

# ICE & STONE

## 2020

WEEK 23: MAY 31-JUNE 6

*Presented by The Earthrise Institute*



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**23**

*Authored by Alan Hale*

# THIS WEEK IN HISTORY



**MAY 31, 2020:** Comet ATLAS C/2019 Y4 will pass through perihelion at a heliocentric distance of 0.25 AU. A previous “[Comet of the Week](#),” Comet ATLAS initially showed potential for becoming a bright object, but it now appears to have all but disintegrated as it has approached perihelion. It is traveling in the same orbit as the Great Comet of 1844 and is almost certainly a trailing component of that comet; this and other comet “pairs” and “groups” are discussed in a future “Special Topics” presentation.



**JUNE 1, 1995:** The “Near-Earth Objects Survey Working Group,” a special commission chartered by the U.S. Congress and led by planetary geologist Eugene Shoemaker, issues its report to Congress and to NASA. Among its major recommendations is the establishment of comprehensive sky surveys to search for potentially threatening near-Earth objects and identify them well in advance. The results of these surveys are discussed in a previous “[Special Topics](#)” presentation, and the surveys themselves are discussed in a future “Special Topics” presentation.



**JUNE 2, 1822:** German astronomer Carl Rumker, then residing at Parramatta, New South Wales, recovers the comet now known as 2P/Encke based upon a prediction made by German mathematician Johann Encke. This was only the second periodic comet to be recovered based on a prediction, and the comet was subsequently named after Encke. Comet 2P/Encke returns to perihelion later this month and is a future “Comet of the Week.”

**JUNE 2, 1858:** Italian astronomer Giovanni Donati discovers a comet from Florence Observatory. Later that year Comet Donati became a spectacular naked-eye object, and it is a future “Comet of the Week.”

**JUNE 2, 2018:** The [Mount Lemmon survey](#) based in Arizona discovers a tiny asteroid, no more than a few meters across, designated 2018 LA. Eight hours later 2018 LA entered the earth’s atmosphere above Botswana and disintegrated, creating a bright fireball in the process. A few meteorites have subsequently been identified in Botswana. 2018 LA and a few similar objects are discussed in a future “Special Topics” presentation.

## COVER IMAGE CREDIT:

Front and back cover: This artist’s conception shows ESA’s proposed Hera Mission to the Didymos binary asteroid system. Hera will carry two CubeSat Opportunity Payloads (COPINS) to support the science goals of the main spacecraft, as well demonstrate deep space inter-satellite link techniques. Courtesy of ESA/ScienceOffice.org.



**JUNE 3, 1861:** Comet Thatcher 1861 I (new style: C/1861 G1), the parent comet of the Lyrid meteor shower, passes through perihelion at a heliocentric distance of 0.921 AU.

**JUNE 3, 1966:** American geophysicist Henry Faul publishes his [paper](#) "Tektites are Terrestrial," wherein he demonstrates that the rocks called "tektites," despite their similar physical appearances to meteorites, are in fact terrestrial in origin, although they are created by soil and sediment heated up due to meteorite impacts. Tektites and their relationship to meteorites are discussed in a previous "[Special Topics](#)" presentation.

**JUNE 3, 2013:** The centaur (10199) Chariklo occults a 13th-magnitude star in Scorpius. Before the actual occultation itself, the star briefly disappeared and reappeared twice, and did the same thing after the occultation, revealing that Chariklo possesses two very thin rings – the only centaur known to do so. [Centaur](#)s, and results like these obtained from observations of [occultations](#), are both subjects of previous "Special Topics" presentations.



**JUNE 6, 1980:** The father-and-son team of Luis and Walter Alvarez publish a [paper](#) wherein they show that sediments from the end of the Cretaceous Period 66 million years ago are heavily enriched with the metal iridium, which is very rare on Earth but somewhat abundant in asteroids and comets. They then propose that the impact of such an object at the end of the Cretaceous Period was responsible for the mass biological extinction event at that time that killed, among many other species, the dinosaurs. The "K-T event," as this has come to be called, is the subject of this week's "Special Topics" presentation.

