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Recent Exploration Drilling Results Highlight Significant Potential for Portugal's Lusitanian Basin

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Steeply dipping beds of Lower Jurassic, organic-rich shaley carbonate source rocks at Sao Pedro do Muel, Portugal.

The Lusitanian basin is located on-and offshore, west-central Portugal, extending from Lisbon to Porto, west of the Iberian Meseta. Abundant oil seeps in the basin attest to working petroleum systems, and have attracted industry interest in the past. Despite intermittent drilling activity since the 1940s, the basin is still relatively unexplored, with significant exploratory tests being approximately 1 well per 150,000 acres.

The Lusitanian Basin originated as a Late Triassic rift system related to opening of the Tethyan seaway. This Mesozoic rift system was superimposed upon an older, Hercynian orogenic terrain of folded lower Paleozoic rocks and taphrogenic, Permo-Carboniferous coal basins. Folds within the Hercynian terrain trend NW–SE, oblique to the primarily NNE–SSW trend of Lusitanian rifting, creating pre-rift, cross-basinal arches that were episodically reactivated during subsequent tectonic phases. Similarly, many significant Hercynian faults were utilized as major rift half-graben boundaries, and hence can define syn-rift, fluvial clastic depocenters. Such faults generally exhibited later episodes of wrench movement as well, particularly at the end of the Middle Jurassic and during Tertiary Alpine orogenesis.

Regional Upper Triassic/Lower Jurassic evaporites divide the Lusitanian Basin stratigraphic column into subsalt and suprasalt hydrocarbon systems with associated exploration plays. The subsalt play targets gas reserves in syn-rift, Triassic continental sandstone reservoirs sealed by salt or anhydrite and sourced from underlying Silurian graptolitic shales and Permo-Carboniferous coals. This system is analogous to the Algerian Ghadames Basin, where prolific production has been established from Triassic continental sandstones, capped by Liassic salt, and charged by a second phase of expulsion from Silurian source rocks. The system is also analogous to the slightly older Southern North Sea gas production from Permian Rotliegendes continental sandstones, capped by Zechstein salt, and charged by Carboniferous coals.

Mohave and partner's first well in the basin, Aljubarrota #1, drilled a large, west-verging overturned fold, probably related to partial inversion of an adjacent Triassic half-graben to the east. Oil and gas shows were encountered in transition zone dolomites and oolitic limestones at the base of the Dagorda evaporite sequence, indicating an approximately 500-m paleo-oil and gas column. Analysis of oil extracts from the shows documented a Lower Paleozoic oil source for these hydrocarbons. The Triassic section encountered was a thin fault sliver. Mohave's second well, Aljubarrota #2, was drilled in the adjacent half-graben and penetrated over 580m of syn-rift Triassic siliciclastics at a structural position 470m low to the Aljubarrota #1. The Silves section in the #2 well had significant mud gas shows throughout, as well as substantial gas in the overlying post-salt section.

Suprasalt hydrocarbon plays targeting post-salt Jurassic carbonate and clastic reservoirs have been the focus of previous exploration in the basin. This petroleum system contains well-documented Jurassic source rocks and has produced sub-commercial amounts of oil. The Mohave Aljubarrota #2 well established the presence of an ~700-m thick gas column in fractured, vuggy carbonates of Lias/Dogger age (see inset photo on cover). Mohave's Aljubarrota #3 and #2 Sidetrack appraisal wells found water-free gas saturation in the target carbonates,

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but did not find the same density and openness of fractures which produced gas in the Aljubarrota #2.

Transitional dolomites and anhydrites of the upper Dagorda evaporite sequence have exhibited oil and gas shows when drilled, and though past operators reported log pay, none of these zones were adequately tested. Additionally, recent wells drilled as part of a gas storage project intersected numerous, porous, hydrocarbon-saturated dolomites in the Dagorda. Seismic expression of this alternating dolomite/anhydrite facies is mapable, outlining potential Dagorda dolomite reservoir fairways. Porous oolitic limestones of the Late Dogger-age Candieirros Formation have been penetrated in several wells and offer significant potential where the oolite fairways overlap properly timed structures which are sealed by overlying marly Montejunto Formation carbonates.

In summary, two petroleum systems are now documented in the Lusitanian basin, a subsalt petroleum system and a suprasalt petroleum system. The primary subsalt reservoirs are sandstones of the syn-rift Silves Formation, capped by a regional evaporite seal in the Dagorda Formation. Trap types are fault block closures and wrench-related anticlines. Multiple reservoirs are present in the suprasalt system, including Lower and Middle Jurassic porous dolomites and fractured vuggy carbonates, Middle and Upper Jurassic oolitic and reef limestones, and Upper Jurassic sandstones. Shaley and marly carbonates of the Brenha and Montejunto Formations offer regional seals. Traps are fault block closures, wrench-related anticlines, stratigraphic pinchouts, truncation traps, and reefs.

Biographical Sketch

THOMAS UPHOFF is chief geologist for Mohave Oil and Gas Corporation, which currently operates 7 concessions in the Lusitanian basin of Portugal and four contracts in the Llanos basin of Colombia. Tom received his BS (1972) and MS (1978) degrees in geology from The University of Texas at El Paso, and began his professional career with Texaco in 1972. Before joining Mohave, he worked 6 years for BHP Petroleum (Americas) Inc. as a new ventures geologist – North and South America, and prior to that, 14 years for Sohio/BP Exploration in a variety of domestic and international assignments. □