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SEISMIC ATTRIBUTES APPLICATION TO DELINEATE STRATIGRAPHIC CHANNELS IN THE NORTH IDKU FIELD, OFFSHORE NILE DELTA, EGYPT

BY

Negm A. (1) and Hammam A .F. (2)

(1) Al Azhar University, Faculty of Science, Geology Department, Cairo, Egypt

(2) Egyptian Geological Survey and Mining Authority (EGSMA), Cairo, Egypt

ABSTRACT

The turbidite sands of the Nile Delta Plio-Pleistocene section have been demonstrated to be a good quality reservoir within the Egyption Mediterranean Gas Province. Exploration has been based in the last decades on the definition of clear direct hydrocarbon indicators (DHI), as the bright spots, flat spots, amplitude shut-offs, polarity reversals,…. etc. In this paper, the seismic attributes technique; such as the root mean square (RMS) amplitude, reflection intensity, instantaneous frequency and Instantaneous phase are applied to the 2D seismic sections, in combination with the well log data, in addition to core data, to delineate the stratigraphic features, such as channels in the Lower Pliocene deposits and to investigate new potential in the Upper Pliocene surrounding North Idku 4-x well. Thus, based on the combined investigation of the geologic cores, geophysical well-logs and seismic attributes two channels and two possible leads are delineated and confirmed in the study area.

Keywords: seismic attributes, core data, stratigraphic channels, North Idku field

INTRODUCTION

The study area is located at the Northwestern offshore part of the Mediterranean Sea, Egypt. It's about 50 km north of Alexandria, and lies between Abu Qir and Rosetta fields. The considered area is located between latitudes 27°52'36.3567" and 31°44'29.5888"N, and longitudes 29°55'26.1522"E and 33°52'27.1008"E (Fig. 1A). The gas reserves have been discovered in the Nile Delta province, as yet reach to about 58 Tcf [1]. Therefore, it is consequently considered the most productive province for gas reserve in Egypt. So, many international companies working hard in this province. Several authors studied the Nile Delta Basin, regarding the depositional history, tectonic evolution, petroleum system, hydrocarbon characterization, and lithostratigraphy [2, 3, 4, 5, and 6].

Seismic attributes have been broadly utilized, as an interpretation tool in seismic exploration [7]. These attributes are responsive to anomalies rise by geologic features related to gas and oil reservoirs and it gives useful details from seismic data like lithology and reservoir properties [8]. In this study, we used the root mean square (RMS) amplitude, instantaneous phase, instantaneous frequency, and reflection intensity attributes extracted from seismic stacked data, that successfully identified the seismic reflection characteristics of the submarine slope channel sands. In addition, the well logging and core data of N. idku - 4 well were used to assess the reservoir properties, the quality, and the hydrocarbon potential of the stacked channel sands, in a combined structural/stratigraphic trap of new possible leads.

GEOLOGIC SETTING

Figure 1B shows a published stratigraphic column of the Western Offshore Nile delta, that includes the general lithostratigraphic framework, the major sequence boundaries and the maximum flooding surfaces [9].

A summary of the lithological description of the geologic formations and the major structural events of the Nile delta is explained by several authors [10, 11 and 12].

The Pliocene cycle, defined by Rizzini et. al. [13], is subdivided from the base to top into Kafr El-Sheikh and El-Wastani Formations. Kafr El-Sheikh Formation, which is incised at the top by low stand and prograding clastic of El-Wastani Formation [14, 15]. El-Wastani Formation was deposited as a regressive sequence, after a starvation event of Kafr El-Sheikh Formation, which indicated by a missed interval of time at the base ranging from 0.45 to 1.22 million years. It started with a low - stand system tract of channel cut and fill at the top of Kafr El-Sheikh Formation. The structural setting of the Nile Delta is controlled by a set of major structural trends (Fig. 2A). The Nile Delta Hinge Zone is a major flexure zone at attitude of about 31° N, separating the South Delta Block from the North Delta basin, these are a set of nearly E-W trending faults, with a big down throw to the North [16]. The NE-SW Rosetta fault trend displays a large - scale structural relief caused by transpressional movement along the Qattara-Eratosthenes trend. El Temsah Trend defines as the Misfaq-Bardawil fault trend, it is a set of parallel NW- SE faults, thier throws are towards the east [3]. Baltim Trend is a set of N-S fault system, which was developed through a phase extended from Late Eocene till the Recent [16].

