# CHAPTER III

# LITHOSTRATIGRAPHY OF KRABI BASIN

## 3.1 General

There is clearly a close connection between the environment of deposition and the nature of the sediment deposited. For ancient sedimentary rocks, the primary data are the rocks and the environment must be interpreted from them. Therefore, the first task is to describe the rocks and to attempt to subdivide them into a number of lithostratigraphic units. Within each lithostratigraphic units, it is generally possible to recognize units that differ in some aspects from those around them.

There is an obvious relationship between the characteristics of a given sedimentary environment and the materials that accumulate there. Some adjacent environments show quite contrasting conditions and sediments; therefore, the rocks produced by such environments will be strictly different. These difference may sufficient to warrant different designations as lithostratigraphic units. Thus adjacent lithostratigraphic units typically represent adjacent depositional environments.

An understanding of depositional systems from the standpoint of modern sedimentary environments and from the rock record requires expertise in the sedimentology and in stratigraphy. In a general way, the study of the modern environment requires more sedimentology than stratigraphy, whereas in the rock record the two descriplines come nearer being equal in emphasis. One of the primary tasks for the

successful understanding of depositional systems is the ability to visualize modern environments as they would appear in the rock to interprete the paleoenvironments represented by the rocks preserved in the stratigraphic records. The modern "soft rock" geologist must be able to do this continually and must be equally competent both in modern sedimentary environments and in analyzing their resultant features in the rock records.

In the present study, the information about Tertiary sedimentary sequences of Krabi basin is mainly obtained from subsurface investigation. Various kinds of subsurface exploration techniques, namely, boring with geologic logging and/or geophysical logging, and seismic surveys have been employed. The basic utilizations of subsurface information are to prepare maps of subsurface structure as where depth and of stratigraphic feature.

Strata in any sedimentary sequences can be subdivided on the basis of their physical characteristics, or fossil content, or their time relationships. Accordingly, three kinds of units have been established. They are lithostratigraphic units, biostratigraphic units, and chronostratigraphic units. In this study, the sedimentary sequences have been classified on the basis of lithostratigraphy.

A lithostratigraphic units is a body of rock strata which is unified by consisting dominantly of a certain lithological type, or combination of lithological types, or by processing other impressive and unifying lithological features. It may consist of sedimentary, or igneous, or metamorphic rocks, or in some case, of intricate interbedding of two or more of these. It is a three dimensional body and its concept must be based on its character as a unit through its

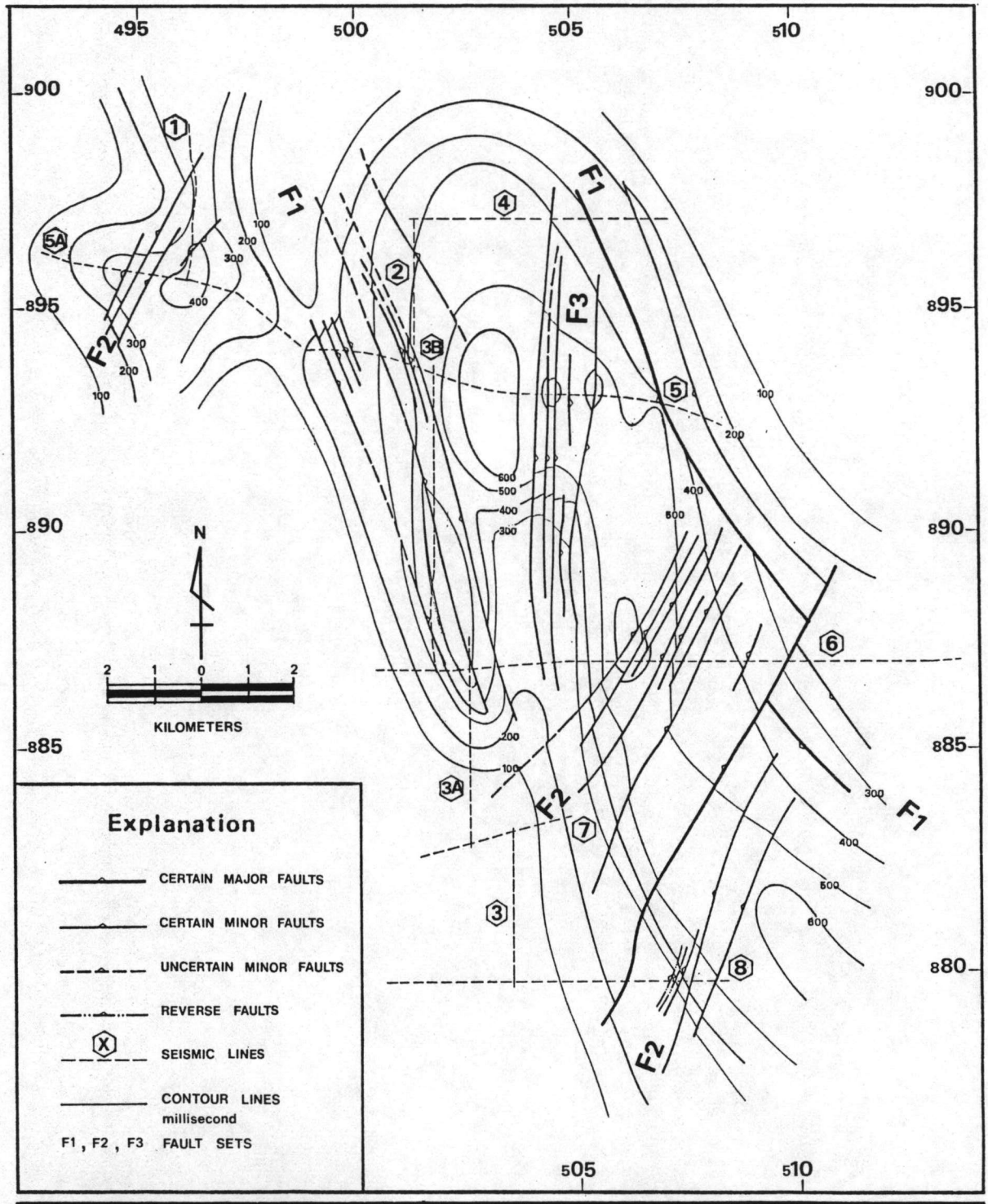
full extent, both vertically and laterally (American Commission on Stratigraphic Nomenclature, 1961).

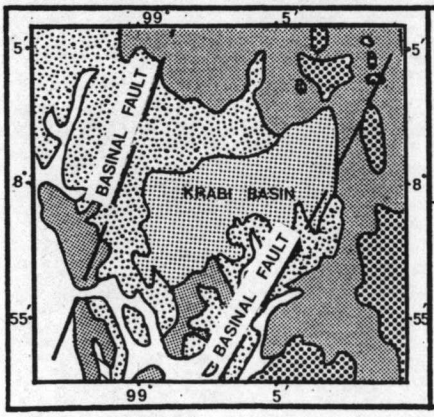
## 3.2 Subsurface Geology

The subsurface geology of study area of 220 sq.km. is basically obtained from the lithological log of 136 drillholes with the depth of penetration ranging from 150-550 m., geophysical log of 92 drill-holes for four parameters, namely, caliper, long density, gamma, neutron, and ground seismic reflection survey of totally 60 line-kilo-meters.

The aforementioned data are synthesized and finally presented in various forms of subsurface maps and diagrams. They include 136 well data sheets pseudobasement structural contour map, geological sections, and fence diagram. These graphic representation are served as a basis for lithostratigraphic classification, description, and tentative nomenclature.

Information obtained from 60 line-kilometers of seismic reflection survey reveals that the configuration of pre-Tertiary basement of Krabi basin within the study area is elongated in the north-northwest/ south-southeast with the closures feature in the north and open feature in the south. The basin is approximately 10 km. wide. There are four main sub-basins with the maximum depth from ground surface to present pre-Tertiary basement of over 600 m. Among these sub-basins, three of them are aligned in the north-northwest / south-southeast parallel to the axis of the main basin,whereas the other one lies on the western margin of the main basin. The pre-Tertiary basinal basement rocks are believed to be the clastic sediment of Carboniferous and Permian, undifferentiated Mesozoic clastic sediments, and some Permian limestone.




Sedimentological Analysis of Tertiary Coal - Bearing Krabi Basin, Southern Thailand

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Figure 3.2 a. Pseudobasement structural contour map.

Seismic evidences show that the basement rocks are heavily faulted by three sets of closely-space faults in the northwest-southeast (F1), northeast-southwest (F2), and north-south(F3). Among these three fault sets, the major ones are the northeast-southwest and the northwest-southeast. A cross-cutting relationship between these two sets further reveals that the northeast-southwest one is relatively younger than the northwest-southeast one (Fig. 3.2 a).

Considering the sedimentary deposits within the basin under the present investigation, they are generally characterized by the fine-grained clastic association with coal seams of Tertiary and Quaternary ages. Synthesis of subsurface geological data and information of Krabi basin reveal the ideal sedimentary sequence as summarized in Figure 3.2 b. This ideal sequence will be served as a baseline data for further stratigraphic classification and nomenclature.

