# 2. THE FLUORITE DEPOSITS

## 2.1 Introduction

There are about 109 fluorite deposits in northern Thailand which can be divided geographically into 8 districts. A representative deposit from each district was selected for this study by using the following criteria:

1) The deposit should be large ; epithermal deposits seem to be the most important fluorite resource.

2) The deposit should be readily accessible.

3) If the deposit contains hot springs in the vein, or close to the vein, it will be useful for studying the relationship between hot springs and fluorite.

4) The deposit should still be in the period of exploitation or exploration. Deposits may be selected if they formerly contained large reserves and are typical in the district.

5) If possible, the selected deposits should include a variety of associated minerals. The selected deposits are described below.

## 2.2 District 1 : Fang Fluorite Deposit

### 2.2.1 Location

The Fang fluorite deposit is situated at Grid Reference 164/064 Map L 7017 Sheet 4848 IV, or Longitude 99° 09' 22" E , Latitude 19° 57' 19" N , near Nam Muang Stream, about 1.2 km south of the well known hot spring ( Fig 2.1). The deposit was found on the paddy field at

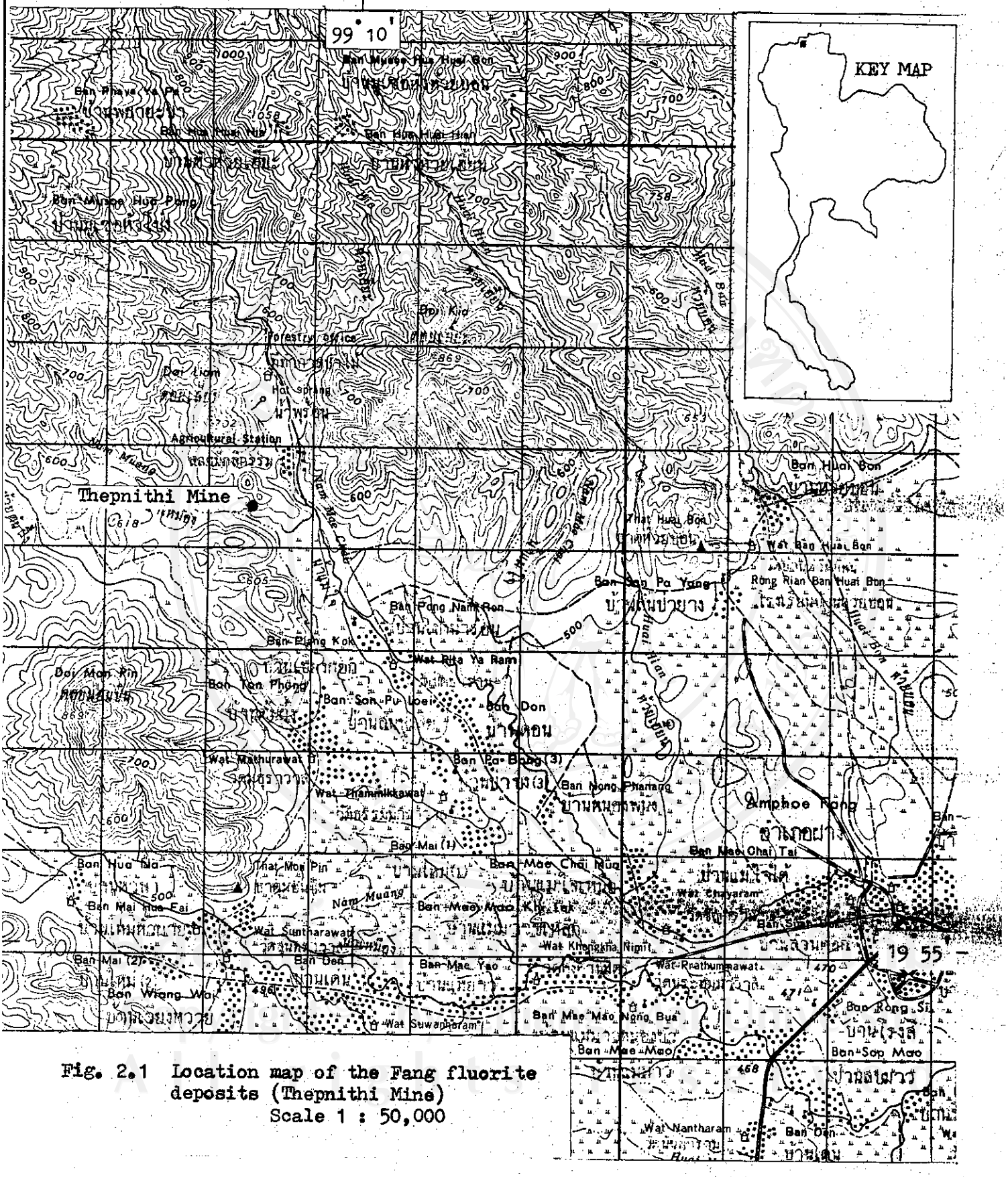



Fig. 2.1 Location map of the Fang fluorite deposits (Thepnithi Mine)
Scale 1 : 50,000

elevation 520 m O.D. Doi Kia (869 m O.D.), is located about 2 km to the northeast, Doi Mon Pin (869 m O.D.), is 2.5 km to the southwest, and Doi Liam (702 m O.D.), is 1.2 km to the northwest. Two streams run south southeast and east toward the central part of the Fang Basin.

2.2.2 Mine Production

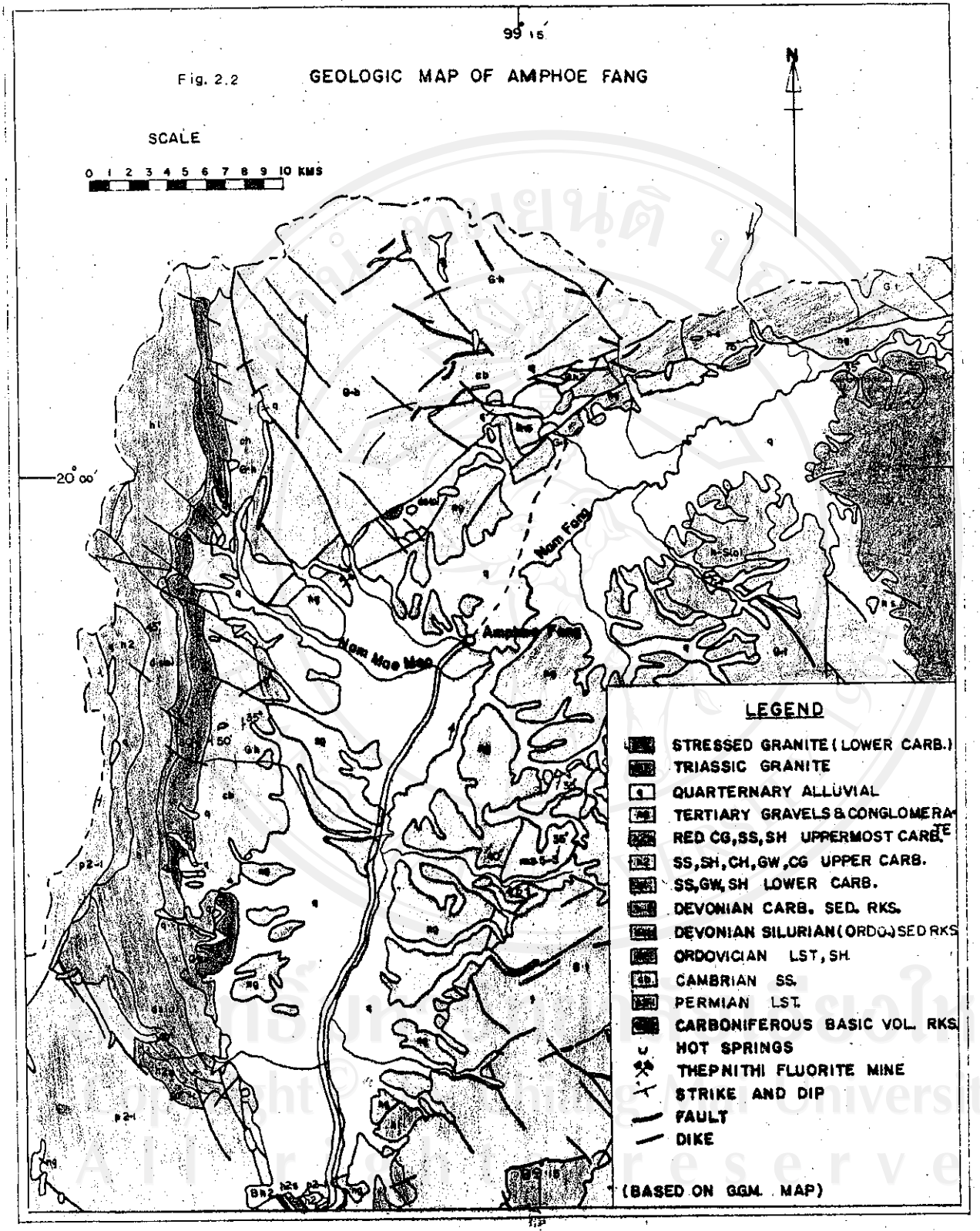
Fang fluorite deposit is under the concession of Thepnithi Mining Co. This deposit has been developed since 1970. Total production is about 50,000 tons of 70-80 % $CaF_2$. The remaining ore reserve is estimated to be about 30,000 tons.

2.2.3 Geology

The country rock in this region (Fig.2.3) is an Ordovician formation overlying Carboniferous stressed granite. The Fang Basin itself is covered by Tertiary ( Neogene ) gravel, conglomerate, shale and sandstone. The youngest formation is Quaternary alluvium. The granite extends northwards over about 200 square km adjacent to the hot spring region and outcrops 1.2 km north of the deposit.

The Ordovician sequence consists of limestones and shales with N-S strike outcropping along the mountain chain 7-8 km west of the deposit. This formation is found locally as lenses near the deposits, and is the country rock of the fluorite veins. The Ordovician strata strike N 75 W dip about 40 NNE. The succession of rocks in the mine from top to bottom is:

Fig. 2.2 GEOLOGIC MAP OF AMPHOE FANG

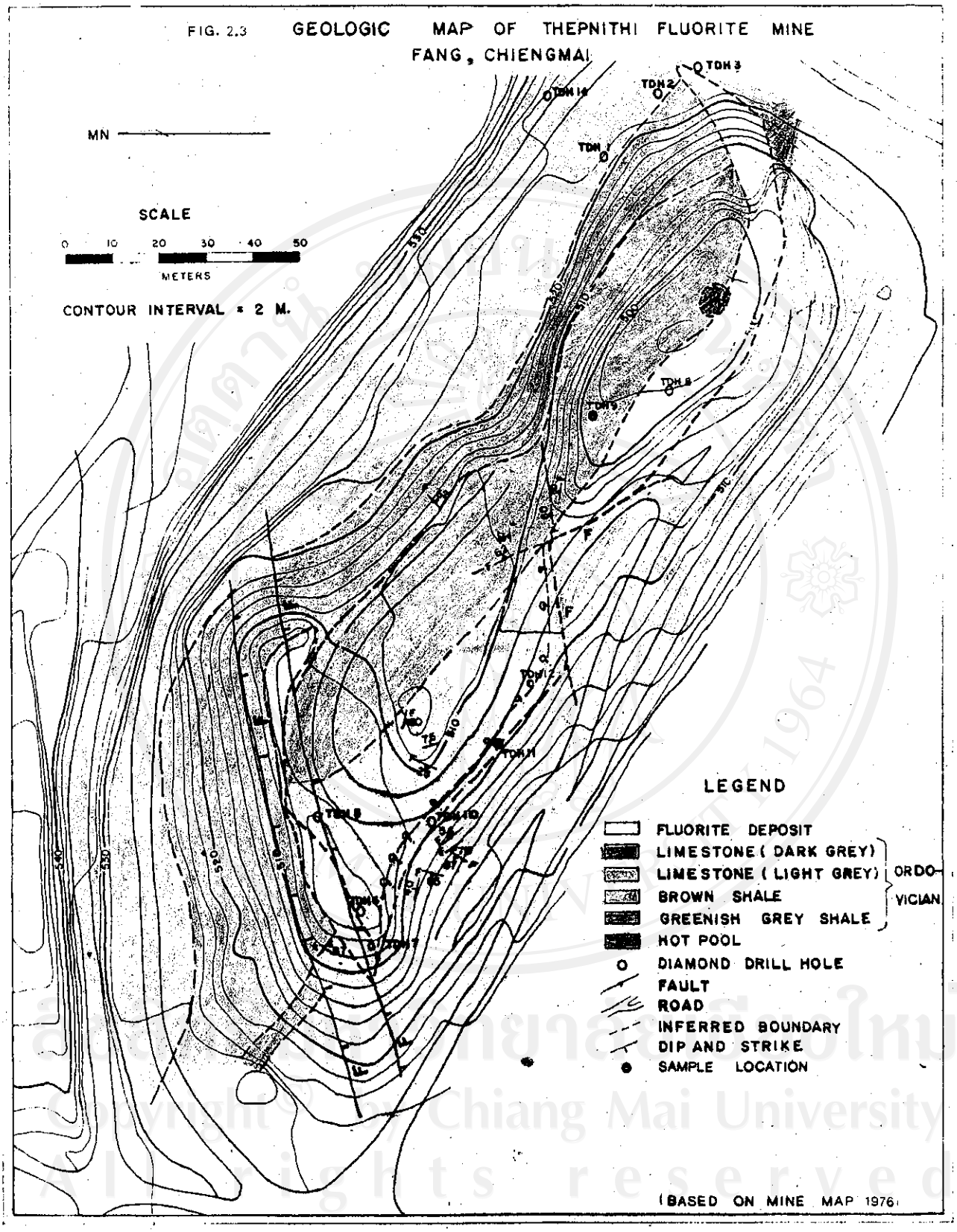


| | | | |
|---|---|---|---|
| Top | 4 | Brown shale. | > 50 m |
| | 3 | Dolomitic dark grey to black limestone thin bedded, with pyrite lense and spots. | ± 10 m |
| | 2 | Highly altered and loose deep greenish grey shale. | 10 m |
| | 1 | Massive white to pale reddish limestone | > 20 m |

Fault displacement has moved the dark limestone and underlying greenish grey shale to the hanging wall. The foot wall block consists of massive white limestone. The black thin bedded limestone seems to be gently folded near the intersection of the two veins. This minor fold plunges about 10° and fold axis trends to the southeast. The Ordovician country rock is strongly altered. The black limestone is altered to brittle green limestone with secondary calcite in cracks. Massive white limestone is altered to a greasy-luster material. Greenish grey shale is altered to a white clayey material in some parts. Alteration is mainly hydrothermal.

The main fault in the area trends WNW. Fluorite veins occur in highly faulted and sheared zones in the Ordovician limestones and shales ( Fig. 2.3). The faults intercept at an acute angle. The N 75° E faults cut the N 60° W fault at the northwest end of the deposit. The fluorite vein in the first fault zone ( N 75° E ) is 70 m long, and in the latter zone is 200 m long. The ore body decreases in size with increasing depth, and is approximately wedge shaped. The average depth may be about

FIG. 2.3 GEOLOGIC MAP OF THEPNITHI FLUORITE MINE
FANG, CHIENGMAI



50 m between elevation 475 m to 525 m O.D.

2.2.4 Fluorite Deposits

Fluorite occurs as open-space filling in the fault zones. Some fluorite also replaces the limestone country rock. The fluorite in the fault zone is botryoidal in form, with layering around the rock nuclei. In the upper part of the deposits at the rice field level, fluorite occurs as concentric layers around pebbles of the Neogene gravel beds, and is called "egg ore" by the local people. This evidence indicates that the mineralization was Neogene or later. The botryoidal fluorite is pale yellowish green and pale violet to grey. It is massive to fine grained crystalline. Small cubic crystals formed in late-stage vugs and veins are rare. Some parts of the veins are of grey fluorite which is massive and very compact. In some places, the veins form stock-work, within loose masses of limestone breccia. Some limestone and shale fragments are enclosed in fluorite. Pyrite occurs as aggregates or layers. Calcite also occurs in vugs in limestone wall rocks. The replacement fluorite is mostly grey, but some is black, pale red and white, reflecting the original colour of the replaced limestone. Fluorite preferentially replaces limestone rather than shale, especially the pale reddish white limestone, so the ore body is conformable to the strike of the limestone beds. This preference for the pale limestone may be caused by the different physical and chemical character of limestones. The black limestone is dolomitic. The grades of fluorite that replace different limestone are:

Average grade pale red fluorite = 90 % $CaF_2$( replaced reddish white limestone)

Average grade black fluorite = 76 % $CaF_2$( replaced black limestone)

Average grade white fluorite = 85 % $CaF_2$( replaced white limestone)

2.2.5 Thermal Water

At the bottom of the open pit near the SE end, there is small warm pool with temperature of about 50°c in the fluorite vein ( Fig.2.3). The composition of water has not yet been determined, but the composition of water from the well known Fang hot spring, 1.2 km in the north, is shown in the Table F-2.

2.3 District 2 : Amphoe Pai fluorite deposits

2.3.1 Location

Mahalanna Fluorite Mine, Amphoe Pai, is situated 4 km to the NE of Ban Sop Sa, Tambol Tung Yao, Amphoe Pai, Mae Hong Son Province, at Grid Reference 426/267 of the Map Sheet 47Q/CD 6 , or Longitude 98° 27' 12" E ,Latitude 19° 14' 02" N (Fig. 2.4). The veins are exposed at elevations from 460 to 700 m O.D. The Pai River which is at 450 m O.D. in this area flows south the Pai Basin and turns to the west near Mahalanna Mine. Many fluorite deposits occur parallel to and close to the Pai River (Fig. 2.6). Amphoe Pai Basin, 5 km north of Mahalanna Mine, stands at 500 - 510 m O.D. Topography around the Mahalanna Mine is highly mountainous. The highest peak is at 1042 m O.D. 1.5 km to the SE.

