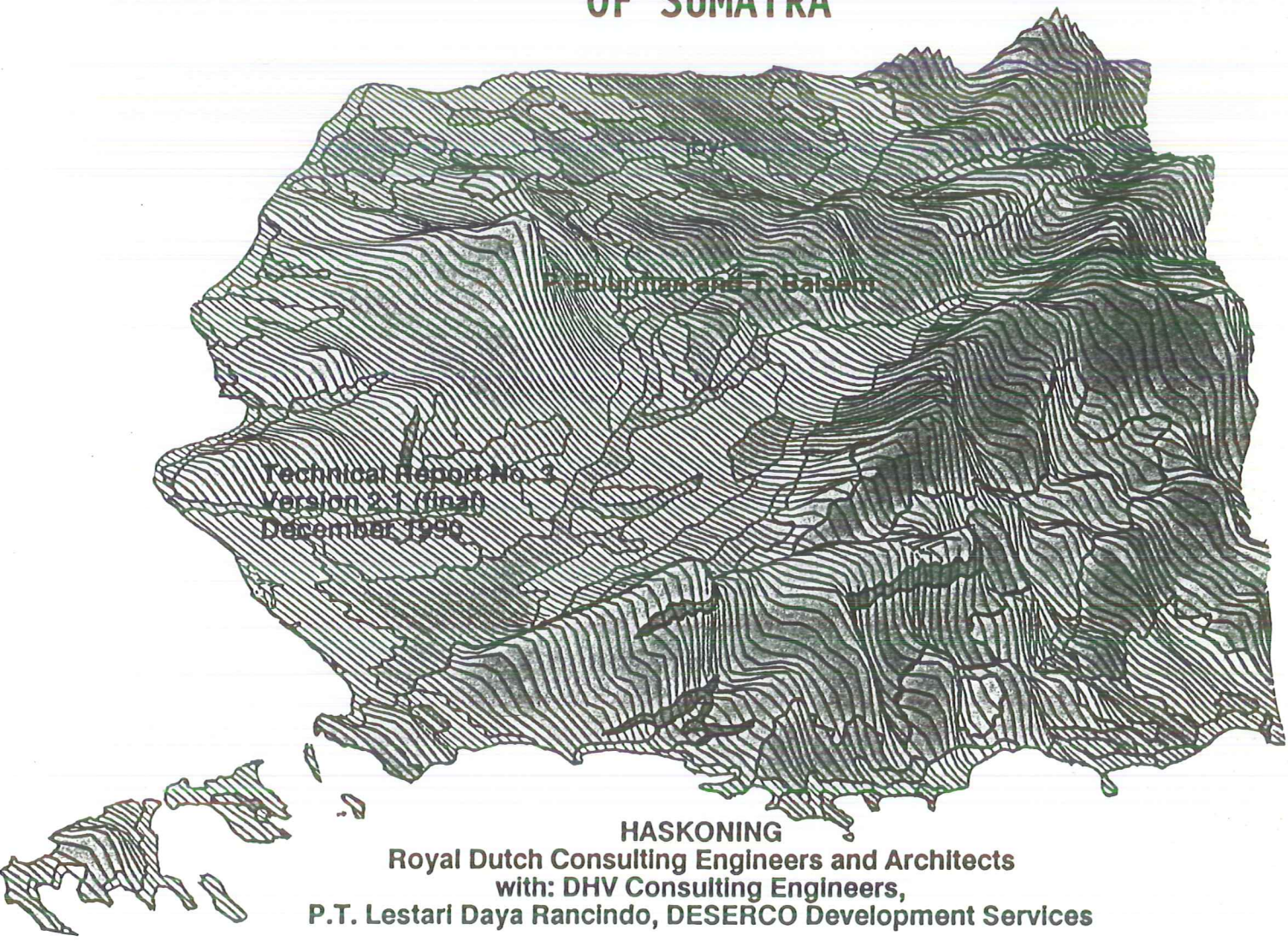
REPUBLIC OF INDONESIA

LAND RESOURCE EVALUATION AND PLANNING PROJECT
ADB LOAN No. 730 - INO

PART 2. SOIL DATA BASE MANAGEMENT

LAND UNIT CLASSIFICATION FOR THE RECONNAISSANCE SOIL SURVEY OF SUMATRA



P. Buurman and T. Balsem

Technical Report No. 4
Version 2.1 (final)
December 1990

HASKONING
Royal Dutch Consulting Engineers and Architects
with: DHV Consulting Engineers,
P.T. Lestari Daya Rancindo, DESERCO Development Services

