CHAPTER III

GEOLOGY OF THE MAE THAN BASIN AND NEIGHBORING AREA

Physiography

The Mae Than basin is a Cenozoic intermontane basin situated between latitude 17°57′N to 18°02′N and longitude 99°26′E to 99°32′E covering approximately 50 square kilometres (Fig. 3.1). The shape of the basin outline is elongated in the NE-SW to E-W directions (Fig. 3.1) which is also conformable to the NE-SW regional structural trend. The elevation of the ground surface within the basin falls within the range of 300-385 metres above the mean sea level. The overall drainage pattern within the Mae Than basin is characterized as a subdendritic pattern under the influence of the local geological structures (Fig. 3.2). The drainage pattern on the eastern part are the subdendritic pattern of tributaries of the Nam Mae Wa which is oriented approximately in the NW-SE direction and flows northwardly (Fig. 3.2). The drainage on the western part is characterized by the subdendritic pattern in both NW-SE and NE-SW directions of tributaries of the Huai Mae Sariam - Huai Mae Than which eventually flow westwardly to join the Wang river further west. The general picture of the landform within the Mae Than basin is represented by both flat and undulating terrain.

The Mae Than basin is almost entirely surrounded by numerous mountain ranges (Fig. 3.1). The northern border of the basin is bounded by Doi Mon Huai Klang (578 metres MSL.), Doi Mafai (467 metres MSL.), and Doi Luang (484 metres MSL.). However, a narrow flat plain of Nam Mae Wa in the northern part of the basin extends northwardly to join the large flat terrain of the Lampang basin. The eastern border of the Mae Than basin is bounded by the complex mountain range of Doi Mon Kha Kao (1,149 metres MSL). The southern part of the Mae Than basin is bounded by the mountain range of Doi Khun Khiat (1,665 metres MSL.). The southwestern corner of the basin is characterized by a narrow flat terrain extending

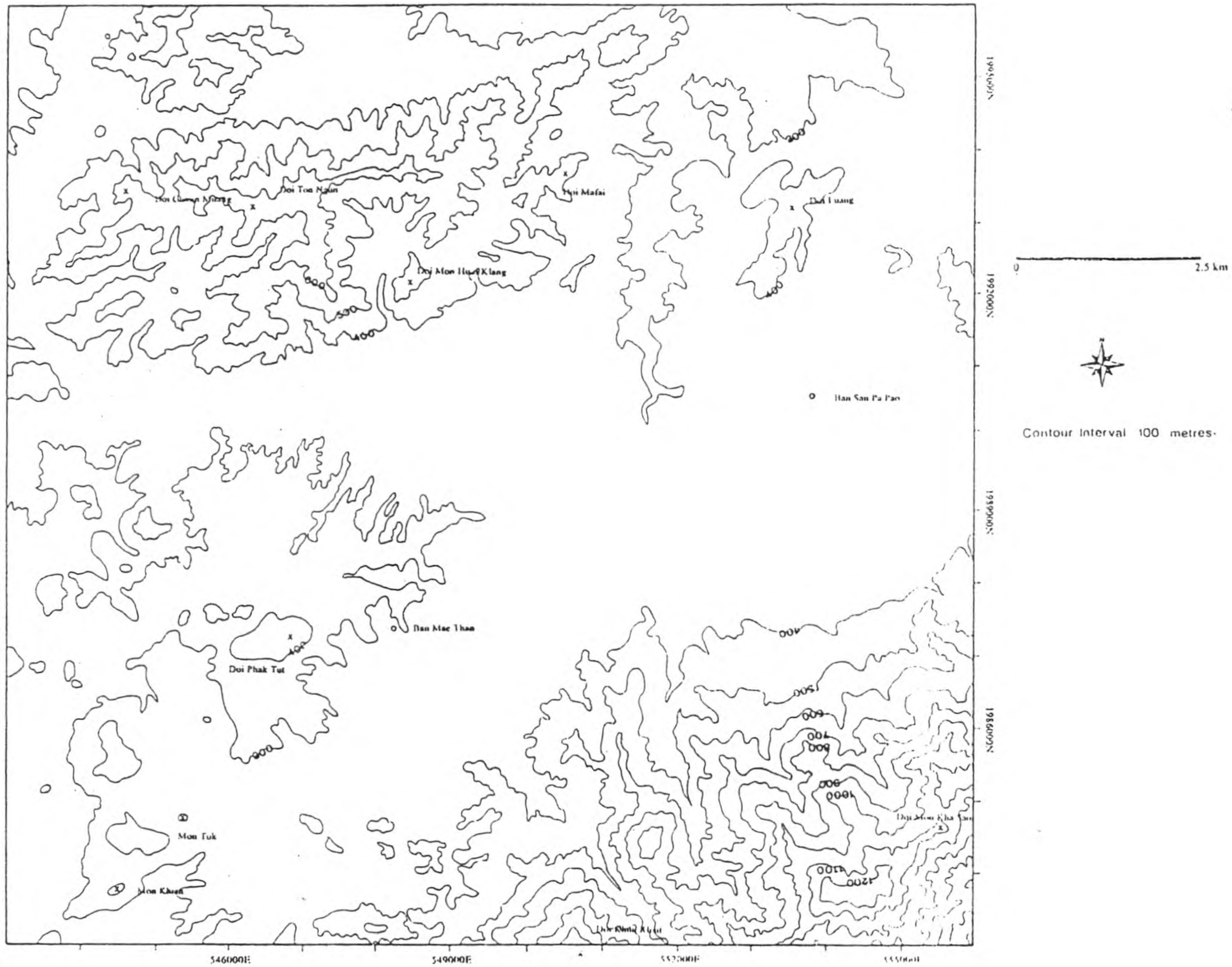

Fig. 3.1 Topographic map of the study area shows high relief mountains in the north and the southeast of Ban Mae Than

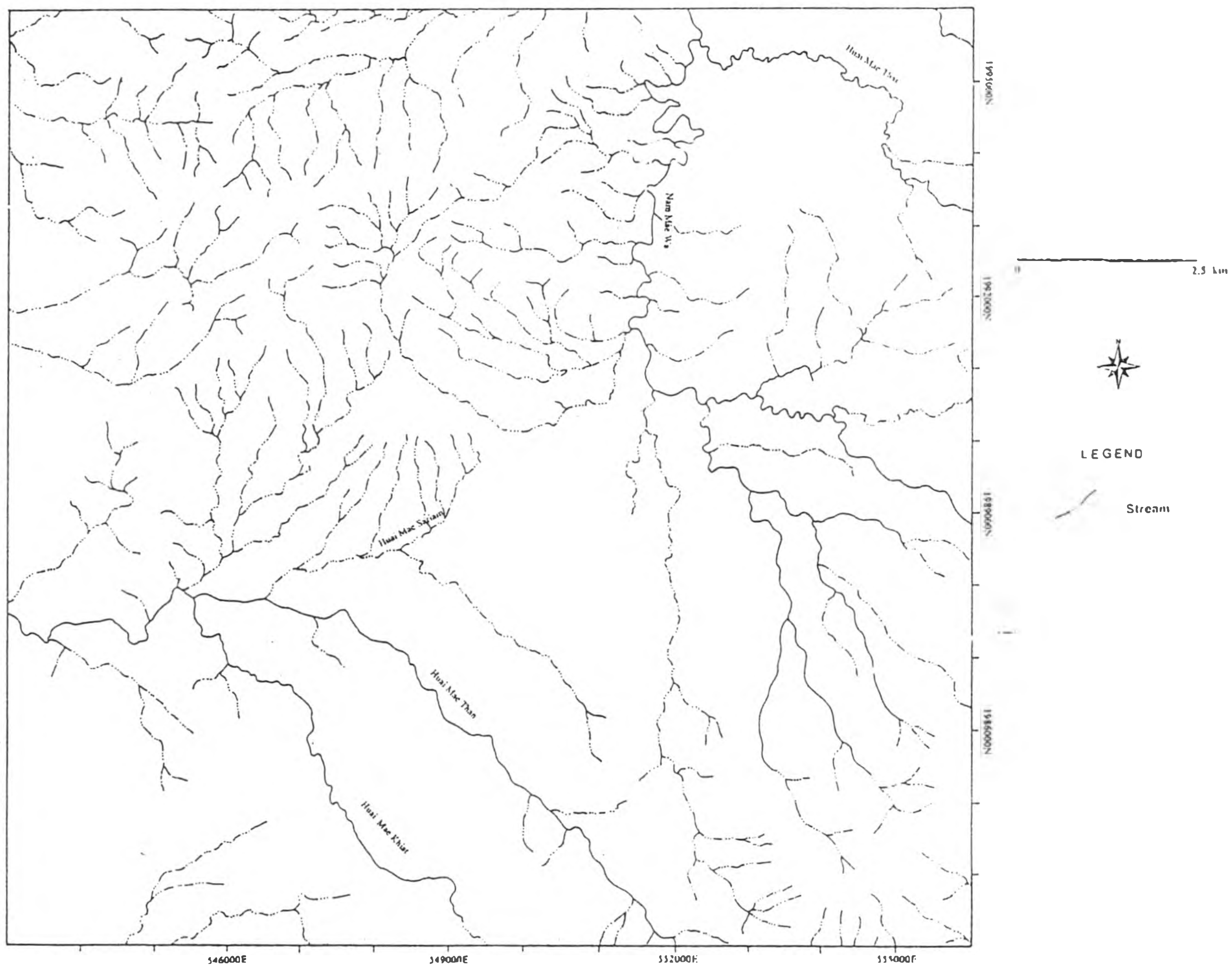

Fig. 3.2 Drainage pattern of the Mae Than area shows predominantly by sub-dendritic pattern.

southwestwardly to join the large flat terrain of the Sop Prab basin. The western part of the basin is border by the mountain range of the Doi Phak Tut (370 metres MSL.), and Mon Tok (405 metres MSL.).

Distribution of pre-Cenozoic rocks surrounding the Mae Than basin

The pre-Cenozoic rocks forming the mountain ranges surrounding the Mae Than basin consist of metamorphic, sedimentary and igneous rocks (Fig. 3.3). They have been mapped into four rock units, namely, Don Chai Group of Silurian-Devonian age, Huai Thak Formation of Permian age, Permo-Triassic volcanic rocks, and Phra That Formation of Triassic age (Charoenpravat et al. 1986 and Tiyapairach, 1990). These rocks probably form the basement rocks underneath the Mae Than basin. They are the potential sources of sediments in the Mae Than basin because the major tectonic and topographic scenario of the country have not been dramatically modified since Tertiary. Detailed description of each of these rock units will be outlined below together with their likelihood to be the source of kaolin-rich sediments in the basin.

The Don Chai Group

This rock unit is exposed on the southeastern part of the Mae Than basin (Fig. 3.3). It forms a very steep mountain range with the highest elevation at 1,267 metres MSL. (Fig. 3.1). Topographically, therefore, it suggests that this rock unit is a highly resistant group of rocks (Fig. 3.4). This unit comprises mainly of schist and minor phyllite and quartzite. Their age is inferred to be Silurian-Devonian.

Schist

In the field, this rock occurs as outcrop and float. The rock shows a well developed schistosity and slightly folded (Fig. 3.5). The attitude of schistosity is approximately NE-SW with moderate northwest dipping. In hand specimen, the rock is light grey on weathered surface and dark grey on fresh surface, highly resistant, and

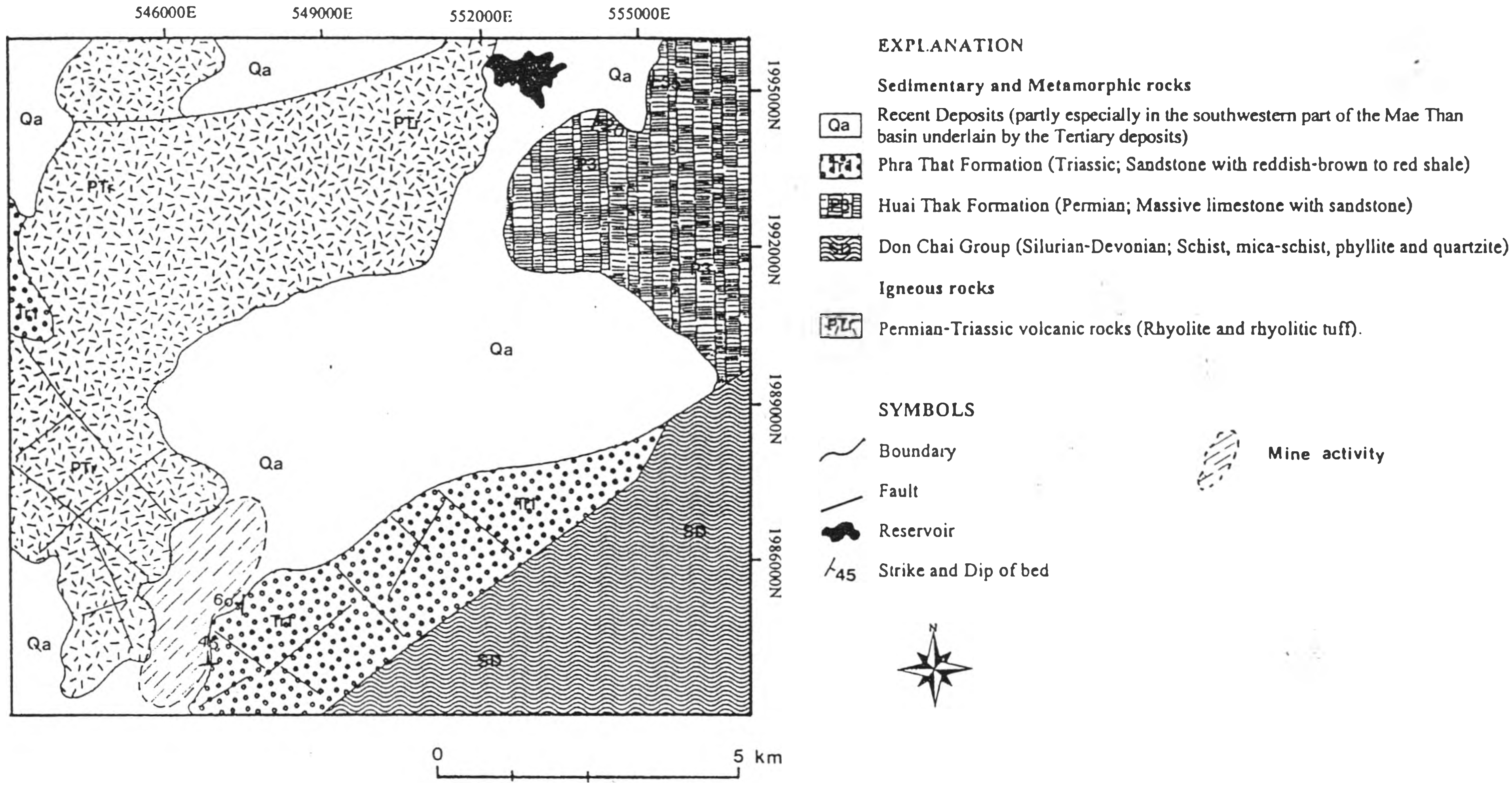

Fig. 3.3 Geological sketched map showing the mining activities in the southwestern part of the Mae Than area (modified after Charoenprawat et al. (1986) and Tiyapairat (1990)).

Fig. 3.4 The rocks of Silurian-Devonian age, the Don Chai Group, show high-relief mountain range indicating a high resistant rock.

Fig. 3.5 Mica-schist of the Don Chai Group exposed naturally, and shows NE-SW schistosity with moderate northwest dipping.

show a well developed foliation of micaceous minerals (Fig. 3.6). Under the microscopic the rock is classified as mica-schist. It is composed mainly of quartz, feldspar and micas with minor opaque minerals (Figs. 3.7, 3.8, and 3.9). The rock is characterized by the preferred orientation of micaceous minerals (mainly muscovite). Ribbon texture of mica-rich layers and recrystallized quartz-rich layers is also noted (Figs. 3.7, 3.8 and 3.9). The grain sizes are fine- to medium-grained, occasionally with porphyroblasts of plagioclase and quartz (Figs. 3.7, 3.8 and 3.9). Rotation of feldspar porphyroblasts is also observed (Figs. 3.7, 3.8 and 3.9).

Phyllite

This rock was found as floats in the Huai Mae Than. In hand specimen, it is purplish-grey, hard, and show well developed phyllitic structure (Fig. 3.10). Microscopically, the rock is very fined-grained, and composed dominantly of quartz and green actinolite with minor hematite and other opaque minerals (Figs. 3.11 and 3.12). Characteristics foliation is recognized by the preferred orientation of finely fibrous actinolite. Small scale folding and micro-folding are also observed under the microscope (Fig. 3.12).

Quartzite

This rock occurs in minor amount and is found as floats in the Huai Mae Than. In hand specimen, the rock is brownish-grey on weathered surface and dark grey on fresh surface, hard. Microscopically, the rock is medium-grained and composed essentially of quartz. Mortar texture, defined by large, old stained quartz grains surrounded by fine, recrystallized new quartz is a characteristics feature of this quartzite (Fig. 3.13).

From the above description, the likelihood of this rock unit to be the source of kaolin-rich sediments in this basin is relatively low.

Fig. 3.6 A specimen of mica-schist of the Don Chai Group showing general characteristics of this rock.

Fig. 3.7 Photomicrograph of mica-schist showing rotation of medium-grained feldspar porphyroblast (G12) with some pressure shadow (F14). Ribbon texture of mica and recrystallized quartz have been noted. The base of the photo is approximately 2 millimetres. (cross nicols)

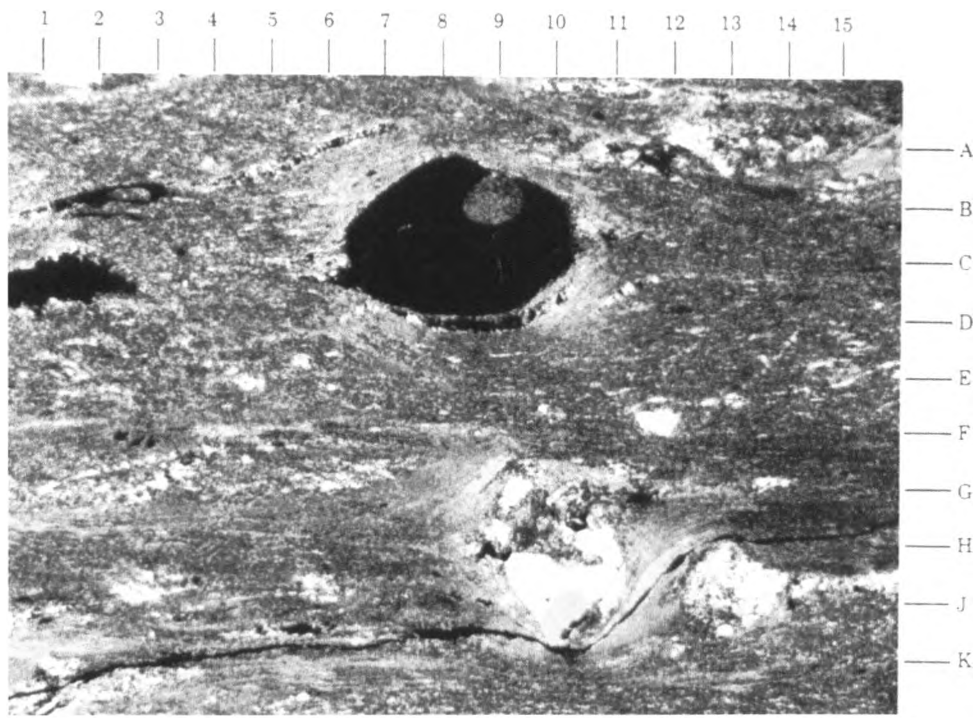

Fig. 3.8 Photomicrograph of mica-schist of the Don Chai Group showing rotation of porphyroblasts (H10), layering of micas and recrystallized quartz, and engulf texture in porphyroblast (B9). The base of the photo is approximately 3 millimetres. (cross nicols)

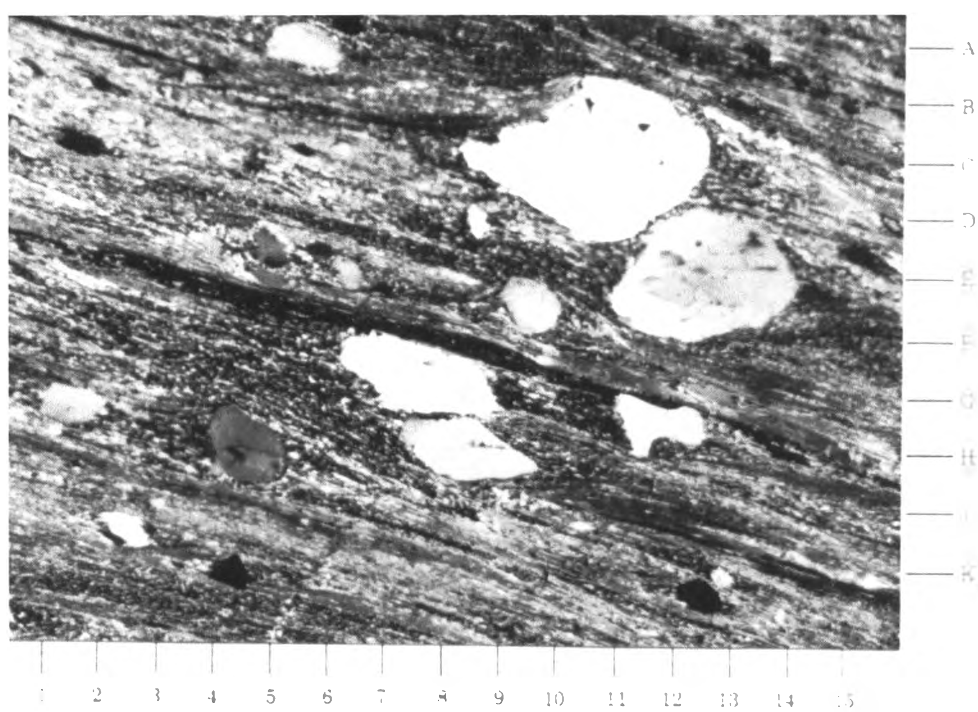

Fig. 3.9 Photomicrograph of the Don Chai mica-schist showing porphyroblasts of quartz (C10), and well-oriented mica flakes (J12). The base of the photo is approximately 1.5 millimetres. (cross nicols)

Fig. 3.10 A specimen of phyllite of the Don Chai Group showing general characteristics of this rock.

