Apatitic Micronodules in Namibian Shelf Sediments: Mineralized Microbes or Diagenetic Precipitates?

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Introduction

• Phosphorous can be the limiting nutrient in a variety of marine and terrestrial ecosystems.
• As a component of fertilizers, it is important in agriculture.

Microbially mediated phosphogenesis

- The origins of phosphorites are still poorly understood.
- One of the proposed formation mechanisms emphasizes the role of polyphosphate-metabolizing bacteria that are capable of storing and releasing phosphate.

Modified, Brock and Schulz-Vogt (2011)
Phosphatization is well-known as a fossilization mechanism

- Apatitic microstructures in ancient and recent phosphorites have been (controversially) interpreted as fossilized microbes (e.g. Lamboy, 1990), therefore providing evidence for the important role of microbial processes on phosphogenesis.
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- The goals of this study are:
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  - to understand if and how phosphate precipitation is controlled/influenced by microbial/biological structures.
  - Recrystallization of ancient phosphorites makes it difficult to recognize primary structures, but comparison with modern phosphorites can help assess controls of past phosphogenesis.
• Samples were collected from the Benguela Upwelling System off of Namibia, a site of modern phosphogenesis.
Diatomaceous silty sand.
The grains are rounded and a few hundred μm in diameter.
The grains are composed of almost pure Ca-phosphate mineral apatite and are typically porous.
The walls of pores are coated with various Ca-phosphate microstructures.
Many of the structures are **cylindrical**. They co-occur with an **organic film-like substance**. The structures are predominantly Ca-phosphatic.
The apatitic structures are composed of **nanocrystallites** arranged along the long axis.
Similar apatite microstructures in phosphorites have been previously interpreted as fossilized microbes (e.g. Lamboy, 1990).

Interpretation: what are these structures?
Many particles are intersecting and typically form intertwined aggregates at angles close to $60^\circ$ and $90^\circ$. 
Different morphologies

In addition to cylindrical particles bigger bundles and dumb-bell shape aggregates occur.
Cylindrical particles show a progression from cylinders to dumbbells with widened ends to finally spherical forms.
Similar apatitic aggregates are found in artificial biomimetic fluorapatite–gelatine nanocomposites.

Busch et al. (1999)

Wu et al. (2010)
Formation mechanism of biomimetic fluorapatite–gelatine nanocomposites

- Fractal growth of an initial seed crystal results in formation of a dumbbell-shape and eventually a closed sphere.
Formation mechanism of biomimetic fluorapatite–gelatine nanocomposites: link to biomatrices

The growth is related to the arrangement and charge of organic molecules in the matrix of the structures.

Modified, Wu et al. (2010)
Conclusions

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● It is still unclear what triggered Ca-phosphate nucleation. Do the microorganisms serve as nucleation templates? How do the phosphatic grains grow?
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