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An old, far-flung rock

Ken Tapping, February 12, 2019

Our Earth, along with the other bodies in the Solar System, formed some 4.5 billion years ago from the collapse of a cloud of gas and dust. Tiny bits collided and stuck together making larger bits, and so on. Sometimes large bits collided and smashed each other back to smaller bits, and the building process had to start over. The Moon may have been formed from debris ejected when the Earth was hit by something big. The youth of the Solar System was a busy place, with growing bodies, collapsing clouds of dust and flying collision debris.

Around four billion years ago, the drama gradually slowed, and more and more of the material had become incorporated into planets. There are still major lumps of building material with collision potential around the Solar System today; the asteroids with orbits crossing the Earth's path around the Sun are good examples. Debris from these high-energy impacts can be thrown off into space where, maybe after many millions of years, they fall on another planet. This is how pieces of rock from Mars have been found here on Earth. However, we have only recently found an example of the reverse process, a piece of the Earth, ejected into space and found on the Moon.

One of the primary objectives of the Apollo missions to the Moon was to bring back samples of lunar material. So quite a lot of lunar dust and rock samples are now sitting in laboratories on Earth. The sample we are discussing here was brought back by the Apollo 14 astronauts, in 1971. It was in a lump of a rock called impact breccia.

When a body such as a small asteroid hits a planet or moon, the impact releases a huge amount of energy. Some of the material making up the two bodies is vaporized, some of it is smashed into fragments, and a lot is melted. When it cools, the melted part glues the fragments together into a rock we call an impact breccia. A huge impact that occurred about 1.9 billion years ago, near Sudbury, Ontario, produced a lot of impact breccia.

The Earth and Moon have both suffered many impacts. However, on Earth the impact craters are erased by erosion and plate motions, which continually recycle the Earth's surface rocks. The Moon has no plate motions, so we see the surface covered with craters and the other results of high-energy impacts, such as impact breccias. Surprisingly, one sample of lunar breccia was found to contain a fragment of rock that did not fit. First of all, it bore the signature of having formed on a water-rich planet. That rules out the Moon. Secondly, the mix of minerals in it corresponded to conditions in the Earth's crust, about 20 km deep.

The next step was to establish the age of the rock. One way to do this is to find some zircons – crystals of zirconium silicate. This material is present in lava, and solidifies into crystals when the lava cools. Uranium dissolves in zirconium silicate, but lead does not. So newly formed zircon crystals contain uranium, but not lead. However, uranium is radioactive, which means over time its atoms split, forming other elements, such as lead. So if we find lead in a zircon, it came from the uranium. Moreover, since the rate at which uranium turns into lead is known and does not change, the relative proportions of uranium and lead tell us how long ago the crystal formed. That rock fragment turned out to be 4.4 billion years old, about the same as the oldest rocks here on Earth. However, due to the continuous recycling of rock by plate motions, really old rocks are rare on Earth, so maybe we have just found the best place to seek the oldest Earthly rocks – the Moon.

Mars lies in the southwest after dark. In the predawn sky, Jupiter shines brightly in the southeast, with Venus, even brighter, to its left, and further left and much fainter, almost lost in the dawn glow, lies Saturn. The Moon will reach First Quarter on the 12th and Full on the 19th.

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