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Avoiding Losses in Depleted and Weak Zones by Constantly Strengthening Wellbores

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Abstract

Drilling depleted or weak zones has always been a challenge, but with the aging of fields and the desire to drill to deeper in-field plays, the situation is becoming more exacerbated. The typical problems associated with drilling these types of intervals are lost circulation, stuck pipe and wellbore instability resulting in significant and expensive non-productive time (NPT) and costly remediation operations. Conventional lost circulation remedies (e.g., pumping lost circulation pills and squeezing) have given way to popular wellbore strengthening solutions. Our approach to strengthening, based on beneficial manipulation of fracture propagation pressure and continuous application of specialized wellbore strengthening additives has had tremendous success in reducing downhole mud losses by more than 80% in Gulf of Mexico deepwater operations and dropping the cost of these incidents out of the top 10 contributors to NPT.

This paper focuses on the various theories and approaches to wellbore strengthening and what the available field and literature data actually support. Building upon this, the approach of gaining wellbore fortification through fracture propagation resistance (FPR) enhancement is introduced, for which experimental results, field data and case histories are shared. Central to our application of FPR to drill challenging deepwater production wells is the notion of providing continuous wellbore protection through a novel and unique solids recovery and reintroduction method that allows for drilling with high concentrations of wellbore strengthening materials (WSM) in the drilling fluid.

Introduction

Delivering Gulf of Mexico (GOM) deepwater wells is complicated by the presence of high geopressures and relatively low fracture gradients leading to very small drilling margins. Lost circulation into induced or natural fractures in particular has been a prevalent source of non-productive time (NPT) and associated trouble cost, associated with events where copious amounts of drilling fluid are lost, contingency casing strings need to be run, lost wellbores need to be re-drilled or sidetracked, etc. Moreover, the deepwater lost circulation challenge is growing as: (1) prospects start to deplete from ongoing production, further reducing already small drilling margins; (2) geomechanical changes associated with depletion and subsidence increase the risk of fault (re-)activation, leading in turn to the sudden appearance of lost circulation zones and problems never before encountered; (3) wells much more challenging from an equivalent circulating density (ECD) perspective, such as extended reach wells approaching 10+ km in total depth, are drilled to more marginal pockets of hydrocarbons. It is little wonder that the industry has devoted considerable attention and resources to developing wellbore strengthening methods that extend drilling margins to prevent severe mud loss, extend and/or eliminate casing string and seats, and guarantee high(er) quality cement jobs.

It is important at this point to clarify what the term “borehole strengthening”, in many ways a misnomer, really means. When conducting a formation strength test, the pressure response observed is determined to a very large extent by in-situ formation stress (and the tangential stress or hoop stress riser generated at the wellbore wall during borehole drilling) and to a much smaller extent by formation tensile strength, which for most formations of interest is either small or negligible in magnitude. Borehole strengthening methods therefore rarely target an increase in formation strength (although chemical treatments are available to enhance rock matrix strength in permeable formations, and have been applied successfully on depleted formations) [1], and are mostly concerned with either: (1) attempting to enhance the near-wellbore stress, thus raising the threshold for fracture (re-)opening and growth; this approach will be referred to in the following as Wellbore Stress Augmentation (WSA), or (2) increasing the formation’s resistance against fracture propagation, referred to in the following as the Fracture Propagation Resistance (FPR) approach. The overall effect of these approaches is that the effective fracture gradient, i.e., the pressure at which fractures grow to significant size and large volumes of drilling fluid are lost, is elevated.