SCI FI-ARIZONA
A Virtual Science Fiction Bookstore And Writer's Workshop

Writer's Workshop Series
The Art of Science Fiction
No. 31

The Sky is Falling, Part I
Dinosaur Killer
By
Michael McCollum

For more than a decade, I was a member of the Speakers' Bureau for the American Institute of Chemical Engineers (AIChE). The speakers' bureau is a program where the national headquarters of the AIChE augments their local sections' programs for their monthly meetings by arranging to have out-of-town speakers talk at one or two meetings each year. A typical tour involves the speaker hitting 3-4 local sections during the same week, thereby maximizing the speaker's effectiveness and spreading the expense of the tour over several sections of the AIChE.

For much of my tenure on the tour, I gave a talk on "Rocket Propulsion and Science Fiction Writing, the Art of Matching Propulsion to Plot." This is a humorous look at the problems associated with being a high tech science fiction writer, including such plot problems as "the man-eating frogs of Neptune," and "the Captain, the Professor, and the Professor's daughter." I was continually amazed at the number of spouses of engineers who come up afterwards and tell me how much they enjoyed my talk. Translation: "That wasn't nearly as boring as I thought it would be!"

Eventually, I began to cast about for another subject on which to speak. The subject I chose was "The Sky is Falling: Asteroids, Comets, and the Total Extinction of Life on Earth." And no discussion of the hazards posed by wayward asteroids and comets hitting the Earth would be complete without mentioning the most famous asteroid strike of all time, the Dinosaur Killer.

It has long been known that the great lizards disappeared from the face of the Earth relatively quickly (on the geological scale of time), but most scientists believed that the big

Source: Encyclopedia Brittanica 1986 Science And The Future Yearbook

Figure 1: Dinosaur Killer Asteroid

lizards failed to adapt to a change in the global climate that had taken a million years or more. In 1978, a geologist named Walter Alvarez proposed a more radical explanation for the extinction. He suggested that the dinosaurs did not die out at all. Rather, they were murdered!

Specifically, Alvarez's theory was that a giant asteroid hit the Earth and killed all of the dinosaurs in the space of a single year. To a scientific establishment whose principle dogma was that geological change happens gradually, those were fighting words. Over the last twenty years, however, Alvarez and his team have pretty much proven their point, and the Dinosaur Killer has been adopted by modern culture. The concept has especially caught on in Hollywood, which issued two major motion pictures (*Deep Impact* and *Armageddon*) on the subject. My interest in asteroid impact dates from when I read an article titled, "Giant Meteor Impact" in *Analog Science Fiction Magazine* back in the mid-1960s.

So, I set about researching the problem and produced a fairly interesting talk on the subject. That then, is our subject for this month. We will examine the possibility that the eminent folk philosopher, Chicken Little, may well have been right.

Maybe the sky *is* falling!

Chicken Little and The Ozone Layer

When people meet me on the lecture circuit, they invariably ask for my opinion of the two great ecological crises of our day: global warming and the hole in the ozone layer. This happens so often that I have developed a set routine for answering the question. Looking down at my questioner (I am 6' 5" tall), I smile my most benevolent smile and answer, "I don't think about either of them very much. Frankly, I try not to sweat the small stuff!"

I have gotten so good at it that I can almost always evoke a gasp of surprise or even an expression of mild shock. What? How can someone be so insensitive as to ignore the two biggest problems facing our civilization today? Well, I suppose if they were the two biggest problems, I wouldn't be so cavalier about them. However, as a science fiction writer, I find that I tend to take a longer view of history than many of my fellow baby boomers. I can't help it. It's an occupational hazard.

When you write science fiction, it is just natural to take a longer view of things. That is because we SF writers do not really live in the here-and-now. We are residents (mentally, at least) of whatever century in which our plot takes place. If you are going to live in a future century, then you cannot help but think about how things will change between now and then. At first you begin to extrapolate existing trends into the future, then you begin to think of inventions that might appear in the next 50 decades. Finally, if you cogitate long and hard enough, you start to call yourself a "futurologist."

Personally, I have a fondness for stories that take place approximately 300 years from now. I don't know why, I just do. So I spend a great deal of time designing a society that 1) feels futuristic, 2) doesn't violate any natural laws, the violation of which isn't necessary to the plot, and 3) can be understood by modern readers. Somehow, the problems of global warming and ozone depletion just don't seem to be serious enough to include them in the problems faced by my future people. In fact, I think it makes good

plot sense to turn the conventional wisdom on its ear. Instead of fearing global warming, we should welcome it. Canada and Russia would become the breadbaskets of the planet. As for ozone depletion, if it exists at all, human beings have less to do with it than a single volcano, Mt. Erebus, in Antarctica.

