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[EA]Surface Geochemical Exploration in Benue Trough, Nigeria*

Onyinye G. Nwaobi[1], Adamu Suleiman[1], A. Bomai[1], S.D. Moses,[1] M.S. Ali[1], R. Dauda[1], M. Kaumi[1], and L. Kigbu[1]

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[1]Frontier Exploration Services Department, Nigerian National Petroleum Corporation, Nigeria (goldagift@yahoo.com)

Abstract

Benue Trough is an important frontier basin in Nigeria of interest in hydrocarbon exploration. The Basin was formed during the Cretaceous Period extending towards Chad on the North and the Niger Delta on the South. The Basin is grouped into the Upper, Middle, and Lower Benue Trough. Surface Geochemical Exploration, an important reconnaissance technique applied to exploration, was carried out in some areas of Benue Trough. The objective was to detect the presence and nature of hydrocarbons in the area since leakages of hydrocarbons from seals in subsurface to near surface occur in most basins. The leakage is predominantly vertical and dynamic (1-3m/day) and provides direct indication of hydrocarbons. Prospects with microseepage anomaly are at times more likely to result in a discovery.

Samples were collected along seismic lines and stored in paper bags and polyethylene bags for microbial and chemical extraction purposes respectively. Laboratory investigations adopted in the study involved integration of microbial, chemical, and fluorescence methods to ascertain the presence of hydrocarbons of interest. The extracts derived from chemical methods were analyzed using GCFID to detect the C1-C4 compounds, while the microbes were subjected to microbial count. Also, traces of liquid hydrocarbons that seeped to near surface were detected using Fluorescence method. The results showed the presence of biogenic, thermogenic gas, and condensate from the concentration of the ratios of C1/C1-C4, while the microbes are measured in Colony Forming Units/Milligram. The fluorescence analyses measured between 220nm-365nm revealing the presence of 2-ring to 3-ring hydrocarbons signifying the presence of liquid hydrocarbons.

Oil accumulations were detected from seepage and gave positive anomaly showing that they group in geological significant ways, with possibilities of vertical microseepage and highly dipping beds. The North East section of the Benue Trough showed higher anomalous concentration with clear indication of thermogenic dry gas in the Maiduguri area. The source rocks were poor but with oil seepage. The microbial technique showed the Benue area had highest occurrence of anomalous microbial samples in the Demsa and Wafango parts of Yola and in the eastern part of the Gassol area in the Middle Benue Basin. In conclusion, the Benue Trough showed presence of thermogenic gas and liquid hydrocarbons in the upper and middle Benue area with possibility of successful exploration.

Introduction

Benue Trough is an intracratonic rift structure with evolution in the Early Cretaceous opening of the South Atlantic Ocean and the Gulf of Guinea. It consist of rift basins which form part of the West African Rift System of Niger, Chad, Cameroun, and Sudan. Basement fragmentation accompanying the opening led to the deposition and accumulation of sediments ranging between 4km-6km. As shown in Figure 1, the Benue trough is divisible geographically into Lower, Middle and Upper Benue (Nwojiji et al., 2013; Abubakar, 2014; Obaje et al., 2006; Obaje and Hamza, 2000; Tukur, 2015). The Upper Benue Trough is further sub-divided into three basins: the east–west trending Yola Basin (Yola Arm), the north– south trending Gongola Basin (Gongola Arm), and the northeast–southwest trending Lau Basin as shown in Figure 2.

Surface Geochemical Exploration is an important reconnaissance technique applied to exploration. Leakage of hydrocarbons from seals in subsurface to near surface occur in most basins as shown in Figure 3. The leakage is predominantly vertical and dynamic (1-3m/day) and provides direct indication of hydrocarbon. Prospects with microseepage anomalies are 4-6 times more likely to result in a discovery.

The primary objective is to give confidence to further exploration of the Benue Trough by determining the presence and nature of hydrocarbons in the areas surveyed. Carrying out surface geochemical exploration would unravel the presence of biogenic, thermogenic, wet gas, and dry gas occurrences in the areas sampled within the Benue Trough. The presence of liquid hydrocarbons would be detected.

Method

Samples collected along seismic lines are stored in paper bags and polyethylene bags for microbial and chemical extraction purposes respectively. Sampling equipment must penetrate the zone of maximum disturbance or any shallow migration barriers. About 250 samples were collected for surface geochemistry for each of the 5 key leads: the Keana, Gassol, Dimsa, Wafango and the large anticline in the Lower Benue trough as shown in Figure 4.

The chemical extracts were subjected to extraction and analyzed using GC-FID to detect C1-C4 compounds while the microbes are subject to microbial count. Also traces of liquid hydrocarbons seeped to near surface was detected using Fluorescence method. The methods applied are shown in Figure 5.

