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Fullbore Formation Micro Imager Logs for Evaluating Stratigraphic Features and Key Surfaces in Thin-bedded Turbidite Successions

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Two coreholes, 50 and 100m deep, were drilled 150m apart, continuously cored, and logged 200 m behind a coastal outcrop of Late Miocene thin-bedded, slope fan (channel-levee) strata in New Zealand. Characteristics of thinly-interbedded sands (Bouma Tb/Tc) and silts which comprise the cores and outcrop were used to calibrate to the Fullbore Formation Micro Imager (a mark of Schlumberger, and hereafter referred to as FMI*) and Platform Express* (a mark of Schlumberger) logs of both coreholes. Cumulative dip (Hurley, 1994) and modified Fischer plot (Hurley, 1996) interpretation techniques were applied to improve correlations.

Mineral composition, permeability, acoustic velocity, and density were determined for selected samples of the core to determine effects on the logs. The mineral composition for both the sandstones and siltstones was determined to be almost the same with quartz (23 percent), illite and chlorite (36 percent), and albite (22 percent) the major individual constituents. A permeability profile, measured at ten centimeter intervals along the length of both cores, shows permeability varies by facies: Bouma T_a = 383.5 md, Bouma T_b= 280.7 md, Bouma T_c= 171.1 md, and Bouma T_e= 20.1 md. Permeability values over 1000 md for the sandstones (Bouma T_a, T_b, T_c) and siltstones (Bouma Te) were measured. The high clay content of the strata and the thin nature of the bedding (average thickness ten centimeters) combine to cause the well logs to exhibit a low resistivity, low contrast appearance. However, the sedimentary facies and features exhibit subtle, but distinct, FMI* characteristics.

Calibration of the core to the FMI* shows there are six identifiable characteristics on the FMI* image logs: lithology, sedimentary facies (Bouma T_a, T_b, T_c, and T_e), bioturbation, scours, dip magnitude, and bed thickness. FMI log images of uniformly higher resistivity correlate with laminated and massive sandstones. These intervals correspond with Bouma T_a or T_b, respectively. FMI log images of cross bedding and climbing ripples show a variable resistivity response. Because of the very fine laminations grading upwards into ripples in some intervals, the beds show a stronger resistance which decreases upward into a slightly wispy appearance. These images correspond to rippled intervals (Bouma T_c) within the core. Siltstone (Bouma T_e) is characterized by very low resistivity. *Helminthopsis*, and *Scolicia* bioturbation are identifiable on the FMI* log images. The *Helminthopsis* bioturbation has an FMI* response which gives a mottled appearance. The *Scolicia* bioturbation has an FMI* response which shows disrupted beds. In addition to the *Helminthopsis* and *Scolicia* bioturbation, the presence of the resistivity banding suggests that intense bioturbation destroyed original bedding in some intervals leaving a faint relict bed. Scour surfaces are identified by the presence of rip-up clasts, an undulous base of a bed, abrupt changes in bed thickness, and abrupt or subtle changes in dip of beds.

FMI* and core characteristics and correlations suggest that one well penetrated a silt-filled channel and the other well penetrated levee strata (Figs. 1 and 2). Outcrop work has identified channels which eroded into thin-bedded levee strata. These large features often contain a basal lag deposit comprised of rip-up clasts supported by a sandy shell fragment matrix. At the base of the cored and logged silt-filled channel, a similar channel lag is observed. Also evident on the FMI* logs and cores is an unconformity (Fig. 1). The unconformity is characterized by a sharp change to a higher dip magnitude and changes from heavily bioturbated strata below the unconformity to slightly bioturbated strata above (Fig. 1).

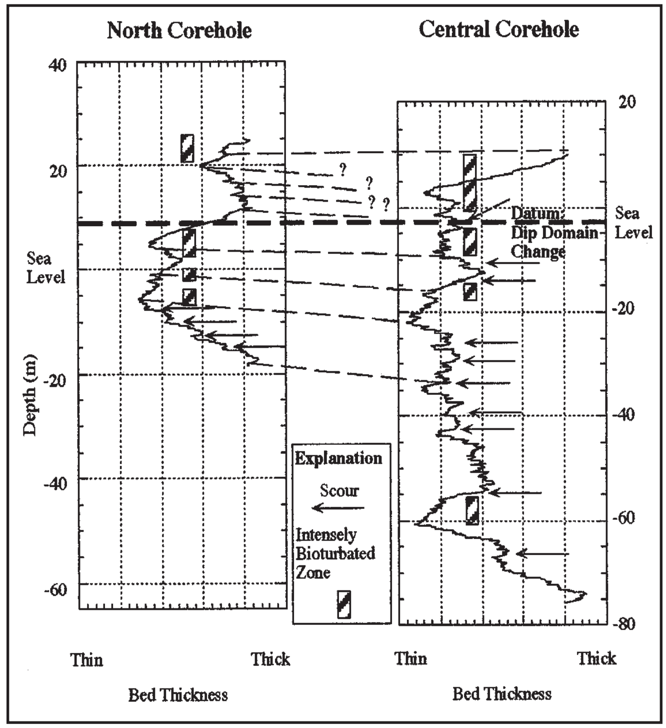

Figure 1. Modified Fischer plot correlation using the dip domain change as a datum. Below the datum there is a good correlation of bed thickness changes and bioturbation zones. Above the datum, correlation is difficult.

