Building blocks of life came from deep Earth

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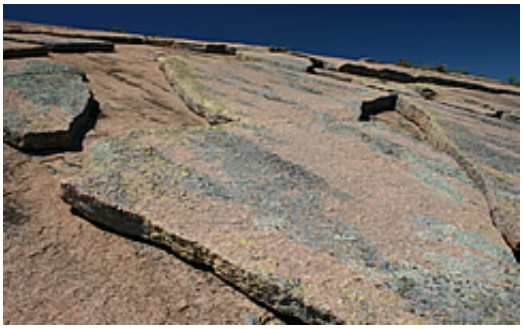

The rise of the first complex life depended on vital metals brought up to the Earth's surface from far below in vast granite deposits, a new study argues.

Metals like copper, zinc and molybdenum are essential ingredients for certain enzymes and proteins. These are needed for life forms with a complex internal structure, known as eukaryotes, to evolve. Without these metals the history of life could have been very different; plants and animals made of many cells could have taken hundreds of millions more years to develop, if they appeared at all.

The new study's authors realised that eukaryotes started appearing soon after a period of unusual geological activity, and wonder if it could have provided the raw materials they needed.

"Biologists have been saying for a long time that these three metals are essential for complex life to develop," says Professor John Parnell, a geologist at the University of Aberdeen and lead author of the paper, which appears in *Geology*. "And geologists have been aware that there was a period of unusual geological activity around the same time that would have brought an extraordinary amount of these metals to the surface. But I think we're the first to put the two together and suggest that the geological changes actually enabled the biological advances."

In particular, eukaryotic life is needed for sex differences to emerge. Until living things have both males and females, rapid evolution is impossible; sexual reproduction allows the mixing of genes from both parents, so that a population can contain much more variation for natural selection to work on. Before sexual reproduction, variations in populations of living things could stem only from occasional random mutations, so evolution moved much more slowly.

The explosion of new life took place during a period known as the Mesoproterozoic, around 1.6 billion years ago. This followed the birth of a new supercontinent known as Nuna or Columbia around 1.9 billion years ago, which triggered major changes in the activity of the Earth's mantle beneath.

Because of the thicker crust below the supercontinent, heat flow at the base of the crust was unusually high, leading to rising magma plumes that brought up metals that had previously been locked deeper in the Earth. After emerging through volcanic activity, this material cooled into vast new fields of granite, with deposits of metal sulphides disseminated throughout. As weathering slowly uncovered these, they turned to sulphates and were washed into rivers, lakes and shallow coastal waters, where they became available for use by living things. With these nutrients in place, the stage was set for the appearance of eukaryotes.

"Metals do come to the surface through normal volcanic processes, but we think this episode of high heat flow greatly accelerated the process. So it's possible that eukaryotes would still have developed if this hadn't happened, but it might have taken a lot longer," says Parnell.

Until recently, scientists thought these metals came instead from changes in the chemistry of the oceans. The discovery is part of a wider move towards theories that complex life got its start on land or in shallow waters rather than the deep ocean, as previously believed.

"I suspect that this increases the focus on the terrestrial origins of eukaryotes, as opposed to the deep marine ones," Parnell comments. "The onus is now on the palaeobiologists to go out and see what traces of early life they can find in the terrestrial record."

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