A closer look at cosmic impacts

Moon-crater survey could improve Solar System surface-dating methods.

NASA/GSFC/ARIZONA STATE UNIV.

On the far side of the Moon, a river of dark rock spills from a 3-kilometre-wide crater and divides like a forked tongue. The flow was formed when an asteroid or comet slammed into the surface and heated the rocks to more than 1,000 °C, causing molten material to spread 3 kilometres from the crater rim. "It really stands out," says Brett Denevi, a planetary scientist at Arizona State University in Tempe.

This impact scar is just one of thousands revealed in unprecedented detail by NASA's Lunar Reconnaissance Orbiter (LRO), which has been circling the Moon since June 2009, taking photographs to map the surface with a resolution of up to 50 centimetres per pixel.

Most of the fanfare surrounding the LRO has focused on the detection of water (see go.nature.com/oDK7he). But the LRO's detailed snapshots, some of which were presented last week at the Lunar Science Forum at the NASA Ames Research Center in Moffett Field, California, are also yielding insights into the mechanics of asteroid and comet impacts and how frequently they occur — information that could improve estimates of the age of geological formations on other planets. The work, says planetary geologist Peter Schultz of Brown University in Providence, Rhode Island, "gives us another foothold into dating the Solar System".

Craters on Earth are quickly eroded, so there are few well preserved impact sites here for scientists to study. But there is little to erase a crater on the Moon except subsequent impacts, so it offers a natural laboratory for understanding how impacts excavate craters and generate pools of molten rock. Denevi and her colleagues have found that craters of similar sizes have a wide range of melt volumes — the forked flow contains an exceptionally large amount — and they are working to determine the factors, such as the speed, composition and approach angle of the impactor, that might account for this variability.

Other researchers are using the data to find newly formed craters. By comparing the LRO pictures with images collected by Apollo missions in the 1970s, they have found five craters that have appeared in the past four decades. That is helping the team to determine how frequently objects strike the Moon, says planetary geologist Alfred McEwen of the University of Arizona in Tucson. They have only surveyed a small sliver of the Moon, and expect to find more craters in the course of several more years of study.

The data could fill a gap in scientists' knowledge of contemporary collision rates for Earth as well as for the Moon, because the pair should have impact rates proportional to their size. Large asteroids that might threaten Earth can

Retraction recommended for enzyme-chip paper

A chip that could provide a rapid snapshot of the total enzyme activity in a cell sounded like a dream come true for biologists. But the dream has faded fast. An investigating committee has recommended that a paper unveiling this 'reactome array' be retracted, because it does not provide experimental support for its conclusions.

The paper described a device carrying 1,676 individual enzyme substrates, tagged with fluorescent dye, that could detect enzyme activity. The project was led by scientists at the Institute of Catalysis and Petroleochemistry (ICP) in Madrid, run by the Spanish National Research Council (CSIC), and at the Helmholtz Centre for Infection Research in Braunschweig, Germany. The chip promised to be a powerful tool for monitoring, for example, how the metabolism of communities of microorganisms varies with environment.

After the paper was published (A. Beloqui *et al. Science* 326, 252–257; 2009), organic chemists raised concerns about the feasibility of the claim, citing errors in the general reaction scheme outlining how the chip was supposed to detect enzymes. On 17 December, *Science*'s editor-in-chief Bruce Alberts took the unusual step of publishing an 'editorial expression of concern' about the work, and asked the authors' institutions to investigate.

The CSIC convened an ethics committee to probe the affair; it then incorporated findings from a parallel inquiry at the Helmholtz centre. The committee now concludes that the paper should not have been submitted or published, noting, among other things, that experiments in the paper lacked proper controls.

Their report says that all of the scientists who signed the paper must share responsibility for its content, and expresses concern about the peer-review process — potentially challenging for interdisciplinary research — that the paper underwent. The CSIC is considering a disciplinary investigation of the scientists involved.

The corresponding authors on the paper, Manuel Ferrer of the ICP, and Peter Golyshin, now at Bangor University, UK, were unreachable for comment on the report.

Some scientists are still convinced that the methodology used to create the array could work. "We don't know," says molecular geneticist Pere Puigdomènech of the CSIC's centre for research and development in Barcelona, who headed the CSIC ethics committee. "We only criticize how the science in this paper was conducted and reported — we'd be very happy if someone could validate it."

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be observed in space, but smaller objects can fall undetected or disintegrate in the atmosphere, whereas they would leave a mark on the Moon.

