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Research Article

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Visualizing Petroleum Geochemistry and Related Data in 2D Contour Plots

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Abstract: Prior to now, the visualization of petroleum geochemistry and related data and research results has always been graphical or tabular, this write up suggests that this should better be done in 2D contour plots. Contour plots need a GPS location data, which give additional bases for interpretation, since locations may infer different regional geologically evolving trends over a time span. The underlying geological processes may contribute largely to differences in data, such as porosity, permeability and organic matter maturity. 2D contour plots is suggested as a viable tool for expressing and presentation of results that will always have a third component.

Keywords: petroleum geochemistry, 2D contour plots.

1. Introduction

All fields of study deal with data, which are generated from different origins and in different ways (Healy, 2019) (Davis, 2002). The sciences deal with data that is not just difficult to understand and interpret, but also entails an enormous task for presentation in a way that could portray a meaningful idea, that not only sustains the study, but vividly provides a lasting picture of its interpretation in the realms of imagination.

Within the circles of petroleum geochemistry and related fields, exploratory geovisualization can be employed, which entails presentation of data as 1D univariate and 2D bivariate plots, in comparative studies, discriminative studies and delinative studies, interactively with maps. 3D cross plots or volume plots have not been popularly considered (Ward, Grinstein, & Keim, 2014) (Evergreen, 2020). Essentially, 2D contour plots which are geospatial data are visualization techniques, and they display 3-dimensional data in 2-dimensional with contour lines. They represent the mapping of 3D data in 2D with color gradients (RockWares, 2020) (Mengxi & Klaus, 2023).

However, in contemporary times, most studies within the circles of petroleum geochemistry entails the inclusion of GPS data, which provides the global position of samples and in consideration of the geological elements provides a typical basis for comparative or discriminative studies, where the evolutionary trends overtime comes to play (Koyamada, 2024) (Marriott, 2025) (RockWares, 2020).

Aspects, such as how chemical elements and compounds within the soil, air, water interact and how nature or human driven changes can affect the ecosystem and human health, can be efficiently reflected by this mode of experimental data expression. Generation of petroleum, its migration and accumulation influence its exploration techniques, how their characteristics could undergo changes over a time frame. And how the traits they possess, impacts on the development of oil fields and the environment.

These features and their variations could be easily portrayed in 2D contour plots, which provides the opportunity to study the variant nature with a clue of the geological element at the background. Their variations could be explained geologically base on events that could have occurred or modification due to natures influences. The intensity of their characteristics or impact could also be observed.

2. The Gap Filled

The usuals for adopting new ideas is that they most have certain advantages over previous concepts, and should provide for the deficiency of the pervious gap.

Some of the reason for preference of 2D contour plots is that they provide spatial insight into the studies, the spatial variations can easily be observed, geological implications can easily be envisioned for the observations. The nature of the plots also provides for easy comparative study based on regions. Areas of steep changes and homogeneity can be identified. These plots can be used to communicate findings of a study with ease. 2D contour plots are excellent tools for identification of patterns. Trends express as gradients can be identified and interpreted (Hanrahan, 2013), (Grunsky & De Caritat, 2017), (Grant, 2019).

3. Examples of Application of 2D Contour Plots

2D contour plots have been tested in the use for petroleum geochemistry studies, to express maturity, biodegradation, oxicity, anoxicity and in environmental oil geochemistry to express TPH (total petroleum hydrocarbon) contaminations in borehole water, and in environmental pollution to express ion concentrations in borehole water for potential drainage of surface water to contaminate groundwater.

Geologically, 2D contour plots can be used to express elevation, which is the height of a specific sample point in relation to the sea level. It can also explain reason for current geological position with respect to geological events, that has occurred overtime past. It could also serve as a base map. Understanding the basic positions of the sample points. This is express as an example in figure 1. Figure 1 shows the elevation and approximate locations of various oil field; the author pleads that the locations may not be very correct since data were obtained from search engines on the net. The approximate elevations could be observed and locations that are offshore can be identified.

