CHAPTER 2

STUDY AREAS AND GEOLOGIC SETTING

The studied areas are divided into three areas. The Northern region includes the area of Chiang Dao District, Chiang Mai Province and Pai District, Mae Hong Son Province. The Northeastern region is Pak Chom District, Loei Province. The area North of Chiang Mai (Fang Chert) lies at the Western side of the Central belt, the Fang Chert is widely distributed in the area between Fang and Chiang Dao, Chiang Mai Province (Kobayashi and Igo, 1966). On the other hand, the Loei area belongs to the Loei-Phetchabun Fold belt on the Western side of the Indochina Block (Chonglakmani *et al*., 1979), which is regarded as a Late Paleozoic-Early Mesozoic orogenic belt formed along the Western margin of Indochina Block. Physiography of the field areas characterized by several mountain ranges. The plains are mostly occupied by territory and cultivated land. Thus, the outcrops are quite rare and mainly located along road cuts and rivers. This research will widely introduce the different three regions and discuss the arguments in favour or against the attribution of Northern and Northeastern Thailand – Paleo-Tethys divided. For the studied areas were selected from Devonian chert sections in each Block (Fig. 1.1).

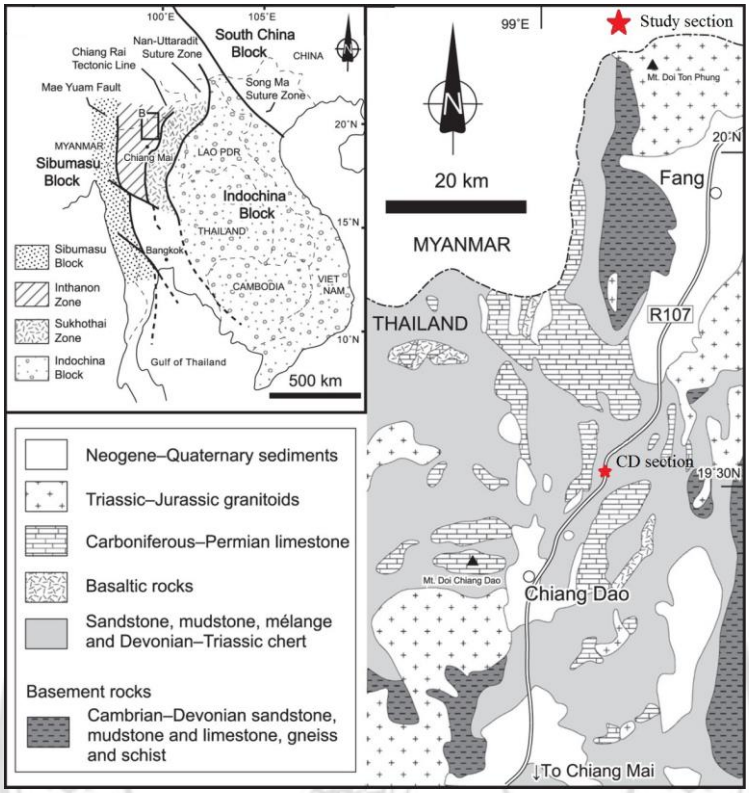
2.1 Geology of Chiang Dao region

The Chiang Dao area is located within the convergence zone of Paleo-Tethyan rocks in the Inthanon Zone. The Inthanon Zone, originally proposed by Barr and Macdonald (1991), is characterized by Paleo-Tethyan oceanic rocks, pre-Devonian basement rocks, and Late Triassic and Early Jurassic S-type granitoids and gneissic rock. The Paleo-Tethyan rocks consist of pelagic Carboniferous-Permian seamount-type carbonate rocks associated with basaltic rocks, Middle Devonian – Middle Triassic radiolarian chert, and mélange-type rocks related to subduction of the Paleo-Tethyan

beneath the Indochina terrane (Ueno and Hisada, 2001; Hara *et al*., 2009; Kamata *et al*., 2009; Ueno *et al*., 2010) (Fig. 2.1A). The Chiang Dao section (CD section) composed of siliceous shale and ribbon bedded chert sequence, which crops out alongside road 107 in the Chiang Dao area, North of Chiang Mai Province, Northern Thailand, was first studied by Kobayashi and Igo (1966). They assigned these oceanic sedimentary rocks to the Middle Ordovician to Lower Silurian based on the occurrence of graptolite fossils from organic-rich black shale. Subsequently, Jaeger *et al*. (1968) and Baum *et al*. (1970) re-interpreted these fossils as lowermost Devonian (Gedinnian to Emsian). Bunopas (1981) re-studied and confirmed the age (Late Pragian), and informally referring this outcrop as the Fang chert. The main sequence of Fang chert is characterized by 15 m of black organic-rich siliceous shale at its base overlain with well-bedded radiolarian-bearing rocks (radiolarites). The characteristic radiolarite facies commonly occurs together with thin intercalated shale. The chert is mostly well stratified in beds 3 to 10 cm thick, with an average of close to 5 cm. As it is common elsewhere, the chert sequence is intensely folded (syn-sedimentary folds) and the true total thickness of the Fang chert is approximately 200 m or less (Wonganan, 2005). Based on the new field and microscopic observations, the siliceous succession in divided into the following five rock types (in increasing stratigraphic order): black shale, siliceous shale, tuffaceous chert, tuff and chert (Hara *et al*., 2010).

The studied section shows exposed bedded chert and alternations of chert and siliceous shale at km 105.80 on highway 107 or the position N19°34′59″, E99°06′03″ in Thai topographic map sheet 4848 III, Amphoe Chai Prakan (Fig. 2.1B). Twenty samples (samples nos. CD 1-20) were collected for radiolarian analysis (Fig. 2.2). This section is composed of grey to dark grey, greenish grey and light grey, well-bedded chert with folding (Figs. 2.3B – C). The greyish black chert with beds 3-10 cm thick (Figs. 2.3D – E). The height of this outcrop is about 5 m and the length is about 25 m (Fig. 2.3A).

