

East Indonesia: Plays and Prospectivity of the West Aru, Kai Besar and Tanimbar Area - Identified from New Long Offset Seismic Data*

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Abstract

This paper is based on an analysis of more than 8000 km of recent 2D seismic data (10,000 m cable) in Eastern Indonesia west of Aru Island, acquired as a multi-client survey run under the jurisdiction of MIGAS. The eastern/southeastern portion of the survey covers part of the Arafura Platform/Basin while its west/northwestern portion covers the Tanimbar and Aru Troughs and the eastern part of the Banda Arc collision zone.

The area is Frontier in nature but is on trend with a number of large fields, the largest of which are the multi-TCF Abadi and Tangguh gas fields. It is relatively unexplored, with the 3 dry wells (Koba-1 drilled in 1984 and Barakan-1 in 1995) offshore on highs in and around the Aru Ridge, and Kai Basar #1 (1996) which was drilled on the island and encountered thick Mesozoic rocks.

The major discoveries in the region lie both to the north and southwest of the survey area ([Figure 1](#) and [Figure 2](#)) where the Jurassic Plover sandstone petroleum system is proven to the north in the Tangguh Field (in the Bintuni Basin) and to the southwest in the Abadi Field; and also further westwards (in fields such as Sunrise, Evans Shoal, Troubadour and Bayu Undan). In this petroleum system, the gas/condensate fields are thought to be charged from equivalent aged deeper lying Early-Middle Jurassic Plover Formation source rocks.

Mesozoic Petroleum System

In our survey area, the Jurassic clastics have been sampled on the islands of Tanimbar and Kai (Charlton, 2004 and 2008) and it has been suggested by a number of authors (eg. Baillie et al., 2004) that reservoir quality sandstones could be present over a large area along the Jurassic shelf margin - which is expected to run northwards from the Bonaparte Basin/Sahul Platform, through our survey area to New Guinea and the Tangguh area (i.e. the Bintuni Basin).

The Jurassic reservoirs are expected to occur both on the western margin of the Arafura Platform (west of the island of Aru and the Aru Ridge, where the Mesozoic section thickens rapidly) and in the western part of the survey area where the seismic data off Tanimbar and around the Kei islands show burial below a Neogene aged melange associated with collision tectonics making up the eastern margin of the islands ([Figure 4](#)). This situation is similar to that seen off the northern coast of Seram Island and off the southern coast of East Timor.

Reservoirs of probable Cretaceous age are also seen to the west and southwest of Aru ([Figure 5](#)) where the Jurassic soles out as it rises from west to east. Here a number of four way dip closures, ranging in size from 25 sq kms to 250 sq kms, have been mapped from the new seismic data.

In addition to this, the presence of deeply buried Early Cretaceous source rocks cannot be discounted, with Barber et al. (2003), suggesting that these could be present along the flanks of the Tanimbar Trough and that they could possess similar attributes to the excellent quality Echuca Shoals Formation source rocks which have sourced oil discoveries in the Bonaparte Basin (for example in the Elang Field in the JPDA area).

It is interesting to note that Cornee et al. (1997) report encountering black laminated marlstones and shales of Early to Late Cretaceous age in samples dredged from the eastern side of Kai Besar Island - on the northern margin of our survey area (the oldest dated as Late Albian which sits above the Echuca Shoals Formation).

Oil and gas seeps are evident on some of the islands of the Banda Forearc, i.e. on Timor, Kei Besar (Charlton, 2008) and Seram. However, to date the only established petroleum producing province in this collision complex is on the island of Seram. Results from an onshore well drilled on the island of Kai Besar (Kai Besar 1) have been reported (Widodo, 2006) to show the presence of mature source rocks of Mid-Late Jurassic Plover Formation and Late Cretaceous Ekmai Formation with potential reservoir rocks at several levels.

It has been proposed (Charlton, 2004) that the tectonism in the outer island arc has involved the inversion of graben basins which were filled with Permian to Jurassic sediment and that these could have potential for hydrocarbon trapping. Charlton (2001) also reports that rock fragments of Triassic and Jurassic (including Jurassic coals) have been ejected from mud volcanoes on Tanimbar Island.

Paleozoic Petroleum System

In addition to the Mesozoic petroleum system, we see thick Paleozoic sediments on the Arafura Platform. These are particularly well developed south of the island of Aru in the South Aru Graben (Livsey et al., 1992) which is possibly filled with several thousand metres of Cambro-Ordovician to late Devonian/Early Permian sediments ([Figure 6](#)). The Graben is characterised by a thin (< 1 sec TWT) cover of often faulted Cretaceous and younger sediments unconformably overlying rocks of Paleozoic age which demonstrate a very high (> 5000 metres/sec from 1 sec TWT) stacking velocity (Adhyaksawan et al., 2010). The Graben attains a depth greater than 10,000 metres in the easternmost part of the survey area. Its petroleum generating potential is evidenced by the presence of gas chimneys and bright reflections (gas sands) ([Figure 7](#)). This Paleozoic petroleum system has been discussed by a number of authors (e.g. Moss, 2001; Bradshaw, 2001) and is believed to be analogous to that seen in parts of the Bonaparte Basin and Goulburn Graben.

