

## CHAPTER III



### RESULTS OF THE STUDY

The results of the study mentioned in chapter I will be separated into two main parts, petrographic characteristics and engineering properties. Petrographic study will involve observation of rocks in outcrop scale, hand specimen and thin section. Engineering properties will be indicated by physical index and strength of granitic rocks.

#### Petrographic Properties.

##### A. Regional Observation.

The plutonic rocks distributed in Loei-Chiang Khan area (Figure 3-1) are selected for thin section preparation. Approximately forty thin sections are made. Modal volume of quartz, alkali feldspar and plagioclase of these rocks are petrographically determined. The results are plotted in QAP diagram (Figure 3-2) as suggested by IUGS (Streckeisen, 1973). This diagram indicates that the plutonic rocks of Loei-Chiang Khan are distributed in three rock groups, granitoids, syenitoids and dioritoids.

##### B. Macroscopic Observation of the Phu Sanao Granites.

Field investigation of Phu Sanao batholith involves lithology and weathered features. The lithologic observation indicates four distinctive types (Table 3-1). Thus, the rocks in the study area can be divided into



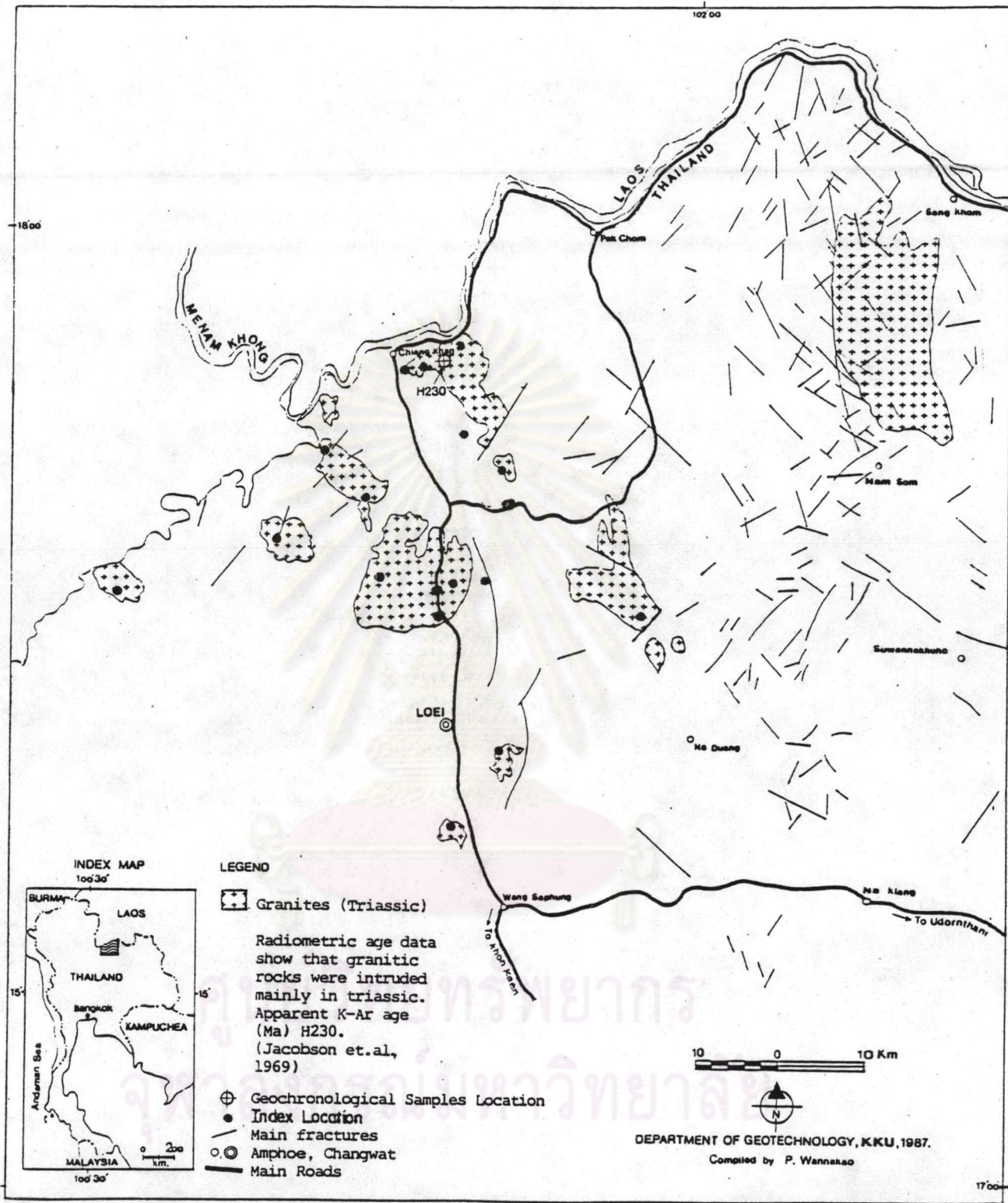


Figure 3-1. Map showing granitic distribution in Loei-Chiang Khan area with some index sample locations.

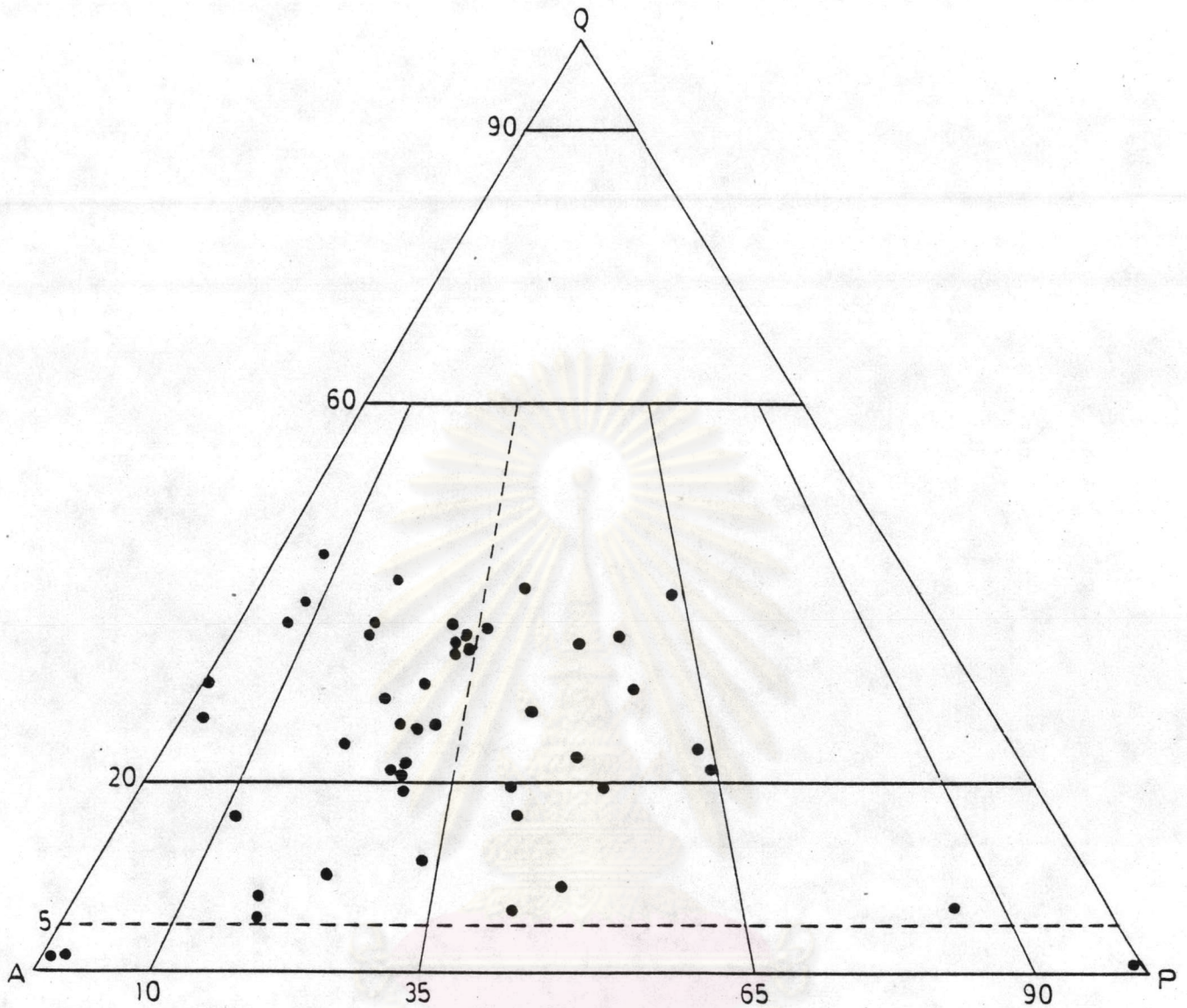


Figure 3-2. Plot of QAP for the plutonic rocks of Loi-Chiang Khan area. Results are mainly lying within the field of granitoids, syenitoids and subordinately dioritoids.



four subunits and named after their typical locations as Phu Sanao, Phu Lek, Ban kok Du, and Ban Na Khaem. Figure 3-3 and Figure 3-4 show the distribution of the four subunits and lithologic cross-sections of the area respectively. Whereas Figures 3-5, a, b, c and d are close-up photographs of polished slap sample of each representative subunits. Distribution of each subunit is also separately shown with 3-dimensional view of the area as in Figures 3-6.

The rock weathering grades and profiles are carefully observed. The schematic weathering grade classification is developed for granitic rocks in the study area (Table 3-2). The weathering profile of each subunit is pictorially illustrated (Figures 3-7 to 3-10). The Phu Lek Subunit reveals complete weathering profile ranging from grade I to VI (Figure 3-7). The Phu Sanao Subunit shows fresh rock grade at the mountain ridge while most of the rocks surrounding mountain ridge in the lower area are in grade V to VI (Figure 3-8). Ban Na Khaem Subunit exposed in the lower undulating topography are significantly weathered to grade V to VI (Figure 3-9) with scattering fresh corestones.

Large blocks of fresh corestones lying in both continuous and discontinuous frame work are common features in Ban Kok Du Subunit (Figure 3-10), hence these weathering profiles could be designated as grade III to IV. The map and cross sections of weathering gradation are established in Figure 3-11 and Figure 3-12, respectively.



Table 3-1. Type localities and their lithologic description of the Phu Sanao Granites.

Locations	Lithologic Description
Phu Sanao (PS)	<p><u>Coarse-grained granites</u>, are pinkish white to white phanocrystalline of coarse grained and porphyritic textures. Phenocrysts are pinkish microclines with average size 8.0 mm. Groundmass is composed predominantly of quartz and plagioclase and subordinate mafic minerals (biotite). These minerals are comprised approximately of 30% quartz, 40% K-feldspar, 30% plagioclase and 1-2% biotite (Figure 3-5,a).</p>
Phu Lek (PL)	<p><u>Coarse-grained granites</u>, whiteish pink to pink phanocrystalline of coarse-grained and porphyritic textures with pinkish, anhedral to subhedral microcline phenocrysts. These phenocrysts have average grain size 8-10 mm while groundmass is average 3-5 mm. Mineral compositions of the rock are comprised predominantly of approximately 50 % K-feldspar, 30% quartz, and 20% Plagioclase and 1-2% subordinate biotite (Figure 3-5,b).</p>
Ban Kok Du (KD)	<p><u>Fine-grained granites</u>, are pink, phanocrystalline, fine - grained, and equigranular textures with average grain</p>



Table 3-1 (cont.)

Locations	Lithologic Description
Ban Na Khaem (NK)	<p>size 1.0 mm. They are composed mainly of K- feldspar (55%) and quartz (40%) and less abundant plagioclase and biotite (Figure 3-5,c).</p> <p><u>Hornblende-biotite medium-grained granites</u>, are pinkish, whiteish to greenish grey, phanocrystalline, medium-grained, and equigranular textures with average grain size 4.0 mm. They are significantly higher in mafic mineral content (~15%) than other units. Mineral constituents of the rock include approximately 22% quartz, 35% K-feldspar, 30% plagioclase, 8% biotite and 7% hornblende (Figure 3-5,d).</p>

