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The basic workflow followed in an Oil Industry to explore Hydrocarbon

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Summary

In this paper we describe the basic work flow used in Oil and Gas Exploration. The processes covered all the basic and important aspects starting from seismic acquisition to volumetric calculation.

***Keywords**: Facies analysis, resistivity, Isochron*

Introduction

To find a convergence in the subsurface of the geologic elements necessary to form an oil or gas pool requires a careful blend of science and art. To discover what geometries and compositions the rocks might possess deep underground, geologists examine the rocks where they are exposed in surface outcrops, or they examine aerial photographs and satellite images when surface access is limited. They do mapping, study of regional geology, Stratigraphic analysis. Geologists also work closely with geophysicists to integrate seismic lines and other types of geophysical data into their interpretations.

In our case, using the well and seismic data, we did seismic to seismic and seismic to well tie analysis to find horizons of our interest. This was followed by marking faults in 2d sections and later producing fault polygons in Inline and cross lines. Further using interpreted horizons and faults, we mapped the subsurface by the Geophysics module of the software.

Later volumetric calculations (reserve estimation) were done followed by risk analysis and maturity of the source rock. Finally, when a prospect has been identified and evaluated, an exploration well is drilled in an attempt to conclusively determine the presence or absence of oil or gas.

Method

Visible surface features such as oil seeps, natural gas seeps, pockmarks (underwater craters caused by escaping gas) provide basic evidence of hydrocarbon generation (be it shallow or deep in the Earth). However, most exploration depends on highly sophisticated technology to detect and determine the extent of these deposits using exploration geophysics. Areas thought to contain hydrocarbons are initially subjected to a gravity survey, magnetic survey, passive seismic or regional seismic reflection surveys to detect large scale features of the sub-surface geology. Features of interest (known as *leads*) are subjected to more detailed seismic surveys.

To see the seismic (2d and 3d data sets) along inline, cross line and random line direction, we can select from Map view. Open it in an Interpretation window (Seismic Data Visualization Window) for analysis. 2D data, although of excellent quality, has a line spacing of 7 – 10 Kms. 3D data has a virtual line spacing of c.100 metres

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Identification of Markers using well logs and well correlation

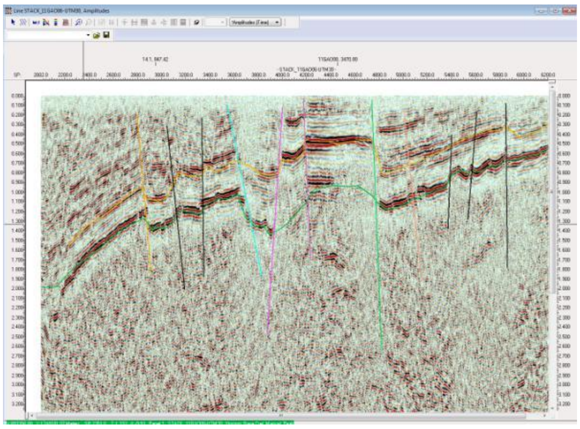

Figure 1: A interpreted seismic profile in 2 dimension showing marking of faults and horizons of interest

The markers are identified on the basis of behavior of Gamma ray log and if SP log is available then it can also be used for marker identification.

These markers also support the other logs – Resistivity, Neutron porosity and Density logs. The wells are correlated to find the extent of any oil field (These wells are known as Appraisal wells). It is also possible that there is a pattern in the logging data which is not found in any adjacent well then it is identified as a pinch-out,

Then we start with marker identification and its tracking throughout the seismic section – we can take the help of well log data.

These markers are tracked throughout the section in an Interpretation window using the Geophysics module of the software (Fig 1). Further the faults are identified and marked. Most importantly this data is in Time Domain which we will convert to Depth Domain for correlation with well data.

Seismic to Well Tie and Well to Well Tie analysis

Seismic to well Tie is generated from the two well logs for correlation with the seismic markers (Fig. 3). Well data is given in Depth domain. So to correlate it with seismic data we have to convert it into Time domain.

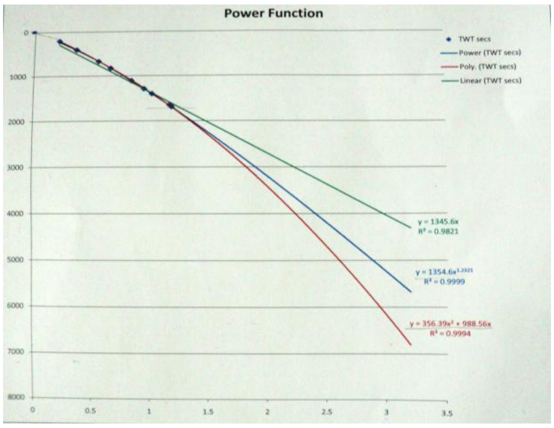

Figure 2: T-D plot to convert Time Domain to Depth Domain

Check shot data is loaded for first well to generate T-D curve (Fig 2). Same T-D curve is shared with other well.

