Some Chicxulub researchers have made interesting speculation, asking, "Were dinosaurs minutes away from surviving extinction," even though the same asteroid would have struck Earth? The site of Chicxulub's impact was particularly devastating for life as the asteroid landed in shallow waters of CO_2-rich limestone and anhydrite sediments. When heated and vaporized, a deadly sulfuric-rich acid rain was like a "kill shot" for the dinosaurs (Holley, 2017). Due to the earth's rotation, even a few minutes might have changed the outcome of the impact. Stan Gulick (UT professor) suggests, "A few minutes earlier or later, the asteroid would have hit the deep water and not slammed into a big, volatile platform that was then vaporized as it spread upward and out." A paleogeographic map illustrating the time of the Chicxulub impact is shown in **Figure 8**. Recent work has been done using the presence of Ruthenium isotopes; its presence would identify the Chicxulub asteroid as a carbonaceous type that would have formed beyond the orbit of Jupiter (Fischer-Godde, 2024)

The M0077 core revealed that an impact-induced hydrothermal system extended to a depth at least 700m beneath the surface of the peak ring. The craters' diameter formed a ring of uplifted mountains around its center. After impact, water flowed back into the crater, leaving only the mountain peaks above the water. (**Figure 9**). The violent impact created porous and permeable fracture systems for fluids depositing several hydrothermal minerals. Some of the minerals are Na-dachiardite, heulandite, and analcime zeolites, and dark green secondary clay accompanied by translucent-white calcite (Kring, 2020). Initially, temperatures of 300° to 400°C circulated from depth, sustained by heat from a central melt pool. Steam was vented upward through the peak ring venting from the seafloor and uplifted range, including Manganese (Mn) rich fluid. Mn in the core is heavily concentrated between peak-ring lithologies and sediment crater fill. The system remained active for over 2 million years, cooling gradually. Paleomagnetic data indicated that the system cooled within geomagnetic Chron 29r, suggesting prolonged hydrothermal activity. The system created niches suitable for microbial life, with evidence of sulfate and sulfur reduction processes. Most accept that the mass extinction at the boundary (KT) (between the Cretaceous and Paleogene) occurred ~66 million years ago (Renne, 2013).

The findings at Chicxulub suggest that impact-generated systems early in Earth's history may have provided niches for life. It could have provided an environment rich in materials suitable for thermophilic and hyperthermophilic organisms. Dr. Kring's "Development of a Concept" (Kring DOC) theorizes that craters from meteor impacts created subsurface hydrothermal systems. These systems may have acted as a crucible for pre-biotic chemistry. They provided habitats for the early evolution of life, a new concept that he has called the impact-origin of life hypothesis. It is something else to examine on the Earth's moon and Mars.

THE DESTRUCTION OF THE CRETACEOUS CARBONATE MARGIN

The impact initially ejected and vaporized kilometers of the carbonate and anhydrite sediments of three kilometers. The asteroid then continued deeper into the crust, creating a cavity deep enough to nearly the Moho discontinuity (~27km). As it deformed, the upper mantle briefly left a hole that then rebounded (Christeson, 2009; Kring, website). Shock waves were created with the energy equivalent thought to create a magnitude 12+ earthquake on the Richter scale (Collins et al., 2002). In addition, the impact initiated huge tsunamis and triggered slope failures around the Yucatan and across the Gulf over 600 km to the West Florida Escarpment (Bryant, 1969; Locker, 1983; Twitchell, 1990; Denne, 2013; Paull, 2014; Poag, 2022). The Yucatan's eastern-facing Cretaceous margin collapsed over a 200 km length, destroying the Cretaceous strata (Hubscher, 2023). Chaytor (2016) used high-resolution multibeam data to estimate the dimensions of the "tsunamigenic" landslide source on the Yucatan Shelf edge. Your word of the day – tsunamigenic. Sanford (2016) suggests that the seismic shaking and ground roll from Chicxulub would have produced a >1 m of vertical motion as far east as the West Florida Platform within five minutes of impact. This motion is followed by ~ one hour of tsunami-driven erosion with sediment redistribution (Sanford, 2016). Denne (2013) details the widespread impact of the tsunami throughout the Gulf of Mexico and its surrounding regions. Denne documents (using seismic and well data) the erosion on the paleo seafloor from the impact on the Yucatan edge to northern Florida, with waters continuing across the northern peninsula. This water flow is named the Suwannee Trough and carries Chicxulub sediment across Florida, which was then deposited onto the Blake Plateau seafloor (Denne, 2013).

The most striking feature of the collapse of the shelf margin area is seen on detailed seafloor bathymetry maps (**Figure 10**). Further evidence of the collapse and faulting of Cretaceous margins is found on seismic (**Figure 11**) and from DSDP (Deep Sea Drilling Project) wells (**Figure 10**). Last month at the HGS Sponsorship Dinner, Andrew Madof and Cody Miller showed fantastic recent seismic lines detailing the destruction of the margin. Their talk was titled "The Day the Dinosaurs Died'.

Two DSDP wells (Site 86 and 94) were drilled and cored along the Yucatan escarpment edge (DSDP, 1973; Paull, 2014) (fig 10). Paull (2014) first used high-resolution bathymetry data collected in 2013 along this escarpment's 612 km long northern face, that targeted a water depth range between -400 and the escarpment base at -3700 m. At site 86, there is an abrupt transition between early Paleocene nannofossil brownish to reddish chalk ooze. This nannofossil ooze

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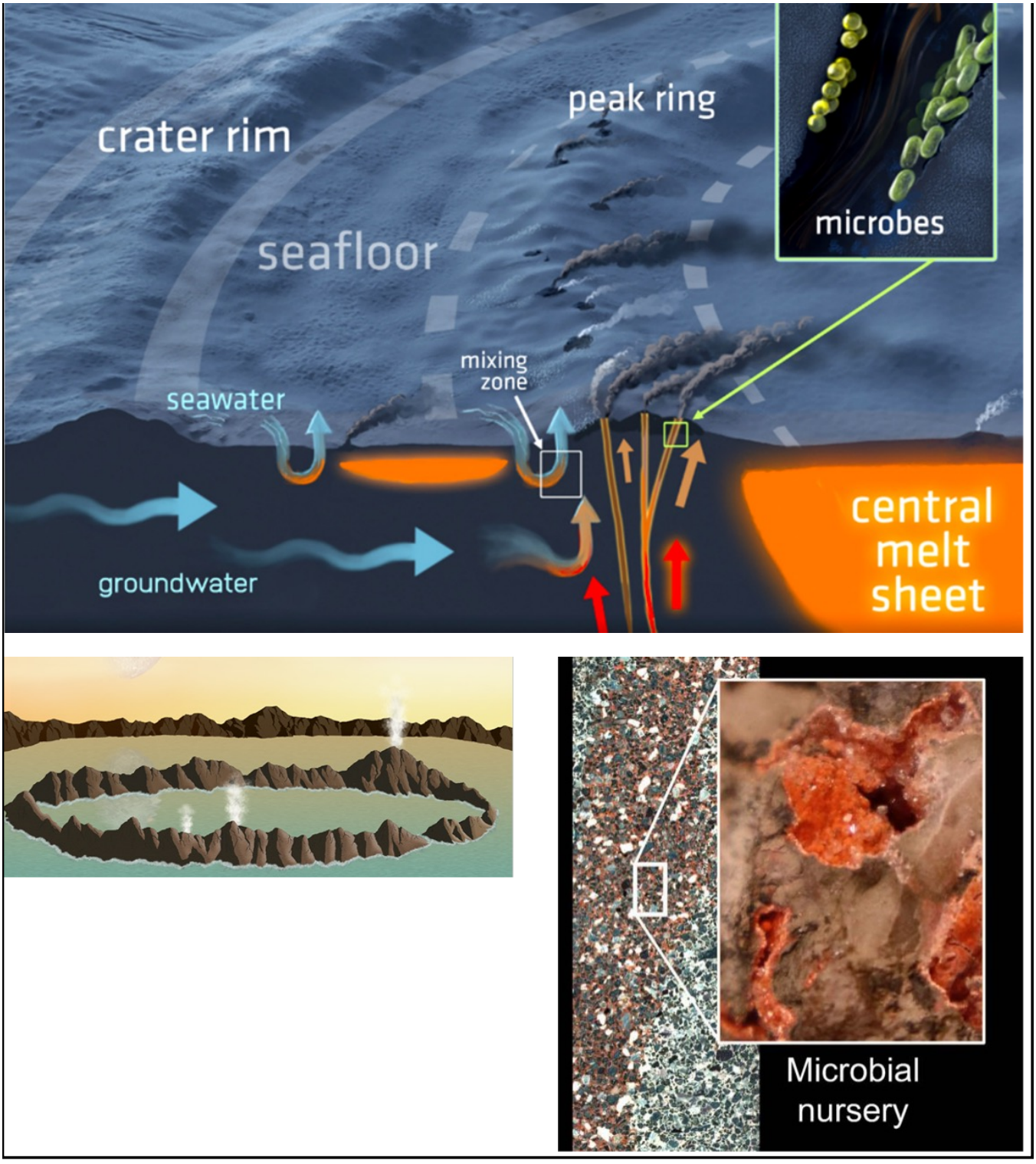

Figure 9 *Upper figure is a three-dimensional cross-section of the hydrothermal system in the Chicxulub impact crater and its seafloor vents. The system has the potential for harboring microbial life. Illustration by Victor O. Leshyk for the Lunar and Planetary Institute. Lower right – A portion of the M0077 core with the hydrothermal minerals dachiardite (bright orange) and analcime (colorless and transparent). The minerals partially fill cavities in the rock that were niches for microbial ecosystems. Image Credit: David A. Kring of the USRA's Lunar and Planetary Institute. Lower left –a conceptual drawing of the peak rings after water returned from tsunamis and settled.*

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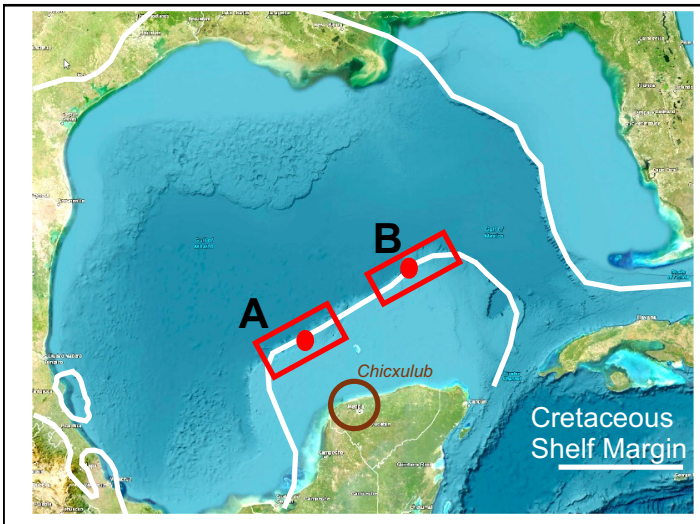
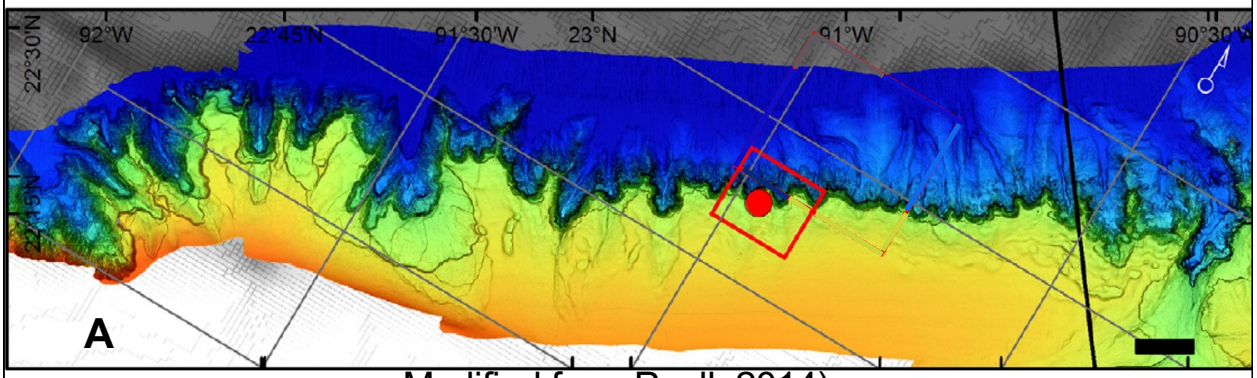
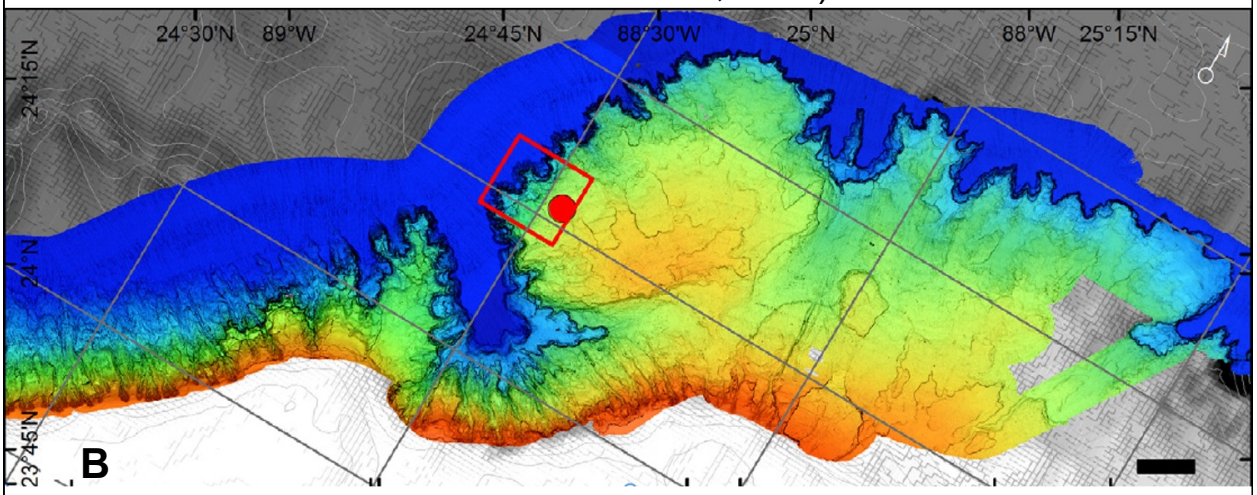


