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An investigation of the evolution and present distribution of residual oil zones (ROZ) in the Permian Basin, West Texas and its implications for carbon dioxide (CO_2) storage

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Potentially significant new resources for tertiary oil production through carbon dioxide (CO_2) enhanced oil recovery (CO_2-EOR) are "residual oil zones" (ROZ), which have been identified in several locations in the Permian Basin reservoirs of West Texas. Although a consensus definition of ROZ is still developing, ROZ are characterized by low-but-economical saturations of oil (So) remaining from reservoirs in which the primary oil accumulations have been displaced. In the Permian Basin, this mechanism is theorized to be heightened ground water flux resulting from regional tilting and an increased area of recharge associated with Basin and Range extension in New Mexico.

Low So zones have been recognized in a few fields in the area for many years, but their potential for recovery has only recently been explored. Many original exploratory wells noted depths of oil shows that only produced water. Other fields had distinctly tilted oil water contacts (OWC), which can result from hydrodynamics tied to regional groundwater flow potentially indicate zones of displaced hydrocarbons displaced below. Later advanced core and well log analysis indicated that there thick zones of oil at saturations commonly between 15-40%. These zones were thicker than would be expected due to normal capillary forces that form the widely recognized transition zones at the base of typical oil reservoirs. The recent rise in oil prices, exhaustion of primary oil production, and widespread development of CO2-EOR in the Permian Basin have made production from ROZ economically attractive and created new interest. However, the understanding of ROZ creation and its regional extent is still in its preliminary stages.

This research aims to improve our understanding of ROZ evolution and distribution. Literature review of original oil field reports across the Permian Basin is used to identify fields showing characteristics presently associated with potential ROZ presence (e.g. tilted OWC, sulphur water). These fields have been mapped to show the regional distribution and compare that to presumed or known regional groundwater flow pathways. Next, an estimate of Cretaceous through Tertiary tilting is determined. Having been deposited on a ≤1º degree slope, the present base of the Edwards Group is correlated at locations across the Permian Basin and the slope calculated. This is used as a proxy for the paleo-potentiometric surface to provide an approximate constraint to estimates on paleo-groundwater flow rates. Future work will identify a small sample of fields that contain and lack ROZ for case-studies including core investigation and review of petrophysical data to further examine potential signatures of ROZ and examine whether simplistic models of tilting induced groundwater flow can serve as a first order explanation of oil displacement and ROZ formation. From this work, implications are drawn as to the potential demand for CO_2 for ROZ production and role of preferential pathways on fluid migration such as a supercritical CO_2 plume over geologic timescales.

Keywords: Residual Oil Zones, Permian Basin, residual oil saturation, Edwards Group, regional flow, Basin and Range tilting, secondary oil migration