



Occurrence of Gas Charged Sediments and Pock Marks in “Semob” Fields Offshore Western Niger Delta: Implications for Offshore Operations

Chuku, Chibuzor H.^{1*}, Odigi, Minapuye I.², Ideozu, Richmond U.³
and Ibe, Chidi A.⁴

¹Department of Geology, University of Port Harcourt, Rivers State, Nigeria.

²Center for Petroleum Geosciences, Institute of Petroleum Studies, University of Port Harcourt, Rivers State, Nigeria.

³Department of Geology, University of Port Harcourt, Rivers State, Nigeria.

⁴Institute of Natural Resources, Environment and Sustainable Development, University of Port Harcourt, Rivers State, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Authors CCH and Author OMI designed the study. Author IRU performed the statistical analysis. Author ICA wrote the protocol. Author CCH wrote the first draft of the manuscript. Authors OMI and CCH managed the analyses of the study. Authors OMI, IRU and CCH managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJARR/2018/v1i313069

Editor(s):

- (1) Muge K. Davran, Associate Professor, Department of Agricultural Economics, Faculty of Agriculture, University of Cukurova, Adana, Turkey.
(2) Shao-Yi Hsia, Professor, Department of Mechanical & Automation Engineering, Kao-Yuan University, Taiwan, R.O.C.
(3) Juan Manuel Vargas-Canales, Professor, Department of Social Studies of the Division of Social and Administrative Sciences, University of Guanajuato, Mexico.

Reviewers:

- (1) Ajay Mandal, Indian Institute of Technology (ISM) Dhanbad, India.
(2) Moses Oghenyoreme Eyankware, Ebonyi State University, Nigeria.
(3) Zhaoyang Chen, Guangzhou Institute of Energy Conversion, Chinese Academy of Sciences, China.
(4) Emmanuel Etim Okon, University of Calabar, Nigeria.
(5) Katie Taladay, University of Hawaii at Manoa, USA.

Complete Peer review History: <http://www.sciencedomain.org/review-history/25722>

Short Research Article

Received 26th March 2018
Accepted 28th June 2018
Published 30th July 2018

ABSTRACT

The safe delivery of operations in offshore province is dependent on the availability of high fidelity information of the geological state of the sea floor. Sediments and sedimentary processes determine the sea bed composition and bathymetry. The study was done in the inner shelf

*Corresponding author: Email: hopechibuzor@yahoo.com;

environment of Gulf of Guinea, in Niger Delta. The acoustic equipment used is side scan sonar and sub-bottom profiler and they work with geophysical principles of sea floor sediments acoustic reflectivity and refraction. The acquisition, processing and interpretation of data reveal the existence of gas charged sediments between the sea bed and the lithified layer (strong seismo stratigraphic layer) and the existence of genetically related depressions with surrounding rings of sand called pock marks which vary between 3 m-10 m in diameter on the sea floor. The gas charged sediments thickness ranges from 20 m-25 m. The areas of the 'Semob' fields that have gas charged sediments and pock marks are liable to endanger the installation and safety of subsea facilities, offshore operations and sea going vessels. Therefore, are geohazards areas and should be avoided.

Keywords: Gas charged sediments; pockmarks; sea floor; lithology; geohazards.

1. INTRODUCTION

The sediments and sedimentary processes of the sea floor is a high-fidelity information tool critical to oil field development in the offshore province [1]. This is to obviate problems related to instability and drifting of drilling rigs, collapse of offshore subsea facilities including production platforms and grounding of operations vessels [2]. This study is a Sedimentological and acoustic investigation of the inner shelf environment of Western Niger Delta offshore-Gulf of Guinea [3]. Generally, analyses of the occurrence and distribution of gas charged sediments show fluid venting areas as potential sites for pockmarks occurrence [4]. In 'Semob' fields, there is heavy existence of oil and gas. Gas which is more mobile tends to sort for routes of escape through the sediments thereby exciting the sediments. Whenever there is weakness in the overlaying sediments at the surface, it appears as marks on

the sea bed which are called pockmarks. Hydrocarbon seepages are of great significance to explorations because they are often direct indicators of the existence of petroleum systems [2,5,4]. The relationship between seabed morphology with shallow gas venting features are well known from Mid Norway, Nile deep-sea fan, Costa Rica [6,7]. Therefore, we made an attempt to analyze the seabed morphology, shallow subsurface structures and shallow deposits in 'Semob' fields using high resolution side scan sonar, sub-bottom profiler (SBP) and single beam swath bathymetry data.

1.1 Aim and Objectives

The aim of this research is to identify geohazards (gas charged sediments and pock marks) of the seafloor in 'Semob' field and their implications for offshore installation and safety in the western Niger Delta.