If you happen to be someone who gets a vicarious thrill out of the thought that the world is constantly on the brink of disaster, I certainly do not want to take the excitement out of your life. Therefore, having pooh-poohed your favorite scary scenario(s), let me replace them with something better. Consider what would happen if tomorrow the sun changed its energy output by 2%. If the sun increased its output by two percent, then we would be cooked and the Earth would be turned into a duplicate of that hellhole, Venus. A few percent cooler and the glaciers would march again.

Or if that seems too farfetched, what about the possibility that a rock the size of a football field could crash down without warning onto your head? Don't think it can happen? Think again!

It not only can happen, it *has* happened — more than once.

So, to get into the proper mood, close your eyes for a moment and imagine that it is 65 million years ago…

The Last Day

Imagine that you are standing on the crest of a small hill on what will one day be the Yucatan Coast of Mexico. The time is early morning and the sun is rising out of the sea in front of you. The air is heavy with humidity and the dew covers every surface in a heavy wet blanket. The morning breeze is cool on your cheek, but the day promises to be warm and muggy.

The air has an earthy, green smell to it, and in the distance, you can hear the roar of a Tyrannosaurus Rex hunting its breakfast. You are standing knee-deep in tall grass amid a small scattering of fernlike plants. Overhead, leather-winged flying reptiles ride the thermals that are even now lifting skyward. There is a small blue lake in the valley to your left, and near the far shore, the big grey hump of a Brontosaurus moves sedately as it plucks plants from the bottom of the lake. In short, it seems a typical day in the 160-million-year-long dinosaur era.

Except it is not a typical day. It is the last day!

In the east, where the sun is just rising, there comes a sudden, blinding violet flash of light that outshines a million suns. Every animal that happened to be looking in that direction is instantly blinded as the heat washes over your position, and suddenly, all of the plants explode into flame. Seconds later, you are knocked off your feet by the ground shock as it races outward from the center of the blast. The airborne shockwave is not far behind. When the sonic boom comes, its noise is loud enough to deafen – and to kill!

Suddenly, out to sea, there appears a black line that stretches from horizon to horizon. That line grows swiftly as you watch, expanding into a giant wave that wells up like a great beast before you. The wave continues to grow as it reaches the shoreline, rising to nearly a mile in height as it washes over your small hill and drowns everything around you in a dark, watery grave. The hill remains submerged for hours while a black mushroom-shaped cloud of fire and dust spreads out over the land. Only much later does

the water recede, taking with it the burned-out remnants of a continent-wide forest as it does so.

For this day that began so ordinarily is the day the dinosaurs died. It is the end of their era. When the fire, water, and choking dust finally recede in a few months time, there will be no dinosaurs left alive. After 160 million years of total dominance over the Earth, the great lizards are gone. And with them go half the species that shared the planet with them. God and fate have visited destruction from the sky.

It is not for the first time. It will not be the last.

Dinosaur Killer

The thing that killed the dinosaurs was an asteroid. It measured six miles in diameter and weighed more than one million million (10^{12}) tons. It sliced through the atmosphere at 20 miles per second – 30 times as fast as a speeding bullet! When it hit, it buried itself 20 miles deep into the crust before exploding upward with the force of a 100 million-megaton hydrogen bomb. Let me repeat ... that was *one hundred million megatons!* The asteroid hit with ten thousand times the power of all the nuclear weapons the human race has ever produced.

The destruction was total and widespread. Because it fell near the sea, the asteroid vaporized several cubic miles of solid rock and liquid seawater. It blasted a hole in the Earth that was wider than the Grand Canyon is long. Some of the magma thrown up by the explosion splashed across the face of the moon, and all over the Earth, white-hot molten rock rained down from out of the sky.

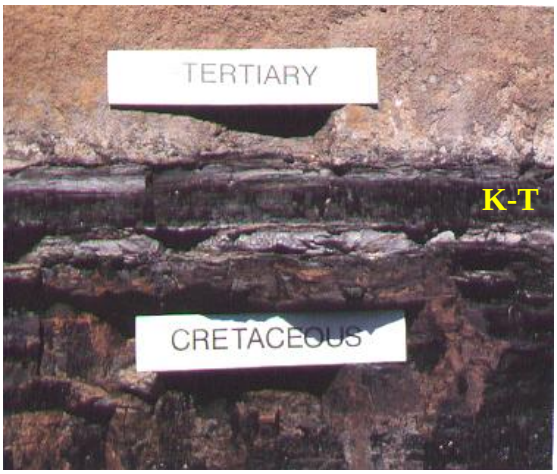

Figure 2: The K-T Layer

The "local" destruction was bad enough. However, the heat, blast, and tidal waves were not the worst of it. The worst came from the deadly pillar of dust that rose into the stratosphere and hung there for long months, blocking out the sun. Without sunlight, the plants died; and without plants, so did the dinosaurs and every other animal bigger than a large rat.