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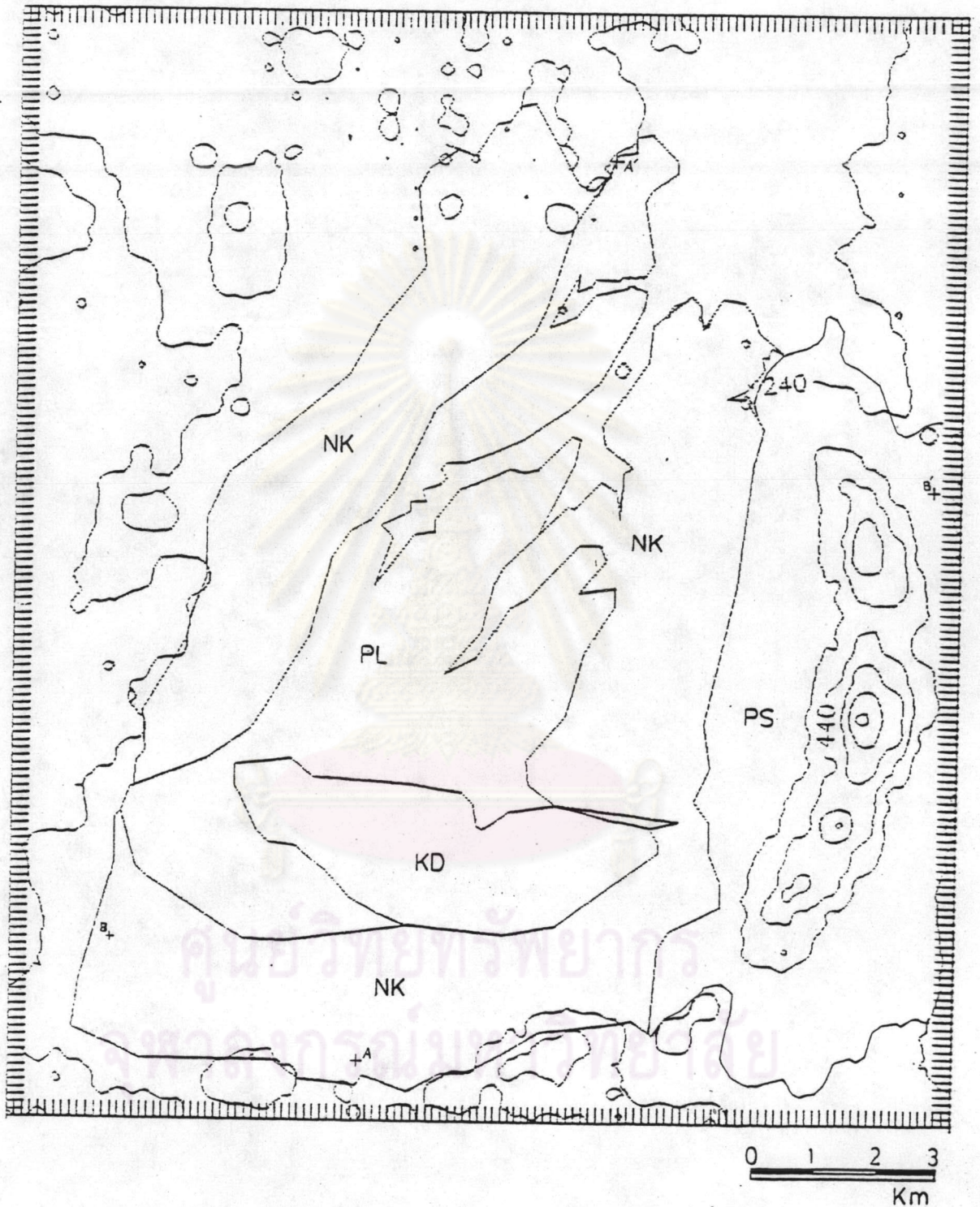


Figure 3-3. Map showing distribution of the Phu Sanao (PS), Phu Lek (PL), Ban Kok Du (KD) and Ban Na Khaem (NK) subunits.



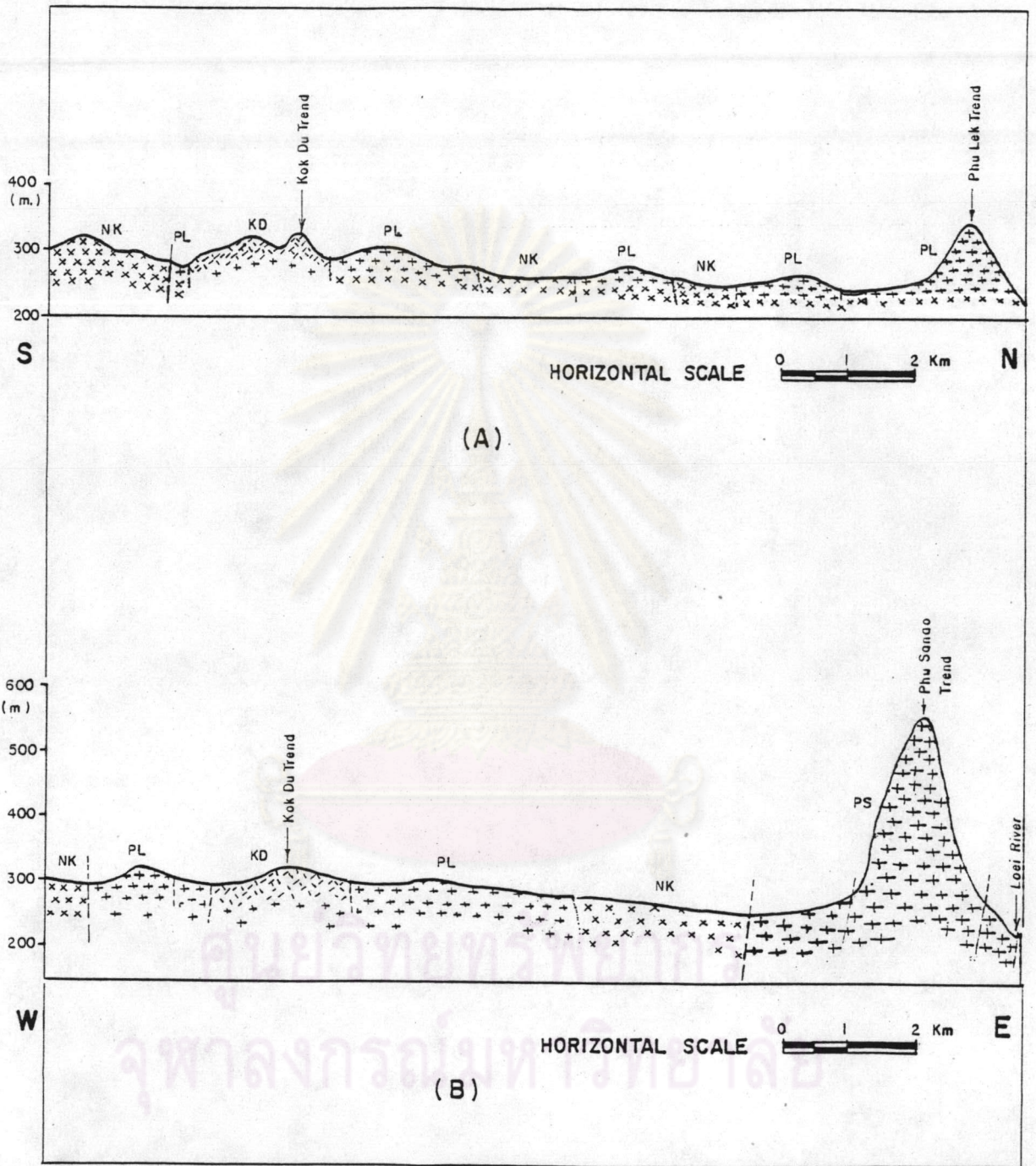
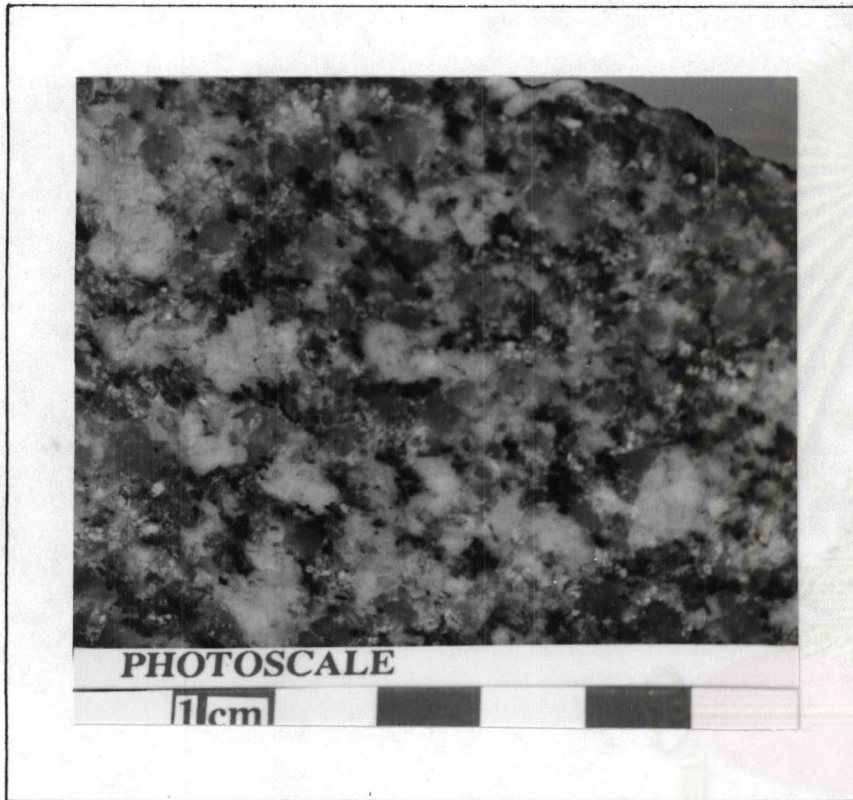


Figure 3-4. Subunits distribution profiles of the Phu Sanao granites, constructed from Figure 3-3, (a) section, A-A', (b) section B-B'.





(a)



(b)

Figure 3-5. The photographs illustrating typical characteristics of different granites, (a) the Phu Sanao Subunit, (b) the Phu Lek Subunit, (c) the Kok Du Subunit, (d) the Na Khaem Subunit.





(c)



(d)

Figure 3-5. (Cont.)

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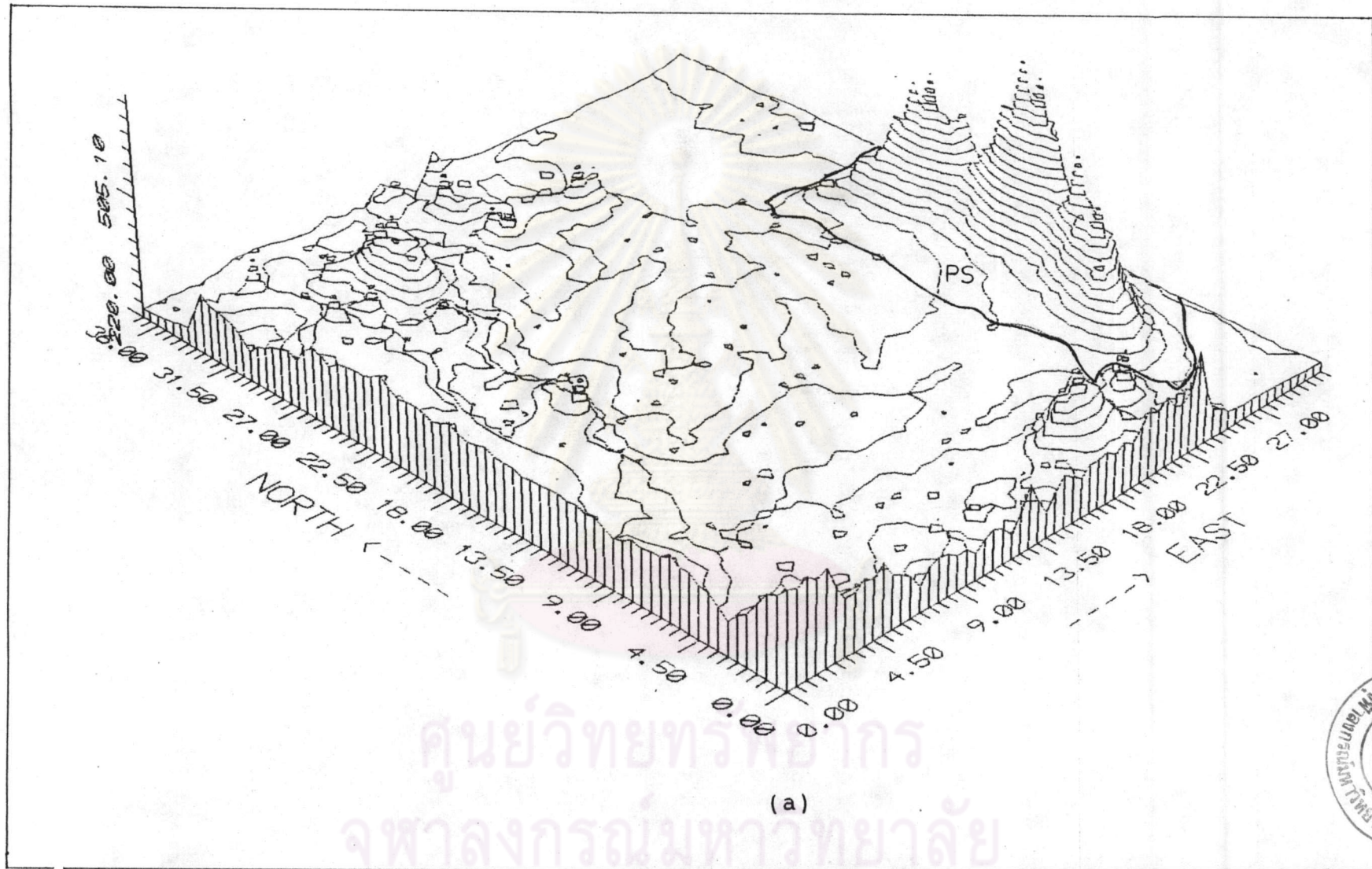


Figure 3-6. 3-dimensional surface and distribution of the Phu Sanao granites, (a) Phu Sanao, (b) Phu Lek, (c) Ban Kok Du and (d) Ban Na Khaem Subunits.





