Discovery of a complex, multicellular life from over two billion years ago

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Virtual reconstruction (by microtomography) of the external morphology (on the left) and internal morphology (on the right) of a fossil specimen from the Gabonese site. © CNRS Photo Library / A. El Albani & A. Mazurier

The discovery in Gabon of more than 250 fossils in an excellent state of conservation has provided proof, for the first time, of the existence of multicellular organisms 2.1 billion years ago. This finding represents a major breakthrough: until now, the first complex life forms (made up of several cells) dated from around 600 million years ago.

These new fossils, of various shapes and sizes, imply that the origin of organized life is a lot older than is generally admitted, thus challenging current knowledge on the beginning of life. These specimens were discovered and studied by an international multidisciplinary team of researchers coordinated by Abderrazak El Albani of the Universite de Poitiers, France. Their work, due to be published in *Nature* on 1st July, will feature on the cover of the journal.

The first traces of life appeared in the form of prokaryotic organisms, in other words organisms without a nucleus, around three and a half billion years ago. Another major event in the history of life, the "Cambrian explosion" some 600 million years ago, marked a proliferation in the number of living species. It was accompanied by a sudden rise in oxygen concentration in the atmosphere. What happened between 3.5 billion and 600 million years ago though? Scientists have very little information about this era, known as the Proterozoic. Yet, it is during this crucial period that life diversified: to the prokaryotes were added the eukaryotes, single or multicelled organisms endowed with a more complex organization and metabolism. These large-sized living beings differ from prokaryotes by the presence of cells possessing a nucleus containing DNA.

While studying the paleo-environment of a fossil-bearing site situated near Franceville in Gabon in 2008, El Albani and his team unexpectedly discovered perfectly preserved fossil remains in the 2.1 billion-year-old sediments. They have collected more than 250 fossils to date, of which one hundred or so have been studied in detail. Their morphology cannot be explained by purely chemical or physical mechanisms. These specimens, which have various shapes and can reach 10 to 12 centimeters, are too big and too complex to be single-celled prokaryotes or eukaryotes. This establishes that different life forms co-existed at the start of the Proterozoic, as the specimens are well and truly fossilized living material! To demonstrate this, the researchers employed cutting-edge techniques that allowed them to define the nature of the samples and to reconstruct their environment.

Complex and organized multicellular macrofossil found in Gabon. © CNRS Photo Library / Kaksonen

An ion probe capable of measuring the content of sulfur isotopes made it possible to map the relative distribution of organic matter precisely. This matter is what remains of the living organism, which has been transformed into pyrite (a mineral formed of iron disulfide) during fossilization. This helped the researchers to distinguish the fossils from the Gabonese sediment (made of clay). In addition, using an ultra-sophisticated, high-resolution 3D scanner (also known as X-ray microtomograph), they were able to reconstitute the samples in three dimensions and, in particular, assess their degree of internal organization in great detail, without compromising the integrity of the fossils, since the method is non-invasive. The clearly defined and regular shape of these fossils points to a degree of multicellular organization. These organisms lived in colonies: more than 40 specimens per half square meter were sometimes collected. Consequently, they constitute the oldest multicellular eukaryotes ever described to date.

By studying the sedimentary structures of this site, which is remarkable both for its richness and quality of conservation, the scientists have shown that these organisms lived in a shallow marine environment (20 to 30 meters), often calm but periodically subjected to the combined influence of tides, waves and storms. In order to be able to develop 2.1 billion years ago and become differentiated to a degree never attained previously, the authors suggest that these life forms probably benefited from the significant but temporary increase in oxygen concentration in the atmosphere, which occurred between 2.45 and 2 billion years ago. Then, 1.9 billion years ago, the level of oxygen in the atmosphere fell suddenly.

Until now, it has been assumed that organized multicellular life appeared around 0.6 billion years ago and that before then the Earth was mainly populated by microbes (viruses, bacteria, parasites, etc.). This new discovery moves the cursor of the origin of multicellular life back by 1.5 billion years and reveals that cells had begun to cooperate with each other to form more complex and larger structures than single-celled organisms. Several research avenues now need to be explored: understanding the history of the Gabonese basin and why the necessary conditions were gathered to enable this organized and complex life to exist; further exploring the site to enhance the collection of fossils; but also comparing the history of the Earth's oxygenation with the mineralization of clays. The most urgent task, however, remains the protection of this exceptional site.

More information: Large colonial organisms with coordinated growth in oxygenated environments 2.1 Gyr. El Albani A., Bengtson S., Canfield D.E., Bekker A., Macchiarelli R., Mazurier A., Hammarlund E., Boulvais P., Dupuy J.-J., Fontaine C., Fürsich F.T., Gauthier-Lafaye F., Janvier P., Javaux E., Ossa Ossa F., Pierson-Wickmann A.-C., Riboulleau A., Sardini P., Vachard D., Whitehouse M. & Meunier A. Nature. 1st July 2010.

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