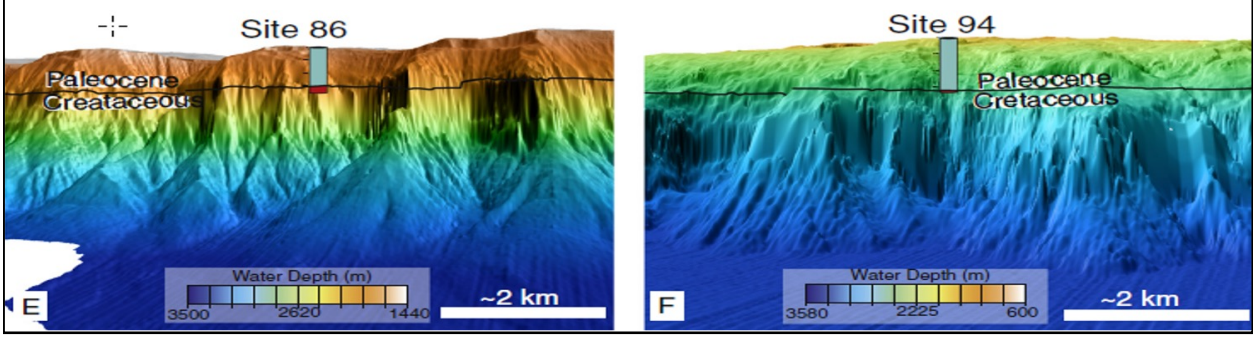
Figure 10 *The upper figure is the index map for areas A and B (middle two maps), showing more detailed Bathymetry and DSDP hole locations. The lower figure is a "profile view" of the rugged escarpment edge with the DSDP well drilled at the cliff edges*

Map from: SRTM15 v2.1 Bathymetry - the Gulf of Mexico region



Modified from Paull, 2014)





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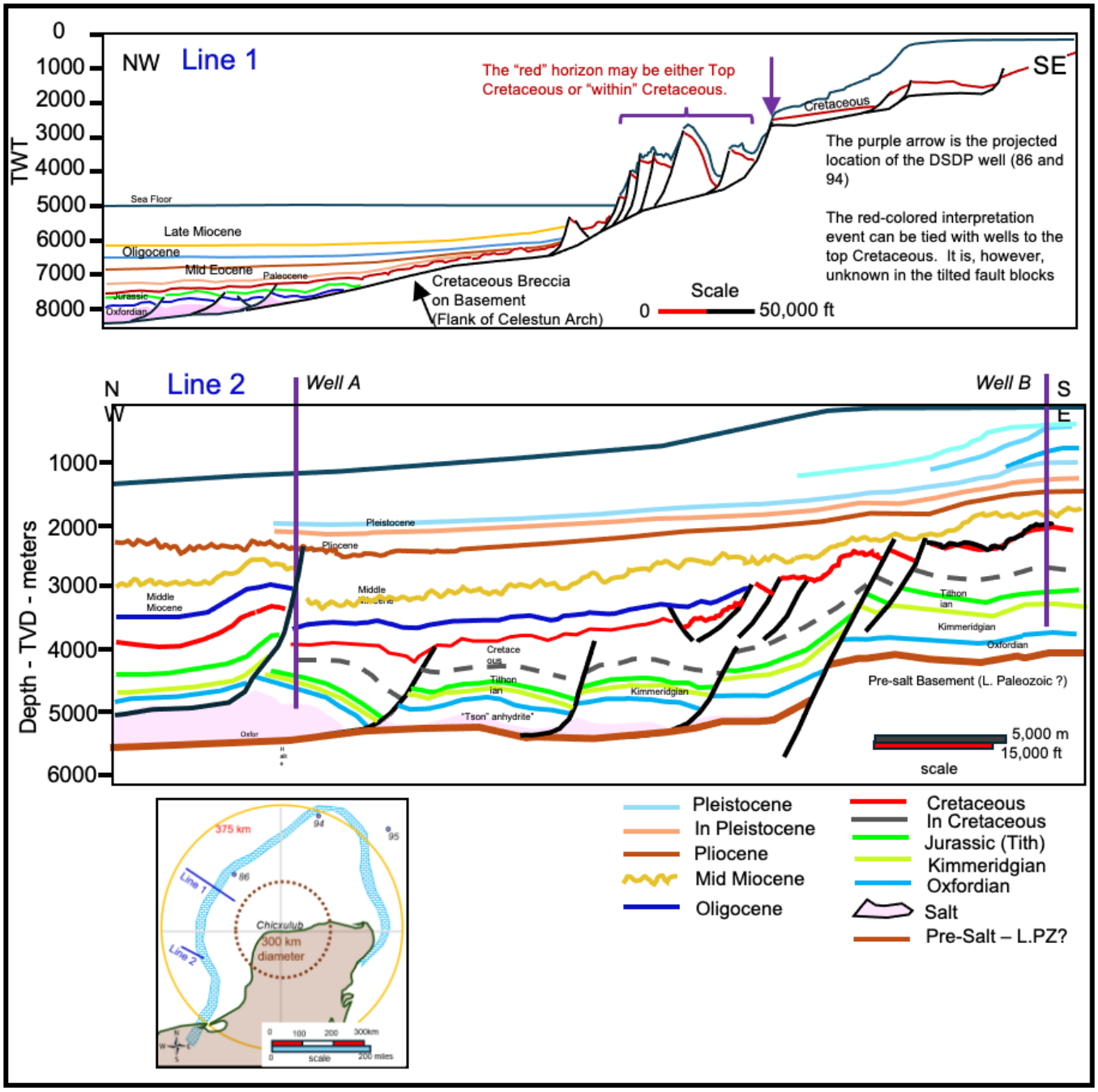

Figure 11 *Two cross-sections are seismic line tracings acquired over the collapsed Cretaceous shelf margin*

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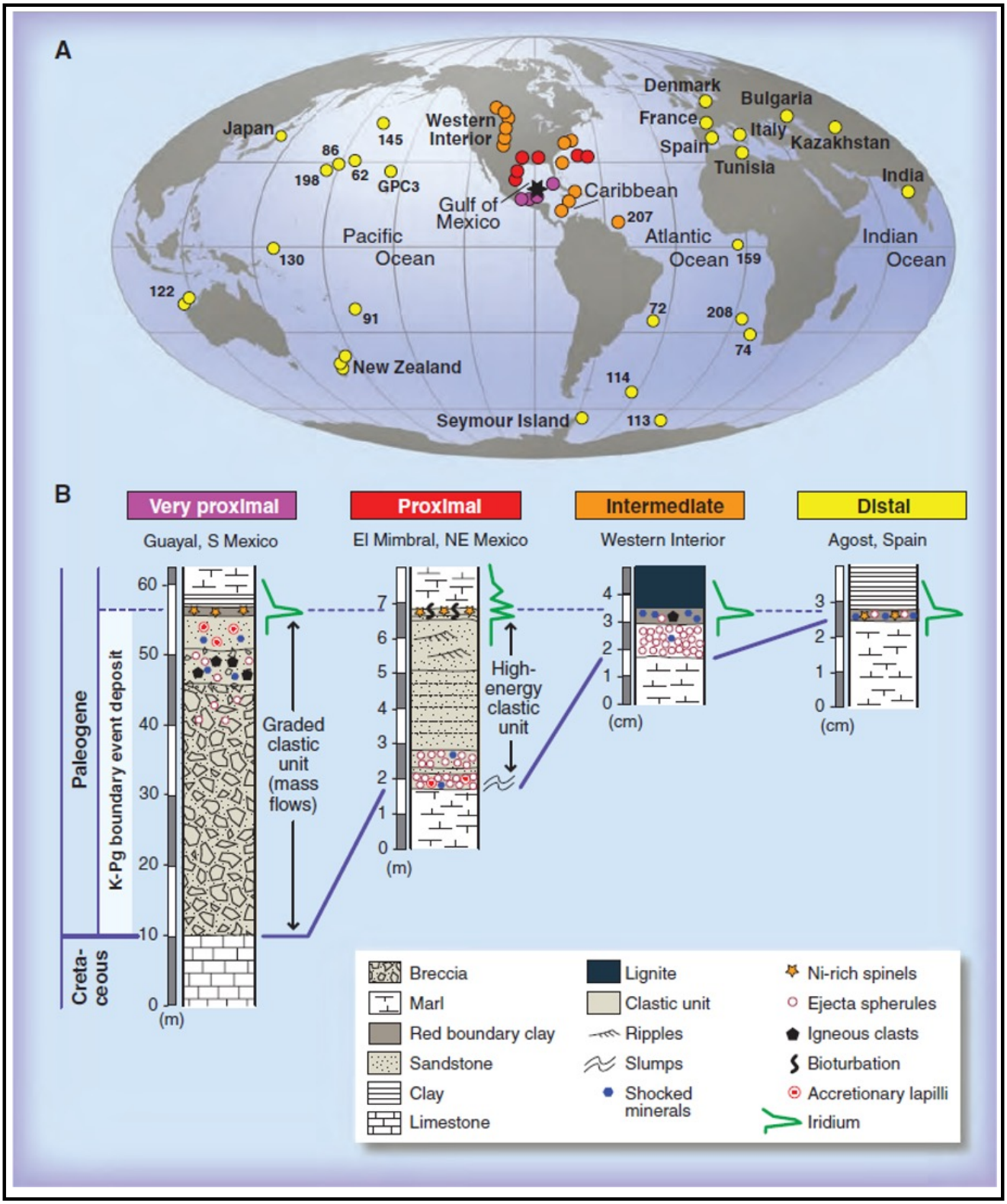

Figure 12 *From Schulte, 2010; Fig. 2. (A) Global distribution of key K-Pg boundary locations. Deep-Sea drill sites are referred to by the corresponding Deep Sea Drilling Project (DSDP) and ODP Leg numbers. The asterisk indicates the location of the Chicxulub impact structure. Colored dots mark the four distinct types of K-Pg boundary event deposit related to distance from the Chicxulub crater (table S1): magenta, very proximal (up to 500 km); red, proximal (up to 1000 km); orange, intermediate distance (1000 to 5000 km); and yellow, distal (>5000 km). Schematic lithologs of the four groups of K-Pg boundary event deposits (B) highlighting high-energy event beds (clastic unit) proximal to the crater and the depositional sequence of different materials that originated in one single impact in proximal to distal sites.*

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is burrowed and has scattered concretions. Below this ooze, Early Cretaceous samples retrieved in the core catcher are described as dolomite with molds of fossil debris with other dolomite pebbles (DSDP, 1973). In site 94, this abrupt change from Paleocene ooze was continuously "cored," encountering early Cretaceous shallow-water carbonates. Carbonates have leached moldic porosity vugs lined with spar infill and dolomite (DSDP, 1973). The shallow marine to supratidal environment of deposition is further supported by more detailed descriptions of dolomitized, algal mat-type stromatolites with desiccation cracks and carbonate sands with shallow-water miliolids. (DSDP, 1973). This KT or KPg unconformity horizon found in both wells is mappable across the Yucatan (Paull, 2014). The cliff edges are the remnant edges now exposed of Cretaceous back shelf to shelf margin areas. Besides the ejected and vaporized sediments releasing a volume of apron debris flows and airborne rock mixtures, other fault blocks were created and collapsed basinward (**Figure 11**)

The current Cretaceous escarpment edge has retreated due to 1) sediment ejection, 2) basinward faulting and slumping, and 3) subsequent erosion. The amount of rock removed via a shoreward retreat of the shelf margin edge is challenging to quantify. Freeman-Lynch (1983) estimated a retreat between 5 and 10km from the shelf margin along the Florida escarpment (see also Paull, 1990). Corso (1989), based on seismic analysis, gives a retreat estimate of 6 km. Poag (2022) proposes a method to estimate "minimum escarpment retreat" (MER). His method is like Corso's (1988) but with some modifications. Poag's measurements indicate an average MER of ~7km with a range of ~3 to 10 km (Poag, 2022). The sedimentary debris was deposited immediately as a continuous apron shoreward of the escarpment, not a transitional unit, but accumulated entirely within days of the early Danian age (Poag, 2022).

RECOGNIZING THE "COCKTAIL" DEPOSITS OF THE IMPACT IN WELLS AND OUTCROPS ACROSS THE GULF

Bralower (1998) originally coined a name for these deposits as the Cretaceous-Tertiary boundary "cocktail." This "cocktail" contains a variable mixture of reworked microfossils (nannofossils and planktic and benthic foraminifers), lithic fragments, and impact-derived materials such as pebbly mudstone and glass spherules (shard and melt rock in a calcite matrix). A primary delivery method that would have occurred first before secondary airfall debris landed is a massive Tsunami, as described by (Sanford, 2016; also Range, 2022). Deposits from the Chicxulub explosion are found across the Gulf of Mexico, North America (Lynch, 2019), Columbia (Mateo, 2020), and likely in the Atlantic at the mouth of the Suwannee water outlet over northern Florida (Denne, 2013; also, Martinez-Ruiz, 2001). Schulte (2010) also illustrates a record of global occurrence of the ejecta-rich deposit consistent and linked to the Chicxulub impact (**Figure 12**). There are examples found in worldwide sediment outcrops at the Kt boundary that contain iridium spiked levels (characteristic of asteroid impacts) (Schulte, 2010; Premovic, 2012; Esmeray-Senlet, 2017; Lowerey, 2018; Snedden, 2019 fig 4.39; Goderis, 2021).

From researchers at Kansas University comes a quite dramatic documentation of a tsunami "kill site" that also had airborne debris effects. This documentation comes from a KT dig site in North Dakota. This site contains a piling or accumulation of animals, fish, terrestrial vertebrates, and broken trees (Lynch, 2019). What is fantastic is that fish found at the site (Acipenseriform; a sturgeon) had already inhaled tiny airborne glass spherules from the Chicxulub site that arrived only hours before the tsunami surge hit, causing massive devastation. It is estimated that a Tsunami wave would take about 17 hours to reach the site from Chicxulub.

THE DISCOVERY OF A WORD CLASS CARBONATE BRECCIA RESERVOIR

Prior to 1975, Mexico had little or no oil available for export. That would soon change, as significant exploration discoveries were made onshore in Tabasco and Chiapas (the Reforma fields) between 1972-75, with first production beginning soon thereafter. These fields suddenly transformed Mexico into a significant oil exporter (Standing, 2006). The Cantarell Field was discovered the next year, 1976 after fisherman Rudesindo Cantarell reported significant oil seeps.