The scientific team that is credited with proving that the dinosaurs were killed by an asteroid was led by the father-son duo of Luis and Walter Alvarez. Walter is a geologist who works at the University of California at Berkeley. Luis Alvarez is a Nobel-laureate physicist at Lawrence Berkeley Laboratory.

The path to discovery began when Walter Alvarez visited the Bottacciani Gorge, in the Apennine Mountains, near the city of Gubbio, Italy. A colleague showed him a thin white layer of clay about one centimeter thick that separates two thick strata of Scaglia (pronounced *Scah-lya*) rossa limestone, a pinkish rock that is prized as a building material. The clay is at the boundary between two major eras of geologic history. These are the Mesozoic ("middle life") Era – the Age of the Dinosaurs – and the Cenozoic

("recent life) Era, the Age of Mammals. More specifically, the clay was deposited at the end of the dinosaur age, in what is known as the Cretaceous Period, and prior to the first age of mammals, the Tertiary Period. The layer of clay is thus known as the K-T Layer (the "K" comes from the German word for Cretaceous). What was interesting about this thin layer was that it seemed to violate one of the most sacred principles of geology.

For virtually the entire history of their science, geologists have held that geological strata are governed by a principle known as "uniformitarianism." This is the belief that nothing much exciting has ever happened in the whole history of the planet. That does not mean that geologists doubt the existence of volcanoes, hurricanes, or tidal waves. It just means that none of these events has been terribly significant in the geological scheme of things. They are localized, transient events that leave no lasting mark on the miles-thick layers of rock that geologists study. Year after year, century after century, millennium after millennium, the rock strata builds in a slow, constant, continuous accumulation, an undisturbed record of the past for anyone who has the knowledge to read it.

The white layer of clay at Gubbio appeared to be an exception to this rule. It was thin, and therefore, should have been laid down over a relatively short period. Yet, geologists had reason to believe that the clay had actually been deposited over many thousands of years. For strata thickness is but one way to measure the age of rocks. Another, more precise method, is to look at the fossils within the rock. They can often date a particular bit of rock closer than other available methods. And the fossils at Gubbio were telling Alvarez something different than was the thin layer of clay.

When you hear the word "fossil," you undoubtedly think of the big-boned skeletons we see in museums. Unfortunately, we have no such skeletons from the end of the age of dinosaurs. In fact, the youngest dinosaur fossil we have is a million years older than the date the K-T layer was laid down. So, we cannot examine the bodies of individual dinosaurs who died in the calamity. We have to infer their fate by indirect means. Luckily, we have an excellent tool for doing so.

There lives at the bottom of the deep oceans a small microscopic organism called the *foraminifera* (or "foram*,"* for short). The forams live down in the dark below where sunlight penetrates the water. When they die, their bodies sink into the sediment, and over the geologic ages, they are turned into limestone. In fact, foram skeletons are the primary constituent of some types of limestone, such as that found in the Bottacciani Gorge at Gubbio. While generally not visible to the naked eye, forams can be spotted in the rock with only a hand magnifier, and studied in detail under a microscope. In fact, forams are so prevalent in limestone that the study of their fossils is an important branch of geology in its own right.

These fossilized microscopic creatures, or *microfossils*, were what caused geologists to question the age of the various layers of Scaglia rossa limestone at Gubbio. For just below the thin white layer of clay, the foram fossils are large and numerous, representing hundreds of different species of the small organisms. The largest of these fossils are a millimeter in diameter and visible to the naked eye.

Yet, a single centimeter higher in the rock strata, the foram fossils are small and scarce, and show none of the species variety that the lower specimen does. As for the layer of clay itself, the forams were virtually non-existent in the clay.

Since the uniformitarian theory holds that such a dramatic change in the nature of these microscopic organisms must take thousands (or millions) of years, the fact that there is so much variability on the two sides of the layer argues that it was laid down over thousands of years. Yet, the thinness of the layer argues just the opposite. Obviously, an experiment was in order to resolve the discrepancy. But what experiment?

Iridium

There are several metals that are even more valuable than gold, all of which belong to what is known as the "Platinum Group." Obviously, platinum is one of these metals, as is Iridium, Element 77. The reason that platinum and iridium are so valuable is that they are very scarce. Metals of the platinum group tend to alloy strongly with iron, and since the Earth's core is nearly 100% iron, most of the planet's supply of platinum and iridium is locked up thousands of miles beneath our feet. Still, platinum and iridium do exist on the Earth. We use both for jewelry and for industrial purposes. However, if the Earth's crust contains only trace amounts of the two metals, where do the jewelers get the raw material to beat into wedding rings?

