Chemistry versus biology – "true" and "false" biosignatures formed through biomineralization and organomineralization processes

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Our ability to identify unambiguously microbial biosignatures in the rock record conditions our knowledge and understanding of life on early Earth and on other planets. This task is complicated by the fact that several abiotic processes can produce microscopic objects, called biomorphs, that closely resemble microorganisms.

Here we will present a new class of biomorphs formed through the reaction of hydrogen sulfide with dissolved organic molecules [1], i.e. through an organomineralization process. These biomorphs have spherical and filamentous shapes, and are composed of elemental sulfur encapsulated in an organic envelope. We will show that they can form in the presence of simple, prebiotic types of organics, and that this organomineralization process might be at the origin of elemental sulfur particles found in a sulfide-rich environment (Frassassi caves, Italy). These new results emphasize the likelihood that organic-sulfur biomorphs might have formed in ancient environments. If preserved in the rock record, these "false biosignatures" would most certainly be interpreted as fossils of spherical and filamentous bacteria.

The question is then: what is a robust biosignature? I will use the example of calcium-phosphate forming bacteria to show that microbial biomineralization can sometimes produce very specific features that can be preserved in ancient rocks. These signatures can be revealed by an approach combining the use of model bacterial systems in the laboratory [2] and the nano-scale investigation of fossil bacteria in the rock record [3].

[1] Cosmidis & Templeton (2016), Nature Communications 7, 12812

[2] Cosmidis, Benzerara, Guyot, Skouri-Panet, Duprat, Férard, Guigner, Babonneau & Coehlo (2015), Frontiers in Earth Science, 3, 84

[3] Cosmidis, Benzerara, Gheerbrant, Estève, Bouya and Amaghzaz (2013), Geobiology, 11, 139–153