APPROACH AND METHODOLOGY

To accomplish the target of the current study, we used the integration among the available seismic data, well logging and core data. The seismic data utilized for this work are 2-D stack seismic sections. This data was processed, by the company owned it, to improve the signal and reduce the noise ratio without deformation of phase and amplitude in order to be used to obtain the valuable information from applying seismic attribute. The optimum processing parameters applied to produce the current used seismic sections is summarized in (Table 1). The seismic attributes comprise deferent features, like the signal analysis of seismic waves [17] and the investigation of thin beds on the seismic data stacked [18].

In this study, we used the RMS amplitude, Reflection intensity, dominant frequency and the instantaneous phase attributes, to delineate stratigraphic channels and determine its geological characteristics. Borehole and core data were provided for a single well (North Idku-4x) drilled to a measured depth of 2300 m. Wireline logs data were used to signify the different petrophysical parameters for the encountered formations by this borehole. In addition, three conventional cores were analyzed, to fulfill the evaluation objectives and to provide sedimentological and detailed petrophysical data, and in order to calibrate the logs and the seismic attributes, as well as to support the development objectives.

RESULTS AND DISCUSSIONS

1. Geological Characteristics of the Upper Chanel

Three conventional cores were cut in North Idku-4x well, to fulfill the evaluation objectives and to provide sedimentological and detailed petrophysical data and support the development objectives. The interval from 1530 m to 1533 m (Fig. 2B) essentially comprises a single amalgamated unit of light olive grey sandstones. At the interval base, these are mainly medium-grained and moderately to poorly sorted.

In some places, coarse/very coarse sand and small pebbles are present. The grain sizes are reduced to fine/very fine sand at the interval top, where it is argillaceous and carbonaceous. It is relatively structureless, with few discernible sedimentary structures, though the uppermost 20cm shows moderate to strong parallel laminations, defined by the clay and carbonaceous content. The coarse and structureless character, in association with the upward fining of sediments, is consistent with the rapid deposition in a channelized setting, by high and low-density turbidity current processes. Such interval gives no indication about the water depth or depositional setting, though the association with the underlying sediments implies a submarine slope channel.

The interval from 1530 m to 1544 m is a complex association of thin and sharp-based sandstone beds (mostly <0.5m) interbedded with mudstone units of similar thickness. The sandstones are generally light olive grey and predominantly fine-grained. Sorting is generally good. Mud clasts are common, in places very common and they are locally difficult to resolve, whether the mud clasts are transported intra clasts or were formed by clastic intrusive processes. No bioturbation was observed in either the sandstones or mudstones. There is frequent evidence throughout this interval for soft-sediment disruption in both the sandstones and mudstones. This takes the form of small-scale sand into mud injection structures, load structures, shearing/over-folding of the mudstones and contortion and overstepping of primary laminations. Another feature is relied concerned the presence of mud clast conglomerates.

The massive ungraded to the weakly graded character of the sharp-based sandstone beds are consistent with rapid and episodic deposition from high and low density turbidity currents. The poorly sorted sandstones with a muddy matrix are the deposits of cohesive debris flows. The thinner sandstone beds are likely to represent unconfined and sheet-like deposits (fan or channel margin), whereas the thicker bedded composite sandstone intervals (e.g. 1537.45- 1539.6m) are more channelized deposits, though the limited thickness of these (maximum of 2.15m) implies relatively small-scale channels. The weak to strong laminations in the associated mudstones and the frequent presence of silty laminae (in places current rippled) imply that the mudstones were deposited by hemipelagic and turbiditic processes as background sediments. The absence of bioturbation implies that, the bottom waters were poorly oxygenated and/or that sedimentation rates were very high and prevented the establishment of benthic fauna. The petrophysical parameters for the upper channel are characterized by high porosity, high resistivity, low gamma-ray and the presence of neutron-density crossover. So, it is considered highly productive zone (Fig. 2C).

2. Geological Characteristics of the Lower Chanel

The interval from 2043 m to 2057 m represents the percentage of Mudstones form over 95% of this interval (Fig. 3A). These are greenish black to dark greenish grey, light olive to olive-grey in the more silty intervals. They are generally moderately to well laminated with laminae. These laminae commonly show 'normal' grading and in places current ripple lamination. The sandstones are typically current rippled and/or laminated, in places the bed bases are loaded onto the mudstones. Small silt to sand grade 'starved' ripples is present in places. Small (mm) scale 'sand' into 'the mud' injection structures are present at 2042.4 m depth. This interval comprises mainly low energy turbiditic muds and silts representing predominantly the background sedimentation. The siltier/sandier intervals may represent distal channel levee deposits. The petrophysical parameter for the lower channel are characterized by high porosity and low resistivity. So, we expect that it contains some residual gases (Fig. 3B).

