

Petroleum geology of the Nam Con Son Basin

NGUYEN TRONG TIN AND NGUYEN DINH TY

Vietnam Petroleum Institute (VPI)
Yen Hoa - Tu Liem - Hanoi

Abstract: The Nam Con Son Basin is situated within 6°6'–9°45'N and 106°0'–109°30'E. Its southern and southeastern boundaries are in the Vietnamese waters which border the neighbouring countries, and its eastern, northern and western boundaries are on the Vietnamese continental shelf. The exploration history of the Nam Con Son Basin can be divided into four periods: the Pre 1975 period, the 1976–1980 period, the 1981–1989 period, and the 1990–present period.

The heterogeneous basement of quartz diorite, granodiorite and Mesozoic metamorphic rocks is unconformably covered by Paleocene-Quaternary sediments composed of the Cau, Dua, Thong-Mang Cau, Nam Con Son and Bien Dong Formations.

All the geological formations in the Nam Con Son Basin can be divided into two complexes of major structural elements, the basement composed of Pre-Cenozoic strata and the cover composed of Cenozoic sediments.

The Nam Con Son Basin can be divided into the following tectonic zones, namely, the Western Differentiated Zone, the Northern Differentiated Zone and the Dua-Close-to-Natuna Zone.

Good source rock sequences are developed in Oligocene lacustrine claystones and in Miocene fine grained clastics. Paleogene reservoir rocks include Oligocene clastics and Lower Miocene reservoir rocks. There are Oligocene and Miocene cap rocks. Potential for both structural and stratigraphical traps are considered to exist in the Nam Con Son Basin.

INTRODUCTION

The Nam Con Son Basin is situated within 6°6'–9°45'N and 106°0'–109°30'E. Its southern and southeastern boundaries are in the Vietnamese waters which border the neighbouring countries, and its eastern, northern and western boundaries are on the Vietnamese continental shelf (Fig. 1). The exploration history of the Nam Con Son Basin can be divided into four periods (Operators for blocks of Nam Con Son Basin, 1978–1993).

1. Pre 1975 period

During this period, the US Oceanographic Service undertook an aeromagnetic survey on a scale of 1:250,000 covering the entire area.

In 1968–1969 a regional seismic survey was conducted by the British Overseas Development Department (Alpine). Then during the 1969–1974 period, a number of oil companies such as Mobil Kaiyo, Pecten etc., carried out geological and geophysical studies in some concessions.

2. 1976–1980 period

A series of companies such as Geco, Deminex, Agip, Bow Valley etc. conducted detailed surveys and drilled 8 wildcat wells in various blocks in the basin.

3. 1981–1989 period

During this period, Vietsovpetro — a 50:50 joint venture between Vietnam and the former Soviet Union — shot a reasonably dense grid of seismic lines and drilled wildcat and production wells in some blocks.

4. 1990–present period

A number of oil companies are presently undertaking geological, geophysical studies and are involved in drilling activities such as ONGC, Enterprise Oil, BP, Shell, BG, Petrocanada, IPL, Cairn, TG, Lasmo, Pedco, AEDC, Astra Petranusa, BHP and MJC (Le Van Cu *et al.*, 1992; Nguyen Trong Tin, 1993).

GEOLOGY

Sedimentology and stratigraphy

Pre-Tertiary formations

Out of 36 wells drilled in the Nam Con Son Basin, 19 wells encountered the basement which is heterogeneous in its composition and composed of quartz diorite, granodiorite and Mesozoic metamorphic rocks.

