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Comparison of Heave Motion Compensation Systems on Scientific Ocean Drilling Ship and Their Effects on Wireline Logging Data

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Abstract

Recovery of cores and logging data from a dynamically positioned drill ship introduces significant heave related depth uncertainties. Heave compensation plays a pivotal role in assuring downhole data integrity by countering the effects of the ship's heave while tools are downhole. A linear displacement wireline heave compensation system has been in routine use on the *D/V JOIDES Resolution* since 1988. A rotary heave compensation system has been designed for the IODP recently to replace the linear unit. The new rotary unit consists of an electro-hydraulic winch, supporting position sensors, electronics and software to add and remove cable slack in response to ship heave.

Analysis of acceleration logs recorded from downhole tools in both time and frequency domain compares the effectiveness of the linear and rotary heave motion compensators. Fourier amplitude spectra of uphole and downhole acceleration indicate that compensation reduces the heave influence on downhole acceleration by an order of magnitude for both compensation systems. These results are consistent for a variety of downhole tools, and suggest an average of 52-74% variance reduction in downhole acceleration for the linear system. Analysis of acceleration data with the rotary heave compensator system shows 75-80% variance reduction between the uphole and downhole spectra. Although these results are preliminary, our analysis shows comparable effectiveness of the rotary and linear compensation systems.

Introduction

Characterization of the dynamics of ship heave and its effect on logging and coring has long been a primary concern for the Deep Sea Drilling Projects (DSDP), the Ocean Drilling Program (ODP), and the Integrated Ocean Drilling Program (IODP) (e.g., Kidd, 1979; Francis, 1981; Goldberg, 1990). The difficulty in recovering deep-sea cores and logging data as far as 8 km below the sea surface from a floating ship presents significant uncertainties. The problem is particularly acute in recovering cm-scale features, such as thin sediment bedding using downhole logs. During ODP, a wireline heave motion compensator (HMC) was designed and installed on the *D/V JOIDES Resolution* to reduce the effect of wave motion and ship heave on the position of downhole instruments on the wireline and core barrels. When the HMC is not operating, the acceleration of the downhole tool is primarily a function of the heave (vertical motion) of the ship, which mimics the uphole acceleration. When the HMC is operating, the downhole acceleration due to heave is minimized (Figure 1). At optimum efficiency, the compensator can reduce the variance of downhole acceleration by over 50% with an estimated downhole displacement of about 1.5 m (Goldberg, 1990).

Controlled by on-board sensors which monitor the movement of the ship by recording ship motion, the HMC system integrates the acceleration twice to yield position (or heave) of the ship. Anticipating the needed compensation, a hydraulic cylinder connected to the wireline sheave is extended or retracted to adjust its position for ship heave. The cylinder moves in opposition of ship's heave. The Borehole Research Group (BRG) at Lamont-Doherty Earth Observatory (LDEO) of Columbia University designed the motion controller for the linear displacement wireline heave compensation system that has been in current operation. Recently, a new rotary heave compensation system has been designed for the IODP by Schlumberger to replace the linear unit. The unit consists of an electro-hydraulic winch, supporting piston sensors, electronics and software to add and remove cable slack, and maintain cable tension. To compare the performance of the two systems, we analyze acceleration data recorded at ship's approximate center of gravity (uphole) and downhole on a wireline tool while operating the linear and then the rotary HMC systems. A time domain comparison of the uphole acceleration data recorded by both systems shows comparable amplitude variations and winch response to ship's motion (Figure 2). We also analyze the frequency domain analysis of acceleration recorded by both systems and compare these to downhole acceleration measurements, both with the HMC on and off.

Data

To evaluate the efficiency of the HMC performance, the wireline acceleration data recorded by the Multi-sensor Gamma Tool (MGT) and Schlumberger's General Purpose Inclinometer Tool (GPIT) are used. In this study, we analyzed MGT acceleration data from Ocean Drilling Program Leg 202