Commotion Over Caribbean Impacts

Among the topics that made a splash at this year's meeting of the Geological Society of America was the search for the site of the giant impact that marked the end of the dinosaur age 66 million years ago. A new candidate site in the Caribbean was put forward, even as debate surged on the merits of two other recently proposed Caribbean sites. Many researchers now seem convinced that the killer asteroid or comet hit in the Caribbean region, but none of the locations identified so far fits the bill unequivocally.

The rush to the Caribbean started last spring when Alan Hildebrand of the University of Arizona and his colleagues announced in the 18 May issue of *Science* the discovery in Haiti of debris ejected by a large impact, one apparently close by, about 66 million years ago. At the time, Hildebrand favored a site in the ocean near Colombia. But at the Geological Society meeting, he and his colleagues announced a possible alternative: Chicxulub, on the north coast of Mexico's Yucatan Peninsula.

The idea that there was a crater there was not news. In 1978, while conducting an airborne magnetic survey for oil for Pemex, the Mexican national oil company, geophysicist Glen Penfield of Intera Technologies, Inc., in Houston stumbled across a huge geologic structure centered beneath the coastal town of Chicxulub. At the 1981 meeting of the Society of Exploration Geophysicists in Houston, Penfield and Pemex's Antonio Camargo suggested that, among other possibilities, the Chicxulub structure might be a gigantic impact crater. Reporter Carlos Byars picked up on the idea and in a news story for the *Houston Chronicle* connected Chicxulub with the then new theory that an impact had killed off the dinosaurs.

Few took notice of the idea, in large part because Penfield didn't promote it. He could not release the survey data, which was the property of Pemex, and all the rock samples from Pemex's exploratory drilling had apparently been ruined in a fire. Hildebrand, for example, did not learn about the Chicxulub structure until this March when he met Byars at another meeting in Houston. Then the Arizona researcher and his colleagues, Penfield now included, got lucky. They were able to locate a few samples from Pemex drill holes that had been shipped to geologist Alfred Weidie at the University of New Orleans before the fire struck.

The examination of those samples and of Penfield's survey data suggested to Hildebrand and his colleagues that the Chicxulub structure is probably an impact crater and an excellent candidate for the long-sought site. Some samples look like the ground-up debris of an impact, not ash from a volcanic eruption, they say. And within that debris they have found grains of quartz bearing the distinctive marks of intense shocking found only in rock blasted by giant impacts. The researchers' major problem is that the age of the apparent impact cannot be pinned down precisely, although they think that it's greater than about 60 million years.

Not everyone agrees, however, that the Chicxulub structure is a crater, much less the site of the killer impact. Planetary geologist Virgil Sharpton of the Lunar and Planetary Institute in Houston has studied drill core samples from the New Orleans cache, but not Penfield's survey data, and he differs diametrically from Hildebrand on almost every interpretation. "If it is an impact crater, it's not the crater Alan Hildebrand wants it to be," says Sharpton, although he notes that it might have been caused by a smaller impact. And, he adds, work in Weidie's lab suggests that the structure, whatever it is, is older than 66 million years.

By the time the Geological Society meeting was over, the credentials of the two other leading Caribbean candidates had also been attacked. One of these, suggested by Bruce Bohor of the U.S. Geological Survey in Denver and Russell Seitz of Cambridge, Massachusetts, on the basis of a literature search, is nestled under the western arm of Cuba. But impact geologists Robert Dietz and John McHone of the University of Arizona reported that they found no evidence of an impact when they visited Cuba last June to attend an international meeting. Bohor maintains that the Arizona researchers were shown the wrong rock outcrops.

The ocean site off Colombia that was originally proposed by Hildebrand also took a serious blow, administered by Glen Izett of the U.S. Geological Survey in Denver. He has found fresh glass in the impact ejecta in Haiti whose chemical composition, unlike that of altered samples analyzed previously, accurately reflects the nature of the rock where the impactor struck. The composition of the unaltered material "rules out an ocean target" for the impact, says Izett. The Chicxulub site, being continental, would still be a possibility.

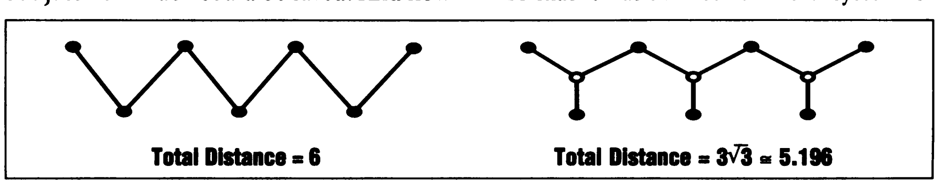
Nevertheless, Hildebrand is not ready to give up on his first site. Two impacts, one oceanic and one continental, might be the answer, he says. ■ RICHARD A. KERR

In Math, Less Is More—Up to a Point

With the political season just over, the familiar politician's promise—to expand services while cutting costs—is fresh in everyone's mind. In politics that promise is generally hot air. But in mathematics it's entirely possible. Mathematicians have long known of a problem in geometry, with significant applications to communications and transportation, where doing more can cost less. For mathematicians the question was not whether such a savings was possible, but just how much could be saved. And now they have the answer to that as well.

Frank Hwang of Bell Laboratories in Murray Hill, New Jersey, and Ding Zhu Du, who is visiting the computer science department at Princeton University from Beijing, have established the limit on the savings that can be realized when a two-dimensional network is redesigned to include extra points. Their proof confirms a conjecture mathematicians have been struggling to prove for 22 years.

A mathematical network is a system of



Networking. *A "shortest" network (left) can be shortened by introducing extra points (right). The savings shown here—13%—is the maximum possible.*

line segments connecting a set of points in a plane, much as the interstate highway system connects U.S. cities. The geometric problem is to find the shortest possible network for a given set of points. Somewhat surprisingly, the entire network can sometimes be shortened by adding extra points.