CENTRE FOR SOIL AND AGROCLIMATE RESEARCH,
BOGOR

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by:

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CHANGES WITH RESPECT TO VERSION 1.2

Version 2 of the Land Unit Classification contains additional background texts that were published previously by Balsem *et al.* (1988) and Buurman (1990).

Major amendmends were made in the subdivision of the Peat Domes, the Hilly, and the Toba Tuff Groups. Minor additions were made to the Marine, Volcanic and Miscellaneous Groups.

INTRODUCTION

The Soil Data Base Management Project (SDBM), which is Part II of the Land Resource Evaluation and Planning Project (LREP) has the task of carrying out a reconnaissance 'soil' survey of Sumatra and to create a geographic information system combining all cartographic data and point observations. The ultimate aim of this task is to facilitate regional (agricultural) planning. The mapping is carried out by the Centre for Soil and Agroclimate Research (CSAR) in Bogor, Indonesia.
The Centre for Soil and Agroclimate Research has carried out soil surveys throughout Indonesia since its inception, in 1905. It has, in the course of time, used various kinds of legends and has more or less closely followed international trends in survey methodology. Until the 1950's, the institute made use of legends that stated soil properties in a direct way, such as *'red clayey basalt weathering soils'*. After 1950, assisted by FAO, it gradually adopted the Great Soil Groups as developed by the USDA and founded an Indonesian soil classification system (Dudal & Soepraptohardjo, 1957). This system has long remained the mainstay of CSR's soil map legends. The Great Soil Group approach was adapted to Indonesian circumstances and amended various times (Soepraptohardjo, 1971, 1976; Suhardjo & Soepraptohardjo, 1981; Suhardjo *et al.*, 1983), eventually strongly leaning towards the FAO/Unesco (1974) Legend.

The necessity of landscape morphological criteria in the national map legends was felt during various surveys (Soepraptohardjo *et al.*, 1973) and FAO's strong presence in the 1970's and early 1980's, combined with increased use of remote sensing techniques, resulted in the introduction of a land form legend with soil parameters at a lower level, based on a *land form* catalogue designed by Desaunettes (1977). This land form legend gained ascendance and was the main legend for CSAR's surveys between 1980 and 1987.

The SDBM systematic reconnaissance soil survey at 1:250,000 scale has specific requirements which can not be fulfilled by the landform legend or any of the legends used so far. A new legend had to be developed and agreed upon.

Criteria for legend selection

The purpose of the project, to make 'soil' maps that can be used as a basis for regional planning by automated procedures, sets a number of specific requirements, apart from those that result from map scale, i.e.:

1. Requirements defined by the user:
   - the legend should be easy to understand
   - it should contain all the parameters that are to be used in evaluation of possible uses
   - it should give all the information that the map scale allows.

   These criteria imply that professional jargon should be avoided as much as possible and that the information provided in the map or in the description of its units should contain specific information, such as: landscape morphology and scale, slopes, altitude range,

fragmentation, soil characteristics (classification, texture, fertility characteristics, toxicity, water retention characteristics, erodibility - reaction to changed use -, etc.).

2. Requirements defined by the maker (mapper):
   - the legend should be related to legends used before, so as not to confuse the survey teams
   - choosing between legend units should be a rather straightforward process, that is not influenced by 'school of thought' or educational level and not open to excessive discussion. Thus the legend should be morphometric rather than morphogenetic.

