Integrated Geochemical and Organic Petrographic Characterization of the Campano-Maastrichtian Sediments Around Enugu Escarpment, Anambra Basin, Southeastern Nigeria*

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Abstract

The Anambra Basin contains a variety of major hydrocarbon source rocks, such as found in the Post-Santonian Enugu Shales and the Mamu Formation. This study attempts to re-evaluate the discrepancies in past investigations based on the prospective value and characterization of the Campano-Maastrichtian source rocks and their hydrocarbon potential taking cognizance of the interactions between source rocks and their prevailing paleodepositional environment.

Fifteen (15) shale and five (5) coal samples collected from outcrops within the study area were subjected to Total Organic Carbon (TOC), Total Sulphur Content (TSC), and Soluble Organic Matter (SOM) analyses. Other standard analysis such as inorganic geochemical (Major and Trace Element Abundance), Organic Petrographic (Maceral) and granulometric (grainsize) analyses were also carried out.

The TOC contents, ranging between 0.65 to 1.82 wt% in shale and 18.35 to 19.12 wt% in the coal samples, exceed the minimum threshold value of 0.5 wt%. Low TSC (0.35 - 0.44) and variable Extractable Organic Matter (EOM) values (998 to 5,900 ppm) were detected for the representative samples with the higher EOM values detected in the coal samples of the Lower Coal Measures. The source rock evaluation indicates fair to good source rock qualities (oil and gas). The TOC values and petrographic count of the maceral analysis show relatively high organic contents in the study area, suggesting that the hydrocarbons are probably being generated in the basin and may not have been expelled in large quantities. The depositional environment of these gas-prone source rocks indicates an oxic, marine environmental condition.

INTEGRATED GEOCHEMICAL AND PETROGRAPHIC CHARACTERIZATION OF THE CAMPANO-MAASTRICHTIAN SEDIMENTS AROUND ENUGU ESCARPMENT, ANAMBRA BASIN, SOUTHEASTERN NIGERIA

By

Akaegbobi, I. M. And Udofia, G. G.*

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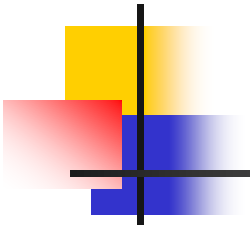


INTRODUCTION

- **The search for appreciable rock qualities (oil and gas) in basically, unexplored regions require intense investigation in consonance with the technical know-how.**
- **Types of sediments found.**
- **Similar sedimentary and source rock quality within the basin.**
- **Disparity in results from past explorers.**