The answer is that they get it from outer space. Platinum and iridium arrive in meteors and in the microscopic grains of cosmic dust, several hundred tons of which rain down from space each day. Recognizing that the iridium content of the K-T Layer was one method for determining how long it had taken to form, Walter Alvarez contacted his father and arranged to have a sample tested by the nuclear physics department at Berkley. Alvarez's theory was that if the K-T Layer had taken a long time to deposit, then it would have a barely measurable iridium content (from the rain of cosmic dust over thousands of years). If it had been deposited quickly, then there would be no measurable iridium in the sample.

The process of determining the iridium content of the clay is a supremely delicate one involving neutron activation analysis. However, it seemed worthwhile to clear up one of the more puzzling problems in geology, so the Alvarezes and their team set about determining the iridium content of the Gubbio clay. Quantitatively, they expected to find 0.1 parts-per-billion (ppb) of iridium if the clay layer had been deposited over thousands of years, and 0.0 ppb if it had been deposited as quickly as its depth suggested.

They found neither. The first sample they tested showed an iridium content of 3 parts-per-billion, and later samples showed up to 9 ppb — some 100 times the concentration that they expected!

It is not often in science that you set out to measure something and suddenly discover a hundred times the expected concentration. However, with only one sample (the Gubbio clay), Walter Alvarez was afraid that his results were being skewed by a local factor – for instance, by contamination from the iridium in someone's platinum wedding band. Therefore, he set out to find another site somewhere in the world where the K-T Layer was exposed. He found it on the coast of Norway at a place called Stevns Klint.

Something bad happened to the Danish sea bottom of 65 million years ago. The material below the clay layer at Stevns Klint was made of white chalk, a soft limestone, and was full of fossils of all kinds, representing a healthy sea floor teeming with life. However, the clay bed just above was black and smelled of sulfur. There were no fossils

except for fish bones in the clay. This "fish clay" proved that the healthy sea bottom had turned into a lifeless, stagnant, oxygen-starved graveyard, where dead fish slowly rotted in the ocean sediment at the precise time that the dinosaur extinction occurred.

What, Walter Alvarez wondered, if this oxygen-starved ocean was related to the extinctions on land? What if the phenomenon had affected the whole world? With growing excitement, he took his samples from Stevns Klint back to Berkeley where they were tested for iridium content. Sure enough, they also showed very high concentrations compared to what is normal for terrestrial rocks.

Upon realizing that the K-T Layer, far from being confined to Italy, actually spread over the whole Earth, and that the layer was everywhere high in iridium content, Alvarez asked a fundamental question: Where on Earth had all of this iridium come from? The answer, of course, was nowhere on Earth. It had all arrived in a single, giant lump in the form of a massive asteroid. The next question was obvious. How big an asteroid was required to account for the total amount of observed iridium in the clay of the K-T layer?

Assuming an iridium composition typical of that in meteors, and making an assumption about the amount of material in the worldwide K-T Layer, Alvarez came up with his answer. To release that much iridium into the environment, the asteroid would have had to be at least 10 kilometers (6 miles) in diameter!

That is one helluva big rock!

Consider for a moment just how large a 10-km asteroid is. If it were on Earth, it would be taller than Mt. Everest. Assuming it has a spherical shape, something not necessarily the case for asteroids, it would contain 500 cubic kilometers (100 cubic miles) of rock and weighs 10^{12} tons.

Suddenly, the geological mystery had been solved, as had the mystery of what happened to the dinosaurs. A whopping big asteroid happened to them! The extinction had not taken place in a million years, as scientists believed. It had happened in a single year! Uniformitarianism had been proved wrong, at least, in this one case. The variation in foram microfossils was not the result of millions of years of steady evolution. It was a change that had taken place practically overnight. Nor were the microscopic forams the only species affected. Half the species alive had been wiped out by the colossal explosion and resulting tidal wave, including every single kind of dinosaur.

The Crater

If an asteroid fell to earth some 65 million years ago, it must have left a whopping big crater. So where was it? Alvarez knew of numerous craters on the Earth, but none that was the correct age to be created by the Dinosaur Killer. It took ten years to find the crater, and when the information was finally unearthed, it came from an oil company.

