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Sedimentary Facies Analysis of Conglomerate Deposits in Northeastern Part of Akwa Ibom State, Niger Delta Basin, Nigeria

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ABSTRACT
Conglomerates abound in northeastern part of Akwa Ibom State, Nigeria along a belt of about 550 kilometers square. The conglomerate deposits consist of six sedimentary facies: paraconglomerate (Cm) consisting of matrix supported massive conglomerates with a matrix of clayey sand , orthoconglomerate (Cc) comprising clast-supported normally graded conglomerates with poorly sorted fine to very coarse sand forming the matrix, massive sandstone (Sm) that is made up of fine to coarse grained massive and poorly sorted pebbly sandstones, crossbedded sandstone (Sc) consisting of medium to coarse grained crossbedded sandstones, parallel laminated sandstone (Sp) comprising fine to coarse grained poorly sorted sandstones with parallel laminations, mudstone (M) consisting of massive claystones and siltstones that lack any observable sedimentary structure and also include bioturbated mudstone. The gravelly, sandy and mudstone facies are stacked in ascending order and it is interpreted as a succession of channel-bar-overbank deposits of a braided fluvial system.

Keywords: *Conglomerate, facies, braided stream, model, environment and sandstone.*

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I. INTRODUCTION

Conglomerates abound in northeastern part of Akwa Ibom State, Nigeria along a belt of about 50km long and 11km wide. The belt cuts across Ini, Ikono, Ibiono Ibom, Itu, Uruan, and Uyo Local Government areas of the State. The deposits show a northwest southeast trend. There are diverse opinions on the depositional environment(s) of these conglomerates. Amajor (1986) studied the conglomerate deposit in Itu Local Government Area of Akwa Ibom State. He interpreted the conglomerate beds to be of alluvial fan origin. Petters (1989) worked on the conglomerate deposit in Itu and Ikono Local Government Areas of Akwa Ibom State. He proposed a beach (marginal marine setting) for the deposit although a close scrutiny of his pebble morphometric result suggests fluvial origin. Amajor (1986) indentified four facies namely:

Facies A: Quartz-pebble conglomerate
Facies B: Pebbly sandstone
Facies C: Interstratified pebbly sandstone and sandstone
Facies D: Sandstone
The present study is necessary in order to provide a regional interpretation of the sedimentary Facies.

GEOLOGIC SETTING

Stratigraphically, the conglomerate deposits belong to Ameki Formation. Reyment (1965) described Ameki Formation as a series of highly fossiliferous grey-green sandy clays with calcareous concretions and white clayey sandstones. The lower part consists of fine to coarse sandstones and intercalations of calcareous shale and thin, shelly limestone, the upper with coarse, cross-bedded sandstones, bands of fine sandstones and sandy clays. It is locally rich in Molluscs, foraminifera and Ostracods. Lithologically, Ameki Formation is very heterogeneous (Wilson, 1925; Reyment, 1965; Adegoge, 1969). Arua and Rao, 1986 noted the presence of pebbles in Ameki Formation. Agagu et. al (1985) and Petters (1978) have interpreted the Ameki Formation to be Estuarine, Lagoon and open marine setting. The Ameki Group consists of the Nanka sand, Nsugbe Formation and Ameki Formation (Nwajide, 1979). The Formation has been considered to be either Early Eocene (Reyment, 1965) or early to Middle Eocene (Berggren, 1960; Adegoke, 1969) and deposited in estuarine, lagoonal and open marine environment content. White (1926) assigned an estuarine environment because of the presence of fish species of known estuarine affinity. Adegoke (1969), however, indicated that the fish were probably washed into the Ameki sea from inland waters, and preferred an open marine depositional environment. Nwajide (1979) and Arua (1986) suggested environments that ranged from nearhore (barrier ridge-lagoonal complex) to intertidal and subtidal zones of the shelf environment, whereas Fayose and Ola (1990) suggested that the sediments were deposited in marine waters between the depth of 10m to 100m. According to Nwajide and Reijers (1996), the progradational Nanka Formation marks the return to regressive conditions. The outcropping deposits of the Eocene regression, which marks the beginning of the Niger Delta progradation, constitute the Ameki Group, which include the tidal facies and backshores as well as pro-delta facies. The prograding shoreface and river deposits are reflected in the subsurface deposits of Agbada Formation in the Northern depobelts of the Niger Delta.