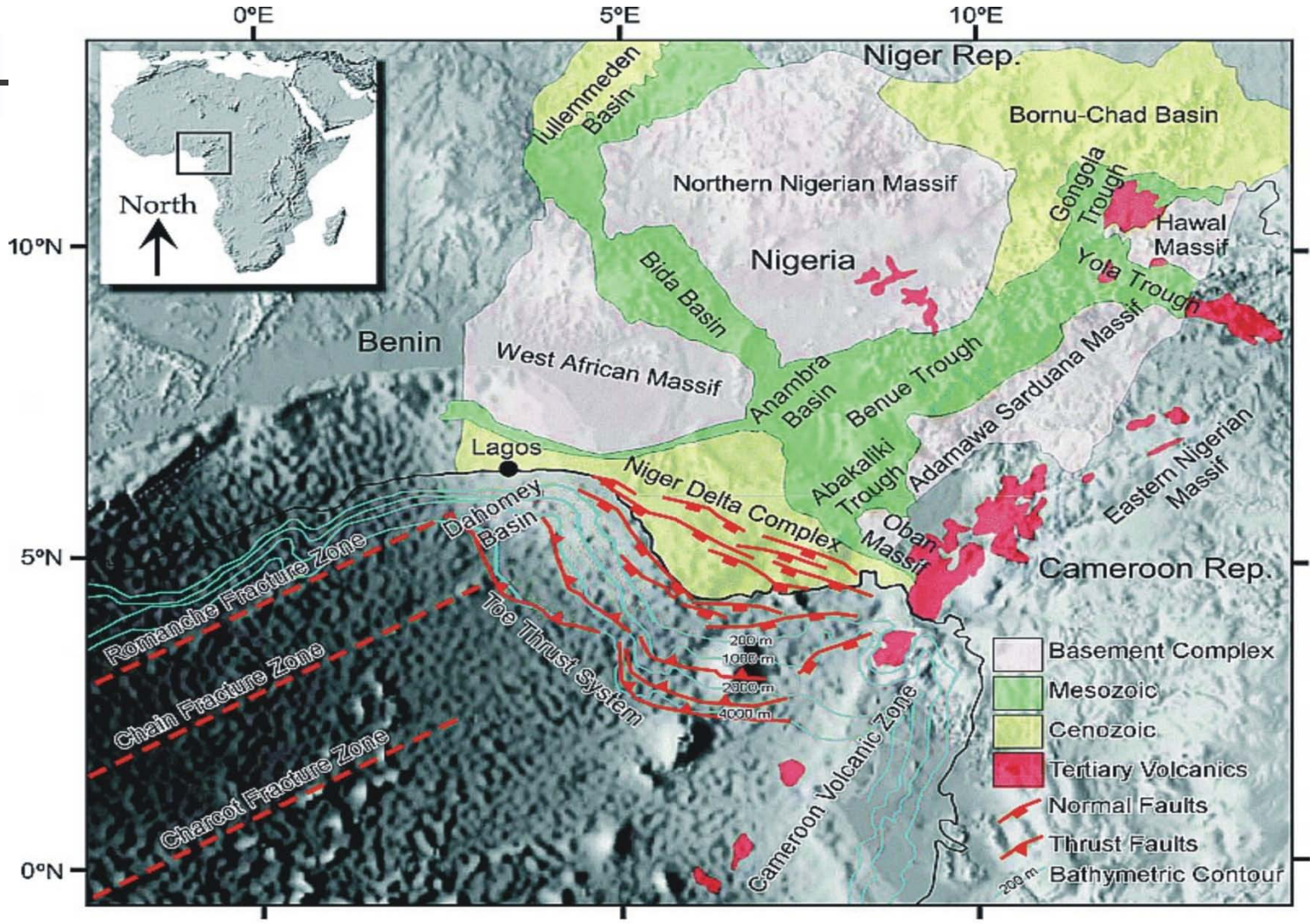
AIMS

- Assess and characterize the hydrocarbon components of the bituminous shale and coal measures of the Owelli, Nkporo and Mamu Formations, in the Anambra Basin
- Use as a predictive tool on the paleodepositional environment.
- Environmental impact analysis will also be put into consideration.
- Identify the existing petroleum system in the basin.

SCOPE OF INVESTIGATION

1. **Determination of the lithology and the lithologic units in the study area should be based on the result of analysed shale and coal .**
2. **Investigate within the existing petroleum system.**
3. **Use the quantitative (geostatistical) analysis of sediments to aid in the deduction and recognition of environmental influences in the basin.**
4. **Use the quantity and quality of mineral matter to determine the hydrocarbon potentials of the area.**

MAP OF NIGERIA SHOWING THE TECTONIC ELEMENTS



(Adapted from Corredor *et.al*, 2005).

STRATIGRAPHY OF THE STUDY AREA

Post-Santonian strata unconformably overlie the Cross River Group. It includes:

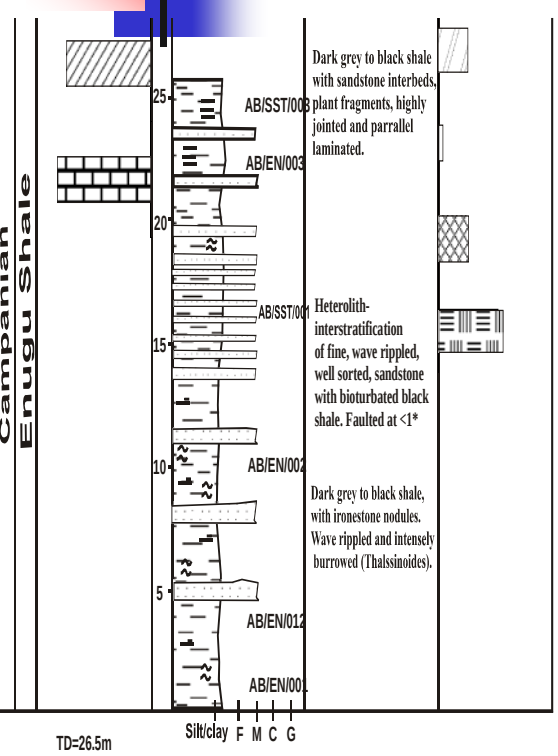
- **Ajali sandstone.**
- **Owelli sandstones**
- **Coal measures of the Mamu**
- **Paralic Enugu (Asata) shale**

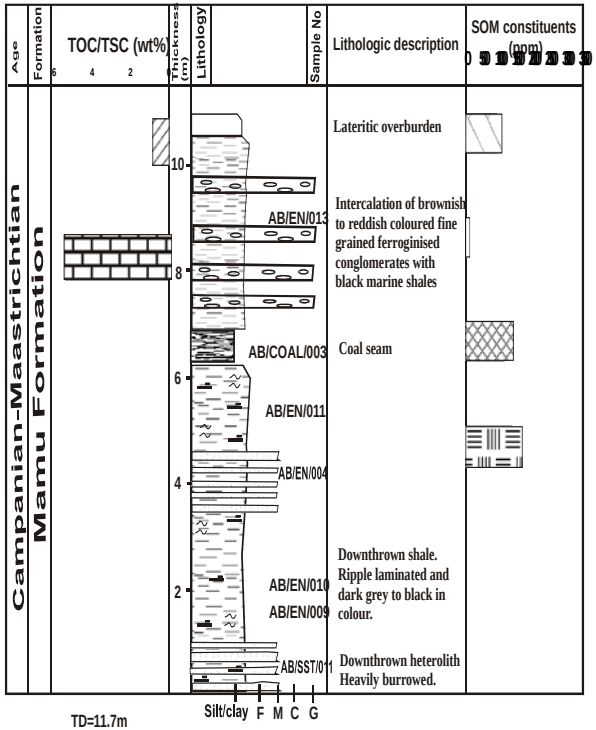
Overview of the Nkporo Shale located near the Onitsha road flyover.
Exposure shows interbedded siltstone and dark grey shale. Top cover is laterite or lateritic soil.

