Jennifer Barth is a 2010 Ed Picou Fellowship winner and needed some extra funding to finish her work on the Crystal Geyser travertine deposits. She will be awarded her M.Sc. from the University of Houston. Her advisor is Dr. Henry Chafetz.

Proposed Research

This study focuses on characterizing the modern travertine deposits precipitating from the waters of Crystal Geyser in east-central Utah. Crystal Geyser is located 14.5 kilometers southeast of the town of Green River, Utah, and is situated on the eastern bank of the Green River, adjacent to the Little Grand Wash fault. This area is located within the northern section of the Paradox Basin, which has producing natural gas and oil fields, as well as carbon dioxide fields (Shipton et al., 2004). The geyser erupts from an abandoned oil well that was drilled in 1935 and is driven by large amounts of degassing carbon dioxide. This study involves petrographic, mineralogical (XRD), elemental (ICPMS), and stable isotopic (mass spectrometer) analyses of samples collected from the field. A scanning electron microscope (SEM) will be used to characterize both abiotic and biotically induced precipitates.

Figure 1: Picture of the modern travertine deposit. The well pipe at the back of the deposit stands about 2 m above the surface for scale.

Description of Travertine

Since 1935, brightly colored travertine has been deposited around Crystal Geyser. Part of the well pipe extends 2 m above the surface. It forms a large orange, red, and yellow steep-terraced mound, which is ornamented with a myriad of micro-terraces and fans toward the river (Fig. 1). The modern deposits lie atop or immediately adjacent to older carbonate precipitates that are believed to be the result of fault-channeled spring flow along the Little Grand Wash Fault. The ancient deposits display large fibrous veins of aragonite (Fig.2). Travertine deposits at this location were identified as early as 1869 by the John Wesley Powell Expedition during his exploration of the Colorado River and related canyons. His very brief description states that he and his crew stopped "to examine some interesting rocks, deposited by mineral springs that at one time must have existed here, but which are no longer flowing" (Powell, 1987, p. 199). Burnside (2010) conducted a U-Th analysis on the ancient travertine deposits and determined that they ranged in age with minimum and maximum of 5,029 and 113,912 years old, respectively. The age of the Little Grand Wash fault is unknown, but cross-cutting relationships show that it was at least active until the Middle Cretaceous (Shipton et al., 2004).

Figure 2: Close-up view of the deposit immediately adjacent to the modern deposit. It is composed of aragonite veins.

Field Methods

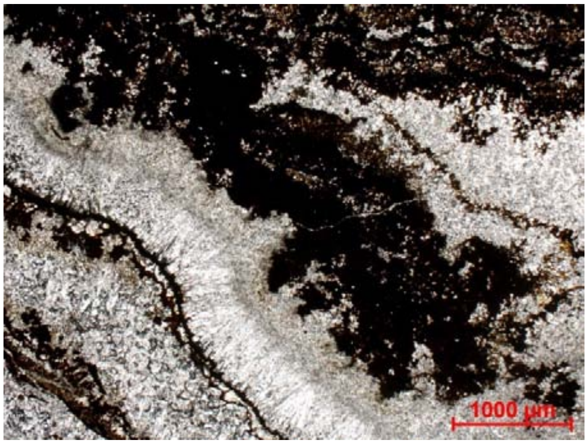
A field trip was made in January of 2010 to conduct initial evaluation and sampling of the travertine at Crystal Geyser. Poor weather conditions did not allow for sufficient sampling and assessment at that time. A return trip was conducted in May of 2010 for further sampling and analysis. Both trips showed that sampling the modern travertine deposit with standard field tools, a rock hammer and chisel, yields insufficient results as the rock at any given spot is either too brittle and is destroyed on impact or it is too spongy to generate a fracture. Therefore, samples were collected from the surface by removing them from the outcrop with a 9-inch angle grinder powered by a portable generator. Nineteen of these surface samples were taken of the modern deposit. In addition, twenty cores with an inner diameter of 5 cm were taken with a maximum depth of 40 cm. Seventeen samples of the older deposits were taken using the angle grinder and standard field tools.

