From space to Earth: The history of meteorites

Professor and museum curator Chris Herd, discusses all things meteorites and why they matter.

By Michaela Ream on July 3, 2018

The University of Alberta is home to 1,400 specimens of more than 210 meteorites. Photo credit: Michaela Ream

Q: Why are meteorites so important to the study of the earth?
A: “Meteorites samples of places where we can’t easily go. They come from the moon and Mars occasionally, but most of them come from asteroids in the asteroid belt, and the asteroids have undergone their own geologic evolution and geologic processes. Meteorites tell us about those processes, and then certain types of meteorites represent stuff left over from the formation of the solar system that didn’t get completely overprinted by those processes in the asteroids and that gives us a sense of what the solar system was like and the timing of it as well.”

Q: How accurately are we able to now date the formation of our solar system?
A: “We know the age of the solar system to within a hundred thousand years. So, 4,567,000,000 years, plus or minus a hundred thousand years of uncertainty. All thanks to the details of the study of what we call primitive meteorites, which are the ones that basically represent the stuff that everything else is made of. In the disc of dust and gas around the early sun that everything else formed from, they escaped getting caught up into large objects and having that record erased—so they preserve that original record.”

Q: From the research that has been conducted so far, what sort of information have we managed to learn about Earth from studying meteorites?
A: “They’re the building blocks as far as we understand for the planets and for everything else. They give us information on the composition of the stuff that the Earth and other planets were made from, and they give us information about what that disc looked like and what was happening in the disc of dust and gas at the time that Earth was forming. And because the Earth formed quite close in to the sun where things were pretty hot, liquid water was actually not stable for a large period of time. So all the water that we have on Earth that’s so important for life we, we think came from the stuff that still had water in it from further out in the disc and was delivered to the Earth slightly later—within a few million years of the Earth forming.”

Q: What about the formation of life?
A: “We think that the formation of life happened several hundred million years later after the Earth was formed, but that the material to start, like the building blocks for life itself, may have been delivered to the Earth by primitive meteorites. Some of these primitive meteorites sample that disc of dust and gas and they also have primitive organics in them, but you need to have the right conditions. Basically there are processes as we understand it in interstellar space where organics can get kind of cooked up or produced, but then those would’ve gotten dumped into the disc of dust and gas around the sun and then what we call accreted into larger objects. So all that stuff comes together with maybe ice and organic matter into an asteroid, and then some heating happens on the asteroid so that the water becomes liquid, and sort of cooks it all and forms other organic molecules. It’s like an incubator in that sense, but then somebody turns off the heat really quickly because they aren’t big enough to have the heat over long term.

"On the Earth, the same type of thing may have happened but in say a hydrothermal vent at the bottom of the ocean, that sort of thing where you have some of those organic components around and you’re able to provide more of a heat source over a longer period of time. But where those organics came from in the first place is a big question and almost certainly some had to be contributed from these asteroid materials.”

Q: Is it a possibility that the kinds of rare metals that can be found in meteorites would have sufficient quantity to make it worthwhile creating an asteroid mining operation?
A: “It comes back to what some of the meteorites tell us about the composition and the processes that have affected those asteroids. So you can think of the planets in the solar system and all these individual asteroids as kind of like their own experiments-you put a certain mix of stuff together into something the size of the Earth and let it run and the core, the mantle, the crust, the atmosphere forms."
“Asteroids are a much smaller scale, but some of them may have been hundreds of kilometers across at one point, and they got broken up. So you have processes like the formation of an iron rich core, rocky mantle and crust, all on the asteroid scale—hundreds of kilometers across. Collisions happen and you break that thing apart and the core itself is exposed and the stuff from the core ends up becoming stuff that becomes meteorites. So we understand from the iron rich meteorites, the so called iron meteorites, that they are enriched in iron and nickel and other elements that went along when the core was formed, including things like iridium, gold, platinum (dissolved inside the iron-nickel metal), those sorts of things that are in relatively higher concentration than what we have at the surface of the Earth typically. With that in mind, people have proposed mostly if the cost of launching things into space comes down, then we could potentially mine these asteroids for these elements.”

