Sequence Stratigraphy of Carbonate Ramp Systems: Implications for "Sweet-Spot" Prediction in the Vaca Muerta Unconventional Resource Play

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ABSTRACT

There are many examples in the geological record where carbonate ramp systems are located adjacent to organically-enriched sediments. In such scenarios, the potential exists for source units and brittle carbonate units to be juxtaposed, which is a stratigraphic arrangement conducive to the development of an unconventional resource play. The emergence of the Vaca Muerta play in the Neuquén Basin, Argentina, has highlighted the importance of carbonate ramp systems as potential hosts for unconventional resource plays and emphasized that these plays can be successfully produced. Carbonate ramps are generally characterized by a low-angle of slope, which makes them highly sensitive to eustatic variations in sea level. This typically results in a heterogeneous system with a high degree of vertical and lateral facies variation, which can make subsurface prediction challenging. In these instances, sequence stratigraphy is a fundamental tool to characterize stratigraphic architecture/variability in the depositional system and reduce subsurface uncertainty. This study uses an integrated dataset (seismic, wireline, geomechanical, and production data) within the predictive framework of a sequence stratigraphic model to establish a relationship between production rate and systems tract in the emerging Vaca Muerta play. Interval-specific production data demonstrates that the highest-producing stratigraphic units are not necessarily the most organic-rich but contain high-frequency, cyclical intercalations of organic-rich units and brittle fractured target horizons. These geomechanically favorable units predominantly occur within the lowstand systems tract, where forced regression of the carbonate ramp induces reworking and detrital carbonate input into the anoxic basin. By upscaling these concepts, an unconventional exploration model can be formulated to guide regional sweet-spot prediction. The unconventional exploration model uses gross depositional environment maps to identify the aerial extent of geomechanical sweet-spots within each defined eustatic sequence. The output is a valuable predictive tool that allows frontier acreage in the Vaca Muerta, and other analogous unconventional resource plays, to be evaluated, compared, and ultimately high-graded.