Results

The accumulations grouped in geological significant ways. The red has the highest concentration of hydrocarbons in the map and yellow associated with red and brown are significant anomalies as shown in the acid extraction technique in Figure 6. The Benue area showed the highest occurrence of anomalous microbial samples in the Demsa and Wafango parts of the Yola Basin, and in the eastern part of the Gassol area in the Middle Benue Basin as shown in Figure 8. The fluorescence analyses measured between 220nm-365nm reveal the presence of 2-ring to 3-ring signifying the presence of liquid hydrocarbons (Figure 7).

Conclusion

Microbial, Acid Extraction, and Fluorescence method were integrated for the surface geochemical studies on the Benue Trough. Surface Geochemical Exploration on Benue Trough samples showed the presence of biogenic, thermogenic gas, and condensate depending on the concentration of the ratios of C1/C1-C4.

The fluorescence result showed strong positive correlation suggesting there is the presence of liquid hydrocarbon in the Basin. The anomalous concentration showed possibility of liquid hydrocarbons in the Middle and Upper Benue Trough area.

Recommendation

Surface Geochemical Techniques for reconnaissance studies is an indispensable tool in exploration in both frontier basins and appraisal studies since it delineates the nature of the hydrocarbon and gives an idea of areas with high anomalous concentration.

Comparing the data from Surface Geochemistry with the analogs of basins would give extensive clarity to studies. It is also important to know the distance of the leakages from the faults to trace the accumulation.

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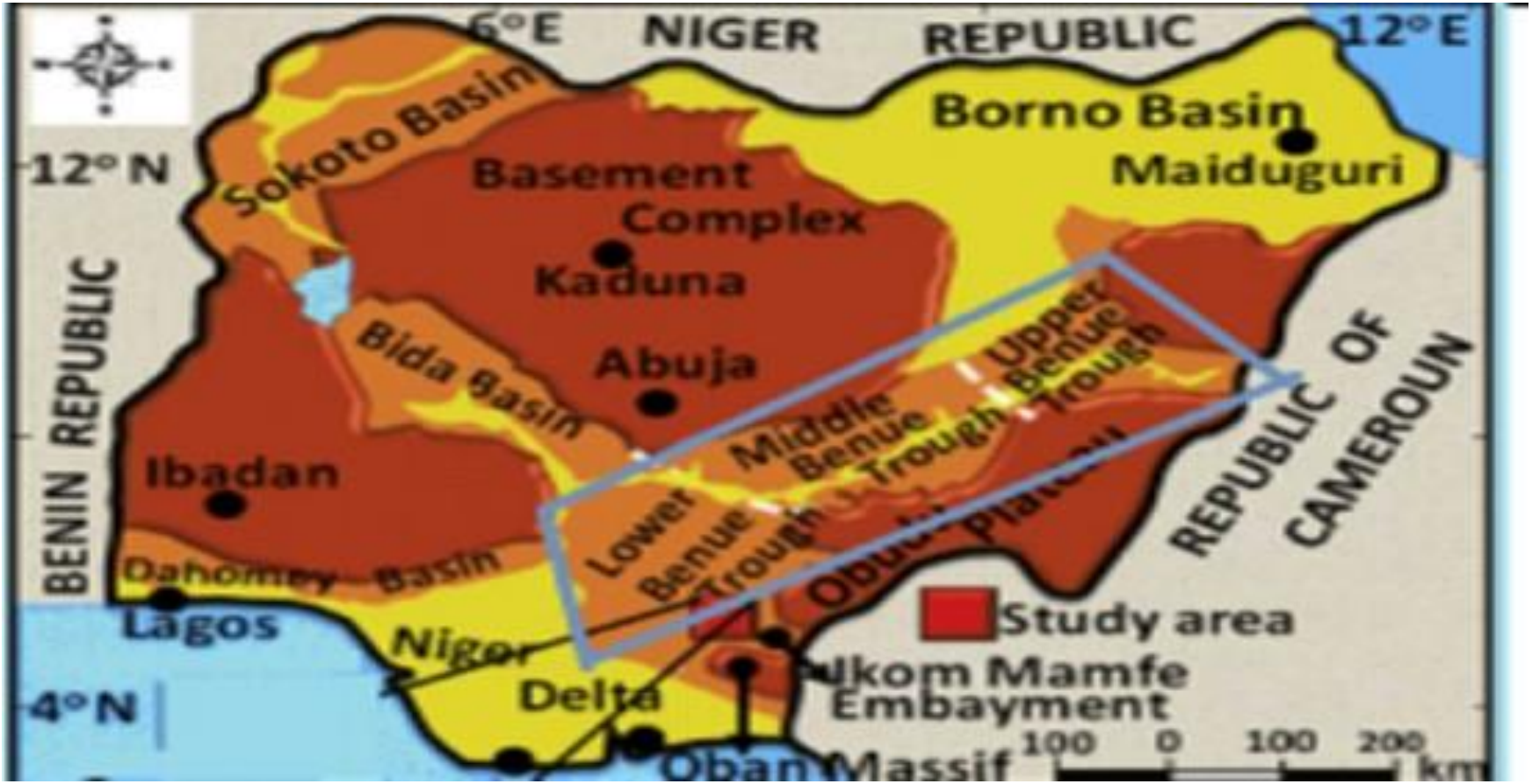

Figure 1. Map of Nigeria showing the Benue Trough Location (Nwojiji et al., 2013).