A



B

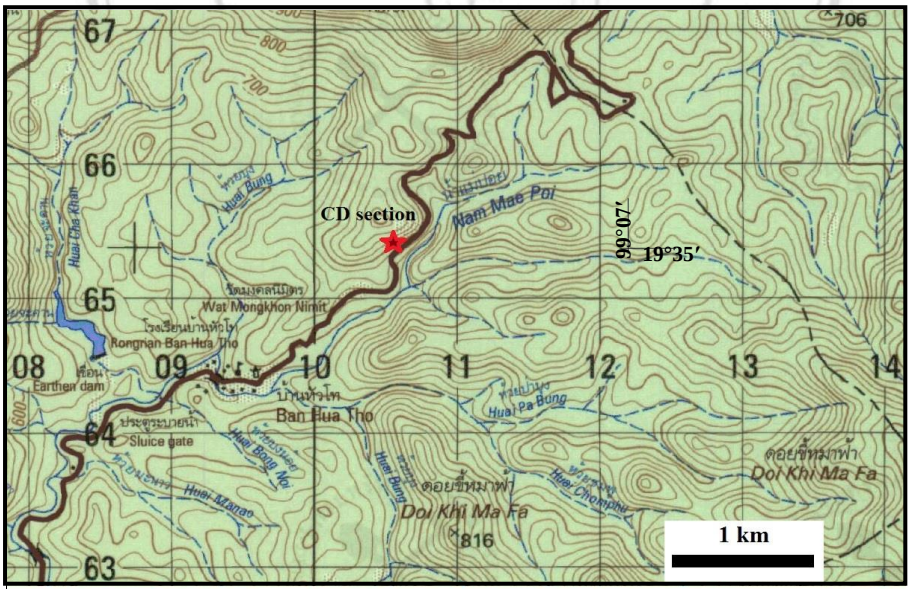


Fig. 2.1 (A) Geology of the Chiang Dao area in Northern Thailand, and surrounding area (modified from Department of Mineral Resources, 1999).

(B) Topographic map showing the locality of the studied section (modified from topographic map scale 1 : 50,000, sheet number 4848 III, Amphoe Chai Prakan, Royal Thai Survey Department, 1969).

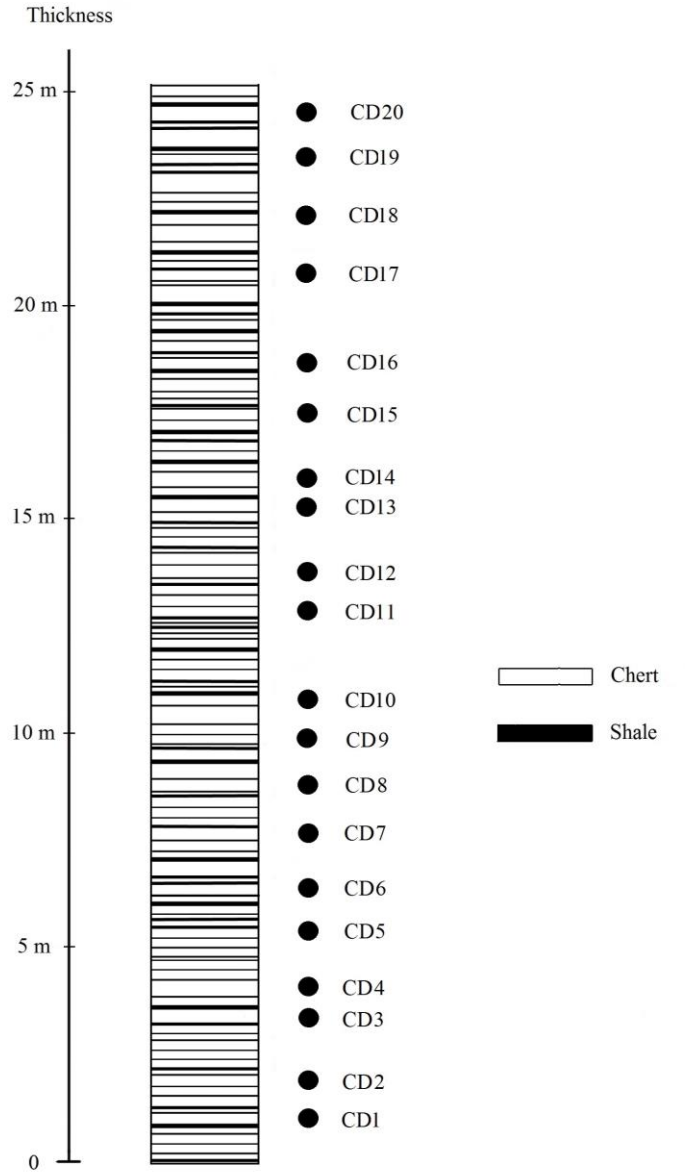


Fig. 2.2 Columnar section of CD section (CD1 – CD20) showing the thickness of chert and shale with spacing of sample collecting.