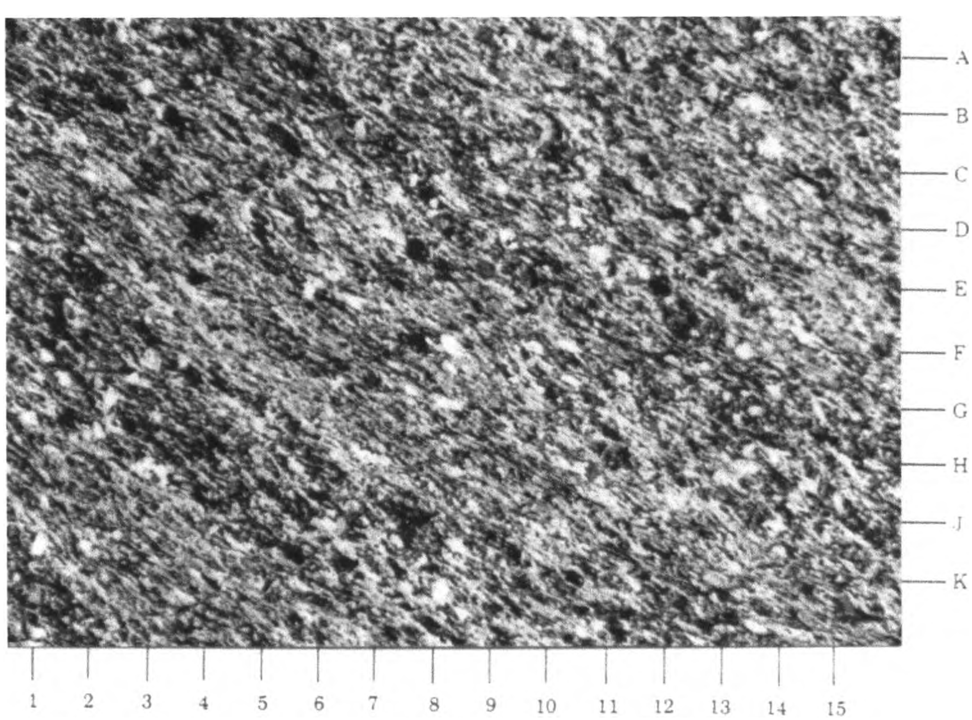

Fig. 3.11 Photomicrograph of phyllite of the Don Chai Group showing phyllitic structure of green actinolite. (cross nicols, 20x)

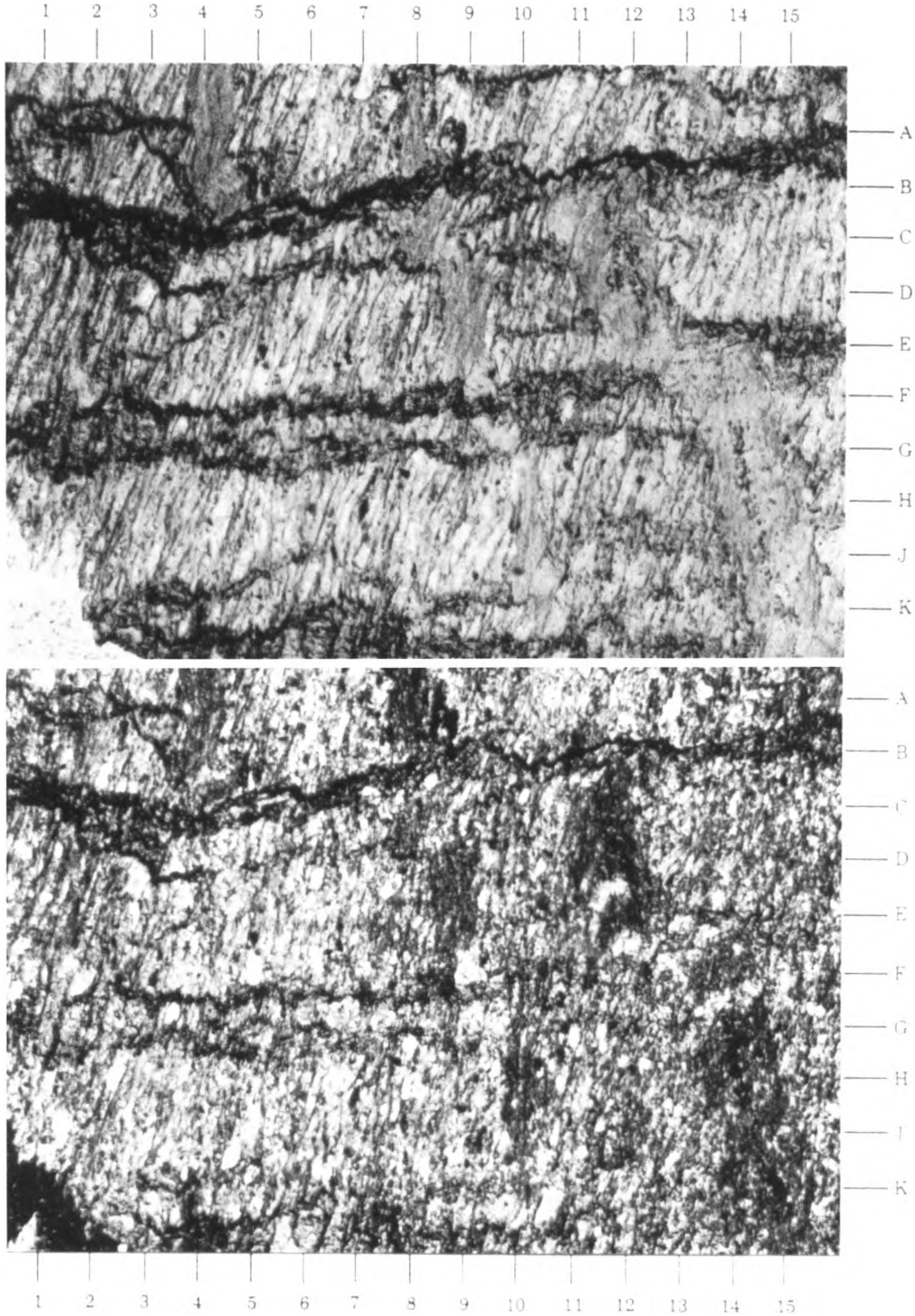

Fig. 3.12 Photomicrograph of phyllite shows microfolds and faults. The base of the photo is approximately 4 millimetres. (upper : uncross nicols, lower : cross nicols)

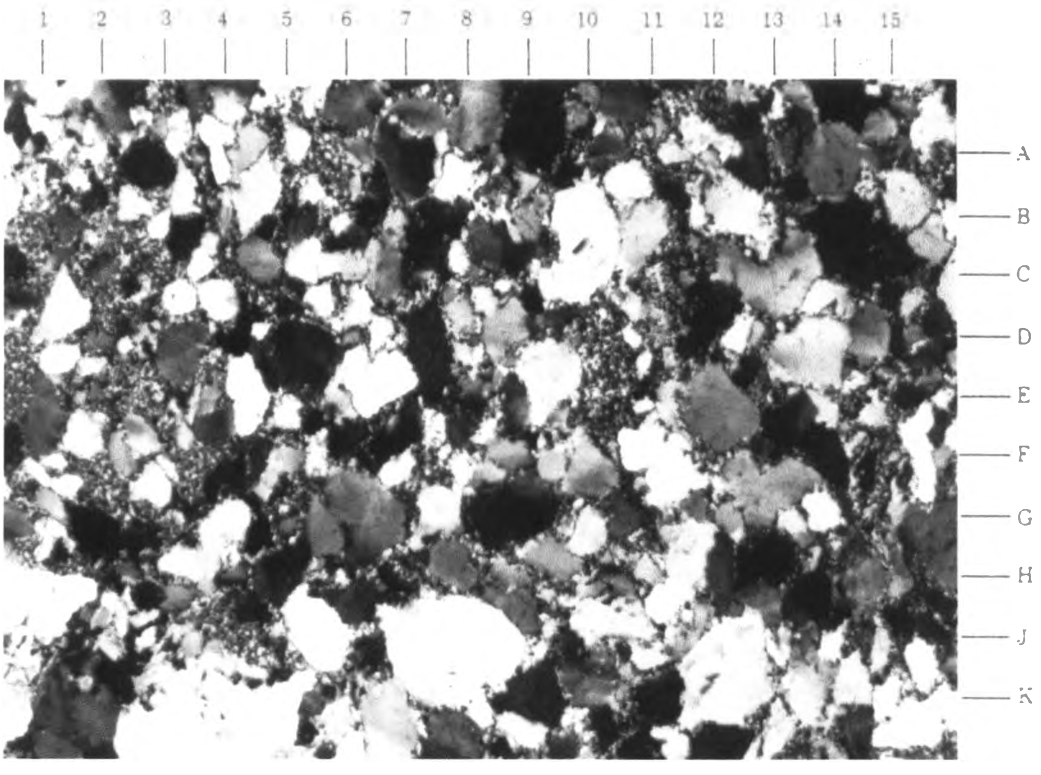

Fig. 3.13 Photomicrograph of medium-grained quartzite showing mortar texture (E9). The base of the photo is approximately 2 millimetres. (cross nicols)

The Huai Thak Formation

This rock unit forms as small steep mountains on the northeastern part of the Mae Than basin (Figs. 3.1 and 3.3). This rock unit comprises dominantly limestone with minor sandstone. The age of this unit is inferred to be Permian (Piyasin, 1972).

In the field, the limestone is massive and fractured (Fig. 3.14). The major fracture system is oriented in the NW-SE direction. In hand specimen, the rock is dark grey finely crystalline (Fig. 3.15). Microscopically the rock is classified as packstone (Dunham, 1962) or biomicrite (Folk, 1959, 1962). It is characterized by 70 per cent grain-supported allochems in 30 per cent micrite matrix (Fig. 3.16). The grain components consist mainly of bioclasts and minor pelloids. The recognizable bioclasts comprise crinoids, foraminifera, bryozoans and brachiopods (Fig. 3.16). The size of the allochems vary from 0.1 to 2 millimetres in diametre. The intergranular spaces are completely infilled by lime mud (micrite) and pseudo-sparite (Folk, 1959, 1962). This limestone is also slightly dolomitized. Dolomite forms as small rhombic-shaped crystals replacing bioclasts. Microstylolites are also commonly observed. Some of this limestone samples are highly deformed in such a way that the primary textures are poorly preserved (Fig. 3.17). The prominent deformation fabrics include deformational twinning of large calcite crystals, gliding or bend twin planes and the formation of parallel layers of dark brown minerals (foliation-like structure) (Fig. 3.17).

The sandstone is found as floats in minor amount. In hand specimen, the rock is purplish-brown and compacted. Microscopically, it is classified as lithic greywacke (Pettijohn et al. 1973, Folk, 1974). The rock is very fined-grained and composed of approximately 80 to 85 per cent grain component and 15 to 20 per cent matrix and cements (Fig. 3.18). The grain component comprises 60 to 65 per cent quartz and 35 to 40 per cent chert rock fragment. The grains are sub-rounded to sub-angular and moderate to well sorted. The matrix is micaceous and other fine-grained minerals with siliceous cement.

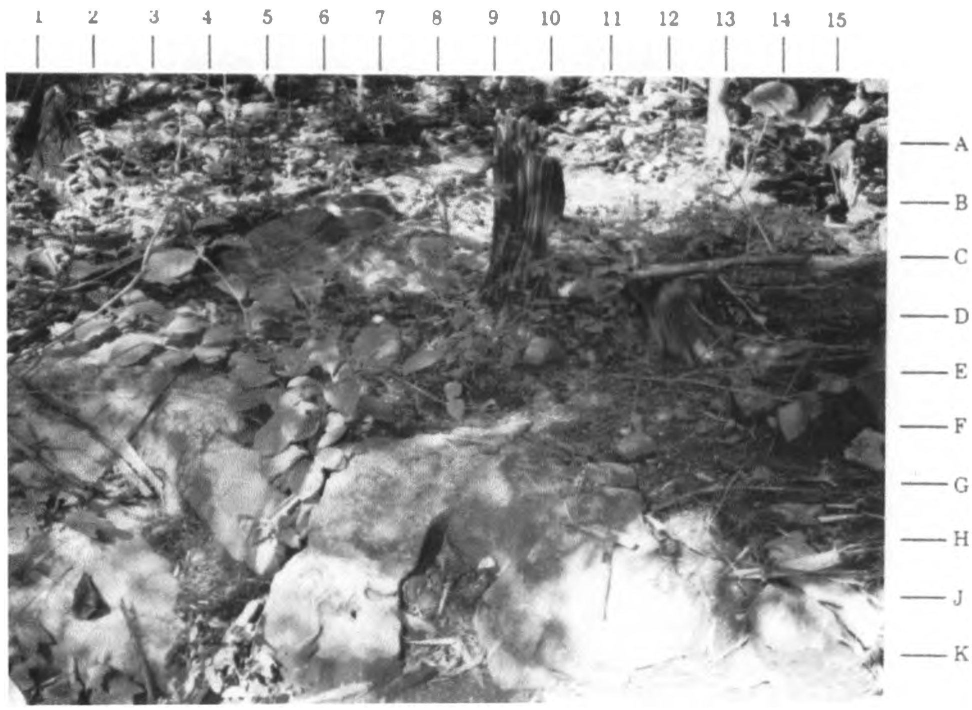

Fig. 3.14 Natural exposure of the Huai Thak rocks shows massive, and fractured in NW-SE direction. (looking northwest)

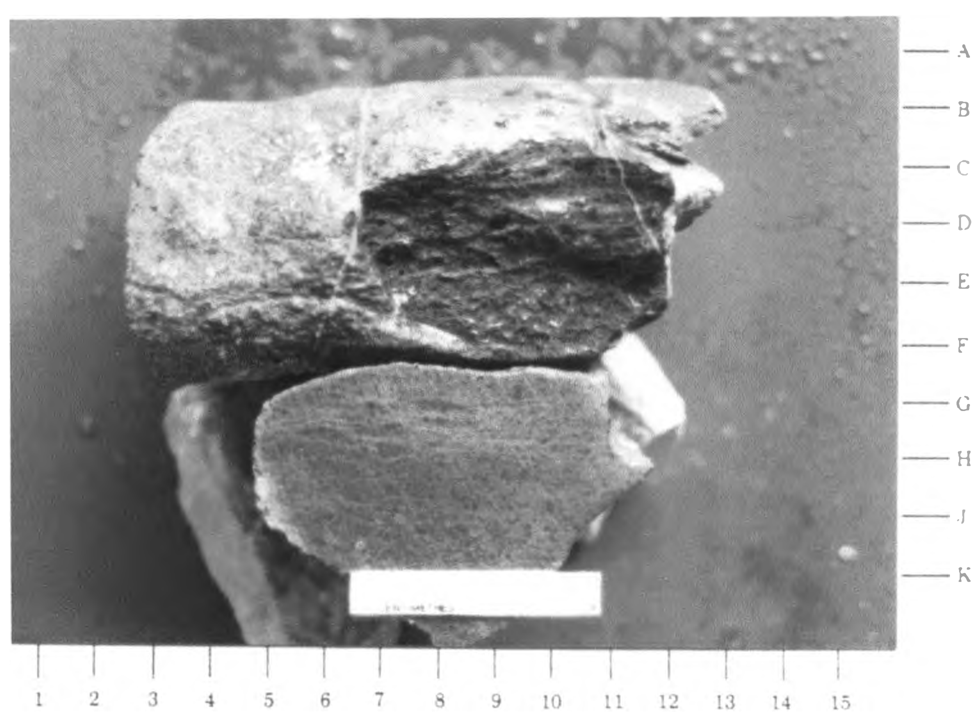

Fig. 3.15 A specimen of the Huai Thak limestone showing general characteristics of this rock.