3. Chanel Identification Using Seismic Attributes Analysis

RMS amplitude was calculated based on the upper and lower channels of the study area. the results of these are shown in (Fig. 4A and B). The high RMS amplitude values (lighter color represents a high value of RMS amplitude) are associated with the reservoir section (sand), while the low RMS amplitude values are associated with the non-reservoir units (shale). As a result of the RMS amplitude application, the upper and lower channels appear as high amplitudes. Therefore, it is expected that these two channels are representative of clear DHI “bright spots”. Also, the well track at N. Idku.4x well location intersects with the upper and lower channels at 1797 ms and 2276 ms TWT, respectively. On the other hand, the zones above and under the upper and lower channels displayed as low RMS amplitudes, which are interpreted to be shale intervals (Fig. 4C and D)

One of the important points in this research is to identify new prospects, therefore we have used more attributes and concluded the following results.

The first promising zone extends from 1532 ms to 1560 ms TWT and is characterized by high amplitude and high reflection intensity and interpreted to be gas-bearing sand surrounded by a thick shale interval appears as low amplitude and reflection intensity. The instantaneous frequency attribute was helpful for the identification of this zone. Moreover, the instantaneous phase attribute was useful for revealing the continuity of the seismic events related to this zone, which varies greatly in their amplitude (Fig. 1A to D).

The second promising zone ranges from 1308 ms to 1405 ms TWT and has imaged as high RMS amplitude, high reflection intensity, with the presence of clear discontinuities . A normal fault is interpreted at the middle part as indicate by the black arrow. This prospect is formed of two parts where the disconnected part indicated by a black (Fig. 5E to H).

Comparing this effect with the instantaneous frequency and instantaneous phase results showed that the occurrence of a normal fault, on the RMS amplitude and reflection intensity, appeared to coincide with the dipping event on the instantaneous frequency and instantaneous phase sections, where the other part indicated by the black circle appeared with the same frequency and continuity of reflectors. This means that the second zone of interest seems to be connected at this part.

CONCLUSIONS

This study integrated the core analysis of two hydrocarbon bearing reservoirs, petrophysical analysis and seismic attributes, to analyze and characterize the facies content of the channel's high amplitude reflector across North Idku field. Seismic attributes analysis was applied to evaluate the gas-bearing sand through the 2-D seismic data as well as to outline new prospects in the study area. Core samples show the characteristics of lithology and reservoir rock properties as upper channel consists of thin-bedded massive sandstones and laminated mudstones showing frequent evidence for sediments distribution. It is interpreted as submarine slope channel and turbidite sheet sand associated with overbank /background muds. Where the lower channel comprises mainly well laminated silty mudstones with rare thin sandstones which interpreted as that outer slope deep marine.

The well-logging data reflect the upper channel as characterized by low gamma-ray a high porosity and low resistivity where the lower channel is displayed as low gamma-ray high porosity and low resistivity. Both the well log and core data revaled the occurrence of the two turbidite channels which are also confirmed by the RMS amplitude attribute. More seismic attributes such as the instantaneous frequency and instantaneous phase were utilized for investigating new prospects. Moreover, the instantaneous frequency and instantaneous phase are helpful for differentiating the potential zones.

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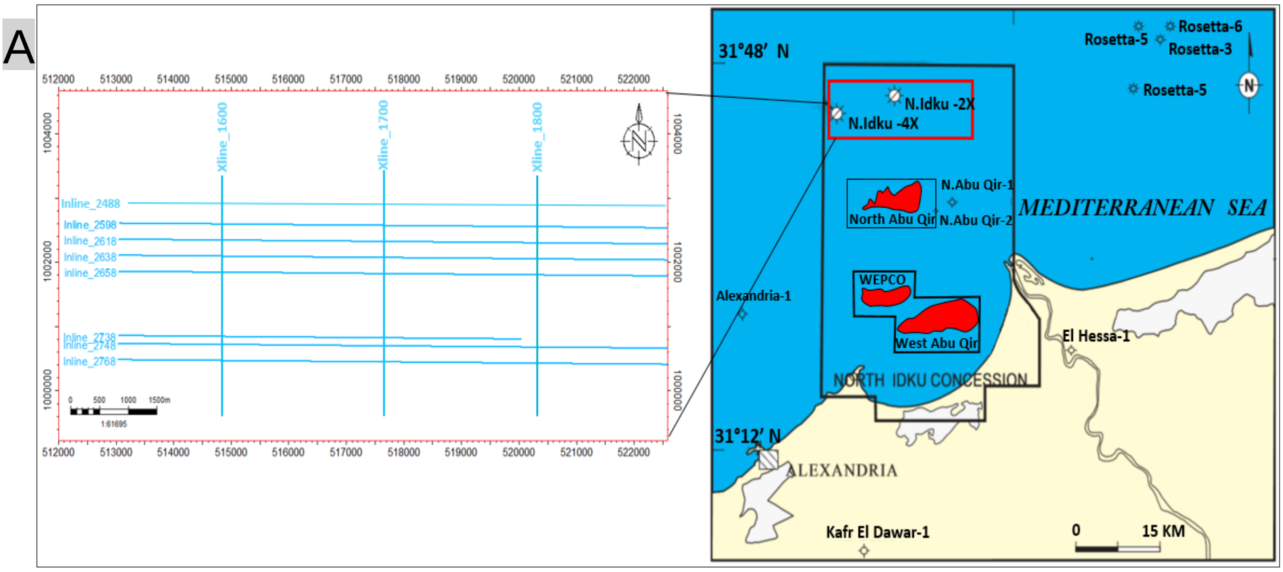
Table 1: The final processing sequence for the true amplitude recovery