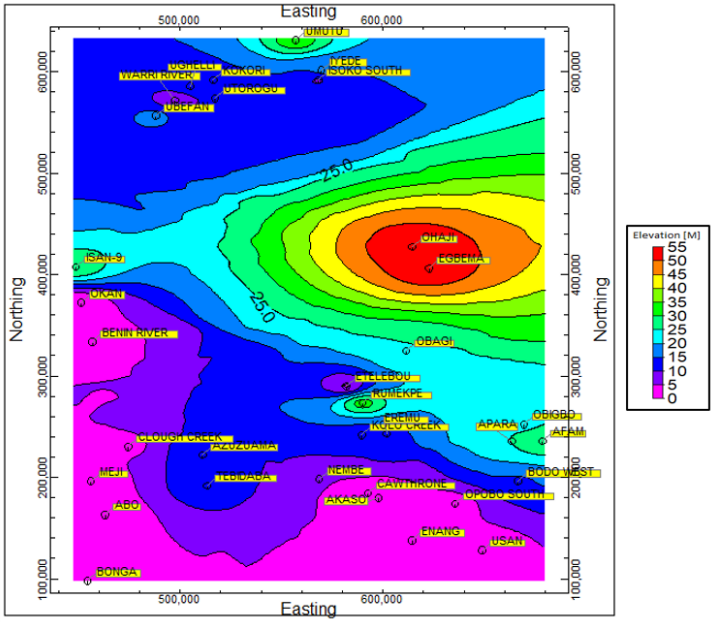

Figure 1: Elevation and Location of various oil fields

Figure 1 shows the maturity of oils from different oil fields as indicated on the plot. Maturity is the average value that represents the maturity of oils from a particular field. On this bases, maturity can be studied, to unravel how it varies, with the geology of the area represented on the diagram, which in this case is the Niger Delta Basin, and given that the basin was deposited in sequences, this fact can be used to uncover reasons for maturity differences considering the deposition time frames of the depobelt.

Maturity is a function of pressure and temperature, both depend on burial (subsidence), exclusive of the Abo and Bonga , maturity is high to the North and East and could partly be attributed to the fact that the Northern fields were earlier deposited as the Northern depobelt and in the East could be facilitated by dykes which are intrusions, probably from the Santonian Event in the Mid Cretaceous.

The Bonga field and the Abo field bears high maturity oils, this could be attributed to rapid deposition of organic matter, with inefficient dewatering which initiates increasing pressure, corresponding to continuous deposition and subsequent burial into high temperature environment, thus facilitating the maturity of organic matter.

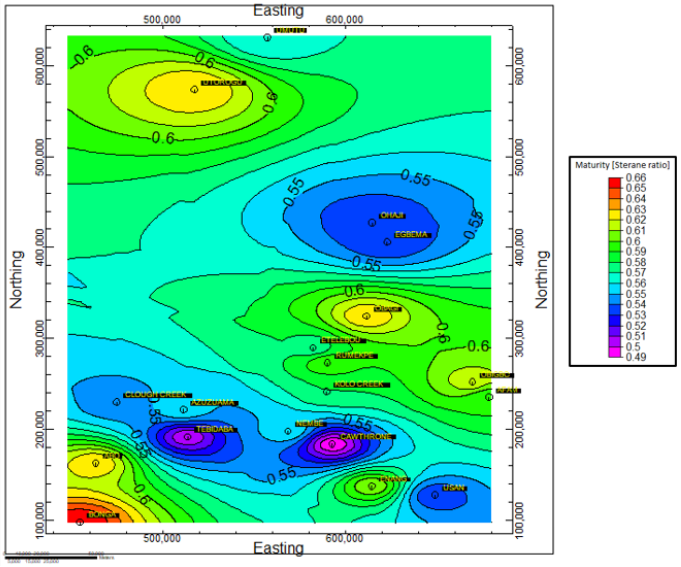

Figure 2: Maturity of the oils expressed as sterane isomerization ratio.

As it can be observed, its easy to relate the geology to the maturity data given the GPS location. Figure 3. is a 2D contour plot for anoxicity expressed as C_{33}-C_{35}/C_{31}-C_{35} Hopanes, the concept is that the hopanes exist originally as bacteriohopanetetrol with 4 to 6 hydroxyl groups, reflecting the C_{33}, C_{34} and C_{35} extended hopanes, the concept is that, these compounds indicate highly reducing marine environment without free oxygen, at shallow nearshore environment the hydroxyl groups react with oxygen and is oxidized into carboxylic acid, which undergo rearrangements of its functional groups, to loss a CO_2 group to form C_{31} and C_{32} hopanes which are found in most Nigeria oils especially the onshore oils.