**\* THERE ARE NO ENTRIES FOR JUNE 4 AND 5.**



Luis Walter Alvarez (left) and his son Walter Alvarez (right) at the K-T Boundary in Bottaccione Gorge, near Gubbio, Italy. Courtesy of Lawrence Berkeley Laboratory.

# COMETS OF THE WEEK: SOHO C/1998 K10 & C/1998 K11

C/1998 K10's Perihelion: 1998 June 1.88,  $q = 0.006$  AU

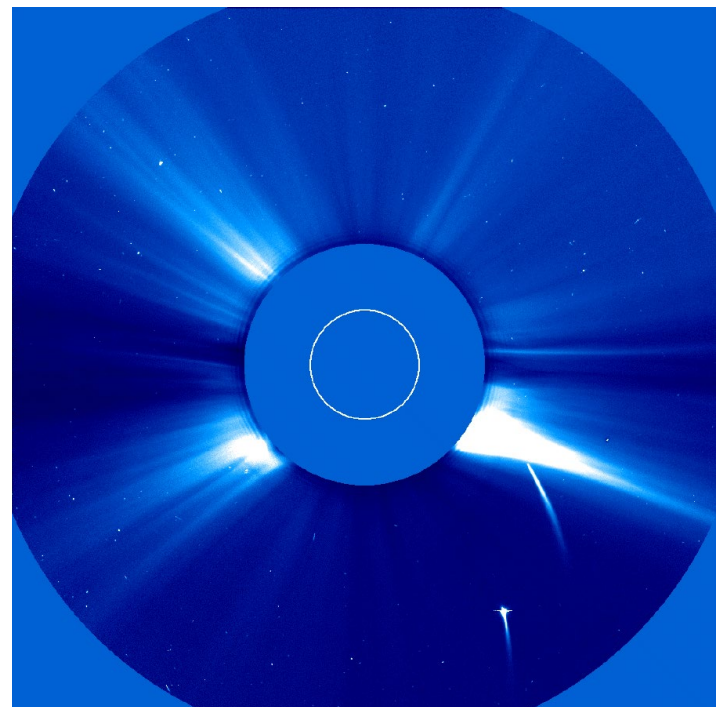
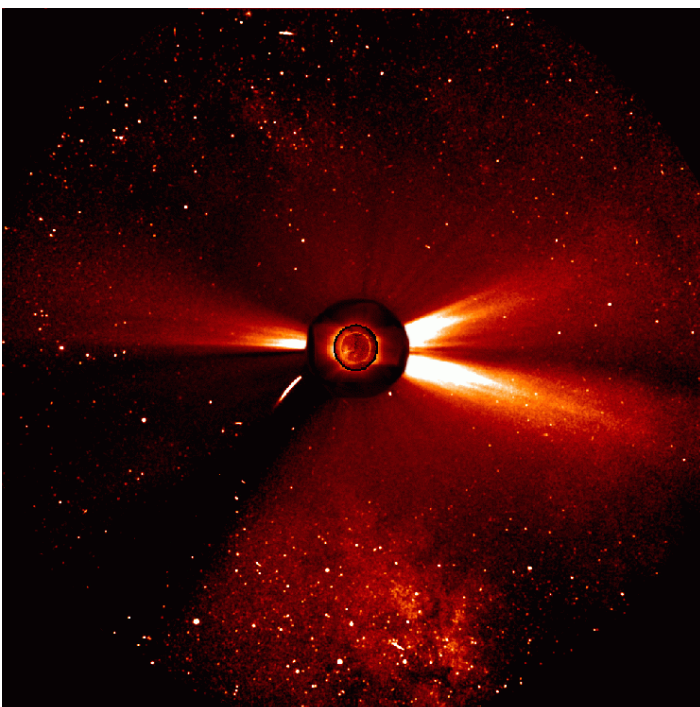
C/1998 K11's Perihelion: 1998 June 2.06,  $q = 0.005$  AU

Various previous "Ice and Stone 2020" presentations have discussed the impact that the joint NASA/ESA Solar and Heliospheric Observatory (SOHO) mission – and in particular the onboard LASCO C2 and C3 coronagraphs – has had on the discoveries of comets. The overwhelming majority of LASCO-discovered comets – over 85% -- are Kreutz sungrazers, two representatives of which have already been "Comets of the Week" and others that will be such in the future; this entire group of comets is the subject of a future "Special Topics" presentation.

