KINGDOM OF THAILAND

MINISTRY OF NATIONAL DEVELOPMENT

MOBILITY ENVIRONMENTAL RESEATCH STUDY

in

THAILAND

* * * * * *

No. 31

INTERIM REPORTS ON THE GREAT SOIL GROUP SURVEY

II : Pran Buri Study Area

by

Santhad Rojanasoonthon

Edited by the Land Development Department

Soil Survey Division
Bangkok, Dec. 1964
31 pages, 1 map
Report SSR - 31 -1964

MOBILITY ENVIRONMENTAL RESEARCH STUDY

in

THAILAND

* * * * * *

INTERIM REPORTS ON THE GREAT SOIL GROUP SURVEY

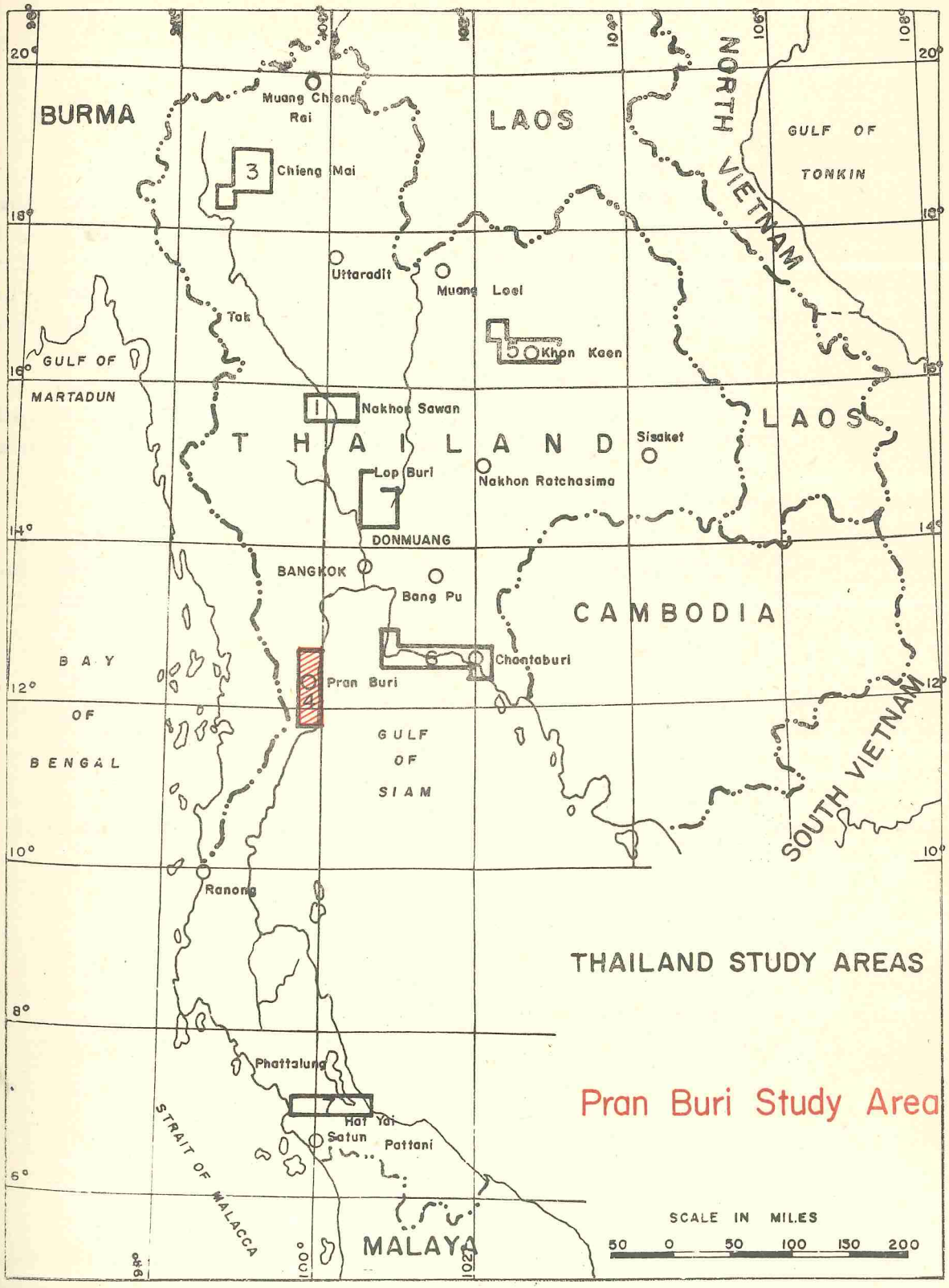
II : Pran Buri Study Area

by

Santhad Rojanasoonthon

Edited by the Land Development Department and Kasetsart University as soil survey report No. 31

Soil Survey Division
Bangkok, Dec. 1964
31 pages, 1 map
Report SSR-31-1964


BURMA
LAOS
NORTH VIETNAM
GULF OF TONKIN
Muang Chiang Rai
Chieng Mai
Uttaradit
Muang Loei
Tak
Khon Kaen
GULF OF MARTADUN
Nakhon Sawan
THAILAND
LAOS
Sisaket
Lop Buri
Nakhon Ratchasima
DONMUANG
BANGKOK
Bang Pu
CAMBODIA
Chantaburi
Pran Buri
BAY OF BENGAL
GULF OF SIAM
SOUTH VIETNAM
Ranong
Phattalung
Hat Yai
Satun
Pattani
STRAIT OF MALACCA
MALAYA
THAILAND STUDY AREAS
Pran Buri Study Area
SCALE IN MILES
50 0 50 100 150 200

Foreword

Under the terms of an agreement between the Research and Development Field Unit-Thailand, Advanced Research Projects Agency, Office of the Secretary of Defense, United States Government, and Santhad Rojanasoonthon, Kasetsart University, a Great Soil Group Study and Mapping is to be undertaken in the seven MERS Study Areas in Thailand, indicated on the location map in this report.

The Land Development Department considers the information, gathered under the terms of this agreement, of sufficient general interest to be published in its series of Soil Survey Reports.

The report and soil map of the Pran Buri Study Area is the second of the Great Soil Group Studies to be edited. It is published simultaneously in the series of "Soil Survey Reports" of the Land Development Department.

CONTENTS

GREAT SOIL GROUP STUDY OF THE PRAN BURI STUDY AREA

I INTRODUCTION

This soil survey report with accompanying generalized soil map is one of the interim reports (No. 2) on the great soil group survey project being conducted in seven MERS study areas in Thailand. The project is sponsored by the Mobility Environmental Research Study in Thailand, U.S. Department of Defense.

The survey is of the reconnaissance type, using AMS topographic map series L 509 at a scale of 1:250,000 as a basis for soil map drafting. Information for this study was obtained mainly from photo-interpretation of 1:40,000 and some 1:20,000 aerial photographs together with several field trips to the area. Data concerning the coastal area in the southern part of the study area was obtained from the MERS semi-detailed soil map recently completed by the Land Development Department survey team *.

