HOW DID LIFE GET STARTED ON EARTH?

The Sudbury Basin is a major geologic structure in Ontario, Canada. It is the second-largest verified impact crater on Earth, as well as one of the oldest.

Geochemists from Trinity College Dublin's School of Natural Sciences may have found a solution to a long-debated problem as to where -- and how -- life first formed on Earth.

In a paper just published in the journal *Geochimica et Cosmochimica Acta*, the team proposes that large meteorite and comet impacts into the sea created structures that provided conditions favourable for life. Water then interacted with impact-heated rock to enable synthesis of complex organic molecules, and the enclosed crater itself was a microhabitat within which life could flourish.

It has long been suggested that the meteoritic and cometary material that bombarded the early Earth delivered the raw materials -- complex organic molecules, such as glycine, alanine, amino-n-butyric acid, and water -- and the energy that was required for synthesis. The Trinity group's work has provided the new hypothesis that impact craters were ideal environments to facilitate the reactions that created these molecules here on Earth and saw the first 'seeds of life' take root. Author **Edel O'Sullivan**, a PhD candidate in Switzerland, says:

> *Studies investigating the origin of life focus on synthesis in hydrothermal environments found at mid-ocean ridges -- a hallmark features of plate tectonics. Yet these did not exist on the early Earth. The findings of this new study suggest that extensive hydrothermal systems operated in an enclosed impact crater at Sudbury, Ontario, Canada.*

The research was part of a wider project funded by Science Foundation Ireland and led by senior author, Professor of Geology and Mineralogy at Trinity, **Balz Kamber**. Although no very ancient terrestrial impact structures are preserved, the Sudbury basin provides a unique opportunity to study the sediment that filled the basin as a guide to what the earlier impact craters would have looked like. The Sudbury structure is distinctive among the known terrestrial impact craters. It has an unusually thick (nearly 2.5 km) basin fill, and much of this is almost black in colour (due to carbon) containing also hydrothermal metal deposits. Due to later tectonic forces, all the rocks of the once ~200 km-wide structure are now exposed at the surface rather than being buried. This makes it possible to take a traverse from the shocked footwall through the melt sheet and then across the entire basin fill. **To a geologist, this is like a time journey from the impact event through its aftermath.** Samples across the basin fill have been analysed for their chemistry and for carbon isotopes, and they revealed an interesting sequence of events. **Edel O'Sullivan** adds:

> *Previously the puzzling presence of carbon in these rocks was explained by washing in from outside the crater basin. However, the new data show that it was microbial life within the crater basin that was responsible for the build-up of carbon and also for the depletion in vital nutrients, such as sulphate. There is clear evidence for exhaustion of molybdenum in the water column, and this strongly indicates a closed environment, shut off from the surrounding ocean,.*

Only after the crater walls eventually collapsed did the study show replenishment of nutrients from the surrounding sea. These sub-marine, isolated impact basins, which experienced basaltic volcanism and were equipped with their own hydrothermal systems, thus present a new pathway to synthesis and concentration of the stepping stones to life.

Thanks to regular and heavy comet and meteorite bombardment of Earth's surface during its formative years 4 billion years ago, the large craters they left behind not only contained water and the basic chemical building blocks for life, but also became the perfect crucible to concentrate and cook these chemicals to create the first simple organisms.

When the Earth formed some 4.5 billion years ago, it was a sterile planet inhospitable to living organisms, It was a seething cauldron of erupting volcanoes, raining meteors and hot, noxious gasses. One billion years later, it was a placid, watery planet teeming with microbial life – the ancestors to all living things.

AK with Notes from Science Daily and Wikipedia