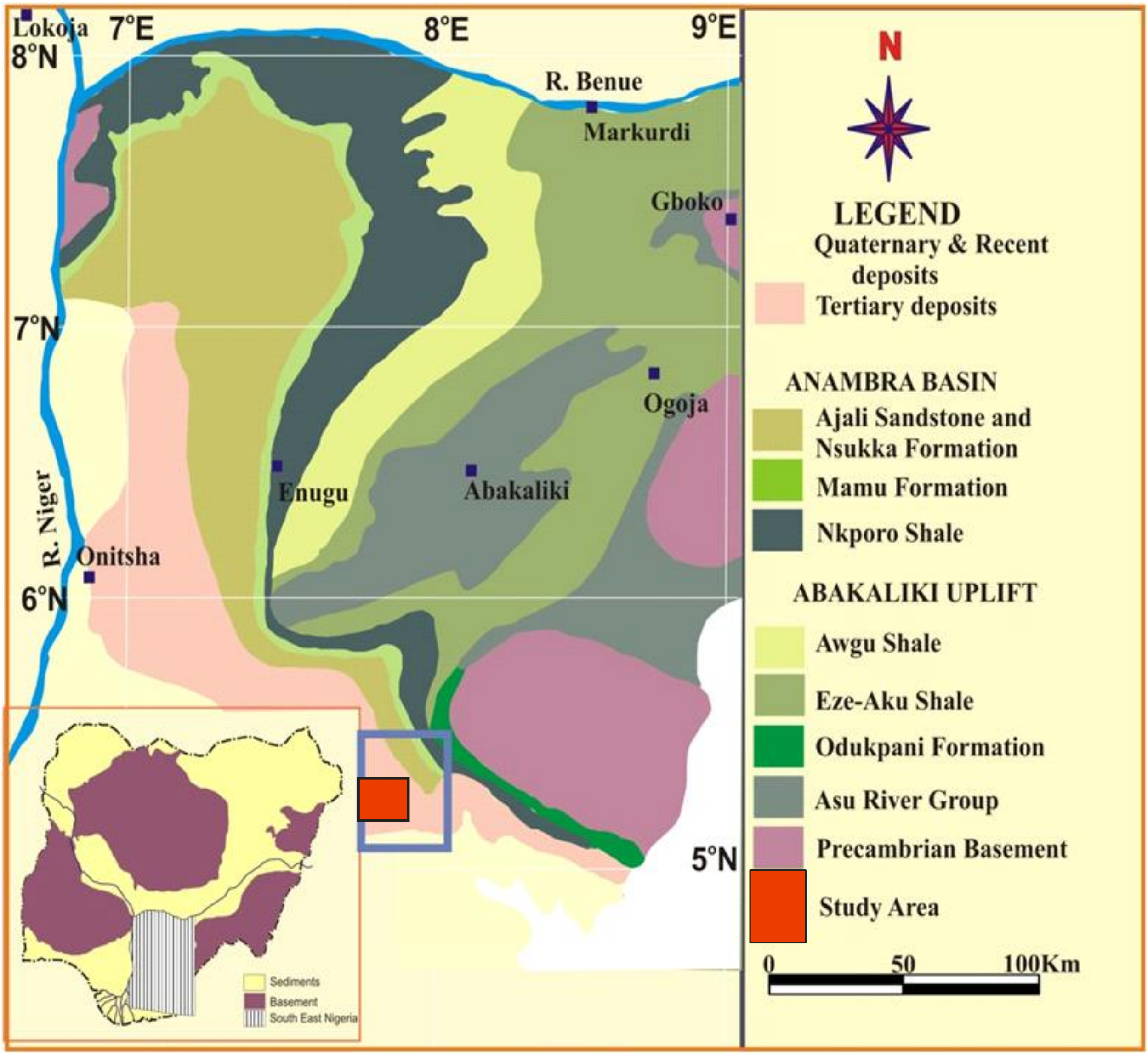

FIG.1 GEOLOGICAL MAP SHOWING THE STUDY AREA

II. METHODOLOGY

Field mapping was carried out using the topographic map of Ikot Ekpene, sheet 322 as the base map. All rock exposures within the study area were sedimentologically logged and described. Attitude of the beds were measured using a compass clinometer. The studied lithologic sections were systematically sampled and important features photographed. Rock samples obtained from the field were subjected to laboratory analyses.