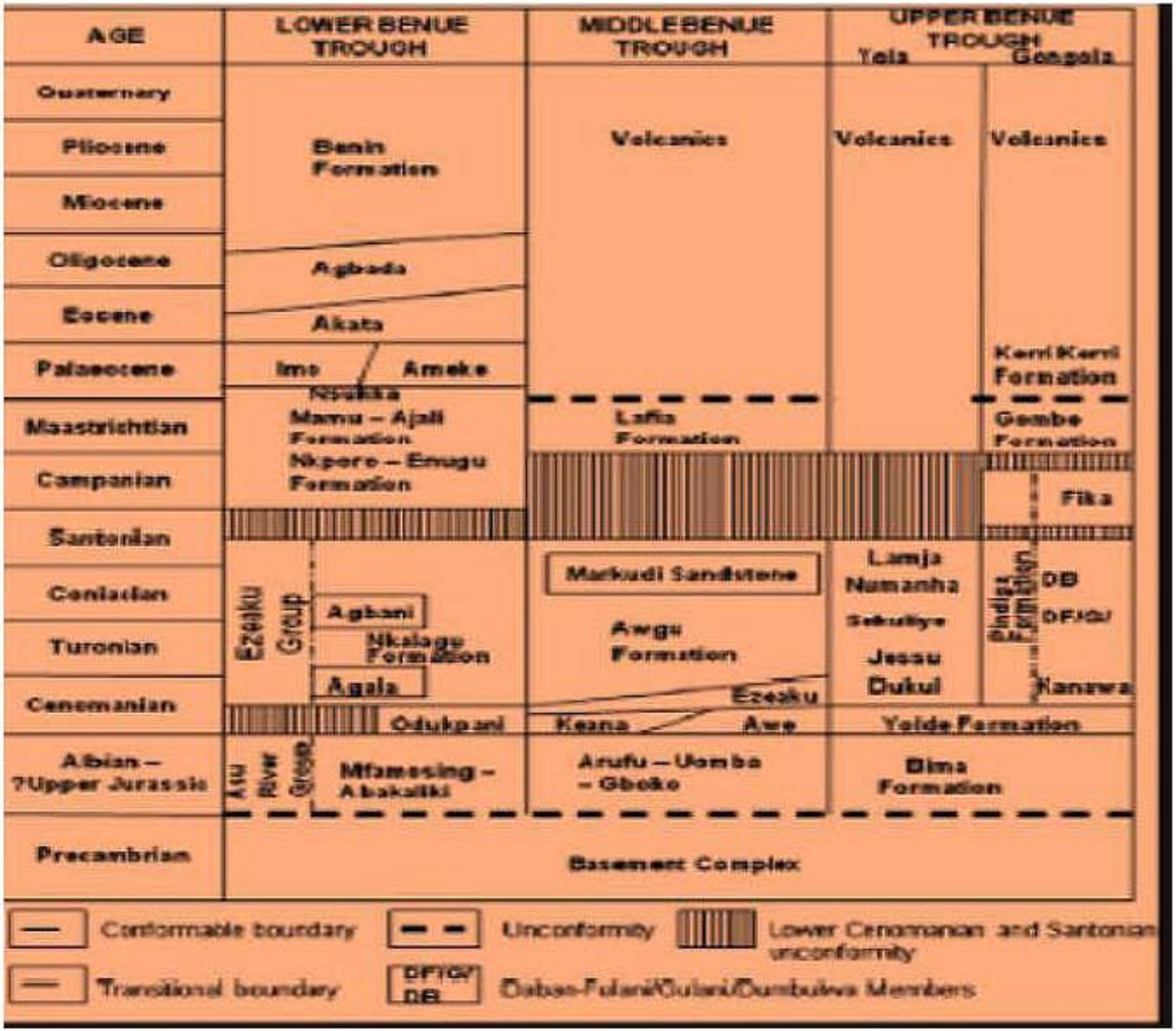

Figure 2. Stratigraphy of the Benue Trough (Abubakar, 2014).