These requirements imply that the legend should preferably have either *soils* or *landscape* at its highest level. Further, the legend should not have a landscape genetic or soil genetic background, because both would require mappers with a solid scientific background and would especially then invite too much discussion.

3. Requirements defined by automation (computerization):
   - legend structure should be such that a specific level in the legend contains similar information
   - it should be suitable for sorting procedures

4. Requirements defined by the structure of the LREP project.
   - because the Soil Data Base Management Project developed a separate coverage for climatic data (rainfall, temperature, length of growing season), based on a data base compiled by LREP-Part I, the legend should be structured in such a way that it can combine with a separate climatic coverage, rather than include climatic parameters.

Legend Options

For legends of 1:250,000 'soil' (natural resources) maps, the following options exist.

- A soil legend, based on soil morphological properties
- A land scape morphological legend, with soil information at a lower level.

The latter is usually called the '**land unit** approach, '**land system**' approach or '**integrated survey**', in which all environmental variables likely to influence the land are integrated.

If a **soil** legend is used at scales smaller than 1:50,000, it is virtually impossible to construct mapping units that consist of one kind of soil only. The result is a **soil association map** or a map that makes use of higher orders only of a soil classification system. Such soil maps do not contain many of the parameters that are required to decide between land use options. Such parameters would have to be added at a lower level of the legend and this would result in a topsy-turvy legend structure, where factors that have a decidedly major impact on land use, such as slope, are at a lower level in the legend than the (less crucial) soil. Moreover, boundaries on a soil association map cannot be obtained by image interpretation.

If a **landscape-morphological** legend is chosen, there are two closely-related approaches:
1. the **land system** approach, and
2. the **land unit** approach.

A **land system** (s.s.) is defined as an area with a recurring pattern of topography, soils and vegetation and with a relatively uniform climate. It has a recurring pattern of genetically linked land facets (Dent & Young, 1981). Land system is a category in the hierarchy *land zone - land province - land system - land catena - land facet - land element*. In this hierarchy,

the land system is the most important category, especially in the preparation of reconnaissance land resource maps from small scale aerial photography and satellite imagery (RePPProT, 1988). In larger-scale mapping (e.g. 1:50,000), land facets, which recur within a land system, are the most convenient category.
As implied in the definition, a land system should have a uniform climate.

A **land unit** on the other hand, is not a category from a specific hierarchy. It is a land area of which one or more attributes have special characteristics, and it refers to an environmental entity of *any size* that can be delineated (Kips et al., 1981). As such it is equivalent with a **terrain mapping unit** (TMU). According to Dent & Young (1981) a land unit is equivalent to a land facet in some Australian surveys, while it may be at a higher level in the hierarchy in others. The latter authors feel that the land unit could be reserved for a category between the land system and the land facet.

The categorical place of a land system is fixed and land systems usually are rather large mapping units. Land catenas and land facets cannot always be indicated at a scale of 1:250,000. For the present purpose, the convention to give land systems a local name which does not immediately translate into landscape properties is a serious setback. Users find it more cumbersome to recognize topographic names than morphological names.

Land Units, on the other hand, not being a category in a system, can be used to distinguish entities of any size. Furthermore, land units are not commonly indicated by local names, but are characterized by a hierarchical morphological nomenclature, which is much more accessible to the user.

For the present purpose, where during extensive surveys much information on soils and soil/landscape relations is gathered, the land system legend is too broad and does not allow the inclusion of sufficient detail. This is amply demonstrated by the number of legend units recognized in the RePPProT land systems maps for Sumatra (<70) in comparison with the number of units on the land unit & soils maps (± 2000).

The land systems legend, although generally suitable for reconnaissance surveys, frequently lacks the specific information that is required for land capability classification; it should include much more information than soils alone (Vink, 1975). For the user it should necessarily be kept as simple and readable as possible (King, 1987).

A **land unit** classification was therefore a logical choice for the present task and subsequent choices regard the structuring of such a legend and the choice of main groups.