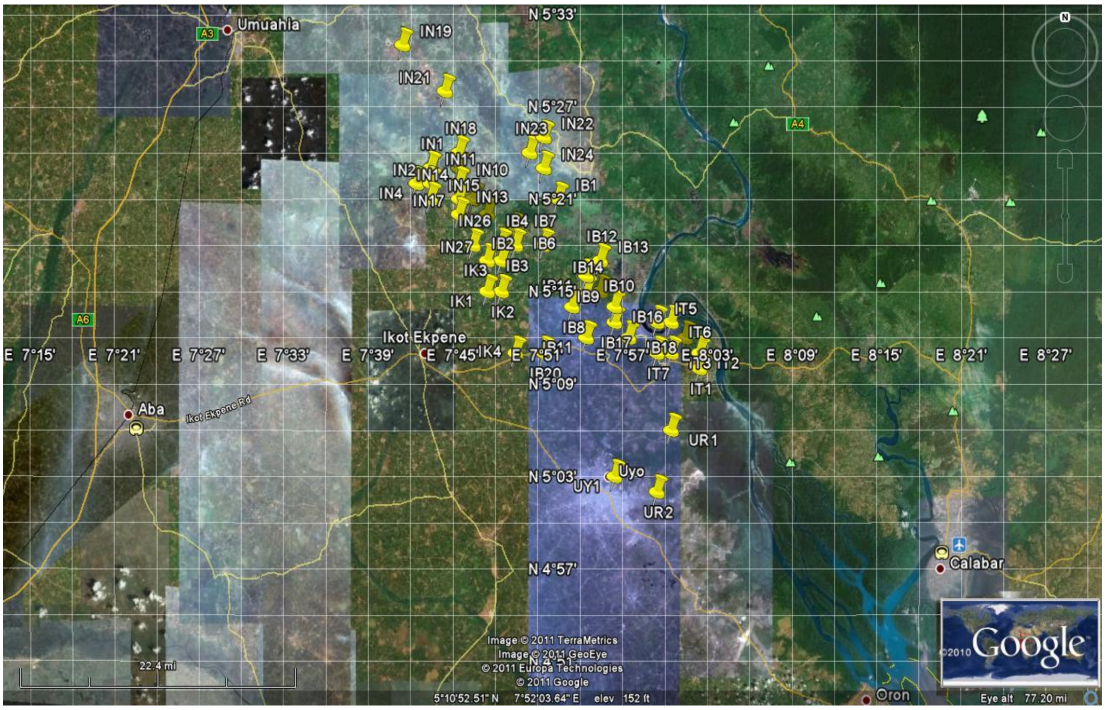

Fig 2: Sample location map

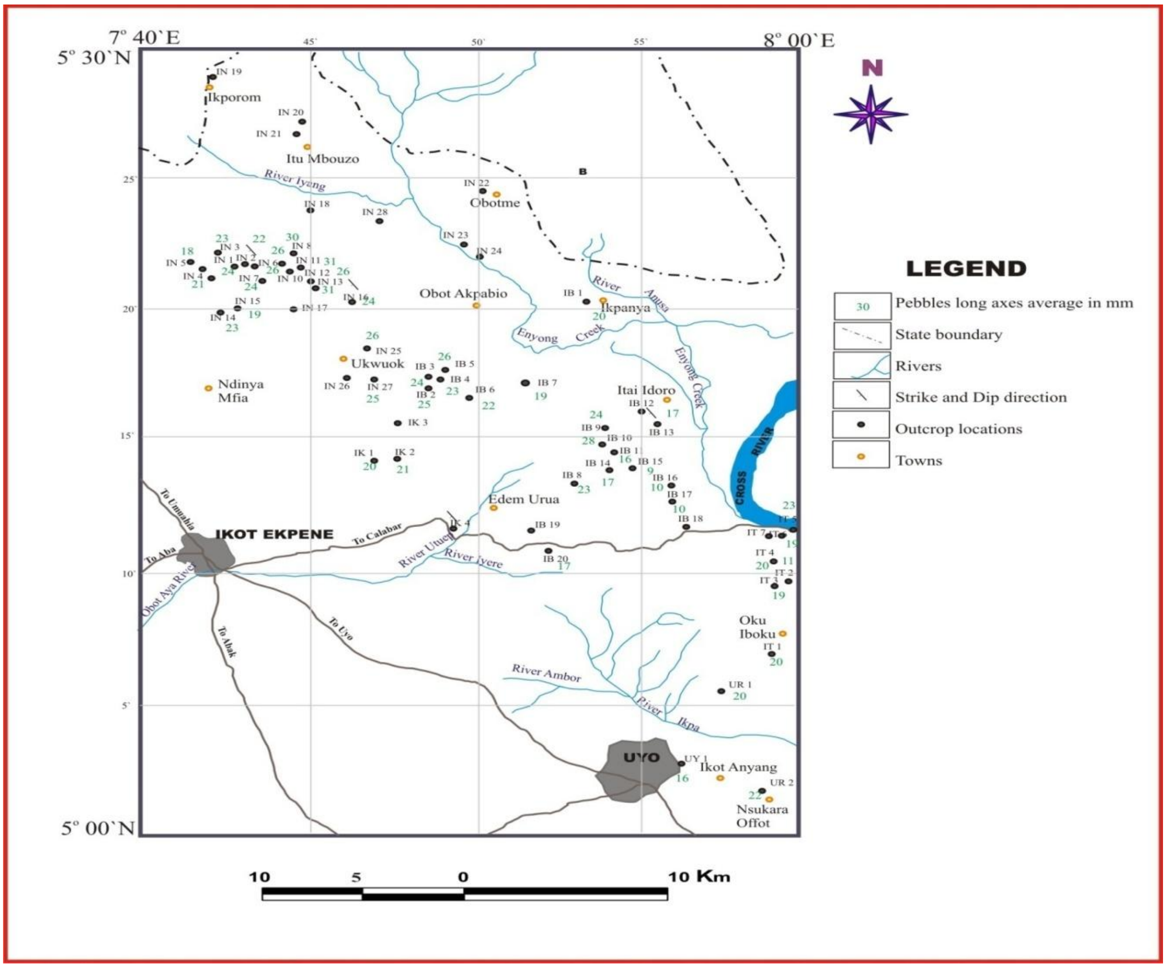

Fig. 3. SAMPLE LOCATION MAP

III. RESULT

Sedimentary Facies

Conglomerate and loosely consolidated sand beds form a belt of about 50km long and 11km wide in northeastern part of Akwa Ibom State. The conglomerate deposits consist of six sedimentary facies, defined on the basis of textural attributes, lithology and sedimentary structures. Most of them are sandstone to conglomerate dominated facies. Mudstone dominated Facies are less common.