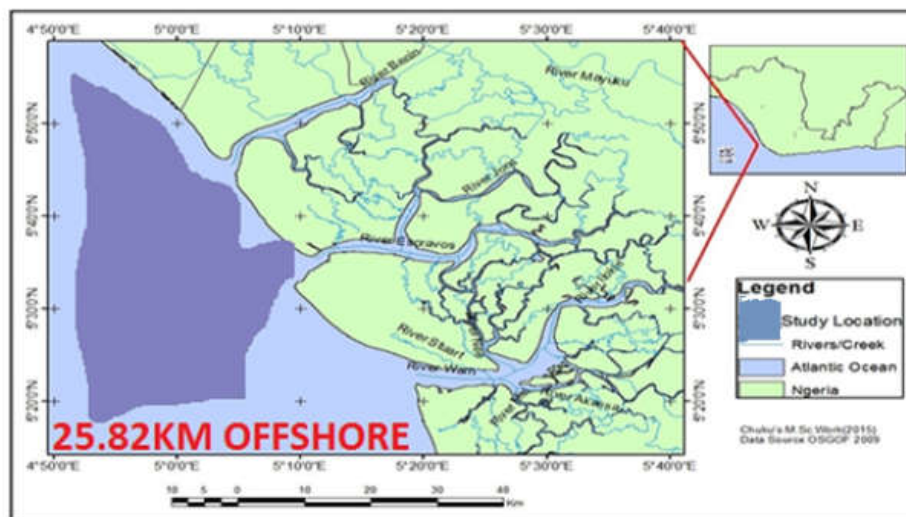


Fig. 1. Location Map of the Study Location 15 km offshore Western Niger Delta (Modified after [2])

The objectives include:

1. To Determine sea bed sediments
2. Determine shallow subsurface profile
3. To Identify the existing sea floor features
4. To determine the possible geohazards of the sea floor in the fields.

1.2 Study Area/Location

The study area is about 10.2 square kilometres. It is situated 10 meters to 12 kilometers off the coast line from the south western end of Benin River in western Niger Delta.

1.3 Geological Setting of the Study Basin

The Niger Delta is situated in Gulf of Guinea on the West central Africa coast and occupies the southern part of Nigeria between latitudes 4°00'N and 6°00'N and longitudes 3°00'E and 9°00'E [8]. It is bounded in the south by the Gulf of Guinea and in the North by older (Cretaceous) tectonic elements which include the Anambra Basin, Abakiliki uplift and the Afikpo syncline. To the East and West respectively, the Niger Delta is bounded by the Cameroon volcanic line and Dahomey Basin [3,2]. The study area is a pockmark field as well as gas charged sediments located within the Gulf of Guinea on the continental margin offshore Nigeria. This continental margin is undergoing slow

deformation by gravity tectonism that initiated in response to both, rapid seaward progradation and loading huge amount of sediment [6].

2. MATERIALS AND METHODS

The data acquisition, processing, interpretation and charting help the understanding of the geological state of the sea floor (Figs. 2 & 3). Side scan sonar, subbottom profiler and echo sounder track lines (24) and sea bed samples were collected in the study area in cruises. Approximately 27 linear kilometres of side scan sonar and echo sounder data were surveyed using Geo acoustics SSS 941 Tow fish and EA 400 single beam hydrographic echo sounder. The accurate positioning of the side-scan sonar, subbottom profiler and echo sounder track lines were accomplished by means of a Kongsberg sea path 330 receivers (DGPS). The backscatter of the surface sediments (side scan sonar) enabled the distinction of the sea floor pockmarks [9,10]. Water depths measured from echo sounders were used to determine the bathymetric classification and location of the study area within the inner shelf environment of the Niger Delta. Bed forms captured from the sea bed scan were matched with the topographical features to deduce the processes shaping the sea floor environment of the study area. The sub bottom profiler enabled the determination of the gas charged sediments.

SEAFLOOR TARGET MEASUREMENT

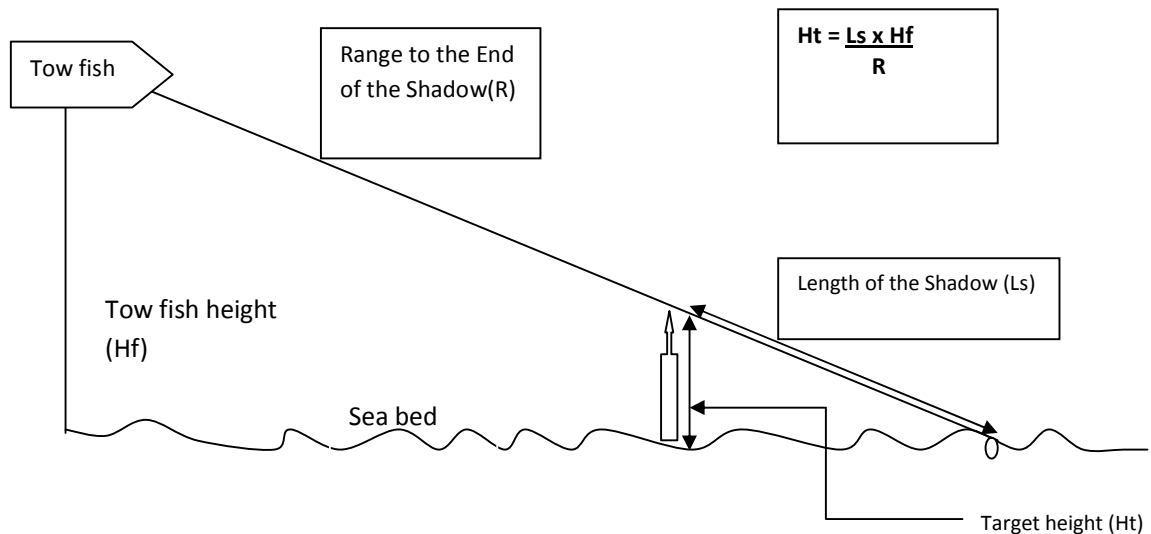


Fig. 2. Target height measurements above sea bed (Adapted from [2])