Step	Parameters
S.D.D. Delay Correction	**-18 m Sec**
Amplitude decay compensation	**Type: Measured exponxial**
Deconvolution before stack (DBS)	**Type: minimum phase least square inverse Application window. 0-200 mSec**
NMO correction	**Ensign combined velocity analysis ,7 function over21 CDPs every 0.5 KM**
Stack	**standard mean amplitude CDP stack, 24-fold with offset dependent outside trace mute applied**
Static correction	**correction for gun and cable 4 mSec**
Deconvolution after stack (DAS)	**Type: minimum phase least square inverse, derived from running average of 15 adjacent auto-correlation**
FK dip filter	**Bandwids +/-4mSec/trace, feedback 0%**
Amplitude balance	**1. Residual amplitude decay composition 2. 200mSec iterative AGC**



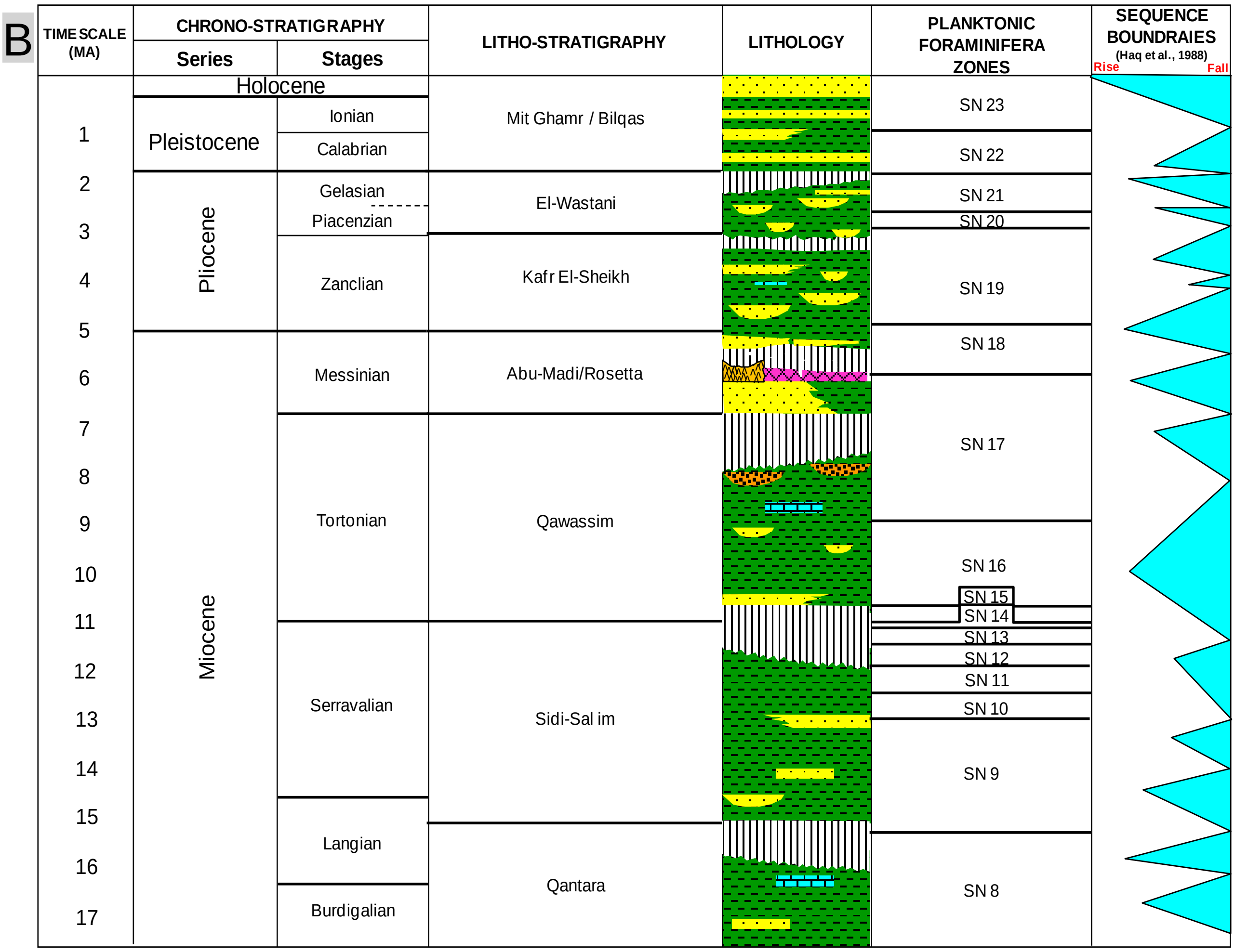


Fig. 1.A: Map showing the location of the of North Idku Field in the offshore Nile Delta, Egypt. B: Stratigraphic column of the Western Nile Delta area modified after El-Barkooky and Helal, (2001).