CONGLOMERATE -DOMINATED FACIES

Cm**:** Paraconglomerate

This Facies consists of matrix-supported, massive conglomerate in beds 1.2 meter to 15.4 meters thick. Clasts range from 0.5cm to 8cm in diameter and made up of granules, pebbles and cobbles set in a matrix of clayey sand. They are subrounded to rounded, poorly sorted and consist of quartz. The long axes of the clasts are randomly arranged and there is neither an imbricated nor a horizontal fabric. The facies is poorly consolidated and has a reddish brown or white colour. There is complete absence of fossils. The base of this lithofacies is irregular and scoured. The presence of irregular bases gives a channel-like appearance to this facies. This facies forms about 10% of the conglomerate deposits. The facies is similar to Facies Gms of Miall, 1977.

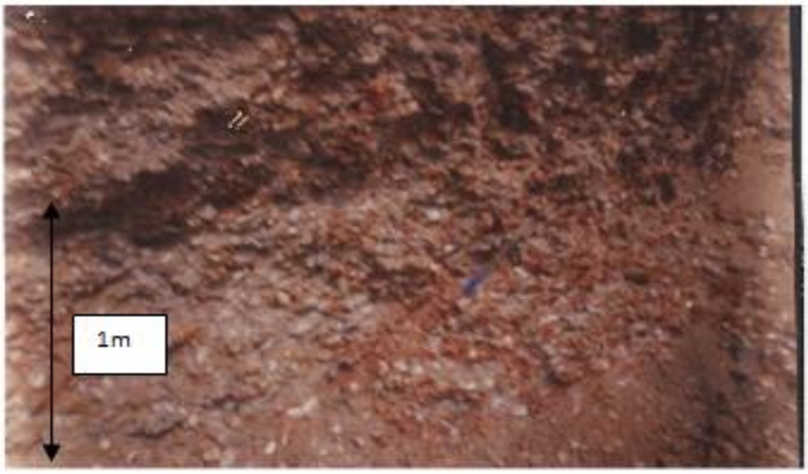

Plate 1: Paraconglomerate (Cm)

Cc: Orthoconglomerate

Lithofacies Cc is the dominant lithofacies in the conglomerate. This facies consists of clasts-supported, normally graded conglomerate in beds 0.5 meter to 12.4 meters thick. The conglomerate is normally graded from cobble as basal lag deposit to pebble size clasts and granules. Clasts range from 0.4cm to 8cm in diameter, subrounded to rounded, poorly sorted and made up of quartz. The matrix is fine to very coarse grained sand and fine grained gravels, occassionally with some amount of plant fragments. The fabric is highly unordered or disorganized with no clasts imbrication and stratification. The conglomerate has a reddish brown or white colour. Fossil is absent and the facies is poorly consolidated.

Thin beds of sand occur. The sandstone beds consists of gravelly, very coarse sandstones that is massive, cross stratified or horizontally stratified. The sandstone bed range in thickness from 10cm to 50cm. The grain size of the sediment is identical to that of the matrix of the underlying conglomerate. Occasionally, there is gradation from conglomerate to sandstone bed, but in most cases the junction is abrupt. The base of this lithofacies is irregular and erosional. A thin ferruginized band marks the lower contact at some places where the Facies overlies shale bed. The band is probably formed as a result permeability barrier between the two lithologies which traps the percolating rain

water from where iron precipitates out. This facies is overlain by sandstone and clay. It forms about 70% of the conglomerate deposits. The facies is similar to facies A of Amajor, 1986 and facies Gm of Miall, 1977.

Plate 2: Orthoconglomerate facies (Cc) exposed in a quarry.

