D-17 A MULTIDISCIPLINARY EVALUATION OF PRODUCING SATAL CARBONATES SIRT BASIN, LIBYA

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Introduction

Ali and Almas oil fields in Sirt Basin/Libya were discovered in 1976 and 1978, respectively. Two fields produced 25.6 mmmbls oil from the Paleocene (Danian) Satal buildups. Recently, the Zueitina Oil Company and PanCanadian Petroleum Limited carried out a joint study which included the geological and geophysical modelling of the fields. Zueitina is an important oil producer in Libya and PanCanadian is a major oil producer in Canada. The PanCanadian Petroleum Limited has offsetting land (NC 185) to the Zueitina lands NC29B/C (Fig1).

Figure 1. Location map

SERIES	STAGE	LITHO-STRATIGRAPHIC UNITS	LITHOLOGY
PALEOCENE	LOWER	MONTIAN	BEDA FORMATION RABIA MEMBER U MABRUK RABIA MEMBER M FARRUD MEMBER RABIA MEMBER L THALITH MEMBER HAGEA FM
		DANIAN	SATAL UPPER
CRETACEOUS	UPPER	MAASTRICHTIAN	LOWER KALASH FM
		CAMPANIAN	SIRTE FM
		SANTONIAN	RACHMET FM
		TURONIAN	ETEL FM
		CENOMANIAN	LIDAM FM

Figure 2. Stratigraphic section

Sedimentology

The Satal Formation in the southern part of NC 29B/C represents an extensive carbonate bank. The unit can be divided into two members: Upper Satal and Lower Satal. The lower Satal overlies the Upper Kalash Formation that consists of deeper water lower energy wackestones and packstones (Fig.2).

From core and thin section study five lithofacies were identified in the Upper Satal member:

- Coralgal Facies
- Redeposited Coralgal Facies
- Lime Sand Grainstone Facies
- Pellet Wackestone/Packstone Facies
- Dolomitized Wackestone/Packstone Facies

In general, the best potential reservoir rocks occur in both facies, corallgal facies and redeposited corallgal facies (bank margin), and moderate to good in the lime sand grainstone facies, (back reef), and dolomitized wackestone/packstone facies (tidal flat).

Sequence Stratigraphy

The Late Cretaceous, Early Tertiary (Paleocene) section of the Sirt Basin consists, in part, of a carbonate platform/bank system and its correlative basinal sediments (Fig 3). Commonly, the lithostratigraphic units have often been confused with time units, so the stratigraphic relationships may be misleading. For example, the top of the Satal Formation carbonate bank has frequently been interpreted as flat (i.e. as a timeline), and foreslope in several different wells have been correlated as a time unit, even though they are demonstrably diachronous.

The Satal Formation comprises of four (third-order) depositional sequences, bounded by unconformities or their correlative conformities. These are termed, from oldest to youngest, Satal I to IV.

The oldest sequence, the Satal I, comprises peloidal/skeletal mudstones to packstones and is about 250 feet thick. Its relatively high response on the gamma-ray log and lack of cleaning-upward profile suggests the aggradational deposition of a subtidal ramp unit. No reservoir quality is observed in the Satal I in the studied wells.

The Satal II has a significantly smaller areal extent than the Satal I. This is due to a major flooding event at the top of the Satal I, which caused a major backstep of the platform margin. The base of the Satal II (Satal IIa) has a log response somewhat cleaner than the Satal I, but consists of skeletal wackestones which likely also represent a subtidal ramp or open platform environment with a poorly developed margin. The upper part of the Satal II (II b & c) displays a rapidly shallowing-upward profile.

The Satal III is approximately 400 feet thick, and comprises the best reservoir unit penetrated in the study area. At least three distinctive parasequence sets are identified- the Satal III a,b and c. Each of the three parasequence sets have reefal, or reef flat sand, potential reservoir unit developed within it (Fig.3). It is also very important to note that the top of the Satal Formation in the study area is not stratigraphically flat, and is not a time line.

Figure 3. Satal sequence stratigraphic model (modified after Zueitina and PanCanadian ,1999)

The Satal IV is present in only one well in the study area, F1-NC29B. It comprises a 100 foot thick parasequence set, passing from basal foreslope through reworked coral lithofacies at the top. The backstepping suggests higher (and younger) Satal Formation buildups occur elsewhere along the trend, which may be prospective traps.

Seismic

Since Occidental Libya became the operator in 1974, they acquired over 6,000 kms of thumber and vibroseis 2D seismic data over the whole NC29B/C block. Approximately 2,000 kms of this data was interpreted under the Zueitina and PanCanadian joint study. The interpretation was carried out on LandMark workstation by using seisworks seismic interpretation software and synthetics plots for several wells. Seismic grid balance was also applied to tie the new reprocessed seismic data in terms of time, phase and amplitude to the existing data in project.

The purpose of this study was to model the Satal buildups utilizing the Lambda Rho approach (LMR) and AVO models, to interpret and finally map of all three Satal units.

Results of seismic reprocessing showed considerable improvements of seismic resolution and reflection continuity. Seismic modeling led to observe velocity/time push down of 10-15 msec under porous portion of reef, high reflectivity along flanks of reef margin, good contrast between zones of reef and inter-reef and poor contrasts between reef and basin. A minor AVO and LMP effect, and good P and S acoustic impedance contrasts were observed on the model.

Based on recently re-processed seismic lines, all the sequence boundaries have been identified and these sequences have been mapped. The seismic lines A and B show the Satal sequences I, II c and III c (Fig 4).

Figure 4. Seismic lines A & B

Conclusions and Exploration Implications

The sequence stratigraphic analysis of the Satal Formation has some important implications for further hydrocarbon exploration/development work along the Satal trend. The Satal II displays a very shallow depositional character, suggesting that there may be an untested coeval reef margin. The presence of such a margin will be seismically investigated (Fig.5).

The top of the Satal is not stratigraphically flat, and not a time line. Different buildup levels are correlated in the three reefal wells in the study area. This suggests some prospectivity of hydrocarbon trapping in the varying topography on the Satal (Fig.5).

The major flooding surfaces which divide the Kalash from the Satal, as well as the Satal sequences from one another may be significant horizons for pinnacle reef initiation in the basin. These possibilities will be evaluated seismically to place any pinnacle anomalies into this stratigraphic framework.

Figure 5. Possible prospective trends map

Acknowledgements

The authors acknowledge Dr. John Weissenberger and Mahmoud Elfil for their sedimentological and Garth Syhlonek for his geophysical modelling contributions. We also thank Zueitina Oil Company and PanCanadian Petroleum Limited for their permission to publish this paper.

Reference:

- Zueitina Oil Company and PanCanadian Petroleum Limited, 1999, Geological and geophysical modeling of producing Satal carbonates: Internal Report.