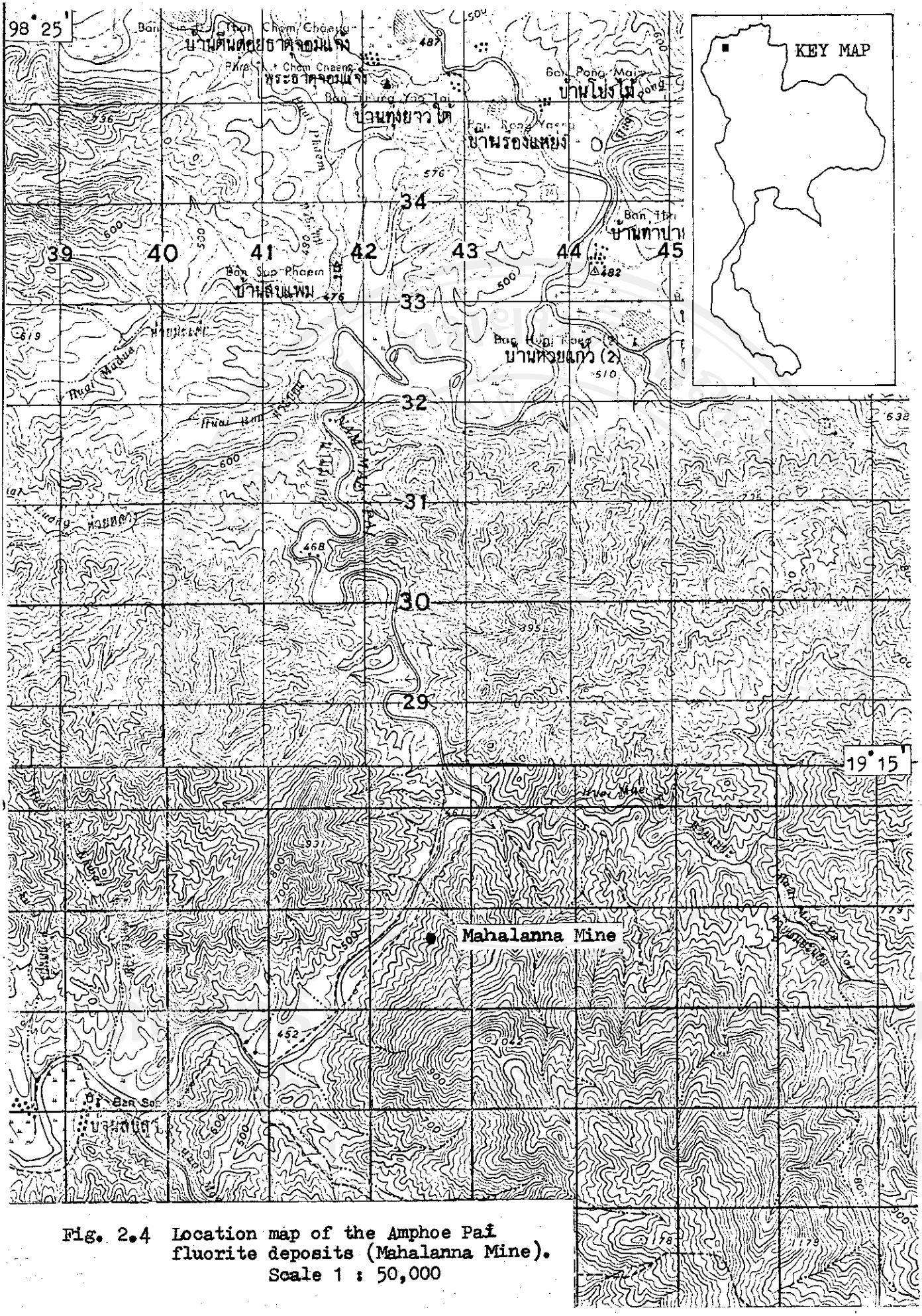
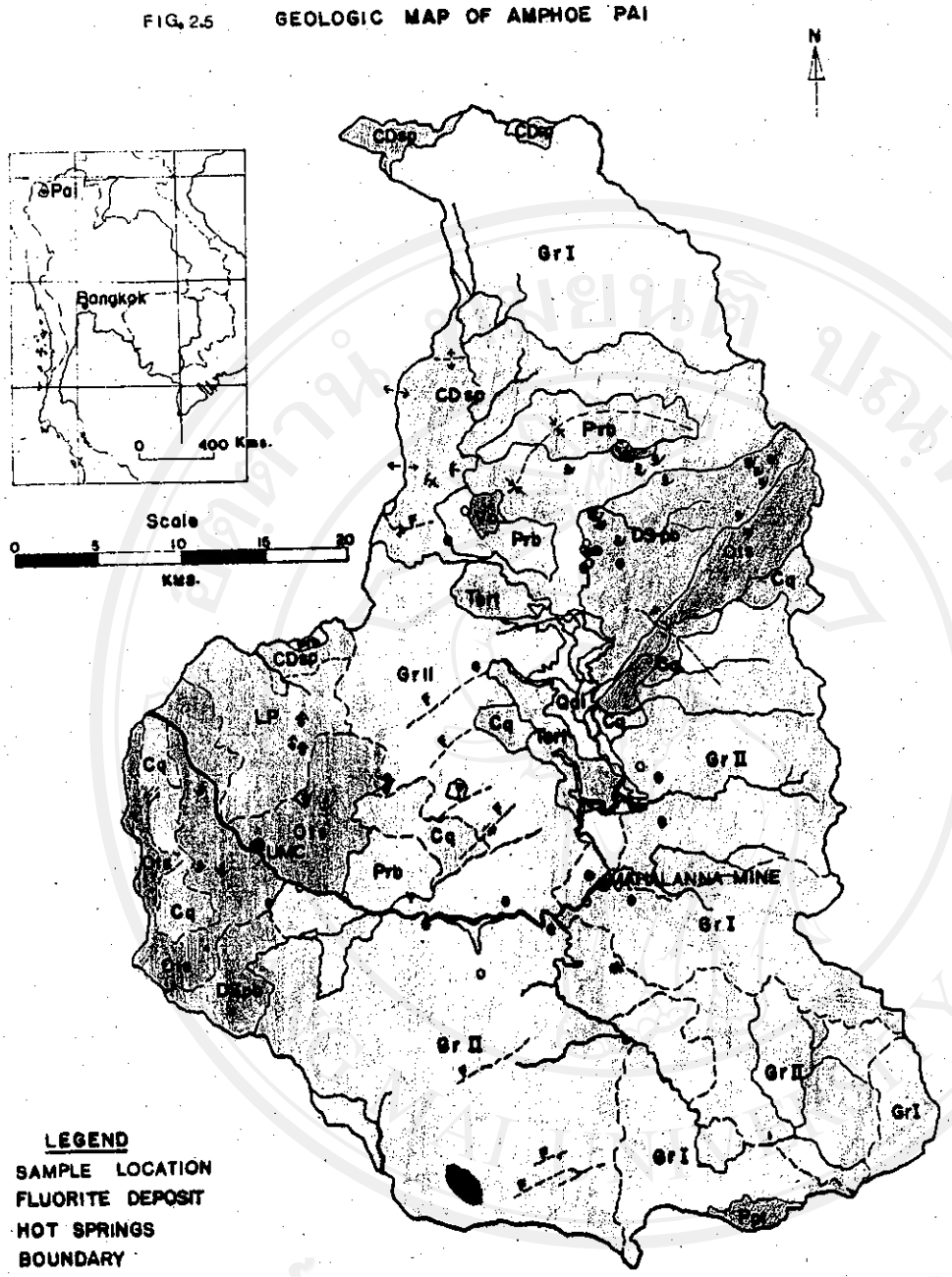



Fig. 2.4 Location map of the Amphoe Pai fluorite deposits (Mahalanna Mine). Scale 1 : 50,000

FIG. 2.5 GEOLOGIC MAP OF AMPHOE PAI




**LEGEND**

- SAMPLE LOCATION
- FLUORITE DEPOSIT
- HOT SPRINGS
- BOUNDARY
- FAULT
- AXIS OF ANTICLINE
- AXIS OF SYNCLINE
- BEDDING TRACE (GENTLE, MODERATE, STEEP)
- DIP AND STRIKE
- DRAINAGE

| | | |
|---|---|---|
| Qal | ALLUVIAL AND RIVER GRAVEL | (QUARTERNARY TO RECENT) |
| Tert | LIGNITE FORMATION | (TERTIARY) |
| Pgt | HUAI TUNG FORMATION | (POST PERMIAN)? |
| Prb | RATBURI FORMATION | (CARB. TO PERMIAN)? |
| CDsp | SAN HUAI POO FORMATION | (CARB.)? |
| Dsp | HUAI PHRA BATH FORM. | (DEVONIAN)? (SILURIAN)? |
| Otg | TUNG SONG FORMATION | (ORDOVICIAN)? |
| Cq | HUAI SAI FORMATION | (CAMBRIAN)? |
| Pv | VOLCANIC TUFF | (PERMIAN)? |
| Gr I | BIOTITE MUSCOVITE GRANITE | (CARB.)? |
| Gr II | PORPHYRITIC BIOTITE GRANITE | (TRIASSIC) |

(BASED ON D.M.R. MAP 1971)

2.3.2 Mine Production

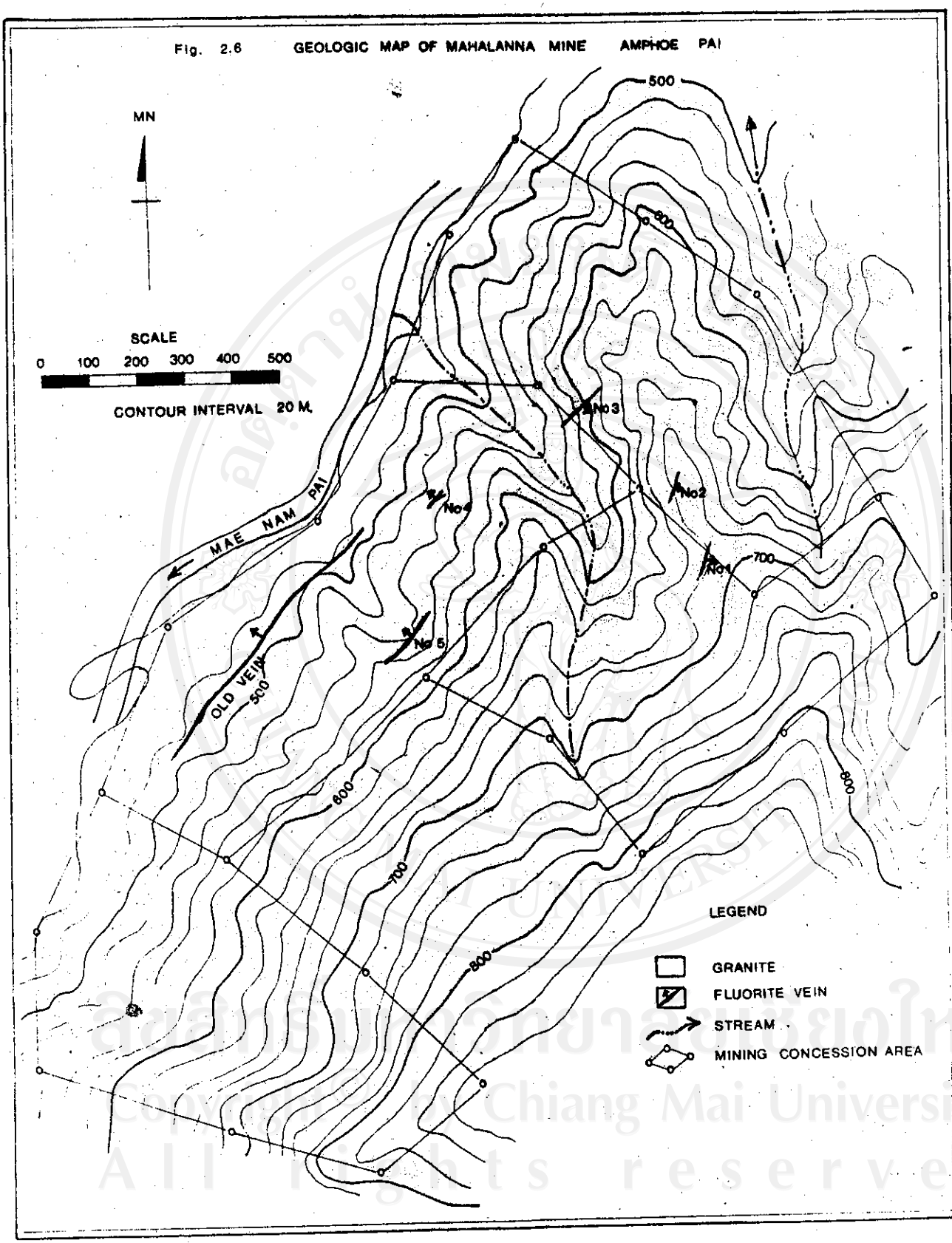
The mine is operated by Mahalanna Co. Since 1968, more than 100,000 tons of ore at 85 - 98 % $CaF_2$ have been mined by the open pit method. Recently underground mining has been applied because of the steep terrain. Fluorite is the main economic mineral discovered in the Amphoe Region and many fluorite deposits are probably undiscovered.

2.3.3 Geology

The country rock is a stressed, coarse grained biotite granite. This granite is Carboniferous in age, and is called "Gneissic Granite" or "Granite I" by Vichit (1971), and "Orthogneiss" by GCM (1972). The granite was intruded by fine grained unstressed leuco - granite in a N - S trending intrusion. This leuco - granite is probably part of "Granite II" ( Triassic ) of Vichit (1971). Foliation in the gneissic granite strikes W and dip 25° N. The faults with strike N 10° E and dip 80° E usually occur in the stressed granite. An aplite dike, 4 m. thick has an E-W orientation. Most of the fluorite veins are found in fractures and faults in granite. They generally trend from N 10-40° E to N 10-40° W. A few fluorite veins occur in sedimentary and metamorphic rocks in the northern and western parts of Amphoe Pai.

2.3.4 Fluorite Deposits

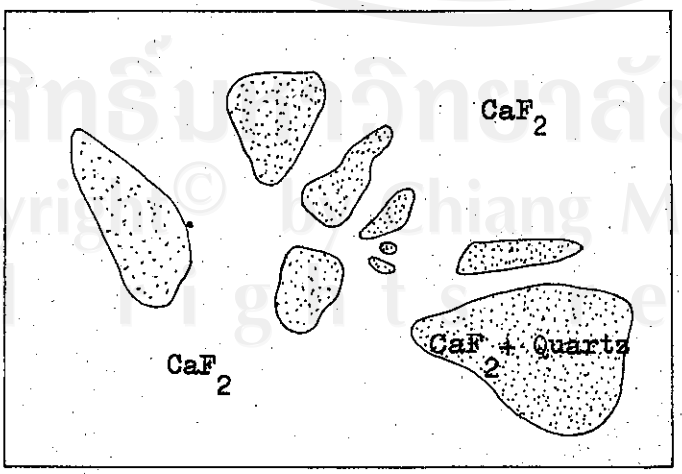
There are at least 6 veins in the Mahalanna claim ; Vein no. 1,2,3,4,5, and old vein ( near the river) -(Fig.2.6). Most of them are about 2 m. thick. The mineralization usually occurs along fault zones in the stressed granite in NE direction as a clear, coarse grained



fluorite, or as microcrystalline aggregates intimately intergrown with silica. This is called flat-layered fluorite. The main gangue in this deposit is quartz, mostly in cryptocrystalline form, intergrown with fluorite. The sulfide mineral is pyrite, as stringers in fluorite. Stibnite is very rare. There is only one sample of fluorite containing stibnite as small elongate crystals. The colour and crystal size of fluorite differs from vein to vein. The open spaces in the fault zones are completely filled by fluorite and quartz. There are no vugs or cavities in any of the vein. All the veins are roughly aligned in the same direction, but their dips are different.

2.3.4.1 Vein no. 1

The vein width is 1 m. The attitude is N 30° E/80 SE within the fault zones in gneissic biotite granite with gneissosity N 25° E/ 20° NW. The fluorite is crystalline and massive, associated with quartz. In the vein, a fluorite-quartz breccia is enclosed by later clear transparent crystalline fluorite (Fig. 2.7). This indicated that at least two stages of fluorite mineralization.




Scale 1 : 2

Fig. 2.7 Breccias of early fluorite and quartz filled by late fluorite at Vein no. 1, Mahalanna Mine, Amphoe Pai.

2.3.4.2 Vein no. 2

The vein width is 1-2 m. The attitude of most parts of the vein is N 12° E/68° SE, but in the upper part, it changes to N 70° E/ 40° NW (Fig. 2.8).

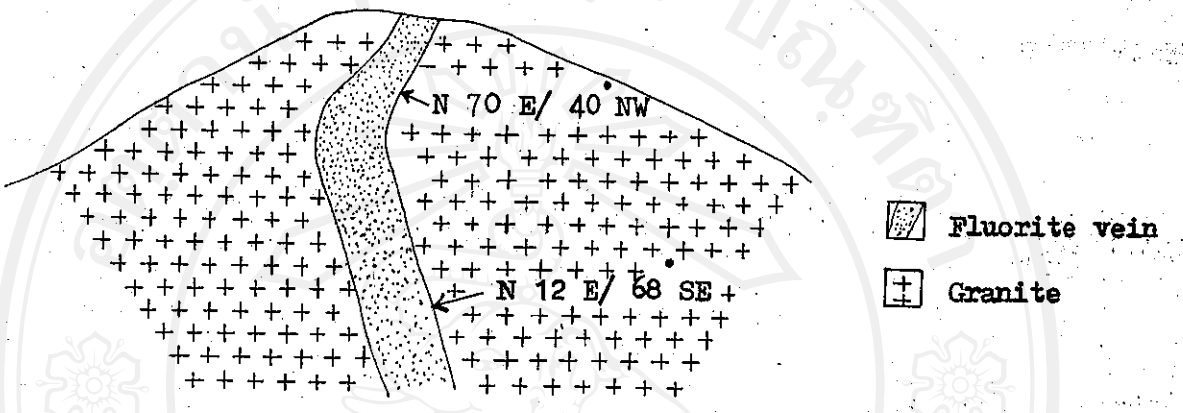



Fig. 2.8 Changes in attitude of the Vein No. 2, Mahalanna Mine, Amphoe Pai.

In this vein the fluorite is clear purple or pale purple and green. The green fluorite is usually in the center of the vein.

2.3.4.3 Vein no. 3

Vein no. 3 contains large reserve and is still being mined. The vein width is 2 m, and the attitude is N 40° E/75° SE. The length is more than 100 m, and the estimated depth is abouth 80 m. The estimated reserve is about 48,000 tons. Slickensides on the fault plane are plunging 25° NE, indicating nearby-horizontal movement. This indicates the movement after mineralization. Fluorite is typically emeral-green and sub-transparent white.

2.3.4.4 Vein no.4

Parts of the vein are of brecciated granite and fluorite, interstitially filled by greenish white cryptocrystalline quartz (Fig.2.9).

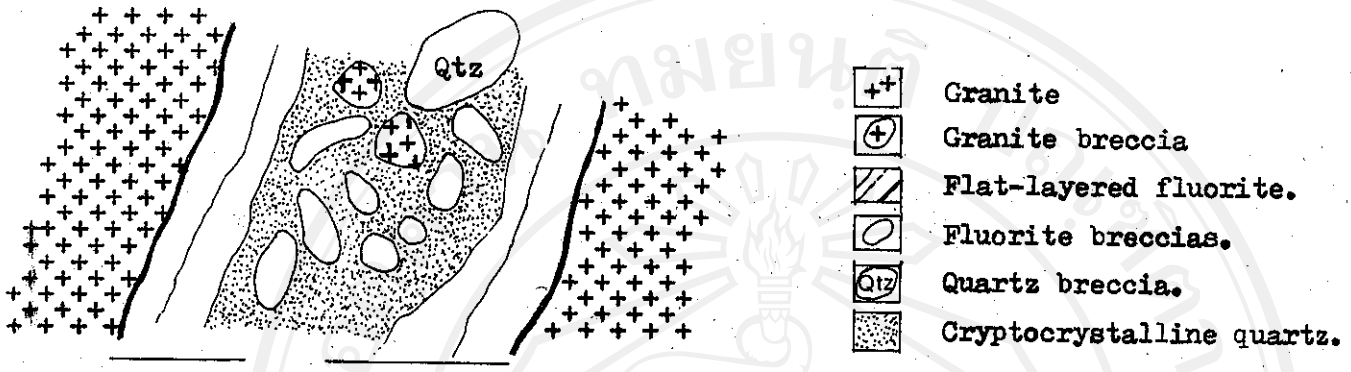



Fig. 2.9 Cross section of the Vein No. 4, Mahalanna Mine, Amphoe Pai. Banded symmetrical layered fluorite on both side of vein, laterally filled by cryptocrystalline quartz.

Most of the fluorite is crystalline and transparent with perfect cleavage, occurring as banded coloured layers at each margin, with the quartz-fluorite interlayering in the middle part of the vein. The vein attitude is N 40 E/85-60NW. The vein splits into 2 branches 1.8-2.0 m wide around a granite wedge (Fig.2.10).

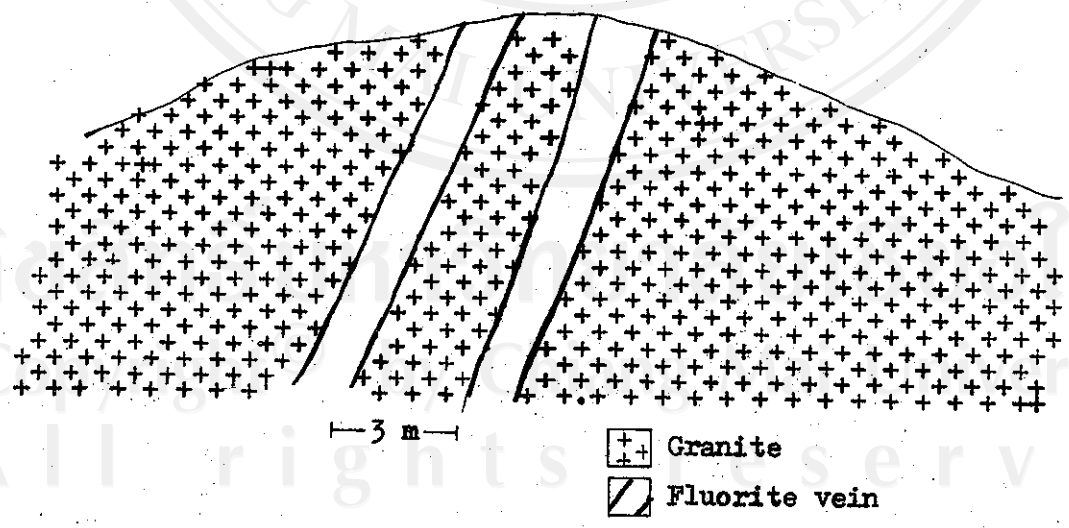



Fig. 2.10 Cross section of the Vein No. 4 showing part of the vein splits into 2 branches with granite wedge in the middle. Mahalanna Mine, Amphoe Pai.

