# CHAPTER II

## 2.1 Regional Geology

As indicated in the first chapter, the study area is located not too far from the western edge of the Khorat Plateau and within the eastern part of the Upper Chao Phraya basin. Regionally, the study are is occupied by several kinds of rocks of different ages and forms part of the Loei-Phetchabun-Ko Chang of Jungyusuk & Khositanon (1992). Based on geologic map modified from Chongrakmani and Sattayarak (1979) shown in Figure 2.1, there are two major rock types observed, sedimentary rocks and the other is igneous rocks.

### 2.1.1 Sediments and Sedimentary Rocks

*Huai Hin Lat Formation*

The rock in this Formation are dominated by yellowish brown conglomerate, yellowish brown to reddish brown sandstone, reddish brown siltstone, green conglomeratic sandstone showing cross-bedding. Part of these rocks is thermally metamorphosed. This formation was found in the western part of the regional area.

*Pha Nok Khao Formation*

The rock in this formation consists of well bedded to massive limestone with black chert lenses, sandstone and shale. The age base on fossils is assigned as Lower-middle Permian.

*Unconsolidated deposits*

The Quaternary sediments are alluvial deposit , river gravel sand, silt, clay and the terrace deposit, talus pile and colluvial deposit, composing of gravel, sand, silt and clay. They were found in the western and eastern parts of the regional area. The western part of regional area is the study area.

### 2.1.2 Igneous rocks

Igneous rocks in this regional study area consist chiefly of 3 kinds of rocks ranging in composition from felsic to intermediate affinities. They are volcanic, pyroclastic and plutonic rocks.

*Volcanic and pyroclastic rocks*

The rocks are tuff, lapilly, agglomerate, volcanic breccia, andesite and basaltic andesite. Stratigraphically, the unit indicates Permo-Triassic age as they were observed to lie between the Middle-Upper Permian and Upper Triassic unit.

Volcanic rocks with intermediate to felsic compositions occur as lava flows, pyroclastic deposits, and dyke and sills. The volcanic rocks are predominantly of andesite, andesite tuff, basaltic andesite, andesitic breccia, rhyolite and rhyolitic tuffaceous rocks. Their ages range from Middle-Upper Permian to Lower Jurassic (Jungyusuk and Khosithanont, 1992). Plutonic rocks are covered by unconsolidated sediments, however, airbone magnetic data indicate that dykes and stocks of granodiorite intruded in the area, particularly in the southern part of the Chatree gold mine. Stratigraphic relations constrain the age of these plutonic rocks to a minimum Triassic age (DMR,1999).

Diemar et al. (1992) have observed volcanic rocks in this Loei-Phetchabun-Kho Chang belt which are basaltic andesite and andesite cross-cut and flowed over middle Permian limestone and locally overlain by Triassic sedimentary rocks. Crossing (2004) has interpreted that in the Chatree region there are several andesitic volcanic centers and a couple of rhyolitic centres. Proximal to the andesictic volcanic edifices are intercalated lavas, pyroclastics and volcaniclast sediments. They display significant lateral unit variation and complex interfingering with adjacent volcanic centers. Thick andesite lava flows interdigitate with andesitic auto breccias, and these are interbedded with lithic (lapilli) tuffs of andesitic composition, and less volumetrically important crystal and ash fall tuffs. The lithic tuffs are often very large and consistent unit and extend well beyond the andesite lavas, suggesting they may be of a large

valley filling or submarine mass flows rather than air-fall tuffs. The volcano-sedimentary sequence is mostly gently folded, with dip angle mostly less than 30 and rarely exceeding 45 except near faults. In general the bedding becomes shallower dipping in the eastern half toward the edge of the Khorat plateau. Steeper dips occur in two NE-SW trending structural zones discussed below, especially in the immediate of large faults.

The Chatree gold mine is located in the Loei-Petchabun volcanic Belt extending approximately N-S through central Thailand. Volcanic rocks along the Loei-Phetchabun Volcanic Belt formed in several episodes from Late Devonian and extending to the Late Tertiary, with features indicating a diverse range of tectonic settings (Intasopa, 1993). The geochronological data of Charusiri (1989) and Intasopa (1993) show the rocks of the Loei-Phetchabun Volcanic Belt are Permo-Triassic to Miocene.

The Loei-Petchabun-Ko Chang volcanic belt, where the study area is located is an arcuate belt of mainly calc-alkaline volcanics that extends north-south along the western edge of the Khorat Plateau from Loei Province in the north to Ko Chang in the south (Gulf of Thailand). It is situated within the Loei-Fold Belt or the so-called Nakhon Thai block of Charusini et. al.,(2002), a Paleozoic-Mesozoic feature that consists of a series of north-south trending granitoid belts and associated volcanics. The Loei Fold Belt formed as a result of collision between the Burmalayan and Indo-Sinain Plates, which resulted in the amalgamation of fossil arcs and micro-continents (Crossing, 2004).

