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A Geomechanical Facies-Based Approach to Optimize Drilling and Completion Strategy of an Unconsolidated Sandstone Reservoir, Saudi Arabia

Ali S. Raba'a, Hazim H. Abass, and Drew E. Hembling, Saudi Aramco, and Thomas Finkbeiner, GeoMechanics International Inc.

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Abstract

Drilling horizontal wells, single and multilateral, is nowadays common practice for Saudi Aramco in most of its oil and gas reservoirs (clastics as wells as carbonates) in Saudi Arabian fields. This study highlights the application of a geomechanics study to evaluate well stability drilled into a friable eolian oil-bearing sandstone reservoir. Saudi Aramco's reservoir management was eager to find the optimum mud type and azimuthal direction to place long reach horizontal wells, so as to minimize the risk of stress-induced borehole breakouts, optimize drilling mud weights, aid in making informed decisions about adequate completion design, and ensure sustainable production under depletion mode.

The reservoir rocks in this field are characterized as a "wet" eolian depositional system with four distinct depositional facies: dune, sand sheet, paleosol and playa. Grouping the lithology into these four recognizable depositional facies significantly enhanced the understanding of facies dependent rock properties and related wellbore integrity. Hence, a critical objective of the study was to combine the knowledge of reservoir and material properties with detailed analyses of the present day in situ stress field. Upon determination of the in situ stress field in the study area, wellbore stability in the principle horizontal stress directions (S_{hmin} and S_{Hmax}) was calculated and compared and the resulting optimum direction was recommended. The effect of mud on rock strength was evaluated and the mud type that caused less rock-strength reduction was selected.

The study concluded that under undepleted conditions horizontal wells should be drilled with oil-based mud parallel to the field-derived maximum principal horizontal stress (S_{Hmax}) azimuth in order to maximize borehole stability and minimize required mud weights during drilling and completion. The results from this detailed study will be incorporated into Saudi Aramco's reservoir management decision tree, in order to maximize wellbore integrity during drilling and completion such that least damage occurs to the reservoir during drilling and in-gauge hole conditions for successful sand control completion deployment can be maintained.

Introduction

The structure of the oil field analyzed in this study is a conventional northwest trending asymmetric anticline. The reservoir consists of a Permian well-developed eolian sandstone that is closely associated with inter-dune and lacustrine deposits. The reservoir rocks can be characterized as consolidated, unconsolidated and very heterogeneous sandstone formations with four distinct depositional facies: dune, sand sheet, paleosol and playa.

To develop the field to its target production, Saudi Aramco's reservoir management team planned to drill a number of horizontal wells, single and multilaterals to ensure maximum reservoir contact. Most horizontal wells are oriented in an E-W direction. Maintaining wellbore stability while drilling into this friable sandstone reservoir presents a considerable challenge as is the tendency for the sanding of the poorly consolidated portions of the reservoir. Sand production has historically been a problem associated with soft or poorly consolidated formations, which result in lost production due to formation sand and fines plugging; erosion of subsurface and surface facilities, casing and/or well bore collapse. Several methods can be applied to minimize the effect of sand production including critical production rate, gravel packing, sand consolidation, FracPacking, oriented and/or selective perforation, standalone or expandable sand screens (ESS^{TM}).

Since Saudi Aramco implemented in the past ESS^{TM} technology successfully in sandstone reservoirs to control sand and improve productivity, this completion strategy was also planned in the study field. The process of expanding ESS has evolved from a fixed diameter using a rigid cone expander into a variable compliant expansion technique to conform to the actual borehole geometry. The compliant expansion technique provides an internal support of the wellbore[1]. The development team selected ESS and other conventional sand screens as the main completions for all horizontal development wells.