Figure 13 *Ejecta Spherules ~1mm in size from Chicxulub; after Univ of Cal-Berkley. https://phys.org/news/2019-03-million-year-old-deathbed-linked-dinosaur-killing-meteor.html*

Cantarell Field has five major fault blocks with separate accumulations. These names are Akal, Nohoch, Chac, Kutz, and Sihil (**Figure 13**). The Akal block has the most oil, containing 83% of the total reserves (Mexico Business News, 2014). Production started in June 1979, mainly from Akal, reaching a peak of 1.16 MMBPD in April 1981. Forty wells were quickly drilled, and this rate was sustained until early 1996 by drilling even more wells. In 1996, the wells totaled 139 (some using gas lifts) (Limon-Hernandez, 1999). The average production depth at Akal is 2300 meters of heavy crude, between 190 and 220 API (Limon-Hernandez, 2001). A type-log of the KT breccia reservoir is shown in Figure 14 (Murillo-Muneton, 2002). The KT Breccia reservoir stands out because of its high permeability and impressive 300-meter thickness (**Figure 15**) (Murillo-Muneton, 2002). The thickness and permeability are so good across all of the breccia

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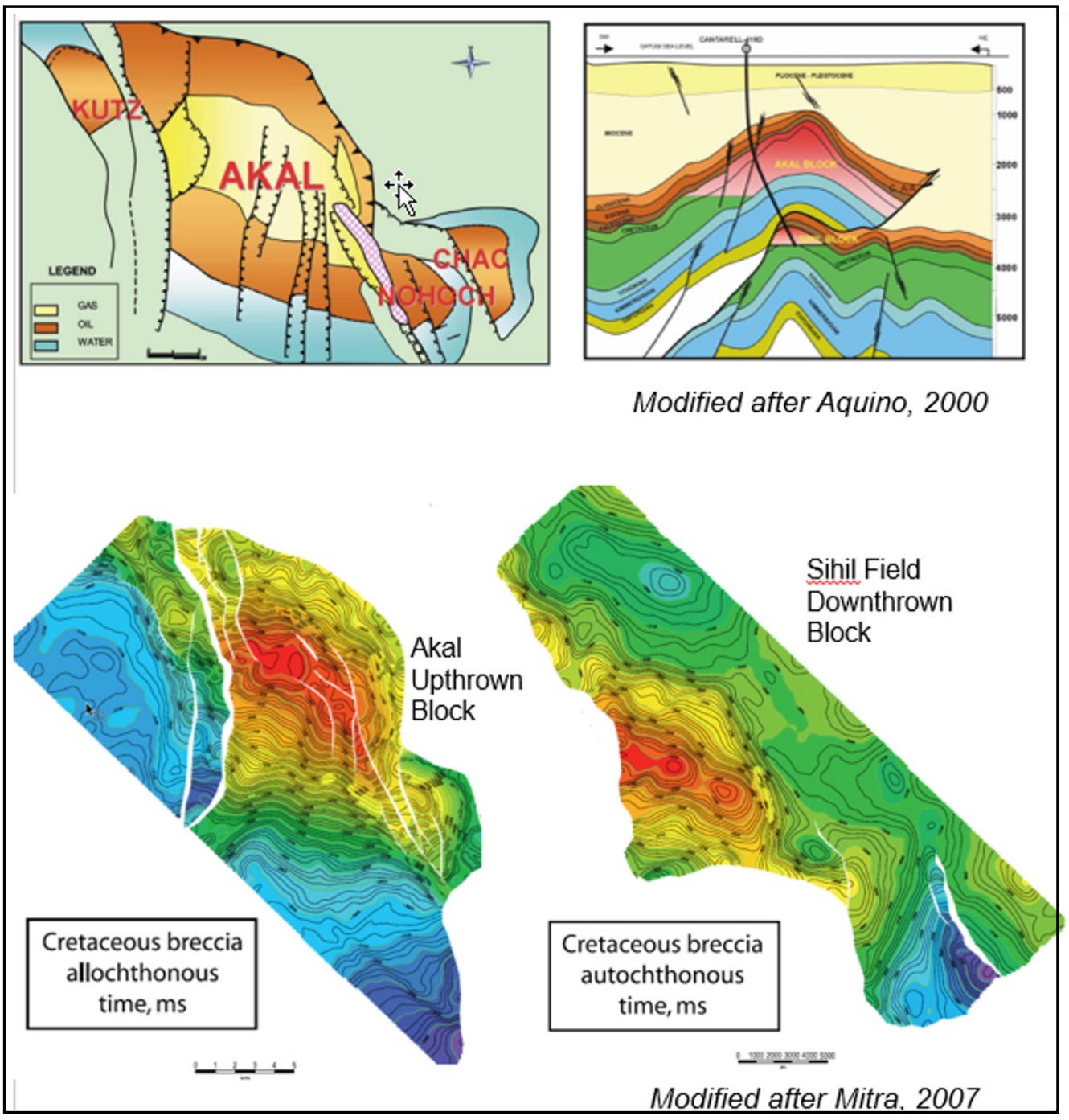

Figure 14 *The upper map and cross-section are taken from Aquino (2000). They show the upthrown faulted blocks of Akal, Nohoch, Chac, and Kutz. In the cross-section, the subthrust block is now the fifth production block (discovered in 1998) of the Cantarell field complex called Sihil field. The lower two structure maps are made on the KT breccia. The left block is the upthrown block, and the lower right is the Sihil structure map*

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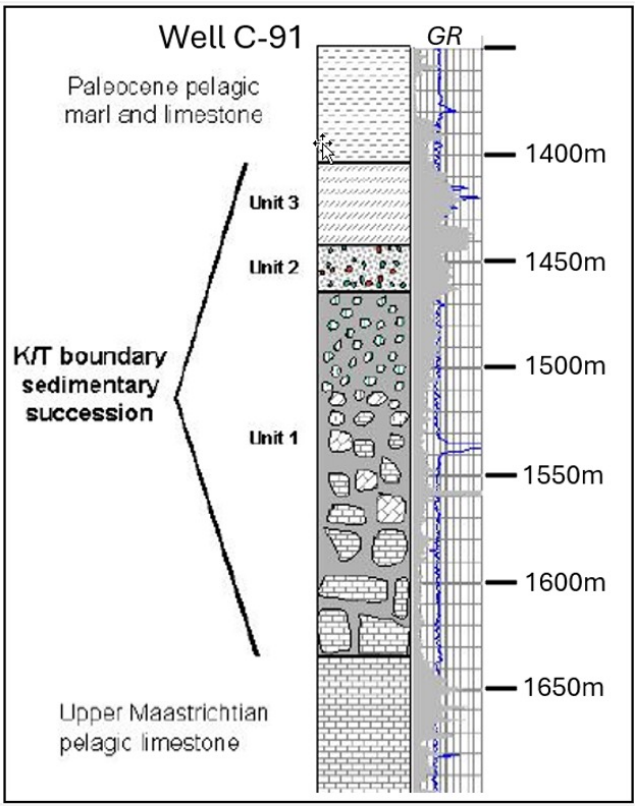

Figure 15 *A type log of the KT breccia; modified from Murillo-Muneton, 2002*

fields (**Figure 16**) that they are all in hydraulic communication (Notes taken from the Madof and Miller HGS dinner presentation "The Day the Dinosaurs Died…").

At Cantarell, there are also other fractured carbonate reservoirs. These are the Kimmeridgian Jurassic oolites, Lower Cretaceous, and Middle Eocene calcarenites (Limon-Hernandez, 1999; Rio-Lopez, 2009). Finding a 2024 cumulative estimate for the field complex was challenging, partly due to the several fields discovered and produced over time and whose volumes get added into "Cantarell Field" (**Figure 16**). Based on an estimate from 2012, the Cantarell complex had a cumulative production of 13 billion barrels (Mexico News Business, 2012). Cantarell is Mexico's second biggest asset next to the KMZ field cluster, also produced from the KT Breccia (**Figure 16**).

Cantarell's KT Breccia reservoir made its first oil in 1981. The origin of these unusual breccias became dogmatic as Pemex was busy drilling success after success in the Cantarell trend. This entrenched model had the breccia moving downslope by slumping and debris flow in carbonate turbidity currents derived from the Yucatan shelf margin (Viniegra-Osorio, 1981; Aquino, 2000). Consider this: Penfield's initial discovery and first publication of the Chicxulub asteroid impact were at the 1981

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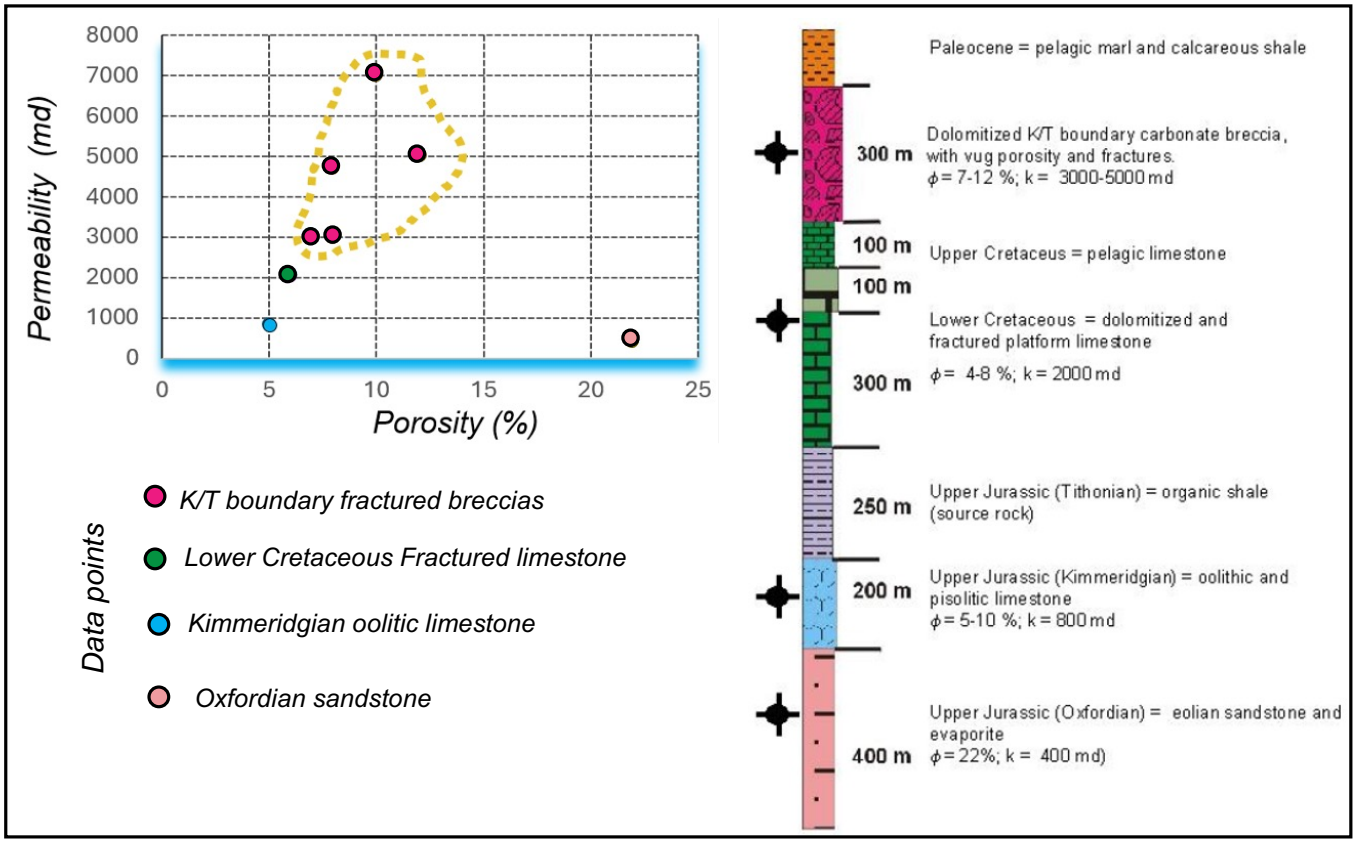

Figure 16 *The column at the right indicates by well symbols the productive reservoirs at Cantarell, along with a brief description and thickness. The left-hand graph shows the outstanding permeability of the KT breccia and compares the porosity and permeability with three other typical reservoir parameters in Cantarell.*

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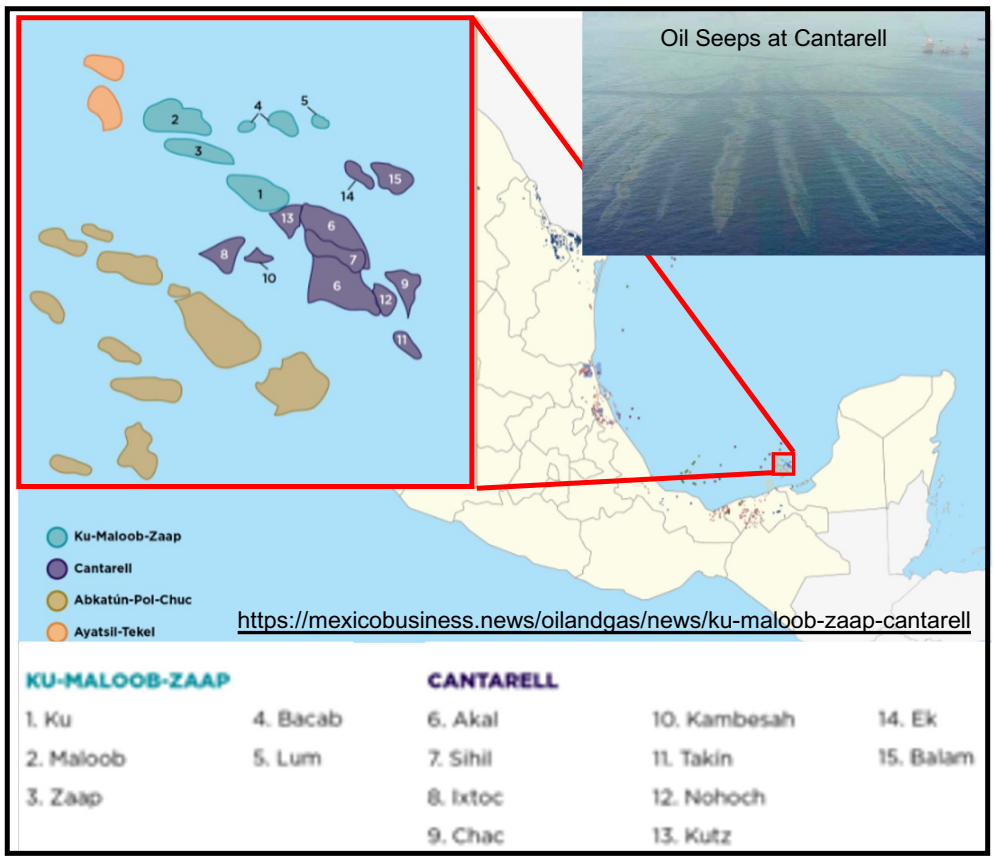

Figure 17 *Index map of the oil fields in the prolific breccia reservoir. Individual fault block accumulations are shown in the Cantrell complex and the Ku-Mallob-Zaap (KMZ) complex. Upper right photo shows the prolific oil seeps above Cantarell that the fishman reported (Saunders, 2016)*

AAPG convention. Even by 1997, an abstract at the CSPG-SEPM convention, in referring to the genesis of the breccia, did not mention the Chicxulub impact but instead "suggested the breccia texture has resulted from the flow of detritus down the Yucatan Carbonate Platform (Gardner, 1997). In 2000, Aquino linked the breccia depositional model to debris flows down a slope margin (see also Angeles et al., 1994; Aquino, 2000). Again, there is no mention of any potential Chicxulub impact as a cause. Having the knowledge and data, it is easy now to retrospectively examine earlier dogmas and interpretations and ask questions. However, if closer descriptions of breccia cores were made even within the first decade of production (1981-1991), they would have revealed key items that were related to an asteroid impact. These observations would have identified typical impact products, including shocked quartz, plagioclase, and altered glass. Collectively, these findings should have prompted inquiries regarding the Chicxulub impact.