In the 1950s and 1960s, the Mexican Oil Company, Pemex, was drilling wells on the Yucatan Peninsula, looking for black gold. Upon examining the results of these explorations, geologists noticed something odd about the strata 3000 feet underground. They found what they believed at the time to be a pocket of hardened volcanic lava. However, taking the results from several wells and running gravity studies over the whole region (a standard method for spotting likely petroleum-bearing formations underground), geologists discovered that a buried crater lay beneath the Yucatan coast. Nor was it an ordinary crater. It was huge, measuring some 300 kilometers (180 miles) in diameter. By studying the cores from their test wells, the oil company geologists put the age of the crater at … you guessed it! … 65 million years.

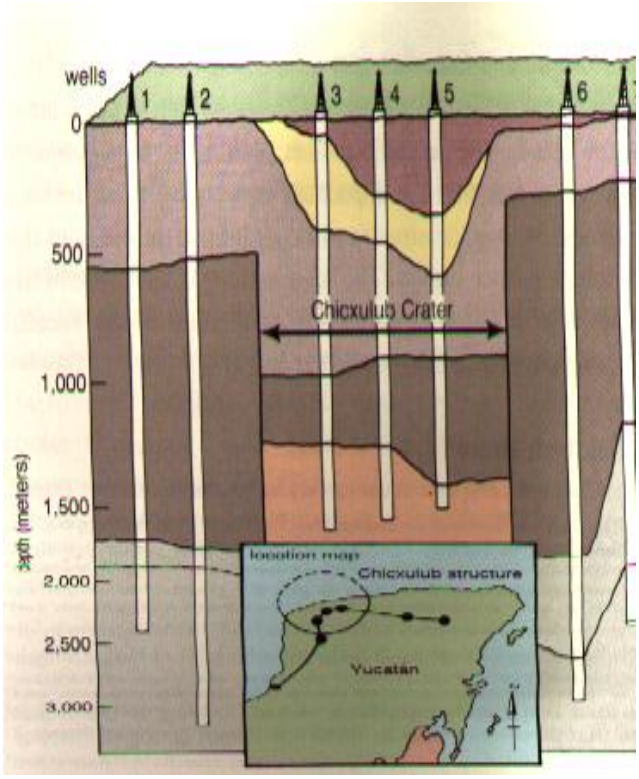

Figure 3: Cross-section of Yucatan Strata from Pemex Discovery Wells

The Chicxulub Crater (pronounced *Cheek-hoo-lube)* is named for the Mexican village near its center. Though invisible on the surface, when we use our instruments to look 3000 feet straight down, we discover one of the most impressive geological features on the face of the Earth. In fact, were it visible, Chicxulub would surpass the Grand Canyon in both grandeur and size.

Figure 3 shows the cross-section of the strata in the area as discovered by the cores from the Pemex exploratory wells. Note that several million years of worth of rock strata are missing from the interior of the crater. Obviously, something happened on that spot to erase a few geological ages worth of history.

Despite the fact that the Pemex survey predates Alvarez's theory, it took until 1990 to find the crater. The reason for this was the oil company geologists, unlike their university counterparts, consider their findings to be classified. That is because their

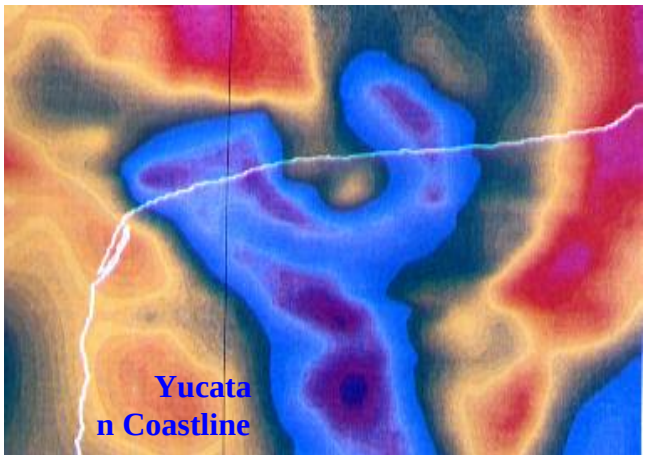

Figure 4: Gravity Gradient of Yucatan Peninsula

employers regard geological data as a form of wealth, which it is, considering the expenditures the oil company makes to obtain the data in the first place.

So, thirty years after they were first taken, scientists went looking for the core samples from the Yucatan wells. Guess what? They couldn't find them. The problem was that the warehouse in which they were stored had burned down in the interim. For a long time, it was thought that they were lost. However, they turned up later and were invaluable in proving that the buried crater was from an asteroid strike.