2.3.4.5 Vein no. 5

Vein no. 5 is the biggest vein, 4 m wide. The attitude is N40E/70NW Slickensides appear on the granite wall with a rake angle of 30 NE. Most fluorite is white, but some is pale green or pale yellow (Fig.2.11). The reserves of the vein no. 5 are 60,000 tons of high grade

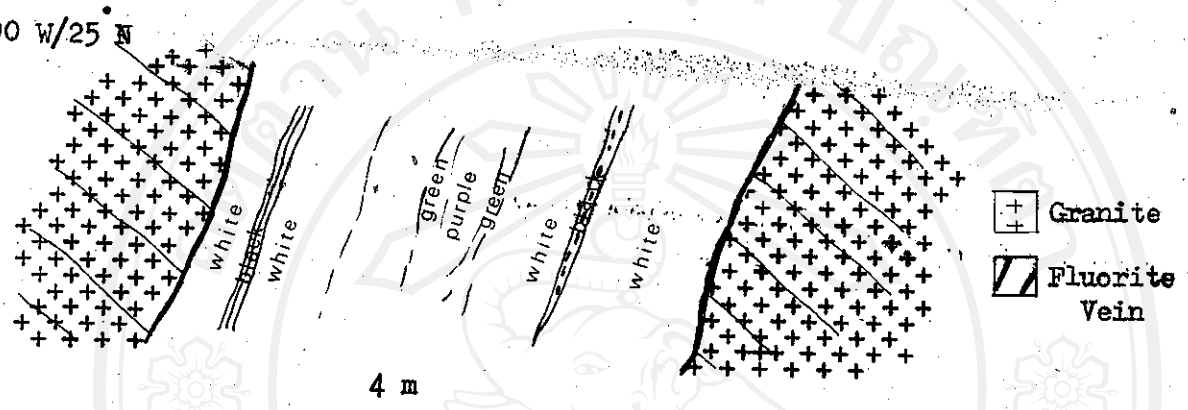



Fig. 2.11 X-section of Vein No.5, Mahalanna Mine, Amphoe Pai. The fluorite vein is in fault zone in gneissic granite. The vein shows symetrical colour layerings.

fluorite ( 85-95 % $CaF_2$). Underground operation is now being carried out for this vein.

2.3.4.6 Old Vein

This vein is already mined out. It was about 500 m long, found at the foot of the hill parallel and adjacent to the Pai River. The attitude isN40E/60 NW The mineralized zone is about 6 m wide, but the massive fluorite zone is only about 1 m wide. On both sides of the 1 m concentrate zone are small veinlets, which were called the low grade ore. The ore is of colour banded fluorite.The colour is mostly purple and white. Fluorite is often found as interlayering with cryptocrystalline quartz.

2.3.4.7 Vertical Changes in Veins

The fluorite veins at lower elevation ( Vein no. 6, and some parts of Vein no. 4 ) are typically fine grained, intergrown or interlayered with quartz ( Fig.2.12). The fluorite is purple and white. At the higher ele- elevation, 600 m O.D., such as Vein 3, the fluorite is usually coarse

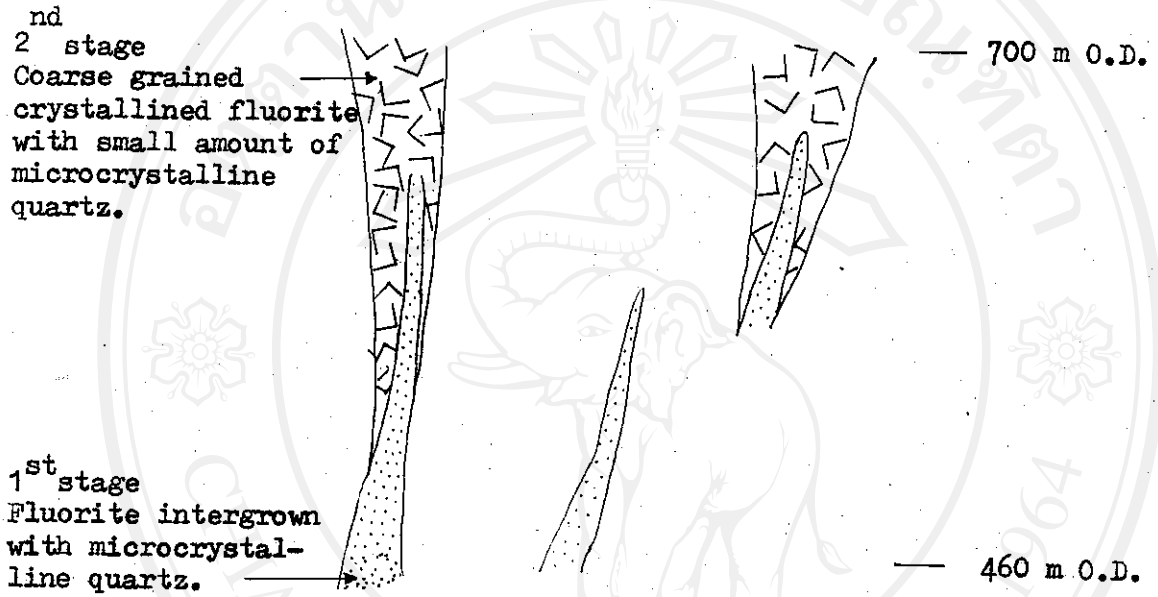



Fig. 2.12 Ideal vertical section of fluorite veins at Mahalanna Mine.

grained, with only small amounts of microcrystalline aggregates. Various shades of colour are also common, e.g. white, green, purple, etc. The same geologic character of the vein was also reported by Vichit (1971) at the Thai Resources Development Mine on the northern bank of Pai River, not far from Mahalanna Mine. (Grid Reference 420 / 275 of the Map Sheet 47 Q / CD 6 ).

2.3.4.8 Paragenesis

Paragenesis of fluorite and associated minerals is shown in Fig.2.13.

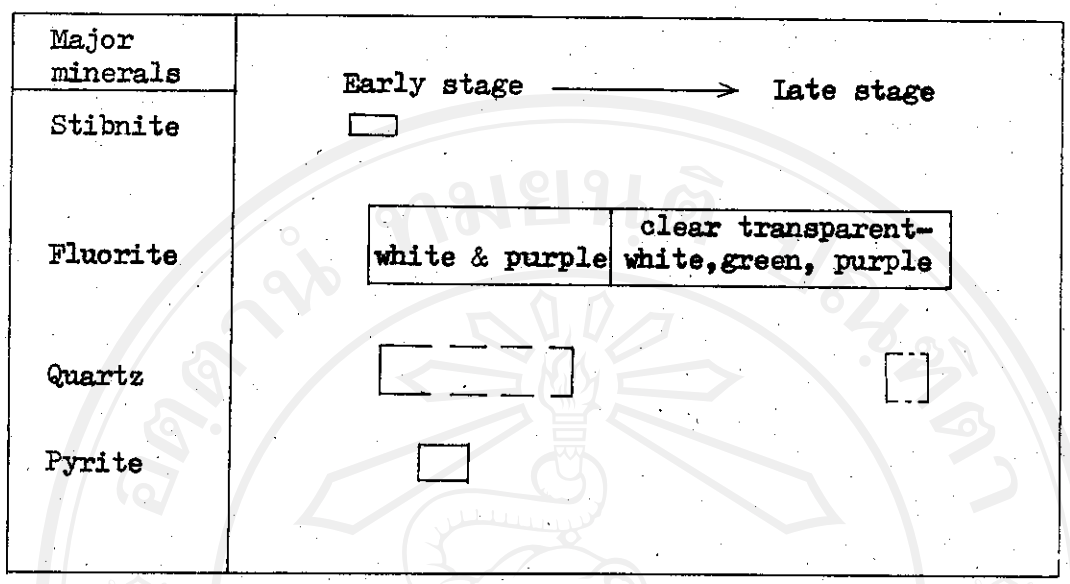



Fig. 2.13 Paragenesis of ore minerals at Amphoe Pai deposits (Mahalanna Mine).

2.3.5 Thermal Springs

The hot springs are found in the Pai River, and can only be seen in the dry season. The hot springs are aligned in the same direction as the strike of the Old Vein and about 200 m away.

## 2.4 District 3 : Mae La Noi Fluorite Deposit

### 2.4.1 Location

The deposit is situated 3 km east of Mae La Noi District, Amphoe Mae Sariang, Mae Hong Son Province, on the southern bank of Nam Mae Hoo, at Grid Reference 920/331 of the Map Sheet 47Q/BC12 or 4545 I, or Longitude 97° 58' 36" E , Latitude 18° 23' 10" N. The topography is mainly mountainous with a N-S trending chain of steeply sloping moutains. The deposit was found on the steep slope of a limestone hill at an elevation of 450-575 m O.D. (Fig.2.15). The peak of this hill is 800 m O.D. Nam Mae Hoo at an elevation of 380 m O.D., flows from west to east across the limestone belt near the deposit. This river joins Nam Mae La Noi 1.5 km west of the deposit, and finally reachs Nam Mae Yuam which flows southerly parallel to the Yuam fault zone.

### 2.4.2 Mine Production

Mae La Noi fluorite deposit is under the concession of S.P. Mining Co. The mine has been in operation since 1969; total production during 1969-1977 was about 30,000 - 40,000 tons of 50-70 % $CaF_2$.

### 2.4.3 Geology

Ordovician limestone interbedded with shale, slaty shale and shaly limestone are the country rocks (Fig.2.16). Limestone, the main rock type, is thin bedded, light or dark grey to white and fine grained. This Ordovician formation is strongly folded, faulted, and has developed a fracture cleavage. The limestone is folded into an overturned anticline with folded axis trending a NNE direction. The west limb is steeply

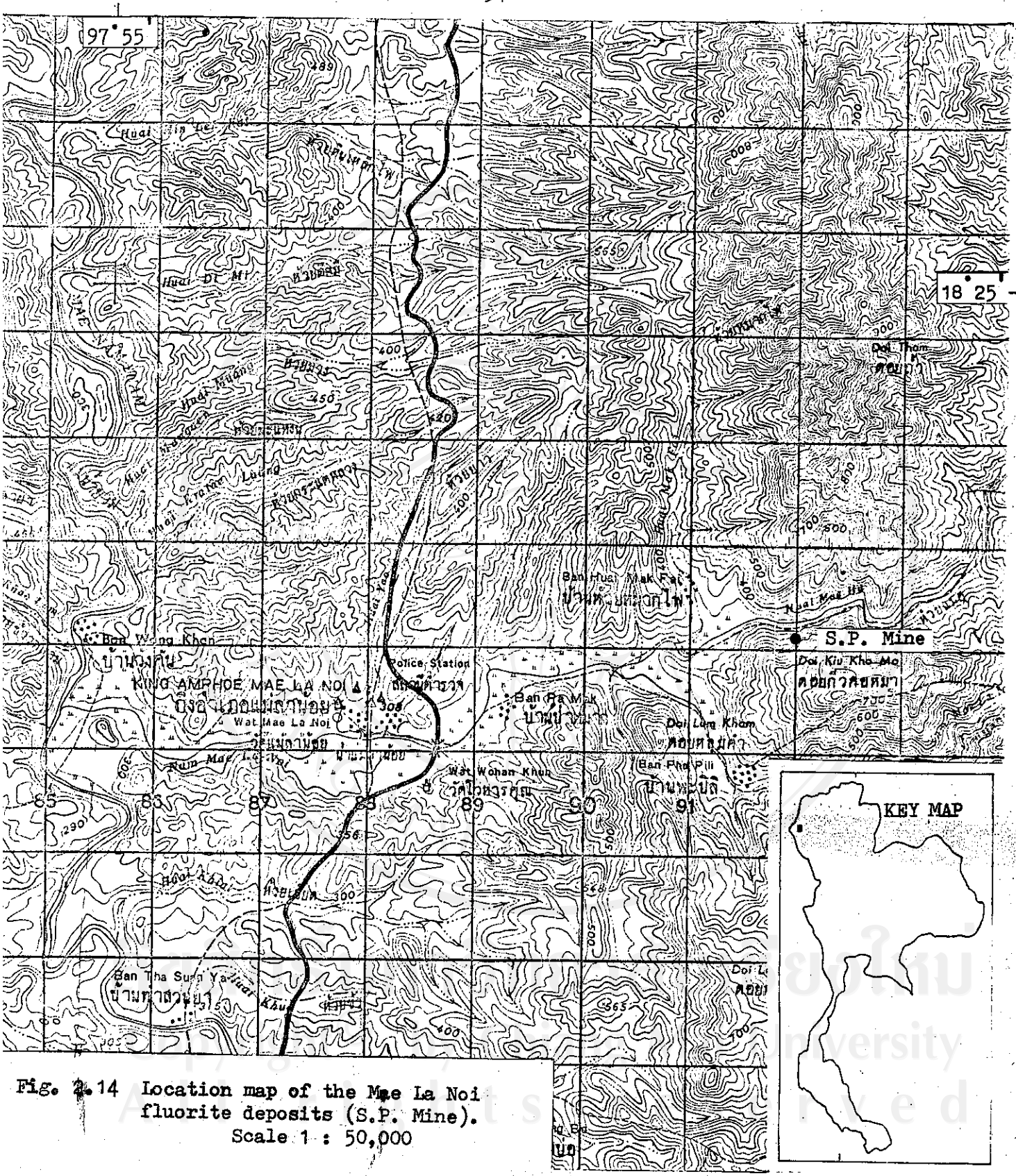



Fig. 2.14 Location map of the Mae La Noi fluorite deposits (S.P. Mine).
Scale 1 : 50,000

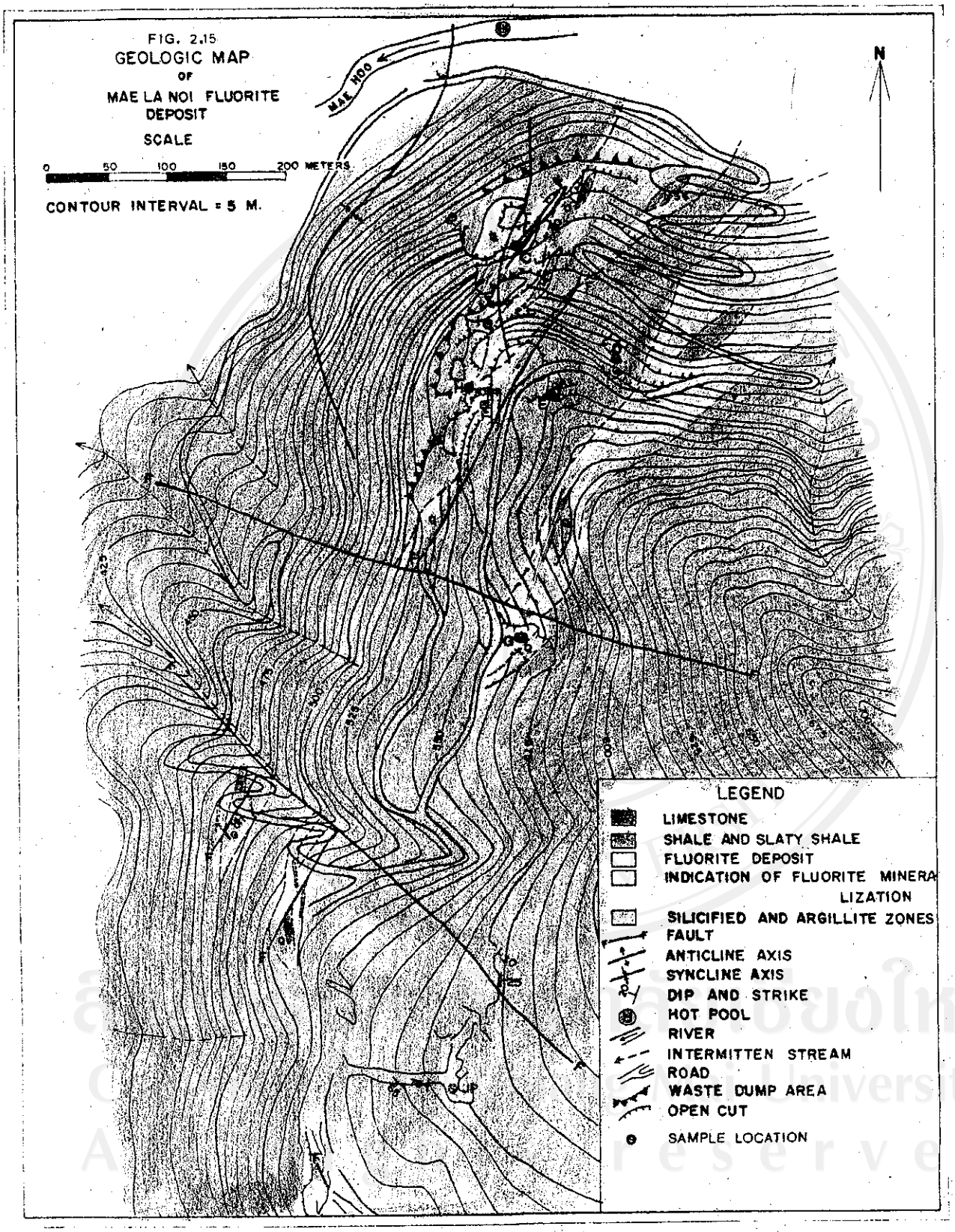


FIG. 2.15
GEOLOGIC MAP
OF
MAE LA NOI FLUORITE
DEPOSIT
SCALE
0 50 100 150 200 METERS
CONTOUR INTERVAL = 5 M.
MAE HOO
N
LEGEND
LIMESTONE
SHALE AND SLATY SHALE
FLUORITE DEPOSIT
INDICATION OF FLUORITE MINERALIZATION
SILICIFIED AND ARGILLITE ZONES
FAULT
ANTICLINE AXIS
SYNCLINE AXIS
DIP AND STRIKE
HOT POOL
RIVER
INTERMITTEN STREAM
ROAD
WASTE DUMP AREA
OPEN CUT
SAMPLE LOCATION

dipping ( 70° ), the east limb is more gently dipping ( 15-30° ).Many faults in the NNE direction are aligned parallel to the axis of the overturned anticline and dip 70° (Fig.2.16). The movement of the blocks indi-

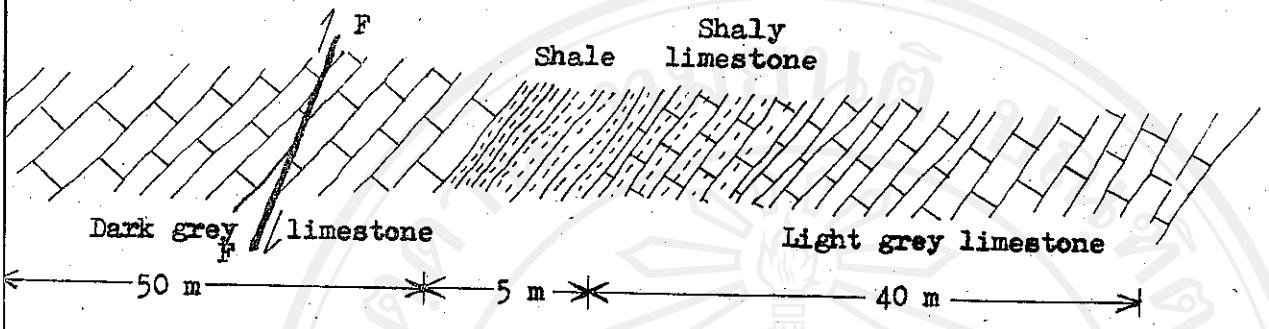



Fig. 2.16 Idealized geologic cross section of the Ordovician formation at S.P. Mine, Mae La Noi.

cates that they are thrust ? faults. Well rounded granite boulders and cobbles are found in the Nam Mae Hoo. The granite is a porphyritic biotite granite.