## 3.3 Stratigraphic Classification and Nomenclature

In this study, an attempt have been made to classified sedimentary sucession in Krabi basin into different lithostratigraphic units in order to fulfil the sedimentological purpose of study. Boundaries separating lithostratigraphic units may be placed at sharp contacts or at arbitary levels with respect to a zone of gradation.

The ultimate objective of subdividing the strata is to find and identify all of them and then to assemble a framework of non-overlapping units for designating them the hirachies of lithostratigraphic units employed in the present study cover the group, the formation, and the member.

With regard to the nomenclature of lithostratigraphic units, informal name have been used for the purpose of tentative reference.

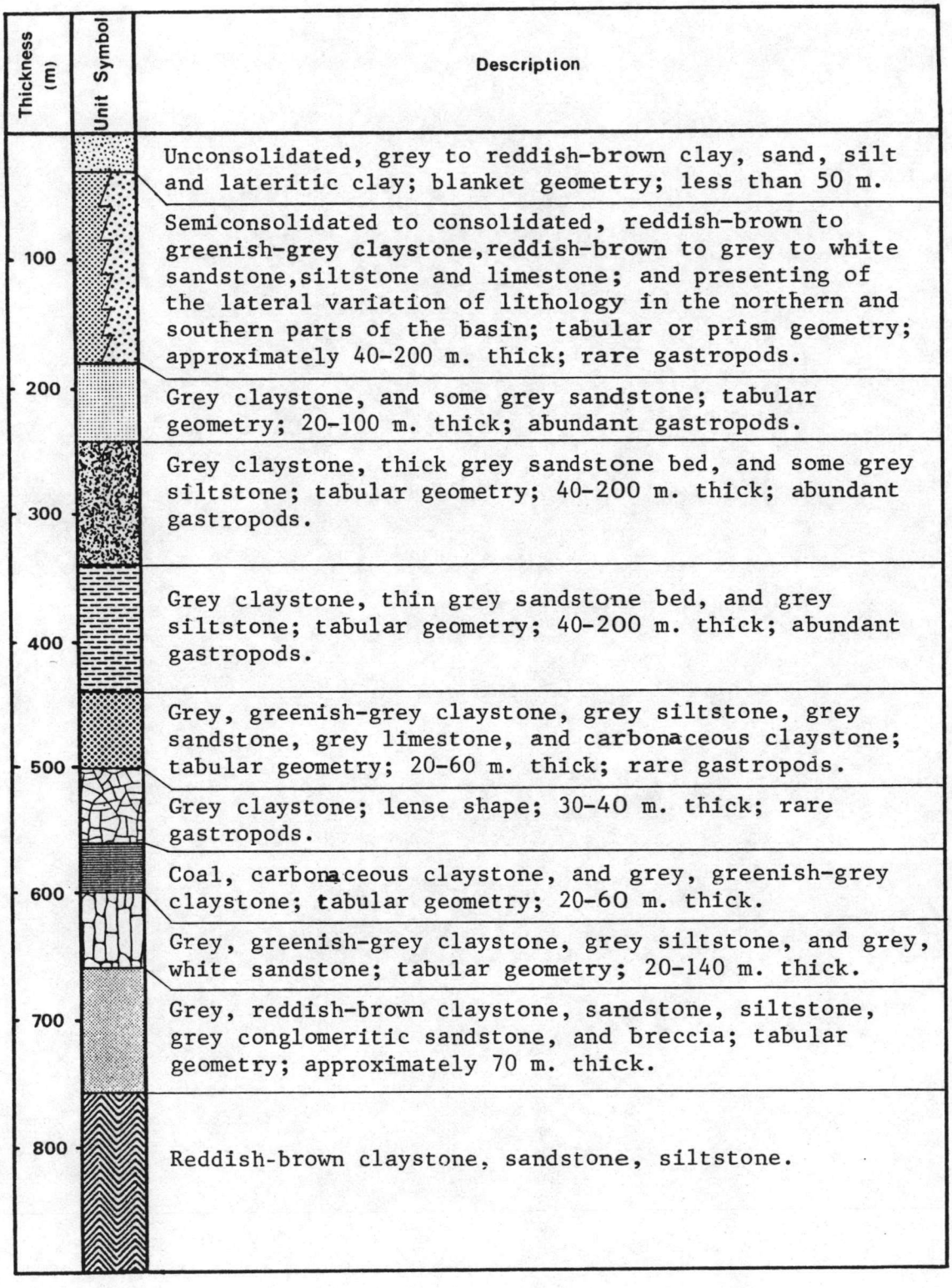



Figure 3.2 b. The idealized sequence of study area.

### 3.3.1 Krabi Group

The Krabi Group was first proposed to represent Tertiary deposits in Thailand by Javanaphet (1969). For Krabi basin, subsurface geological evidences indicate that the basement rocks are Permian limestone of Ratburi Group and Mesozoic clastic rocks of Khorat Group. The sedimentary sucession within Krabi basin is essentially Tertiary sediments. Therefore, the Tertiary sediments within Krabi basin with thickness exceeds 300 m can be classified under the largest lithostratigraphic unit of Krabi Group. Overlying the Krabi Group in Krabi basin is the sedimentary succession of Quaternary age. These Quaternary deposits vary in thickness from a few meters to 50 m. The sediments are informally assigned under the tentative lithostratigraphic unit called "Q Group" in this study. Therefore, there are altogether 2 main lithostratigraphic units in Krabi basin, namely, "Q Group" and Krabi Group, in descending order.

It is believed that the sedimentary sequences of Krabi Group overly unconformably the basinal basement rocks of Permian limestone and/or Mesozoic clastics. Krabi Group in Krabi basin can be classified, according to subsurface geological information and data under present study, into five formations, namely, A Formation, B Formation, C Formation, D Formation, and E Formation, in ascending order (see Appendix D). Detailed description of each formation will be discussed in following passage.

#### 3.3.1.1 A Formation

The A Formation, the lowermost formation of Krabi Group, is generally characterized by reddish-brown and grey claystone, siltstone, and white to grey sandstone interbedded with some limestone and carbonaceous claystone. The thickness of this formation ranges

from 70 m. to over 200 m. and it is found to be widely distributed throughout Krabi basin. The geometry of this formation is therefore concluded to be tabular with varying thickness. Due to the fact that only a few boreholes have penetrated this formation, therefore lithological characteristic of the formation is accordingly limited. No attempt has been made to further subdivide this formation into smaller lithostratigraphic unit.

It is noted that on the western edge of Krabi basin, there appears to be high sand/clay ratio of 1:4 to 1:1 in sedimentary sucession of the A Formation. The amount of sand in the succession has progressively decreased toward the central part of the basin as well as the eastern edge of the basin. The characteristics of the A Formation is summarized in Figure 3.3.1.1 .

3.3.1.2 B Formation

The B Formation overlies conformably the A Formation with gradational lithological contact. The lithology of this formation is characterized by greenish-grey to grey claystone, sandstone, limestone, carbonaceous claystone, and coal with total thickness of 70-180 m. Due to the fact that the sedimentary succession of this formation shows distinctive lithological characteristics which can be differentiated including different geophysical log signature, the B Formation can be subdivided into four members, they are B1, B2, B3, and B4 Members in ascending order.

The lowerest member of B Formation is the B1 member which is characterized by grey to greenish-grey claystone, grey sandstone, light brown to grey limestone, and carbonaceous claystone. The sand/clay ratio of this member is lesser than 1:6. The geometry of this member is tabular with maximum thickness in the upper-central part of