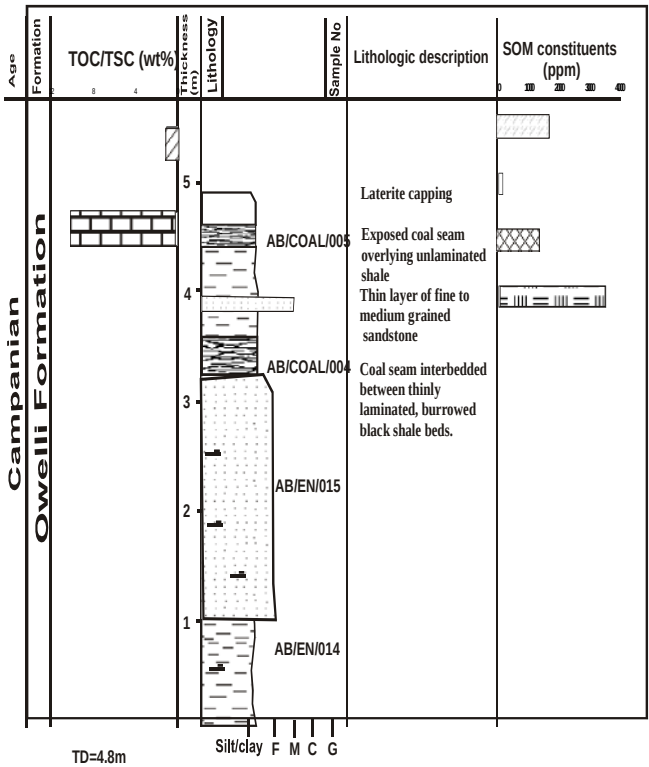
Trace fossils

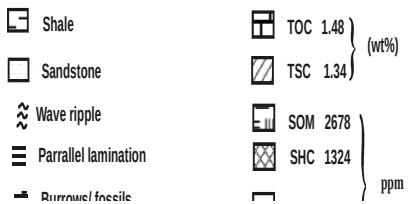
Coal Seams

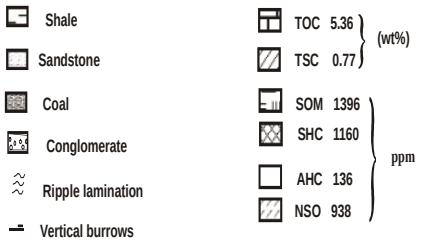
LITHOLOGIC LOG AND INTERPRETATION

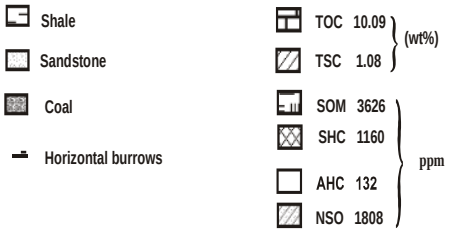




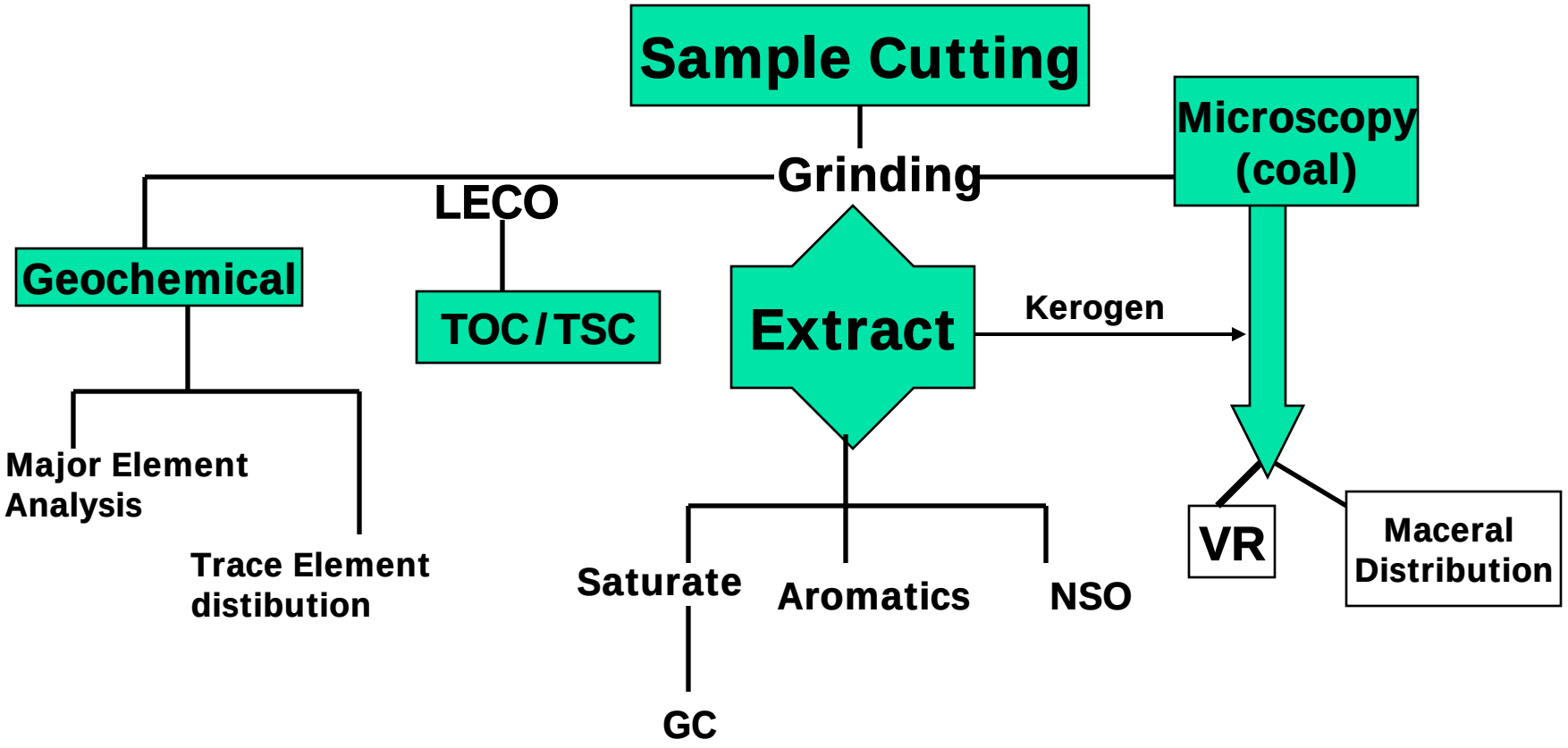








METHODOLOGY



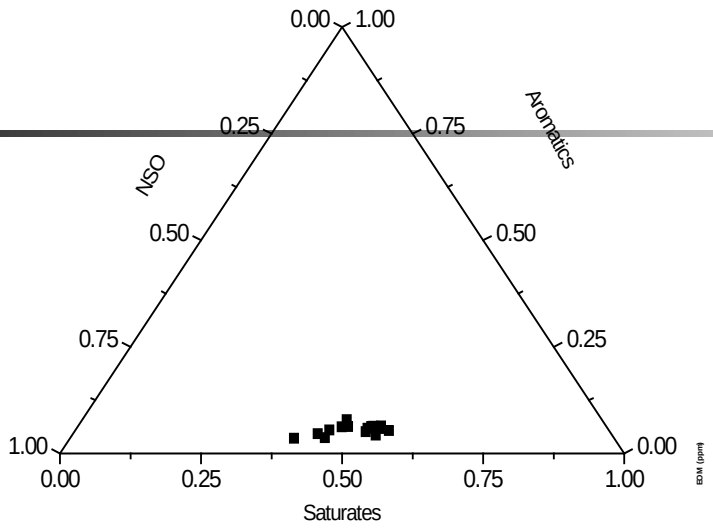
RESULTS AND DISCUSSION

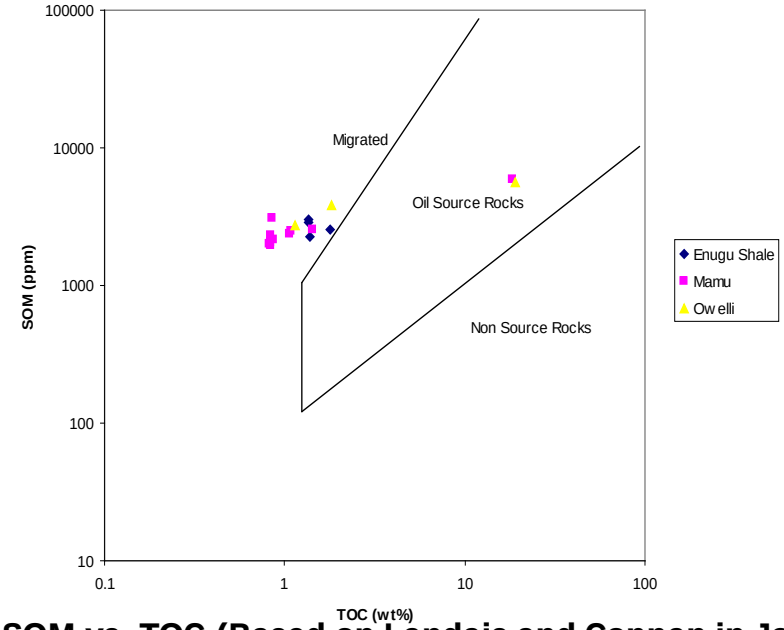
- **Hydrocarbon Source Potential Characterization**
  - Quantity of organic matter (organic richness)
  - Quantity of Extractable Organic Matter (type)
  - Source rock contamination (maturation)
- **Potential Petroleum System**
- **Prevalent Depositional Environment**
  - Determined based on the results from the organic and inorganic Geochemical Analysis
- **Environmental Deductions**

