Closing in on the *Killer*

The Caribbean gains favor as the scene of an ancient global catastrophe

First in a two-part series

By RICHARD MONASTERSKY

Geologist Walter Alvarez spent a dozen years wondering whether nature had played a cruel joke on his profession. It all started in the late 1970s, when Alvarez, his father Luis and several co-workers from the University of California, Berkeley, unearthed evidence suggesting that a huge bolide – a meteorite or a comet – slammed into Earth 65 million years ago, at the end of the Cretaceous period. Such a cataclysm, they reasoned, could explain why the dinosaurs and many other organisms went extinct around that time. Over the next decade, geologists accumulated considerable evidence backing up the impact theory, but they failed to find the most crucial element of all: a crater left by the killer crash.

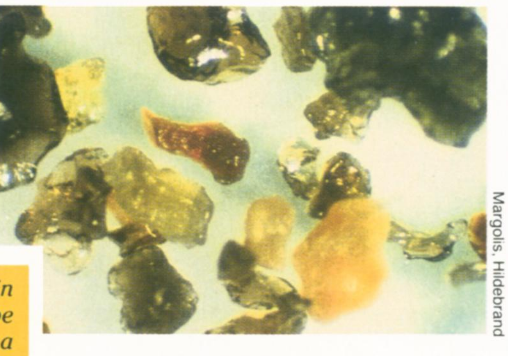
Alvarez despaired that geologists might never locate ground zero for the bolide. Since the time of the crash, some 20 percent of Earth's crust has disappeared into the interior of the planet through a recycling process called subduction. If one of these absent sections of crust held the long-sought crater, then geologists would search in vain from here to eternity.

"But all that pessimism has changed in the last couple of years," Alvarez noted enthusiastically at a meeting of the Geological Society of America in October. The search picked up speed in 1990 when several scientific teams reported finding evidence suggesting the planet-disrupting bolide struck in the Caribbean-Gulf of Mexico region – a proposal that sparked a race toward the tropics to find additional clues. Now comes a set of new discoveries, presented at the October geology meeting and in scientific journals, that greatly strengthens the case for an ancient Caribbean splashdown at the boundary between the Cretaceous (K) and Tertiary (T) periods.

Some researchers think they have located the actual site of the K-T crater. Alan R. Hildebrand of the Geological Survey of Canada in Ottawa and his co-workers report in the September GEOLOGY that a circular structure buried deep beneath the Yucatán peninsula appears to be an impact crater of about the right age and size.

"I'm 99 percent sure that this is the K-T boundary crater," Hildebrand told SCIENCE NEWS.

While few scientists share Hildebrand's certainty, many look toward the Yucatán structure with hope. The prospective impact crater has worn several different labels over the decades as its character has gradually come to light. The Mexican national petroleum company, PEMEX, discovered the first signs of the structure while drilling several exploratory wells in this region in the 1950s. After penetrating a kilometer of the ubiquitous limestone that covers the Yucatán, the drills hit a layer of different rocks, unusual for that region. Geologists could tell that these rocks had solidified from a molten state, so they identified the layer as volcanic in origin.



Margolis, Hildebrand

Tiny fragments of glass found in Mimbral sediments are believed to be tektites, formed when an impact sends a spray of molten rock into the atmosphere. As it falls, the rock cools into glass.

In the late 1970s, a magnetic survey of the area by PEMEX revealed a large circular structure buried beneath the surface. The magnetic data and an older gravity survey suggested the strangely symmetrical circle measured a whopping 180 kilometers in diameter. Centered near the town of Chicxulub on the north coast, the feature extended out under the Gulf.

In 1981, two researchers working for PEMEX, Glen T. Penfield and Antonio Camargo, suggested the buried circle could have formed during an asteroid impact. While speaking at a conference that year, Penfield even proposed this site as a candidate crater to fit the Alvarez group's new theory about the K-T extinctions. But Penfield dropped that bombshell on the wrong audience – a conference of oil geologists, who cared about as much for impact craters as they did for dermatology.