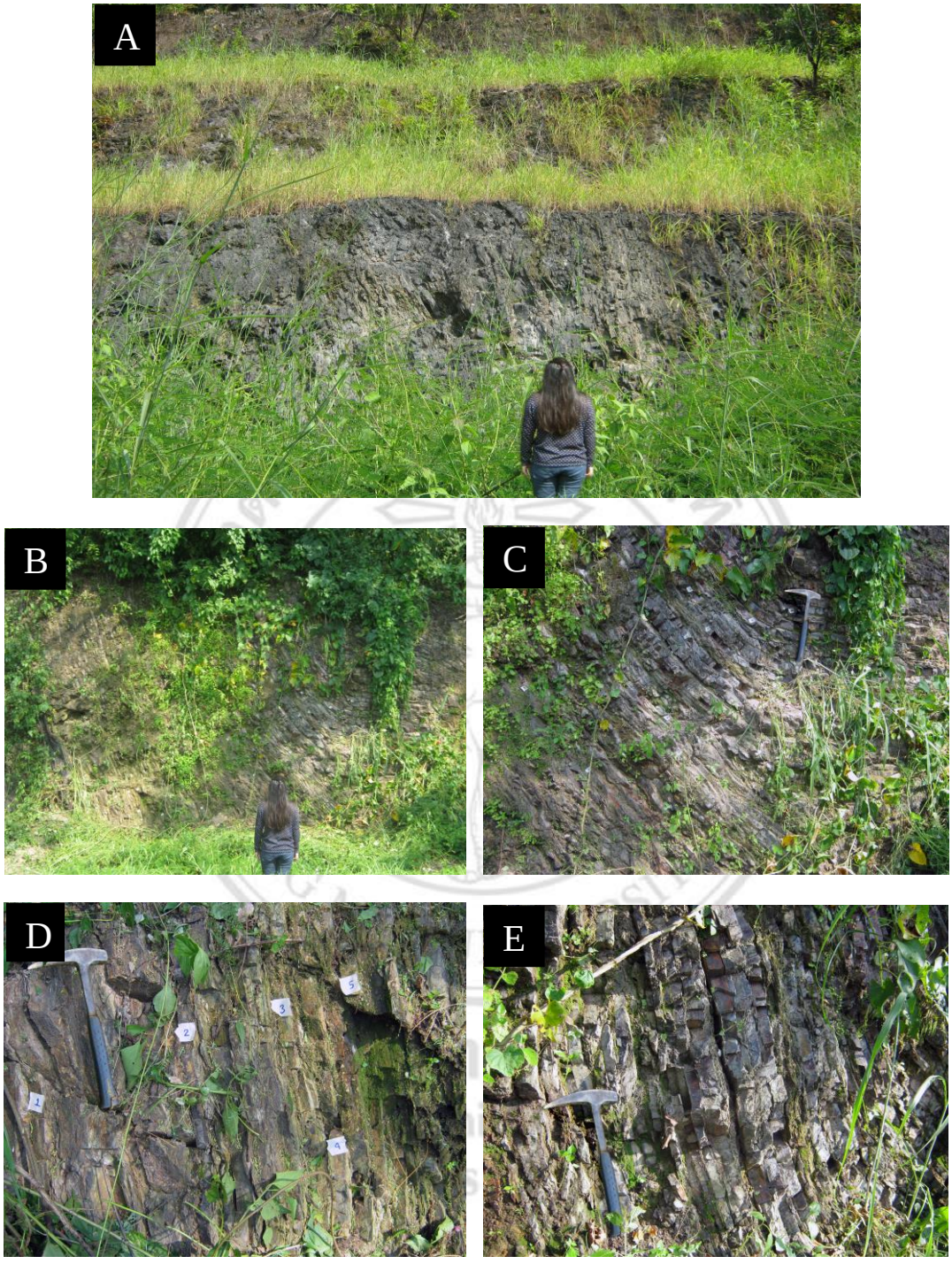


Fig. 2.3 (A) General view of the Chiang Dao section, showing chert and alternations of chert and siliceous shale.

(B, C) Grey to dark grey well bedded chert with folding.

(D, E) Greyish black well bedded chert, of Chiang Dao section (scale = 41 cm).

2.2 Geology of Pai region

The Pai area is located in Northwestern Thailand, approximately 110 km from Chiang Mai city. According to Bunopas (1981), the main Paleozoic sedimentary rocks exposed in Northwestern Thailand are those of the Silurian-Devonian Mae Hong Son Formation (Bunopas, 1981). However, these same rocks have been considered Carboniferous and Permian (Chuaviroj *et al*., 1985; Intawong *et al*., 1997). The Mae Hong Son Formation consists of massive and bedded sandstones, shale and chert. The area also has limestone that forms many isolated karst hills. The limestone has abundant Carboniferous and Permian foraminifera, as well as other fossils. It is considered to be the limestone of the Ordovician Limestone Group (Bunopas, 1981). Lithologically, the limestone is massive to very thick bedded, locally dolomitic, and contain lenses and nodules of chert. According to field observation limestone rocks unconformably overlain the siliceous sediments, and the contact is occasionally observed as a faulting with rock breccias (Wonganan and Caridroit, 2005b) (Fig. 2.4A).

The Pai section is located in Ban Pang Paek, Pai District, Mae Hong Son Province or the position N19°25′04″, E98°20′17″ in Thai topographic map sheet 4647 I (Fig 2.4B). The studied section shows exposed bedded chert and alternations of chert and shale at kilometer 118.350, on highway 1095. Thirty samples (samples no. 118N-1 – 118N-15 and 118S-1 – 118S-15) were collected for radiolarian analysis (Figs. 2.5 and 2.6). The height of this outcrop is about 3.5 m and the length is about 6 m (Fig. 2.7A). Strongly folded chert beds occur in the middle part of the Pai section (Fig. 2.7B). These chert beds trend North-South and dip vertically. The rocks consist of grey, dark grey, and black, bedded chert, with individual beds generally 2 to 5 cm thick, though some beds are 6 to 8 cm thick (Fig. 2.7C).

