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Environmental vs microbial control on ca-carbonate precipitation in fluvial tufa (NW Calabria-Italy)

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Modern freshwater calcium carbonate (tufa) forms in the Parmenta stream, a tributary of the Corvino River, along the west coast of Northern Calabria. The stream flows in a narrow steep-sided wooded valley, receiving three ephemeral tributaries and draining Mesozoic carbonate succession. Tufa deposits vary along the stream length (about 3 Km) occurring scattered up-stream and almost continuously down-stream for at least 1 Km. At the confluence with the Corvino river carbonate deposits end.

The tufa deposits belong to the barrage model that includes waterfalls, dams and pools. Pools vary in length and in width from a few decimetres to 5 metres. Carbonate deposits are absent on the larger pool floor, where sand to gravel sediment accumulates. Dams occur as sinuous to irregular barriers usually spanning the channel. An up-stream ramp of the dam is generally steeply inclined, and characterized by an irregular surface covered in partially calcified leaves and wood fragments. The rear wall height for the mature dams ranges between 10-30 cm. In contrast, the down-stream ramp, after a smoothed surface passes to tongue-shaped lobes. Lobes form normally 20-60 cm width deposits, even if there are also meters-size tongues, with a steep slope, occurring in correspondence of the major waterfalls.

The downstream surface of dams and the upper surface of the tongue-shaped tufa deposits are colonized by a soft, 1-4 mm thick, biofilm. It consists of an epilithic and partially endolithic community composed mainly of oscillatoriacean cyanobacteria (Phormidium sp.), diatoms, fungi and insect larvae. Carbonate precipitates on the upstream wall of the dams lack a biofilm.

Tufas are basically of two main types, essentially distinguish on their internal fabric in laminated-stromatolitic tufas and vacuolar tufas. Both facies are mainly composed of low-Mg calcite with Mg 1-4 mole % and Sr 0,8-1,2 mole %. Stromatolitic tufas form centimetric beds on the external surface of the tongue-shaped lobes and on the upper downstream face of the dams. Vacuolar tufas, which are observable on the upstream surface of the dams, compose the inner part of the dams and the core of the tongue-shaped bodies.

Lamination of stromatolitic tufa is almost even and regular with only gentle doming. Laminae, which are 1-2 mm in thickness, originate by the alternation of two main types of microstructure: dendrolitic and detrital layers. Dendrolites, up to 1-1.5 mm thick contain mineralised upward-branching filaments a few micron in diameter, forming bush-likes fans. Filaments coalesce upward to form a solid carbonate layer. Filaments coalesce upwards to form a solid carbonate layer. They are formed by an envelope of micritic crystals of calcite around the sheath of individual cyanobacterial filaments. Detrital layers consist of a minor amount of mineralised cyanobacterial filaments, which appear mainly in transverse section. Carbonate minerals form thin radiating fibrous crystals around the filaments. Micron sized platy crystals of clay minerals and allochthonous dolomitic grains are abundant in such layers. Laminae of stromatolitic tufa also are characterized by the presence of empty tubes, subspherical/lenticular in section, probably originated by insect encrusted larvae.

Vacuolar tufas consist of calcified plant remains that contain abundant large voids. Plant leaves, often with a preferred orientation, are the main component, with stems, twigs and mosses. Sub-millimetric carbonate crusts, which form around the plant material, consist of micro-spar fan-shaped calcite crystals 50-100 µm thick. Remains of cyanobacteria filaments, fungal hyphae and diatoms are absent within these calcite crusts, probably since no was biofilm on their external synsedimentary surface.

Calcium carbonate tufa precipitation in the Parmenta stream is probably strongly controlled by the calcite supersaturation of the water, since the saturation index is about 0,7. Calcite in vacuolar tufas lacking evidence for the form presence of biofilm, probably represents the product of an abiotic precipitation over plant substrates. Conversely,

stromatolitic tufas forming strictly in association with a biofilm, probably results from biomineralization processes.