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Stratigraphy and sedimentary structures: Umunya section, Niger Delta Basin, Nigeria

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ABSTRACT

The sedimentary process of Umunya isa replica of what took place in the ancient time and gave rise to prolific reservoirs of the Niger Delta Fields like the Agbami and BongaGiant Fields. Little work has been done in this section to ascertain its geology. The need for such knowledge is pressing. As a step towards understanding this geo-history, this study examines the stratigraphy and sedimentary structures of the Umunya section of the Eocene Nanka Formation, a component of the Ameki Group of the Niger Delta Basin. From a panoramicview across the Onitsha/Enugu express way, the lenticular Umunya section is observed to comprise three subunits. This interpretation is supported by abundant sedimentary structures indicative of tidal influence (clay drapes, reactivation surfaces, cross-bedding, and heterolith). The exposure is considered as one of the most instructing and educating field trip destinations in the area. The field demonstration of Walther's Law, clastic sedimentary structures, reservoir properties, SequenceStratigraphy, variability in depositional environments and techniques in environmental diagnosis is evident.

Key Words: Clay drapes, Heterolith, Reactivation surfaces, Channels, and Ripples.

INTRODUCTION

Umunya is located inAnambra State, Southeastern Nigeria.The study area is located about 18km from Onitsha on the Onitsha/Enugu expressway, with the section exposed on both sides of the road near the Rhema Mountain Cathedral Umunya. The southeastern Nigeria is dominated by cuesta topography. The cuesta is an asymmetrical ridge, traced from the left bank of the Niger River at Idah in Kogi State andstretches northwards to the Benue River, turns south past Enugu and Okigwe, swings East and terminates near Arochukwu at the right bank of the CrossRiver.Most of the scarp slope of the cuesta faces the Cross River plain. Its crest constitutes a long sigmoidal drainage divide between the Anambra River plain to the west and the Cross River catchment area to the East. The crest of the cuesta is characterized by smoothly grassed inselbergs. The sedimentary structures ofUmunya locality lies within the Niger Delta Basin [2].According to [2],todays Niger Delta Basin starts from Idah and can be mapped in an area about halfway between Enugu and Onitsha which is somewhere around the Oji River Bridge . Here, the Nsukka formation is overlain by the Imo formation which is the Basal unit of the Niger delta sedimentary package.

