KINGDOM OF THAILAND

MINISTRY OF NATIONAL DEVELOPMENT

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No 42 : CHEMICAL AND MINERALOGICAL STUDY OF SUBSURFACE HORIZONS OF CHIANG MAI

by

Samarn Panichapong

, Belgium.

Soil Survey Division
Bangkok, Oct. 1965
20 pages, 2 fig
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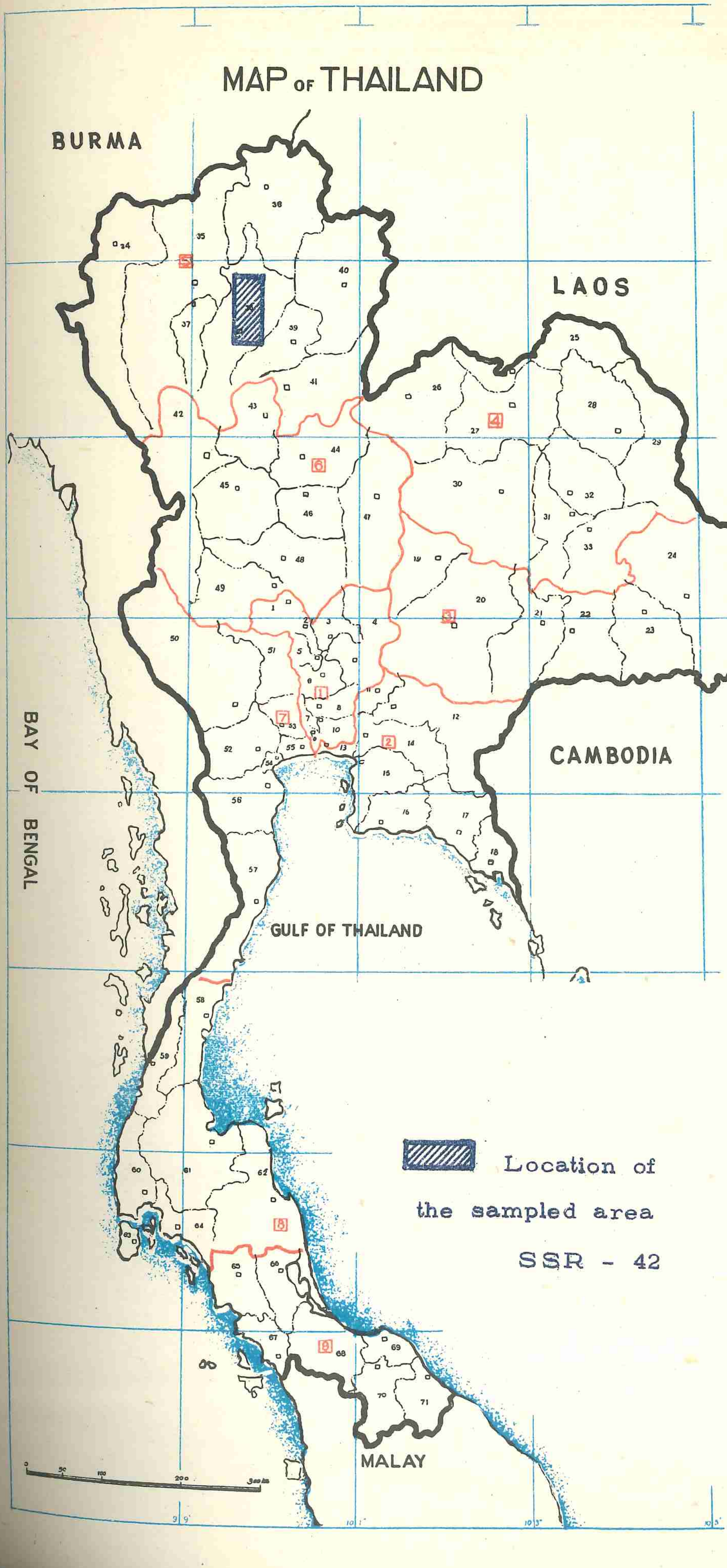

No.	Province	REGION
1	Chai-Nat	
2	Singh-buri	
3	Lopburi	
4	Sara-buri	
5	Ang-thong	
6	Ayuthya	
7	Nonthaburi	
8	Pathum-thani	
9	Thonburi	
10	Phra-nakhorn	
11	Nakhornayok	
12	Prachinburi	
13	Samutprakan	
14	Cha-choengsao	
15	Cholburi	
16	Rayong	
17	Chant-buri	
18	Trat	
19	Chayaphum	
20	Nakhornratsima	
21	Buriram	
22	Surin	
23	Srisaket	
24	Ubonratthani	
25	Nong-kai	
26	Loei	
27	Udornthani	
28	Sakonnakhorn	
29	Nakhornphanom	
30	Khon-kaen	
31	Mahasarakham	
32	Kalasin	
33	Roi-et	
34	Mae-hongsorn	
35	Chiengmai	
36	Chiengrai	
37	Lamphun	
38	Lampang	
39	Phrae	
40	Nan	
41	Uttaradit	
42	Tak	
43	Sukhothai	
44	Phitsnulok	
45	Kamphaengphet	
46	Phichit	
47	Phetchbun	
48	Nakhornsawan	
49	Uthai-thani	
50	Kanchanaburi	
51	Suphanburi	
52	Ratburi	
53	Nakhornpathom	
54	Samutsongkhram	
55	Samutsakhorn	
56	Phetburi	
57	Prachuap-khirikhan	
58	Chumphorn	
59	Ranong	
60	Phang-nga	
61	Surat-thani	
62	Nakhornsrithamrat	
63	Phuket	
64	Krabi	
65	Trang	
66	Phatalung	
67	Satun	
68	Song-khla	
69	Pattani	
70	Yala	
71	Nara-thiwat	

