Impacts and Rare Metals: Searching for Evidence

After reaching qualified agreement at a meeting last fall that the 65-million-year-old layer of iridium-rich clay that marks the boundary between the Cretaceous and Tertiary periods was deposited after an extraterrestrial body hit the earth, scientists scattered back to their respective institutions to consider a whole raft of problems raised by the findings (SN: 11/14/81, p. 314). The results of some ensuing inquiries are emerging, and reflect both the excitement and the scrutiny with which scientists are eyeing the rock and fossil records.

Several obvious questions follow the general consensus that the iridium at that boundary is associated with an impact. In other parts of the geologic record, for example, are findings of high levels of iridium and other rare metals also related to impacts by extraterrestrial bodies? And, are impacts associated with mass extinctions of prehistoric biota, as may be the case at the end of the Cretaceous period 65 million years ago?

In another part of the record, a layer of transparent, glassy particles known as the North American microtektite field provides geologists with their best, non-crater evidence for a major impact. The North American microtektites, one of four known strewn fields, were deposited over much of the earth's surface 34.4 million years ago near the boundary between the Eocene and Oligocene periods. The particles are widely assumed to have formed from earth melted when a large asteroid or meteorite hit the planet. Now some scientists suggest that the microtektites may be linked to both iridium concentrations and extinctions.

In the May 21 SCIENCE two papers examine different aspects of this linkage. The first paper, by R. Ganapathy of J.T. Baker Chemical Co. in Phillipsburg, N.J., reports that five major species of radiolarians — marine microplankton abundant during the Eocene period — became extinct near the time when the microtektites were deposited. These species, he writes, constituted more than 70 percent of the total Radiolaria. Heightened levels of iridium also are cited, though Ganapathy's article states that the microtektites and the iridium are separated by 30 centimeters of sediment.

When Ganapathy presented his findings at a meeting in Snowbird, Utah last fall at which the subject of large-body impacts was considered, participants were concerned about the 30-centimeter separation. In the interval between the Snowbird meeting and the article's publication in SCIENCE, Billy Glass of the University of Delaware in Newark, an authority on microtektites, examined the core of marine sediments from which Ganapathy drew his conclusions. To his surprise, Glass saw two distinct layers of particles. This finding helps explain Ganapathy's results, but also complicates the picture of the microtektite field. The upper layer is composed of "normal" glassy particles, and may have been deposited as much as 90,000 years after the lower layer, which consists of partially crystalline and nearly opaque glasses.

"It's my guess that the extinctions are probably associated with the upper layer, though that would be difficult to prove," Glass told SCIENCE NEWS. The lower layer, however, coincides directly with the heightened concentrations of iridium.

At other sites, Glass says, particles from the lower level are fused with those of the upper level. This makes it appear to be a single event, rather than the two distinct events implied by the core used by Ganapathy. Glass emphasized, however, that the North American microtektite field (or fields) is well below the boundary between the Eocene and Oligocene periods, and may have preceded it by as much as 200 million years.

The second paper, by Walter Alvarez of the University of California at Berkeley, and Frank Asaro, Helen V. Michel and Luis W. Alvarez of the Lawrence Berkeley Laboratory in Berkeley, also cites high iridium concentrations coincident with the North American microtektite field. In previous work, this team of scientists had detected iridium at more than 25 times normal levels in the Cretaceous-Tertiary boundary clay from Gubbio, Italy. This marked the first time that the iridium was noted in such high concentrations. The authors suggested that it accumulated following an impact by an asteroid. The hypothesis was supportable because the amounts of iridium and other metals that are plentiful in asteroids but rare on earth far exceeded those that would have been deposited under sedimentation rates normal 65 million years ago (SN: 6/2/79, p. 356; 6/14/80, p. 381).

In an effort to learn if other parts of the geologic record also exhibit high iridium levels, the scientists analyzed a core containing the North American microtektites. The core they selected, they discovered, is missing meters of sediments deposited at the base of the Oligocene period. The incompleteness of the core is unfortunate, Walter Alvarez says, but adds: "The important thing is, here is a place where you have the best evidence — microtektites — that anybody knows for a major impact, and there is a substantial iridium anomaly associated with it. That says iridium anomalies can be interpreted as indicating an impact. In the case of the Cretaceous-Tertiary, we don't have the direct evidence of glass spheres, but we do have the iridium."

An outstanding problem presented by the impact scenarios is the lack of evidence, other than the known microtektite fields, of the dramatic effects, such as tsunamis or craters, that major impacts would cause. At the meeting in Houston this spring of the Lunar and Planetary Institute, Thomas J. Ahrens and John O'Keefe of the California Institute of Technology described calculations of some effects to be expected from an asteroid impact large enough to explain the Cretaceous-Tertiary boundary layer. Such an impact probably occurred in the oceans that covered much of the earth at that time, and would have induced a mechanical shock equivalent to a Richter magnitude-12 earthquake. A tsunami, initially about five kilometers high, would have propagated in the deep ocean at about 0.2 kilometers per second. Within 27 hours of the impact, all low-lying continental areas would have been inundated by at least 150 meters of water.

So far, no evidence of either the tsunami or the submarine landslides that would have been triggered by the impact has been found.

"I can't believe the statistics are totally wrong about the number of objects that have hit the oceans," says Henry Menard of Scripps Institution of Oceanography. Hits, even by objects one kilometer in diameter, ought to produce detectable effects. "That means to me that probably we have found such a phenomenon but we've been explaining it some other way, or not at all." One possibility, he suggests, could be something like the graded sediments found in the deep oceans where they are least expected.

The search for evidence of major impacts reflects growing awareness that such events on earth, while rare, can be important geological phenomena and that they may even mark breaks between chapters of earth history. The correlation in two instances of impacts and rare-metal anomalies is "extremely significant," says David Roddy of the United States Geological Survey in Flagstaff, Ariz. "Many of the things that we see that we thought we could explain by standard geologic processes will be up for grabs again."

The question of impacts and their relationship to extinctions still is far from resolution. Says David Raup of Chicago's Field Museum of Natural History: "If even one of the mass extinctions can be shown to have been caused by a large-body impact, then I think paleontologists and evolutionary biologists will rethink a lot of the ways they look at the evolutionary record."

— *C. Simon*