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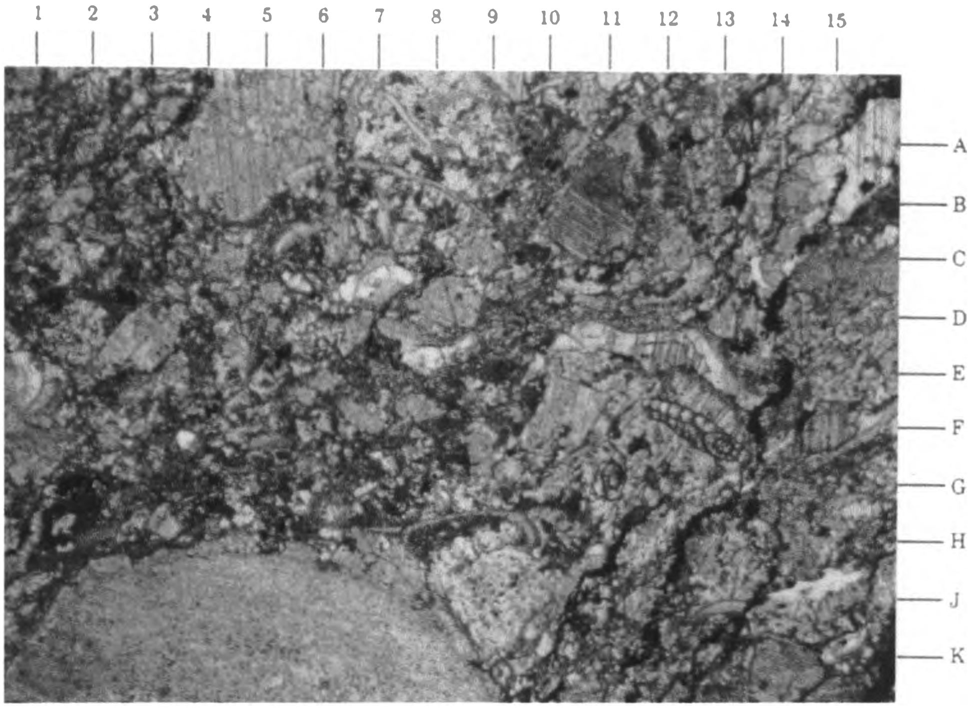

Fig. 3.16 Photomicrograph of biomicrite (Folk, 1959, 1962) showing recognizable bioclasts (namely, crinoids (A5, K4), foraminiferas (G13), bryozoans, and brachiopods (H9). The base of the photo is approximately 4 millimetres. (uncross nicols)

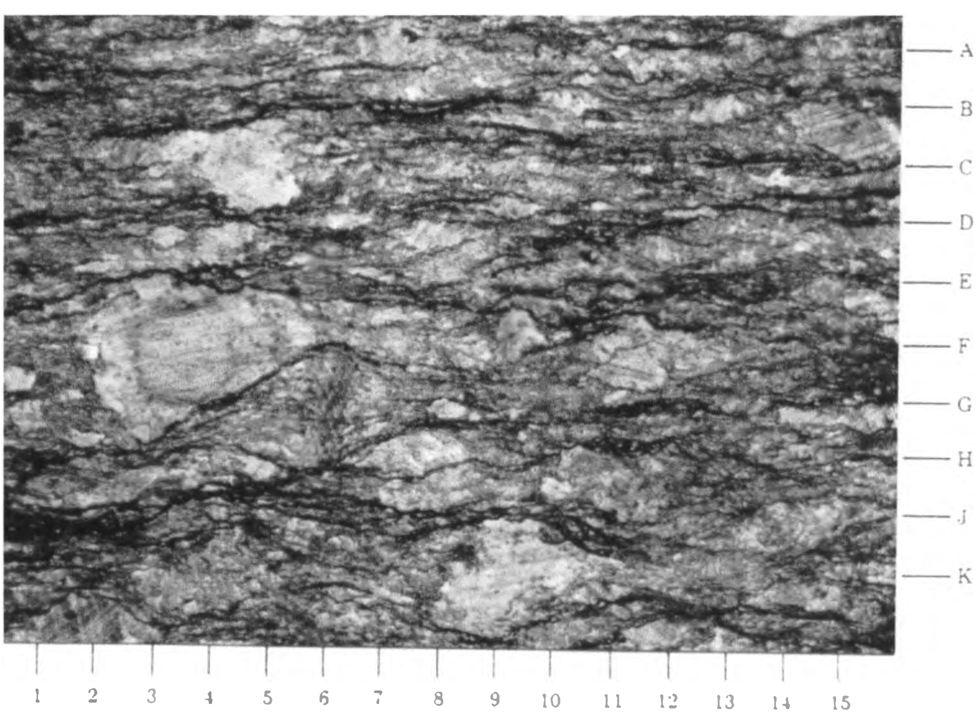

Fig. 3.17 Photomicrograph of packstone (Dunham, 1962) showing strongly deformed twin of calcite crystals and the formation of parallel layers of dark brown minerals (foliation-like structure). The base of the photo is approximately 4 millimetres. (uncross nicols)

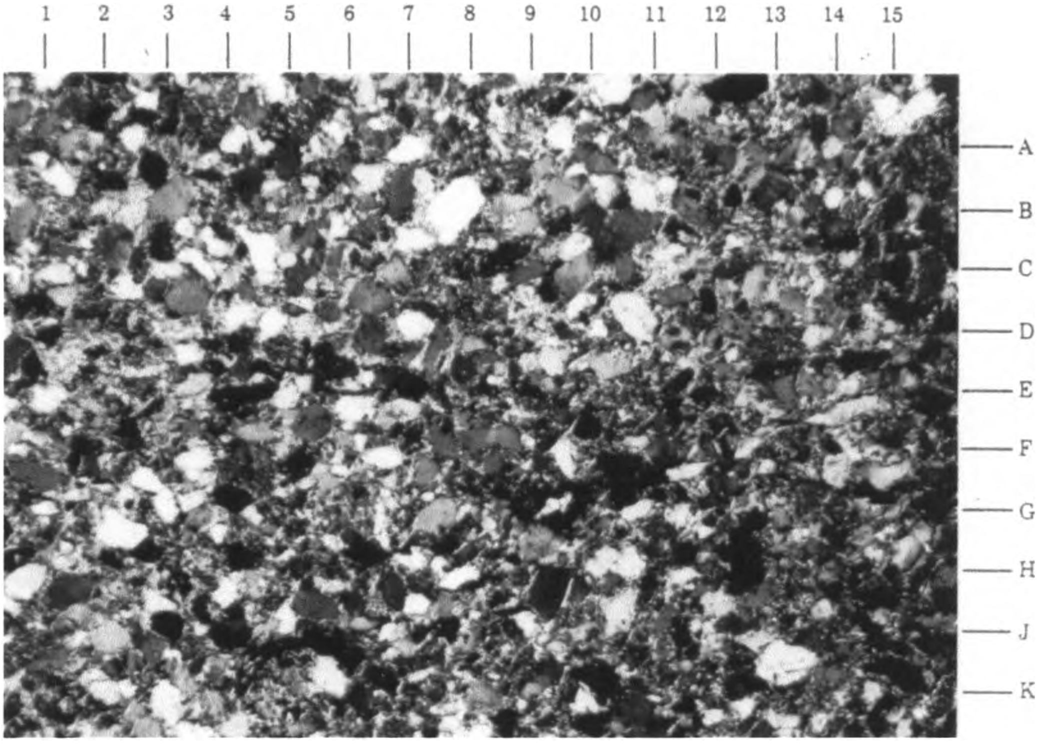

Fig. 3.18 Photomicrograph of very fine-grained lithic greywacke showing sub-rounded to sub-angular and moderate to well sorted. The base of the photo is approximately 2 millimetres. (cross nicols)

The likelihood of this rock unit to be the source of kaolin-rich sediments in this basin is relatively low.

The Permo-Triassic volcanic rocks

This rock unit is a volcanic association of Permo-Triassic age (Piyasin, 1971). It covers the northern and the western margin of the Mae Than basin (Figs. 3.1 and 3.3). This unit comprises mainly of rhyolite and rhyolitic tuff. The Permo-Triassic volcanics in this area will be divided into two areas, namely, the northern area and the western area, based on the differences in geological characteristics (i.e., lithology, and degree of weathering), and physiography. Detailed of two areas will be described as follows :

The volcanic rocks in the northern area form the high mountain range with the highest elevation at 679 metres. MSL. (Fig. 3.1). They are oriented in the E-W direction. The dominant rock of this unit is rhyolite (Fig. 3.3). In the field the rhyolite is slightly weathered, massive, hard, and fractured (Fig. 3.19). The major fracture systems are oriented in NW-SW and NE-SW directions. In hand specimen, the rock is yellowish-brown on weathered surface and whitish-grey on fresh surface, finely crystalline with porphyritic texture (Fig. 3.20). Microscopically, this rock is classified as rhyolite. It is characterized by 15 per cent subhedral quartz grains as phenocryst (size ~0.5-1 millimetres) in 80 per cent microcrystalline quartz as groundmass and 5 per cent mica (muscovite) flakes (Fig. 3.21). Glomeroporphyritic quartz is occasionally found. Quartz phenocrysts commonly show embayment texture.

The likelihood of this rock unit to be the source of kaolin-rich sediments in this basin is relatively low.

On the western part of the Mae Than basin, the volcanic rocks form a group of N-S trending low hills (Figs. 3.1, 3.3 and 3.23). The highest elevation is about 408 metres MSL. at the unnamed hill, north of the Mon Tok (Fig. 3.1). Many NW-SE and

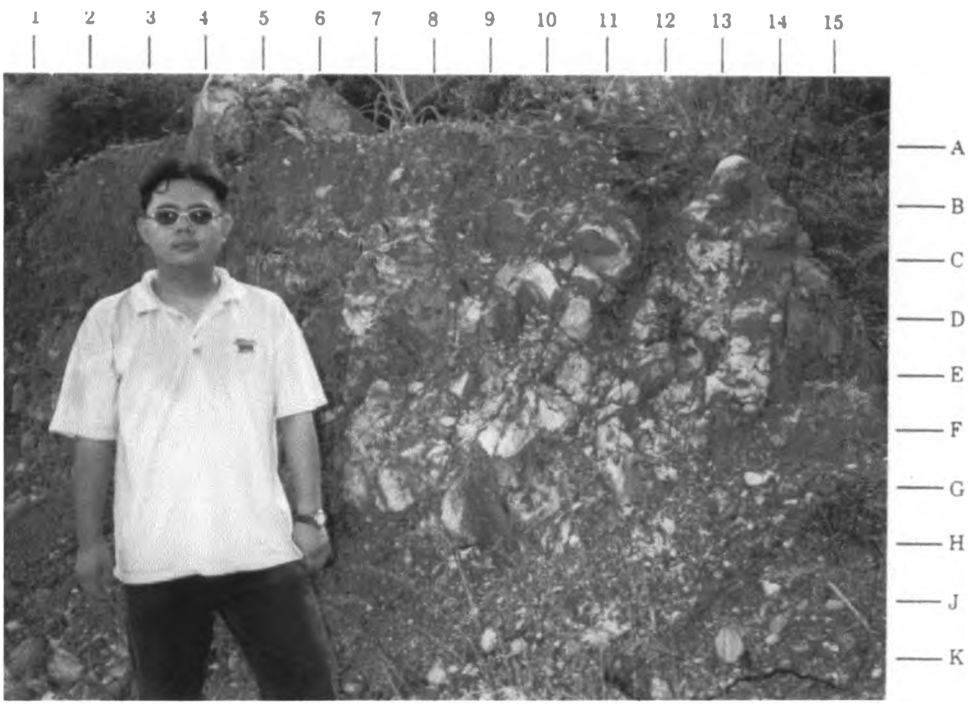

Fig. 3.19 Man-made exposure in the northern area of the Permo-Triassic rocks showing slightly weathered, massive, hard and fractured in NW-SE and NE-SW directions. (looking west)

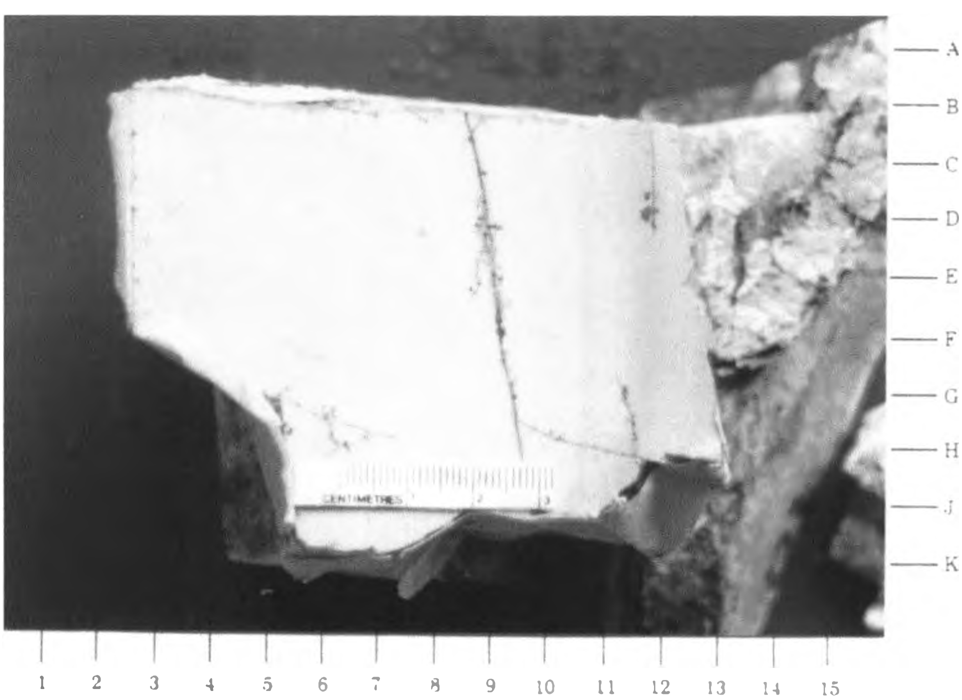

Fig. 3.20 A specimen of Permo-Triassic volcanic rocks in the northern part of the Mae Than basin showing aphanitic and porphyritic textures.

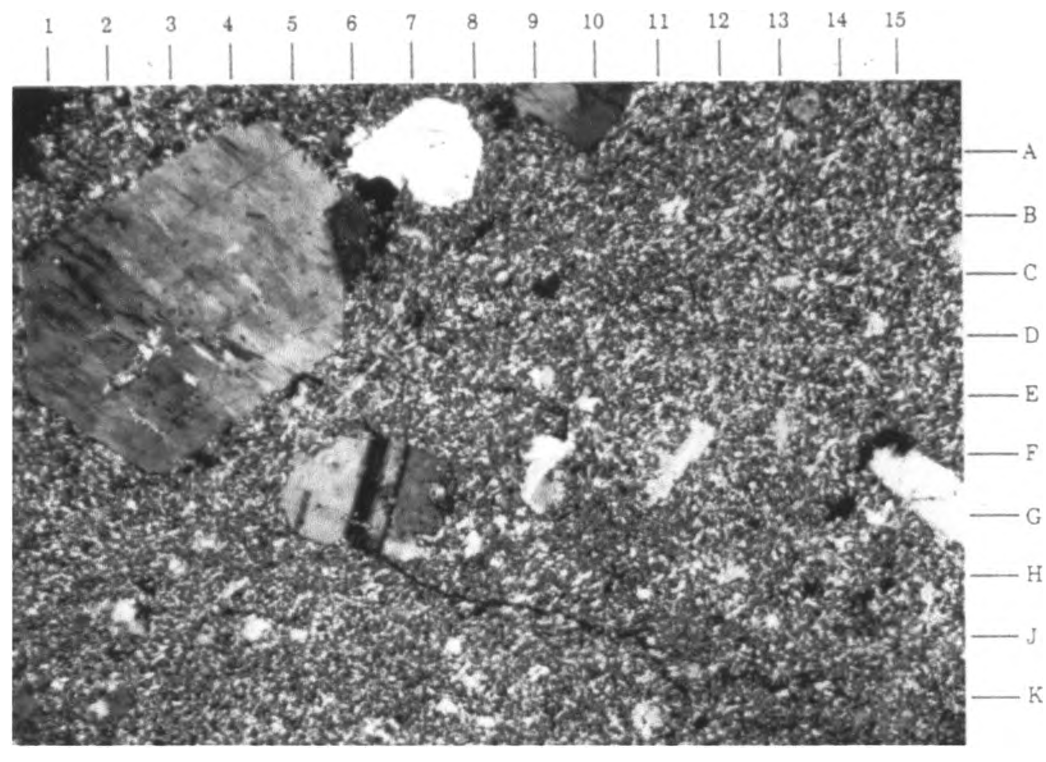

Fig. 3.21 Photomicrograph of rhyolite in the northern area shows phenocrysts of lath-shaped feldspar, microcrystalline quartz as groundmass with some mica. The base of the photo is approximately 4 millimetres. (cross nicols)

NE-SW faults or fracture systems are noted in this unit (Fig. 3.1). This rock is described as rhyolitic tuff. In the field, the rhyolitic tuff is highly altered, soft, and friable (Figs. 3.22, and 3.23). It still shows some relicts of folding (Fig. 3.24). In hand specimen, this rock is yellowish-white, soft, and fine-grained which make it impossible to make thin-section and study under microscope. This rock is therefore studied by means of x-ray diffractometry, differential thermal analysis and electron microscopy methods for mineral identification. The x-ray diffractometry reveals that this rock consists mainly of quartz, illite, and kaolinite with minor amount of pyrophyllite and chlorite-smectite mixed layers (Fig. 3.25). The amount of kaolinite increases in finer fraction (Fig. 3.26). Clay fraction of this rock is tested by DTA/TG method and confirmed that it is kaolinite (Fig. 3.27). The DTA/TG pattern shows the exothermic peak at low temperature about 100°C of adsorbed water, the main endothermic peak at 566.5°C, and the exothermic peak at 995.7°C of kaolinite (see discussion of this peak in Chapter IV). This rock under electron microscope shows stacks of kaolinite and euhedral quartz (Figs. 3.28, 3.29, 3.30 and 3.31) with EDS curves (Figs. 3.32 to 3.36).

The occurrence of pyrophyllite in this altered rhyolitic tuff as well as the presence of many faults and fractures in this rock unit suggest that this rock might have been subjected to some degree of hydrothermal alteration which make them more favorable for weathering later on.

Hence the likelihood of this rock unit to be the source of kaolin-rich sediments in this basin is relatively high.

The Phra That Formation

This rock unit forms small hills on the southeastern part of the Mae Than basin (Figs. 3.1 and 3.3). It is noted that the Phra That Formation (Piyasin, 1972, 1975; Chonglakmani, 1972, 1981) is synonymous with the Phra That Muang Kham (Bunopas, 1981) which is only exposed in the Lampang sub-basin (Chaodumrong,

Fig. 3.22 Panoramic viewed of the volcanics in the western area displayed by a group of low hills.

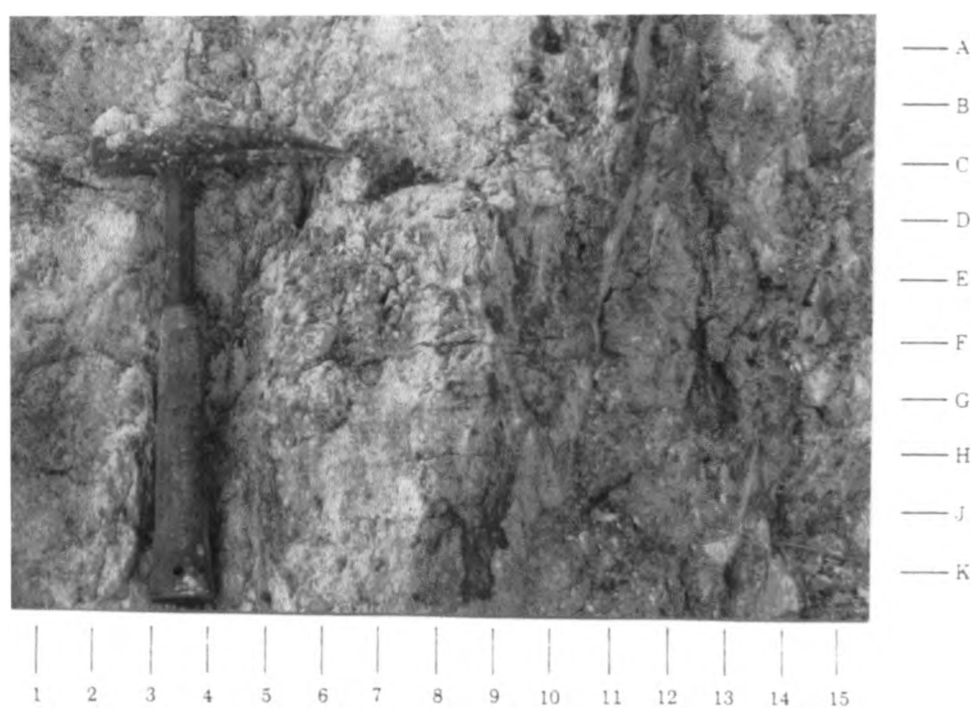

Fig. 3.23 Characteristics of rhyolitic tuff in the western area is highly altered, soft, and friable.

Fig. 3.24 Relicts of folding of rhyolitic tuff are observed in the western area.

