SAN DIEGO COUNTY

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WEDNESDAY, DECEMBER 5, 1990

Dinosaur Impact Theory Broadened by Scientists

■ Extinction: Several objects may have hit the Earth, they say at conference on the beasts' demise.

By LINDA ROACH MONROE
TIMES STAFF WRITER

SAN FRANCISCO—The comet or asteroid that killed off the dinosaurs may actually have been several extraterrestrial objects, or the remnants of a single one that shattered and sent pieces ricocheting through the atmosphere and back down to Earth, scientists supporting the impact theory of extinction said Tuesday.

Either way, recent finds of crater remnants leave little doubt that there is more than one impact 65 million years ago to look for, they said.

"A few years ago, our problem was that we didn't have any craters to point our fingers at, whereas now we've got several," said Walter Alvarez of UC Berkeley. "So now, maybe instead of a smoking gun we've got a smoking firing squad."

Although Alvarez and others at the meeting contend there is little doubt that the dinosaurs were killed off by a large impact on the Earth, some scientists in other fields continue to favor volcanism or gradual climatic change as possibilities for the mass extinctions. Either volcanoes or a significant cooling of the atmosphere, they argue, could have blocked sunlight with ash and dust, causing plants and the animals that depend on

Please see DINOSAURS, A32

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- Thick clouds of nitrogen oxides formed, resulting in an acid rain that killed land plants, plankton and the animals dependent on them. Recent studies of sediments from the time show abnormally high amounts not only of nitrogen oxides, but also of strontium and heavy metals, which are leached from rocks by acid rain, said Ronald G. Prinn, of Massachusetts Institute of Technology.
- Even small impacts could have had large planetary effects if an object hit the Earth at an oblique angle, sending pieces skipping across the surface and ricocheting into orbit and back again. Experiments shooting rocks from a special air gun at 2.7 miles per second showed there could be as many as 1,000 impacts from a single object in this way, said Peter H. Schultz of Brown University.

Only multiple impacts or perhaps a double asteroid would explain the sometimes contradictory evidence scientists are reading in rocks formed since then, Alvarez said.

He noted that Jet Propulsion Laboratory images taken last year of an asteroid that closely approached the Earth show it to be a double asteroid—two half-mile-wide objects that orbit each other, almost touching.

"It appears that multiple objects are not all that uncommon," Alvarez said. "I think it's really interesting that the first time anybody has taken a close-up photograph of an asteroid it turns out to be a double one."

The need to investigate multiple-impact mechanisms comes about because recent studies have suggested strongly the existence of three separate candidates for the "smoking gun" crater: A crater in Iowa, a buried crater on a beach in the Yucatan Peninsula of Mexico and a suspected undersea crater off Colombia, he said.

Furthermore, the University of Arizona research team that identified the Yucatan and Colombia sites also found evidence in Haiti of an ocean impact. The sediments contained glass-like beads whose composition indicated they came from ocean crust—indicating an ocean impact by an extraterrestrial object.

However, no crater has been found, and locating one would be particularly difficult under water, said William Boynton, a member of the Arizona group.

An ocean impact might leave no evidence at all, said Brown University's Schultz. His group's air-gun experiments found that, when the object was shot into water, it left very little cratering, he said.

Daily Universe
Tues. Feb 24 1984

ientists link star, ehistoric extinction

KLEY, Calif. (UPI) — Sci- an uncharted "deathstar" ersed the earth with comets years ago probably rid the inosaurs and other prehis- ns of life. It will happen said, but not for another years.

port to the Lawrence Ber- oratory, the researchers University of California at said they used evidence ars metals and ancient ers dotting the earth to ay certain species of life o extinct at regular inter- the past hundreds of mil- ears.

ntists describe the star as a or smaller star, which orbits a companion to the sun and million years to complete one ey conceded they have only evidence that the star exists.

Greek's Nemesis

want to call the star "Neme- the Greek goddess who "re- y persecutes the excessively nd and powerful." They also re is no immediate cause for because the next shower of s not due for about 15 million

theory was contained in two ubmitted to the international journal Nature. The report astrophysicist Richard A. eologist Walter Alvarez and astronomers Marc Davis, all of Berkeley, and Piet Hut, who normally is attached to Princeton University's Institute for Advanced Study.

