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Study of the Mineralization Process of granular apatites in Weng'an Baidou Phosphate Deposit Using Microbeam Analyses

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1 Introduction

Studies of marine sedimentary phosphate rock have lasted decades, scholars proposed some standpoints about mineralization, however, the genesis of mineral deposits remains to be a controversial question (She et al., 2013). There are many viewpoints of mineralization about the Doushantuo phosphorites, Central Guizhou, including biological mineralization (Mi et al., 2010; Shi et al., 2005), hydrothermal mineralization (Chen et al., 1988), mechanical mineralization and chemical/biochemical mineralization. The reason why there are disputes about mineralization is that previous studies mainly focused on the macroscopic features of phosphate deposit, such as the time-space distribution of phosphorites system, the rock facies and palaeogeography of sedimentary basin, but few detailed studies were conducted to dissect the microtexture of phosphorites on microscopic scale (Liu, 2008).

In this work, optical microscope, electron probe microanalysis (EPMA) and scanning electron microscope (SEM) were used to analyze the structure and tectonics of phosphorites, measure the chemical compositions of apatites, and observe their microtexture, especially bioclastic apatites. On the basis of these investigations, the formation mechanism and process of granular (algae) apatites in Weng'an Baidou were discussed.

2 The microscopic micro area characteristics

2.1 Mineralogical characteristics

The phosphorite deposites, located in Central Guizhou, are mainly hosted in Dousahntuo Formation, underlain by light gray medium-thick dolomicrite and overlain by Nantuo Formation tillite. The textures of apatites observed under optical microscope are: spherical, axiolitic, cambiform, anomalous and irregular shapes. Suppoting relationships of granules are grain-supported and matrix-supported pattern. Phosphorite bands with 0.5-2mm width, observed under optical microscope, are devided into dark band consisting of apatites cementated by detrital material and light band consisting of purely granular apatites.

According to the microarea composition analyse, elementary composition of apatite is: Ca: 38.31%, P : 17.692%, F : 3.487%, indicating that apatite belongs to fluorapatite. In addition, according to the electron back-scattering images and secondary electron scanning images, apatite can be devided into four types: spherical apatite, bioclastic apatite, clastic apatite and amorphous phosphate component, of which spherical apatite accounts for the majority. Mineral component of phosphorites are apatite, dolomite, pyrite, quartz and silicon-aluminum detrital material.

Most surfaces of granular apatite are smooth and spherical, while some surfaces of bioclastic apatites are rough with obvious microbial traces. The interior of algae bioclastic apatites composes of spherical and radial algae bioclastic apatites, while the outer sphere of algae bioclastic apatites is isopachous apatite cement. The microtextures of algae bioclastic apatites are mainly spherical, zonal, radial and micelle pattern, among them, irregular zonal pattern accounting for the majority of bioclastic apatites. What's more, fibroid bioclastic apatites in Doushantuo phosphorites were also be discovered (She et al., 2013).