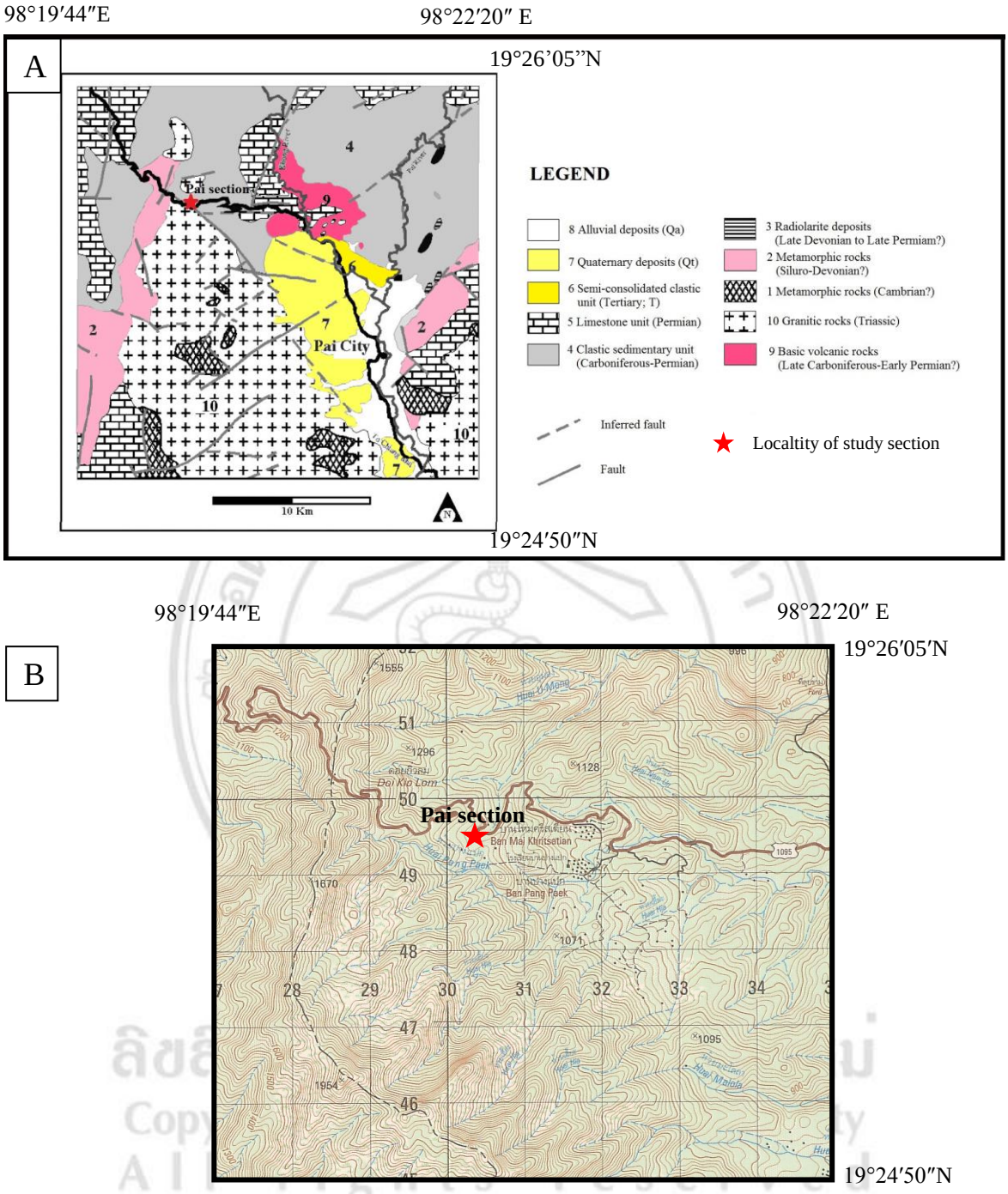


Fig. 2.4 (A) Geologic map of Ban Pang Paek area, showing the distribution of rock units and sampling location (modified after Chuaviroj *et al*., 1985; Intawong *et al*., 1997; Wonganan and Caridroit, 2005b).

(B) Topographic Map showing the locality of Pai section exposed at Ban Pang Paek area, Northwest of Pai city (modified from the topographic map scale 1 : 50,000 sheet number 4647 I, Royal Thai Survey Department, 1997).