Grajales-Nishimura (2000) first suggested the breccia resulted from the Chicxulub impact. In his paper, he described the following three sequences of deposition. These events likely occurred within minutes or hours of impact. In sequence 1, with a carbonate platform collapse due to shaking, deposition of the lower breccia occurred. In Sequence 2, it was deposited from ballistic impact ejecta, including layers with impact minerals. Sequence 3 is a reworking of the ejecta layer, mixed with coarser material by impact-generated tsunamis, reflecting back-and-forth movement across the Gulf of Mexico. Lastly, Ricoy-Paramo (2005) provides a comprehensive study of the Cantarell field illustrated with seismic lines, maps, and core photos for further investigations.

A map of the ariel extent of the KT Breccia is seen in **Figure 17**. The colored polygons are all existing oil fields. The yellow polygons have the KT Breccia reservoir based on publicly available data. The blue polygons are fields that do not have the KT Breccia but have deeper water limestones (wackestone-mudstones). The gray polygons have no public data to indicate if the KT Breccia is present. Notice also the arc-shaped orange line, which roughly defines the depositional limit of the KT Breccia, at least in terms of larger class sizes, as defined in mudlog descriptions. Zooming out to view a larger area that included the impact site, this orange (now) circle defines the extent of the coarse-grained breccia (**Figure 18**).

THE CANTARELL FIELD COMPLEX WITH EXAMPLES OF THE BRECCIA RESERVOIR AND ITS DISTRIBUTION

Structurally, the oil fields in the greater area of the world-class K-T Breccia reservoir are salt-cored anticlines cut by thrust faults. This article does not have space to detail the structural episode that led to the present structures. My favorites are a regional structural overview (Pindell, 2011) and a localized Cantarell view (Mitra, 2011). Briefly framed, the recent compressional direction is from southwest to northeast. Pindell (2011) referred to the thin-skinned thrusting in the Campeche as an orocline. As compression continued its thrusting northeastward, movements of the thrust front rotated to the northwest due to impingement against the Yucatan basin block embayment. It is unusual for the depositional dip direction of the Mesozoic to be at right angles to the compressional direction. Structurally, the most important consequence of these opposing directions of sediments and structure is the salt thickness, which is where the thin-skinned

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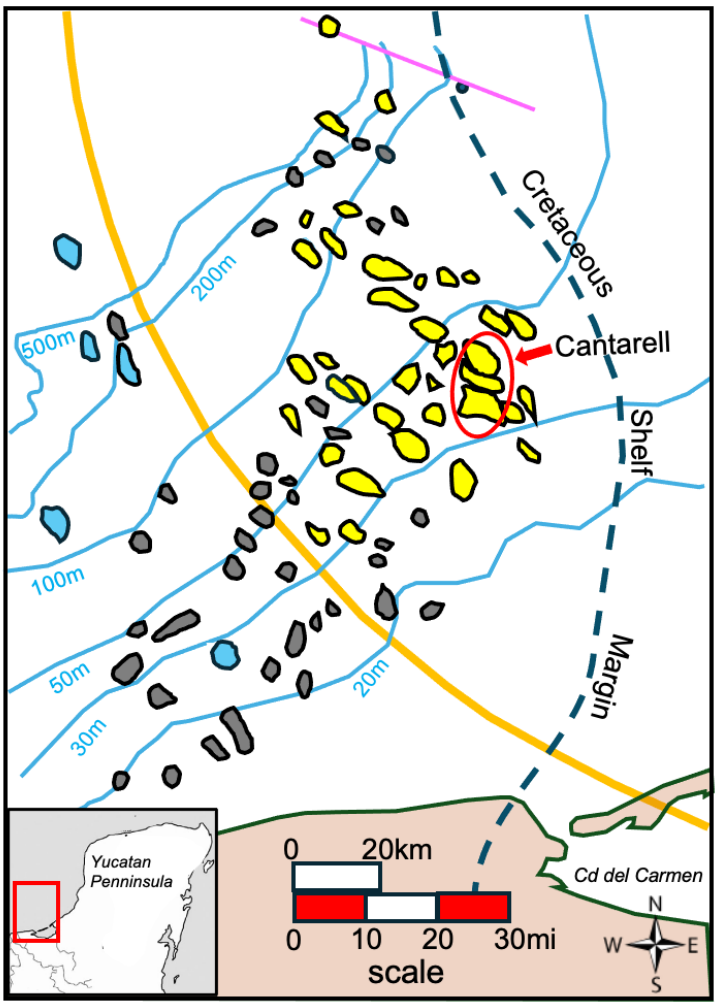

Yellow Polygons — *KT Breccia coarse grained*
Gray Polygons — *No data on KT Breccia presence*
Blue Polygons — *Well data with no KT coarse grained Breccia present*

Figure 18 *A map of the fields in the Campeche Basin. Notice the position of the Cretaceous Shelf edge in a dashed line. Also, the orange arc is the limit around the Chicxulub crater where coarse-grained breccias are present. Fields colored in yellow have publically released data to confirm the presence of breccia. The blue-filled polygons have data but do not describe coarse-grained breccias. Figure is modified and constrained after, Viniegra, 1981; Guzman, 1981; Peterson, 1983; Perrodon, 1983; Magoon, 2001; Ricoy-Parmo, 2005; Murillo-Muneton, 2002)*

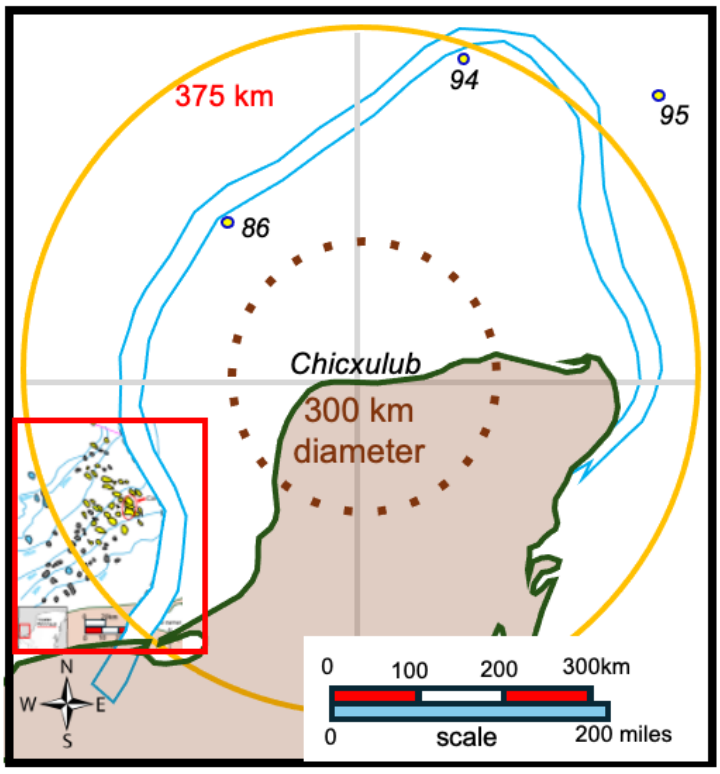

Figure 19 *A wider view area of the impact site of Chicxulub with the 375km radius as it circles around the impact. Within the orange circle it is expected where coarse-grained breccia will be (and have been) found; Modified after, Viniegra, 1981; Guzman, 1981; Peterson, 1983; Perrodon, 1983; Magoon, 2001; Ricoy-Parmo, 2005; Murillo-Muneton, 2002)*

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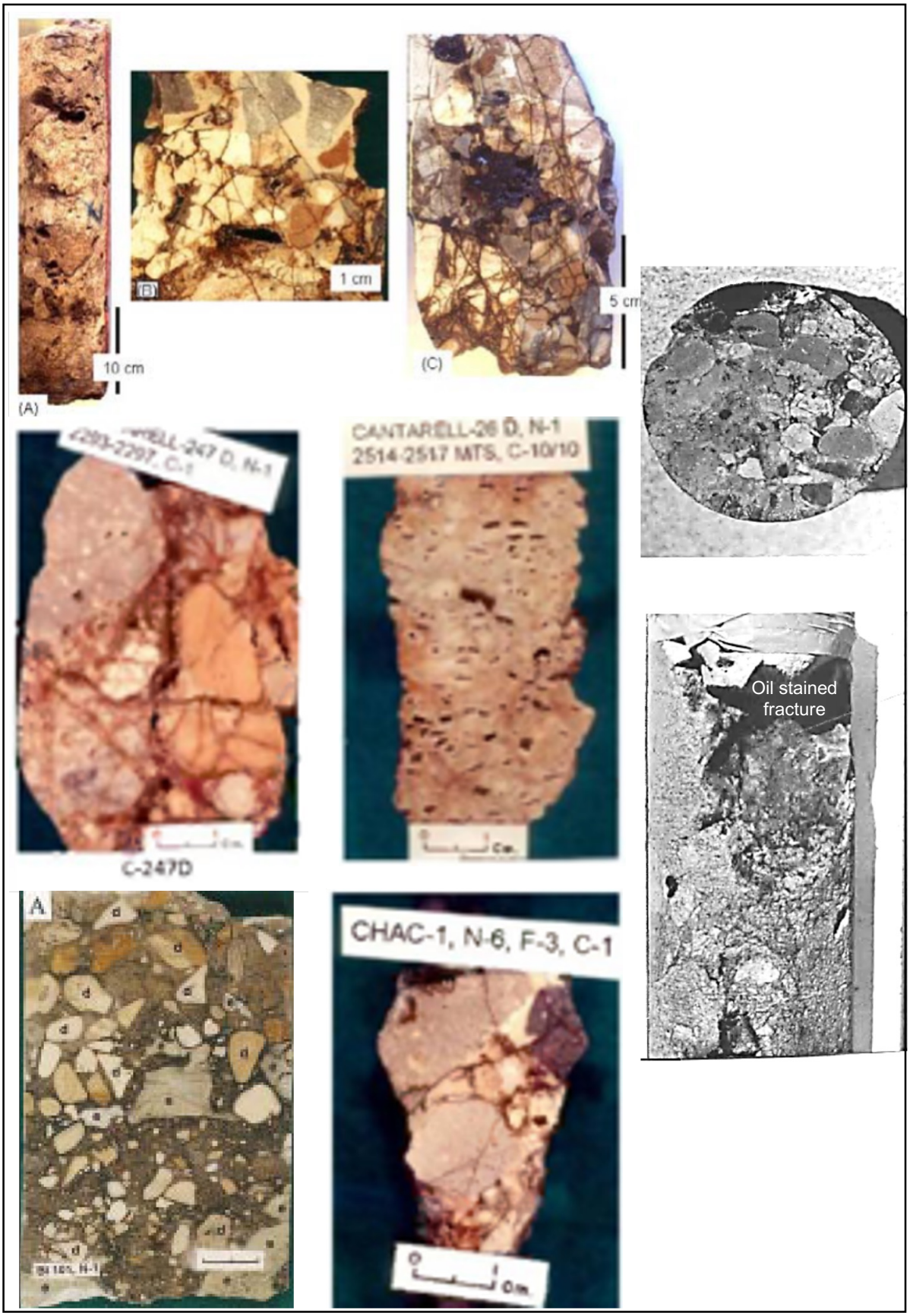

Figure 20 *Representative KT Breccia cores Murillo-Meneton, 2002; Ricoy Paramo, 205; PEMEX reports*

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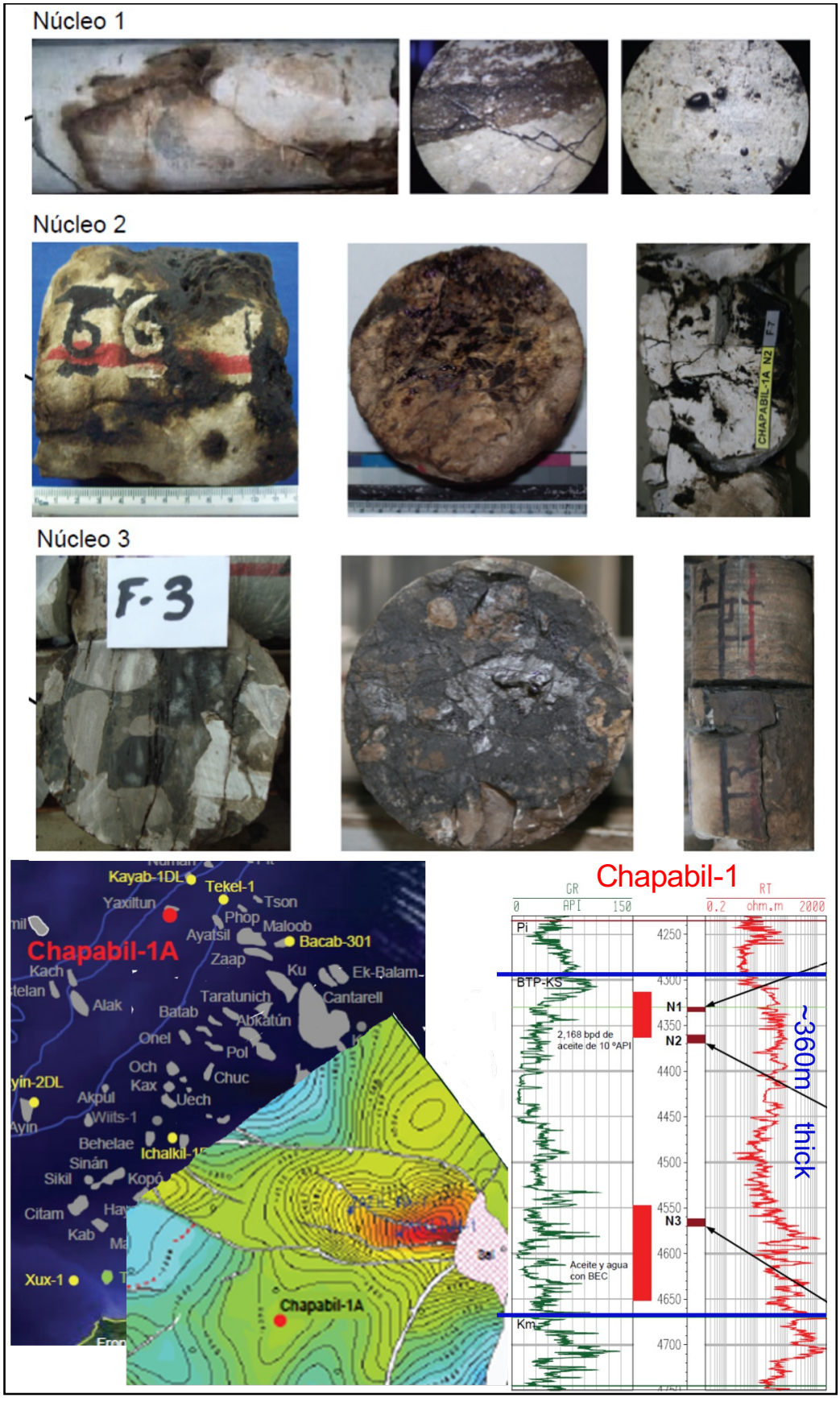

Figure 21 *KT Breccia cores from Chapabil 1-A, see structure map and log with three core intervals highlighted by the black arrows*

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fault detachment rides. As the salt thickens westward, initial compression creates salt pillows and domes, which then get cut by the faults, incorporating more salt. Closer to the updip limit of salt deposition, this thinner salt acts more as a lubricant, causing thrust faults to take on a more "ramp and platform" style. This ramp and platform faulting is unique to the Cantarell structure, where the hanging wall block (called Akal) was the location of the initial discovery (**Figure 13**). It was not until better 3D seismic data revealed a hidden footwall block with the KT Breccia objective beneath the Akal hanging wall (Aquino, 2000). The footwall block was a discovery and is called Sihil. Lastly, core photos of the KT breccia are shown in **Figures 19** and **20**.