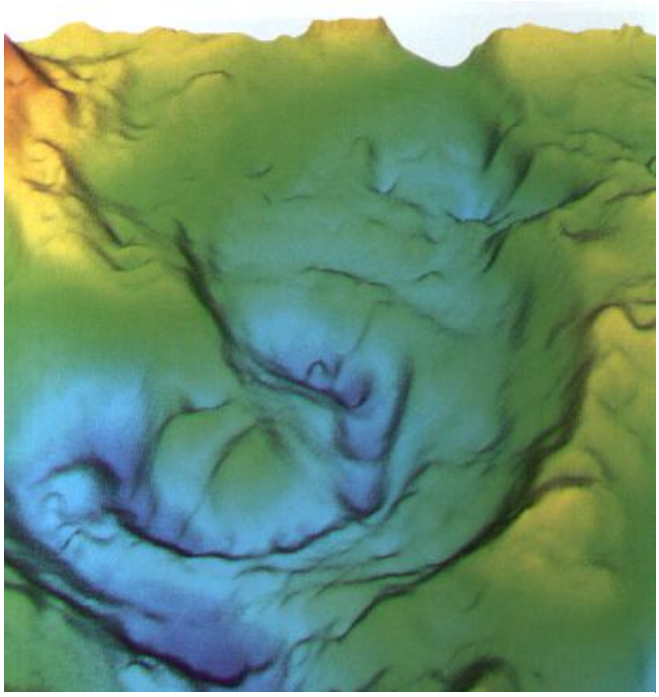

Figure 5: 3-D Computer Plot Showing Chicxulub Crater Profile

Figure 4 shows the results of the gravity survey performed by the oil company. Note the circular structure of the crater, which is nearly 50% intact, and the diagonal line marking the modern shoreline of Yucatan. Figure 5 shows a three-dimensional computer rendition of this same data, while Figure 6 shows a plot of iridium concentration versus rock depth through the Cretaceous-Tertiary boundary. The blue area at the top of the graph represents the iridium concentration. Note that nowhere else in the whole strata is there a similar concentration. This indicates that the iridium is associated with the K-T Strike, and is not due to a recurring terrestrial cause.

Nor is the crater data the only evidence we have. For in addition to digging a large hole, the asteroid generated a tsunami that was at least a mile high when it went ashore in Texas. The tsunami left an indelible mark on the geology of Northern Mexico and Texas. There are numerous sites surrounding Yucatan where limestone formed by deep-sea sediments is mixed with bits of petrified wood and spherules of shock melted glass. The petrified wood is the result of burning forests being submerged by the wave and then pulled out to sea as it retreated.

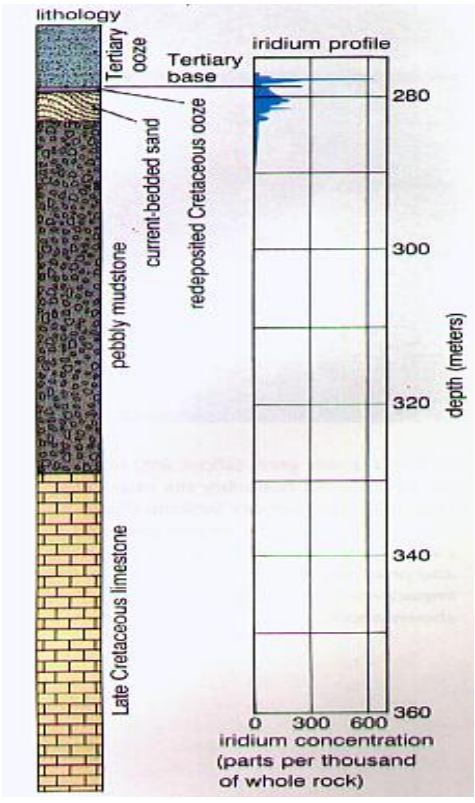

Figure 6: Iridium Profile in Strata

An Occasional Catastrophe can be a Good Thing

The day the asteroid fell from the sky was definitely a bad day for the dinosaurs!

It was not, however, a bad day for everyone. The day the Dinosaur Killer landed was actually a good day for the human race. That is because our ancestors were among the small rat-sized creatures that survived the calamity. Had the asteroid not killed the dinosaurs – thereby clearing out their ecological niche for mammals – it is unlikely that the human race would ever have evolved. When you say your prayers tonight, you might want to give thanks for that errant chunk of rock that fell from the Yucatan sky some 65 million years ago.

This brings to mind an interesting question. Who, do you suppose will benefit the next time the Earth finds itself in the way of one of the hurtling mountains from outer space? Will the next strike be a bad day for human beings, and a good day for the cockroaches? (They survived the last couple of strikes, so there is no reason to believe they won't survive the next one.)