TECTONIC ELEMENTS OF SOUTH VIETNAM OFFSHORE

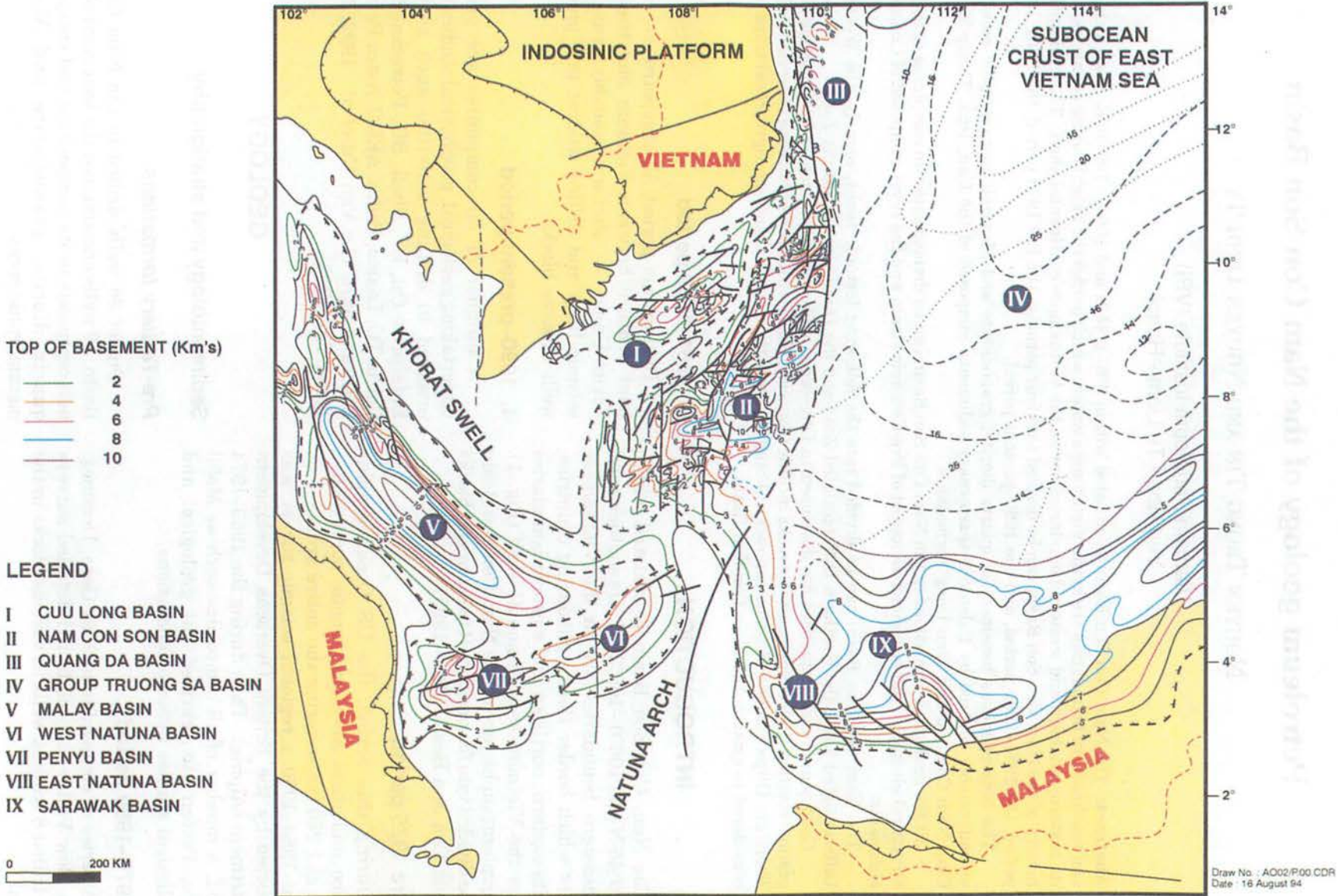


Figure 1. Tectonic elements of south Vietnam offshore.

Cenozoic formations

The heterogeneous basement is unconformably covered by Paleocene-Quaternary sediments composed of Cau, Dua, Thong-Mang Cau, Nam Con Son and Bien Dong Formations.

Cau Formation (Oligocene, Eocene?, Fig. 2). This Formation corresponds to the 'A' seismic sequence composed of the Bawahm, Keras, and Barat Formations. It is lithologically characterized from bottom to top by:

- Brownish grey sandstones intercalated with several beds of silty clay.
- A thick bed of dark grey clay intercalated with light coloured oilstone, locally fine grained and calcareous.
- Quartz sandstone intercalated with greyish-black, firm claystone.
- Dark grey, greenish grey clay, intercalated with beds of sandstone, and siltstone.

The thickness of this formation varies between 200 m and 800 m.

Dua Formation (Lower Miocene, Fig. 3). The sediments of this formation, unconformably overlying the Cau Formation, correspond to the lower part of the Arang Formation and constitute the 'BI' seismic sequence. This formation is composed of light grey, bright-grey sandstone, interbedded with blackish-grey silty clay. The main components of the sandstone are fine to medium grained, angular, quartz, with carbonate cement, and glauconite associated with fossil fragments.

The thickness of this formation varies from 200 m to 800 m, locally up to over 1,000 m (Block 05-3).

Thong-Mang Cau Formation (Middle Miocene, Fig. 4). The sediments of this formation correspond to the middle part of the Arang Formation and constitute the lower part of the 'B II' seismic sequence. The sediments are of clastic origin, interbedded with biogenic carbonates. The lithology of this formation can be divided into two distinct parts:

- Lower part: Quartz sandstone and calcareous sandstones interbedded with clays and siltstones. Fine to medium grained sandstones with carbonate cement and glauconite and fossil fragments.
- Upper part: Light grey, whitish/grey, locally reddish brown dolomitized carbonates with thicknesses varying from 10 m to 100 m. Intercalated with these carbonates are clays friable siltstones and fine grained, calcite-cemented sandstones.

Nam Con Son Formation (Upper Miocene, Fig. 5). This Formation corresponds to the Tereambu Formation and constitutes the top part of the 'B II'

seismic sequence. It unconformably overlays the Thong-Mang Cau Formation. This formation is composed of:

- Lower part: Clay, calcareous clay and grey sandstones.
- Upper part: Whitish grey carbonate and quartz sandstones.

At the western margin of Blocks 12, 20, 21, 11-1 and 11-2 this formation is mainly composed of calcareous clastic sediments.

The thickness of this formation varies between 100 m and 500 m, locally up to 600 m (Block 04-3).