Figure 3, shows that the C_{33}-C_{35}/C_{31}-C_{35} ratio, which in the context of this study expresses anoxicity, is increasing from North (Uturogu Field) to the South (Bonga Field). The Offshore fields tend to show more marine characters probably due to the influx of marine waters with marine organisms during the opening of the Southern Atlantic.

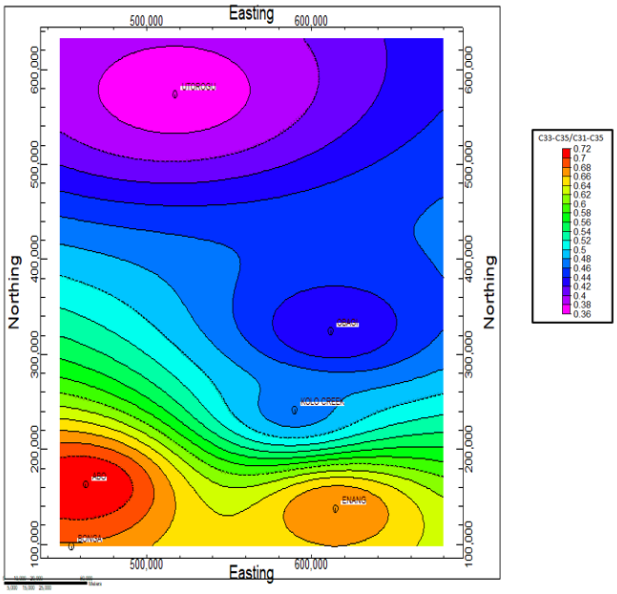

Figure 3: Showing anoxicity based C_{33}-C_{35}/C_{31}-C_{35}

One of the key oil characteristics is its biodegradation status, it expresses the tendency for lighter ends to be removed. In this study, the ratio used is the 1,3,6, trimethylnaphthalene/1,2,4 trimethylnaphalene. The ratios are always the most degrading to the least degrading; thus, ratio decreases with increasing biodegradation. In the light of this, it is observed that biodegradation increases from Northern depobelt to Offshore depobelt for the suite of oils that were evaluated.

This mode of expression of petroleum geochemistry results can also be adopted for mapping both surface and subsurface or isosurface TOC and Kerogen of an area or a region. Figure 4a and b shows subsurface mapping of Kerogen and TOC at 6,900ft. The data allows for stimulation using the subsurface data to understand potential hydrocarbon generation areas.

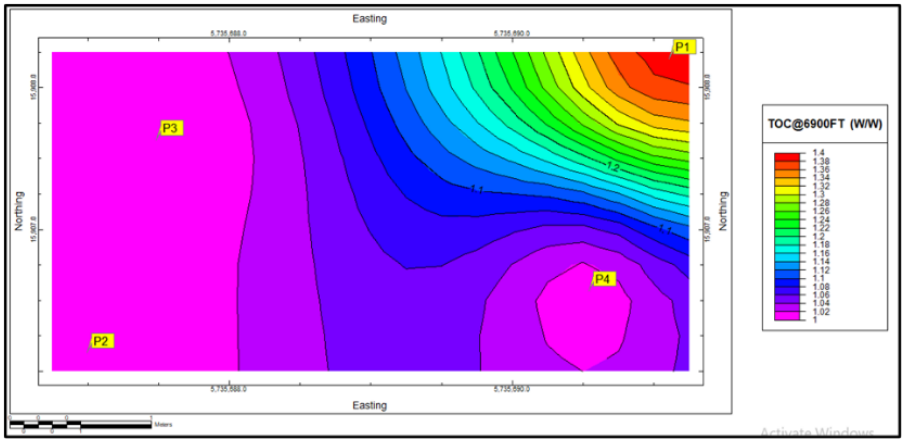

Figure 4a: Subsurface Mapping of TOC in Pearl Field.