Regarding the Paleozoic petroleum system, a number of authors (Moore et al., 1996; Struckmeyer et al., 2006; Kennard et al., 2007) have reported on the nature and petroleum potential of the undrilled Northern (Australian) Arafura Basin and contrasted it to that of the Goulburn Graben to its south (an analysis of the wells drilled unsuccessfully there can be found in Earl, 2006). The contention being that since the platform area to the north is less deformed than the Goulburn Graben, this area could be less risky as far as the timing and expulsion of hydrocarbons is concerned; and since the Paleozoic rocks are not so deeply buried, the reservoirs could have improved qualities.

The petroleum potential of the Arafura Platform is borne out by the recognition (on the Australian side north of the Goulburn Graben) of seeps both on satellite altimeter data and on sub-bottom profiles from a marine seepage survey; and by amplitude brightening on seismic data (Kennard et al., 2007). The primary source rocks are thought to be near the base of the Cambrian, but other source rocks could occur in the Devonian to Permian section. With the platform running north/northeastwards from the Goulburn Graben to New Guinea, a similar scenario could be expected in the southeastern part of our survey area.

Conclusions

The new long offset data has allowed us to recognise a number of different plays in the survey area – these are defined by their relationship to the main structural/stratigraphic provinces outlined briefly above and summarised below and in [Figure 8](#):

Tertiary:	Structural plays within the Melange (i.e. East of Tanimbar and Kei Islands)
Cretaceous:	Sub-Melange Platform Margin west and southwest of Aru
Jurassic:	Sub-Melange Aru Trough
Paleozoic:	South Aru Graben

It is interesting to note that:

- 1) There are a number of petroleum systems in play, rather than just the Cenozoic one which is generally the case in the Far East (USGS 2010). The geology has much in common with that of the NW Shelf of Australia.
- 2) Discoveries could well be in the multi-TCF range and include oil as well as gas.

We can also note that the long offset data, together with the use of Pre Stack Time Migration, has been particularly good in:

- 1) Assisting the imaging of the data below the Melange, which has been formed by uplift and collision tectonics in this part of the Banda Arc and which runs along the eastern margin of the Tanimbar and Kei Islands.
- 2) Helping with extracting primary data from multiples on the shelf and thus illuminating the data within the underlying Paleozoic grabens such as the South Aru Graben.

It will also be useful in future work which may involve AVO.

The data is being used to assess the petroleum potential of the area which is currently unlicensed. It will be used by the authorities to help them decide the number and size of the exploration blocks which will be put up in future Bid Rounds.

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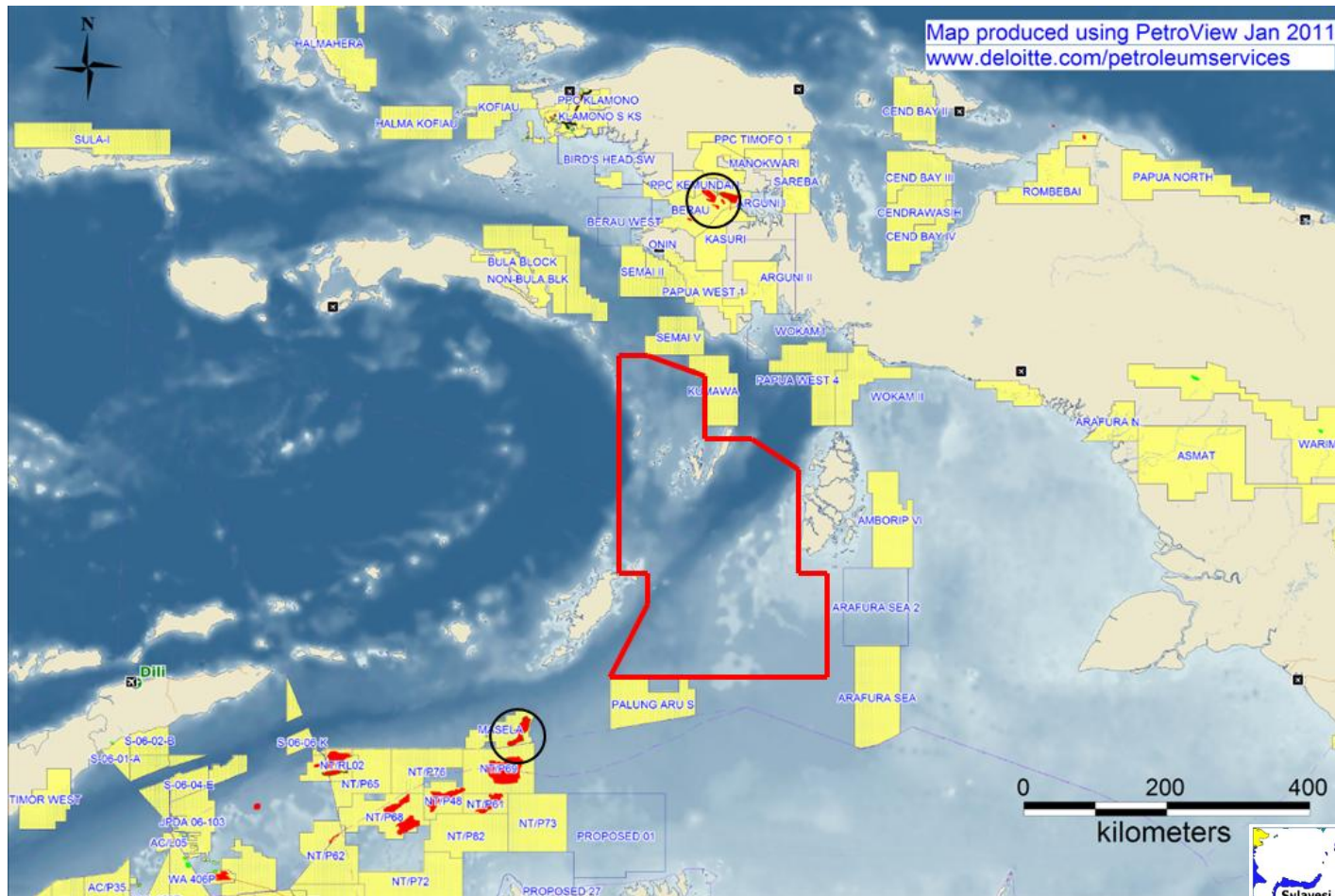


