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Research Article

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Shoreline Changes Using Seabed Bathymetric, Sediments Scan and Profiles Observations in "Zarum" Gas Field Offshore Niger Delta

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Abstract

Seabed bathymetry, sediment scan and profiles are relevant geological and hydrographic observations widely used in marine geology to predict shore line changes as it concerns offshore fields development in the Niger Delta. Reliefs and heterogeneous sediment distribution, both across the seabed surface and in the shallow seabed profiles below, were examined. This study of the "Zarum gas Field" in the outer shelf environment offshore eastern Niger-Delta was from the results of measurements using high fidelity onboard instrumentation: Edgetech 4600 Multibeam and Sidescan, and Edgetech Sub Bottom Profiler. These instruments were side mounted on MV Cosco and towed along survey grids, within the designed corridor with the survey speed of 3knots.Seabed features were interpreted based on the acoustic sound reflectivity and refractions. The bathymetric values were reduced to the lowest astronomical tide, LAT of Opobo River entrance and range from 20.20m-25.89m with a deepening trend from the northwest to southeast caused by seabed current regimes and storm processes affecting the shoreline zones. The sediments of the scan vary from sand, through silt to clay which are of arenitic origin. Weak seismostratigraphic layer of 30m thick was observed below the seabed, which is presently undergoing secondary lithification. The study also shows existence of depressions and sediment fill in them called spud cans which vary between 10m-40m in diameter and debris, associated with previous rig movements; jack up barges and their drags. Observed are some subsea facilities pipelines and jackets. Based on findings, recommendations have been formulated for development of this gas Field.

Keywords: Bathymetry, sediments, Seismostratigraphic layers, Shoreline zones, Debris and Spud cans.

Introduction

The past three decades, have witnessed the use of high resolution acoustic systems, which include multi and single beam sounder, side-scan sonar, and sub bottom profilers (tuned transducers, electromechanical and sparker), have been extensively used in marine geophysical explorations. The acoustic data presented here were collected, processed and interpreted by EK-party chf,, OO-data processor, CH-geophysicist and SN-engineer GEOSED from the zarum gas field in the eastern Niger Delta. The survey was carried out 14th –28th of January, 2018. The shoreline changes and acoustic-characterizations are critical information tools use to unravel the geological and hydrographic state of the seabed for oil and gas fields development offshore. This study is an investigation of the outer shelf environment of Eastern Niger Delta offshore (Gulf of Guinea) using Edgetech 4600 Multibeam and Sidescan, and Edgetech Sub Bottom Profiler technique.The present study, focused especially on the marine sedimentological application of the geoacoustic systems to explain the sediment distribution and impact on the existing subsea facilities and bedforms of the field, as well as the Stratigraphy and impacts on subsea features burial (Fig. 6).

Study Area

The study area is 500m by 500m radius. It is situated100 kilometers off the coast line from the south eastern end of Calabar River in eastern Niger Delta (figure 1).