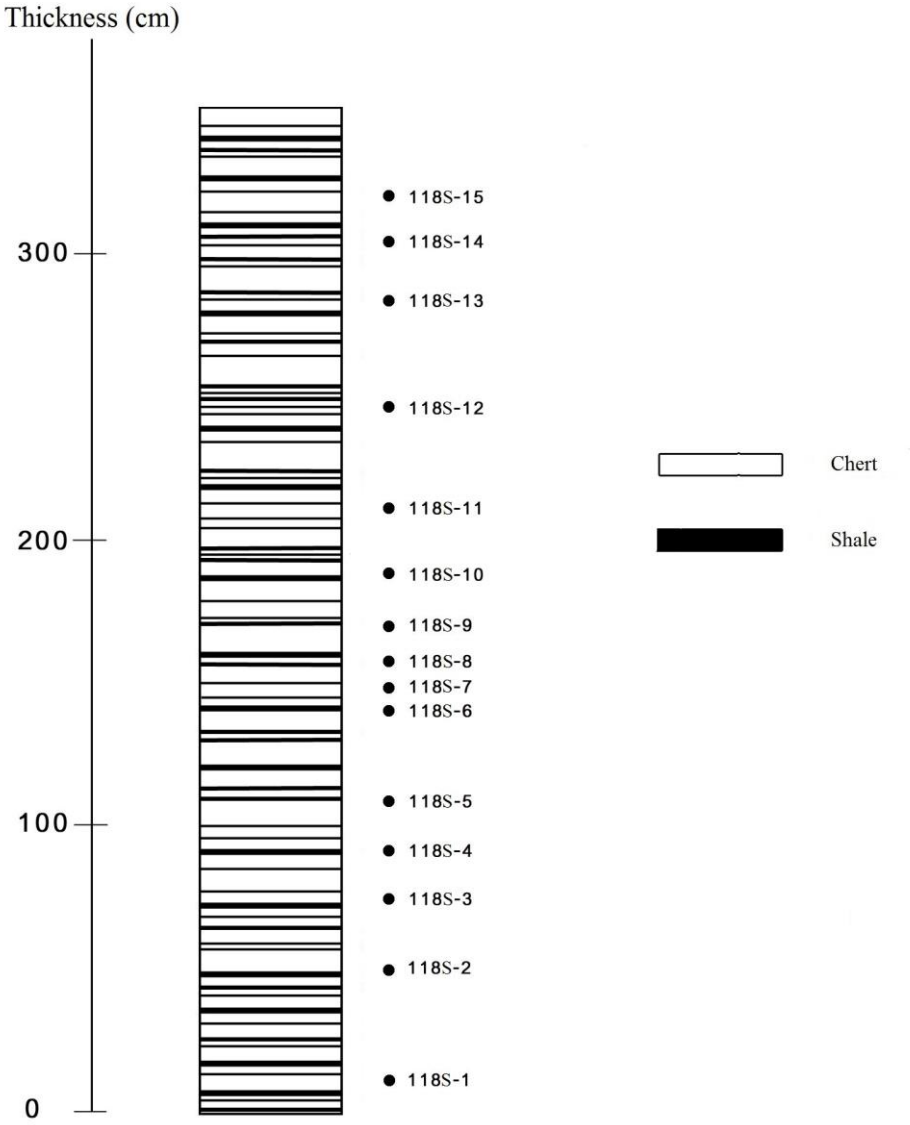


Fig. 2.5 Columnar section of Pai section (118S-1 – 118S-15) showing the thickness of chert and shale with spacing of sample collecting.

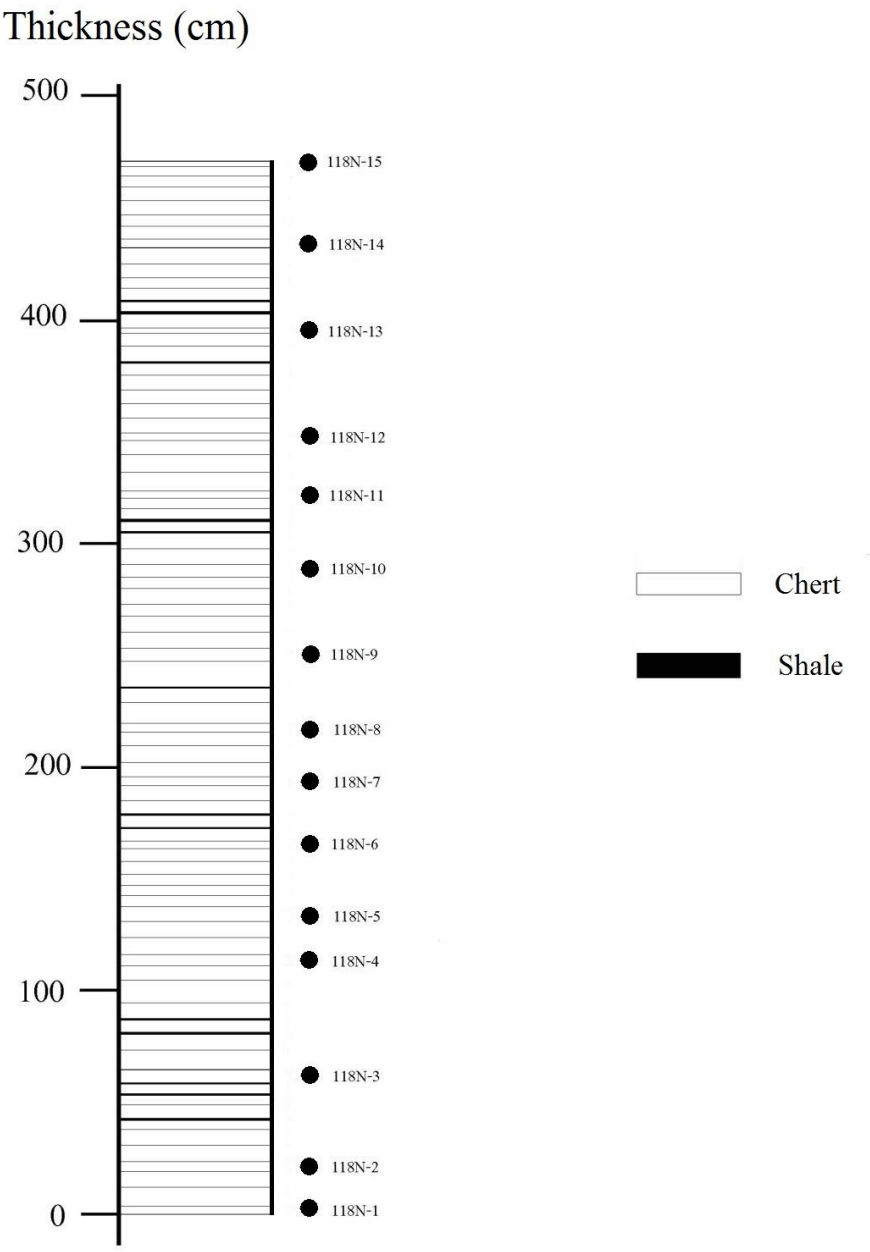


Fig. 2.6 Columnar section of Pai section (118N-1 – 118N-15) showing the thickness of chert and shale with spacing of sample collecting.