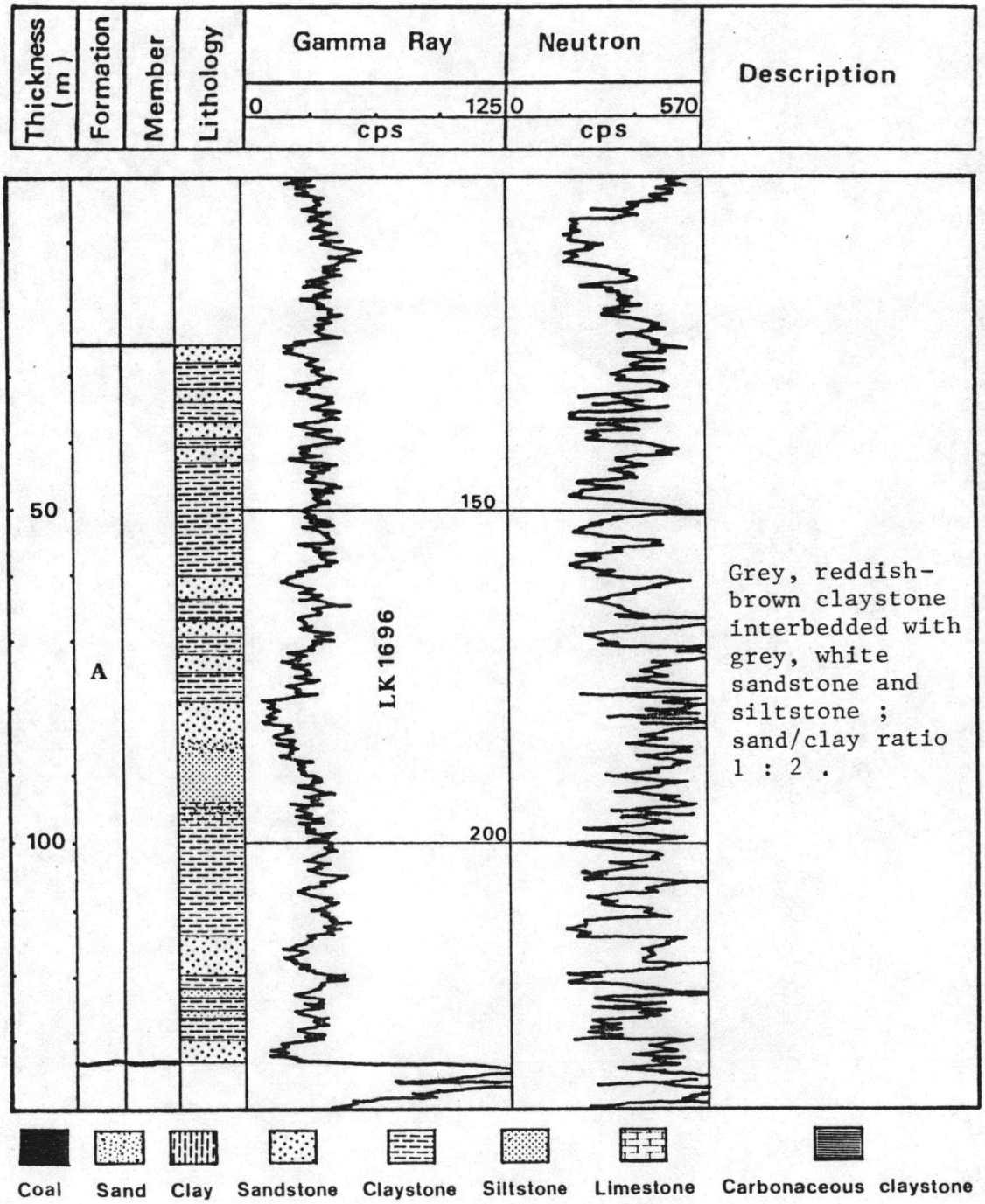



Figure 3.3.1.1 The characteristics of the A Formation .

the basin. To the west, the B1 member is drastically thinning out, whereas the member progessively decreases in thickness in the other direction. In general, the thickness of this member varies within the range 20-140 m. The lower limit of this member is gradational type.

Overlying conformable the B1 Member with sharp contact is the B2 Member. The B2 Member is characterized by coal, carbonaceous claystone, grey to greenish-grey claystone, and thin-bedded grey sandstone. The sand/clay ratio of the member is approximately equal to 1:1. The thickness of the member varies within the range of 20-60 m. It is noted that there is more sand layers in the sequence of the B2 Member in the northern, western, and eastern margins of the basin, whereas thin-bedded limestone is present in the southern margin of the basin. The coal seam contains sand partings in the northern part, whereas clay partings are dominant in the middle and southern parts. The overall geometry of the coal seam, B2 Member, is considered to be tabular. It is noted that the B2 Member in the north-central and middle-central parts of the basin is separated by the claystone lens of the B3 Member.

The B3 Member is characterized by grey to greenish-grey claystone with some carbonaceous claystone and grey sandstone. The member is distributed in two separated zones, namely, north-central and middle-central having a lens-shaped geometry of 40 m. thick by 4 km. wide, and 40 m. thick by 1.5 km. wide, respectively. The sequence of B3 Member in the eastern part of north-central zone appear to contain more sand content of up to 1:5 of sand/clay ratio. The lower and upper contacts of B2 Member with respect to B2 Member are sharp.

The uppermost member of the B Formation is B4 Member which overlies conformably the B2 Member. Lithology of the member is charac-

terized by grey claystone, grey sandstone, grey siltstone, and grey limestone in decreasing order of abundance. The B4 Member is distributed in two separated zones, notably, north-central and south-central zones. The geometry of the member in the north-central zone is lens-shaped of 40 m. thick and approximately 2 km. wide, whereas the south-central zone has a tabular geometry of 40-100 m. thick and morethan 4 km.wide. The sequence of this member in the north-central zone is predominantly grey limestone and grey claystone with thin-bedded sandstone. The sand/clay ratio of this zone varies from approximately 1:1 to 1:4. For south-central zone, the sequence of this member is predominantly claystone interbedded with sandstone. Some gastropod fossils have been found in the claystone. Detailed lithostratigraphy of the B Formation is summarized and presented in Figure 3.3.1.2 .

3.3.1.3 C Formation

The C Formation overlies conformably the B Formation with gradational contact. This formation is characterized by grey to greenish-grey claystone, white to grey sandstone siltstone, grey limestone and containing abundant fresh-water gastropods, namely, Melanoides sp., Viviparus sp. (Ingrawat, 1981). The distribution of the formation is found wide-spread throughout the area with varying thickness of 100-400 m. The geometry of C Formation is considered to be tabular. The formation can be subdivided into three members on the basis of their lithological characteristics and sand/clay ratio, namely, C1 Member, C2 Member, and C3 Member in ascending order.

The C1 Member is the lowest of the C Formation which overlies the B Formation with gradational contact. The lithology is characterized by grey to greenish-grey claystone, grey sandstone, grey siltstone, and grey limestone in decreasing order of abundance. The C1 Member is

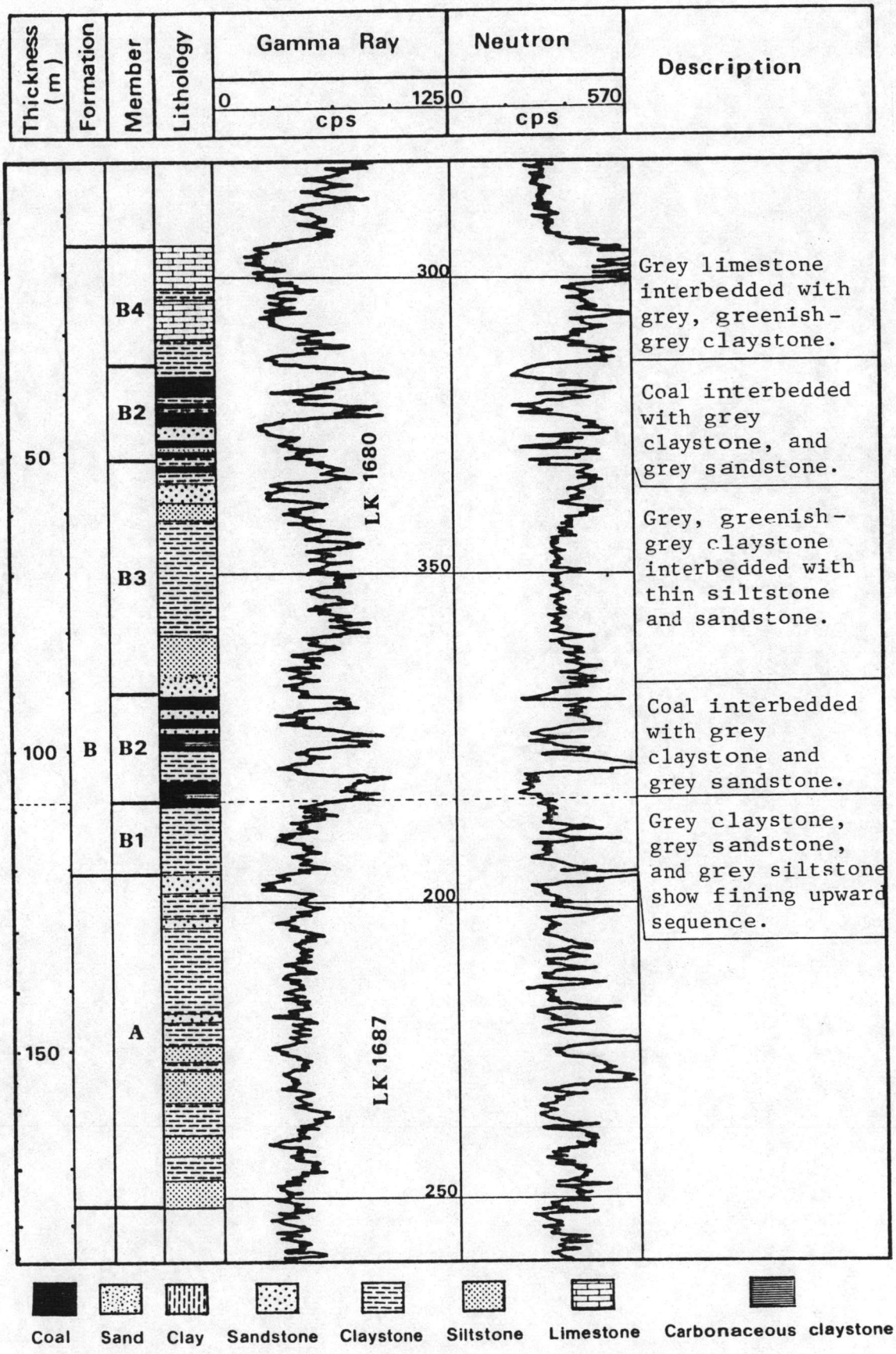



Figure 3.3.1.2. The characteristics of the B Formation.

wide-spreadly distributed with varying thickness in the central part of the basin. The sand/clay ratio of this member is less than 1:6. It is noted that there is more sand layer in the C1 Member sequences in the northern, western, and eastern margins of the basin, whereas rare sand layer is present in the central of the basin and the thin-bedded fossiliferous limestone is found in the south-central of the basin. The gastropods are abundant in the western and northern parts of the basin.