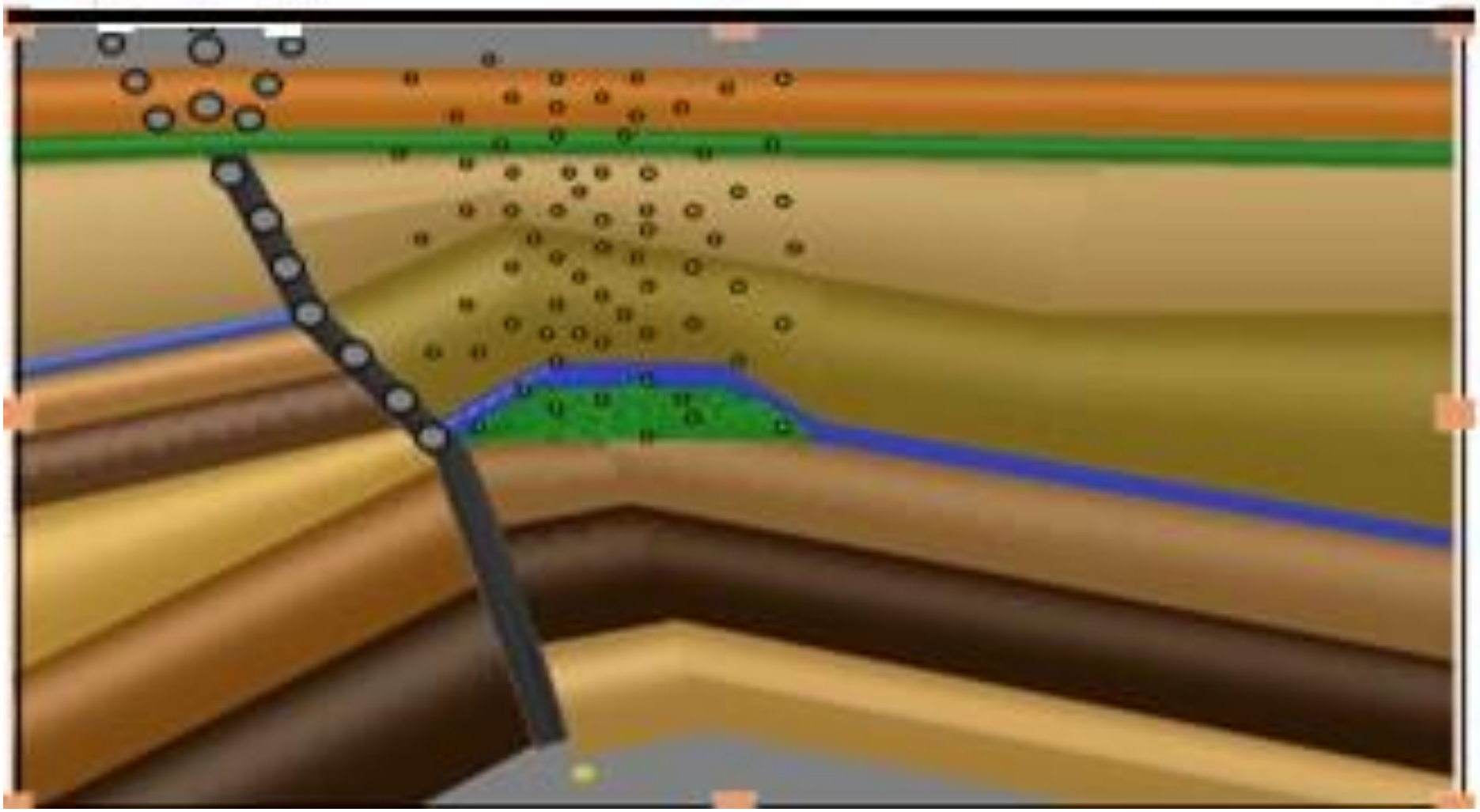

Figure 3. Vertical migration of hydrocarbon micro seepage from the subsurface. This is affected by buoyancy, pressure, porosity, and net pay (AGI, 2016).