2.4.4 Fluorite Deposits

Fluorite mineralization coincides with the NNE vertical faults and also occurs in open space at the crest of the anticline (Fig.2.18A). The region of intersection of the N 20° E fault with the crest of the anticline trending N 5° E contains the major part of the fluorite deposit.(Fig.2.15). In the sheared and brecciated zone, 4-10 m wide, the fluorite is found as open space ( cavity ) filling and replacement in limestone. The fluorite replacing fine grained limestone is generally fine grained. Fluorite preferentially replaces limestone rather than shale. Open space in most cavities also contains calcite. For example, ome cavity contains a colloform layer of fluorite 5 cm thick in the

outer shell and is interstitially filled completely by coarse crystalline calcite (Fig.2.17). The volume of calcite is considerably more than fluorite. Early calcite next to the fluorite layer is dark brown and smaller in size than the later white calcite in the middle of the cavity. There

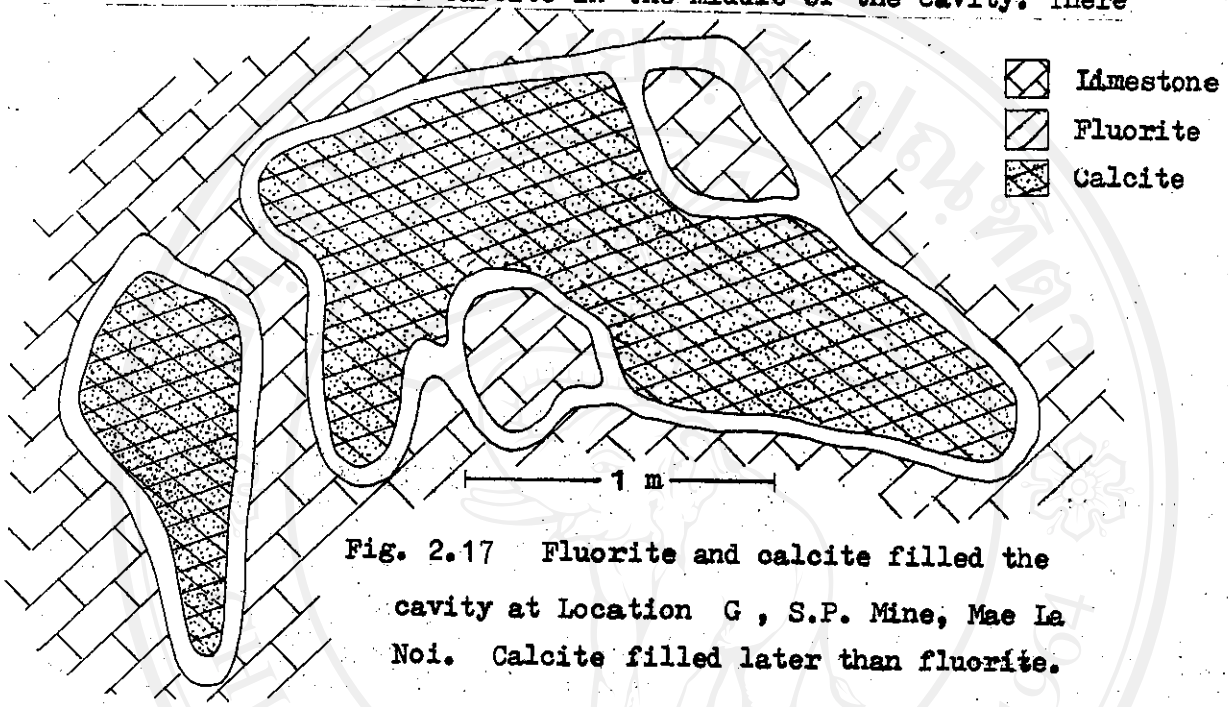



Fig. 2.17 Fluorite and calcite filled the cavity at Location G , S.P. Mine, Mae La Noi. Calcite filled later than fluorite.

are also some vugs and cavities that are not completely filled by fluorite and calcite.

Fluorite layers surrounding rock nuclei, fragments, and even previous fluorite breccias are also common. Fluorite has various shades of colour e.g. brown at sample location no. 1, colorless, pinkish violet, deep bluish violet, and grey to black (original limestone colour) at sample location G and others. The colour depends on the type of occurrence. Most of the deposit consist of replacement and layered fluorite with botryoidal or pseudo-botryoidal appearance. There are no small cubic crystals of fluorite in vugs. Quartz is associated with fluorite but in smaller amount than calcite. The paragenesis is

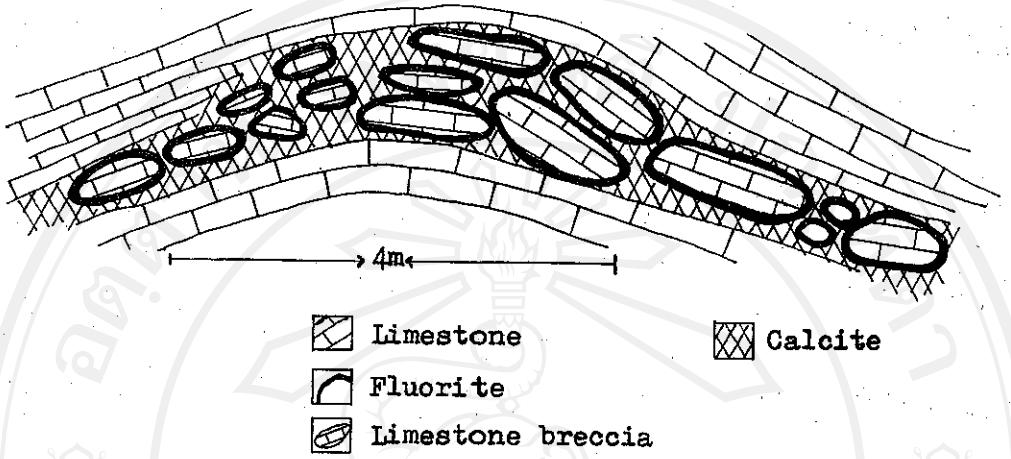



Fig. 2.18 A. Fluorite deposit at crest of anticline. Japanese opencut, S.P. Mine, Mae La Noi. Fluorite occurs as thin layers around limestone breccias, and calcite filled after fluorite.

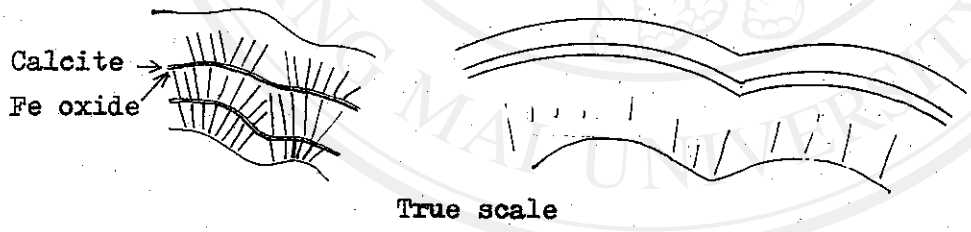



Fig. 2.18 B. The true-scale size of the thin-layered pale purple fluorite described in Fig. 2.18 A. The crystals are radiated perpendicular to the layers. Very thin calcite layers ? (cream colour), and Fe oxide layers are interlayered with fluorite.

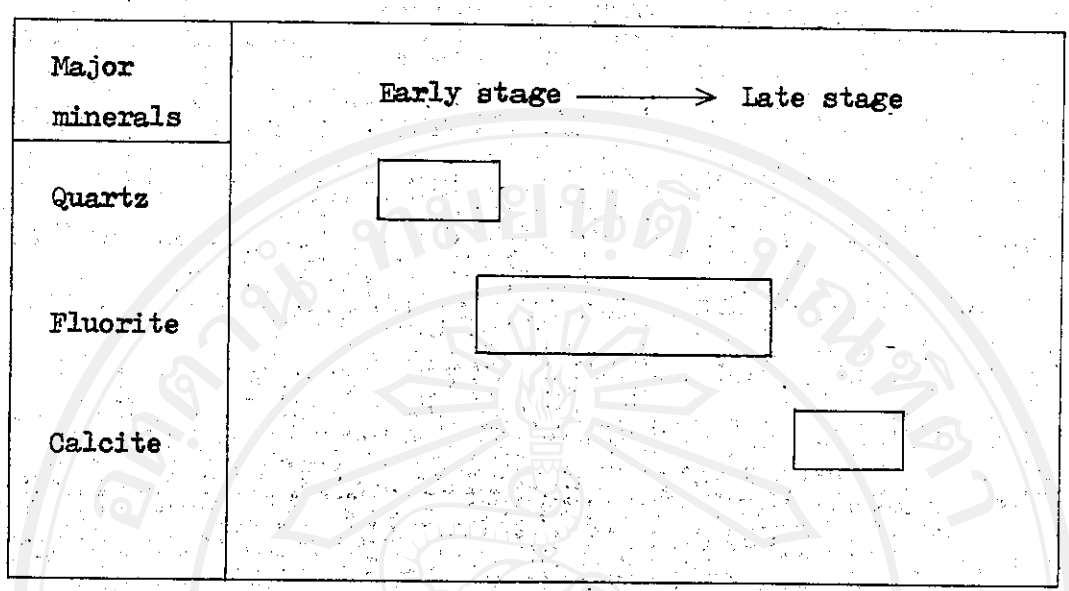



Fig. 2.19 Paragenesis of ore minerals at Mae La Noi deposits. (S.P. Mine).

2.4.5 Thermal Springs

Hot pools at an elevation of 360 m O.D. in Nam Mae Hoo rest upon limestone. They are located in the stream and are less than 1 m wide, and 2 m long. The bubbles of warm water come out at 20-30 bubbles per minute. The hot pool is aligned in the same direction as the fault zone in the highly folded limestone. The surface temperature is 80 °c, and the approximate subsurface temperature recorded by T ($SiO_2$) geothermometer is 152 °C ( Ramingwong and others, 1978).

## 2.5 Mae Tha Fluorite Deposit

Mae Tha fluorite district is not included in any fluorite district, but it is close to the district 5 ( Ban Hong District). It needs to mention because of the big ore reserve of economic importance.

### 2.5.1 Location

Mae Tha fluorite district is located in Ban Mae Kha-nad, Tumbol Tha Kad, Amphoe Mae Tha, 20 km south of Lamphun Province in the Map Sheet 47Q/CC12.

The deposits are in the concession of three mining companies.

1) Thepnithi Mine Grid Reference 995/323 or Longitude 98° 59' 45" E
   Latitude 18° 22' 56" N
2) Universal Mine Grid Reference 992/324 or Longitude 98° 59' 35" E
   Latitude 18° 22' 57" N
3) Ban Tha Mine Grid Reference 988/320 or Longitude 98° 59' 20" E
   Latitude 18° 22' 51" N

All the deposits are in a small basin near Doi Wae. The elevation of the deposit is about 380-400 m O.D. between two hills 500 m high to the north and 680 m high to the south. The deposit is at the edge of the Mae Tha Basin, (Fig.2.20), about 2.5 km east of the Nam Mae Moei.

### 2.5.2 Mine Production

The fluorite deposits have more than 600,000 tons estimated ore reserve. The productio of the Universal Mine during January

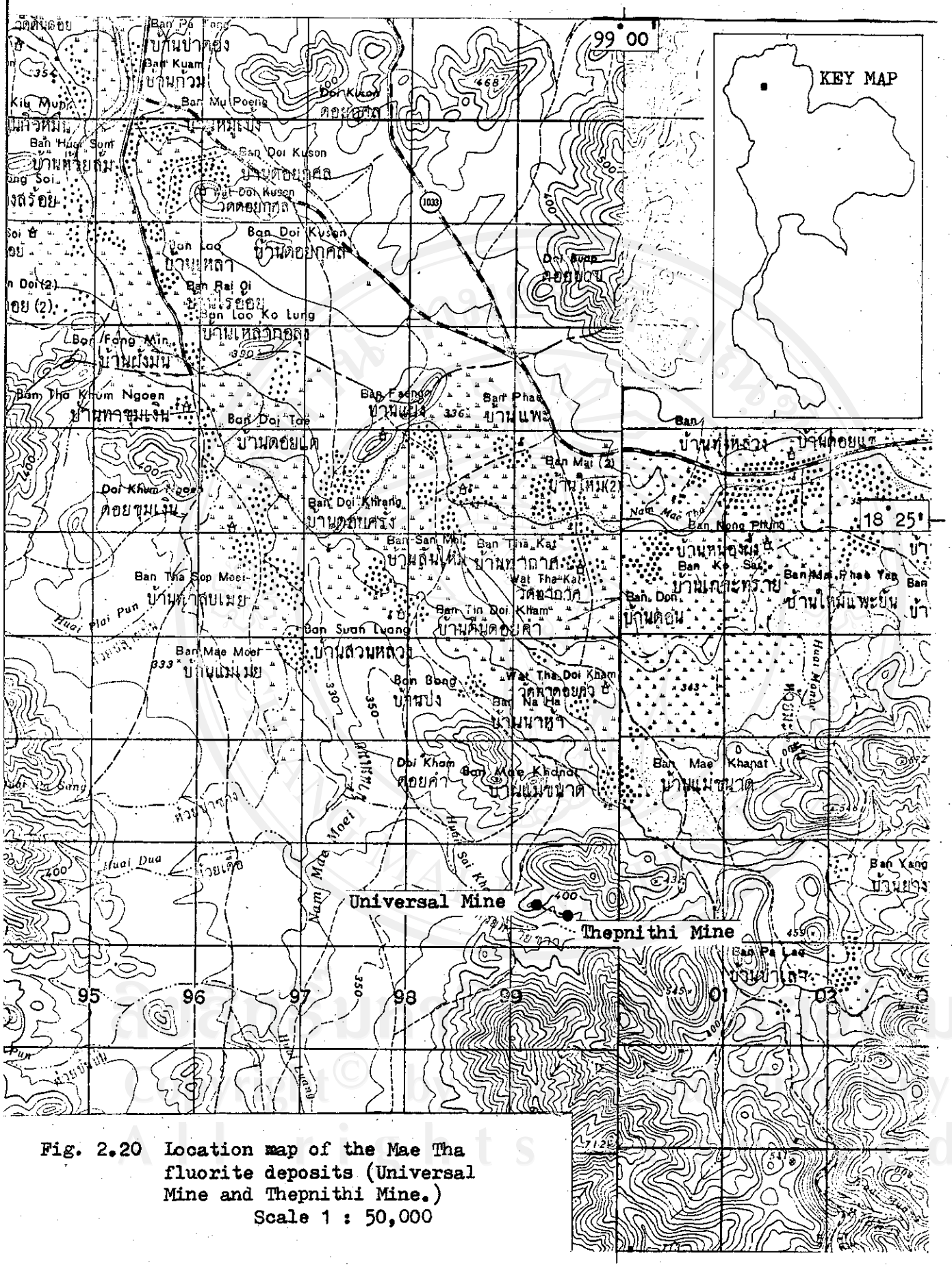



Fig. 2.20 Location map of the Mae Tha fluorite deposits (Universal Mine and Thepnithi Mine.)
Scale 1 : 50,000

1967-June 1977 is about 419,000 tons of 75-82 % $CaF_2$ (Table B.-2.1). In the Thepnithi claim, the new subsurface ore body found during diamond drilling has been proved to be 150,000 tons.

2.5.3 Geology

The country rocks are intermediate volcanic rocks, tuffs, limestone and shales of Permo-Carboniferous Age. Younger sandstone and acid volcanic rock are exposed mostly on the northern side of the vein. Limestone is found mostly in the Universal claim, (Fig.2.21 ), while the intermediate volcanic rocks are mainly in the Thepnithi claim, (Fig. 2.22). The younger sandstone and rhyolite occurs in both claims. The stratigraphic sequence is shown in Fig. 2.23.

The intermediate volcanic rocks are composed only of a variety of agglomerates and tuffs (Fig.2.23). The green and red andesitic tuffs are strongly weathered, and contain white irregular spots of calcite. The total thickness of red and green andesite is about 5 m, found on the southern side of the limestone in the Universal claim. Agglomeratic tuff with andesitic fragments 3-4 cm in diameter is found on the western side, approximately at the boundary of the two mining claims. Most of the lower part of the Thepnithi open pit is andesitic agglomerate and other volcanic rocks. The top part is mostly sandstone, shale and some rhyolite flows, continuing across the northern flank into the Universal claim.

The limestone is cavernous, massive, light grey, and recrystallized. The total thickness is about 50m. Rare fossiliferous beds about 3 m thick contain mostly fusulinids, some crinoid stems and algae.

FIG.2.21 GEOLOGIC MAP OF MAE THA FLUORITE DEPOSIT
UNIVERSAL MINING CO., MAE THA, LAMPHUN
(BASED ON MINE MAP 1977)

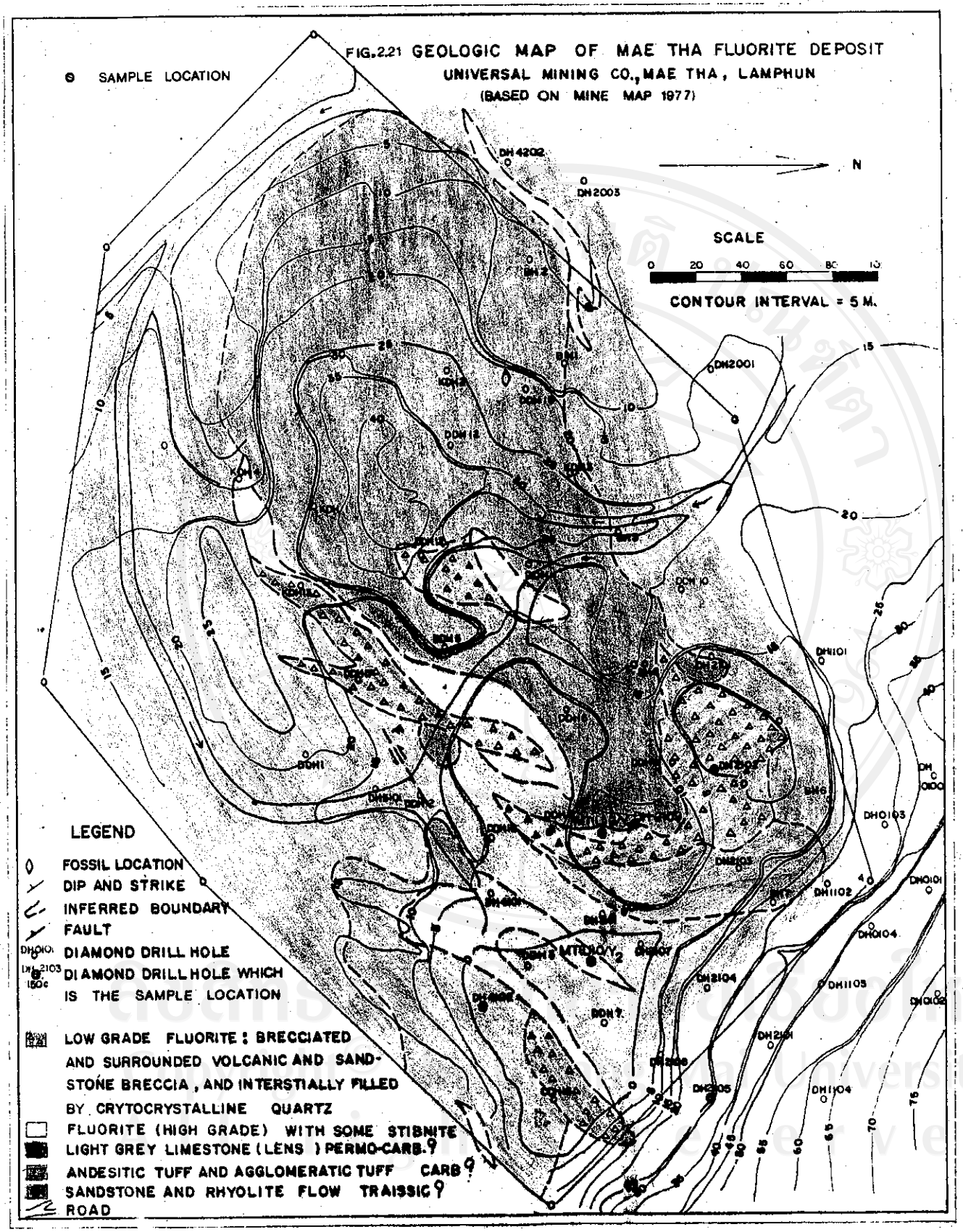
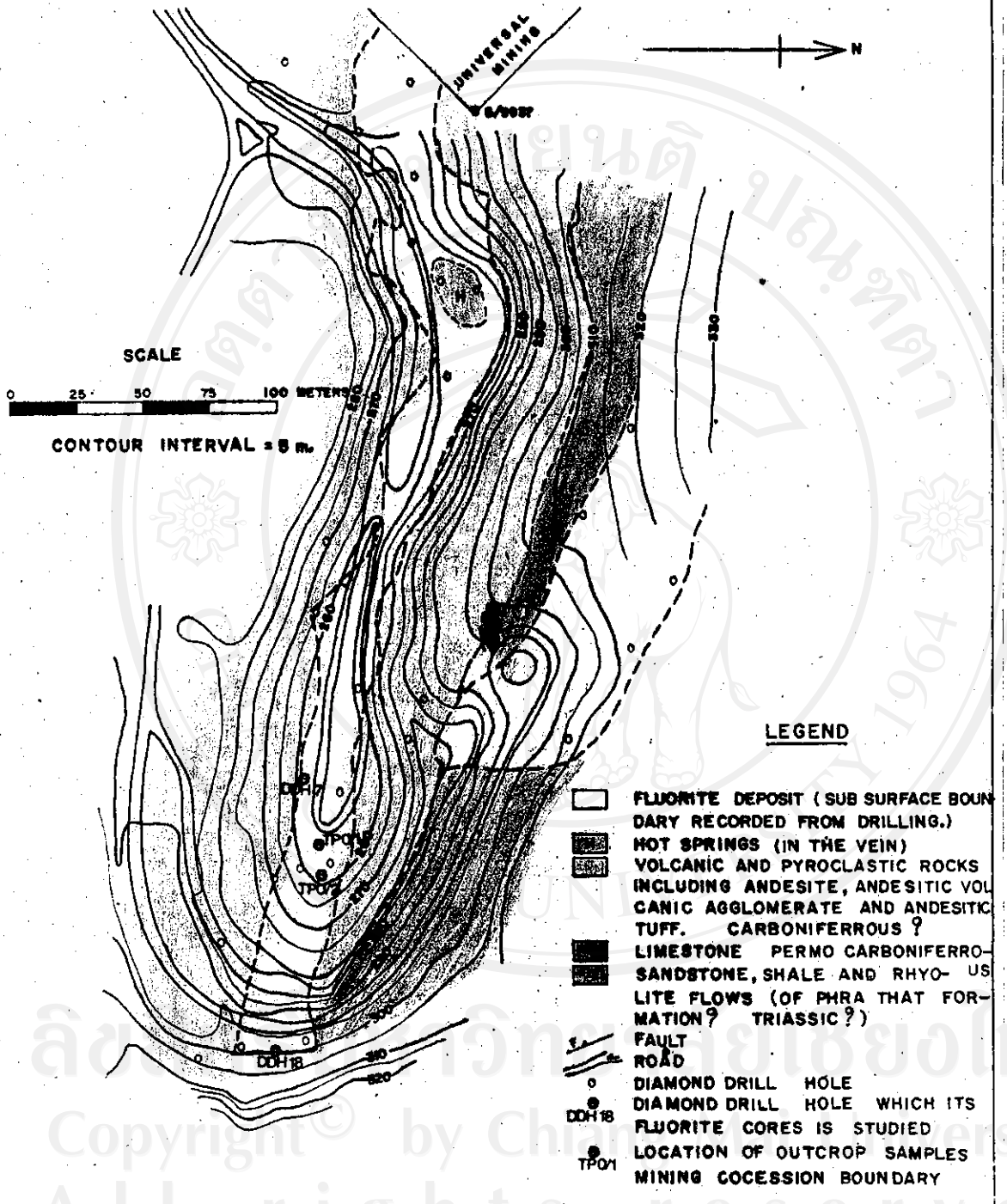


