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Identification of Bottom Simulating Reflectors (BSRs) to help uncover potential gas hydrates within the Orange Basin, South Africa

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Bottom Simulating Reflectors “BSRs” were identified and mapped to determine the likelihood that gas hydrates exist in an area covering approximately 40000km^2, within the Late Jurassic to present day Orange Basin passive margin off the west coast of South Africa [1]. They were interpreted on 2D multichannel seismic attribute data, time, relative acoustic impedance and well data. BSRs are the result of an acoustic impedance contrast between sediments containing gas hydrates and those with free gas, and exhibits reverse polarity compared to the seafloor [2]. They were observed and mapped between 0.3s (~300m) and 1.1s (~900m) on 2D seismic within the Late Cretaceous. BSRs were recognised on the continental shelf up to 200km seaward from the South African shoreline in water depths ranging between 150 and 450m. Furthermore, BSRs were found to be generally continuous along seismic sections and to exhibit a decrease in acoustic impedance. The identification of these reflectors is only a small step in gas hydrate evaluation for Orange Basin, but it is important to note that gas hydrates can still occur even without the presence of BSRs [3]. Regardless, BSRs within the northern and central Orange Basin are often accompanied by deep-seated vertical and polygonal faults, fluid escape and sediment collapse features within the sub-surface, as well as carbonate mounds, pockmarks and possible mud volcanoes at the seafloor. Hartwig et al. identified NNE-SSW aligned fault striking Eocene pockmarks along the north-western slope of the Orange Basin [4]. For the largest part it would appear that these vertical faults or hydrothermal fluid escape zones act as direct conduits of gas from deeper within the sedimentary section that result in the development of gas hydrates/BSRs, and these accompanying features. This would suggest an authigenic origin instead of ocean precipitation for some of the carbonate mounds within the area of interest.

The primary purpose in identifying BSRs was to tentatively define the base of the gas hydrate stability zone “GHSZ”. The thickness of the GHSZ varies between 0.2s and 0.6s (two-way-time), and the calculated thickness differs between approximately 150m to 600m within the study area. Average seismic velocities range roughly between 1500ms^{-1} and 1800ms^{-1}. The zone is thickest in the north and southcentral parts of the Orange Basin, and thins towards the present-day shoreline. The estimated geothermal gradient for wells in the study area is 3.18^{0}C/100m [i.e. 31.8^{0}C /km], which is higher than the average worldwide geothermal gradient of 25-30^{0}C/km for continental crust. The difference is likely due to an inaccurate assessment of the geothermal gradients as suggested by the sometimes large variance in the calculated values from well data. Nonetheless it may also be attributed to volcanic intrusions in the basin, deep fault zones, sediment burial and overburden.

The recovery of this unconventional gas resource through different methods such as drilling, dredging and coring remains the optimal way in demonstrating the existence of this would-be energy resource within the Orange Basin. However, even if large resources are found, the optimum production of gas hydrates poses a challenge even though major strides over the last few years have been made by industry leaders such as the USGS, DOE/NETL, and JOGMEC towards this realization. If the presence of gas hydrates materializes within the Orange Basin, future work will need to focus on classifying and determining the origin of these, as well as identifying gas sources and gas-hydrate-bearing units that are of sufficient reservoir quality to be viable future resource development targets for South Africa.

References:

[1] Paton et al. (2008) AAPG Bulletin 92(5): 589-609

[2, 3] Tomasini et al. (2011) Journal of Geological Research doi:10.1155/2011/326250

[4] Hartwig et al. (2012) Marine Geology 332-334: 222-234