Figure 30 Location of survey area (base map courtesy of Deloitte).



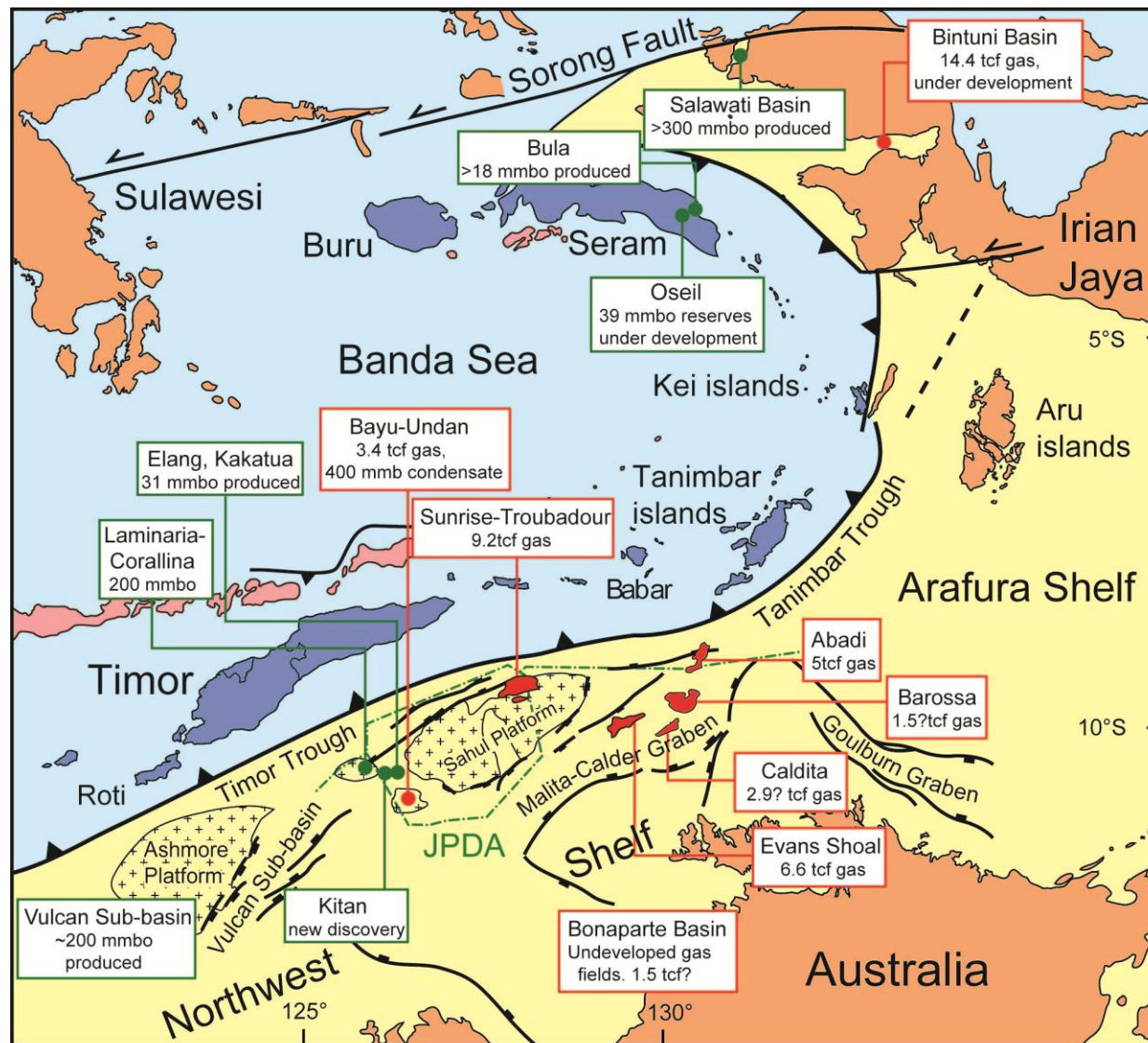


Figure 40 Structural elements map (Charlton 2004, updated 2011).

