Designing Craters: Creating a Deep Impact

The Importance of Cratering in the Solar System

STUDENT TEXT

What happens when you throw a rock into a pond? Before it sinks, there is a splash and ripples travel outward from the point where the rock hit the water. We all enjoy throwing things, yet do you realize that the gravitational force of the Sun and the planets can also throw things around the Solar System? The gravitational force of the Sun controls the orbits of the planets. They travel in elliptical orbits at speeds varying from over 10,000 mph of distant Pluto to the almost inconceivable speed of 107,000 mph, the speed of Mercury. Other planets can force less massive bodies off course, occasionally causing that stray material, or small bodies, to collide with the Earth.

So, you haven't been hit by a falling star? Few people have; yet some people have had meteorites fall through the roofs of their homes or smash into the trunks of their cars. Elsewhere on Earth, we can see the scars of past impacts from objects that were on a collision course with our home planet.

What happens when a small body hits Earth? It sometimes leaves a hole in the ground called a crater. The energy from the moving body is transferred into the earth; the ground is compressed, while the shock wave carrying the energy rebounds and carries debris into the atmosphere. This ejecta falls back to earth and a circular hole in the ground remains. This is the equivalent of the splash and ripples that are formed when you throw a rock into a pond. This process also includes a heat pulse that causes some chemical reactions at the surface. We have a difficult time predicting the specific chemical reactions because we can't reproduce planetary impacts in our laboratories on Earth.

If projectiles collide with Earth, it is easy to imagine that they must also collide with other planets. How much has our Solar System been impacted by such collisions? Look at the Moon for example. The bright areas on the Moon are heavily cratered surfaces. The smooth, flat and dark areas are regions that were excavated by huge impactors (projectiles) and were subsequently filled in by lava. We call these dark areas maria, which is Latin for sea. We also can see craters on the surfaces of Mercury, Mars, the asteroids, and even the satellites of the giant planets in the outer Solar System. To view images of some of these craters, visit NASA's Planetary Photojournal at: http://photojournal.jpl.nasa.gov/index.html. Cratering is a primary sculptor of those planetary surfaces that are without active interiors, and those with little atmosphere and weather that would erase impacting features. We conclude from this evidence that impact cratering is a process that occurs throughout the Solar System.

NASA image of the Moon taken by Galileo Orbiter in 1992. The dark areas are the lunar maria or impact basins that have been filled in with lava.

Crater formation is not as prevalent *now* as it was 4.5 billion years ago, when our Solar System was just a rotating disk of gas and dust out of which the planets grew. Going back to the lunar maria, notice that they are smooth and flat. Today, we can only see a few small craters in the maria. This reassures us that since the giant basins were filled in 4.2 to 4.3 billion years ago, there have been few impacts. Therefore, we don't have to worry about being hit by large bodies today.

We can see that throughout the Solar System some craters have been erased by lava flow or obliterated by frequent impacts. There is evidence, from dating lunar rocks with radioisotope dating methods, that

most of the cratering took place back at the beginning of the Solar System when planets were being swept up and growing. Today, we are only hit by the occasional stray body and most of them are small.

But wait a minute, what about bodies traveling on extremely elliptical orbits, like the comets? They are in orbits that are stretched like a rubber band. What stops them from hitting the Earth?

Photo by John Annexstad, NASA JSC

Scientists have found thousands of meterorites preserved in ice in Antarctica.

The answer, for the most part, is Jupiter. Since its mass is second only to the Sun in the Solar System, Jupiter causes significant gravitational perturbation or disturbances in the Solar System. The path of most stray bodies in the Solar System will be perturbed by Jupiter and are captured into Jupiter's orbit, ejected into the outer Solar System, or sent into the inner Solar System as Jupiter family comets. We can determine the orbits of Jupiter family comets. Using Newton's Law of Gravity and computer computations, we can predict how these orbits will change in the future. And, we know that none of the known comets will hit the Earth during the next two hundred years.

But there remains a small probability that we could be hit today by a big fragment, or a small asteroid or comet, and that it might do damage to Earth and people on it. To address this probability, we study the asteroids and comets and learn as much as we can about them, so that in the event that we do find one on a collision course, we might be able to figure out how to divert it from its path.

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