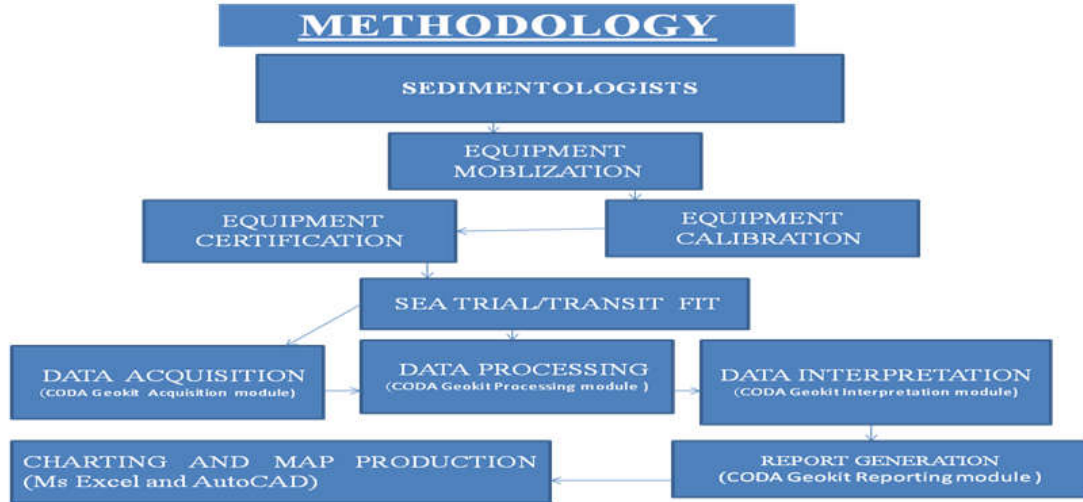


Fig. 3. Methodology Work flow chart

See Appendix A: Pictorial methodology and Appendix B: Materials

3. RESULTS AND INTERPRETATION

3.1 Sub Bottom Profile Data of Gas Charged Sediments

The seismic record of the survey area suggests the presence of the lithified sediments (strong seismo stratigraphic layer) at approximately 20.0 m to 25.0 m below the sea bed. The gas charged

sediments are found between the sea floor and the lithified layer. The gas charged sediments thickness ranges between 15 m - 20 m. Between the sea bed and lithified sediment is the sediments as shown in the Figs. 4, 5, 6 & 7.

Generally, analyses of the occurrence and distribution of gas charged sediments show a precursor to the occurrence of pock marks [1]. These are chimneys for fluid venting in the field and are isolated in offshore operations.

