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Low-Frequency Drill Bit Seismic While Drilling

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Abstract

A breakthrough has been discovered for controlling seismic sources to generate selectable low frequencies applicable to many seismic applications. All possible borehole pulsed sources, including hydraulically driven devices, explosives, and etc., by their very nature produce high frequencies. This is counter to the need for long transmission through rock. Specifically, we are reporting the application of an otherwise high frequency sparker source on the drill string for Drill Bit Seismic While Drilling (SWD). The low frequency source provides real-time imaging in deep (15,000 feet+) high-temperature (150°C) high-pressure (HTHP) wells ahead of the bit for accurate pore pressure determinations and geosteering, reservoir model verification, and near wellbore diagnostics. Furthermore, to have additional energy available at the drill bit can result in increased rates of penetration.

Introduction

It has been said, “The time is coming when we will not drill without looking ahead of the bit anymore than we would drive at night without headlights – occasionally shining a lamp to see what we hit.” An alternative seismic source for the roller bit as it was being replaced by the PDC bit is something oil and service companies have sought since the early 1990’s.

A breakthrough has been discovered for controlling seismic sources to generate selectable low frequencies (< 40 Hz) applicable to many seismic applications. All possible borehole pulsed sources, including hydraulically driven devices, sparkers, explosives, etc., by their very nature produce high frequencies. This is counter to the need for long distance transmission through rock. Specifically, we have demonstrated the application of an otherwise high frequency sparker source which can be encorporated into a drill bit for Drill Bit Seismic While Drilling (SWD). The low frequency source, capable of creating selectable mid-band frequencies of 1 to 20 Hz, provides a source to perform real-time imaging in deep (15,000 feet+), high-temperature (150 degrees C), high-pressure (HTHP) wells for (a) geosteering, (b) accurate seismic hole depth, (c) accurate pore pressure determinations ahead of the bit, (d) near wellbore diagnostics with a downhole receiver and wired drill pipe, and (e) reservoir model verification. Furthermore, to have additional energy available at the drill bit for rock desintergation can result in increased rates of penetration.

Drill Bit SWD provides real-time measurements which equate to data normally obtained by conventional vertical seismic profiling (VSP) or reverse VSP methods. That is, seismic data is obtained with the receiver in the drill string and the source at the surface: VSP; or, alternatively, a downhole seismic source with receivers deployed at the surface: reverse VSP. Drill-bit seismic methods utilize downhole acoustic energy without interruption of the drilling process. Conventional VSP surveying techniques use wireline systems with recording tools in the borehole. Interruption of the drilling process increases operating costs and risks. Drill Bit SWD helps overcome the higher costs and risks, and provides the geophysicists and drillers with valuable information to optimize drilling efficiency and to steer to the target with the ability to predict pore pressure ahead of the bit and verify reservoir models in real-time. In this way, the renewed application of Drill Bit SWD by the petroleum industry can offer an