ANALYSIS

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Discovery

# Drill Core exploration for estimation of Limestone resources in Effium area near Abakaliki, S/E Nigeria

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**Limestone is essential and a principal raw material including and for Portland cements manufacturing. During geological investigation and evaluation, the geology and geometry of its deposits is ascertained. Ideally the information expected should cover all the properties which are important in the resource's valuation. This directs and enhances the quarry design and the operational methods. Detailed surface reconnaissance geological mapping were complimented and probed with exploratory core-drilling using diamond impregnated bits on core recovery barrel appendaged on a GX-Y-1 rotary rig. Cored-holes logging, recovered litho-core sample logging including strata-logging and correlation check-mated by subsequent attesting laboratory analysis of the litho-cored samples exercise were performed. Suitable softwares such as Mapsource, Rockworks 16 and excel were used at different times where and when needed in the course of this research. Lithologic units properties were imported into Rockworks 16 software environment and used to establish the limestone reserve estimates within the exploration lease area. The deposit estimate infers an economic viable resource.**

**Keywords: Core-drilling, limestone, litholog, Portland cement, reconnaissance, Rockworks 16, viable resource.**

## INTRODUCTION

Establishment of a factory requires a preliminary investigation for the availability of the foremost raw material; its quantity and quality. Low attention given to the industrial implication of improper preliminary investigation of the raw material most often leads to imminent failure. Several workers (Adeleye and Fayose, 1978; Petters and Reijers, 1997; 1987; Ekwere *et al*., 1994; Chidomerem, 2004; Akpan *et al*., 2014; Onyeagocha, 1986; Rahman *et al*., 1988; CRSG, 1989; Edet, 2004; Reyment 1965, Dessauvagie 1968, Nair *et al*., 1982, Zaborski 1982, Ramanathan and Nair 1984, Akpan 1992, Onwe *et al*., 2017a and b) have reported the occurrence of limestone deposit within the Benue trough. The geological history of the Nigeria Benue trough basin appears to have Limestone-forming environments especially the shallow coastal marine conditions, occurred, re-occurred several times and re-occuring. From the Calabar Flank, one of the main carbonate province- Mfamosing, Odukpani, Ewen, Agbangana through Utuma Omon, Mbiabong Ukwa, Arochukwu, Ikwo, Odomoke, Nkalagu and Effium in Easthern Nigeria to Agila, Igumale and Yandev in the central Nigeria to Ashaka Pindiga, Kanawa, and Gombe in the northeast of the country; Kambaina Sokoto in the north western and Ibeshe, Shagamu in the western Nigeria. Economic viable limestone resources in Nigeria appears to be contained and constrained within the Benue trough. Nearly all the limestone deposits in the trough are used for the manufacture of cement. Ibeto cement company investigated the viability of limestone deposit in some parts of these areas for the establishment of a Portlant cement production plant. This research evaluated the volumetric estimate of limestone occurrence using recovered core logs from core drilling program. The Rockworks 16 software were used for this evaluation.

## Geological Setting

The study area occupies the lower part of the Benue trough. It is located within N6$^0$ 44.626', E08$^0$ 00.762'; N06$^0$ 42.876', E08$^0$ 02.870'; N06$^0$ 40.137', E07$^0$ 59.507' and N06$^0$ 41.855', E07 57.411' (Fig.1). Effium belongs to southern equatorial climatic zone, characterized by heavy rainfall and short dry seasons. The mean annual rainfall is 150 – 186 cm while annual relative humidity is over 80%. Mean annual temperature exceeds 21$^0$C. Reconnaissance survey of the area reveal dendritic drainage pattern is prevalent. The land is covered with tall grasses of lush savannah and tropical bush which is supporting agriculture of various types. However, due to climatic change observed in recent times, there is a gradual shift on these records. Rainfall becoming varied, humidity low and gradual disappearance of trees and tall grasses. The depositional history of the Benue trough is characterized by phases of marine regression and transgression (Murat 1972; Reyment 1965; Short and Stauble 1967). Its sedimentary sequences were interrupted by large scale tectonism which occurred in two phases: the Cenomanian and the Santonian deformations (Nwachukwu 1972; Olade 1975), table 1.

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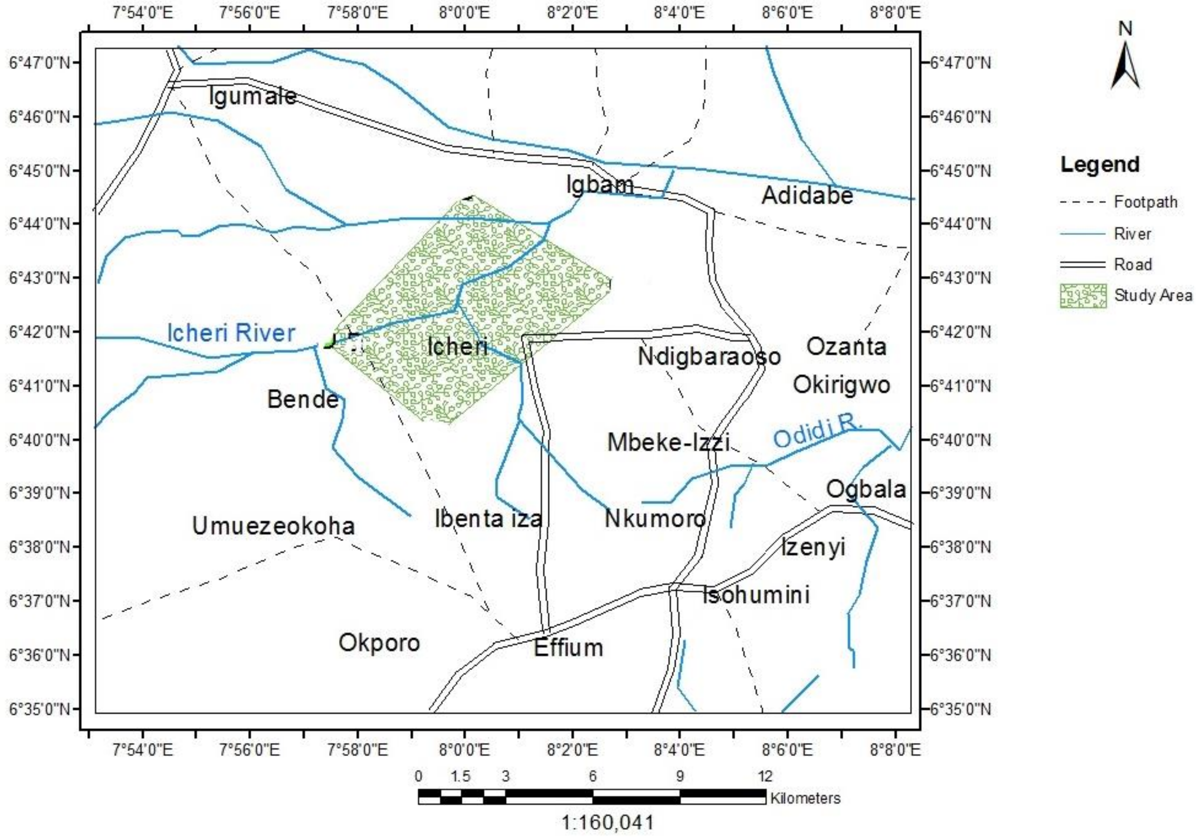