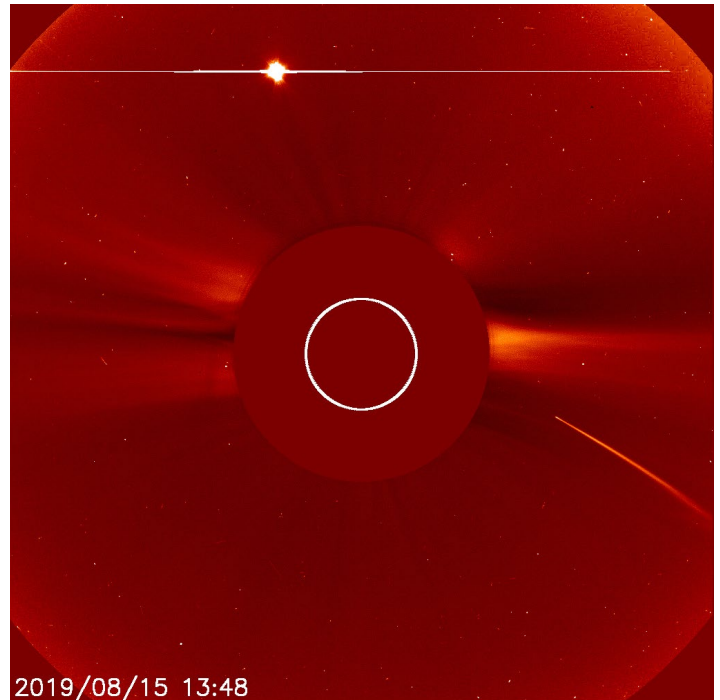
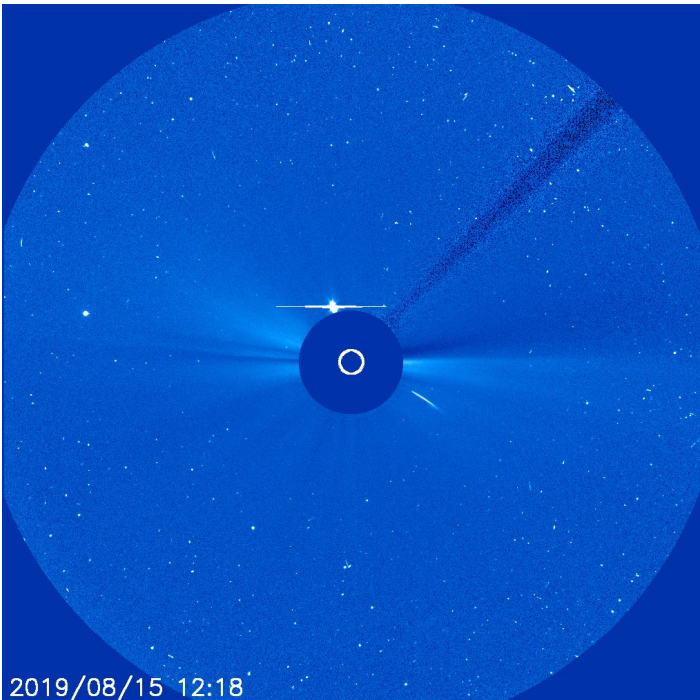
The first Kreutz sungrazer to be discovered by a spacecraft – and, indeed, the first comet of any kind to be so discovered – was found in August 1979 by the SOLWIND coronagraph aboard the U.S. Defense Department's P78-1 satellite; this is a future "Comet of the Week." SOLWIND detected several additional Kreutz sungrazers over the next few years before its destruction in 1985, and meanwhile the coronagraph aboard NASA's Solar Maximum Mission (SMM) spacecraft detected several more sungrazers between 1984 and the time it entered Earth's atmosphere in late 1989.

