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Impact of wellsite biostratigraphy on exploration drilling in the deepwater offshore Nigeria

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ABSTRACT

The application of wellsite biostratigraphic technique has aided the reconstruction of the subsurface geology in the Nigerian deepwater region. It has further aided decision making during drilling operations including the planning of well paths. Critical decisions regarding casing setting, coring point selection, overpressure zone determination and total depth picks, are easily achieved through confirmation of well prognosis and correlation to offset wells. This technique is very important in the tectonically active Nigerian deepwater region which is characterized by varying degrees of both syn-depositional and post-depositional deformation. Accurate interpretation of basin architecture, lateral variation and facies change is required before drilling. Confirmation of well prognosis during drilling operation is equally important.

It has been proved that wellsite biostratigraphic technique helps to "get it right at first" when integrated with the traditional lithologic description, log signature correlation and seismic profile interpretations. The modern and rapid processing technique of calcareous nannofossil, for instance, provides 'real time' result for the exploration team for confirmation of, or adjustment to, the drilling program. The attendant contribution in saved time, cost and safe and successful drilling operation makes the technique beneficial for all operators.

This paper presents practical experience of wellsite biostratigraphy application in three oil prolific Nigerian deepwater regions: the Niger Delta, Joint Development zone of Nigeria/Sao Tome and Principe area (JDZ) and Benin (Dahomey) Basin.
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1. Introduction

In drilling any well, the planning team puts priority on saving time and consequently money. This is vital even on onshore rigs where the cost of drilling is less expensive. Deepwater drilling is very expensive, bearing in mind the cost of drillship, personnel conveyance and supply boats. The daily rates of specialized services in sinking a well in the deepwater environment are generally in the tune of hundreds of thousands of dollars. With this in mind, every minute matters a lot to all operators who want to ensure that as much time as possible is saved.

Besides planning of logistics and the drilling program proper, it is important to put together the various aspects of exploration that will ensure that you 'get it right at first'. When targets are missed, the drilling process is either repeated in the form of sidetracks or the data obtained managed with greater risks, with both situations having cost implications. If the target is missed and an attempt to make any correction involves pulling out of hole, the loss could run into hundreds of thousands of dollars. Besides, adequate prediction is required to ensure safety of lives of rig personnel and marine lives most especially in areas with overpressured shales, which is a common phenomenon in the Niger Delta.

The Niger Delta area and the adjoining basins are situated in a tectonically active region and are subjected to both syn-depositional and post-depositional deformation. The Niger Delta basin has witnessed varying degrees of both syn- and post-depositional deformation (Fig. 1) with gravity tectonism as a primary deformation process (Ajakaiye and Bally, 2002). The principle of original horizontality is disturbed by tectonism in many areas. Thus, horizontally laid sediments are distorted in such an unpredictable manner that their succession can only be interpreted using the most modern exploration techniques. The Toe Thrust belt shows the extent of deformation in the Niger Delta deeper waters. Besides tectonic activities, basin architecture, lateral variation and facies changes in deposited sediments need to be accurately interpreted. Else, the same lateral sequence of sand grading into shale could be mistaken for different horizons.

Two discrete evidences of post-faulting deformation mechanisms have been documented by Maloney et al. (2010) with the

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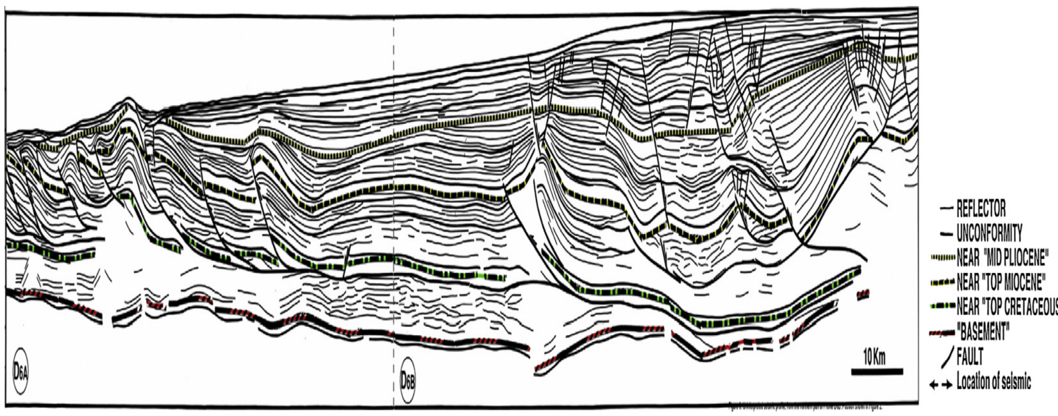

