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INTERNATIONAL JOURNAL OF CURRENT RESEARCH

International Journal of Current Research
Vol. 8, Issue, 11, pp.42538-42541, November, 2016

ISSN: 0975-833X

RESEARCH ARTICLE

LOW VELOCITIES AT DEPTH: IMPLICATIONS FOR ENHANCED HYDROCARBON RECOVERY IN ONSHORE NIGER DELTA

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ARTICLE INFO

Article History:
Received 24th August, 2016
Received in revised form
03rd September, 2016
Accepted 04th October, 2016
Published online 30th November, 2016

Key words:
Low Velocities, Onshore,
Niger delta, Depth.

ABSTRACT

Low velocities corresponding to the distorted reflections at depth has been examined with respect to the implications they could have on the enhancement of hydrocarbon recovery in onshore Niger delta. Detailed velocity analysis using VITAL revealed these low velocities, which were observed to remain low with increase in depth beyond 3seconds. Prestack Depth Migrated sections using the result of the detailed velocity analysis showed that although we might have multiple reflections to contend with (especially at the footwall of main boundary faults), the lower velocities give us better imaging at depth than the higher velocities that were conventionally used for previous depth migrations in the study location. Thus, if we could considerably attenuate multiples, account for anisotropy and settle overpressure concerns which are other likely causes of low velocities, then properly estimating low velocities will help us unlock hydrocarbon potentials hidden behind poor seismic imaging at depth.

Citation: Azuoko George-Best, 2016. "Low velocities at depth: implications for enhanced hydrocarbon recovery in onshore Niger delta", *International Journal of Current Research*, 8, (11), 42538-42541.

INTRODUCTION

Onshore Niger Delta, 3d seismic data processing haduntil recently only been solely focused on velocities of reflection events that flatten offset gathers during Normal Move Out correction. Every other velocity resulting from other reflection events, especially the low velocities has often been treated as noise, being cut off as parts of reflection events that are not flattened out during Normal Move Out (NMO) correction. Previous studies have revealed that 3d seismic sessions from the area (Onshore Niger Delta) has distorted seismic imaging as one goes beyond 3secs two way time (Azuoko, 2016). Through detailed velocity analysis, it has been established that the velocities of the distorted reflection events are anomalously lower than the velocities of the more continuous reflection events above 3secs and the near field surrounding the area where these distorted reflections were found to be dominant (Azuoko, 2016). Efforts have been made by previous researchers to relate these distortions to anisotropy, overpressure and (most recently) multiples (Aikulola *et al.,* 2010; Oni *et al.,* 2011). Looking on the positive side of things however, this study further analyzes these low velocities and theirsignificances with respect to the pivotal role they could play in the general quest to move into deeper prospects onshore Niger Delta and ultimately enhance hydrocarbon recovery.

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Geology of the study area

Most suitable for this study is newly acquired 3D seismic data from a producing field onshore Niger Delta. The area which is dominated by the geology of the southern part of Nigeria and Southwestern Cameroon (Fig.1.)is flanked on the North by the Benin Flank, the Abakaliki High on the Northeast side and the Calabar Flank on the East-South-East direction. The southern and southwestern area is flanked by the two-kilometer sediment (or the 4000 meter bathymetric contour in areas were the thickness of the sediment is greater than two kilometers), while the Eastern boundary of the Dahomey basin and the Cameroun volcanic line respectively mark the Eastern and Western boundary of the region (Michele *et al.,* 1999). Three stratigraphic subdivisions – the Akata, the Agbada and the Benin Formations (Fig. 2.) best describe the tertiary section of the Niger Delta (Reijers *et al.,* 1997).At the base of the basin, we have the Akata Formation which is of marine origin. This formation comprises of thick shale sequences (which is a potential source rock), turbidite sand and minor amounts of clay and silt. The Formation is estimated to be about 7,000m thick and is typically over pressured (Doust and Omatsola, 1990). Overlying the Akata Formation is the Agbada Formation which is the major petroleum bearing unit in the delta. It comprises of paralic-silici-clastics over 3,700m thick and represents the actual deltaic portion of the sequence. The lower Agbada Formation has shale and sandstone beds deposited in equal proportions, though the upper portion is mostly sand with only minor shale interbeds (Ejedawe, 1981; Evamy *et al.,* 1978; Doust and Omatsola, 1990).