Bien Dong Formation (Pliocene-Quaternary, Fig. 6). Following AGIP this formation corresponds to the Muda Formation. It constitutes the 'C' seismic sequence and is developed throughout the basin. It is Pliocene-Quaternary in age and can be subdivided into two parts:

- Upper part: Quaternary in age, composed of quartz sand (angular to rounded) in the lower section gradually changing to silty clay in the middle section and quartz sand containing shell fragments in the top section.
- Lower part: Pliocene in age, composed of siltstones, friable claystones, and grey calcareous clays intercalated with white or light yellow quartz sandstone, rich in carbonate and containing glauconite.

The sediments of this formation were deposited under coastal/marine, shallow to deep marine conditions. Their thickness varies from several meters to 200 meters.

Tectonic-structural features

Faulting

In the Nam Con Son Basin the following major fault system exist:

- N-S Fault System: Concentrated in the western differentiated zone, sub-zone next to Natuna
- NE-SW Fault System
- E-W Fault System
- NW-SE Fault System

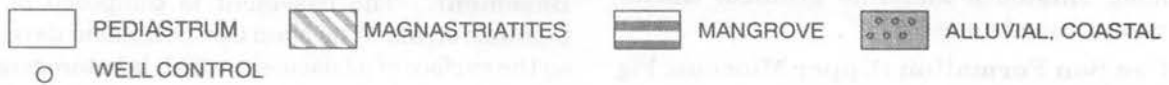
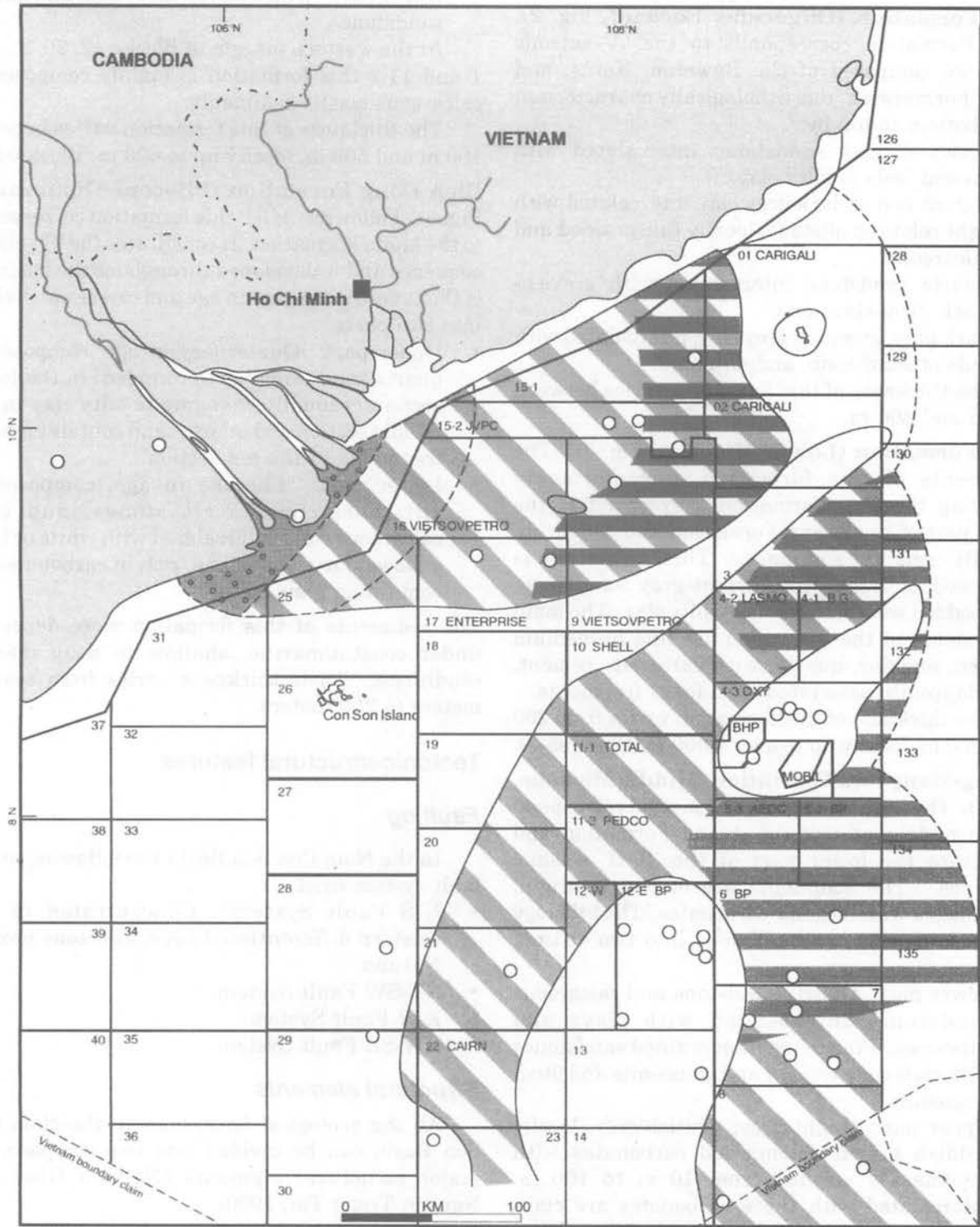
Structural elements

All the geological formations in the Nam Con Son Basin can be divided into two complexes of major structural elements (Nguyen Giao and Nguyen Trong Tin, 1990).