The study of the soils in the Pran Buri area was completed in November 1964, covering a total of about 2,110 square kilometers or 814.5 square miles (excluding the sea). The MERS Pran Buri Study Area is in Phet Buri and Prachuap Khiri Khan provinces, covering from north to south, parts of Amphoes Cha-am (Phet Buri), Hua Hin, Pran Buri, Kui Buri and Amphoe Muang respectively. The geographical limits of the study area are at latitudes 12° 45' and 12° 00' for the north and south boundaries whereas the east-west limits are at longitudes 100° 00' and 100° 45' respectively.

Dr. F.R. Moormann, FAO Soil Specialist to the government of Thailand, assisted in the establishment of the map legend and the final drafting of the map.

II GENERAL DATA

1. General description of the area

The Pran Buri Study Area occupies a rectangular tract which is situated along the eastern coastal plain of Peninsular Thailand.

* To be published as Soil Survey Report No.29 by the Land Development Department.

On the west,the area is bordered by the main Tanaosi (Tenasserim) mountain range, with the Thai-Burma borderline at approximately 40 kilometers west of the northern part of the study area. Further south, this border is only 20 kilometers away from the study area. The eastern boundary of the study area is formed by the shore line of the Gulf of Thailand. Amphoe Cha-am is approximately 5 kilometers north of the northern limit of the surveyed area. The southern end of the study area is at Ban Bo Nok which is 24 kilometers from Prachuap Khiri Khan township.

The national highway route No. 5 (Phet Kasem)as well as the southern railway pass through the study area,joining the peninsula with Central Thailand. A series of roads,tracks and footpaths, normally running in east-west direction,connect the hills and the shore line throughout the surveyed area. Only few of them,however can be used by motor vehicles in the rainy season. Since the area west of the national highway is now extensively used for field crop plantation, many of the existing roads and tracks have been recently improved for transporting agricultural products to the markets.

Two lines of hills with a N-S trend cut through the area. The western hill ranges are part of the Tanaosi mountain chains; they range in height from 200 to 400 meters. The eastern line of hills meet the northern boundary at a NW-SE trend, then stay close to the coast from around Hua Hin town until the Sam Roi Yot limestone hills area. Most of the hills range from 200 to 300 meters in height but become higher,400 to 600 meters, in the Sam Roi Yot limestone area. Many low hills (100 to 200 meters) are scattered throughout the area,mainly near or around the main hill ranges.

The only important river in the area is the Pran Buri river which cuts across the plain and drains into the sea at Amphoe Pran Buri. South of the Pran Buri river, numerous creeks and drainageways drain either into the depressinn west of the Sam Roi Yot hills or into the sea. Two of the most important creeks are Klong Kui and Huai Nong Khang. North of the Pran Buri river there are fewer creeks. Two main creeks Huai Sap Phang and Huai Wang Khun Phon drain into Phet Buri river, 5 kilometers to the north.

The coastal area is normally lined by sandy beaches and few low dunes. A few rocky shore areas are present to the south of Hua Hin and Pran Buri towns whereas muddy or swampy areas are found to the west and the southeast of the Sam Roi Yot hills and at the river or creek estuaries.

The topography of the study area is generally flat to gently undulating with moderate gradients. The hilly areas are steeply rolling, but the limestone hills of the Sam Roi Yot area have very steep slopes and escarpments. South of the Pran Buri river, the terrain is situated at about 70-80 meters elevation along the western hill area and gradually slopes down to the elevation of 5-10 meters in the depressions and lower spots near the shore. North of the Pran Buri river, the plain between the west and east hill ranges is rather flat at 60 to 70 meters average elevation, with a gradual slope to the south towards the Huai Sam Phan Nam depression. This depression which is parallel to the Khao Sam Phraya hill range itself, slopes down towards the Pran Buri river to an elevation of less than 10 meters.

The beach formations are normally composed of sandspits and low dunes showing a distinct micro-relief topography. A series of ridges and shallow troughs are commonly observed parallel to the shore line. Tidal flat areas are prominent,especially south of the Sam Roi Yot hills

2. Physiography and geology

In order to discuss the different physiographic patterns of the study area, it is quite proper to separate out the broad geomorphologic features or land units which can be readily distinguished in the field and from aerial photographs. These physiographic patterns are : a) the recent alluvial and eolian formations, b)the semi-recent terrace c) the old terrace, d) the "remnant" older terrace,& e) the hills.

a) The recent alluvial and eolian formations :- In these formations, which are mainly found in the coastal areas, a variety of sedimentation patterns can be observed.

The fresh water alluvial plain of the Pran Buri river is of a very limited extend and may be observed near Pran Buri town. To the west,this alluvial plain becomes extremely narrow; to the east it borders the saline estuary area of the Pran Buri river. Most of the river sediments are clayey, but adjacent to the river channel, somewhat silty river levee deposits may be observed.

The recent marine alluvial plain occupy an extensive part of the Sam Roi Yot area i.e., in the vicinity of Ban Na Wan Priang, Ban Khao Daeng and the Khlong Kui estuary. Non- acid marine alluvial deposits are also found as narrow strips alternating with the sandy beaches or dunes of the recent beach formations. The material of these formations is essentially clayey in nature with abundant shell fragments in many localities. In the estuaries of creeks and rivers, e.g. the Pran Buri river, the Khao Daeng and the Kui creeks, the tidal flats are saline, bearing mangroves or other halomorphic plants. More inland, the marine alluvial plains have been reclaimed for rice land.

The recent brackish water plains constitute the larger part of the Sam Roi Yot depression; smaller areas occur further south. The deposits are completely acid, with the formation of acid sulphate soil showing straw yellow spots (catclay) at shallow or medium depths. Cf interest is the formation of the Sam Roi Yot depression adjacent to the limestone hills. The limestone hills served as a protective barriers which closed off the depression from the sea. Furthermore, these hills were a base from which sandbars grew, sealing off the whole area completely from salt water inundation.

The recent beach formations include sandspits and bars, which were laid down by water as well as low dune, formed in certain places by wind action on top of the bars. These sandy beaches are found extensively along the total length of the coast in the study area, interrupted on by rocky shores and muddy estuaries.

b) The semi-recent river terrace :- This area occupies the major plain south of the Pran Buri river. The terrace has been formed by a series of creeks draining from the hills in a west-east direction.

Thus, the area is in fact composed of a series of overlapping alluvial fans, which were progressively built out in the shallow coastal sea. The sediments appear fresh and unweathered, usually are medium to fine textured. Locally, some coarser material is found; gravel beds of limited extent occur near the apex of some of the alluvial fans. Along the old coastline of the semi-recent river terrace, the sediments were influenced by a saline or brackish water environment.

In the brackish water millieu of the shallow coastal sea, sulphide compounds were fixed and accumulated. Later oxidation and hydrolysis of these sulphide compounds give rise to the formation of the straw yellow streaks of acid sulphate soils, commonly known as "catclay" (6).