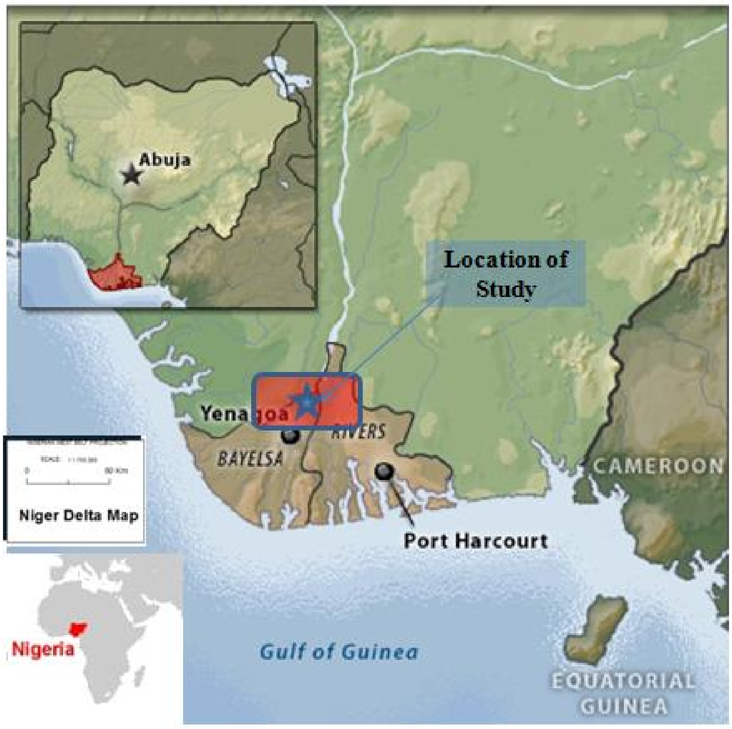

Fig. 1. Map of the Niger Delta

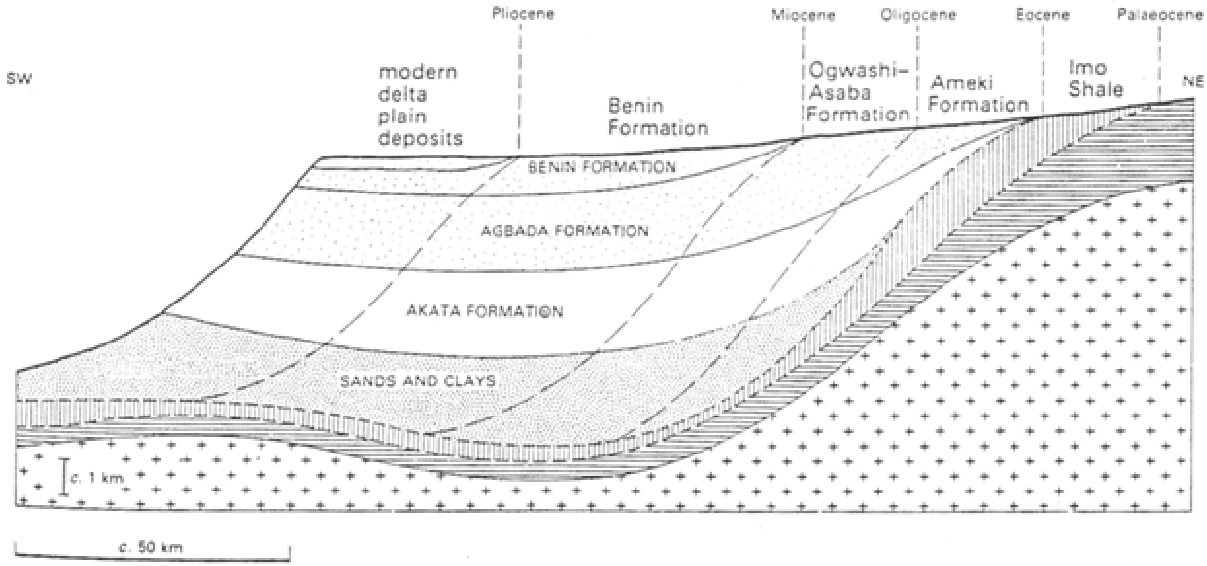

Fig. 2. Longitudinal Cross section showing the successive Formations in the Niger Delta

The third Formation – Benin Formation is a deposit of alluvial and upper coastal plain sands, up to 2,000m thick (Avbovbo, 1978). Generally, rollover anticlines located before growth faults are very instrumental in oil exploration in the Niger Delta basin. The dilemma however is that as we go deeper in onshore Niger Delta, it becomes almost impossible to delineate the main fault line, especially at the footwall of the fault. Also, the mapping rollover structures traps, seals and closures are made evasive by the distorted nature of the reflection events.

MATERIALS AND METHODS

3d Seismic data from an onshore Niger Delta field was used for the study. The data set was provided by The Shell Petroleum Development Company, Port Harcourt. Being Novel, the data was acquired with latest acquisition parameters including 6km cable length, single deep hole, among others. These helped us to adequately image deeper reflection events. Standard data preparation and enhancement procedures for onshore data ranging from statics correction to common mid-point sorting helped us ensure improved signal to noise ratio (SNR) of the data. Detailed velocity analysis involved manual picking of velocities on a velocity semblance panel. This was done using VITAL, a velocity analysis tool which provides a platform that allows velocity information to be extracted from common image point gathers and displayed as a plot of variation of root-mean square velocity with two way time. The highest energy clusters were picked on the semblance plots. This velocity analysis approach is based on Dutta's submission that for primary reflections, hyperbolic move out energy corresponds to the highest energy clusters on semblance plots (Dutta, 2002). The picked root mean square (RMS) velocities are used to generate interval velocity depth models which are ultimately used to migrate in the prestack depth domain.Depth migrated seismic images are finally analyzed to observe the resultant effect of the low velocities that dominate seismic imaging beyond 3secs.