*Plutonic rocks*

The intrusive rocks can be divided into 3 phases, diorite, granodiorite and granite. The diorite is dark grey with porphyritic texture. Pheonocrysts are plagioclase and hornblende with the average size of 1 x 1.5 cm. The granodiorite is dark grey, mainly fine grained with porphyritic texture with 1 x 0.5 cm. Phenocrysts of hornblende. The granite is white, creamy white, pinkish white and yellowish grey in color. It has a porphyritic texture with phenocrysts of plagioclase. Muscovite was observed locally in some granite phase. The plutonic rocks are of Triassic age but some may be younger.

Because some of them were observed to intrude the upper Triassic sediment units. The study area is located on boundary between Phichit and Phetchabun provinces, north-central Thailand. The study area lies within Loei-Phetchabun volcanic fold belt (Diemar et al., 2000) which extends from northern Laos through central Thailand and occupies east of Raub Bentong structure in Peninsular Malaysia. In Thailand, the belt is significantly bound by upper Permian and Triassic parallel zones of ancient island arc that contains acid to intermediate volcanic and marine sedimentary rocks.

Plutonic rocks are covered by unconsolidated sediments, however, airbone magnetic indicate that dykes and stocks of granodiorite intruded in the area, particularly in the southern part of the Chatree gold mine. Stratigraphic relations constrain the age of these plutonic rocks to a minimum Triassic age (DMR, 1999). Crossing, 2004, various intrusive ranging in composition from felsic to mafic intrudes the sequence as small to medium sized stocks and dyke. Most common are mafic intrusive dominated by diorite but ranging in composition from granodiorite to dolerite, and texturally from fine, even grained to porphyritic. Granitic intrusions occur as several clusters of stocks and dike, often associated with regional structural trends. Two such clusters occur in the vanity of Chatree gold mine where they appear to be spatially associated with intersecting and southeast structural trends; however the largest cluster is arranged along a NE-SW structural trend extending through Ban Khlong Takhian, and most of these are porphyritic texture. Large intrusions of granodioritic and diorite composition also occur to the south and southeast of this area, and some of these are also porphyritic (Crossing, 2004)

## 2.2 Geology of the Chatree gold mine

### 2.2.1 Volcanic Rocks

A package of the volcano-sedimentary sequence of the Chatree region contains several andesitic volcanic centres and a couple of rhyolite centres. Large and well-exposed andesitic volcanic centres are at Ban Mai Wang Takhian, Chatreee mine, and

Khao Phanompha (Crossing, 2004). Proximal to andesitic volcanic edifices are intercalated lavas, pyroclastic and volcaniclastic sedimentary rocks displaying significant lateral unit variation and complex interfingering to the adjacent volcanic centres. Thick andesite lava flows interbedded with andesitic autobreccias, and these interbedded with lithic tuffs mixed provenance sedimentary rocks. Crystal and ash fall tuffs are less volumetrically important (Crossing, 2004). The rhyolitic volcanic centre at Khao Khieo was formed by a very thick rhyolitic crystal tuff with occasional lithic fragments, which distally interbedded with andesite units. It contains some thin interbeds of tuffaceous sediments and appears to overlay the adjacent andesitic lithologies. At Ban Nikhom village flow banded rhyolite, rhyolitic tuff and peperite are exposed in several shallow dams.

### 2.2.2 Sedimentary Rocks

More distally these volcanic units interdigitate with generally thick, well-bedded sequence of interbedded fine-grained volcaniclastics and epiclastic siltstone and shale, massive tuffaceous mudstone and more distally epiclastic siltstone and shale. These units are well-exposed at Wang Pong. Small exposures are found in the mine.

### 2.2.3 Plutonic rocks

Various intrusives ranging in composition from felsic to mafic intrude the volcanic sequence mostly as small- to medium-sized stocks and dykes. Volumetrically most important unit is mafic intrusives dominated by diorite but ranging in composition from granodiorite to diorite, and texturally from fine-grained, equigranular to porphyritic. Crossing (2004) reported that granitic intrusions occur as stocks and dykes, one to the north of the Chatree gold mine around Ban Wang Phlap, and other to the south (Ban Lang Du). They appear to be spatially associated with northeast and southeast structural trends. Kamwong (2004) studied plutonic rock at Wang Pong district (about 50 km from Chatree gold mine) and described small stocks which range in composition from granite to diorite. He classified two types namely, biotite granite and granodiorite.