**Figure 1** Map of the study area

**Table 1** tectonic phases in Benue trough

| AGE | LOWER BENUE | | | | |
|---|---|---|---|---|---|
| Quaternary | Third tectonic phase | Niger Delta | Benin | | |
| Pliocene | | | | | |
| Miocene | | | Agbada | | |
| Oligocene | | | Akata | Nanka | |
| Eocene | | | | | |
| Palaeocene | Second | Anambra Basin | Ameki | Imo | Nsukka |
| Mastrichtian | | | Ajali | Owelli | Mamu |
| Campanian | | | Nkporo | Enugu | |
| Santonian | First tectonic phase | Cross River Group | | | |
| Coniacian | | | Agbani | | |
| Turonian | | | Nkalagu | | |
| Cenomanian | | | Agala | | |
| | | | Odukpani | | |
| Albian | | | Asu River group | Mfamosing | |
| | | | | Abakaliki | |
| Pre-Albian | | | Basement | | |

Unconformity
Santonian deformation
Transitional boundary

**Table 2** Depositional Sedimentary cycles in the Benue trough

| AGE | FORMATION | SEDIMENTARY CYCLE |
|---|---|---|
| Pliocene | Benin Formation | Niger-Delta basin (Third tectonic phase) |
| Pleistocene | Ogwash-Asaba Formation | |
| Eocene | Ameki Formation | |
| Paleocene | Imo Shale | |
| Maastrichtian | Nsukka Formation<br>Ajali Sandstone<br>Mamu Formation | Anambra-Afikpo Basin (second sedimentary cycle). |
| Campanian | Nkporo/Enugu Shale (including Afikpo Sandstone and Owerri Sandstones). | |
| Santonian<br>Coniacian | Awgu Shale | Abakaliki-Benue Basin (first sedimentary cycle). |
| Turonian<br>Cenomanian<br>Albian | Ezeaku Formation<br>Odukpani Formation<br>Asu-River Group | |