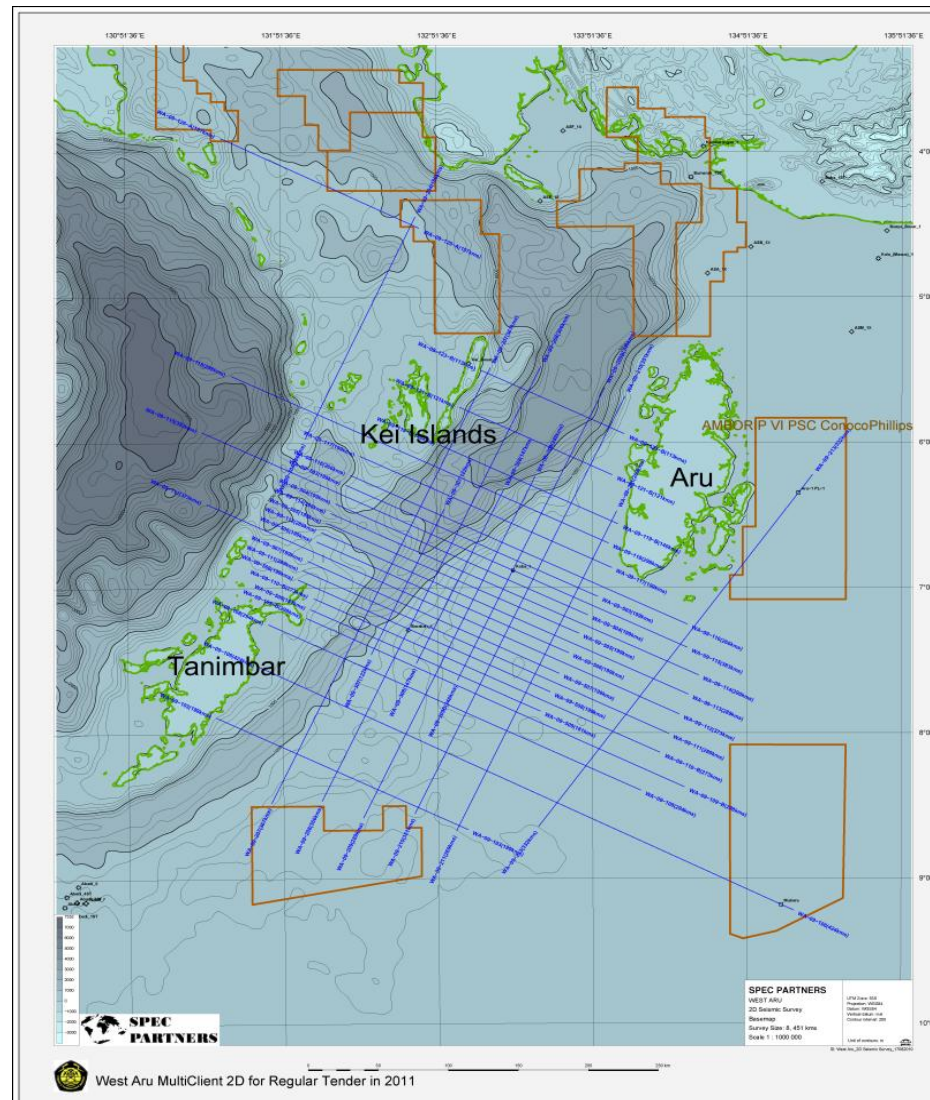
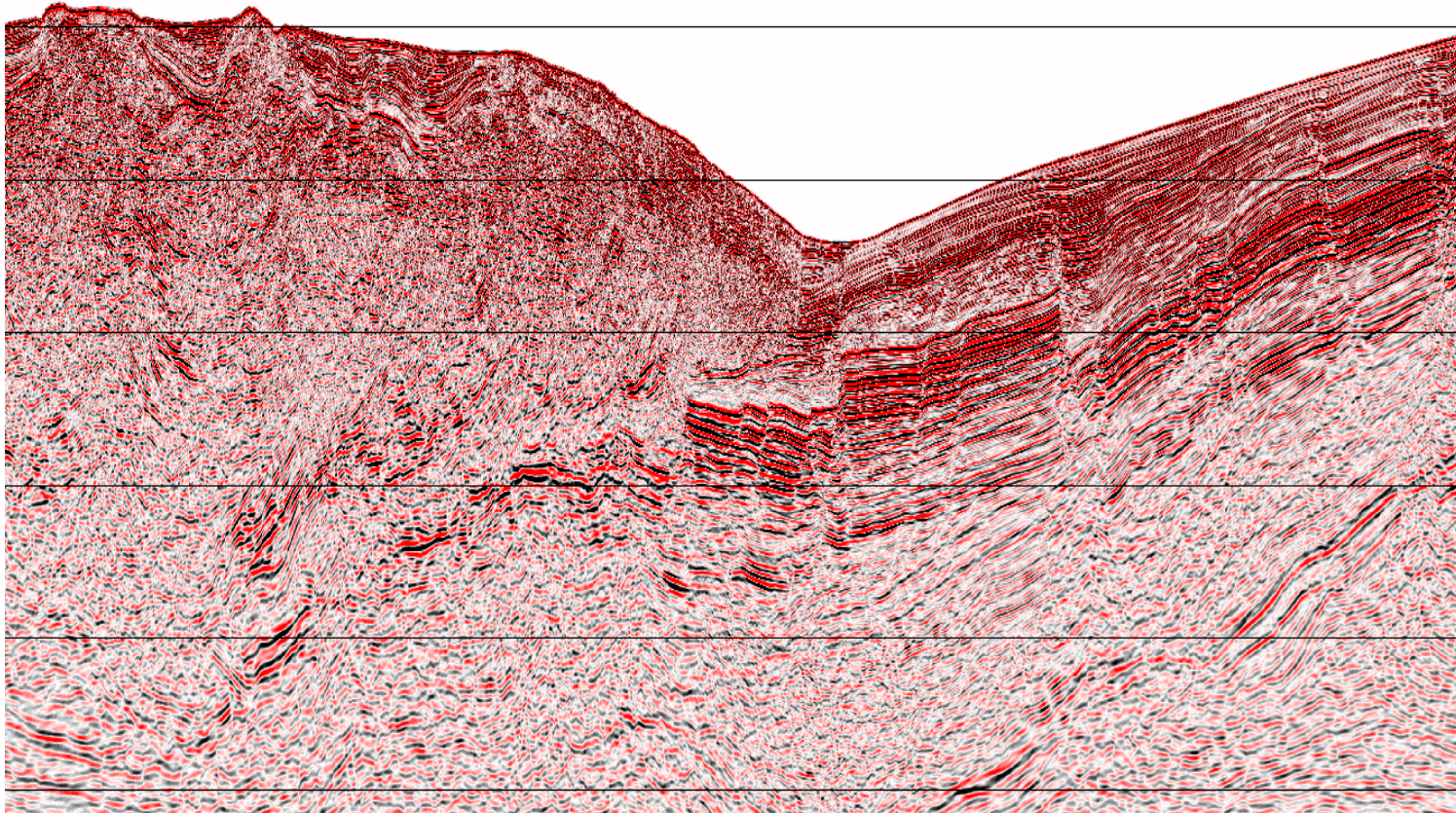
