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Reservoir Analog Model for Oolite-Microbialite Sequences, Miocene Terminal Carbonate Complex, Spain

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Static 3-D reservoir-analog models were constructed for the Miocene Terminal Carbonate Complex (TCC) in southeastern Spain. The models used field data collected from two areas containing exceptional 3-D exposures (La Molata; La Rellana-Ricardillo). Four TCC sequences in each area are composed of oolite, microbialite (thrombolites, stromatolites), bioclastic sands, and coralgal reefs. The goal was to integrate field, laboratory, and petrophysical data to evaluate reservoir characteristics in relation to paleotopography in order to develop quantitative models of reservoir heterogeneity suitable for use in subsurface examples.

Static Petrel™ models were initially populated with detailed facies distributions as determined in the field (Figure 1). Petrophysical data from 499 core-plug samples of the representative facies provided porosity and permeability data. Those data reveal reservoir-quality values with the potential for substantial hydrocarbon storage for many facies. Flow and baffle facies were next distinguished for the models based on thickness, lateral distribution, porosity and permeability values (Figure 2).

Flow-analog facies for the field areas are laterally extensive, have significant thickness, large storage quantities, and good permeability values providing good lateral connectivity. The flow facies, all with reservoir-quality values, consist of trough cross-bedded ooid grainstone, massive ooid grainstone, beach sequence lithofacies, trough cross-bedded ooid bivalve grainstone, cross-bedded oolitic gastropod grainstone, vuggy thrombolite boundstone, volcaniclastic-rich planar bedded ooid grainstone, and *Porites* boundstone (Table 1).

Baffle-analog facies for the field areas vary in their lateral extent, have lesser storage capacities due to less pore volume, and are commonly thin accumulations with poor permeability values. The baffle facies consist of stromatolite, dense thrombolite boundstone, and fenestral ooid grainstone. Some of the baffle facies have reservoir-quality values, however, the low permeability values would hinder exploitation (Table 1). Baffle facies are concentrated stratigraphically along sequence boundaries and would likely constrict connectivity between sequences. Stromatolites deposited above fenestral ooid grainstone would create laterally extensive baffles with significant thicknesses at the sequence boundaries.

Table 1. Petrophysical data for flow and baffle facies calculated from 499 core plug measurements

Lithofacies	Porosity ave (%)	Permeability ave (mD)
Beach sequence (BS)	25	1106.897
BS-Trough cross-bedded ooid grainstone	26.3	1605.825
BS-Bioturbate ooid grainstone	24.97	863
BS-Planar bedded ooid grainstone	21.1	126.782
Trough cross-bedded ooid grainstone	25.2	602.138
Cross-bedded oolitic gastropod grainstone	33	2220
Trough cross-bedded ooid bivalve grainstone	23.4	1613.28
Volc-rich planar bedded ooid grainstone	21.2	273.137
Fenestral ooid grainstone	17.116	11.039
Massive ooid grainstone	24.3	2330
Porites boundstone	12.5*	1500*
Stromatolite	17	70.5
Dense thrombolite boundstone	19.1	68.91
Vuggy thrombolite boundstone	31.8	4201

* Denotes data taken from previous study in the area.

Trough cross-bedded ooid grainstone is volumetrically the most abundant lithofacies within both models, is laterally extensive across the entirety of sequences, and has large storage capacities with good permeability. The lithofacies would also have good connectivity with other flow facies. This lithofacies represents the best reservoir-quality facies and would be the primary target for hydrocarbon exploitation.

Analog exploitation strategies of hydrocarbons would differ in the two field areas. At La Molata, a central paleotopographic high would be the best place for the initial well. Hydrocarbons would flow updip to the central high through the reservoir facies. Multiple perforations would be needed to extract oil from the sequences because of the baffle facies located at the sequence boundaries. At La Rellana/Ricardillo, the best location for well penetrations would differ for the sequences. Sequence 1 is absent west of the Ric 11 section. If the hydrocarbons remained trapped within this sequence, west of this onlap would still remain prospective. The contact between Sequence 1 and 2 at La Rellana/Ricardillo lacks the concentration of baffle facies that occurs at other sequence contacts. Sequence 1 fenestral ooid grainstone has variable lateral connectivity and Sequence 2 has no stromatolites at the base. Hydrocarbons would likely migrate from Sequence 1 into Sequence 2. The highest preservation of Sequence 2 deposition occurs at 257 m elevation. This would be the preferred location for exploitation. The most updip preservation of Sequence 3 occurs at 240 m elevation (just west of section Ric 12). Baffle facies of fenestral ooid grainstone from Sequence 2 and stromatolites from Sequence 3 would hinder connectivity between the sequences. In order to exploit the hydrocarbons stored in Sequence 3, an additional well would be needed at the updip limit of Sequence 3. Sequence 4 is only preserved as a partial sequence and lacks significant storage capacities.