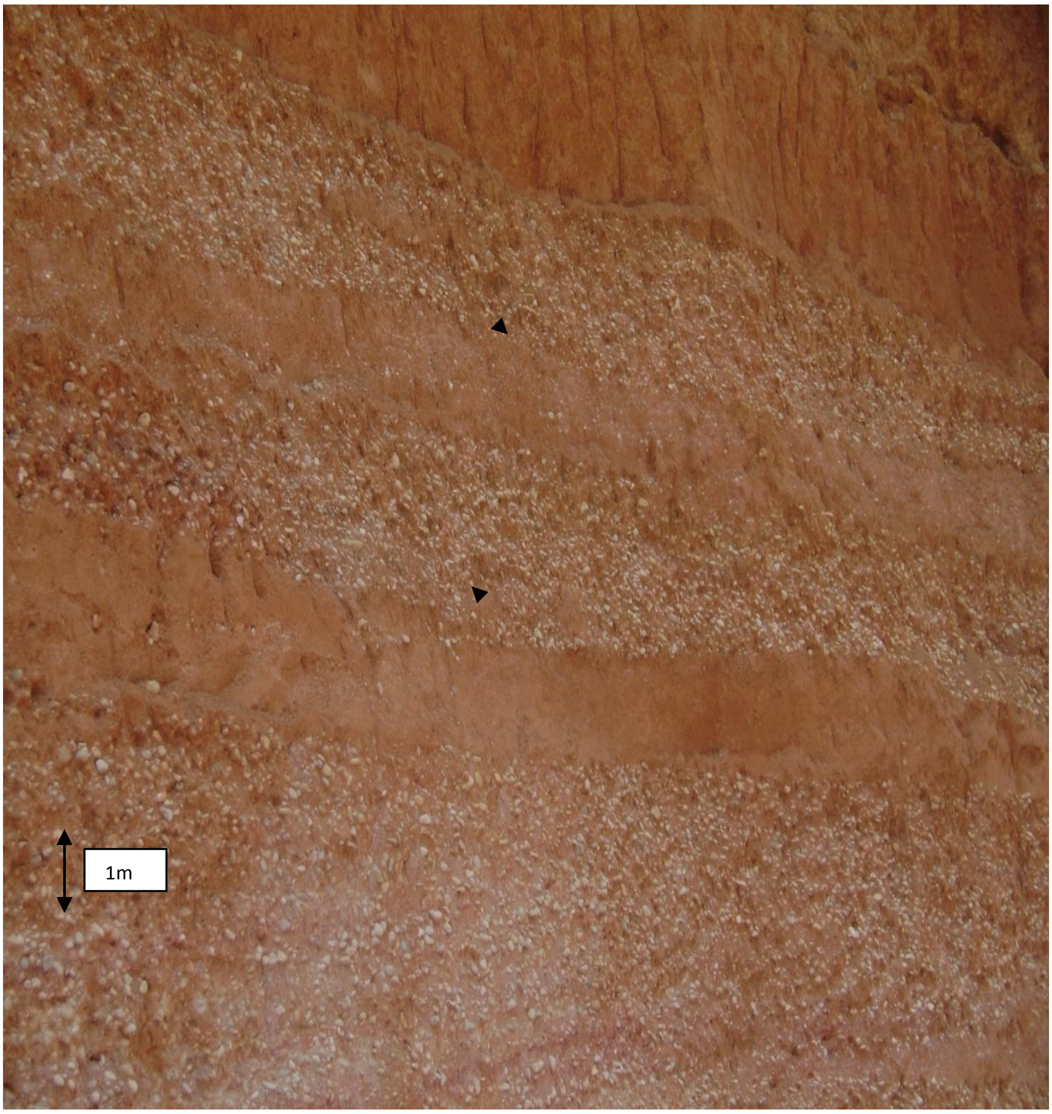

Plate 3: Orthoconglomerate facies (Cc) showing thin beds of sand.

IV. SANDSTONE-DOMINATED FACIES

Sm: Massive sandstone

This Lithofacies is a minor component of the conglomerate package, but commonly occurs within the sandstone rich section. It consists of fine to coarse grained massive sandstone in beds a few meters to centimeters thick. The sand grains are angular to subrounded and poorly to moderately sorted. Scattered pebbles ranging from 1cm to 2cm in diameter are present at some locations. Small organic fragments occur. The facies is friable, unconsolidated and does not exhibit any sedimentary structure nor contain any fossil. The colour of this facies is white or reddish brown. The base of this facies is sharp. This facies occupies about 10% of the conglomerate deposist. The facies is similar to facies B of Amajor, 1986.

Plate 4: Massive sandstone (Sm)

Plate 5: Facies Sm (Massive sandstone) exposed in a quarry.

Sc: Crossbedded sandstone

This lithofacies is a small proportion of the conglomerate package as a whole, but a major component of the sandstone rich fraction. It consists of medium to coarse grained, planar and trough crossbedded sandstone in beds a few meters to centimeters thick. Set thicknesses range from 30 to 100 centimeters. The sandstone is pebbly at some locations. Maximum pebble size observed is 2cm. The sandstone is poorly sorted, angular to subrounded with granules concentrated in some forests. The Facies is unconsolidated and does not contain any fossil. The colour of this Facies varies between shades of yellow, red, brown and white. The base of this Facies is abrupt. This Facies forms about 5% of the conglomerate deposits. The Facies is similar to Facies Sp of Miall, 1977.