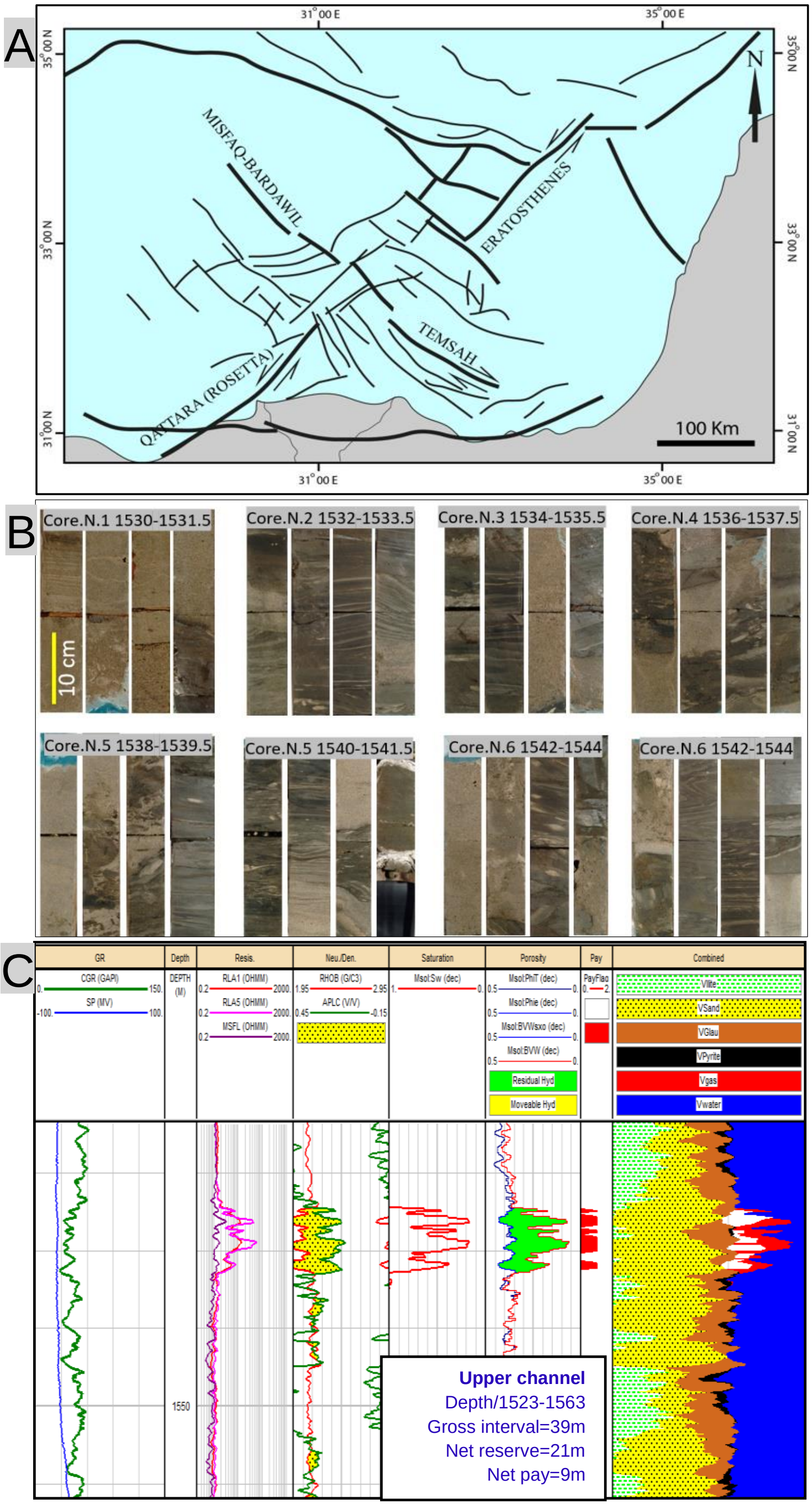


Fig.2.A: East Mediterranean structural domain with its main fault trends modified after Abd El Aasxl et. al.,(2000). B: Core photograph show the characteristics of lithology and reservoir rock properties of the upper channel. C: Litho-Saturation Cross-plot of upper channel in North. Idku – 4 well (interval 1479-1600)

