Travertine-Tufa Deposits

Eric M. Parks

ABSTRACT

Travertine and tufa, despite their identical chemical composition and similar characteristics, are different in their lithofacies and depositional environments. A review of the chemistry behind travertine-tufa deposition is given. Travertine and tufa originate in different depositional environments. Warm water systems such as karstic hydrothermal springs and fissure ridges yield travertine while cool fresh water systems such as calcite-rich perched spring lines, cascades, fluvial, and lacustrine environments produce tufa.

INTRODUCTION

Travertine and tufa deposits are composed of calcium carbonate precipitations both from organic and inorganic processes. Generally they are found at karstic or hydrothermal springs, small rivers, and swamps.

The term travertine originates from the city of Tivertino, Italy where an extensive travertine deposit is found. However, these deposits have been referred to by many different names including tufa, calc tufa, calcareous tufa, plant-tufa, petrified moss, spring-sinter, calcic sinter, and Chironomid tufa. Many geologists simply refer to all carbonate incrustation on plant remains as travertine in an effort to avoid confusion (Julia, 1983). There are, however, some differences in the basic characteristics of travertine and tufa, these being that tufa has a higher porosity, woody texture, and is generally a cool fresh water deposit. Conversely, travertine is commonly deposited in warm water, and is more lithified. Atabey (2002) stated that travertine is composed of diagenetic old calcerous tufa deposits with significant amounts of calcite spar added to its framework.

PRECIPITATION PROCESSES

Ford et al. (1996) states that calcium carbonate is absorbed by percolating waters which pass through soil horizons above limestone. These soil horizons, due to biogenic activity, often have high CO_2 levels which move much of the calcium carbonate into solution. From there in the subsurface the water may travel some distance until it surfaces at an outlet or spring.

Once the water reaches a certain level of oversaturation of $CaCO_3$ relative to CO_2, precipitation becomes a possibility. The CO_2 levels change by physical aspects such as temperature, pressure, and turbulence and by biochemical means such as photosynthesis. It is this change in CO_2 levels that will drive calcium carbonate out of solution. When the CO_2 levels drop, the water becomes supersaturated with calcium carbonate. At that point any sort of perturbation will cause the calcium carbonate to precipitate (Merz-Preib et al., 1999).

According to Julia (1983), there are two main trends in the deposition of travertine and tufa which are regulated by physio-chemical and biochemical parameters. The first trend is the predominance of the physio-chemical processes over the biochemical processes. This occurs when water turbulence, temperature, and/or pressure changes are the dominant agents in releasing CO_2. The second trend is the dominance of biochemical processes over physio-chemical processes. This occurs in calmer waters where photosynthesis is foremost in regulating the amount of CO_2 in the water, thus indirectly regulating the rate of calcium carbonate precipitation. In light of these physio-chemical and biochemical processes and the unique characteristics of travertine and tufa we can better understand the settings in which either one is generally precipitated.

TRAVERTINE

Travertine is more commonly found in higher temperature systems. There are several thousand thermal springs around the world according to Ford et al. (1983), and of them, several hundreds have travertine deposits. Julia (1983) states that karstic and thermomineral springs are ideal for travertine precipitation. This is due mainly to temperature and pressure changes as thermal waters reach the surface. In these high temperature systems organisms are relatively scarce, however, as the temperature falls and the water cools, organisms may begin to thrive which can slowly turn the system into a tufa producing environment. Sometimes organism growth is prevented by toxins commonly found in thermal springs which inhibit their colonization (Ford et al., 1996).

Travertine can often be found at fissure ridges where faulting allows hydrothermal water to rise to the surface. In these cases the calcium carbonate often precipitates at the fissure and can build high narrow mounds. These mounds sometimes form thermal pools. Fissures from a single point often build pinnacles.

Travertine has also been known to build terraces. As water cascades away from the source, CO_2 levels drop from cooling and/or turbulence as it cascades over an edge. Here the calcium carbonate precipitates as planer sheets and spreads over faulted blocks from the fissure ridges (Ford et al., 1999). These often build up to form successions of natural dams. Over time more and more diagenetic precipitate is added and, as is characteristic of travertine, these deposits are well lithified and form sheets with smooth tops (Ford et al., 1999).