Basement. The basement is composed of Pre-Cenozoic strata. The Nam Con Son Basin developed on the surface of a basement which is heterogeneous, and it is displaced and strongly incised by faults into subsidence troughs at various levels.



DISTRIBUTION OF OLIGOCENE SEDIMENTS NAM CON SON BASIN



DRAW. No. AM03/P.02.CDR
Date : 2 August 94

Figure 2. Distribution of Oligocene sediments, Nam Con Son Basin.

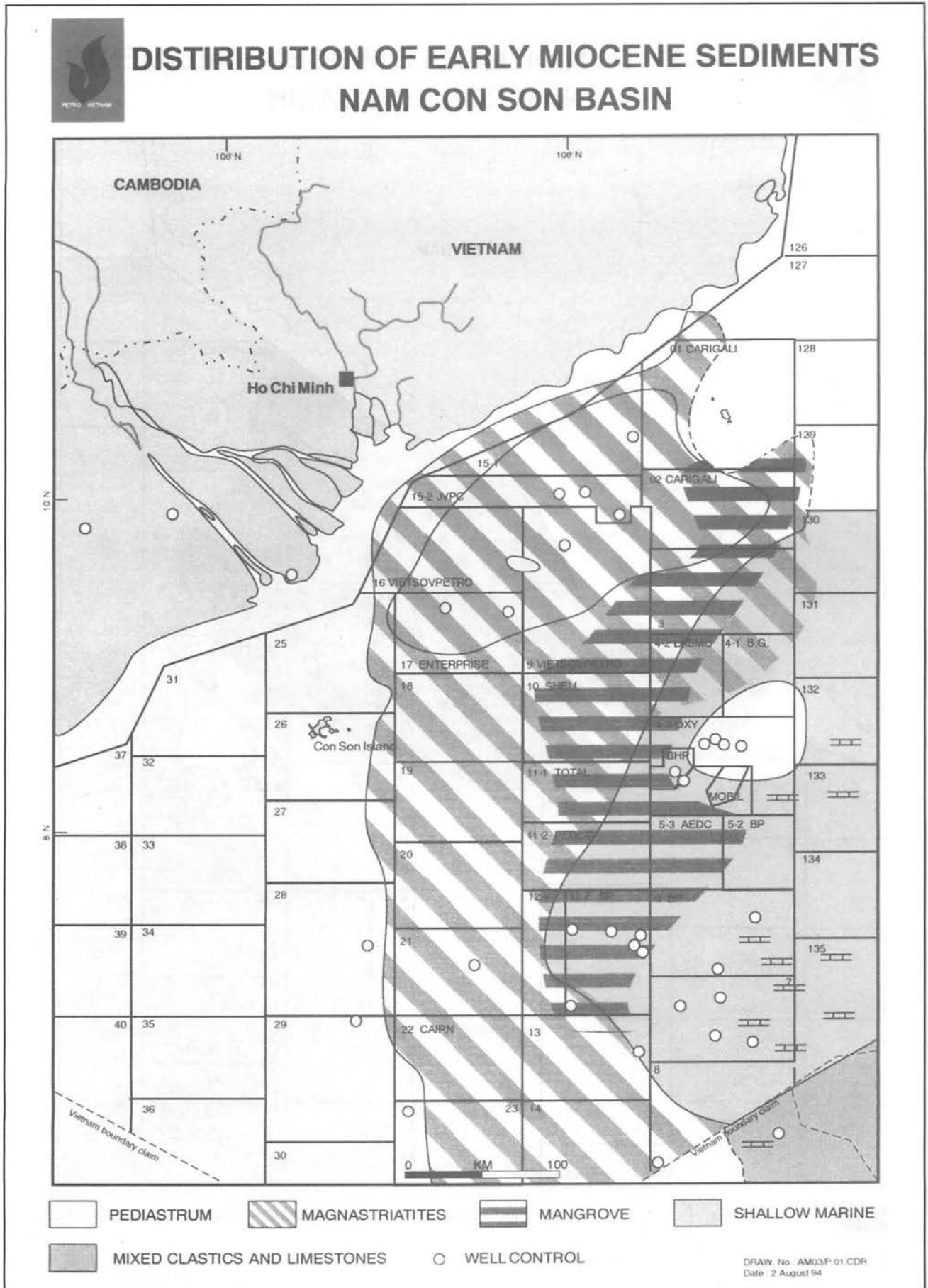


Figure 3. Distribution of Early Miocene sediments, Nam Con Son Basin.