RESULTS

Velocity depth plots (Fig.3) from the detailed velocity analysisshow that velocity in the study location increases with depth from the surface to about 3.8km, corresponding to 3sec. (3000ms) two way time. Beyond 3secs, lower velocities are predominant, fluctuating, but remaining lower than the normal velocities expected at such great depths. On 3d migrated sections, these lower velocities are observed to give better imaging and more clarity of reflection events, giving a better handle on the mapping of structures on the seismic section (Figs. 4 – 6). Figure 4. is a typical prestack depth migrated section as is obtainable in the study location prior to the velocity picking that accounted for the low velocities beyond 3secs. The depth migrated section in Figure 4.0shows continuous reflectors before 3secs. and distorted seismic beyond this two way time. Figure 5. however, is a depth migrated section that took into consideration, the low velocities that were observed beyond 3secs. Comparing the circled areas in Fig. 4. with the corresponding areas in Figure 5., we observe improvements in reflector continuity and structural clarity in Figure 5. Figure 6. compares the area at the footwall of a boundary fault after (a) and before (b) considering the low velocities observed during velocity analysis. We can clearly see an improvement in the orientation of the reflectors especially within the circle. The orientation of the fault line borderingthe distorted zone is also more defined in (a) than in (b). Generally, the low velocities are seen to favor the deep (beyond 3secs.) than the *normal* velocities which were used in the migration of the PSDM section in (b).

