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THE IMPORTANCE OF ISOCHORE MAP IN RESERVOIR CHARACTERIZATION

Ikponmwen M. O.[1] and Aseogwu I. K.[2]

[1]Department of Physics, University of Benin, Benin city, Nigeria.
[2]Department of Industrial Physics, Chukwuemeka Odumegwu University Uli, Nigeria.

Abstract

This paper focuses on the use of Isochore map in constraining and quality checking of seismic interpretation process aimed at enhancing reservoir compartments visualization and modelling of a hydrocarbon reservoir in the MOI field onshore Niger Delta. Isochore maps was generated using the various well top data from the reservoir. The generated map was then engaged in the interpretation process because of the fact that, thickness maps are in most cases more regular and therefore more easily constructed from scattered well data than structural maps.
This novel interpretation process resulted in a forward visualization of the expected reservoir compartments before proper interpretation. This was then used to narrow the fault and horizon interpretation phase of the study. The final result generated was a fit for purpose representative static model used in characterising of the reservoir.

Keywords: Isochore, Compartmentalization, Reservoir.

Introduction

Interpretation of subsurface geology can be greatly improved by 3-D seismic data, and this accounts for its pertinence in today's search for dearth oil and gas resources. Seismic interpretation has two fundamental disciplines at its hub: These are seismic geomorphology and seismic stratigraphy. Plan views allow the Explorationist utilize the principles of geomorphology, based on analogies with modern sedimentary systems, to interpret depositional environments and even predict facies distributions. Whereas section views utilised stratigraphic interpretation and help determine stratal architecture and the temporal development of the depositional system. Both approaches give insight into the geological processes that formed the hydrocarbon play[1]. This paper focuses on the application of isochore map from available well tops in the MOI field to generate a forward visualization of the expected reservoir compartments which will be used to constrict the seismic interpretation process thus aiding in the generation of a fit for purpose structural map as well as static reservoir model.

Geology of Study Area

The MOI field is situated eastern part of the Niger Delta, with a STOOIP of 78 x 10^6 (492 million STB). The real name of the field is not given for confidentiality reason but named MOI-field for the purpose of this study.

The Niger delta sedimentary basin which sits on the Benue Trough, the failed rift arm of a triple junction associated with late Aptian to Albian opening of the South Atlantic Ocean [2]. The Niger delta is subdivided into five depobelt that range in age from Eocene to Plio-Pleistocene. They are the Northern delta, Greater Ughelli, Central Swamp, Coastal Swamp and the Offshore Depobelt. Most of the "depobelts" are bounded by a landward normal listric growth fault system and seaward by a counter-regional fault system. These Faults sole-out onto a regional detachment surface in Cretaceous bathyal shales that are just above basement. These five concentric depositional units are differentiated by growth fault punctuations that terminated each depositional episode during the formation of the depobelts. Each of the events that formed a depobelt occurred within a time line and deferred in age from the adjacent depobelt [3].

Correspondence Author: Ikponmwen M.O., Email: osarogie.ikponmwen@uniben.edu, Tel: +2348078677461

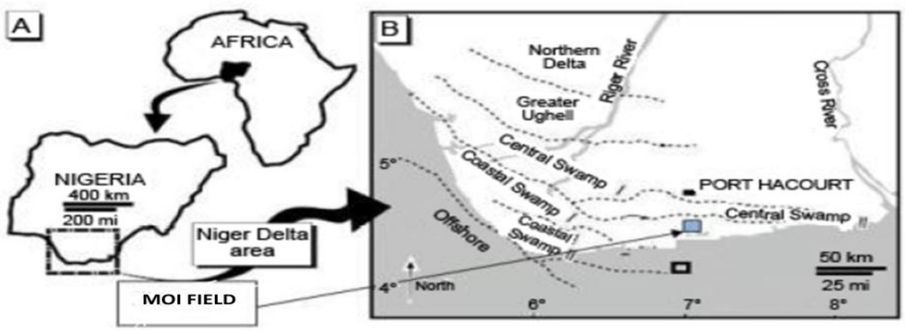

Fig. 1: Map of Study area showing the field of study [4].

The study area for the research falls within the Coastal Swamp depobelt in the western part of the Niger Delta sedimentary basin (Fig. 1). Three traditional formations of the Niger Delta include: the Akata Formation, Agbada and the Benin Formation [5]. The Akata Formation is the basal stratigraphic unit of the Niger Delta. It is composed of predominantly overpressured marine shale with pockets of turbidite sands towards the top. Most of the hydrocarbon accumulated in the paralic Agbada sequence is generated in this shale. The Agbada Formation is an offlap sequence of foreset beds in an alternating sand/sandstone and shale successions. Top of the Agbada occurred at about 5000ft to 6000ft within the swamp and coastal swamp depobelts. It can be encountered as shallower as about 1850ft in the shallow offshore area in the eastern part of the basin[6].