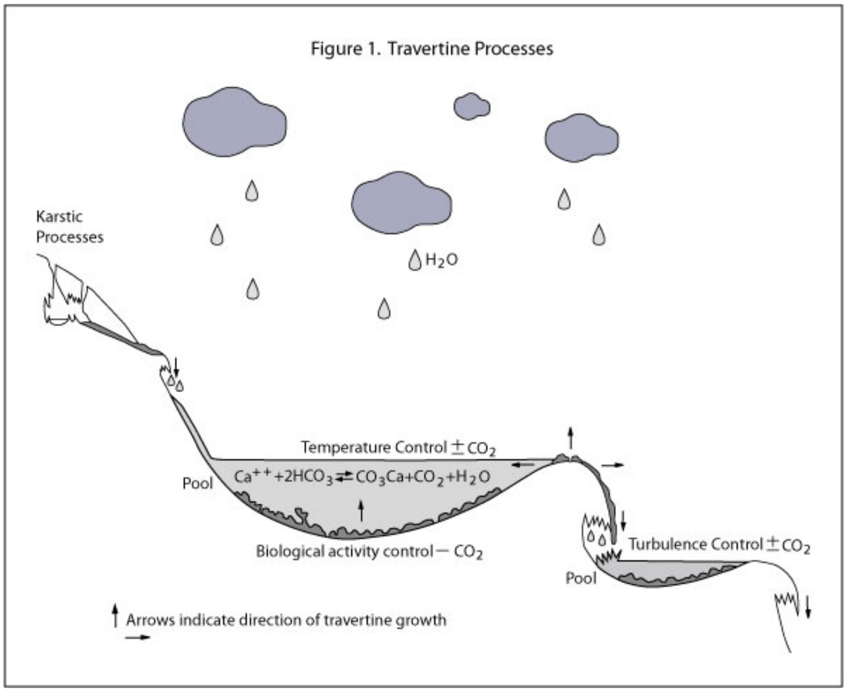

Figure 1. Diagram showing favorable conditions for travertine deposition. Effect of turbulence and biological activity shown.

TUFA

Tufa, being more commonly found in cool water systems, have much more variety in their lithification than do travertines. Tufa precipitates are normally preserved by clinging to the surface of living plants forming a cast around them. Therefore the variety of tufa lithification is due mainly to the fact that cool water systems have a greater variety of organics to which the calcium carbonate precipitates. As the precipitate encrusts these organics, their irregular shape is manifested on the surface as a variety of tufa textures.

One of the common tufa depositional settings is the perched spring line. Pedley (1990) described these as convex lobes forming at the source of the spring on a valley side. The steepest parts of the deposit are where tufa growth is fastest. As the water cascades down the slope away from the source it can form small terraces. These build up at the edges, causing water to pond up behind them and sometimes form small stromatolitic growths.

Calcium carbonate-rich cascades are another common tufa environment. These occur where water flow is most vigorous. Cliffs and ledges with waterfalls and spills are ideal for this type of tufa growth due to the coating of moss that builds up on the cliff or ledge surface. The turbulence of the falling water then brings about degassing of CO_2. Pedley (1990) stated that these mosses become entombed in steeply inclined sheets of calcium carbonate as carbonate-rich waters flow over the organic screens. Water will sometimes drip down from overhanging slopes and form bulbous growths on the ground stacking vertically, resembling stalagmites.

The bulk of tufa deposits fit into the fluvial model. Ford et al. (1996) state that these are found in both shallow braided and meandering streams, but manifest differently in the two settings. In braided streams they form asymmetrical stromatolitic mounds, and oncoids forming linear foresets. In meandering streams, however, growths often occur at a point where flow is restricted, such as a log jam, or buildup of debris. The building tufa can quickly dam water flow and cause ponding behind its barriers forming terraces downstream. Pedley (1990) has documented such barrages as being kilometers in length and tens of meters deep.

Tufas can also be found at lake shorelines. According to Wood (2003), these occur when the lake water pH increases to allow supersaturation of calcium carbonate which is driven by agitation of waves and biological activity. These are generally stromatolitic in appearance formed by encrusting layer after layer of cyanobacteria until their tops form overhanging edges (Pedley, 1990). Wood (2003) documented that some lake tufa deposits are often composed of cemented breccias called tufaglomerates with a flat tufa caprock representing the water plane at its time of deposition.

MINEROLOGY

Travertine and tufa deposits are principally composed of calcite with low magnesium content. In deposits originating from thermomineral springs, there are sometimes low levels of aragonite, and some deposits contain up to five percent silica (Julia, 1983).

CONCLUSION

Travertine and tufa deposits are similar in many respects, and often grouped together by many geologists. After a review of their similarities and differences the distinction between the two becomes clearer, the main diferences being lithification and depositional environment. Travertines display a more solidly lithified surface, having undergone a higher degree of diagenesis, and are commonly found in thermal warm water systems, whereas tufas are far more porous due to their various cool water environments boasting a greater diversity of organisms upon which they build.

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