THE SEQUENCE STRATIGRAPHY, SEDIMENTOLOGY, AND ECONOMIC IMPORTANCE OF EVAPORITES AND EVAPORITE-CARBONATE TRANSITIONS

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ABSTRACT:
World class hydrocarbon accumulations occur in many ancient evaporite-related basins. Seals and traps of such accumulations are, in many cases, controlled by the stratigraphic distribution of carbonate-evaporite facies transitions. Evaporites may occur in each of the systems tracts within depositional sequences. Thick, basin-center evaporite successions are best developed during sea level lowstands due to evaporative drawdown. These saline giants represent 2nd-order supersequence set (20-50 m. y.) lowstand systems that, in many basins, cap the sedimentary fill, and provide the regional seal for the hydrocarbons contained within these basins. Large-scale withdrawal of salt from the world?s basins has been followed by significant hydrocarbon source rock deposition.

Large-scale marine evaporites have been deposited in the Phanerozoic when tectonic-eustatic-climatic conditions have conspired to provide basin restriction and net evaporative conditions. These halite-dominated saline giants generally occur in low-latitude regions at distinct times in earth history that are characterized by widespread withdrawal of marine waters from continental shelves, aridity, and where basin architecture and the surrounding landmasses provided restriction of marine waters. The saline giants have occurred under both greenhouse and icehouse conditions. They are not sudden events, but are often preceded by cyclic carbonate-evaporite sequences that reflect progressive climatic deterioration and basin restriction. Conditions conducive to large-scale evaporite deposition are not present in the Recent. Sea level is at highstand, global oceans are well circulated, continental dispersion is at a maximum and there is little potential for basin restriction in low-latitudes.

Saline giants can be grouped into three tectonic settings that are conducive to hydrographic restriction: continental interior sag basins; subbasins in post-orogenic forelands; and late-stage syn-rift basins partially connected to oceanic regimes. The Lower Paleozoic giants occur in continental interior sag basins, and were deposited in the Early-Middle Cambrian and Middle Ordovician (e.g., Siberia), the Late Silurian (e.g., Michigan basin), and the Middle Devonian (e.g., Western Canada basin). The Upper Paleozoic and Late Neogene giants occur in post-orogenic foreland basins. These include the Middle Pennsylvanian Paradox salts of the Four Corners region, western US, the Middle Permian of the Pre-Caspian, and the Late Permian along a trans-highland region that stretched from west Texas through Northern Europe and Arabia to central Russia. Thick salt deposits occur in late-stage, syn-rift Atlantic basins during the Mesozoic

(Lower-Middle Triassic, North Atlantic region; Middle Jurassic, Central Atlantic and Gulf of Mexico; and Aptian, South Atlantic).

Evaporite-carbonate transitions at the 3rd-order and higher scale occur in each of the systems tracts and can result in hydrocarbon seal and trap potential. Where reservoir-bearing slope carbonate buildups occur, lowstand evaporites that onlap and overlap these buildups show a lateral facies mosaic directly related to the paleo-relief of the buildups. Examples come from the Silurian of the Michigan basin, and the Pennsylvanian of the Paradox basin, Four Corners, USA. Where lowstand carbonate units exist in arid basins, the updip facies change from carbonates to evaporite-rich facies also provide traps for hydrocarbons. The change from porous dolomites composed of high-energy, shallow water grainstones and packstones to nonporous evaporitic lagoonal dolomite and sabkha anhydrite occurs in the Upper Permian San Andres/Grayburg sequences of the Permian basin, and the lowstand system of the Smackover Limestone of the Gulf of Mexico. Transgressions in arid settings over under filled platforms (e.g., Zechstein (Permian) of Europe; Ferry Lake Anhydrite (Cretaceous), Gulf of Mexico) can result in deposition of alternating cyclic carbonates and evaporites in broad, shallow subaqueous hypersaline environments. Evaporites in highstand systems tracts are characterized by thick successions of meter-scale, brining upward parasequences in platform interior settings. The Seven Rivers Formation (Guadalupian) of the Permian basin typifies this transition. Condensed sections, laterally equivalent to transgressive and highstand carbonate platforms that were deposited during 2nd-order transgressions are, in many basins, composed of organic-rich black lime mudstones and shales that have sourced significant quantities of hydrocarbons.

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