It is the most deformed stratigraphic unit due to upsurging shale diapirism from the Akata Formation and the presence of growth faults. In most of the accumulations, hydrocarbons are trapped in structural closures supported by these major boundary growth faults and their associated rollover anticlines. The shale components of the Agbada Formation form good seals and potential source rocks especially towards the base of the Formation.

The Benin Formation overlies the Agbada Formation, and is composed of continental sediments deposited within the fluvial systems. It is made up of majorly loose sands, gravels and pebbles (clear, transparent - translucent, medium – coarse grained, occasionally very coarse grained, loose, sub-angular to sub-rounded, sub spherical - sub elongated, poorly sorted) and minor claystone beds. Woody materials, peats and lignite streaks have been recovered from this unit. In onshore oilfields (Northern Delta Depobelt, Greater Ughelli Depobelt), the base of the Benin sand occurred at about 7400 ft; about 1850ft in the shallow offshore area, and totally absent in the deep offshore. In the study area, the base of the Benin Formation is at about 1750 ft. The Benin Formation do not contain oil and gas but may contain some biogenic gases that appear as background gas during drilling operations[7].

Isochore is a contour connecting points of equal true vertical thickness of strata, formations, reservoirs or other rock units. A map that displays Isochore is an Isochore map.

The terms Isopach and Isopach map are incorrectly used interchangeably to describe Isochores and Isochore maps. Isopachs and Isochores are equivalent only if the rock layer is horizontal[8]. Figure 2 shows interval 'c' depicting the isochore while interval P depicts the Isopach. The right-hand side of the section shows that the difference between isopach and isochore becomes negligible with small dips, say, below 10°.

Isochore maps can be very useful aids in structural mapping, largely because thickness maps are in most cases more regular and therefore more easily constructed from scattered well data than structure maps[9].

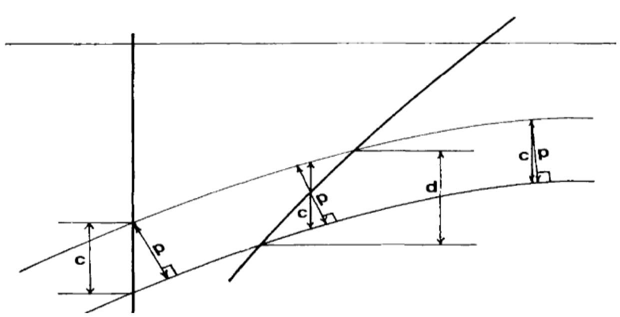

Fig. 2: Diagramatic representation of Isochore

Theoretical Background

The standard gridding algorithm (Convergent in Petrel) is used with the modified data to build the thickness grid by interpolating and extrapolating known thickness from wells data set to areas without wells on the reservoir.

The general interpolation and extrapolation equation can be written mathematically as shown in equation (1) and (2) respectively.

Where $y - y_0 = \frac{y_1 - y_0}{x_1 - x_0}(x - x_0)$ (1)

is used in interpolation of for a point (x, y) between points (x_0, y_0) and (x_1, y_1) known values, while for two data points represented by (x_{k-1}, y_{k-1}) and (x_*, y_*), which are to be extrapolated from a known nearest the point x_*, linear extrapolation gives the function[10]:

$y(x_*) = y_{k-1} + \frac{x_* - x_{k-1}}{x_k - x_{k-1}}(y_k - y_{k-1})$ (2)

Materials and Method

The materials available for the research includes

i. 3-D PosSTM Seismic volume,
ii. Checkshot Data for Well 1, Well 4, Well 9, Well 10 , Well 11,
iii. Deviation Data for Well 1, Well 4, Well 9, Well 10 , and Well 11
iv. Base Map of study area showing distribution of wellls
v. well logs(Ascii)

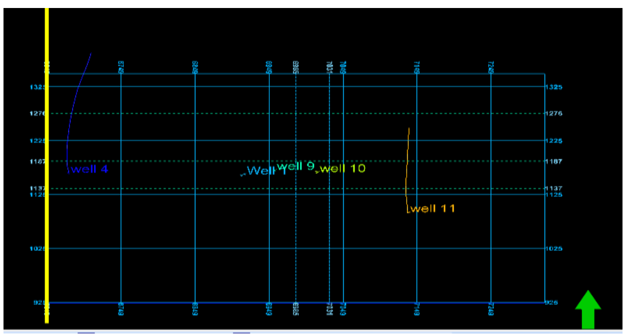

Fig. 3: Base map of the study area showing the distribution of five wells.