The present legend leans towards land units consisting of land forms and combinations of land forms, whereby the Catalogue of Landforms for Indonesia (Desaunettes, 1977) has been used as a basis. Because it is built on the principle of recurrence, it can be used for all of Indonesia, although new units will have to be added.
To avoid confusion, genetic concepts such as *peneplain, piedmont plains* have not been used. Instead, purely descriptive terms are adopted.
Local names have mostly been avoided. Instead, codes are used that directly convey detailed information. The legend has been structured in such a way that subdivisions of groups are as similar as possible.

The SDBM land unit classification

Because both the land form legend of Desaunettes, with its many differentiating criteria at the same hierarchic level, and the Land System legend of RePPProT with its lack of hierarchy, its large units and its use of local names were considered inadequate for the Soil Data

Base Management Project, a new legend was developed that -as much as possible- fulfills the criteria stated before . In short, it should:
- make use of morphological names which are simple and recurrent,
- have a hierarchical structure,
- be an open system that can be amended for use anywhere in Indonesia,
- allows all mappable units to be indicated, depending on map scale,
- not contain climatic parameters,
- be closely related to existing legends without being confusing.

To this end, the following structure, which borrows elements from Desaunettes (1977), RePPProT (1985) and Kips et al (1981) was devised:

Group level	: general morphogenetic groups of landscapes
Level 1	: lithology
Level 2	: - in flat landscapes: sedimentary history and vegetation - in other landscapes: landform, relief
Level 3	: - in rather flat landscapes: dissection - in other landscapes: relief
Level 4	: (in accidented landscapes) dissection.
Level 5	: this level has not been elaborated. It can be used to subdivide higher levels by e.g. different soil characteristics.

The resulting structure is illustrated in Table 1.

Although it is clear that also in this legend, differentiating criteria do not always occur at the san level, they do occur in a fixed sequence and they are similar in similar groups. The legend w need further additions for other parts of Indonesia. The usual subdivision into *lowlands, uplan 'special groups'* and *miscellaneous* is also found back in the present legend. Several choices m not seem so straightforward and need further explanation.

Table 1. Structure of the SDBM land unit classification and its differentiating criteria.

Group	Subdivision at Level 1	Level 2	Level 3	Level 4
A Alluvial	lithology	morphology	facet	(dissection)
B Marine	lithology	morphology sedimentology	facet vegetation	open
D Peat Dome	(lithology)	nutrients	salinity reclamation	thickness
H Hill	lithology	morphology	relief	dissection
I Acid Tuff Plain	lithology	relief	dissection	open
K Karst	lithology	morphology	dissection	open
M Mountain	lithology	morphology	relief	dissection
P Plain	lithology	relief	dissection	open
Q Toba Tuff	lithology	morphology	relief	dissection
T Marine Terrace	lithology	relief	dissection	open
V Volcanic	lithology	morphology	relief	dissection
X Miscellaneous	towns,water bodies, gorges,dumps,mines. No lower levels.			

