ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 11| Issue: 9| September 2025|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2025: 8.691 || ISI Value: 1.188

INTEGRATED FACIES CHARACTERISATION OF HIGH-SINUOSITY FLUVIAL BODY, WESTERN FLANK OF ANAMBRA BASIN, SOUTHERN NIGERIA: A PRELIMINARY STUDY

Bayonle A. Omoniyi*, Samuel Falaye, Olaitan Oloruntoba
Department of Earth Sciences, Adekunle Ajasin University, Akungba-Akoko, Nigeria

**Corresponding Author:*
Present Address: Department of Earth Sciences Adekunle Ajasin University, Akungba-Akoko 342007, Ondo State, Nigeria

ABSTRACT

This paper presents preliminary interpretation of geological attributes of a high-sinuosity fluvial outcrop with the primary purpose of describing principal sediment facies, sand-body architecture, internal geometry, and initial assessment of facies-scale reservoir quality based on field observations and measurements. The information is used to conceptualise a geological concept for the fluvial body, which covers an estimated area of 48 km^2.

Four principal facies groups are recognised based on dominant lithology. These are: (F1) sand-prone heterolithic, (F2) sandstone, (F3) mud-prone heterolithic, and (F4) mudstone.

Field observations show that thick floodplain mudstone separate point bars, creating isolated stacking of sand bodies with potential as flow barriers. Presence of reservoir-quality sand in crevasse splays may help to improve vertical connectivity between two point bars. Presence of mud-lined lateral accretion surfaces within point bars may act as barriers to fluid flow in reservoir analogues. Furthermore, clay plugs that are randomly distributed, particularly at the basal parts of point bars, may cause flow baffling in reservoirs with similar depositional setting and geological attributes.

KEYWORDS: *Outcrop Analogue, Fluvial Reservoirs, High-Sinuosity, Sand-Body Architecture, Internal Geometry,*

1. INTRODUCTION

Fluvial deposits form complex hydrocarbon reservoirs that are difficult to characterise and simulate when modelling their flow behaviour. Although they are known for their hydrocarbon productivity in many basins (Miall, 1981), they are characterised by variable degree of sedimentary heterogeneity that makes sand bodies in these reservoirs to behave differently during passage of fluids. While low-sinuosity fluvial reservoirs lack extensive floodplain mudrock, displacement of hydrocarbon through them is affected by occurrence of randomly distributed clasts of claystone or mudstone, which act as baffles.

High-sinuosity fluvial systems are composed of mixed sediment load. As described in many ancient records (e.g. Miall, 2006, 2014, 2022; Galloway and Hobday, 1996; etc.), sequences of these systems comprise bedload sediment, usually sand, that is typically overlain by suspended load. In these sequences, it is common to have pebbles or gravels as basal lags overlying a scoured surface that precedes sandy intervals. Consequently, mixed load develops a point bar with characteristic upward-fining and upward-thinning bed succession. However, sand bodies in this succession are commonly separated by a thick mud plug, which is attributed to deposition by lateral accretion during flood event when fine sediments, usually clay-sized particles, are stripped from flow.

This paper presents preliminary interpretation of geological attributes of a high-sinuosity fluvial outcrop with the goal of describing its principal sediment facies, sand-body architecture, internal geometry, and an on-field evaluation of reservoir quality to conceptualise its geology. It is hoped that the information will lay a foundation for further study that will incorporate classification of architectural elements, lithostratigraphic concept, and geological modelling for better understanding of spatial distribution of sand bodies and assessment of their reservoir potential.