SUMMARY

This article aims to continue the monthly theme the editor has emphasized: how we think. Do we listen to others' interpretations, such as the original observation/idea that an anomalous feature did not look like a volcano but rather an impact structure? Do we occasionally call the idea names like "Glen's sky rock"? Do we sometimes become dogmatic in our models, as in the case of discovering a world-class, 300-meter-thick breccia that our model of a talus debris flow could only be the right model? Did we not look at the core in detail for possible impact-related debris?

This article was also written to inform readers interested in a wide range of subject matter who might find it interesting or informative about the applications of geophysics, geology, geochemistry, biology, and astrology. The story of how the world-class breccia reservoir was deposited in an area rich in source rock and with a high density of structures for prospecting is fascinating. ■

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A Proposal to Reinstate the Wolfcamp Formation as a Formal Lithostratigraphic Unit, Delaware Basin, New Mexico and Texas

By Wayne K. Camp

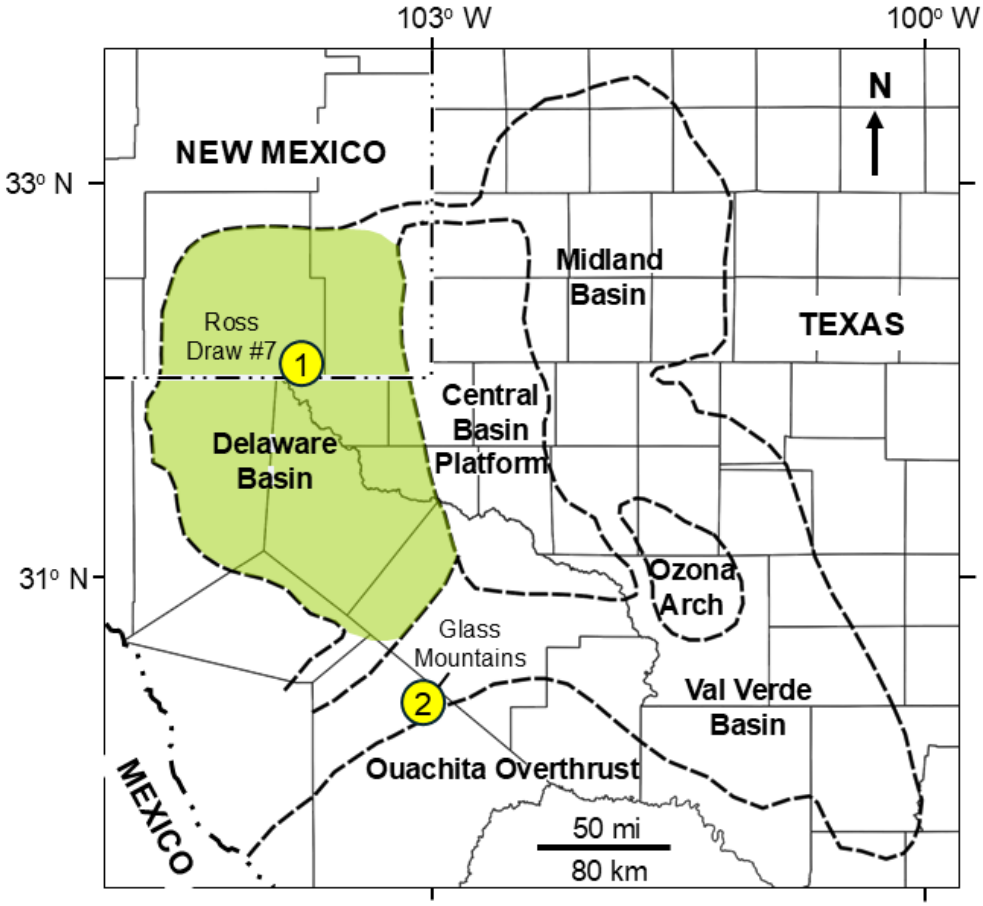

Figure 1. *Map of Permian Basin area showing location of Delaware Basin and other tectonic features. Numbered circles (yellow) show locations of Ross Draw #7 proposed reference section and Glass Mountains stratigraphic section shown in Figure 4.*

The Wolfcamp shale in the Permian Basin of west Texas and New Mexico is a major tight oil resource, but did you know that this shale does not have a formal lithostratigraphic name? The Wolfcamp Formation was originally described by Udden (1917) for outcrop exposures in the Glass Mountains of West Texas in an area known as the Wolf Camp Hills (**Figure 1**). Ross (1959) subdivided and renamed the Wolfcamp Formation the Neal Ranch and Lenox Hills formations, thereby making the name "Wolfcamp Formation" obsolete, and it is no longer recognized as a formal lithostratigraphic unit (Geolex, 2025). However, the Wolfcamp Series/Epoch, defined from the same outcrop area, has remained used as a formal North American biostratigraphic interval.

The lack of a formal lithostratigraphic name for the "Wolfcamp shale" has created somewhat of a quandary for geologists preparing formal reports that require stratigraphic names to conform to the North American Stratigraphic Code published by the North American Commission on Stratigraphic Nomenclature (NACSN, 2021). This has led to the use of a variety of informal names in the published literature, but more importantly is the lack of a formal definition for the Wolfcamp shale in the Delaware and Midland basins that is needed for improved communication and map consistency.

To this end, it is proposed to reinstate the Wolfcamp Formation, retaining its historical name, as a formal lithostratigraphic unit for the subsurface Delaware Basin of New Mexico and Texas. The proposed Wolfcamp Formation is defined as the predominate mudstone interval between the base of the lowermost sandstone of the Bone Spring Formation and the top of the Strawn Formation/Group limestone. It is also recommended to adopt the more contemporary and internationally accepted Cisuralian Series over the provincial North American Wolfcamp Series to avoid name duplication between bisostratigraphic and lithostratigraphic units, such as the current protocol of the U. S. Geological Survey (Orndorff et al., 2023), and published by the International Commission on Stratigraphy (Cohen et al., 2013), and the Society of America (Walker and Geissman, 2022).

DEFINITION

A formation is the fundamental lithostratigraphic unit defined as a mappable unit that is lithologically distinct from overlying and underlying units in layered stratigraphic successions. Formations may be subdivided into formally named members or informal zones to map layers of a heterogeneous formation. Formations are time transgressive, and thus, their boundaries are not defined by a particular geologic age.

A Proposal to Reinstate the Wolfcamp Formation *continued on page 35*

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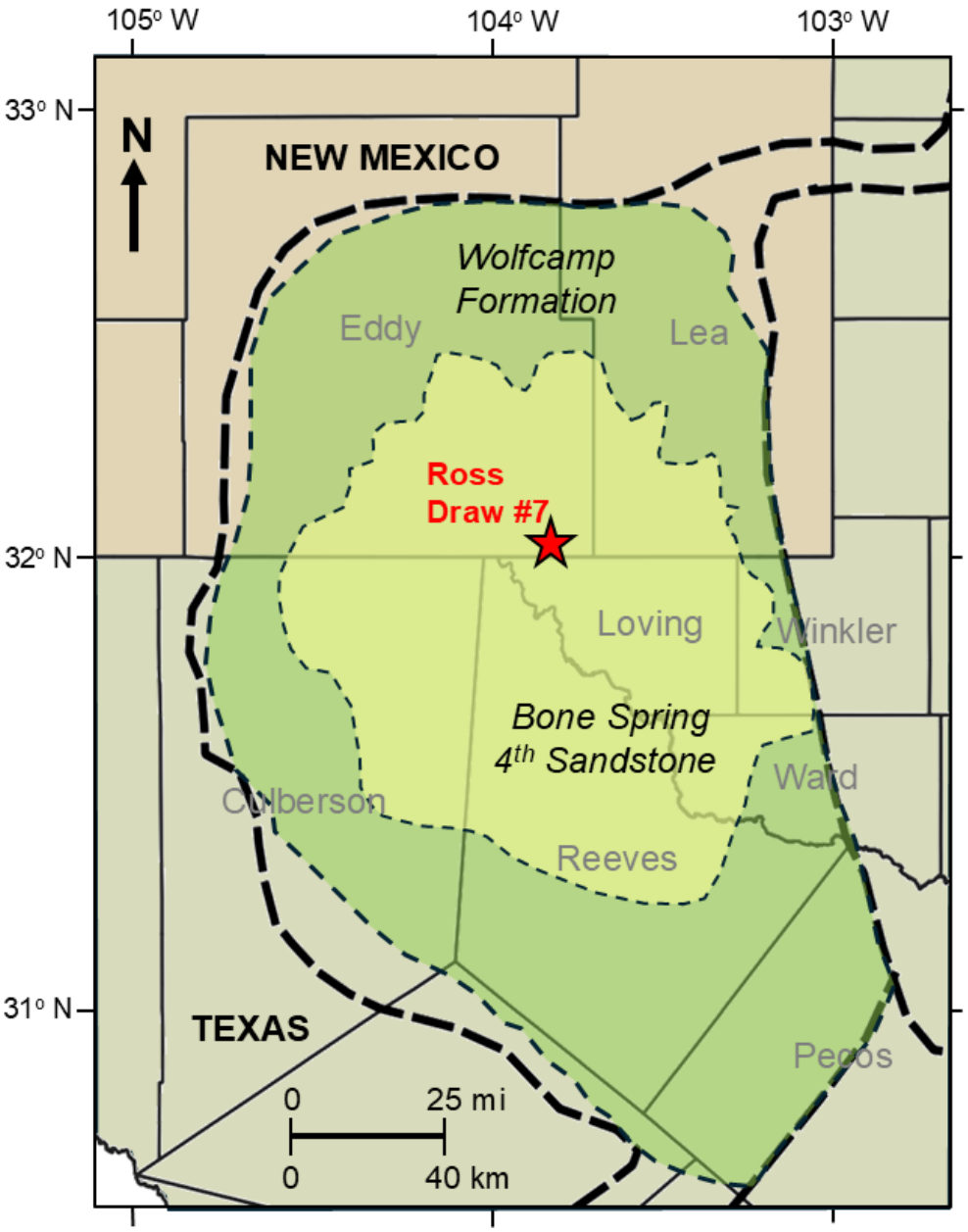

Figure 2 *Map of Delaware basin showing mapped extent of proposed Wolfcamp Formation in green after Gaswirth (2920), and Bone Spring 4th sandstone (yellow) modified from Minisini and Desjardins (2024).*

ft (1089 m) to the total depth of well at 14,428 ft (4397 m). Copies of the well logs are available from the Oil Conservation Division of the New Mexico Energy Minerals and Natural Resources Department (EMNRD, 2025).

The Ross Draw #7 well is proposed as the principle reference section because it is centrally located within the Delaware Basin and because the U.S. Geological Survey previously used it (Gaswirth, 2020) to illustrate the boundaries of the informal Wolfcamp shale interval, which was used in preparing structure and isopach maps based on a proprietary IHS Market (2023) database.

The proposed Wolfcamp Formation is 2900 ft (884 m) thick in the Ross Draw #7 well. The top of the proposed Wolfcamp Formation placed at the base of the lowermost sandstone of the Bone Spring Formation at a measured drill depth of 10,850 ft (3,307 m) and the base is placed at the top of the prominent limestone bed of the Strawn Formation at 13,750 ft (4,191 m) on the borehole gamma-ray/resistivity logs of the Ross Draw #7 well (**Figure 3**). Note the proposed formal formation boundaries are revised from the informal map intervals illustrated by Gaswirth (2020, Figure 4, p. 7).

STRATOTYPE

The North American Stratigraphic Code (NACSN, 2021) requires specifying a stratotype (type section/location) to define a proposed formal geological unit that is accessible for study by others. The proposed principle reference section for the subsurface Wolfcamp Formation in the Delaware Basin is the RKI Exploration (Florida Gas Exploration) Ross Draw #7 well (API #30015228100000) that was drilled in 1979, located 1980 ft from the south line and 1980 ft from the east line of Section 26-Township 26S-Range 30E, Latitude 32.011494, Longitude -103.849762, Eddy County, New Mexico (**Figure 2**). Continuous open hole gamma-ray and resistivity logs were run from the base of the surface casing at 3572

The proposed formal formation contacts are mappable over a wide area of the Delaware Basin, as recognized from borehole logs (**Figure 2**). Defining formation contacts using drill cuttings alone may be less definitive because of caving from overlying rocks. Therefore, the formation boundaries should be defined by correlative stratigraphic position, with the top defined as the highest occurrence of dark mudstone and the base as the highest occurrence of limestone in the absence of borehole logs.