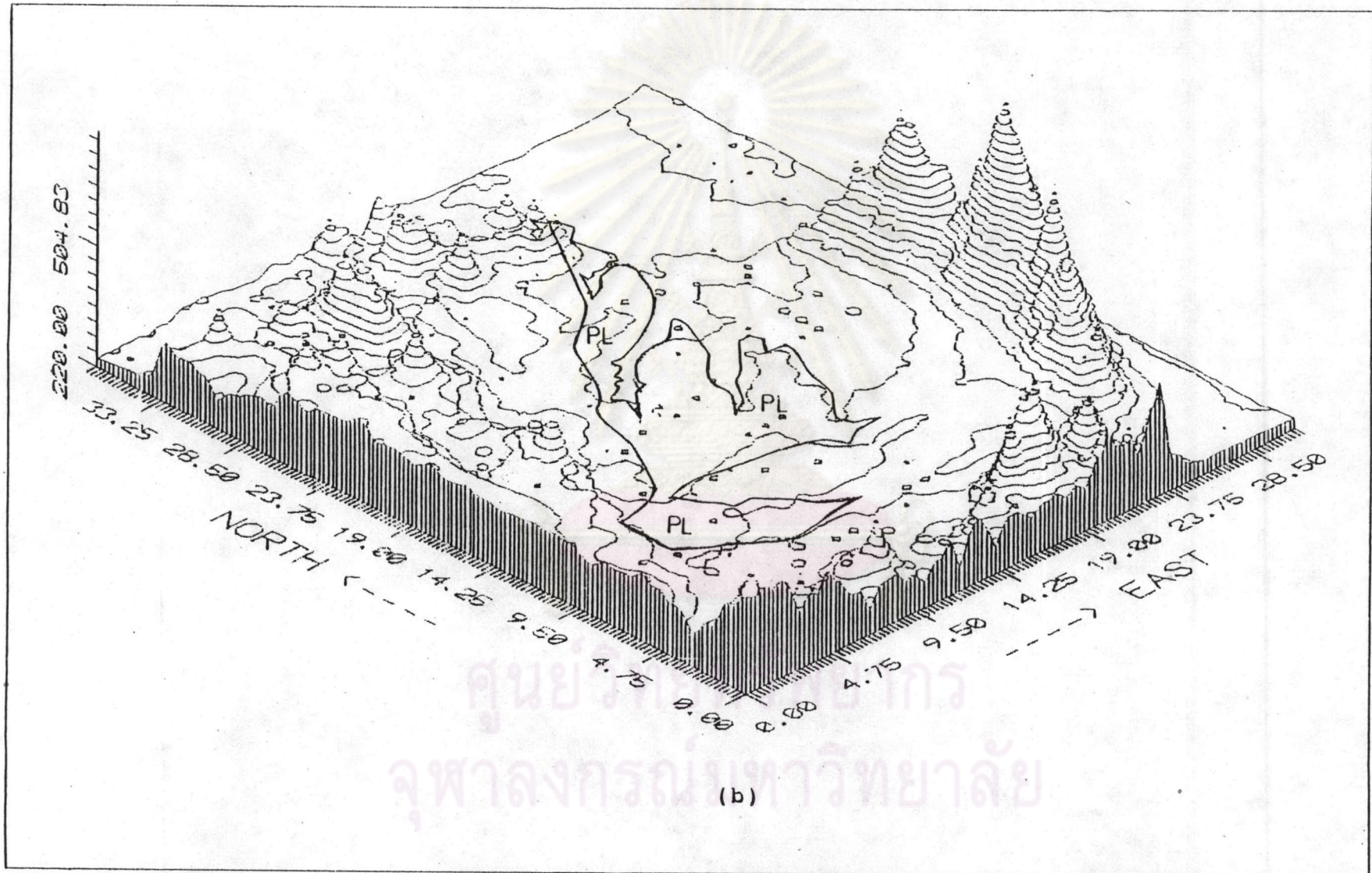
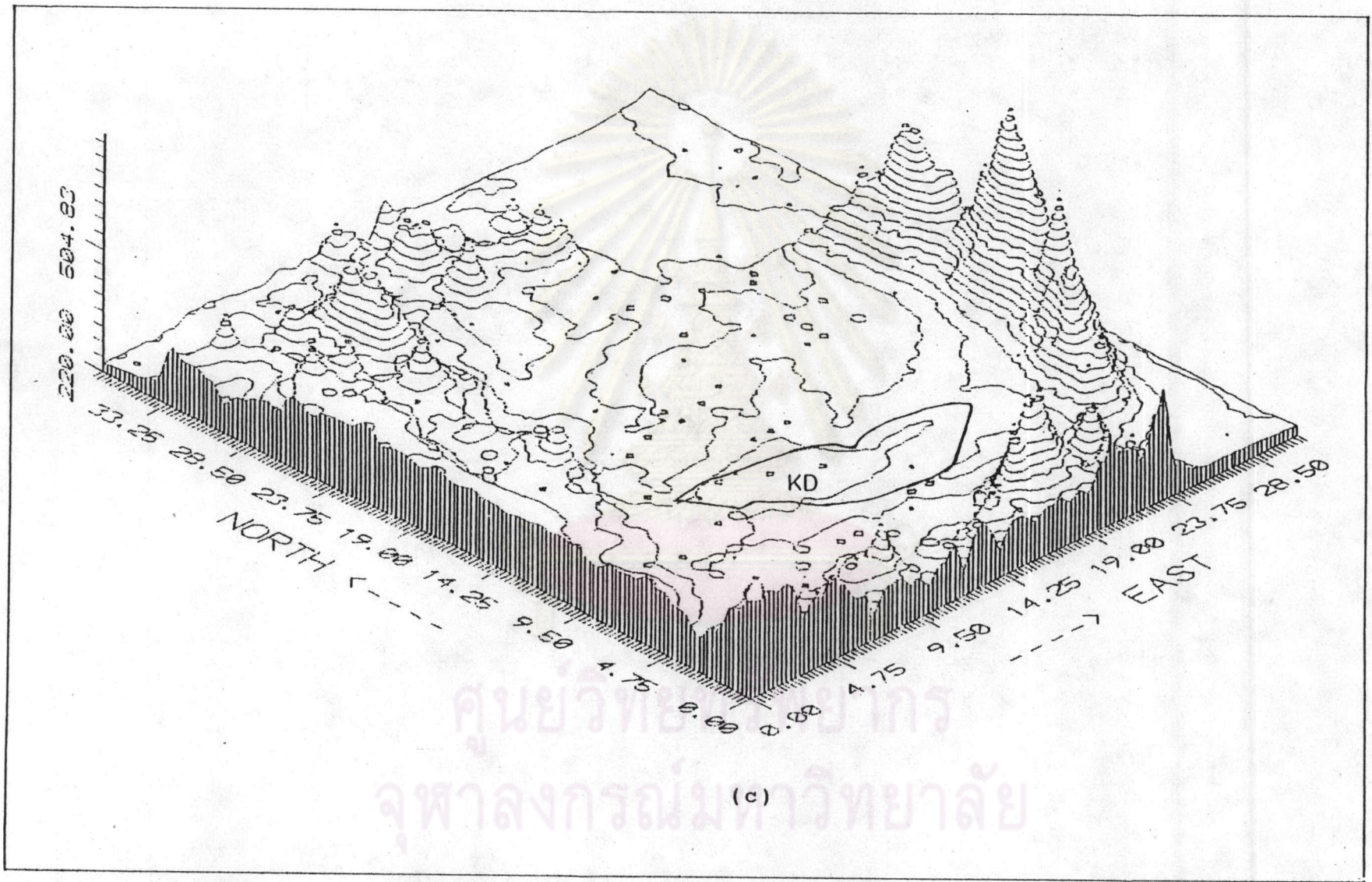


Figure 3-6. (Cont.)





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Figure 3-6. (Cont.)



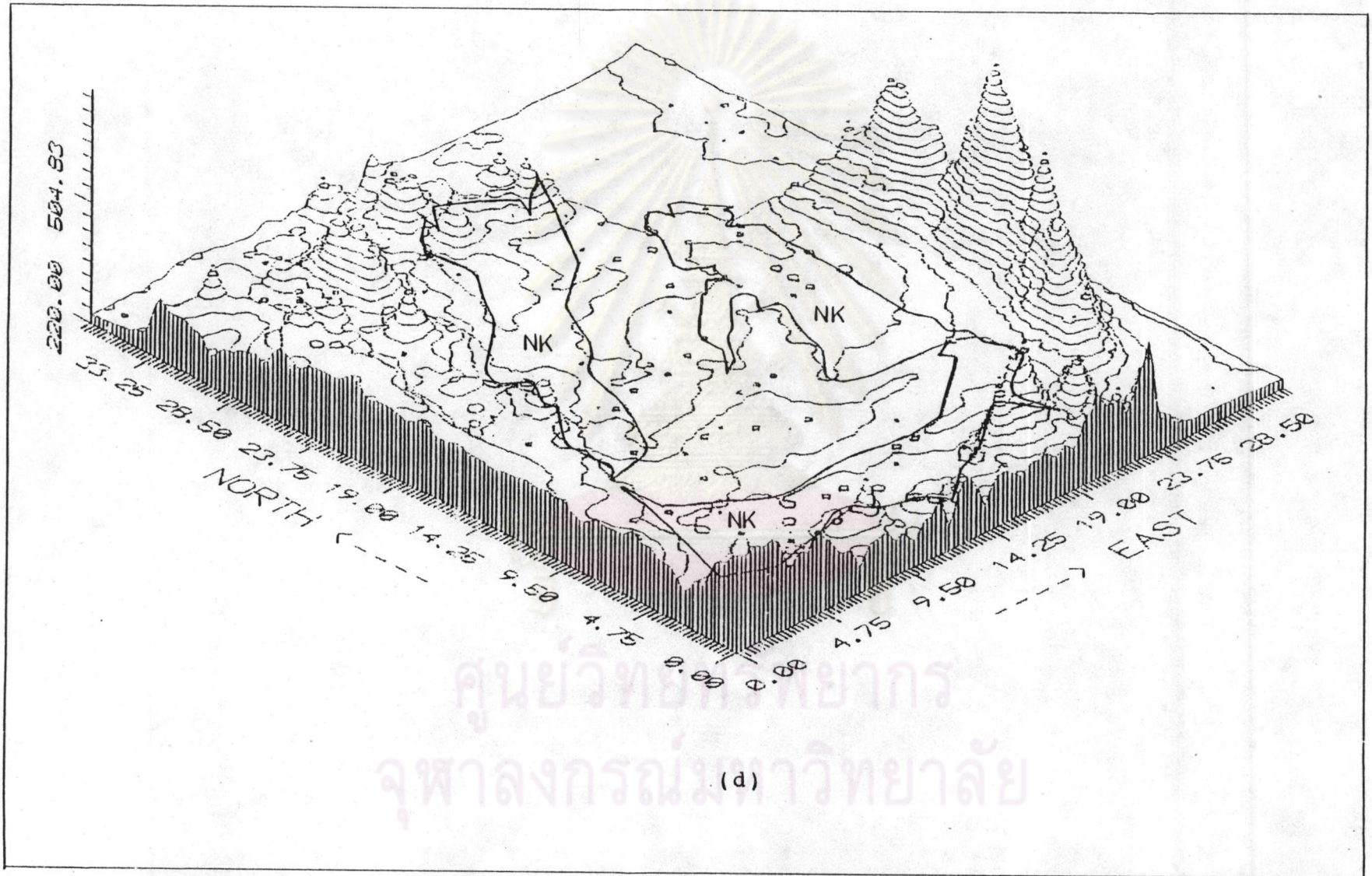


Figure 3-6. (Cont.)



Table 3-2 The weathering scheme for granitic material at  
Phu Sanao, Amphoe Muang, Changwat Loei.

CLASSIFICATION		DESCRIPTION
WEATHERING GRADE	TERM	DISCOLORATION/DECOMPOSITION/DISINTEGRATION
I	FRESH (F)	No visible sign of weathering, mineral constituents are fresh and sound, without microfracturing evident.
	IIi FRESH TO SLIGHTLY WEATHERED (F-SW)	Slightly discoloration (straining) on major discontinuity surfaces, mineral constituents are sound, with hardly visible sign of microcracks.
II	IIii SLIGHTLY WEATHERED	Partially discoloured (<50%), P, Bi, Hb, slightly decomposed, Microfracturing are visible sign.
	IIiii SW	Partially discoloured (>50%), Bi and Hb are slightly decomposed and beginning to stain some of the surrounding minerals, slightly microfractured (over 10 mm spacing).
	IIiv SW-MODE-RATELY WEATHERED (MW)	Completely discoloured with P are partial gritty, without any appreciable weakening of the rock.
	IIIi MW	Completely discoloured, slightly decomposed with less than 10% of the rock material is decomposed, P and K-f are moderately decomposed (gritty), Bi are moderately decomposed and staining many



Table 3-2 (Cont.)

CLASSIFICATION		DESCRIPTION
WEATHERING TERM		DISCOLORATION, DECOMPOSITION, DISINTEGRATION
GRADE		
		of the surrounding minerals.
III		Completely discoloured, Moderately (10-50
	IIIiii MW	%) decomposed and/or disintergrated to soil (appreciable weakening of the rock) either as continuous or discontinuous seams. Fresh or discoloured rock is present either as a continuous framework or as corestone.
IV	HIGHLY WEATHERED (HW)	Completely stained, highly decomposed (>50% rock material is decomposed) with granular disintergration developing and joint planes giving rise to a fresh of discoloured frame work rock or corestone.
V	COMPLETE- LY WEATHERED (CW)	Completely soil stained, most of P, K-f and Bi are completely decomposed (clayey), some K-f are highly decomposed (gritty to clayey), complete granular disintegration of the rock, but the original structure and texture are still largely intact.
VI	RESIDUAL SOIL(RS)	Residual soil, deep stained, all feldspar decomposed, quartz grains are reduced in size, the mass structure and material fabric are destroyed and losing of granitic texture.