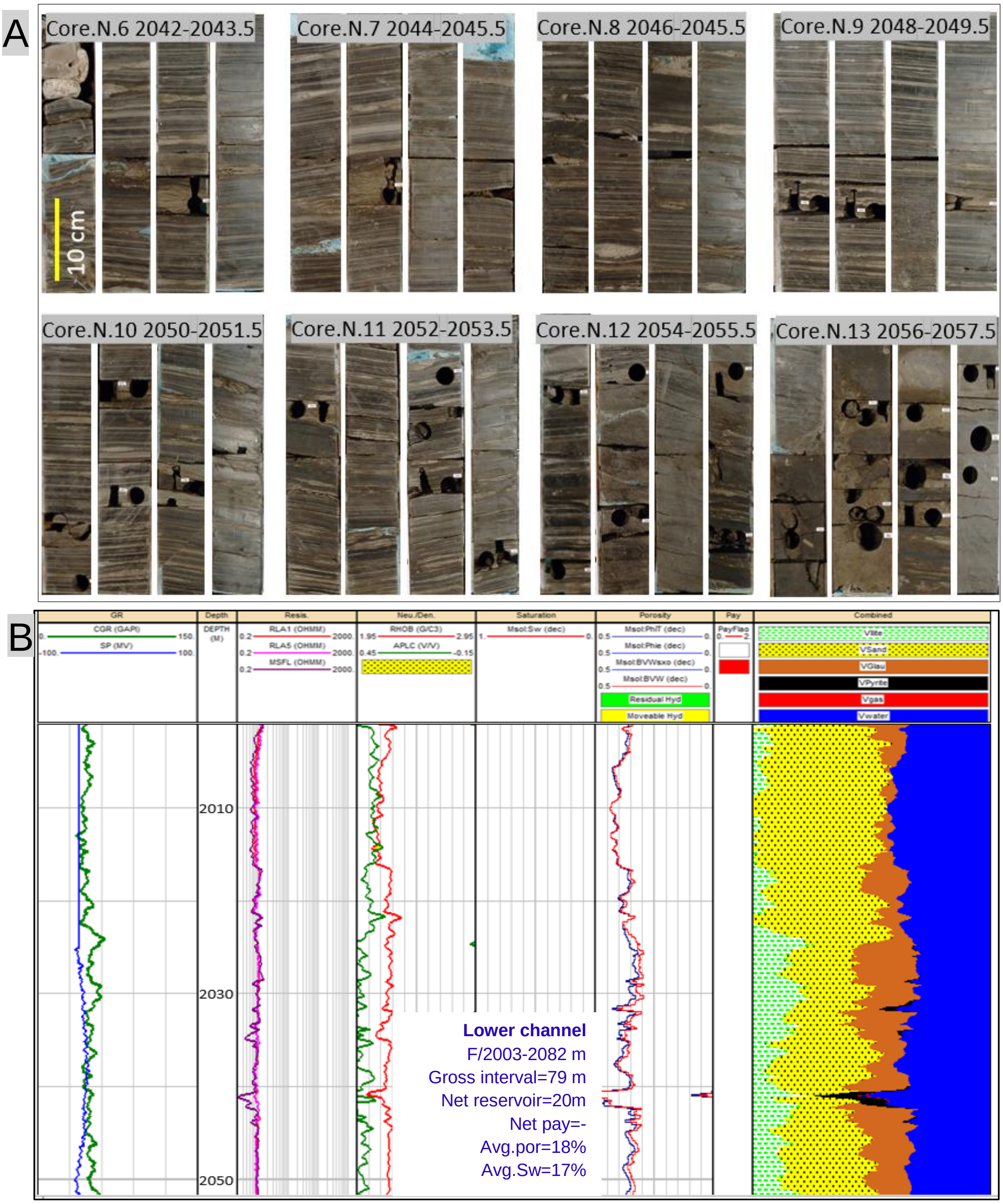


Fig. 3.A: Core photograph show the lower channel comprises of mainly well laminated silty mudstones with rare thin sandstones which interpreted as that outer slope deep marine. B: Litho-Saturation Cross-plot of lower channel in North Idkue – 4 well (interval 2000 - 2053 m)

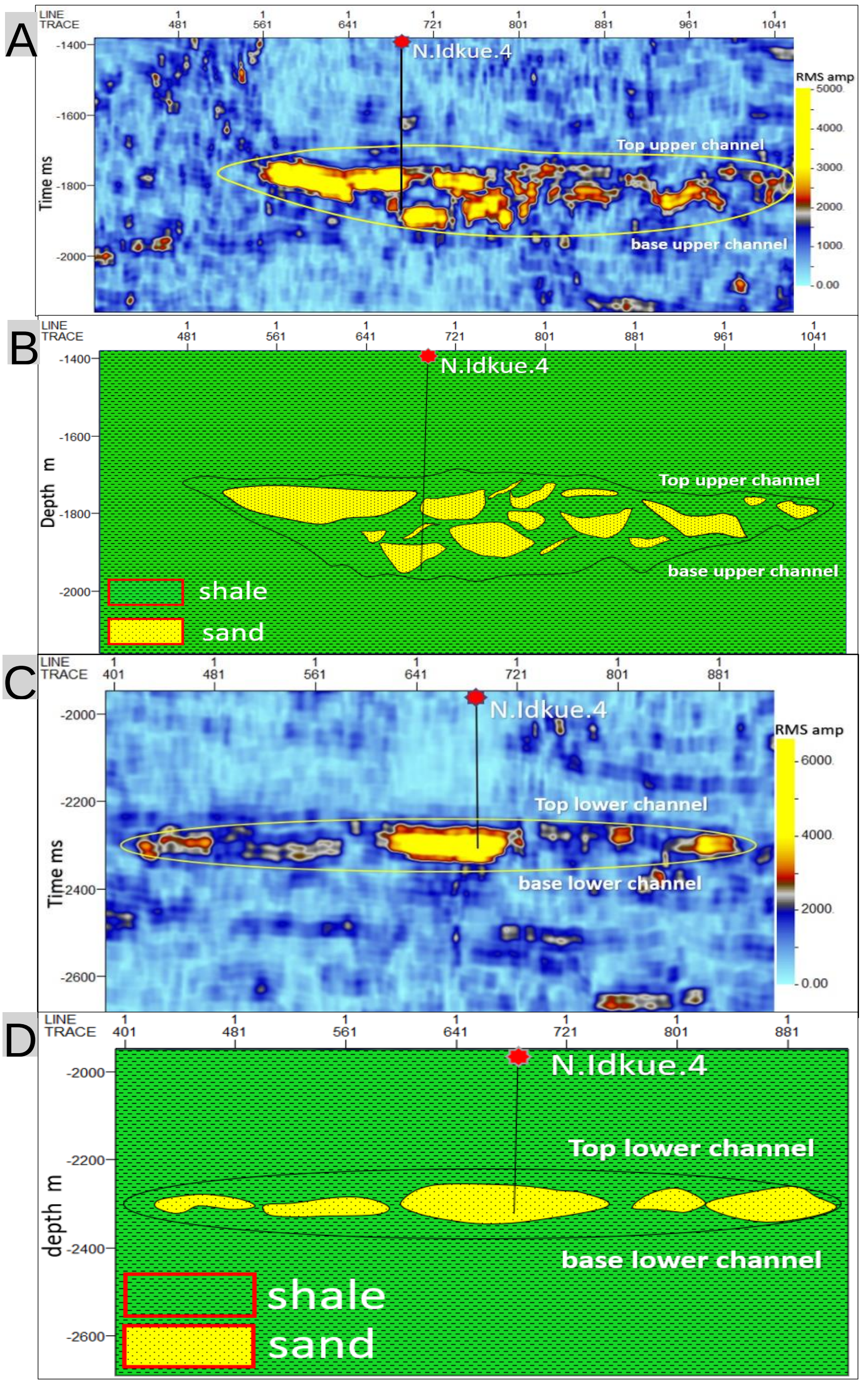


Fig. 4.A: Root-mean-square (RMS) amplitude cross section showing the upper channel interpreted as high amplitude value. B: Geoseismic section Crossline section showing the upper channel sands correspond with high amplitude value .C: Root-mean-square (RMS) amplitude cross section showing the lower channel interpreted as high amplitude value. D: Geoseismic section Crossline section showing the lower channel sands correspond with high amplitude value

