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Core and Outcrop Calibration of Upper Cambrian Microbial Textures

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Key Findings

• Upper Cambrian microbial buildups outcropping in Central Texas consist of a core and rind and, once nucleated on thin lenses of flat pebbles interpreted as transgressive lags, evolved through three distinct growth phases, entailing a well-defined initial "colonizing" phase, a "vertical aggrading and lateral expanding" phase, and finally a well-defined "capping/demise" phase

• Systematic core drilling documents varied microbial textures that vary spatially and temporally and as such can serve as valuable examples for interpretation elsewhere.

Significance

Interest in microbial deposits has increased following discoveries of hydrocarbon reservoirs in pre- salt deposits of offshore Brazil and Angola. Systematic core drilling of outcrops in central Texas documents varied microbial textures that vary spatially and temporally within an Upper Cambrian buildup complex, and as such can serve as valuable examples for interpretation elsewhere (Hopson, 2018). These buildups display a core and rind and evolved through three distinct shallow marine growth phases. Initial outcrop characterization revealed the successive growth morphologies, repeatedly identifiable across several separate outcrops (Khanna et al., 2020). Grounded on these geometries, a three-phase growth model was constructed, entailing a well- defined initial "colonizing" phase, a "vertical aggrading and lateral expanding" phase, and finally a well-defined "capping/demise" phase (Figure 1). Such temporal variations in morphology evidence changes in sea level fluctuations, as well as paleoenvironmental and paleoclimatic conditions, during growth.

Methods and Preliminary Results

Lateral and vertical transects of shallow cores detail buildup growth by internal structures and microbial fabrics. Nucleating on lenses of flat pebbles, Phase 1 growth results in 3-4 m high buildups defined by a distinct thick, early cemented outer thrombolitic rind. Buildup interiors exhibit amalgamated microbial heads with poorly preserved internal structure enveloped by cm-thin thrombolitic rinds. The buildups grew in high-energy conditions, but their rinds did not interact with coeval interbuildup oolitic-bioclastic grainstones. Phase 1 terminated with onlapped terrigenous and calcareous silts (~35% $CaCO_3$). The overlying Phase 2 growth produced buildups up to 8 m thick, characterized by a mutual interaction with interbuildup high-energy oolitic bioclastic grainstones and packstones and lacking a well-developed external rind. Internally, Phase 2 growth consists of vertically aggrading and laterally expanding stromatolitic columns, each exhibiting cm- thin thrombolitic rinds directly interacting with intercolumn bioclastic grainstones. Phase 3 of growth develops a well-defined, 2-3 m thick thrombolitic rind either crowning the top of Phase 2 or growing as individual buildups on top of Phase 2 buildup flanks and interbuildup sediiments. Mixed ($\leq$ 16% $CaCO_3$) silts onlap these large buildups.

Carbonate mineralogy mapped on split core surfaces by hyperspectral scaning, along with the detailed core and thin section descriptions, graphically show varied microbial textures that were responsible for growth of the buildups (Figure 2). Thrombolitic fabrics evidence carbonate precipitation induced by microbial colonies. This fabric dominantly consists of original microbial micrite with fossil fragments in an extremely tight framework that hindered diagenesis and, therefore, the original calcite was preserved. In contrast, stromatolitic fabrics, prone to diagenesis, show alternating laminations of microbially precipitated calcite and amalgamated trapped grainstones. In addition to the original calcite, some with iron oxide, Hyperspectral scans and thin sections exhibit ferroan dolomite replacement and subsequent oxidation of these grains (Figure 2).