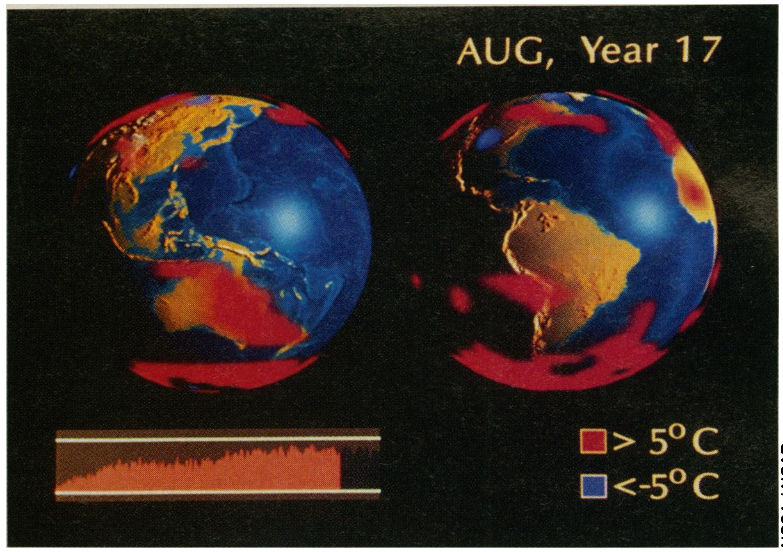
For example, the shortest highway system connecting Kansas City, San Diego, and Seattle consists of a 1700-mile road from Kansas City to San Diego and a 1300-mile segment from San Diego to Seattle. But if Salt Lake City is added as a hub, the total becomes: 1150 miles from Salt Lake to Kansas City, 800 to San Diego, and 900 to Seattle, for a total of 2850, or 5% less than the original total of 3000.

That's interesting, but specific. What, in a more general sense, is the most that can be saved by adding points? For three points, the greatest savings are achieved when the points are at the vertices of an equilateral triangle. In that case, using the center of the triangle as a hub reduces the length of the network by a factor of $\sqrt{3}/2$—a saving of some 13%. The saving is the same for a larger network when the points lie in an equilateral zigzag pattern. But is there a pattern that allows for a savings of more than 13%? Hwang and Du now provide the answer: No.

That negative rejoinder had been conjectured in 1968 by Edgar Gilbert and Henry Pollak of Bell Laboratories. Subsequent work (including some by Hwang and Du) verified their conjecture for systems including four, five, and six points. But then the attack bogged down. Further assaults—relying on messy computations—showed that the maximum savings couldn't be more than 18%. But there the effort stalled, although mathematicians still had the uneasy feeling that the Gilbert-Pollak conjecture was correct.

By contrast, Hwang and Du's proof is "conceptual in nature and requires essentially no computation," says Hwang. Their proof takes a totally new approach. It begins by formulating the initial conjecture as a "minimax" problem—a type of problem in game theory in which one player seeks to minimize the payoff available to the opponent. In the minimax version of the problem, it can be shown that any counterexample to the conjecture must take the form of points spaced in a regular, equilateral fashion. The proof now shows that the conjecture holds when the points are spaced that way.

Hwang and Du are looking beyond the network problem to a number of other mathematical optimization problems to which the new approach could be applied, but that "so far we haven't really seen an immediate application." Maybe they should take a look at the Federal budget. ■ BARRY CIPRA



The right greenhouse model? *This climate simulation for Earth under doubled carbon dioxide is uncertain by several crucial degrees.*

Climatologists Debate How to Model the World

Will global warming be modest or catastrophic? The White House is pushing an initiative to help find out

THE BUSH ADMINISTRATION IS PUTTING together a proposal for an ambitious national program to develop a new generation of supermodels of the world's climate. The goal: to get a better fix not just on how warm the climate of the 21st century will be but how specific areas of the globe—the U.S. breadbasket, for example—will fare in the greenhouse world.

Initial funds for the venture are expected to be included in the budget the White House will send to Congress early next year—if a committee of the Office of Science and Technology Policy, which is managing the effort, can come up with a plan acceptable to the climate modeling community. The community has already balked at two draft proposals that would have used an Apollo-style approach to produce a single climate model. Instead, the effort is likely to generate several competing models, each built upon the contributions of researchers at many institutions. It will be no small task, and it should take a decade to accomplish. Computer speeds will have to increase by a factor of 10,000 over those of current machines, a major observation program will be needed to gather data to plug into the models, and a lot of fresh talent will be required to piece it all together.

There's little argument that better climate models are needed. In 1979, a committee of the National Academy of Sciences under pioneer meteorologist Jule Charney estimated that a doubling of carbon dioxide in the atmosphere would cause anything from a modest 1.5°C global warming to a 4.5°C catastrophe. And the current models are still coming up with the same awkwardly broad range.

A major problem facing the modelers is that they do not understand how the real world works well enough to tell a model how to simulate climate realistically. For example, how does a high, icy cirrus cloud reflect incoming and outgoing radiation compared with low, thick stratus clouds? The answer could make all the difference to predictions of global warming, so researchers want more field studies of clouds—not to mention plants, soils, oceans, and myriad other participants in the shaping of climate. Current models, moreover, can predict climate changes only for large areas; they lack the data and computing power to gauge how temperature and rainfall might change in a small region, such as the Iowa cornfields.

The new modeling initiative has been in the works since the U.S. Global Change Research Program was launched as a Presidential initiative 3 years ago. By early this year, that program had elicited two competing proposals for organizing a national model development effort. Both were sharply criticized by climate researchers for being too narrowly focused.

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