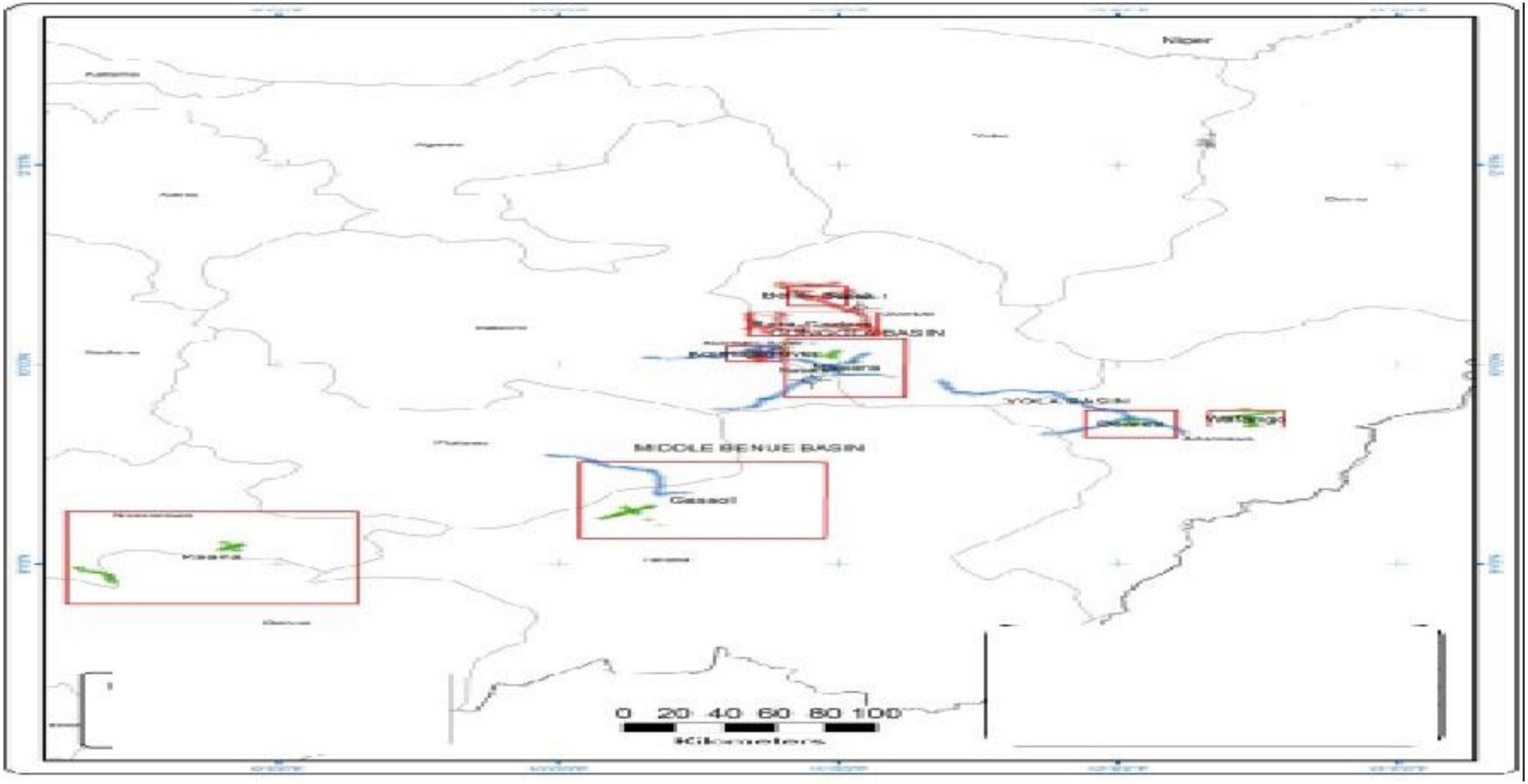

Figure 4. Sample location Map (FES, 2016).