Ever since SOHO's launch on December 2, 1995, the LASCO coronagraphs have proven especially adept at detecting Kreutz sungrazers. The first such object to be discovered was Comet C/1996 Q2, which was detected by SOHO scientist Shane Stezelberger on August 20, 1996; this was a relatively faint object which never got brighter than 6th or 7th magnitude. The first bright LASCO-discovered sungrazer, C/1996 Y1, was also found by Stezelberger, in C3 images taken on December 22, 1996; over the course of the next day it became quite bright – at least 3rd magnitude, quite possibly brighter – as it entered the C2 field of view and exhibited a bright, curved tail almost two degrees long before disappearing behind the C2 occulting disk and apparently disintegrating. Shortly thereafter the SOHO team released a dramatic movie showing this comet approaching the sun against the rich star fields of the Sagittarius Milky Way, and this was the first public announcement about the comets that LASCO was detecting.

While the first several comet discoveries were made by scientists associated with the SOHO project, since the images taken by the various SOHO instruments are publicly available [on-line](#) various amateur astronomers



LEFT: A montage of images taken by various instruments aboard SOHO. A LASCO C3 image of Comet C/1996 Y1 is to the lower left of the sun. RIGHT: LASCO C2 image of Comets C/1998 K10 (top) and C/1998 K11 on June 1, 1998. The horizontal "spike" through C/1998 K11 is an artifact caused by saturation of the detector. Both images courtesy NASA/ESA.



LASCO C3 (left) and C2 (right) images of one of the most recent bright Kreutz sungrazers, on August 15, 2019. The bright object above the sun is Venus, near superior conjunction. Courtesy NASA/ESA.

from around the world began scanning the LASCO images on a full-time basis, and the number of comet discoveries has skyrocketed. These discoveries have included those made from older archived images, and in fact the earliest-appearing sungrazer that has been found is C/1996 B3, which appeared on January 27, 1996, less than two months after SOHO's launch. At this writing over 3900 comets have been detected in LASCO images, roughly 3400 of these being Kreutz sungrazers; approximately 180 are detected, on average, every year.

Most of the LASCO-discovered sungrazers have been faint objects, barely detectable in the LASCO images. After C/1996 Y1, two of the brightest sungrazers were "the twins," C/1998 K10 and C/1998 K11, that were discovered by SOHO scientist Kevin Schenk in C3 images taken May 30 and 31, 1998, with C/1998 K11 trailing the first comet by about four hours. As they approached the sun over the course of the next day and entered the C2 field of view they both became quite bright and exhibited a bright curving tail up a degree or more in length. As has been true for all LASCO-discovered sungrazers, both comets began fading as they approached the C2 occulting disk and apparently disintegrated after disappearing behind it.

Due to the faintness of most LASCO sungrazers and the brief nature of their appearances, it has been difficult to obtain any physical observations of them. A handful of them have been detected with the UltraViolet Coronagraph Spectrometer (UVCS) instrument aboard SOHO; detailed analysis of the UVCS data of comet C/1996 Y1 suggests that its nucleus is tiny, perhaps no more than six or seven

meters in diameter. Since this was one of the brightest of the LASCO-discovered sungrazers, this in turn would suggest that the majority of these objects are very tiny objects indeed. Analyses of the orbits of these comets suggest that their production is almost a continuous process, and it may be that they are the largest representatives of a "Kreutz meteor stream." If this is the case, this would suggest that, if we had sensitive enough detectors, we would probably be detecting Kreutz "comets" almost continuously.

For obvious reasons, these LASCO-discovered sungrazers are not detectable from the ground, except, theoretically, during a total solar eclipse. As I have described in a previous "[Special Topics](#)" presentation, I have in fact attempted to do so during several previous eclipses, but thus far have been unsuccessful. As also discussed in that presentation, one LASCO-discovered sungrazer, C/2008 O1, was successfully [photographed](#) during the total eclipse on [August 1, 2008](#).

