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An Assessment of Formation Damage: A Case Study for the Cusiana Reservoir, Colombia

W.R. Blosser* and Santiago Mujica, BP Exploration Colombia Ltd.

*SPE Member

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ABSTRACT

The Cusiana reservoir in the Casanare region of Colombia is currently being appraised and developed. Cost effective development of the reservoir will be dependent on applying optimum drilling and completion practices. The purpose of this poster session is to provide a case study history for the approach and evolution of the project as it pertains to attaining an improved understanding of formation damage mechanisms.

INTRODUCTION

Background

Cusiana Field is located in the Llanos Foothills, 150 miles northeast of Bogotá, Colombia. Light (>34° API) oil, gas and condensate in Cusiana occur at drilling depths which average 16000 ft. in an asymmetric hanging wall anticlinal trap 14 miles long and 3 miles wide, formed during the Miocene-to-Recent deformation of the Eastern Cordillera. Top and lateral seals are provided by marine mudstones of the Oligocene Carbonera Group, and support a hydrocarbon column of over 1600 ft. The region is tectonically stressed in the formations which overlay the Cusiana reservoir. Because of this, drilling conditions are difficult with wellbore instability, mud losses, and stuck pipe common.

Geology and Mineralogy

Over 50% of the reserves occur in Late Eocene Mirador Fm sandstones, deposited in fluvial and shallow marine environments. Additional, deeper reservoirs include fluvial and shallow marine Paleocene Barco Fm sandstones, and the shallow marine Campanian Upper Guadalupe Sandstone Fm.

Porosity in Cusiana is relatively low, and averages 9% in the Mirador Fm. Good permeability is retained, however, because the reservoirs are pure quartz-cemented quartz arenites, in which permeability-reducing authigenic clays and carbonate cements are absent. Core and well test analysis indicate matrix permeability, not fracture permeability, provides the high deliverability (>12,000 BOPD) of Cusiana wells.

Reservoir Fluids

Cusiana hydrocarbon phases exist in a near-miscible, critical point state. Analysis indicates very high liquids recoveries will be achieved using reinjection of produced gas. The field will therefore be developed using reinjection of produced gas to maintain reservoir pressure and vaporize residual liquids. The field contains significant volumes of hydrocarbon liquids and large volumes of gas.

DISCUSSION

Key Components of the Well Process Analyzed

The study focuses on evaluating the key phases within the well process that are known to influence mechanical skin damage and corresponding well productivity. The phases analyzed include conceptual planning, reservoir mud systems, wellbore constraints, mud losses, hardware constraints, perforating parameters, kill pill designs, and completion brines.

Drill Stem Testing Operations

16 drill stem tests have been conducted for Cusiana over the previous 2 years that are considered valid for analyses and calculation of mechanical damage skin. The majority (7 out of 8 DSTs) of the data analyzed to date which indicate high levels of mechanical skin damage ($S_d > +10$) can be accounted for due to a known operational problem and/or constraint encountered during the operations.

Drill Stem Testing Analyses, Results, and Applications

The remaining data set (9 out of 16 DSTs) have been analyzed on a hygraded basis. Trends of mechanical skin damage have been correlated to operational parameters that influence flow efficiency and overall well productivity. These trends have then been used to identify suspected phases and operations throughout the well process that induce formation damage. The magnitudes of skin damage have been used to risk predicted well productivities in defining projections for well count and material procurement requirements.

Correlation of the DST Results with Other Data

To date, evaluation of well productivity potential has been based on 5 sources of information. These 5 items are core analyses, open hole log data, drill-stem test results (as mentioned above), long term test production performance, and technical service laboratory programs.

CONCLUSIONS

This study has gathered operational data throughout the drilling, data acquisition, and completion phases of the well, and correlated this data to mechanical skin damage. The data has reconfirmed known parameters that influence well productivity, yet emphasizes which parameters are particularly sensitive for specific conditions unique to Cusiana. Out of this analysis, a listing of lessons learned and recommendations have been issued and implemented. The three key messages from this study specific to the Cusiana reservoir are:

- Minimize losses of fluids and solids to net pay reservoir intervals during drilling, data acquisition, completion, and workover phases. This includes reducing the filtrate loss of the mud filter cake, minimizing mud weight overbalance, the use of kill pills, and proper filtration.
- Due to the unique hardness of Cusiana rock, perforate with large diameter, big charge, high shot density, tubing or drill pipe conveyed gun systems shot at high underbalances.
- Increased awareness, attention to detail, and quality control are required when conducting open hole or cased hole operations across net pay reservoir intervals.

Out of this work, modifications to well operations have been implemented, and a tracking system with measurable targets and objectives has been established.

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