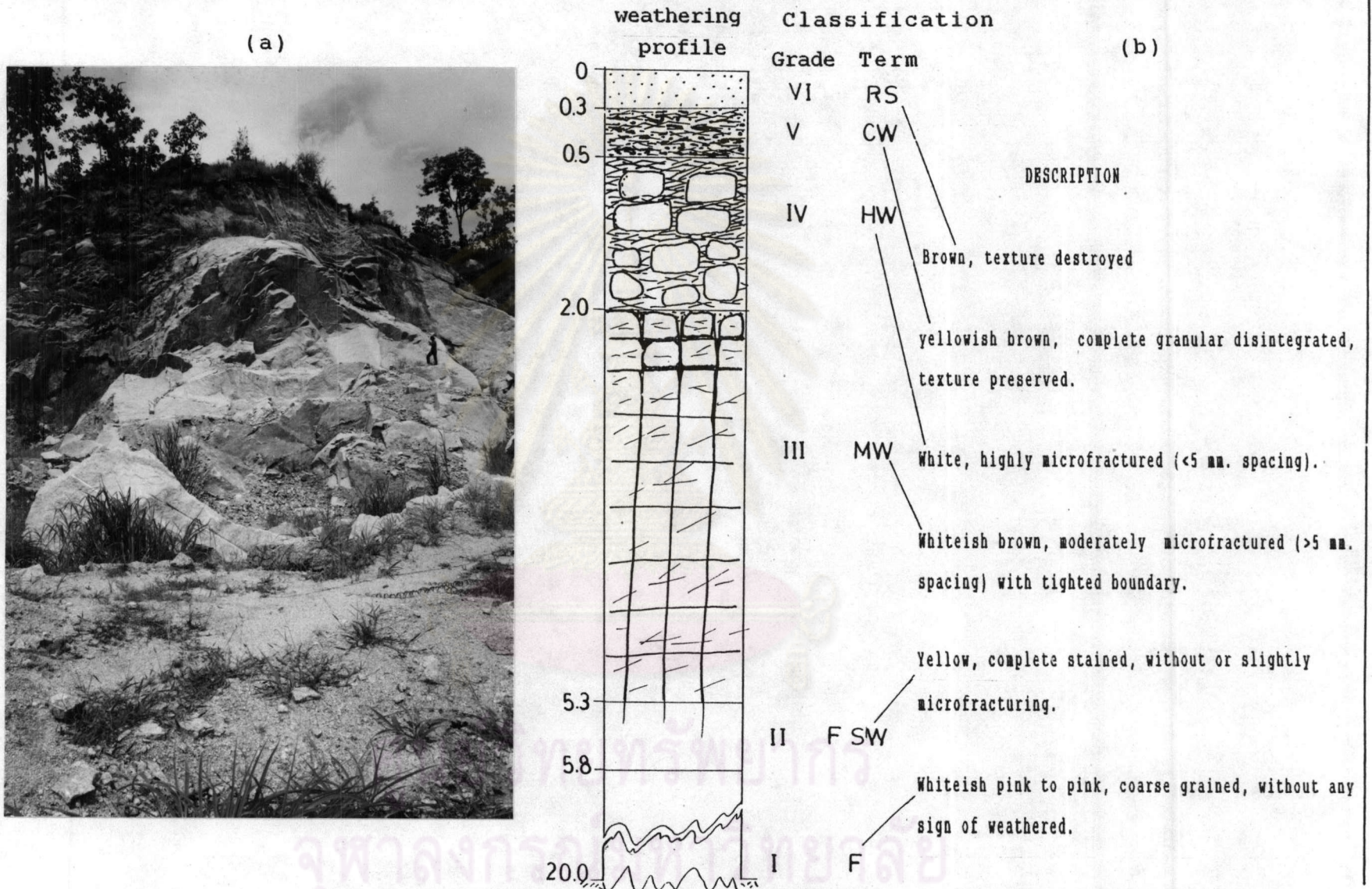


Figure 3-7. Mass weathering profile of the Phu Lek subunit, (a) photograph of measuring section (at Phu Lek), (b) weathering profile classification.



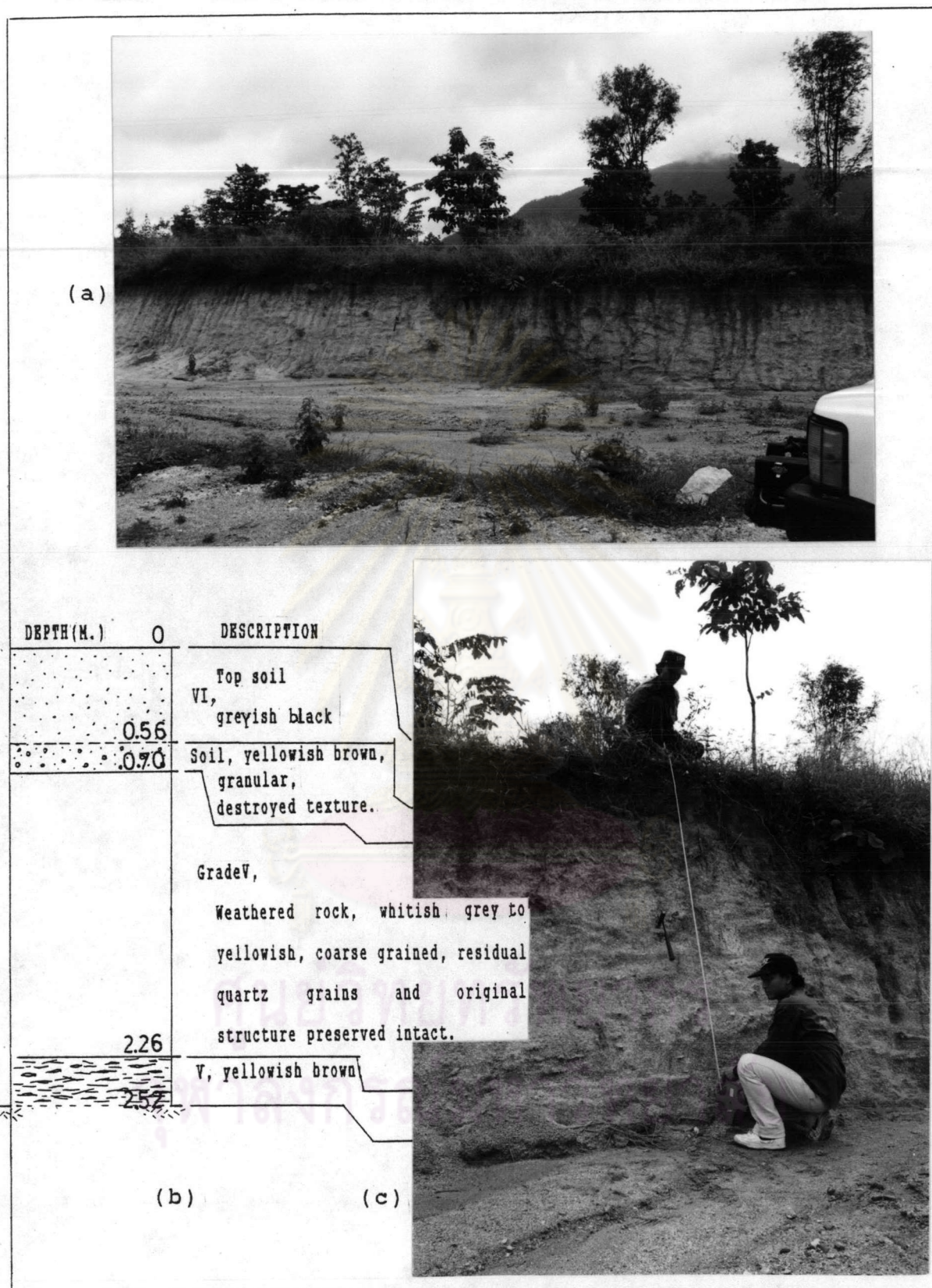


Figure 3-8. Measured section of weathered granite grade V of the Phu Sanao Subunit, (a) general view showing Phu Sanao (top right), (b) weathering profile, (c) measuring section.





Figure 3-9. Typical weathering characteristic of the Ban Na Khaem Subunit, (a) weathering profile of grade V-VI, (b) grade V, (c) grade IV-V and (d) grade IV



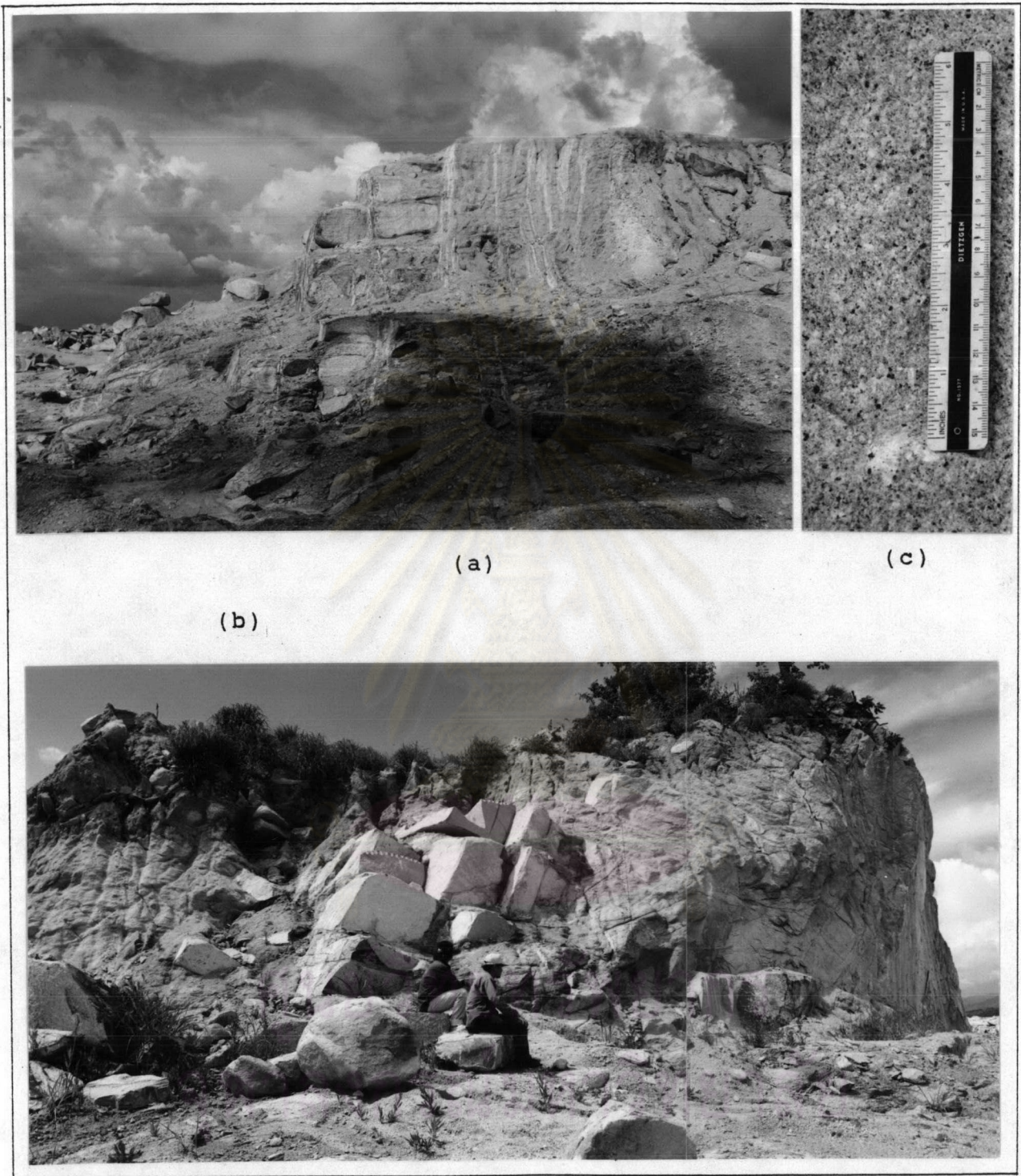


Figure 3-10. The weathering profile of Ban Kok Du Subunit, shows continuous frame work to discontinuous corestone of grade I (a) and top left of (b) set in weathered granitic mass grade IIIi to IV. Fresh surface of corestone also shows in (c) (top right).



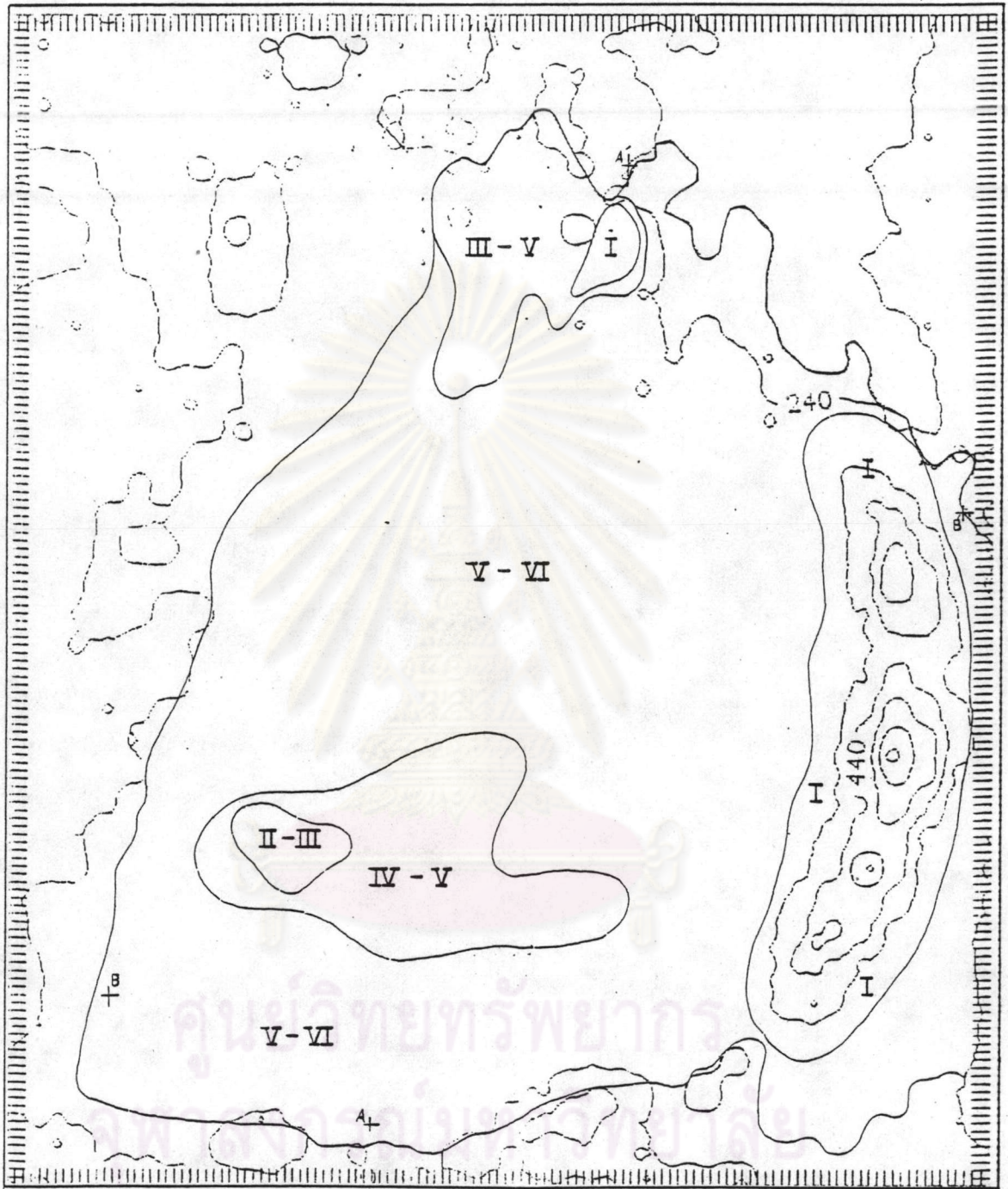


Figure 3-11. Generalized weathering map of the Phu Sanao granitic terrain.