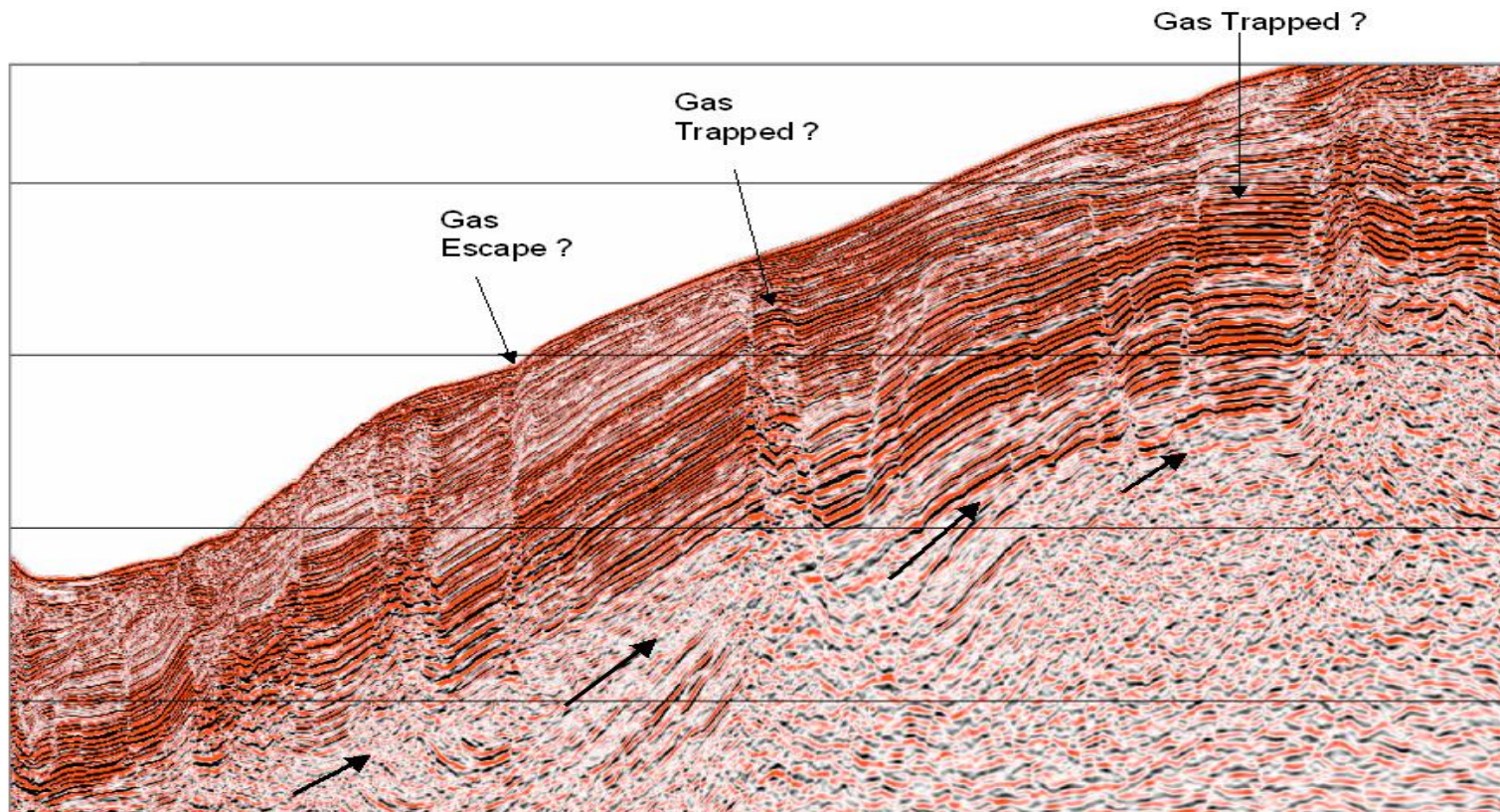