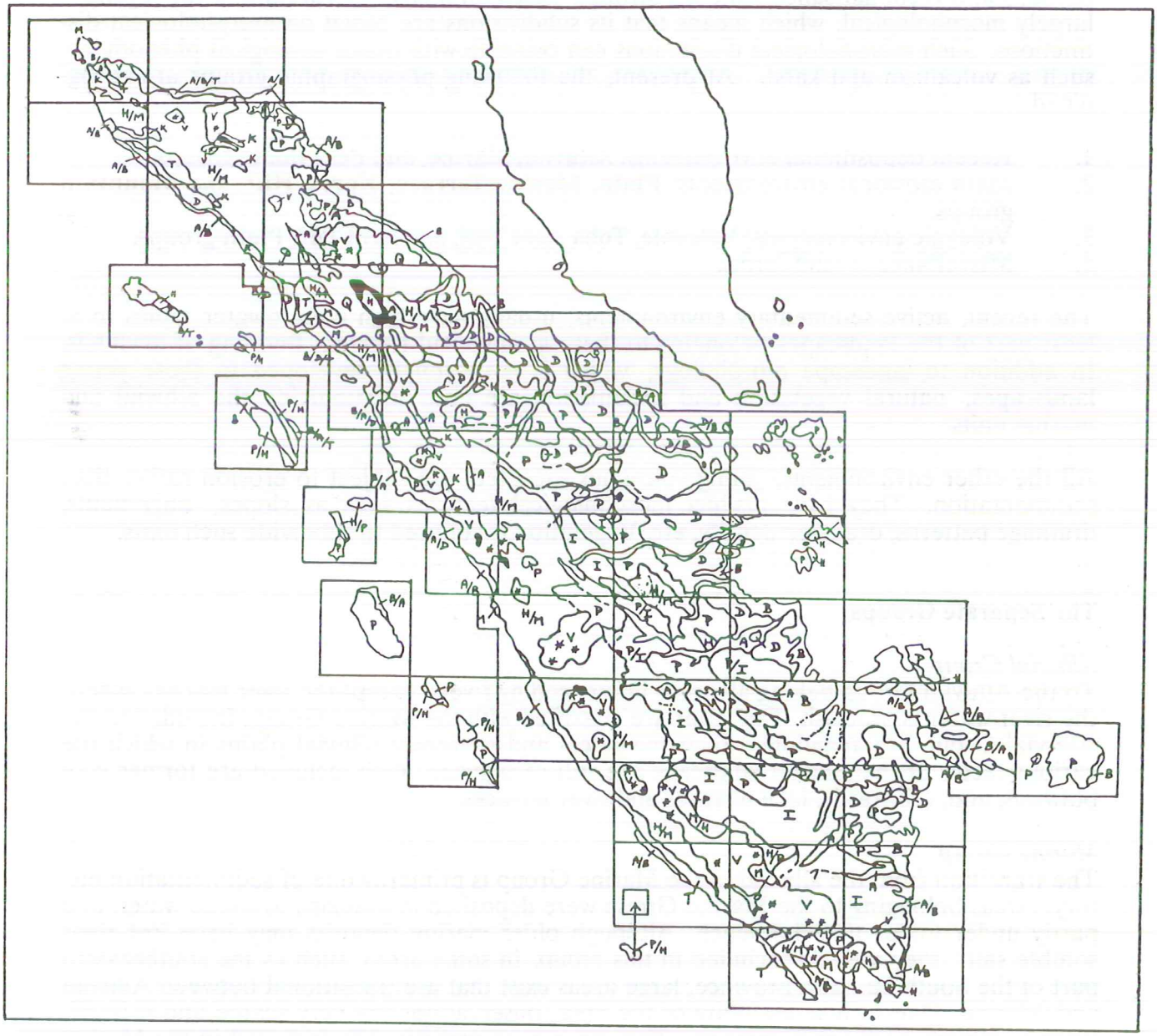

Figure 1. **Map of Sumatra with the main physiographic groups and sheet distribution of the 1:250,000 scale Land Unit and Soil map.**

BACKGROUND AND OPTIONS OF THE PRESENT LAND UNIT CLASSIFICATION

The Land Unit classification used by the Soil Data Base Management Project was especially developed for the reconnaissance soil mapping of Sumatra. Because unit boundaries in maps at a reconnaissance scale are strongly based on image interpretation, the legend is largely morphological, which means that its subdivisions are based on morphological distinctions. Such morphological distinctions can coincide with major geological phenomena, such as volcanism and karst. At present, the following physiographic groups are recognized:

1. Recent depositional environments: **Alluvial, Marine,** and **Peat Dome** groups.
2. Main erosional environments: **Plain, Marine Terrace, Karst, Hill,** and **Mountain** groups.
3. Volcanic environments: **Volcanic, Toba Acid Tuff,** and **Acid Tuff Plain** groups.
4. **Miscellaneous** land forms.

The recent, active sedimentary environments, usually have high groundwater tables in at least part of the landscapes belonging to these groups, and frequent flooding of lowlands. In addition to landscape morphology, which is not strongly developed in these young landscapes, natural vegetation and reclamation are used to subdivide the alluvial and marine units.