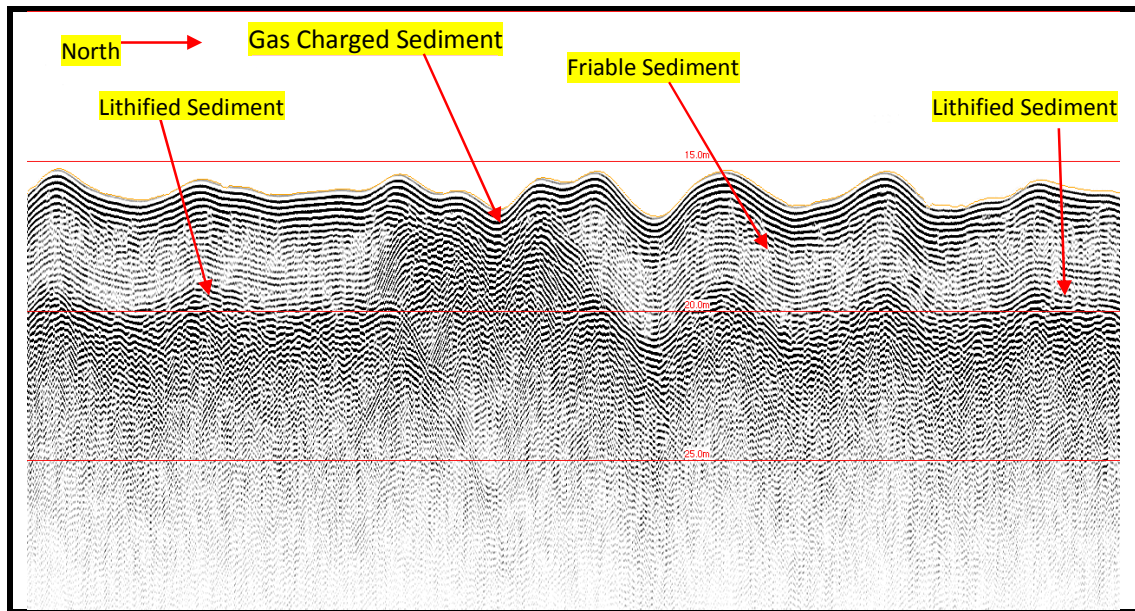


Fig. 4. Sub bottom profiler Data extract indicating Gas charged sediments

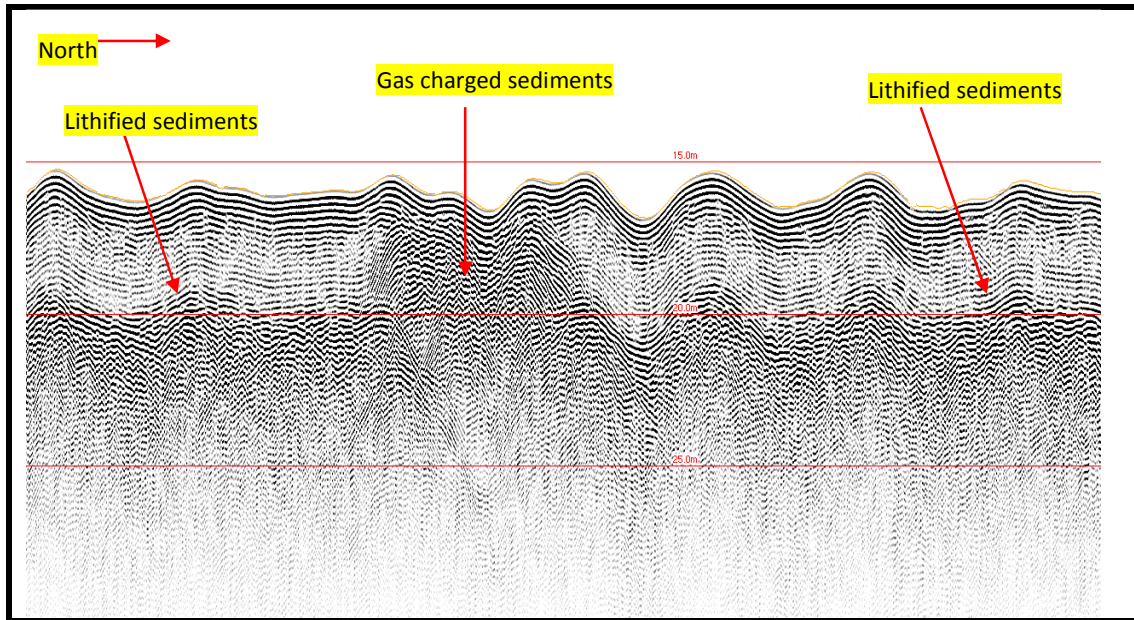


Fig. 5. Sub bottom profiler Data extract indicating occurrence of gas charged zone below seabed

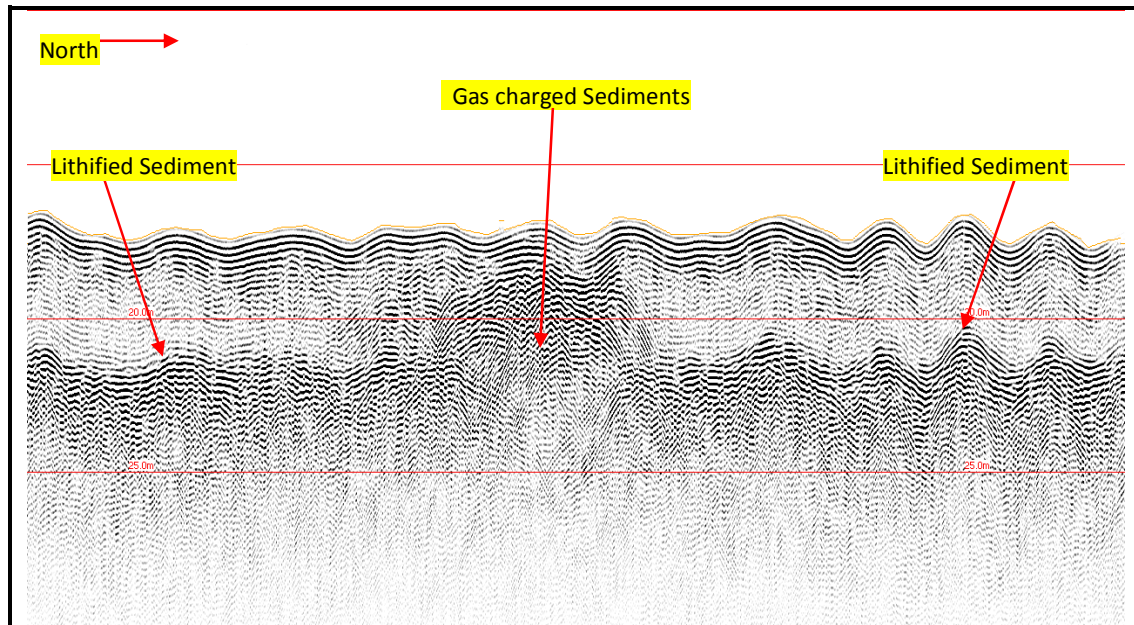


Fig. 6. Sub bottom profiler Data extract indicating occurrence of gas charged zone below sea floor

3.2 Pockmarks

Many Pockmarks of varying diameters were observed in the study area. The pockmarks pose threats to the mechanical integrity of the subsea

facilities and offshore operations, since they are actually shallow gas vents. The Table 1 provides the position details of these pockmarks: Also, the Figs. 8-14 show the pock marks on the sea bed.