2. GEOLOGICAL SETTING, MATERIAL AND METHODS

This paper showcases some preliminary interpretations based on geological attributes of a high-sinuosity fluvial outcrop, following an ongoing geological fieldwork in the western flank of Anambra Basin. The intracratonic basin extends from the Lower Benue Trough to the west (Figure 1) and consists of sediments that are up to 5,000 m thick (Murat, 1972; Nwajide and Reijers, 1996). A review of the stratigraphy of the basin is presented by Omoniyi and Imagbe (2025).
The outcrop is located at Latitude N 07^{0}11'28.6" and Longitude E 006^{0}26'44.8" along Imiegba-Igodo township road in Edo North, southern Nigeria. It is accessible as a road cut and well preserved with only sparse vegetation at the top. It is about 48 m thick and

extends laterally for about 1 km, outcropping along the way towards Igodo town in the SW (Figure 2).

Twelve sedimentological logs were produced across selected points within the exposure based on observations and measurements made. The logs provide vertical views of variability in bed thickness, grain size, sorting, small-scale sedimentary structures, and facies relationships. Outcrop sketches were also made to describe lateral properties of the outcrop including sand-body architecture, internal geometry and dimension, sand-body continuity and lateral facies change, and more.

3. RESULTS AND DISCUSSION

3.1 Lithofacies Description

Based on lithology, we recognise four principal facies in the outcrop. These are summarised as follows:

Facies 1: Sand-prone heterolithic – silty/muddy sandstone, internal grading from sandstone to mudstone, very poor-to-poor sorting. Internal structures are current ripples, small-scale scour and fill. Generally, sandstone-to-mudstone ratio is 55:45.

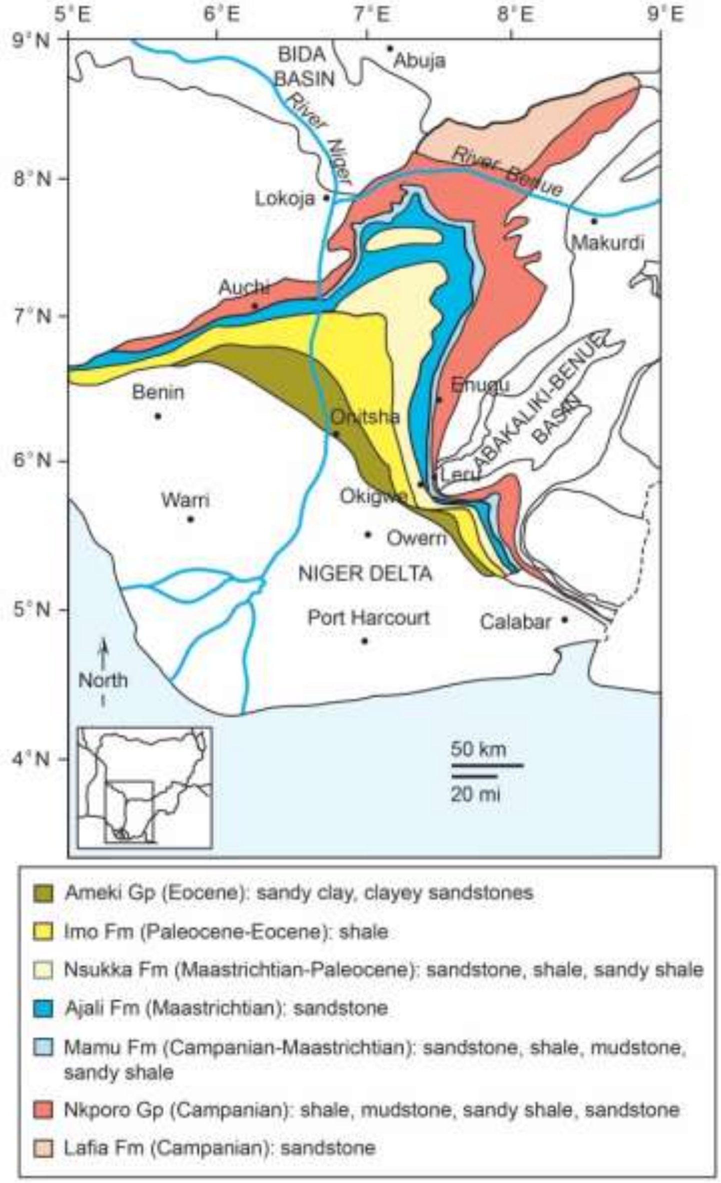

Figure 1. Map showing stratigraphic succession of Anambra Basin (Hoque and Nwajide, 1985).