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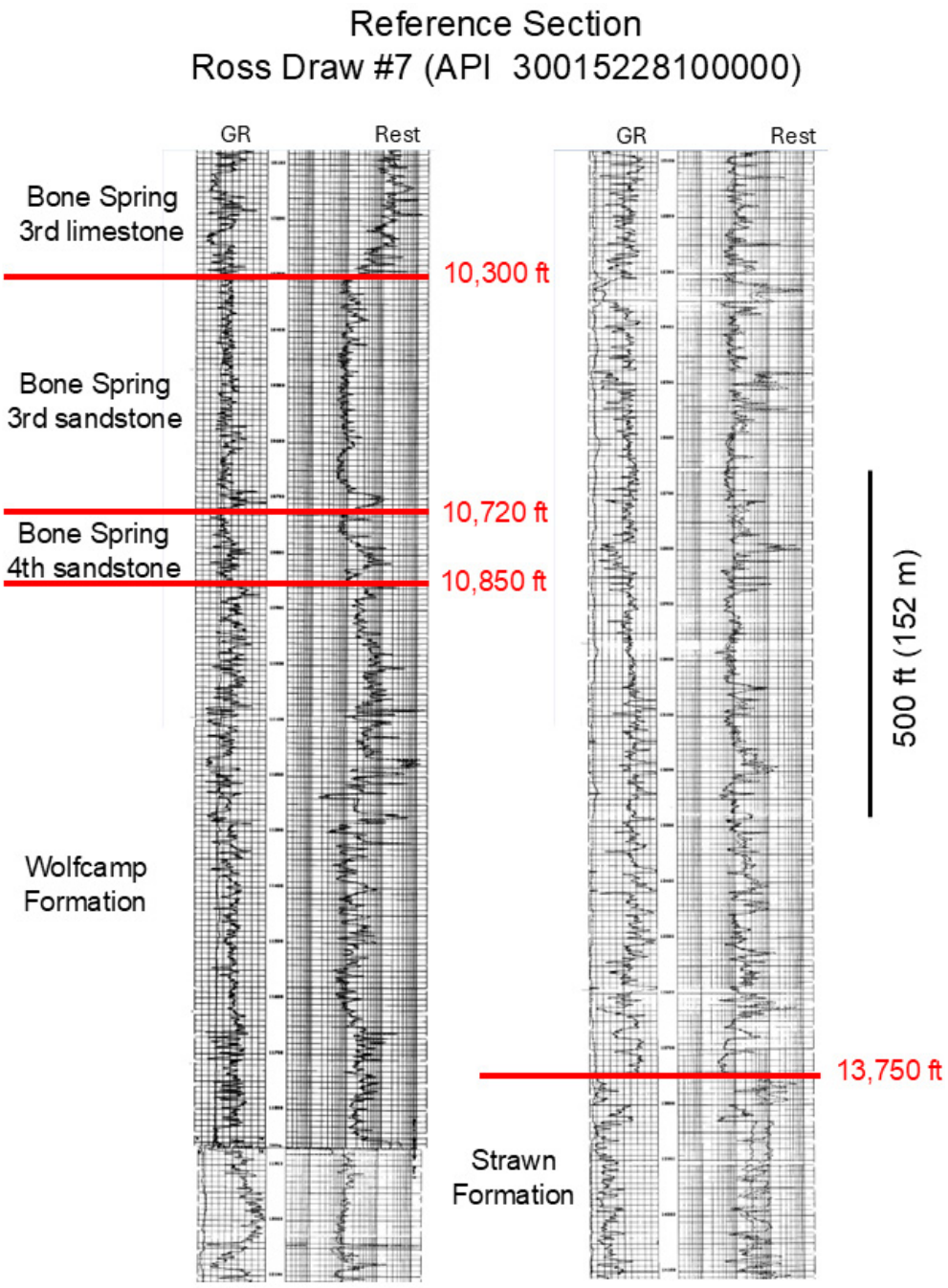

Figure 3 *Gamma-ray and resistivity borehole logs of the Ross Draw #7 well showing depths of the top (10,850 ft) and base (13,750 ft) of the proposed Wolfcamp Formation.*

GEOLOGIC AGE

The Glass Mountain region, where the Wolfcamp Formation of Udden (1917) was originally described and named, also became the standard chronostratigraphic unit for the lower Permian Wolfcampian and overlying Leonardian series (Figure 4). The base of the Wolfcampian Series is marked by an unconformity and defined by the first occurrence of the benthic foraminifera Pseudoschwagerina (Adams, 1939). The geologic age of the Wolfcampian Series ranges from Asselian to Artinskian (Geolex, 2025).

The age of the proposed Wolfcamp Formation is not well constrained in the basinal sediments deposited in the Delaware Basin. The age of the Strawn Formation/Group (base of the proposed Wolfcamp Formation) is considered Middle Pennsylvanian (Geolex, 2025). In the northern Midland Basin, the base of the Wolfcamp shale has been dated as Late Pennsylvanian (Barrick and Wahlman, 2019). Recent absolute Zr-age dates (287.8 + 0.3 Ma and 285.12 + 0.12 Ma) obtained from two bentonite beds (altered volcanic ash) near the top of the proposed Wolfcamp Formation in the Delaware Basin (Pickering et al., 2023; Minisini and Desjardins, 2024) correlate to the Artinskian Age and are consistent with Artinskian age dates of 288.2 + 1.7 Ma and 287.2 + 0.5 Ma reported by Tian et al. (2022) from age correlative volcanic tuff beds from the upper Wolfcamp shale in the Midland Basin.

USE OF INFORMAL ZONES

It is common practice for geologists to define informal zones to facilitate subsurface mapping based on well-log characters tied to core descriptions and analysis. Borehole well logs generally provide the ability to define finer-scale informal intervals than formal members defined in outcrop sections. Petroleum companies working in the Midland Basin were first to subdivide the Wolfcamp shale into several informal zones named alphabetically in which they were drilled (A through D). This nomenclature has also been applied to the Wolfcamp shale by several petroleum companies working in the Delaware Basin. While this approach may be useful, the defined zones lack consistency between operators, and the interval boundaries are subject to change as new information is obtained from drilling or seismic data. Furthermore, the zones appear to lack lithologic continuity to facilitate confident mapping over regional scales to

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System	Series		Stage	Age (Ma)	Glass Mtns Formation	Delaware Basin Formation	Delaware Basin Zone
Permian	Cisuralian	Leonardian	Kungurian	283.5	Skinner Ranch	Bone Spring	3rd Sandstone
							4th Sandstone
		Wolfcampian	Artinskin	290.1	Lenox Hills	Wolfcamp	A[1]
			Sakmarian	293.5			B
			Asselian	289.9	Neak Ranch		C
Pennsylvanian	Upper		Gzhelian	303.7	Gaptank		D[2]
			Kasimovian	307.0	Haymond		
	Middle		Moscovian	315.2		Strawn	

[1] age from Minisini and Desjardins, 2024 (Delaware Basin)

[2] age from Barrick and Wahlman, 2019 (Midland Basin)

Figure 4 *Stratigraphic chart showing correlation between Glass Mountains and Delaware Basin as proposed by this study.*

be recommended as formal members of the proposed Wolfcamp Formation, especially not over the large distance between the Midland and Delaware basins (e.g., Popova, 2020).

Some petroleum companies locally use the name "Wolfcamp X-Y sand" for a sandstone interval that overlies the Wolfcamp A zone. This creates a nomenclature problem because it does not follow the sequential alphabetical order of the underlying Wolfcamp A through D zones. It would be more logical to place a zone using the letters X and Y at the base of an interval rather than at the top. Because of lithologic similarity with the overlying Bone Spring sandstones, the X-Y sands arguably should be part of the Bone Spring Formation rather than the Wolfcamp shale. The "X-Y sand" interval is present regionally. It is correlative with a sandstone interval that is used to define the base of the Bone Spring Formation at the Ross Draw #7 proposed stratotype and is informally referred to as the 4th Bone Spring sandstone, following the established numerical nomenclature (1st through 3rd sandstone) used for informal subdivision of the Bone Spring Formation in the Delaware Basin.

Minisini and Desjardins (2024) interpret the base of the 4th Bone Spring sandstone as a regional sequence boundary that marks a significant transition from mudstones of the underlying Wolfcamp shale to sandstone of the Bone Spring Formation. Pickering et al. (2023) identified a thin bentonite (altered volcanic ash) bed that they referred to as the "alpha ash" near the base of the Bone Spring 4th sandstone that they correlate to a gamma-ray log marker used to define the top of the Wolfcamp shale. The 4th Bone Spring sandstone is interpreted as a distal turbidite sandstone deposit that pinches out along a structural high in the southern portion of the basin (Pickering et al., 2023, Figure 10, p. 12).

SUMMARY

The Wolfcamp Formation became obsolete when the type outcrop section was renamed the Lenox Hills and Neal Ranch formations by Ross (1959), and therefore the Wolfcamp is no longer recognized as a formal lithostratigraphic unit (Geolex, 2025). To improve communication and map consistency, it is proposed to reinstate the Wolfcamp Formation as a formal lithostratigraphic unit for the predominately mudstone interval between the base of the Bone Spring Formation and the top of the Strawn Formation/Group in the Delaware Basin, New Mexico and Texas. The Ross Draw #7 well, drilled in southern Eddy County, New Mexico, is centrally located in the Delaware Basin and is proposed as the principal reference section for the proposed Wolfcamp Formation. Nomenclature currently used by petroleum companies to subdivide and map the Wolfcamp shale in the subsurface are considered informal zones and are not recommended to be raised to formal member status because of inconsistent use and limited areal map extent. A more complete proposal and documentation consistent with the recommendations of the North American

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Figure 5 *Microsoft Bing AI image generator showing hypothetical Bone Spring and Wolfcamp formation outcrops, Delaware Basin.*

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Commission on Stratigraphic Nomenclature (NACSN, 2021) is being prepared by the author. ■

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WORD BRECCIA – A GEOLOGY WORD JUMBLE

Unscramble the words below and rearrange the circled letters to find the answer to the clue.

Words are Rock Lithologies and/or Elements

RYHTAINDE ◯ _ _ _ _ _ _ _ _ _

ITESUEV ◯ _ _ _ _ _ _ _

INTRGAE _ _ _ _ _ ◯ ◯

EICBCAR _ ◯ _ _ _ _ _ _

LMTOEIOD _ ◯ _ _ _ _ _ _ _

DIRIMUI ◯ _ _ _ _ _ _

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GIVING BACK

Annual Volunteer Day at YMCA Camp Cullen

Geological Society Members and friends are needed for our Annual Volunteer Day at YMCA Camp Cullen!

SATURDAY MARCH 22, 2025

Do you have a burning desire to "give back"? The HGS is teaming up with the YMCA to have a Volunteer Day on Saturday March 22nd, 2025. The volunteer work we do that day will be at Camp Cullen, a YMCA summer camp located near Trinity, Texas. We chose to help Camp Cullen this year for several reasons. First of all, most of the kids attending Camp Cullen are from the Houston area. Also, many are from underprivileged families and attend the camp free of charge. Last, but not least, there is a significant geology component to the camp's programs with an actual geologic field trip in the quarry, a geology lab with hand samples onsite, and a "gold" panning area for younger kids. HGS has conducted its Outcrop Family Campout there in past years.

The work planned this year includes building a shade structure in our quarry, working on the Marathon Slide Project, installing hitching posts for horses, cleaning/painting fence line, and a variety of arts and crafts projects.

So, if you would like to do a good deed, spend a nice day in the Piney Woods, and help get kids interested in geoscience, please consider donating part of a Saturday to this effort. You don't need any special skills, just a willingness to help. Depending on where you are located in the Houston area, it takes about 1 to 1 ½ hours to get to the camp. If you want to help, you can sign up by "clicking" https://www.signupgenius.com/go/10C0D49AFAA2DAAF8C16-54439567-camp . Please contact HGS member John Adamick at jadamick@stauroliteconsulting.com if you have any questions.

Attention HGS Members: Camp Cullen is always looking for ways to improve the quality of its geoscience education programs. A paid geoscience intern position currently available (funded by AAPG) to teach classes this Spring and we also are always on the lookout for volunteers to help develop curriculum. If you would like to get involved, please contact HGS member John Adamick at jadamick@stauroliteconsulting.com if you have any questions.

Monday, March 10, 2025

5:30 – 8:00 p.m.

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HGS General Dinner Meeting

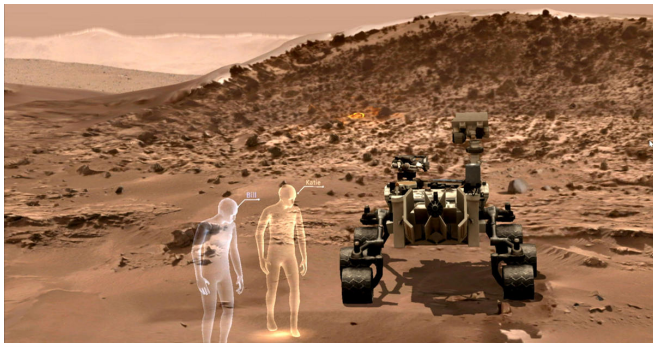
Kevin Bohacs

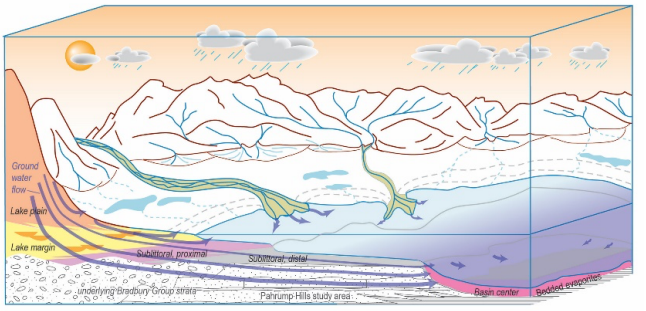
The Path to Gale and Jezero Craters-the Role of Terrestrial Field Work in Selecting Landing Sites on Mars and Interpreting the Resulting Observations

The highly capable Mars Science Laboratory on the Curiosity rover has accomplished most of the mission objectives assigned to this robot geologist (including evidence of ancient conditions quite conducive for microbial life). Essential to this success was choosing an appropriate field area based on remote sensing data. Predictive tools and detailed analogues developed during decades of field work on Earth provided robust guidance for selecting the landing site for the Curiosity rover and pinpointing outcrops to address specific mission objectives

We'll discuss how our expeditions on rocks up to one billion years old across six continents generated tools for pre-landing prediction and post-landing interpretation of analyses within geological context. (Field work is the essential first step in acquiring samples for detailed analyses in geological context, interpreting lab results, and constructing tools that allowed predictions to be made from remote sensing data.) In particular, our lake-basin-type classification* serves as a powerful framework for analyzing Mars paleolakes and interpreting the Curiosity and Perseverance rovers' observations. Results so far confirm pre-landing predictions and point to promising things to come.