Whatever its origins, the Chicxulub enigma lay in relative obscurity for more than a decade.

Not any longer. Hildebrand and his co-workers revived interest in the buried circle after finding rocks in Haiti that appear to bear scars produced by a nearby impact. When the researchers heard about the Chicxulub structure, they decided to check it out, knowing that the Yucatán would have sat much closer to Haiti 65 million years ago than it does today.

PEMEX had collected rock samples while drilling their exploratory wells in the 1950s. Although a warehouse fire had destroyed most of the samples, Hildebrand's group managed to locate a few surviving core sections. When they analyzed these rocks, they found "shocked" quartz grains – slivers with a particular arrangement of microcracks believed to represent the calling card left by an extraterrestrial impact.

Suddenly, scores of scientists found themselves stumbling over the name Chicxulub, a Mayan word whose pronunciation lies halfway between *CHEESH-oo-loob* and *CHICKS-oo-loob*, according to Penfield, who named the structure after the town near its center. The term translates roughly as "devil's tail," he says.

If, as the shocked quartz suggests, the Chicxulub feature formed during a bolide crash, it will rank as one of the largest impact craters known on Earth – a fitting honor for the agent that apparently closed the curtain on the Mesozoic era, known as the Age of the Reptiles, and cleared the stage for the rise of the order Mammalia.

But before the Chicxulub impact goes down in history as the dinosaur destroyer, scientists must make sure this crash is the right one. Fossil evidence from the 1950s suggested that the circular structure formed during the middle of the Cretaceous period – too early to explain the extinctions that mark the K-T boundary. Hildebrand's group, however, believes those mid-Cretaceous dates are wrong.

Several researchers are trying to date some of the drill-core samples from inside the crater, using the radioactive decay of potassium. But most agree that they have only one way to settle the question decisively: by drilling new holes into the Chicxulub structure to obtain an incontrovertible geologic record. Scientists working toward this goal hope that in the next few years they will obtain funds for drilling, although no formal project is yet underway.

As news of Chicxulub spread at scientific meetings and in journals, Walter Alvarez and his crew began planning a trip to mainland Mexico. They reasoned that if a bolide had hit the Yucatán, nearby locations must have preserved clear evidence of the crash. Last February, Alvarez headed for northeastern Mexico with Jan Smit of the Free University of Amsterdam and Berkeley colleagues Nicola H. M. Swinburne and Alessandro Montanari.

In the Arroyo el Mimbral, their search paid off. The geologists located a section of sedimentary rocks that they believe provides a detailed scenario of the catastrophic event, with different layers representing successive acts in the ancient tragedy.

The curtain opens on a serene seafloor as recorded by the shells of tiny plants and animals that piled up in undisturbed layers lasting millions of years. At this time, during late Cretaceous, the Mimbral region lay in fairly deep water, perhaps 500 meters or deeper, Swinburne says.

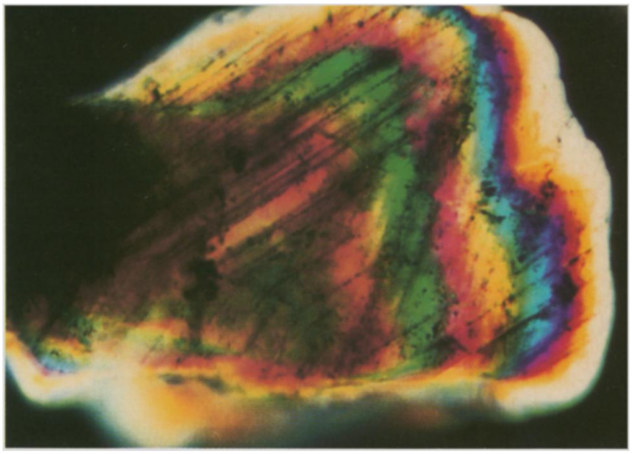
The tranquility ended at the K-T boundary, where a succession of disturbed sedimentary layers tells the tale of the purported crash. Reading from bottom to top, the climactic act starts with the appearance of tiny rocks shaped like spheres and dumbbells that measure several millimeters in size. The researchers identify these rocks as tektites — hardened droplets of rock that had been melted by the impact and ejected high into the atmosphere.