The former one is fine-, to medium-grained and the later one is medium-grained inequigranular texture. Petrochemical study suggested that it is A-type granite (Kamwong, 2004). Besides, small stocks of granitoid rocks also reported at Khao Ron Thong of Chon Daeng district (Rodmanee, 1992). Diorite (?) porphyry also have been encountered in drill holes at N-prospect and V-prospect (Mahotorn et al., 2008).

### 2.2.4 Structures

Major structures of the region area trend north to south, and comprise the southerly pluging Loei anticlinorium in the north, the NNW - oriented Chum Phae synclinorium, and the WNW - trending Saraburi anticlinorium (Garwin, 1993). Regional faulting is in a north-south, north-west and north-east direction associated with collision of the Shan-Thai and South-east Asia Plates, (and the South China Plate). Subsequent uplift, are the dominant structural features. Bedding attitudes of volcaniclastice in the $10^{\circ}$ to $30^{\circ}$ range may suggest open folding or tilting of structural blocks in the volcanic sequences. A reactivation of the north-west and north-east (transform) faults may have occurred during extensional tectonism associated with the Tertiary opening of the Chao Phraya Basin

### 2.2.5 Mineralization

Metal mineralization occurring in the Belt, regional area is characterized by base metals (Cu,Pb,Zn), iron ore, barite, manganese, pyrite, silver and gold. It is believed that the majority of metallogenesis in the Belt is likely related to the Permo-Triassic intrusive and extrusive igneous rocks (Neusuprab et al.,2005) and volcanic rock and structural preparation provided by anticlinal folds formed during the late Triassic Indosinian Orogeny (Garwin, 1993).

## 2.3 Detailed Geology

The Chatree gold mine is located within a zone of silicified volcanic over an area of 7.5 X 2.5 $km^2$ which forms a slightly elevated landform (see Figures 2.2 and 2.3). The

mineralization is considered to be adularia-sericite epithermal style in the classification of Corbett and Leach (1997). Lithologies present within the mineralized zone are porphyritic latitic and trachytic flows and their pyroclastic equivalents with subordinate fine to medium grained volcaniclastics and sediments (Barron,1995a ,1995b,1996,1998,1999). The basal sequence in the mineralized area is comprised of an undetermined thickness of potash feldspar microporphyritic (± quartz) (± vesicular) (±autobrecciated) latie-trachyte flows

This basal sequence is overlain by a middle sequence of interlayered and interfingered latite-trachyte flows and crystal/lithic/vitric tuff and fine lapilli tuff of porphyritic latite-trachyte origin. Volcaniclastics containing sandstone, siltstone, chert and worn volcanic fragments occur. A stratigraphic thickness of this middle sequence is up to 200 metres.

The volcanic and volcaniclastic sequences are considered to have been deposited near a marine aerial interface. Rare thin layers of marl containing fragments of bryozoa,crinoid stem and mollusk fragments,a coarse tuff occurrence containing numerous large singular corals and tuffaceous siltstone/claystone (± carbonaceous) containing radiolarian and plant remains are all indicative of shallow marine conditions.

Dykes of varying mineralogy are common within the mineralized zone. Thay vary in thickness from a many different orientations controlled by faulting. Dedenczuk,1998 described them in thin section as porphyritic andesite,greenish grey andessite-dacite,dark greenish grey basalt and coarse feldspar dacite,Barron described them as a suite of very shallow quartz monzonite,monzodiorite,latite and trachyandesite dykes.While all are clearly post mineralization thay appear to be derived from similar parent material to the volcanic and are interpreted to be upper Triassic

C-H Pits are composed mainly of volcanic rocks and sedimentary rocks (Figure 2.2). Volcanic rocks can be divided into coherent and non-coherent rocks. The coherent rocks

are composed mainly of andesite and porphyritic andesite. The non-coherent rocks are classified into monomictic, polymictic, and fiamme breccias.

In the C Pit, the main volcanic sequence strikes 310° and dips at an average 30° to the northeast. The H Pit has a strike of 350° and dips north west at between 20° and 45° and merges with the C Pit at its northern end. In C-H Pit the parent structures show strong evidence of pre-, syn-, and post mineralization movement. The youngest movements are represented by uncemented and breccias voided breccias that are interpreted to be Tertiary. The most likely age of mineralization is considered to be Triassic, thereby suggestion that movement on the structures has been periodically active between the upper Permian and Tertiary.