The C2 Member overlies the C1 Member with gradational contact The lithology is characterized by grey to greenish-grey claystone, grey sandstone, and grey siltstone in decreasing order of abundance. This member is widely distributed throughout the area with varying thickness of 40-200 m. However, the member has tabular geometry with maximum thickness in the central part of the basin. The sand/clay ratio of the C2 Member is ranged from 1:1 to 1:4. The member consists of more sand layer in the northern, western and eastern margins of the basin, whereas there is less sand layer in the central part of the basin. The gastropods are abundant in the western and eastern margins of the basin.

The C2 Member is overlain by the C3 Member with gradational contact. The lithology of the C3 Member is characterized by grey to greenish-grey claystone, grey siltstone, and grey sandstone in decreasing order of abundance. This member has sand/clay ratio less than 1:6. The distribution of the member is wide-spread only in the southern and north-central parts of the basin with varying thickness of 20-100 m. The C3 Member is considered to be tabular geometry with maximum thickness in the central part of the basin. There are more sand layer in the south-central part of the basin, whereas the clean

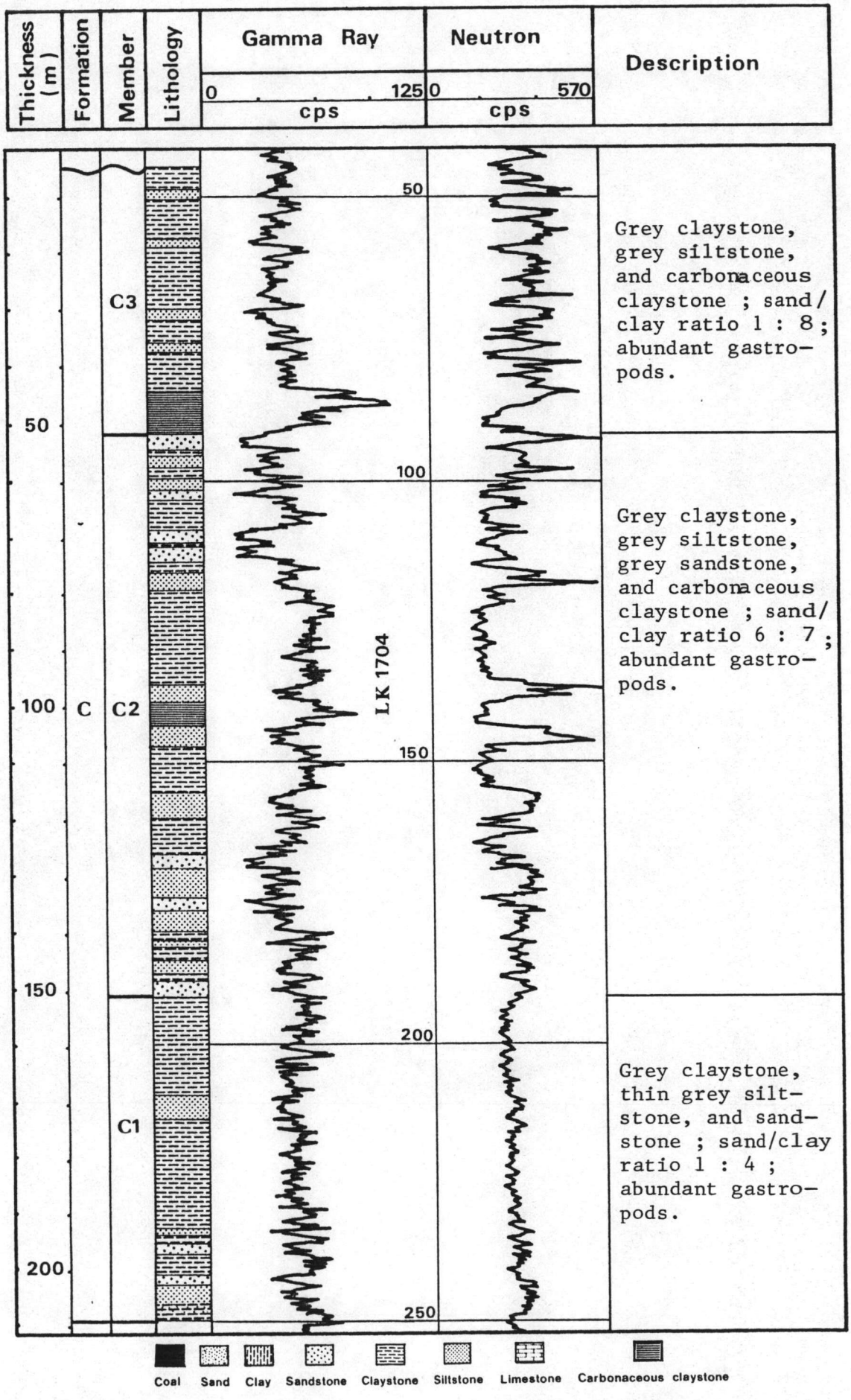



Figure 3.3.1.3. The characteristics of the C Formation.

claystone is found in the north-central part of the basin. The gastropods are abundant in the north-central part of the basin.

The characteristics of the C Formation is summarized in Figure 3.3.1.3. The C Formation is overlain by the two different characteristics of the rocks deposited in the northern and southern parts of the basin. These two different characteristics of rocks will be described in the foregoing passage.

3.3.1.4 D Formation

The D Formation is the topmost of the sedimentary sequence of Krabi Group. This formation overlies the C Formation only in the northern part of the basin with erosional sharp contact. The lithology of the D Formation is characterized by greenish-grey to grey to reddish-brown claystone, grey to white sandstone, and grey siltstone in decreasing order of abundance. This formation is distributed only in the northern part of the basin with varying thickness of 40-160 m. The geometry of this formation is considered to be tabular to prism. The signature of geophysical logs show the fining-upward character. The D Formation can be subdivided, according to geophysical data, into two members, namely, D1 and D2 in ascending order.

The D1 Member overlies unconformably the C Formation. This member is characterized by reddish-brown to grey claystone, grey sandstone, and grey siltstone in decreasing order of abundance. The D1 Member is considered to be tabular and prism geometry with varying thickness of 40-100 m. The sand/clay ratio of the member is approximately 1:1. The fining-upward character is shown by signature of geophysical logs.

Some of the northern part of Krabi basin, the D1 Member is overlain by the D2 Member with conformably gradational contact. The