CONTENTS

CHEMICAL AND MINERALOGICAL STUDY OF SUBSURFACE HORIZONS OF SOME SOILS OF CHIANG MAI

I INTRODUCTION

The Chiang Mai province is one of the most outstanding agriculture areas of northern Thailand. Many agriculture development projects have been established there during the past five years. Hence, soil investigation of the region became necessary and was considered as the first necessity. Soil maps of different project areas were made using the soil classification system developed by the late Dr. R. PENDLETON. His system had been used until 1962 when the need for more effective soil maps of the region reached its peak. The U.S.D.A. system developed by BALDWIN, KELLOGG and THORP in 1938 was tried out for the first time in Thailand by Dr. F.R. MOORMANN, F.A.O. soil specialist. The results seem to be very satisfying, but in order to be more up to date, the newest U.S. soil classification system intoduced by Dr. G.D. SMITH was also tried out. The results seem to be very promising. It is believed that the system will be employed in the future when more data are available.

Up to the present only field observations of the region as well as of the whole country have been carried out. Extensive chemical and mineralogical analyses are not conducted as yet. Without analytical data, the knowledge about the soils of the area is not complete and some genesis problems cannot be solved. The intention of this paper is therefore to study the chemical and mineralogical properties of some soils developed from different parent materials in the Chiang Mai province (see map).

The samples studied here came from a subsurface horizon of four profiles : 1. Low Humic Gley soils, 2. Red-Yellow Podzolic soils, 3. Reddish Brown Lateritic soils and 4. Red-Yellow Podzolic - Reddish Brown Lateritic Intergrade.

These soils, especially 1, and 2, have been found extensively in south-east Asia. DUDAL and MOORMANN (2) reported that the Low Humic Gley soils are a prominent soil group formed on all older terraces of the main rivers of continental south-east Asia, especially on the Mekong terrace in Thailand, Cambodia, Laos and the republic or Vietnam. In Thailand, Low Humic Gley soils are normally found on the low terrace but small patches are often found on the footslopes in the hilly country. The Red-Yellow Podzolic soils of south-east Asia, which have commonly been referred to as "Lateritic soils", are found in the wetter regions where non-basic parent materials occur in nature to senile landscapes. These soils cover more than 50% of the total surface of the Republic of Vietnam. In Indonesia, Red-Yellow Podzolic soils are important soil groups in the non-volcanic area, being strongly represented in Java, Sumatra and Borneo. Current observations indicate a similar pattern in Malaya and other countries.

In Thailand Red-Yellow Podzolic soils are found scattered over many parts of the country with the majority in the southern and south-eastern parts, where the average annual rainfall is higher.

DUDAL and MOORMANN (2) also reported that these two soil groups (Low Humic Gley and Red-Yellow Podzolic soils) have a low content of exchangeable bases, mostly less than 25 me/100 g of clay. The clay mineral composition of the Red-Yellow Podzolic soils is predominantly kaolinite. Other clay minerals could be either illite or montmorillonite if there are any.

Reddish Brown Lateritic soils are not common and mostly formed on slope colluvium from shales.

II GEOMORPHOLOGY AND CLIMATIC CONDITIONS

1. Geomorphology of the region and parent material of the samples

All the samples are collected from soils formed in the Chiang Mai valley which is situated in the Phi Nam physiographic subprovince (5). This subprovince is characterized by a series of parallel mountain ridges, alternating with valleys eroded by the rivers in the softer beds. The Chiang Mai valley is formed by the Mae Nam Ping (Ping river).

The valley has been filled up with alluvial sediments during different periods. The sedimentation periods left their traces in the form of river teraces. At present, four terraces have tentatively been distinguished : 1, alluvial plain; 2, low terrace; 3, middle terrace; 4, high terrace. These different terrace levels form a step pattern and are easily recognized. However, complication of the land forms is created by deposition of slope colluvium and alluvial fans at the border between the valley and the mountain range. The landscapes are more complex where the lateral creeks and drainage ways enter the main valley.

The materials of the different terrace levels can be summarized as follows (5) :

i Alluvial plain : mainly clay, sometimes heavy clay; sometimes sandy in the subsoil; or even sandy in the river levees and some abandoned riverbeds; characterized by a considerable amount of micas.

ii Low terrace : mainly weathered clay, some loamy and sandy materials; including non-sedimentary lateritic concretions.

iii Middle terrace : mainly sandy to loamy with gravelly material in the deeper subsoil.

iv High terrace : the composition is highly variable; mostly very gravelly materials, strongly weathered.

The material of the slope colluvium varies depending upon the type of rocks it darived from. In the case studied here the slope colluvium was derived from shale.

The relative situation of the soil groups in the landscape is shown in figure 1.

2. Climate

The climate of the Chiang Mai province follows the typical monsoon pattern of the major part of Thailand, with only a slight difference due to the higher elevation and the land-locked position of the valley. The main difference is that the rainy season of the Chiang Mai province is extended to the last part of October and that the mean monthly temperature of December-January is lower. The climatic data of the area are shown in table 1.