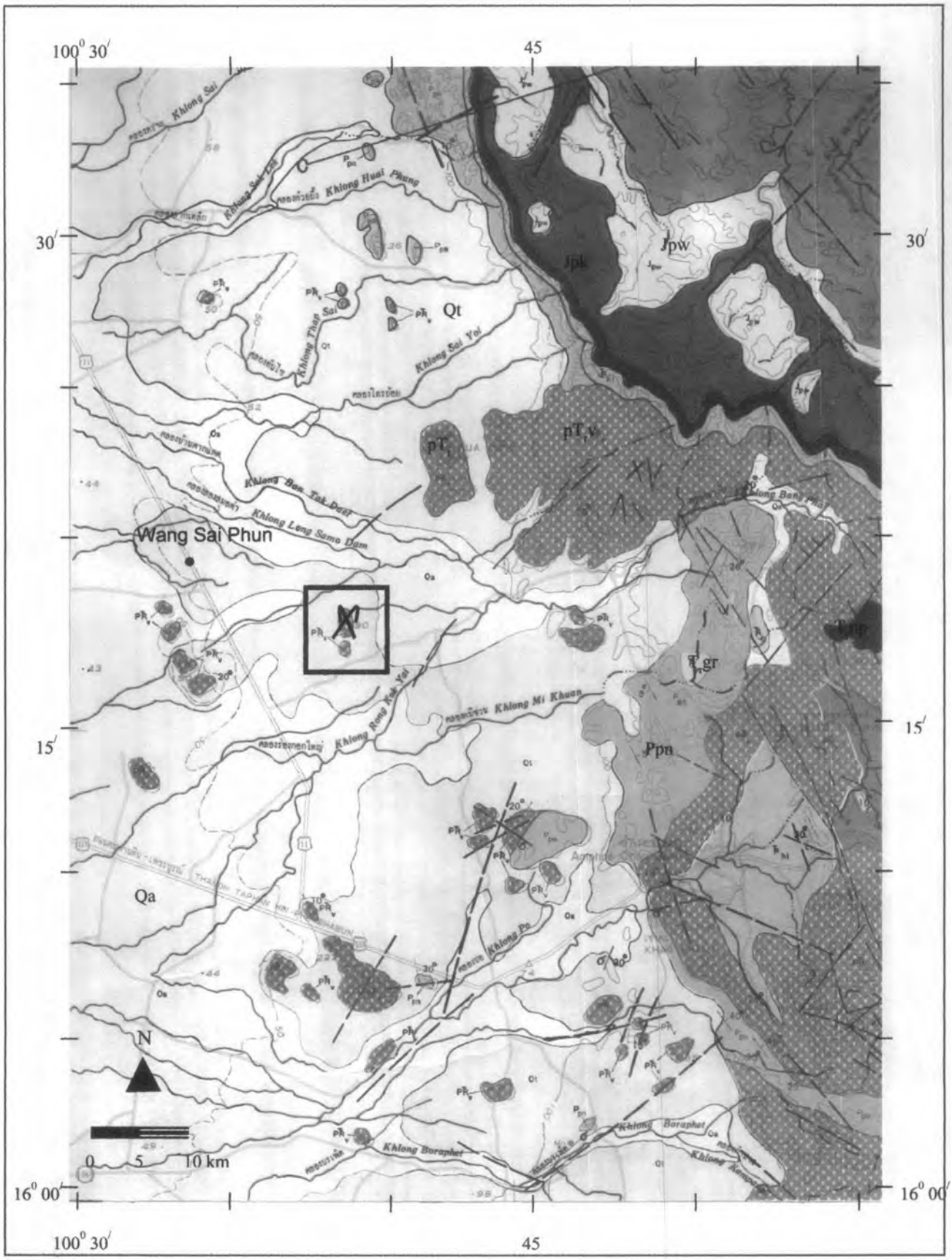


**Figure 2.1.** Geology of the Chatree gold mine and its surrounding region based on the 1:250,000 DMR geological map of by Chonglakmani and Satayarak (1979). Legend on the next page.

