

Microstructural analysis of a urinary stone as evidence of experimentally observed processes of their formation

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Careful and detailed comparative morphology analysis of individual crystals and crystal aggregates forming real urinary stone and its comparison with experimental results provides evidence of the processes that were previously identified in laboratory experiments. This study is based on electron microprobe observations of a polished thin-section of a surgically removed stone formed by oxalates and apatite. The original concrement was surgically removed from upper part of the left ureter. The patient was 72-year-old man with normal laboratory values. The nidus of the stone was not distinguished.

We found possible link between the observed structures with processes and structures obtained from *in vitro* experiments dealing with kidney stone formation and growth [1–4]. Our study demonstrated that the detail analyses of the inorganic component of a concrement could help to understand the processes of its *in vivo* formation.

Analyses of a section through the complete concrement with a diameter of 5 mm was performed on electron microprobe (CAMECA SX 100) in back scattered electron mode. The same equipment was used for quantitative determination of observed phases in wave-length dispersive mode.

Apatite

Figure 1 display a zone formed mainly by apatite spherules, 1–3 μm in diameter, labeled as A1. Other similar zones are visible on Fig. 2 in lower magnification. The amount of spherules increases from the bottom to the top of each layer. The massive apatite is forming the uppermost part of the layer. The upper edge of each apatite layer is usually sharp; whewellite commonly grows over the apatite (Fig. 2). Formation of apatite spherules was experimentally proved by [3]. The authors supposed that “the precipitation of liquid-like amorphous phosphate particles is promoted using anionic polypeptide additives and these droplets coalesce to form globules that later crystallize into apatite spherulites”. We suppose that the observed structure may originate by similar process. However, we were not able to analyse the possible organic component by electron microprobe method to prove it without any doubt.

Oxalates

Kavanagh [4] distinguished homogeneous and heterogeneous nucleation, which are responsible for initiation of concrement formation. Tiny tabular crystals of primary whewellite (type O1) are displayed in Fig. 1. Their euhedral shape indicates free crystallisation in the fluidal environment supersaturated with respect to whewellite. No older nucleation centers were found in these crystals, thus, those crystals are formed via homogenous crystallisation in bulk solution at conditions that are characterised by higher degree of supersaturation with respect to whewellite [4]. The “floating” crystals formed by homogenous nucleation could also subsequently nucleate on the surface of previously precipitated apatite layer (Fig. 2), forming a layer

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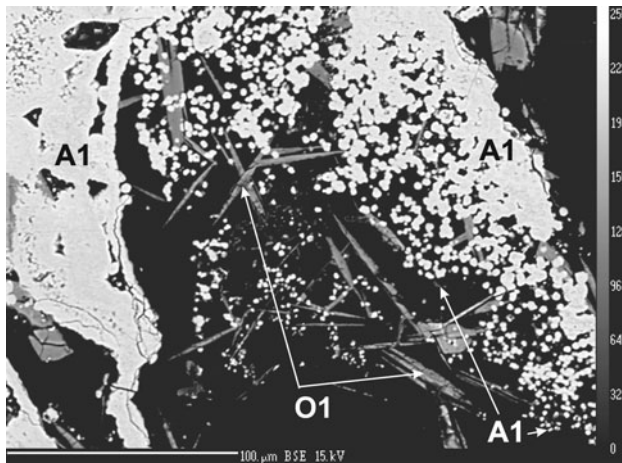


Fig. 1 Tiny tabular crystals of whewellite (O1) and apatite spherules (A1)

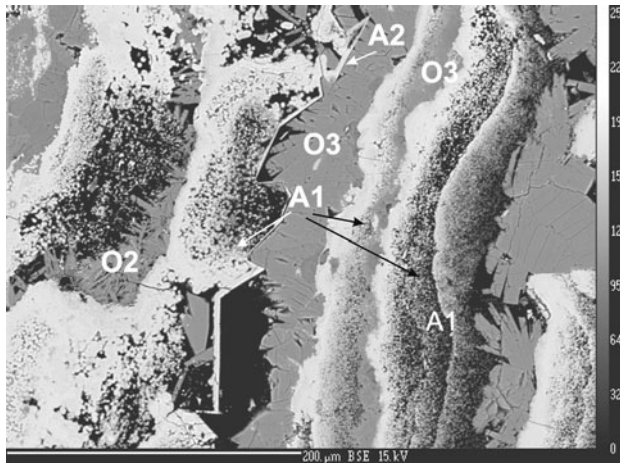


Fig. 2 Whewellite crystal (O2) accreted on the apatite surface. Apatite A2 growing over the large weddellite (O3) crystals in the upper part of the picture

consisting of individual, lath-shaped crystals (O2). This process was firstly described as a stone enlargement by aggregation in [2]. These floating whewellite crystals coexist with apatite spherules shown in Fig. 1. However, Fig. 2 indicates that the spherules are younger, because they develop around the accreted whewellites.

Large homogenous euhedral grains of primary weddellite (O3), forming imperfect layers composed of individual

crystals are documented on Fig. 2 as well. They are partially dehydrated into the whewellite. Such crystals grow from nucleation centers, based on the lower apatite layer, into open space on the actual margin of the growing stone. This microstructure is a product of heterogeneous nucleation [5] followed by the stone enlargement via crystal growth. The bottom layer, usually formed by apatite, served as a nucleation center. The main crystal forming process is crystal growth [2] from supersaturated solution. However, the degree of supersaturation is lower compare to the free crystal growth in the previous case [4, 5]. This evolution is conditioned by sufficient supply of calcium and oxalate ions from the surrounding fluids in a relatively constant physical and chemical conditions.

Very thin (up to 10 μm) homogeneous apatite layers (A2) coating the large weddellite crystal (Fig. 2), originated by the same mechanism: heterogeneous nucleation. However, the oxalates served conversely as nucleation centers.

The structures briefly described here indicate that several processes of crystal nucleation and growth are responsible for formation of particular concrement. These processes can be reconstructed retrospectively by comparing with experimental results.

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