Enzymatically induced apatite formation as a key mechanism in fish fossilization – an experimental study

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Exceptionally preserved fish fossils are known from various locations and throughout most of Earth's history. They play an important role in understanding the history of life and process of evolution, yet the process that leads to their formation remains mostly unclear. Phosphorous is a scarce resource in the whole modern ocean and there is no evidence for this being different over the Phanerozoic. Nevertheless there are numerous examples for fish fossils preserved in apatite e.g. Solnhofen Plattenkalk (Jurassic of S' Germany), Gogo Fm. (Devonian of N' Australia) or Santana Fm. (Cretaceous of E' Brazil). Hence there is a need for a mechanism that provides exceptionally high amounts of P to facilitate the precipitation of large quantities of apatite.

In this study we investigate the role of microbially produced alkaline phosphatase (AP) as a source for the needed phosphate. AP is an ubiquitous enzyme throughout the world of bacteria and liberates phosphate from organic (macro)-molecules. It is known to provide phosphate for the formation of apatite *in vitro* (Cosmidis et al. 2015).

We conducted experiments, where AP was used to liberate phosphate from organic matter and, through oversaturation of the surrounding fluid, ultimately precipitated inorganically as apatite on fish scales. This might be the first step towards permineralization of the organic matter that is needed for fossilization. To strengthen the hypothesis the resulting apatite crystals were compared using TEM analysis with existing fossils. The result of these investigations showed a striking mineralogical similarity between the laboratory made and natural apatite crystals. This suggests that inorganic precipitation of apatite from an oversaturated solution indeed is a possible pathway for permineralization of a carcass which would ultimately lead to an exceptionally preserved fossil. Additionally this could mean that the fossil itself could be used as a geochemical and petrological indicator for the surrounding conditions, both of the sediment and the seawater, during its formation.

Cosmidis J, Benzerara K, Guyot F, Skouri-Panet F, Duprat E, Férard C, Guigner J-M, Babonneau F, Coelho C (2015): Calcium-phosphate biomineralization induced by alkaline phosphatase activity in Escherichia coli: localization, kinetics, and potential signatures in the fossil record. – Frontiers in Earth Science 3, 84