Alvarez, a Nobel laureate, and associates who include his son, Walter, and other nuclear scientists have spent the past five years analyzing the rare metallic element iridium lying in layers within the earth's crust. They have found evidence of the layers throughout the world and have dated the deposits at two distinct geologic periods.

One was about 65 million years ago and the other about 230 million years ago.

Comets collide

Each time a burst of comets collides with earth, the scientists say, the planet is plunged into a period of darkness and cold that may extinguish anywhere from 20 percent to 70 percent of all plants and animals existing at the time.

Once the catastophe is ended, new families and species emerge, the researchers say. They are convinced their theory will eventually settle arguments over why earth's dinosaurs disappeared abruptly some 65 million years ago.

The comets are unleashed on the sun and its planets, they believe, when the star's orbit is closest to earth, or 3 trillion miles away. The star is now at the farthest point of its orbit around the sun, or 14 trillion miles away.

Daily Universe Monday March 5 1984

Fossil evidence show comet killed dinosaur

WASHINGTON (UPI) - Armed with support from new fossil finds, a California research team says scientists should now accept the idea that a comet or asteroid collided with Earth 65 million years ago and wiped out dinosaurs and many other life forms.

"There is by now a large amount of detailed astronomical, geological, paleontological, chemical and physical information which supports the impact theory," Walter Alvarez, a geologist at the University of California at Berkeley, said in a report in the journal Science.

He and his father, Luis Alvarez, at the Lawrence Berkeley Laboratory, developed the global catastrophe theory four years ago on the basis of a jump in the element iridium in sediments formed at the end of the [illegible] taceous Period, 65 million years [illegible]

Iridium is 1,000 times more abundant in extraterrestrial material [illegible] on Earth, suggesting the extra [illegible] dium came in the form of [illegible] strewn about by the impact of a gi[illegible] tic meteorite.

A refinement of the idea propo[illegible] last month suggested that a my[illegible] rious star companion to the sun [illegible] responsible for sending a comet [illegible] ward the Earth.

The impact of the comet strik[illegible] the earth is believed to have kicked [illegible] a global dust cloud that blocked [illegible] sunlight for months, suppressing [illegible] photosynthetic processes by wh[illegible] plants grow and eliminating food s[illegible] plies for many creatures.

boundary layer contained 6 parts per billion of iridium, 30 times the amount in the limestone.

More Findings

New Zealand samples showed 20 times more iridium in the boundary layer than in surrounding strata. And the Danish samples showed a 160-fold difference.

Such concentrations of iridium in the earth's surface at the time of the dinosaur extinction are much too high to have resulted from ordinary settling of meteoritic dust, the chemical society pointed out.

"Alvarez and his coworkers propose, therefore, that they (high iridium concentrations) resulted from a collision of the earth with an asteroid that was characteristically high in iridium. They figure the body would have been about 10 kilometers (6 miles) in diameter," the society reported.

It explained that dust from the asteroid and its impact crater would be tossed into the stratosphere and remain there for several years, reducing the amount of sunlight reaching the earth.

Photosynthesis would thus be suppressed, dooming many species of plants and animals, including the dinosaur. Some species would survive, however to carry on after the dust settled.

Settles to Earth

Seeds and roots would survive in the ground. Small animals and other organisms could have found sufficient food. And, as the dust finally drifted to earth, iridium from the asteroid would deposit in the Cretaceous-Tertiary boundary, then forming at the surface.

The Alvarez findings have been generally confirmed by analysis of the boundary layer in Spain by J. Smit, geologist at the Geological Institute in Amsterdam, and Belgian geochemist J. Hertogen, the society said. The two scientists found iridium concentrations 50 times normal in the boundary layer.

Doomed Dinosaur

Special to The Tribune

WASHINGTON — What happened to the dinosaurs about 65 million years ago?

There have been many theories but, for the first time, "solid physical evidence" now suggests the mammoth beasts (and up to 75 percent of other species on earth at the time) vanished in the wake of a collision of the earth with an asteroid, the American Chemical Society has reported.

The evidence, it said, has been found in sediments marking the geologic strata of the Cretaceous-Tertiary boundary, which comprised the earth's surface during the period of the "great extinction."

