Planetary Science

The Formation of Craters

Commentary:
The asteroid that formed the Ries Crater had a destructive force equivalent to nearly 20,000 megatonnes of explosive. Nuclear explosions are one way of reproducing the high pressures and temperatures that occur during an impact. Fortunately there are some safer experiments that enable us to model impact processes. In the late 1980's Peter Schultz, working at the NASA Ames Research Center, used a compressed air gun to accelerate a projectile to several kilometres per second to study the formation of craters. The whole process lasts less than a second, so high speed cameras are used to record the action.

Peter Schultz:
That's great. OK, that did just what we expected. Here we can see where the red temper that we had on the surface of the target has been covered by the lighter material that was below it. Now, you can see the decay and eventually that of the thickness of that ejector, and eventually it gives out about here where predominantly it becomes red, and as you go farther out you can see just primarily red clumps that have impacted.

Commentary:
By slowing down the impact to one-sixteenth of normal speed we can see the curtain of ejecta that forms as the projectile hits the target. From such experiments we can reconstruct the Ries impact. The asteroid crosses the Earth's atmosphere and becomes a brilliant fireball. At a speed of more than 35,000 kilometres per hour, this cosmic bullet penetrates the Earth's surface and comes to rest at a depth of approximately one kilometre. As a highly compressed gaseous body, it explodes and a shockwave spreads from the base of the crater. Molten, vaporised and pulverised rock is then ejected. In less than one tenth of a second this has reached its climax. During the next minute or so a red-hot mixture of solid, liquid and gaseous material forms a blazing cloud over the crater. The high temperatures at the centre of the crater cavity melt large amounts of the target rock. These fragments of green glass have the same chemical composition as the Jurassic and Triassic sandstones in the Ries. They were found in Moldavia in the Czech Republic, over 400 kilometres from the crater. Not surprisingly, they're known as Moldavites. The same kind of glass is produced by melting the target in the high velocity gun experiments. It, too, is thrown a long way from the point of impact, as this photograph shows. The tremendous amount of energy released by the impact sends shockwaves deep into the earth and obliterates anything in its path.

Ian Gilmour:
Just imagine the sheer power of a meteorite hitting the ground in the Ries. This is a shatter cone, in fact from a crater in Canada, but it shows the kind of features that we expect to see. However, this specimen comes from a crater at Steinheim, less than 40 kilometres from here, which just goes to show that both lightning and meteorites can hit the same place twice. Quite frankly, what we have here is a mess. Just look how chewed up these rocks are as a result of the impact. There's really not much left of the original sediments. We have a combination of suevite and this mixed-up rock that has been almost totally destroyed by the force of the impact. In fact this rock consists of Triassic and Jurassic sediments that have been blasted across the landscape by the force of the impact, rolled on top of themselves, and then this curtain of suevite descended down on top of them. This entire process couldn't have lasted more than a few minutes at most. Quite amazing, really.

Commentary:
In fact, this fracturing extends to some of the fossils we find in the rocks. This belemnite, for instance, has been broken apart by the force of the impact and then re-cemented later. The

destruction even extends to the granites that lay more than half a kilometre below the surface. The temperature generated by the impact was enough to melt these and reset their radiogenic clocks which tells us when the impact occurred: 14.7 million years ago.
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