FIG. 2.22 GEOLOGIC MAP OF THEPNITHI OPEN PIT MINE
MAE THA, LAMPHUN




(BASED ON MINE MAP 1975)

Calcite usually fills in limestone cavities. Limestone near the fractures is usually black due to hydrothermal solution during the stage of mineralization. This effect of alteration in limestone is more pronounced in the east end of the outcrop. Small limestone lenes are found in the Thenithi claim at the contact with the pyroclastic sedimentary rocks.

The interbedded sandstone, shale, and rhyolite overlies the limestone. In the Universal claim (western part), sandstones are found at the contact with limestone, but in Thepnithi claim ( eastern part) sandstones are in contact with intermediate volcanic rocks.Most of the sandstones are brown, coarse grained, and compact, with poor sorting of sub-rounded grains and showing graded bedding. The sand particles are of white quartz, green mineral?, etc. Other sandstone beds are well sorted, and medium grained with a feldspathic matrix.The thickness of bed ranges from 15 cm to 2 m. Sandstones are metamorphosed to meta-quartzite, but the original grain boundaries can still be seen. The rhyolite flows, mainly red in colour contain very small quartz phenocrysts in the very fine grained ground mass of the rhyolite. The resistance to weathering varies from flow to flow.

According to Ingawat (1979, personal communication) fossils in limestone were identified as :-

Parafusulina sp.

Neoschwagerina sp.

Cribogenerina cf. Sumatrana (Volz.)

Neofusulinella

These indicate a Kazanian and Kungarian Age (middle Permian)

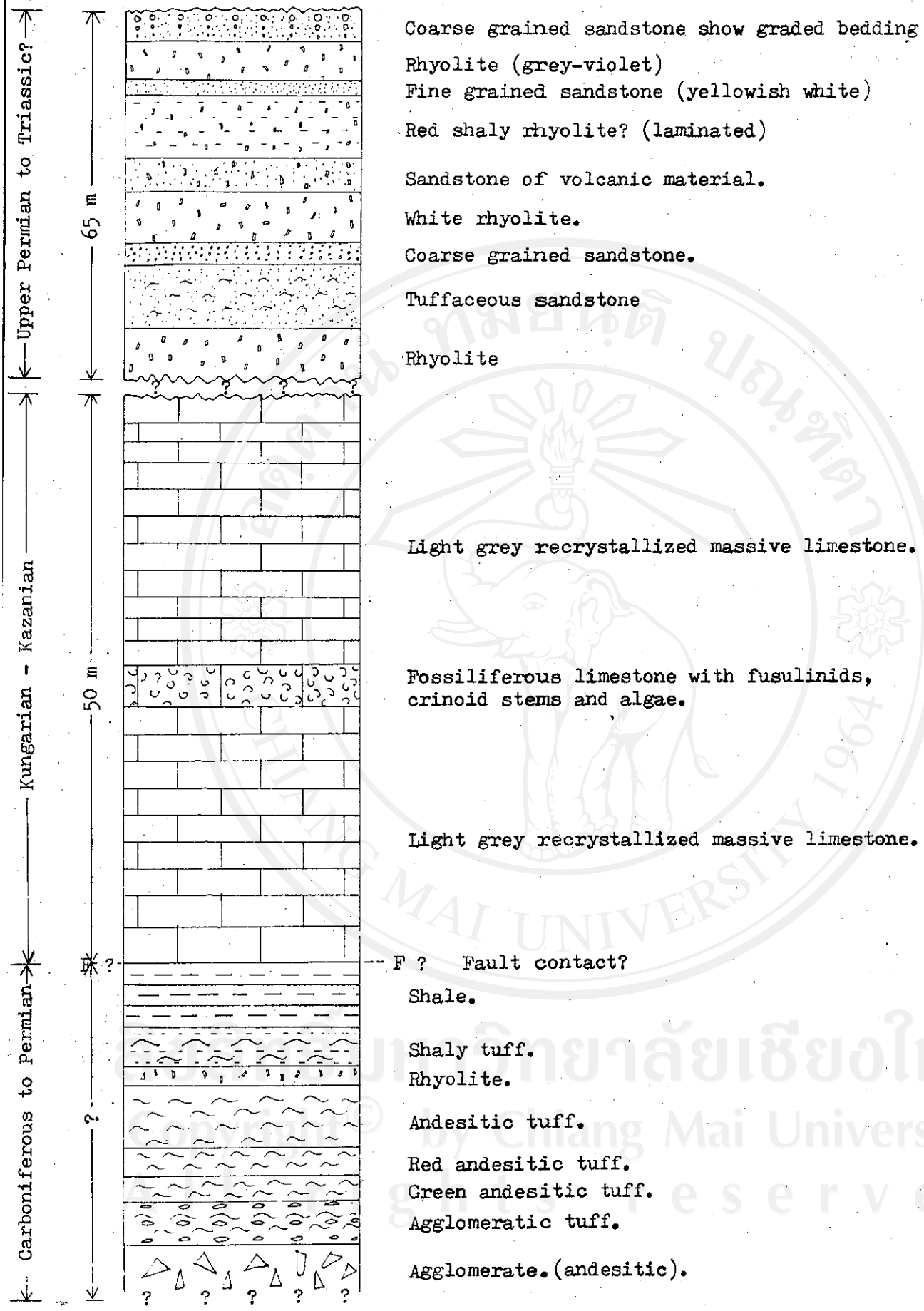



Fig. 2.23 Stratigraphic column in the Universal Mine and Thepnithi Mine region, Mae Tha.

Japakasetr (1973) reported the brachiopods Marginifera sp. and Rectiscularia sp. in the silicified brecciated shale? close to the small fluorite veinlets at the Thepnithi claim, indicating a Permo-Carboniferous Age.

The basic volcanic rocks and tuffs below the light grey limestone may range from upper Carboniferous to lower or middle Permian Age if there is no unconformity between volcanics and limestone.

The volcanic and clastic sediments above the middle Permian limestone may range in age from upper Permian to Triassic.

The country rock near the fluorite deposit is mostly altered. The tuffaceous rocks and parts of limestone are altered to grey and white clay minerals. These clay minerals fill in fluorite vugs and occur adjacent to the fluorite vein. Alteration of the rock is widely distributed.

2.5.4 Structure

The deposit is in a region of highly faulted rock. Limestone beds dip at N52W/ 75° SW. Sandstone dips N 84 W/48° NE, N 80 E/ 45° NW ( graded bedding, with fracture N25E/63° SE , N60E/40° SE . Most of the rocks dip north.

There are many faults in the area, occurring both before and after the main stage of mineralization.

1) The major fault trends approximately E-W and parallel to the strike of most country rocks. This fault serves as the open space for the main fluorite vein and can be traced from the Universal claim to the Thepnithi claim at the east end. Part of this fault in the

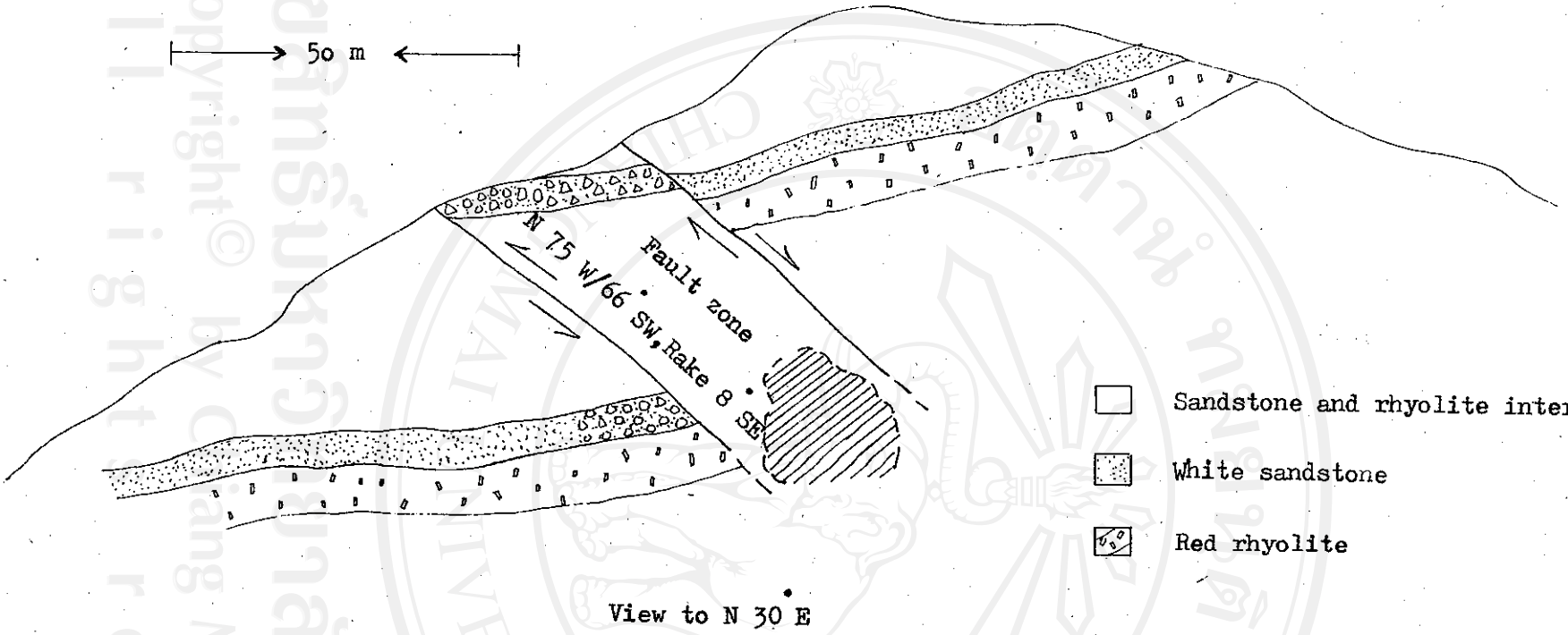



Fig. 2.24 Section on the north flank of the vein in Universal's claim. Section parallels to the length of the vein. The foot wall move down indicated thrust faulting. The vertical displacement observed is about 20 m.

Universal claim occurs between limestone and tuffs and is oriented at about 68° / S 60 W with rake 70° W. The attitude in the Thepnithi claim is about N 75 W, dipping north with about the same angle of dip, and found in intermediate volcanic rock. In the Universal claim, there is another fault of the same attitude occurring between limestone and younger sandstones, the fluorite is also localized in this fault. Thus, there are two branches of fluorite veins coinciding with faults at both sides of the contact zone between limestone and other rocks in Universal's property. While in the Thepnithi claim, there is only one regular vein.

2) Minor faults with the attitude N75W/66° SW, N65W/ 75° SW and rake 8° SE, are clearly observed in sandstones north of the veins (Fig. 2.24). The movement of the faults displaced the brown sandstone to the present contact with the rhyolite flow, with changing the attitude of the beds. The rake of the fault plane indicates horizontal movement. These faults probably also acted as channels for fluorite deposition.

3) Minor gravity faults. These faults are mostly nearly perpendicular to the strike of the vein, and caused a minor displacement of the vein attitude. They occur later than the main stage of fluorite mineralization.



2.5.5 Fluorite Deposits

Fluorite veins occur in E-W trending fault zones from the east end in intermediate volcanics in the Thepnithi claim to the

west end in limestone, tuffs, sandstones in the Universal claim, the length of the vein is about 825 m. Half of the veins in the Thepnithi claim are 5 to 10 m wide. In the Universal claim, the veins are irregular and split into 2 branches. Fluorite deposits coincide with the faults or occur as cavity filling in the limestone.

Fluorite is mostly grey, colourless, and purplish with layers. The purplish layered fluorite was found only in the upper parts of the vein, as the concentric layering surrounded the replaced rock breccia. Most fluorite at lower elevations is grey, associated with stibnite. The grey fluorite is of coarse granular type intergrown with the euhedral bladed stibnite aggregates with the crystal size ranging from mm to 10 cm. The bladed stibnite crystals also formed interlayered with fluorite. Stibnite occurs both in the initial stage of mineralization, localized in limestone or other rocks before the formation of fluorite, in vugs after the main stage of fluorite mineralization. Small amounts of fluorite crystallized at the latest stage as small cubic crystals coated on the bladed prismatic stibnite crystals in the vugs. At least 2 stages of stibnite mineralization are recorded. (Plate 18, No.4).

Chalcedony occurs as a gangue mineral in some places. In the Universal claim, fluorite breccias near the fault were interstitially filled by pale yellow chalcedony, and were called "Low grade ore" (Plate 19, No.6) Paragenesis of the mineral assemblages observed from the field evidence and under microscopic study is shown in Fig. 2.25.

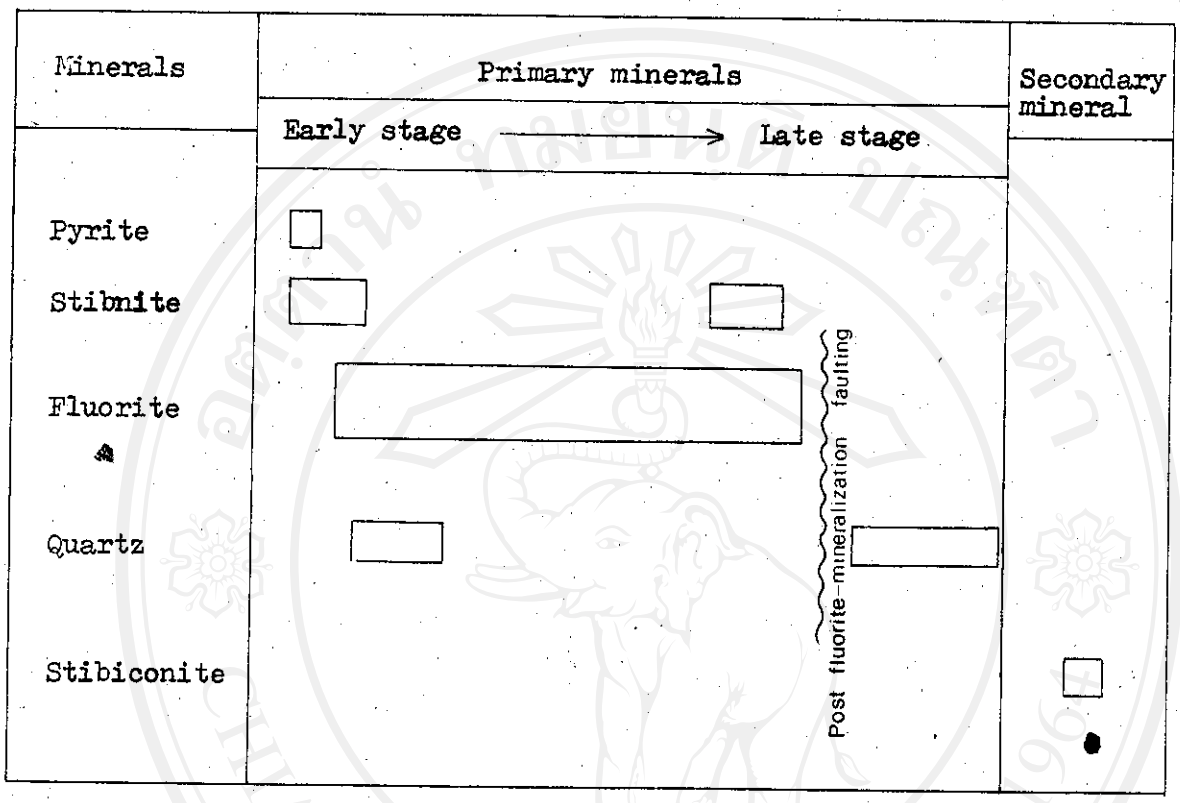



Fig. 2.25 Paragenesis of ore minerals at Mae Tha deposits. (Universal Mine and Thepnithi Mine)

Pyrite and stibnite 1 formed in the early stage of mineralization, usually associated with limestone host rock. Granule fluorite replaced rims of stibnite 1. Stibnite 2 formed in vugs later than the main stage of mineralization. Some fluorite is later than stibnite 2 (Fig.2.25). The crystalline quartz deposited simultaneously with the beginning of stibnite mineralization, but in only small quantity. Chalcedony was deposited after brecciation of the fluorite vein. Stibiconite is secondary mineral formed after-oxidation of stibnite.

2.5.6 Thermal Springs

Hotsprings are found in the Thepnithi claim (Fig.2.22 ). The warm pool is at 42° c at the surface, containing some black undissolved material and $H_2S$ odor. The fluorite content in this water is 25 ppm ( Ratanasathien , 1979). The area of the warm pool is about 50 square m. The mining can not operate in this region because of the warm water. The country rock in the vicinity is intermediate volcanic agglomerate. The large gravity faults run through the hot springs.

## 2.6 District 5 : Ban Hong Fluorite Deposit

### 2.6.1 Location

Ban Hong fluorite deposit is located in Tumbol Ban Pa Phlu, Amphoe Ban Hong, Lamphun Province at km 725 from Bangkok or 53 km from Lamphun on the Paholyothin Highway. It can be found in the Map Sheet 47Q/CC 8 at Grid Reference 834/134, or at Longitude 98° 50' 38" E , Latitude 18° 12' 39" N . The main fluorite production of the Ban Hong District was formerly from this deposit. The district is easily accessible. The main deposits crop out along the hill about 100 m to the east of the Paholyothin Highway at km 725. They also extend across to the western side of the road. Another deposit in the Ban Hong District was later discovered at Doi Thon, 48 km from Lamphun , at Grid Reference 843/107 of the Map Sheet 47Q/CC 8, or at Longitude 98° 51' 07" E , Latitude 18° 11' 12" N. The deposit is in the Nam Mae Li Basin which trends NNW between the steep mountain chains (Fig.2.26).Nam Mae Li flows north and connects with Ping River . The deposit is about 1.5 km west of the Nam Mae Li.