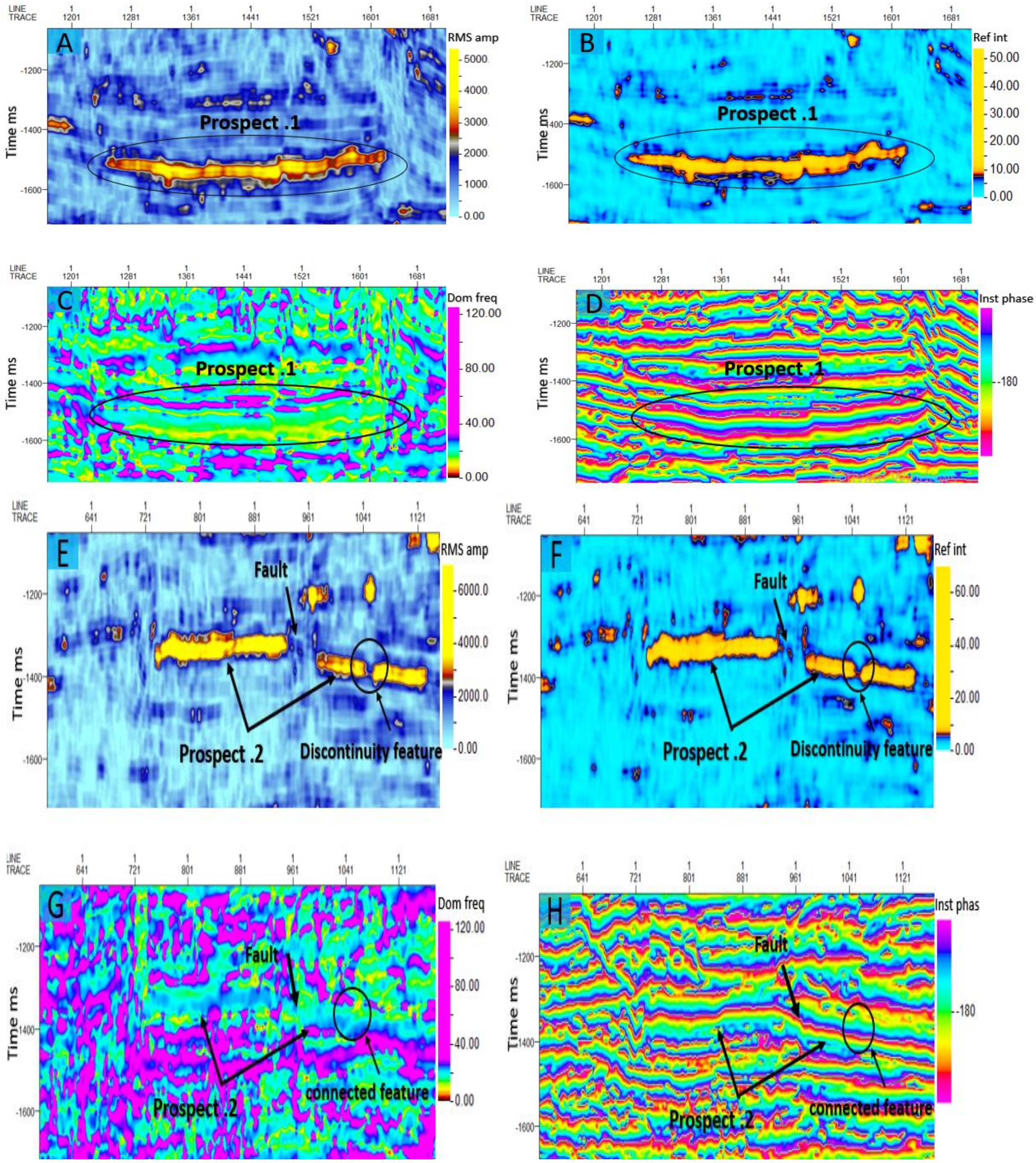


Fig. 5: Results of the A: Root mean square amplitude, B: Reflectivity intensity, C: Instantaneous frequency, D: Instantaneous phase, applied on prospect.1 where E: Root mean square amplitude, F: Reflectivity intensity, G: Instantaneous