Asteroid strikes have occurred periodically throughout the history of our planet and are likely to continue into the distant future. That is, unless we humans do something to remedy the situation. Nevertheless, recognizing that the hazard exists is only half the battle. Before we can get excited about the problem, we have to quantify just how much risk there is. Do we need to worry, or can we continue on, blissfully ignorant of what lies just over our heads?

We will take up that question and more in our next installment of "The Sky is Falling." In the meantime, if the sky is clear where you live, you might want to go outside and look up into the heavens. If a large asteroid is near, it will appear to be a star that crosses the sky with the speed of an airplane. If you spot such a light, try not to worry. It is probably just the Mir Space Station, or the Space Shuttle, or a big satellite.

And even if the light is an inbound asteroid on a collision course with Earth, try not to get upset. You don't want to die tensed up!

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The End

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The Makers searched for the secret to faster-than-light travel for 100,000 years. Their chosen instruments were the Life Probes, which they launched in every direction to seek out advanced civilizations among the stars. One such machine searching for intelligent life encounters 21st century Earth. It isn't sure that it has found any...

2. Procyon's Promise - ^{US}$7.50

Three hundred years after humanity made its deal with the Life Probe to search out the secret of faster-than-light travel, the descendants of the original expedition return to Earth in a starship. They find a world that has forgotten the ancient contract. No matter. The colonists have overcome far greater obstacles in their single-minded drive to redeem a promise made before any of them were born...

3. Antares Dawn - US$6.00

When the super giant star Antares exploded in 2512, the human colony on Alta found their pathway to the stars gone, isolating them from the rest of human space for more than a century. Then one day, a powerful warship materialized in the system without warning. Alarmed by the sudden appearance of such a behemoth, the commanders of the Altan Space Navy dispatched one of their most powerful ships to investigate. What ASNS Discovery finds when they finally catch the intruder is a battered hulk manned by a dead crew.

That is disturbing news for the Altans. For the dead battleship could easily have defeated the whole of the Altan navy. If it could find Alta, then so could whomever it was that beat it. Something must be done…

4. Antares Passage - US$7.50

After more than a century of isolation, the paths between stars are again open and the people of Alta in contact with their sister colony on Sandar. The opening of the foldlines has not been the unmixed blessing the Altans had supposed, however.

For the reestablishment of interstellar travel has brought with it news of the Ryall, an alien race whose goal is the extermination of humanity. If they are to avoid defeat at the hands of the aliens, Alta must seek out the military might of Earth. However, to reach Earth requires them to dive into the heart of a supernova.

5. Antares Victory – First Time in Print – US$7.50

After a century of warfare, humanity finally discovered the Achilles heel of the Ryall, their xenophobic reptilian foe. Spica – Alpha Virginis – is the key star system in enemy space. It is the hub through which all Ryall starships must pass, and if humanity can only capture and hold it, they will strangle the Ryall war machine and end their threat to humankind forever.

It all seemed so simple in the computer simulations: Advance by stealth, attack without warning, strike swiftly with overwhelming power. Unfortunately, conquering the Ryall proves the easy part. With the key to victory in hand, Richard and Bethany Drake discover that they must also conquer human nature if they are to bring down the alien foe …

6. Thunderstrike! - US$7.50

The new comet found near Jupiter was an incredible treasure trove of water ice and rock. Immediately, the water-starved Luna Republic and the Sierra Corporation, a leader in asteroid mining, were squabbling over rights to the new resource. However, all thoughts of profit and fame were abandoned when a scientific expedition discovered that the comet's trajectory placed it on a collision course with Earth!

As scientists struggled to find a way to alter the comet's course, world leaders tried desperately to restrain mass panic, and two lovers quarreled over the direction the comet was to take, all Earth waited to see if humanity had any future at all…

7. The Clouds of Saturn - US$7.50

When the sun flared out of control and boiled Earth's oceans, humanity took refuge in a place that few would have predicted. In the greatest migration in history, the entire human race took up residence among the towering clouds and deep clear-air canyons of Saturn's upper atmosphere. Having survived the traitor star, they returned to the all-too-human tradition of internecine strife. The new city-states of Saturn began to resemble those of ancient Greece, with one group of cities taking on the role of militaristic Sparta...

8. The Sails of Tau Ceti – US$7.50

Starhopper was humanity's first interstellar probe. It was designed to search for intelligent life beyond the solar system. Before it could be launched, however, intelligent life found Earth. The discovery of an alien light sail inbound at the edge of the solar system generated considerable excitement in scientific circles. With the interstellar probe nearing completion, it gave scientists the opportunity to launch an expedition to meet the aliens while they were still in space. The second surprise came when *Starhopper's* crew boarded the alien craft. They found beings that, despite their alien physiques, were surprisingly compatible with humans. That two species so similar could have evolved a mere twelve light years from one another seemed too coincidental to be true.