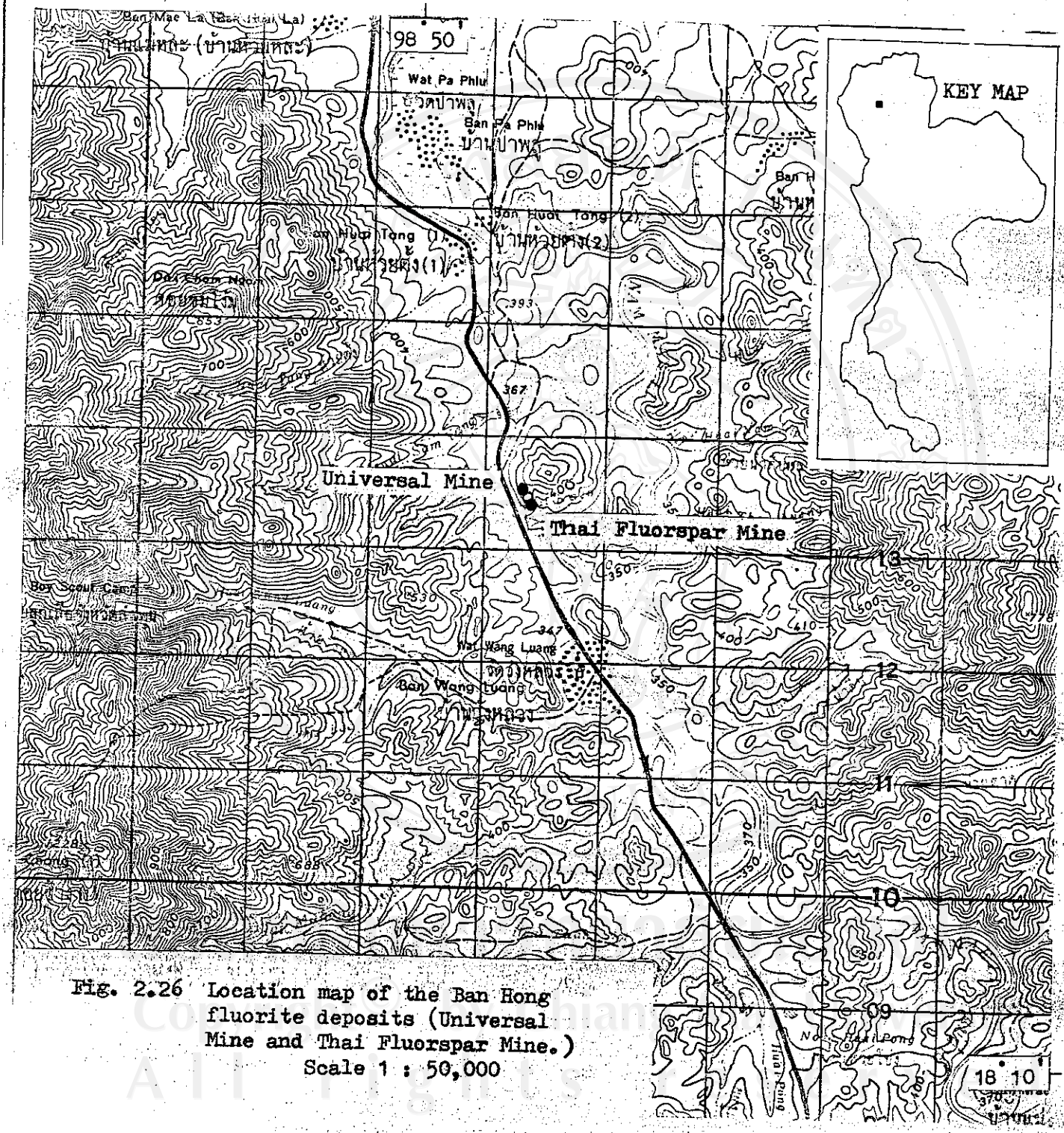



Fig. 2.26 Location map of the Ban Hong fluorite deposits (Universal Mine and Thai Fluorspar Mine.)
Scale 1 : 50,000

The elevation of the outcrop is about 360-400 m O.D., while that of Nam Mae Li is about 345 m O.D. The elevation of the highest north trending mountain on the east side of Nam Mae Li is 1020 m O.D., and Doi Chang to the SW is about 1228 m O.D.

2.6.2 Mine Production

This district is under the concession of 4 mining companies VIZ : Universal Mining Co.,Thai Fluorspar and Minerals Co., Nithiwatana Co., and United Mining.The major veins in this area are in the Universal and Thai Fluorspar properties. The total production from the Universal claim during 1962-1965 was 72,000 tons, and during 1966-1975 was more than 1,300,000 tons of +80 % $CaF_2$. The total production from Thai Fluorspar claim during 1962-1975 was probably more than 500,000 tons ? of the same grade. The total ore reserves estimated by Gardner (1964) was about 3,550,000 tons.

2.6.3 Geology

The country rocks are a thick sequence of phyllite, shale siltstone, sandstone, limestone, quartzite, and conglomerate of the Kanchanaburi Series ( Silurian - Devonian), and the Ratburi Group (GGM reports, 1972). The succession of rocks in Ban Hong District from bottom to top is :

| | | |
|---|---|---|
| Top | Quartzite | Kanchanaburi Series (Silurian - Devonian) |
| | Limestone | |
| Bottom | Slaty shale and phyllite | |

Shale and phyllite of Kanchanaburi Series are exposed along the road cuts north and northwest of the deposits. Limestones have been found by drilling into the hillside to the south between the two main veins in the Universal claim, and are exposed along the open cut of the Thai Fluorspar claim. Quartzite occurs as boulders along the top of the ridge. The strike of the rocks is N 40 W, and they dip steeply, generally to the southwest. The schistosity in some of the country rock to be N 2 W/ 60 SW. Slaty shale is light to medium brown and grey. The limestone is light grey and fine grained to sacharoidal texture. Quartzite is light brown to medium to coarse grained. The Kanchanaburi series is locally metamorphosed, with slate changed into phyllite, and quartzitic sandstone changed to quartzite. In some places, limestone is interbedded with quartzite (Sukto and Sanansiang, 1965). The limestone of Ratburi Group, with fusulinids of Permo-Carboniferous age, are the formation which is closely related with the ore deposits. It strikes N-S with moderate to steep dip. The formation consists of massive grey limestone, green phyllite, red conglomerate, quartzitic sandstone and tuff. At the open pit of Universal and Thai Fluorspar claims, ( Figs. 2.28, 2.29,2.30) the limestone is cherty and contains crinoid stems and some fusulinids ( Sukto and Sanansiang, 1965). In some parts, the limestone is recrystallized to marble. The limestone overlies a 90 m sequence of green, grey, purplish and black shale which contains large amount of pyrite.

Tertiary rocks in northern part of Amphoe Ban Hong consist of semi-consolidated fluviatile deposits of clay, sand and gravel with oil shale and lignite (GGM report, 1972). At the fluorite deposits, the

Tertiary gravel bed consists of pebbles of quartz, quartzite, sandstone, shale and limestone. Unconsolidated shale is also found underlying the gravel bed in some places ( Sukto and Sanansiang, 1965).

Quaternary gravels consisting of terrace deposits and river gravels are found along the banks of the Li River. A granite batholith of Triassic Age (GGM report , 1972), 30 km long in a N-S direction and 7 km wide, outcrops 6 km east of the deposits and a smaller one lies about 9 km west of the deposit. Altered granite has been discovered at depth during diamond drilling in the fluorite deposits. The granite at Doi Chang is a coarse grained hornblende-biotite granite (Charoensri, 1972 ).

The main regional structures are a series of very large N 20-30° W trending anticlines and synclines together with large fault blocks. The faults run in the same direction as the granite trend. The dip of the fault planes is generally steep. The deformation was probably caused by igneous intrusion and orogeny in Triassic to Early Jurassic, and late Tertiary to Quaternary Times ( Gardner and Smith , 1965).

2.6.4 Fluorite Deposit

Fluorite deposits in the Ban Hong region are scattered over a distance of 26 km along the major fault zone parallel to the Li River (GGM report, 1972). In the Universal and Thai Fluorspar areas which is the biggest deposit, the rocks of Ratburi Group including limestone(Permo-Carboniferous), shale and tuff are faulted against Tertiary gravels. Charoensri (1972) concluded that the Ratburi Group is probably folded and plunged with the axis in SE-NW direction, after this faulting

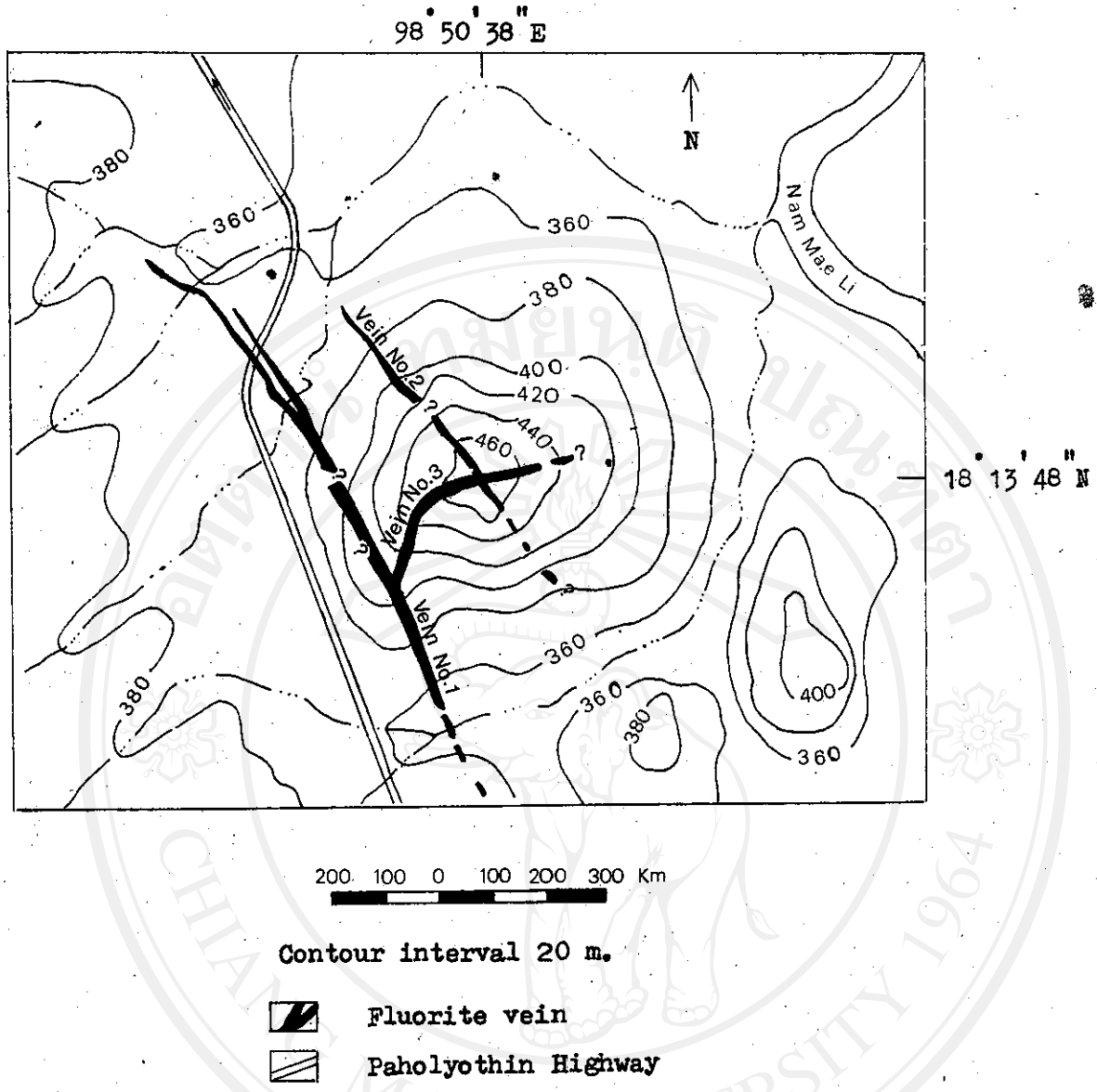



Fig. 2.27. Ban Hong fluorite deposits (Universal Mine and Thai Fluorspar Mine). Based on the Universal's map year 1961.

FIG. 2.28 GEOLOGIC MAP OF FLUORITE DEPOSIT
UNIVERSAL MINING CO. ( MAIN ORE BODY)
BAN HONG, LAMPHUM
(BASED ON U.M.C. MINE MAP 1969)

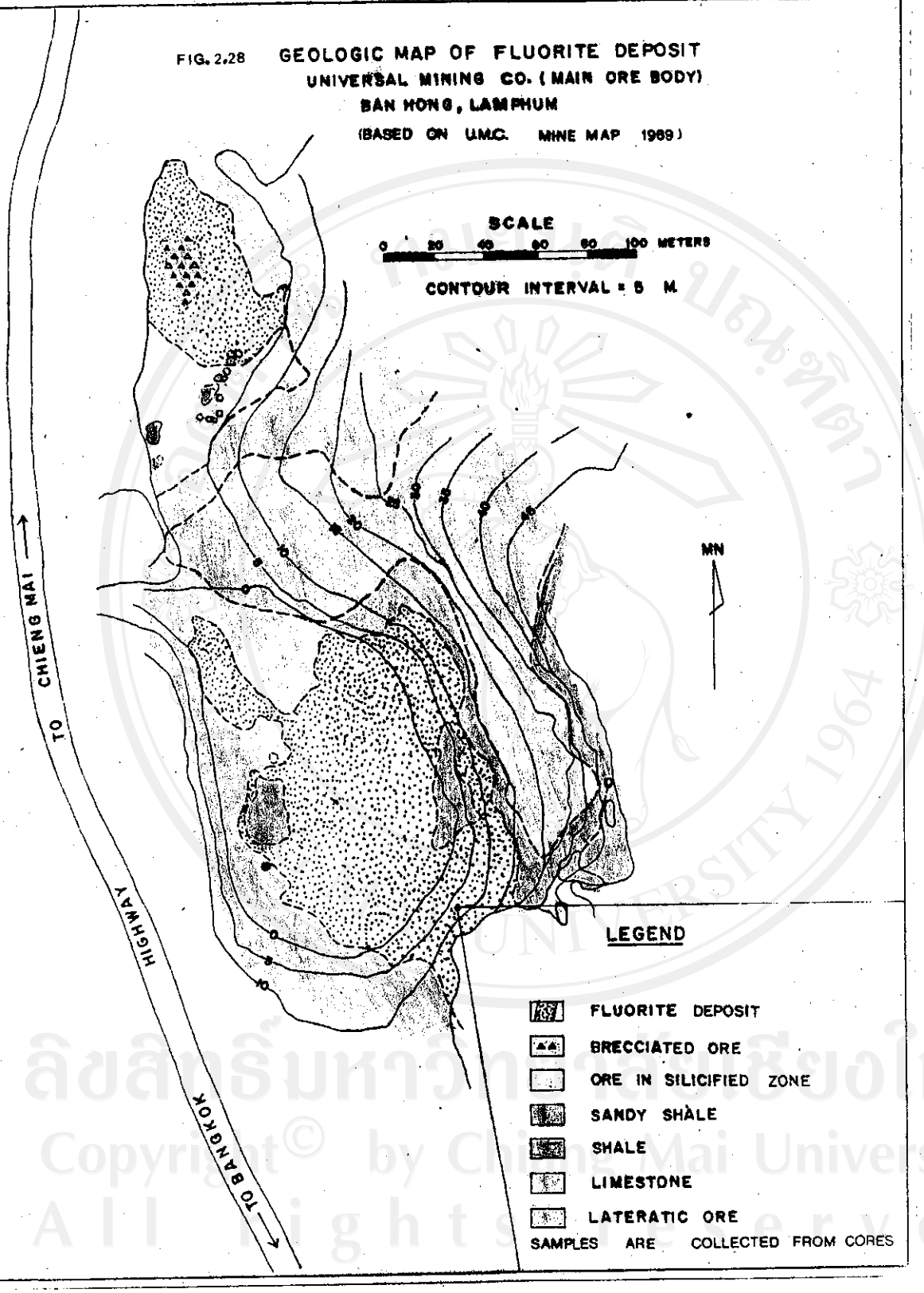


FIG. 2.29 GEOLOGIC MAP OF UNIVERSAL FLUORITE MINE, SAN HONG, LAMPHUN
(BASED ON MINE MAP YEAR 1972)

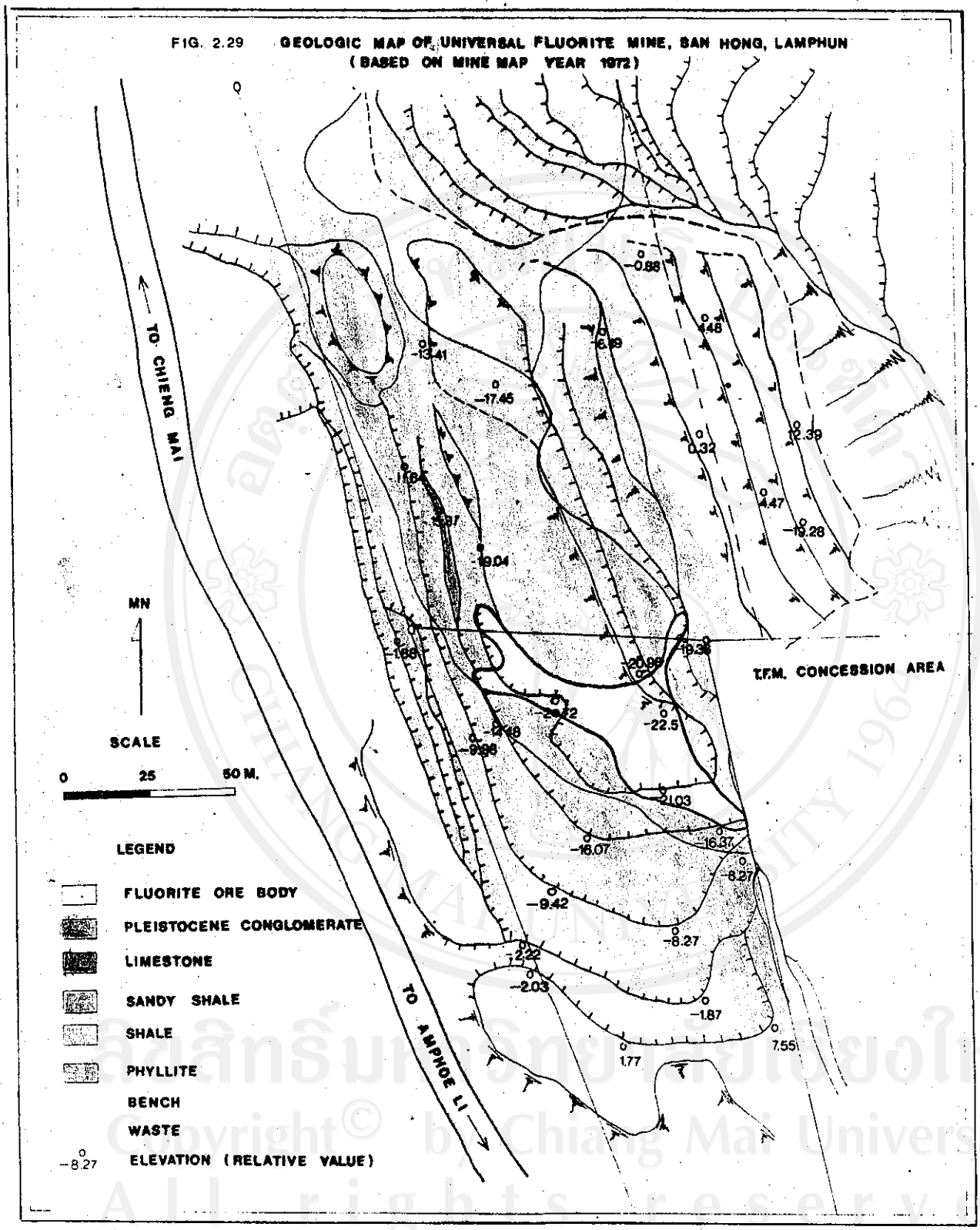
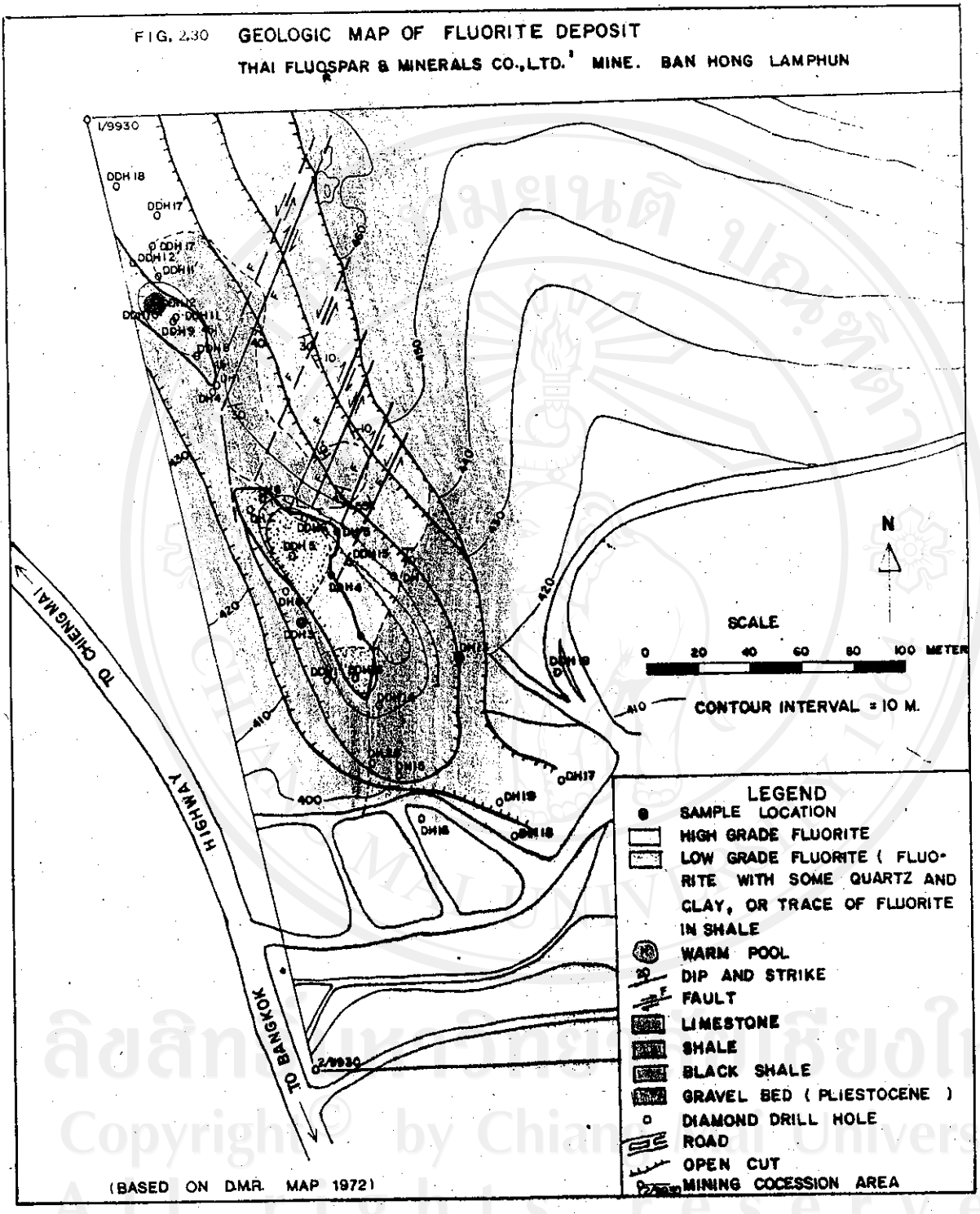


