TARGET EARTH
March 6, 1992

By Bill Mason

An asteroid more than 1 kilometer in diameter slammed into the Pacific Ocean yesterday about 1,000 miles west of Los Angeles. The impact, which could be heard in Seattle, caused tsunamis that killed tens of thousands of people and destroyed billions of dollars worth of property throughout the Pacific islands and coasts. Relief efforts are under way ...

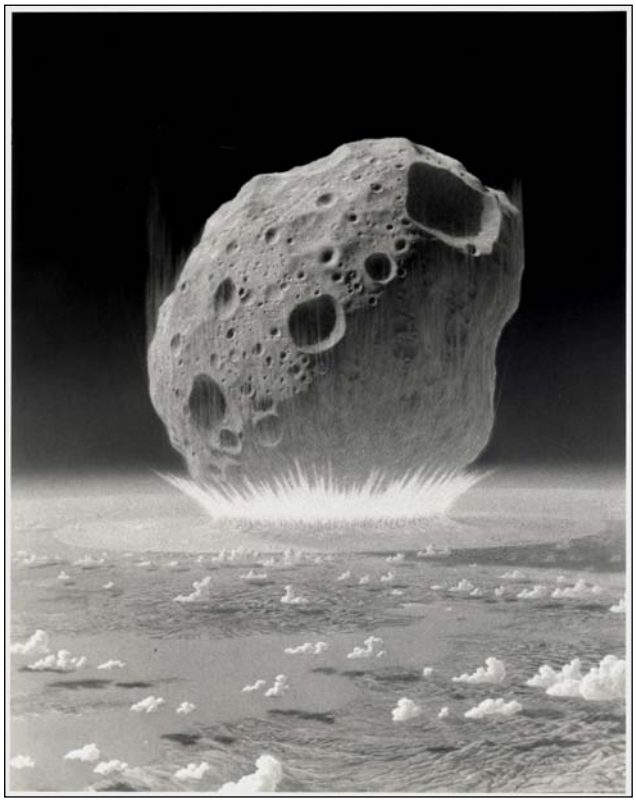
The United States has reported a near-complete crop failure because of the drop in temperature and sunlight brought on by the 12 billion tons of dust lifted into the atmosphere by the asteroid hit last March. The news followed similar reports from Canada, Argentina, Australia and Europe.

The report ignited food riots in San Francisco, Chicago and New York. Europe has already been savaged by widespread looting as people try to find food and protection from the coldest winter ever recorded. Governments in Russia, China and Mexico collapsed last month when they could no longer cope with their civil unrest.

World grain supplies have been exhausted, offering little hope of relief. It is estimated that 1 billion people will starve to death during the next year ...

This devastating impact scenario may seem far-fetched, but according to Dr. David Morrison, chief of the Space Sciences Division at Ames Research Center, who spoke at JPL on Feb. 24, "There is a 1 in 20,000 chance that your tombstone will read, 'Killed by a cosmic impact.' In fact, the chances of dying from an impact scenario are the same as the chances of dying from an airplane accident."

Craters, which are caused by impacting asteroids and comets, are common features throughout the solar system. Earth has not escaped.



"There are more than a hundred known craters on the Earth, including Meteor Crater in Arizona, which is very small — about 1.2 kilometers in diameter — and about 50,000 years old. At the other extreme is what may be the largest crater on Earth, the Chicxulub Crater in Yucatan — about 150 kilometers in diameter — which is about 65 million years old and was responsible for at least one of the impacts associated with the end of the dinosaurs," he said.

Earth exists within a "swarm of asteroids and comets," and "near-Earth asteroids larger than one or two kilometers in diameter account for about 75 percent of the risk" associated with globally catastrophic impacts, he said. Near-Earth asteroids are those with Earth-crossing orbits or that come close enough to be perturbed into such orbits.

The orbits of these asteroids are unstable. During their 100-million year lifetimes, they will either be ejected from the solar system or impact a planet. Morrison added, "Something like 30 percent of them will ultimately strike and crater Earth."

One can only estimate the number of asteroids. "We have observed only the proverbial tip of the iceberg. The vast majority — even of the larger ones — remain undiscovered," he said.

Comets with Earth-crossing orbits account for about 25 percent of the threat, but both impacting comets and asteroids can produce an "impact winter" — killing substantial numbers of people in the environmental aftermath while destabilizing civilization. "Such impacts take place at least once per million years — perhaps several times per million — and note, we're not talking about mass extinctions. The fact that a billion people starve to death does not mean the end of

humanity," Morrison said.

Mass extinctions have occurred on Earth because of impacts, the most well-defined being that of the dinosaurs. According to Morrison, the evidence is a several-centimeter thick layer of iridium-rich, fine-grained material at the boundary between the cretaceous and tertiary fossil records that settled out of the atmosphere after the impact. "This is the kind of thing we would expect with a 10- or 15-kilometer diameter impactor," he said, "and, happily, there aren't too many objects that size out there in near-Earth space."

But Earth has had much larger impacts: "A hundred kilometer projectile will produce 10 billion megatons of energy," Morrison said. "That would strip away most of the atmosphere, boil away at least the top 100 meters of the ocean and kill most marine life. We believe that such events took place frequently during the first half-billion years of Earth history."

Fortunately, scientists don't know of any near-Earth objects of that size, he said, and we seem to have reached a point in solar system history where the interval between impacts of that size is billions of years, so "we don't have to worry about it."

This environmentally harsh period in early Earth history is of interest to scientists, however, because that is when life formed on Earth, he said. "That says something about the ease with which life forms." He continued, "It also says something about the possibility of finding fossil life on Mars, because Mars had a very similar climate to the Earth at one time."

Today the Earth has an asteroid encounter every year that produces 10 or 20 kilotons of energy, according to Morrison. The Hiroshima bomb yielded about 13 kilotons. Those objects disintegrate very high in the atmosphere, producing a very bright fireball with a shock wave that turns around and "blasts upward," he said.

While it is unlikely that the Earth will be hit by a 1-kilometer or larger diameter object during our lifetime, Morrison said, the catastrophic impact winter that would follow makes it a threat worth dealing with. "It is entirely possible that one could sneak up on us at any time," he added. The problem is further complicated because the impacts may not be randomly distributed — they may come in showers or "clumps."

To deal with the problem, Morrison proposed a three-step approach. The first step is to search for objects in near-Earth space that could pose a threat, and then track their orbits to see if there are any "with our name on it." These objects can be found with about six telescopes using ordinary reflective sunlight, and at a cost of $100 million to $200 million over 25 years, he said.

The next step would be to investigate the properties of comets and asteroids because, "if you should find one heading for the Earth and want to deflect it — the fact is, we don't know how," Morrison said. "Asteroids are not simple billiard balls you hit with a stick — they may be gravel piles," he explained. "Comets are even less understood. They create their own surface jets and can change their orbits spontaneously.

"The scientific aspect is obvious," Morrison said. "We need asteroid and comet missions, like CRAF — which happens to be the only planetary exploration mission with some practical use."

The third step is a gentle deflection of the threatening object. It is not necessary to obliterate it, he said. "There are places in the orbit where changing its velocity by as little as a centimeter a second is enough to avoid an Earth impact."

Morrison compared himself to an insurance salesman: "I'm selling you insurance against a low-risk probability. And the reason I think I can sell it is because the thing you're insuring is so important — namely, the population of the Earth."

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