For example, at the Pahrump Hills in Gale Crater, the site of the most ex extensive dataset of physical and geochemical observations yet collected on Mars, we integrated sedimentology, stratigraphy, mineral and elemental analyses, geochemical modeling, lab experiments, and Earth analogs in a sequence-stratigraphic and paleogeographic framework. It shows these strata accumulated as an evaporative lake facies association in an underfilled lake basin with closed surface hydrography but through-flowing hydrology. Lake waters were saline to hypersaline; lake levels, shorelines, and salinities fluctuated greatly at various temporal scales. Previous





work envisioned a freshwater lake with stable lake levels. The Pahrump succession and its lateral equivalents contain all the sequence-stratigraphic elements known from terrestrial strata, with 16 parasequences in five depositional sequences. Two of the sequence boundaries are unconformities that record significant shifts in the behavior and paleogeographic configuration of the fluvio-lacustrine system. This contrasts with the previous view that all facies are genetically related.

As an added bonus, come and see the sequence-stratigraphic interpretation of the first detailed stratigraphic column and

The Path to Gale and Jezero Craters *continued on page 42*

**{ e.g., Carroll, A.R., K.M. Bohacs 1999, Stratigraphic classification of ancient lakes: balancing tectonic and climatic controls, Geology v. 27, p. 99 - 102.*
Bohacs, K.M., Carroll, A.R., Neal, J.E., and Mankiewicz, P.J., 2000, Lake-basin type, source potential, and hydrocarbon character: an integrated sequence-stratigraphic—geochemical framework in Gierlowski-Kordesch, E. and Kelts, K., (editors), Lake Basins Through Space and Time. AAPG Studies in Geology 46, p. 3-37.
Bohacs, K.M., Carroll, A.R., and Neal, J.E., 2003, Lessons from large lake systems-- thresholds, nonlinearity, and strange attractors, in Chan, M.A., and Archer, A.W., editors, Extreme depositional environments: Mega end members in geologic time: Boulder, Colorado, Geological Society of America Special Paper 370, p. 75-90.}

The Path to Gale and Jezero Craters continued from page 41

cross sections from another planet—another illustration of how geological techniques based on first principles apply across our solar system. ■

BIOGRAPHICAL SKETCH

Kevin M. Bohacs is a sedimentologist and stratigrapher whose work integrates many scales of field and laboratory investigation, from plate tectonics to molecular geochemistry, to quantitatively reconstruct the climate, oceanography, tectonics, and ecosystems of ancient depositional systems ranging from deep ocean to swamps and lakes. He recently retired as Senior Research Scientist from ExxonMobil Upstream Research Company and now operates KMBohacs GEOconsulting LLC. His primary focus is to integrate field work, subsurface investigation, and laboratory analyses to inform business decisions. He works closely with exploration groups in evaluating hydrocarbon and aquifer systems, teaches field schools in sequence stratigraphy, sedimentology, basin analysis, and field safety leadership, and conducts field work for research and exploration.

An Eagle Scout, Dr Bohacs was graduated from the University of Connecticut with a BSc (Honors) in Geology and earned an ScD in Experimental Sedimentology from MIT, constructing and running the world's largest flume. He has conducted fieldwork and training on six continents and in more than thirty countries from the high Arctic to the tropics and written more than 110 scientific contributions on the stratigraphy and sedimentology of mudstone/shales, hydrocarbon source and reservoir rocks, and continental depositional systems. Dr Bohacs is the co-author and editor of books on sequence stratigraphy, lacustrine hydrocarbon reservoirs, and field safety. He has received many best paper citations and awards and served as distinguished lecturer for several societies nationally and internationally. He is an active volunteer with the American Red Cross Safety and Disaster Relief Services and with the Boy Scouts of America—including serving as Visiting Geologist in the backcountry of Philmont Scout Ranch.

HGS NEOGEOS

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MARCH 2025

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
						1
2 **AAPG Galveston Field Trip with Erik Scott** *https://www.hgs.org/civicrm/event/info?id=2637*	3	4	5	6	7	8
9	10 **HGS General Dinner Meeting** *The Path to Gale and Jezero Craters* *Page 41* *https://www.hgs.org/civicrm/event/info?id=2578*	11 **CCUS Carbon Capture Conference (AAPG)** *https://www.hgs.org/civicrm/event/info?id=2566*	12 **HGS E&E Dinner Meeting** *TBD* *https://www.hgs.org/civicrm/event/info?id=2614*	13	14	15
16	17	18 **New Energies Committee Luncheon** *TBD* *https://www.hgs.org/civicrm/event/info?id=2600*	19	20 **HGS NeoGeos Corn Hole Tournament** *Page 43* *https://www.hgs.org/civicrm/event/info?id=2643*	21	22
23 30	24 31	25	26	27	28	29

RESERVATIONS The HGS prefers that you make your reservations online through the HGS website at WWW.HGS.ORG. If you have no internet access, you can e-mail OFFICE@HGS.ORG, or call the office at 713-463-9476. **Reservations for HGS meetings must be made or cancelled by the date shown on the HGS website calendar, normally that is 24 hours before hand or on the last business day before the event.** If you make your reservation on the website or by email, an email confirmation will be sent to you. If you do not receive a confirmation, contact the HGS office at OFFICE@HGS.ORG. Once the meals are ordered and name tags and lists are prepared, no more reservations can be added even if they are sent. **No-shows will be billed.**

Make your reservations online at hgs.org

INSTRUCTIONS TO AUTHORS

Materials are due by the first of the month for consideration to appear in the next month's publication. Submissions should be emailed to editor@hgs.org. The Editor reserves the right to reject submissions or defer submissions for future editions.

Text should be submitted as a Word file. Figures or photos may be embedded in the document or submitted separately. The following image formats are accepted: tif, .jpg, .png, .psd, .pdf.

Feature submissions, e.g., Rock Record, should be approximately 600 words. Technical papers should be approximately 2000 words or less (excluding references).

NeoGeos 2025 Happy Hours

FEB 20
UH AAPG WILDCATTERS NIGHT
Kirby Ice House
(3333 Eastside St.)

MARCH 20
IMPAC - EXPLORATION SERVICES
Corn Hole Tournament
Eleven Below (Spring, TX)

APRIL 17
INTERTEK
Trivia Night
Location TBD

MAY 22
CORE GEOLOGIC
Members Drink Free
Kirby Ice House
(1015 Gessner Rd.)

JUNE 19
CO-SPONSORSHIP AVAILABLE*
Intern Night
Cottonwood

JULY 17
SPONSORPSHIP AVAILABLE
Location TBD

AUG 21
SABATA ENERGY CONSULTANTS
Platypus Brewing

SEPT 18
GVERSE-GEOGRAPHICS
Trivia Night
Location TBD

OCT 16
GEOMARK & PETRICORE
Pickleball Tournament
PKL Social

NOV 13
SPONSORSHIP AVAILABLE
End of Year Celebration
Location TBD

ALL EVENTS 6-9PM

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Science & Engineering Fair Houston (SEFH) 2/15/25

By Dorene West, *Chair, Science and Engineering Fair Committee,*

SEFH competition was held at the Fort Bend Epicenter. HGS sent a team of 10 special award judges to review Junior and Senior Division projects. All photographs courtesy of Catherine Strong. Volunteer judges were from left to right back: Glen Lowenstein, James Ostrikoff, Larry Welch, David Miller, Jim Tucker, Sharma Dronamraju, David Risch, and seated: Penny Patterson, Sandy Rushworth, Mike Erpenbeck, and Dorene West.

We split into two teams: the Junior Division (Sandy, both Davids, and Jim) and the Senior Division (Glen, James, Larry, Sharma, Penny, Mike, and Dorene). HGS judged 10 Junior and 13 Senior earth science-related projects. All HGS "Place" Special Awardees received a framed certificate signed by Penny (frames, parchment paper, and winner name labels donated by Dorene and Larry). All "Place" and "Honorable Mention Awardees" received a copy of "Roadside Geology of Texas" (donated by Cathy Strong and inscribed with a personal message by Penny).

The Engineering Council of Houston (ECH) and Houston Museum of Natural Science (HMNS) have notified us that HGS will support the same interns we supported last summer: Prachi Natoo, 1st Place Senior Division, and Ram Magathala (both 2 weeks/full internship), Shri Chada and Heba Badat (both 1 week)/ half internship). ■

AWARD WINNERS

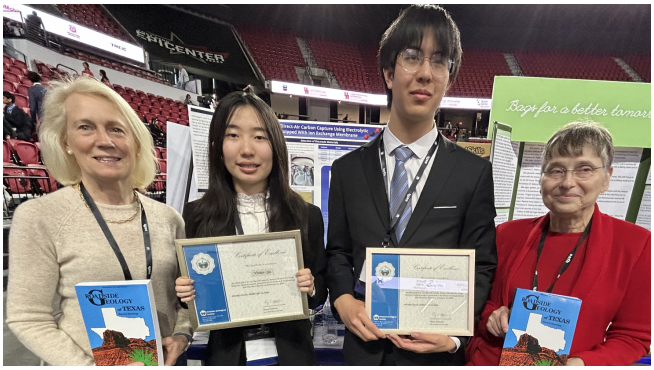
1st Place Senior & HMNS	Prachi Natoo	Role of Forced Convection in H Generation	Conroe ISD/AST
2nd Place Senior & HMNS	James Li	Flood Risk Simulation	Village School
3rd Place Senior & HMNS	Boning Dai & Vivian Qin	Optimized Direct Air Carbon Capture	John Cooper HS, Spring
Honorable Mention Sr	Kemli Vo & Phuong Le	Green Cobalt Nanoparticle Aquatic Oil Spills	Alief ISD
Honorable Mention Sr	Neev Pratap & Saketh Tam-misetti	Energy Generation Through Serpentinization	Fort Bend ISD/Elkins HS
1st Place Junior	Fatema Zahra	Phosphorescence Lunar Meteor	Al_Hadi SAL
Honorable Mention Jr	Chetan Kodali	Natural Substances Reduce Fe from H_2O?	Conroe ISD/Knox JH
Honorable Mention Jr	Eduardo Garza	Asteroid Odyssey	Houston ISD/BCM Rusk MS
Honorable Mention Jr	Tram Huynh	Meteoric Events	SST-Champions CP HS
Sr Nominate for HMNS	Ram Magathala	Quantum Horizons	Cypress Ranch HS
Sr Nominate for HMNS	Shri Chada	Bio-plastic Coated Fertilizers	Chada Homeschool
Sr Nominate for HMNS	Heba Badat	Effect of Medium's Temperature	Eisenhower HS

Science & Engineering Fair Houston (SEFH) 2/15/25 *continued on page 48*

Science & Engineering Fair Houston (SEFH) 2/15/25 continued from page 47

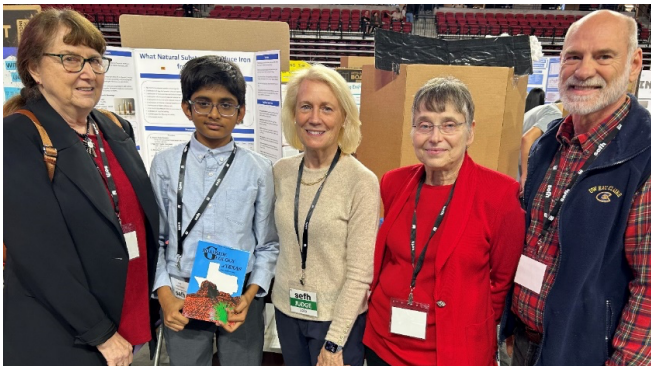
First Place Senior Division with HGS President and Science Fair Committee Chair, who were also Senior Division judges (left to right): Penny Patterson, Prachi Natoo, Dorene West.

Second Place Senior Division with HGS President and Science Fair Committee Chair (left to right): Penny Patterson, James Li, and Dorene West



3rd Place Senior Division with HGS President and Science Fair Committee chair (left to right): Penny Patterson, Vivian Qin, Boning Dai, Dorene West.

1st Place Junior Division with Junior Division judges, HGS President, and Science Fair Chair (left to right): Sandy Rushworth, Penny Patterson, Fatema Zahra, Dorene West, David Risch.



Honorable Mention Junior Division with Junior Division judges, HGS President and Science Committee Chair (left to right): Sandy Rushworth, Chetan Kodali, Penny Patterson, Dorene West, David Risch.

Honorable Mention Junior Division with HGS Junior Division judges, HGS President, and Science Committee Chair (left to right): Sandy Rushworth, Penny Patterson, Eduardo Garza, Dorene West, David Risch..

Honorable Mention Junior Division with Junior Division judges, HGS President and Science Fair Committee Chair (left to right): Sandy Rushworth, Dorene West, Tram Huynh, Penny Patterson, David Risch.

21st Annual NATUREFEST

TOM S. RAMSEY, P.E. HARRIS COUNTY PRECINCT 3 COMMISSIONER

SATURDAY, MARCH 1st
10 AM TO 2 PM

- OWLS, SNAKES & TURTLES
- CONCESSIONS
- PLANT SALES
- 30 EDUCATIONAL EXHIBITS
- ARCHERY
- FREE MINOR BIKE REPAIRS
- FISHING BOOTH
- ANIMAL TRACKS
- SCOUT TROOPS WELCOME
- 8 AM BIRD HIKE

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Volunteers Needed

Upcoming Events — Educational Outreach 2025

By Phil Caggiano, Chuck Caughey, Steve Johansen, Janet Combes, Debbie Caperon, Letha Slagle, Sarah Davis

THE 21ST ANNUAL NATURE FEST WILL BE HELD ON 1 MARCH, 9 A.M. TO 2 P.M AT JESSE JONES NATURE CENTER

This is an outdoor event, weather permitting, to encourage families to come to the park and enjoy the natural outdoors. Jesse Jones Park is on Spring Creek, directly west of Humble. HGS uses a poster session we previously constructed that introduces the families to the basic deposits of river point bars as seen in the park. It also presents some very basic concepts of river fair weather and flood stages and the basic hydrology of the river floodplain sediments. We expect 1-2K people will filter through 30 educational and interactive exhibit booths within the park. Steve Johansen is the HGS organizer. **VOLUNTEERS NEEDED.**

MARCH 5, 5:00-8:00 PM, HISD GEOSCIENCE CHALLENGE, HIGH SCHOOL LEVEL. VIRTUAL STEM COMPETITION

Students in Teams of 3-4 put together a project describing water usage in Houston and its effects on the environment. HGS will provide names of people students can interview and references for completing the project and participating in the judging. Sarah Davis is the organizer and **VOLUNTEERS NEEDED**.
Project summary:
Details of this event:

Each team will give a 5-minute presentation on their project on March 5, 2025, from 5:00 to 8:00 p.m.