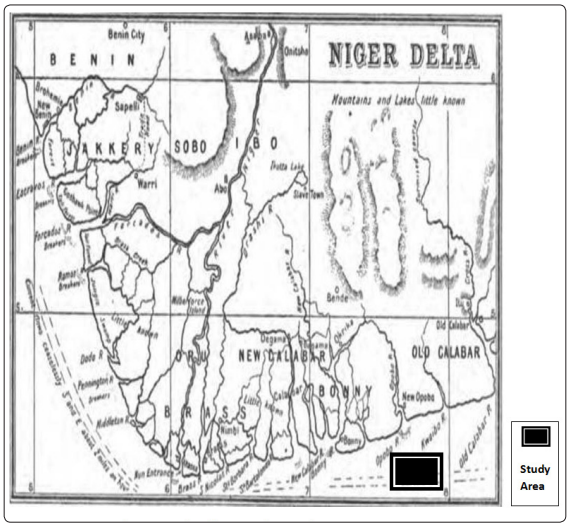

Figure1: Map of Niger Delta showing the study area

Materials and Method

The geoacoustic equipment and acquisition methodology used are well suited for shoreline bathymetry, sediments and profiling. Methodologies used to collect the required data and challenges associated with the location were addressed. Horizontal and vertical control was obtained with dual-channel DGPS (C-Nav) and data were referenced to the World Geodetic Survey 1984, Universal Transverse Mercator (UTM) Zone 32 west and local Mean Low Water (MLW), respectively. Vessel and transducer motion were corrected using motion reference unit (MRU) sensor. In contrast to fixed-angle algorithms utilized by beam-forming multibeams, interferometric swath systems determine angle and travel time for every sampling interval. The EdgeTech 4600 is a combined, fully integrated swath bathymetry and side scan sonar system that produced real-time high resolution 3D maps of the seafloor while providing co registered simultaneous side scan and bathymetric data. The entire study location was fully mapped in various cruises by 20-26 parallel-cross survey lines providing resolution of three-dimensional features ranging in size from centimeters to meters(see Appendices A,B&C). Waves combined with shallow shifting depths made the location accessible for the research vessel and, as a result, led to better observations of high data quality. The MV Cosco was specially designed to operate in the shoreline zones and which was critical for the high-resolution survey data obtained. Sub-bottom seismic profiling Chirp (EdgeTech SB 216s) sub-bottom profiles were collected simultaneously with the swath bathymetry utilizing the same RTK-DGPS positioning data string and survey track lines. The chirp tow fish was suspended from a 10m davit such that the transducer and receivers were fixed approximately 5m below the water surface. Davits were set so that the tow fish could be towed close to the vessel but outside of the propeller wash. The wide frequency range (0.5–12 kHz) made possible by the chirp acquisition pulses provides high resolution with consistent penetration depths of 50m below the seafloor and as much as 25m in substrates with more optimal acoustic characteristics. The scanning range of the system was adjusted to 50rn, 75m, 100rn and 120rn scales (per channel), depending on operational needs (see Appendices A, B&C).

Results

The three data sets presented in this section are compilation of nearly six (6) months of observations collected by GEOSED marine research group from "Zarum" field site. As such, the findings draw on both previous survey work and on more recent data obtained. All published data are explicitly referenced in both the text and figures. The average water depth in the surveyed area is 25m; the depth of penetration of the acoustics of the acquisition software based on the achievable time varying gain is about 30m below the sea bed (figure 2).The weak seismostratigraphic layer was observed below the seabed, which is presently undergoing secondary lithification (figure 3). The acoustic backscatter properties of this layer indicate that the layer is composed of water-sediments interphase of terrigeneous origin which is about 30m thick. The subsea facilities including other features observed in the profile are oil pipelines (figure 3).

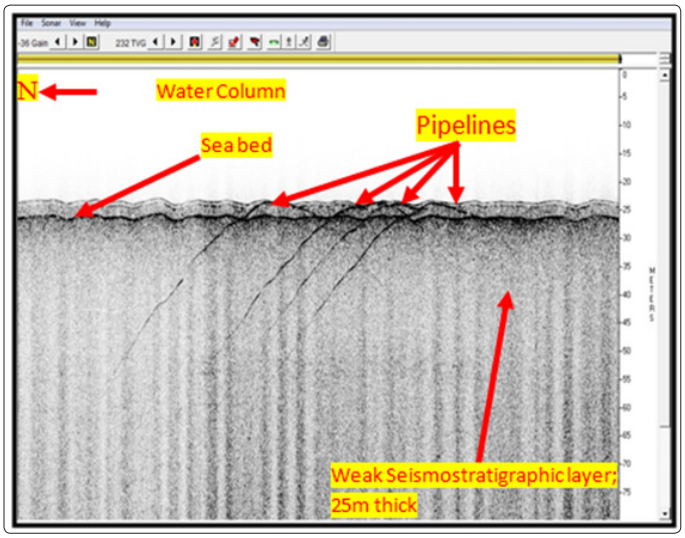

Figure 2: SBP Data Extract showing sea bed features and pipelines in the study area

