Hot-springs, microbes and precipitates

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Hot springs are commonly located in tectonically active areas like those found in the African Rift Valley, Iceland, New Zealand, and Yunnan Province, China where subsurface heat can moderate the temperature and geochemistry of the groundwater. When ejected at the Earth's surface, precipitates that form from these hydrothermal waters are characterized by their mineralogical diversity and morphological complexity. Such variability reflects the fact that precipitation is controlled by the interplay of many different variables including the chemistry of the spring water, the rate at which the water cools, degassing of the spring water, and the activity of the microbial populations that are invariably present. These systems are therefore superb natural laboratories for assessing the factors that control the precipitation of the different polymorphs of calcium carbonate as well as the incredible range of crystal forms that can develop.

Precipitation of calcite and aragonite in hot spring environments is controlled principally by saturation levels that vary at all scales. The microbial mats that thrive in these environments commonly play a critical role in the precipitation of these minerals. These mats, formed of the microbes and copious amounts of exopolysaccharides, are characterized by numerous microdomains (micron scale) with each domain having its own geochemical signature. Thus, aragonite may be precipitated in one microdomain whereas amorphous calcium carbonate or calcite may be precipitated in an adjacent microdomain. The morphology of the calcite and aragonite crystals that form in hot spring systems is controlled by many different factors, including supersaturation levels, evaporation, degassing, and supercooling that are collectively constitute the "driving force". As the driving force increases, so the crystal morphology progressively changes skeletal crystals, to dendrite crystals, to spherulitic crystals. Many of these crystals are crystallographically complex with growth patterns that are difficult to determine. The hallmark of $CaCO_3$ deposits that form in hot spring settings is their mineralogical and crystallographic diversity that commonly reflect subtle, microscale variations in the microenvironments where they formed.