Stratigraphic control on production in unconventional reservoirs: a Permian Basin example

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Abstract

Fluid production in unconventional reservoirs is usually interpreted to reflect drainage of a homogenous shale via hydraulic fractures connected to natural fractures that re-activate during stimulation. However, lithofacies with elevated permeability contrast (e.g., one or more orders of magnitude above the mudstones) may also represent preferential flow pathways during production in these reservoirs. We demonstrate the presence of such permeable layers in the Wolfcamp, Bone Spring, and Spraberry formations in the Permian Basin. These layers represent siliciclastic and calciclastic sediment gravity flow deposits that are significantly more permeable (e.g., 25x) than the mudstones, which is the dominant lithofacies in these reservoirs and the source of most of the produced fluids. We conducted steady-state liquid permeability measurements in core plugs from different Wolfcamp lithofacies. The dolomitized calcareous lithofacies exhibit permeabilities up to 2000 nd, whereas the permeability in the mudstones is less than 60 nd. Mercury injection capillary pressure (MICP) analyses further confirm a positive correlation between permeability and pore throat size in these samples. MICP measurements obtained in samples from the Bone Spring and Spraberry formations suggest that they also contain permeable lithofacies with similar permeabilities as those measured in the Wolfcamp. To study the role of these permeable layers during production, we built a layered flow model to run flow simulations at the completion scale. We observed that flow is focused through the permeable layer and that production rates increase up to four times compared to a reservoir composed of mudstones only. This integrated study highlights how stratigraphy controls production in unconventional reservoirs, and its importance to select the most optimal landing zones and appropriate spacing between fracturing stages and between wells. We suggest that thin permeable layers exist in many if not all unconventional basins. Determining, and characterizing, these permeable layers is critical to optimizing unconventional reservoir production.