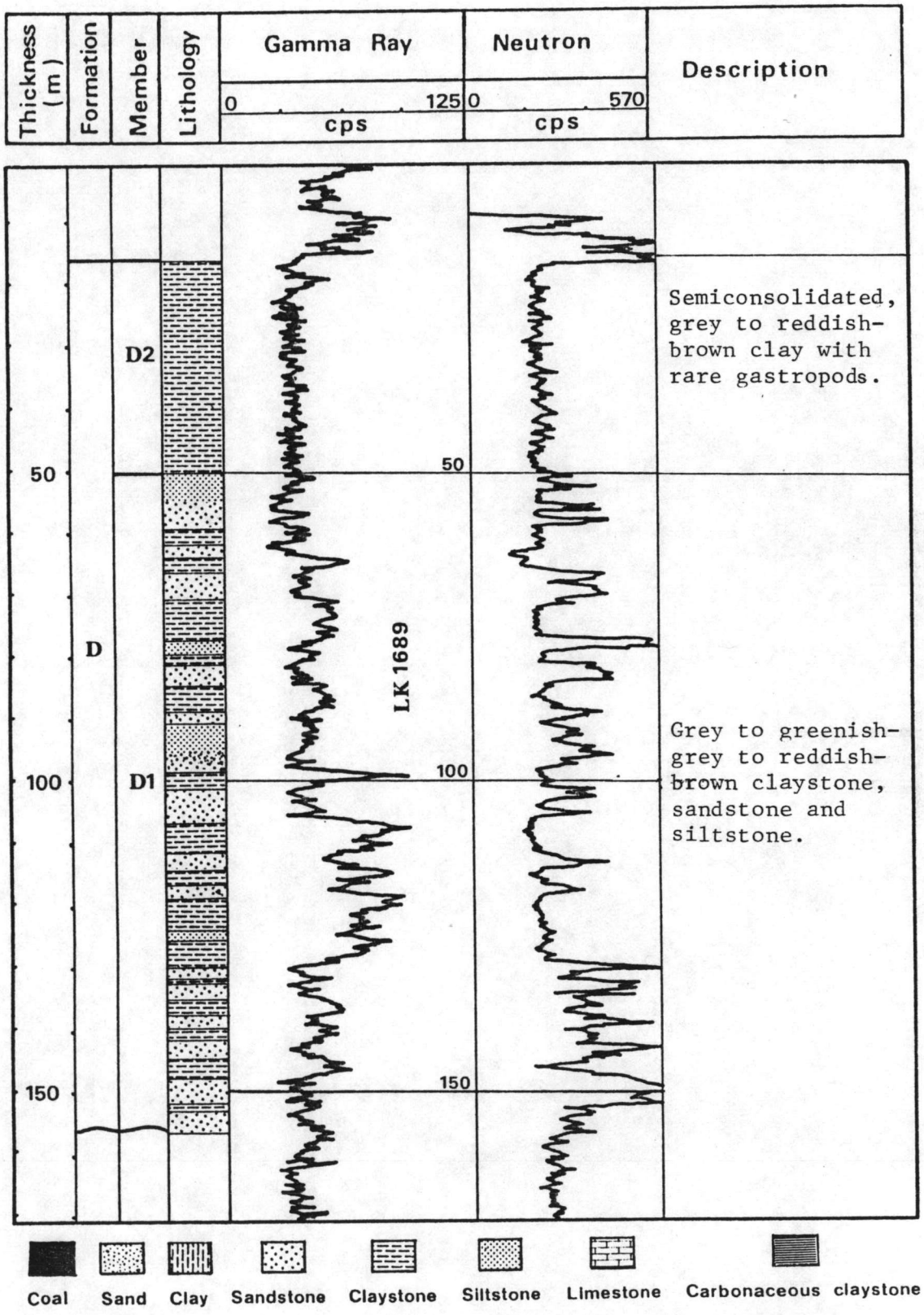



Figure. 3.3.1.4. The Characteristics of the D Formation.

lithology is characterized by grey to reddish-brown claystone, thin-bedded grey limestone. The D2 Member is bounded by syn-depositional faults. The geometry of the member is considered to be tabular with varying thickness of 40-60 m. The distribution of the D2 Member is limited within the separated grabens. The gastropods are rare. The characteristics of the D Formation is summarized in Figure 3.3.1.4.

3.3.1.5 E Formation

The E Formation is another topmost sequence of the Krabi Group. This formation overlies the C Formation only in the southern part of the basin with conformable contact. The lithology is characterized by grey to reddish-brown claystone, grey to white fine-to coarse-grained sandstone, and a few carbonaceous claystone in decreasing order of abundance. The distribution of the E Formation is wide-spread througout the southern part of the basin with varying thickness of 40-200 m. This formation is considered to be tabular geometry with slightly thickening southwardly. The D and E Formations represent the lateral variation of lithology in the northern and southern parts of the basin respectively. The E Formation can be further subdivided into two members, namely, E1 and E2 Members in ascending order.

The E1 Member overlies conformably the C Formation with gradational contact. The lithology of the E1 Member is characterized by grey to reddish-brown claystone, sandstone, siltstone, and limestone in decreasing order of abundance. This member is found only in the southern part of the Krabi basin with varying thickness of 40-160 m. The geometry of this member is considered to be tabular. The sand/clay ratio of the member is approximately 1:1 to 1:4.

The E2 Member overlies conformably the E1 Member. The lithology of this member is characterized by brown to reddish-brown sandstone and

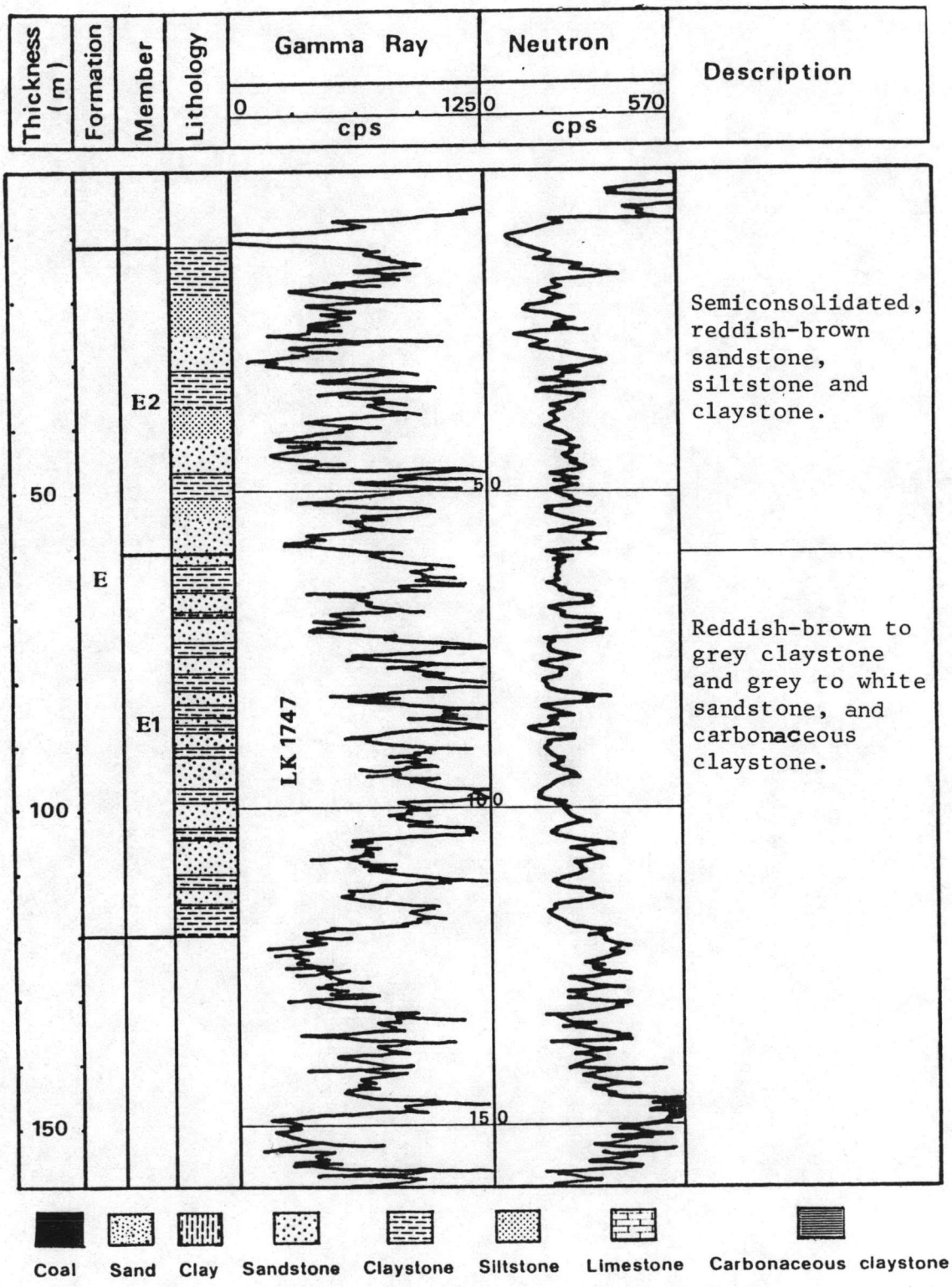



Figure 3.3.1.5 The characteristics of the E Formation.

siltstone in decreasing order of abundance. The E2 Member is considered to be prism geometry with varying thickness of 50-160 m. The distribution of this member is confined only in the central zone of the southern part of the basin. The characteristics of the E Formation is summarized in Figure 3.3.1.5.

### 3.3.2 Quaternary deposits

The Krabi Group of Krabi basin is covered by semiconsolidated and unconsolidated Quaternary deposits which are tentatively refered to as the "Q Group" is characterized by reddish-brown, yellowish-brown clay, sand, gravel, lateritic clay, semiconsolidated sandstone, and claystone. The "Q Group" is widely distributed throughout the basin with varying thickness of 2-50 m. thick. This group has a blanket and tabular geometry. The thickness of the group is less than 10 m. in the northern part of the basin, whereas the thickness is varied approximately 20-50 m. in the southern part of the basin. The characteristics of this group is summarized in Figure 3.3.2.

## 3.4 Lithostratigraphy of Krabi Basin

Evidences from seismic reflection survey and geophysical loggings reveal that the configuration of the pre-Tertiary basinal basement in the area under present investigation is elongated in the north-northwest / south-southeast with the closure structure in the north and open southwardly. Besides, there are at least four main subbasins within Krabi basin. Among these, three of them are located along the approximate main basin axis, whereas other one lies on the western side of the main basin axis in the northern part.