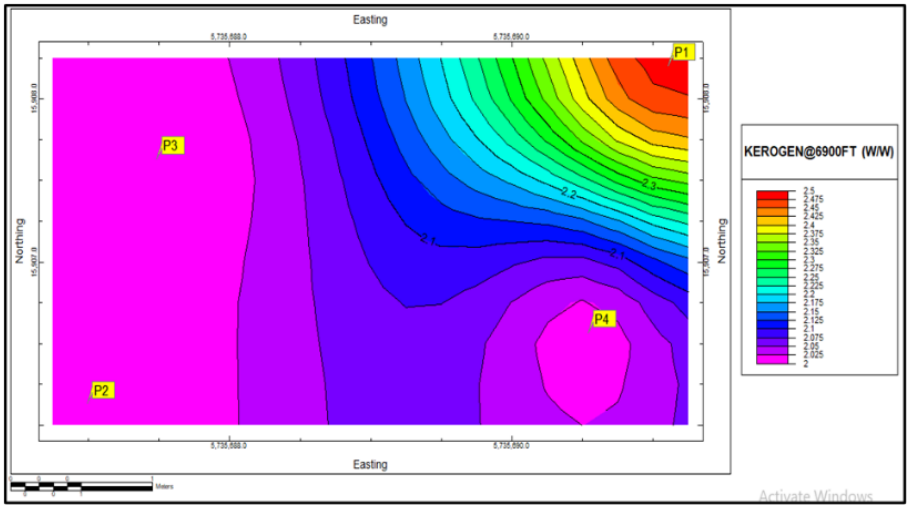

Figure 4b: Subsurface Mapping of Kerogen in Pearl Field.

The mapping of an area or region for petroleum generation characteristics is essential, because its carries valuable information, on maturity distribution, identifying zones that are mature and immature and also hydrocarbon generation, outlining areas that are generating and with geological features such as fractures, faults and extensive sandstone deposits, delineates migrational pathways. If such maps are superimposed/georeferenced on googlemaps bearing structural features, a lot of information could be deduced. Figure 5 is a TOC map of various oil field at various sample depth depending on sample availability reflecting the Niger Delta Basin.

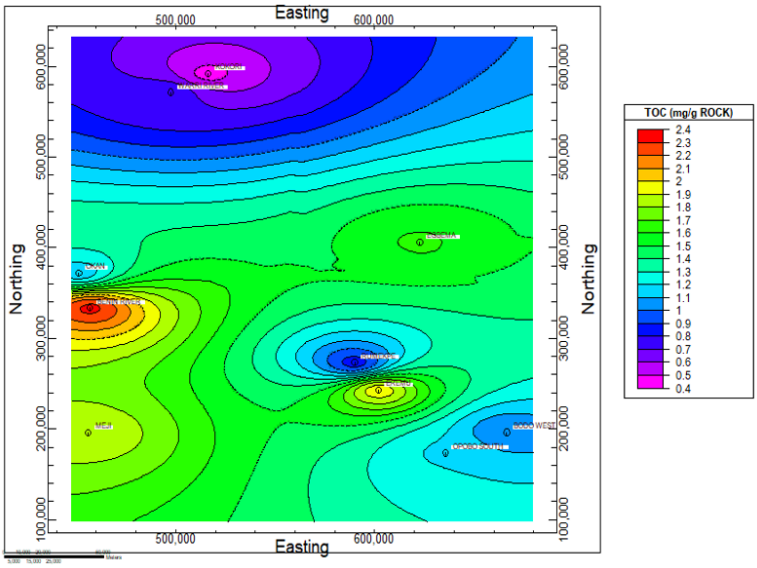

Figure 5: TOC Map of various fields in the Niger Delta Basin, at depth where sample were available

The suite of samples used in figure 5, shows that Benin River oil field had the highest TOC of 2.4 % [w/w], while Kokori oil field had the lowest TOC at 0.4%[w/w]