It is unclear at this time how much longer SOHO will be operational. I am hopeful that it can continue operating through at least the total solar eclipse on [April 8, 2024](#), which would seem to provide my best upcoming opportunity to observe one of these LASCO-discovered sungrazers. The coronagraphs aboard the twin Solar TERrestrial RELations Observatory ([STEREO](#)) spacecraft that were launched in October 2006 have also detected near-sun Kreutz sungrazers – although not in the frequency that LASCO has been detecting them – however STEREO-B is no longer operational; presumably STEREO-A might be able to fill in the gap somewhat, if necessary.

# SPECIAL TOPIC: THE K-T EVENT



The K-T boundary layer (light-colored band in center) in a rock collected from Wyoming. Courtesy [San Diego Natural History Museum](#).

For many people, one of the most fascinating periods of Earth's natural history is the Mesozoic Era, which spanned from roughly 252 million years ago to 66 million years ago. This period of time is often called the "Age of Dinosaurs," and indeed these large reptiles were the dominant animals on Earth for well over 150 million years. This era came to a rather abrupt end at the end of the Cretaceous Period 66 million years ago, when the dinosaurs and a significant fraction – approximately three-fourths – of Earth's other biological species disappeared within a (geologically) short period of time. This episode of "mass extinction" is generally referred to as the "K-T Event," the "K" referring to the Cretaceous Period (from its name in

German) and the "T" referring to the Tertiary Period at the beginning of the Cenozoic Era – within which we are now living – although the Tertiary Period is now formally called the Paleogene Period. (The K-T Event is thus more formally the "K-Pg Event.")

Additional mass extinctions have taken place from time to time throughout Earth's natural history. Indeed, the Mesozoic Era began with the largest one of all, at the end of the Permian Period 252 million years ago. During that particular mass extinction – the "Permian-Triassic" event – as many as 70% to 80% of all biological species, including over 90% of marine species, disappeared.



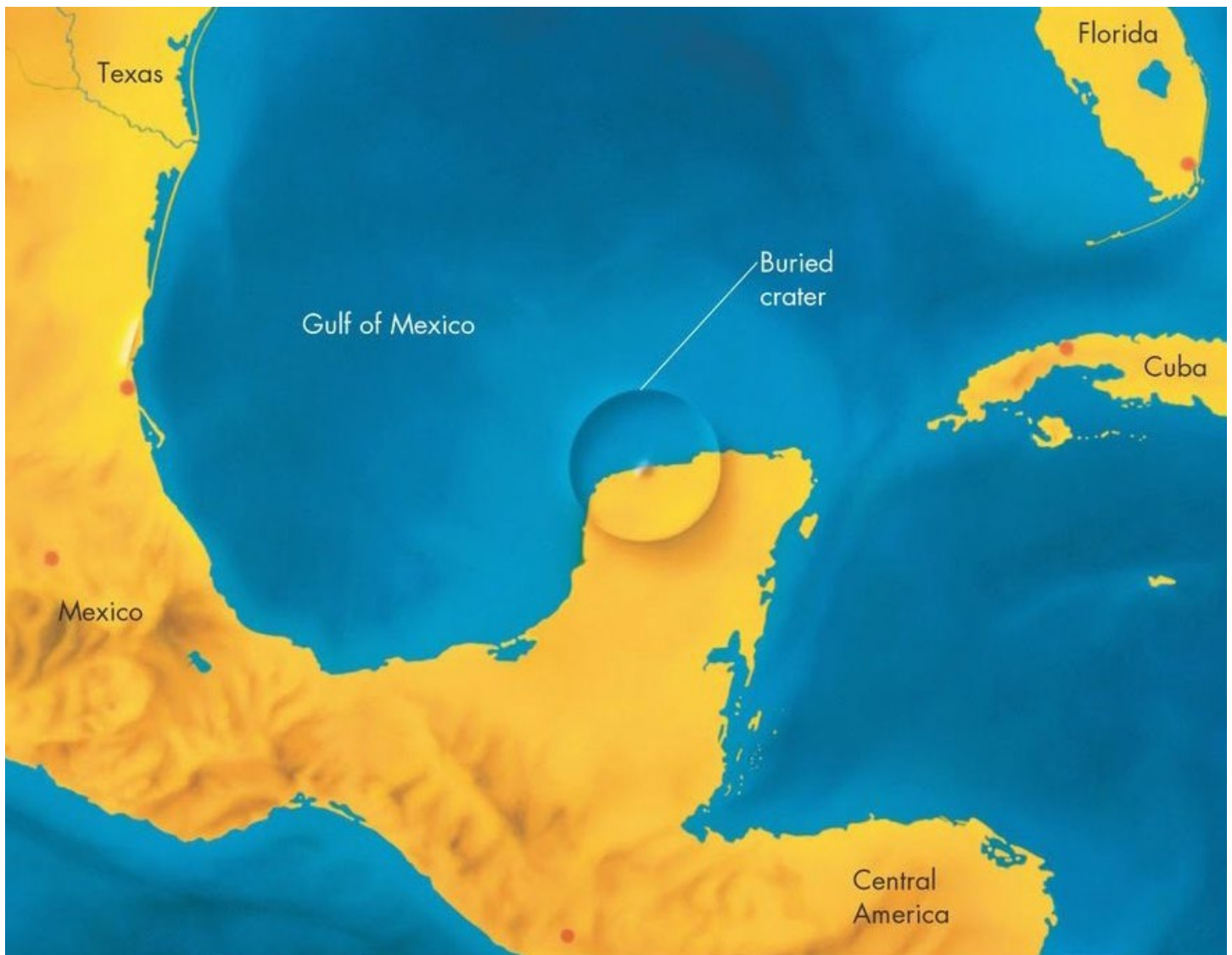
Artist's conception of the K-T impact. Courtesy NASA/Donald Davis.