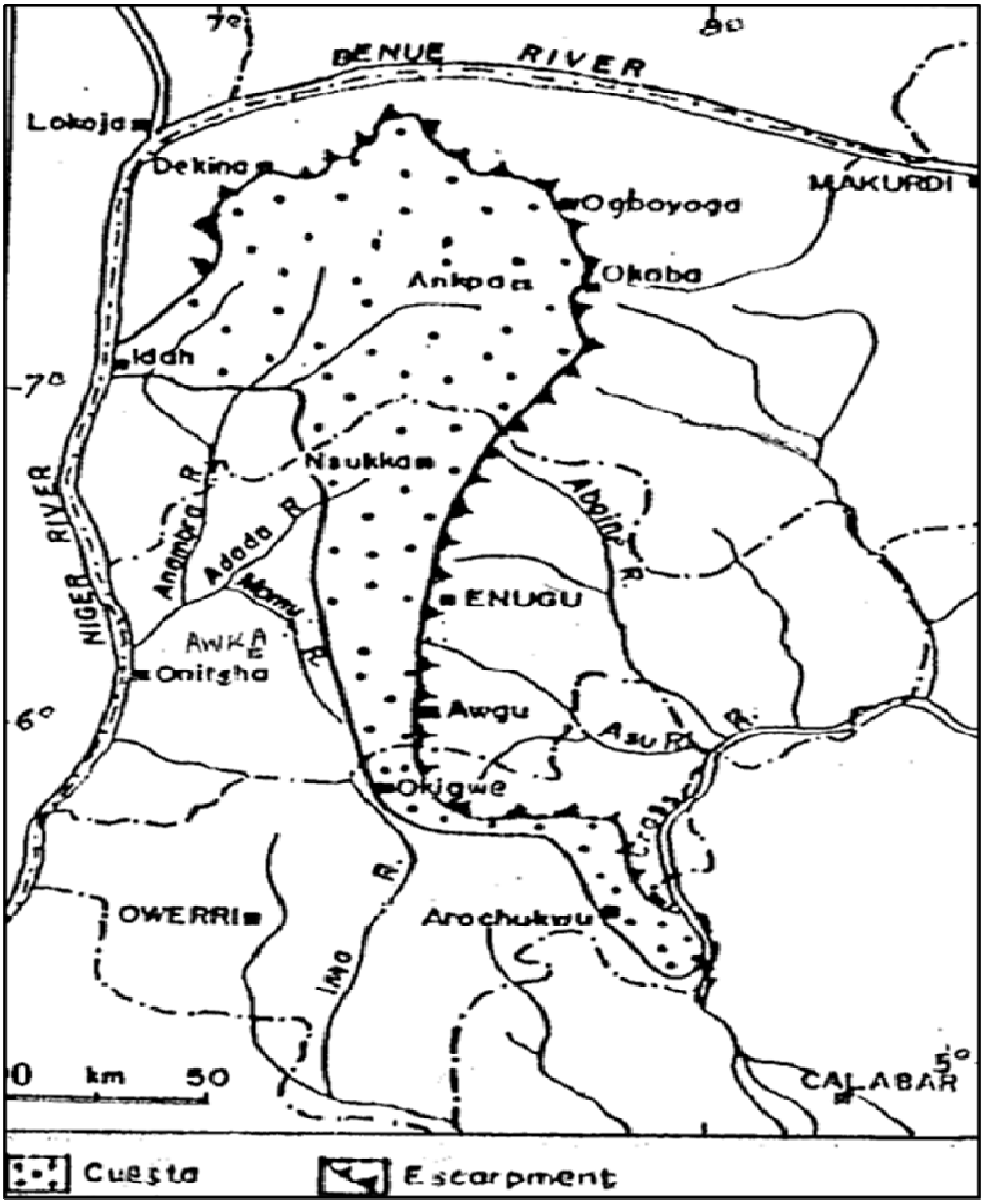

Fig. 1 Cuesta topography of the South eastern Nigeria

Stratigraphic Framework

Umunya section consists of three subunits namely:

- Lower Subunit
- Middle Subunit
- Top Subunit

Fig. 2 Panoramic view of the Umunya section

The Lower Subunit

The Lower subunit is about 12cm thick and constitutes half the thickness of the entire section. It consists largely of clayey, fine grained and well sorted friable sandstone. The geometry is of thick tabular beds and the sands appear to be deposited in sub meter. Quartz and clay are the main mineral constituents.Physical Sedimentary structures evident in this subunit include claydraped planar foresets, wave ripple lamination, reactivation surfaces, channels, and tidal bundling.

- **Clay Drapes** resulted from the deposition of suspended load during slack water time stages of the tidal cycle during periods of no flow. These clay drapes are seen and interpreted to be resistant to erosion during periods of strong current which led to their being preserved, and they coalesce with adjacent drapes to form wave rippled master beds.The **c**lay drapes thicken upwards to form about 30 cm thick claystone intervals with Thallasinoides (horizontal burrows) which concentrate at the interface of clay and overlying sandstone. The clay drapes on a given foreset extends beyond the underlying sand foreset to coalesce with sub and superjacent drapes to form wave ripple laminated master beds with sand lenticles that thicken progressively.

- **Planar cross-bedding,**as observed within the section dip 15 to 30° with azimuths consistently rangingbetween 40 to 55°, 48° on average and trending northeast. Foreset vary in thickness in a rhythmical pattern, like the strings of a playing accordion, along a given bedset from about 1cm to up to 10cm, approximately a sine curve.[6] attributed this to the action of spring and neap tides.

- **Channels** - further upwards of the section, a 2m thick sandstone interval displays channels and small scale trough cross beds. The channels are about 10m in width and trend north-south. This sub-unit is capped by an erosional surface over which lies a meter thick sandstone/claystone heterolith

- **Reactivation surfaces** are minor erosional surface formed within planar cross stratified beds.They result when reverse current dominantly modifies previous cross stratified deposit by eroding part of the crest of the dune. When the bed form resumes migration in the dominant direction, cross strata build out from the erosional surface.

- **Ripples –** wave ripple lamination was seen occurring in the middle of the section replacing the cross-beds.