QUANTITY OF ORGANIC MATTER (ORGANIC RICHNESS)

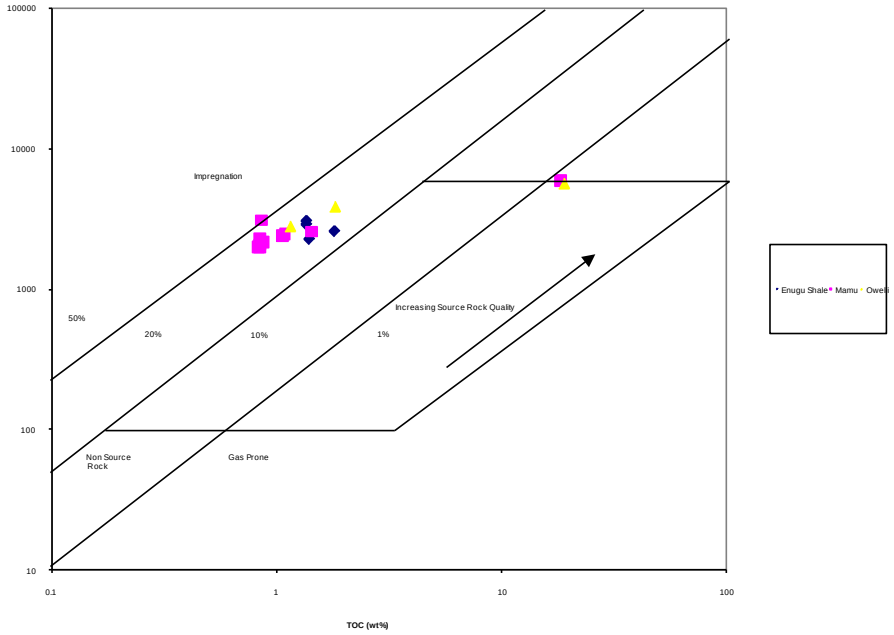
- **Range of values:**
  - **TOC = 0.82 – 1.82/18.35 – 19.12wt%**
  - **TSC = 0.34 – 0.44/ 1.72 – 1.9wt%**
  - **SOM = 1987 – 3072ppm**
  - **Saturates = 1024 – 1629ppm**
  - **Aromatics = 105 – 202ppm**
  - **NSO = 817 – 2179ppm**
  - **BR = 142 – 245mgExt/gTOC**

QUANTITY OF EXTRACTABLE ORGANIC MATTER (TYPE)



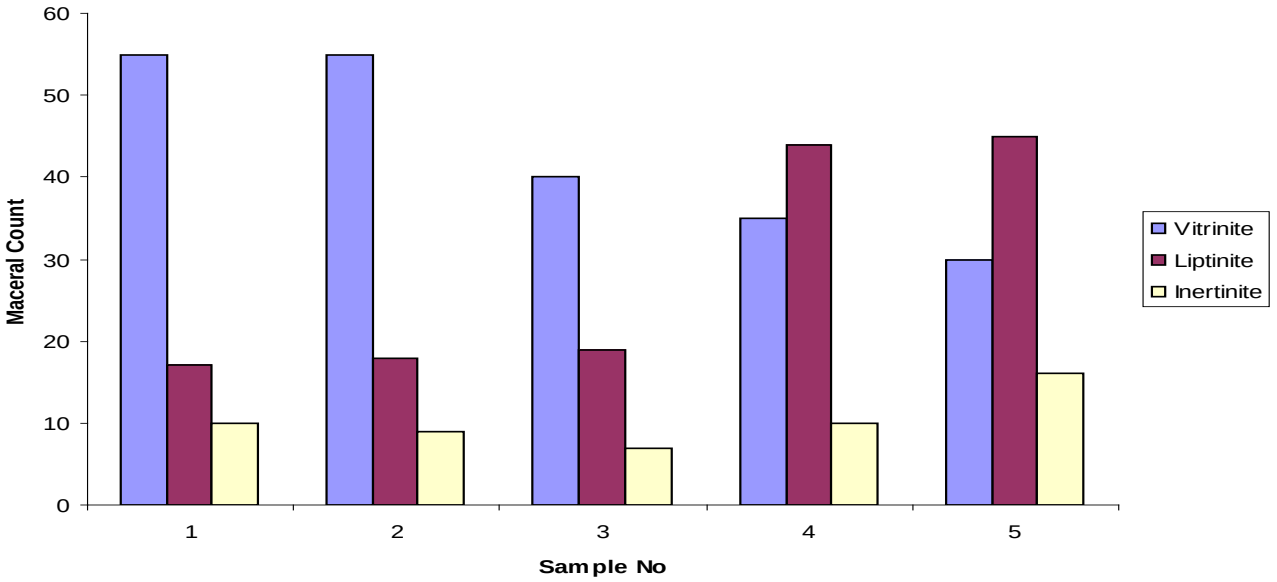


SOM vs. TOC (Based on Landais and Connan in Jovancicevic et al., 2002)