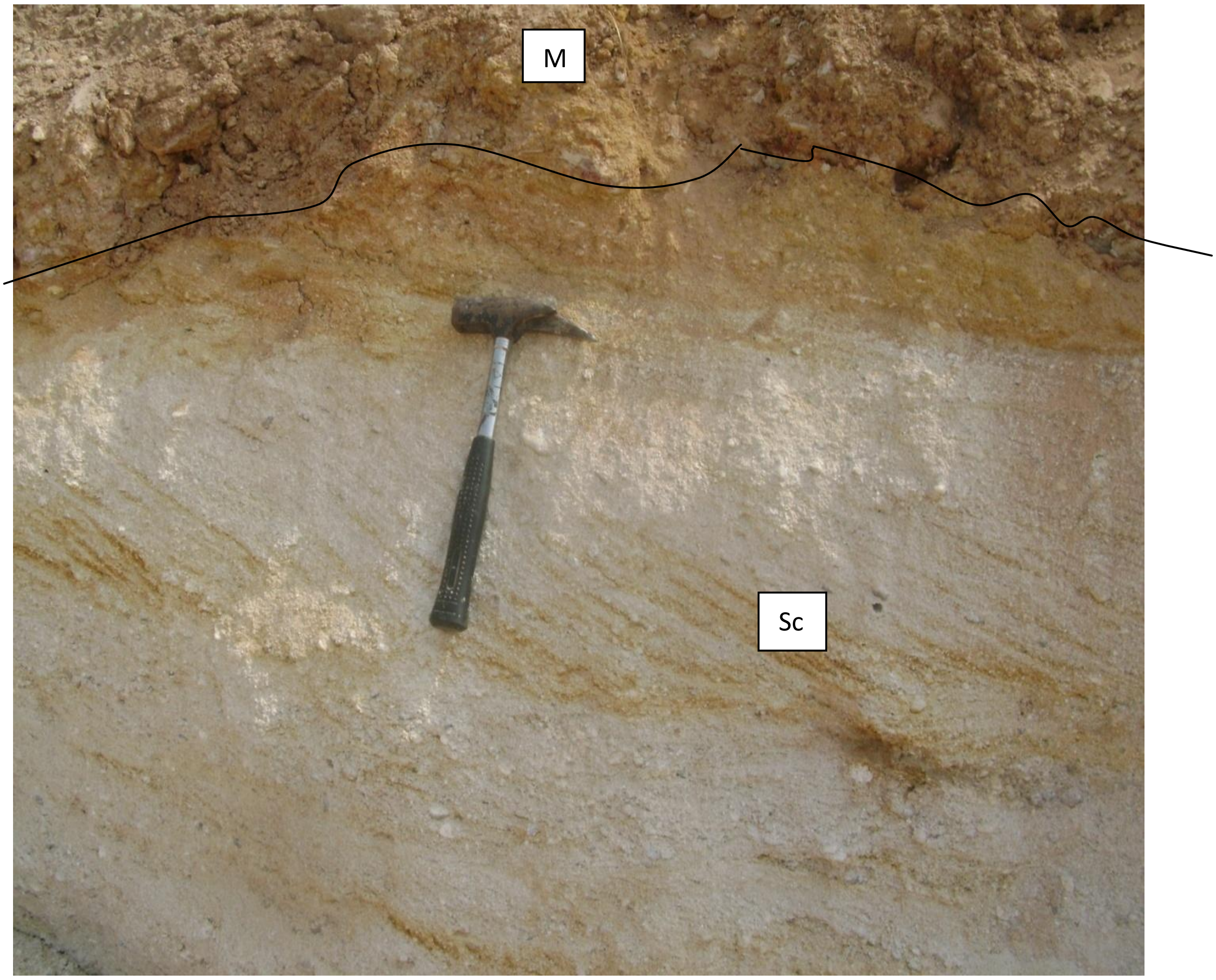

Plate 6: Crossbedded sandstone (Sc). The sandstone is overlain by mudstone.

Sp (Parallel laminated sandstone)

This lithofacies is characterized by parallel laminations. The stratifications appears as changes in grain size and by the presence of very thin fine grained siliciclastic rock laminae. The sandstone is fine to coarse grained, subangular to subrounded, poorly sorted, friable and has a white colour. There is complete absence of fossil. The base of this facies is sharp. This facies make up about 5% of the conglomerate deposits and either overlies the conglomerate or occurs as interbeds. The facies is similar to facies Sh of Miall, 1977.

Plate 7: Facies Sp (parallel laminated sandstone)

V . MUDSTONE-DOMINATED FACIES

M: Mudstone

This Facies consists of massive claystone and siltstone that lack any observable sedimentary structure, and also include bioturbated mudstone. This fine grained facies is Whitish, yellowish brown and mottled. Organic fragments are apparent. The base of the facies is flat or irregular but not erosional. This facies make up about 5% of the conglomerate deposits and mostly overlies the conglomerate and sandstone facies. The facies is similar to facies Fm of Miall, 1977.