The next layer up consists of coarse sediments, fossilized bits of wood and pine cones — materials not normally present in deep ocean deposits. Swinburne says these objects reached their unusual resting place when the impact unleashed a monster wave, or tsunami, that surged up onto the land and dragged rocks and pieces of wood back into the deep sea. The swells may have sloshed back and forth across the Gulf of Mexico in much the same way as water does in a bathtub.

This scene fades into the last act as beds of finer sediments appear atop the coarse tsunami deposits. The stronger swells died out over a period of perhaps days, leaving weaker waves that carried small sediment grains to the then-submerged Mimbral site. At the same time, dust particles lofted into the air by the impact fell back to Earth. These particles contained a high abundance of the element iridium, which is rare on Earth's surface but concentrated in meteorites. As the dust settled on the oceans and drifted down, it created a global iridium-rich layer. The discovery of this layer is what led the Berkeley researchers to propose the impact hypothesis more than a dozen years ago.

The Mimbral story ends with a return to quieter times. Above the disturbed layers, deep-water sediments reappear, filled with the shells of tiny ocean plants and animals from the millennia following the K-T boundary.

As in all good tales, though, the curtain closes on a world forever altered by the intervening drama. Many of the species alive after the disturbance are completely different from those that previously filled the seas.


Hildebrand

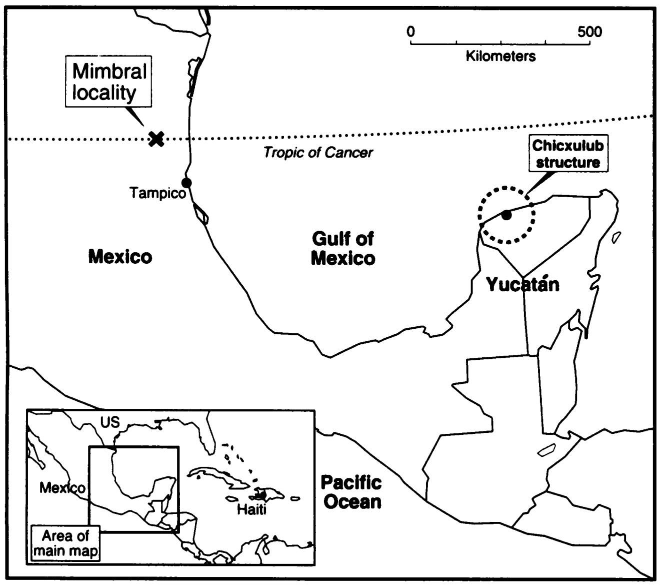
Shocked quartz from Chicxulub crater. Parallel dark lines running through this quartz grain are microscopic fracture planes, formed from the shock waves of an impact. This grain has eight sets of intersecting planes.

The Mimbral evidence washes well with discoveries made at other sites in the region. Even before the Berkeley field party journeyed to Mexico last February, Alvarez examined the cores of deep-sea sediments recovered a decade ago from two drilling sites, 536 and 540, located between the Yucatán and Florida. At the October geology meeting, he reported that these sediments bear the scars of a large wave, probably generated by an impact. Other researchers have described similar wave deposits found in Haiti, which formed part of the deep-ocean floor 65 million years ago.

"There must have been an absolutely enormous wave in the Gulf of Mexico, like nothing anyone has ever seen evidence for before anywhere on the Earth at any time," Alvarez says.