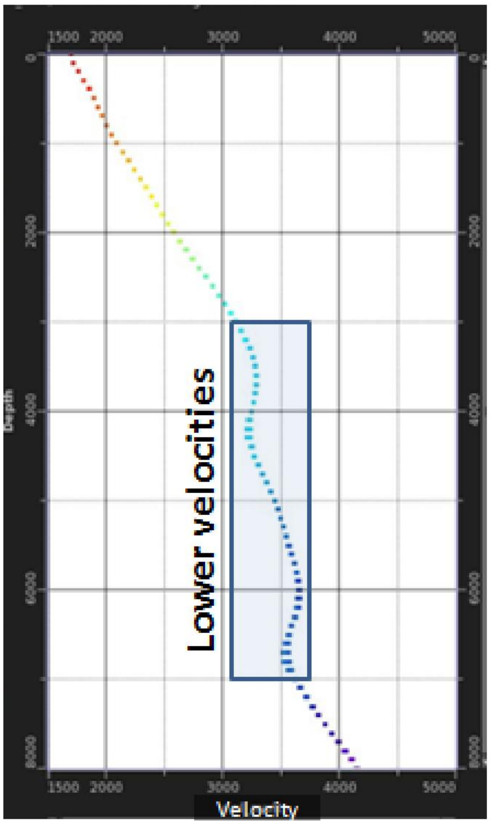

Fig. 3. Velocity-Depth Plot showing prevalence of low velocities at depth

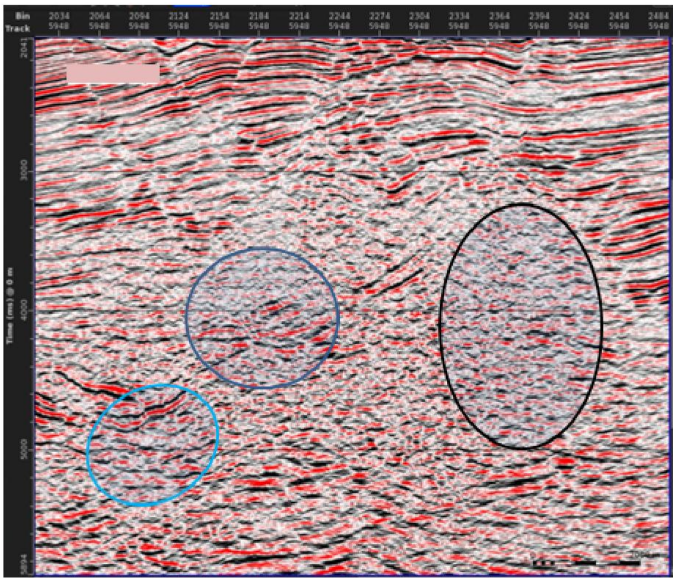

Fig. 4. 3d PSDM section Prior to Detailed velocity analysis as applied in this study; beyond 3000ms, reflection events are indiscernible, fault lines and structures are unidentifieable

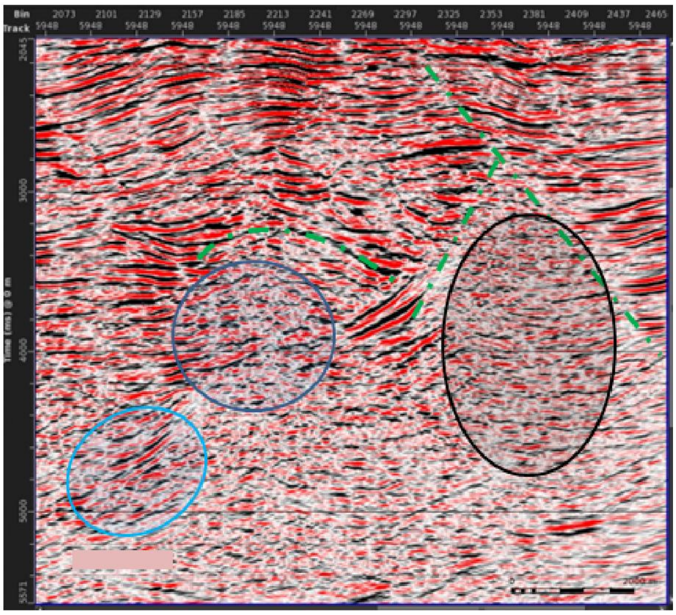

Fig. 5. 3d PSDM section after detailed velocity analysis as applied in this study; event continuity is enhanced within the circled zones; Fault lines are clearer and a rollover strucure becomes more identifiable than in the previous section