Field study indicates that sea level interacting with both paleotopography and paleogeography were the main controls on sequence development and significant reservoir complexities. An understanding of these controls can aid in exploitation of microbialite-oolite sequences.

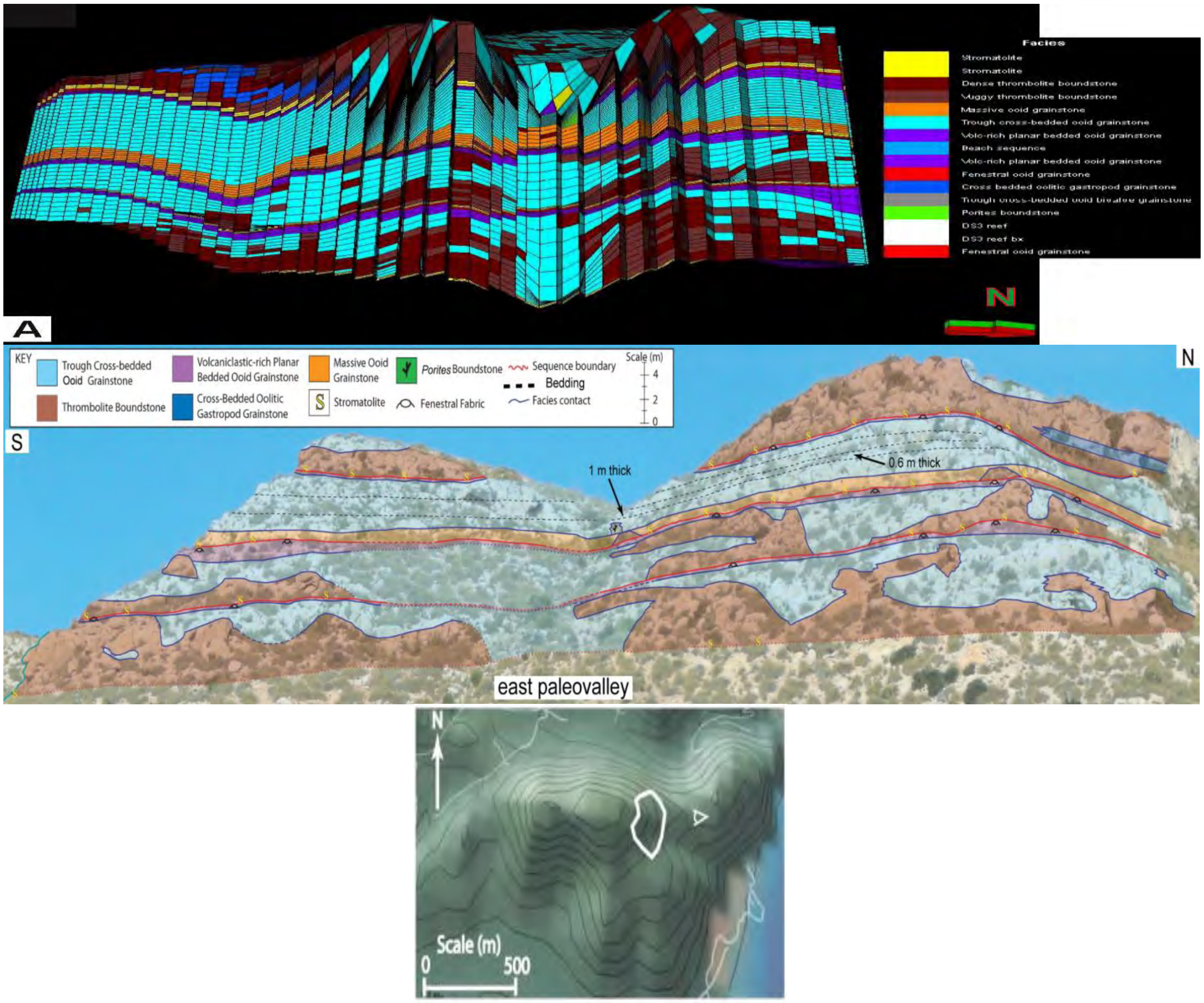

Figure 1: Comparison of model result (A) and field data (B).

