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A paleogeographic model for the sandstone members of the Imo Shale, south-eastern Nigeria

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ABSTRACT

A new interpretation of the Palaeocene to Eocene strata of SE Nigeria has been developed based on field facies analysis and borehole data from the area. The area is considered to have been a tidally-dominated shelf setting which underwent a series of changes in sea level during the deposition of the Imo Shale. An initial transgression led to the deposition of a widespread marine shale unit that is interpreted as an offshore succession. This was followed by an influx of sands that are texturally mature, coarse to fine-grained that show large-scale cross-stratification with dip angles of between 15° and 25°. These are interpreted as the deposits of large sandwaves on a tidally-dominated shelf. Transport direction determined by the dominant large scale cross beds indicate a north-westerly transport direction. The presence of illite and nontronite clay mineral types in the offshore shales typically suggest marine environment whereas the occurrence of kaolinite which indicates terrestrial influence. A shale bed above the sand wave unit is overlain by wave-ripple cross-laminated sandstone considered to have formed in an upper shoreface setting. An overlying fossiliferous shale with a restricted fauna and shell lag is interpreted as having been formed in a lagoon with restricted circulation. The progradational succession is capped by a return to deeper water facies comprising a mixed carbonate–siliciclastic succession. This includes mudstone with limestone layers, calcareous sandstone with fossiliferous marl beds, fossiliferous and bioturbated sandstone. These beds represent a relative sea level rise on the shelf, accompanied by a decrease in siliciclastic input. This data provides a new conceptual model for the paleogeographic evolution of the sandstone member of the Imo Shale.

1. Introduction

A discussion of the Imo Shale Formation, commonly known as Imo Shale, was first published under the title "Imo River Shales" by Tattam (1944). The unit is widely distributed across south-eastern Nigeria, and dated Paleocene to lower Eocene (Short and Stauble, 1967). Its outcrop area extends from the Calabar Flank, through the Afikpo area, across the River Niger and westwards to the Okitipupa ridge. It is referred to as the proto-Niger Delta and known to be the lateral equivalent and an updip continuation of the subsurface Akata Formation of the Niger Delta Basin (Frankl and Cordry, 1967; Short and Stauble, 1967; Kogbe, 1976; Petters, 1991). The unit is estimated to be *ca.* 1000 m thick (Reyment, 1965, p. 90) and contains three sand bodies – Ebenebe Sandstone, Umuna Sandstone and Igbaku Sandstone.

Various studies – palynological, sedimentological and stratigraphic – have depicted the lower sandstone member as a foreshore–shoreface deposit (Reijers et al., 1997), delta front facies (Anyanwu and Arua, 1990), and an estuarine lithic fill (Oboh-Ikuenobe et al., 2005). A sequence stratigraphic framework has been formulated for the unit (Odunze and Obi, 2011).

This study uses facies associations and results of clay mineral studies to propose a new paleogeographic model for the Imo Shale and its sandstone members. Palynology is also integrated to provide additional information on the depositional environment of the Imo Shale, particularly the Ebenebe–Awka axis and to test the interpreted paleoenvironment of deposition based on sedimentological facies analysis.

