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Integration of 3-D Seismic and Satellite Data for Subsurface Fluid Flow Analysis in the Lower Congo Basin, Offshore Angola

Hugo S. Putuhena[1] and Mads Huuse[1]

[1]School of Earth and Environmental Sciences, The University of Manchester, Manchester, Greater Manchester, United Kingdom.

ABSTRACT

Improvements in 3D seismic imaging has enabled the analysis of subsurface fluid flow phenomena beyond conventional tectono-stratigraphic analysis by the identification of fluid conduits that bypass the stratigraphy including otherwise sealing intervals. These are collectively known as ‘seal bypass systems’ (Cartwright et al., 2007). Although often spectacularly imaged using modern 3D seismic data, the genesis and long-term function of these bypass systems is often poorly understood due to a paucity of calibration. The detection of seepage slicks based on satellite images allows the calibration of the seismic interpretation of oil seeps and thus serves as a useful calibration provided the sea surface slicks can be linked to the subsurface fluid flow phenomena. This study analysed the upper Cenozoic succession in a high-quality 3D seismic dataset from the petroliferous Lower Congo Basin, Offshore Angola on the West Africa passive margin and integrated observations of subsurface fluid flow with seepage slick analysis of satellite images to constrain the subsurface plumbing systems in the study area. Several focused fluid pathways were interpreted within the area including pipes, clustered pockmarks, open faults, and shallow salt structures. The salt-tectonically deformed stratigraphy provides a first order control on fluid expulsion at the surface by re-routing any upward moving fluids to salt diapir flanks above which narrow sub-vertical wipe out zones emanating at seabed pockmarks suggest the presence of highly efficient fluid flow pipes. The integration with seepage slick information allows a distinction between pockmarks and fluid flow structures related to oil seepage and those related to likely biogenic gas, possibly derived from degraded thermogenic hydrocarbons stored in shallow reservoirs within some salt mini basins. This integrated study highlights the presence of a prolific petroleum province with significant natural leakage to the surface. The study further demonstrates that only a subset (30%) of the numerous pockmarks observed are linked with demonstrable petroleum leakage, suggesting the majority of mini-basin pockmarks may due to biogenic gas or pore water expulsion. By integrating 3D seismic and seepage slick information it becomes possible to target specific seeps for geochemical sampling and to undertake reverse migration analysis to potentially discover new oil reserves.