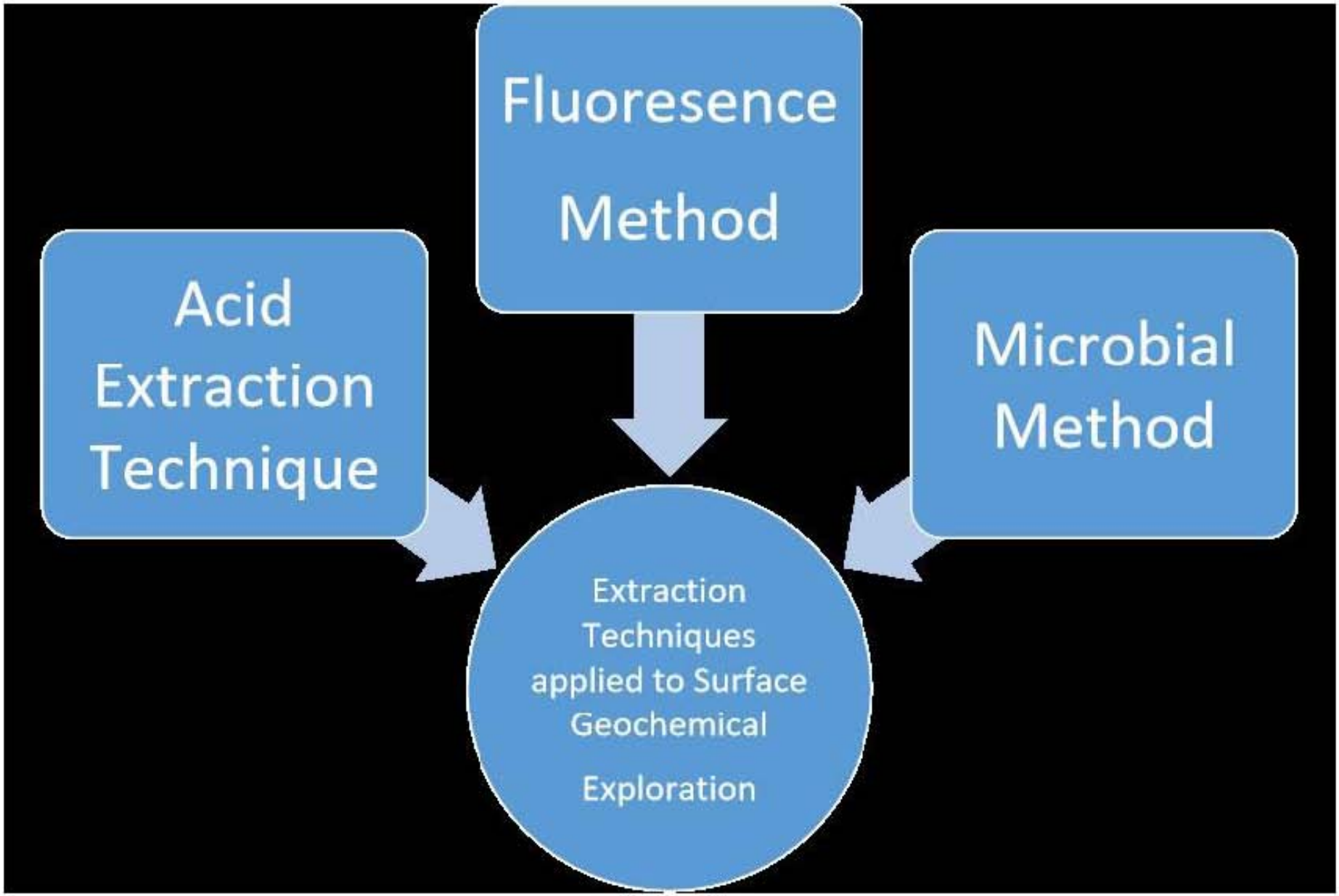

Figure 5. Methods applied to surface geochemical exploration of Benue Trough, Nigeria.