Walter Alvarez and coworkers at the University of California, Berkeley, have found abnormally high concentrations of iridium in that boundary strata, the society said.

Meteorite Dust?

Iridium is a heavy metal in the platinum group, far less abundant in the earth's crust than in smaller bodies of the solar system. The probable reason, some scientists speculate, is that the earth's original supply of the heavy element has become concentrated at the core because of gravity.

In fact, there is evidence that the iridium now in the earth's crust was deposited largely in dust from meteorites passing through the earth's atmosphere, the report noted.

The Alvarez group first analyzed samples from the Italian site, where the Cretaceous-Tertiary boundary is a layer of clay about one centimeter thick. The scientists found much less than one part per billion of iridium in the limestone layer above the boundary layer and expected to find about the same concentration in the boundary clay.

Surprisingly, the boundary layer contained 6 parts per billion of iridium, 30 times the amount in the limestones.

Asteroid May Have Doomed Dinosaur

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DINOSAURS

Continued from A1
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But it was the extinction theory that took center stage at the American Geophysical Union conference here. Alvarez was the keynote speaker during a day of scientific sessions on the idea that he and his late father, Luis, helped originate.

A succession of researchers at the meeting—none opposing the impact theory—detailed their findings:

- A rain of sand-size particles so hot that unprotected animals would have been broiled in their tracks pelted Earth. A computer study at the University of Arizona concluded that the cloud easily could have spread worldwide.
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More support for the theory that asteroids caused . . .

The demise of the dinosaurs

By Walter Sullivan
N.Y. Times News Service

NEW YORK — New evidence has been found supporting the view that 65 million years ago the earth was struck by an asteroid whose explosive disintegration spread debris over much, if not all, of the planet. Such an event has been blamed for mass extinctions that occurred about that time, including the demise of the dinosaurs.

The new finding concerns properties of the element osmium found by researchers at a number of sites around the earth in the layers of sediment laid down at that time, a turning point in evolution at the end of the Cretaceous Period.

The presence of osmium, and particularly of large amounts of iridium, in those layers has been taken as evidence that an asteroid impact caused the extinctions. Iridium is rare on the earth but relatively common in meteorites and, presumably, asteroids.

Osmium that has been found by researchers at a number of sites around the earth in the layer marking the transition from the Cretaceous to the Tertiary Period has proved more typical of that from meteorites or from deep within the earth than of the osmium that is found in the earth's crust.

Dr. Karl K. Turekian, head of Yale University's geology department, and Dr. Jean-Marc Luck, a postgraduate student at Yale, reported in the Nov. 11 issue of the journal Science that they had analyzed the osmium from the layer at two localities — Stevns Klint in Denmark and the Raton Basin in Colorado.

"The simplest explanation" of the results, they said, is that both samples are from one or more meteorites."

The osmium analyses were done to determine the percentages of various isotopes within it. Isotopes are slight variants of an element that differ in the composition of their atomic nuclei; all isotopes of each element contain the same number of protons, which determine the electric charge of their nuclei and therefore their chemical behavior. The nuclei also contain neutrons with no electric charge, and the varying number of neutrons accounts for slight differences in the weight of each isotope.

Osmium-187 [illegible] particles (76 protons and 111 neutrons) whereas [illegible]

within the earth the two isotopes occur in roughly equal abundances, whereas in crustal rocks osmium-187 is from 13 to 30 times more abundant.

Colorado one it was 1.29. While these ratios are higher than those in meteorites it was suggested that contamination with osmium from the earth's [illegible]

[illegible] origin for the [illegible] volcanic activity [illegible]

The Yale scie[illegible]

