Reinterpretation of the Sembakung Oilfield, Kalimantan, Indonesia utilizing modern 3D seismic data

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Abstract
The Sembakung field was discovered in 1975 by ARCO. It is located in northeast Kalimantan, some 50 miles (80 kilometers) from Tarakan Island. The field has been in production since 1977 and a total of 19 wells had been drilled up until the recent redevelopment efforts undertaken by Perkasa Equatorial Sembakung Ltd., under a technical assistance contract awarded by PERTAMINA. A 3D seismic program has recently been acquired, processed and is being interpreted to identify new well locations and to derive a new model for better reservoir simulation and to assist in the establishment of a field wide pressure maintenance scheme.

Introduction
The Sembakung oilfield is the most northerly onshore oilfield in Indonesia (fig. 1). The field has produced in excess of 36 mmbbls of oil during its 25 year production history and is destined to produce more as a result of a field redevelopment effort which is currently underway. In late 2000 CGG completed the acquisition of 3D seismic data, the processing, pre-stack full Kirchhoff time migration and the pre-stack depth migration was finished by mid-2001. This paper presents results from the interpretation of this 3D seismic data.

All the fields in the basin produce from a variety of stacked deltaic sands of Miocene and Pliocene age in structurally controlled traps. The producing reservoir intervals at the Sembakung field are thinly interbedded sands and shales of the Tabul Formation. The reservoirs are distributed over the subsea interval –1600 feet to –3500 feet and the reservoir sands vary in thickness from a few feet up to 30 feet. The reservoirs are divided in to 35 main sand groups with separate oil water contacts and occasional discreet gas caps. The produced crude oil is 36-37 API gravity, 50-60 degrees F pour point. The GOR of producing wells varies from 150 to more than 2400 scf/bbl. Permeabilities in the reservoir vary from 1 to 900 md, and porosities vary from 11 to 30%, with water saturations estimated at 20-50%.

Regional Geological Setting
The Northeast Kalimantan basin has been divided in to four subbasins, the Muara and Berau to the south, the Tarakan in the central area, mostly offshore, and the Tidung in the north. All are Tertiary depositional areas dominated by eastward regional tilt toward the Sulawesi Sea. The area is characterized by eastward and southeastward prograding deltaic sequences.

The main geological work in the area predates World War II and was published and summarized by van Bemmelen (1949). The Tabul formation, the productive interval at the Sembakung field is comprised of marls and shales interbedded with sandstones. Although reservoirs can be present in both carbonates and clastics, it is trapping in sandstones that forms the bulk of the hydrocarbon potential. These clastic reservoirs have a complex distribution with many delta fans coalescing throughout the area. Source rocks in the basin are generally considered to be the coal-bearing sequences and probably are in the late mature phase in the Tidung subbasin (van Bremmelen, 1949).

Sembakung Field
Earlier the Sembakung structure was defined by a loose grid of 2D seismic data, the new 3D data provided structural details and helped to resolve the location of high angle reverse bounding faults.The feature is a northwest to southeast oriented anticline with a broad northern end and a steeper western flank. Both the west and east sides of the anticline are controlled by reverse faults forming a positive flower structure. The producing interval at Sembakung is over approximately 2000 feet (600 m). The reservoir has been divided in to 35 separate sand intervals. The bulk of the hydrocarbons produced are in the interval 21bc to 29 sands, with the vast majority of the reserves contained within the 24ab to 28 interval.

Because of the highly stratified nature of the reservoir all the wells have co-mingled flow, with multiple zones completed in each well. In the early life of the field peak production exceeded 11,000 bopd, but because of the shallow nature of the reservoir these rates quickly fell. A second phase of drilling by ARCO briefly brought production back to 10,000 bopd. Following this the field was left to decline naturally until 1995 when a series of well workovers, pump resetting and new zone perforations briefly raised production again to in excess of 4000 bopd.

Processing and the stratigraphic inversion
A high resolution processing flow was used, which included two passes of decon with a 3D FK conical filter in between to remove the strong linear noise. As can be seen in figure 2 the data is highly structural. DMO gathers were used to finalize a detailed stacking velocity grid. The DMO stack was finally FX migrated and a FX projection filter was applied post-migration for random noise elimination.