Depositional dip orientations from the FMI* logs were used to project the log data to the outcrop to provide 3-D correlation of strata and the unconformity. Projection of the unconformity from the wells to the outcrop showed that the well unconformity correlates to a lithology change in the outcrop. This projection also provided a means of tying the wells and outcrop to a high resolution (≈150 Hz) seismic reflection line that was shot at the base of the outcrop. Overlying the modified Fischer plot on the seismic reflection line showed that major changes in bed thickness correspond to interpreted surfaces on the seismic line.

Correlation and calibration of well logs and cores to outcrops have provided a means of better visualizing and understanding features of thin-bedded, slope fan (channel-levee) reservoirs that are commonly observed in Gulf of Mexico FMS*/FMI* logs and cores. These features include: low resistivity-low contrast log response of thin-bedded strata; channel-fill and levee successions; Bouma facies; scour surfaces; and unconformities. Comparison of the logs and core with outcrop provides insight into lateral aspects of slope fan (channel-levee) strata when such features are identified in subsurface data.

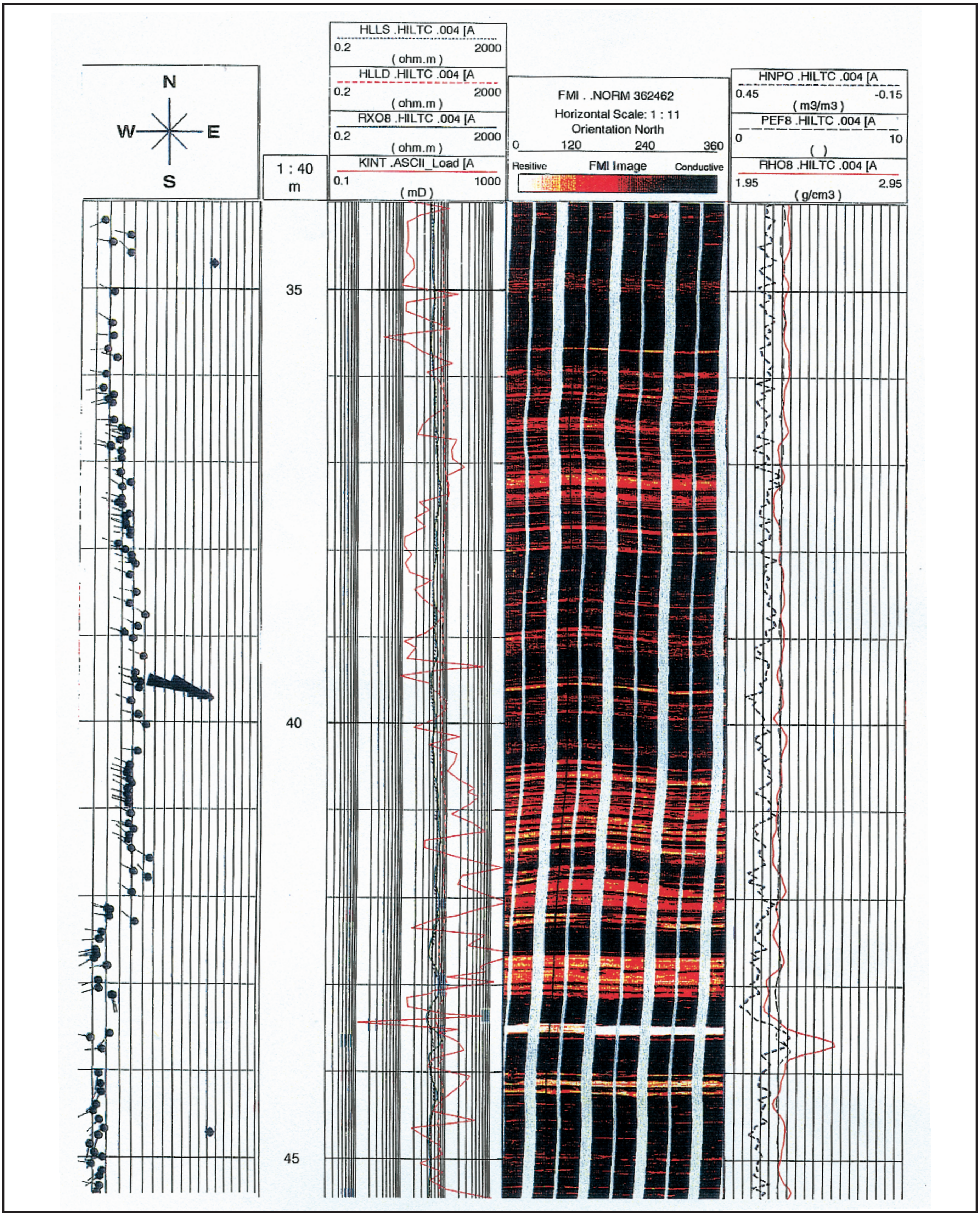

Figure 2. FMI log from the Cental well. The solid red curve in track two is the permeability profile. Channel lag occurs from 42.2–41.2 m. The unconformity is at the base of the channel lag. A dip magnitude increase occurs at the top of the channel lag (41.2 m). The bright resistive streak at 42.5 m is a concretion.

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