**Table 3** Core drill locations identification and briefs

| S/n | Core Point id | Location Name | Coordinates | Date Started | Date Stopped | Dept (m) | Major rock types |
|---|---|---|---|---|---|---|---|
| 01 | EFM 3004 | Otukpo Akparata | N 06 43 X E 08 01 X | 13/10/15 | 16/10/15 | 35 | Limestone, granitic rock |
| 02 | EFM 3005 | Ndiulo Akparata | N 06 43 X E 08 01 X | 16/10/15 | 18/10/15 | 18 | Granitic Breccias |
| 03 | EFM 3007 | Ndiulo Akparata | N 06 43 X E 08 01 X | 13/10/15 | 16/10/15 | 18 | Granitic Breccias |
| 04 | EFM 3008 | Enwumiri Akparata | N 06 43 X E 08 01 X | 17/10/15 | 18/10/15 | 5 | Granitic Breccias |
| 05 | EFM 3009 | Ekpeeka Akparata | N 06 43 X E 08 01 X | 13/10/15 | 16/10/15 | 34 | Limestone, granitic rock |
| 06 | EFM 3010 | Ekpeeka Akparata | N 06 43 X E 08 01 X | 18/10/15 | 19/10/15 | 35 | Limestone with shale intercalation |
| 07 | EFM 3011 | Ekpeeka Akparata | N 06 43 X E 08 02 X | 18/10/15 | 21/10/15 | 35 | Limestone, granitic rock |
| 08 | EFM 3012 | Lebadagom Akparata | N 06 43 X E 08 02 X | 22/10/15 | 24/10/15 | 35 | Sandstone, limestone, shale |
| 09 | EFM 3013 | Lebadagom Akparata | N 06 43 X E 08 02 X | 22/10/15 | 23/10/15 | 35 | Sandstone, limestone, shale |
| 10 | EFM 3014 | Lebadagom Akparata | N 06 43 X E 08 02 X | 23/10/15 | 25/10/15 | 35 | Sandstone, limestone, shale |
| 11 | EFM 3015 | Lebadagom Akparata | N 06 43 X E 08 02 X | 21/10/15 | 23/10/15 | 35 | Siltstone, ferruginized mudstone |
| 12 | EFM 3016 | Lebadagom Akparata | N 06 42 X E 08 02 X | 19/10/15 | 21/10/15 | 35 | Siltstone, ferruginized mudstone |
| 13 | EFM 2010 | Okpudu | N 06 43 X E 07 59 X | 24/10/15 | 28/10/15 | 35 | Shaly- limestone |
| 14 | EFM 2011 | Okpudu | N 06 43 X E 07 59 X | 24/10/15 | 26/10/15 | 35 | Limestone with shale intercalation |
| 15 | EFM 2012 | Okpudu | N 06 43 X E 07 59 X | 26/10/15 | 29/10/15 | 35 | Limestone with shale intercalation |
| 16 | EFM 2013 | St. Paul, Onu-Nwokporo | N 06 42 X E 08 00 X | 29/10/15 | 05/11/15 | 35 | ? Basaltic, Arenaceous Siltstone |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 17 | EFM 2014 | Onu-Nwokporo | N 06 42 X E 08 00 X | 30/10/15 | 04/11/15 | 35 | Arenaceous Siltymudstone |
| 18 | EFM 2017 | Okposo | N 06 42 X E 08 00 X | 28/10/15 | 30/10/15 | 35 | ? Basaltic, Arenaceous Siltstone |
| 19 | EFM 2018 | Okposo | N 06 42 X E 08 00 X | 03/11/15 | 06/11/15 | 18 | ? Basaltic, Arenaceous Siltstone |
| 20 | EFM 2019 | Okposo | N 06 46 X E 08 00 X | 03/11/15 | 07/11/15 | 35 | Ferruginized siliceous, mudstone |
| 21 | EFM 2020 | Inyimagu I | N 06 42 X E 08 01 X | 13/11/15 | 15/11/15 | 35 | Limestone, shale |
| 22 | EFM 2021 | Inyimagu I | N 06 42 X E 08 01 X | 07/11/15 | 11/11/15 | 45 | Clay, Limestone, limyshale, mudstone |
| 23 | EFM 2022 | Inyimagu I | N 06 42 X E 08 01 X | 08/11/15 | 11/11/15 | 45 | Clay, Limestone, limyshale, mudstone |
| 24 | EFM 2023 | Inyimagu I | N 06 42 X E 08 01 X | 06/11/15 | 07/11/15 | 35 | Ferruginized siltymudstone, shale |
| 25 | EFM 2024 | Inyimagu I | N 06 42 X E 08 01 X | 08/11/15 | 10/11/15 | 35 | Ferruginized siltymudstone, shale |
| 26 | EFM 2032 | Inyimagu II | N 06 41 X E 08 02 X | 11/1115 | 12/11/15 | 35 | Ferruginized siltymudstone, shale |
| 27 | EFM 2033 | Inyimagu II | N 06 41 X E 08 02 X | 13/11/15 | 14/11/15 | 35 | Ferruginized siltymudstone, shale |
| 28 | EFM 2604 | Akparata | N 06 43 X E 08 01 X | 23/11/15 | 26/11/15 | 35 | Limestone, shale |
| 29 | EFM 2605 | Akparata | N 06 42 X E 08 01 X | 23/11/15 | 26/11/15 | 35 | Limestone, shale |
| 30 | EFM 2606 | Akparata | N 06 42 X E 08 01 X | 23/11/15 | 26/11/15 | 35 | Limestone, shale |
| 31 | EFM 2303 | Onu-nwokporo | N 06 43 X E 08 00 X | 25/11/15 | 27/11/15 | 50 | Limestone, shale |
| 32 | EFM 2304 | Isisa | N 06 42 X E 08 01 X | 27/11/15 | 28/11/15 | | Limestone, shale, Artesian |
| 33 | EFM 2305 | Isisa | N 06 42 X E 08 01 X | 26/11/15 | 29/11/15 | | Limestone, shale intercalation, Artesian |
| 34 | EFM 2306 | Isisa | N 06 42 X E 08 01 X | 27/11/15 | 29/11/15 | 35 | Limestone, shale intercalation |
| 35 | EFM 2012B | Okpudu | N 06 42 X E 07 59 X | 23/11/15 | 24/11/15 | 35 | Limestone, shale intercalation |
| 36 | EFM 2801 | Onu- nwokporo | N 06 43 X E 08 00 X | 28/11/15 | 30/11/15 | 35 | Limestone, shale |
| 37 | EFM 1010 | Obeagu Inikiri | N 06 40 X E 07 59 X | 30/11/15 | 02/12/15 | 35 | Limestone, Sandstone, shale |
| 38 | EFM 2303 | Onu- nwokporo | N 06 43 X E 08 00 X | 01/12/15 | 02/12/15 | 35 | Limestone, Sandstone, shale |
| 39 | EFM 1009 | Obeagu Inikiri | N 06 40 X E 07 59 X | 01/12/15 | 02/12/15 | 35 | Limestone, Sandstone, shale |
| 40 | EFM 1011 | Obeagu Inikiri | N 06 40 X E 07 59 X | 01/12/15 | 03/12/15 | 35 | Limestone, Sandstone, shale |
| 41 | EFM 1206 | Onu-Inikiri Benard | N 06 41 X E 08 00 X | 02/12/15 | 04/12/15 | 35 | Limestone, Sandstone, shale |
| 42 | EFM 1008 | Obeagu Inikiri | N 06 40 X E 07 59 X | 03/12/15 | 04/12/15 | 35 | Limestone, Sandstone, shale, Artesian |
| 43 | EFM 1606 | Eguenyi I/ Onu- nwokporo | N 06 41 X E 08 00 X | 03/12/15 | 05/12/15 | 35 | Arenaceous sandstone, mudstone |
| 44 | EFM 1205 | Onu-Inikiri | N 06 41 X E 07 59 X | 04/12/15 | 06/12/15 | 33 | Limestone, Sandstone, shale |
| 45 | EFM 1405 | Eguenyi I | N 06 41 X E 08 00 X | 05/12/15 | 07/12/15 | 35 | Limestone, Sandstone, shale |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 46 | EFM 1204 | Onu-Inikiri | N 06 41 X E 07 59 X | 05/12/15 | 06/12/15 | 35 | Limestone, Sandstone, shale |
| 47 | EFM 1605 | Eguenyi I/ Onu-nwokporo | N 06 41 X E 08 00 X | 06/12/15 | 07/12/15 | 35 | Limestone, Sandstone, shale |
| 48 | EFM 1406 | Eguenyi I | N 06 41 X E 08 00 X | 07/12/15 | 08/12/15 | 35 | Limestone, Sandstone, shale |
| 49 | EFM 1404 | Eguenyi I | N 06 41 X E 08 00 X | 08/12/15 | 09/12/15 | 35 | Limestone, Sandstone, shale |