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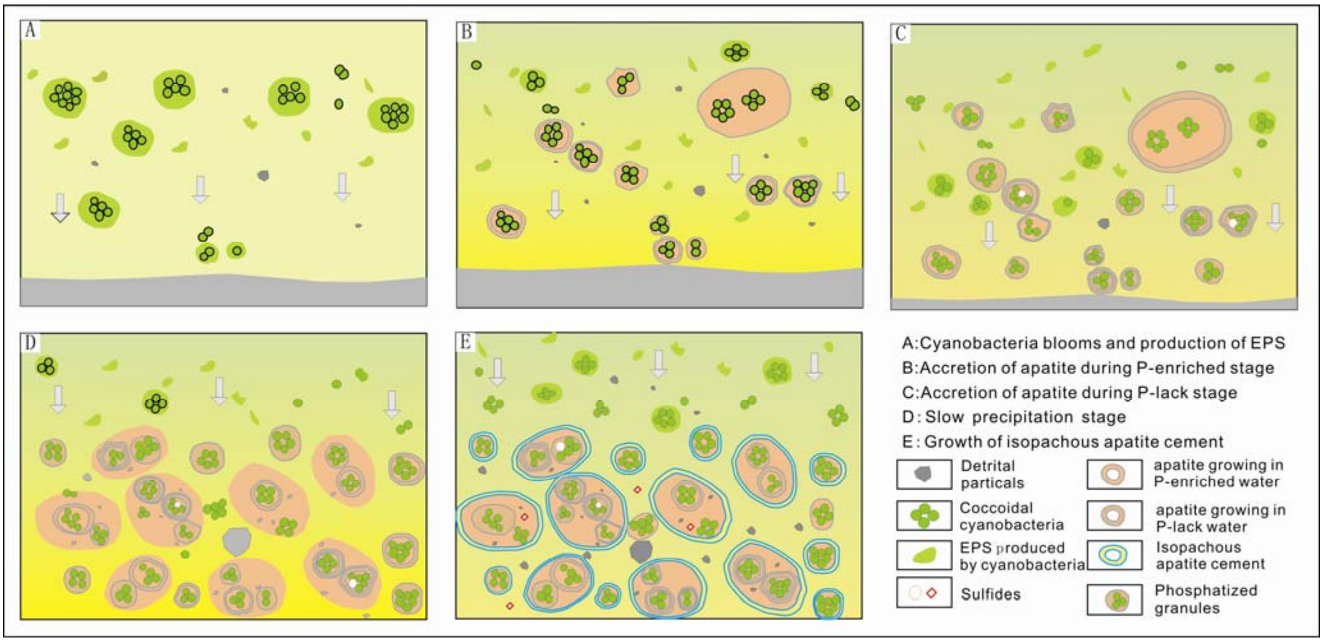

Fig 1.The formation process model of bioclastic apatite in Weng'an Baidou, Doushantuo Formation phosphorites.
(A: Cyanobacteria blooms and production of EPS, B: Accretion of apatite during P-enriched stage, C: Accretion of apatite during P-lack stage, D: Slow precipitation stage, E: Growth of isopachous apatite cement.

2.2 The formation process of bioclastic apatite

Microorganism mineralization of phosphorites can be explained by bioclastic apatite microtextures, and the model of bioclastic apatite formation process (Fig. 1) is constructed on the basis of microtexture observations. Bioclastic apatites experienced four formation stages: Cyanobacteria blooms and production of EPS, accretion of apatite during rapid precipitation (accretion during P-enriched stage and P-lack stage), slow precipitation stage, growth of isopachous apatite cement. After Nantuo glacial period, algae microorganisms bloomed and produced excess extracellular polymeric substances (EPS) which provided nucleation sites and promoted precipitation of carbonate minerals by biosorption of P and mentals(Fig.1 A), so that apatite precipitated around microorganisms (Liang et al., 1984; She et al,.2013). Microbially-mediated accretionary growth, during rapid precipitation stage, consumed P and other minerogenic materials, resulting to decrease of P content in local regions, whereafter P was supplied from surrounding seawater, which resulted to periodical changes of P content during accretionary growth and zonal structure of bioclastic apatites (Fig.1 B, C). Along with accretionary growth, detrital materials and sulfides were adsorbed into apatites. Phosphorites were formed by slow deposition during intermittent nutrient-limited and EPS-limited stages (Fig.1 D), when isopachous apatite cement was formed without microbial action (Fig.1 F).

3. Conclusions

Though the investigations of EPMA and SEM, according to microtexture and micromorphology, granular apatites were devided into four types: spherical apatite, bioclastic apatite, clastic apatite, amorphous phosphate component. The formation process of bioclastic apatites devided into four stages: Cyanobacteria blooms and production of EPS, Accretion of apatite during rapid precipitation (accretion during P-enriched stage and P-lack stage), Slow precipitation stage, Growth of isopachous apatite cement.

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