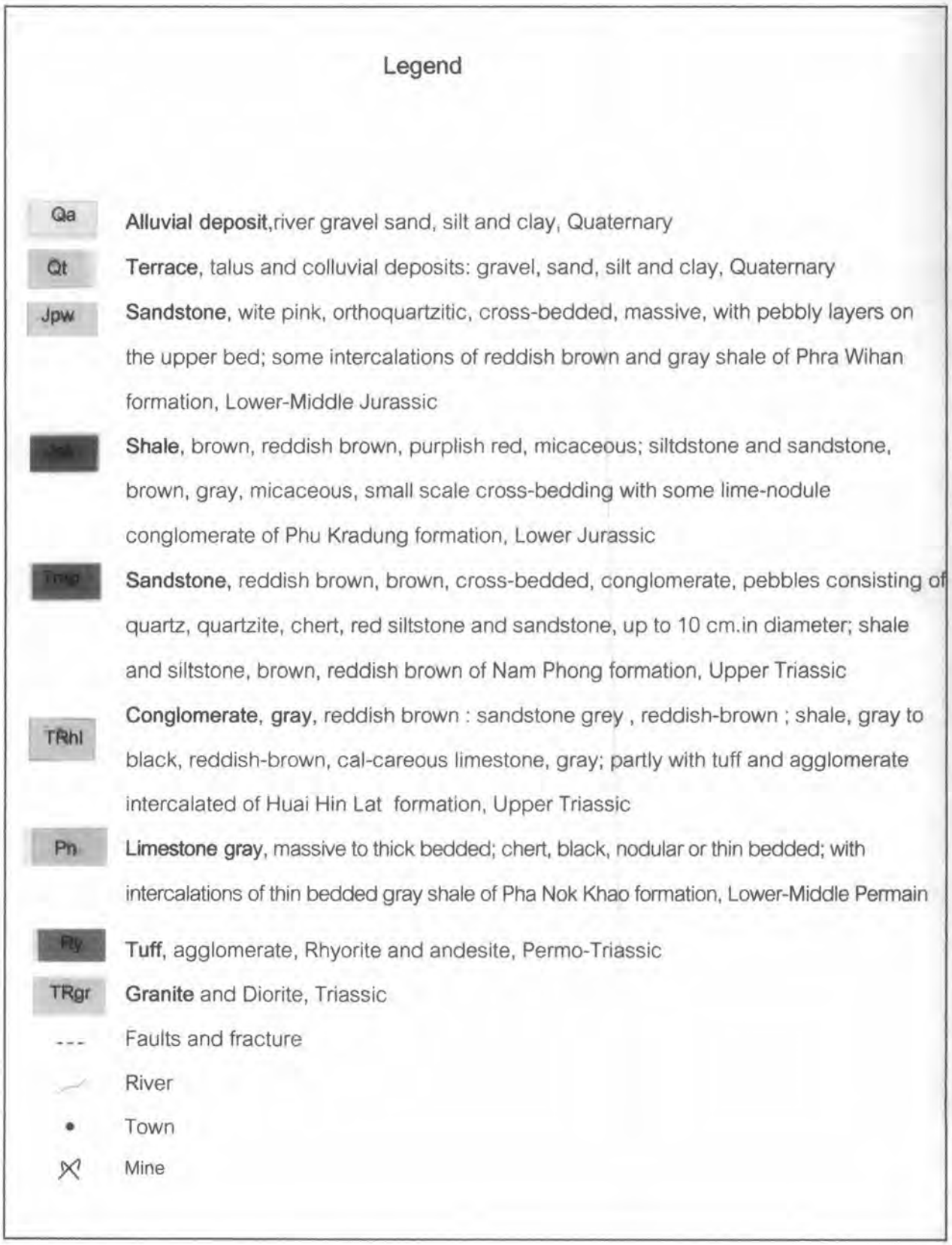


**Figure 2.1.** (cont.)

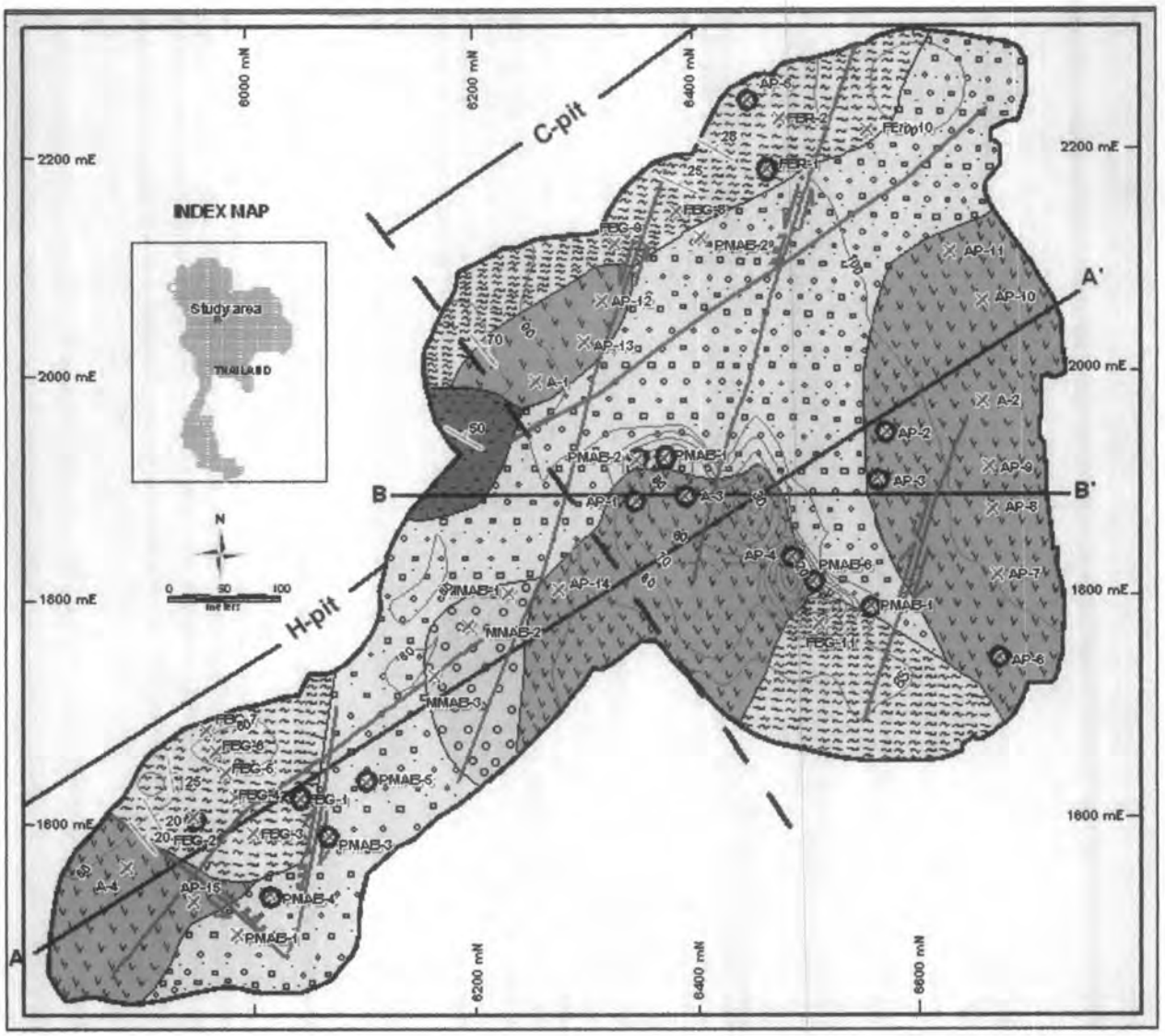


**Figure 2.2.** Geologic map of C-H pit in the Chatree gold mine, Phichit Province, central Thailand (modified after Nakchaiya et al, 2008) (see legend on the next page).

