BIO-INDUCED CALCIUM CARBONATE PRECIPITATION IN EASTERN ALPINE SPRING TUFAS

Diethard Sanders[1], Doris Gesierich[2], and Eugen Rott[2]

[1] Institute of Geology and Palaeontology, University of Innsbruck, Austria
[2] Institute of Botany, University of Innsbruck, Austria

In Alpine tufa-precipitating springs cyanobacteria, micro- and macroalgae and moss directly induce or indirectly favour the precipitation of a major portion of total calcium carbonate. Other precipitates such as flowstones and pore-filling cements of calcite or aragonite overall are insignificant with respect to volume.

In all investigated tufas, calcium carbonate formed in association with microbes represents a significant to prevalent precipitate that forms first or very early in diagenetic succession. Among the microbes involved in tufa formation, filamentous cyanobacteria, the coccoid desmid *Oocardium*, filamentous chlorophytes and diatoms are important, in variable relative amounts. The filamentous cyanobacterium *Rivularia* shows a wide spectrum of calcification, ranging from scattered isolated crystals to layers of merged crystals, to complete calcification of filament sheaths in large crystals up to about 10 mm in size of calcite. Other filamentous cyanobacteria (e. g. *Scytonema*, *Petalonema*, *Calothrix*, *Phormidium*) were observed to induce precipitation of micro- to orthosparitic crystal aggregates. For these cyanobacteria, the style of calcification seems to depend mainly on the tufa-precipitating potential of the water, such that the resulting microfacies may range from porous aggregates of microsparite to small-crystallite sparite to well-calcified fabrics with the outline of the former cyanobacterial colony well recognizable. A similar style and range of calcification was observed for filamentous zygnemaleans (e.g. *Zygnema*, *Mougeotia*). Overall, however, filamentous zygnemaleans seem to be of minor significance in tufa formation.

The simple coenobia-forming desmid *Oocardium* shows a specific style of calcium carbonate precipitation by forming a calcite ring in the proximity of the immediate cell environment. Concomitant with calcite precipitation, the alga moves up, leaving a tube of mucilage surrounded by calcite behind. Fresh, unaltered calcite tubes show a circular outline, and appear to grow upward on 'step-dislocation like' facets. The precise mode of calcite precipitation immediately adjacent to *Oocardium* cells, however, as yet is poorly documented. By this style of crystallization, laminae of tufa up to nearly 10 mm in thickness per growth season (spring-autumn) can be formed. The initial crystal shape of *Oocardium* tufa, however, is highly unstable; combined recrystallization and further calcite crystallization starts within weeks to months after initial formation. Without knowledge of initial growth form, the resulting microfabric of very large (up to > 10 mm) single crystals of „combispar" calcite (with relicts of *Oocardium* growth tubes) may be difficult to recognize in its origin. In diatom mats, precipitation of densely-spaced but initially isolated calcite micro- to orthospar crystals is induced. The calcite crystals show a set of shapes that perhaps result from different influences (diffusion, fluid transport) during crystallization. Individual diatom frustules may provide a crystallization center to a calcite crystal. Because some diatoms grow in firm mats, the resulting layer of orthosparitic calcite may appear as a cement fringe in field and polished slab, yet owes its first origin to growth of numerous calcite crystals within a densely-populated diatom mat.

Among the macroalgae, the xanthophyte *Vaucheria* gives rise to a specific microfacies. This alga calcifies by progressive nucleation, growth and merging of calcite crystals (mainly well-defined rhombohedra) directly on its surface, until the entire algal filament is encased by micro- to orthospar calcite. *Vaucheria* tufa prevails on a few waterfalls, but typically is present in minor amounts. With respect to their initial calcification, moss plants may show (a) a coating of orthospar calcite, (b) a coating of micrite, (c) a coating of micropeloids, (d) large orthospar crystals on the tips of leaves and/or at the basis of leaves, (e) calcification of cyanoids (e. g. *Rivularia*) or *Oocardium* settled on the moss, and (f) combinations of (a) to (e). We guess that the role of moss primarily is a passive one. By providing a large surface area for water spray and for evaporation, as well as by providing a settlement area to microalgae which, in turn, can induce calcification, moss tufts favour calcium carbonate precipitation. We could not identify a specific type of calcium carbonate crystallisate exclusively tied to moss plants; this underscores that the role of moss rests mainly in its large differentiated surface rather than in physiological traits.