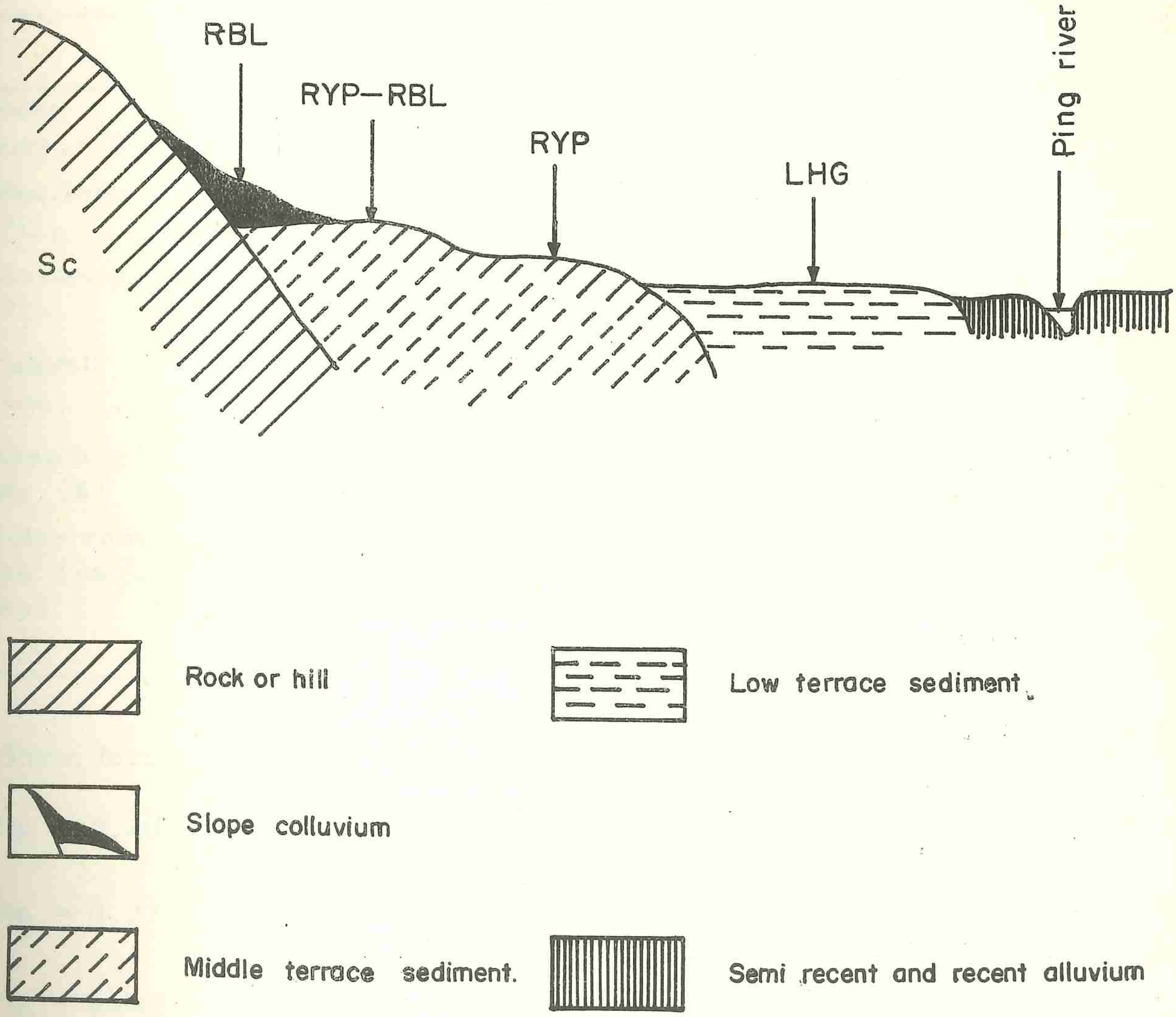

Fig 1: Schematic cross-section of the terrain, to demonstrate the relative position of the soil groups (without scale). The letter symbols indicate the relative position of the soil groups in the landscape.

Table 1 Climatic data

	J	F	M	A	M	J	J	A	S	O	N	D	An.
Mean temp. (°C)	21.3	23.1	26.0	28.6	28.6	28.0	21.4	27.0	26.9	26.2	24.6	21.8	25.7
Max. temp. (°C)	33.5	37.5	39.3	41.2	34.6	39.5	36.5	34.4	35.5	35.2	34.7	33.3	-
Min. temp. (°C)	6.0	6.4	10.5	13.2	19.4	19.1	18.9	20.0	19.7	14.2	10.2	6.1	-
Rainfall (mm)	7	12	15	49	144	146	188	231	289	126	38	10	1257
Mean humidity (%)	72	65	59	63	73	78	80	83	83	81	79	76	74
Solar radiation (cal/cm2/day)	393	438	422	494	506	444	390	458	439	444	429	414	-

The evapotranspiration of the area was calculated by the "Turc formula" (6) :

$$Etp = 0.40 \frac{t}{t + 15} (Ig + 50)$$ (except for Feburary :

$$Etp = 0.37 \frac{t}{t + 15} (Ig + 50)$$

Etp = potential evapotranspiration of the month (mm)

t = mean temp. of the month (°C)

Ig = global radiation of the month ($cal/cm^2/day$).

The potential evapotranspiration curve is shown in fig. 2.

