

Ancient diamonds show Earth was primed for life's explosion at least 2.7 billion years ago

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One of the 2.7 billion year-old diamonds used in this work. Credit: Michael Broadley

A unique study of ancient diamonds has shown that the basic chemical composition of the Earth's atmosphere which makes it suitable for life's explosion of diversity was laid down at least 2.7 billion years ago.

Volatile gases conserved in diamonds found in ancient rocks were present in similar proportions to those found in today's mantle, which in turn indicates that there has been no fundamental change in the proportions of volatiles in the atmosphere over the last few billion years. This shows that one of the basic conditions necessary to support life, the presence of life-giving elements in sufficient quantity, appeared soon after Earth formed, and has remained fairly constant ever since.

Presenting the work at the Goldschmidt Geochemistry conference, lead researcher Dr. Michael Broadly said, "The proportion and make-up of volatiles in the atmosphere reflects that found in the mantle, and we have no evidence of a significant change since these [diamonds](#) were formed 2.7 billion years ago."

Volatiles, such as hydrogen, nitrogen, neon, and carbon-bearing species are light chemical elements and compounds, which can be readily vaporised due to heat, or pressure changes. They are necessary for life, especially carbon and nitrogen. Not all planets are rich in volatiles; Earth is volatile rich, as is Venus, but Mars and the Moon lost most of their volatiles into space. Generally, a planet rich in volatiles has a better chance of sustaining life, which is why much of the search for life on planets surrounding distant stars (exoplanets) has focused on looking for volatiles.

On Earth, volatile substances mostly bubble up from the inside of the planet, and are brought to the surface through such things as volcanic eruptions. Knowing when the volatiles arrived in the Earth's atmosphere is key to understanding when the conditions on Earth were suitable for the origin and development of life, but until now there has been no way of understanding these conditions in the deep past.

Now French and Canadian researchers have used ancient diamonds as a [time capsule](#), to examine the conditions deep inside the Earth's mantle in the distant past. Studies of the gases trapped in these diamonds show that the volatile composition of the mantle has changed little over the last 2.7 billion years.

Lead researcher, Michael Broadley (University of Lorraine, France) said "Studying the composition of the Earth's modern mantle is relatively simple. On average the mantle layer begins around 30km below the Earth's surface, and so we can collect samples thrown up by volcanoes and study the fluids and gases trapped inside. However, the constant churning of the Earth's crust via [plate tectonics](#) means that older samples have mostly been destroyed. Diamonds however, are comparatively indestructible, they're ideal time capsules."