At the transitional zone between the semi-recent river terrace formations and the more recent alluvial deposits, fossil coral reefs are found in localized spots. These corals can be found in the soil profile in some localities, usually, but not necessarily associated with the formation of solonetzic soils.

c) The old terrace :- The old terrace formations are commonly found in the plain north of the Pran Buri river, having in general an undulating topography. It is believed that the old terrace as a whole has a marine origin whereas locally in the areas close to the hills and in the western part of the northermost section, the sediments may be partly or entirely colluvial or river deposits. In the old terrace plain between the western and eastern hill ranges, medium textured sediments are normally found; however, the area to the north and the east of Khao Sam Phraya contains rather coarse textured sediments which may have been deposited as an old beach.

Along the lower part of the old coastal terrace formations, the sediments are usually finer in texture and typically gave rise to the formation of solonetzic soils.

Ponded terrace sediments are found locally within this terrace area. Such sediments are fine textured and are situated in shallow depressions e.g., the depression near Ban Thuang Luang.

d) The "remnant" older terrace :- This older terrace formation is found in a restricted area, normally with undulating to gently rolling topography. It occurs as a remnant of a more extensively coastal terrace level. Only two areas of these older terrace formations were found, one along the north bank of the Pran Buri river and the other along the national highway near Khao Tao village. This older terrace obviously was protected from complete erosion because of its situation near hills. Similar "island" terraces, mostly with deep red soils can be found elsewhere in South East Asia. High, red, river terraces were mapped in the Khon Kaen area (9) as Yasothon series, and remnants of red marine terraces were also observed in southeastern Thailand, near Amphoe Siracha.

e) The hills :- Three different types of hills, corresponding with major groups of bedrocks can be distinguished - i.e. quartzite-phyllite hills, limestone hills and gneiss-schist hills.

i) The quartzite-phyllite hills occupy the trend along the western part of the study area. They are in fact parts of the more extensive hill ranges further west. These hills are predominantly rounded with few or no bare rock outcrops on the moderately steep hill slopes. Colluvial fans are commonly found along the footslopes. The rocks are uniformly dark gray green and brownish quartzites and phyllites, but sandstones, sandy shales and slates are also found. This formation belongs to the geological Kanchanaburi series of early Carboniferous (?), Devonian (?), Silurian ages (1). Limestone is probably a common inclusion in these rock formations.

ii) The limestone hills are mainly limited to the coastal area near Sam Roi Yot, but areas of limestone hills are found to the north and the south just outside the study area as well. Isolated limestone knolls also occur in the area of the Thanarat Replacement Training Center. The main component of the hills is a light gray, hard limestone, interbedded with quartzite, sandstone and shale. The hills have a craggy appearance with many bare rocks and steep spiny peaks. They belong to the geological Rat Buri series of Carboniferous (?) and Permian ages.

iii) The gneiss-schist hills orient themselves along a NW-SE trend and form the upper half of the coastal hill range, ending just north of the Sam Roi Yot limestone area. Most of the hills are composed of solid granitic gneiss rocks such as found near Hua Hin and Khao Tao. However, in many areas (e.g. south of the Pran Buri river esutary) the rocks show bands of gneiss, quartzite veins and mica schist. The gneiss-schist hill normally appear rounded with many large rock outcrops and much less craggy than the limestone hills; they are of pre-Permian (?)ages.

3. Soil forming materials

Following groups of parent materials, of which the majority is alluvial in origin, have been distinguished in this area:

i) Transported materials.

a. Recent alluvial sediments and eolian sands.

1) Non-saline sediments of the river plain. These materials have a limited occurrence, they are found in the alluvial plain of the Pran Buri river. The texture is medium to fine.

2) Brackish water sediments with acid sulphate soil conditions. These sediments are mostly fine textured; they are commonly found in the alluvial depressions, especially in the Sam Roi Yot depression.

3) Saline water sediments, non-acid, often calcareous with shell fragments. These sediments are mostly clayey, with locally sandy layers. They are commonly found in the recent marine lowlands near the coast.

4) Beach and dune sediments. These sandy materials are commonly found along the shore line throughout the study area.

b. Semi-recent alluvial sediments.

1) River terrace sediments. The materials are mostly medium textured but locally clayey. Close to the hills the sediments may be sandy to gravelly. They occupy the semi-recent river terrace areas south of the Pran Buri river.

2) Brackish water sediments. These sediments are normally clayey in texture and usually found along the transitional zone between the semi-recent river terrace and the recent alluvial plain.

c. Old alluvial sediments.

1) Very old, red clayey sediments (old marine?). These very old sediments are found in a limited area close to the hills. They are usually fine textured.

2) Old leached sediments. These old alluvial materials occupy the old terrace plain, north of the Pran Buri river. The materials are mainly sediments, ranging from sand to clay.

2) Ponded, fine textured sediments. These materials are found in a depression of the old terrace plain in the northern part of the study area. They are commonly fine textured.

ii) Sedentary and colluviated materials.

a. Residuum and local colluvium of quartzite, slate or phyllite :- These materials are normally found on or around hills or near rock outcrops. They are usually medium to fine textured and contain varying amounts of rock fragments, mostly quartzite with sometimes lateritic gravels.

b. Residuum and local colluvium of limestone and associated rocks :- These materials are normally found on or around hills, especially in colluvial fans. The coarse fractions are mainly composed of the asssociated rocks (quartzite and phyllite dominate), but larger boulders of limestone may be present. The finer fractions are usually fine textured, but texture varies on the nature of the associated rocks.

c. Residuum and local colluvium of granitic gneiss, quartzite and mica schist :- These materials are commonly medium to fine textured and contain varying amounts of rock fragments sometimes with lateritic gravels. They are normally found on or around the hills or near rock outcrops.

4. Climate

The Pran Buri study area can be described as having a Köppen "Aw", tropical savannah climate (8). This particular area, extending from Kanchanaburi to Prachuab Khiri Khan provinces is definitely drier compared to other parts of the Kingdom. The dry season, which lasts from December to March is somewhat shorter and not so pronounced as in the continental part of Thailand. Rainfalls mostly coincide with the southwest monsoon from April through November, with a maximum in October.

Yearly averages of rainfall at Hua Hin and Prachuab Khiri Khan (date over 20 years) are 1008 mm and 1160 mm respectively *, but the average rainfall in parts of the surveyed area may be somewhat below 1000 mm., due to the sheltering effect of some of the hill ranges in the area. The yearly average temperature is 27.5° C at Hua Hin with no pronounced variations throughout the year, as is to be expected in a region close to the sea.

* Data obtained from the Meteorological Dept., Bangkok, Thailand.

Vegetative growth and agricultural activities follow the rainfall pattern closely. Vigorous growth can be observed during the wet months. In drier months, vegetative growth almost ceases due to lack of available water.

5. Vegetation and land use

The natural vegetation of the study area is quite distinctly related to soils, topography and hydrologic conditions.

The more or less shallow and stony hill soils are mostly covered with forest inwhich Dipterocarp species dominate. Rock outcrops on the limestone and gneiss hills are practically bare of any vegetation. Near habitation centers, much of the forest on the hills has been cut and is replaced by shrubs or even short grass savannah.

The vegetation on the diverse terrace, where not replaced by cultivated land, is dominated by scattered trees, shrubs, often thorny, and bamboo. In places, the bamboo stands may be rather pure. Where the soils are sandy, however, little bamboo occurs and the low trees are mostly Disterocarp spp., Manilkava spp, Atalantia spp. The older plains, north of the Pran Buri river, show almost everywhere traces of shifting cultivation. The semi-recent river terrace, south of the Pran Buri river, is now mainly under pernament cultivation. Recently abandoned terrains on the terraces are quickly overgrown with weeds. (Eupatorium odoratum and Imperata cylindrica).