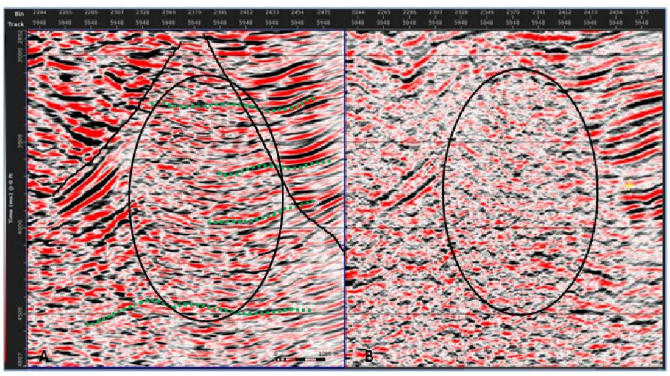

Fig. 6. Comparison of areas at the footwall of the fault; Observe the chaotic nature of reflection eventswithin the circled zone in B; Events are more continious in the corresponding circle in A – (illustrated by the green dotted lines in A)

DISCUSSION

Low velocities observed during velocity analysis in onshore Niger Delta has been examined in this study. Conventionally, velocity increases with depth as a result of compaction and overburden. Within the study area however, a plot of the variation of interval velocitywith depthrevealsthese velocities which are generally lower than expected interval velocities at such depths.Previous studiesconsidered these low velocities with respect to anisotropy, overpressure and multiples. Azuoko, (2016) specifically tied these low velocities to multiple reflection events generated by stronger reflectors located between 2.5secs and 3.2secs., in agreement with works by previous authors (Kelamis and Veschuur, 2000; Weiglein *et al.,* 2011 and Retailleau *et al.,* 2012). However, although instances of fluctuating high and low interval velocities abound beyond 3secs on an interval velocity depth plot from the study area, they remain lower than the velocities of shallower reflection events. This can be rightly adjudged to indicate that velocities beyond 3seconds are generally low, whether they are as a result of primary or multiple reflection events. On PSDM sections, especially beyond 3seconds depth migrated sections using the velocity model in which the low velocities were considered yielded better depth migrated seismic images, with improvements in event continuity and structural clarity. Continuity of the reflection events in the near field and their extension into the chaotic fault shadow zone increases the possibility of extending horizon interpretation into the zone, effectively delineating the fault line that could not be clearly seen before and properly mapping structures that were undecipherable initially. This will ultimately unlock hidden hydrocarbon within this zonewhich has been estimated at millions of recoverable barrels by previous studies of the near field volume (Kanu *et al.,* 2014). Thus, despite having revealed the prevalence of multiples at depth in 3D seismic images from onshore Niger delta, especially at the footwall of main boundary faults (Azuoko *et al.,* 2016), properly estimating these low velocities has been seen to improve depth imaging and will ultimately enhance hydrocarbon recovery if anisotropy and overpressure concerns are adequately attended to and multiple reflections are appreciably attenuated.

Conclusions

Onshore Niger delta, the trend of increase in velocity with depth is reversed beyond 3secs two-way time by the anomalous occurrence of low velocities. These low velocities if adequately captured during velocity analysis have been shown to aid improved depth imaging.Although multiples are made more obvious by proper estimation of these low velocities, attenuating themultiples before any robust velocity analysis would appreciably take care of them, leaving us with primary reflection events that can be interpreted for recoverable hydrocarbon. Thus, for every velocity analysis in onshore Niger Delta, a major key to improved seismic imaging lies in coming to terms with the fact that beyond 3secs all velocities (not just multiple velocitiesbut also primaries) are lower than normal, with the velocities of multiples being even lower than the primary velocities.