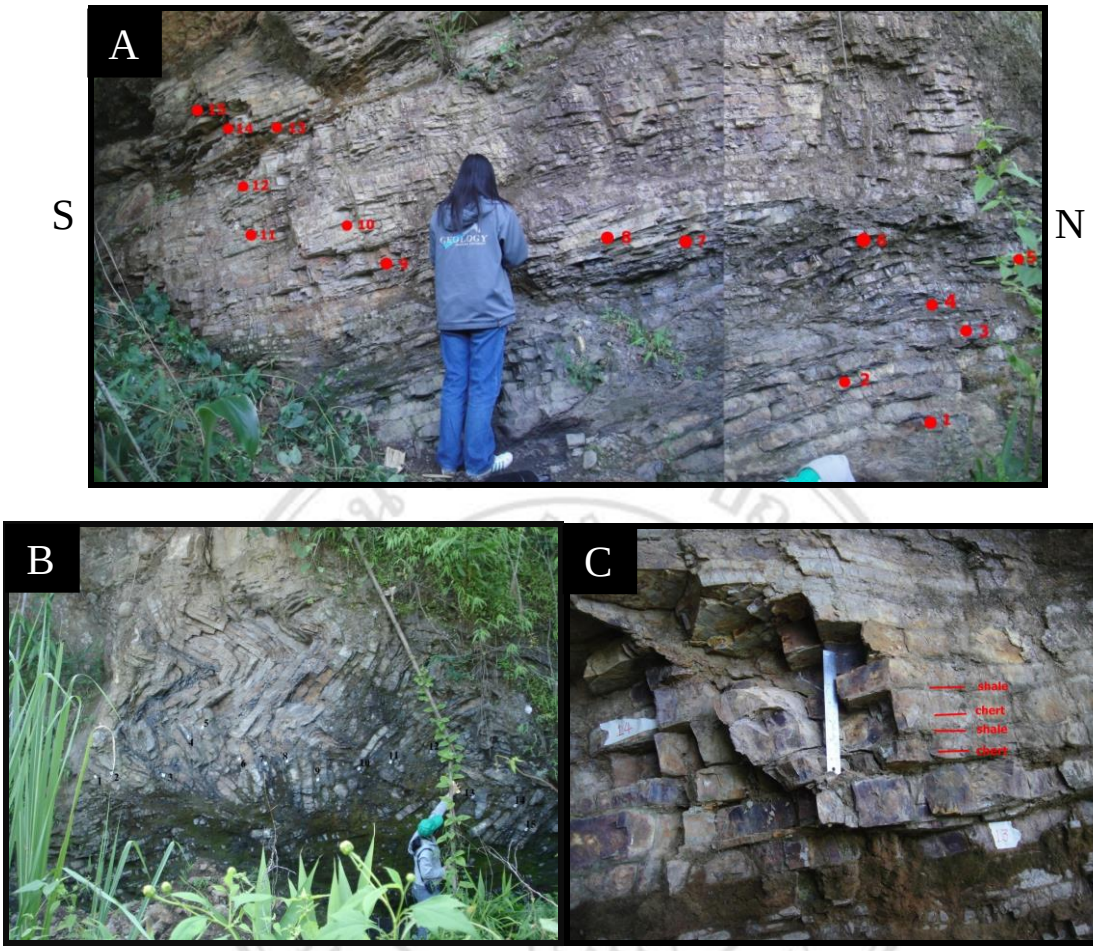


Fig. 2.7 (A) Well bedded chert intercalated with shale of Pai section, view towards West.

(B) Outcrop showing well bedded chert with strongly folded chert beds.

(C) Well bedded chert with very thin shale intercalation (scale = 15 cm).

2.3 Geology of Pak Chom region

The Pak Chom area is located in Loei Province, Northeastern Thailand. The Middle to Upper Paleozoic rocks are underlie the Mesozoic Khorat Group and crop out along the Western escarpment of the Khorat Plateau. Fossils contained in these Paleozoic strata have been documented by Toriyama (1984). Fontaine *et al*. (1981) and Fontaine and Tantiwanit (1987) reported the occurrence of abundant Devonian and Carboniferous fossils in the area North of Loei. Sashida *et al*. (1993) recovered Middle Devonian to Early Carboniferous, Late Carboniferous and Early Permian radiolarian

faunas from chert, siliceous shale, and tuffaceous siliceous shale at several localities in the Pak Chom-Loei area. They collected radiolarian bearing rocks from a chert-clastic section in this area, where the rock sequence can be correlated to the Pak Chom Chert Member of the upper part of the Devonian Pak Chom Formation and the lower member of the Carboniferous Wang Saphung Formation (Bunopas, 1992). The Pak Chom Chert Member is more widespread East of Loei, especially in the Pak Chom District and West of Udon Thani (now in Nong Bua Lam Phu Province), and consists of chert and intercalations of tuff and shales, and a limestone band containing Middle Permian stromatoporoids and corals (Fontaine and Tantiwanit, 1987). The lower member of the Wang Saphung Formation covers a wide area in the Pak Chom area and consists of a shale, sandstone and limestone lens containing crinoid stems, bryozoans, trilobites, fossil leaves and latest Devonian to Early Carboniferous spores (Fig. 2.8A).

The Pak Chom section (PC section) is located in Ban Si Phuton, Tambon Pak Chom, Pak Chom District about 90 km North of Loei Province or the position N18°1′17″, E101°52′40″ in Thai topographic map sheet 5345 III (Fig. 2.8B). Fifty samples (samples no. PC 1-50) were collected for radiolarian analysis (Fig. 2.9). This section is composed of greenish grey to brownish grey, well bedded chert, with beds 2-5 cm thick (Figs. 2.10E – F), with intercalated thin layers of dark grey to black siliceous shale (Figs. 2.10B - D). The height of this outcrop is about 3.5 m and the length is about 20 m (Fig. 2.10A).