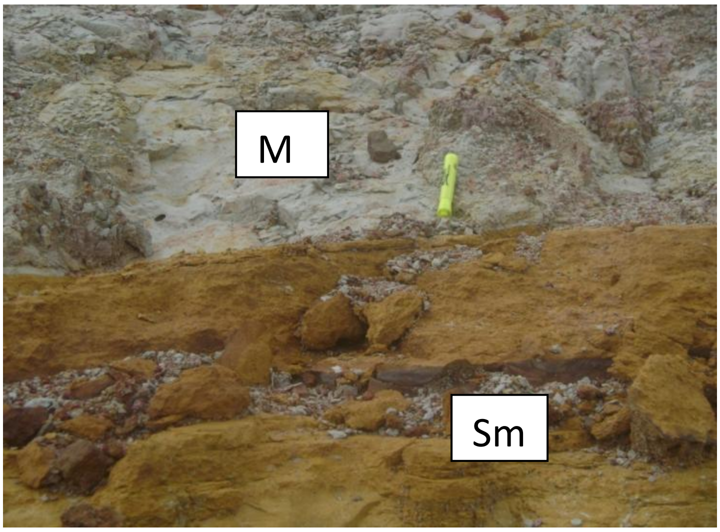

FIG.15: Sharp contact between facies M and Facies Sm.

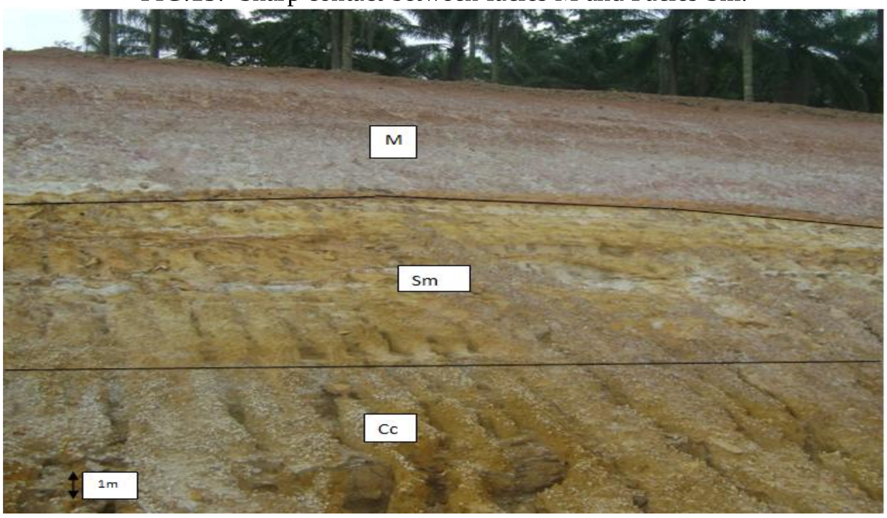

Plate 8 Facies Cc, Sm, M displaying a fining upward sequence.

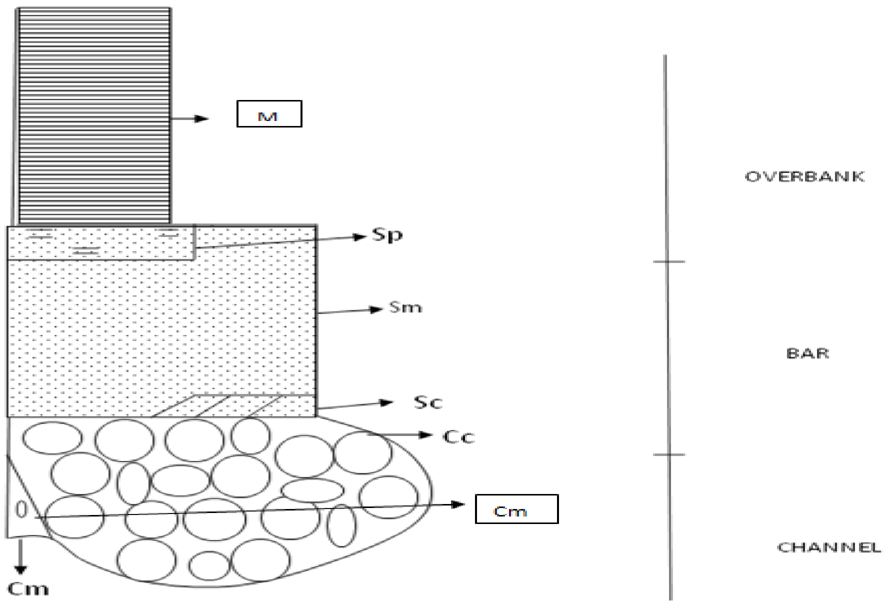

Fig.3 Vertical sedimentary facies model for the conglomerate deposits.