All the other environments, young volcanoes excepted, are subject to erosion rather than sedimentation. They have distinct morphological features such as slopes, alignments, drainage patterns, drainage density, etc. Vegetation is not used to subdivide such units.

The Separate Groups

Alluvial Group
To the Alluvial Group belong all areas influenced by rivers, except the river mouths, where the river water is brackish. The latter are classified with the Marine Group. Included in the Alluvial Group are abandoned river meanders and subrecent alluvial plains in which the various facets of the alluvial landscape are still recognized. Also included are former lake bottoms, and, arbitrarily, lake terraces and river terraces.

Marine Group
The transition from the alluvial to the Marine Group is primarily one of sedimentation history. Areas belonging to the Marine Group were deposited in brackish to saline water, and partly under under tidal influence. Although older marine deposits may have lost their soluble salts, they are still included in this group. In some areas, such as the southeastern part of the South Sumatra province, large areas exist that are transitional between Alluvial and Marine. Due to inaccessibility of the area, observations are very scarce and it is difficult to classify such areas correctly. They have been provisionally included in the Marine Group (transitional to Alluvial).

Peat Domes Group
Peat Domes are subdivided into eutrophic domes and oligotrophic domes. Further subdivision is according to salinity (fresh, brackish), reclamation (compaction), and peat thickness. Although the Peat Domes Group is best characterized by the extensive peat domes on the eastern coast of Sumatra (Riau, Jambi, Sumatera Selatan), it is not restricted to coastal lowlands or dome-shaped occurrences. A characteristic peat dome is higher than the surrounding landscape and usually has slopes of + 3% descending to the dissecting rivers, where peat covers on levees are thin or even absent. Peat domes can rise more than 15m above the rivers.

Peat domes are usually characterized by ombrogenous peat (rainwater peat) and are, by their very nature, poor in nutrients (oligotrophic). Their fringes, however, may be mixed with sediments of alluvial or tidal environments.

Thick peat deposits also occur in landscape depressions. These occurrences do not have a dome shape and they are usually more fertile (eutrophic). They are, however, included in the same group. Alternately, thin peat covers on alluvial material can be included in the Alluvial Group.

Thick peat occurrences in mountainous areas, such as may occur under *blang* vegetation, are excluded from the Peat Dome Group. Morphologically, these high-mountain peats do not belong to peat domes (see also Volcanic Group). Occurrences of mountain peat are indicated with a peat cover (I) indication preceeding the Group code (e.g. IVa2 : peat on volcanic upper slope).

Plains

The legend recognizes three main subdivisions of basically flat or nearly flat erosional landscapes: Plain, Acid Tuff Plain, and Marine Terrace. The terminology expressly avoids terms such as 'peneplain' and 'pediplain', because these concepts give rise to too much discussion. Originating from flat surfaces due to erosion or sedimentation, plains may be strongly dissected and may show a strong internal relief with steep slopes.

Marine Terrace. The Marine Terraces are mainly uplifted coastal areas. They are usually of variable lithology (coarse and fine sediments in rapid succession) and can still be recognized as former shores. Although much of Sumatra's east coast might be included in this group (the east coast consists mainly of uplifted marine sediments that are covered with a thin layer of alluvial, marine, or peat sediments), they are not classified as Marine Terraces. On the west coast of Sumatra, where uplift has been relatively fast, the Marine Terraces are well-expressed and form large units. The land-inward reaches of these uplifted coastal sediments are usually folded against the Barisan Mountains and would therefore be classified in the Hilly Group.

Acid Tuff Plain. The East and Southeast coasts of Sumatra have very extensive covers of Late Tertiary and Quaternary ignimbrites[1] (acid volcanic tuffs). These ignimbrites, which are found most prominently in the Upper Palembang beds, the Lampung tuff, and the Ranau tuff, still cover very extensive areas.
The Upper Palembang Beds are found as far north as Riau, and extend southward into Lampung. The Ranau and Lampung tuffs are restricted to Lampung and small areas in South Sumatra. Because of their very specific weathering environment and the resulting particular soil association (high mobile silica and aluminium), the landscapes on these acid tuffs were put together in a separate group, the Acid Tuff Plain.