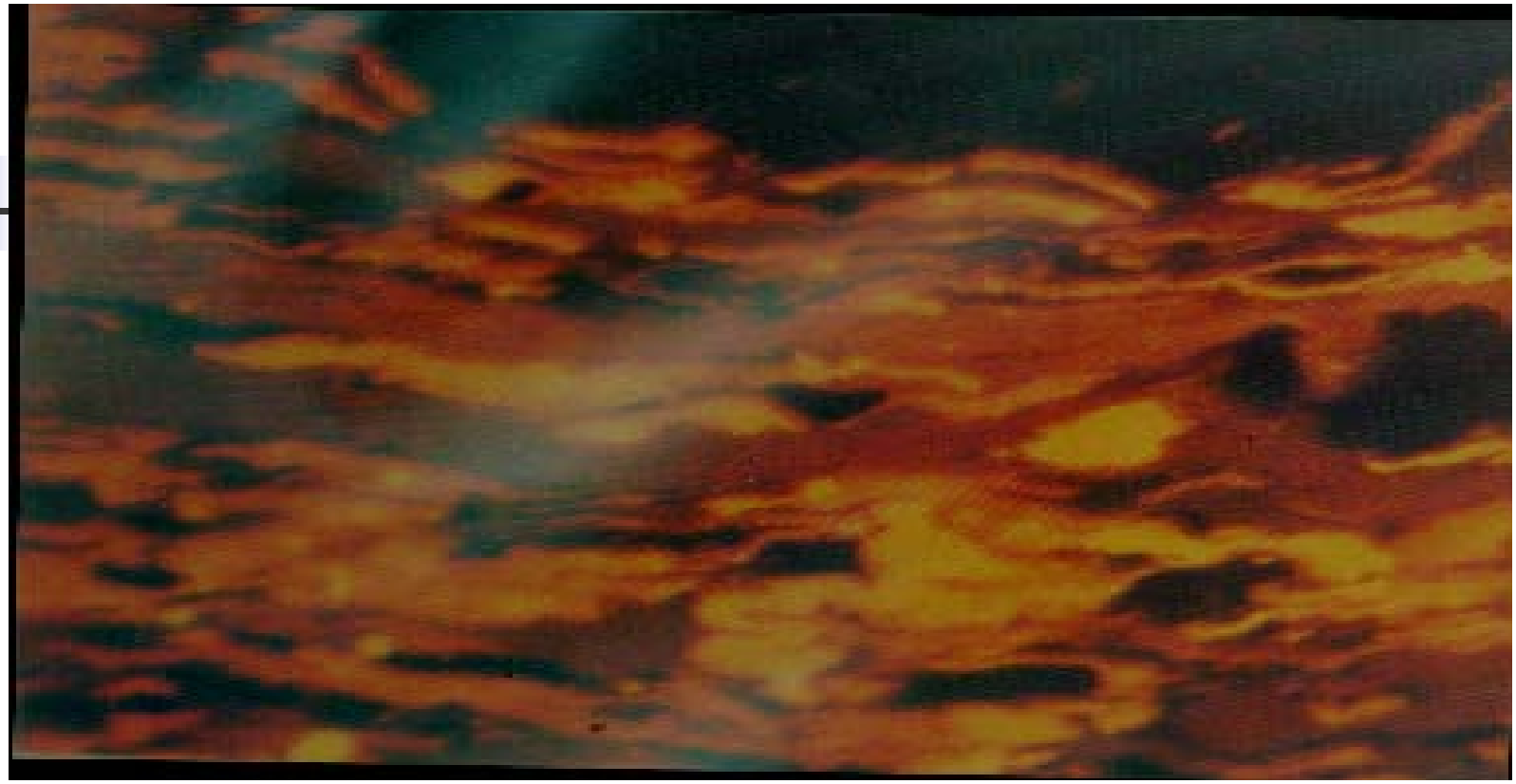


Plot of EOM vs. TOC (based on Hunt, 1979 and Tran and Philippe, 1993).