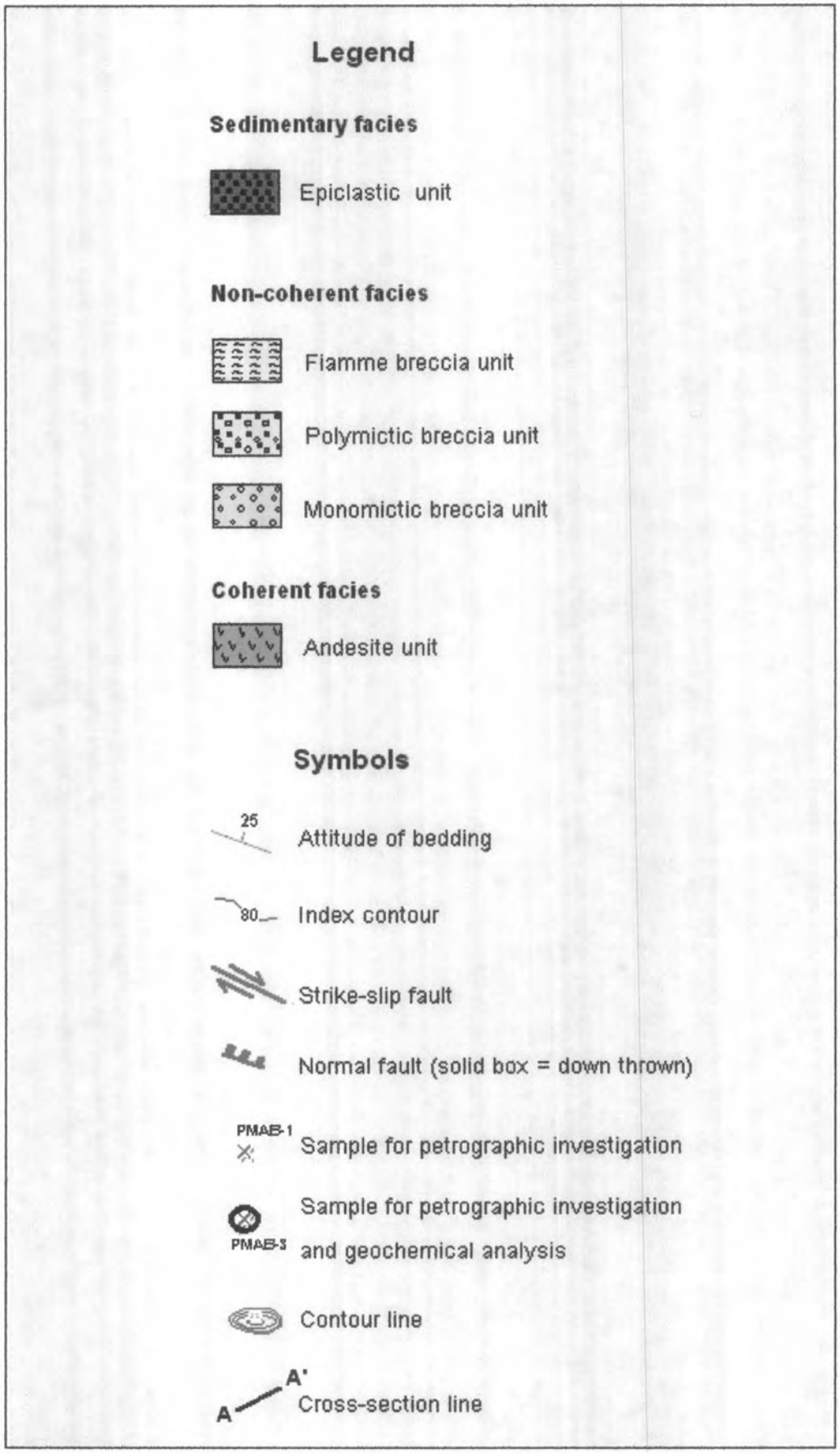


Figure 2.2. (cont.)