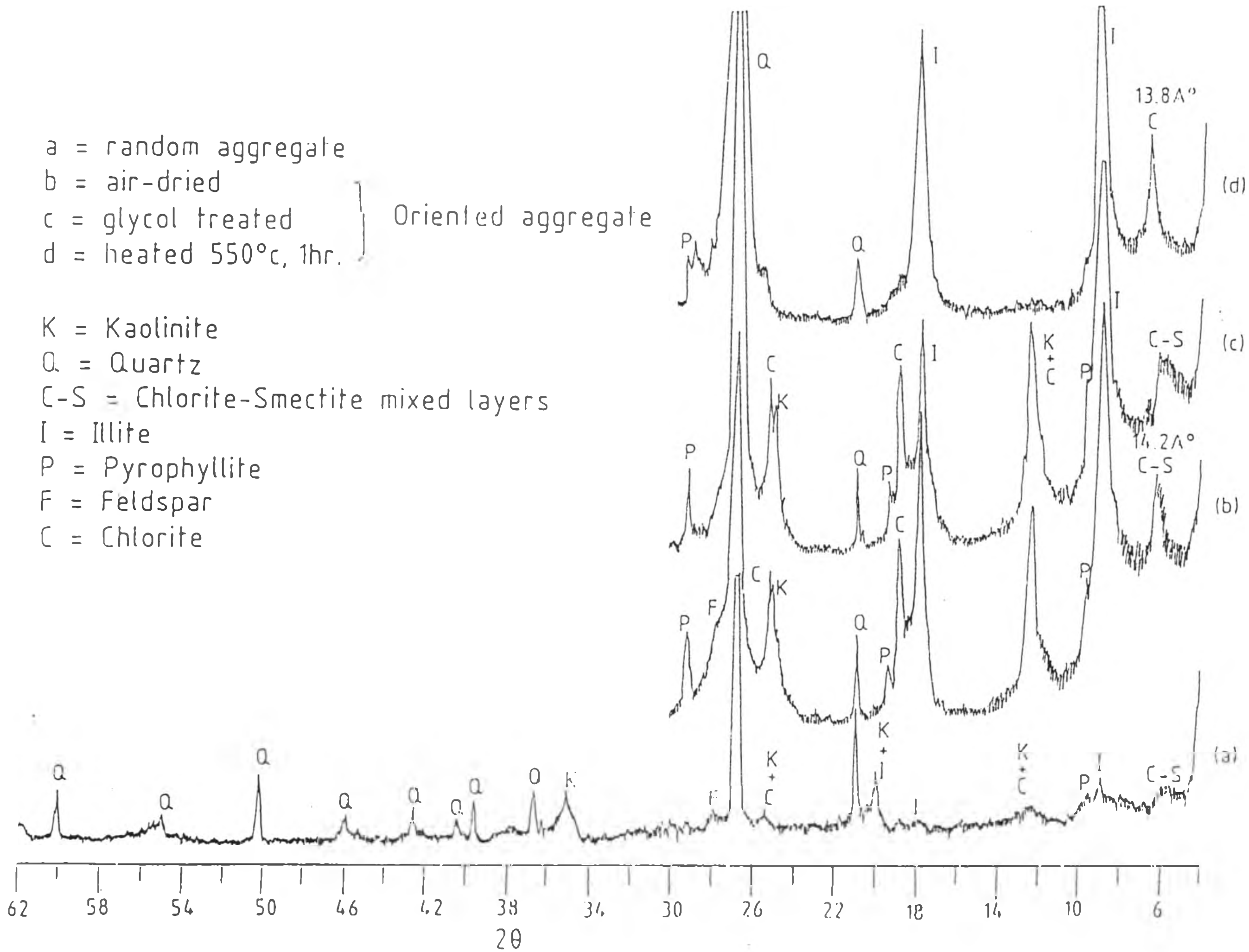

Fig. 3.25 X-ray diffractograms of the Permo-Triassic rhyolitic tuff in the western area.

I Illite
Py Pyrophylite
K Kaolinite
Q Quartz

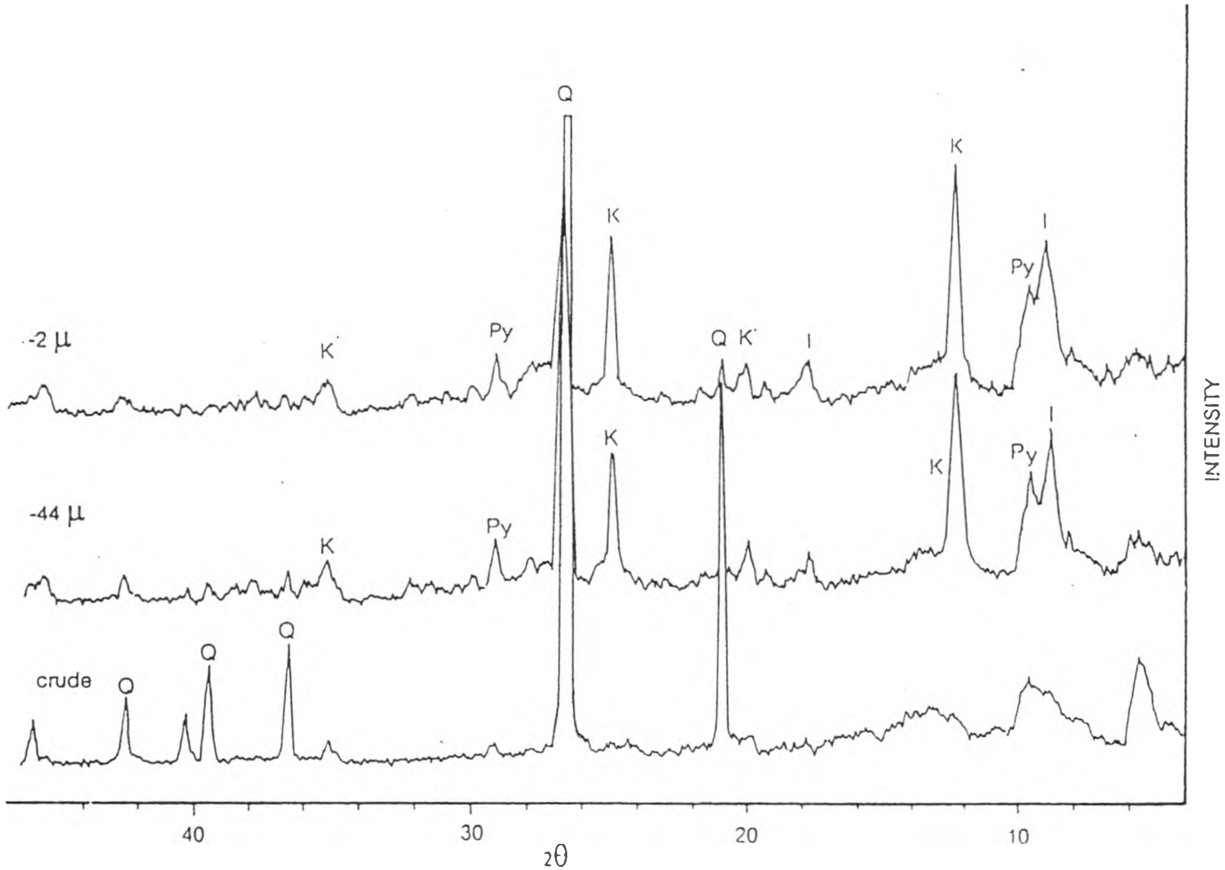

Fig. 3.26 X-ray diffractograms of various particle size fractions of the Permo-Triassic rhyolitic tuff in the western area.

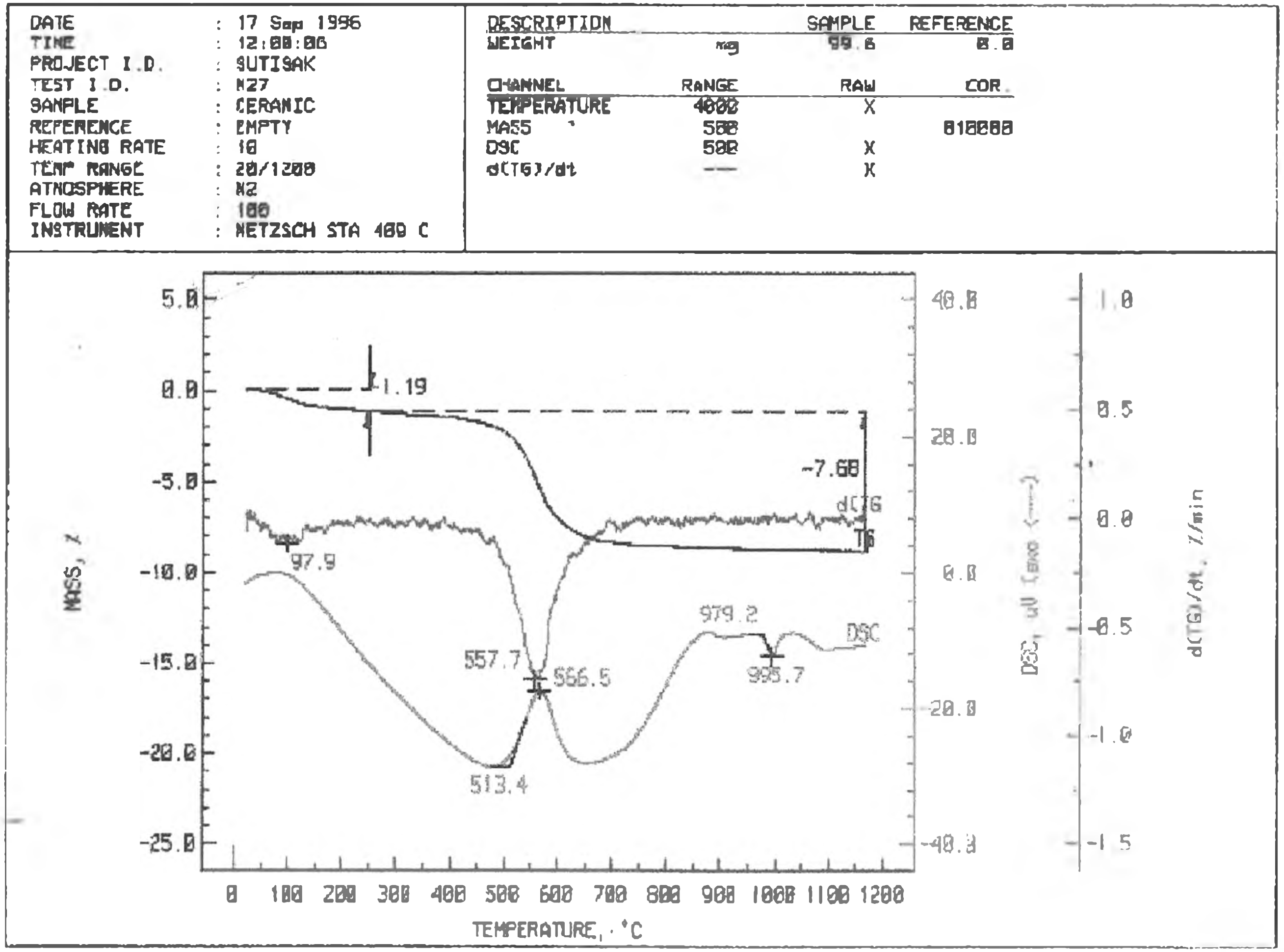

Fig. 3.27 Thermal analyses (blue curve : DTA, red curve : d(TG), and violet curve : TG) of clay size fraction of the Permo-Triassic tuff in the western area showing the main pattern of kaolinite; heating rate at 10°C/minute under N_2 condition.

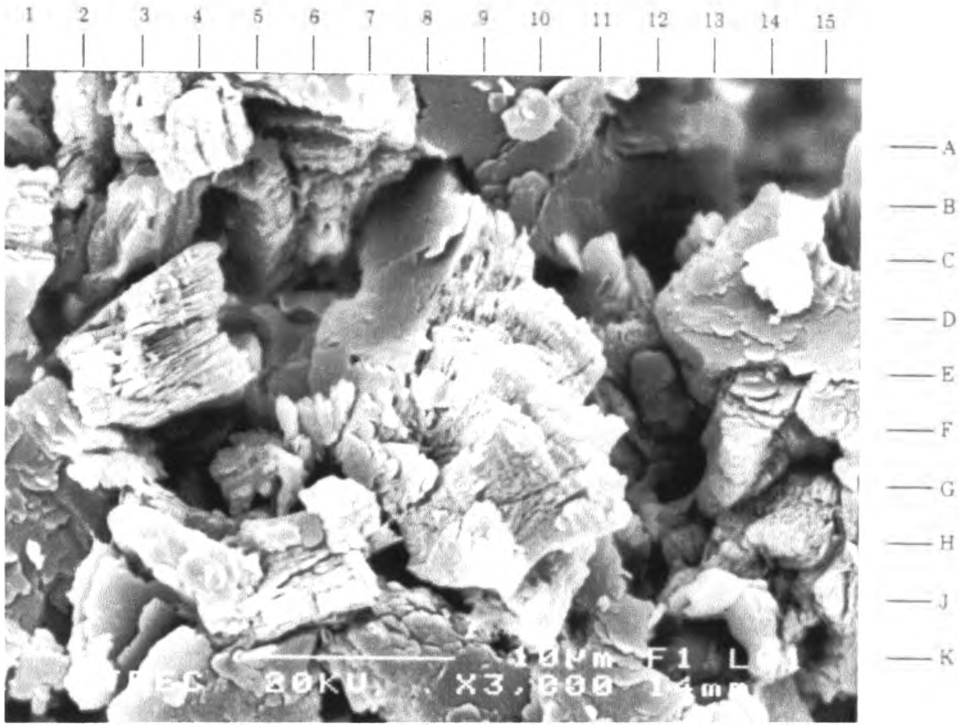

Fig. 3.28 Scanning electron micrograph of weathered rhyolitic tuff from the west of the basin showing stacks of kaolinite in the form of "book", indicative of *in situ* formation (see EDS curves of kaolinite (C8) in Figure 3.32).

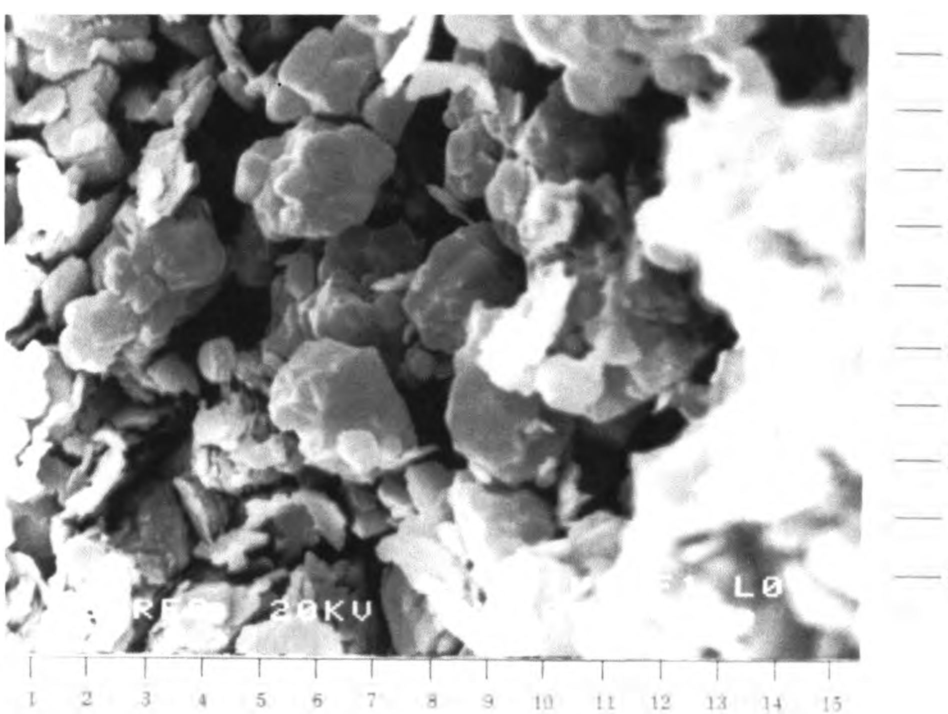

Fig. 3.29 Scanning electron micrograph of weathered rhyolitic tuff from the west of the basin showing angular quartz grains (see EDS curves in Figure 3.33) at C6, E9, and G6.

Fig. 3.30 Scanning electron micrograph of weathered rhyolitic tuff showing the mixtures of kaolinite (A7, J6) and illite (F7, F9) (see EDS curves in Figures 3.34 and 3.35).

Fig. 3.31 Scanning electron micrograph of weathered rhyolitic tuff shows probably the morphology of pyrophyllite (E9) (see EDS curves in Figure 3.36).

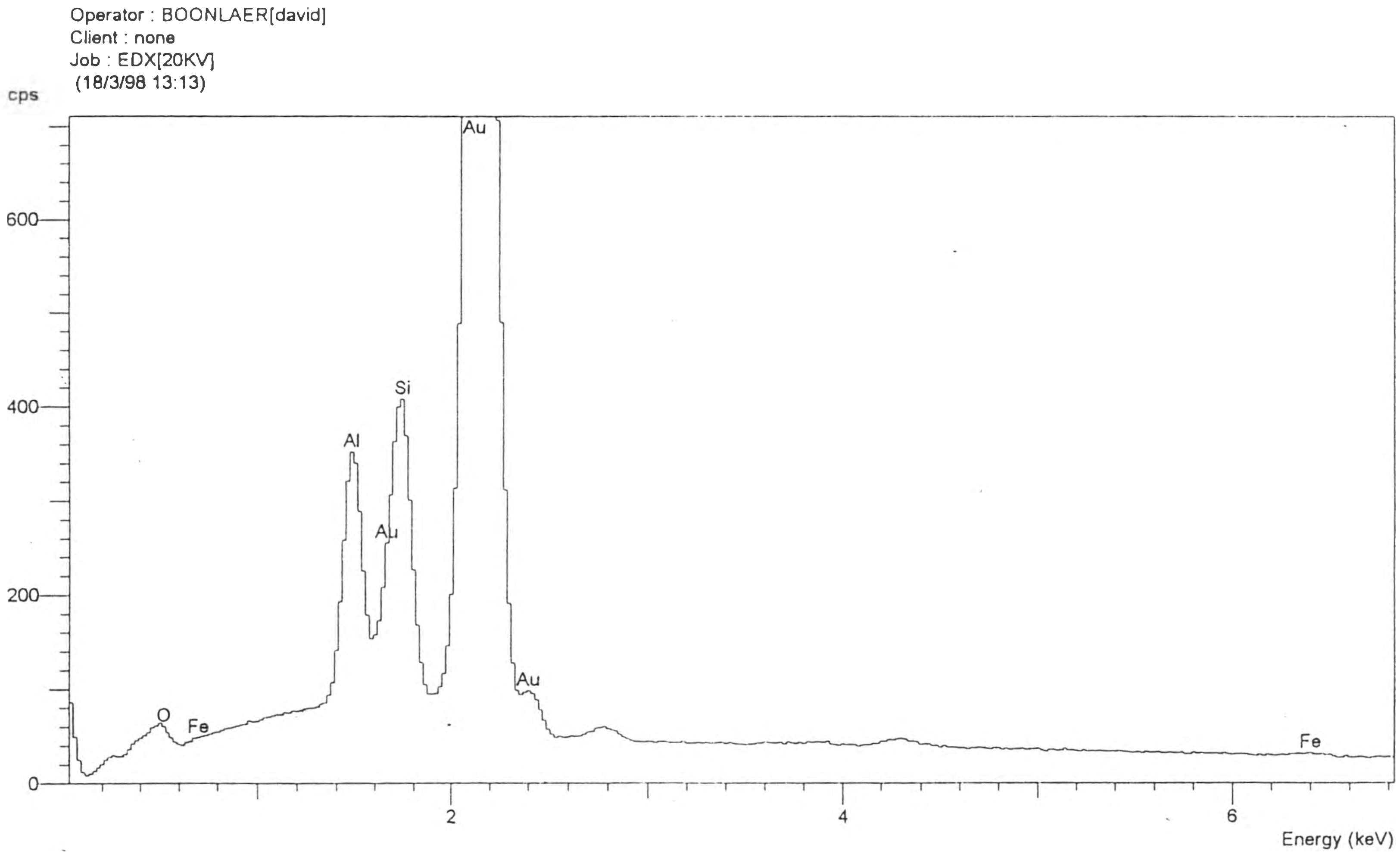

Fig. 3.32 Energy dispersive X-ray spectrum of kaolinite. All the specimen was coated with gold which appears as the prominent peaks.