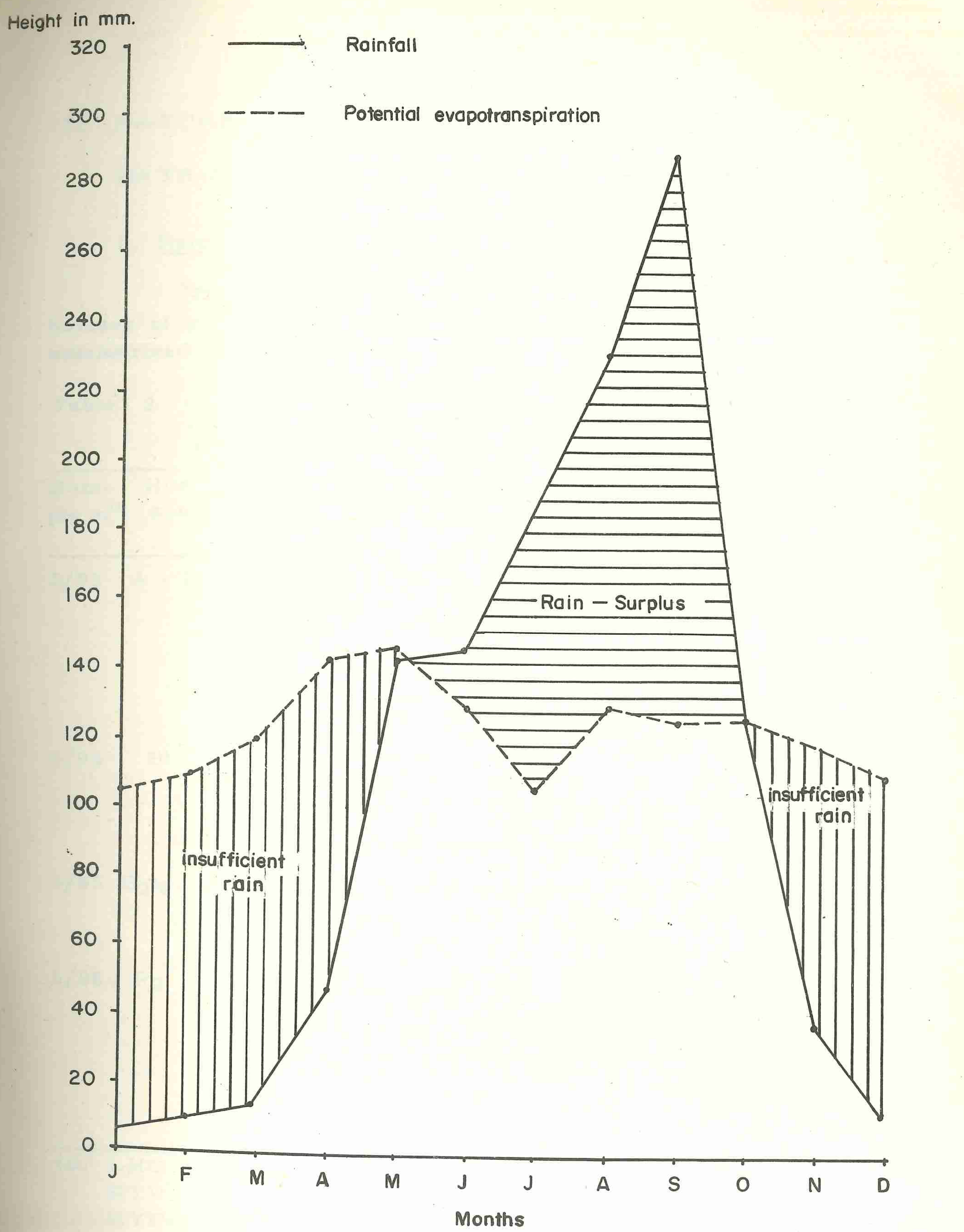

Fig 2 : Potential evapotranspiration curve of Cheingmai province calculated by the Turc equation.

III NATURE OF THE SAMPLES AND ANALYTICAL MATHODS

1. Nature of the samples

The samples used in this study are from a subsurface horizon of four profiles, as mentioned previously. Their nature is summarized in table 2.

Table 2 General information about the samples.

Sample n°	Horizon	Soil Group (n)	Soil Series	Parent materials	Vegetation and Land Use
5/93	A + B	RYP-RBL integrede	Mt : Mae Taeng	Old alluvium of middle (?) terrace, homogeneous, non-gravelly	Open dipterocarp forest with some shrub and 80% grass-covered
5/94	Bt	RBL	Li : Li	Slope colluvium shales	Dense forest with bamboo and some teak
5/95	B_2tg	LHG	Lp : Lampang	Low terrace material	Rice
5/96	P_2	RYP	MrC : Mae Rim complex	Old alluvium of middle (?) terrace	Secondary dipterocarp forest with bunch grasses

(n) LHG = Low Humic Gley soils. (Ultisols - Aquult - Ochraquult)
RYP = Red-Yellow Podzolic soils (Ultisols-Ustult-Plintustult)
RYP-RBL= Red-Yellow Podzolic and Reddish Brown Lateritic intergraded soils.
RBL=Reddish Brown Lateritic soils. (Alfisols or Ultisols)

The profile descriptions of three profiles are given below ; no profile description was made of the Reddish Brown Lateritic soil.

Profile of Red Yellow Podzolic soil - Reddish Brown Lateritic soil intergrade.

Area : Changwat Chiang Mai, Amphoe Mae Taeng, roadcut east of Chiang Mai - Fang highway at km 43.1

Vegetation : Open Dipterocarp forest, some shrubs and 80% grass cover.

Patent Material : Old alluvium of middle terrace, homogeneous, gravelly below solum.

Elevation : 390 m.

Topography : undulating non eroded terrace, slope 2%, close to rolling, dissected terrace area.

