Fungi are key players of the deep biosphere

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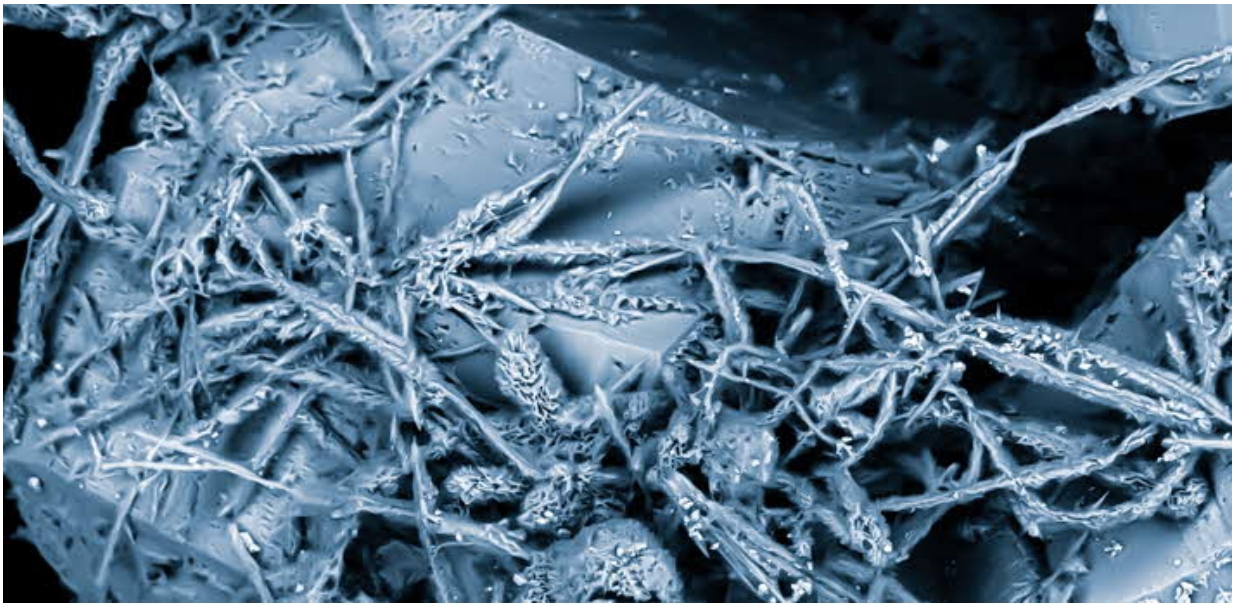

Partly fossilized mycelium of fungal hyphae on a zeolite crystal from 740 m depth in fractured granite. Back-scattered Environmental Scanning Electron Microscopy image. Width of view 600 µm. Credit: Henrik Drake, Magnus Ivarsson

In addition to the life on the surface of the Earth and in its oceans, ecosystems have evolved deep under us in a realm coined the "deep biosphere" which stretches several kilometers down into the bedrock. Down there, the conditions are harsh and life is forced to adjust to a lifestyle that we at the surface would call extreme. One major difference to surface conditions is the lack of oxygen; a compound we take for

granted and consider to be a prerequisite for survival but which subsurface life has to cope without.

The knowledge about ancient life in this deep environment is extremely scarce and most studies so far have focused on the prokaryotes. A new study by an international team of researchers led by Dr Henrik Drake of the Linnaeus University and Dr Magnus Ivarsson of the Swedish Museum of Natural History sheds light on eukaryotes in this deep setting. They present the first in situ finding of fungi at great depth in the bedrock. This ancient life is found at 740 m below the ground surface. It represents a new piece in the deep biosphere puzzle.

Henrik Drake, lead author of the study, explains the discovery:

"In a cavity hidden within a vein in a drill core I was examining, there were beautiful mineral crystals and abundant mycelium of fungal hyphae. To me this was like observing a small community frozen in time."

Magnus Ivarsson discusses the fungi:

"Our detailed synchrotron-based investigations clearly prove that it is fungi adapted to anaerobic conditions. The fungi is partly mineralized and partly organically preserved, which is a rare find that tells how organisms in this environment are fossilized and preserved."

High spatial resolution isotope analysis within the minerals that occur along with the fungi revealed that a variety of microbial processes had occurred in the caveat, including methane consumption and sulfate reduction. The fungi could not be dated precisely but there are proxies pointing to an age of tens of millions of years.

The study confirms a previously hypothesized consortium between fungi

and sulfate reducing bacteria, a coupling that has yet been unsupported by direct evidence in nature. As fungi provide hydrogen gas that fuel prokaryotes, the findings suggest a re-evaluation of the energy cycling within the energy-poor deep continental biosphere. Eukaryotes have been neglected in the deep biosphere research. This new finding proposes that they may be key players in this globally vast realm.

Studies of subterranean life-forms have implications for early life on our planet and for life on other planets, where hostile conditions may have inhibited colonization of the surface.

More information: Henrik Drake et al. Anaerobic consortia of fungi and sulfate reducing bacteria in deep granite fractures, *Nature Communications* (2017). DOI: 10.1038/s41467-017-00094-6

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