Tuffs deposited on land are rather pure; those deposited in a marine environment are usually mixed with marine sediments such as sands and clays. Both the Lampung tuff and the Upper Palembang Beds locally show an intricate mixture of tuffaceous and non-tuffaceous sediments. The Lampung beds appear to be more purely tuffaceous close to Lampung Bay, pure tuffs of the Palembang Beds are found close to the Barisan mountains and in thin layers throughout the deposit. The Upper Palembang beds have the additional difficulty that they are part of a folded and eroded sequence and are locally covered by

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1. An ignimbrite is a 'pumice flow deposit' or 'ash flow tuff' formed by explosive volcanic activity, irrespective of the degree of welding or volume.

younger sediments. Part of the Ranau tuffs is strongly reworked by alluvial activity. Such reworked parts are included in the Alluvial Group; the tuff origin is then indicated by lithology (code *d*).

Plain. The Plain Group contains all those rather flat areas that are not included in the Marine Terrace and the Acid Tuff Plain. It contains former sedimentary as well as erosive landscapes. Its transitions to the Acid Tuff Plain are locally diffuse. Examples of largely sedimentary plains with incipient erosion are widespread in Riau, Jambi, and South Sumatra. Typical examples of erosive plains (peneplain) can be found on the islands of Bangka and Belitung, part of the Riau archipelago (Lingga, Singkep, Kundur, Batan, Bintan), and north of Tanjung Karang in Lampung.

Volcanic Group

The Volcanic Group contains all landscapes that are morphologically due to recent volcanism. The Toba ignimbrites (Toba Acid Tuff Group) of north Sumatra and the large ignimbrite plains (Acid Tuff Plain Group) of south and east Sumatra are excluded from this group. Also excluded are volcanic rocks that are included in older, folded or faulted strata (included in Hilly and Mountain Groups). The Volcanic Group is subdivided into three main groups of land units:

- V1. those that have stratovolcano morphology.
- V2. volcanic plains, lava plateaus and all those stratovolcanoes that are so strongly eroded that the stratovolcano morphology has all but disappeared.
- V3. fluvio-volcanic fans, disconnected from the main body of the volcano.

To the first group belong all active and most of the extinct Quaternary volcanoes in which the cone shape is still preserved. Units belonging to this group are subdivided into craters, calderas, upper, middle, and lower slopes, volcanic plains, and lahars or lava flows. At this level, no subdivision is made according to altitude. The effects of altitude are reflected in weathering and soils, which are displayed at the lowest level in this landscape classification.

The second group contains such volcanic remnants that are too strongly eroded to allow recognition of the features listed above. This group contains single crater plugs that stand out in the landscape (plugs, necks, dikes), and more complex, many-topped, hilly and mountainous reliefs that result from heavy erosion of large stratovolcanoes. In some cases, only low plateaus or isolated hills remain after erosion (e.g. north Aceh, Sukadana in Lampung).

All these volcanic landforms can be built up of felsic or intermediary efflata, or of intermediate to mafic lavas, or mixtures of these. This implies that the few stratovolcanoes that are built up of acid tuffs are included in the Volcanic Group, while the acid tuffs covering the adjacent or remote plains, are <u>not</u> included in the Volcanic Group but in the Acid Tuff Plain Group.

Volcanic fans, which are sometimes completely separated from their original eruption centre and may contain alluvial admixtures, are separated in the third subgroup.

Sumatra's mountains and hills contain many faulted and partly metamorphosed volcanic rocks. These rocks do not have any relation to existing volcanic centres; they have been compacted, they are sandwiched between other kinds of rocks, and they are strongly distorted. Morphologies formed on such rocks do <u>not</u> belong to the Volcanic Group.