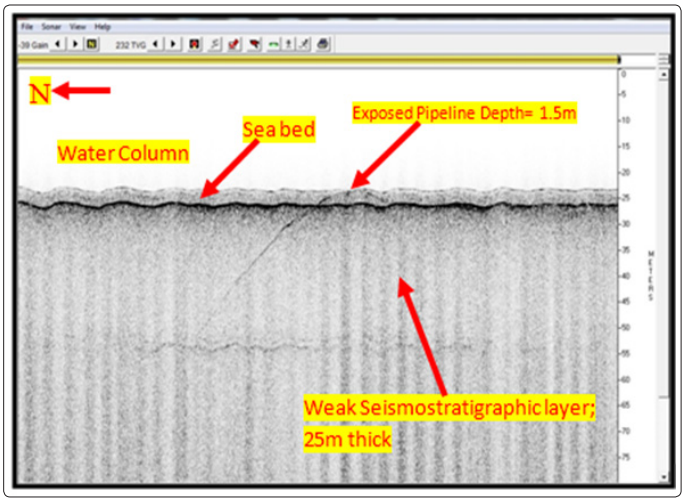

Figure 3: SBP Data Extract showing seabed features and pipeline

The sediment scan records of the surveyed seabed area are dominantly of low and high reflective sediments, interpreted to be composed of Silt, Clay and Sand (figure 4 and 5). The high reflective sediments, interpreted to be composed of silty sand were observed as widespread in its southeast. Ripples marks of high crests were also observed implying an area of high current energy regime (figure 6).

The distribution of the sea-floor sediments in the field was found to be closely related to local sediment supply, waves and current dynamics, as well as the topography of the sea floor. The spatial coverage (Mosaic) of the survey location and the entire seabed features observed is in figure 7.

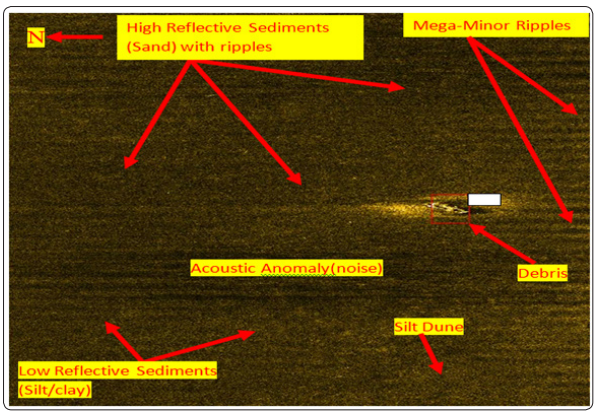

Figure 4: SSS Data extract showing High and Low reflective sediments and Debris accumulations

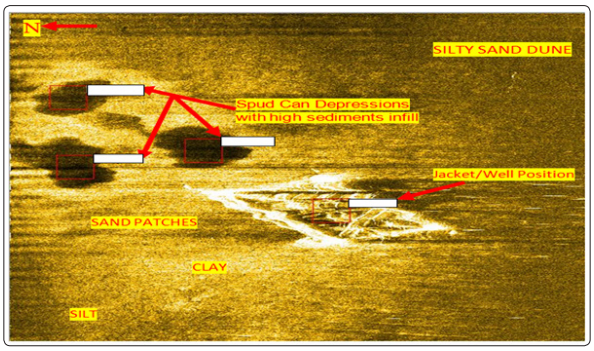

Figure 5: SSS Data extract showing different sediments accumulations and Spudcans Depressions

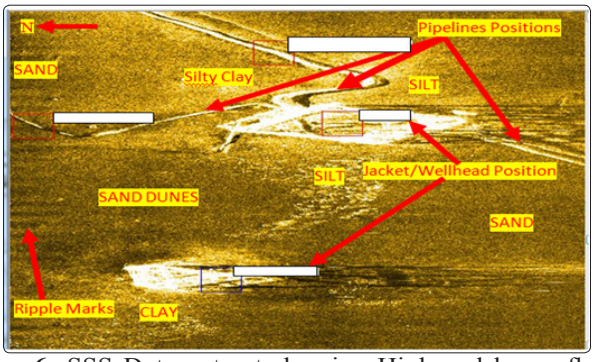

Figure 6: SSS Data extract showing High and low reflective sediments accumulations, Jacket and flare