The method focuses on generation of an Isochore map and the utilization of this map in quality checking the seismic interpretation process with the sole aim of obtaining a fit for purpose reservoir model. It involve the creation of zones on the well logs to define the flow units. This zones were then converted into isochores and used to create stratigraphic intervals between the horizons. It allows a further refinement of the vertical resolution of the 3D grid on the seismic data.

Result and Discussion

A time slice at a depth of 2200ms which falls within the depth of the reservoir of interest was made on both the raw seismic volume and the variance seismic volume generated as shown in fig 4 and 5 respectively.

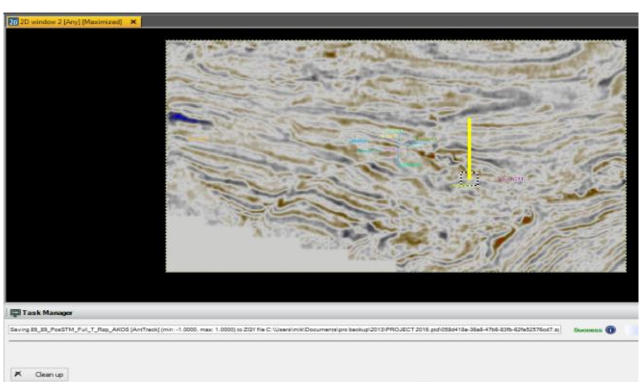

Fig. 4: Time slice of input seismic volume at -2200ms

The raw seismic volume as seen in Fig. 4 shows no significant variation. Thus variance attributes which is known for extracting fault automatically was used to extract the fault as seen in Fig 5. The result showed a great extent of structural complexity with discontinuities ranging from the northern part to southern part of the reservoir.

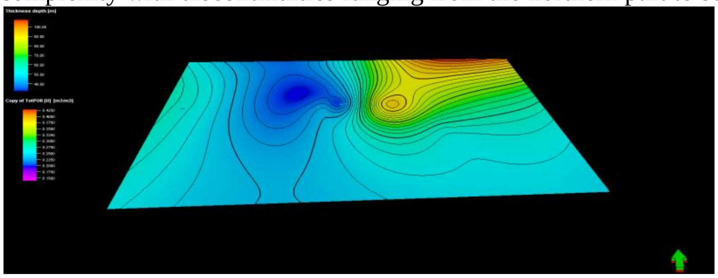

Fig. 5: Generated Isochore map.

The Isochore map shown in Figure 5, clearly revealed two major compartments separated by a saddle and an incomplete compartment truncated by the cropped seismic volume. Isochore map was used in quality checking seismic interpretation aimed at enhancing reservoir compartment visualization and modelling of a hydrocarbon reservoir.

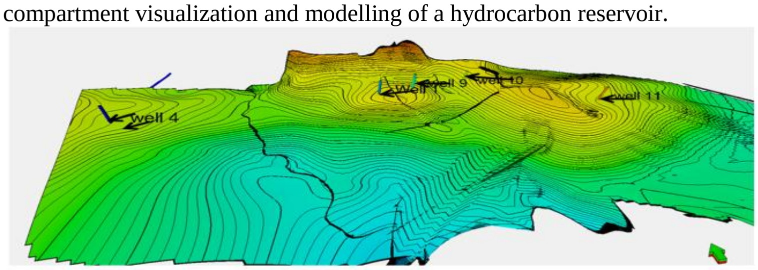

Fig. 6: Static Reservoir Model of Interpreted Horizon

This novel ideal resulted in a better visualization of the reservoir compartments arising from the well data sets which was thus used in the generation a robust representative static model (Figure 6) thereby leading to a better characterisation of the reservoir.

Conclusion

Isochore map generated within the framework of this research have been used to constrain and quality check interpretaion of the information about the mapped reservoirs and identified structural traps aimed at a better delineation of hydrocarbon prospects and improved reservoir characterization. It has been further demonstrated that sgeneration of an isochore map is complementary to the information derived through traditional methods of seismic interpretation. Generation of an Isochore map from well data can bring to fore new information and insights into stratigraphic as well as structural interpretations. The deliverables from the Isochore map and analysis will help greatly in reducing further development and exploitation risk.

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