In Search of Crater Chains

05.12.2006

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May 12, 2006: As the fragments of shattered comet 73P/Schwassmann Wachmann 3 glide harmlessly past Earth this weekend in full view of backyard telescopes, onlookers can't help but wonder, what if a comet like that didn't miss, but actually *hit our planet*?

For the answer to that question, we look to the Sahara desert.

In a remote windswept area named Aorounga, in Chad, there are three craters in a row, each about 10 km in diameter. "We believe this is a 'crater chain' formed by the impact of a fragmented comet or asteroid about 400 million years ago in the Late Devonian period," explains Adriana Ocampo of NASA headquarters.

Right: A space-based radar image of Aorounga South. [More]

Ocampo and colleagues discovered the chain in 1996. The main crater "Aorounga South" had been known for many years—it sticks out of the sand and can be seen from airplanes and satellites. But a second and possibly third crater were buried. They lay hidden until radar onboard the space shuttle (SIR-C) penetrated the sandy ground, revealing their ragged outlines.

"Here on Earth, crater chains are rare," says Ocampo, but they are common in other parts of the solar system.

The first crater chains were discovered by NASA's Voyager 1 spacecraft. In 1979 when the probe flew past Jupiter's moon Callisto, cameras recorded a line of craters, at least fifteen long, evenly spaced as if someone had strafed the moon with a Gatling gun. Eventually, eight chains were found on Callisto and three more on Ganymede.

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At first the chains were a puzzle. Were they volcanic? Had an asteroid skipped along the surface of Callisto like a stone skipping across a pond?

The mystery was solved in 1993 with the discovery of Comet Shoemaker-Levy 9. SL-9 was not a single comet, but a "string of pearls," a chain of 21 comet fragments created a year earlier when Jupiter's gravity ripped the original comet apart. SL-9 struck back in 1994, crashing into Jupiter. Onlookers watched titanic explosions in the giant planet's atmosphere, and it only took a little imagination to visualize the result if Jupiter had had a solid surface: a chain of craters.

Astronomers have since realized that fragmented comets and rubble-pile asteroids are commonplace. Comets fall apart rather easily; sunlight alone can shatter their fragile nuclei. Furthermore, there is mounting evidence that many seemingly solid asteroids are assemblages of boulders, dust and rock held together by feeble gravity. When these things hit, they make chains.

Above: A crater chain on Jupiter's moon Ganymede. [More]

In 1994, researchers Jay Melosh and Ewen Whitaker announced their finding of two crater chains on the Moon. One, on the floor of the crater Davy, is spectacular--an almost perfect line of 23 pockmarks each a few miles in diameter. This proved that crater chains exist in the Earth-Moon system.

But where on Earth are they?

Earth tends to hide its craters. "Wind and rain erode them, sediments fill them in, and the tectonic recycling of Earth's crust completely obliterates them," says Ocampo. On the Moon, there are millions of well-preserved craters. On Earth, "so far we've managed to find only about 174."

Sounds like a job for Google. Seriously. Amateur astronomer Emilio González pioneered the technique in March 2006. "I use Google Earth," he explains. Google Earth is a digital map of our planet made of stitched-together satellite images. You can zoom in and out, fly around and inspect the landscape in impressive detail. It's a bit like a video game—except it is real.

González began by calling up Kebira impact crater in Libya—the Sahara's largest. It was so easy to see, he recalls, "I decided to look around for more." Minutes later he was "flying" over the Libya-Chad border when another crater appeared. And then another. They both had multiple rings and a central peak, the telltale splash of a high-energy impact. "It couldn't be this easy!" he marveled.

Right: The crater candidates González found are circled in red. [More]

But it was. At least one of the craters had never been catalogued before, and both, almost incredibly, lined up with the Aorounga crater 200 km away: map. In less than 30 minutes, González had found two good impact candidates and possibly multiplied the length of the Aorounga chain. Hours of additional searching produced no new results. "Beginner's luck," he laughs. (If you would like to hunt for your own craters online, González offers these tips.)

Ocampo doubts that these new craters are related to Aorounga. "They don't appear to be the same age." But she can't rule it out either.

"We need to do some fieldwork," she says. To prove a crater is a crater—and not, say, a volcano—researchers must visit the site to look for signs of extraterrestrial impact such as "shatter cones" and other minerals forged by intense heat and pressure. This kind of geological study can also reveal the age of an impact site, marking it as part of a chain or an independent event.

Answers may have to wait. Civil war in Chad and the possibility of war between Chad and Sudan prevent scientists from mounting an expedition. Meanwhile, researchers are scrutinizing candidate chains in Missouri and Spain. Although those sites are more accessible than Chad, researchers still can't decide if they are chains or not. It's difficult work.

Ocampo believes it's worth the effort. "The history of Earth is shaped by impacts," she says. "Crater chains can tell us important things about our planet."

And so the search goes on.