Figure 2. Outcrop section used in this study. The outcrop has an areal extent of about 48 km^2, and extends approximately 1 km to the SW.

Facies 2: Sandstone - entirely sandstone. Sorting is poor-to-moderate. Internal structures are trough cross bedding, scoured surface, and current ripples. Better visual porosity than sand-prone heterolithic facies.

Facies 3: Mud-prone heterolithic – silty and sandy mudstone, ferruginised sandstone. Hard, very poorly sorted, no visual porosity.

Facies 4: Mudstone – entirely mudstone, locally shaly and fissile, carbonaceous in places.

Detail description of geological attributes of constituent sub-facies within the facies groups is expected in future work.

3.2 Sand-body architecture, internal geometry, and reservoir potential

A representative section showing sand-body architecture and internal geometry is presented in Figure 3. The section produced from photo coverage shows alternation of sandstone/sand-rich heterolithic layers and mudstone/mud-rich heterolithic layers. Thick sandy intervals are composed of mud-rich lateral accretion surfaces. Sandstone is both laterally discontinuous, separated by thin mudstone, and vertically isolated by thicker, often carbonaceous mudstone. In the upper section, sandstone is both laterally continuous, thick-bedded, and vertically connected. This part is mud-poor and comprises moderately-to-well sorted fine-to-medium sand. At the lower part of this section, sand is poorly cemented and friable. Sandstone-to-mudstone ratio in this part is 99:1. Internal structures are parallel bedding, internal lamination, and local internal grading.

Overall, the depositional architecture is dominated by mud-lined lateral accretion surfaces that develop within intervals of respective point bars (see Figure 3). These sequences are characterised by internal grading from coarse, locally pebbly sandstone in the basal part to fine silty sandstone and sandy mudstone at the top (Figure 4). In mudstone intervals, thin laterally extensive sandstone beds occur either below or above thick sandstone bodies as crevasse splays. These thin sandstone beds are absent in the upper part of the exposed section. Based on field-based assessment of sand-body architecture in the section, we summarise that:

1. Geological attributes of the section reflect deposition by a meandering river.
2. Visual porosity is best in lower parts of point bars.
3. Mud-lined lateral accretion surfaces that form within point bars may act as barriers to fluid flow in reservoir analogues.
4. Thick floodplain mudstone that separate point bars will impede vertical flow of hydrocarbon.
5. Randomly distributed clay plugs in point bars may act as flow baffles.
6. Because of their lateral extent, reservoir-quality sands in crevasse splays may improve vertical connectivity of two point bars where present.