Due to structural complexity of the data, a full Kirchhoff prestack time migration based on the straight rays assumption (TIKIM) was applied (fig. 3a) (***Suaudeau, and Siliqi, 2001***). A depth migration (***Hanitzsch et. al., 2001)*** was also carried out with the geological objectives of improving the fault definition at reservoir level and improving resolution and continuity of events in previously poorly imaged areas (fig.3b). Finally, a 3D stratigraphic inversion (TDROV) was done to identify the sand/shale sequences, their geological trends and also the lateral changes within the reservoir sands in terms of their porosity and hydrocarbon saturation (fig. 4) (Scott et. al., 2000).

Development Plan

The current plan of development is to drill sufficient wells to reduce the overall field well spacing to around 30 acres. This process is underway with the first two pads and initial fourteen wells targeting the crestal part of the field already completed. The 3D survey also revealed the presence of a significant structural extension southward of the feature, and potential for additional exploration of low-stand features on the flank of Sembakung. The placement of final wells in the program will be guided by the interpretation of the 3D seismic data.

Conclusions

Current redevelopment efforts on the Sembakung field are aimed at reducing the well spacing from the current approximately 100 acres to around 30 acres. This is intended to access more efficiently sands within the inter-well areas, access new untapped channel sands and allow for additional boreholes to be used to introduce a pressure maintenance scheme to the reservoirs. Early interpretation of the 3D seismic data has supported the recent drilling results that the new untapped reservoirs do exist within the area of the field. In addition the most recent results also tend to indicate that fault blocks around the field may exist which are not being drained by the existing wells. It is believed that the utilization of modern high-resolution 3D seismic data will aid in the understanding of both reservoir distribution and the nature of structural compartmentalization of the field. It is anticipated these results will aid in further extending the area of hydrocarbon distribution on Sembakung to the south and west.

Acknowledgements

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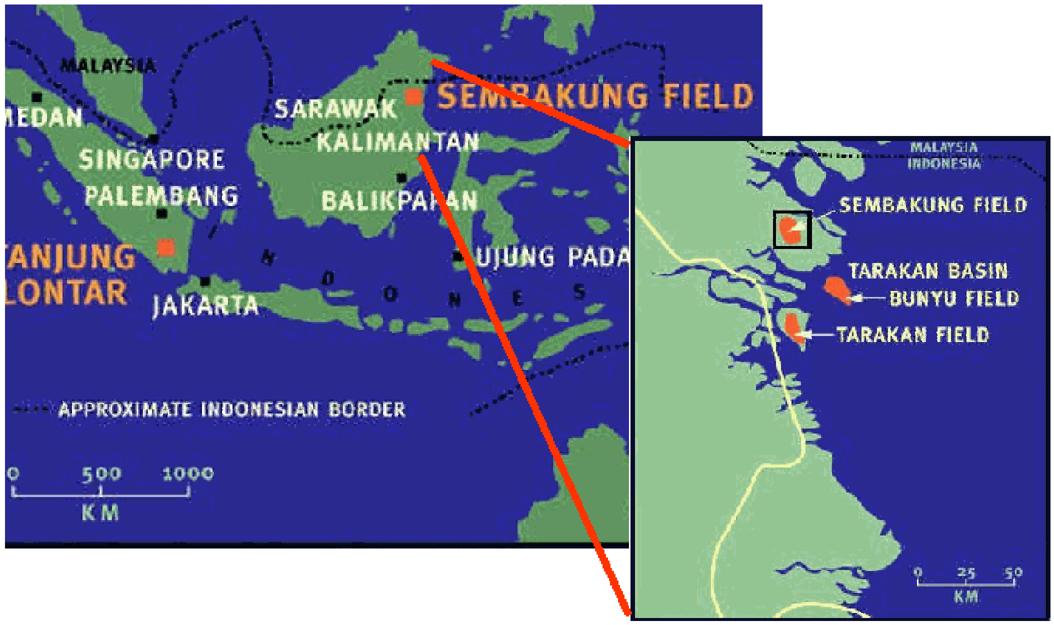
FIGURES

Figure 1 Location map of the Sembakung oilfield and other nearby oilfields at Tarakan and Bunyu.

Figure 2 Comparison of a 2D and 3D seismic data.

Figure 3 A seismic line after (a) Pre-stack full Kirchhoff time and (b) Pre-stack depth migration.