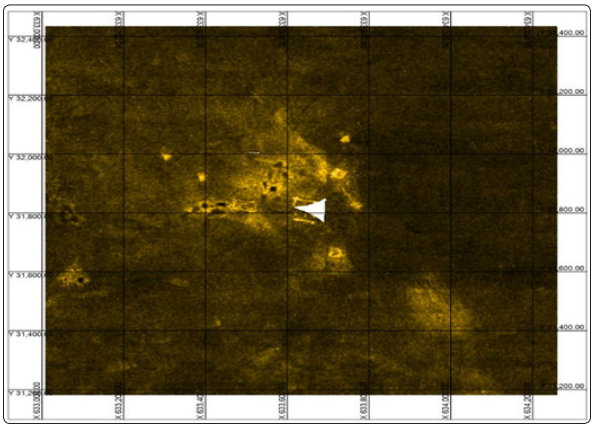

Figure 7: Seabed Mosaic of the "Zarum" Gas Field eastern Niger Delta

The multibeam and single beam bathymetric values were reduced to the lowest astronomical tide, LAT of Opobo river entrance and range from 20.20m-25.89m with a deepening trend from the northwest to southeast caused by seabed current regimes and storm processes.

Discussion

Geological and hydrographic state of the zarum gas field encompasses a substantial length of wave-domination, indicative of the morphology and sediment complexity, both horizontally across the seabed and vertically into the underlying weak seismostratigraphic layer, which are overwhelmed by the high current energy of the location. Repeated surveys indicate small-scale movement of the sand bars but the overall position and morphology of the shore-oblique features are usually maintained [1].The breaking wave crests closely follow the bathymetry [2]. This sustained or recurring shore-oblique morphology and sediment heterogeneity is remarkable given the high-energy events typical of the shoreline [3]. Acoustic backscatter images with chirp seismic profiles show tremendous heterogeneity in sediment characteristics across the seabed surface and in the shallow sub layers below in the study area. Miselis &McNinch found that thicknesses were higher for the convex shore face north of the Kitty Hawk shore-oblique bar field than south of it due to the regional variability of the continuous reflection surface and not simply positive seafloor morphology [4]. The presence of very coarse sand in this study location strongly correlates to the position of shoreline troughs, which also correlate to the presence of large underlying lithified sediments. The process of elevated turbulence over the sand may sustain the troughs, maximizing fill-in of the spud cans from sandbars. The bathymetry suggests the sediments outlay features persist during storms and maintained their overall morphology and position over inter annual time scales. The sediment logical properties of the underlying weak seismostratigraphic layer vary considerably in metres, horizontally and vertically. The presence of a lithologically distinct layer, underlying the seabed, or exposed in places, is important because of potential hydrodynamic-seabed interaction and its temporary constraint on the volume of sediment readily available for subsea facilities covering. Results presented in this paper and in recent literature indicate strong spatial associations between palaeochannels, heterogeneous sediment, shore oblique features, and elevated decadal shoreline change but relevant process-relationships remain purely speculative. These features may lead to alongshore gradients in wave dissipation and sediment transport, ultimately affecting the location changes. The association of near shore sediment volume, defined by geology-based sediment thickness, has also been established for in this research.

Conclusion

In this paper, we have shown the geological and hydrographic variability of Zarum gas field of shoreline of eastern Niger Delta and implications on subsea facilities. The sub-bottom acoustic backscatter properties indicate that the layer is composed of water-sediments interphase of terrigeneous origin which is about 30m thick. The subsea facilities including other features observed in the profile are gas pipelines. All observed seabed features, were fully digitized to their lateral extents and displayed. Bathymetric data showed an average water depth within the area was 25m. Sediment scan records of the surveyed seabed area are dominantly of low and high reflective sediments, interpreted to be composed of Silt, Clay and Sand. The high reflective sediments, interpreted to be composed of silty sand were observed as widespread in its southeast. The multibeam and single beam bathymetric values were reduced to the

lowest astronomical tide, LAT of Opobo river entrance and range from 20.20m-25.89m with a deepening trend from the northwest to southeast caused by seabed current regimes and storm processes. Occurrences of sand patches indicate strong current activities.

Recommendation

- No apparent impediment to sea going vessels, jackup barges and Rigs navigation was detected.
- The seabed of the location is slightly undulating, therefore may require trenching at the northern portion. To avoid unprecedented subsea facilities exposures as a result of sediments wash off.

Acknowledgements

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