The vegetation of the non-cultivated parts in the transitional zone between the terrace area and the younger coastal formations is usually composed of low shrubs, and numerous patches with scanty growth of short grasses.

In the low coastal plains, vegetation and land use varies widely. Areas which are not too saline or too acid are usually under rice fields. A large part of the Sam Roi Yot depression is not cultivated and has a vegetation of grasses and rushes. The low areas, influenced by sea water, often are bare or have a scanty vegetation of halomorphic plants. Only near the mouth of Khlong Khao Daeng, extensive growth of mangrove forest is observed.

On the sandy beach areas, the vegetation is composed dominantly of low shrubs. Cactus sp. are very common in the southern beach areas. Other important species are Casuarina equisitiforia, Pongamia., Terminalia sp. etc.

Rice fields are mainly found in the low coastal depressions, but elsewhere in the area small clusters of rice fields may be observed in depressed spots. Upland crops are grown in various locations, the largest consolidated upland crop area is found on the semi-recent terrace. Here, common crops are pineapple, sugarcane, castor bean, kapok and a variety of truck gardening and fruit crops, including coconut.

6. Hydrography

The water regime of the study area closely related to the general nature of the soils as well as the physiographic features of the area.

The hill areas and footslopes normally receive water during the rainy period only. Creeks and drainage channels on and around the hill areas, therefore are dry most of the year except during heavy rains.

The plain to the north of the Pran Buri river has few creeks. These creeks which either drain into more or less closed depressions or into the river, are intermittent in nature, carrying water only in the rainy season. The soils of this older terrace plain normally have a rather poor water retention capacity, drying out deeply during the long dry season. South of the Pran Buri river the conditions are quite different. The younger semi-recent terrace plain is cut by a multitude of creeks and drainageways. Nearly all of these creeks contain no water during the dry season. The soils, however, tend to retain moisture well into the dry season.

The two major creeks of the area, the Pran Buri river and the Khlong Kui, contain water all through the year but the water level in the dry season is quite low and the current only sluggish.

The recent coastal alluvial plains and depressions are distinctly wetter than the surroundings because of their low position and of intake of additional water by surface runoff. Occasionally, high tides may inundate parts of the coastal areas, but normally, salt water only intrudes in the low shore land.

The sandy beach and dune formations retain very small amounts of water and most of the sandy area dries up quite rapidly after the rains.

III SOILS

1. General nature of the soils

The great soil groups which have been distinguished in this study area were classified according to the system proposed by Dudal and Moormann in 1962 (2). Additional data regarding the classification and morphology of the soils was obtained from the report on the preliminary soil survey of the Mae Klong irrigation project area, 1962 (5), the report on the soil survey of the Khao Tao area, 1964 (3), and the report to accompany the provisional map of the soils and surface rocks of the Kingdom of Siam, 1953 (7).

Regosols

Formation and environment :

Regosols are soils derived from recent sediments, other than young water deposited materials in floodplains. The main parent materials for regosols are beach and dune sand, slope colluvium and colcanic ash. In this area, only regosols on beach and dune sand materials have been observed. These sandy regosols are found mainly along the coast, occupying strips of varying width, usually narrow bands alternating with sandy to loamy lagoons or depressions between beach ridges. There are no particular climatic conditions that govern the formation of the regosols; thus, their morphology is mainly determined by the nature of the parent material.

The topography of the sandy regosol areas is generally flat to undulating with a distinct microrelief.

Morphology and diagnostic characteristics :

The regosols of the surveyed area have in common their sandy texture and their lack of profile differentiation.

Near the shore line, the profiles are composed of loose sand, containing considerable amounts of weatherable minerals. No or only a very weak A_1 horizon is present.

More inland the regosols show a slightly better developed profile, due to leaching and the action of the vegetation. Here, the horizon sequence is A_1-C or A_1-A_3-Cg.

Texture of these somewhat older beach and dune sand soils is sand or loamy sand. The loamy sand soils of the flat beaches may show a certain compaction of the surface soils which is very distinct when the soil is dry. Whereas mostly the regosols are yellowish brown, in some areas, e.g. near Khao Tao, reddish sands are found.

Generally, the drainage of the regosols is excessive. In the slight depressions and in the wider flat beach areas, groundwater may be relatively high in the wet season so that mottling occurs in such profiles from a depth of 30-60 cm down.

pH values of the young regosols are around 7.0; those in the older soils are approximately 5.0.

Known series differentiation in the region :

In the study area, the Hua Hin series is in general use for all sandy regosols. No attempt was made to separate the younger shifting dune or beach soils from the soils of the older beaches and dunes. Rough geomorphologic units for shifting and for fixed dunes were however recognized in the soil survey of Khao Tao area (3).

Vegetation and land use :

The regosols are usually too poor and dry out too deeply for cultivation purposes. In areas where the groundwater table is not too deep, coconut trees, cassava and other dryland crops can be grown. Most of the areas under regosols have an open vegetation of low shrubs, bamboo clumps and cacti with a sparse ground cover of short grasses.

Alluvial soils

Formation and environment

Alluvial soils are composed of young, water deposited sediments of the flat to concave or gently sloping areas of river, floodplains marine plains, lake beds, deltas, etc. The materials from which the alluvial soils have been derived vary considerably, both in composition and in texture. In wider floodplains or in areas near the coastline, the influence of the source of parent materials in the catchment area is not evident. Distinction can be made however, between sediments deposited in a saline, brackish or fresh water environments. The alluvial soils, formed on those different kinds of alluvium, are distinctly different in morphologic characteristics.

Morphology and diagnostic characteristics :

Alluvial soils do not show a prominent horizon differentiation; mostly, the surface horizon (A_1 or Ap) is the only genetic horizon developed. The common genetic soil horizon sequence is A-C or Ag-Cg where g denotes the gleying in the profile. Organic matter content, pH values and base saturation as well as texture are quite variable. Commonly, the alluvial soils in the study area have a pH of about 5.0-6.5. The calcareous or saline members of the tidal flat area usually have a higher pH value of 6.5-8.0. Lower pH values of 3.0-4.5 are common for acid sulphate soils. The base saturation is ranging from 70 to 100% with lower figures for the acid sulphate soils. Cation exchange capacity of the clay fraction is mostly above 20 me for 100 gm. clay.

Drainage conditions of the alluvial soils differ greatly. Most of them are clayey, poorly drained, grayish in color with distinct mottling throughout the profile. Better drained, medium textured soils are found on river levees, usually soil colors are brownish throughout or with mottling only at medium depth. Under rice cultivation, surface gleying has formed even on freely drained soils. This phenomenon is known as "inverted gley" .

The A horizon of the poorly drained depressional soils tends to be dark and well developed with a distinct organic matter accumulation. In the case of saline influence, a thin crust of salt may be found on the soil surface when dry.

