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## Advances in Image Log Visualization and Interpretation

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### ABSTRACT

Image logs provide a remarkable opportunity to visualize subsurface geological and petrophysical relations around the borehole. As opposed to standard omnidirectional (average) logs, image logs offer azimuthal variations of key log parameters around the wellbore. Earliest techniques at recording azimuthal variations developed in the 1930s. Azimuthal coverage progressively increased as more pads were added, and as array sensors were developed. Wireline acoustic caliper and imagers offered a rotating sensor that provided full azimuthal coverage. In the logging while drilling (LWD) environment, the sensors rotate with the drill string, yielding sectored azimuthal data. LWD azimuthal data (image logs) are now available for most primary log datasets, including high-resolution microresistivity, gamma ray, formation bulk density ( $\rho_{\text{ob}}$  and  $\Delta\text{tarho}$ ), photoelectric factor, sonic, caliper, and azimuthal propagation resistivity. Neutron porosity and nuclear magnetic resonance remain omnidirectional due to current physical limitations, although potential may exist for focused, pulsed neutron technology to yield azimuthal components of neutron porosity data. Resolution (both wellbore parallel and azimuthal) as well as depth of investigation (DOI) of course vary with the given dataset, but in particular variations in DOI from sub-inch to several feet can be quite useful for reservoir navigation. Technology for real-time uphole streaming of LWD data continues to advance, from early LWD devices connected by cable through the drill collar, to current industry-standard mud pulse transmission, to emerging wire-by-pipe applications.

The implications of real-time multi-dataset azimuthal image logs toward geosteering applications are obvious, especially with integration of other geoscience datasets. Real-time dip analysis is of critical importance, as in many lateral wells even fractions of a degree off can result in drilling out of the reservoir. Present techniques include qualitative and quantitative monitoring of basic cosinusoidal patterns on the image log. Some simple manipulations of the basic image log format greatly enhance interpretation, including contrast/color enhancement, slicing/dicing, scale compression/stretching, cross-sectional presentation, 3D visualizations, and image log movies. With an existing infrastructure in many geoscience offices, it is quite easy to envision real-time data streaming into a 3D immersive environment with the reservoir navigation team literally standing inside a wellbore surrounded by image log data, monitoring and reacting to changes. A click of a button and a different image log is shown. Click, click, click and the interpreter is remapping key horizons. Another click and the view zooms out to show the wellbore relative to the original planned trajectory or to seismic data or other datasets, and so forth.

The logs themselves can become interactive as well—just as measured depth (MD) logs are routinely converted to true vertical depth (TVD) logs, with real-time dip analysis we can generate real-time thickness logs, both vertical thickness (VT) and true strati-

graphic thickness (TST), including generation of negative thickness logs (negative sign indicating drilling upsection). Thickness logs and curves can be iteratively and integratively developed as continued knowledge about the stratigraphy and its structure is obtained during the drilling process. All in all, we will continue to increase our understanding of where we are at relative to XYZ space, relative to the target strata and structure, relative to fluid contacts, and so on. Overall, integrated analysis with enhanced visualization techniques will result in better prediction and thus in the geosteering (reservoir navigation) environment more time for reaction.