References

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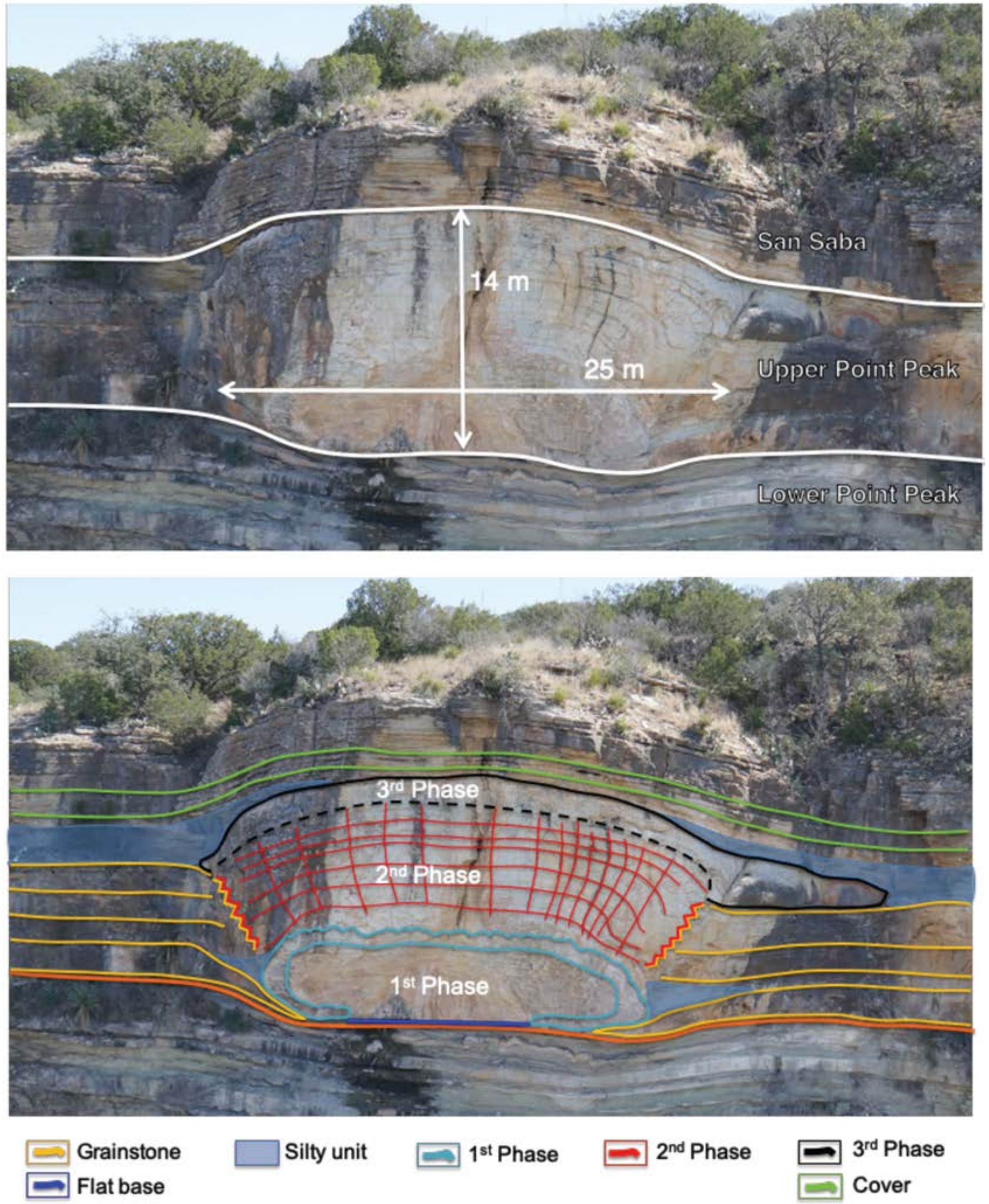

Figure 1. (Top) Oblique drone photo of cliff along Llano River in Central Texas showing large-scale Upper Cambrian microbial buildup. (Bottom) Photo is annotated to highlight internal growth phases of buildup. Modified from Khanna et al., 2020.