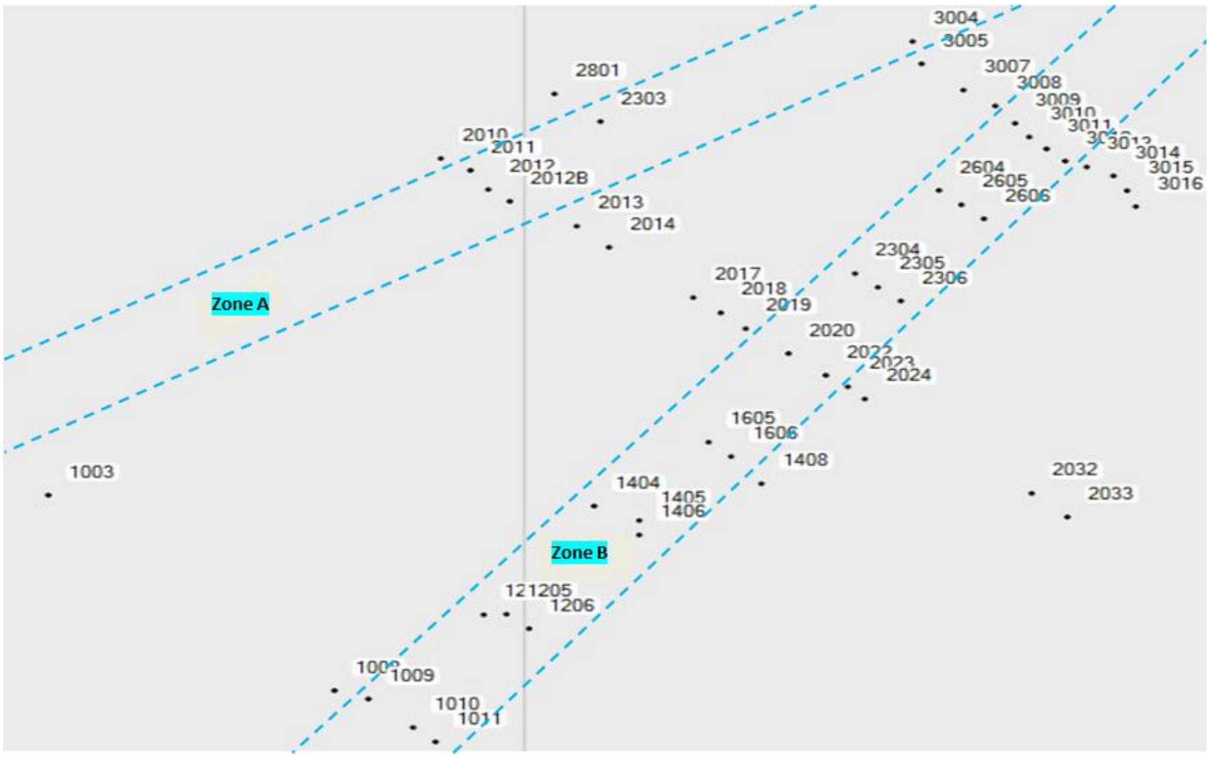
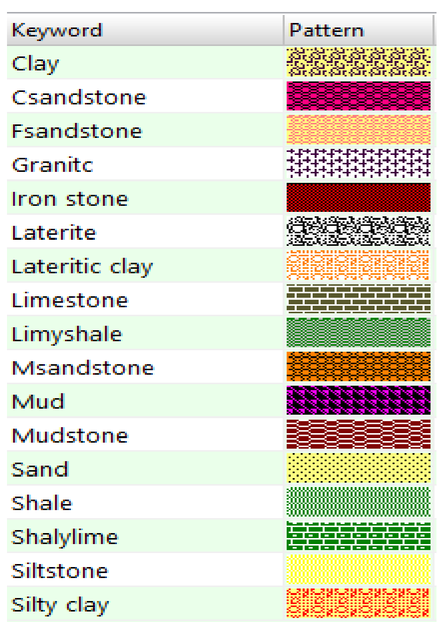



**Figure 2** Limestone mineralization area and window trend



| Keyword | Pattern |
|---|---|
| Clay | |
| Csandstone | |
| Fsandstone | |
| Granitc | |
| Iron stone | |
| Laterite | |
| Lateritic clay | |
| Limestone | |
| Limyshale | |
| Msandstone | |
| Mud | |
| Mudstone | |
| Sand | |
| Shale | |
| Shalylime | |
| Siltstone | |
| Silty clay | |

**Figure 3** lithologs keyword and pattern

In the Southern Benue trough, the cretaceous stratigraphic record is represented by sediments deposited by three main marine depositional cycles: Albian-Cenomanian; Turonian-Santonian and Campano-Maastrichtian (Reyment, 1965, Ofoegbu, 1985), table 2. Shortly after the breakup of African and South America, a continental condition favourable for the deposition of fluvio-deltaic sediment occurred in the Albian age. The first marine transgression in this trough occurred in the mid Albian age with the deposition of the Asu river group sediments with type locality along the banks of Asu River (Reyment, 1965). The sediments consist of rather poorly bedded sandy shales with sandstone and sandy–limestone lenses. The Santonian age was heralded by a tectonic event. This tectonic epirogenic event led to the uplift, folding and widespread erosion of the pre-Santonian sediment in the trough. The Santonian deformation was characterized by compressive folding, generally along a NE-SW direction, parallel to the trough margin. The folding episode that took place during the Santonian strongly affected the development of the Abakaliki Anticlinorium. The predominantly compressional nature of the folds that developed during this period is revealed by their asymmetry and the reversed faults associated with them. Benkhelil [11], in a detailed report of the geology of Abakaliki suggests that the compression responsible for the large scale folding and cleavage was directed N155$^{o}$E. The magmatism that occurred resulted in the injection of numerous intrusive bodies into the shale of the Eze-Aku and Asu River Group. Around Abakaliki, the shales are associated with pyroclastic rocks.

The sediments that occur in Effium area belong to the following geological formations: Albian Asu River Group, Turonian Eze Aku Shale, Agala/Amasiri sandstone (Turonian), Coniacian Awgu Shale, Agbani (Coniacian) and Campanian Nkporo Shale. The study area falls within the Lower/middle Benue Trough interface. The investigated sediments were supposedly formed during the second of three major Cretaceous transgressions which flooded the Benue Trough when the lateral equivalent Nkalagu sediments formed (Holger Gebhardt, 1999). The sections represent inland situated outcrops of a bathyal deposits known in the Benue Trough. The Sedimentation in the Benue Trough was controlled by two dominant factors namely: the progressive eustatic rise in sea level in the Albian times and its consequent widespread flooding of the continental margins. This creates vast interior seaways during the Cenomanian and Turonian times and a local diastrophism. These processes resulted in the transgressive – regressive cycles that characterized sequence depositional pattern. Agagu (1978) recognized five repetitive cycles depositing marine shales and limestones and fluvio-deltaic sandstones and shales in the Upper Cretaceous sequence while the Tertiary have only one cycle. Calcareous shales were deposited in the structural depressions during transgressive phase while shoal carbonates developed on submerged structural highs (platforms, horsts) protected from clastic influx. Extensive deltaic sediments fill the subsiding basin by predominantly fine clastics (shallow marine shales) deposits over the structural highs dominated the regressive phases. The local geology is made-up of a cyclic sequence of fossiliferous upward fining shales and limestone beds.

## RESULT

The table 3 shows the locality, geographical cordinates, depths and abridged remarks of the drill core. Chipped samples analyzed yielded different rock types including limestone, marlstone, shale, ironstone, granitic and sandstone. The samples are heavily fossilified except the granitic samples. Structural features include bioturbation, solution cavities; vertical, horizontal, parallel and cross-cutting joints and faults/gorges. Core sample contain vugs/sparry cement of calcite. Some samples contain breccias and intraclasts of carbonate mud hence suggesting fault presence. The drill core logs reveal rock types sequence with gradational and in some cases sharp contacts. The Limestone in the area is not uniformly distributed in terms vertical and lateral extent, it showed variable thickness, narrow linear window trending along the general strike of NE/SW, figure 2. Figure 3 is interpretation generated from the core log geodata using Rockworks 16 software.