Soil series : Mt : Mae Taeng series

Description :

0 - 8 cm, A1 : loamy sand, brown ($7\frac{1}{2}$ YR 4/3), massive single grained, friable, many roots, pH 5.5, smooth clear boundary

8-14 cm, A2 : loamy sand, reddish brown (5 YR 4/4), locally with redder spots, massive single grained , friable, many fine tubular pores, common roots, pH 5.5, smooth gradual boundary

14-24 cm, A & B : sandy loam and loamy sand (average sandy loam), spots of dissolving Bt horizon, surrounded by A2 material, reddish brown ($2\frac{1}{2}$ YR 4/4. average), weak fine subangular blocky structure, slightly hard, many fine inped tubular pores, some roots, pH 5.5, smooth gradual foundary

24 - 200 cm +, B_2t : sandy clay loam, red ($2\frac{1}{2}$ YR 4/6) moderate fine subangular blocky structure, discontinuous clay skins, firm, many very fine tubular inped pores, few roots, pH 5.5.
At approximately 300 cm, transition to mottled clay over gravel beds.

Profile of Reddish Brown Lateritic soil (in complete, summary description).

Area : Changwat Chiang Mai, Amphoe Mae Taeng, roadcut west of Chiang Mai - Fang highway near km 58.

Vegetation : Dense forest with Dipterocarp, teak and bamboo.

Parent Material : Slope colluvium from shales, mixed with some terrace sediments.

Elevation : appr. 420 m.

Topography : hilly, steep slopes; gorge of the Ping river cutting through a northeast south west oriented hill range.

Soil series : Li Li series (?)

Summary description

A_1 : fine gravelly clay loam dark, reddish brown (5 YR 3/3) fine granular structure

A_3 : do , fine subangular blocky structure

Bt : fine gravelly clay, some rounded pebbles, dark reddish brown, fine subangular blocky structure, some clay coatings.

Profile of Low Humic Gley soil.

Area : Changwat Chiang Mai, Amphoe San Sai, Mae Cho agricultural station, near station office.

Vegetation : Lawn, formerly ricefield

Parent material : Old alluvium of the low terrace

Elevation : 310 m

Topography : gently undulating to flat non eroded lower terrace, slope appr. 1%

Soil series : Lp : Lampang series

Description :

0-10/13 cm, Ap1 : fine sandy loam or loam, dark gray (10 YR 4/1 some mottling, gray and yellow spots, weak fine to medium crumb structure, friable, clear, wavy boundary.

10/13-18 cm, Ap2g : fine sandy loam or loam; grayish brown (10 YR 5/2) matrix, mottled with yellowish brown and some black small spots, weak fine subangular blocky structure, firm, clear smooth boundary.

18-33 cm, A2g : loam, gray (10 YR 6/1) matrix, strongly mottled with yellowish brown and black spots, weak fine subangular structure, firm, gradual wavy boundary.

33-69 cm, B2tg : loam to silty clay loam, gray (10 YR 6/1) matrix, strongly mottled with larger yellowish brown and black spots, common fine soft Fe/Mn concretions within mottles, moderate fine subangular blocky structure, slightly sticky slightly plastic, patchy clay coatings, clay movement in pores and root channels, gradual smooth boundary.

69 cm-96 cm +, Cg : loam, pinkish gray ($7\frac{1}{2}$ YR 7/2) matrix, common distinct mottles, few larger Fe/Mn concretinns, weak medium subangular blocky, slightly sticky slightly plastic.

<u>Profile</u> of Red Yellow Podzolic soil.

Area : Changwat Chiang Mai, Amphoe San Sai, Mae Cho agricultural station, appr. 500 m East of station office.

Vegetation : Secondary open Dipterocarp forest with 30-50% ground cover of bunch grasses.

Parent Material : Old alluvium of middle terrace

Elevation : 320 m

Topography : gently undulating, transition zone of middle terrace to lower terrace, 2-3 % slope.

Soil unit : MrC : Mae Rim complex.

Description :

0-7/15 cm, Ap : loamy sand, mixture of original A1 and A2 horizons, ploughed, average color brown (10 YR 5/3) with lighter and darker spots and streaks, massive single grained, soft, few roots, common pores, pH 6; abrubt wavy boundary.

7/15 - 14/19 cm, A2 : locally absent horizon, loamy sand, light yellowish brown (10 YR 6/4) with gray and whitish spots, massive single grained, soft, few roots, common pores, pH 5.5, clear wavy boundary.

14/19-41 cm, AB : sandy loam, reddish yellow (7½ YR 6/5), weak fine subangular blocky, friable, few roots, common pores, pH 5.5, abrubt wavy boundary.

41-75 cm, P1 : gravelly loam, multicolored with reddish yellow (7½ YR 6/5) matrix, appr. 70% plintite concretions of diameter up to 20 mm, few mottles, increasing with depth, pH 5.5, gradual wavy boundary.

75-110 cm +, P2 : gravelly clay loam, "mottled clay" with light gray (10 YR 7/1) to pale brown (10 YR 6/3) matrix and red brown reticulate mottling, soft plintite with appr. 30% hardened concretions within the colored mottles; pH 5.5.

2. Methods used

The methods of soil research used in this study are :

i micromorphological study of thin sections,

ii X-ray diffraction for the mineralogical study of the clay size particles (3),

iii mechanical analysis by KOHN's pipette method (3),

iv cation exchange capacity (CEC) and base saturation by MEHLIGH's method(3),

v iron oxide determination by DEB's method (modified)(3),

vi organic carbon determination by WALKLY & BLACK's method(3).