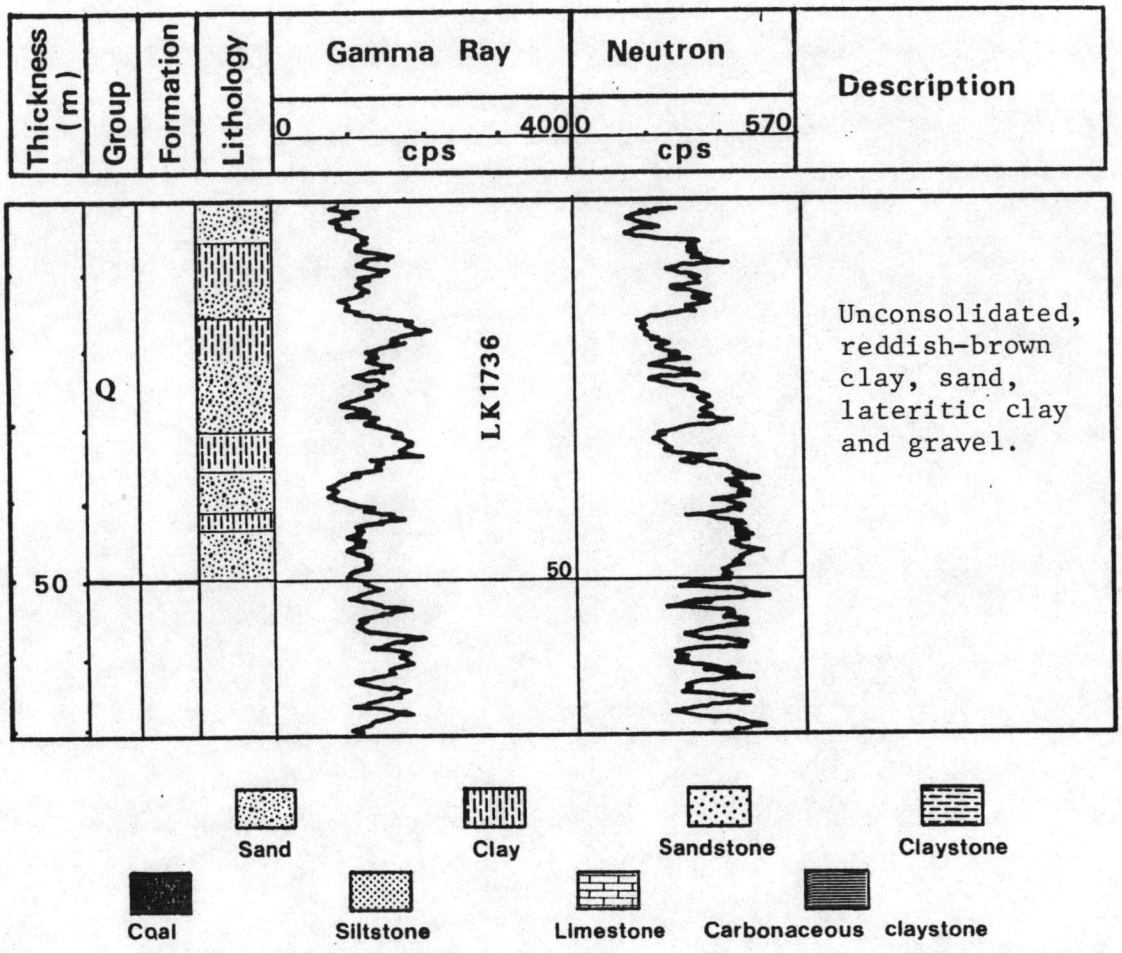



Figure 3.3.2. The characteristics of the Q Group.

The basement rocks of Tertiary Krabi basin are mainly clastic rocks of Triassic-Jurrasic age as evident from some deep borehole samples. However, it is probable that some Permian limestone and clastic rocks of Permo-Carboniferous age might be present in some parts of the Krabi basinal basement.

The Tertiary sediments in the Krabi basin lie unconformably on the pre-Tertiary basement rocks. The sedimentary successions of Tertiary deposits in this basin is estimated to have a total thickness in the range of 280-710 m. Unconformably overlying the Tertiary deposits are semi-consolidated to unconsolidated Quaternary deposits of approximately 250 m. thick.

Detailed analysis of subsurface geology of Krabi basin reveals that the Krabi Group can be informally subdivided into five formations with tentative names of A, B, C, D, and E Formations in ascending order. The lower most Formation, A Formation, is characterized by reddish-brown, grey claystone, and grey, white sandstone and siltstone. This formation is found very wide-spread over the basin with thickness greather than 70 m. The A Formation is overlain by the B Formation with gradational contact. The lithology of B Formation is characterized by grey claystone, grey sandstone, grey limestone and coal. The distribution of this formation is also widespread, over the basin with varying thickness of 70-180 m. The B Formation can be further subdivided into four members on the basis of coal beds present, namely, B1, B2, B3, B4 Members in ascending order. Among these members,the B2 Member is the key member characterized by the present of the coal seam. The C Formation overlies the B Formation with gradational contact. This formation is characterized by grey

claystone, grey sandstone, and grey siltstone and abundant gastropods. This formation is widely distributed throughout the area with varying thickness of 100-400 m. The C Formation can be further subdivided into three members on the basis of the sand/clay ratio, namely, C1 , C2, and C3 Member in ascending order. The C1 and C3 Member have sand/clay ratio less than 1:6, whereas the C2 Member has sand/clay ratio between 1:4 and 1:1. The D Formation overlies the C Formation with erosional sharp contact. The lithology is characterized by reddish-brown, grey claystone, and grey sandstone. This formation is distributed only in the northern part of the basin with varying thickness of 40-160 m. The geophysical logs of this formation indicate the fining-upward characteristics. The D Formation can be subdivided into two members, namely, D1 and D2 in ascending order. In the southern part of the basin, the E Formation overlies the C Formation with gradational contact. The E Formation is characterized by reddish-brown to grey claystone interbedded with grey to white sandstone with total thickness of 40-200 m. In addition, the E Formation can be subdivided into two members, namely, E1 and E2 in ascending order. The D and E Formations represent the lateral variation of lithology in the northern and southern parts of the basin.

The Krabi Group of Krabi basin is covered by the younger sediments, unconsolidated, reddish-brown clay, sand, lateritic clay and sandstone. The Quaternary deposits is widely distributed throughout the basin with varying thickness of 2-50 m. the geometry of this group is blanket and unconformably overlying the Krabi succession. In the southern part of the basin, the Quaternary deposits progressively decreases in thickness northwardly.