**Q:** Once a meteorite has been discovered, how is it stored?

**A:** “Most meteorites are finds because it’s rarer to have a fireball and then find a meteorite. So for a find because it’s been subjected to moisture and oxidation at the Earth’s surface, the idea there is just to slow or stop that process—you don’t go to great lengths because it already has had things happen to it. So you do like you would with any other specimen or piece of art, you basically just bring it into a controlled environment and you keep it in a controlled environment. Most of the meteorite collection is in that controlled environment where we have things in plastic bags or double bagged, labels are always essential, and in an environment that’s dry and protected. We keep the humidity low, and we control the air quality in the environment because particles that are in the air can contaminate the samples so we remove those particles and keep the air high purity air.

**Q:** The Tagish Lake meteorite is kept frozen, while the Bruderheim meteorite is kept in a vacuum seal. Why do these two have such special storage methods?

**A:** “For Tagish Lake, it fell in a frozen lake and was collected without direct hand contact using plastic bags by the fellow who found it and has been kept frozen ever since. Some of the first studies that we did after we acquired it included finding molecules that will evaporate or be lost if you kept it at room temperature. It’s actually kind of a miracle that it even survived, but that’s the way it is. We’re lucky to have that and so we do go to great lengths to preserve it, and it’s as close as possible to preserving what it was like out there in space. In the case of Bruderheim, there are these two custom made vacuum tubes with specimens of Bruderheim in them. The people at the time had the foresight to recognize that these things will rust over time or they’ll oxidize if they’re exposed at the Earth’s surface, so maybe we should do something to preserve a couple of these representative samples. The cool thing is those were encapsulated in 1960, before the space age started - before we even had an idea of how best to preserve samples from space.

**Q:** What are some of the other significant meteorite falls that have been collected with regards to the scientific research they have provided?

**A:** “Tagish Lake is the most significant meteorite fall in Canadian history for scientific reasons but prior to that, in 1960, there was a major fall, the Bruderheim meteorite, where 300 some kilograms of meteorite fell on the town of Bruderheim. The University was able to acquire that, which really kicked off growth in the collection, but also it was a major meteorite fall at the beginning of the space age. Peace River in 1963 and then Allende in ’69 is also really significant, because in ’69 all these laboratories around the world were getting ready to receive Apollo 11 samples. So you had all this state of the art equipment that had just been funded and ready, and this thing falls in February of 1969 when people are expecting things back later in the year from the Moon.

Then there was another one in 2011 called Tissint in Morocco, and it was a fireball observed in July of 2011, but you don’t go out to the middle of Morocco in the middle of July because it’s too hot. So people went out in October and they found these fresh samples and they’re from Mars and that’s the significant thing, is that it’s the most recent Martian meteorite since 1962—so it’s been awhile since there’s been an actual fall of a Martian meteorite. We’re lucky to have some in the collection.

**Q:** Can you tell me a bit about the Fireball cameras? Their background, what they mean for the research at the University of Alberta, and where these cameras will take future research?

**A:** “The cameras are part of a global fireball observatory which started in Australia where they have these cameras that are always looking up at the sky, and they’re watching for fireballs and as soon as you get a detection, three or more of these cameras from different angles can triangulate the trajectory both forwards and backwards. So you can predict where meteorites will have fallen, the location, and you can also calculate the orbit. So you can back calculate where in the solar system it came from, and that’s a really cool thing, because the more observations that you make, the better you get of where they are coming from relative to the Earth’s orbit.

“There are two advantages to the cameras: one is to participate in a global network so that we can help to understand where everything is coming from. But the second thing is that if you have a detection on these cameras, you can tell very precisely where something might have fallen. So the whole idea, in the context of what we are talking about here and the advantages that we have, is we know exactly what to do for any meteorite that gets tracked by this network and falls on the surface. Which is the other advantage, that it will automatically notify us when there’s been a detection and where the likely fall zone is to a relatively small area, which makes it worthwhile to go and look for that material and collect it right away. The sooner you collect it, the less chance it has for rusting or altering and the sooner you can get it into the lab, the more science you can do with it. That’s the looking forward kind of side to it, is that this network of cameras is going to bring it kind of end to end. We will be able to have information about where the object came from in the solar system, the material itself, we can analyze and understand it, and we know the best methods for curating it as well, to preserve it and maximize the science that we would do from it.”

Source: Faculty of Science