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Lacustrine Microbial Carbonate Facies in Core from the Lower Cretaceous Toca Formation, Block 0, Offshore Angola

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Lacustrine carbonates are an important reservoir in Block 0 offshore Cabinda, Angola, with total production from the Toca carbonate reservoir of >260 MMBO from 3 main fields. The Toca was deposited during the late rift stage of the break-up of Gondwana during the early Cretaceous. The Toca consists of fossiliferous grainstones to wackestones with variable amounts of microbially mediated grains such as oncoids, ooids, and other microbial fabrics including boundstones similar to those deposited in today's East African Rift Lakes (e.g. Cohen and Thouin, 1987). Kambala Field is one of the main fields in Block 0 producing from the Toca, and is the only field where the Toca has been extensively sampled with core having been acquired from 5 wells. The core from the Kambala well "A" contains the majority of facies that are found in the Toca formation, especially the microbialite facies that are common to the Lower Toca. The 500 foot core captures portions of the Upper and Lower Toca as well as the Upper and Lower Bucomazi Formation, which is a deep water facies associated with the Toca. The core not only shows the full gamut of facies within the Toca, but also displays the major diagenetic events including subaerial exposure, karstification, and hydrothermal dolomitization. Core descriptions have been augmented by detailed thin section analysis and carbon and oxygen stable isotope analyses.

Seven facies dominated by microbially mediated grains and fabrics have been identified. Oncoids composed of clay (talc-stevensite) and carbonate minerals are common in at least three of the facies and range in texture from oncoidal grainstones rich in fossils to poorly fossiliferous and peloidal wackestones (Figure 1). Furthermore, one of the grain-rich oncoidal facies commonly has ooids with similar mineralogies to that of the oncoids. The oncoidal facies generally have some siliciclastic material in the matrix, with some mud-rich facies being almost entirely silt and clay. Multiple boundstone facies have been identified including stromatolites with variable amounts of fossils and peloids, to dendritic (bushy) microbial growths that are typically clotted and lack identifiable internal characteristics (Figure 1). The dendritic microbial morphologies have been observed (1) growing off of oncoids that were likely stabilized, and (2) growing directly off the substrate which is typically a mix of carbonate and siliciclastic muds. The final microbial facies is composed of small (< 1 cm) rounded microbial grains that lack internal characteristics and displays a continuum of textures from packstone with carbonate mud in matrix to siliciclastic shales with scattered microbial grains.

Vertical facies heterogeneity is distinct in core from Kambala well "A" where rapid facies successions and shifts between carbonate and siliciclastic dominated deposition are common. In some intervals, depositional variation through multiple facies can be observed on the foot down to the inch scale, with some facies successions displaying as many as 10 different facies in a three foot section. The microbially dominated facies successions in the core are typically quite heterogeneous and display both rapid and gradual facies transitions through the multiple types of microbial development (Figure 2).