THE BEGINN

When Worlds Col

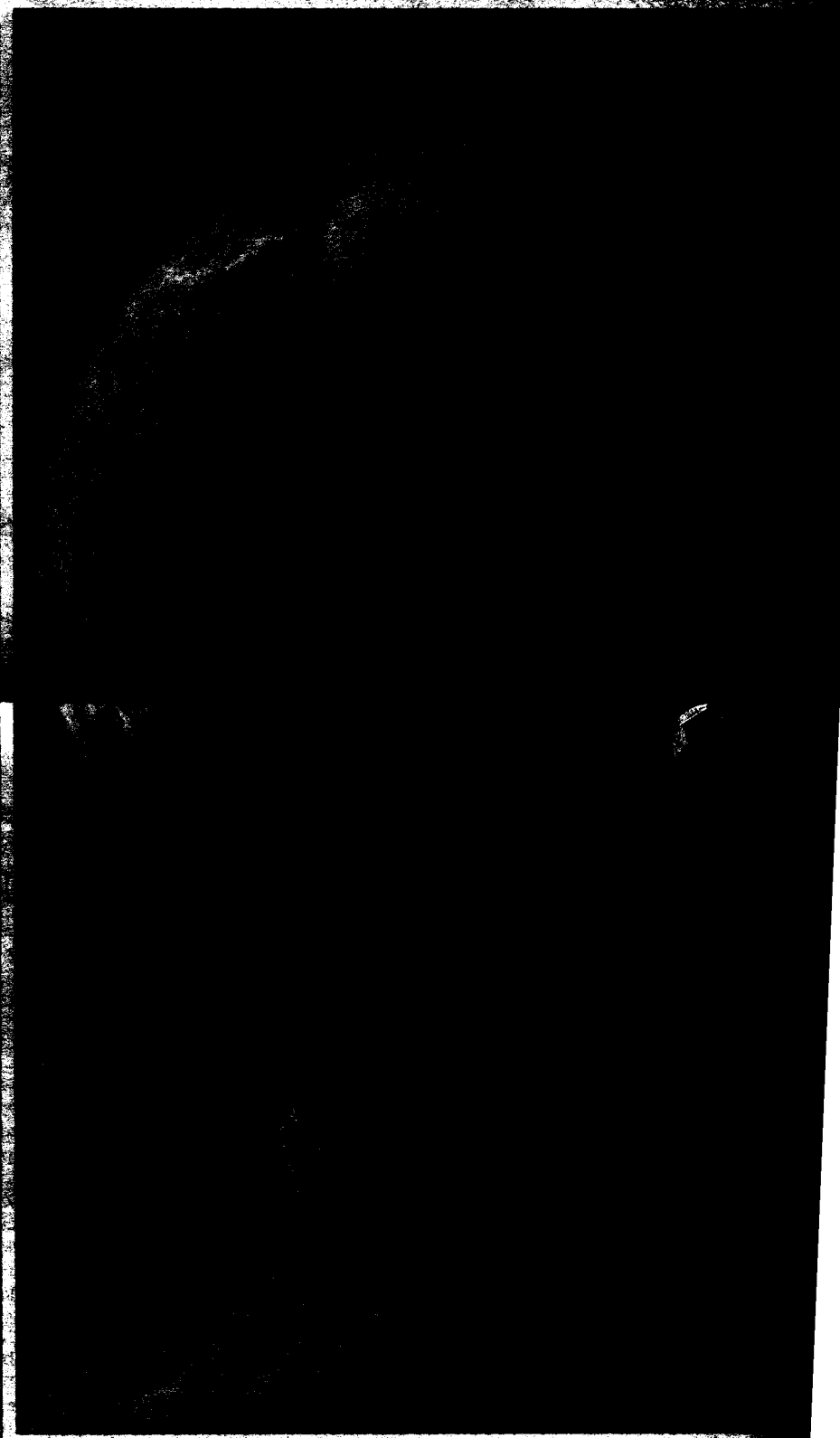
THERE'S SOMETHING FUNNY ABOUT Saturn. When, in 1610, Galileo used the world's first astronomical telescope to view the planet—then the most distant world known—he found something very peculiar. There seemed to be an appendage on either side, which he likened to "handles" and other astronomers to "ears." The cosmos holds many wonders, but a planet with jug ears was perplexing. Galileo went to his death with this bizarre matter unresolved.

As the years passed, observers found the "ears" dwindling and then reasserting themselves. Eventually, it became clear that what Galileo had discovered was a thin ring, which surrounded Saturn at its equator but touched it nowhere. In some years, because of the changing positions of Earth and Saturn in their orbits, the ring had been seen edge-on and seemed to disappear. In other years, it had been viewed more face-on, and the "ears" grew bigger. But what was it? A flat, solid plate with a hole cut out for the planet to fit into? We now know that the rings of Saturn are a vast horde of tiny worlds, each on its separate orbit, each bound to Saturn by the giant planet's gravity. In size, [illegible] to houses. They are spaced out in an exquisite set of concentric rings first revealed in their true majesty by the two *Voyager* spacecraft in their 1980/81 flybys. In our century, the Art Deco rings of Saturn have become emblematic of the future.