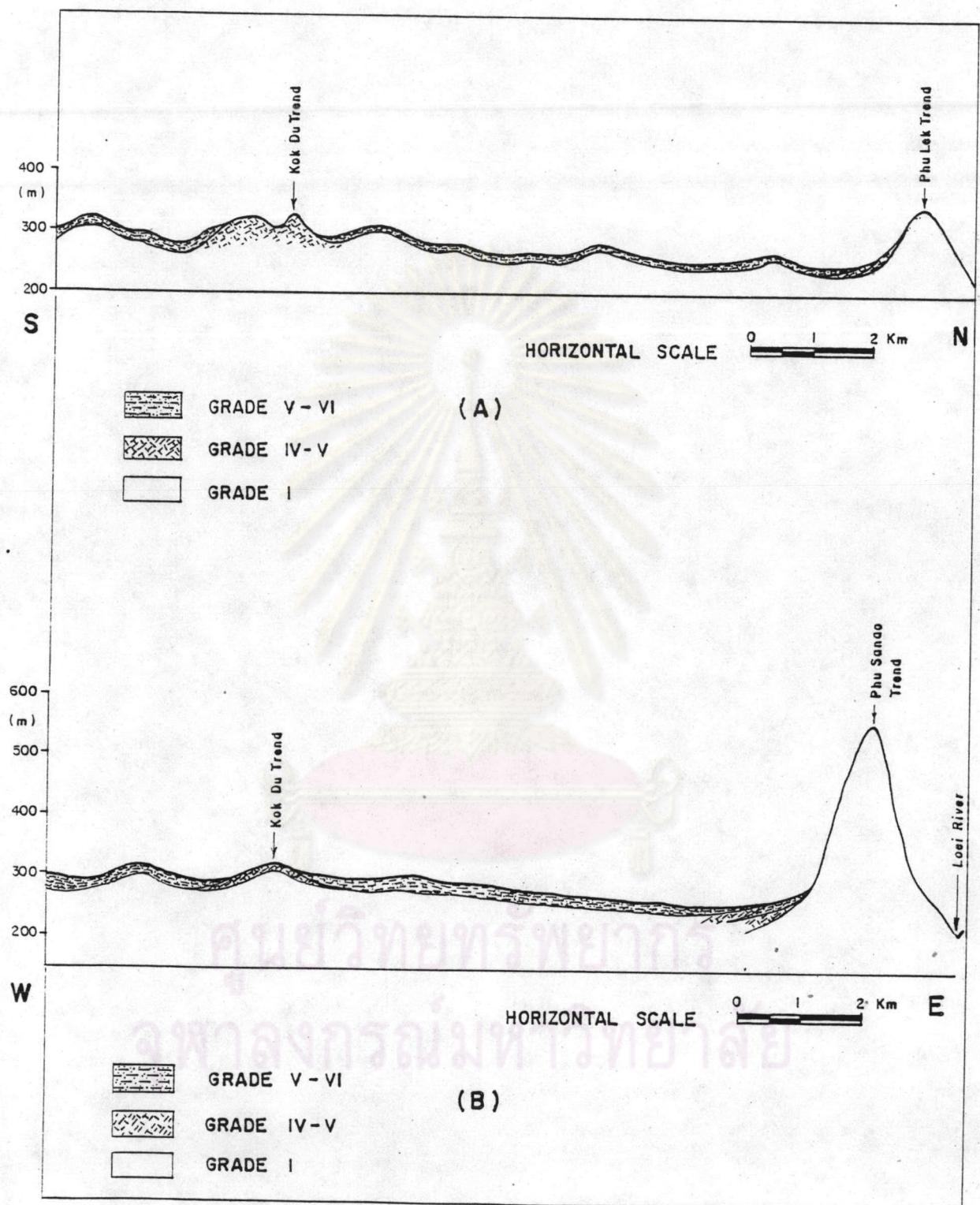


Figure 3-12. Generalized weathered profiles across terrains of Phu Sanao granites, (a) section A-A', (b) section B-B'.



### C. Microscopic Determination.

Thirty six selected thin sections of Phu Sanao granitic rocks are examined for mineralogical contents and textural characteristic. The main mineral composition that found in the rocks are quartz, alkali feldspar, plagioclase, mafic minerals and accessory minerals. Textural features identified are mineral grain size and grain contacts. The results of microscopic determination are summarized in Table 3-3. The mineral percentages are also plotted in QAP diagram (Figure 3-13). These microscopic results also indicate four distinctive subunits similar to macroscopic observation. Thus the rocks could be classified as Phu Sanao Syenogranite, Phu Lek Syenogranite, Ban Kok Du Alkali feldspar granite and Ban Na Khaem Hornblende-biotite Monzogranite. Detailed microscopic description of each subunit is tabulated in Table 3-4. Photomicrographs of these subunits are illustrated in Plate 3-1 to Plate 3-5. The results in Table 3-3 can be expressed as graphic plots to initially compare their relationships (Figure 3-14, Figure 3-15).

### Engineering Properties.

The prepared samples from previously described Chapter are designated to test both physical and mechanical properties. Results are summarized in Table 3-5 for further interpretation and correlation. The relationship between some physical and mechanical properties are also initially shown in Figure 3-16 and 3-17 respectively.



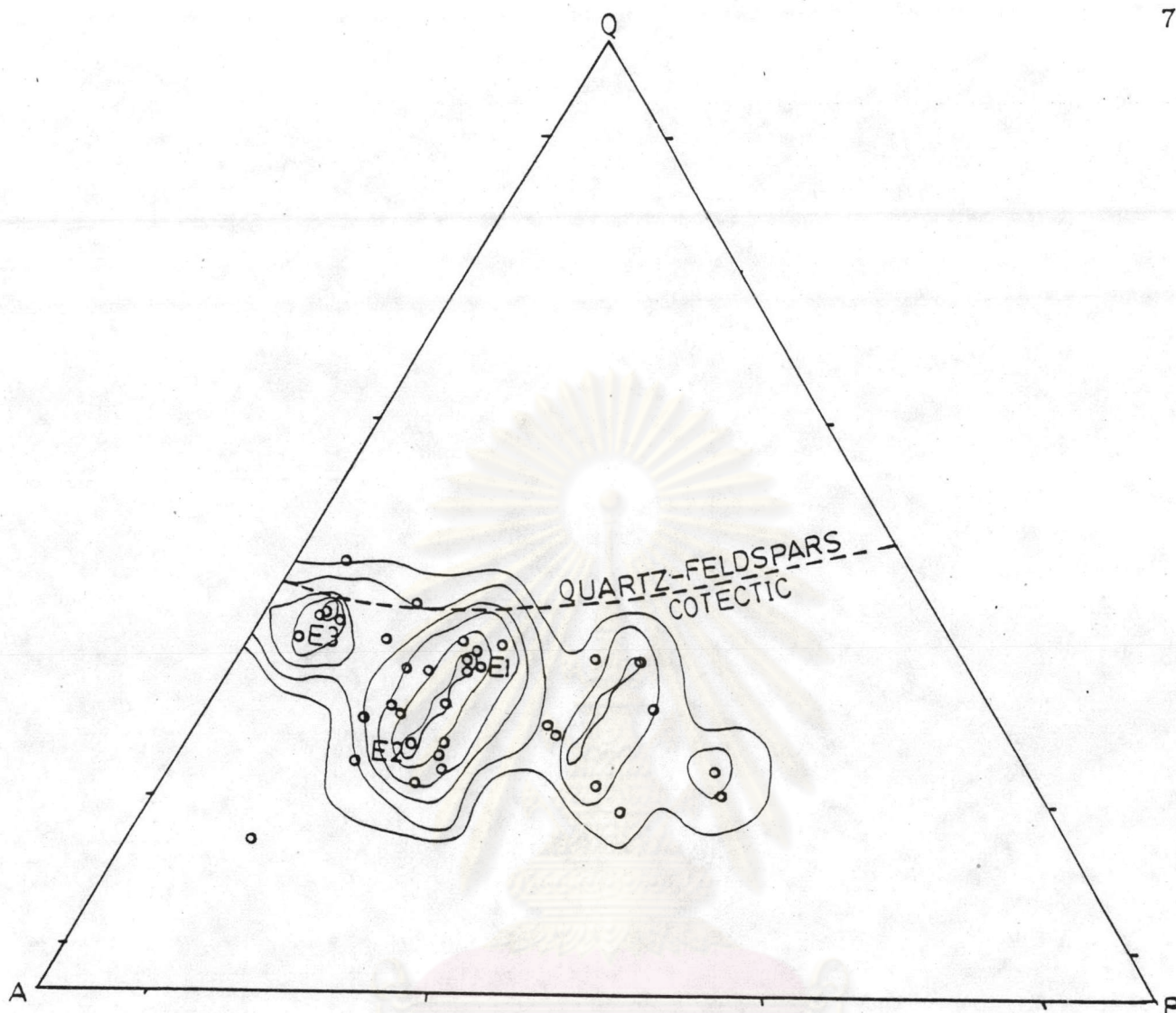


Figure 3-13. Plot of QAP for the Phu Sanao granites.  $E_1$ ,  $E_2$ ,  $E_3$  are eutectic points of Phu Sanao, Phu Lek and Ban Kok Du subunits respectively.

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Table 3-3. Petrographic properties of the Phu Sanao granites.

SAMPLE NO.	MINERALOGY (%)							TEXTURES											WEATHERING	
	Q	A	P	B	H	M	R	GRAIN SIZE (mm)				GRAIN CONTACTS (%)							Id	GRADE
								T	D	Q	K	F	M	T	S	C	I			
PS-1	21.17	53.00	21.67	2.33	0.67	3.00	1.17	3.66	3.67	3.48	4.21	3.28	10.00	5.00	31.00	49.00	15.00	0.10	I	
PS-2	25.00	49.43	22.00	3.43	0.00	3.43	0.14	3.09	2.69	3.08	3.60	2.59	11.00	0.00	33.64	55.46	10.91	0.10	I	
PS-3	33.50	42.50	21.38	1.25	0.00	1.25	1.38	2.00	1.88	1.76	2.59	1.65	10.00	1.03	26.80	61.86	10.31	0.25	III-IIIi	
PS-4	35.33	48.67	11.33	4.00	0.00	4.00	0.66	2.05	1.91	2.00	2.76	1.37	11.00	0.00	17.92	61.32	20.75	0.20	IIIi	
PS-5	36.50	43.33	18.50	1.17	0.00	1.17	0.50	2.50	2.20	3.06	2.27	2.18	10.00	1.95	28.16	55.34	14.56	0.25	III-IIIi	
PS-6	24.33	52.00	19.33	3.50	0.00	3.50	0.83	2.50	2.13	1.89	3.37	2.23	10.00	1.98	22.77	60.40	15.84	0.25	III-IIIi	
PS-7	33.50	42.67	20.67	2.33	0.00	2.33	0.83	2.53	2.18	1.83	3.62	2.15	11.00	2.80	19.63	54.21	23.36	0.30	IIIi	
PS-8	32.67	44.17	21.17	2.00	0.00	2.00	0.00	2.68	2.69	2.74	2.83	2.50	11.00	2.70	27.03	52.25	18.02	0.35	IIIi-IIIiII	
PS-9	36.30	39.90	22.30	1.60	0.00	1.60	0.00	2.60	2.29	2.28	3.55	1.98	8.00	0.00	37.80	48.78	13.41	0.35	IIIi-IIIiII	
PS-10	23.00	51.43	24.71	0.80	0.00	0.86	0.00	2.86	2.60	3.03	3.75	1.79	8.00	0.00	48.81	40.48	10.71	0.70	IIIiII	
PS-11	32.11	44.58	20.39	1.98	0.00	1.98	0.68	2.75	2.04	2.43	2.50	1.43	10.00	1.49	27.48	58.33	2.42	0.25	III-IIIi	
PS-12	31.53	44.45	17.11	4.92	0.00	4.92	0.71	2.36	2.11	1.91	3.25	1.93	40.00	2.39	20.66	58.64	19.98	0.20	IIIi	
PS-13	34.66	44.50	21.82	2.59	0.00	2.59	0.00	2.79	2.56	2.70	3.33	2.22	10.00	0.00	32.82	52.16	14.11	0.45	IIIi-IIIv	
PS-14	29.00	38.00	30.00	3.00	0.00	3.00	0.00													
PS-15	28.86	27.71	26.86	8.86	7.29	16.15	0.43													
PS-16	34.15	41.95	20.98	2.93	0.00	2.93	0.00													
PS-17	15.80	72.50	10.10	1.50	0.00	1.50	0.00													
PL-18	23.40	58.60	16.30	1.70	0.00	1.70	0.00	3.26	2.61	2.52	4.64	2.62	10.00	0.99	22.77	50.50	25.74	0.10	I	
PL-19	33.33	47.17	17.33	2.17	0.00	2.17	0.00	2.93	2.41	1.81	4.43	2.56	10.00	0.00	30.35	51.58	16.84	0.45	IIIi-IIIv	
PL-20	28.44	55.89	13.56	2.89	0.00	2.89	0.00	3.07	2.69	3.14	4.24	1.84	9.00	0.00	21.35	58.43	19.10	0.35	IIIi-IIIiII	
PL-21	32.71	49.43	14.86	2.43	0.00	2.43	0.57	2.38	2.20	2.45	2.80	1.89	9.00	0.00	24.72	67.42	7.86	0.65	IIIi-IIIiII	
PL-22	28.63	52.63	17.13	1.63	0.00	1.63	0.00	2.73	2.53	2.45	3.69	2.04	9.00	0.00	32.18	59.77	8.05	0.20	III-IIIi	
PL-23	29.30	52.74	15.84	2.16	0.00	2.16	0.11	2.78	2.46	2.30	4.12	2.08	10.00	0.00	27.99	61.55	7.65			
KD-24	37.30	58.30	4.00	0.40	0.00	0.40	0.00	1.19	1.13	1.16	1.45	0.96	11.00	0.88	36.28	48.67	14.16	0.10	I	
KD-25	38.00	55.20	5.00	1.80	0.00	1.80	0.00	1.17	1.09	1.01	1.42	1.08	10.00	0.99	33.66	47.52	17.82	0.15	II-III	
KD-26	37.60	53.80	7.20	0.60	0.00	0.60	0.80	0.95	1.00	1.08	1.12	0.66	8.00	1.25	33.75	47.50	17.50	0.30	IIIi	
KD-27	44.10	50.50	4.30	1.10	0.00	1.10	0.00	1.11	1.11	1.08	1.33	0.91	10.00	1.04	34.56	47.87	16.49	0.70	IIIiII	
NK-29	21.60	44.00	24.33	6.50	3.33	9.83	0.33													
NK-30	15.30	30.14	33.30	8.60	12.30	20.90	0.43													
NK-31	20.00	41.10	18.10	10.40	10.40	20.80	0.00													
NK-32	19.75	35.63	33.38	9.00	3.38	12.38	0.13													
NK-33	26.40	21.90	26.90	9.90	4.70	14.60	0.20													
NK-34	38.50	42.40	11.80	7.30	0.00	7.30	0.00													
NK-35	24.90	36.60	28.80	5.60	3.90	9.50	0.20													
NK-36	16.60	22.00	40.30	8.40	12.60	21.00	0.10													