DISTRIBUTION OF MIDDLE MIOCENE SEDIMENTS NAM CON SON BASIN

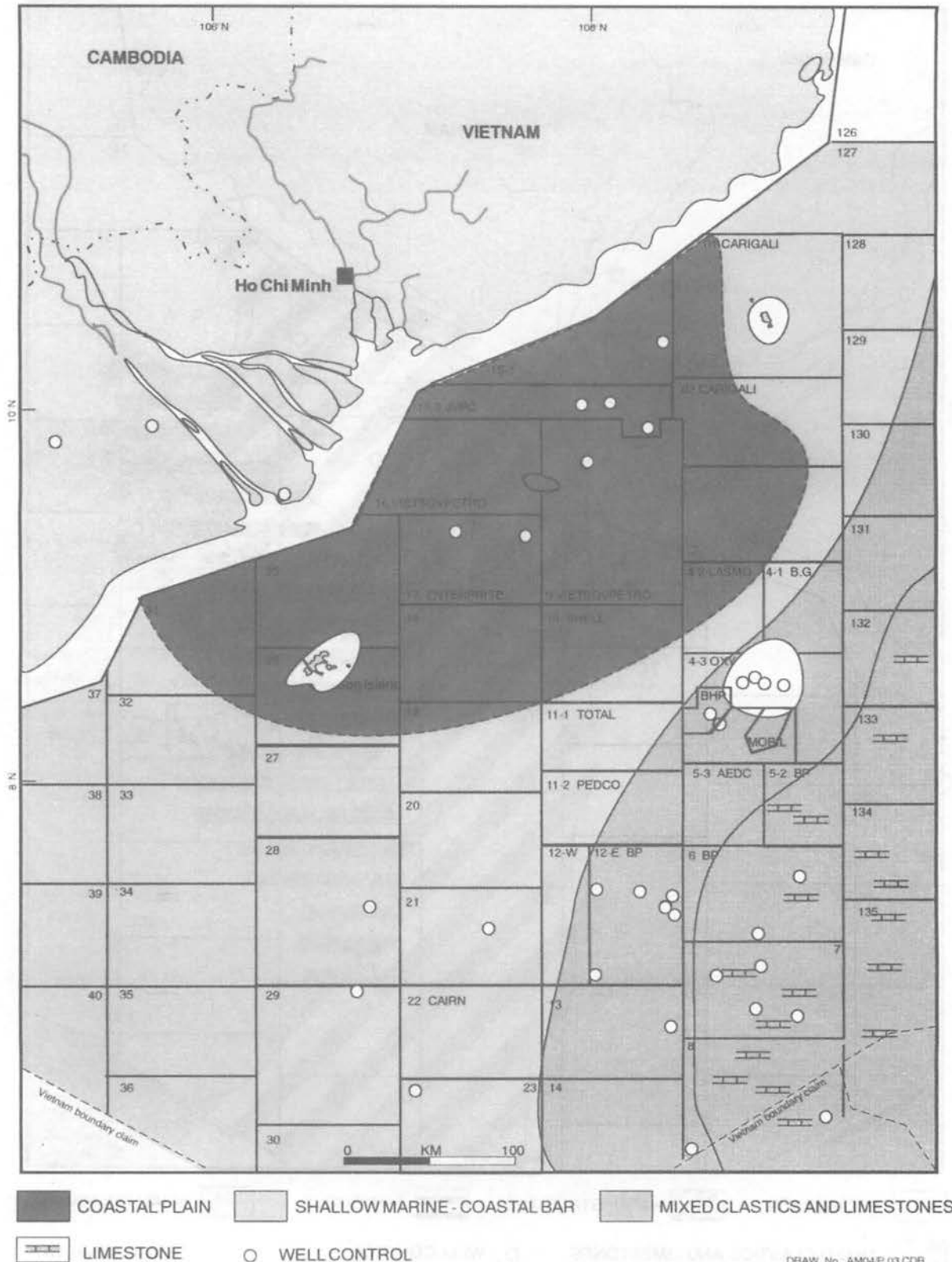


Figure 4. Distribution of Middle Miocene sediments, Nam Con Son Basin.