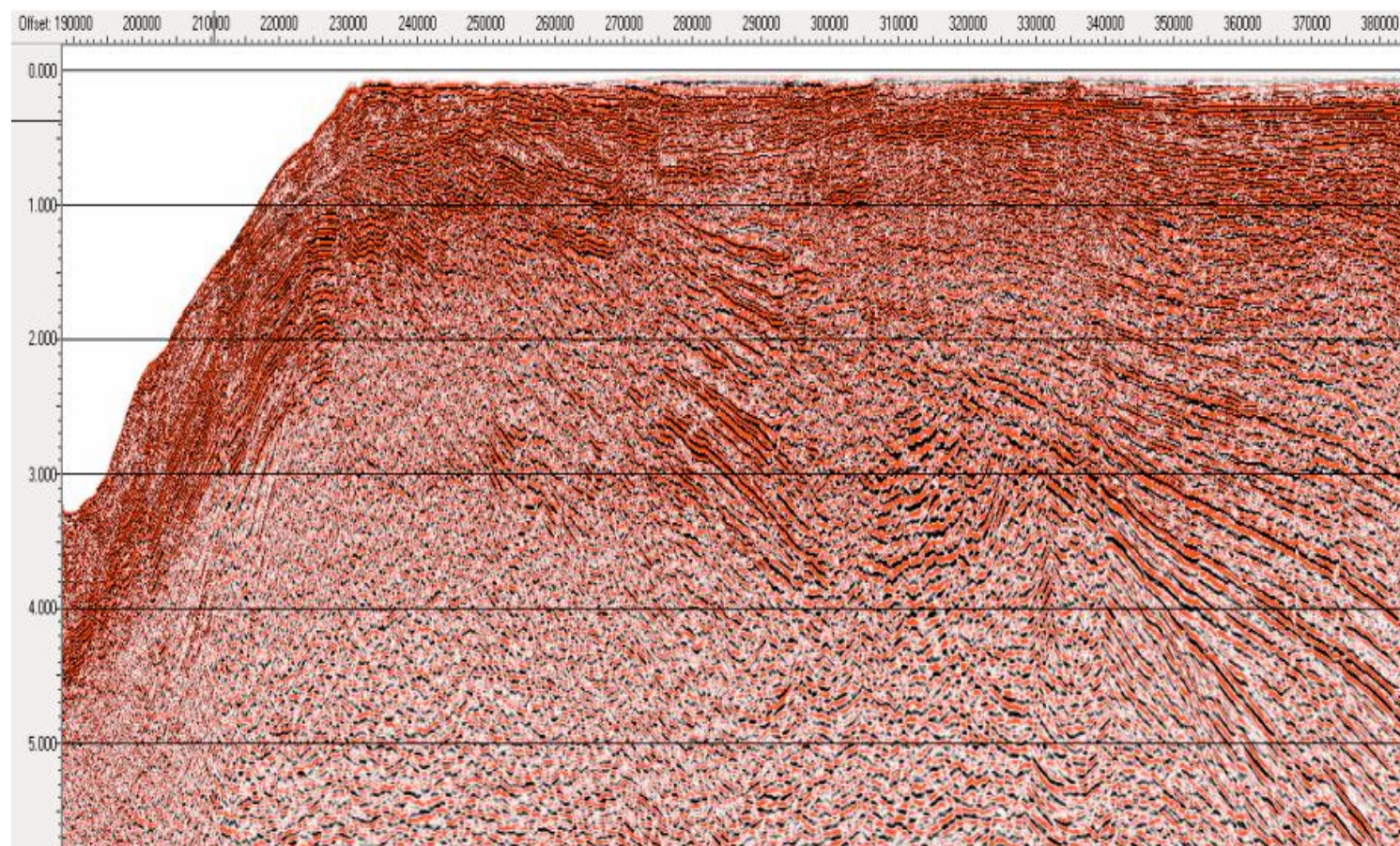
Figure 50 Seismic data coverage (Spec Partners Ltd).