The Haiti site has also yielded tektites like those found at Mimbral. These two groups of tektites are unusual because a small fraction of them contain glassy cores representing the original rock that solidified from the molten droplets. Such tektites have buoyed the hopes of geologists who thought it would be nearly impossible to find glass from a time so long ago. Because glass has no real crystalline structure, it is easily dissolved and converted to other minerals over millions of years. Researchers who have examined K-T boundary sections around the world have found tiny clay spherules that they believe represent the remnants of once glassy tektites. But until the last two years, no one had found original glass from that era.

Tektite glass can serve as important clues because they carry a chemical fingerprint of the impact site, says Stanley V. Margolis of the University of California, Davis, who has analyzed glass from



Scene of the crime? The Chicxulub circular structure lies hidden beneath the northern Yucatán. At the time of the impact, it would have sat roughly equidistant from Mimbral, drillholes 536 and 540 (located between the Yucatán and Florida) and Haiti, which originally sat southwest of its current position.

Mimbral and Haiti, as well as smaller pieces from deep-sea holes 536 and 540. According to Margolis, the composition of the glass at Mimbral and Haiti matches the composition of the rocks found deep inside the Chicxulub structure. "Just imagine that [the bolide] came down, melted the rock and threw the stuff from there all over the place and we're finding pieces of melted Yucatán in Haiti and Mexico," says Margolis.

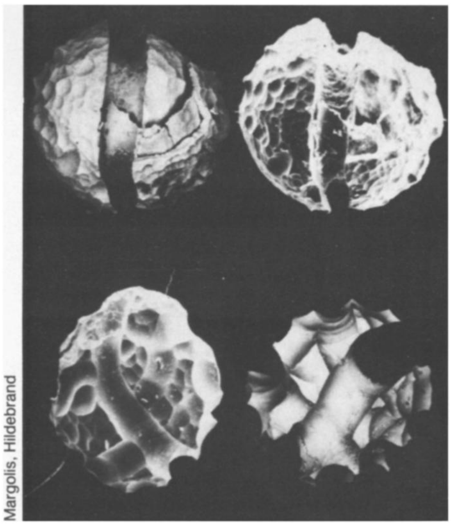
Margolis sees other evidence pointing in the direction of Chicxulub. Of all the K-T boundary deposits known around the world, the thickest occur at Mimbral, Haiti and sites 536 and 540. These spots have the largest known spherules, and they are the only locations so far to yield pieces of glass from K-T time. Margolis reasons that the impact must have occurred in the Caribbean-Gulf of Mexico region – a provision fulfilled by the Yucatán site, which would have sat in the middle of these various deposits.

At the time of the K-T boundary, the Yucatán peninsula lay covered by perhaps 100 meters of water at the edge of the ancient North American continent. Because the size of a tsunami depends on water depth, an impact into the shallow Yucatán sea could not have directly spawned a giant wave, Hildebrand says. However, a bolide moving at more than 20,000 miles per hour would have hit the ground with a tremendous force, perhaps comparable to a magnitude 11 earthquake – almost a million times more powerful than the quake that rocked northern California in 1989. Such a tremendous shock could have sent gigantic mudslides down the continental slope and into deeper waters capable of generating a tsunami, Hildebrand explains.

As Chicxulub's star has risen during the past year, it has stolen the attention of many earth scientists who had earlier placed their bets on a crater in Iowa, called the Manson Impact Structure. Scientists have dated the Manson crater at roughly 65 million years ago, which would mean that it formed at the same geologic time as the other events recorded at the K-T boundary. But with a diameter of only 35 kilometers, Manson has always appeared too puny to explain the extinctions and the impact evidence deposited around the world.

But researchers may not have to choose between Manson and Chicxulub. The K-T deposits in the United States apparently record impacts at both sites, says Glen A. Izett of the U.S. Geological Survey in Denver. "Because of the twofold nature of the boundary interval in the western interior sites, that suggests two impacts very close in time," Izett says.