Although such mass extinctions spelled the end of many of Earth's life forms, at the same time they created opportunities for other species to thrive and eventually become dominant. For example, while the K-T Event brought about the demise of the dinosaurs who had been dominant so long, among the survivors were small, shrew-like mammals. The "hole in nature," as it were, created by the disappearance of the dinosaurs allowed these mammals to thrive and eventually become dominant; we are here as a direct result of that.

The specific cause, or causes, of the K-T mass extinction has long been a matter of much speculation and debate. Global climate change has often been considered at least one of the dominant causes, although what might have precipitated this has in turn engendered additional debate and speculation. A series of massive volcanic eruptions that produced the Deccan Flats region of India and covered that area with volcanic

basalts and other igneous rocks is known to have been occurring at that time, and these would have released massive amounts of dust and greenhouse gases into the atmosphere; these eruptions were widely considered to have been at least partially responsible for creating the conditions that led to the K-T extinction.

During the late 1970s the Nobel Prize-winning physicist Luis Alvarez and his geologist son Walter Alvarez found that sediments around the world that were deposited between those of the Cretaceous and Paleogene Periods are enriched with the metal iridium, sometimes by a factor of several hundred over its natural occurrence. Iridium is, in fact, a very rare metal on Earth's surface, but is much more common in meteorites. From this, the Alverezes concluded that Earth had been struck by a fairly large – 10 km or so – asteroid (or comet) just before the end of the Cretaceous Period, and that it was this event that in turn created the conditions that led to the K-T mass



Location of the Chicxulub impact crater. Copyright Pearson Prentice Hall, Inc.

extinction. Their [paper](#) was published in June 1980 in the journal *Science*.

The Alvarezes' hypothesis created quite a sensation in scientific circles, but as is true for most dramatic scientific ideas it was not especially widely accepted at first. Over the subsequent decade acceptance began to grow as more and more sediments from that time frame were analyzed and as the study of effects of meteorite impacts progressed. Meanwhile, at around this same time two geologists, Glen Penfield and Antonio Camargo, who were conducting survey work for the Mexican state-owned oil company Pemex, began detecting evidence of a large subterranean impact crater underneath the northern coast of the Yucatan peninsula near the village of Puerto Chicxulub. Detailed analyses of this feature over the next few years, conducted in part by American geologist Alan Hildebrand, determined that this crater, 150 km in diameter, dates from the exact same time as the K-T extinction event, and in 1991 Hildebrand and Penfield published their [paper](#)

concluding that the impact that produced the Chicxulub crater was the event hypothesized by the Alvarezes that led to the K-T mass extinction – the “smoking gun,” in popular parlance.