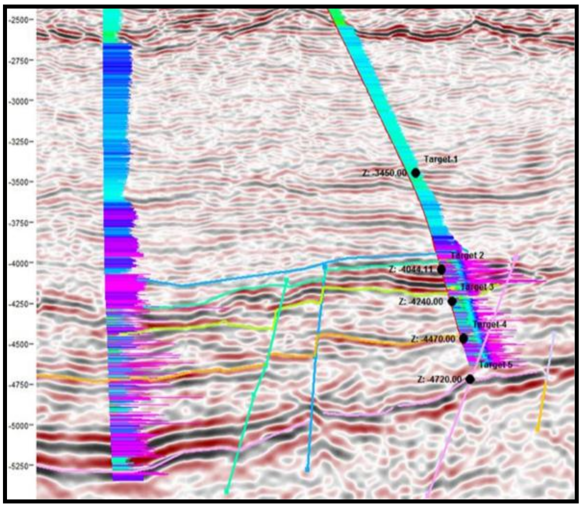

Figure 3: Section showing seismic to well tie and well to well tie

Surface mapping and contouring

—From the picked horizon in every 5th inline and crossline, surface is created by using interpolation method on well tied seismic loops.

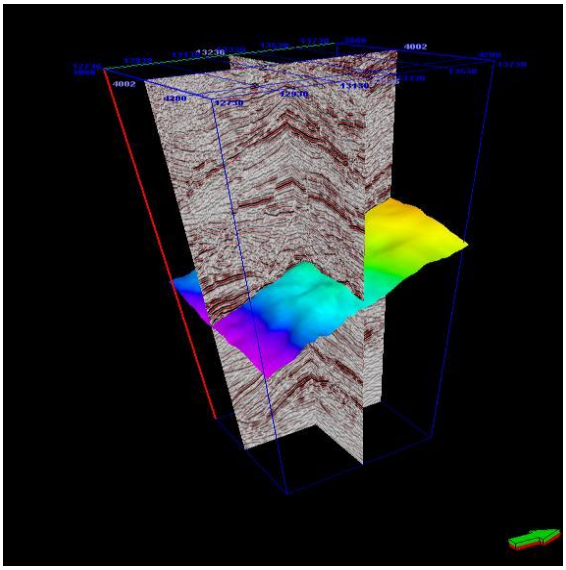

Figure 4: Sub surface with inline and crossline seismic sections.

The surface along with inline and crossline is shown in 3D window (Fig. 4). From 3D visualization and color coding, trend and dip of the surface is identified.

From the figure we can observe the structurally high areas which may be the possible prospective zone for hydrocarbon therefore wells are drilled at these sites.

The surface is viewed in the map window in a suitable scale like 1:25000. Contouring of this surface is done by using altitude attribute of Geophysics module of Petrel. A suitable contour interval is taken. Finally the map is shown in the Map window.

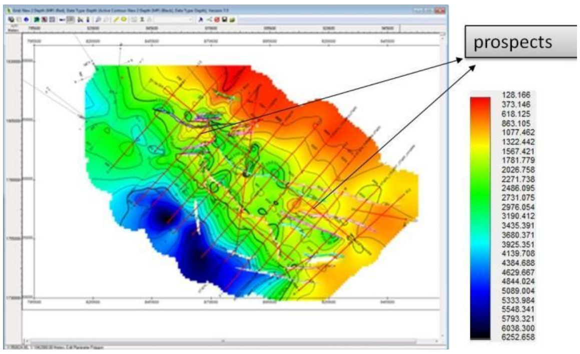

Figure 5: Isochron Map showing Prospect in the Oil field (Mali, Africa)

In order to represent the geological model of the study area it is ideally desirable to prepare structure maps, tectonic features and isochron maps. Two antiforms are shown in this contour map which could be suitable prospects. Different faults were associated with each other to form series of faults which are shown as fault polygons on the map.

Maturity Estimation for Source rock

Acquiring knowledge of the maturity of source rocks is a basic step towards the exploration in any basin.

Following equations are used for the maturity calculation: (Data required: Surface T, Temp Grad, Thickness of units, Top and bottom ages, TTI (= 0))

1. TEMP = STemp + CumThick * Tgrad / 1000
2. TT = age * 2 ^ ((TEMP - 105) / 10)
3. TTI = TTI + TT (Iteration)
4. Ro = 10 ^ (-0.4769 + 0.2801) * (Log(TTI) / Log(10)) -0.007472 * (Log(TTI) / Log(10)) ^ 2

Based on Ro value maturity is calculated as:
If Ro <= 0.5 -- Immature
If Ro > 0.5 And Ro < 1.3 – Oil window
If Ro >= 1.3 And Ro < 3 – Gas window
If Ro >= 3 And Ro < 5 -- Dry Gas
If Ro >= 5 – Over cooked
Where Ro is Vitrinite reflectance and TTI is Time Temperature Index
(Courtsey: Heritage Oil Plc., UK)

Reserve Estimation

The volumetric method for calculating the amount of oil in place (N) and gas in place (G) is given by the following equations:
$N(t) = V_b \Phi S_o(t) / B_o(t)$ &
$G(t) = V_b \Phi S_g(t) / B_g(t)$.