As he reads it, Chicxulub came first, then Manson. Iowa's geological bureau and the U.S. Geological Survey are currently drilling into the Manson structure



Margolis, Hildebrand

Scanning electron micrograph shows microtektites from Mimbral. Chemical weathering over 65 million years has sculpted the noticeable grooves and gouges.

to determine more precisely when and how it formed. To explain the possible double whammy, Izett theorizes that a comet or meteorite might have broken into pieces before it reached Earth. The larger piece then slammed into the Caribbean; a smaller piece hit the North American interior.

Hildebrand argues that the Caribbean and Manson impacts may have nothing to do with each other. Because of uncertainties regarding the dates of the two impacts, one could have happened a million years or more before the other, indicating they were totally unrelated, says Hildebrand.

Hildebrand, Alvarez and other scientists in the Caribbean camp say that no matter what the date of the Manson crash, the much larger Chicxulub impact must have caused most of the worldwide damage at the time.

Researchers have dreamed up a vast range of disastrous effects that would accompany a crash of such mythic proportions. Aside from kicking up a light-blocking cloud after the impact, the bolide would also cause problems on its way down. Speeding through the atmosphere, the comet or meteorite would ionize air molecules, generating intensely acidic rainfall, as corrosive as battery acid according to some calculations. That rain would lower the pH of the ocean's surface, perhaps making it acidic enough to dissolve the calcium carbonate shells of certain plankton.

Things get even worse. A strike in the Yucatán would have proved particularly deadly, says Hildebrand, because this region consists of a limestone (calcium carbonate) platform more than 3 kilometers thick. During the collision, the limestone would have vaporized, spewing so much carbon dioxide into the air that it raised the concentration of this gas to perhaps 50 times its present level, suggests Hildebrand. The resulting global warming could have hiked up Earth's temperature by 10°C in a long-lasting enhanced greenhouse effect.

All of this makes Chicxulub an even more appealing site in which to find the K-T crater. But while Hildebrand and the Alvarez group have placed their bets on the Yucatán, many other researchers are holding their money until they have a definitive date for Chicxulub and other scientists have a chance to examine the Mimbral and Haiti sites.

The skeptics do not all fit into one neat category. Some believe an impact did cause extinctions at the K-T boundary but question whether it occurred at Chicxulub. Others challenge the entire impact idea, arguing that volcanic eruptions or other terrestrial processes best explain the extinctions and the purported impact evidence.

Charles B. Officer of Dartmouth College in Hanover, N.H., has marshalled the anti-impact crusade in the United States. For any piece of evidence raised by the sizable impact crowd, Officer throws up a counterinterpretation. In his view, volcanic eruptions produced the global iridium layer, shocked quartz and glassy rocks found in the Caribbean. Neither Manson nor Chicxulub represents an impact crater, he insists. Instead, Officer suggests volcanic processes could have produced the Manson structure while the Chicxulub feature may represent an ancient sinkhole, like the ones found in the Florida platform, which bears a close resemblance to the Yucatán.

In his own country, Officer finds relatively few allies from the fields of geology and geophysics to support the anti-impact theory.

"I think in the U.S. most people would have a view that, yes, there probably was an impact," says Gerta Keller, a paleontologist at Princeton (N.J.) University.

Lest anyone dismiss Officer's viewpoint entirely, however, U.S. scientists must consider that the impact theory enjoys far less support outside North America. "If you go to Europe, you're going to have a hard time finding people who believe in the impact at all," Keller says.

Although she has long criticized the pro-impact camp for overestimating the number of species that went extinct right at the K-T boundary, Keller herself thinks the evidence supports the idea that a bolide struck Earth 65 million years ago.

Officer remains hopeful that the scientific community can resolve this sometimes rancorous debate. "Eventually – maybe it's wishful thinking on my part – the facts will speak for themselves," he says.

When that day comes, Chicxulub may have the final say. □

Next: The death toll