IV RESULTS AND DISCUSSIONS

1. Chemical and mechanical analysis

The results of the analysis are shown in table 3.

Table 3. Analytical data of the samples.

Sample n°	Sources (n)	Mechanical analysis 2 %	2-50 %	50-2mm %	Texture USDA	pH KCl	pH H_2O	CEC me/100g soil	Base sat. %	Org. carbon %	% Fe_2O_3 Free	Total
5/93	A+B -RYP -RBL integrade	16.95	26.35	56.70	sandy loam	4.4	5.6	9.2	49.0	0.35	1.101	3.692
5/94	Bt +RBL	57.65	27.15	15.20	clay	5.2	6.2	25.4	60.6	0.24	4.948	10.180
5/95	B_2tg-LHG	24.90	47.05	28.05	loam	5.8	6.8	15	76	0.20	1.374	6.010
5/96	P_2(Plin-thite) -RYP	31.20	23.90	44.90	clay loam	4.8	5.7	13	60	0.04	2.989	14.947

(n) See table 2

The mechanical analysis of all samples but one correspond with the field estimation. Sample n° 5/95 (B2tg of the Low Humic Gley soil) surprisingly shows a higher silt fraction (2-50 mu) than expected. However, out of 47% of the fraction, 24% fall in the 2-10mu range. This fraction can be easily misjudged in the field. If this analytical datum is correct (the mechanical analysis of this sample was repeated and the results were the same),then it is doubtfull whether this horizon would be an illuvial horizon (Bt), because the analytical data indicated very little clay illuviation. This could be explained by the fact that this soil is normally suffering from a high ground - water table, which subsequently will impede the percolation rate. It seems likely that this soil does not derive from clay size particle material, but rather from silt material or larger which was gradually weathered down to clay size material during the soil formation processes. More careful study of the whole profile is necessary to confirm this hypothesis.

As one could expect the CEC values increase with the clay content. The base saturation as well as the CEC values are higher than normally expected. The base saturation values seem to be directly related with the pH values.

2. X-ray analysis

The X-ray diffraction of the 5 mu fraction for clay mineral study has been made. The results are shown in table 4.

Table 4 : Clay mineral composition of the soils.

Sample n°	Sources	Clay minerals
9/93	A+B-RYP-RBL	Kaolinite
9/94	Bt - RBL	Kaolinite, Illite
9/95	B_2tg - LHG	Kaolinite, Illite
9/96	P_2 (Plinthite)-RYP	Kaolinite

Kaolinite is the dominant clay mineral in each of the samples. Illite is found in the samples from Bt - RBL and B_2tg LHG. The illite of B_2tg- LHG is well crystallized, but the 9.98 A° peak almost vanishes when the sample is either heated to 650° C or treated with ethylene glycol.

Quartz is present in all samples. However, there is a much smaller quantity in the sample from Bt-RBL than in the others.

The presence of illite in the Bt-RBL and the B_2tg-LHG indicates that these soils are subjected to a relatively smaller weathering degree than the other two soil materials (A+B - RYP-RBL and P2 - RYP). This fact is associated with the poorly drained character of the RBL and LBG soils. The drainage condition of the RBL is impeded by the heavy texture and by a high ground-water table for the LHG.

3. Heavy minerals

Counting of heavy minerals is shown in table 5. The heavy sand fraction of the samples appears to consist almost entirely or the uniquitous mineral association (tourmaline, zircon, rutile). Only a few fragments of weatherable minerals (hornblende, epidote, schist fragments) are counted. This phenomenon indicates that these soils are either derived from originally poor parent material (except the Reddish Brown Lateritic soil which has developed from shale) or have been subject to severe weathering processes.

Table 5 - Heavy mineral anaylsis.

Minerals	A+B RBL-RYP intergrade	Bt RBL	B2tg LHG	P2 RYP
Op aque	45	48	14	5
Tourmaline	19	7	4	2
Zircon	66	79	77	78
Rutile	10	3	17	19
Anatase	3	1	-	1
Brookite	1	-	-	-
		-		
Andalustite	1	-	-	-
		-		
Garnet	trace	2	-	trace
Epidote	-	1	-	trace
Hornblende (green)	-	-	-	trace
Hornblende (brown)	-	1	-	-
Alterite	-	6 (Tourmaline ?)	1	-
Muscovite	-	trace	-	-
Schist fragments	-	-	1	-

4. Micromorphological study

i A+B horizon of a Red-Yellow Podzolic soil Reddish Brown Lateritic soil Intergrade (sample n° 5/93).

1) S-matrix

Skeleton grains

The soil material is dominated by skeleton grains which are mainly quartz. The grains are angular in shape and vary in size. Very small unidentified fragments of weatherable minerals,are present (cf. table 4). Some unhumified organic remains are also observed.

Plasmic fabrics

The plasmic material is homogeneous brownish red and is influenced by organic matter in many places. Most of the plasma shows birefringence, but varies in appearance from place to place. The plasmic fabric is (vo)-skelsepic.

2) Voids

Voids are few, and some of them are filled with plasmic material. The walls of few of these voids are covered with plasmic separation substance (vosepic). More show plasma concentration. Some voids do not show any of these features. All voids are to be considered as pores.

3) Pedological features

Cutans

Plasma concentration is present and is mostly associated with voids. Most of the cutans are of the illuviation type. The other type is the diffusion one. In some parts, these cutans are close to one another causing difficulty in identification.