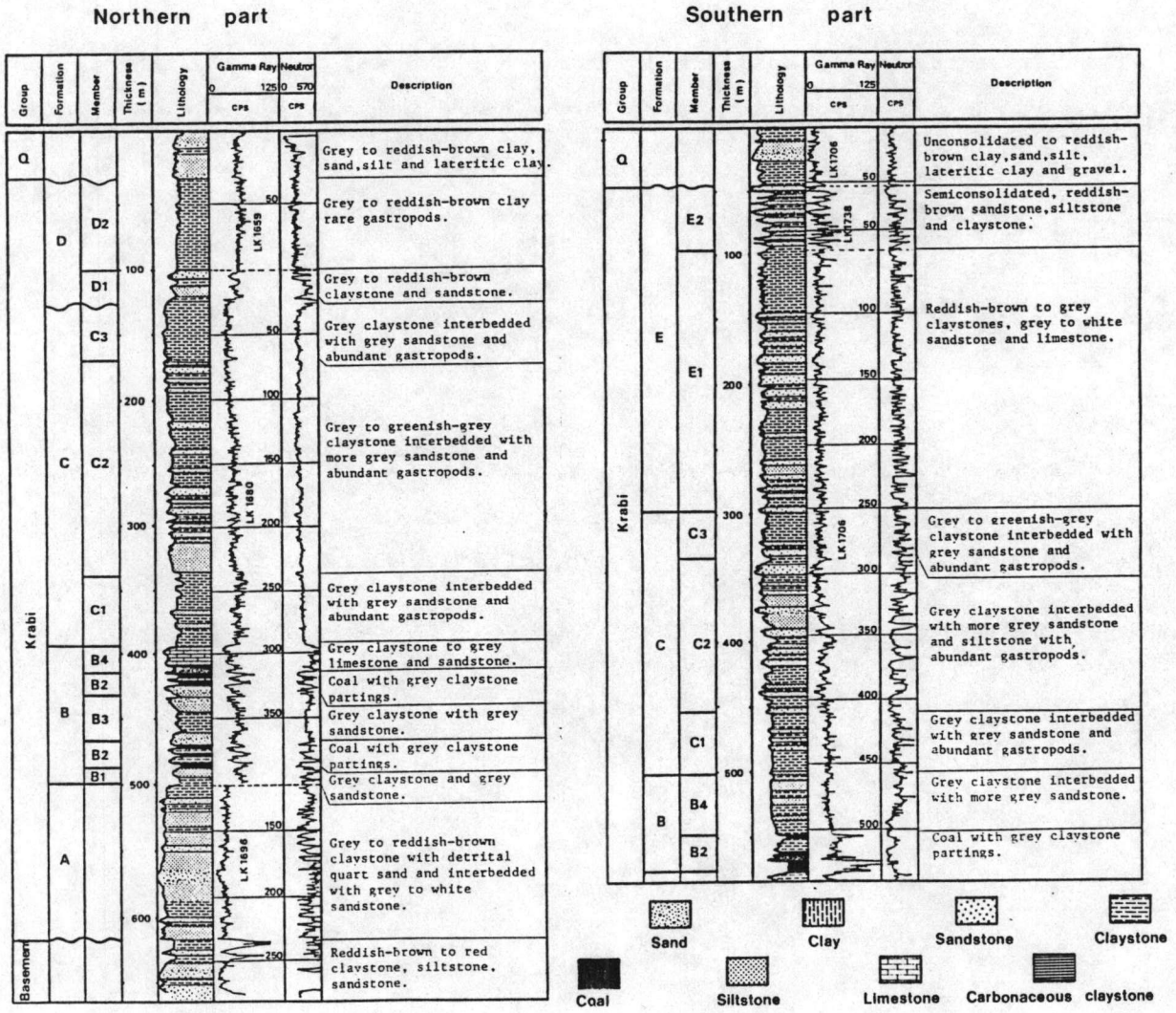



**Figure** 3.4 a. Stratigraphy of northern and southern parts of study area.

It is noted that there is a lateral variation of lithostratigraphy of Krabi basin particularly in the northern and southern part of the study area particularly regarding the B, D, and E Formations. The B Formation in the southern part of the basin can only be further subdivided into B2 and B4 Members, whereas in the northern part the same formation can be subdivided into B1, B2, B3, and B4 Members. For the uppermost lithostratigraphic units of Krabi Group, the D Formation is present in the northern part and laterally changing over into the E Formation in the southern part of the study area. These differences in lithostratigraphy are presented in Figure 3.4 a.

The lithostratigraphy of sedimentary succession of Krabi basin under the present investigation is summarized and presented in Figure 3.4 b. With respect to the present distribution pattern of lithostratigraphic units within Krabi basin, an attempt has been made to present this picture in terms of a series of geological sections and fence diagram . Altogether 7 geological sections in the east-west direction have been prepared covering the study area from north to south (Fig. 3.4 c, d). Besides, the fence diagram has been prepared to illustrate the distribution of various lithostratigraphic units concerned including the geological structure (Fig. 3.4e).