Higt'60 W-E seismic section through the sag basin showing Mesozoic development below the melange. Section width 55 km. Timing lines every 1 second (1.0 to 6.0 secs).



Hilgert'70 Example of a Mesozoic Platform play on ~ W-E seismic line: Arrows indicate possible HC migration and areas where gas may have escaped or been trapped. Section width = 45 km.



Hi wtg'80 South Aru Graben on RHS half of seismic section. Section width = 190 kms.

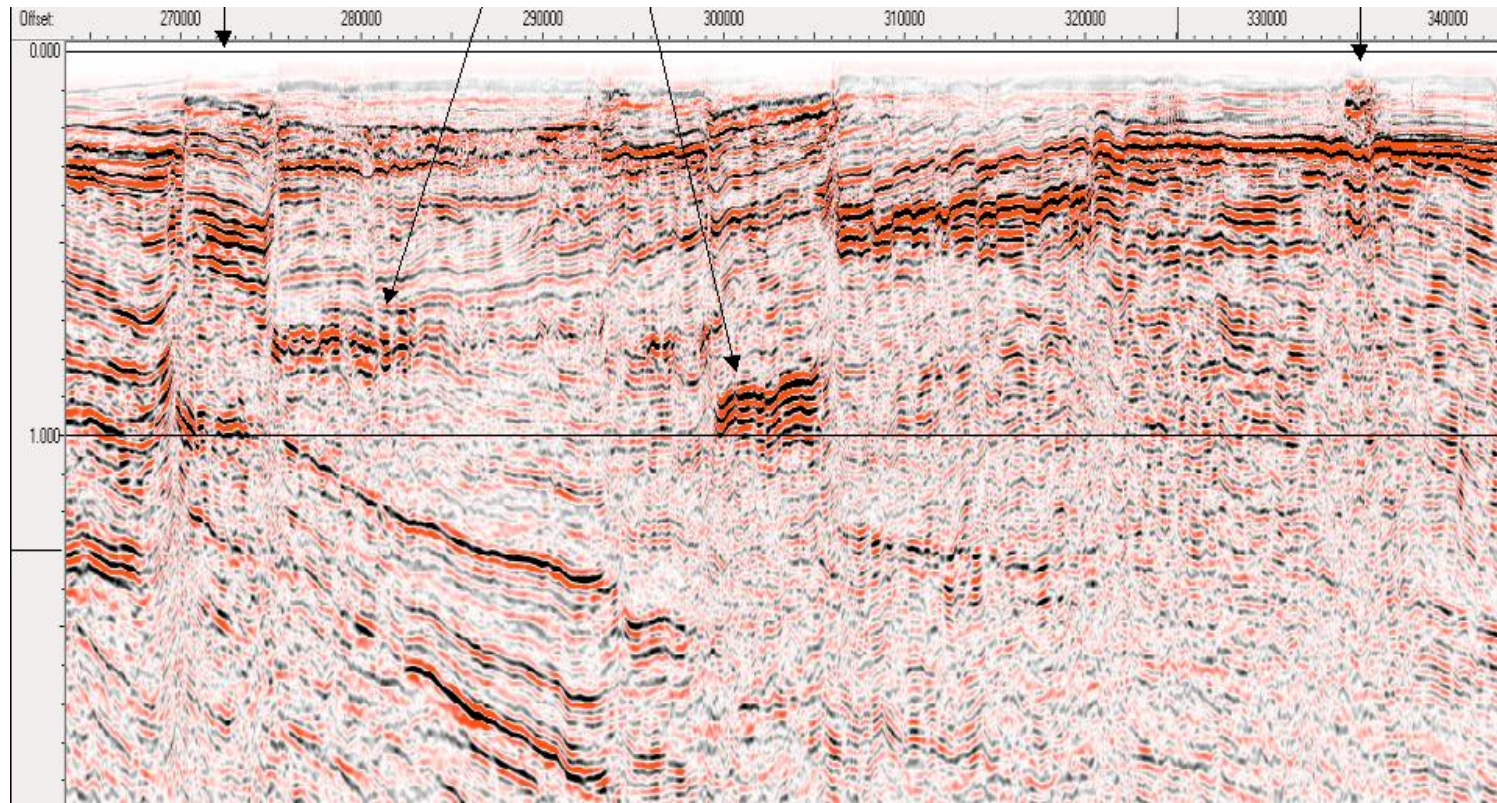