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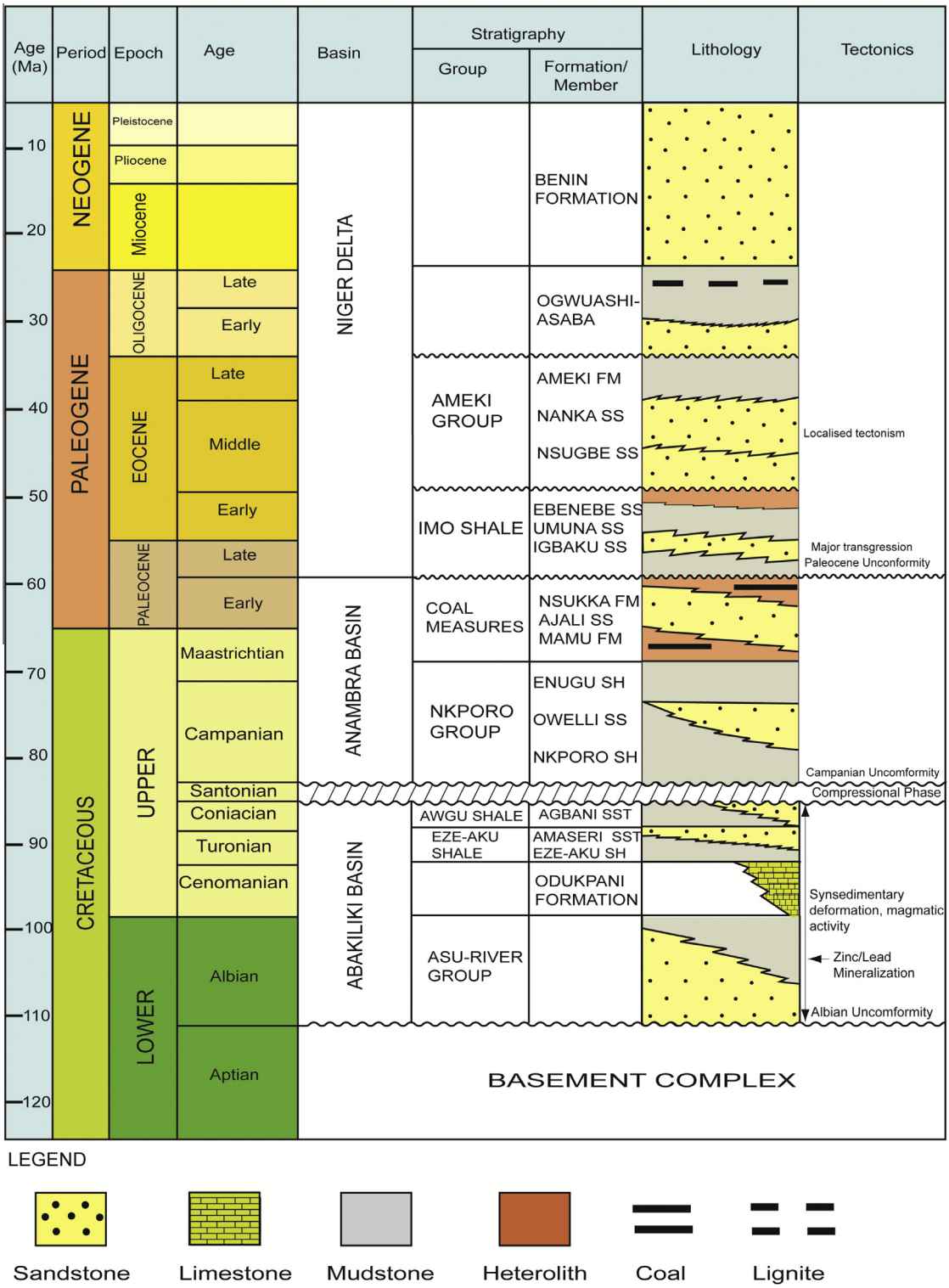

Fig. 1. Stratigraphic succession in the Anambra Basin and Niger Delta (redrawn and modified from Short and Stauble, 1967; Nwajide, 2005).

2. Regional geological framework

The stratigraphic frameworks of the southern sedimentary basins are represented in three depositional phases which are the Aptian–Santonian, the Campanian–Early Eocene and the Late Eocene–Pliocene depositional phases (Short and Stauble, 1967; Nwachukwu, 1972; Murat, 1972; Oboh-Ikuenobe et al., 2005).

The Aptian–Santonian phases began with Aptian sediments thought to be of continental origin (Benkhelil, 1989), and characterised by non-fossiliferous, arkosic, cross-bedded quartzose sandstone (Short and Stauble, 1967). The geology, sedimentology and stratigraphy of the Aptian–Santonian phase is well documented in the works of Short and Stauble (1967), Nwachukwu (1972), Hoque (1977), Benkhelil (1989). This sedimentary phase ended with the Santonian thermotectonic event (Fig. 1) that led to the uplift, faulting and folding of the sediments. Subsequent to the Santonian folding, the Abakaliki Basin became flexurally inverted forming anticlinorium and displacing the depocentre to