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Drilling a Deepwater Wildcat Off the North Coast of Brazil: A Case Study

D.M. Sparkes, J.S. Wellings, and G.T. Rheaume, BP PLC

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Abstract

It is well known that delivery of projects according to plan and for minimal costs depends on having the right people, processes, and technology in place. The consequences of not adequately implementing these elements for difficult drilling projects can result in total failure to reach objectives and/or substantial overspending of both planned and theoretical minimum cost. This case study will outline the processes used to get the appropriate people and technology in place to deliver a high pressure, high temperature, deepwater wildcat off the north coast of Brazil. The paper will focus on the management of down hole problems, logistics, technology transfer, and high currents for a well drilled at the boundaries of worldwide experience on multiple fronts.

Introduction

Algodoal-1 was a 5650m wildcat exploration well drilled in late 2004 in 776m of water approximately 200 miles off the northern coast of Brazil with the drill ship Jack Ryan (see **Figure A1** and **Figure A2**). The project set records as the deepest well ever drilled off the north coast of Brazil and the highest pore pressure well ever drilled in Brazil.

This paper is a high level discussion of a selection of the most challenging aspects of the well with a focus on what was deemed necessary to achieve success drilling the well in terms of people, tools, and technology transfer. Specific technical challenges such as cement design, drilling fluid design, equipment Quality Assurance / Quality Control (QA/QC), cuttings handling, and data acquisition were equally challenging but are not discussed as the themes are recurring.

The discussion applies to the world's most difficult drilling projects that are both costly and high risk. Themes of logistics and technology transfer can certainly be applied beyond deepwater drilling, however focus on high current and small differences between pore and fracturing pressures maintain much of the paper's focus on deep water exploration drilling.

The intent of the discussion is to promote understanding of the likelihood of failure in a frontier drilling operation and the infrastructure of technical resources that is necessary to successfully and cost effectively execute such a project.

Well Control: Managing Formation Ballooning

Algodoal-1 was planned with 9 strings of casing using seismic derived pore and fracture pressure gradients for shale and derived fracture gradients for permeable intervals (i.e. Sand Fracture Gradient). **Figure A3** shows the basis of design for the well and details the pre-drill predicted shale pore/ fracture pressure and the potential sand fracture pressures at depth. The casing design was based on the most likely shale pore and fracture pressure profiles. A risk assessment and peer review were conducted on the well design to determine contingencies required for higher than expect pore pressure and to look at how lower sand fracture pressures, if encountered, would potentially compromise reaching the planned Total Depth (TD) of the well. Contingencies for extra casing strings were included in the well design to cover a high side pore pressure/low fracture pressure well. The actual pore and fracture pressure profile of the well showed that indeed the pore pressure was higher than the seismic derived pore pressure prediction and sand fracture pressures were on the low side, which resulted in the well using all 9 casing strings and some innovative drilling techniques to reach the planned well TD.

During drilling operations, permeable intervals encountered significantly reduced the pore/fracture pressure window which led to severe well bore ballooning (loss of drilling mud with pumps on and gaining lost mud with pumps off) due to additional bottom hole pressure caused by the Equivalent Circulating Density (ECD). As in most deep water operations, the tight pore/fracture pressure window must be managed to ensure each casing string is set as deep as possible in order to reach the target TD with the available casing strings. For the Algodoal well, this was accomplished by use of several tools to ensure each casing setting depth was managed to reach optimum depth. The risks of losing the well versus not reaching objective were weighed continuously and managed to ensure no harm to personnel or the environment. Drilling in these conditions was enabled only through the use of some of the best available equipment, software, and experienced people.

Tools

Several tools proved to be advantageous in differentiating between a formation kick and ballooning.