How do rings form? One possibility, emerging from the Voyager ... Rings are made when worlds collide and moons are smashed to smithereens.

In the late 1960s, at a scientific meeting, I was asked to summarize the outstanding problems in planetary science. One, I offered, was the question of why, of all the planets in the solar system, only Saturn had rings. This, it turns out, is a nonquestion. No one then knew that *all four* giant planets in our solar system—Jupiter, Saturn, Uranus and Neptune—in fact, have rings.

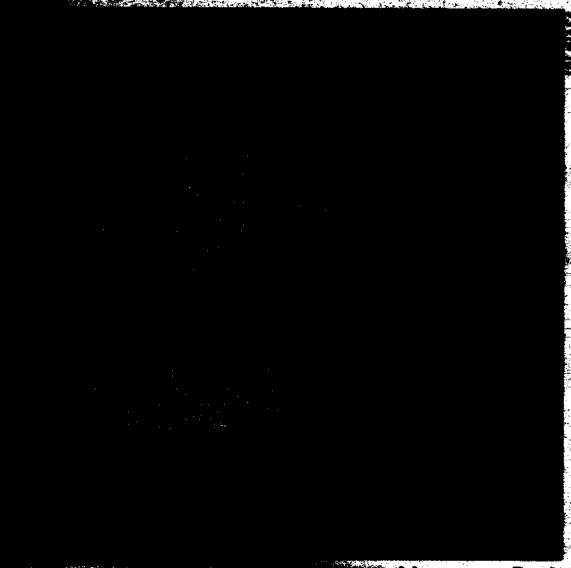
Each ring-system has distinctive features. Jupiter's rings are tenuous and made mainly of dark particles the size of those in cigarette smoke. The bright rings of Saturn are composed mainly of frozen water and could be described as made of snowballs or ice balls; Saturn has thousands of rings, some twisted, exhibiting strange, dusky, spokelike markings that form and dissipate. The dark rings of Uranus seem to be composed of elemental carbon and organic molecules—something like charcoal or chimney soot; Uranus has nine main rings, a few of which sometimes seem to "breathe," expanding and contracting. Neptune's rings are the most tenuous of all, varying so much in thickness that, when detected from Earth, they appear only as partial arcs and not complete circles. Each ring-system displays an austere, appropriately unearthly beauty.



Sometime in the 21st century: As a small asteroid passes nearby, it is greeted from Earth. An astronaut peers into a large crater produced by an ancient asteroid this size or larger were to hit the Earth, the consequences would be There are, however, steps we can take to prevent it. (Painting by Don Davis.)

BY CARL SAGAN

How do rings form? One possibility is connected with the tides: If an errant world passes close to a planet, its near side is gravitationally pulled toward the planet more than its far side; if it comes close enough, it can literally be torn to pieces. Another possibility, emerging from the *Voyager* reconnaissance of the outer solar system, is this: Rings are made when worlds collide and



moons [illegible] ithereens. Both possibilities must have played a role.

[illegible] between the planets is traversed by an [illegible]tion of rogue worldlets, [illegible] them in orbit about the Sun. A few are as big as a county or even a state; many [illegible] surface areas like those of a village or [illegible] big ones, and they range in size down to particles of dust. Some of them travel on long, stretched-out elliptical paths, which make them cross the orbit of one or more planets.

[illegible] there is a moon in the way. The collision can shatter and pulverize both the interloper and the region of the moon that's hit. The resulting debris is made of whatever the colliding bodies were made of, but usually more of the "target" moon than the impacting interloper. If the colliding worlds are icy, the net result will be rings of ice particles; if they are made of organic molecules, the result will be rings of organic particles (which will slowly be processed by radiation into carbon). All the mass in the rings of Saturn could have resulted from the pulverization of one icy moon. The disintegration of smaller moons can account for the ring-systems of the three other giant planets.