FIG. 2.30 GEOLOGIC MAP OF FLUORITE DEPOSIT

THAI FLUOSPAR & MINERALS CO.,LTD.' MINE. BAN HONG LAMPHUN




(BASED ON D.M.R. MAP 1972)

occurred on the west flank. It plunged 70° to the north. Mineralization is clearly related to this fault (Fig. 2.31 A and B ), which is repeated some 1000 m further to the west. The best ore was formed by replacement of limestones of the Ratburi Group adjoining the faults (GGM report , 1972). Some minor amounts of fluorite also occur in the gravels. Gangue is quartz with traces of disseminated pyrite. The total length is 800 m and the width is 30-60 m (Japakasetr and others, 1973).

In the Universal claim, the deposits at the beginning of the mining consisted of three long thick veins. Vein no. 1 lies to the west and no. 2 to the east while Vein no. 3 connects them (Fig. 2.27). The veins strike about N 40° W, parallel to the main structural trend (anticlines and synclines) of the regional and local area. Both veins (1,2) cross the steep ends of the hill and adjacent revines with little change in trend, indicating vertical dip of the ore body. The main deposit is Vein no. 1 (Fig.2.28), which is about 800 m long, from a few meters to more than 30 m wide, and exposed through a vertical distance of about 57 m. The maximum width suggested by Abe and others (1962) is about 40 m, and by Sagawa (1963) is 80 to 100 m (Thephasdin Na Ayuthaya, 1964). This was the richest ore in the district and furnished most of the production during 1960-1975. The Vein no. 2 of the Universal claim is exposed for a length of about 420 m with a depth of about 85 m. It ranges in width from about 5 m in the southern part to about 10 m or more in the northern part. The grade of ore is nearly the same as in Vein no. 1. Vein no. 3 curves northeastward and then eastward from Vein no. 1 to merge with vein no. 2. The length is about 295 m, with a probable width

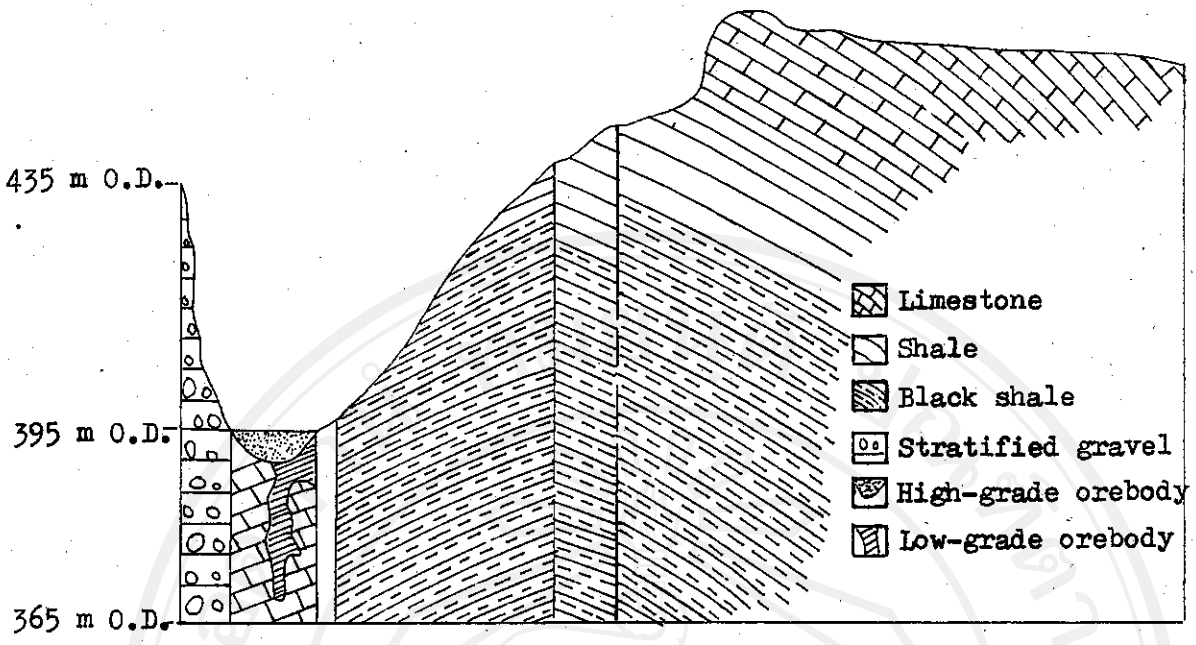



Fig. 2.31 A. X-section perpendicular to the length of fluorite vein at Thai Fluorspar Mine, Ban Hong, showing the fluorite orebody in the major faults between black shale, limestone, and stratified gravel. The low-grade ore in limestone is the lower part of orebody. (After Charoensri, 1972).

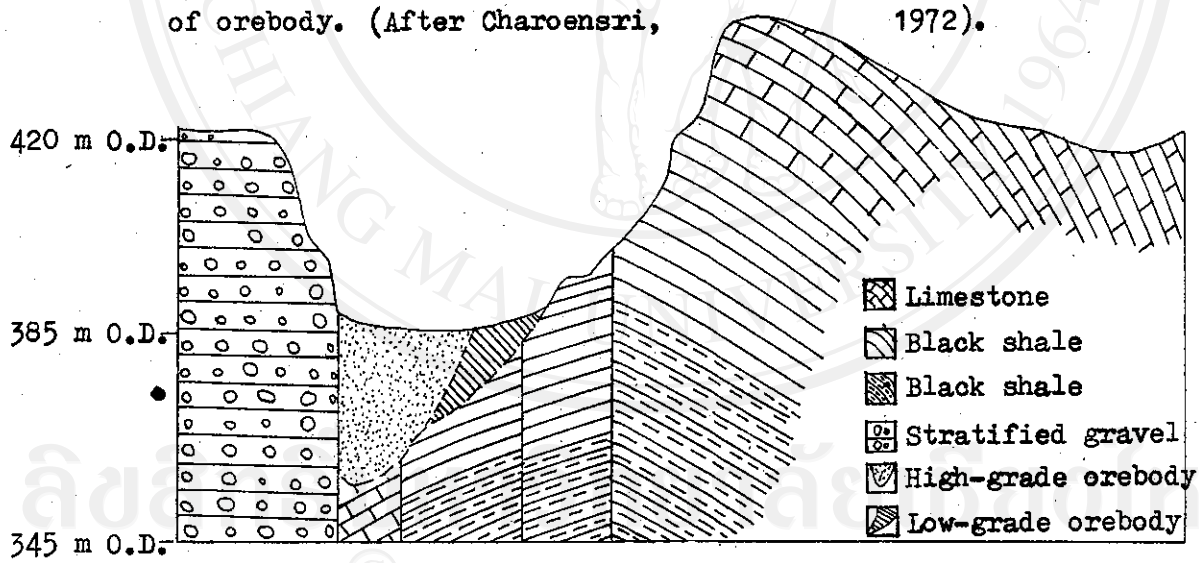



Fig. 2.31 B. X-section perpendicular to the length of fluorite vein at Thai Fluorspar Mine, Ban Hong, showing the fluorite orebody in the major faults between shale, limestone, and stratified gravel. The low-grade ore is the outer zone of orebody. The fault between limestone and stratified gravel is very distinctive. (After Charoensri, 1972).

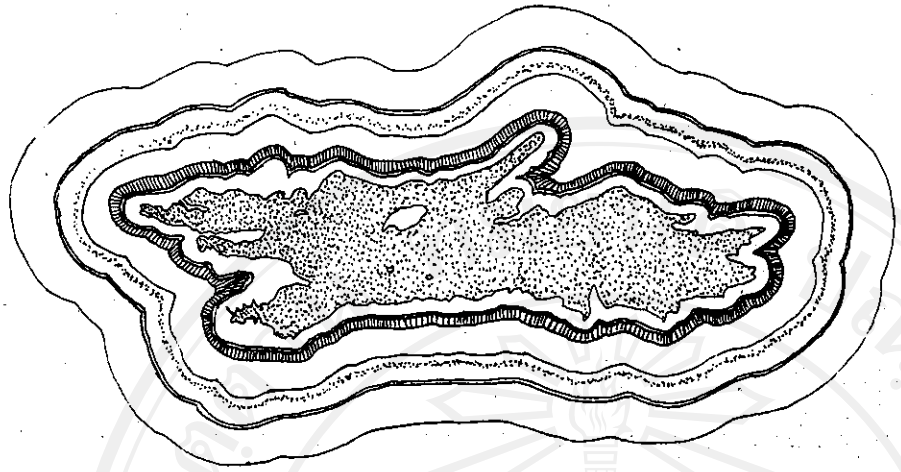
of about 10 m, and it is exposed through a vertical distance of 66 m. The dip probably decreases westward from vertical near Vein no. 2 to about 60° SE near Vein no. 1

The fluorite is more resistant to erosion than the country rock, especially the slaty shale and phyllite. The veins hold up crests of ridges. Fluorspar boulders are concentrated along the outcrops and in the talus material that has slid down the west side of the hill. The deposits consequently appear to be wider than they really are.

At the top of the ore body, the vein is continuous throughout its length, but in the lower portion of the ore body, the fluorite become more brecciated and the vein is discontinuous along it length ( Charoensri, 1972).

Most of ore is massive, and coarsely crystalline, banded and botryoidal in form. The botryoidal fluorite is higher in grade than the banded fluorite. The botryoidal fluorite is usually honey-brown and the botryoidal loop ranges from 1 to 10 cm. It consists of irregular shaped limestone ( and shale?) rock nuclei surrounded by layers of pale yellowish brown and brown botryoidal fluorite. Banded fluorite is usually grey to black, and is mostly found within black shale.

Silica in the form of quartz, black chalcedony and opal ranges from a few percent to almost 100 % of the vein material. It occasionally found as geodes associated with fluorites. Some quartz gangue occurs as well crystallined quartz 1-5 mm long lining vugs in the fluorite (Fig. 2.33).



Rock nucleus

Concentrically layered fluorite

Zone of primary fluid inclusions.

Fig. 2.32 Concentrically layered fluorite surrounded rock nucleus. (Note : zone of primary inclusion parallels to the colour-zoning.) Thai Fluorspar Mine, Ban Hong.

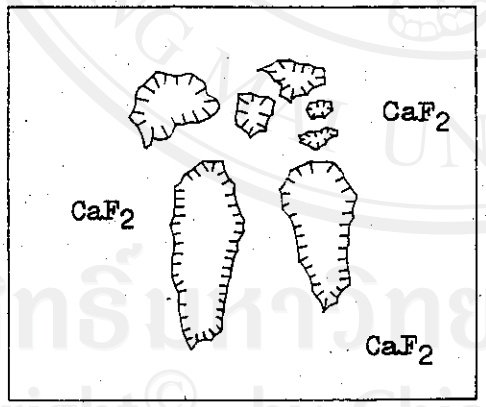



Fig. 2.33 Vugs in fluorite. Small quartz crystals deposited within the vugs. Universal Mine, Ban Hong.

Paragenesis of the mineral and gangue (Fig. 2.34) studied from the field evidence and microscopic study can be illustrated as :

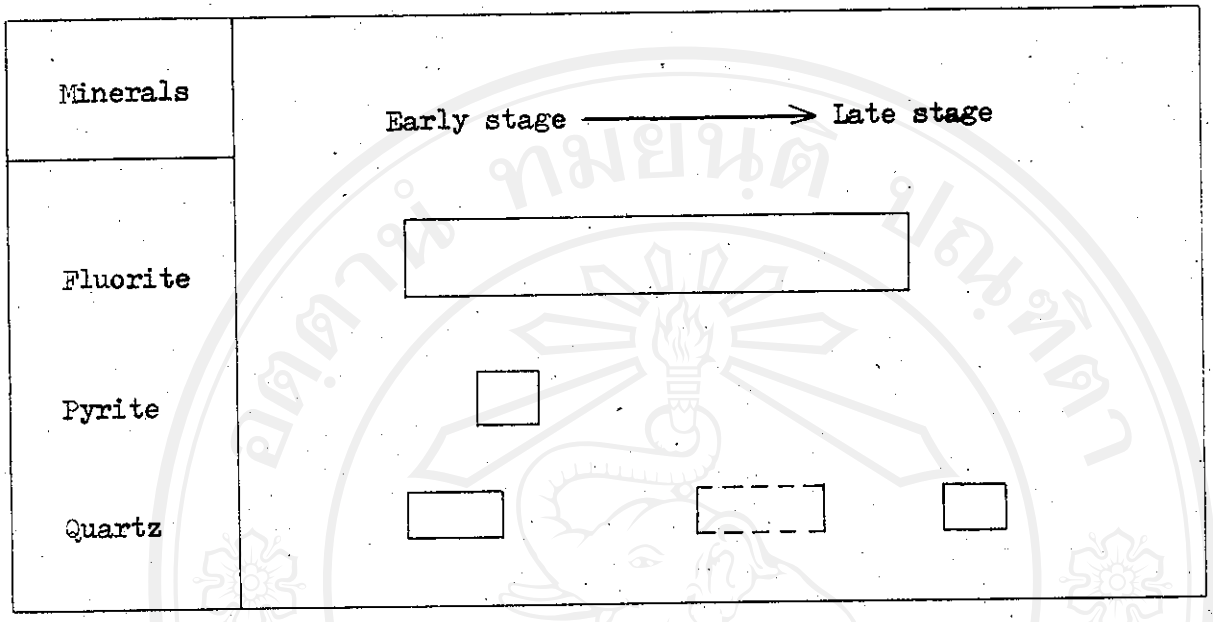



Fig. 2.34 Paragenesis of ore minerals at Ban Hong deposits. (Universal Mine and Thai Fluorspar Mine).

2.7 Tha Song Yang Stibnite-Fluorite Deposit.

The deposit is situated at Grid reference 142/178 of the Map Sheet 4643 IV or at Longitude 98° 11' 34" E, Latitude 17° 20' 47" N. This mine can be reached by the highway from Tak to Mae Sod (83 km), and from Mae Sod via Amphoe Mae Ramat and Amphoe Tha Song Yang to Ban Mae Usu (93 km). The deposit lies 7 km to the NE of Ban Mae Usu. The ore is mined in two open cuts, No. 1 and No. 2. The area is mountainous. The highest elevations are 715 m 0.D. 1.5 km NW of the deposit and 1032 m 0.D. 4.5 km NE of the deposit. Nam Mae Usu flows to the south, passing deposit No. 2, to the Moei River which is about 100 m 0.D. The elevation of the deposit is about 400 m 0.D. (Fig. 2.35).

This deposit has been operated by the South Pacific

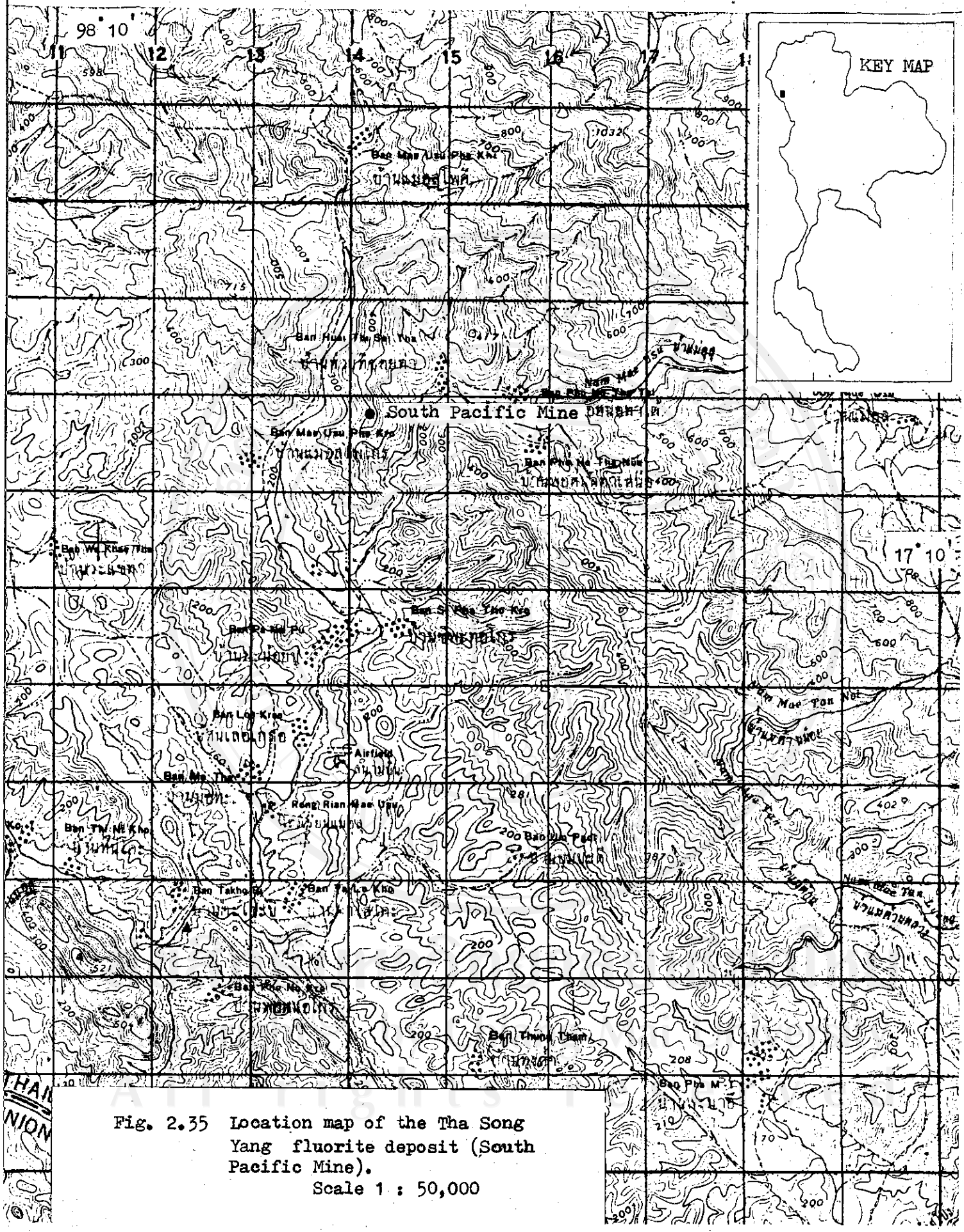



Fig. 2.35 Location map of the Tha Song Yang fluorite deposit (South Pacific Mine).
Scale 1 : 50,000

Enterprise Co. since 1977. At present, 400 tons of low grade ore (5-10 % Sb), and 100 tons of high grade ore (60 % Sb) have been produced.