Interpretation of Depositional Processes/Discussion

The coarseness of the paraconglomerate facies (Cm), its poor sorting, absence of grading and stratification, lack of fossils and pebble imbrications and the general absence of associated crossbedding are all suggestive of a debris flow mode of origin (Blissenbach,1954; Beaty, 1963; Hook, 1967; Johnson, 1970, Fisher, 1971; Bull, 1972, Walker, 1975; Lowe, 1976; Kim and Lowe, 2004). The absence of preferred fabric means that the clasts were restricted in movement reletative to each other. The channeled form on some conglomerates of this facies came into being because the flows passively occupy preexisting channels (Miall,1996).

The thickness of the orthoconglomerate facies (Cc) beds and the arenaceous matrix implies the operation of mass-flows or streams of considerable magnitude. The presence of framework support may be due to the rolling and accretion of clasts along a bed. The matrix of very coarse sandstone is thought to have been transported in suspension simultaneously with bedload rolling of the large clasts. The essentially unstratified nature of the

conglomerates or paucity of imbricated fabric indicates that bedload rolling of clasts in equilibrium with ambient flow conditions was limited.

The graded bedding of this facies Cc indicates deposition from a single current as the energy and flow strength diminished. The erosional base of this facies represents channel scour that was formed by avulsion at relatively high water stage (William and Rust, 1969; Miall, 1977; Yagishita, 1997). It may also implies that facies Cc was deposited following a flood that eroded the strata below this Facies.

The gravelly very coarse sandstone wedges of facies Cc could have been transported in suspension by the same flow which was transporting the gravels of the underlying conglomerate as bedload (Walker,1975a). The sandstone wedges may therefore represent the upper part of a conglomerate sandstone couplet, deposited towards the end of the discharge cycle after flow velocities had wane slightly. The generally abrupt contact between orthoconglomerate and overlying sandstone wedge reflects the change from bedload rolling to suspension as the main transport mechanisms, and need not reflect sudden or large decrease in flow strengths. Based on the aforementioned interpretations, it is likely that the gravelly facies suggests deposition in channels. facies Cc is overlain by sandy and fine Facies Sm, Sp, and M.

Sedimentation in a given channel or channel complex results in aggradation above the surrounding area and a progressive loss of stream competency in response to the reduction in slope. This processes are reflected in the gross finding upward sequence. Probably during a flood event, the channel wall is breached and flow is diverted into topographically lower areas. The old channel or channel system is abandoned and the last sediment formed are fine grained deposit (Miall, 1977; Dyer,1970).

Massive sandy beds of facies Sm might be formed in response to depositional processes (McCabe, 1977; Jones and Rust, 1983) or by post depositional deformation (Allen, 1986). In the present interpretation, deformation is considered as irrelevant based on the absence of its indicators in any bed associated with facies Sm. Accordingly, this facies is interpreted as resulting from transport and deposition by short-lived mass flows.

The presence of planar cross-bedding, the grain size variations, and the thickness of the sets of crossbeds of facies Sc suggest that it might be formed by migration of 2-D dunes or bars. Their lee faces were the likely sites of avalanching of coarse sands and granules. Textural variations, where the coarse sands and granules tend to concentrate in foresets, were formed because sand is typically sorted by the process of ripple migration up to the stoss side of the dune or bars (Miall,1996).

The horizontal stratification exhibited by facies Sp is probably due to upper flow regime plane bed conditions.

Considering the nature of facies Sm, Sc and Sp and their close relation with facies Cc and M, these sandy facies are interpreted as channel to bar deposits. They are overlain by facies M.

The massive nature of facies M may be due to a very homogeneous and possibly rapid deposition from suspension or to lack of platy grains (Collinson and Thompson, 1982). facies M represents floodplain deposition.

Based on the aforementioned interpretations, it is clearly indicated that the overall fining upward association represents a sequence of channel-bar-overbank deposits of a braided fluvial system. Pebble morphometric result on these conglomerates support fluvial origin of the deposits (Udo in press). The linear outcrop pattern of the conglomerates is consistent with deposition in a valley confined braided river.

The conglomerates are not alluvial fan deposits of Amajor, 1986 because alluvial fans are localized accumulations formed where a stream emerges from a confined onto a trunk river or broad alluvial plain (Rust, 1979). In the case of the conglomerate of the study area, evidence showing that they are localized by any structural features or ancient mountain fronts have not been encountered. The poorly sorted nature of the conglomerates, paucity of imbricated fabric and discoidal pebbles nullifies the beach origin of Petters, 1989.

The conglomerate deposits are not meandering stream deposits because such deposits are made up of mainly sand, silt and clay (Nichols, 1998). The presence of larger clasts and the absence of facies usually associated with meandering stream environment in the study area suggest that these deposits are definitely not meandering.

Furthermore, the absence of striations means that the conglomerates are not of glacial origin. The conglomerates are not turbidity currents deposits because of the absence of Bouma sequence of sedimentary structures.

VI. CONCLUSION

This study reveals that the conglomerate deposits in Northeastern part of Akwa Ibom State, Nigeria which hitherto were regarded as either alluvial fan (Amajor, 1986) or beach (Petters, 1989) in origin, were likely deposited in a braided fluvial system.

VII. ACKNOWLEDGEMENT

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