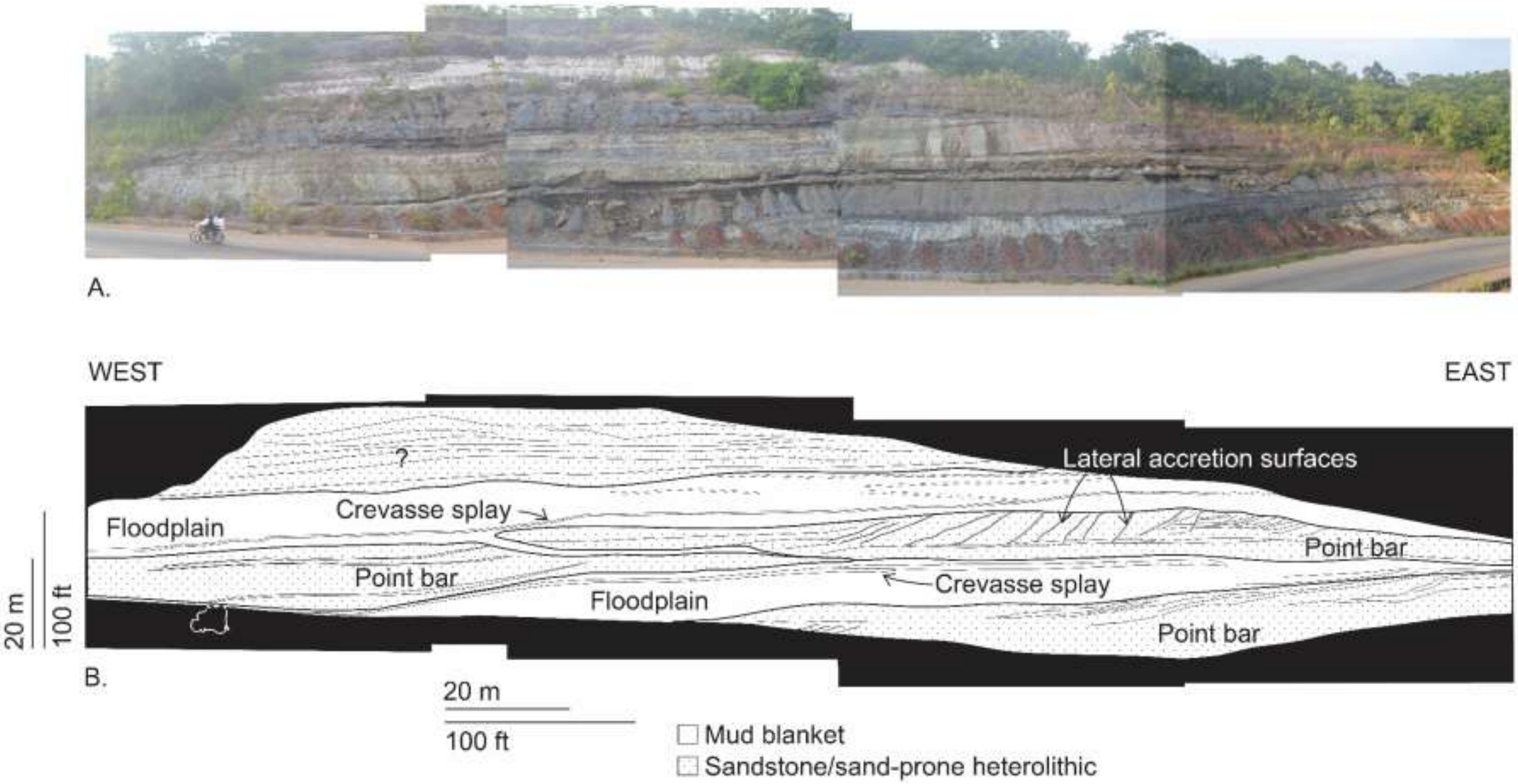

Figure 3. (A) Outcrop section, and (B) sand-body architecture of high-sinuosity fluvial body.