The crater count could also lead to a recalibration of methods for estimating the age of surfaces elsewhere in the Solar System. Right now, the Moon acts as a sort of fundamental clock. Scientists have dated lunar samples returned to Earth by Apollo and linked those dates to the crater density of the sample's original terrain. So when a surface with a certain crater density is found on Mars, for example, researchers compare it with surfaces on the Moon to pin down its age.

However, corrections must be applied, owing to differences in impact rates between the Moon and Mars. These are estimated from asteroid orbit calculations, Mars's location in the Solar System and models that account for its greater size and gravity.

By combining LRO observations with those from other spacecraft, scientists may be able to determine relative impact rates throughout the Solar System more directly. McEwen and his team have been finding new craters on Mars for the past four years, using data from NASA's Mars Reconnaissance Orbiter. And a current impact rate for Mercury may emerge when NASA's MESSENGER mission begins to orbit the planet next year, although McEwen says that new craters would have to be very large to be detected.

Schultz says that this is an opportunity to improve the dating of surfaces on other planets with measurements rather than models. "You want to see what nature shows you," he says. ■

Roberta Kwok

But David Cane, a biochemist at Brown University in Providence, Rhode Island, believes that a single chip capable of monitoring all the enzymes in a cell is not currently feasible.

He points out that enzymes are picky about the shapes of their preferred substrates. In the reactome array, substrates are attached to a dye molecule and to a linker holding them to the chip, which may change their shape enough to stop them fitting into an enzyme's active site. Cane says that the paper presents no evidence that the assay would work with choosy enzymes.

Ronald Frank of the Helmholtz centre, who coordinated the German investigation, says that a meeting will be held on 11 August to discuss whether there should be further consequences for scientists there. A spokesperson for *Science* says that the journal is in discussions with some of the institutions involved and will make a decision about the paper "very soon". ■

Alison Abbott
Additional reporting by Daniel Cressey

Nate Lewis (left) will direct a $122-million research project to make fuel directly from sunlight.

US seeks solar flair for fuels

The US Department of Energy has launched an 'artificial photosynthesis' initiative with the ambitious goal of developing, scaling up and ultimately commercializing technologies that directly convert sunlight into hydrogen and other fuels.

The Joint Center for Artificial Photosynthesis (JCAP) will receive US$122 million over five years, and will be jointly led by the California Institute of Technology (Caltech) in Pasadena and the Lawrence Berkeley National Laboratory in Berkeley, California. Announced on 22 July, JCAP is the second of three Energy Innovation Hubs that US energy secretary Steven Chu plans to establish this year.

The hubs aim to get basic science out of the lab and into the real world. "We have to scale up from the nanoscale to the macroscale," says Nate Lewis, a Caltech chemist who will direct the JCAP programme, which will ultimately employ 150–200 people in two buildings at Caltech and the Berkeley lab.

Existing photovoltaic cells capture photons and produce electricity, which can be used to split water molecules and produce hydrogen. With artificial photosynthesis, photons from the Sun would drive a 'wireless' chemical conversion process to generate fuels. The most likely fuel is hydrogen, which can be used as it is or converted into other liquid fuels as a replacement for petroleum.

Caltech and the Massachusetts Institute of Technology in Cambridge are already leading a similar effort, known as 'Powering the Planet', that was funded with a $20-million, 5-year grant from the National Science Foundation in 2008. But Lewis says that project focuses more on basic science questions at each step of the process, such as how to boost the number of photons captured by a given material or increase the efficiency of a given catalyst.

By contrast, JCAP aims from the outset to build a solar-fuel system that will ultimately prove commercially viable. Potential advances in electrolysis and photovoltaic solar panels would be welcome but incidental, says Lewis. "That's the dividing line that we drew intellectually." Lewis adds that the centre will compare materials and processes used by competing researchers to determine which scientific avenues look most promising.

"We have to scale up from the nanoscale to the macroscale."

Chu initially proposed eight energy hubs, but Congress authorized the energy department to move forward with three. The first energy hub, which focuses on advanced nuclear reactors, was announced in May. A third hub aimed at energy-efficient buildings will follow in the coming months. Chu has called the energy hubs 'Bell lablets' after the famous Bell Laboratories in Murray Hill, New Jersey.

Earlier this year in its fiscal 2011 budget, the energy department requested $34 million for a fourth hub, focusing on batteries and electricity storage, but Congress has yet to approve it. ■

Jeff Tollefson