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Using Inverted 4-D Seismic and Well Data to Characterise Reservoirs from Central Swamp Oil Field, Niger Delta

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Abstract : Monitoring of reservoir properties prior to well placements and production is a requirement for optimisation and efficient oil and gas production. This is usually done using well log analyses and 3-D seismic, which are often prone to errors. However, 4-D (Time-lapse) seismic, incorporating numerous 3-D seismic surveys of the same field with the same acquisition parameters, which portrays the transient changes in the reservoir due to production effects over time, could be utilised because it generates better resolution. There is, however dearth of information on the applicability of this approach in the Niger Delta. This study was therefore designed to apply 4-D seismic, well-log and geologic data in monitoring of reservoirs in the EK field of the Niger Delta. It aimed at locating bypassed accumulations and ensuring effective reservoir management. The Field (EK) covers an area of about 1200km2 belonging to the early (18ma) Miocene. Data covering two 4-D vintages acquired over a fifteen-year interval were obtained from oil companies operating in the field. The data were analysed to determine the seismic structures, horizons, Well-to-Seismic Tie (WST), and wavelets. Well, logs and production history data from fifteen selected wells were also collected from the Oil companies. Formation evaluation, petrophysical analysis and inversion alongside geological data were undertaken using Petrel, Shell-nDi, Techlog and Jason Software. Well-to-seismic tie, formation evaluation and saturation monitoring using petrophysical and geological data and software were used to find bypassed hydrocarbon prospects. The seismic vintages were interpreted, and the amounts of change in the reservoir were defined by the differences in Acoustic Impedance (AI) inversions of the base and the monitor seismic. AI rock properties were estimated from all the seismic amplitudes using controlled sparse-spike inversion. The estimated rock properties were used to produce AI maps. The structural analysis showed the dominance of NW-SE trending rollover collapsed-crest anticlines in EK with hydrocarbons trapped northwards. There were good ties in wells EK 27, 39. Analysed wavelets revealed consistent amplitude and phase for the WST; hence, a good match between the inverted impedance and the good data. Evidence of large pay thickness, ranging from 2875ms (11420 TVDSS-ft) to about 2965ms, were found around EK 39 well with good yield properties. The comparison between the base of the AI and the current monitor and the generated AI maps revealed zones of untapped hydrocarbons as well as assisted in determining fluids movement. The inverted sections through EK 27, 39 (within 3101 m - 3695 m), indicated depletion in the reservoirs. The extent of the present non-uniform gas-oil contact and oil-water contact movements were from 3554 to 3575 m. The 4-D seismic approach led to better reservoir characterization, well development and the location of deeper and bypassed hydrocarbon reservoirs.

Keywords : reservoir monitoring, 4-D seismic, well placements, petrophysical analysis, Niger delta basin
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