One human being soon discovered that coincidence had nothing to do with it...

9. Gibraltar Earth – First Time in Print — $7.50

It is the 24th Century and humanity is just gaining a toehold out among the stars. Stellar Survey Starship *Magellan* is exploring the New Eden system when they encounter two alien spacecraft. When the encounter is over, the score is one human scout ship and one alien aggressor destroyed. In exploring the wreck of the second alien ship, spacers discover a survivor with a fantastic story.

The alien comes from a million-star Galactic Empire ruled over by a mysterious race known as the Broa. These overlords are the masters of this region of the galaxy and they allow no competitors. This news presents Earth's rulers with a problem. As yet, the Broa are ignorant of humanity's existence. Does the human race retreat to its one small world, quaking in fear that the Broa will eventually discover Earth? Or do they take a more aggressive approach?

Whatever they do, they must do it quickly! Time is running out for the human race…

10. Gibraltar Sun – First Time in Print — $7.50

The expedition to the Crab Nebula has returned to Earth and the news is not good. Out among the stars, a million systems have fallen under Broan domination, the fate awaiting Earth should the Broa ever learn of its existence. The problem would seem to allow but three responses: submit meekly to slavery, fight and risk extermination, or hide and pray the Broa remain ignorant of humankind for at least a few more generations. Are the hairless apes of Sol III finally faced with a problem for which there is no acceptable solution?

While politicians argue, Mark Rykand and Lisa Arden risk everything to spy on the all-powerful enemy that is beginning to wonder at the appearance of mysterious bipeds in their midst…

11. Gibraltar Stars – First Time in Print — [US]$7.50

The great debate is over. The human race has rejected the idea of pulling back from the stars and hiding on Earth in the hope the Broa will overlook us for a few more generations. Instead, the World Parliament, by a vote of 60-40, has decided to throw the dice and go for a win. Parliament Hall resounds with brave words as members declare victory inevitable.

With the balance of forces a million to one against *Homo sapiens Terra*, those who must turn patriotic speeches into hard-won reality have their work cut out for them. They must expand humanity's foothold in Broan space while contending with a supply line that is 7000 light-years long.

If the sheer magnitude of the task isn't enough, Mark and Lisa Rykand discover they are in a race against two very different antagonists. The Broa are beginning to wonder at the strange two-legged interlopers in their domain; while back on Earth, those who lost the great debate are eager to try again.

Whoever wins the race will determine the future of the human species… or, indeed, whether it has one.

12. Gridlock and Other Stories - US$6.00

Where would you visit if you invented a time machine, but could not steer it? What if you went out for a six-pack of beer and never came back? If you think nuclear power is dangerous, you should try black holes as an energy source — or even scarier, solar energy! Visit the many worlds of Michael McCollum. I guarantee that you will be surprised!

Non-Fiction Books

13. The Art of Writing, Volume I - US$10.00

Have you missed any of the articles in the Art of Writing Series? No problem. The first sixteen articles (October, 1996-December, 1997) have been collected into a book-length work of more than 72,000 words. Now you can learn about character, conflict, plot, pacing, dialogue, and the business of writing, all in one document.

14. The Art of Writing, Volume II - US$10.00

This collection covers the Art of Writing articles published during 1998. The book is 62,000 words in length and builds on the foundation of knowledge provided by Volume I of this popular series.

15. The Art of Science Fiction, Volume I - US$10.00

Have you missed any of the articles in the Art of Science Fiction Series? No problem. The first sixteen articles (October, 1996-December, 1997) have been collected into a book-length work of more than 70,000 words. Learn about science fiction techniques and technologies, including starships, time machines, and rocket propulsion. Tour the Solar System and learn astronomy from the science fiction writer's viewpoint. We don't care where the stars appear in the terrestrial sky. We want to know their true positions in space. If you are planning to write an interstellar romance, brushing up on your astronomy may be just what you need.

16. The Art of Science Fiction, Volume II - US$10.00

This collection covers the *Art of Science Fiction* articles published during 1998. The book is 67,000 words in length and builds on the foundation of knowledge provided by Volume I of this popular series.

17. The Astrogator's Handbook – Expanded Edition and Deluxe Editions

The Astrogator's Handbook has been very popular on Sci Fi – Arizona. The handbook has star maps that show science fiction writers where the stars are located in space rather than where they are located in Earth's sky. Because of the popularity, we are expanding the handbook to show nine times as much space and more than ten times as many stars. The expanded handbook includes the positions of 3500 stars as viewed from Polaris on 63 maps. This handbook is a useful resource for every science fiction writer and will appeal to anyone with an interest in astronomy.