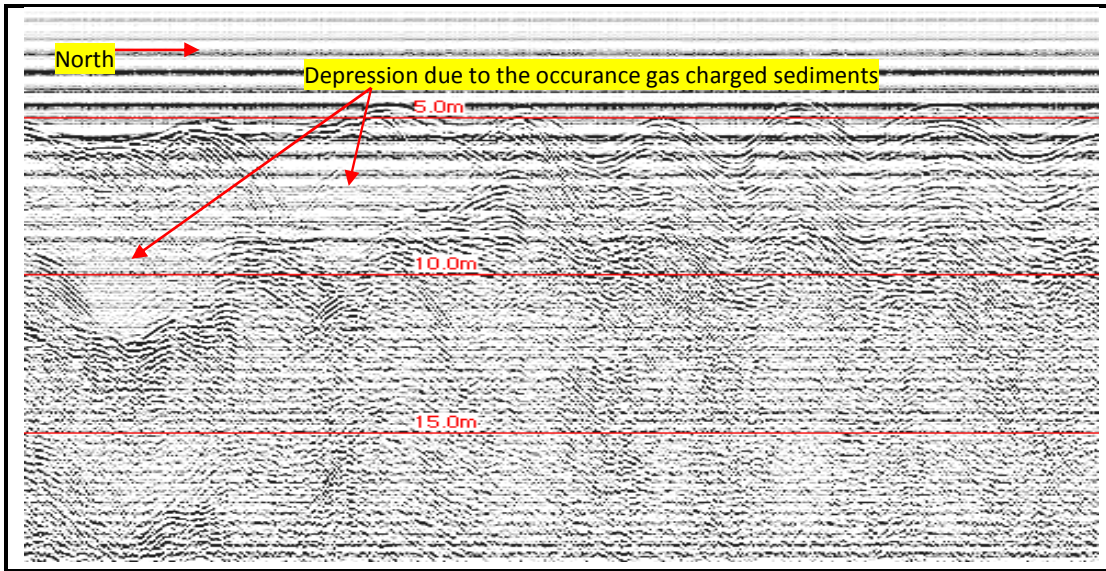


Fig. 7. Sub bottom profiler data extract indicating sea floor depression due to the presence of the gas charged sediment below the sea bed

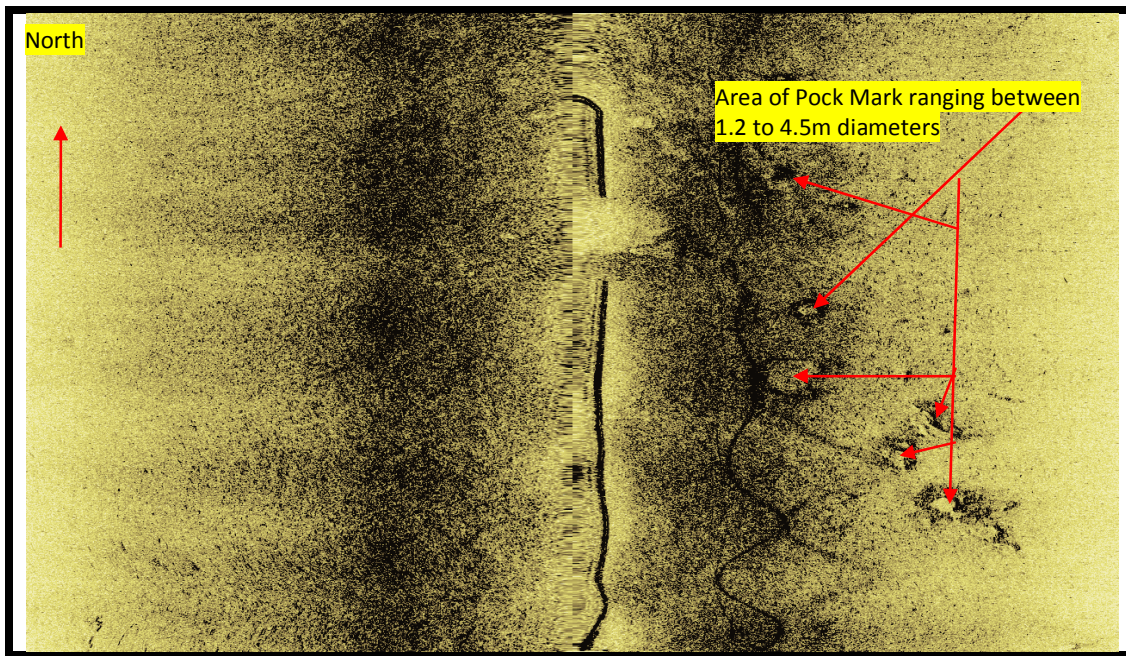


Fig. 8. SSS Data extract showing area of pockmarks in the field

Table 1. Details of the Pockmarks within the Study area

Sl. No.	Position of the pockmark		Diameter (m)
	Easting (m)	Northing (m)	
1	295638.8	173024.1	0.9
2	294842.5	172363.2	5.2
3	294343.9	172034	4.8
4	294283.9	171964.8	7.8

Sl. No.	Position of the pockmark		Diameter (m)
	Easting (m)	Northing (m)	
5	294273	171960	3.2
6	293928.3	171700	3.2
7	293376.9	171346.1	5.4
8	292992.8	170931.2	7.0
9	292986.2	170903.6	5.6
10	292986.1	170934.5	4.2
11	292984	170921.7	3.8

