Balbuena Supersequence, Salta Basin, Argentina: A Good Analog for Phanerozoic Lacustrine Microbialite-Bearing Reservoirs

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Abstract

The Pre-Salt Cretaceous giant oil fields discovered in offshore Brazil led to the search for analogs around the world. One of the best examples was found in the Salta Basin, Province of Salta, Argentina. This basin was developed since the early Cretaceous to the Eocene under an extensional regime. This tectonic setting enabled the development of a rift basin filled with siliciclastics sediments overlain by a sag basin with eolian sandstones and lacustrine carbonates of the Balbuena super-sequence. The upper part of the Balbuena Supersequence corresponds to the Yacoraite Formation (Upper Cretaceous to Lower Paleocene), which was deposited during the first sag phase of the basin, and is characterized by microbialite-bearing successions and subordinate pelitic rocks. In the southern portion of the basin (Metán-Alemania Sub-Basin) the sedimentation was developed under lacustrine conditions with the deposition of a carbonate-siliciclastic succession. Besides the northern part of the basin (Lomas de Olmedo and Tres Cruces sub-basins) had marine influence, the Metán-Alemania Sub-Basin based on 87Sr data indicates a clear continental depositional environment. This conclusion is also supported by the lack of marine facies (including salts) and fossils what, in association with exposure features (abundant paleosoils and mudcracks on basin borders), indicate a lacustrine setting under a balanced fill regime. Three orders of cyclicity (3rd, 4th and 5th orders) have been described and logged (multispectral gamma ray) in large outcrops of the Paleocene Balbuena Sequence 4, in the Cabra Corral Dam area (figure 1). In this area, the 40-60 m thick Balbuena Sequence 4 comprises a complete 3rd order cycle, spanning up to 1 to 4 m.y., which lower part has higher (>80 %) carbonate content, more frequent cracks and karstic surfaces, and less siliciclastic supply, which suggest dry environmental conditions. The 3rd order lower part is characterized by 4th order frequency cycles with symmetric pattern and gradual facies changes. In the upper part of this 3rd order cycle, the microbialite-bearing facies and marls occur in similar proportions with the higher siliciclastic supply interpreted as a more humid period. In the upper part of this 3rd order cycle it is also observed that the facies changed abruptly into higher-frequency cycles. The detailed mapping and facies sequence analysis of the 5th order cycles (10 cm to 1 m-thick, spanning up to 20 to 40 k.y.) allowed (1) the recognition of sharp boundaries between humid and dry periods; (2) the correlation of each 5th order cycle for more than 50 km, and (3) the recognition of different vertical facies succession in the 5th order cycles located in the dryer- or wetter-climate portions of a 3rd order cycle. The ideal 5th order cycle is composed, from the base to the top, of rudstones, marls, grainstones, laminites, stromatolites, and karstic features. In any situation, a Maximum Dry Surface is located at the top of the stromatolite beds. A Maximum Humid Surface is clearly defined within the marly interval of the wet cycles, whereas it is defined at the lower part of the grainstones of the dry cycles (figure 2). Nowadays the biggest challenges of Petrobras are the characterization and modeling of carbonate reservoirs from the Pre-Salt section, in order to avoid and/or control future problems related to differential depletion, which could seriouly the final recovery rates. The characterization of high-resolution stratigraphic cycles and the measurement of parameters, such as the lateral continuity of the main architectural elements from the Salta Basin microbialite successions,

have been used as input for the definition of production zones, predictability of reservoir facies, and geocellular modeling of microbial carbonate reservoirs from the Pre-Salt in Brazil.

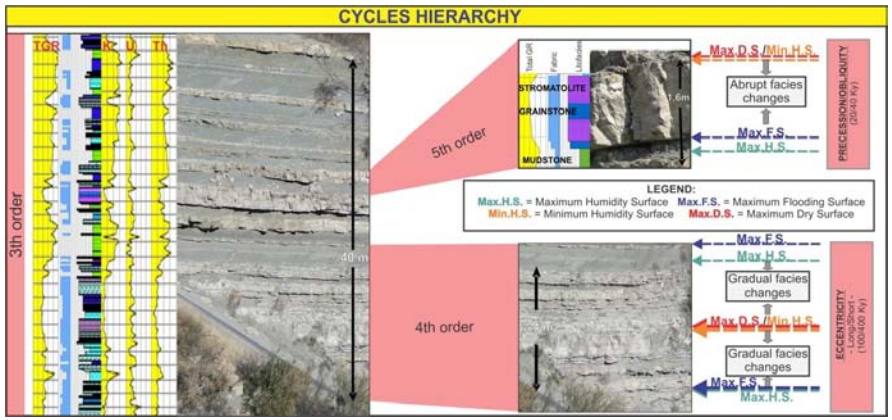

Figure 1 - 3rd, 4th and 5th order cycles in Balbuena Sequence 4, Cabra Corral Dam area.

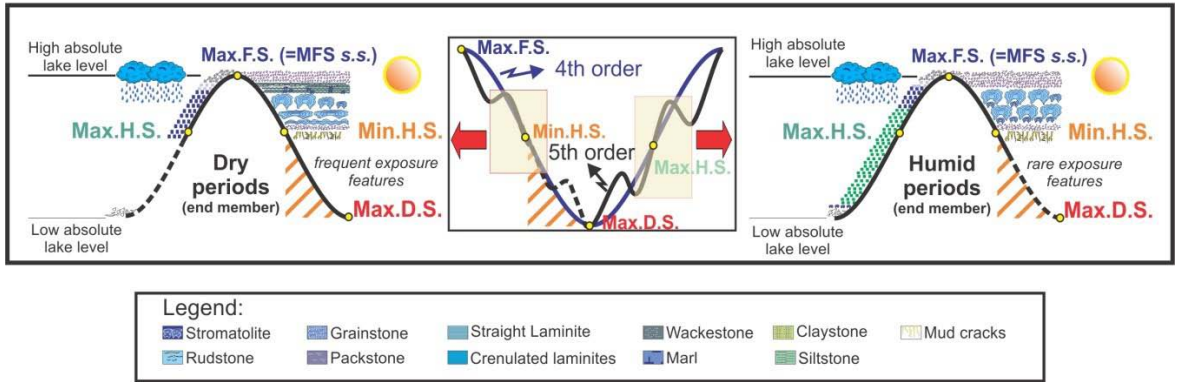

Figure 2 – High resolution environmental conditions and facies distribution of 4th (central square) and 5th orders cycles in Balbuena Sequence 4 (3rd order dry periods to the left and humid periods to the right), Cabra Corral Dam area. Max.H.S.= Maximum Humid Surface; Min.H.S.= Minimum Humid Surface; Max.F.S.=Maximum Flooding Surface; Max.D.S.=Maximum Dry Surface.