## DISCUSSION

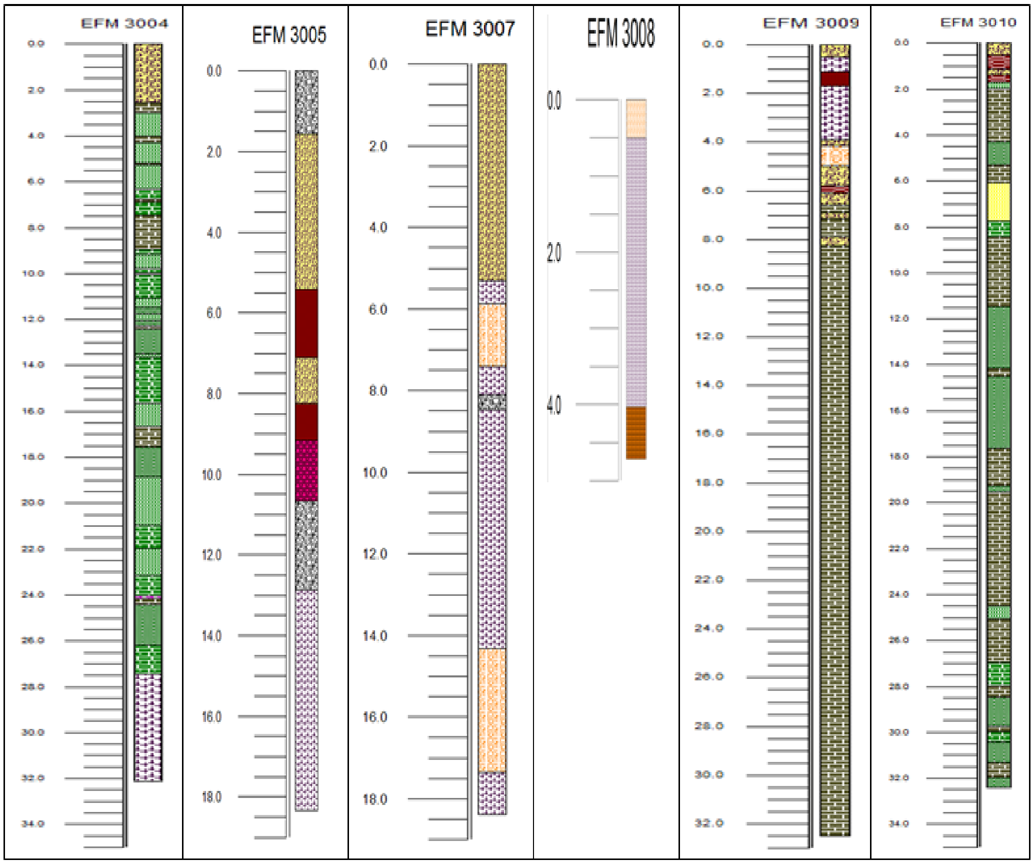
The limestone varied in colour (dark grey-light grey, brownish), nodular, lenses, porous, sandy-silty and/or shally. The sandstone are brownish-reddish and in some places agglomerated, conglomeratic, friable and false bedded. The sandstone are poorly sorted containing sub-angular grains, in which quartz, as monocrystalline unstrained grains is the major constituent and beds fine upwards. Also present are grains of strained quartz, quartz grains showing intergrown ‘hydrothemal’ textures, fine quartzite, microcline, albite and orthoclase.

Outcrops of ferruginized iron stone exposures were also in some locations. Iron is present as oxide coatings and occasionally as pyrite on the limestone and sandstone especially where they are exposed or fractured showing brownish coloration. The shales are dark grey-bluish grey, fissile and structurally deformed. Exposed shales are fissile and friable.

The Limestone in the area is not uniformly distributed in terms vertical and horizontal extent. It showed variable thickness and linear window spread. It has a limited areal extent, locally constrained, a fair dissemination and generally trends Northeast/southwest. The limestones are surrounded and at some places capped by sandstones and or sandy clays or laterites or by shales with some inter-fingering marls. There is a general lithologic upward fining of the beds. Several cm to m thick limestone and marl beds are interbedded with shales.

The limestone beds show typical characteristics of turbiditic and debris flow sedimentation, graded bedding and exotic components (e.g. shallow water bivalves). The beds are interpreted as debris flows and turbidites since they show their typical characteristics (fining upward sequences, matrix supported exotic components, etc.), although complete Bouma sequence not proven.