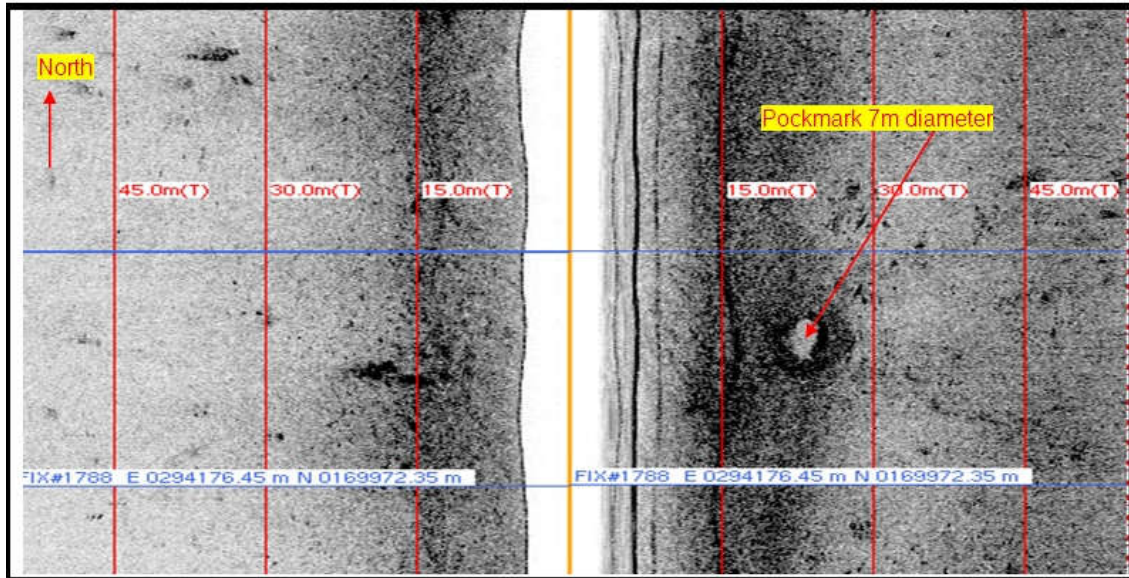


Fig. 9. Side scan sonar data extract showing pockmarks on seafloor of the field.

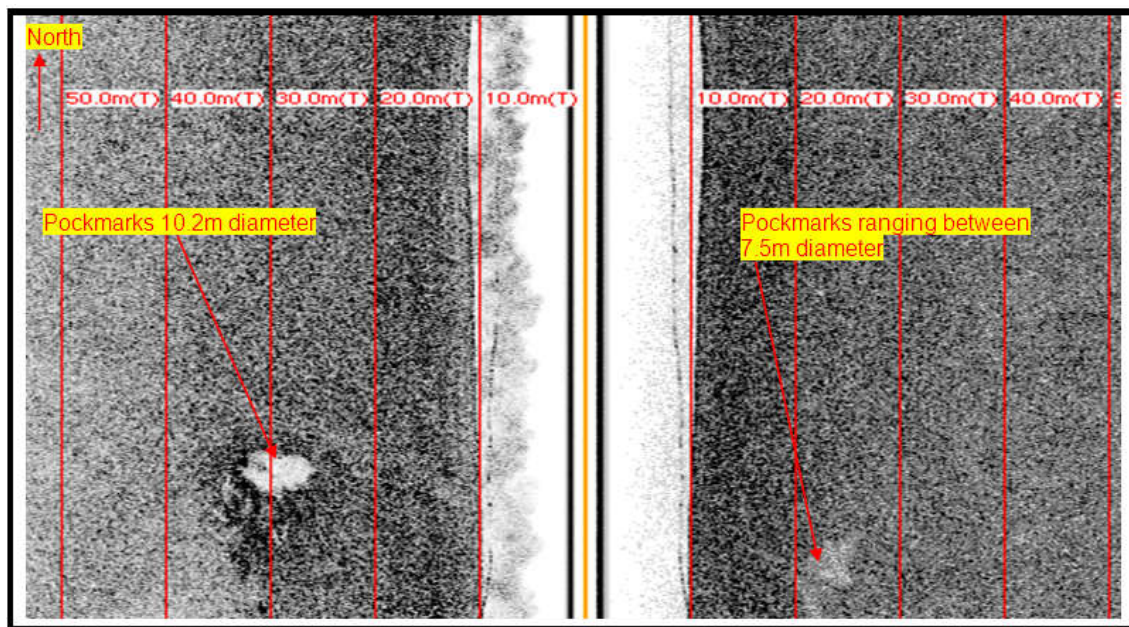


Fig. 10. Side scan sonar data extract showing pockmarks on seafloor of study area

