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Real-time Downhole Monitoring and Logging Reduced Mud Loss Drastically for High-Pressure Gas Wells in Tarim Basin, China

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Abstract

This paper describes a real-time case study to prevent mud loss and blowouts while drilling a high-pressure gas well in Tarim basin, China. The complex geological structure, high tectonic stresses, and overpressured and fractured reservoir formations in the field present a huge challenge to drilling. Of the seven wells drilled in the field in 2005, two did not reach target depths, four experienced huge mud loss, and the other experienced a blowout resulting in lost control of the well. In early 2006, PetroChina teamed up with Schlumberger and Petroleum University of China to form a collaborative technical group to develop a better understanding of mud loss and blowout mechanisms. The key component of the study was to establish a geomechanical earth model based on offset well data prior to drilling, update the model using downhole monitoring and logging data during drilling, and predict a safe mud weight window in real-time.

Real-time prediction of a safe mud weight window with annular pressure monitoring helped ensure that downhole annular pressure was maintained within the safe mud weight window during drilling and tripping. The study resulted in a 20-times reduction in mud loss and 10-times reduction in nonproductive time, and elimination of an extra casing. A better understanding of mud loss/blowout mechanisms was achieved and guidelines for preventing mud loss/blowouts specific for this gas field were developed.

Introduction

The target well is located in a highly fractured complex geological structure with abnormally high pore pressure in reservoir section. Of the seven wells drilled in 2005, two did not reach the target depth due to over pressure. Huge mud loss (averaged approximately 1500 m³ per well) was experienced in the other four wells. The mud loss was responsible for 42% of total drilling incidents, significant non productive time (33.38% of total NPT) and over budget (see **Figure 1**). An underground blowout occurred in a recent well resulted in lost control of the well. It has been observed that a mud weight slightly too high could hydraulically fracture the borehole and result in significant mud losses, and a mud weight slightly too low could lead to blowout with potentially disastrous consequences. It is therefore critical to be able to predict, in realtime, the extremely narrow safe mud weight window so that necessary measurements can be taken to mitigate the risks.

In early 2006, PetroChina teamed up with Schlumberger and China Petroleum University to form a collaborative technical group to develop a better understanding of mud loss and blowout mechanisms. Based on the technical group's suggestion, a real-time pore pressure monitoring was conducted for an appraisal well to be drilled in 2006 in the field. The study primarily consisted of three stages – pre-drill planning, execution during drilling and evaluation post drilling. The key task of this process was to build and update a Mechanics Earth Model (MEM), which formed the basis for safe mud weight window prediction.

The objectives of this study were:

- Based on the experiences of the seven offset wells, to investigate relationships between mud loss incidents and MEM, lithology, structure, faults, nature fracture distribution, and fluid type and distribution, and to identify mud loss