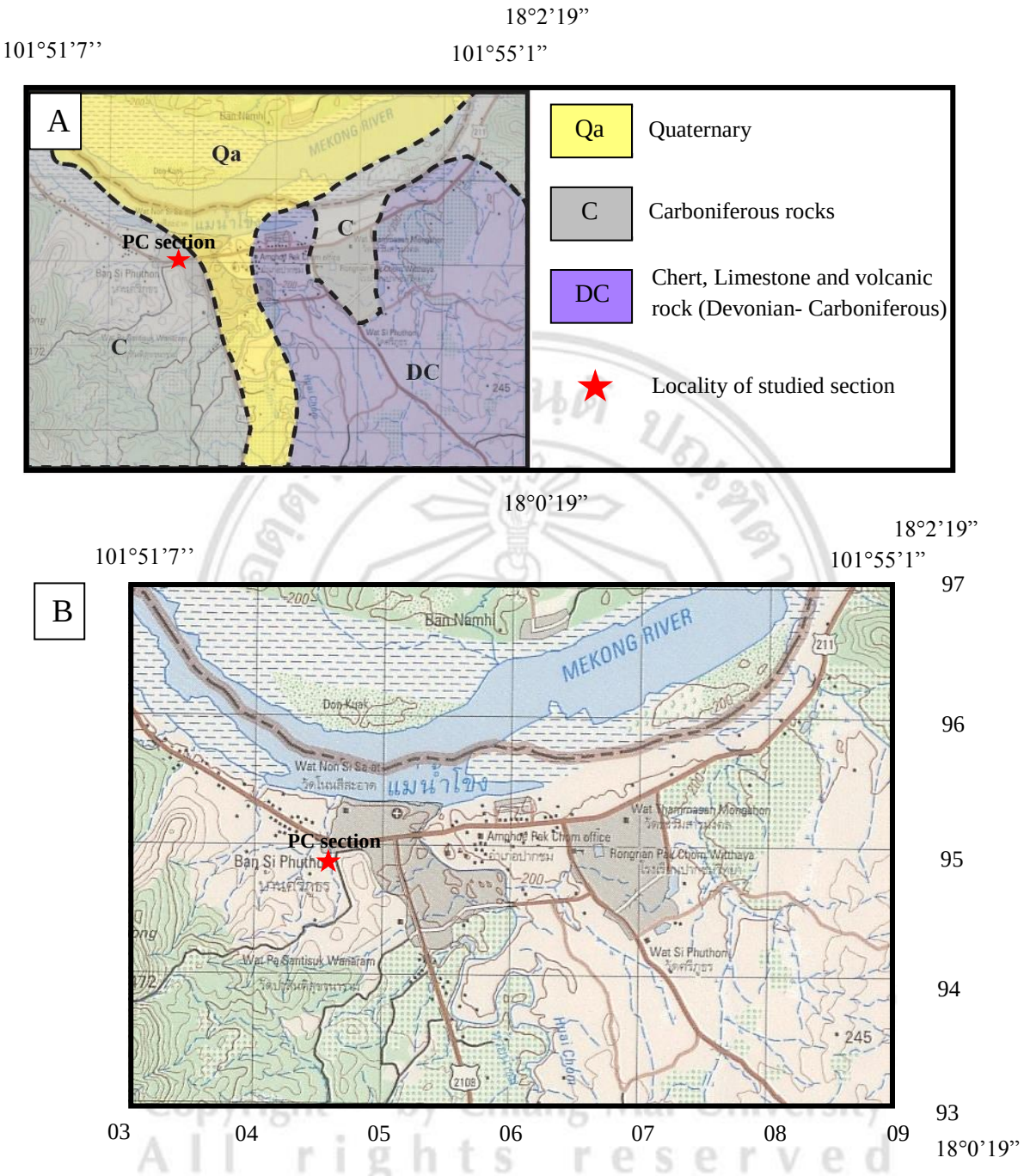


Fig. 2.8 (A) Simplified geologic map of the Pak Chom area, showing the distribution of rock unit and sampling location (modified after Sriburee, 2008).

(B) Topographic map showing the localities of the studied section (modified from topographic map scale 1 : 50,000, sheet number 5345 II, Amphoe Pak Chom, Royal Thai Survey Department, 1999).