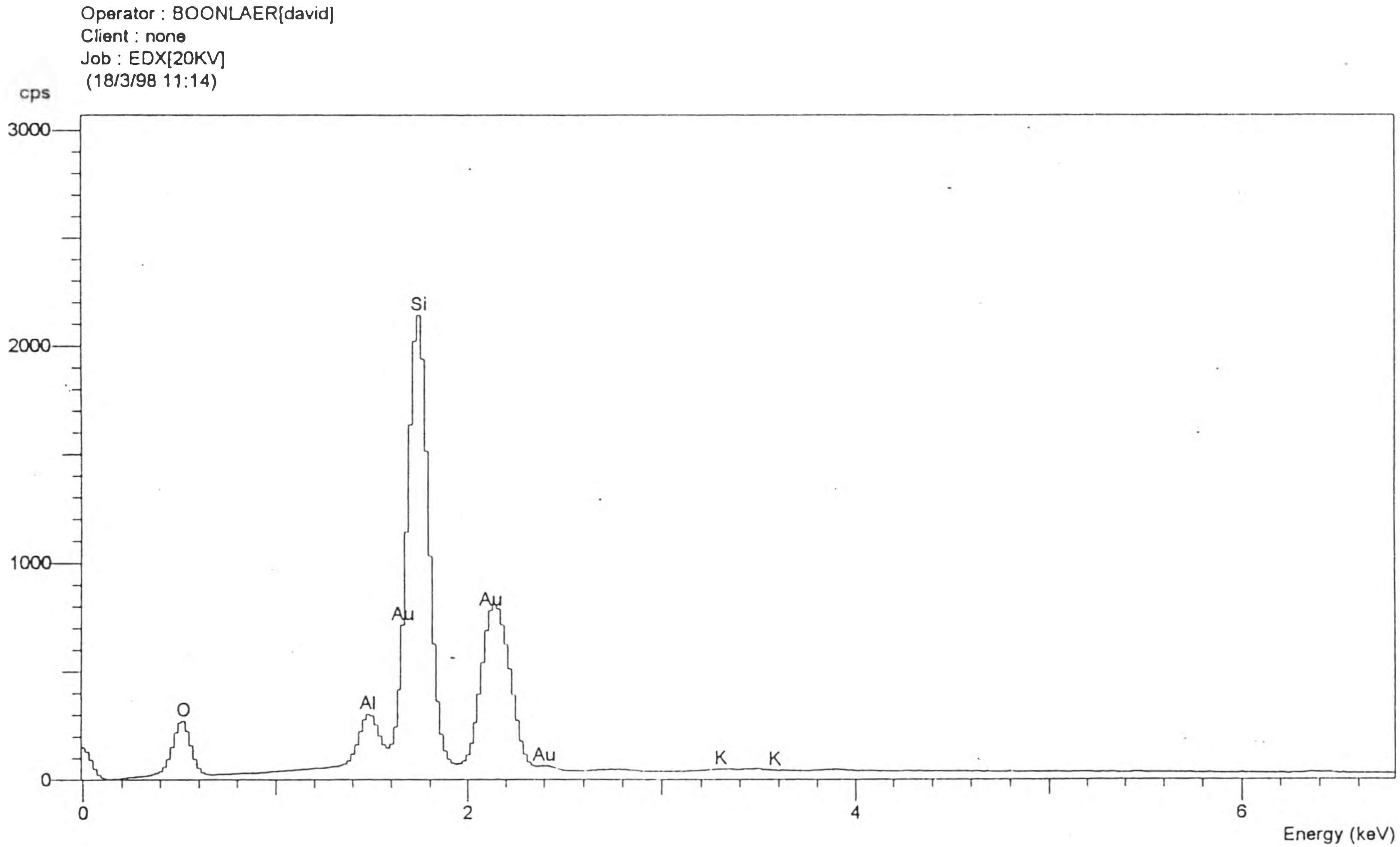

Fig. 3.33 Energy dispersive X-ray spectrum of quartz.

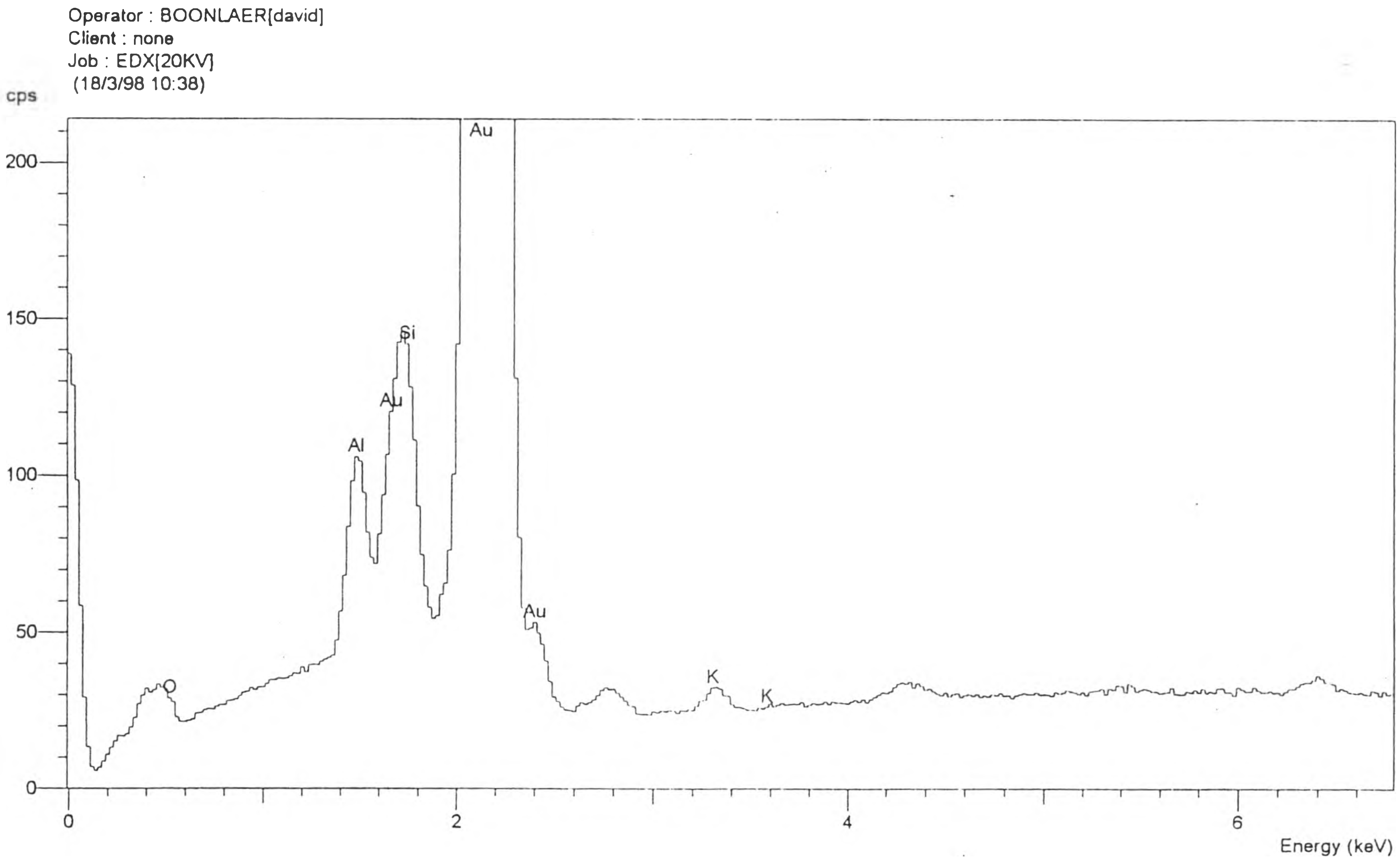

Fig. 3.34 Energy dispersive X-ray spectrum of illite.

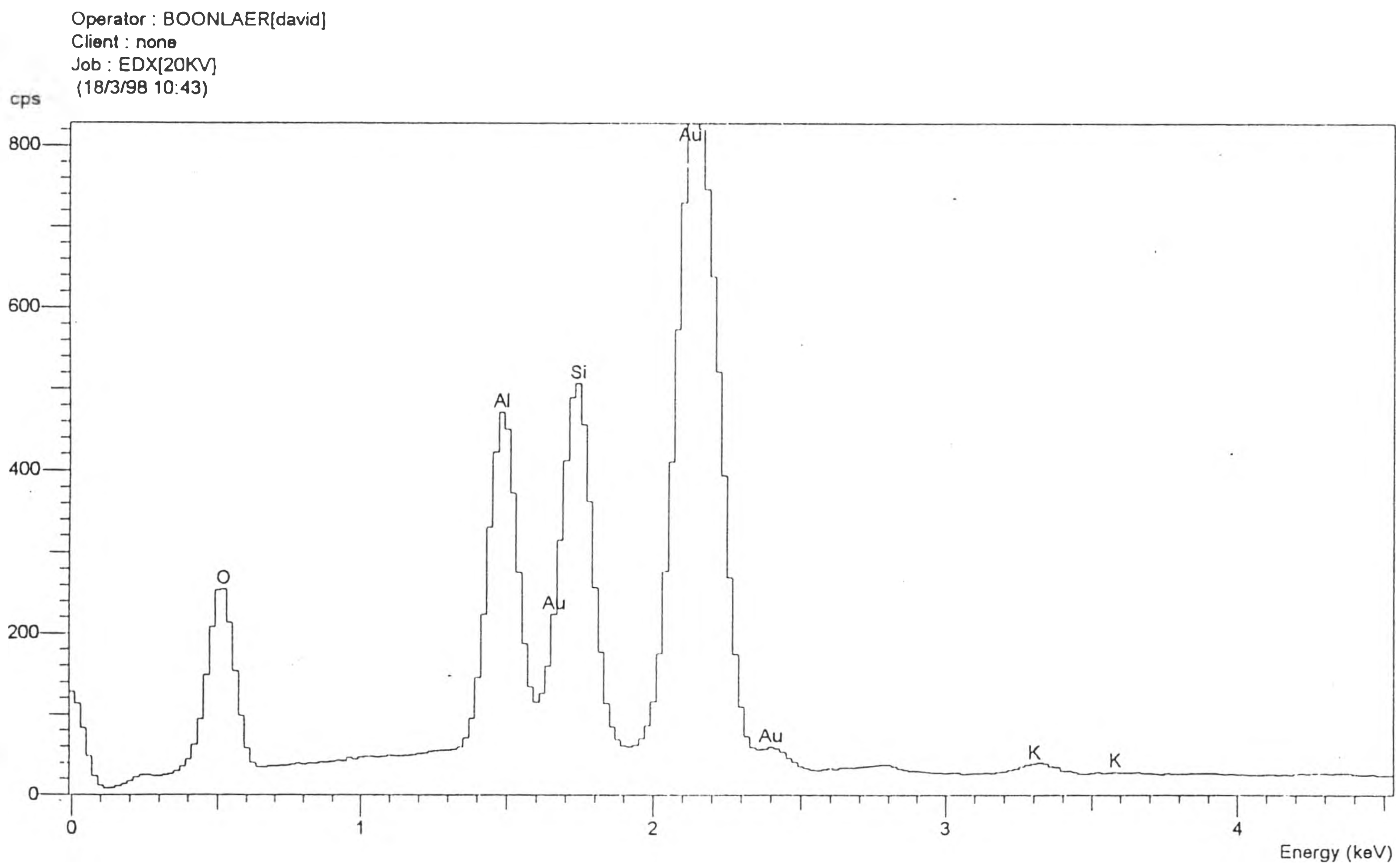

Fig. 3.35 Energy dispersive X-ray spectrum of kaolinite.

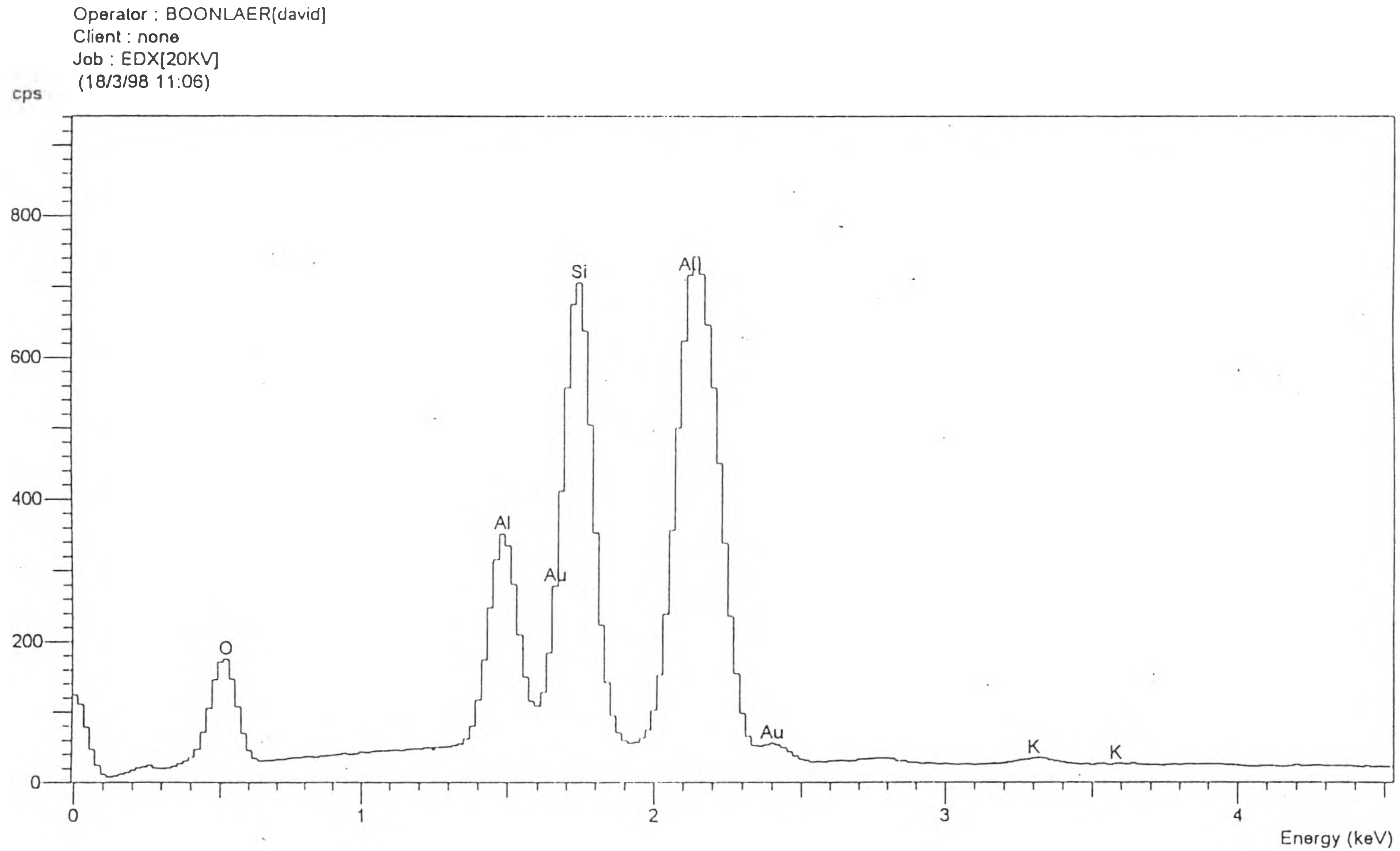

Fig. 3.36 Energy dispersive X-ray spectrum of pyrophyllite.

1992). This rock unit consists mainly of fine- to medium-grained sandstone interbedded with siltstone (Fig. 3.37) and pebbly sandstone. The age of this unit is inferred to be early Triassic (Anisian-Scythian) based on Piyasin in 1975.

In the field, exposure of this unit is medium- to fine-grained sandstone interbedded with siltstone (Fig. 3.37). They are oriented in S80°W trend with 45° dip. The major fracture systems are oriented in NE-SW and NW-SE directions. In hand specimen, sandstone is purplish-brown, dense, hard, and fine-grained (Fig. 3.38). Siltstone is purplish-brown, soft, and friable. Pebbly sandstone is purplish-brown, dense, hard, medium- to coarse-grained with pebbles (Fig. 3.39). Microscopically, it is classified as lithic greywacke and litharenite according to Folk in 1974 (Figs. 3.40 and 3.41). Lithic greywacke is fine- to very fine-grained and composed of approximately 80 to 85 per cent grain component and 15 to 20 per cent matrix and cement (Fig. 3.40). The grain component comprises 75 to 80 per cent volcanic rock fragment, 20 to 25 per cent quartz, and minor amounts of feldspar. The grains are sub-rounded to sub-angular and moderately sorting. The matrix is fine-grained minerals with ferrugenous cement. The other, litharanite is medium- to coarse-grained and composed of approximately 85 to 90 per cent grain component and 10 to 15 per cent matrix and cement (Fig. 3.38). The grain component comprises of 75 to 80 per cent rock fragment, and 20 to 25 per cent quartz. The grains are sub-angular to angular and moderately sorted. The matrix is fine-grained minerals with ferrugenous cement.

The likelihood of this rock unit to be the source of kaolin-rich sediments in this basin is relatively moderate.