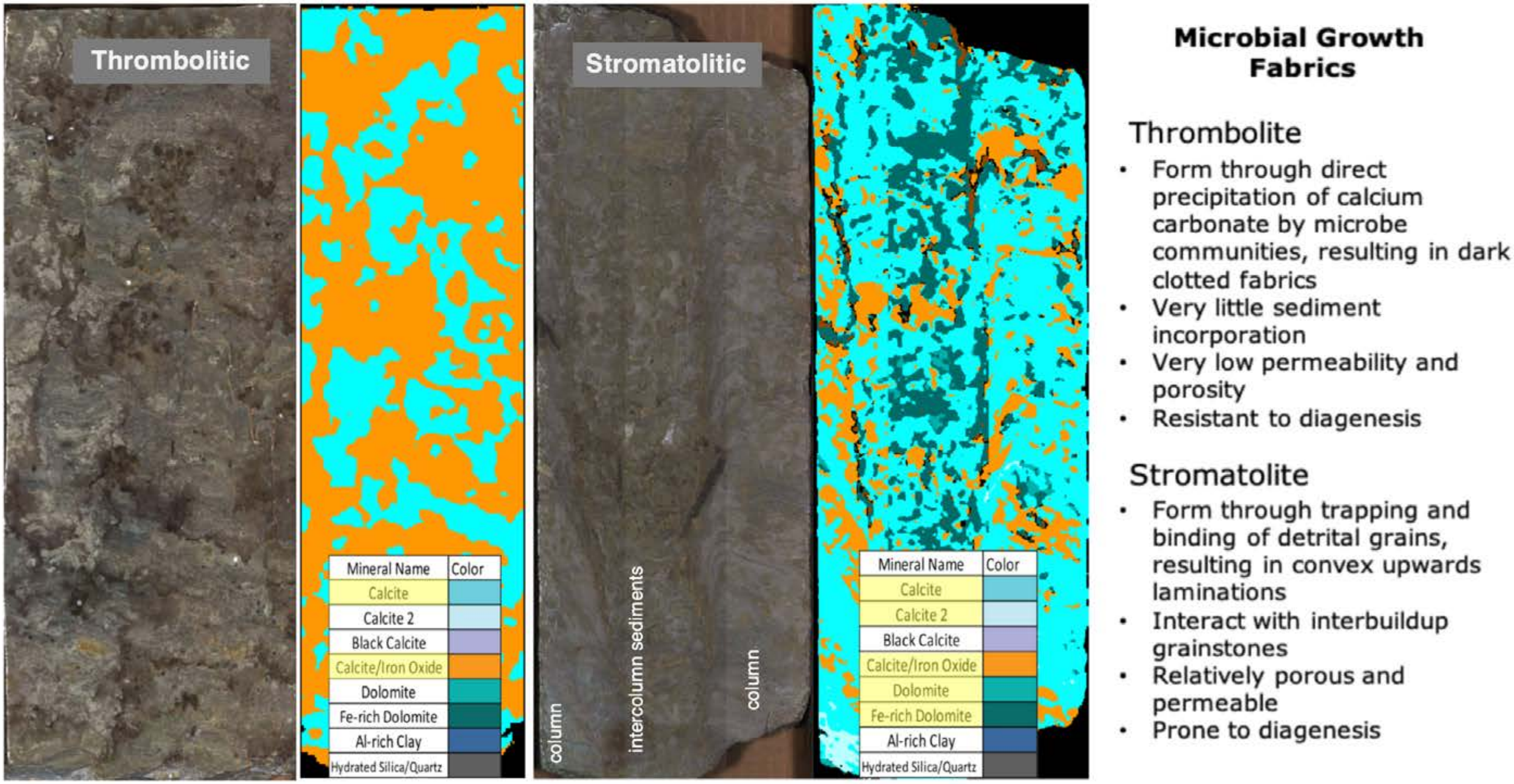

Figure 2. Core photos and paired hyperspectral scans showing typical thrombolitic and stromatolitic fabrics. The rinds in Phase 1 and 3 exhibit a thrombolitic fabric composed of calcite and calcite with iron oxide. The remnant of stromatolitic fabrics is usually observed in Phase 2. Small-scale rinds are iron oxide coated calcite, whereas much of the intercolumn sediments have been dolomitized. Modified from Hopson, 2018.