T = Average total grain size  
 D = Median grain size  
 Q = Average grain size of quartz  
 K = Average grain size of alkali-feldspar  
 P = Average grain size of plagioclase  
 M = Number of grain contacts  
 T = Tangent grain contact  
 S = Straight grain contact  
 C = Concave convex grain contact  
 I = Intergrown grain contact  
 Id = Weathering Decomposition

Q = Quartz    A = Alkali-feldspar    P = Plagioclase  
 B = Biotite    H = Hornblende    M = Total mafic  
 R = Accessory minerals



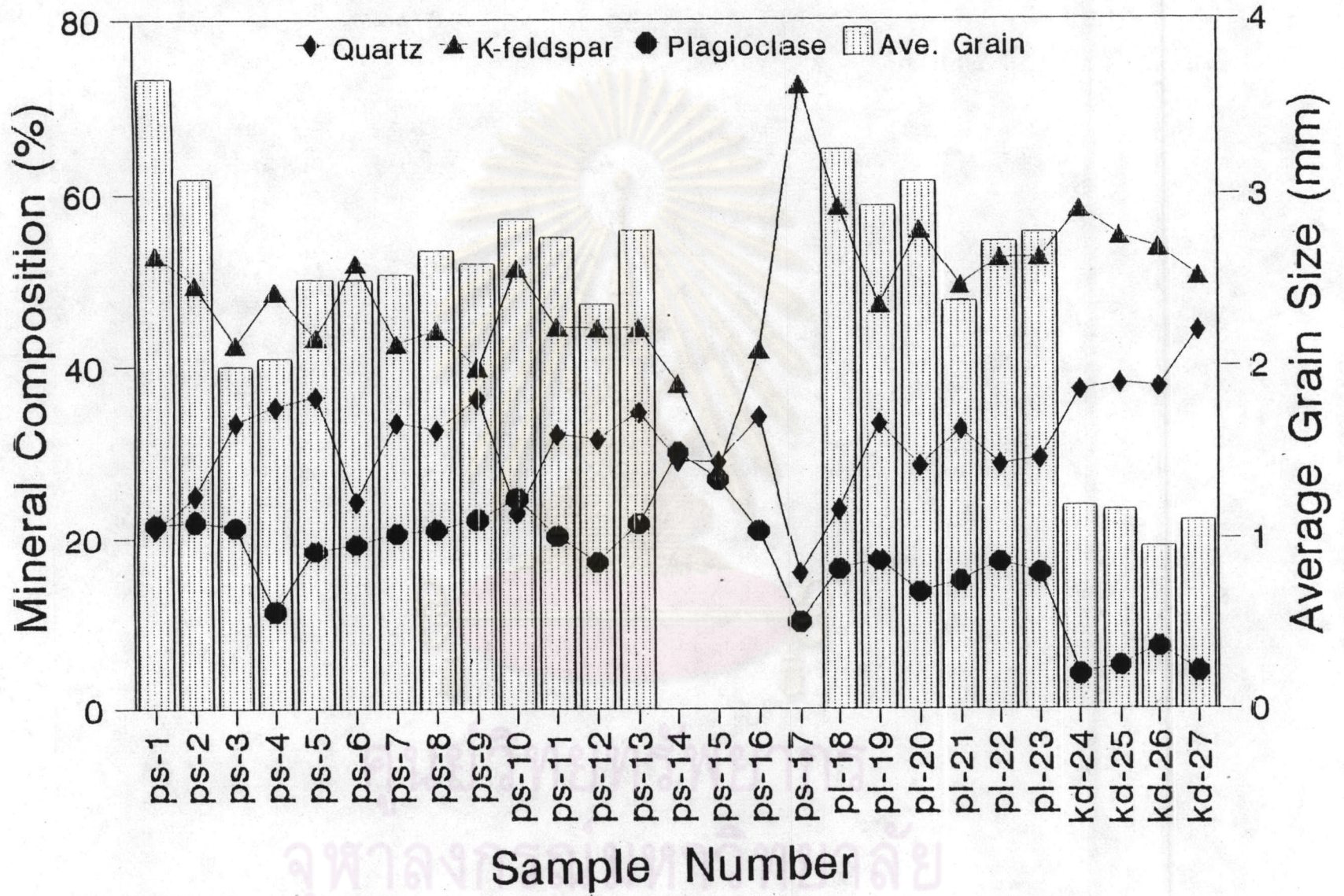


Figure 3-14. The relationship between major mineral constituents and average grain size of Phu Sanao, Phu Lek and Ban Kok Du subunit.



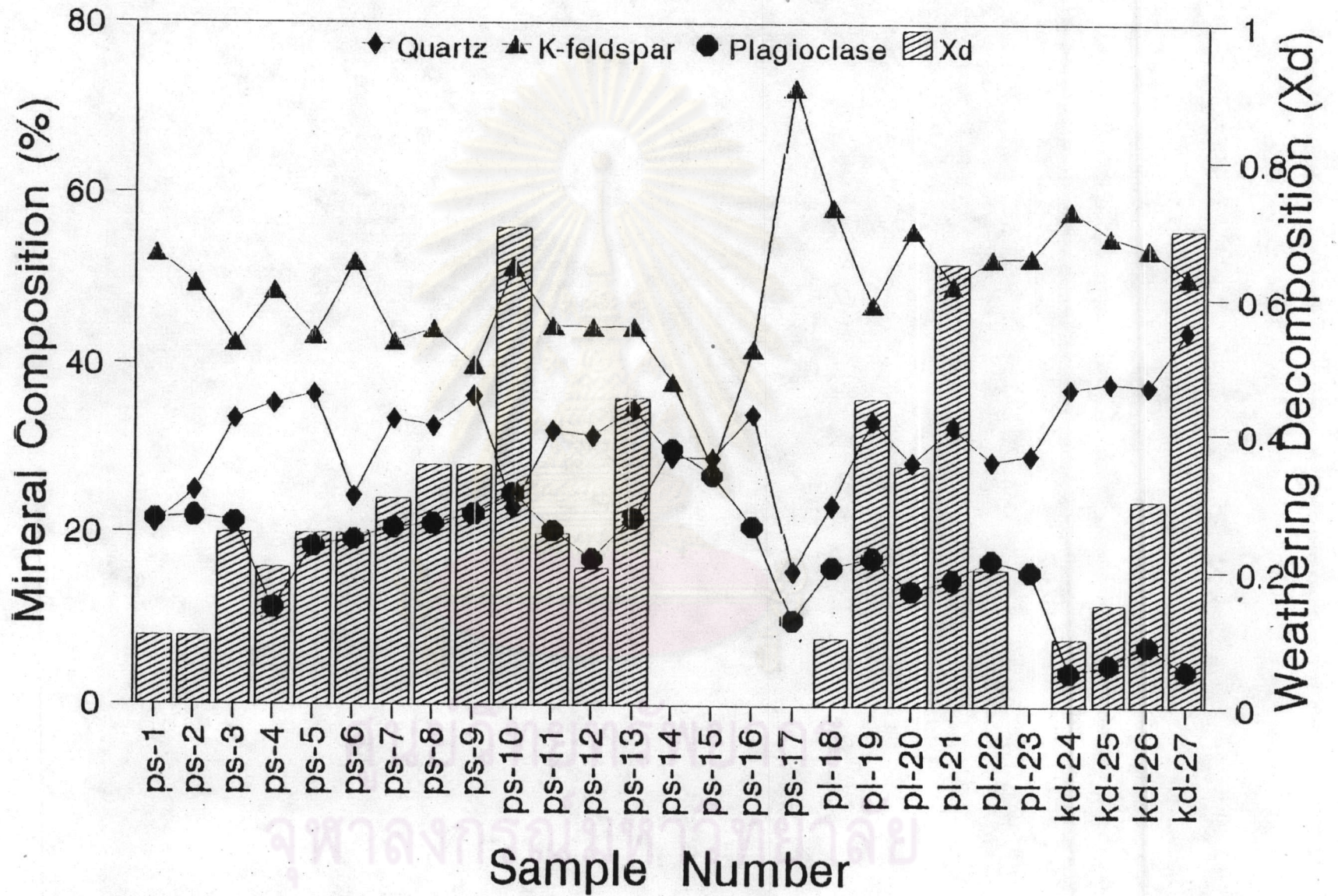


Figure 3-15. The relationship between mineral composition contents and weathering decomposition of Phu Sanao, Phu Lek and Ban Kok Du subunits.



Table 3-4. Microscopic description and classification of the Phu Sanao granites.

Petrographic Classification	Microscopic Description
Phu Sanao Syenogranite	<p>It is holocrystalline , medium- to coarse-grained allotriomorphic with inequigranular porphyritic texture (Plate 3-1). Phenocrysts are subhedral perthitic microcline which commonly occurring as larger oikocrysts (host minerals) enclosing smaller chadacrysts (guest minerals) of other minerals.</p> <p>The rock composed approximately of 46% perthitic microcline, 29% quartz, 21% plagioclase 3% biotite and minor of accessory minerals.</p> <p>Microfabrics of dynamic structures are common such as crushing gliding and bending of mineral grains resulted from mechanical stress (Plate 3-2).</p>
Phu Lek Syenogranite	<p>It is holocrystalline medium- to coarse-grained , inequigranular porphyritic, and allotriomorphic rock. The microcline phenocrysts preferrably illustrate perthitic textures and bending cataclastic structures (Plate 3-3; PL-B3). The main mineral contents of the rock are</p>



Table 3-4. (Cont.)

Petrographic Classification	Microscopic Description
	<p>perthitic microcline (53%), quartz(29%), plagioclase (16%) and biotite (2%).</p> <p>Dynamic structures are also commonly present (Plate 3-3;PL-C3 and PL-D3). Micrographic textures are specially found in some specimens (Plate 3-3;PL-E3, PL-F3, PL-G3 and PL-H3).</p>
Ban Kok Du Alkali feldspar granite	<p>The rock is fine-grained and equigranular equigranular textures with average grain size of 0.5 mm. Its fabrics are granular grains with interlocking contacts to mosaic textures (Plate 3-4). Mineral constituents of the rock are composed mainly of alkali feldspar (55%), quartz (39%), plagioclase (5%) and the lesser amount of accessory minerals.</p>
Ban Na Khaem Hornblende- biotite Monzogranite	<p>It is holocrystalline, medium-grained equigranular allotriomorphic rock with average grain size of 2.0 mm. The considerable amount of hornblende content is a diagnostic feature of the subunit. It commonly displays as euhedral</p>



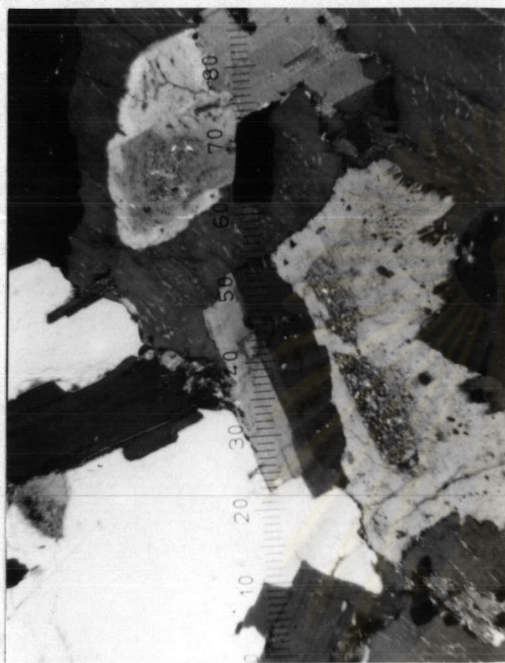
Table 3-4. (Cont.)