Current and Future Water Usage in your Community: A tale of two sources – Surface vs. Groundwater

1. Summarize the sources and uses for water in the Houston Area: surface water versus groundwater. Where does our Surface Water come from, and how much is used? Where does our groundwater come from, and how much is used? How has this allocation changed historically, and why?

2. What are the pros and cons of surface water versus groundwater use in the greater Houston area? Which is more costly? What are the future predicted cost changes for surface water in Greater Houston? Which is better for the environment?

3. Local Impact: What types of water are used within a 10-mile radius of your school? What are ways to conserve and/or reallocate water usage among these two types in a 10-mile radius of your school, and why?

MARCH 8 REACH FOR THE STARS — MIDDLE SCHOOL GIRLS STEM EVENT AT RICE.

https://space.rice.edu/ReachForTheStars/

Because of the block scheduling, exhibitors are requested to staff all day (10-12:30 and 1:45-3:30) - note that each interest group comes at a different time. Lunch is provided for your team (up to 5 people). Janet Combes is the organizer. **VOLUNTEERS NEEDED**

MARCH10-14 12:00-4:00

EOG Resources has requested Success Skills Center to have an activity tent in Discovery Green during spring break. Sarah Davis of SSC would like the HGS to volunteer and/or present k12 (mostly elementary school) activities for families we could have in our tents. The activities would need to be longer than a couple of minutes. Sarah Davis is the organizer – **additional volunteers are welcome**

HGS Scholarship Night 2025- "Game Over" for the Dinosaurs 66 Million Years Ago

By Linda Sternbach

Congratulations to Scholarship Night leaders Fang Lin, Allison Barbato, and Jeff Lund for rolling out a "high impact" event on February 10, 2025 at the Norris Center with the talk "The Day the Dinosaurs Died' featuring speakers Andew Madof and Cody Miller from Chevron. Scholarship Night 2025 achieved a record milestone for sponsorship of over $54,000 in contributions, which provide additional funds to the graduate Calvert Scholarship Fund and HGS Undergraduate Scholarship Fund. Corporate Platinum sponsors include Chevron, Shell, and Oxy. Gold corporate sponsors include Houston Energy and Hess. Silver corporate sponsors include ExxonMobil and Thunder Exploration. Bonze corporate sponsors include Petrophysical Solutions, Patterson Geoscience Group and Rock Flow Dynamics. And, Individual Sponsors include Staurolite Consulting, LLC.

Penny Patterson, HGS President, began the evening with opening remarks thanking all the sponsors, HGS committee chairs, committee members, volunteers and HGS staff. She also provided a few guiding goals to the students. The goals involved developing skills such as networking, inquisitiveness, creativity, and excellence in their work as they move along in their studies and career paths. On hand for the award night were HGS Foundation Chair Joe Lynch and Treasurer Angela Hammond, Calvert Fund Chair Jeff Lund and Vice Chair Nicole Villarreal, Treasurer Dick Bishop, and Secretary Judy Schulenberg. Jeff Lund announced additional sponsorship contributions were received in memory of Dave Orchard and Mike Barnes, both of whom recently passed away.

Fang Lin, Scholarship Night Chair, announced that next year's chair would be Allison Barbato, a recent HGS scholarship awardee from LSU and a recent new hire at Chevron in Houston. Allison said, "From personal experience, your scholarship donations have an enormously positive impact on aspiring petroleum geologists because every scholarship HGS sends out feels like a vote of confidence to students who may not feel confident about stepping into the industry – the message that it sends to them is "we believe in you – and we're all here for you and believe that you have what it takes to enter this industry successfully."

The night's feature presentation by Cody Miller and Andrew Madof highlighted their research of the rock record left by the Chicxulub Impact on the Yucatan Peninsula 66 million years ago. They used animated movies to describe the day the dinosaurs perished and the tremendously destructive impact of a postulated 10-mile-across asteroid on the Mesozoic atmosphere 66 million years ago. Here are some facts and interpretations brought up in the presentation:

1. The asteroid hit in springtime, coming in from the northeast and striking the west side of the Yucatan Peninsula in the Bay of Campeche. The asteroid was traveling 45,000 miles per hour. The resulting crater was 180 km across and delivered the power equivalent to 10 nuclear bombs.

2. A one-mile-tall tsunami resulted, striking North America and Central America. The rocks at the impact site include carbonate shelf rocks and evaporates. The impact created a sulfur-rich cloud of debris, which poisoned Earth's life and caused the extinction of many land species.

3. Their study of TGS 2D seismic lines in the Gulf of Mexico shows the unconformity at the impact horizon, traced laterally to prograding debris flows in the deep basin and erosional truncation on the shelf.

Madoff and Miller tied their observations on seismic to reservoir porosity created by the impact debris buried in Mexico's giant Cantarell oil field. Cantarell complex, which includes several oil fields, has produced 23 billion barrels of oil from shattered Mesozoic carbonate reservoirs with a shared water aquifer. Miller has studied Mesozoic-aged cores and reports that the rocks became dolomitized and vuggy due to diagenesis after the 66 MY impact. The speakers expressed admiration that "nature finds a way," and some marine species recovered soon after the effect, leading to the recovery of life on Earth as soon as 10,000 to 100,000 years later. They also said that today's chickens are descendants of the dinosaurs, and both speakers cited the movie "Jurassic Park" (1983) as a reason they studied geology as a career.

Allison Barbato, Scholarship Night chair for next year, closed the evening, saying, "College is an incredible time—one to enjoy, but also a time to reflect. When opportunity knocks, answer. And if it doesn't, build a door with whatever resources you have to find a way to fall forward in the direction you want. And when you do land opportunities, always ask yourself, Who can I lift along the way? These actions shape your character, which will take you further than anything else.

In closing, Walter Light Jr., past HGS President, challenged attendees to make additional contributions to Scholarship Night. Walter's challenge brought in an additional $1,670 to support student scholarships. Hence, Scholarship Night contributions brought in a total amount of $57,080 for 2025. What an outstanding finale to close the evening's celebrations!

I look forward to seeing you all at the 2026 HGS Scholarship Night. ■

HGS Scholarship Night 2025 *continued on page 52*

Names of Student Awardees

CALVERT AWARDEES PHD CANDIDATES

Edgar Contreras	University of Houston
Leiser Silva	Colorado School of Mines
Nicolas Ferry	University Kansas
Marissa Rene Castillo	Ohio State University
Jordan Thomas Walker	Baylor
Evan Madill	Case Western Reserve
Gabriel Ahrendt	Michigan Tech
William Hunt	University Missouri
April Moreno-Ward	University Oklahoma

CALVERT AWARDEES MASTERS CANDIDATES

Joseph Pelren	University of Tennessee
Ariana Rodriguez	Stephen F Austin
Colton Klatt	UT San Antonio
Hunter Mason	Northern Illinois
Jarely Mendez	Virginia Tech
Lars Koehn	Virginia Tech
Sarah Bancroft	LSU
Kacey Palmbeck	University pf Missouri
Alexa Crawford	LSU

UNDERGRADUATE SCHOLARSHIP AWARDS

Abram Riggs	University of Houston
Joey Hlavac	Texas A&M
Caeli Richard	Sam Houston State University
Jacob Hadaway	Stephen F Austin University
Anthony Valdez	Lamar University

CONTRIBUTIONS IN MEMORY OF MIKE BARNES

Ken Boester

Duncan DuBroff

Mark Gregg

James Grubb

Andrew Hampf

Brian Horn

Fang Lin

Marie Orchard

Portfolio Exploration, LLC

Anthony Moherek

James Richards

Richard Stinson

Thunder Exploration

Don Tobin

Butch Wilson

CONTRIBUTIONS IN MEMORY OF DAVID ORCHARD

Elizabeth Ann De Leon-Naestas

Beverly DeJarnett

David & Beth Dykhuizen

James Grubb

Andrew Hampf

Paul Hardwick

Fang Lin

F. Lomonte

William Mills

Joanne Morrison

Portfolio Exploration, LLC

Monica Pride

Robert Reeves

Thunder Exploration

Robert Wiener

Butch Wilson

HGS Scholarship Night 2025 *continued on page 53*

Calvert Scholarship Memorial Awards pictured from left to right are Dick Bishop, Treasurer; Nicole Villarreal, Vice Chair; Judy Schulenberg, Secretary; Sarah Bancroft. MS Student at LSU, Walter Light. HGS Past President, Jeff Lund. Calvert Chair, Penny Patterson, current HGS President, Allison Barbato Scholarship Night co-chair, John Tubb. HGS Past President

HGS Foundation Scholarships to undergraduates were presented by Chair Joe Lynch and Treasurer Angela Hammond. Students are from left to right are Jacob Hadaway, Caeli Richard, Joey Hlavac, Abram Riggs, Anthony Valdez

Fang Lin, Scholarship Night Chair, announced that next year's chair would be Allison Barbato

Speakers Andrew Madof and Cody Miller presented the evening's talk on The Day the Dinosaurs Died…

HGS Scholarship Night 2025 *continued on page 54*

Attendees from sponsor Exxon

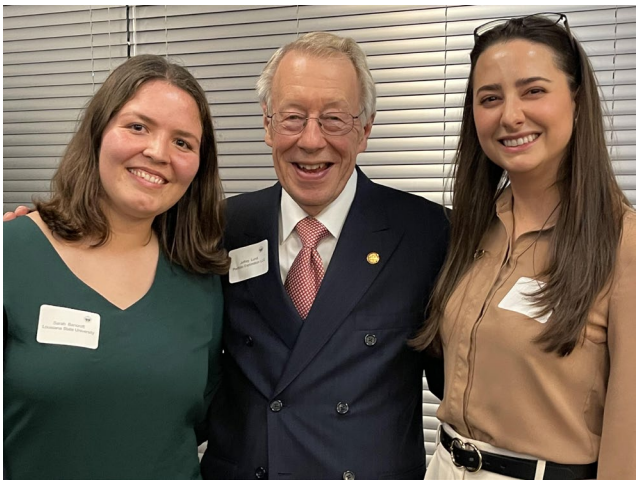
Charles, Allison and Linda

Janet Combes and Stacie Gibbons

Jim Tucker, Carl Seffenson and Craig Dingler

Attendees from sponsor Shell Oil

HGS Scholarship Night 2025 *continued on page 55*



Sarah Bancroft (MS student LSU), Jeff Lund, Allison Barbato

Passing the Baton for Scholarship night chair (past chairs) John Tubb - Charles Sternbach - Fang Lin (current chair) and now Alison Barbato

Judy Schulenberg, Calvert Secretary; Jeff Lund, past HGS president; and Penny Patterson, current HGS president

HGS Bulletin's previous editor, Caroline Wachtman, and current editor, Ted Godo

HGS Membership Application

Houston Geological Society
14811 St Mary's Lane Suite 250 Houston
TX 77079
Phone: (713) 463-9476
Email: office@hgs.org

Active Membership

In order to qualify for Active Membership you must have a degree in geology or an allied geoscience from an accredited college or university or, have a degree in science or engineering from an accredited college or university and have been engaged in the professional study or practice of earth science for at least 5 years. Active Members shall be entitled to vote, stand for election, and serve as an officer in the Society. Active Members pay $36.00 in dues.

Associate Membership

Associate Members do not have a degree in geology or allied geoscience, but are engaged in the application of the earth sciences. Associate Members are not entitled to vote, stand for elections or serve as an officer in the Society. Associate Members pay $36.00 in dues.

Student Membership

Student membership is for full-time students enrolled in geology or an allied geoscience. Student Members are not entitled to vote, stand for elections or serve as an officer in the Society. Student Member dues are currently waived (free) but applications must be filled out to its entirety. Student applicants must provide University Dean or Advisor Name to be approved for membership.

Membership Benefits

Digital HGS Bulletin

The HGS Bulletin is a high-quality journal digitally published monthly by the HGS (with the exception of July and August). The journal provides feature articles, meeting abstracts, and information about upcoming and past events. As a member of the HGS, you'll receive a digital copy of the journal on the HGS website. Membership also comes with access to the online archives,with records dating back to 1958.

Discount prices for meetings and short courses

Throughout the year, the various committees of the HGS organize lunch/dinner meetings centered around technical topics of interest to the diverse membership of the organization. An average of 6 meetings a month is common for the HGS (with the exception of July and August). Short courses on a variety of topics are also planned throughout the year by the Continuing Education Committee. These meetings and courses are fantastic opportunities to keep up with technology, network, and expand your education beyond your own specialty. Prices for these events fluctuate depending on the venue and type of event; however, with membership in the HGS you ensure you will always have the opportunity to get the lowest registration fee available.

Networking

The HGS is a dynamic organization, with a membership diverse in experience, education, and career specialties. As the largest local geological society, the HGS offers unprecedented opportunities to network and grow within the Gulf Coast geological community.

Please fill out this application in its entirety to expedite the approval process to become an Active/Associate member of Houston Geological Society.

Full Name _____ Type *(Choose one)*: Active Associate Student

Current Email *(for digital Bulletin & email newsletter)*_____

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Preferred Address for HGS mail_____

This is my home address _____ business address _____

Employer *(required)*_____ Job Title *(required)*_____ Will you volunteer? ____ (Y/N) Committee choice: _____

Annual dues Active & Assoc. for the one year *(July 1st-June 30th)* **$36.00**_____

Student **$0.00**_____

OPTIONAL Scholarship Contributions- Calvert/HGS Foundation-Undergraduate **$5.00**_____

Total remittance_____

Payment:

Check #_____

Credit card: V MC AE Discover

Credit Card#_____

CVV code (req'd): _____ Expiration: _____ (mm/yy)

Signature: _____ Date: _____

To the Executive Board: I hereby apply for membership in the Houston Geological Society and pledge to abide by its Constitution & Bylaws.

Company*(required, mark 'in transition' if unemployed)*_____

Company Address _____

City *(Work)* _____ **State** *(Work)* _____ **Postal Code** *(Work)* _____

School *(required)*_____

Major *(required)*_____ **Degree** *(required)*_____

Year Graduated _____

School *(optional)*_____

Major *(optional)*_____ **Degree** *(optional)*_____

Year Graduated _____

Years Work Experience *(required)*_____

Please submit a brief statement regarding your work experience in the practice or application of earth science or an allied science.

AAPG Member Number _____ OR

HGS Sponsor's Name _____

Signature: _____ **Date:**_____

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Seeking Prospects: Coastal Texas

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Consulting Geologist

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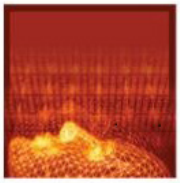

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