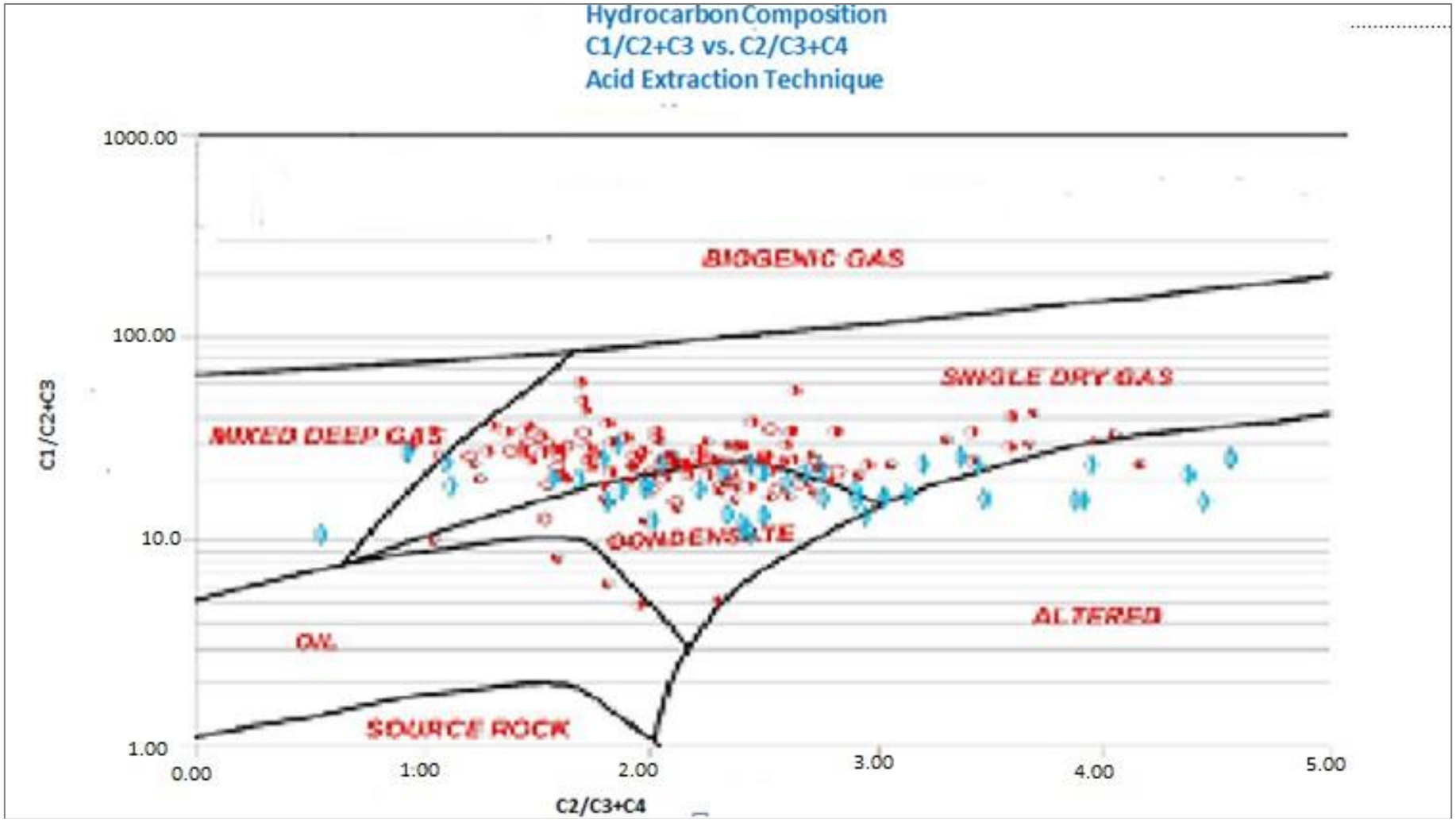

Figure 6. Acid Extraction Technique Result showing nature of hydrocarbon.