Figure 4 (a) Impedance section showing the sand-shale sequence and (b) a layered impedance map corresponding to 24-sand sequence (Blue is low and Red is high impedance).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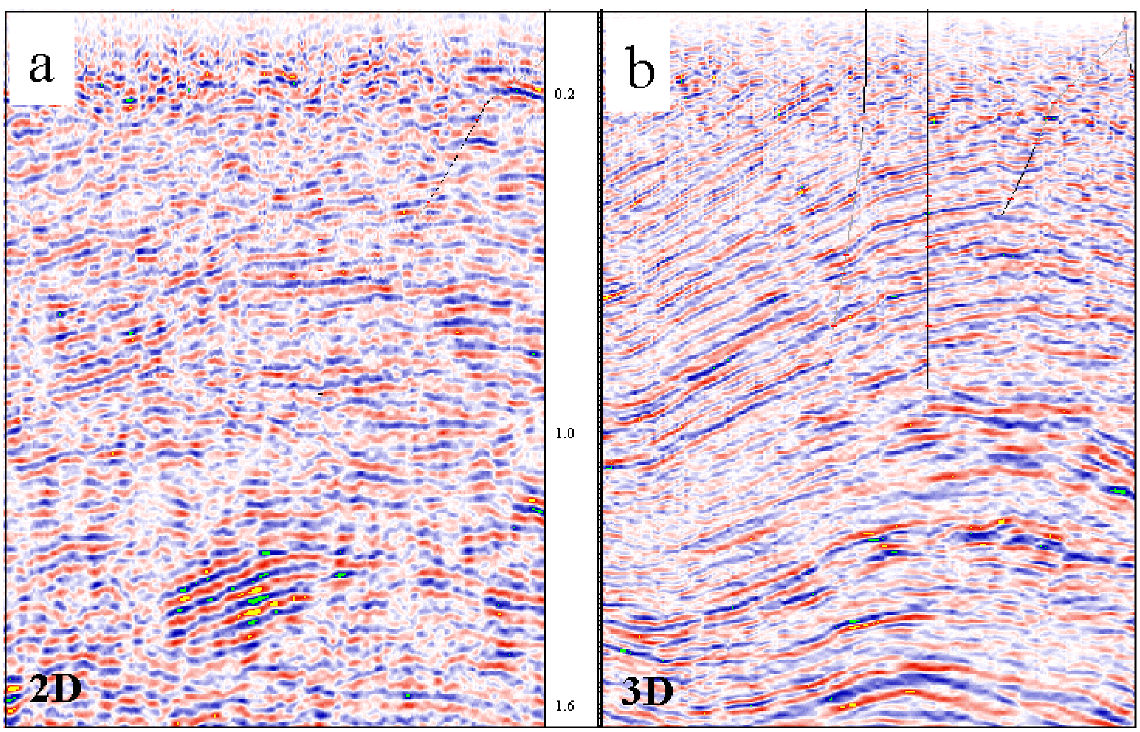