Petrographic Observations and Interpretation

Detailed analysis of hand samples was done using a binocular microscope and of 50 thin sections using a petrographic microscope. The modern deposit has shown a wide variety of carbonate crusts including beautiful yellow crystalline splays of aragonite fans, delicate "lacy" horizontal laminations, densely crystalline horizontal laminations, and densely crystalline columnar growths that have been interpreted to be micro-stromatolites. Some of the micro-stromatolites are stained by iron. There is a broad range of spherulites in the modern deposit, displaying a variation in structure of fibro-radiating crystals splaying from a nucleus, often composed of irregular clumps of iron. Very well-rounded and irregular pisoids have been observed in samples taken near the well vent. Well-rounded pisoids have been interpreted to have formed in the well, their structure being a result of constant agitation, and were ejected during eruptions. Irregular pisoids likely developed in the pond that forms exterior to the well during eruptions. Plant roots have been observed displaying crystal growth on their exterior walls, indicating that they may be inducing precipitation by removing CO2 from the water or they may be passive substrates. Shrubs (a term referring to bacterial growths that resemble garden variety plants) composed of iron are frequently seen in the modern deposit (Fig. 3). These strongly resemble the ancient marine fossil Frutexites. Iron structures such as these have been documented in many modern environments associated with ponds, springs, and mines (Chan, 2006). Frequently, microscopic twisted stalks and sheaths, demonstrated to be iron-oxidizing bacterial fossils from Gallionella Ferruginia, Liptothrix, and other associated bacteria, are found in these deposits. Twisted stalks and sheaths are polysaccharide strands secreted by some iron-oxidizing bacteria to prevent entombment by iron and to serve as a pathway of energy into the cell (Fortin and Langley, 2005). The bacteria eventually shed these extracellular polymers, which pack together, leaving behind the distinguishing shrub features. Similar structures have also been observed in some of the ancient deposits (Fig. 4). The ancient deposit, located immediately adjacent to the modern deposit, is almost completely composed of beautiful splays of aragonite crystals. The older of the ancient vein deposit often contains slivers of the sandstone host rock that it formed within.

Continuing Research

Detailed mineralogical (XRD), elemental (ICPMS), and stable isotopic (mass spectrometer) analyses will be conducted in the lab. Eighty-eight samples of the modern and ancient deposits have been powderized for these procedures. X-ray diffraction (XRD) and Inductively Coupled Plasma Mass Spectrometry (ICPMS) will be used to characterize the mineralogies and elemental compositions, respectively, of the samples. Mass spectrometer analysis will be conducted to identify isotopic compositions in an effort to understand the variations in composition throughout the deposit relative to degassing, seasonal variations, and biotic influence. A scanning electron microscope (SEM) will be used to characterize both abiotic and biotically induced precipitates. SEM has been used successfully in the past to identify the remnants of bacterial bodies in travertines (Meredith, 1980; Chafetz and Folk, 1984; Folk, 1993; Chafetz and Guidry, 1999). Samples for this experiment are currently being prepped in the lab.



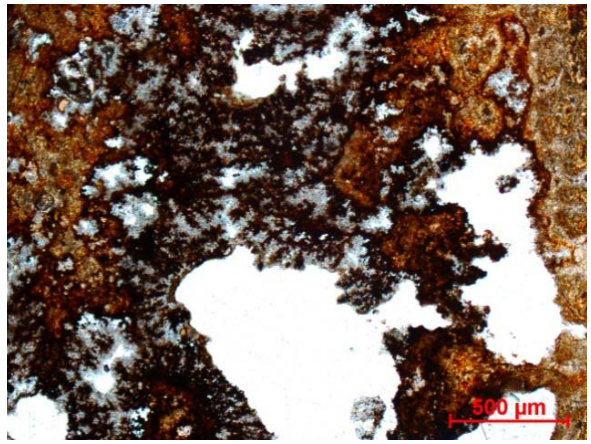


Figure 3: Bacterial shrub growth in the modern deposit growing into pore spaces between travertine crusts.

Figure 4: Bacterial shrub growth in the ancient deposit. Growth was likely hindered by the rapid precipitation of the aragonite crystals.

Summary

This study investigates the physical and geochemical characteristics of the travertine deposits of Crystal Geyser. Through this, a detailed description will be provided concerning the origin of precipitation and diagenesis of this unusual cold-water geyser deposit. This study involves hand sample, petrographic, X-ray diffraction, SEM, and geochemical analysis to aid in understanding the evolution of this modern travertine deposit. In addition, analysis is being conducted on the ancient deposits of the Little Grand Wash Fault to discover its relationship to the modern deposit and further understanding of the geologic history of the area.

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