The country rocks are Permian limestone and shale. The Permian limestone belt is aligned in a NW direction 5 km west of the deposit. Fluorite deposits also occur in shale and sandstone more than 1600 m thick, and of uncertain age, probably Permian or older. At Huai Mae Usu Luang, pebbles and boulders of stressed biotite granite are found along the river channel. The country rocks strike N 20 W and dip gently. The major structural geology of this deposit is an overturned anticline with both limbs dipping 30-40°. The fold axis trends N-S and probably plunges SE. Major faulting also occured along a N 20 W direction.

The fluorite-stibnite deposits are in joints, faults, and at the crest of the anticline in sandstone and shale. The ore is rich only at the intersection of the two joint sets N 20 W / 90°, and N 75 W / 80° SW. The second is probably a system of tension fractures in the sandstone.

At the intersection of the sets, the ore occurs as stibnite-fluorite pockets (Fig.2.36). There are two stages of fluorite mineralization. In the first stage, seen at Open Cut no. 1, interstitial greyish white to colorless sub-transparent fluorite formed after the bladed, radiated crystalline aggregates of stibnite. The volume ratio of stibnite : fluorite is 10 : 1. In the second stage, (seen at Open Cut no. 2), with crystalline cubic fluorite formed in cavities at the crest of the anticline (Fig.2.37). The crystals are 1-1$\frac{1}{2}$" in size with

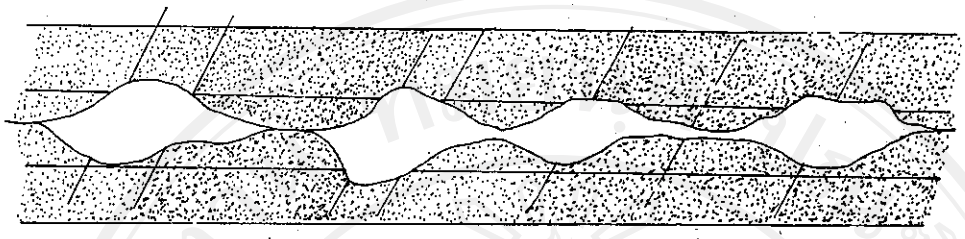


Fig. 2.36 Pockets of stibnite-fluorite concentrate at the intersection of joints in sandstone. South Pacific Mine, Tha Song Yang.

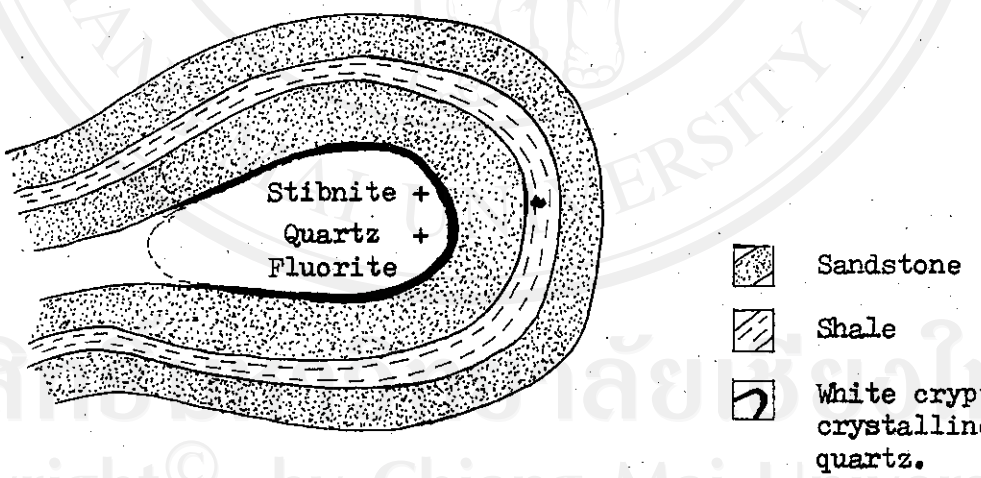



Fig. 2.37 Fluorite (well crystallized cubic crystals), quartz and stibnite filled in cavity at crest of anticline. South Pacific Mine, Tha Song Yang.

zonal change of colours ( pale violet to violet in the middle, and green in the outer layer). In the first stage, the associated gangue minerals are pyrite, arsenopyrite, and cryptocrystalline quartz. In the second stage, the gangue is mainly cryptocrystalline quartz formed simultaneously with the fluorite. Stibnite is absent in this stage.

2.8 District 8 : Ban Sop Lan Fluorite deposit

This fluorite deposit is situated near Ban Sop Lan, Tumbol Yang Piang, Amphoe Omkoi, Chiang Mai Province, at Grid Reference 372/444 of the Map Sheet 4644 II , or at Longitude 98° 24' 32" E. Latitude 17° 35' 13" N. Access is by road 30 km south from Amphoe Omkoi to Ban Sop Lan. This unpaved road is very steep and can not be used in the rainy season. The deposit is on the slope of a granite mountain near Ban Sop Lan at an elevation of 760 m O.D. The highest elevation, 2 km to the SW, is 1000 m O.D. Ban Sop Lan stand at a lower elevation at 540 m. O.D. Nam Mae Had flows from the NW to the NE of the deposit, and joints Nam Mae Tun about 2.5 km east of the deposit.

The deposit is still undeveloped. Its reserve is about 6,000 tons of 85-95 % $CaF_2$.

The deposit is in granitic country rock. Granite mountains, trending N?S cover most of the region. Thin bedded recrystalline limestone is found 1.5 km east of the deposit, near the Nam Mae Tun River. The granite is medium to fine grained muscovite granite, muscovite-biotite granite, and biotite granite. Small pegmatite veins and quartz veins are common in the granites.

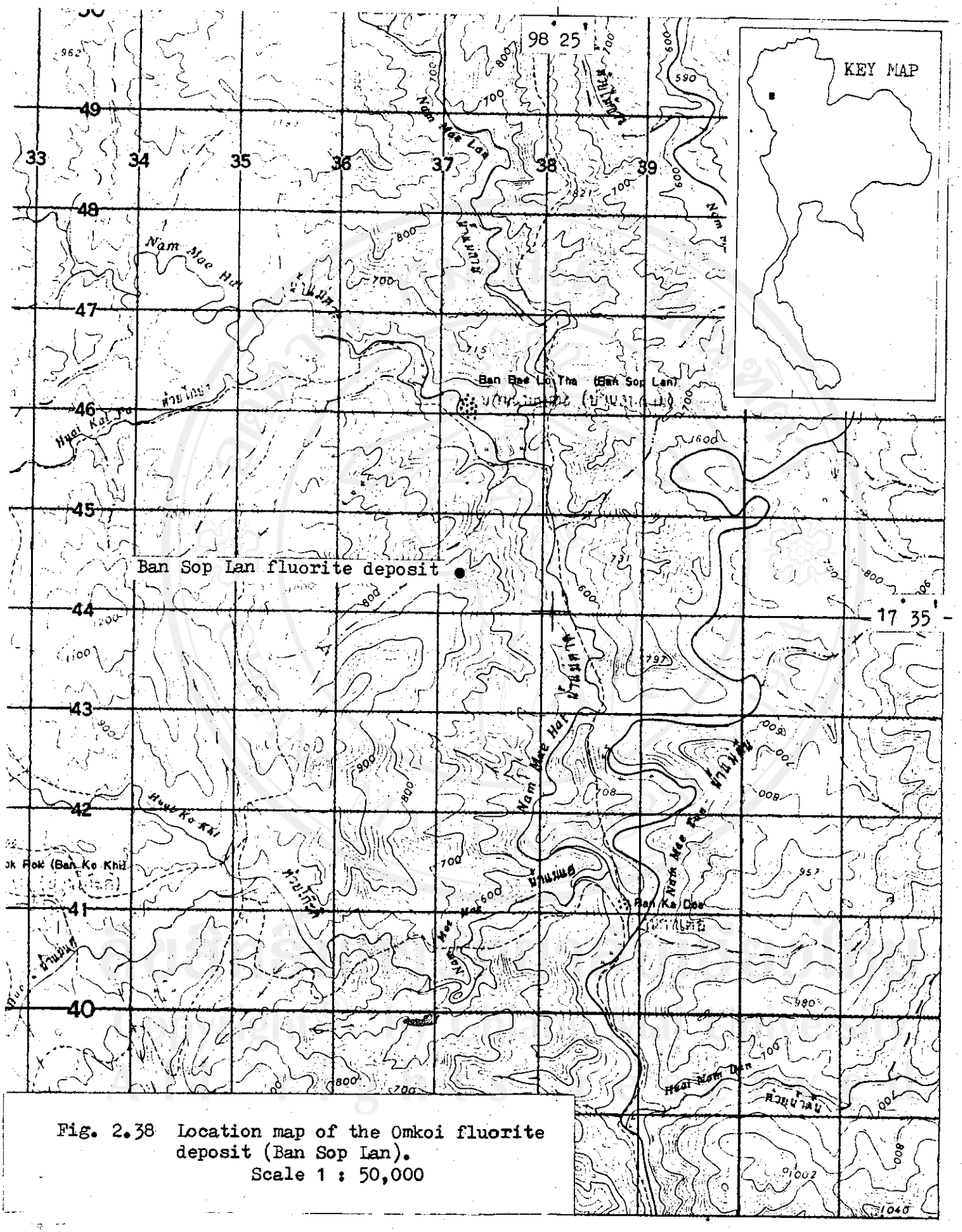



Fig. 2.38 Location map of the Omkoi fluorite deposit (Ban Sop Lan).
Scale 1 : 50,000

Fluorite vein occurs in a fault zone running in a NE direction within the granite. This fault is believed to be more than 1 km long. The attitude of the vein is N 30 E / 70° NW. The length is about 1 m with irregularity, due to pinching and swelling. The fluorite is a coarse grained crystalline with cubic crystals up to $1\frac{1}{2}$" in diameter. The colours are sky blue, deep green, and purple. Fluorite is high grade ore (85-95 % $CaF_2$) associated with cryptocrystalline quartz, and in some places, fluorite is less abundant than quartz. Cryptocrystalline quartz occurs separately in the same fault zone.

2.9 Ban Muang Ngai Fluorite Deposit

The deposit is located at Grid Reference 929/565 of the Map Sheet 47Q/CD 16 or 4748 II, or at Longitude 98° 55' 57"E and Latitude 19° 30' 16"N in Amphoe Chiang Dao, Chiang Mai Province (Fig.2.39). From km 72 on the Chiang Mai - Fang Highway, the lateratic road runs 5 km to Ban Muang Ngai, and 6 km further NW to the deposit. Topography is generally mountainous. The highest peak is 845 m. O.D., 1.5 km NW of the deposit. Elevation of the deposit is 650 m O.D. Elevation of Huai Nam Ngai running south of the deposit is 500 m O.D.

The country rocks consist of sandstone, shale and limestone. Limestone and shale of Permian Age, striking E-W, are the host rocks of the deposit. There is no igneous rock found near the deposit. NW-SE faults dip east at Huai Mae Ngai, and are probably traceable for more than 5 km. Tertiary conglomerate, sandstone and shale are found east of the deposit near the Ping River.

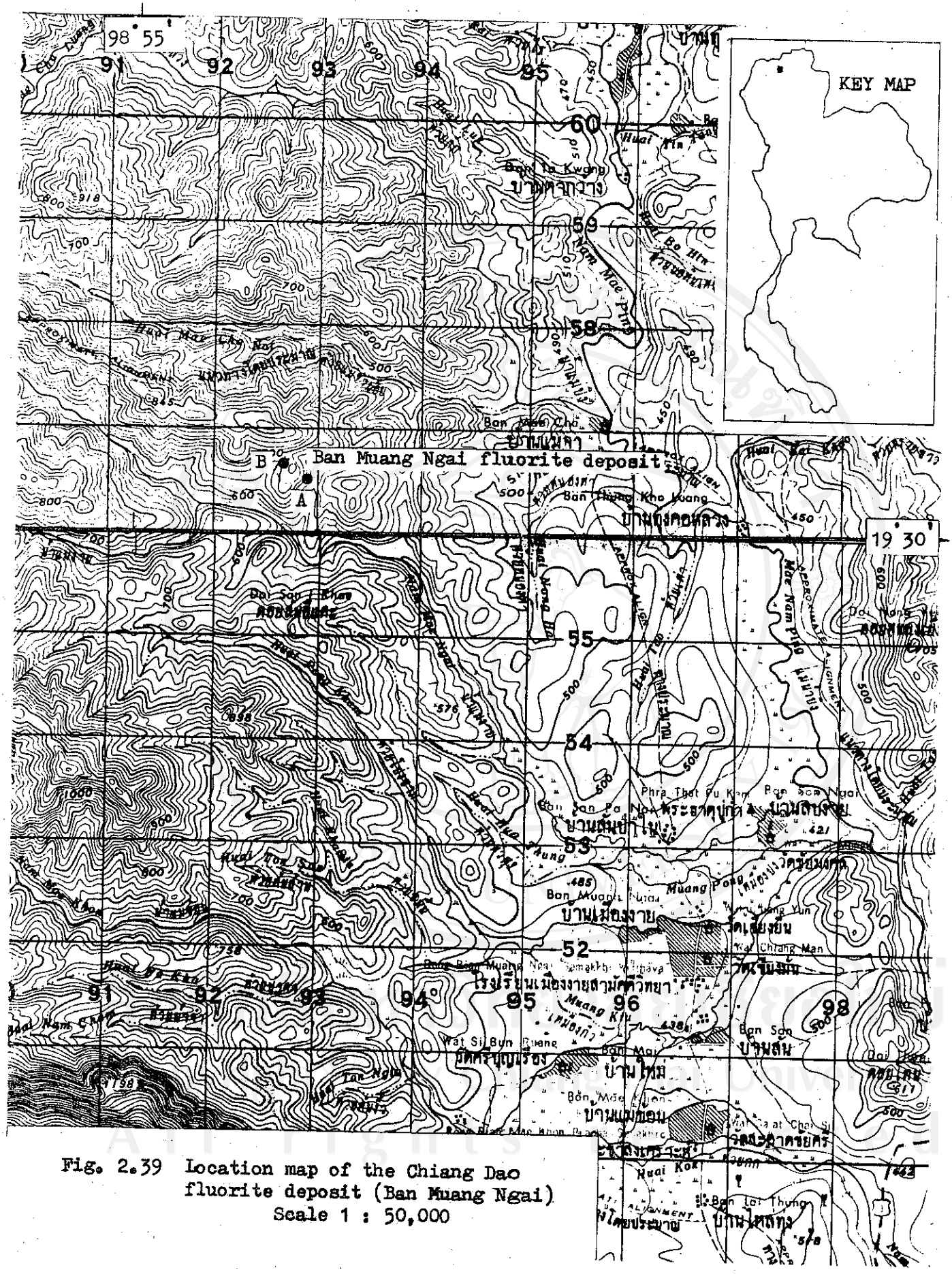



Fig. 2.39 Location map of the Chiang Dao fluorite deposit (Ban Muang Ngai) Scale 1 : 50,000

Deposit A. ( Thai Fluorspar and Minerals Co.), is at Grid Reference 929/565. The fluorite replaced limestone, along a NW-SE direction. The length of the deposit is about 130 m, and the average width is about 30 m (Charoensri, 1972). Fluorite veinlets occur in this zone, and in the country rocks around the deposit. Fluorite are transparent white, brown and grey to greyish black, showing botryoidal and small cubic crystal forms. Some fluorite occurs along the bedding planes of silified shale. White quartz occurs as a gangue mineral. Greyish black chalcedony is also common in some places. Quartz seems to have crystallized before fluorite.

Deposit B. is at Grid Reference 926/566, or at Longitude 98° 55' 45" E , Latitude 19° 30' 19" N . The fluorite vein, 1 m thick, is found along a fault zone on the slope of a sandstone mountain about 500 m from Deposit A. Fluorite occurs in this fault as fissure-filling. It is white concentrically layered fluorite surrounding replaced rock nuclei. The layered fluorite is similar to fluorite at Amphoe Pai.

2.10 Other Deposits

Other interesting fluorite deposits in northern Thailand, which are not included in the present study are :-

-At Mae Sariang, Mae Hong Son Province, botryoidal and layering fluorite occurs as irregular cavity filling and replacement in limestone and sandstone. Associated minerals are silica and stibnite. Fluorite vein strikes N?S and attains up to 15 m in width.

-At Ban Mae Tern, Amphoe Thoen, Lampang Province,(District

7), fluorite occurs as botryoidal, layering and replacement in limestone and sedimentary rocks in fault zones at the same elevation as the stream. Hot pool is found in the fluorite vein.

At Saeng Thong Mine south of Amphoe Hod, Chiang Mai Province, fluorite occurs as replacement in limestone and Tertiary conglomerate. The ore body is massive and wider in the lower portion of ore body.

At Mae Ao Mine, SE of Lampang Province, numerous fluorite vein dissected flat lying limestone. Replacement is also occurred in limestone.

-At Doi Tao District ( District 6) SW of Ban Hong, Lamphun Province, mineralized vein trending NE, ENE occur in granite and sedimentary rock as cavity filling in partly brecciated rocks.

At Pa La Door, Amphoe Mae Ramat, Tak Province, fluorite and cryptocrystalline quartz occur as fissure veins and replacement in limestone in fault zone trending NE. Hot pools are found in the vein 20 m above the Mae Tun River, and in the river channel itself.

At Ban Pong Nam Ron, Amphoe Muang, Kamphaeng Phet Province, a group of fluorite veins formed by fissure-filling and replacement in Permian limestone and sandstone. Few veins are in Carboniferous? granite. Thermal pool is about 1 km away from the deposit in granite. Some fluorite deposits are in Tertiary terrace gravel bed and used the individual rounded pebbles as nuclei for concentric layering of mineralization in the altered clay matrix. This indicates the young age of mineralization. Grade of fluorite is different from place to place ranging from 30-75%$CaF_2$.

At Mae Phu , Amphoe Thoen, Lampang Province (District7), 9 km north of Amphoe Thung Saliam, Sukhothai Province, fluorite-stibnite veins occur on flat topography in fault zone in dark grey fine grained thin bedded limestone interbedded with slate. The direction of the vein is nearly perpendicular to the bedding plane. Star-bladed stibnite less than 1 cm in sizes with layering of fluorite is found through out the deposit. Stibnite in the lower portion of the vein is more than the upper part of the vein. The other gangue minerals are milky quartz and brown chalcedony. Aplite is found in the region near the deposit.

2.11 Summary of Fluorite Varieties

Summary of varieties of epithermal fluorite in the deposits described are :

1) Replacement Fluorite. (usually grey,or original-rock colours.)

2) a. Concentric Layered Fluorite (with rock nuclei)

b. Thin Layers around Rock Nuclei in Breccia

c. Botryoidal, Fine Grained Fluorite

This fluorite variety is usually brown,grey and colorless.

3) Nodules of Fluorite with Radiated Crystals ( various shades of colour in zoning around nucleus).

4) Flat-Layered Fluorite in Veins, (may be associated with quartz ; various shades of colours)

5) a. Coarse Granular Fluorite Associated with Stibnite. (usually colorless to grey)

b. Less-Granular Fluorite ( Layers), No Stibnite. (usually colorless to grey)

6) Coarse Cubes of Fluorite. (colour zoning and various shades of colour).