Comparable to Nkalagu investigations, Effium sections show that the sediments have been deposited in a deeper water, indicated by turbidites and debris flows following (Banerjee 1981; Oti 1990; Amajor 1992) and the occurrence of keeled planktonic foraminifera (Petters 1980; Gebhardt, in prep.); and in a non-anoxic environment, which is shown by the presence of relatively large benthic foraminifera (Gebhardt, in prep.) and ostracodes (this paper, plate 1) as well as relatively low TOC, abundance of vitrinite, rarity of biodegraded phytoplankton and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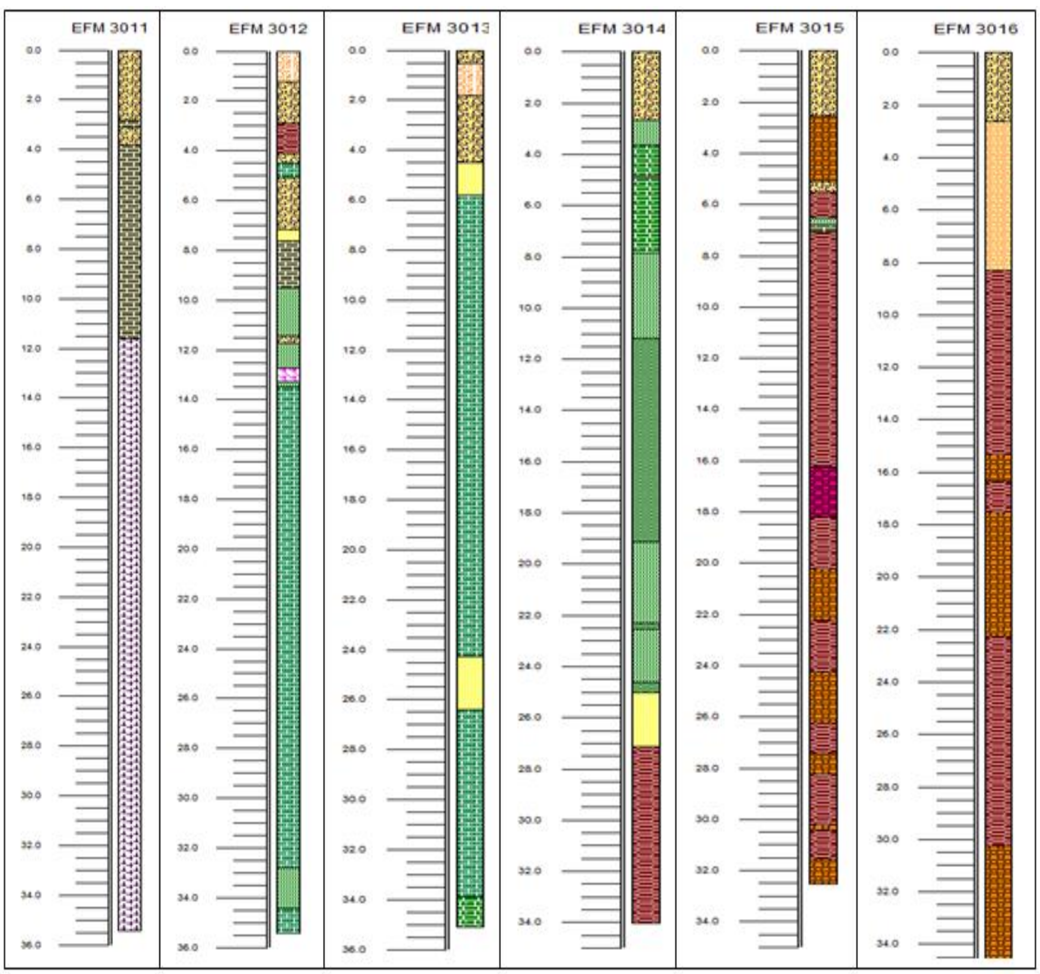
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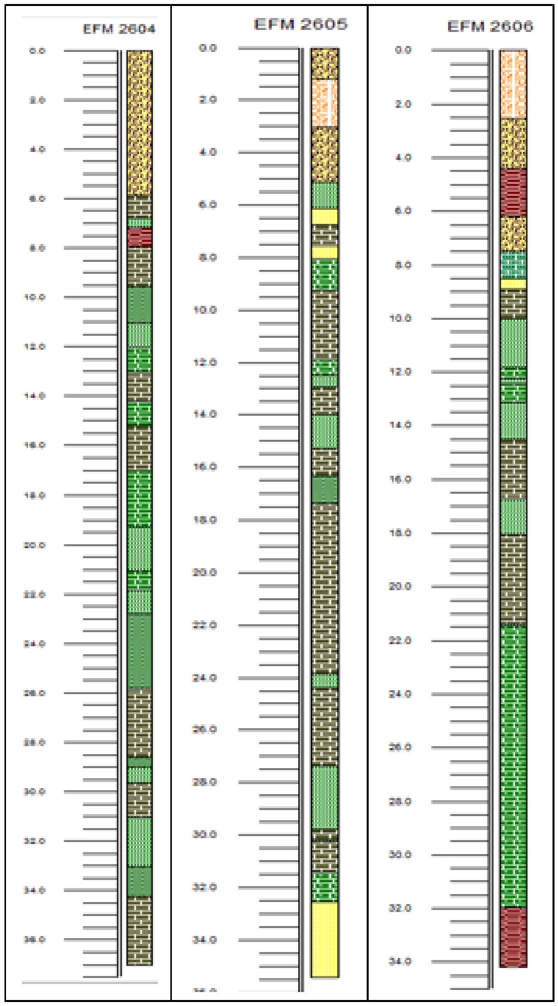
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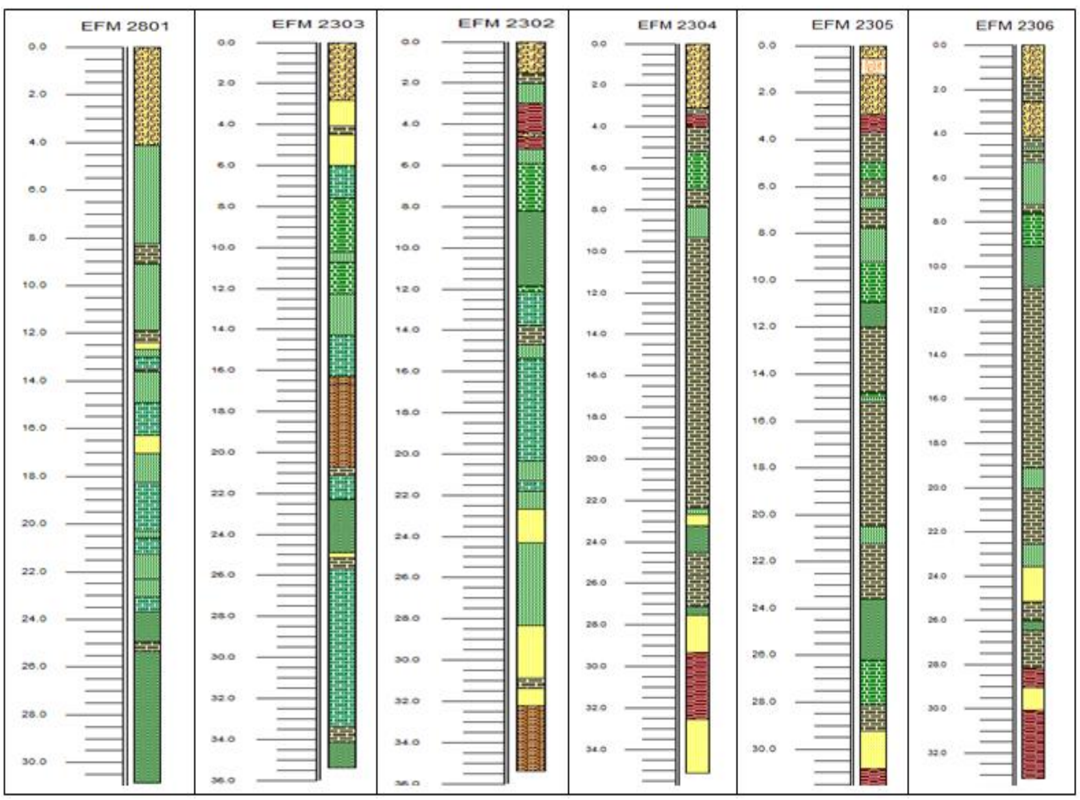
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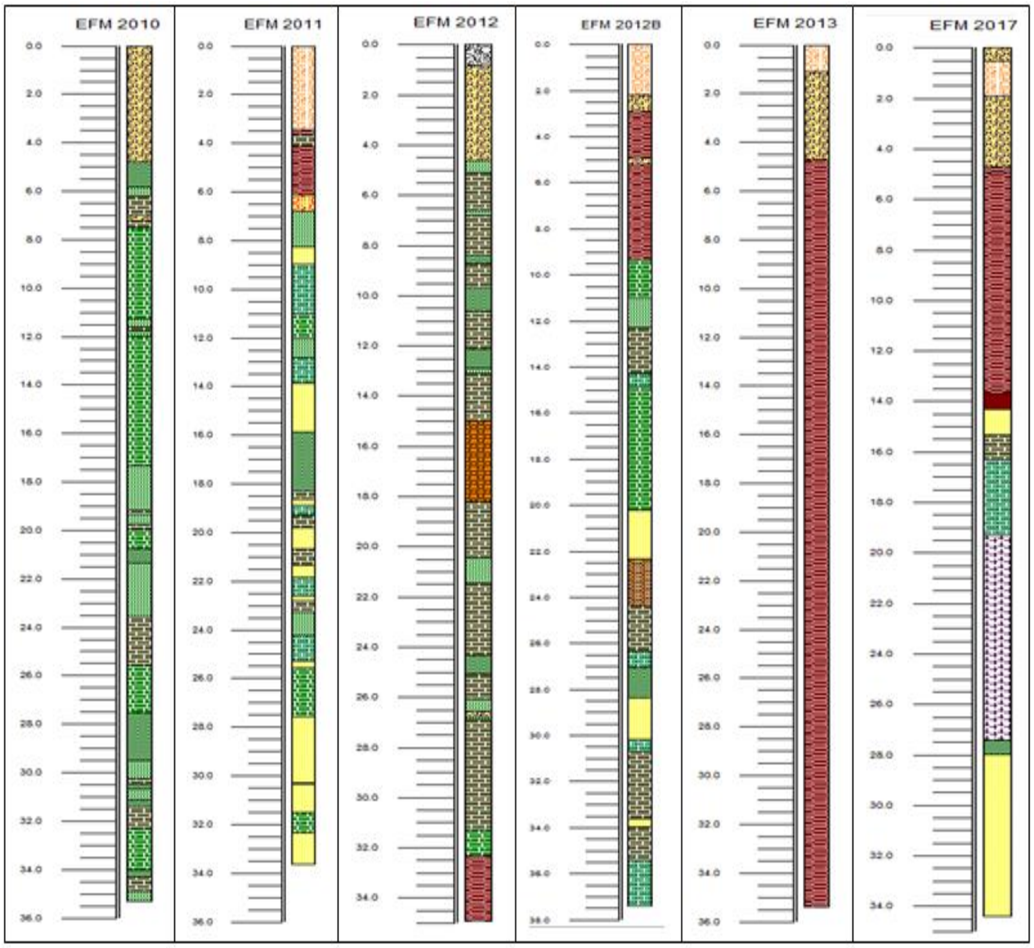
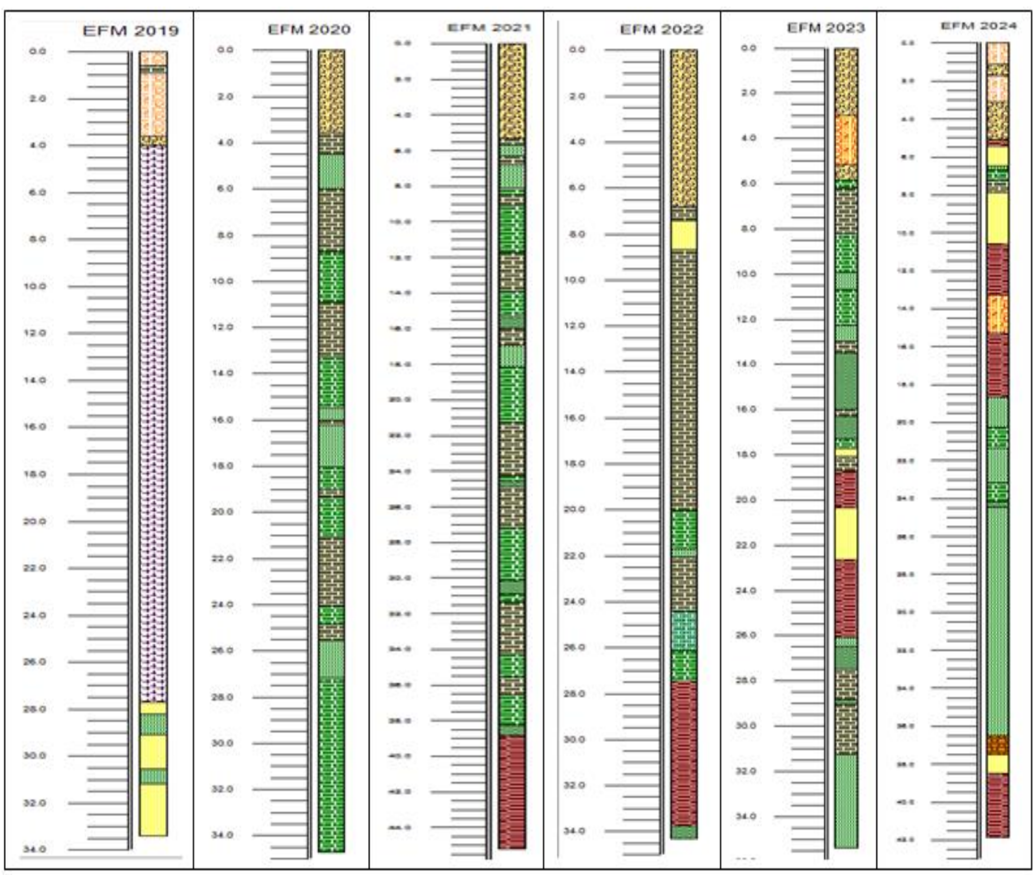