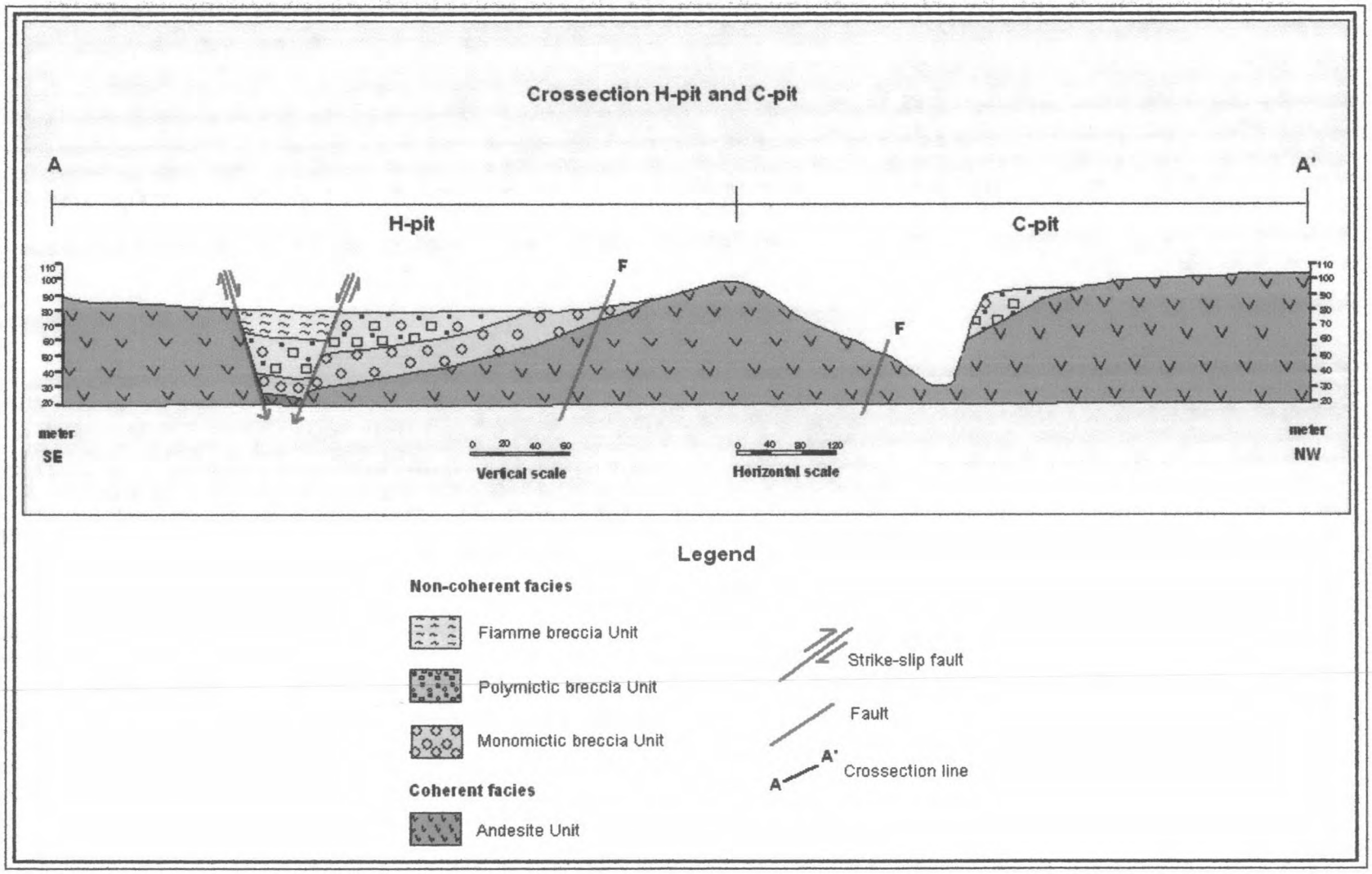


Figure 2.3(A) Cross section NE-SW trend.