Fig. 3Clay draped foresets, Reactivation Surface, Accordion Structure, and Ripple-laminated Upper section of Lower Subunit

The Middle Subunit

The Middle subunit consists of poorly laminated grey to dull white claystone. The lower third of the subunit is seen to consist of two lenses of ferruginous sandstone which are medium to coarse grained with a bottom and top layer of ironstone.The subunit appears not to be laterally extensive, but grades laterally into grey siltstone to the southward direction. The claystone is composed of basically kaolinite,conspicuously free of sand and silt size grains, poorly laminatedand trace fossils are completely absent.It is suggested to be of lagoonal origin.The sandstone lenses is poorly sorted, medium to coarse grained, and consists of exclusively quartz.The lensoid geometryresulted when there was more of suspended load in the depositing medium which gave rise to deposits of clay with sand lenses andwave rippled laminated master bed with sand lenticels.

Planar cross beds as observed in this subunit are of small to medium scale with reverse grading. The foresets dip 15°, azimuth consistently southwest at about 230°

According to [3], the sandstone lenses are assigned to fluvial channel facies believed to have been deposited across a lagoonal area at a period of relative sea level fall when the lagoon emptied. This must have occurred twice before lagoonal claystone depositional conditions became fully restored. A latter rise in sea level filled the channels with bedloadmaterials; with the process also occurring two times at the time this part of the Nanka Formation was being formed, fitting into the overall progradational delta construction.

The Top Subunit

The top subunitas observed is a heterolithwith rapid alternation of very fine to fine sandstones with fairly laminated claystone of sub-equal amount, each lithotype varying in thickness from about 1cm to 30cm. The sandstone is ferrugenized and wave ripple laminated with the crest of the ripple striking northwest-southeast.Bedding units are all laterally persistent, extending for tens of metres. At the bottom of the heterolith to the south is an evidence of recumbent fold occurrence. The folding as observed is localized and thought to be of convolute lamination, a type of soft sediment deformationattributable to the stresses produced by the emergence of a depositional surface leading to liquefaction and flow in the underlying sediment [5].

Fig.4Claystone bounded by incased sandstone

Fig. 5Heterolithic stratification showing alternation of ferrugenized sandstone and claystone

Sequence StratigraphicInterpretation

A shallowing profile in this section was noticed. Facies change from sub tidal sand wave deposits to channeled foreshore-to-upper shoreface. Furthermore, tidal mixed flat heterolith of sand and clay; overlain by a laterally circumscribed claystone facies shows rapid shallowing. This is succeeded by evidence of subaerial exposure as documented by the temporary establishment coastal plain showing channeling and fluvial channel deposits. The occurrence of subaerial/continental plain facies on shallow marine deposits indicates a progradational shore system within an ancient tide and river influenced system [7]. A third or fourth order sequence boundary could therefore be placed above the short heterolith interval or above the channeled sandstone.

Biogenic Sedimentary Structures

Most of the biogenic sedimentary structures found within the Umunya section result from the burrow of ancient organisms. The sedimentary structures are intensely bioturbated particularly in an exhumed, ferrugenized firm ground. The ichnofacies are abundant and include:Ophiomorpha**,** Chondrite**,**Thalassinoides, Paleophycus, Planolites. These ichnogenera have been classified with glossifungitesichonofacies by some scholars. Within the section isolated Ophiomorpha tubes cut through the foresets vertically.

Fig. 6 Intensely Bioturbated Sandstone

Reservoir implications of the Umunya Section

The ferrugenized bands as seen in this section affect vertical permeability with little effect on horizontal permeability although vertical permeability is fairly enhanced by vertical structures of Ophiomorpha shafts in the lower part of the tidally influenced sand bodies. This also enhances good reservoir interconnectivity.The laterally extensive cross-bedded, tidally-influenced fluvial channel sands also show good reservoir intervals with good lateral extent (sigmoidal geometry) continuity. However, the presence of clay drapes on the foreset planes of the cross-beds is likely to affect permeability (thereby impeding the flow of fluid). Different facies have their peculiar effects on reservoir properties; coarse- grains of channel base may result in increased permeability, the cross-bedded boundaries and grain size variations results in permeability contrast at a lamina scale, while ripple laminated siltstones function as impermeable barriers to fluid flow between discrete intervals [8].According to [9], primary porosity is best preserved in channel sandstones because they have not been subjected to severe changes that may occur due to continuous transportation, re-deposition. In reservoirs where thin beds oflaterally extensive heterolith with claystone layers serving as bottom and top seals occur, horizontal wells can be used to maximize production if the reservoir fluid is seen to be of commercial viability.

