Paper 4

Borehole image log interpretation: making the most of your data and realising the limits, an illustration using fluvial, shallow marine, and deep marine environments

ADRIAAN BAL, JEREMY PROSSER AND KENRICK VAN NOORD

Baker Atlas GEO*Science*
2nd level Adelaide House, 200 Adelaide Tce, East Perth, Perth, WA
6004, Australia
Phone: (618) 9225 0600 Fax: (618) 92257810
adriaan.bal@bakeratlas.com

The application and development of ichnofabric, architectural elements, and depositional process concepts to petroleum industry core studies is relatively advanced, and has demonstrated its usefulness in correlation, sequence stratigraphy and elucidation of depositional environments. Furthermore, acquisition and development of dipmeter and image log technology is equally advanced. However their usefulness for high level sedimentology remains under utilized. We too often limit our interpretations to locating and quantifying the dip and azimuth of faults and fractures, tectonic tilt, and palaeocurrent directions. Using examples, this paper demonstrates how we can realise the limits.

Fluvial deposits often result in high quality image/dipmeter datasets because of the absence of bioturbation. Therefore surfaces can often be differentiated into bed boundaries, set boundaries, coset boundaries, or cross bedding crucial surfaces that tell us something about bedform and channel geometry. The definition of the geometry of architectural elements in 3-D is crucial to interpretation of fluvial regimes. Depositional elements identified from dip-azimuth vector plots are firstly assumed to be in-channel sandy bars (macroforms), and "upgraded" to higher-orders (e.g. 5th-order main channel or 6th-order channel belt) if they can be convincingly correlated between wells. A geological model of a fluvial reservoir (Yodel-Echo NW Shelf Australia) is developed and subdivided on the basis of image log sedimentology for reservoir modelling (Fig. 1) and placement of development wells.

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A shallow marine setting in the China Sea, illustrates the use of image fabric index (IFI), akin to the bioindex, for understanding environmental controls at reservoir and exploration scale. The inverse of the IFI mirrors wave energy. When the wave energy index is displayed opposite sandstone intervals over hundreds of metres, specific packages reflecting high- and low-stand deposition are identified. These indices, when combined with other dipmeter/image log techniques, provide a robust database when integrated with log and core information (Fig. 2).

Deep-marine mass-flow successions pose challenging problems for image-log interpretation due to the wide range of potential causes for sedimentary dips > 10°. Soft-sediment deformation structures, such as slump folds, offer a more reliable alternative to palaeocurrent study through the stereographic analysis of their fold axes (axial trends). In general, the axial trend of the majority of slump-folds are oriented parallel to the slope on which they were emplaced (cf. Woodcock). As such, palaeoslope orientation is merely a bipolar choice perpendicular to the fold axis. Imbrication planes near the base of the slump, filtered palaeocurrents, or other data may help to limit this result to one direction only. In the example shown (Fig. 3), an axial-trend walkout plot has been used to highlight major and minor palaeoslope orientations within a succession from SE Asia. Other than a distinct change in slope orientation, differences in palaeoslope strike may have other causes, such as in-channel slumping, slumping off the levee or simply rotation of the slump axis downslope. It is only by combining sedimentological study of the image with slump-fold analysis that the cause of fold-axis orientations can be better understood (Fig. 3).