Subsequent study of the Chicxulub crater has continued to reinforce this conclusion, and today the idea that this impact event 66 million years ago created the conditions that led to the K-T extinction, including the demise of the dinosaurs, has gained wide acceptance. According to the general scenario, the impact would have released several hundred million megatons of energy, and would have thrown up large amounts of dust into the atmosphere – to be carried globally by atmospheric winds – as well as instigated large tsunamis. Furthermore, the heat generated by the impacting object's passage through the atmosphere would have ignited forest fires in large areas surrounding the impact site; these in turn would have expelled large amounts of smoke into the atmosphere that also would have been carried globally. The net result would have been a





Fossilized fish from the Hell Creek Formation in North Dakota. Image copyright Robert DePalma.

global shrouding of the sun and widespread global cooling – phenomena sometimes incorporated under the phrase “nuclear winter.” This would have persisted for several years as various biological species up and down the food chain died, creating the mass extinction.

Just a year ago a provocative [paper](#) published by American geologist Robert DePalma describes large numbers of fossils of fish and other biological species at the Hell Creek Formation in North Dakota, that show evidence of these creatures having died on the very day of the Chicxulub impact. Tektites – described in a previous [“Special Topics”](#) presentation – created during the impact apparently rained down upon and were ingested by the creatures, and then a large mass of onrushing water – apparently created by a tsunami generated by the impact – buried them. Much research remains to be performed at this site, but if these conclusions are verified in coming years they can offer valuable insights into the goings-on during the midst of an extinction event.

While acceptance of the idea that the Chicxulub impact led to the demise of the dinosaurs is quite widespread at this time, the idea that this one single event was responsible for the entirety of the K-T mass extinction is not universally accepted. There

is evidence that other, smaller impacts may have occurred within the same general time frame and contributed to the various extinctions, and the contributing effects of the Deccan Traps eruptions are also a matter of debate. Since the Deccan Traps region is almost directly opposite the earth's center from the Chicxulub crater it is conceivable that the impact heated the subterranean magma to such an extent that this contributed to the Deccan Traps eruptions; while these had started before the Chicxulub impact, this event might have greatly increased their strength and their output.

In any event, the realization that an impact event at the end of the Cretaceous Period is at least substantially responsible for the deaths of much of the life on Earth at that time has created a paradigm shift in our understanding of natural history. Prior to that, a “uniformitarian” worldview, i.e., natural history comprises a steady series of gradual changes, was the dominant viewpoint, as opposed to “catastrophism,” i.e., natural history is a series of catastrophic events. The incorporation of the Chicxulub impact and the resulting K-T mass extinction into our understanding of Earth's natural history has shown that these two viewpoints are not mutually exclusive, and in fact catastrophic events like impacts are now recognized as being a regular part of a uniformitarian natural progression. This has been further reinforced in more

recent years by events like the Shoemaker-Levy 9 impacts into Jupiter in 1994 – just three years after the identification of the Chixculub crater as being the impact site, and the subject of a future “Comet of the Week” presentation – as well as the increased discovery rate of Earth-approaching asteroids and comets and a better understanding of the role that impacts have played with other worlds in our solar system.

This increased understanding has in turn led to speculation that other extinction events in Earth's natural history, for example, the one at the end of the Permian Period, may also have been due to impact events, and it is indeed entirely possible that this is true in at least some cases. During the 1980s, as the Alvarez hypothesis was gaining acceptance, some researchers claim to have identified an approximate 26-million-year periodicity in the occurrence