Glaebules

Some glaebules can be recognized in few places. There are several evidences of pseudogleyification which are given by the presence of decomplexated iron forms (partly crystallized, even till the stage of hematite). These stain-like extensions are not to be considered as true nodules nor glaebular haloes, in their present stage.

4) Interpretation

It is rather difficult to draw any definite conclusion from the study of one thin section from a single horizon of one profile. However, the presence of some ferruginized quartz in the thin section indicates the allochtonous origin of the soil material. This soil is believed to be derived from poor parent material as can be explained by the lack of the heavy minerals association. The angular shaped quartz grains in the soil material are probably derived from the breaking down of gravels in situ during the soil formation processes.

ii Bt horizon of a Reddish Brown Lateritic soil (sample n° 5/94)

1) S-matrix

Skeleton grains

The soil material contains many rock fragments (shale and quartzite). Some of these are ferruginized. Mica fragments, more or less altered, are also found. Quartz represents the majority of the skeleton grains. Their dimension is varying from silt to sand size. These grains are rarely round-shaped. Occasionally, more or less altered mafic mineral grains can be pointed out (cf. table 4). There are many small incomplete humified plant remains, which do seem locally associated with iron stains.

Plasmic fabrics

The plasmic material is much more important than the skeleton grains. It is organized into several fabric types, which are: 1 mosepic, locally combined as, 2, in-mosepic, 3, vosepic, in many area s associated with thin plasma voids or true channel voids, 4, skelsepic, around most of the skeleton grains and around "phanthoms" of pre-existings, actually altered (mafic ?, feldspathic ?) minerals. The more or less round-shaped character of this specific skelsepic plasma separation should not be considered as an indication of alteration of feldspars. Nevertheless, these "phanthoms" are always individualized from the enclosing soil material, because 1, they coincide with a well- marked association of easily visualized damains of mosepic plasmic fabrics and because 2 they are associated with a most stronger coloring (more red, more brown) of the plasma mass. The ferric coloration together with the presence of plasma separations give great monotony to fabric appearance in general.

2) Voids

The number of voids are varying from one area to another. Some are big channel voids ; most of them are small to vary small interconnected metavughs. The smoothness of their walls is accentuated by the presence of many thin vosepic separations.

3) Pedological features

Cutans

No true (illuviation, diffusion) cutans are observed. Only stress cutans can be pointed out in some areas, associated with skelsepic plasmic fabrics.

Glaebules

Well localized stains and flecks may show an evolution to irregular or still growing nodules. Despite the small number of these features, they are a clear indication of pseudogley conditions in this horizon. Few indistinct papules are also noticed.

4) Interpretation

Although the soil material contains a tremendous amount of plasmic substance, it does not show an indication of movement. There are no illuviation cutans and only few stress cutans. But the presence of different plasmic fabrics (separatinns) indicates that the plasmic substance is formed by the weathering in situ of materials rich in clay. Shale is indeed described as the parent material of this soil in the field.

Comparing this soil with the others that are studied here, it seems to be the youngest and the richest. This is explained by the presence of more observable weatherable minerals.

iii B2tg (?) horizon of a Low Humic Gley soil (sample n^o 5/95)

1) S-matrix

Skeleton grains

The soil material is dominated by the skeleton grains, which are mostly quartz of varying size from silt to sand. Silt size and fins sand particles are predominating. These quartz grains are somewhat rounded. Ferruginized quartz grains are also scattered throughout the thin section.

Plasmic fabrics

Because of the very sharp difference in appearance between the stained parts and the non-stained parts, they are described separately.

a. Stained parts. The plasmic fabrics are of the skel-masepic type. In some areas the masepic type shows two distinct directions so that bi-masepic can be identified.

b. Non-stained parts. The plasmic fabrics of these parts are of vo-masepic type, but they are more local and much less important than the stained parts.

2) Voids

a. Stained parts. The voids are vughs (metavughs) and packing voids. These voids are relatively smaller than the voids in the non-stained parts. The interconnections between the voids are not distinct.

b. Non-stained parts. The most important voids of these portions are channel and packing voids. They are larger and show as irregular pattern. The interconnections between the voids are distinct in some areas and undistinct in other.

3) Pedological features

Cutans

It is necessary to describe the stained parts and non-stained parts separately.

a. Stained parts. The cutans are numerous, most of them being illuviation and diffusion types. Some of the diffusion cutans are very distinct and extend into the s-matrix material. Most of the cutanic materials are iron-decomplexated, forming the "sesquan" or "ferran" type.

b. Non-stained parts. The cutans are of the illuviation type, but in a much smaller quantity than in the stained parts. They are either associated with voids or not. The ones which are associated with voids, are sometimes difficult to separate from the vo-sepic separations, when only a very thin layer of plasmic substance is present along the walls. The plasmic substance bears iron in reduced form.

3) Pedotubules

Few indistinct pedotubules are observed.

4) Interpretation

The alternation between the stained and non-stained areas seems to be an indication for alternation of a wet and dry pedoclimate. The stained portions, which show more oxides, represent the drier parts and the non-stained portions, which contain iron in reduced form, represent the wetter parts.

Compared to the others, the finer texture and the rounder shape of the skeleton grains (see table 3 for size distribution) of this soil, indicate that the soil is developed from a well sorted material.