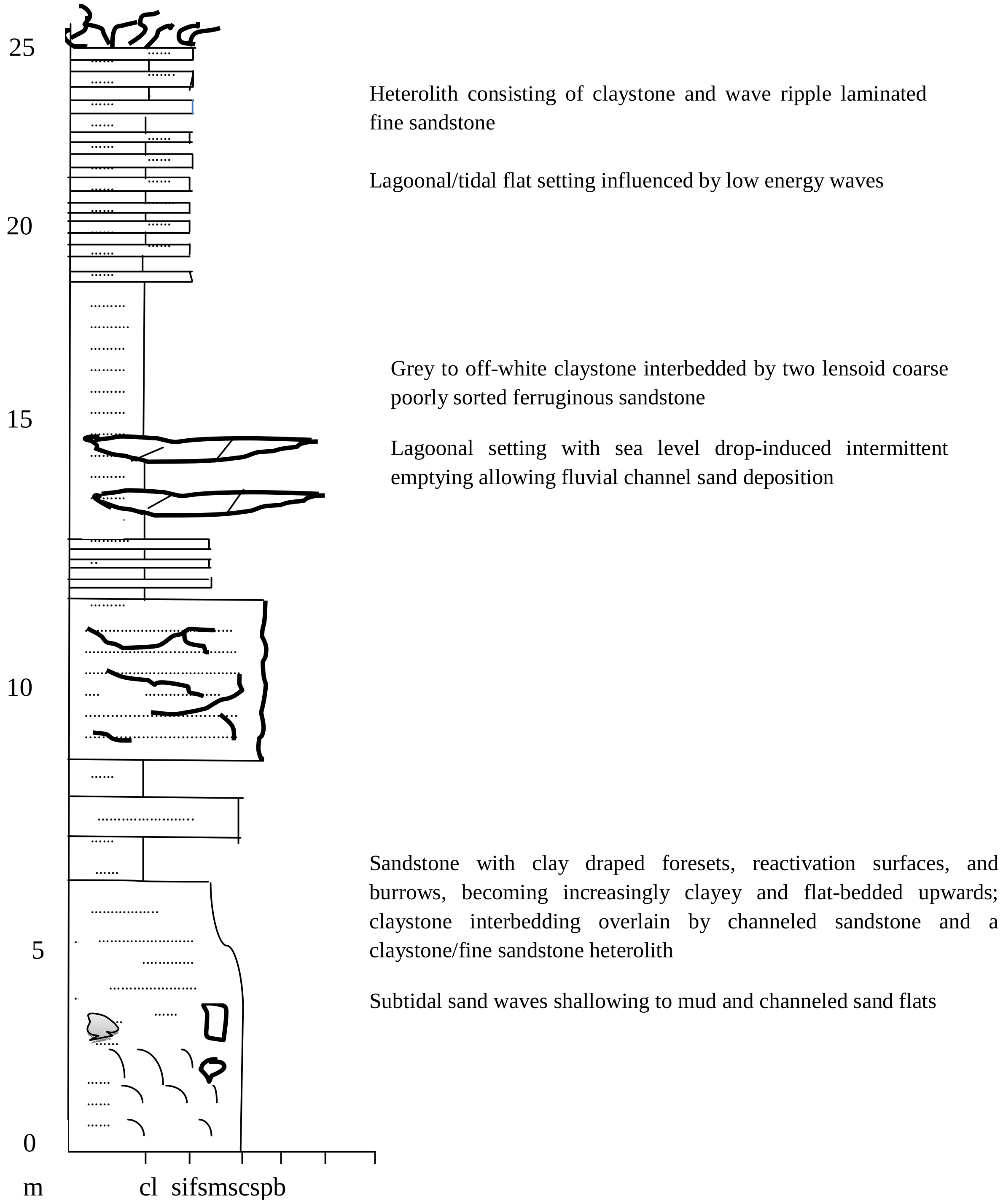

Fig. 7 Litholog of the Umunya Section

CONCLUSION

Umunya section, as observed from this study can be referred to as the Niger Delta Basin on the 'surface'. Much study has not been carried out in the Umunya section to actually ascertain its hydrocarbon potential and quality.

However it is evident from this study that Umunya sectioncontains a wealth offeatures indicative of tidal influence such as cross-stratification and clay drapes.The area documented soft sediment deformation in form of convolute bedding (recumbent fold) at the topmost unit.

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