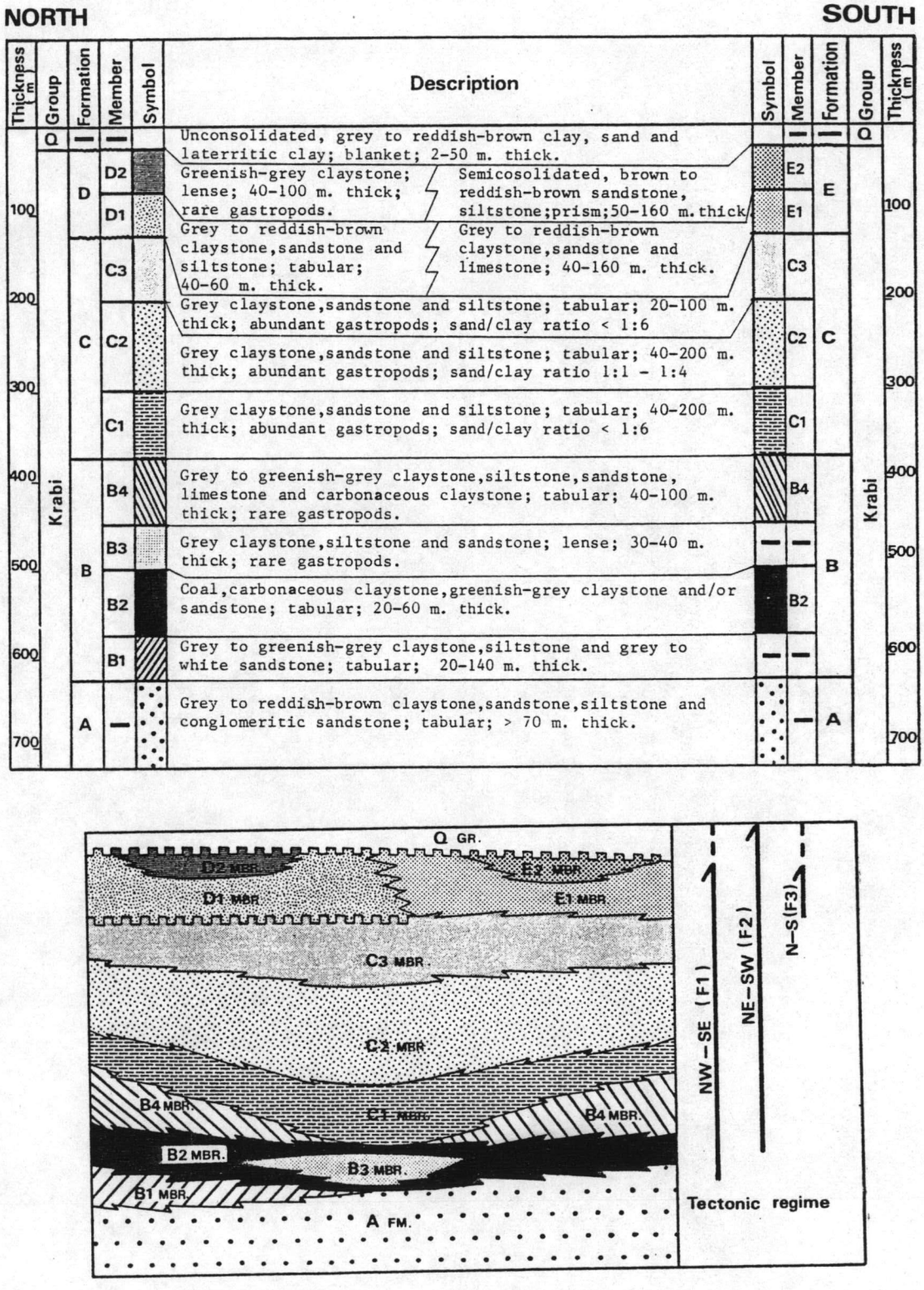



**Figure** 3.4 b. Generalized stratigraphic sections of the northern and southern parts of the study area .

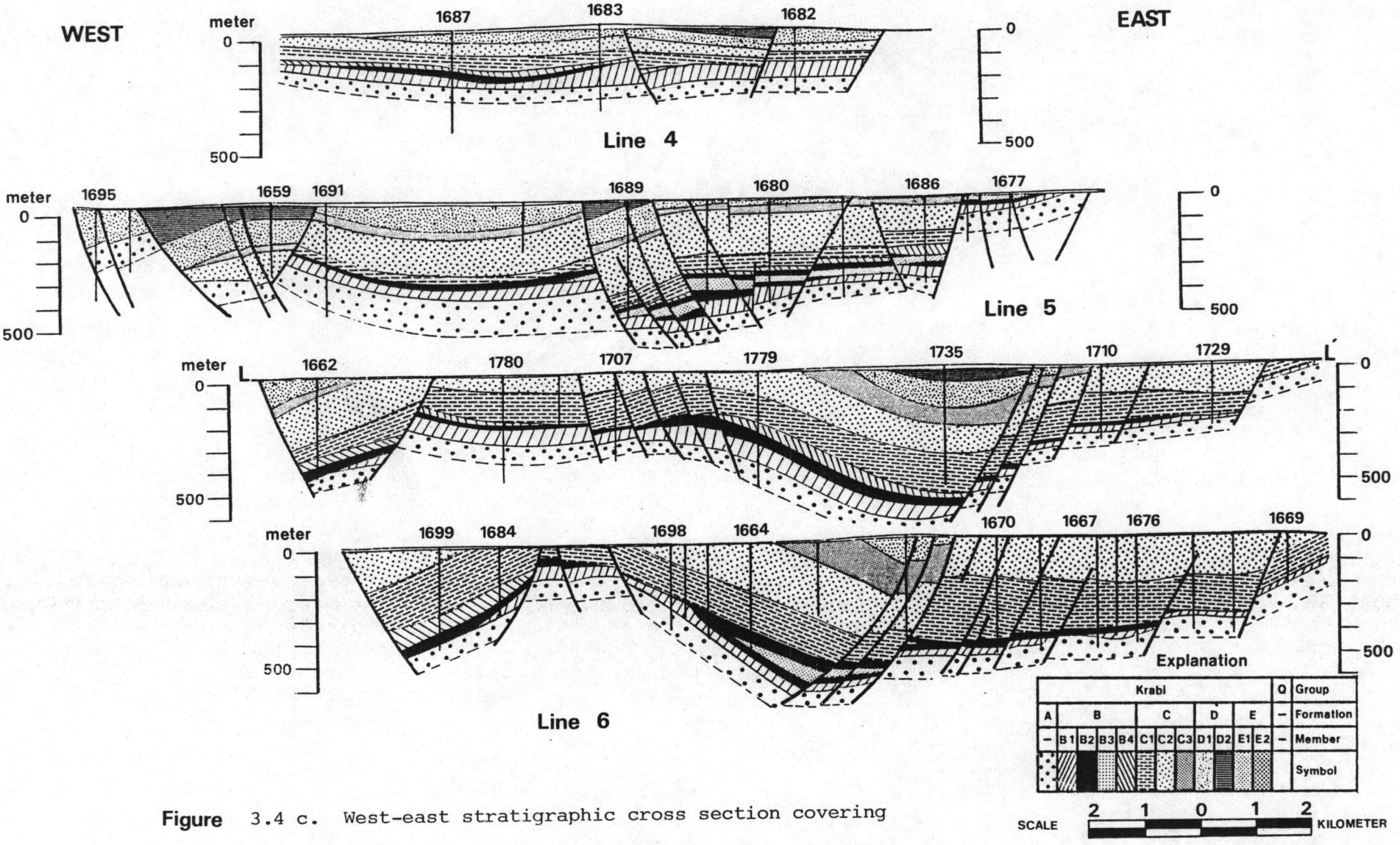



**Figure** 3.4 c. West-east stratigraphic cross section covering the northern part of study area from north to south.

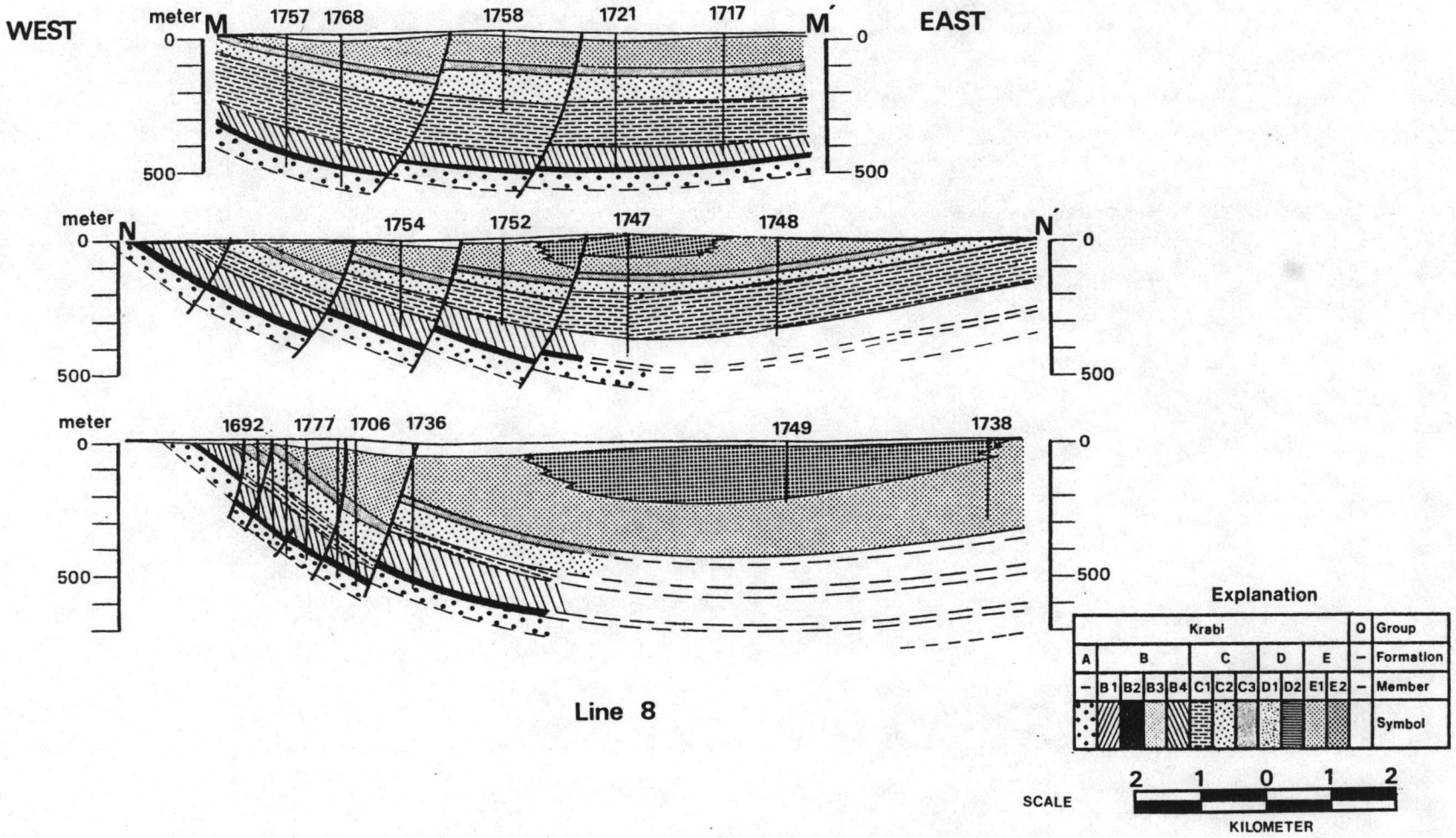
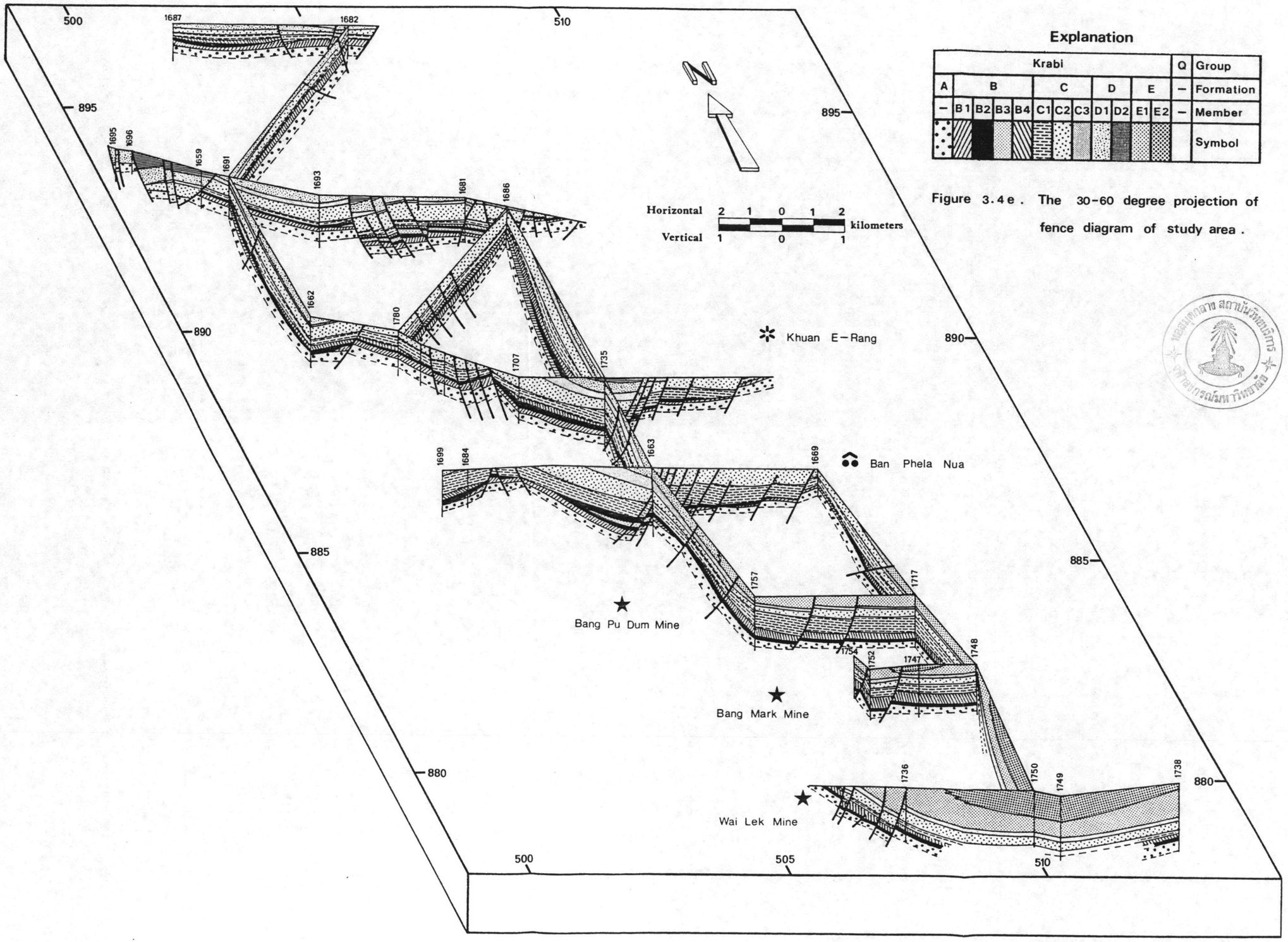



**Figure** 3.4 d. West-east stratigraphic cross section covering the southern part of study area from north to south.




**Explanation**

| Krabi | | | | | | | | | | | | Q | Group |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | | | | C | | | D | | E | | – | Formation |
| – | B1 | B2 | B3 | B4 | C1 | C2 | C3 | D1 | D2 | E1 | E2 | – | Member |
| | | | | | | | | | | | | | Symbol |

Figure 3.4e. The 30-60 degree projection of fence diagram of study area.