Geology of the Cenozoic rocks in the Mae Than basin

The Cenozoic sediments of intermontane basins in the northern Thailand, including those in the Mae Than basin, commonly overlie unconformably on pre-Cenozoic rocks (Piyasin, 1975). The Cenozoic rocks in the Mae Than basin are generally characterized by the sedimentary rocks of the Tertiary age overlain by the

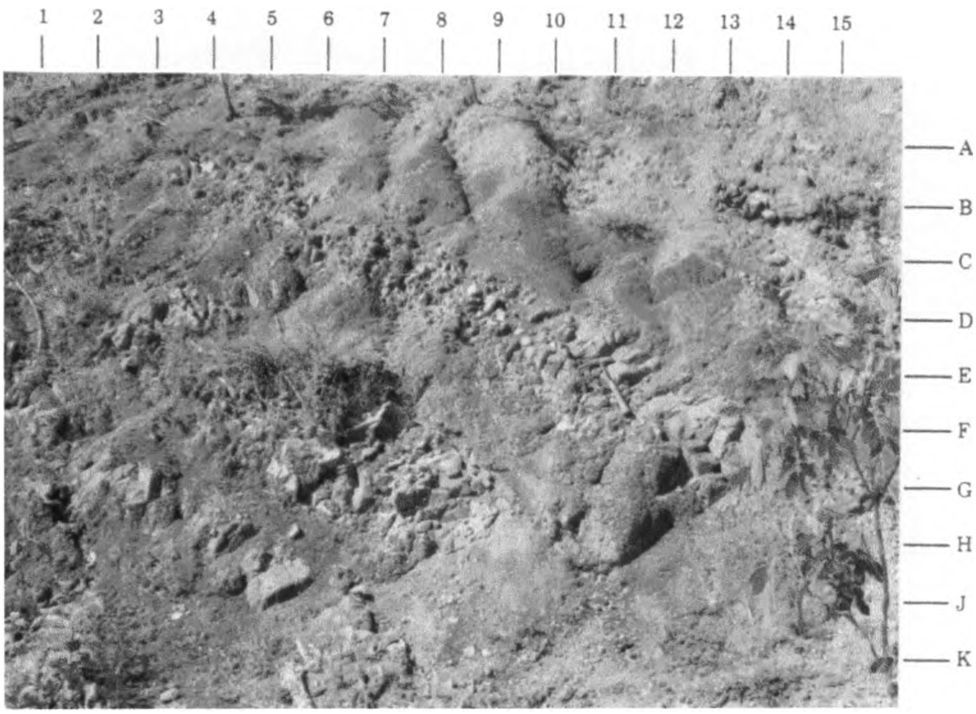

Fig. 3.37 An exposure of the Phra That Formation showing coarse-grained sandstone interbedded with siltstone with well develop fractures. (looking west)

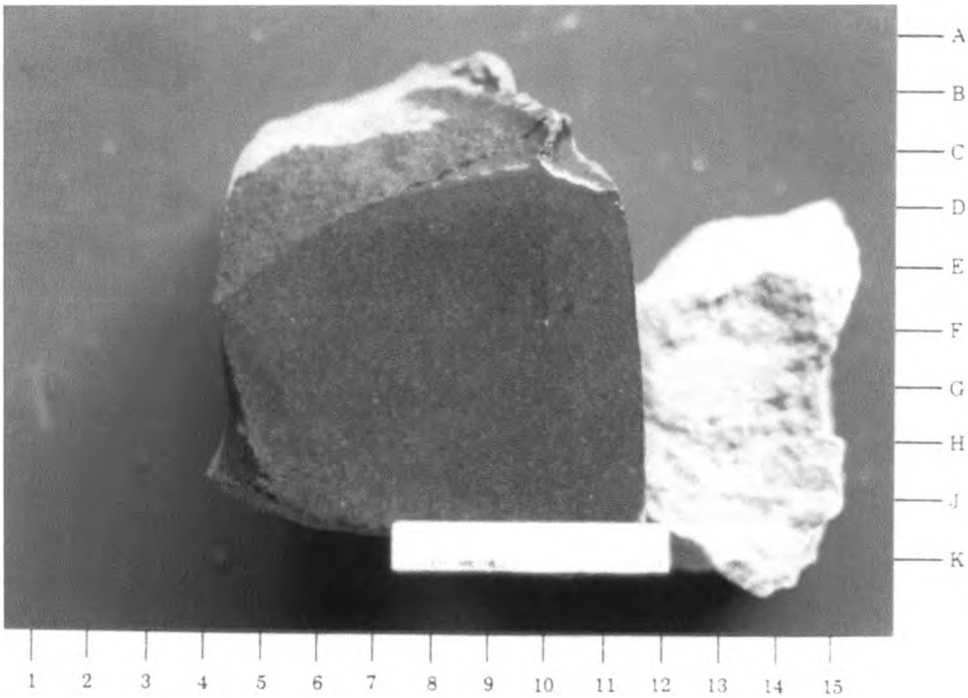

Fig. 3.38 A specimen of sandstone of the Phra That Formation showing characteristics of this rock.

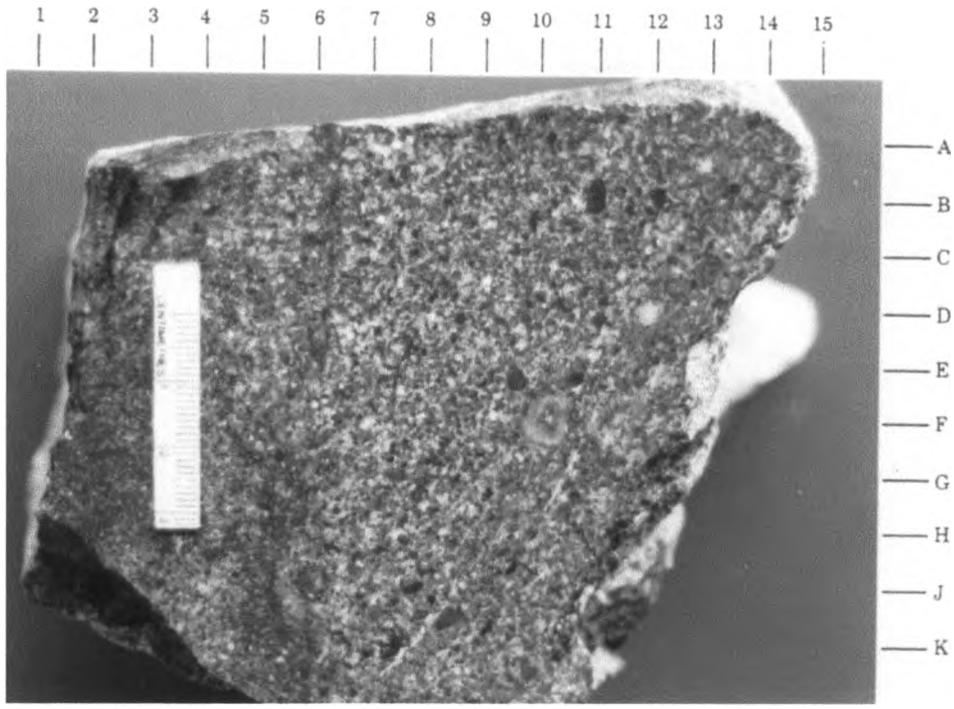

Fig. 3.39 A specimen of pebbly sandstone of the Phra That Formation and showing general characteristics of this rock.

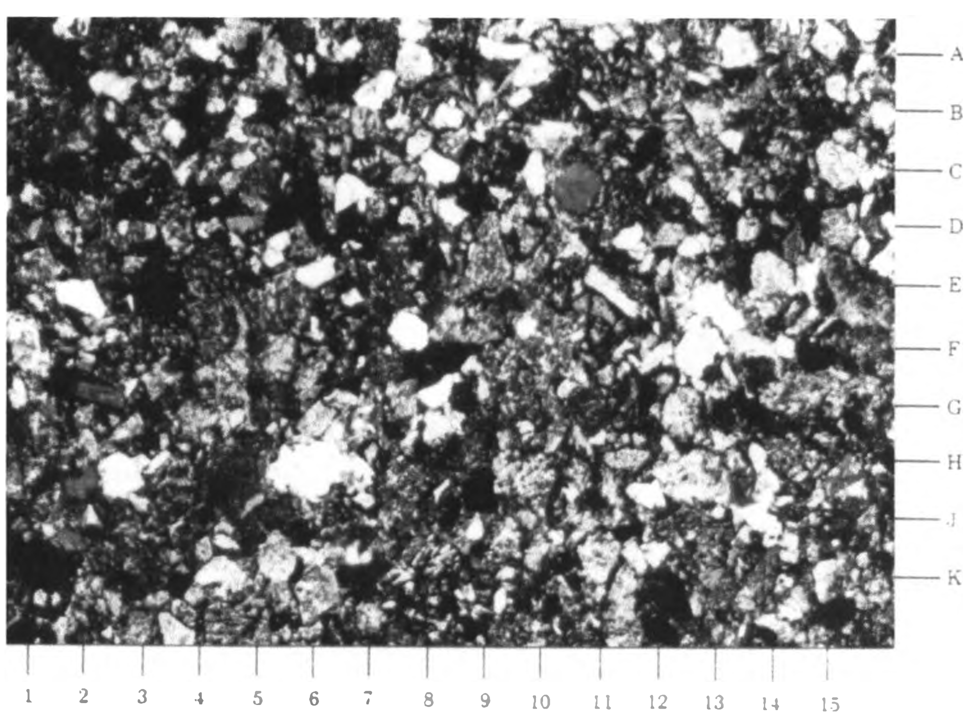

Fig. 3.40 Photomicrograph of very fine-grained lithic greywacke dominated by volcanic rock fragment and quartz grains. The grains are sub-rounded to sub-angular and moderately sorted with ferruginous cement. The base of the photo is approximately 2 millimetres. (cross nicols)

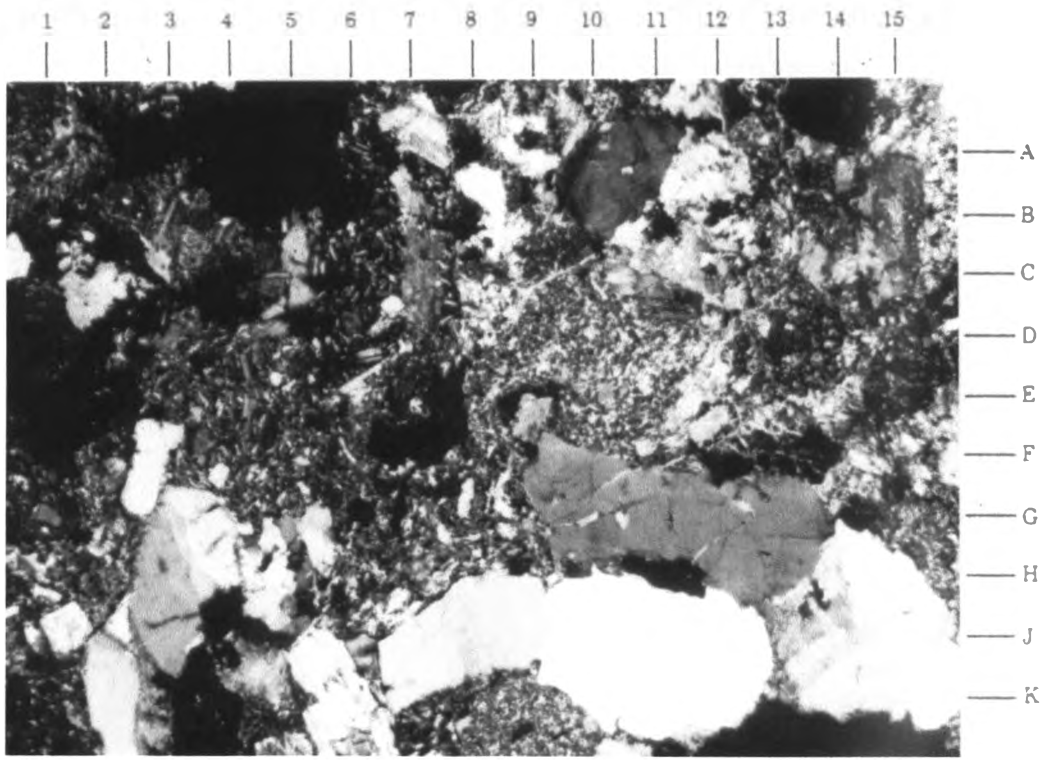

Fig. 3.41 Photomicrograph of medium- to coarse-grained litharenite showing rock fragment as major and quartz as minor. It is characterized by sub-angular to angular and moderately sorted with ferruginous cement. The base of the photo is approximately 4 millimetres. (cross nicols)

unconsolidated sediments of the Quaternary age (see drill-hole correlation later). They are commonly formed as low-lying area and/or undulating terrain (Fig. 3.1). In the Mae than basin, the Tertiary deposits are covered almost entirely by the Quaternary unconsolidated sediments except in the southwestern part of the basin where the Tertiary rocks are exposed in the mine pits (Fig. 3.3). Thus the information on Cenozoic rocks are obtained mainly from the pits and drill-hole samples in the southwestern part of the basin covering an area approximately 5 square kilometres (Fig. 3.1). All together 5 exploration drill-holes of totally 810 metres in length were used in this study. They are drill-holes nos. MT-2, MT-12, MT-13, MT-14, and MT-15 (Fig. 3.42). Detailed lithological description and sampling of each bed were undertaken continuously from the top to the bottom of the holes ranging in depth from 90 to 220 metres. Because the drilling purpose of these holes was to explore for coal, the total depths of these holes were aimed to penetrate only the lower coal seams without reaching the basement rocks. Hence the complete sequence of Cenozoic rocks cannot be obtained in this study. The core samples were separated into sand, silt and clay fractions using wet sieving and pipette analysis techniques. The clay-sized fraction was also used for determination of relative proportion of clay mineral content. The information on core description, sand/silt/clay ratio, relative proportion of clay-mineral content in clay size fraction in combination and field observation in the mine pits were used as a basis to reconstruct the sedimentary sequence of the Mae Than basin with the main emphasis on the southwestern part.

Stratigraphy of the Cenozoic rocks in the Mae Than basin

The sedimentary sequences of the Cenozoic rocks on the southwestern part of the Mae Than basin can be summarized in Figures 3.43 and 3.44. At least 6 sedimentary units or facies of the Cenozoic rocks in the basin can be recognized based on their distinct lithological characteristics. They are tentatively named unit A to F in descending order. Detailed description of each unit together with the interpretation on the environment of deposition are outlined in the following paragraphs.

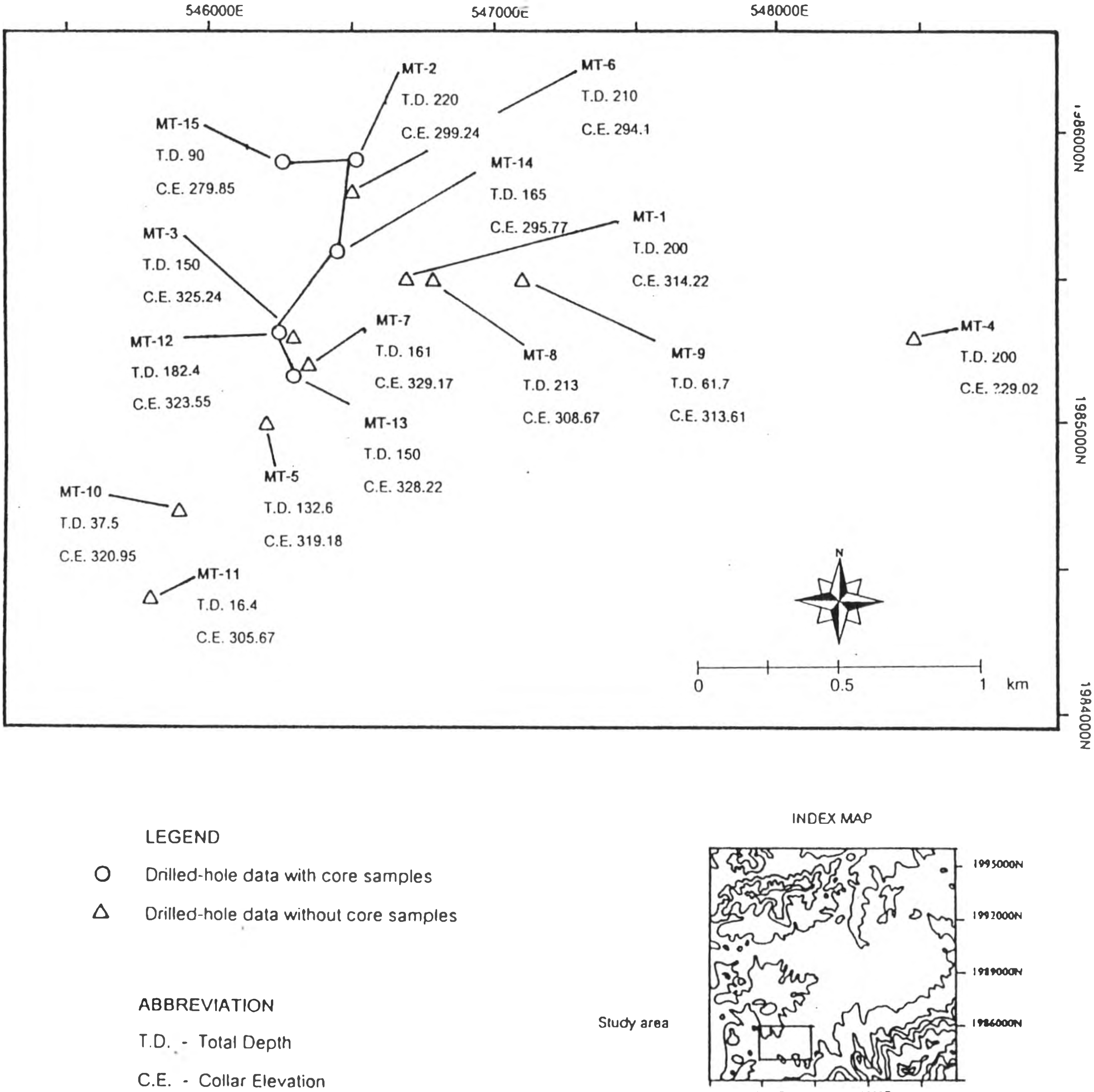

Fig. 3.42 Drill-hole location map showing the 5 drill-holes, MT-2, MT-12, MT-13, MT-14, and MT-15 that are used for correlation in the study.

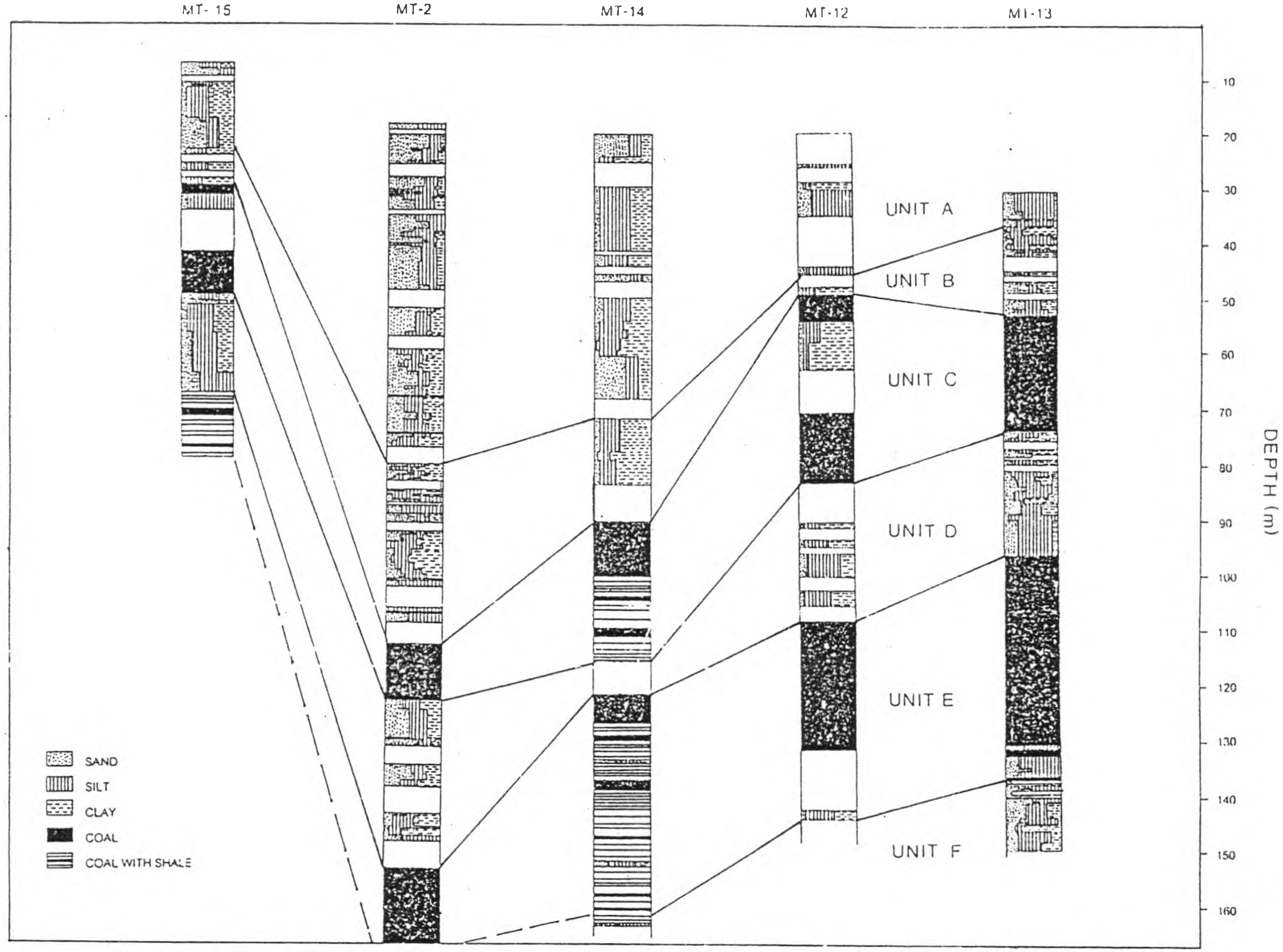

Fig. 3.43 Drill-core correlation of the Cenozoic rocks in the Mae Than basin which can be divided into 6 units based on their distinct lithological characteristics.