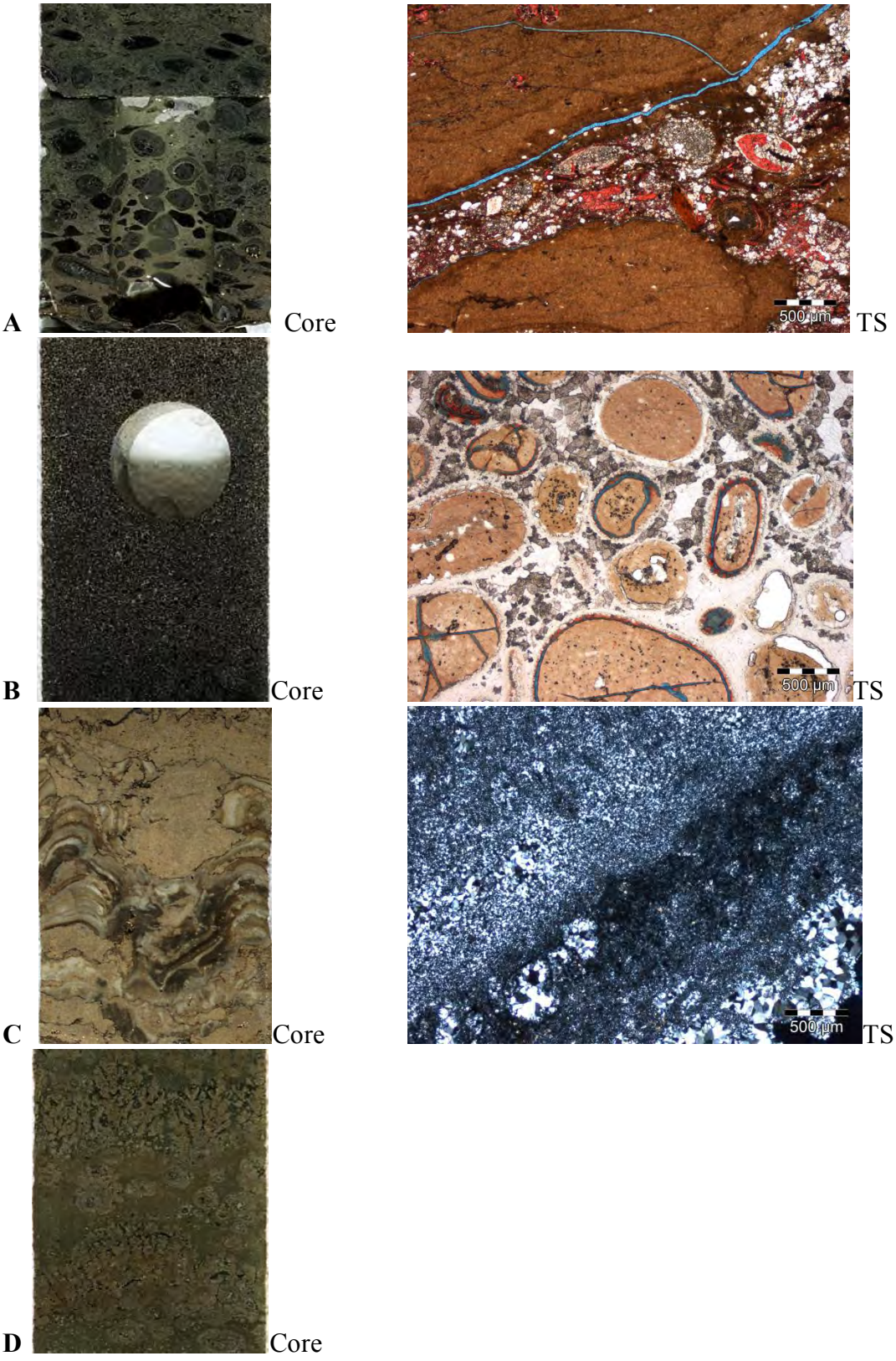

Figure 1 – Paired core images and thin section photomicrographs of various microbial facies from the Kambala Well A core. Each core image is from 6" sections of the core. **A.** Example of the Oncoid/Fossiliferous Wacke/ Packstone facies common throughout much of the core. Most of the oncoids are composed of layers of

talc/stevensite and variable amounts of diagenetically derived dolomite and rarely calcite. Thin section shows detail of interior of some oncoids and the matrix material between them which has largely been altered to dolomite or calcite spar. **B.** Image of Ooid/Oncoid/ Fossiliferous Pack/Grainstone facies. Similar to the oncoids in the previous sample, the ooids from this sample are largely composed of layered talc/stevensite. Thin section nicely displays the layered talc/stevensite as well as the matrix material which has been replaced by rhombic dolomite crystals and multiphase chert. **C.** Example of intensely altered Stromatolitic Boundstone facies, the original stromatolitic structure has been replaced by chert, while the matrix has been replaced by finely-crystalline dolomite. Thin section image in cross polars showing retention of some of the stromatolitic layering by the chert, but much of the detail has been lost through diagenesis. **D.** Image of a Microbial Boundstone with dendritic growths developing off of original oncoids. There is no corresponding thin section image for this facies.

Figure 2 – Three-foot core section from the Kambala A Well showing variable microbial fabrics observed in the core as well as the rapid facies succession common throughout the Toca, with multiple facies occurring within just a few feet.