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Sequence stratigraphic controls on reservoir-scale mechanical stratigraphy of shallow-water carbonates (Sorrento Peninsula, Italy): insights on distribution and arrest of vertical trough-going joints and implications for fluid flow

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Studies on mechanical stratigraphy of shallow-water carbonates have shown that the distribution of fractures is controlled by depositional facies, sedimentary cycles/sequences, and diagenesis. Understanding the role of these sedimentary controls is crucial in the characterization of matrix-tight reservoirs, where fractures may represent the main conduits for fluid flow. Nonetheless, the relation between fracture distribution and sedimentary controls is not always investigated at scales that are relevant to reservoir and fluid flow characterization. In this study, we tackle the problem by integrating sequence stratigraphic analysis and multi-scale fracture characterization of a 300-m wide and 200-m high carbonate platform outcrop in the Sorrento Peninsula (southern Italy).

This outcrop is the surface analogue of subsurface hydrocarbon reservoirs and consists of a nearly vertical cliff exposing gently-dipping shallow-water limestones and dolostones, crossed by several vertical fractures ranging in height from few cm up to few tens of m. Due to the partial inaccessibility of this cliff, field measures have been combined with remote sensing on a virtual outcrop model.

This study allowed us to recognize that major through-going fractures generally crosscut thick beds (bed thickness > 30 cm), whereas they tend to abut against packages made of thinly stratified layers. Sequence stratigraphic analysis allowed us to identify the key control exerted by 3rd order sedimentary cycles on the formation of the thinly bedded levels. Moreover, these study results also demonstrated that through-going fractures abut against “weak” levels, deposited during late highstand system tracts, in the same manner as bed-confined fractures abut against less competent interlayers.
Discrete fracture network (DFN) models have been used to analyze the connectivity of the fracture system. These DFN models show that through-going fractures guarantee vertical connectivity through the reservoir, playing a primary role in terms of permeability. Thus, the thinly stratified “weak” levels, which arrest the propagation of through-going fractures, act both as mechanical and permeability barriers, and can therefore cause a vertical compartmentalization of the reservoir.

Integrating the occurrence of these mechanical barriers in a sequence stratigraphic framework can help to predict the distribution of through-going fractures and provides critical insights to improve the understanding of fluid flow in the analogue carbonate reservoirs.