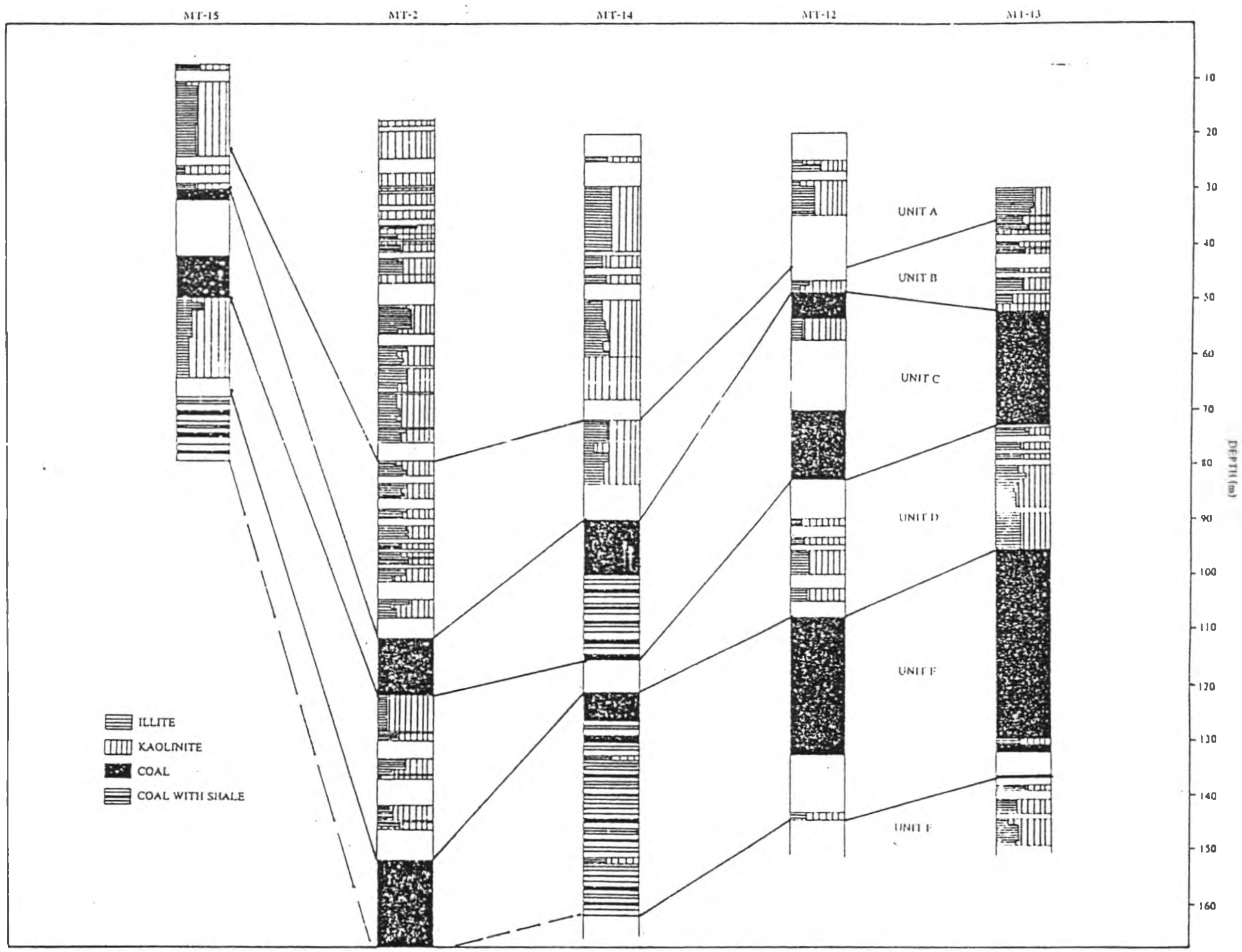

Fig. 3.44 Drill-core correlation shows the variation of clay minerals (mainly illite and kaolinite) in each unit.

Unit A

This upper most unit is characterized by top soil deposits underlain by layers of gravelly sands. The thickness of this unit is 7 to 65 metres. They are yellowish-brown to pale reddish-brown, unconsolidated sediments and composed of a mixture of gravels, sands, silts, and clays (Fig. 3.45). The sands are the dominant component. The sand grains are very fine to very coarse but mostly medium-sized, poorly sorted, sub-angular to sub-rounded and mixed with 30 per cent muds and 15 per cent gravels. The clay mineral contents of the separated clay-sized fraction are dominantly kaolinite of approximately 50-60 per cent and illite of approximately 40-50 per cent (Fig. 3.44). The details of clay mineral identification are referred to in Chapter IV (in this study, the word "illite" is used to represent a fine-grained micaceous material that appear at 10 °A on the XRD pattern; Thorez, 1976; the 7 °A peak is the kaolinite group minerals which can be kaolinite, halloysite, dickite or nacrite. The positive identification of the kaolinite group mineral is referred to Chapter IV).

Characteristics of this sedimentary sequence reveals several cycles of upward fining sequence deposited by recent stream system. Hence they are interpreted to be deposited in a fluviatile environment of Quaternary age.

Unit B

This unit is represented mainly by light grey to medium grey claystone with minor interbedded silty claystone and sandy claystone and brownish-black, carbonaceous claystone. Minor amount of ironstone nodule is also noted. The thickness of this unit varies from 5 to 35 metres. The claystone, containing 50 to 80 per cent clay component, is generally soft, semi-consolidated and particularly the carbonaceous claystone, is highly plastic. Some parts of this unit, the carbonaceous claystone in particular, have been commercially exploited under the trade name as "ball clay" (Fig. 3.46). Their chemical and ceramic properties will be discussed in a separated chapter. The clay mineral contents of the clay-sized fraction are mainly

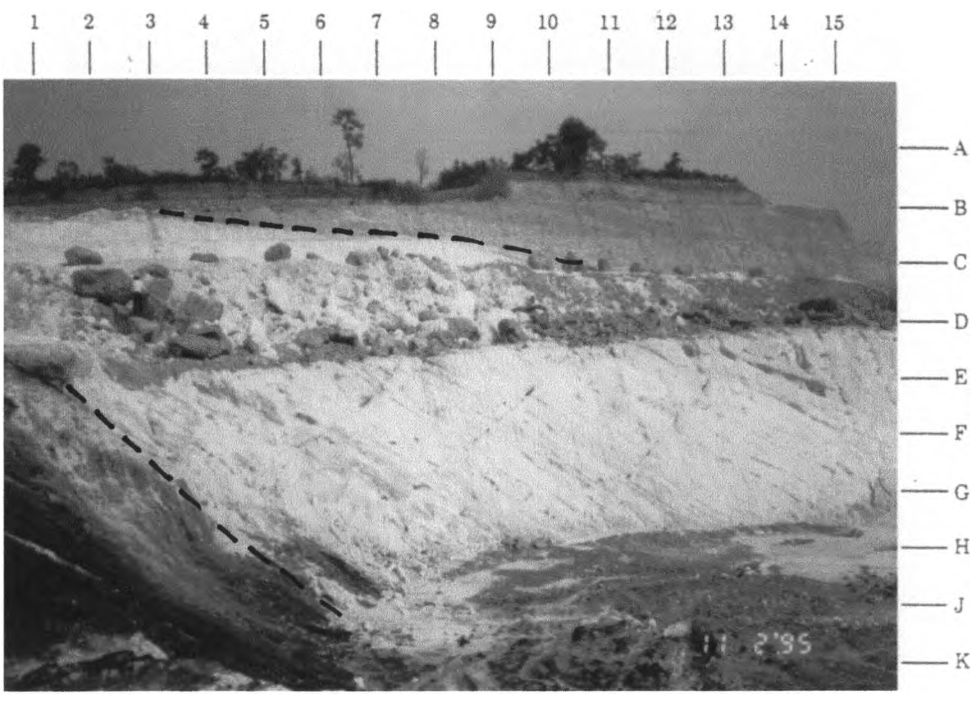

Fig. 3.45 Uppermost part of Unit A show light brown and sub-horizontal dipping which differed from the lower unit, namely, Unit B (light colour) and C (coal seam).

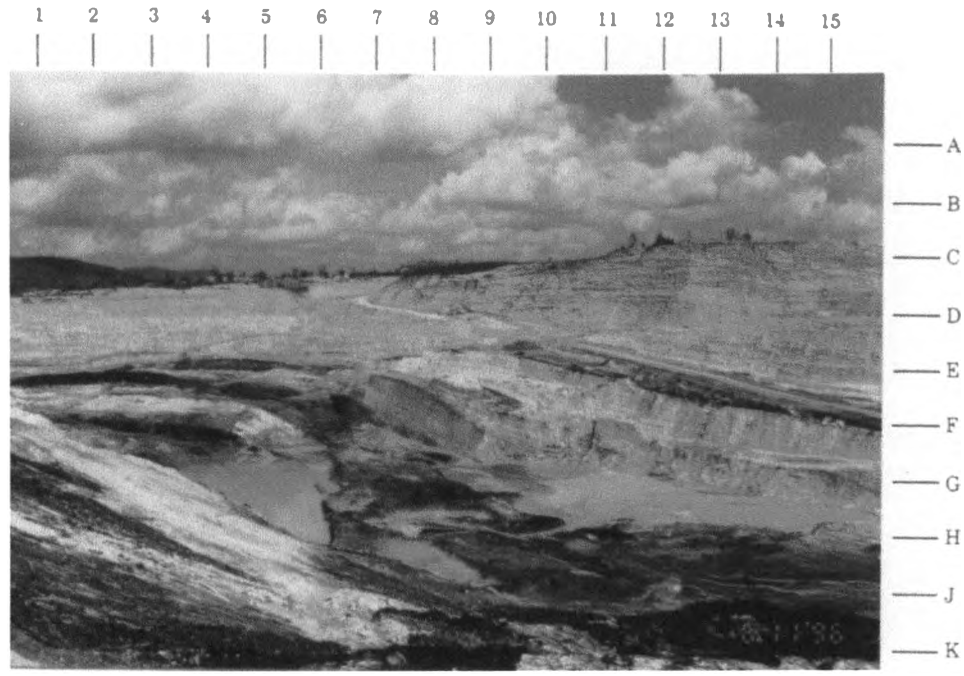

Fig. 3.46 Claystone of Unit B, splitted coal, and upper coal seam (Unit C) are shown clearly dipping into the east. (looking northeast)

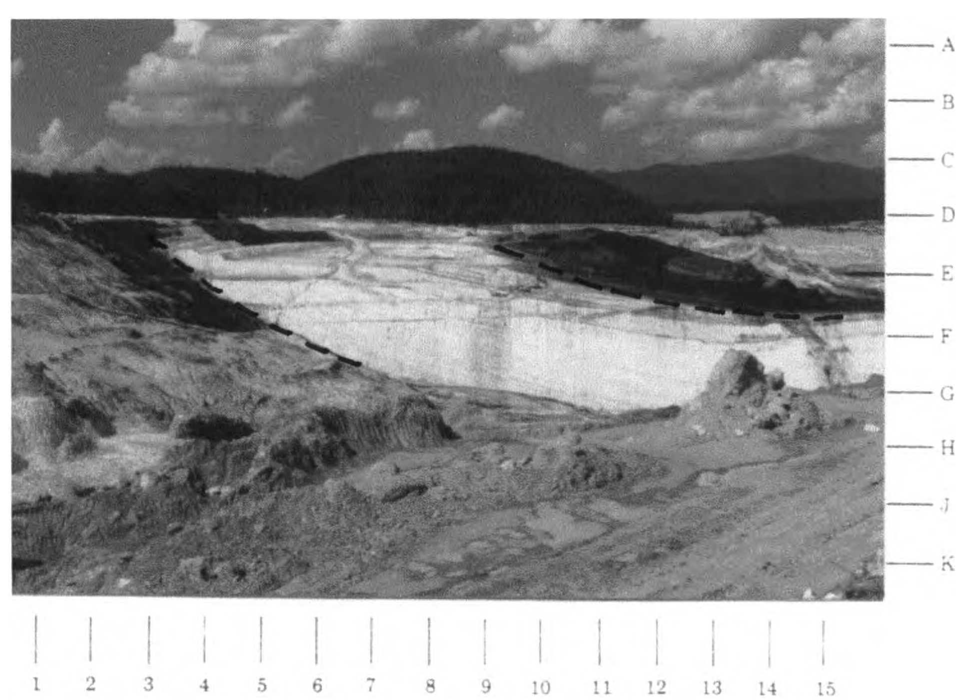

Fig. 3.47 Claystone of Unit D lies between the upper coal seam (Unite C) and the lower coal seam (Unit E) with moderate dip angle. (looking north)

kaolinite (~70-80 per cent), minor illite (~20-30 per cent) and trace amount of smectite (< 5 per cent) (Fig. 3.44). Thinly coal beds are occasionally interbedded in this unit.

Characteristics of this sedimentary sequence suggest that this unit was deposited in a fresh-water lacustrine environment of presumably Tertiary age.

Unit C

This unit is represented by the so-called "Upper Coal Seam". They comprise mainly of thickly to thinly (~0.2 to 13 metres) coal beds with partings of claystone and thinly bedded coaly claystone (Fig. 3.47). The thickness of this unit varies from 10 to 35 metres. This coal seam has been commercially exploited at the present time. The coal is brown to black, friable and dull. The claystone is dark yellowish-brown to brown, soft and moderately plastic. The coaly claystone is dark yellowish-brown, soft and sometimes contains coal fragments.

Characteristics of this sedimentary sequence suggests that the Unit C was deposited under the subsiding peat swamp and lacustrine environments of presumably Tertiary age. The relatively thick coal seam of sub-bituminous rank indicated that the reactivation of faulting during the peat formation was essentially required.

Unit D

This unit is represented by yellowish- to greyish-white claystone intercalated with lens of fanglomerate, ironstone and thinly-bedded ligneous claystone (Figs. 3.48 and 3.49). The thickness of this unit varies from 30 to 40 metres.

The claystone varying in thickness from 0.2 to 3 metres is generally soft, semi-consolidated moderately plastic. The clay contents of this claystone vary from 50 to 60 per cent. The clay minerals of the clay-sized fraction are mainly kaolinite (~75-80

Fig. 3.48 The uppermost part of Unit D is represented by the interbedded between sandstone and claystone with some coal splitting.

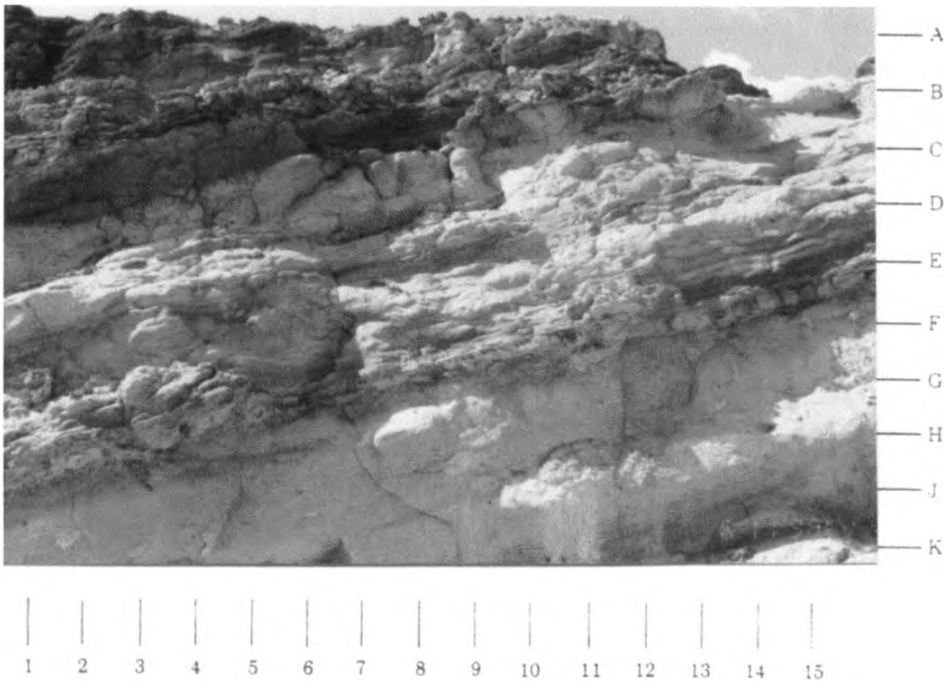

Fig. 3.49 Close-up figure from Figure 3.48.

per cent), minor amount of illite (~20-25 per cent), and trace of smectite (< 5 per cent) (Fig. 3.44).

The fanglomerate occurs as lenses or bed intercalated or interbedded with claystones. It is characterized by a yellowish-grey mixture of heterogeneous fragments of all sizes. The coarse fragments are angular to sub-angular, poorly sorted, varying in size from 1 to 3 centimetres (Figs. 3.50, 3.51 and 3.52) and composed of quartz, rock fragments, and coal fragments.

This sedimentary sequence indicates that this fanglomerate was probably the introduction of alluvial fan intermittently deposited in the marginal facies of the fresh-water lacustrine environment.

The ironstone is characterized by a compact, hard, dark brown to reddish-brown lenses or nodules with size up to 2.0 metres in length and 0.5 metres in thickness (Fig. 3.53). The ironstone is mainly found near the coal seam both on above and below. The ironstone is composed of iron carbonate (siderite) cementing and replacing quartz grains and clays (Figs. 3.54, 3.55 and 3.56). The siderite usually form spherulitic texture with dark brown iron oxide surrounding grain boundary (Fig. 3.57). The secondary replacement texture of siderite suggest that this iron carbonate might have been remobilized from the nearby peat swamp environment. The remobilization siderite may be supported by the presence of spherulitic siderite replacing the volcanic basement rocks (Pisutha-Arnond, per. com.).

The characteristics of sedimentary facies in this unit indicate a lacustrine environment of presumably Tertiary age.