EFM 2010
EFM 2011
EFM 2012
EFM 2012B
EFM 2013
EFM 2017


EFM 2019
EFM 2020
EFM 2021
EFM 2022
EFM 2023
EFM 2024

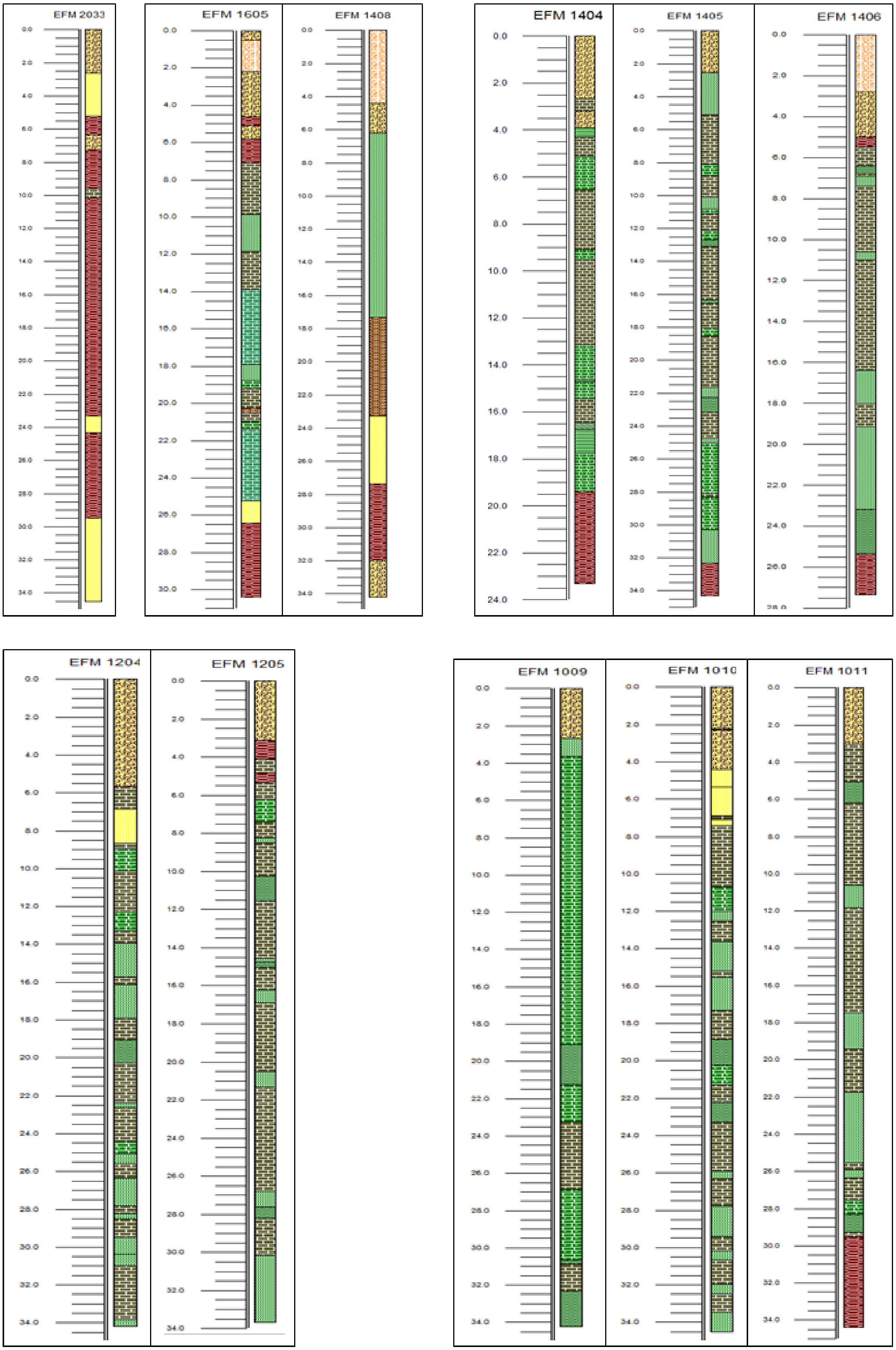



**Figure 4** Drill holes core logs of the area

by high values of pristane/phytane (Unomah and Ekweozor 1987). Thus, an upper Bathyal and suboxic palaeoenvironment as assumed for the Nkalagu Quarry Sections.

## Resource estimation

The ore belongs to sedimentary deposits and are in sequence with general strike direction of NE/SW. The drillings to restrain the ore seam are all distributed on a prospecting lines perpendicular to strike direction while control drills are along the strike line. Prospecting lines keep parallel to each other. The general survey of the drill cores indicates that the mineralization thins out across the strike line in the East-West from Zone B to Zone A. Thence, suggesting that Zone B is more economical. Using EFM 2012 core hole in Zone A and EFM 3009 in Zone B respectively as control holes to estimate the reserve in research area and formula for ore resource reserve in the block is Q given as

$$Q = V*D$$

where,

Q is ore resource estimate of the block

V is block volume

D is ore bulk density

The total amount of ore reserve estimation in the exploration area, $Q_t = \Sigma Q_i x$, $i = 1, 2, \ldots, n$ blocks

$x = 1, 2, \ldots, n$ seams.

For Zone A, using EFM 2012 core hole as control. This hole has nine limestone seams with the following thicknesses- 1.5, 1.58, 1.0, 1.50, 1.91, 2.20, 2.88, 1.0, and 4.39m totalling 17.96m.

Hence, Q = 8000*700*17.96*2.68 = 269,543,680 mt.

For Zone B, using EFM 3009 core hole as control. It has three seams with thicknesses of 0.32, 0.76 and 24.26m. Total estimate, Q =25.34*8000*800*2.68 = 434,631,680mt.

## METHOD

### Resource investigation method

This research was carried out in phases- surface reconnaissance geological mapping, subsurface investigation via drilling core, logging and analysis. Prior to the core drilling, preliminary surface geological mapping of the area was undertaken. Investigation of the subsurface by core drilling followed a pilot plotting of core drilling coordinates. Core drill points were aligned to resource mineralization trend after surface mapping plots on the base map. Control core holes were parallel to the mineralization strike direction at 1km apart and others adjoining the control core holes across the strike (i.e. along dip) at 200m apart respectively. Core drilling on these points is a function of the actual general condition of the immediate environment therein. Some of the points that fell on difficult terrains such as water logged, steeply slopes are translocated but not to more than 50m the diameter of the proposed position. Drilling was completed throughout the deposit on such a variable spacing and depths between 5 to 50m.

A diamond impregnated bit attached to a 12 ft core recovery barrel mounted on GX-Y-1, 16 hp rotary rig is used. A 0.065 m diameter core was produced from a 0.0777m diameter holes. Water is used for the drilling fluid to avoid contaminating the core sample. Occasionally vugs/sparry cement, fractured breccias, intraclastic mud (gouge in-fillings) and splitting of the core wedge in the core barrel. When wedging occurred it was necessary to pull the drill stem and clear the core from the core barrel before continuing the drilling. All samples recovered were boxed prior to geostatistical analysis.

Groundwater condition especially groundwater table, recharge and drawdown were monitored using selected core holes. Depth to groundwater in the cored hole were measured and at intervals to study the groundwater characteristics of the area.

All the rock core sample chips were logged for lithology, alterations and mineralisation in accordance with core logging procedure. Colour, RQD and other additional qualitative comments were also recorded. Core samples were further subjected to dilute Hydro Chloric (HCl) acid preliminary testing. This was complimented by scanning with point analyses using portable X-ray fluorescence spectrometry (Phillips PW 1400 XRF). Magnifying hand lens and measuring tape were also used to take measurement of the litho unit thickness of the rock types assayed. The geodata so measured is recorded in a proforma data sheet and subsequently imported into the Rockworks 16 software platform for interpretation.

Forty-nine (49) borehole cores were logged and analyzed, thirty (30) showed between two (2) to five (5) high-calcium interbedded limestone bands of more than 1m thickness. Bands having considerable limestone bed thickness of ≥0.5m and strip ratio of at most 1:2 were used as economical representative and used to estimate the reserve.

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