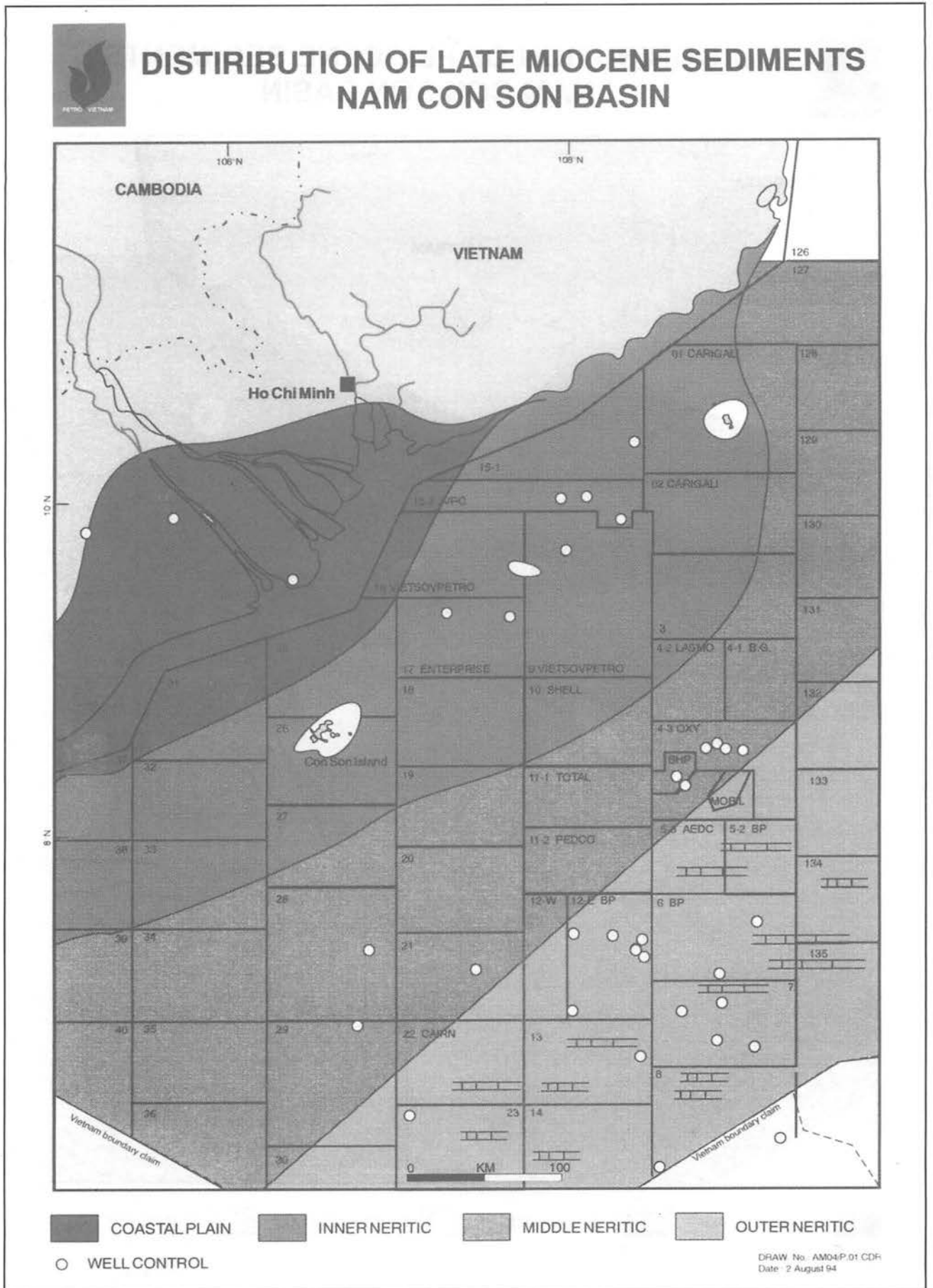


Figure 5. Distribution of Late Miocene sediments, Nam Con Son Basin.

