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A New Treatment for Wellbore Strengthening in Shale

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Abstract

The increase in complexity and associated costs with wells as a result of infield drilling, drilling below old fields and striving for deeper targets has generated industry interest and attention in wellbore strengthening. This heightened interest is demonstrated in the number of recent publications that have been prepared on the subject. These have primarily focused on and described methods that are effective in raising the fracture resistance of permeable formations such as sands. However, a much bigger impact can be made on the overall drilling operation if it is also possible to strengthen low permeability rocks such as shale along with the sands. The industry has seen this as a major challenge and to date the technology and expertise required to achieve this has not been consistent or reliable.

This paper will demonstrate that wellbore strengthening in shale is indeed feasible. A treatment pill was developed in the laboratory and successfully field tested at a US land-based location. The treatment consisted of a blend of particulates (known as stress cage solids) and proprietary cross-linked gelling polymers which set with time. Properties of the system such as compressive strength, adhesion to shale and the sensitivity to temperature and pressure were evaluated, and modeling work was done to engineer the size and concentration of bridging solids required.

Field testing was carried out in a 50-ft section of competent shale below the 9⅝-in. shoe in an operation where oil-based mud was being used. The initial fracture gradient was measured using leak-off tests to establish the native formation strength. The treatment was squeezed and allowed to set under pressure before drilling out, leaving a strengthened wellbore. Formation Integrity Tests (FIT) were conducted to confirm the presence of the strengthening effect. The robustness of the treatment was demonstrated by circulating drilling fluid for increasing periods of time and performing further FIT tests. The well was left in a strengthened state at the end of the test period.

This trial demonstrates that by using appropriate technologies and methods it is indeed possible to reliably raise shale fracture resistance.

Introduction

Emphasis on "Wellbore Strengthening" has been growing over the past few years, as reflected by the increase in frequency and variety of technologies that have been applied to this goal. Options ranging from cement and chemical resins to tools (*i.e.*, expandable casing, casing drilling) have been employed to strengthen wellbores. The primary impetus of these endeavors has been time and cost (actually one in the same), although extending the drilling envelope has been becoming increasingly important.

Drilling in depleted zones, or intervals where high pressured formations are interbedded with normally and abnormally pressured layers, has given rise to the need for implementation of these strengthening technologies. The goal is to raise the fracture resistance of weaker formations and thereby avoid whole mud losses, wellbore instabilities and potential loss of the drilled interval. The primary consequences of these undesired events are an increase in the well non-productive time (NPT) and associated costs. In addition to avoiding these problems, the economic benefits that wellbore strengthening can provide is the possible elimination of a casing string or more importantly, the ability to reach deeper reservoir targets.

One of the most popular wellbore strengthening technologies is that of inducing an increase in wellbore stresses using sized particulate additions to the drilling fluid. The common name for this approach is "stress caging".[1,2,3] The stress cage model is addressed in depth elsewhere,[3] but briefly the principle is to increase the hoop stress around the wellbore by using fractures to cause stress changes in the rock. These fractures would be held open using bridging material, thereby creating the stress cage effect or strengthening of the wellbore (Fig. 1). This bridge of particles across the mouth of the fracture must be of low permeability to provide pressure isolation between the fluid in the wellbore and that in the fracture; thus preventing any further fracture elongation. The degree of stress caging relative to the native stresses is a function of both fracture width and radius and rock properties (Young's modulus and Poisson's ratio). Furthermore, to achieve this effect, the proper type, size and amount of loss-prevention material (LPM) must be employed. Utilizing the