Integration Triaxial Induction Logs and High-Resolution Borehole Images: Application for Modeling Mass Transported Deposits

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9.29.2020 - 10.1.2020 – AAPG Annual Convention and Exhibition 2020, Online/Virtual

Abstract

A great quantity of sediments in the Gulf of Mexico (GOM) are found to be mass transported deposits (MTDs). Recent studies indicate MTDs have great impact on deepwater reservoir architectures. The spectrum of impacts MTDs have on an area can include everything from erosion of reservoirs in their path of movement to creating new accommodation space behind the MTD where new sandstone reservoirs can be deposited. Sometimes the MTDs, themselves, can be sand rich and contain hydrocarbon. Common methods to study the MTDs include seismic imaging, borehole imaging, and core observation. Wireline logs except borehole images are rarely used to study MTDs. In this paper, a new method using a standard wireline log, the triaxial induction, is proposed for quantitively describing MTDs. Triaxial induction tools have been widely applied in petroleum exploration and development. They have revolutionized thin-bed formation evaluation petrophysics, while also providing, in anisotropic formations, a robust dip measurement for geologists. Now, based on integrated studies of triaxial induction data and high-resolution borehole images, triaxial induction data can be applied to provide critical information about MTDs, and hence, reservoir distribution. MTDs usually have great variation in dip magnitude and azimuth. Large variance in dip magnitude and azimuth from a shale section can, in specific situations, be used as an indicator of MTDs. Whereas, direct use of dip information alone may not be the best approach for studying MTDs, triaxial induction tools also provide ratios of resistivity perpendicular (Rv) and parallel (Rh) to bedding, i.e., Rv/Rh. Rv/Rh ratios are directly related to resistivity anisotropy of the formation

and, therefore, can be relied upon in the study of MTDs. Depending on the position in deposition, MTDs can be divided into several subtypes and each will have different petrophysical properties. A very common type of MTD is the slumped shale. As can be anticipated, this MTD type will have lower resistivity anisotropy and, therefore, lower Rv/Rh ratios. Our study shows that slumped shale usually has $Rv/Rh < 2.0$, which can be used to differentiate this MTD type from hemipelagic shale. Resistivity anisotropy, however, can also be affected by many high contrast factors, such as strain and fractures. The best practice to study the MTDs in the subsurface environment, therefore, is to use the visual interpretation from the high-resolution borehole images to guide the interpretation from the triaxial induction data, and to use the triaxial induction data to provide a quantitative method to model MTD facies in the final reservoir model.