Figure 90 Close up of western part of the South Aru Graben (part of the same line shown in Figure 6) with the amplitude lowered to show gas chimneys and gas sands (?) arrowed. Section width 80 km.

Tanimbar Basin to South Aru Graben - Schematic Cross Section (after Pertamina B.P.P.K.A., 1996)

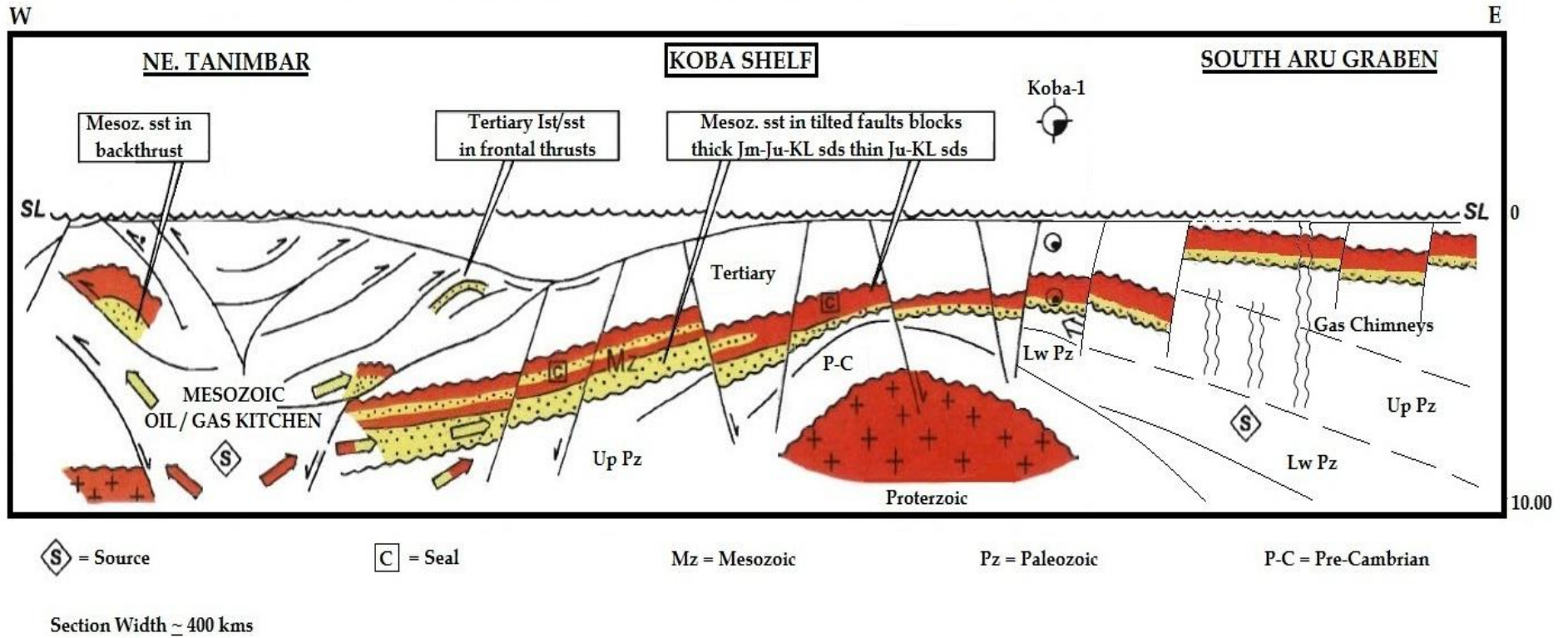


Figure 8. Tanimbar Basin to South Aru Graben - Schematic Cross Section (modified from Pertamina BPPKA, 1996). Width ~ 400 km; Depth ~ 10 km.