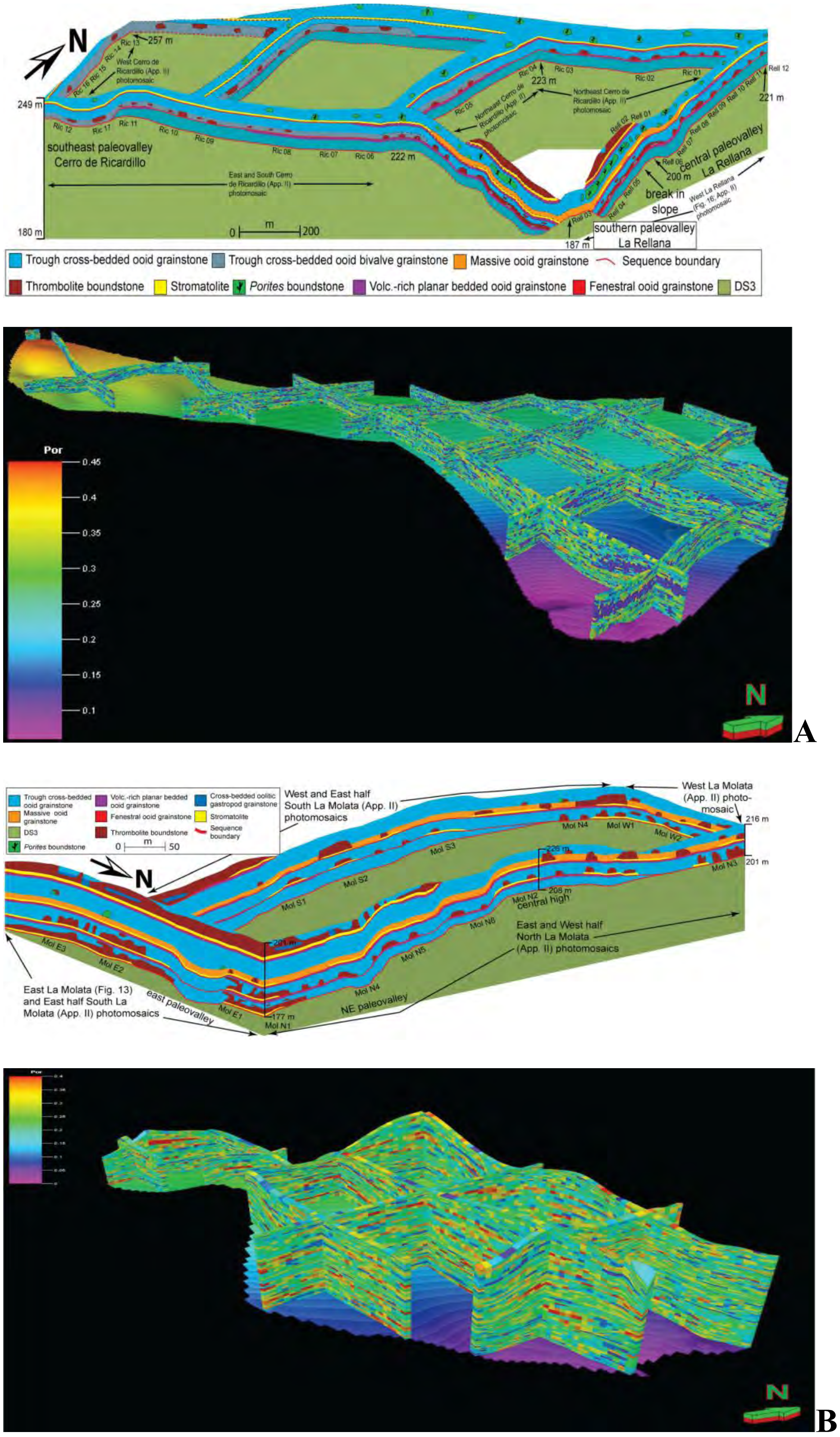

Figure 2. Fence diagrams illustrating facies distribution and paleotopography and 3D porosity models for the TCC. (A) Ricardillo area, (B) La Molata area.