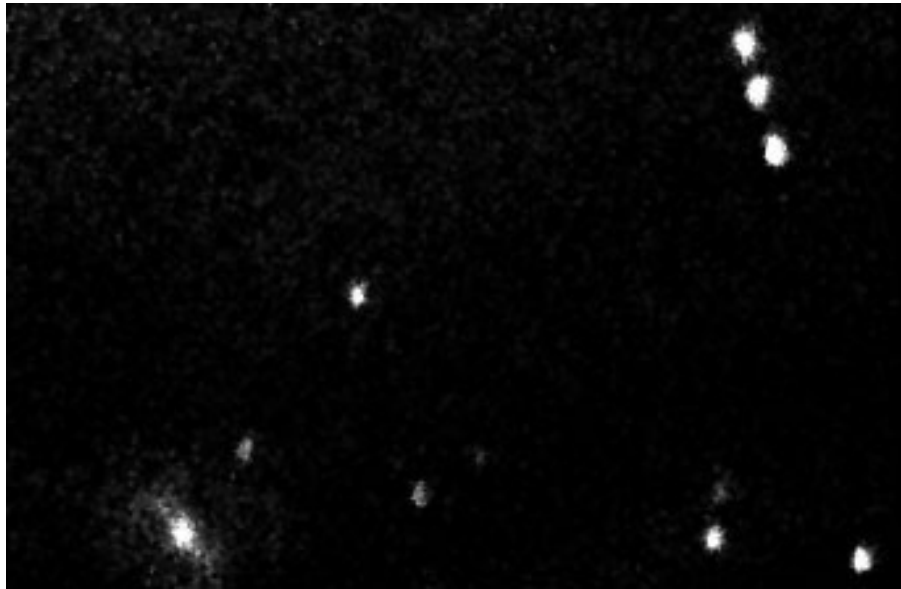
of mass extinctions, and proposed that a distant, possibly sub-stellar, companion of the sun dubbed “Nemesis” would pass through the Oort Cloud at such intervals and send “comet showers” inward towards the inner solar system, thus leading to increased chances of impacts and resulting mass extinctions when they arrived. Other researchers have pointed out that the evidence for this periodicity in extinction events is quite weak, and in the meantime despite comprehensive sky surveys – including in the infrared, where any such object should be readily apparent – no “Nemesis” has been found, and this idea is currently not widely accepted. This notwithstanding, as covered in a previous “[Special Topics](#)” presentation passing stars do on occasion pass through the Oort Cloud, in turn sending potential “comet showers” inward and thereby creating increased risks of large impact events and potential mass extinctions.

There have been efforts over the years to find the source of the Chicxulub impactor. In 2007 some astronomers suggested that an asteroid associated with the main-belt asteroid (298) Baptistina might

have been responsible. According to the scenario, approximately 160 million years ago a fairly large asteroid – perhaps 170 km across – was struck by another, smaller asteroid, with the result being the fragmentation of the larger object into several thousand smaller ones. The largest of these is Baptistina, and the others travel in roughly similar orbits and are collectively are called the “Baptistina family.” (Asteroid “families” are discussed in a future “Special Topics” presentation.) Over time, due to gravitational and other orbital influences, some of these smaller asteroids were perturbed into Earth-

crossing orbits, and eventually one of these found its way to Earth 66 million years ago.

However, a detailed examination of Baptistina and other asteroids in its “family” carried out by the Wide-field Infrared Survey Explorer ([WISE](#)) spacecraft in 2010-11 shows that the asteroid collision event that produced the Baptistina “family” occurred close to 80 million



Three “stacked” CCD images of the main-belt asteroid (298) Baptistina that I took on April 19, 2008. The asteroid is the sequence of three “stars” at the upper right; the galaxy at lower left is MCG -2-34-54.

years ago. Since it normally would take several tens of millions of years for asteroids in the main belt to get perturbed into Earth-crossing orbits, this does not leave enough time for one of the fragments from that collision to make its way to Earth. Whatever struck Earth, then, at the end of the Cretaceous Period would have had to have come from elsewhere.

The increased awareness that has come with our better understanding of the goings-on at the end of the Cretaceous Period and the knowledge that Earth has been repeatedly struck by asteroids and comets throughout its natural history, together with our increased knowledge of the objects still present in near-Earth space, has spawned the realization that, at some point in the future, Earth will be struck again. We would obviously not want the dinosaurs' fate to happen to us, and thus the emphasis on survey programs and other impact-mitigation activities that are discussed throughout “Ice and Stone 2020.” If humanity is to bypass the fate of the dinosaurs, we need to be able to identify and deal with potentially threatening objects, and/or be able to expand into space.

# ASTEROIDS

...are nature's way of asking:



“How’s that space  
program coming along?”

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