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Tapping, Ken

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BIRTH OF THE SOLAR SYSTEM

Ken Tapping, 21st February, 2017

Any rock that was once molten contains two important things: a clock that tells us how long ago it was last molten, and frozen information on the conditions at that time.

Many rocks contain uranium, which was frozen into them when they solidified. Uranium is radioactive, which means its atoms disintegrate at a fixed rate, giving off radiation and turning into lead. By measuring the relative proportions of uranium and lead we can determine how long ago the rock solidified. Some of the atoms and molecules in molten rock respond to the magnetic field passing through it. For example, when the rock solidified the direction and intensity of the magnetic field are recorded in the rock. This is how we determined the ages of the oldest rocks on Earth: something like 3.8 billion years. By looking at rocks of various ages, we have been able to follow the changes in the Earth's magnetic field and other conditions in the young Earth.

Meteorites are debris from space that has fallen to Earth. Some are made of rock, others of nickel and iron, and there are many meteorites that have intermediate compositions. Most of them were formed during the birth and extreme youth of the Solar System, although new ones are still being produced by collisions and impacts. Just as in the case of rocks on Earth, we can use the uranium/lead ratio to determine their age; their composition and trapped magnetic fields tell us what conditions were like at that time.

Our Solar System was born some 4.6 billion years ago through the collapse of a huge cloud of cosmic gas and dust. As it collapsed, the dust got hot, melted and collided into bigger lumps. Some of those lumps stayed as they were, cooled off and solidified. Others grew, smashed into each other, got melted again and continued the process, eventually forming the Sun and planets. The process ended when the Sun lit up and its radiation and solar wind blew away the remaining material in its birth cloud, leaving the Sun, planets and a vast number of orbiting fragments. Over its lifetime, as it orbits the Sun, the Earth has run into a huge number of these fragments. Many were vaporized or disintegrated by the atmosphere, but a large number survived to reach the Earth's surface. Together, the bits of information from each of those fragments can tell us about the birth of the Solar System.

Space is pervaded by a very weak magnetic field. This field was present in the Solar System birth cloud. As the cloud collapsed, it dragged the magnetic field with it, and as fragments of material cooled and solidified at various stages in the collapse, they "remembered" the strength of the magnetic field at that time. From all our meteoric samples, we have put together a story that at first sight is what we expected. As the collapse proceeded, the samples show a rapidly increasing magnetic field, which reached a high peak value, and then it dropped to almost the original cosmic value, showing the collapse had stopped and the Sun had blown the cloud material away. However, the big surprise is that the meteorites tell us the whole process took only 3.8 million years! Our computer simulations suggest it would take a lot longer than that. We are still some way from understanding "how we got here".

Even 3.8 million years is a very long time in human terms, so there is little chance we will be able to follow the whole birth process. However, our telescopes are picking up lots planetary systems at all stages of formation, so we have plenty to work with. We probably won't be getting any meteorites from them though – not for a long time.

Mars and Venus lie in the Southwest after sunset. Venus is very bright. Mars, redder and fainter, lies close to its left. Jupiter rises around 10pm. The Moon will be New on the 26th.

Ken Tapping is an astronomer with the National Research Council's Dominion Radio Astrophysical Observatory, Penticton, BC, V2A 6J9.

Tel (250) 497-2300, Fax (250) 497-2355

E-mail: ken.tapping@nrc-cnrc.gc.ca