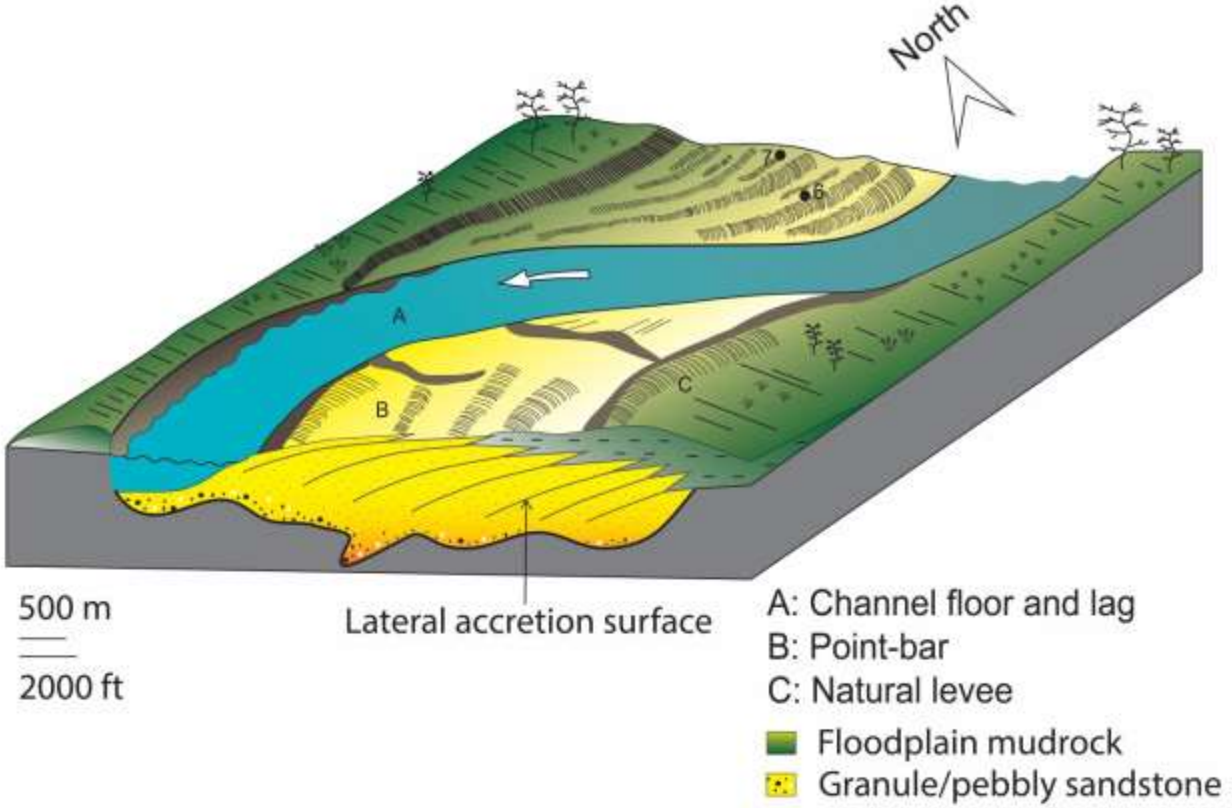

Figure 4. A block diagram of the geological concept illustrating depositional architecture of the fluvial body.

Acknowledgements

The authors are grateful to the two anonymous reviewers for their positive feedback.

REFERENCES

1. *Galloway, W.E., Hobday, D.K., 1996. Terrigenous Clastic Depositional Systems: Applications to Fossil Fuel and Groundwater Resources, second edition. Springer-Verlag.*
2. *Hoque M, Nwajide C.S., 1985. Tectono-sedimentological evolution of an elongate intracratonic basin (aulacogen): The case of the Benue Trough of Nigeria. Mining and Geology 21, 19-26.*
3. *Miall, A.D., 1981. Analysis of fluvial depositional systems. Canada. American Association of Petroleum Geologists Education, course note series 20, 75 p.*
4. *Miall, A.D., 2006. The geology of fluvial deposits: sedimentary facies, basin analysis, and petroleum geology. Springer, Berlin.*
5. *Miall, A.D., 2014. Fluvial depositional systems. Springer.*
6. *Miall, A.D., 2022. Stratigraphy: A modern synthesis, second edition. Springer.*
7. *Murat R.C., 1972. Stratigraphy and paleogeography of the Cretaceous and Lower Tertiary in southern Nigeria, in: Dessauvagie T.F.J., Whiteman A.J. (Eds.), African Geology. University of Ibadan Press, Ibadan, p. 251-266.*
8. *Nwajide C.S., Reijers T.J.A., 1996. Sequence architecture in outcrops: Examples from the Anambra Basin, Nigeria. Nigerian Association of Petroleum Explorationist Bulletin 11, p. 23–33.*
9. *Omoniyi, B.A., Imagbe, L.O., 2025. Anatomy and facies analysis of fluvial body, western flank of Anambra Basin, southern Nigeria: an outcrop study. Geography, Environment and Earth Science International 29(2), p. 43-65.*