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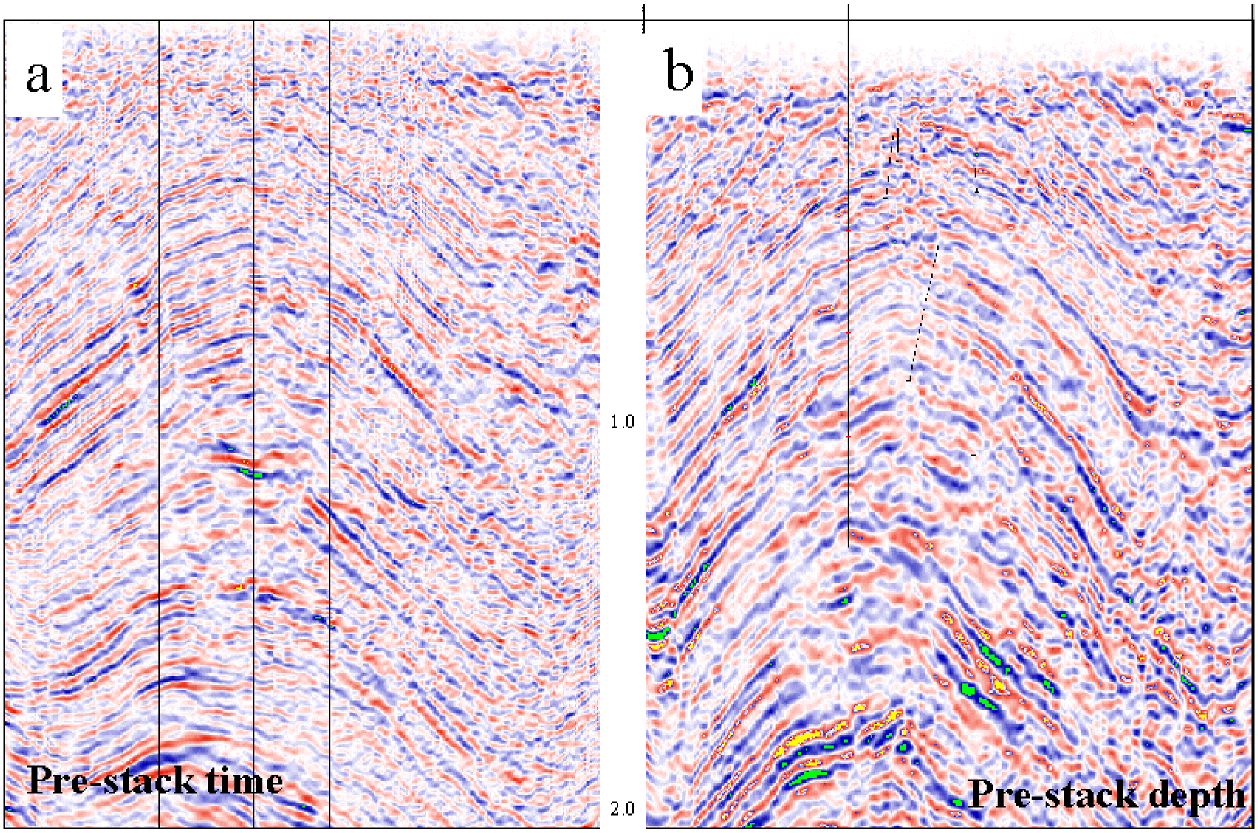
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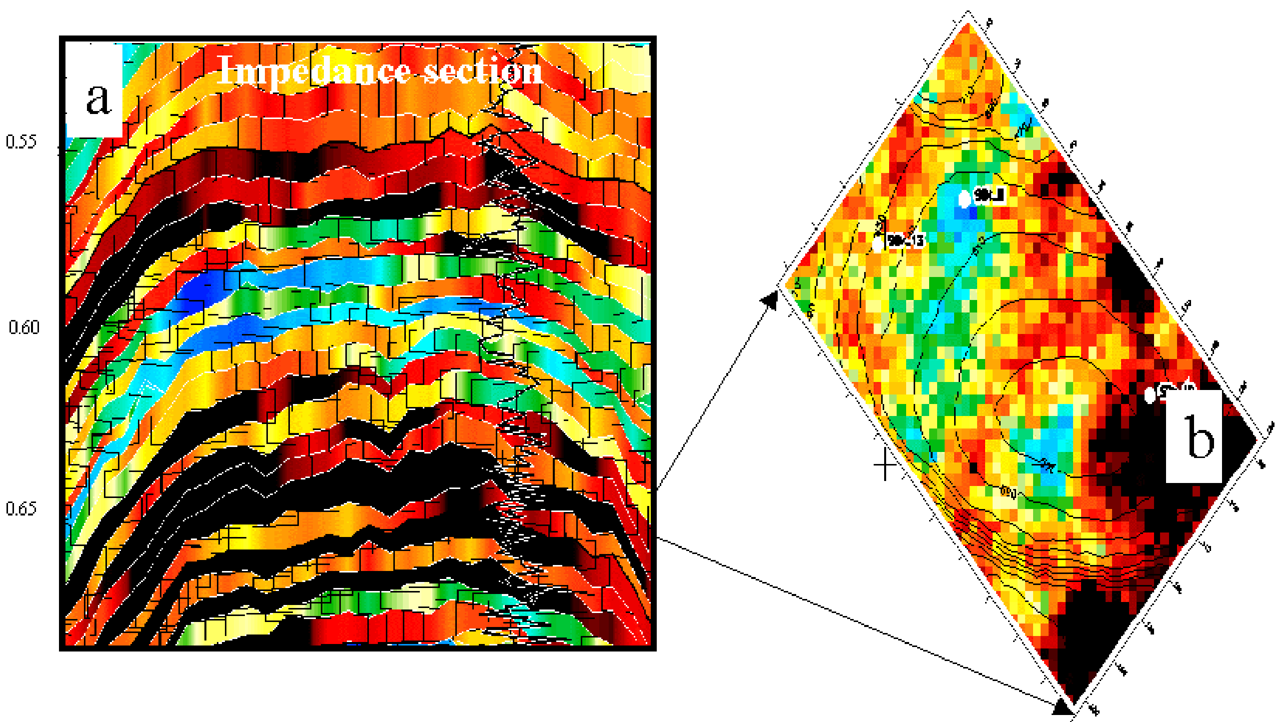
b
Pre-stack depth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Impedance section
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b