RESULTS OF THE MACERALS

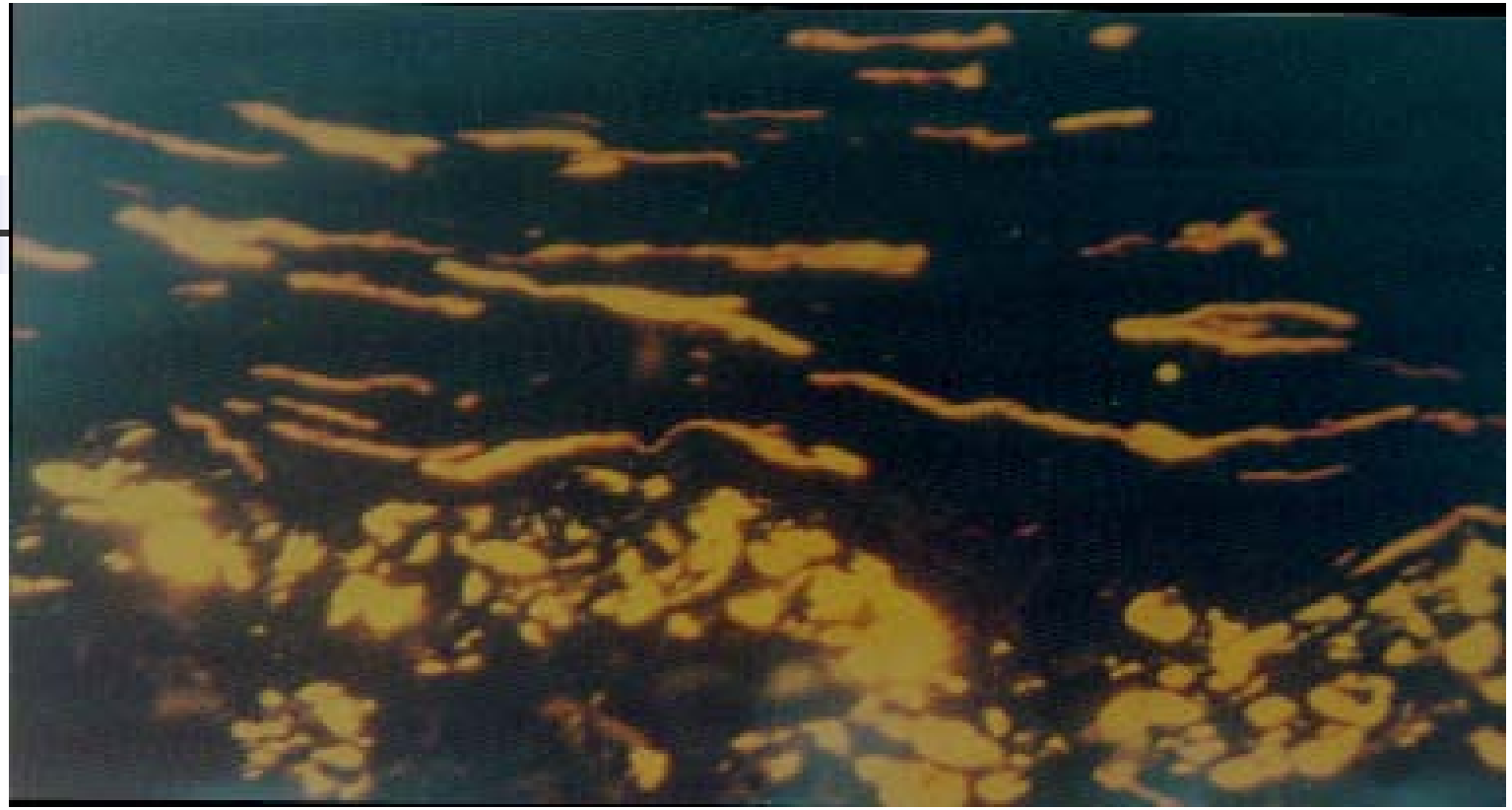


- **Vitrinite=52%, (mainly formed of the remains of plant parts in coals)**
- **Liptinite=35%,**
- **Inertinite=13%,**



V (55%), L (17%), I (10%)

Sample AB/COAL/001 (Mamu Formation)



V (40%), L (19%), I (7%)

AB/Coal/004 Owelli Formation

SOURCE ROCK CONTAMINATION (Maturation)

- Minimal based on the low TSC content,
- BR and VR shows that the sediments verge on the near peak window indicating their near-mature level.
- Presence of NSOs (20%) also point to their increase in maturity.

POTENTIAL PETROLEUM SYSTEM

Using the basic concepts, (elements and processes occurring in time and space), Dr I. M. Akaegbobi has recognized the prevalent petroleum system in the area as the Upper Cretaceous–Lower Paleocene Petroleum system.