Known series differentiation in the region :

In the study area, many series of alluvial soils have been recognized :

i) On riverine alluvium :

Tm - Tha Muang series soils are the levee soils of the Pran Buri river. They have a silty loam to clay loam texture and are yellowish brown in color. Mostly, these soils are well drained but sometimes mottling occurs in the subsoil. The pH is around 7.0 small mica flakes are present throughout the profile.

Rb - Rat Buri series soils are the clayey soils of the river floodplains, found behind the river levees. They are mottled throughout, the pH is about 7.0.

ii) On marine alluvium :

Tc - Tha Chin series soils are soils of the tidal flats, regularly inundated with sea water. Mostly, they are clayey but sandy Tha Chin soils are also observed. They are strongly saline; pH 7.0-8.0 with a dark surface and a reduced, soft, subsoil.

Wp - Wan Priang series * soils are soils of the tidal flats which are protected from sea water inundation and which, under rice cultivation have lost of the salt in the surface layers. These soils usually are clayey, calcareous (abundant shell fragments) and with a pH of around 8.0 throughout.

Bk - Bangkok series soils are soils of the tidal lands, already in use for rice cultivation for some time. Hence, the surface layers are somewhat leached, with a pH of 5.0 to 6.0, whereas the subsoil is neutral to slightly alkaline and calcareous. The soils are mostly clayey throughout.

---

* This soil series is now being mapped as Sm-Samut Prakan series.

Lm - Bang Lamung series soils are soils of the depressions between sandy beach ridges. These soils have predominantly a sandy texture, pH values are rather low (4.5 - 6.0). They are in use for rice cultivation.

iii) On brackish alluvium :

Ca - Cha-am series soils are soils found in the present day brackish water lagoons, where sea water mixes with fresh, river or run off water. These soils are acid sulphate soils, showing catclay and being saline at the same time. They are usually clayey with a reduced and soft subsoil.

Ok - Ongkarak series soils are acid sulphate soils found in depressions which are now protected from sea water inundation. Soils are clayey and acid throughout (below 4.0) with catclay occuring at varying depth and with a highly humiferous A horizon.

Tq - Tha Khwang series soils are clayey soils with an only slightly acid (marine) surface soil and with catclay in the subsoil. The A horizon is not strongly humiferous.

Sy - Sam Roi Yot series soils are clayey soils on brackish water sediments of some age. Catclay is found at varying depth; their drainage is somewhat better than that of the previously described series.

Vegetation and land use :

Most of the alluvial soils are cultivated, mainly to rice except for the too acid or too saline soils of the coastal area and the deeply flooded soils near Sam Roi Yot. Grasses, rushes, mangrove forest orhalomorphic plants are found in the non-cultivated areas, in accordance with their environmental conditions. Bamboo and thorny shrubs may be found on the less acid or saline soils which are not or only briefly flooded.

Solodized solonetz soils

These solonetzic soils are not included in the classification by Dudal and Moormann, 1962 (2). Informations were obtained from the U.S. soil survey manual, No. 18 (10) and from Soils of Ceylon, 1961 (4).

Formation and environment :

Solodized solonetz commonly occur in dry zones such as this study area. The occurrence of these soils is related to the presence of the salts in parent materials. In the study area, they are found on the clayey part of former estuaries and shores, which range in age from semi-recent to fairly old.

Morphology and diagnostic characteristics :

The solodized solonetz soils show a distinct profile differentiation. The A horizon clearly shows leaching and can be divided into A_1 and A_2. The A_1 horizon is commonly dark gray brown compared to the lighter gray brown color in the A_2. The A horizon is structureless and usually has a loamy sand to sandy loam texture. The boundary between the A_2 horizon and the Bt is abrupt and distinctly wavy due to the coarse columnar structure in the Bt horizon. The texture of the Bt horizon normally is sandy clay loam. This horizon has an extremely hard consistence when dry. In profile exposures, this B horizon stands out prominently. Mottling is stronger in the B than the upper horizons whereas the C horizon is strongly gleyed. The pH is usually about 5.0 - 5.5 in the upper part of the solum. In the lower Bt and C horizons, higher pH values of 7.0 or 8.0 are not uncommon, this is probably related to the salt content which increases sharply with depth.

Known series differentiation in the region :

Nong Kae is the only series provisionally named for the solodized solonetz soils in this study area.

Nk - Nong Kae series soils are soils of the marine terrace. They have a sandy to loamy surface over a clayey subsoil. The A_2 is moderately leached with an abrupt and wavy transition to the columnar Bt horizon. Fossil corals are commonly found in the deeper layers. The subsoil is often saline, especially in those soils in a relatively low topographic position.

Vegetation and land use :

The vegetation is predominantly composed of grasses with thorny shrubs and scattered trees. Bare spots occur frequently. These soils are only rarely in use for agriculture. In some lower and gently sloping areas, rice fields are found; these rice fields have a low productivity and are often abandoned due to the lack of water and/or the high salt content of the soil when submerged.

Non calcic brown soils

Formation and environment :

The formation of these soils is generally determined by the parent material and the climate. The parent material is mainly from acid to intermediate rocks with only limited amounts of dark colored ferromagnesium minerals. The climate is normally dry, with a rainfall, lower than 1500 mm and with a long and pronounced dry season.

In tropical countries such as Thailand, the occurrence of non calcic brown soils is normally limited to parent materials of relatively young age; on older parent materials, leaching has progressed too far.

In the surveyed area, the non calcic brown soils are found on the semi-recent terrace with undulating topography.

Morphology and diagnostic characteristics :

The non calcic brown soils have A_1 and A_2 horizon with brown and yellowish brown colors respectively. Hardening of the A horizon usually occurs in the dry season. The profiles have a medium textured surface soil with a heavier subsoil (Bt). In the lighter textured profiles the textural B horizon becomes less pronounced. A common horizon sequence is A_1-A_2-Bt. The color of the Bt horizon is yellowish brown to reddish brown. The blocky structure of the Bt horizon is moderately well developed, there are rather clear evidences of clay coatings. In the surveyed area, the solum is normally deeper than a meter.

The non calcic brown soils generally have a high base saturation, increasing with depth; concurrently the pH values are above 5.0 in the surface layers and increasing with depth. In the study area, however, the pH values are usually somewhat lower in the subsoil (5.0 - 5.5). The cation exchange capacity of the clay fraction is between 20 - 40 me for 100 grams of clay.

These soils are mostly well drained; they are not found in poorly drained depressions.

Known series differentiation in the region :

In the study area, the non calcic brown soils include the Pran Buri series and the Kamphaeng Saen series.

Pr - Pran Buri series soils are the dominant series of the semi-recent terrace in the area. The surface layers are usually silt loam, the subsoils are silty clay loam. Some sandier profiles are also found. The Ap horizon is about 25-35 cm. thick, gray brown to brown in color, with a pH of about 6.0 - 7.0. The color of the Bt horizon is yellowish brown to reddish brown with a pH of 5.0-6.5. No or very few micas are found in the soil material.

Ks - Kamphaeng Saen series soils may be present in the extreme northern part of the study area. They differ from the previous series in having a higher subsoil pH and showing small mica flakes in the soil material.