The presence of illuviation cutans indicates some movement of clay material, especially in the drier parts (stained parts). The amount of this type of cutan is not significant in the non-stained parts. The mechanical analysis data also show little clay accumulation in this horizon. The movement of the clay in this case may be local and incidently due to movement from wetter parts to drier parts (lateral movement).

iv P2 (Plinthite) horizon of a Red-Yellow Podzolic soil (sample n° 5/96)

1) S-matrix

Skeleton grains

The skeleton grains consist of quartz grains of different size. The grains are mostly angular with somewhat smooth edges. No weatherable minerals are observed. Besides quartz only one small crystal of tourmaline was found (see table 5). Ferruginous substance (Fe^{3+}) is present on the surface of many skeleton grains (ferruginized quartz), mainly in the cracks of these grains. This phenomenon indicates an allochtonous origin of the present skeleton material. It is believed that it derived from a soil material previously existing elsewhere.

Plasmic fabrics

Three plasmic fabric types are found in the soil material. The skel-mosepic type is dominating in the intervoidal mass. In some parts, only the mosepic type is observed. Along the voids, the plasmic fabric is mainly of the vosepic type.

2) Voids

Some of the voids are very small (packing voids), being formed by random packing of the skeleton grains. The most important voids are the channel voids. They are found scattered over different parts.

3) Pedological features

Cutans

Genetically the cutan types are identified as illuviation cutans and diffusion cutans. Illuviatinn cutans seem to domonate. According to the surface affected single grain and chennel cutans can be distinguished. The grain cutans dominate, but are locally difficult to distinguished from skelsepic plasmic fabrics. These cutans have a pale brown to brown color, due to the gradual decomplexation of the iron compounds. Decomplexation of the ferric iron compounds may produce diffuse or concentrated layers or bands.

Glaebules

The following glaebular classes are found.

Nodules. Nodules are the most important ones. They are composed partially of numerous, fine, highly crystalline, hematite crystallites (lateritic stage of plasma evolution in KUBIENA's sense). Many parts of the material have an opaque appearance. These nodules belong to the normal type, having relatively sharp boundaries and mostly smooth surfaces. In the skeleton, many quartz grains encrusted with more or less crystallized ferruginous plasma are observed (ferruginized quartz). This indicates that a big part of the parent material of the nodules was a previously existing soil material before becoming part of the present soil material.

It should be noticed that some nodules have less distinct boundaries and are more or less irregular in shape. Very important also is the fact that many morphological characteristics in the nodules (e.g. lateritics in the nodules, e.g. lateritic-filled cracks) are simply broken at the edge. This indicates very clearly the detritical origin of these nodules.

Papules. Few papules are found, sometimes along with glaebular haloes. In one area three successive stages of papule formation can be studied. They clearly show that papules are formed by gradual alteration of (unrecognizable) mineral grains.

Glaebular haloes. As mentioned before, some glaebular haloes are found along with papules. They are stained and flecked. The presence of glaebular haloes is a good indication of the hydrological conditions.

4) Interpretation

The study of the thin section has indicated following facts :-

a. The parent material of this soil is of allochtonous origin.

b. Comparing this soil with the Red-Yellow Podzolic - Reddish Brown Lateritic Intergrade, it seems to have been derived from material of the same origin and age. The small difference in mineralogical composition of these soils is probably due to the difference in degree of weathering. The Red-Yellow Podzolic - Reddish Brown Lateritic Intergrade has been under weaker weathering than the Red-Yellow Podzolic soil

c. The presence of angular shaped skeleton grains (mostly quartz) is believed to be the result of the breaking down in situ of gravels which were transported along with the finer material.

d. The lateritic modules in the soil material are believed to be transported from elsewhere along with the parent material of this soil. However, field observation shows that this horizon contains mostly soft plinthite with approximately only 30% of hard concretions. This phenomenaseems to indicate that the soil contains two types of lateritic nodules. The hard ones, observed micromorphologically as nodules and described as concretions in the field, are of allochtonous origin. The soft lateritic nodules as described in the field and the undistinct boundary nodules as observed under microscope may have been formed in situ.

V CONCLUSION

The chemical and mineralogical study of the subsurface horizons of four soil groups (Red-Yellow Podzolic, Reddish Brown Lateritic, Red-Yellow Podzolic - Reddish Brown Lateritic Intergrade and Low Humic Gley) from Chiang Mai, the northern province of Thailand, was made in the hope that a better understanding of their pedogenesis would be reached. The results lead to the follow conclusions.

1. The Red-Yellow Podzolic, Red-Yellow Podzolic - Reddish Brown Intergrade and Low Humic Gley soils are developed from allochtonous parent materials. The parent material of the Low Humic Gley soil consists of finer textured and better sorted material than that of the parent material of the Red-Yellow Podzolic and the Red-Yellow Podzolic - Reddish Brown Intergrade. The coarse fragments and gravels, in this two soils were disintegrated in situ to fine fragments, forming angular skeleton grains in the soil material.

2. The Reddish Brown Lateritic soil is indeed derived from clayey material, eg weathered shale. The micromorphological study indicates that the horizon where the soil material was taken from has no illuviation phenomena. More careful study is necessary to obtain definite answers.

3. The lateritic concretions found in the P2 layer of the Red-Yellow Podzolic soils are thought to be of two types :

   1 the hard concretions were formed elsewhere and have been transported to their present location in a later period;

   2 the soft concretions are formed in situ.

These conclusions can only be treated as temporarily ones, because they are made upon only few samples and some data are still uncertain. Due to the same reasons, an attempt to make a precise classfication of these soils, according to the new U.S.D.A. system (7th Approximation), has to be postponed till adequate information of better representative samples are made available. The proposed classification of the soils is mentioned elsewhere in the text.

This study has also emphasized the necessity for chemical and mineralogical study - especially the micromorphology for obtaining a more precise classification of the soils.

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