Fig. 1. Line drawing of seismic profile D6A and D6B in the Toe-Thrust zone of the Niger Delta (adapted from Ajakaiye and Bally, 2002).

use of two- and three-dimensional seismic reflection data from the deep-water Niger Delta fold and thrust belt mechanisms. They interpreted an early phase of thrust-propagation folding followed by folding caused by thickness changes within the basal shale detachment unit. The later phase of folding was said to have been caused by a lateral redistribution of the strata within the basal detachment unit. Corredor et al. (2005) used the patterns of growth, sedimentation, fold shapes, fault plane seismic reflections and combined conventional and shear fault-bend folding theories to describe and model the structural styles and kinematics of the fault related folds and imbricate thrust systems that compose the two large fold and thrust belts in the Deep-water Niger Delta. Leduc et al. (2012) used two- and three-dimensional seismic data to describe the structural geology of the lateral margin of a deep-water delta lobe within the Niger Delta that has undergone basin-ward, gravitationally driven translation. They referred to this region as “lateral strike-slip domain”.

Whatever mechanism is responsible for the structural complexities described above, there is the need to resolve the distorted sequences and place them sequentially to aid exploration activities. Biostratigraphy plays a big role as one of the techniques in the subsurface interpretation of the sequences most especially at the point of drilling.

The use of seismic method with its advancement up to the 4-D is an important tool in predicting the subsurface geology. Consequently, pre-drilling interpretation is made of the subsurface using all available techniques especially seismic. Where available, projections from offset/adjacent wells’ data are made. Through this, depth to targets, overpressured zones and major horizons are calculated. From these, the drilling program is drawn and the different operations outlined. Casing depths, primary and secondary targets depths are estimated and coring point depths are projected. It is also possible to estimate the depth to the overpressured zone where such is suspected and to predict the well’s total depth (Ramirez et al., 2005).

It is equally important to ensure that during drilling operations, the prognosis falls in place and that discrepancies are located where they occur so that adjustments can be made to the drilling program. Traditionally, results of lithologic description, log signatures and seismic are employed to effect these. These results are correlated to the point of reference which could be an offset well. This method has proved to be very effective. Occasional mismatching, however, occurs. As drilling in the offshore requires a degree of precision that will ensure cost saving and eliminate the risk of loss of lives, integrating all available exploration techniques is important.

While laboratory biostratigraphic studies contribute to the final evaluation of wells, critical decisions are to be taken during drilling operations. Such decisions are directly related to the results of the ongoing drilling operation and how the prognosis of the stratigraphy agrees with the actual situation. The application of biostratigraphy to solving wellsite drilling problems has been highlighted by Copestake (1993). Most commonly, variations occur between the prognosis and actual well stratigraphy. The employment of the services of a Paleontologist during drilling to provide real time biostratigraphic data is thus very important. When such biostratigraphic data is integrated with lithologic description, log signatures and seismic data, it provides a formidable data base in monitoring the drilling operations. Information supplied by the wellsite paleontologist includes the traditional functions of biostratigraphy such as age determination, fault/unconformity identification, paleoenvironmental analysis and formation characterization/fingerprinting. Biostratigraphic data are also invaluable in well correlation and sequence stratigraphic studies. Giwa et al. (2006) stressed the use of biostratigraphy as providing a framework for correlating Maximum Flooding Surfaces and determining facies associations with the option of biosteering being explored. Biosteering (usually in conjunction with geosteering) is intended to maximize reservoir penetration by biostratigraphically “fingerprinting” the reservoir, enveloping non-pay stratigraphic units during drilling (Marshall and Nairn, 2005; Shipp and Marshall, 1995).

Three main microfossil groups namely: foraminifera, calcareous nannofossils and palynomorphs are commonly employed in wellsite biostratigraphic work. The fossil group employed at the wellsite depends on the kind of geological problems envisaged at the drilling site (well/field). In marine areas where paleobathymetry data is required, foraminifera will serve the purpose and provide clues to the age as well as structural interpretation. Palynological studies are efficient for paleoenvironmental interpretation and age determination of nearshore coastal sediments where foraminifera and nannofossils may be poorly distributed. Dinocysts in particular are useful in the marine environment. Nannofossils are the most precise fossil group for all age and structural interpretation in the deepwater marine environment.

Wellsite Calcareous nannofossil biostratigraphy has proved very useful in geological monitoring and minimizing correlation problems. The effectiveness of these exclusively marine fossils is enhanced by their short stratigraphic ranges resulting from the rapid evolutionary trends of many species. Resolution is thus of tens of thousands of years. This is further aided by the speedy processing technique that yields rapid results for real time age determination.

Experience in the use of local events in the Deep Offshore Niger Delta and the Gulf of Guinea has led to the subdivision of the entire

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