Petrographic Classification	Microscopic Description
	<p data-bbox="605 521 1410 788">crystals with trapped panidiomorphic magnetite inclusions (Plate 3-5;NK-A5,NK-B5, and NK-C5). Zoning textures of plagioclase are commonly present as well as of hornblende (Plate 3-5;NK-D5).</p> <p data-bbox="605 816 1410 1083">Mineral contents of the rock are mainly composed of 34% K-feldspar, 27% plagioclase, 23% quartz, 8% biotite, 7% hornblende, and lesser amount of accessory minerals.</p>

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Plate 3-1. Photomicrographs of the Phu Sanao Subunit illustrate general texture and mineral constituents of the rock.



A1 B1  
PS  
C1 D1

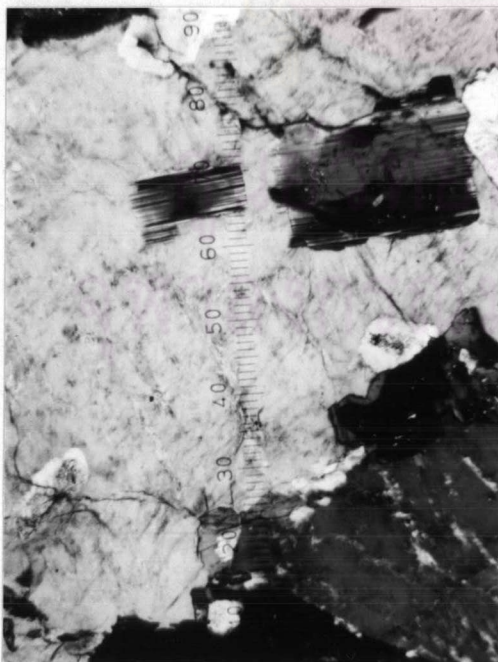




Plate 3-1. (Cont.)

PS-A1 : Syenogranite showing perthitic microcline oikocryst (bluish grey;right) enclosed chadacrysts of plagioclase (light grey), biotite (pink) and opaque minerals (black). Quartz (black, white) and biotite (green) are also presented at topped-right and topped-left respectively.

PS-B1 : Syenogranite showing perthitic microcline (black;bottom-right, anhedral quartz (yellow), subhedral to euhedral plagioclase (grey), biotite (brown) and accessory panidiomorphic-opaque minerals (black; central).

PS-C1 : Syenogranite showing completed crystallization of euhedral plagioclase chadacrysts within microcline host.

PS-D1 : Syenogranite showing inequilibrium crystallization texture of perthitic microcline with exsolved albite intergrown.

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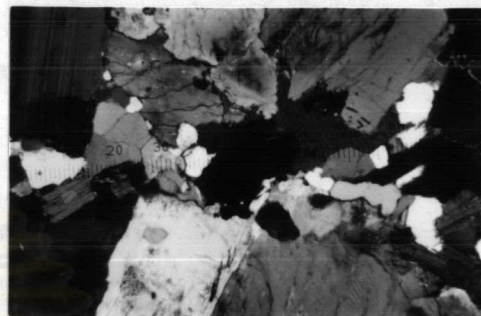
The Phu Sanao Syenogranite from Loei ;  
Magnification 38X, XPL  
(Micrometer, 10 divisions equal 0.25 mm).



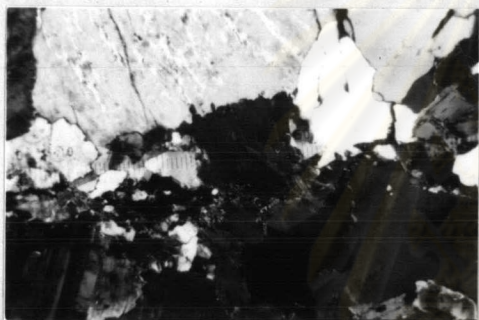
Plate 3-2. Photomicrographs of the Phu Sanao Subunit illustrate dynamic textures of the stress granites.



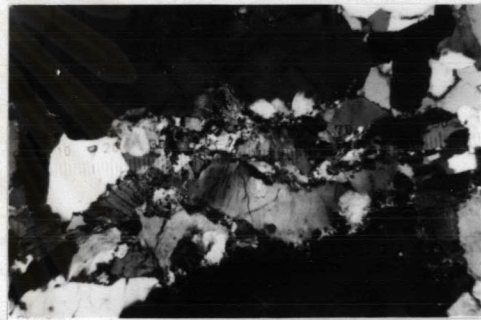
PS-A2



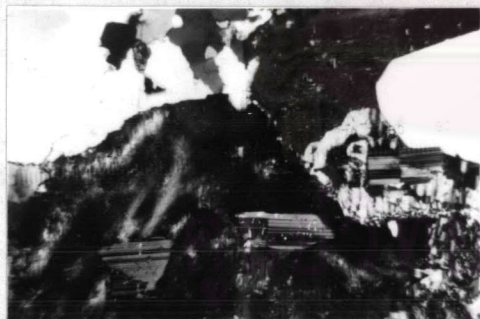
PS-B2



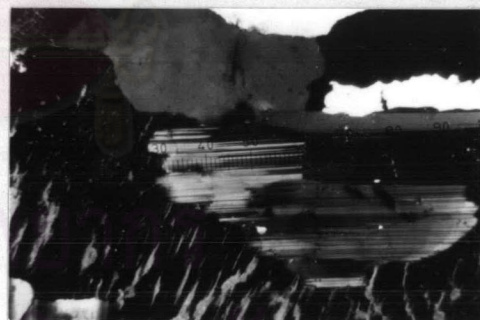
PS-C2



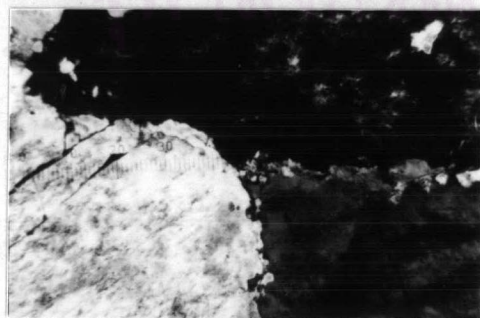
PS-D2



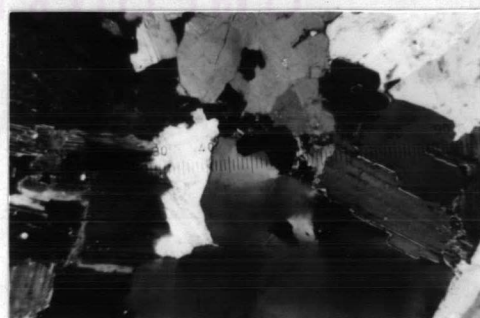
PS-E2



PS-F2



PS-G2



PS-H2



Plate 3-2. (Cont.)

- PS-A2 : Stress granite showing bending cataclastic texture of biotite and perthitic pattern gliding of microcline.
- PS-B2 : Stress granite showing twin gliding of plagioclase (topped-left) and developed of finer grains of quartz and feldspars by crushing.
- PS-C2 : Stress granite showing dynamic crushing/fracturing across plagioclase, quartz, K-feldspar and biotite.
- PS-E2 : Stress granite showing twin gliding of plagioclase chadacrysts and microcline hosts with interfractures fine-grained cataclasites.
- PS-F2 : Stress granite showing twin gliding of plagioclase and undulatory extinction quartz with long irregular crushed shape (topped-right).
- PS-G2 : Stress granite showing crushed fine grained minerals, developed along intergrain boundaries of microcline.
- PS-H2 : Stress granite showing bending cataclastic and twin gliding of plagioclase (left).

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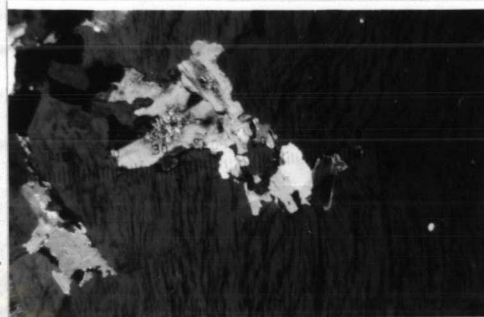
The dynamic syenogranite of the Phu Sanao Subunit ;  
Magnification 24X, XPL  
(Micrometer, 10 divisions equal 0.25 mm).



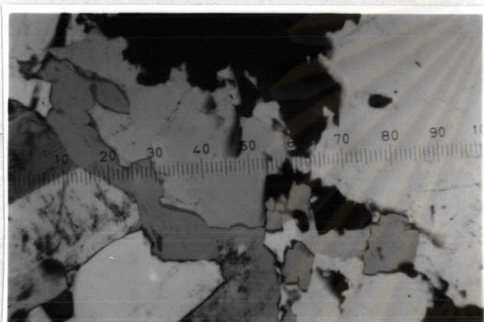
Plate 3-3. Photomicrographs of the Phu Lek Subunit.



PL-A3



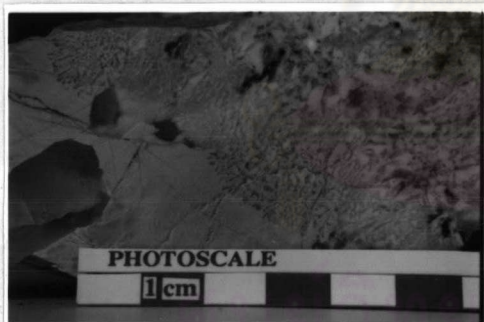
PL-B3



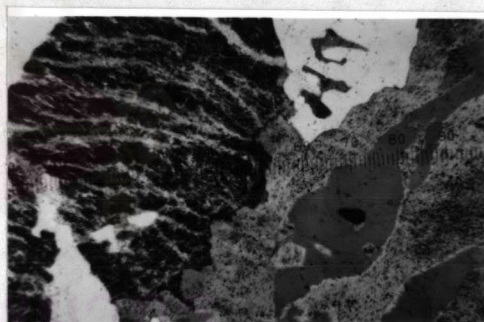
PL-C3



PL-D3



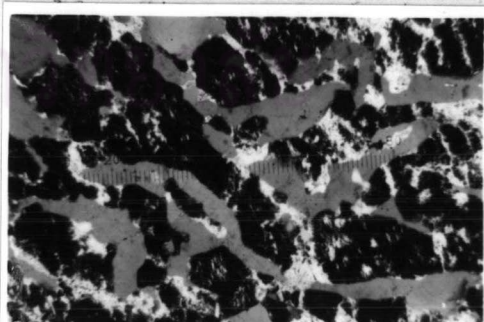
PL-E3



PL-F3



PL-G3



PL-H3



Plate 3-3. (Cont.)

- PL-A3 : Syenogranite showing almost of perthitic microcline with guest minerals of quartz (topped border), patches of albite and opaque magnetite (black ; topped-right).
- PL-B3 : Dynamic Syenogranite showing micro-kink band (sinistral) of perthitic pattern gliding of microcline.
- PL-C3 : Dynamic Syenogranite showing undulatory extinction of quartz with long irregular shape resulted by cataclasis.
- PL-D3 : Stress syenogranite showing microveinlet of fine-grained crushed quartz with saw teeth interlocking structure of their grain boundaries (left).
- PL-E3 : Photograph of graphic alkali feldspar granite.
- PL-F3 : K-feldspar granite showing micrographic texture of exsolved quartz (yellow) on albitic-alkali feldspar and perthitic microcline (right and left, respectively).
- PL-G3 : Micrographic K-feldspar granite showing exsolution texture of quartz (guest) and albitic-rich feldspar (host).
- PL-H3 : Micrographic K-feldspar granite showing exsolution texture of quartz and perthitic microcline.

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The Phu Lek Syenogranite from Loei ;

Magnification 24X, XPL

(Micrometer, 10 divisions equal 0.25 mm).





Plate 3-4. Photomicrographs of the Ban Kok Du Subunit illustrate general texture and mineral constituents of the rock.

KD-A4 : Alkali feldspar granite showing fine grained perthitic microcline (grey), chlorititic biotite (high birefringence), quartz (white) and plagioclase (grey with albite twin ; central).

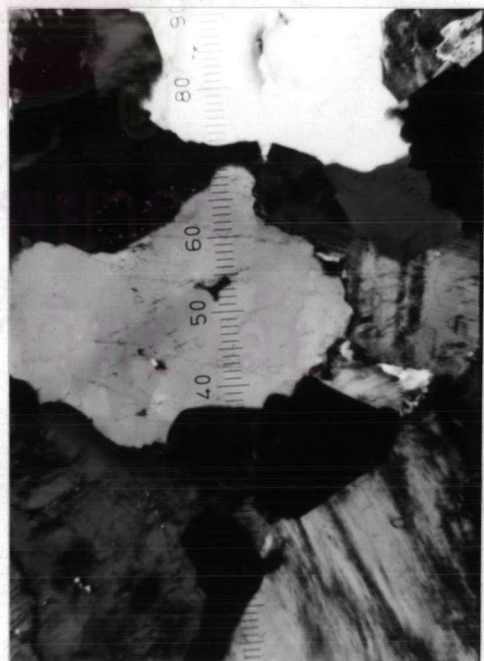
KD-B4 : Alkali feldspar granite showing fine grained anhedral quartz (white, yellow and greenish grey), microcline (grey and black) and plagioclase (bottom).

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The Ban Kok Du Alkali-feldspar Granite ;  
Magnification 38X, XPL  
(Micrometer, 10 divisions equal 0.25 mm.)