Vegetation and land use :

The natural vegetation on the non calcic brown soils is open forest and low shrubs with some thorny species. Since these soils have a high potential for dryland cropping; most of them are under agricultural use for such crops as pineapple, castor bean, sugarcane, corn, and fruit trees. The chief limiting production factor is the lack of water, especially in the dry season.

Low humic gley soils

Formation and environment :

The formation of low humic gley soils is closely related to relief and more in particular to drainage. These soils are generally found in poorly drained depressions. The important factor which governs the formation of these soils is the periodically high groundwater level (perched or true water table). The parent materials are mostly transported materials, either alluvial or colluvial, of the terrace deposits. In this area, mostly low humic gley soils occur in a ponded depression of the old terrace, associated with the gray podzolic soils which are the dominant soils of the old terrace area. Occasionally some small low areas which are usually under rice are found on the semi-recent terrace; the soils, observed here, can be classified as low humic gley soils.

Morphology and diagnostic characteristics :

Low humic gley soils are soils with dominant signs of wetness. Gleying is found throughout the profile or starts immediately below the surface horizon. Common profile sequence is A_1 (Ap)-A_2-Btg.

The A horizon is not prominant, normally with a thin, gray to gray brown A_1 and with a lighter and leached A_2 horizon. These horizons are often mixed due to rice cultivation. The illuvial B horizon is strongly mottled with a light gray to olive gray matrix. Groundwater laterite may occur in the lower part of the B horizon.

Commonly, the base saturation is low throughout with pH values varying between 5.0-5.5. Some low humic gley soils of the semi-recent terrace have a higher base saturation, with pH values between 6.5-7.0 in the subsoil. The cation exchange capacity is mostly below 25 me per 100 gm clay.

Known series differentiation in the region :

In the study area, the low humic gley soils include the Chon Buri and Nakhon Pathom series.

Cb - Chon Buri series soils are the dominant low humic gley soils in SE Thailand. The soils are commonly under rice cultivation. The color is usually grayish brown with mottling throughout. Texture in the surface is fine sandy loam, whereas clay loam dominates in the subsoil. The pH values vary from 4.5 to 6.0. These soils occur in conjunction with the Sattahip series soils.

Np - Nakhon Pathom series soils are found in the depressions of the semi-recent terrace in conjunction with the Pran Buri series. These soils have a clay loam to clay texture with a somewhat coarser textured surface horizon. The profile are mottled with a gray brown to brown matrix, pH values vary between 5.5 - 7.0, with the highest values in the subsoil.

Vegetation and lan use :

Most low humic gley soils are in use for rice cultivation, but dry years are common and the fields are often abandoned for one or several years when not enough rain falls.

The natural vegetation is commonly wet grassland and scattered low shrubs often with spiny species.

Gray Podzolic soils

Formation and environment :

The majority of the gray podzolic soils is formed on transported materials of old alluvial plains which are normally acid, poor in weatherable minerals and coarse to medium textured. Undulating to smoothly rolling relief is an important factor in the formation of these soils, since it causes slow surface drainage. Steeper slopes with excessive run off do not normally produce gray podzolic soils. They occur predominantly under the climatic conditions of a wetdry monsoon type.

Gray podzolic soils in the study area are formed on the old terrace formations north of the Pran Buri river. This old terrace plain has an undulating topography.

Morphology and diagnostic characteristics :

A typical characteristic of gray podzolic soils is the strong "shifting" on the surface, due to the loose binding between the organic and mineral components of the surface soil. Organic matter and clay particles have been washed away (micro-erosion) consequently, patches of separated loose sand and compacted, more clayey puddles are typical surface phenomena of these soils.

A typical profile shows a weak horizon differentiation. The common horizon sequence is A_1 (Ap) A_2-Bt. The color below the weak and thin A_1 horizon is rather uniform, commonly light gray brown, but the material may become slightly redder or more yellow with depth. A somewhat harder layer may form underneath the surface; when dry it shows a definite compaction. In eroded profiles, this layer may stand out prominently. The illuvial B horizon is normally weakly expressed and may reach to a depth of 100 to 200 cm. When developed on medium textured materials, the Bt horizon is more pronounced. Concretionary laterite layers occur in the profiles between 1 meter to 5 meters, but little laterite was observed in the surveyed area. In soils where the water table has been lowered, the laterite is usually hard.

Gray podzolic soils do not show prominent signs of wetness, but mottling may occur at medium depth. The pH values are mostly 4.5 - 5.5. Base saturation varies from 10% to 65% but is normally low except in loamy profiles. The cation exchange capacity is often below 10 me for 100 gm of clay.

Known series differentiation in the region :

In the surveyed area, gray podzolic soils include the Sattahip series and the Patthaya series. (Both series were recognized and described in SE Thailand).

Sh - Sattahip series soils are comparable to the Korat series of NE Thailand. In this area, these soils have a fine sandy loam texture in the surface soil, which is light grayish brown to yellowish brown. The subsoil is fine sandy (clay) loam and has a brown to yellowish brown color. The pH value is around 6.0 in the surface, decreasing with depth to 4.5 - 5.0.

Py - Patthaya series soils are formed on sandy materials (sandy, loamy sand). The profile is weakly developed, brown to yellowish brown in color. The pH values vary from 5.0 - 6.0.

Vegetation and land use :

Gray podzolic soils are mostly under open shrubs with thorny species, bamboo and some dipterocarp species.

Most of the gray podzolic soils are not in permanent agricultural use. Shifting cultivation is commonly practiced on the Sattahip series soils, whereas very little cultivation is found on the sandy Patthaya series soils.

Red yellow podzolic soils

Formation and environment :

Red yellow podzolic soils develop on various kinds of parent materials, the common ones are acid to moderately basic materials. These parent materials may be either residuum from sedimentary, igneous and metamorphic rocks or transported materials. The topography is variable, normally undulating to hilly.

In the surveyed area the red yellow podzolic soils are formed on residuum and colluvium from quartzite - phyllite and gneissic rocks as well. They are found on and around the hills and rock outcrops.

Morphology and diagnostic characteristics :

Red yellow podzolic soils do not show dominant signs of wetness. They have a textural B horizon with colors of high chroma, varying from red to yellow. The common horizon sequence is A_1-A2-Bt-C or R. The A_1 is moderately humiferous, over a somewhat lighter colored and leached A2. The Bt horizon normally has a (gravelly) sandy clay loam texture with common clay coatings.

The pH values are mostly 4.5-5.5 in the subsoil. The base saturation is low, varying from 10% to 50% and the cation exchange capacity is less than 15 me per 100 gm of clay.

Known series differentiation in the region :

Red yellow podzolic soils in the study area commonly occur on the hill slopes and are included in the complex hill mapping units. Two series were described for the gravelly red yellow podzolic soils developed on quartzite-phyllite and gneiss parent rocks.

Ty - Tha Yang series soils are shallow residual soils on hill slopes with gravelly material at less than 50 cm depth.

Ly - Lat Ya series soils are deeper soils on lower part of the hill slopes mostly on colluvial materials derived from acid parent rocks. Gravelly material, if present, is found at more than 50 cm depth.

