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The Use of LWD Data for the Prediction and Determination of Formation Pore Pressure

Jeremy Greenwood, Rick Russell, and Mike Dautel, Halliburton

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Abstract

The ability to predict and determine formation pressure has been an important issue since the beginning of the industry. This issue has become of increasing importance in deepwater environments where the relationships between increasing pore pressures, formation fracture gradients, and ultimately wellbore stability becomes of critical importance and can determine whether or not a well can be successfully drilled to total depth (TD).

Pre-drill modeling using seismic, structural, and geological data can be used to attempt to predict pore pressure regimes. Traditional methods of monitoring pore pressure while drilling have relied on methods, such the use of drilling exponents, and other indirect methods, including the monitoring of connection gases and observations of cuttings shapes. These methods are often imprecise, and their success depends on the actual pore pressure generation mechanism.

The development of new logging-while-drilling (LWD) technologies in recent years has added powerful new tools for the accurate determination of pore pressures and wellbore stability. LWD resistivity and sonic measurements can indicate overpressure in shale sequences. Measurements in hole sizes as large as 30 in. make it possible to establish compaction trends in deepwater wells from near the seabed. Direct measurements of formation pressure can now be made with LWD formation pressure tester tools, which can accurately measure formation pressures directly while drilling and, when used with pressure-while-drilling (PWD) measurements, can precisely manage effective mud weights in narrow mud weight window environments.

Advanced LWD imaging technology can now be used to evaluate wellbore stress fields, which can enhance the understanding of hole stability and overpressure generation mechanisms. This paper reviews the use of LWD sensors for pore pressure analysis and uses case histories to demonstrate their application and value.

Introduction

Effective pore pressure prediction hinges on establishing the generation mechanisms that are active in the prospect. The generation mechanism dictates the selection of the appropriate prediction method and the information sources required for each technique. A number of generation mechanisms have been identified in the literature, which are broadly summarized in **Table 1**.

The methods available for estimating pore pressures can also be subdivided into estimation techniques in argillaceous formations and estimation techniques in permeable formations.

Argillaceous formations require the use of measurements that respond to changes in the porosity or the effective stress state of the rock, combined with an understanding of the expected compaction rate of the formations and a knowledge of any secondary compaction changes through unloading mechanisms. Compaction and porosity reduction varies from basin to basin and is controlled by properties, including the type of clay mineral, particle sizes and distribution, adsorbed cations, temperature, and pH. These properties influence the water content of argillaceous sediments under applied loads and contribute to the different porosity vs. depth relationships.

Permeable formations require the direct measurement of formation pressures and knowledge of the pore fluid type, water, or hydrocarbons. In addition to the pore fluid type, a knowledge of the geological structures, formation relief, and faulting, as well as the identification of sealing formations, are required to develop predictions and refine modeled estimates.