Unit E

This unit is the "Lower Coal Seam" with partings of claystone and coaly claystone. The thickness of this unit varies from 10 to 40 metres. The coal is

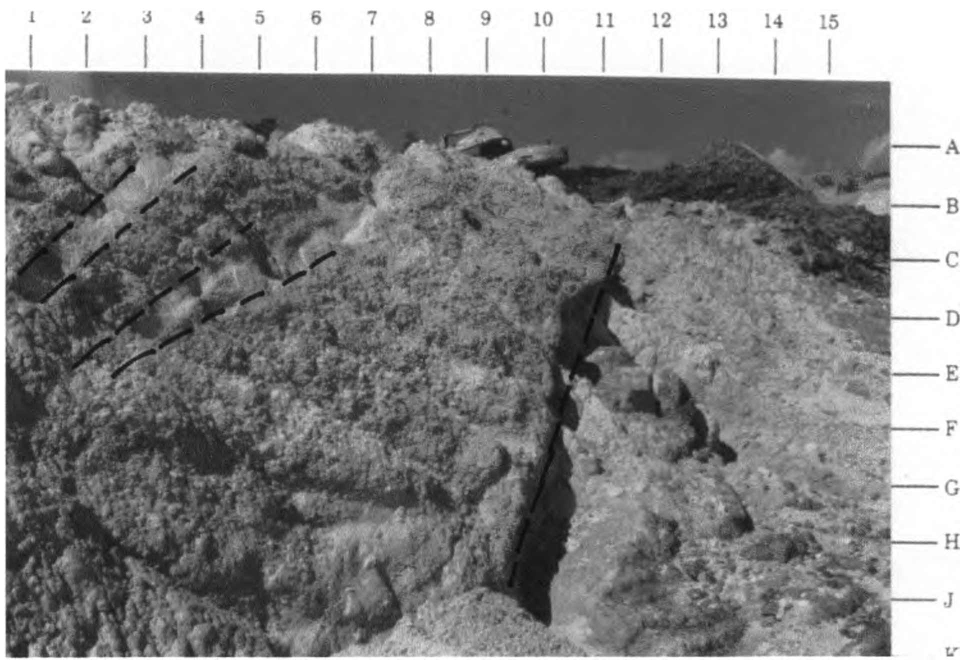

Fig. 3.50 In Unit D, the fanglomerate deposits form generally as bed and interbedded with clay bed. (looking southwest)

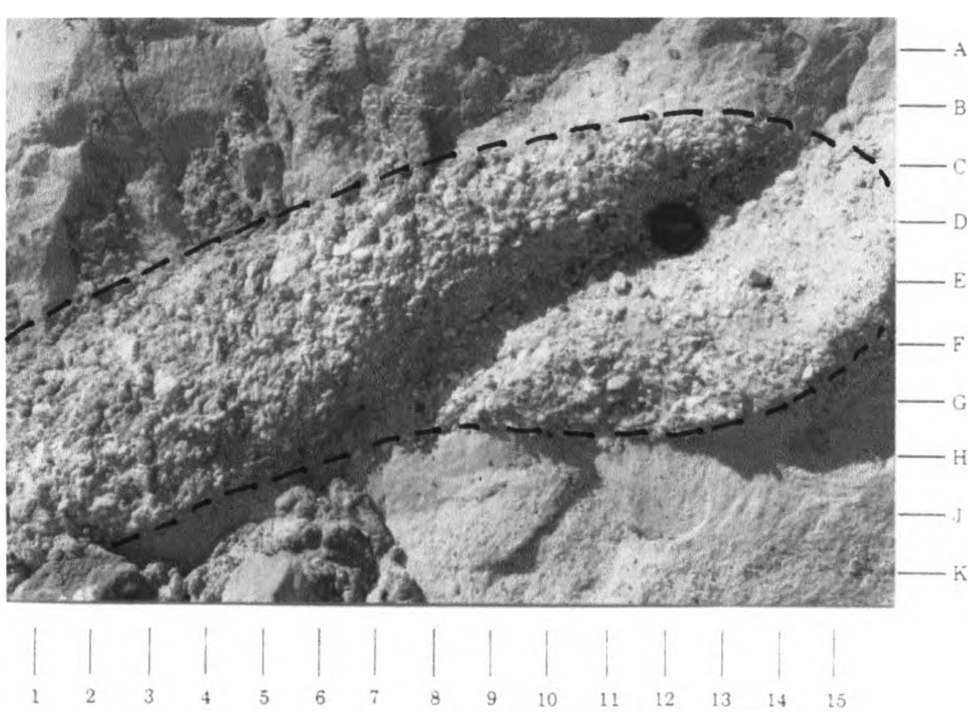

Fig. 3.51 Sometimes, fanglomerate deposits form as lens in a clay bed.

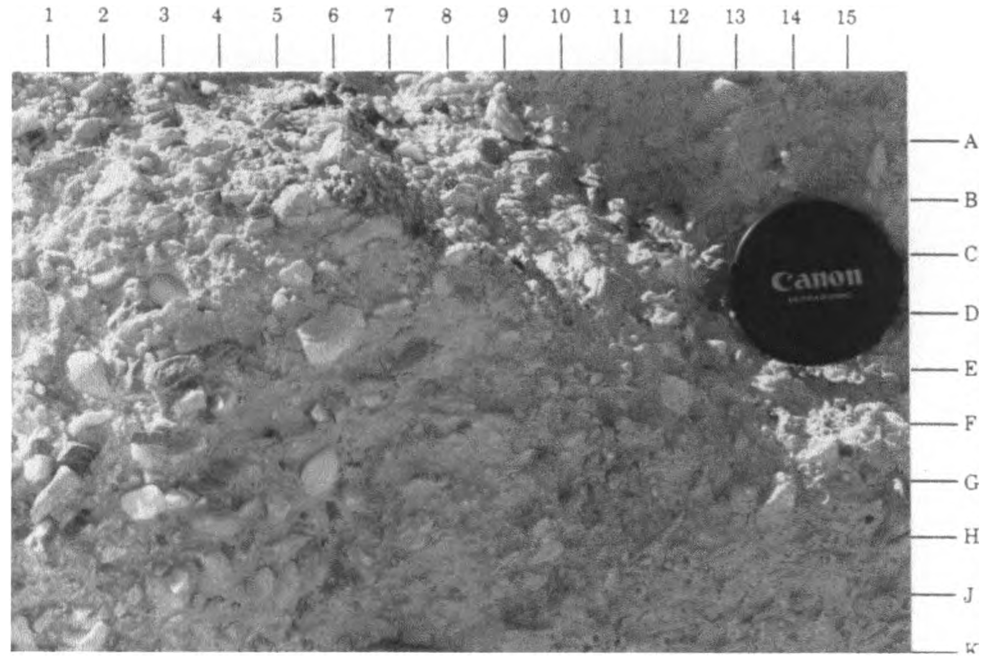

Fig. 3.52 Close up figure of fanglomerate sediments in Unit D, consist of 2 to 3 centimetres gravels of quartz and rock fragments with low sphericity, sub-angular to angular, and poor sorting.

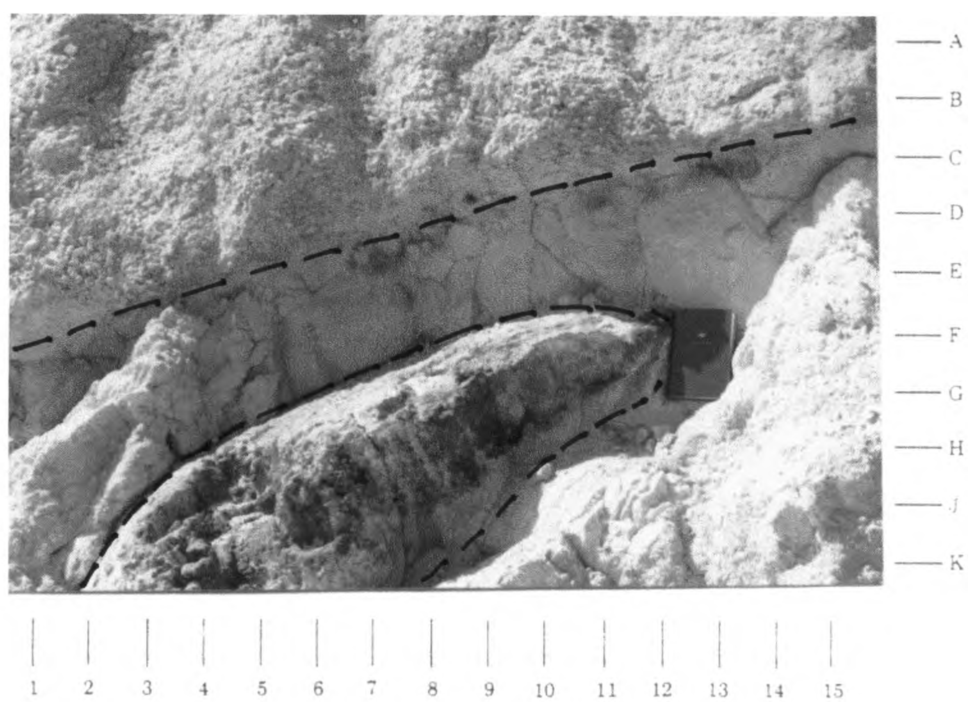

Fig. 3.53 Siderite always shows as a nodule in fine-grained sediment bed (clay bed).

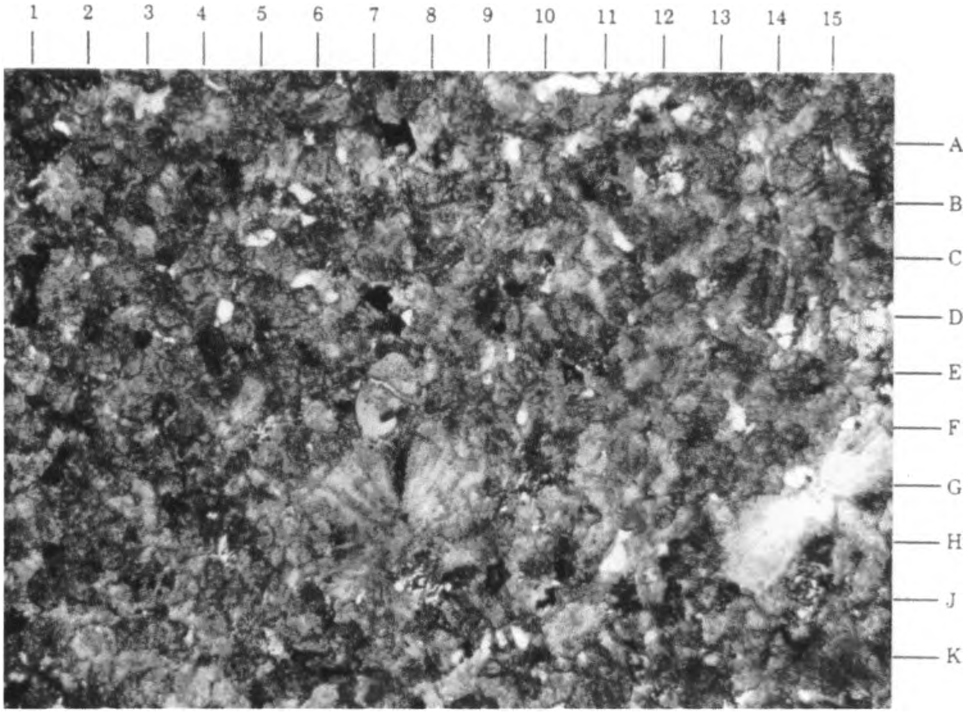

Fig. 3.54 Photomicrograph showing replacement of siderite (G8) in sand-dominated sediments with some spherulitic texture. The base of the photo is approximately 4 centimetres. (cross nicols)

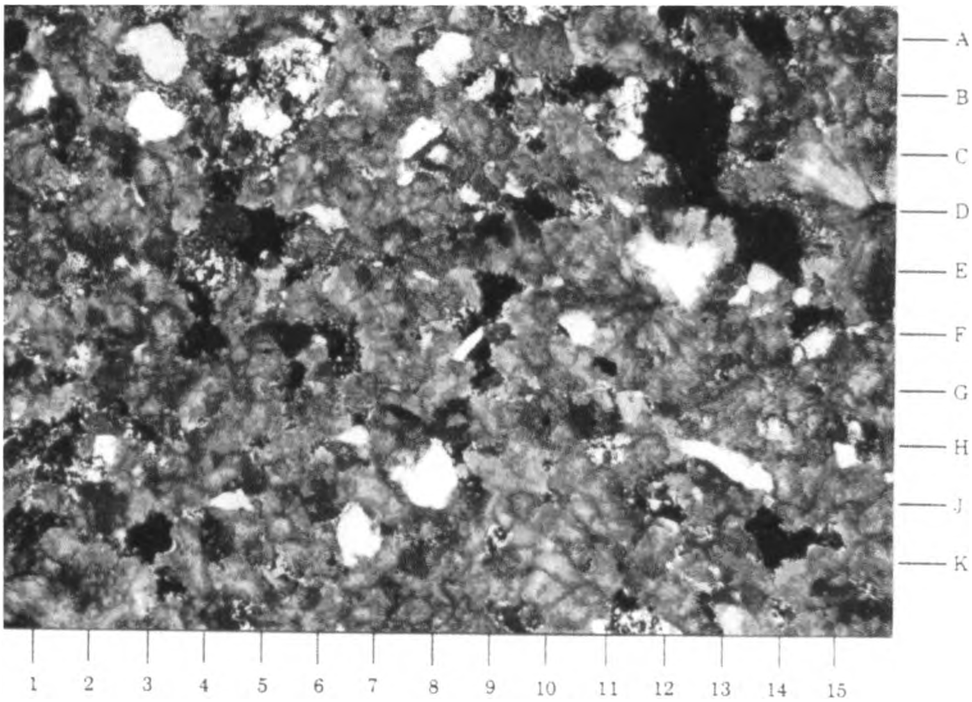

Fig. 3.55 Photomicrograph showing spherulitic texture and growth of recrystallized quartz in voids. The base of the photo is approximately 4 centimetres. (cross nicols)

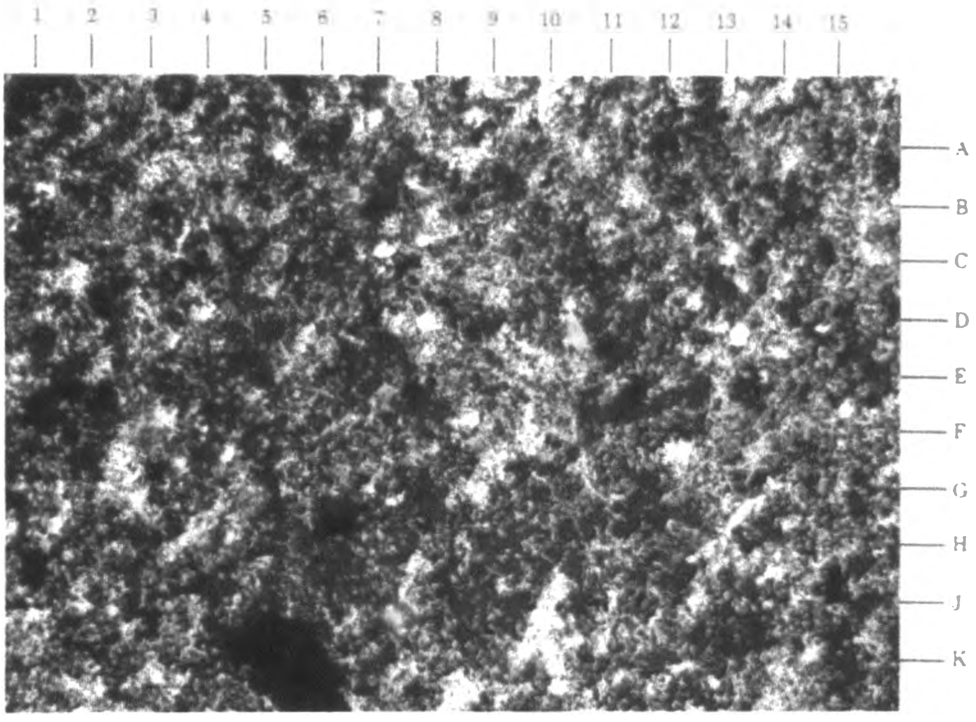

Fig. 3.56 Photomicrograph of siderite and iron oxide replaced in the fine-grained sediments (clay). (cross nicols, 10x)

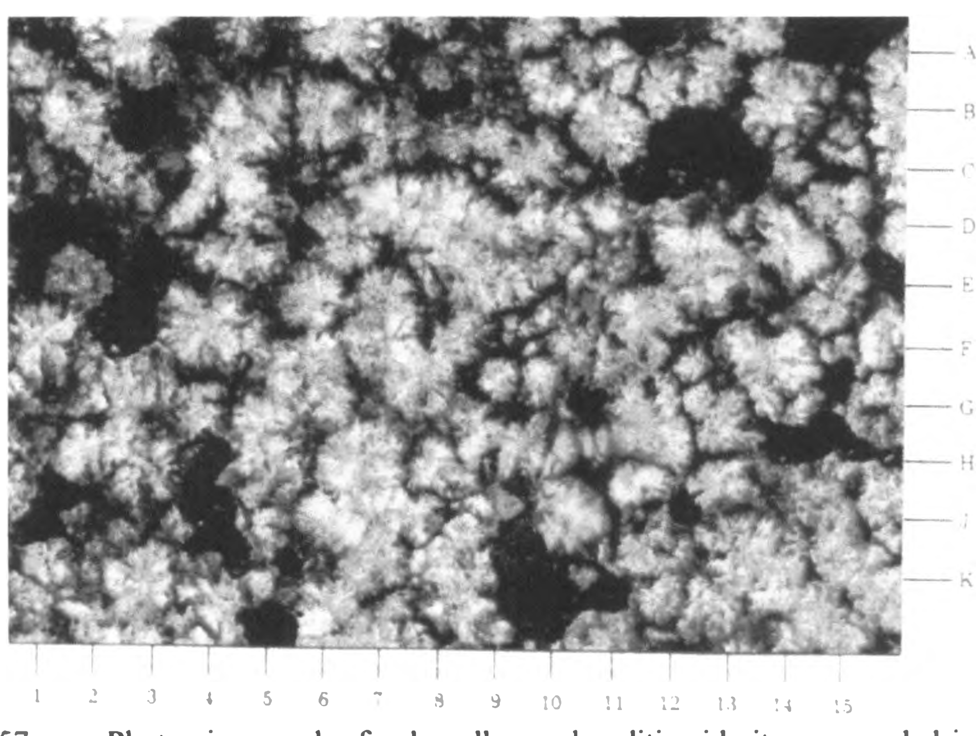

Fig. 3.57 Photomicrograph of pale yellow spherulitic siderite surrounded in the boundary with dark red iron oxide. The base of the photo is approximately 4 centimetres. (cross nicols)

characterized by brown to black, friable and dull. The claystone is dark yellowish-brown, moderately plastic and composed of 80 per cent clay fractions. The clay minerals in the clay fraction comprise kaolinite (~75 per cent) and minor illite (~25 per cent) (Fig. 3.44). The coaly claystone is dark yellowish-brown, soft and contains coal fragments.

The characteristics of sedimentary facies in this unit indicate peat swamp and lacustrine environments of presumably Tertiary age.

Unit F

This is the lowest unit obtained from drill-hole no. MT-13. It is represented by yellowish-brown, soft claystone with interbedded sandy siltstone. The information on this unit is rather poor due to the limitted core sample available. This unit is interpreted to be deposited in lacustrine environment of presumably Tertiary age.

It should be noted that in most drill-holes, the kaolinite content in the clay-sized fraction dominate over the illite content. However, the fluviatile facies of Unit A seems to contain relatively lower kaolinite/illite ratios than those of the lacustrine facies of Units B, D and F. It is possible that some illite might have been transformed into kaolinite which is more stable in acidic peat swamp and lacustrine environments.

In conclusion, the sedimentary sequence in the southwestern part of the Mae Than basin is interpreted, in the light of sedimentary facies, to be of fluvio-lacustrine and peat swamp in origin. It is also noted that the reactivation of intra-basinal and basin-marginal faultings are believed to occur intermittently throughout the depositional history of the sediments in this southwestern part of the basin. Evidences of active subsidence due to faulting in sedimentary environments are lateral thickening of numerous sedimentary units, relatively thick coal seam, fanglomerate deposits intercalated with lacustrine facies, etc.

The sedimentary sequence, the sedimentary facies, and proposed reconstruction of depositonal environment of the Cenozoic deposits in the southwestern part of the Mae Than basin are summarized and present in Table 3.1.

Table 3.1 Summarizing the sedimentary sequence, sedimentary facies, and proposed depositional environment of the Cenozoic deposits in the southwestern part of the Mae Than basin.

Sedimentary Unit/ Thickness (m)	Lithological characteristics	Sedimentary facies	Depositional environment
Unit A (7-65 m)	Several cycles of gravel, sand, mud association with sand dominant, fining-upward sequence. Locally overlain by top soil.	Fluviatile facies	Fluviatile environment
Unit B (5-35 m)	Dark-colour claystone, some ironstone nodules, laminated, carbonaceous	Lacustrine facies	Fresh-water lake
Unit C (10-35 m)	Upper coal seam with some clay partings, coaly claystone	Peat swamp facies	Subsiding peat-swamp environment
Unit D (30-40 m)	Dark-colour claystone, laminated association with fanglomerate and ironstone bed and coaly claystone.	Lacustrine facies assoc. with fanglomerate facies	Fresh-water lake / distal alluvial fan environment
Unit E (10-40 m)	Lower coal seam with some clay partings, coaly claystone.	Peat swamp facies	Subsiding peat-swamp environment
Unit F	Laminated claystone, siltstone	Lacustrine facies	Fresh-water lake environment