Vegetation and land use :

Most of the red yellow podzolic soils are under sparse forest and low shrubs. Some hills have been cut over and have a secondary growth vegetation of short grasses and shrubs.

Red-yellow latosols

Formation and environment :

Red-yellow latosols occur both on transported and residual parent materials. When found on transported materials, as in this case, these soils develop on old high "remnant" terrace formations. The present climate has no or very little relation to their formation. In the surveyed area, these soils occur on older coastal terrace materials which were protected between hills from erosion. Topography is undulating to gently rolling.

Morphology and diagnostic characteristics :

Red-yellow latosols have deep and uniform profiles, showing little horizon differentiation. These soils are deeply weathered, having a low content of primary materials. The clay fraction is dominanted by kaolinite and sesquioxides. The soils have commonly a red to dark red color, but with poorer drainage, lower iron content and higher rainfall, the soils tend to become more yellow. The horizon sequence is A_1-Box, where "ox" denotes latosolic characteristic. The thin A_1 passes diffusely into red or dark red clay or sandy clay of the B horizon which may extend to 3 meters or more. Generally, these soils have a very friable consistence, great aggregate stability and show a high porosity.

Red-yellow latosols have a pH values of about 4.5, with a base saturation of not more than 30%. The cation exchange capacity is below 20 me/100 gm clay.

In the study area, only the red members of this great soil group were observed.

Known series differentiation in the reginn :

The Siracha series is the only red-yellow latosol described for the area.

Sr - Siracha series soils have a sandy loam texture in the surface; the texture becomes finer with depth (sandy clay loam, sandy clay). The color in the top soil is usually brownish. The subsoil has a typical dark red to reddish brown color.

Vegetation and land use :

The red latosols are under low shrubs, bamboo and scattered trees. Under cultivation, fruit trees and pineapple are commonly grown. In the Thanarat Replacement Training Center, much of the previously cultivated red latosol area has now reverted to dense shrubs.

2. Description of soil mapping units

Mapping units for this survey are based on three main features, i.e. :-

i : Soils, distinguished at the level of the great soil group,

ii : broad groups of parent material, and

iii : land forms, as expressed by the general topography.

In each mapping unit, inclusions are found and these inclusions will be specified as far as possible in the text. The general topographic terms used are according to the designated ranges of slope percentages as described in USDA soil survey manual No. 18 (10).

1. Regosols, sandy, on recent and semi-recent beaches and dunes; flat to undulating topography; locally low dunes.

This mapping unit is found as elongated bodies along the shore line as well as on some older beach and dune areas situated further inland. The topography is flat to undulating with a microrelief of alternating ridges and depressions. Occasionally the relief is more accentuated where low dunes are found. The area of this unit is mostly freely drained on account of the predominance of sandy soils.

Common inclusions are small patches of marine alluvial soils which are more clayey, hydromorphic and usually saline, some small low hills and rock outcrops of mapping unit 12 and 13 as well as solodized solonetzic soils.

2. Alluvial soils, undifferentiated, on recent river alluvium; flat topography.

This mapping unit is indicated in a limited area near Pran Buri where the Pran Buri river plain widens considerably. Elsewhere along the Pran Buri river as well as along other creeks, the alluvial plains are too narrow to be delineated on the soil map of this scale. The unit includes the levee soils as well as the river alluvial plains and basins. The drainage is poor to very poor on the average, with commonly silty to clayey textures. The topography is flat to concave with slight micro-relief in the levee area.

Inclusions are solodized solonetz, non calcic brown soils and acid sulphate soils.

3. Alluvial soils, saline, on recent marine alluvium; flat topography.

This mapping unit is found along the shoreline in the low areas normally connected with, and inundated by the sea. The area includes river or creek estuaries and depressions surrounded by beach formations. The texture is mostly clayey with generally a very poor drainage. Mangrove forest and other halomorphic plants are commonly found. The topography is flat to concave.

Common inclusions are regosols, non saline alluvial soils as well as some small low hills and rock outcrops (mapping units 12 and 13).

4. Alluvial soils, non-saline, on recent marine alluvium; flat topography.

This mapping unit is found in depressions at some distance from the shoreline, which are not or very seldom inundated by the sea. The unit includes most of the elongated strips of rice fields found between the sandy beaches or dunes and a larger tidal flat area in the south of the Sam Roi Yot depression. The area has a flat to slightly concave topography. Poorly drained soils with a clayey texture throughout are dominant.

Common inclusions are regosols, saline alluvial soils and acid sulphate soils.

5. Acid sulphate soils, on recent and semi-recent brackish alluvium; flat topography.

This mapping unit includes the area in the northern half of the Sam Roi Yot depression which extends as far as Pran Buri township and the area south of this depression in the vicinity of Kui Buri. The area has a flat to concave topography. Near the edge of the semi-recent terrace, the terrain is somewhat higher and slightly undulating. Soils are clayey, poorly drained and subject to deep flooding in some rainy seasons.

Common inclusions are regosols, saline and non saline marine alluvial soils, solodized solonetz and a few low hills or rock outcrops of mapping unit 12.

6. Solodized solonetz, on marine terrace sediments; flat to undulating topography.

This mapping unit occurs in the areas adjacent to the beach formations in the northern part of the surveyed area and at the transition between the terrace formations and the recent alluvium in the middle and southern parts. These strips of soils occupy a relatively low position and they are usually poorly drained on the average. The soils have a loamy sand to sandy loam texture with a heavier subsoil.

Common inclusions are regosols, gray podzolic soils, non calcic brown soils, acid sulphate soils and some low hills or rock outcrops of mapping unit 13.

7. Non calcic brown soils, on semi-recent river terrace sediments; flat to undulating topography.

This mapping unit is found on the flat to undulating terrains south of the Pran Buri river. In places, especially close to the hills, the relief is locally accentuated due to the presence of incised drainage valleys. The soils have a silt loam to sandy loam texture and are well to moderately well drained. Close to the hills the texture may become coarser whereas along the transitional zone to the lower recent alluvial plain finer materials are common.

Common inclusions are low humic gley soils, red yellow podzolic soils and solodized solonetz and small low hills and rock outcrops of mapping unit 14.

8. Low humic gley soils, on ponded terrace sediments; flat to concave topography.

This mapping unit is found in isolated depressions of the old terrace. The unit is commonly used for rice cultivation. The soils have a medium to fine texture and are poorly drained, but dryout deeply in the dry season. The area has a flat to slightly concave topography.

Common inclusions are gray podzolic soils, both the medium textured and the sandy ones.

9. Regosolic gray podzolic soils, on sandy marine terrace sediments; undulating topography.

This mapping unit covers soils with excessively drained, sandy profiles which occur on terrains with undulating topography. The unit occurs in the northern part of the surveyed area; to the west it grades into the finer textured gray podzolic soil unit. The dominant vegetation is a poor open forest with dipterocarp sp. In the lower parts, an open vegetation of low shrubs, bamboo with numerous bare spots is observed, as well as some intermittently cultivated rice lands.

Common inclusions in the area are solodized solonetz, gray podzolic soils and gneissic rock outcrops (mapping unit 13).

