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AST 191

Activity 4

9.30.13

When you look at the moon, you see that it is riddled with craters that cover much of its surface. When you take a look at the Earth’s surface, you rarely see any craters. The Earth and moon are so close that you’d expect to see similar features like craters but this isn’t the case. Our driving question for activity 4 is ‘why does Earth have so few large craters compared to the moon?’.

We discussed a number of conjectures that try and say why the Earth has so few craters compared to the moon. The first conjecture says that the Earth has an atmosphere that burns up meteors that are headed for Earth. Yes maybe our atmosphere could burn up smaller meteors but what about large meteors? We see that the moon has many, many large craters but Earth only has about 5. We know that our atmosphere is about 30 km thick and that we have craters that range in size from 15 to 300 km. We also know that in general a crater’s diameter is 10 times the size of the meteor that made it. That would mean for larger craters on earth, a meteor with a diameter roughly the diameter of our atmosphere caused it. There is no way our atmosphere could burn up a meteor of that size. This conjecture does not hold for why we have so few large craters.

The next conjecture says that most large meteorites landed in the ocean so we can’t see them. When you look at a picture of the moon you can see that the falling of meteors, large and small, is random. When our oceans take up 71% of our surface, you would still expect to see a great number of craters that impacted on land and we see only a few so we know this conjecture is not sound.

The third conjecture claims that the moon blocks meteors from hitting Earth. This makes little sense, however, since Earth is 13.5 times larger than the moon, which makes it a much bigger target for meteors. That being said, that would mean that Earth would actually have a better shot of blocking meteors from hitting the moon, yet we see the moon littered with craters and the Earth having next to none so we know this conjecture does not hold.

The 4th conjecture says that erosion and tectonics have destroyed many craters on the earth. When we look at images that highlight where craters are on earth, there is an obvious trend. Nearly all craters lie away from tectonic plates. Conjecture 4 is something to seriously consider.

We have already disproven conjecture 5 since we know that the only significant conjecture so far is 4.

Conjecture 6 gives us a little more to think about in that maybe there is something more going on here. When we discussed this activity in class, we came up with a model to show that something else is going on. We see how many craters on the moon and being 13.5 times larger than that moon, we would expect to see that many more craters. The moon has around 1700 craters so we would expect to see almost 23000 craters on Earth. We would only be able to see about 30% of these since we wouldn’t see the ones in the ocean so that number drops to almost 7000 on land. We know that earth is 4.6 billion years old so that means we should see a large crater every 1.5 million years. Taking into account erosion and tectonics, if we say that large craters live only 500 million years, we would expect to still be able to see about 750 large craters. We see 5. This shows that there is certainly something else going on here. We will look at the moon to get to the bottom of this problem.

We looked at an image of the Maria and the Highlands on the moon. They both have similarities and differences. They both contain craters in them and both look like a similar rocky surface. They are quite different, however. The highlands look like craters cover every inch while the mare only has a few small craters. By observing the highlands, the mare, and the craters on the mare, we can relative age date them. When we look at the spot where the mare and highlands meet, we can see where it looks like craters have been partially filled in by lava then it extends to flat-ish surface. By Steno’s laws, we know that the craters in the highlands have to be the oldest and the craters that once covered the mare, were then filled in by lava, which makes the mare younger than the highlands. We also can tell by Steno’s laws that the craters on the mare had to come after the mare because they would have been covered by lava otherwise.

The average size of large crater in the highlands based off of measuring the 10 largest craters in the image is about 2.48 cm. The average size of large crater in the mare based off of measuring the 10 largest craters in the image is about 0.315 cm. This is quite a large difference and pretty concretely shows that the majority of large craters were created before the mare.

When we look at the same measured area in the highlands and the mare we also see that the crater density is quite different. I am counting a crater as a circular disk with apparent raised edges and different shadowing on the rim and the innards. I am using these same criteria to count the number of craters in both the mare and highlands areas. The number of craters counted in the highlands area was 63. The number of craters counted in the highlands area was 8. We know from radiometric dating of rock samples that the highlands date back to 4.5 billion years and the mare dates back to 3.5 billion years. From this and the above crater densities, we can deduce that in the first billion years, there where many, many more meteors hitting the moon than in the last 3.5 billion since the mare only has a handful of craters. Theses numbers show that there were almost 88% more meteors hitting the moon in the first billion years compared the last 3.5 billion years.

From our analysis above, we can safely make a generality about the Solar System in the first billion years. We have seen that many more meteors where hitting planets and many more larger meteors were hitting planets in the first billion years compared to the last 3.5 billion. This statement leads us back to our original driving question: Where are the big craters on the Earth? We can now conclude that nearly all of the meteors that hit earth and left large craters hit in the first billion years. From our model, we said that it takes a large crater to be covered up by erosion and tectonics about 500 million years. That means that all the large craters that came from the first billion years are now gone. We also saw from the mare on the moon that about 7 craters existed per unit area in the last 3.5 billion years. We would also expect to see less than this because much of those would have been eliminated by erosion and tectonics except for the ones in the last 500 million years. After our analysis, it is very easy to see why there are so few large craters on Earth.