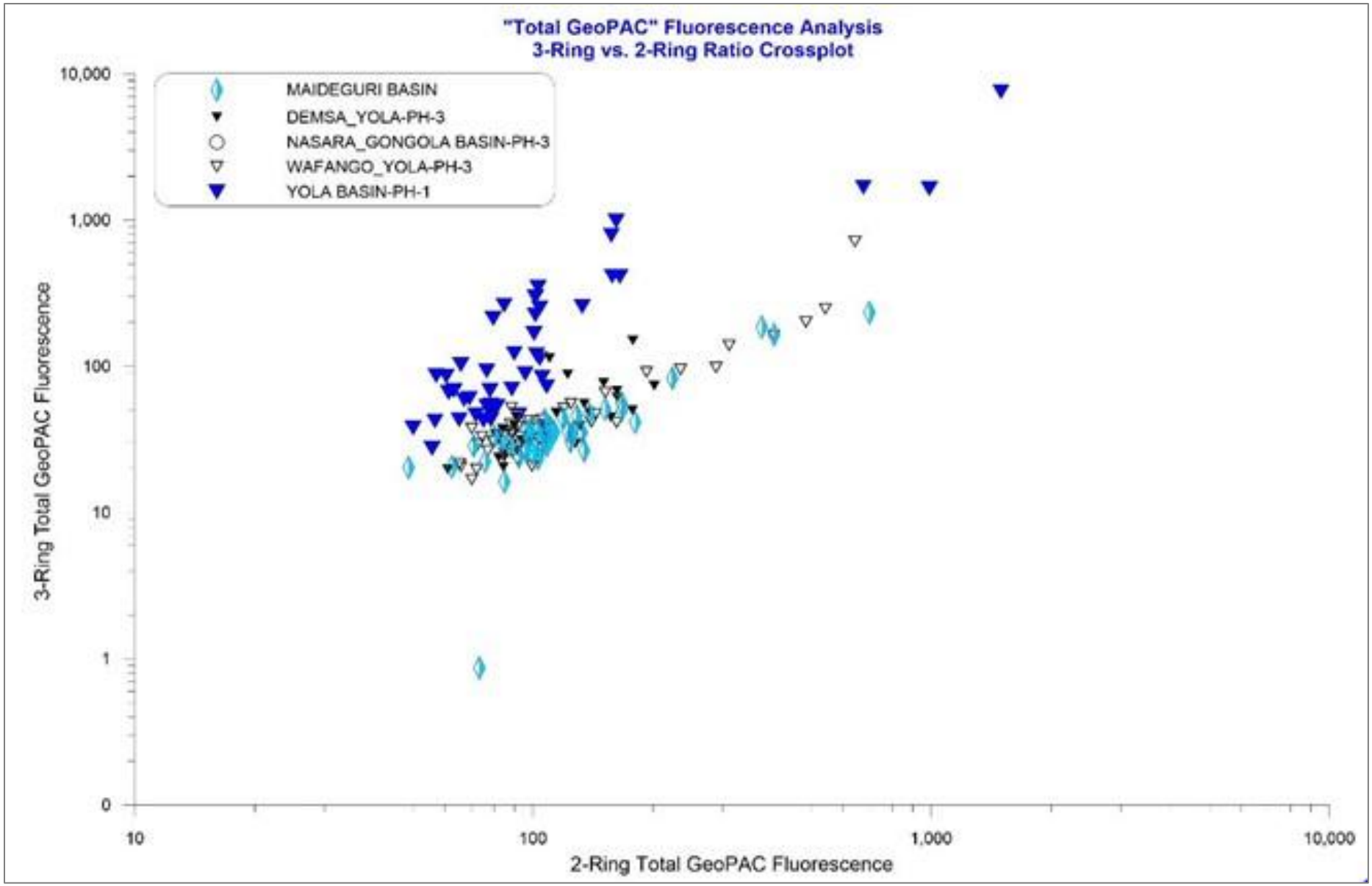

Figure 7. Fluorescence Technique showing the presence of liquid hydrocarbon.

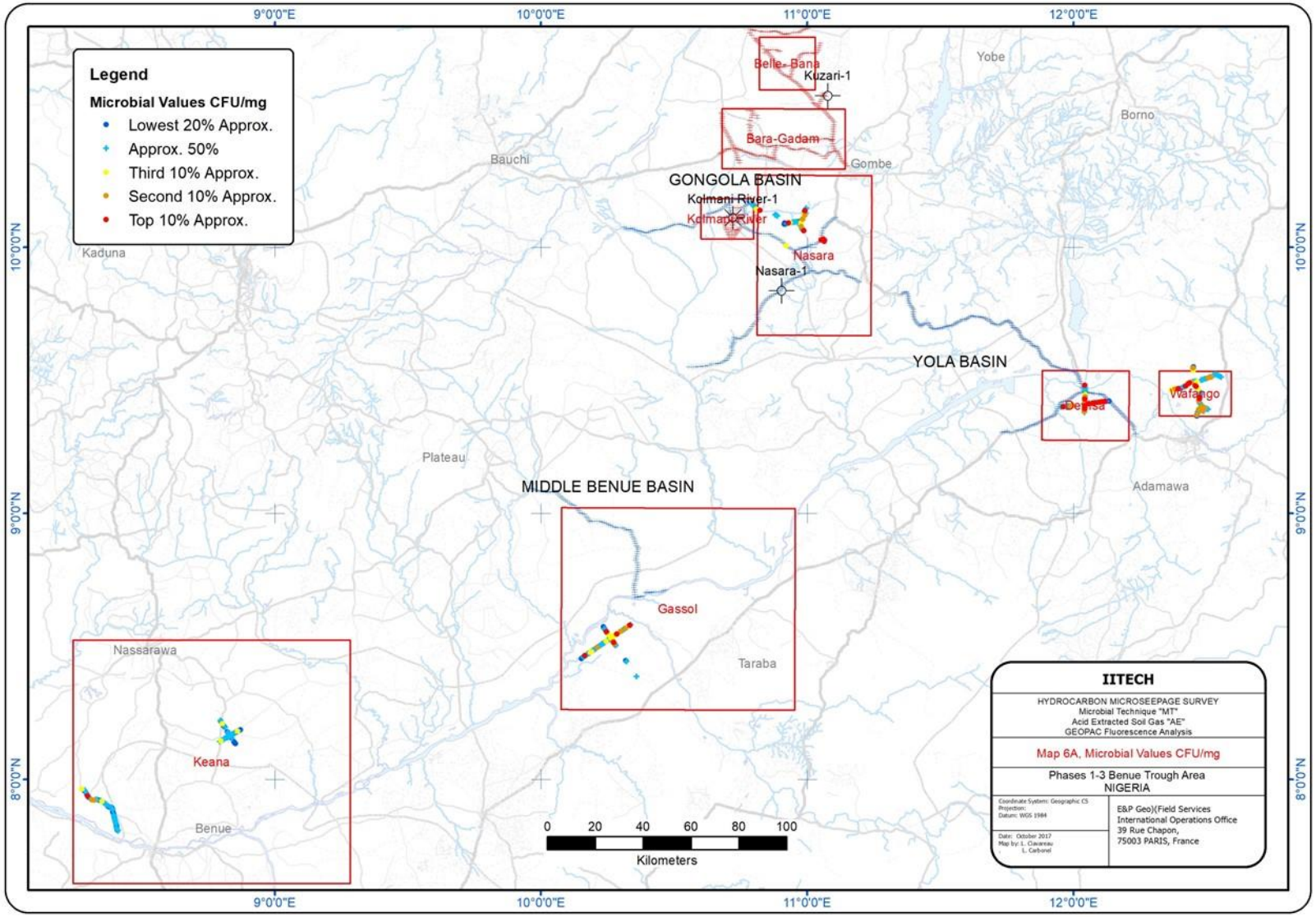

Figure 8. Results from Microbial Techniques used in showing areas of high concentration of hydrocarbon.