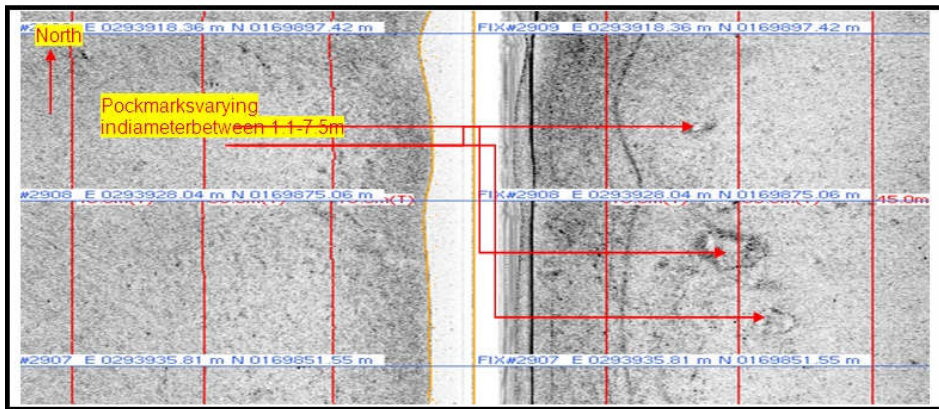


Fig. 11. Side scan sonar data extract showing pockmarks on seafloor of study area study area

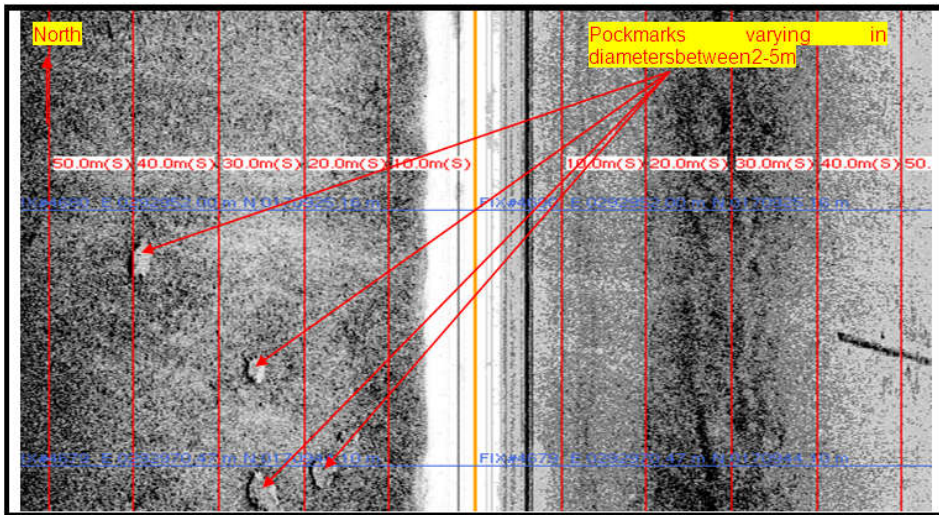


Fig. 12. Side scan sonar data extract showing pockmarks on seafloor of 'Semob' field