These oil and gas in place will now be multiplied by Recovery factor to get the Estimated Ultimate Recovery of an oil and a gas field respectively of an oil reservoir.

[V_b = bulk reservoir vol; H = average reservoir thickness(ft); A = reservoir area(acres); φ = average reservoir porosity; $S_o(t),S_g(t)$ = average oil and gas saturations; B_o, B_g = oil and gas formation volume factors at reservoir pressure p, RB/STB]

The Effective porosity can be calculated using : Sonic, Density and Neutron Density logs. Oil & gas saturation is indirectly calculated from water saturation by Archie's formula in terms of true resistivity of the formation. This parameter can also be used in Formation Evaluation for facies analysis. [$S_{hc} = 1 - S_w{}^n$]

A critical part of any appraisal program is determination of the fluid contacts (gas/oil, gas/water, and oil/water) in a petroleum pool. Until a well is drilled into the ground, such contact depths can only be estimated on the basis of a calculated spill point or a direct petroleum indicator from seismic. A common plan is to drill the exploration well on a prospect in such a position that it proves a volume of petroleum (updip) that is deemed to be economically viable. Following the success of that well, the first appraisal well will be drilled in such a position as to penetrate the expected petroleum/water contact and, in consequence, define the size of the pool.

Risk Calculation

In the risk assessment process it may be useful to establish a set of general qualitative descriptions for the relative probability scale. These are pro-posed in the table below. The scale is related to the certainty attached to the model for the relevant geological factor and to data control.

A distinction is also drawn between proven geo-logical models and analogue/ theoretical models. These expressions may be useful during discussions related to the assignment of probability factors.

P	General scale	Analogue or theoretical models	Proven geological models	P
1.0	Condition is **virtu-ally to absolutely certain**. Data quality and control is excellent.	Only possible model applicable for the concerned area. Unfa-vourable models are impossible.	Identical geological factor to those found in fields and discoveries in immediate vicinity. Conditions are verified by unambiguous well and seismic control.	1.0
0.9		The model is very likely to abso-lutely certain. Unfavourable models are not impossible.		0.9
0.8	Condition is **most probable**. Data control and quality is **good**. Most likely interpretation.	The model is very likely. Only minor chance that unfavourable models can be applied.	Similar geological factor successfully tested by wells in the trend. Lateral continuity is probable as indicated by convincing well and seismic control.	0.8
0.7		The model is likely to very likely. Unfavourable models can be applied.		0.7
0.6	Condition is **probable** or data control and quality is **fair**. Favourable interpretation.	The model is mor likely than all otherunfavourable models.	Similar geological factor is known to exist within the trend. Lateral continuity is probable as indicated by limited well and seismic data.	0.6
0.5		Likely model, however, unfavourable are also likely.		0.5
0.4	Condition is **possible** or data control and quality is **poor to fair**. Less favourable inter-pretation possible.	Unfavourable models are more likely than applied model.	Similar geological factor may exist within the trend. Valid concepts, but unconvincing data only hints at possible presence of the feature.	0.4
0.3		The model is questionable. and unfavourable models are likely to very likely.		0.3
0.2	Condition is **virtu-ally to absolutely impossible**. Data control and quality is **excellent**.	The model is unlikely and very questionable. Unfavourable models are very likely.	The geological factor is not known to exist within the trend. Conditions are verified by unambiguous well and seismic control.	0.2
0.0		The model is unlikely and highly questionable. Unfavourable models are very likely to certain.		0.0

Courstey: Heritage Oil Plc.,UK

Probability of Reservoir rock, Source rock, Trap and Timing (Maturation) combined will give the Total Geological risk of the Oil Field

What after Seismic interpretation

Following seismic interpretation we do well tie with the log data, we also estimate reservoir properties using hard core samples data and other laboratory analysis. All steps are followed to delineate the reservoir horizons sub-surface, know its extent, calculate the PP properties, estimate reserves and do risk analysis for developing the virgin field. Finally, when a prospect has been identified and evaluated and passes the oil company's selection criteria, an exploration well is drilled in an attempt to conclusively determine the presence or absence of oil or gas. A well drilled to find a new gas or oil field is called wildcat well. Geologic and geophysical clues are enticing, but drilling is the only way to learn if an oil or gas field really exists. Once a well is drilled, well logs yield data on the types of rock present and, most important, what fluids these rocks contain. The information interpreted from the logs is used to decision whether a well should be completed and used to produce oil and gas, or filled with cement and abandoned. The logs are also used to update the geologic models originally used to locate the well.

Today, the average wildcat well has only one chance in ten of finding an economic accumulation of hydrocarbons.

Conclusion

The mapped subsurface is successfully interpreted to finally recognize two possible potential hydrocarbon prospects (marked in Fig. 5) which are structurally high - domal structures present in the NW and SE ends of the map respectively.

Acknowledgement

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