Acknowledgment

The author acknowledgesShell Petroleum Development Company Port Harcourt for providing the research internship opportunity to carry out this research, the data, software and permission to publish the work.

REFERENCES

Aikulola, U.O., Olotu, S.O, and Yamusa, I. 2010, “Investigating Fault Shadows in the Niger Delta”: TLE, P. 16-22.

Avbovbo, A. A. 1978, “Tertiary Lithostratigraphy of Niger Delta”: *AAPG*Vol. 62, p. 295-300.

Azuoko G.B., Ehirim C.N., Ebeniro J.O., and Uraechu D.N. 2016. "Multiples in Onshore Niger Delta from 3D PreStack Seismic Data":*International Journal of Physical Sciences* (accepted for publication: 24th October, 2016).www. academic journals.org/IJPS

Azuoko, G.B. 2016, “Multiple Generators in Onshore Niger Delta”: *International Journal of Scientific & Engineering Research,* Volume 7, Issue 10; Pp 368 -372.

Doust, H., and Omatsola, E. 1990. Niger Delta, in Edwards J.D., and Santogrossi, P.A., eds.”, “Divergent and Passive Margins Basins”*AAPG*Memoir 48, P. 239-248.

Dutta, N. C. 2002, “Geopressure prediction using seismic data: Current status and the road ahead” -Y2K Review Article, *Geophysics*, VOL. 67, No.6 p.2012-2041.

Ejedawe, J.E. 1981, “Patterns of Incidence of Oil Reserves Patterns of Incidence of Oil Reserves in the Niger Delta Basin”:“*American Association of Petroleum Geologists*, v. 65, p. 1574-1585”.

Evamy, B.D, Herebourne, J., Kameling, P., Knap, W.A., Molley, F.A., Rowlands, P.H., 1978. “Hydrocarbon Habitat of Tertiary Niger Delta”, AAPG bulletin, 62: 1-39.

Kanu, M, Madiba, G., Emakpor, J., Olotu, S., Mbah, R., and Obilaja, S. 2014. “Demystifying The Fault Shadow Challenge in Onshore Nigeria”, “*Shell Petroleum Development Company, Port Harcourt Nigeria”.*

Kelamis, P. G., and Verschuur D. J. 2000, “Surface-related multiple elimination on land seismic data Strategies via case studies”: *Geophysics*, 63,719–734.

Michele L. W. Tuttle, Ronald R. Charpentier, and Michael E. Brownfield, 1999. “The Niger Delta Petroleum System: Niger Delta Province, Nigeria, Cameroon, and Equatorial Guinea, Africa”.

Oni, A.A, Madiba, G, Bertram, M. O. 2011. Anisotropic Imaging of Okubotin 3D, Onshore Niger Delta, Article, January, 2011; www.researchgate.net

Reijers, T.J.A., Petters, S.W., and Nwajide, C.S. 1997. “The Niger Delta Basin”, *in*Selley, R.C., ed., “African Basins – Sedimentary Basin of the World 3”: *Amsterdam, Elsevier Science* P. 151-172.

Retailleau, M.G., Benjamin, N., Pica, A., Bendjaballah, M., Plasterie, P., Leroy, S., Delmas, L., Hugonnet, P., Khalil, A., Gulunay, N., Smith, R., and Shorter, J., 2012, “Advanced 3D Land Internal Multiple Mod-eling and Subtraction, A WAZ Oman Case Study” : 74th EAGE Con-ference & Exhibition incorporating SPE EUROPEC 2012 Copenhagen, Denmark.

Weglein, A.B., Hsu, S.Y., Terenghi, P., Li, X., Stolt, R. H., 2011. “Multiple Attenuation: Recent Advances and the Road Ahead”: “*The Leading Edge, August,* 2011”.

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