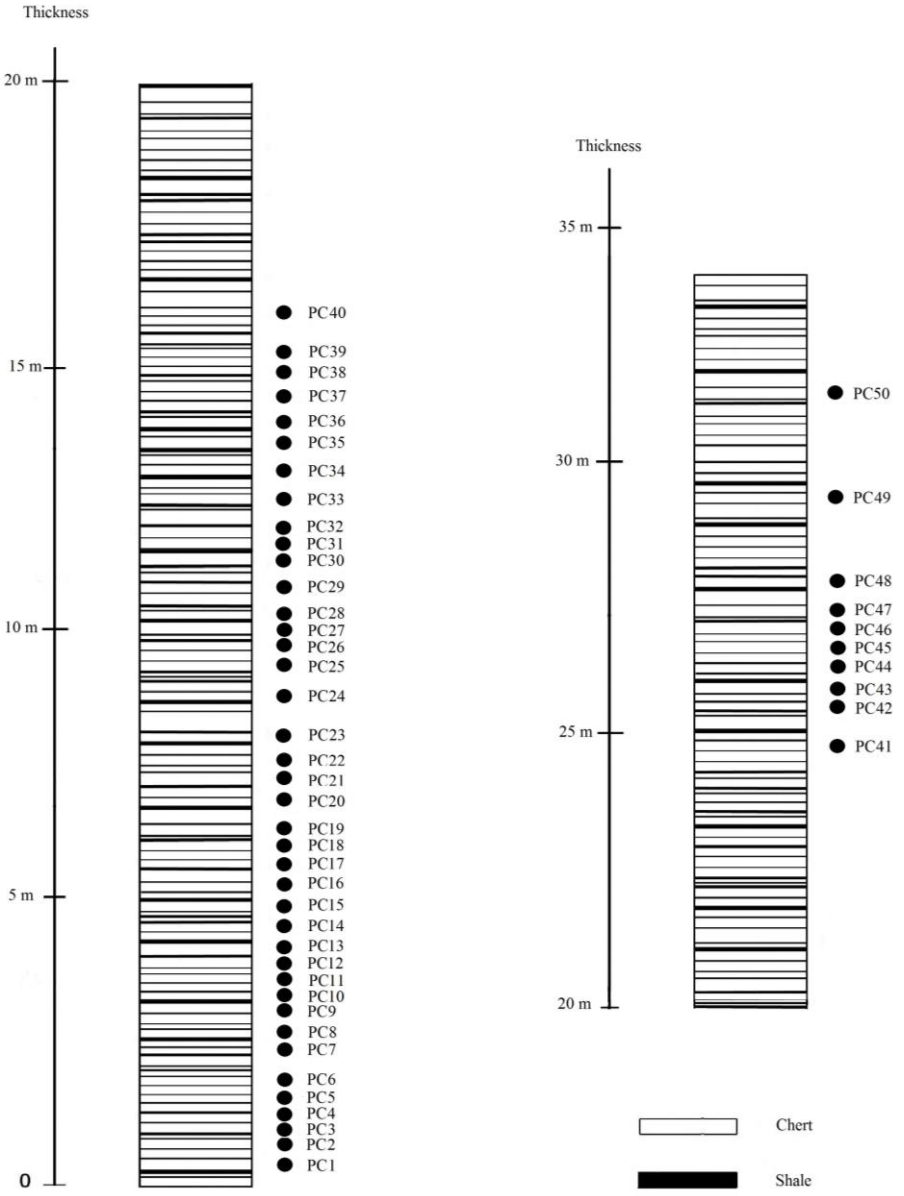


Fig. 2.9 Columnar section of PC section (PC1 – PC50) showing the thickness of chert and shale with spacing of sample collecting.

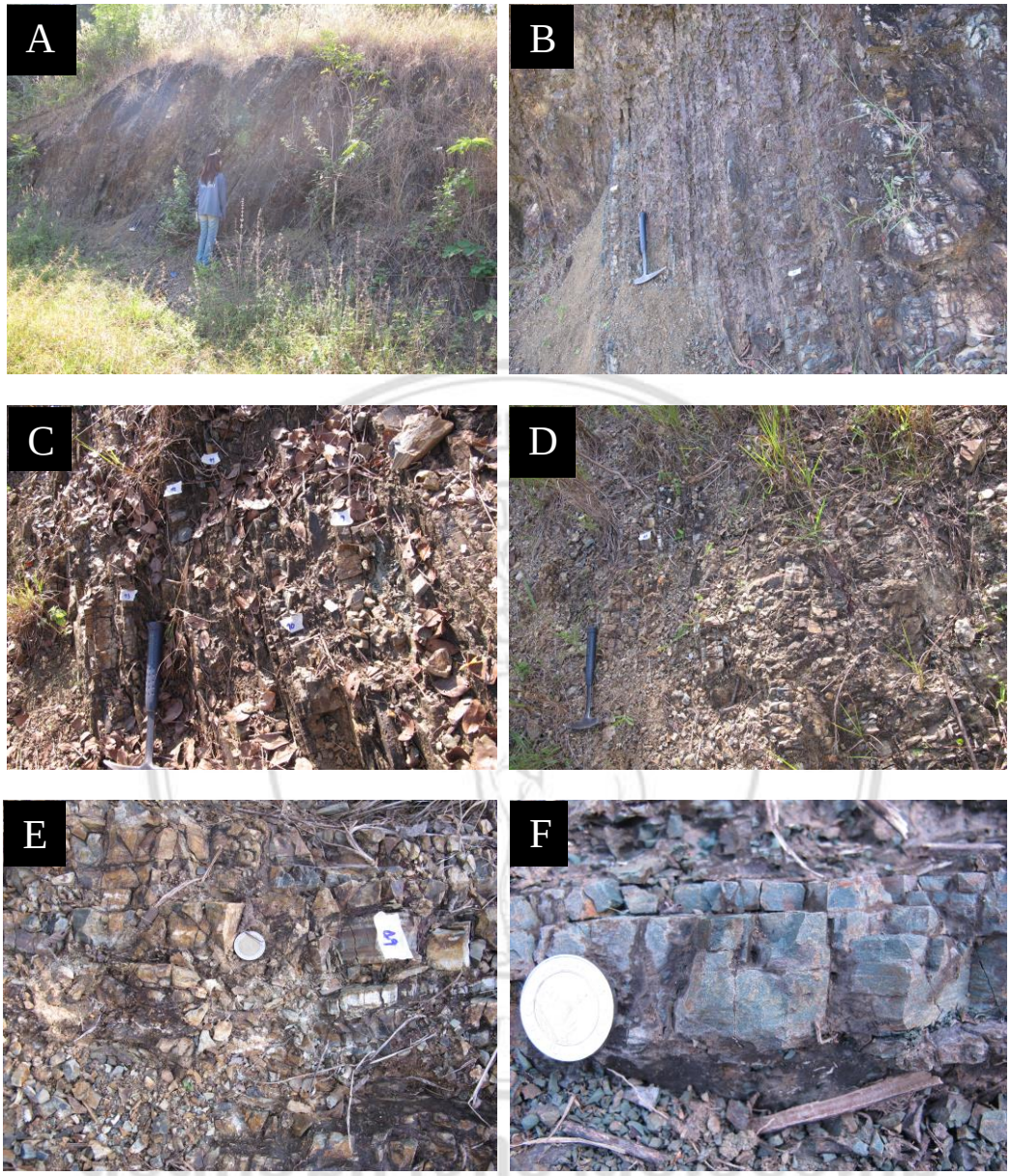


Fig. 2.10 (A) Detail photo of the part of PC section, well bedded chert.
(B, C, D) General view showing the greenish grey chert intercalated with shale in the PC section (scale is = 41 cm).
(E, F) Outcrop showing greenish grey to brownish grey well bedded chert with 2 to 5 cm thick (scale diameter = 2.5 cm).