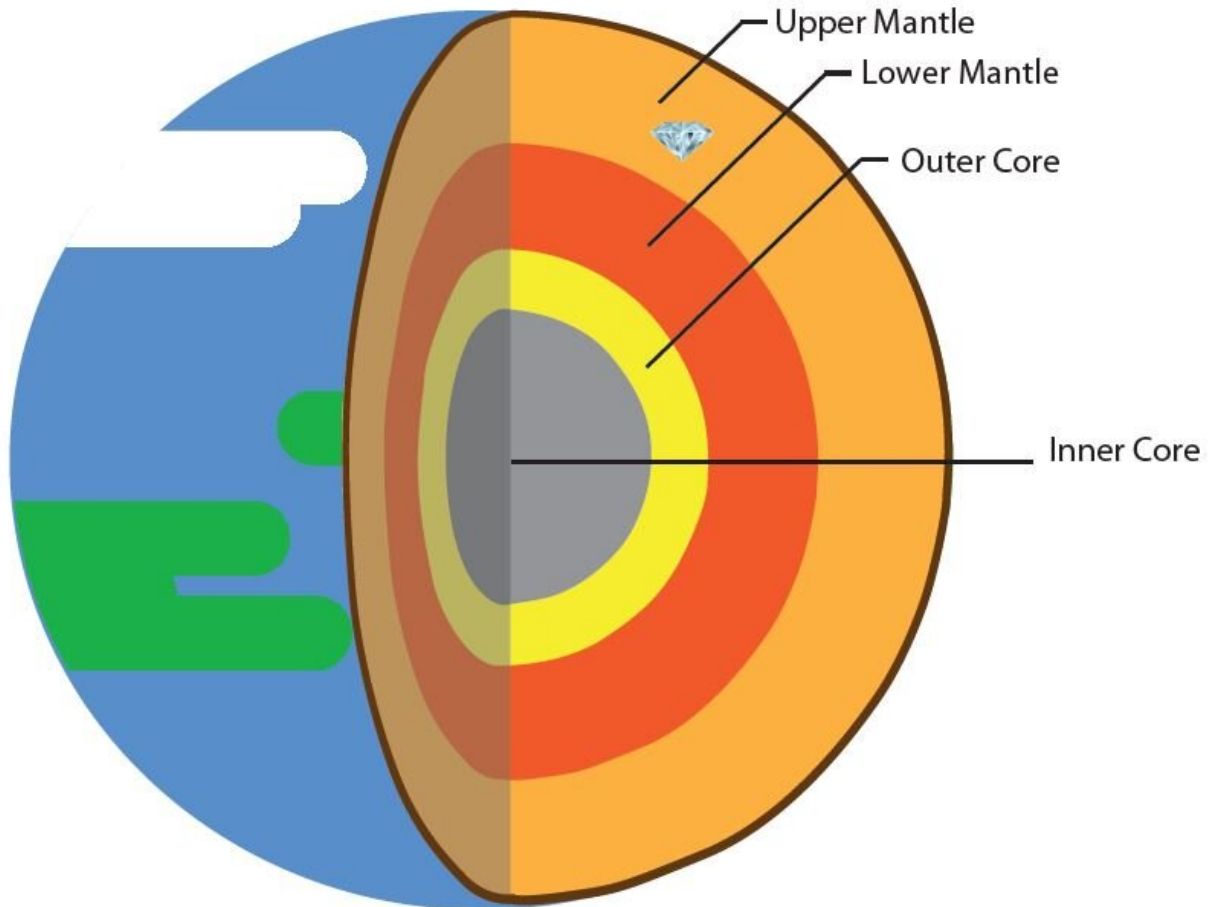


Diagram of the Earth's layers, showing the position the diamonds were formed in the Upper Mantle. Credit: Michael Broadley

We managed to study diamonds trapped in 2.7 billion year old highly preserved rock from Wawa, on Lake Superior in Canada. This means that the diamonds are at least as old as the rocks they are found in—probably older. It's difficult to date diamonds, so this gave us a lucky opportunity to be sure of the minimum age. These diamonds are incredibly rare, and are not like the beautiful gems we think of when we think of diamonds. We heated them to over 2000 degrees C to transform them into graphite, which then released tiny quantities of gas for

measurement."

The team measured the isotopes of Helium, Neon, and Argon, and found that they were present in similar proportions to those found in the upper mantle today. This means that there has probably been little change in the proportion of volatiles generally, and that the distribution of essential volatile elements between the mantle and the atmosphere are likely to have remained fairly stable throughout the majority of Earth's life. The mantle is the part between the Earth's crust and the core, it comprises around 84% of the Earth's volume.

Dr. Broadley said, "This was a surprising result. It means the volatile-rich environment we see around us today is not a recent development, so providing the right conditions for life to develop. Our work shows that these conditions were present at least 2.7 billion years ago, but the diamonds we use may be much older, so it's likely that these conditions were set well before our 2.7 billion year threshold."

Dr. Suzette Timmerman (University of Alberta, Canada), who was not involved in the research, said, "Diamonds are unique samples, as they lock in compositions during their formation. The Wawa fibrous diamonds specifically were a great selection to study—being more than 2.7 billion years old—and they provide important clues into the volatile composition in this period, the Neoproterozoic period. It is interesting that the upper mantle already appears degassed more than 2.7 billion years ago. This work is an important step towards understanding the [mantle](#) (and atmosphere) in the first half of Earth's history and leads the way to further questions and research."

More information: 2021.goldschmidt.info/

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