PLOT TO INDICATE DEPOSITIONAL ENVIRONMENT

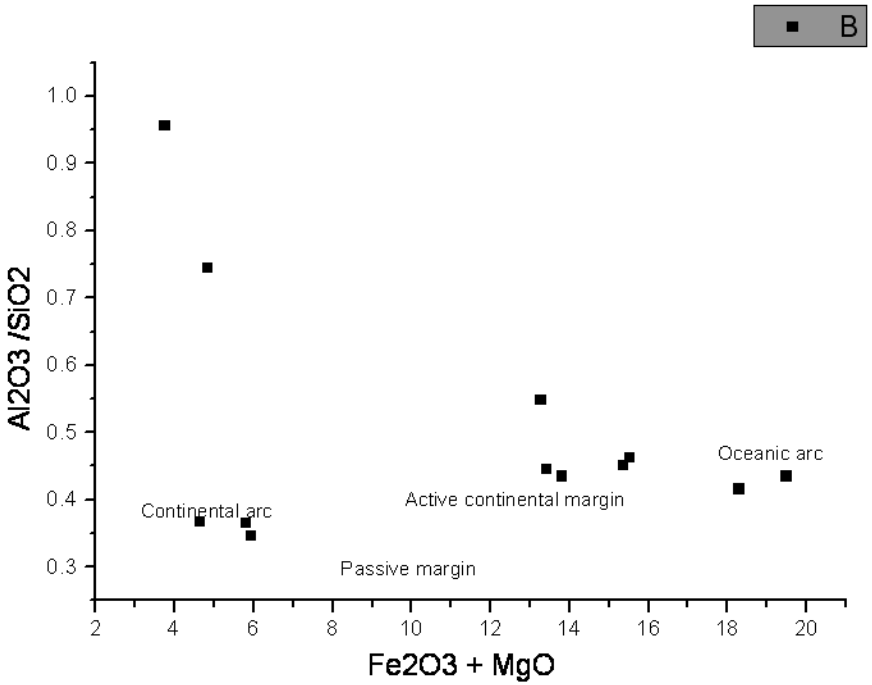
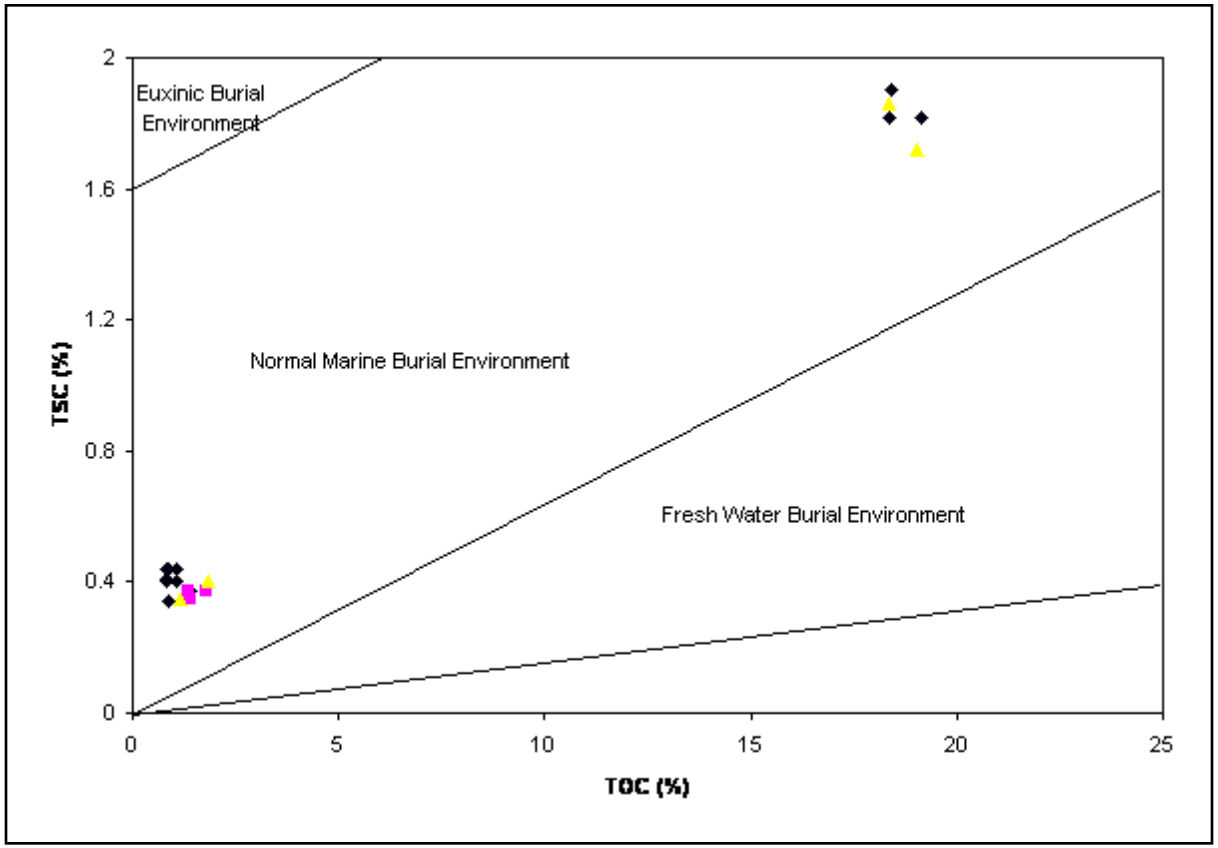


Fig. 10 Discriminant diagram for tectonic signatures of the Campano-Maastrichtian sediments (After Bhatia, 1983).

PLOT OF TOC vs. TSC



ENVIRONMENTAL DEDUCTIONS

- The CIA indicates a moderately weathered source (Nesbitt and Young, 1982).

$$CIA(\%) = \frac{Al_2O_3}{Al_2O_3 + CaO + Na_2O + K_2O} \times 100$$

The 85% results of the study area indicates moderately weathered source while high CIA% (>90%) is caused by weathering under humid conditions

CONCLUSIONS

- The best source rock characteristics occur in the coals and shales found in the Enugu Shale and the Mamu Formation
- High vitrinite values indicate that the coals are gas prone.
- Prevalent deposition environment is marine.
- Environment of deposition is conducive to HC production.

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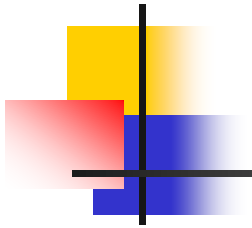

Thank you