10. Gray podzolic soils, on marine terrace sediments; undulating topography.

This mapping unit is found on terrains with an undulating topography. It occupies the intermontane plain north of the Pran Buri river. The unit dominantly contains leached soils with a medium texture which are moderately well drained.

Patterns of shifting cultivation are observed throughout the area; the secondary growth consists mainly of dense shrubs and bamboo.

Common inclusions in the unit are sandy gray podzolic soils, low humic gley soils, solodized solonetz, non-calcic brown soils and low hills and rock outcrops of units 13 and 14.

11. Red-yellow latosols, on older coastal terrace sediments; undulating to rolling topography.

This unit occurs on remnants of more extensive older terraces near the hills and the area directly north of the Pran Buri river. The topography is undulating to gently rolling. The red latosols are well to somewhat excessively drained with medium to fine textured profiles. The color is characteristically red to dark red throughout.

Common inclusions are gray podzolic soils, solodized solonetz and some rock outcrops, connected with units 12, 13 and 14.

12. Complex soils and lithosols; bedrock predominantly limestones; rugged topography.

This unit covers the limestone hills and common associated rocks (quartzite and shale) together with the areas of colluvial fans and lower hill slopes. The soils found in this mapping unit are shallow and normally very complex; red brown earths, red yellow podzolic soils, brown forest soils and rendzinas occur in an intricated pattern.

Mostly, the soils are stony or gravelly with medium to fine textures and a steep topography. The unit is found mainly in the southeast of the surveyed area.

Inclusions in the unit are marine alluvial soils, regosols and soils on quartzite or phyllite rocks (unit 14).

13. Lithosolic red yellow podzolic soils and lithosols; bedrock predominantly gneiss; steep topography.

This mapping unit is found mainly in the eastern hill range which extends from the north to the Sam Roi Yot limestone area. The area includes moderately deep soils of the lower hill slopes and shallow soils and bare rocks on the higher and steeper slopes. The topography is hilly to steep.

Common inclusions in this unit are regosols, gray podzolic soils, reddish brown lateritic soils on mica schist and marine alluvial soils.

14. Lithosolic red yellow podzolic soils; bedrock predominantly quartzite and phyllite; steep topography.

This mapping unit occupies the whole western hill range. The topography is hill to steep. The area includes deeper colluvial soils on the lower hill slopes with gravelly, medium to fine textured soils and shallow, gravelly to stony soils higher up the hills.

Common inclusions are gray podzolic soils, non calcic brown soils and, probably, some reddish brown lateritic soils on shales.

IV LITERATURE CITED

1. Brown, G.F. et al. 1951. Geological reconnaissance of the mineral deposits of Thailand. U.S. Geo. Sur. Bull. No. 984., Washington D.C. (Reprinted Geo. Sur. Mem. No. 1, 1953. Royal Dept. of Mines, Bangkok, 183 p.)

2. Dudal, R. and F.R. Moormann. 1962. Major soils of South-East Asia. Misc. Soil Reports No. 8, Min.of Agr., Bangkok, 56 p.

3. Land Development Dept. 1964. Note on the soil survey of Khao Tao area. Soil Sur. Reports No. 17. Min. of National Development, Bangkok, 11 p.

4. Moormann, F.R. and C.R. Panabokke. 1961. Soils of Ceylon, Dept. of Agriculture, Ceylon. (Reprinted from Tropical Agriculturist, Vol. CXVII No. 1. 1961, 65 p.)

5. Moormann, F.R. 1962. Report on the preliminary soil survey of the Mae Klong irrigation project area. Misc. Soil Report No. 1 Min. of Agriculture, Bangkok, 27 p.

6. Moormann, F.R. 1963. Acid sulphate soils (cat-clay) of the Tropics. Soil Science 95: 271-275.

7. Pendleton, R.L. 1953. Report to accompany the provisional map of the soils and surface rocks of the Kingdom of Siam. U.S. Special Technical and Economic Mission to Thailand, Bangkok, 290 p. (Mimeographed).

8. Pendleton, R.L. 1963. Thailand. American Geographical Soc. Handbook. Duell, Sloan and Pearce Co., New York, 321 p.

9. Rojanasoonthon, Santhad. 1964. Interim reports on the great soil group survey I : Khon Kaen Study Area. Soil Survey Report No. 28. Min. of National Development, Bangkok, 17 p.

10. U.S. Department of Agriculture. 1951. Soil Survey Manual, Washington, 503 p. (Handbook No. 18).

List of Miscellaneous Soil Reports

1. Report on the Preliminary Soil Survey of Mae Klong Irrigation Project Area.

2. Report on the Preliminary Soil Survey of the Lam Takong Irrigation Area.

3. Report on the Preliminary Soil Survey of the Tung Samrit Irrigation Area.

4. Report on the Preliminary Soil Survey of the Lam Nam Oon Irrigation Area.

5. Report on the Soil Survey of the Huai Si Thon Irrigation Project.

6. Report on the Preliminary Soil Survey of the Greater Chao Phya Irrigation Area (in preparation).

7. Report on the Soil Survey of 10 Villages in Changwat Ubon.

8. Major Soils of South - East Asia.

9. A Key to the Soil Survey of North - Eastern Thailand.

10. Report on the Soil Survey of the Site of the Proposad Agriculture Centre near Sathani Nam Phong (Khon Kaen Province).

11. Report on the Soil Survey in the Ban Si Than Area (Khon - Kaen Province).

12. Detailed Reconnaissance Soil Survey of the Lam Pao Irrigation Project (Kalasin Province).

13. Report on the Soil Survey of a Pilot Area in Changwat Roi Et.

14. Detailed Reconnaissance Soil Survey of the Mae Taeng Irrigation Project (Chiang Mai Province).

15. Report on the Soil Survey of the Tha Phra Agriculture Station and Surrounding (Khon Kaen Province).

16. Detailed Reconnaissance Soil Survey of the Lam Phra Phloeng Irrigation Project (Nakhonratsima Province).

List of Soil Survey Reports

17. Note on the Soil Survey of the Khao Tao Area.

18. Report on the Soil Survey of the Proposed Land Settlement Area at Nam Phong (Khon Kaen Province).

19. Report on the Soil Survey of the Nong Ya Ma Tank-Irrigation Area (Roi Et Province).

20. Note on the Soil and Land use in the Hills of Tak Province.

21. Report on the Soil Survey of the Huai Kut Kaen Tank-Irrigation Area (Roi Et Province).

22. Report on the Soil Survey of the Kut Daeng Tank-Irrigation Area (Roi Et Province).

23. Report on the Soil Survey of the Thawat Chai Tank-Irrigation Area.

24. Report on the Soil Survey of the Proposed Land Settlement Area at Non Sang (Udon Province).

25. Report on the Soil Survey of the Land Development Project Area in Kamphaeng Phet Province.

26. Report on the Soil Survey of the Chieng Pin Land Settlement Area (Udon Thani Province).

27. Report on the Thai - Malayan Soil Correlation Meeting, 1964.

28. Interim Report on the Great Soil Group Survey.
I : Khon Kaen Study Area.

29. Report on the Soil Survey in the Sam Roi Yot Area.
(Prachuab Khiri Khan Province).

30. Report on the Soil Survey of Roi Et Province (in preparation).