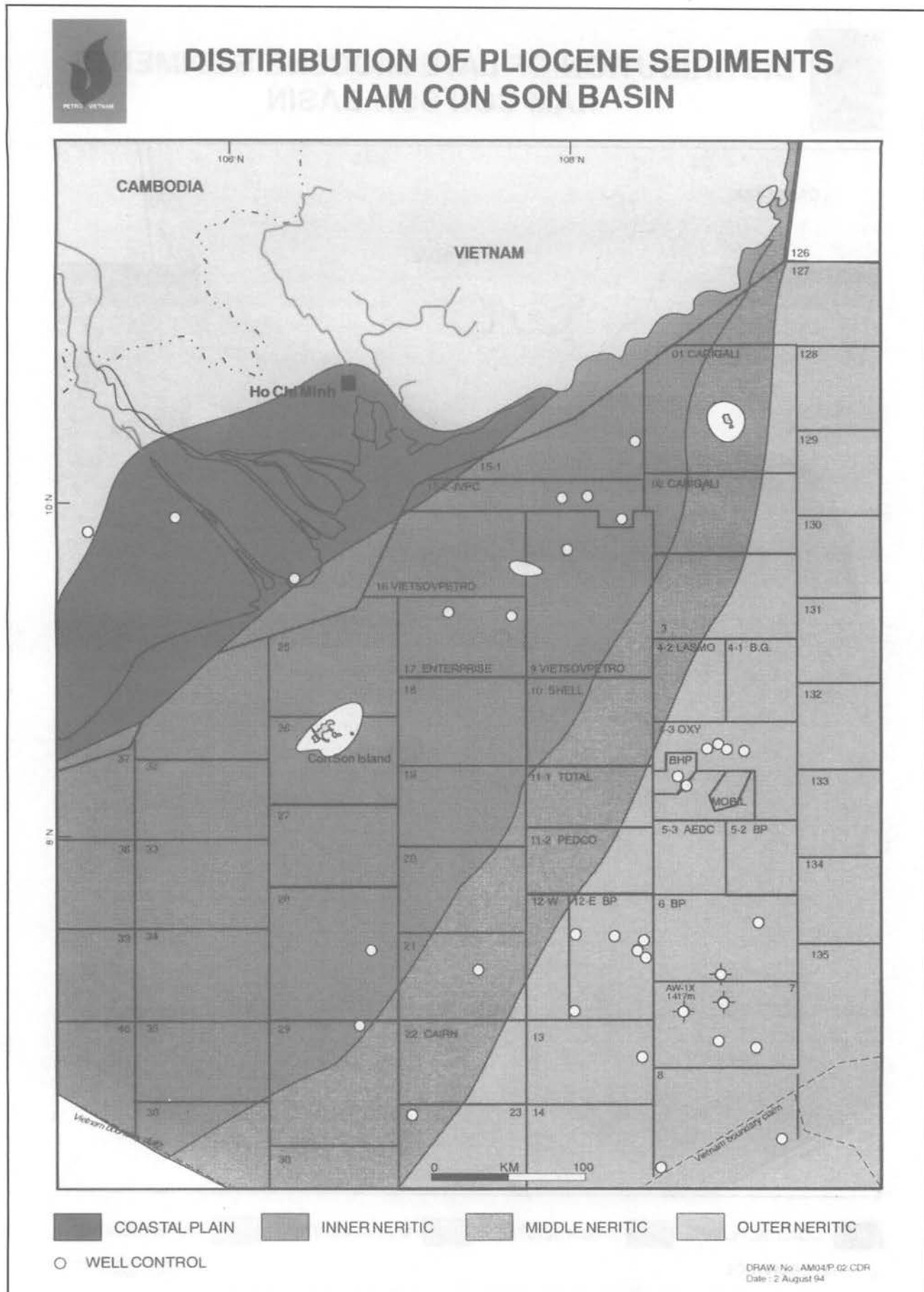


Figure 6. Distribution of Pliocene sediments, Nam Con Son Basin.

Cover. Composed of Cenozoic sediments, and subdivided into three sequences:

- Lower sequence: Composed of the sediments of the Cau Formation which is Paleogene in age.
- Middle sequence: Composed of the Miocene sediments of the Dua N^1_1 , Thong-Mang Cau (N^2_1), and Nam Con Son (N^3_1) Formations.
- Upper sequence: Corresponding to the Bien Dong Formation (Pliocene-Quaternary), composed mainly of clastic and coastal marine carbonates.

Tectonic zonation

The Nam Con Son Basin can be divided into the following tectonic zones:

The Western Differentiated Zone. This zone covers Blocks 27, 28, 29, 19, 21 and 22 and it is mostly characterized by the presence of narrow deep troughs, major faults accompanying sub-meridian trending anticlines. This zone is subdivided into two smaller structural subzones by the Hau Giang Fault:

- The western marginal sub-zone
- The western differentiated sub-zone

The Northern Differentiated Zone. To the north this zone is limited by the Dong Nai Fault, and it is developed along deep troughs in the east. This zone is also subdivided into two smaller units:

- The northern marginal sub-zone
- The northern transitional sub-zone in the southwest.

Dua-Close-to-Natuna Zone. The eastern trough zone comprising:

- The northern trough sub-zone
- Mang Cau sub-zone
- The central sub-zone

In short the existence of the above mentioned various structural elements reflects the diversity of the basement relief and cover structure as well as the multiphase tectonic activities of the basin.

HYDROCARBON POTENTIAL

Source rocks

Good source rock sequences are developed in Oligocene lacustrine claystones with a TOC content of 0.57–1.78% and in Miocene fine grained clastics with a TOC content of 0.52–0.84 belonging to the types II and III kerogen type. Source rocks are widely distributed throughout the basin (Fig. 7).

Reservoirs

Pre-Cenozoic fractured basement rocks with porosities of up to 16–20%.

Paleogene reservoir rocks: Oligocene clastics deposited under marshy, shallow marine, coastal marine conditions, and mainly composed of quartz sandstones with porosity of 12–16%. Reservoir thickness varies between 2 and 80 m.

Lower Miocene reservoir rocks deposited under deltaic, coastal marine and shallow marine conditions, and mainly composed of quartz sandstones and poly-mineral sandstones intercalated with thin silt and claystone layers. Porosity varies between 18% to 25%. Reservoir thickness varies between several meters and several dozens of meters.

Miocene limestone reservoir have proved to be very prospective with porosities of up to 25%.

Cap rocks

Oligocene cap rocks (Cau Formation)

Argillite claystone with shale intercalations and thin siltstone and fine grained sandstone layers. Clay and shale thickness is between 100–400 meters, constituting a good local seal.

Miocene cap rocks

Shales intercalated with silt and thin sandstone beds mainly deposited in deltaic flank, estuarine/shallow shelf setting providing a good local seal. The mid-Miocene 45 meters thick shale sequence can even be considered as a good regional seal.

Traps

Potential for both structural and stratigraphical traps are considered to exist in the Nam Con Son Basin (Nguyen Giao, 1987).

Rollover structures

This trap type is likely to offer one of the most prospective plays in the eastern blocks of the Nam Con Son Basin.

Tilted fault blocks

These traps are considered to have formed during the Middle to Late Miocene, and contain Middle/Lower Miocene and Oligocene sediments which may all be highly prospective.