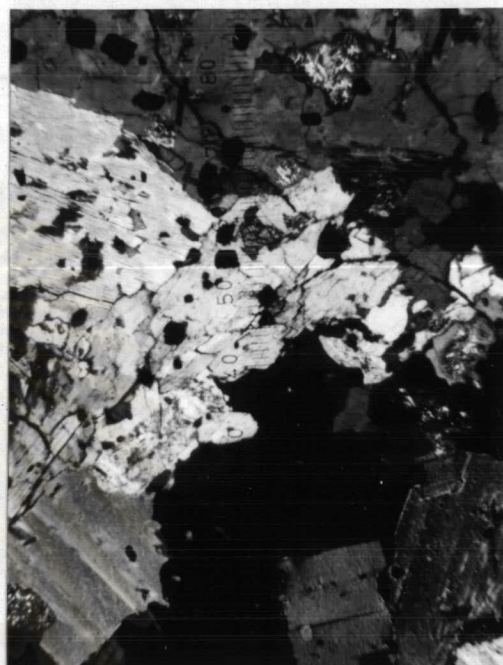
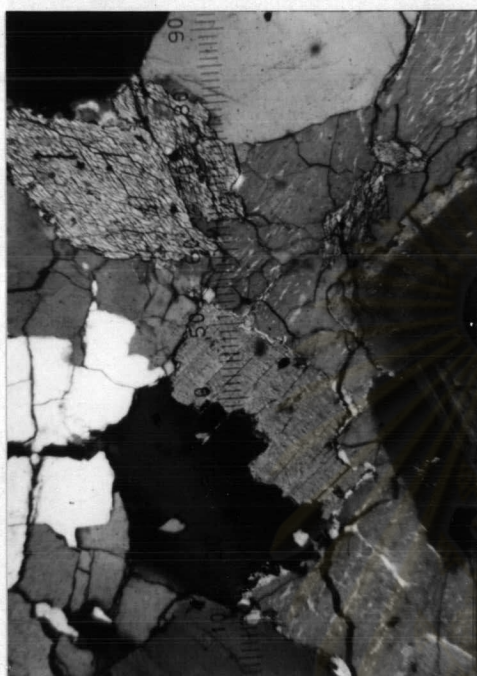
KD-A4



KD-B4



Plate 3-5. Photomicrographs of the Ban Na Khaem Subunit illustrate typical texture and mineral constituents of the rock.



A5 B5  
C5 D5  
NK





Plate 3-5. (Cont.)

- NK-A5 : Hornblende-biotite monzogranite showing typically noticeable amount of hornblende (yellow, euhedral) and biotite. Quartz (white, whitish grey and black) and plagioclase (bottom) are also present. All of these minerals are common chadacrysts in coarse grained microcline host (bluish grey with perthitic pattern).
- NK-B5 : Hornblende-biotite monzogranite showing assemblage of hornblende (with panidiomorphic magnetite inclusion; black) and biotite.
- NK-C5 : Hornblende-biotite monzogranite showing euhedral hornblende with lamella-twin, and quartz.
- NK-D5 : Hornblende-biotite monzogranite showing zoning plagioclase and hornblende.

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The Ban Na Kaem Hornblende-biotite Monzogranite;  
Magnification 38X, XPL  
(Micrometer, 10 divisions equal 0.25 mm.).



Table 3-5. Summary of Physical and Engineering Properties of Phu Sanao Granites.

Sample No.	Sat. Moisture Content (%)	Porosity (%)	Bulk Density Saturated (g/cc)	Bulk Density dry (g/cc)	Core Sample			UCS MN/sq.m	Is50 MN/sq.m	ID1	ID2	% of wear	UF
					Moisture	Density	Density						
ps-1	0.37	1.10	2.91	2.90	0.21	2.61	2.60	127.41	5.10	99.67	99.03	43.88	0.25
ps-2	0.50	1.40	2.91	2.90	0.18	2.61	2.61	266.51	-	99.52	99.01	-	-
ps-3	0.44	1.30	2.89	2.88	0.14	2.60	2.59	91.92	10.80	-	-	45.40	0.23
ps-4	0.73	2.10	2.91	2.89	0.27	2.62	2.61	114.17	4.57	99.84	99.70	39.98	0.34
ps-5	1.13	3.30	2.96	2.93	0.16	2.59	2.59	78.38	2.85	98.68	98.09	67.03	0.27
ps-6	1.30	3.80	2.93	2.89	0.39	2.58	2.57	74.76	2.50	98.83	98.19	59.25	0.26
ps-7	2.12	6.20	2.98	2.92	0.63	2.55	2.53	35.81	1.15	98.84	97.34	68.26	0.34
ps-8	1.20	3.50	2.92	2.89	0.46	2.59	2.57	45.87	2.63	98.36	97.49	57.16	0.26
ps-9	1.79	5.20	2.94	2.88	0.54	2.58	2.56	45.07	1.18	98.65	97.20	72.99	0.35
ps-10	1.63	4.70	2.92	2.87	0.45	2.53	2.52	54.41	-	97.75	96.42	70.83	0.35
ps-11	0.45	1.30	2.96	2.95	-	-	-	-	7.00	99.29	98.67	42.44	0.24
ps-12	0.49	1.40	2.93	2.92	-	-	-	-	10.55	99.28	98.76	48.36	0.36
pl-18	0.10	0.30	2.88	2.88	0.13	2.61	2.60	150.75	9.85	99.51	95.15	36.23	0.23
pl-19	1.06	3.10	2.96	2.93	0.58	2.57	2.55	56.22	1.50	98.35	97.00	63.96	0.27
pl-20	1.16	3.30	2.92	2.88	0.34	2.58	2.57	56.12	-	98.67	95.20	40.63	0.48
pl-21	1.64	4.80	2.62	2.92	0.65	2.53	2.51	37.34	1.38	95.90	93.43	75.56	0.37
kd-24	0.48	1.40	2.93	2.91	0.19	2.60	2.60	224.89	11.10	99.66	99.53	25.66	0.22
kd-25	0.42	1.30	2.95	2.93	0.23	2.59	2.58	265.53	12.25	99.62	99.40	26.40	0.22
kd-26	2.73	7.90	3.01	2.97	0.65	2.52	2.51	72.24	2.10	95.96	99.40	86.14	0.52
kd-27	1.60	4.60	2.90	2.86	-	-	-	-	3.35	-	-	70.29	0.34



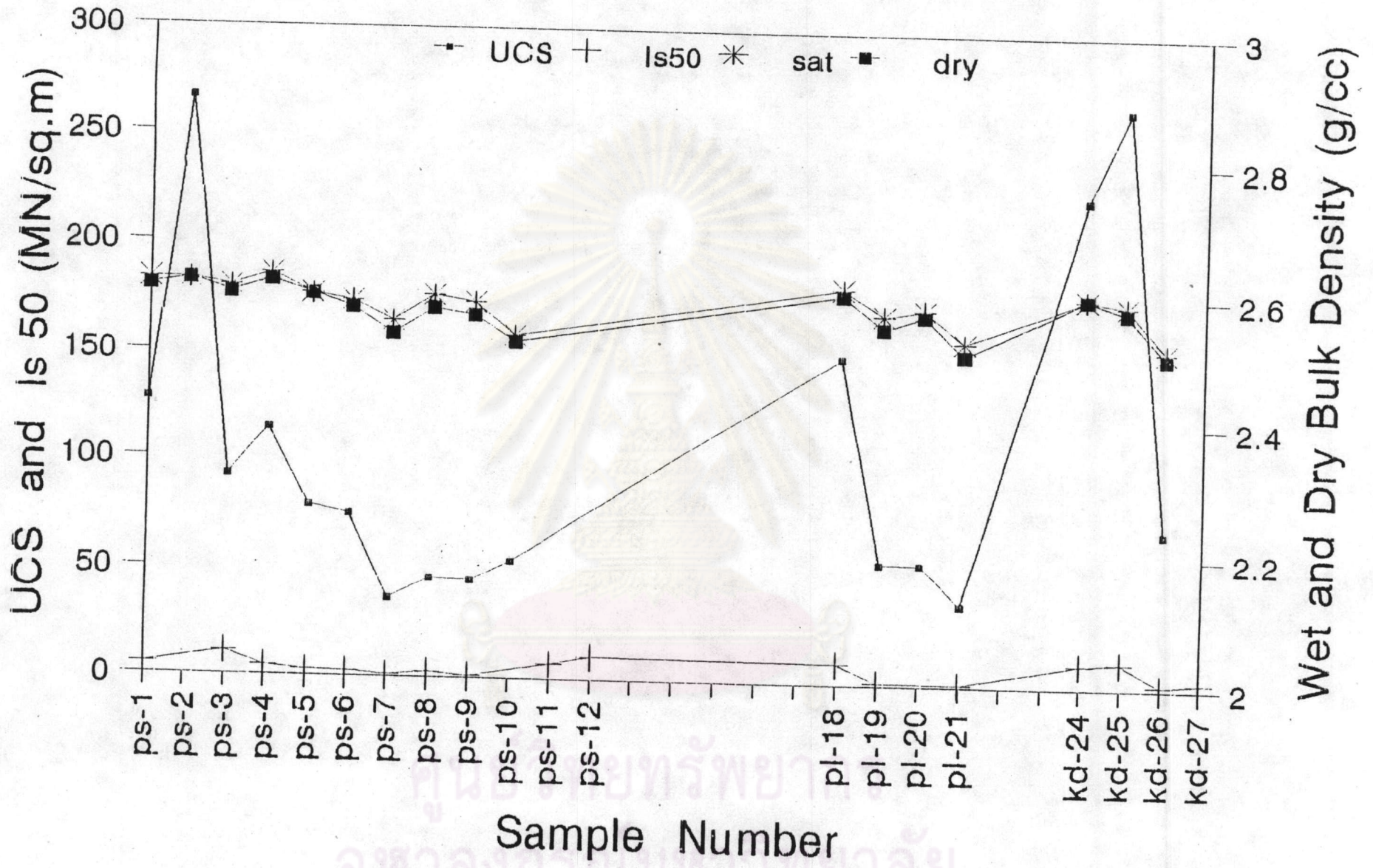


Figure 3-16. The relationship between unconfined compressive strength, point load strength index and bulk density of Phu Sanao, Phu Lek and Ban Kok Du subunits.



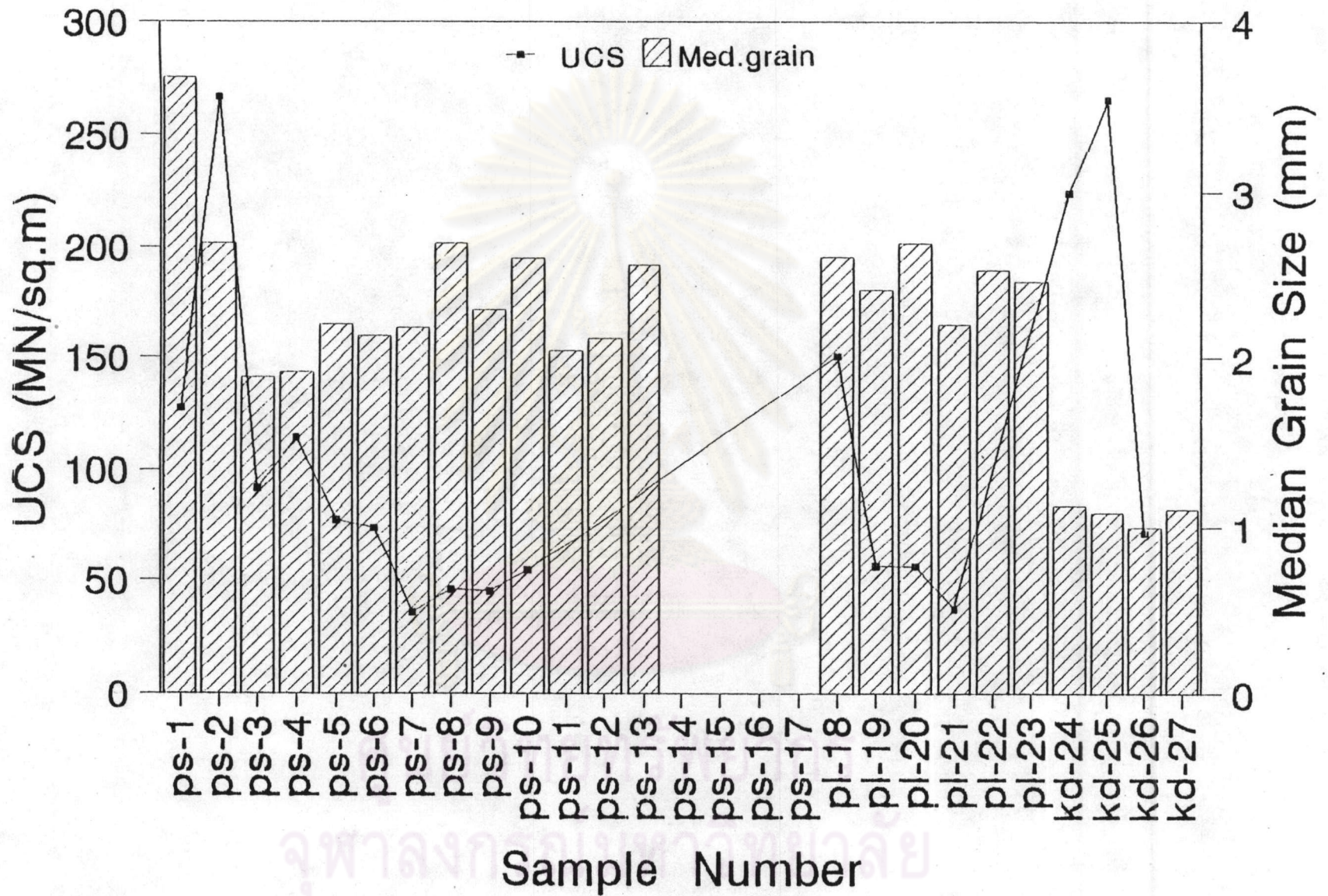


Figure 3-17. The plot of unconfined compressive strength and median grain size of samples from Phu Sanao, Phu Lek and Ban Kok Du subunits.