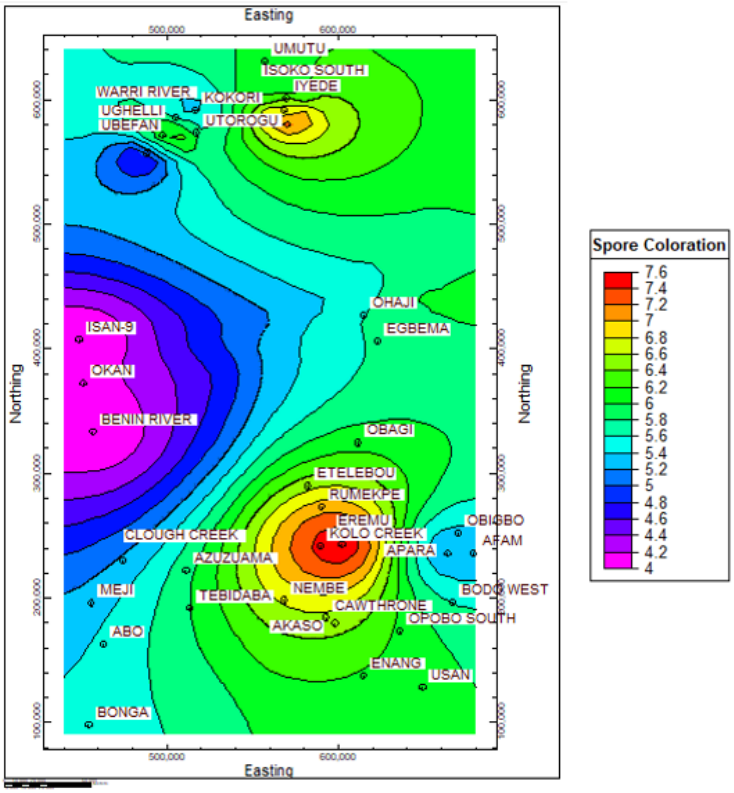

Figure 6: Spore Coloration for sample in the Niger Delts Basin.

Spore Coloration refers to the color of spores in the matrix of rock samples, this is an aspect of Optical Geochemistry, spores have different shades of color, depending on the maturity of the spores. Maturity varies from light yellow to dark brown and black for post mature spores. These have been used to express maturity of source rock.

4. Peculiarity with Niger Delta Basin

Geologically, the mesozoic constitutes the Triassic of large arid land and deserts, and the Jurassic, hailing the advent of marine systems and environment, followed by the Cretaceous with the emergence of swampy environments, when the Niger Delta Basin began to develop.

The peculiarity of this mode of expressing petroleum geochemistry result for the Niger Delta Basin related research, is rested on the pillar, that the Niger Delta Basin was deposited as mega sequences, spanning a range of geological time frame for each sequence, thus the basin can be portioned into depobelts. With correct GPS data the oil fields belonging to each depobelt can be presicely delineated. Additionally, each sequence has its maturity, since the organic matter were not deposited at the same time. Though, maturity process and mechanism may differ, as a result of subsidence and exposure to high temperatures, which is most likely to occure in the East relative to the West, due to volcanic activity and possibilties of dikes and intrusions, which will be a source of heat to foster organic matter maturity. Regional variations in heat, pressure and subsidence will influence maturity of organic matter and oils.

5. Atmospheric Pollution

Atmospheric and soil pollution are aspects in which 2D contour plots, applies very well. Figure 7 is an imprecise location data for air quality index for major cities in Nigeria (pls permit its usage). This mode of presentation gives a better analytical media for such data relative to graphical or tabular presentations.

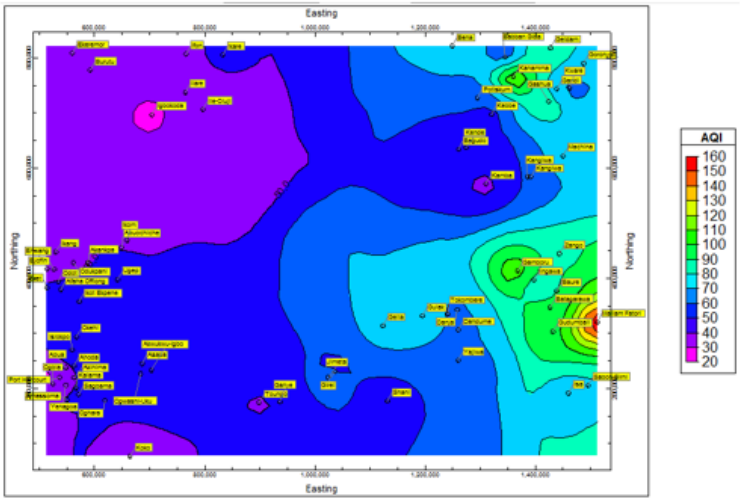

Figure 7: Imprecise location data for air quality Index of some major Nigeria cities

6. Conclusions

2D contour plots has not been a popular choice for expressing data/research findings in Petroleum Geochemistry, Mineral Exploration and some aspects of pollution studies. This is suggested to be a tool that will give at a glance interpretation of data and research results.

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