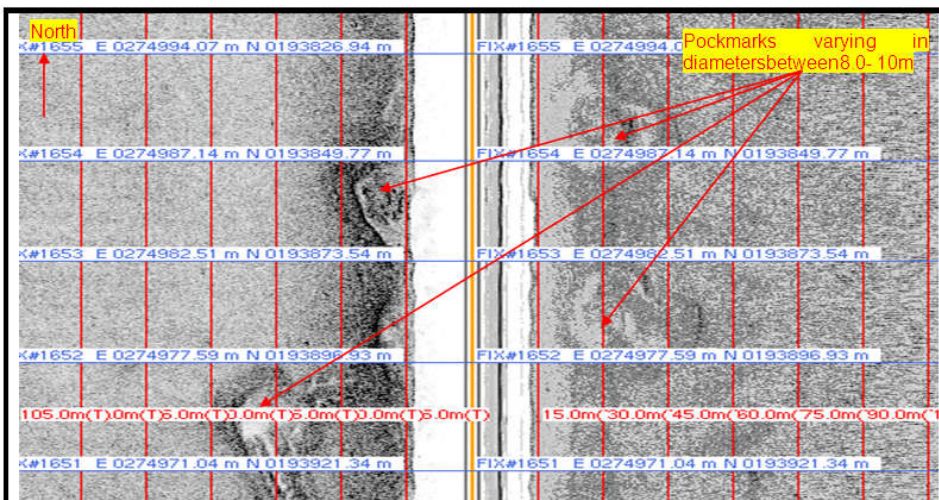


Fig. 13. Side scan sonar data extract showing pockmarks on seafloor

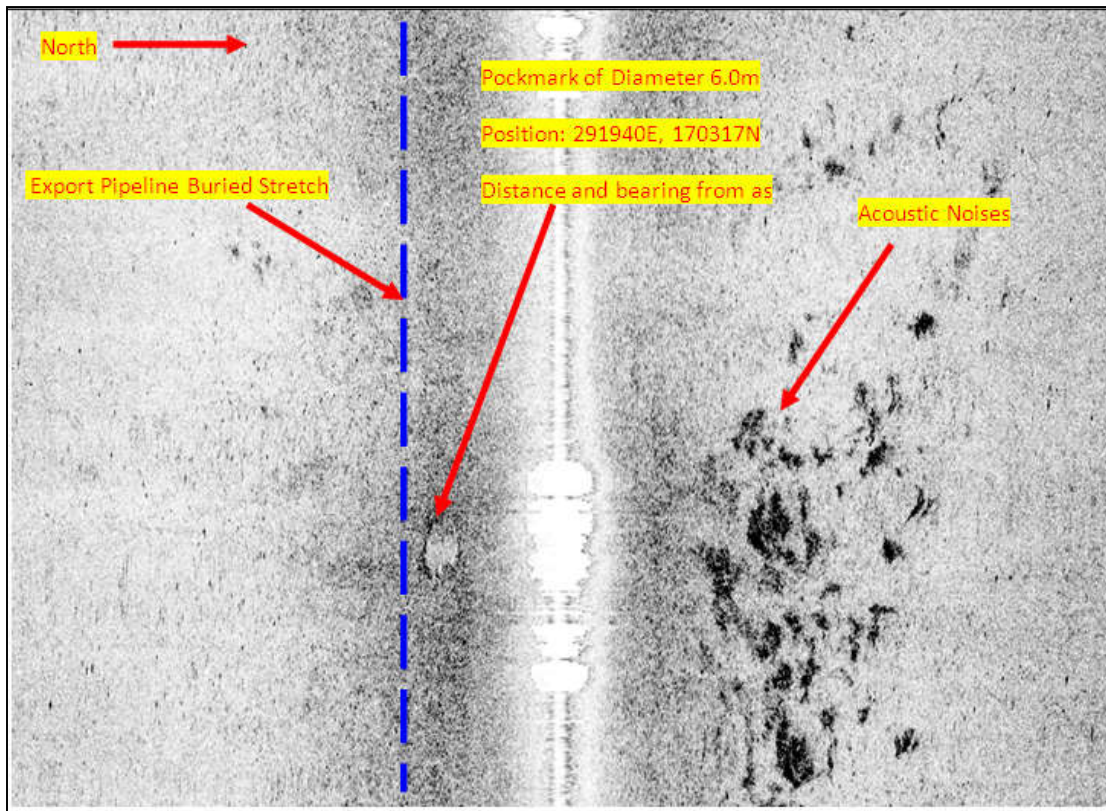


Fig. 14. Side scan sonar data extract showing Scar marks and pockmarks in the field

4. CONCLUSION

The prominent seismo- stratigraphic interface refers to the lithified sedimentary sequence within the study area was found 20 m below the sea bed. Gas charged sediments about 10 m-15 m thick occurred between the seabed and the lithified layer. The sea floor scan also shows existence of genetically related depressions and surrounding rings of sand called pock marks which vary between 0.5 m-9 m in diameter. The areas of the 'semob' fields that have gas charged sediments and pock marks are liable to endanger the installation and safety of subsea facilities. Therefore should be avoided.

5. RECOMMENDATION

Avoid areas with pock marks/ gas vents within the study area due to great potential for the collapse of subsea facilities, if situated on them.

Areas of shallow gas sediments should be considered during offshore operations since these areas could be unstable during the operations.

Seafloor sedimentary processes study should be carried out at least in every six (6) months, to ascertain the integrity of the subsea installation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Anderson JT, Holliday R, Kloser DG. Acoustic seabed classification: Current practice and future directions. ICES Journal of Marine Science. 2008;65:1004-1011.
2. Chuku HC, Ibe AC. Topography and lithofacies of the sea floor in Meren field, offshore Western Niger Delta. IJSIT. 2015;4 (6):524-551.
3. Babangida J. (2015) Seismic imaging of seabed morphology offshore Niger Delta. Universal Journal of Geoscience. 2008; 3(2):25-70.

4. Tesmi J. Seabed pockmark sand seepages impact on geology, biology and marine environment, Graham and Trotman, London. 2008;6-20.
5. Loncke L, Masclé J, Parties F. Mud volcanoes, gas chimneys, pockmarks and mounds in the Nile deepsea fan (Eastern Mediterranean): geophysical evidence. *Marine and Petroleum Geology*. 2004; 21(6):669-689.
6. Damuth JE. Echo character of the western equatorial Atlantic floor and its relationship to the dispersal and distribution of terrigenous sediments. *Marine Geology*. 1975;18:17-45.
7. Emery KO. Perspectives of shelf sedimentology: In marine sediment transport and coastal management. 581-591, Published by John Wiley and Sons Incorporated; 1976.
8. Ibe, AC, Awosika LF, Ibe CE, Inegbodion LE, Adekanye JE. Hydrographic and Topographic Survey of the Ugborodo, Bendel State Shoreline. A Report for Oluonye and Partners, 24p + map; 1989.
9. Rao Y, et al. Anomalous seismic reflections related to gas/gas hydrate occurrences along the western continental margin of India. *Geo Mar. Lett*. 2001;21:1-8.
10. Chuku CH, Odigi MI, Ibe CA, Ideozu RU. Geophysical and geotechnical investigations of the sea floor sediments for offshore subsea facility installation in "Emobs" oil fields, Western Niger Delta Nigeria AJARR.40989. 2018;1(1):1-16.

APPENDIX A

PICTORAL SHOW OF MATERIALS AND METHODS



Equipment Calibration



ES/SBP/SSS Hangers



Deployment of Equipment



Data Acquisition Room setup



Seafloor Features Identification/Recording



Preliminary Charting



Vessel Navigation/Positioning



Recovery of Equipment

APPENDIX B MATERIALS



© 2018 Chibuzor et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
<http://www.sciencedomain.org/review-history/25722>