

Travertine formation and other pattern forming processes on sloping surfaces

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Carbonate precipitation around hot springs commonly produce spectacular terrace patterns on scales ranging from millimeters to meters (Fig.1). Similar patterns can be observed in a variety of other natural and synthetic systems where growth processes on sloping surfaces takes place in connection with fluid flow. The large-scale terraces (meter-scale) of major travertine deposits may result from positive feedbacks between local fluid flow velocities and the rate of carbonate precipitation. This feedback has been suggested to arise due to fluid flow controls on the rate of CO₂-loss. It would thus be specific to the carbonate system.

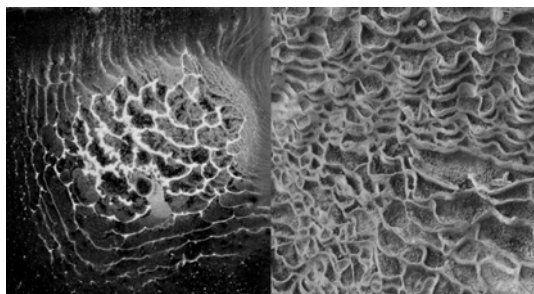


Figure 1. Left: Terrace-pattern formed during flow of water with suspended particles on a glass slide. Field of view ca. 2 cm. Right: Natural travertine terraces from the Arctic hot springs at Bockfjord, Svalbard. Field of view ca. 10 cm.

Smaller-scale terrace patterns with approximately constant step-heights may however be controlled by coupled flow and aggregation processes rather than carbonate precipitation. The structures forming are thus not specific for the water-carbonate system, but arise in a variety of systems with slow flow of particle laden fluids. We will present experimental and theoretical results that constrain the conditions under which such patterns form and what factors that affect their geometry.

Field and laboratory evidence of formation of uranyl phosphates within leached layers of dissolving apatite in undersaturated solutions

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The formation of uranyl phosphates on the surface of dissolving apatite, Ca phosphate, in solutions undersaturated with respect to the uranyl phosphates was investigated in the field and laboratory to better understand mineral growth at mineral-water interfaces. Saleeite, Mg uranyl phosphate, was formed on the surface of apatite in the secondary U ore deposit at Koongarra, Australia. Saleeite replaced apatite completely in some cases. Thermodynamic calculations by EQ3NR revealed the bulk ground waters were undersaturated with respect to saleeite, which suggests local saturation for the formation mechanism. In the laboratory, 10 x 10 x 1-mm apatite samples reacted with 20 mL of uranyl solution of 4.0 x 10⁻⁴ mol/L U at pHs ranging from 2 to 4 and 25 °C for 10 days. A layer of autunite, Ca uranyl phosphate, was formed on the surface of apatite. The formation of autunite instead of saleeite occurred because of no availability of Mg. All solutions were undersaturated with respect to autunite. Rutherford backscattering spectrometry (RBS) revealed that the thickness of the autunite layer increased with increasing dissolution of apatite. RBS indicated that the autunite layer becomes thicker without increasing the distribution density of autunite in the autunite layer as the reaction proceeds. RBS also revealed that a leached layer of apatite, about 100 nm thick, was present between fresh apatite and the autunite layer, and characterized by a lower U concentration than that in the autunite layer and by higher and lower Ca concentrations than those in the autunite layer and apatite, respectively. Our results by RBS strongly suggest that the surface mineralization proceeds in the leached layer by local saturation and that autunite formed is finally added to and accumulated in the autunite layer, which also explains the saleeite formation in the fields. The present study demonstrated mineral growth at mineral-water interfaces in undersaturated solutions and long-term U fixation in a natural system.