Ice 'lightning' may have helped life survive Snowball Earth

2 November 2015, by Jon Telling

Between a rock and a hard place. Credit: Eddy Hill

The ice sheets and glaciers that extend over roughly 11% of the Earth's land mass are home to a surprisingly abundant source of life. Sections of liquid water beneath and inside the ice provide a habitat for a genetically diverse variety of microbes . And studying these organisms gives us some clue what life may have looked like if there were indeed periods of the planet's history when the land was entirely covered in ice for millions of years.

How exactly life managed to survive during these proposed "Snowball Earth" events is still something of a mystery. With the soil trapped under ice for so long, the typical nutrients that microbes eat would have become depleted. But research by my colleagues and I at Bristol University has revealed a mechanism that could have allowed these creatures to free energy from the water itself in the form of hydrogen.

Hundreds of millions of years ago, in the period of Earth history termed the Neoproterozoic, ice sheets likely covered all of the Earth's continents in multi-million year global glaciations. Substantial sections of ice sheets don't freeze due to a combination of underlying geothermal heat, the pressure of the overlying ice, and friction as ice slides and grinds forwards. This has led some scientists to argue that these extensive wet sub-glacial habitats may have acted as refuges for life or "refugia", preserving some biodiversity during these extended ice ages.

In these cold, dark habitats, no light is available for photosynthesis. Some microbes under today's glaciers survive by "eating" sulphide minerals in rocks, but others consume the remains of soils and vegetation picked up as the ice rivers roll across the landscape. But these "organic" food sources would have gradually disappeared if the whole of the land mass was covered with ice for millions of years.

New energy source

Our research suggests that reactions at the surface of rocks underneath the ice sheets can provide a novel source of energy that is enough to support sub-glacial microbes. These reactions are similar to those that happen when flint is struck against another flint or steel to produce sparks for lighting fires.

The impact against the freshly exposed silicate of the flint breaks the chemical bonds of the molecules on its surface. The highly reactive broken bonds (or "free radicals") react rapidly with gases in the atmosphere releasing enough energy to form sparks, in a similar way to how lightning forms.

Glaciers and ice sheets are also effective at grinding rocks together, eroding huge volumes of rock and changing the physical landscape over thousands of years. To replicate this process in the lab, we crushed a variety of different rocks in a ball mill to similar grain sizes of glacier sediment, and then added cold water. We found that mixing ground silicate with water at 0°C always produces hydrogen gas. The finer the rock is ground, the more hydrogen is produced.

This hydrogen is most likely formed when the highly reactive surfaces of freshly fractured silicate minerals react with and split water. Hydrogen is a ready source of energy – effectively food – for many sub-glacial microbes. The reactions produce enough hydrogen to potentially support a range of microbial life in this environment.

This means these mineral surface "lightning" reactions that split water provide a novel way for sustaining life and biodiversity under ice both today and during historic Snowball Earth events. This suggests that it is possible for life to exist in some of the most harsh environments we can imagine. The exciting prospect this raises is that life might be found in the seemingly inhospitable surroundings of other icy planets and moons throughout the galaxy.

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