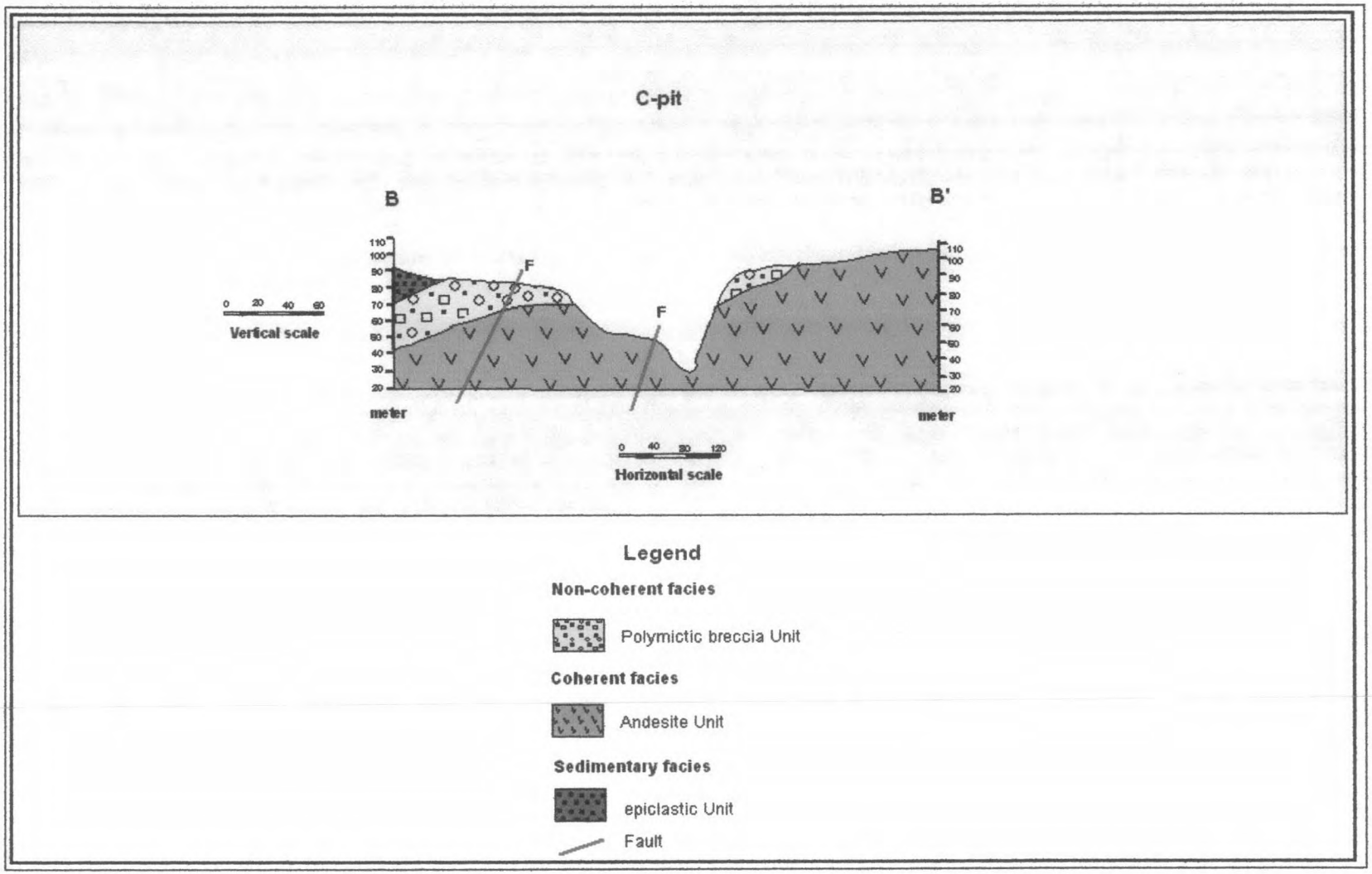


**Figure 2.3(B)** Cross section E-W.