Unless it is very close to its planet, a shattered moon (or at least a fair fraction of it) gradually reaccumulates. The pieces, roughly still in the same orbit about the planet, fall together helter-skelter—what used to be a piece of the inside is now on the outside, and vice versa. The resulting surfaces might look very odd. Miranda, one of the moons of Uranus, shows disconcertingly jumbled surface features and may have had such an origin. In fact, individual small moons may have been destroyed and reconstituted several times early in the 4.5 billion-year history of the solar system—phoenixes repeatedly rising from their own ashes, recycled worlds.

On the other hand, a moon that's very close to a planet and gets pulverized cannot reform—the gravitational tides of the nearby planet prevent it. The resulting debris, once formed and spread out into a ring-system, might be very long-lived.

These ideas, derived from *Voyager* data and championed mainly by Eugene Shoemaker of the U.S. Geological Survey, are supported by the appearance of a number of satellites in the solar system. Phobos, the inner moon of Mars, has a large crater named Stickney; Mimas, an inner moon of Saturn, has a big crater named Herschel. These craters—like those on our own Moon and, indeed, as seen on worlds throughout the solar system—are produced by collisions. An interloper smashes into a bigger world and makes an immense explosion at the point of impact. A bowl-shaped crater is excavated, and the smaller impacting object is destroyed. If the interlopers that dug out the Stickney and Herschel craters were only a little larger, they would have had enough energy to blow Phobos and Mimas to pieces. These moons barely escaped the cosmic wrecking ball.

Every time a world is smashed into, there's one less interloper in the solar system. The very fact that many such collisions have occurred means that rogue worldlets have been largely used up. Those that are on circular trajectories around the Sun, those that don't intersect the orbits of any other worlds, will be unlikely to smash into a planet. Those on elliptical trajectories, those that cross

[illegible] from the solar system. The planets almost certainly accumulated from worldlets which in turn had condensed out of a great flat cloud of gas and dust surrounding the Sun—the sort of cloud that can now be seen around nearby younger stars. So, in the early history of the solar system before collisions cleaned things up, there should have been many more worldlets than we see today.

Indeed, there is clear evidence for this in our own backyard: If we count up the interloper worldlets in our neighborhood in space, we can estimate how often they'll hit the Moon. If we assume there has always been a similar population of interlopers, we can calculate how many craters there should be on the Moon. The number we figure is much less than the number we see on the Moon's ravaged highlands, so the unexpected profusion of craters on the Moon speaks to us of an earlier epoch when the solar system was in wild turmoil, churning with worlds on collision trajectories. Four billion years ago, the lunar impacts seem to have been hundreds of times more frequent than they are today; and 4.5 billion years ago, when the planets were aggregating and forming, collisions happened perhaps a billion times more often than in our comparatively placid era.

What about the Earth? Why isn't it pock-marked and disfigured like the nearby Moon? Our world must have been pummeled from space like all those others. There are few impact craters left on Earth today, because of efficient erosion by air and water and the great internal engine that moves continents and crinkles up mountain ranges. The most satisfactory explanation of the origin of our own Moon, using knowledge of its chemistry derived from the *Apollo* missions, is that it was formed more than 4 billion years ago, when a world the size of Mars struck the Earth and spewed out debris, most of which then gradually reaccumulated—atom by atom, boulder by boulder. Much of the Earth's rocky mantle was reduced to dust and hot gas and blasted into space. If that unknown impacting world had been only a little larger, the result would have been the fragmentation of the Earth. Perhaps there once were other worlds in our solar system—good citizens, minding their own business—hit by some demon worldlet and utterly demolished, and of which today we have not even an intimation.

Four billion years ago, our solar system was a violent and dangerous place in which the chaos may have been relieved by much more flamboyant ring-systems than grace the planets today. If they had moons, the Earth, Mars and the other small planets may then have been adorned by their own ring-

[illegible] worldlets, others, small moons. But these are arbitrary categories—real worldlets may breach these human-made partitions. Some asteroids are rocky, others metallic, still others rich in organic matter. None is bigger than 1000 kilometers across. They are found mainly in a belt between the orbits of Mars and Jupiter. Astronomers used to think these "main-belt" asteroids were the remains of a demolished world, but another idea is now more fashionable: The solar system may once have been filled with asteroids, many of which went into building the planets. Only in the asteroid belt near Jupiter did the gravity of this most massive planet pre-

continued