Fractured-weathered basement high

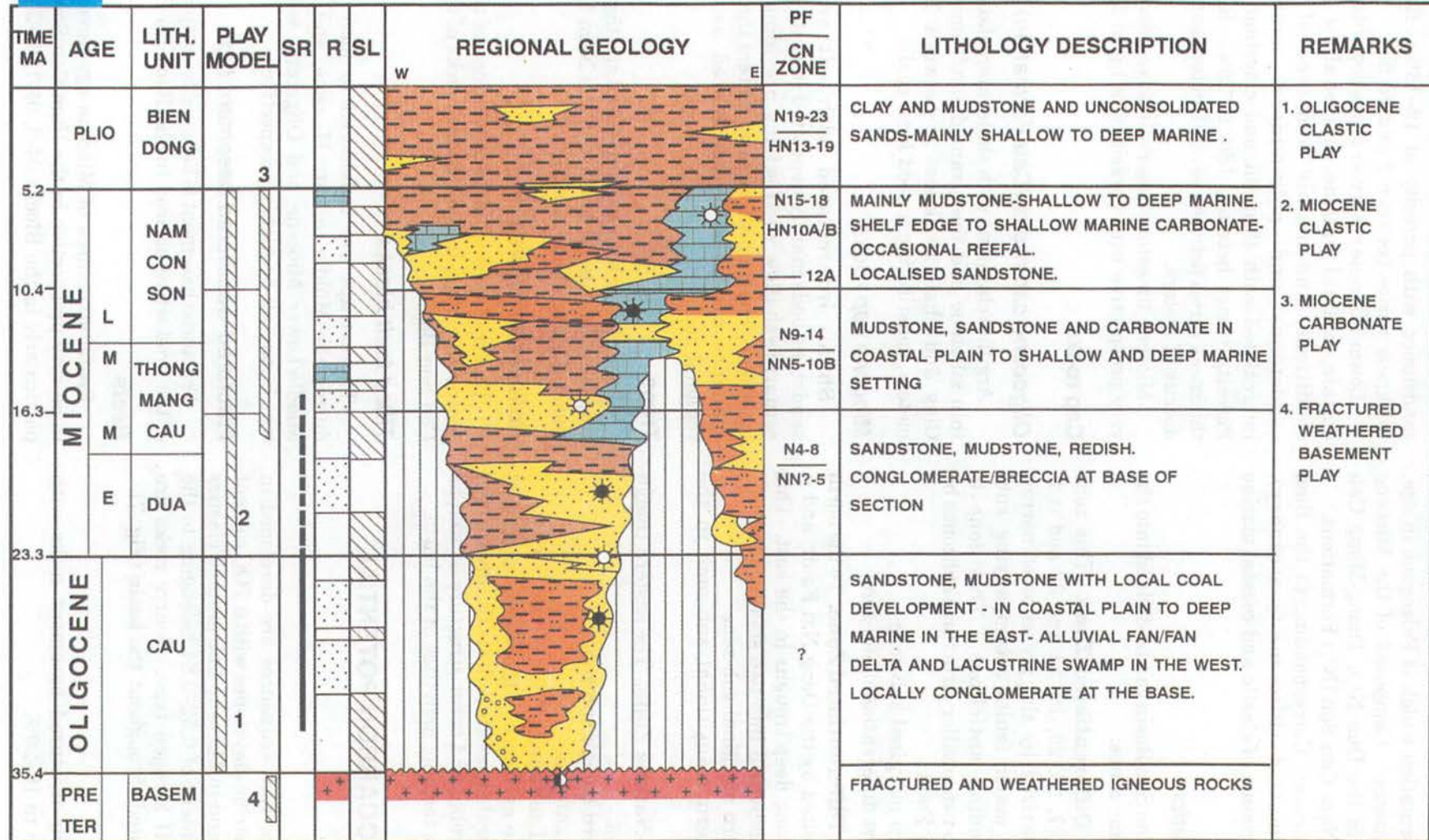
Fractured basement is believed to comprise part of the productive horizon in the Bach Ho Field.

Reefs

Reefal structures of Miocene age have proved to be very prospective in the Nam Con Son Basin, particularly in the Blocks 04-3, 05-1, 05-2 and 06.



PLAY TYPES OF NAM CON SON BASIN



Draw No. : AHD1.P00.CDR
Date : 3 August 94

Figure 7. Play types of Nam Con Son Basin.

The Nam Con Son Basin is the largest proven oil and gas basin in Vietnam offshore with a number of proven oil fields.

REFERENCES

- LE VAN CU, HO DAC HOAI AND TRAN LE DONG, 1992. Structural geology of marine area Thuan Hai-Minh Hai. *Petrol. Vietnam Project Report*.
- NGUYEN GIAO, 1987. *Structural geology and hydrocarbon potential of Tertiary sedimentary basins in East Viet Nam Sea*. USSR Academy.
- NGUYEN GIAO AND NGUYEN TRONG TIN, 1990. Structural geology and hydrocarbon potential assessment of Nam Con Son Basin. *Petrol. Vietnam Project Report*.
- NGUYEN TRONG TIN, 1993. Hydrocarbon potential assessment of blocks on the Nam Con Son Basin. *Petrol. Vietnam Project Report*.
- OPERATORS FOR BLOCKS OF NAM CON SON BASIN, 1978-1993. Geophysical, geological and wells reports. *Petrol. Vietnam Project Report*.

Manuscript received 23 August 1994