Similarly to the ignimbrite-covered plains, the fully ignimbritic deposits and landforms of the Toba eruption are not included in the Volcanic Group. This separation was done for

various reasons.
First, it is almost impossible to classify, according to stratovolcano morphology, the various morphological features associated with the Toba eruption. Ignimbrite eruptions do not build up ash cones, although they may leave large calderas. Second, the transport mechanism of ignimbrites is different from that of ashes ejected from stratovolcanoes. In a stratovolcano the ejecta contain relatively little gas (and glass); they are thrown up into the air, loose speed and descend at distances regulated by grain size and wind direction and speed.

In ignimbritic eruptions, the magma contains very large amounts of gas, and the ejecta behave as a hot aerosol (nuèe ardente), traveling large horizontal distances, flowing like water, following lows in the landscape, and leaving thick, homogeneous covers over very large areas, but extra thick covers in valleys. Close to the eruption centre, the ignimbrites may be strongly cemented due to high temperatures.
The area affected by the Toba eruption is very large (more than 1.5 million hectares), and this also warrants a separate treatment.

Toba Acid Tuff Group
The landscapes of this groups are virtually restricted to the extension of the volcanic products of the Toba eruptions and adjacent ignimbritic fissure eruptions. The centre of the Toba eruptions is the present Lake Toba. Unlike stratovolcanoes, the central dome of the Toba area is not built up of volcanic efflata, but consists of upheaved Palaeozoic and younger rocks, with a thick ignimbritic cover.

Morphologically, the Toba group is here subdivided into the 'plateau' area and the 'lower slopes' area. The plateau area contains Lake Toba and its immediate surroundings, and all those ignimbritic areas that are contained between the mountains surrounding Lake Toba. In the west, south and east, the plateau is fringed by chains of the Barisan Mountains; in the north by outliers of the Barisan Mountains and by the Tertiary volcanic systems of the Simbolon and Takur-Takur. On the plateau, we find flat to sloping areas, but also very large filled-in valleys which are now dissected.
Because ignimbrite flows behave like water, they filled most major valley systems that drained the Toba area. Such filled-in valleys may have hundreds of metres of ignimbritic filling, but are usually very dissected; they are very conspicuous in the mountain areas west of Toba.
Northeast of Lake Toba the way to the lowland was more open, and here we find a continuous slope of Toba deposits all the way to the coast. There is a gradual transition from deposits in generally primary position, on convex reliefs, to washed-out and relocated acid tuffs, with a concave relief. Roughly, this transition lies around 700 m above sea level. The units above the transition are grouped with the 'plateau', and usually have soils with andic properties. The lowland units have more strongly weathered soils.

Karst Group
The word *karst* refers to a specific morphology due to dissolution of limestone, that is specific to calcium-carbonate rich rocks. The expression of this morphology depends strongly on the purity and density of the limestone, the angle of its stratification, and the density of fissures (diaclases).
Very pure karstic reliefs are found on dense, pure limestone with clear diaclase systems, such as on the west coast of North Aceh, the area between Sawahlunto and SungaiDareh in West Sumatra, and others.

Less clearly defined karstic reliefs are encountered on virtually horizontal, impure calcareous rocks. All transitions are found in Sumatra, except for the karstic reliefs related to

a fairly dry climate.
In general, all areas with limestone as the predominant rock have been included in the *Karst Group*, without referring to the intensity of karstic features. The very few areas of horizontally bedded, marly sediments have been excluded.

Hilly and Mountain Groups
The Hilly and Mountain Groups are structurally similar, but are separated by relief amplitude (the maximum distance between lows and highs in the landscape). Hills have relief amplitudes of 50-300m (below 50m amplitude, the landscapes would generally be included in the Plain Group), and Mountains have relief amplitudes of more than 300m, irrespective of altitude.

Mountainous areas are of little importance to regional planning, and subdivisions have been kept simple. The main criterion for subdivision is slope steepness.

Hills have been subdivided according to structure and steepness. Structure (random, parallel, complex, monoclinal) was deemed important because it determines access and drainage.

Miscellaneous Landforms
Miscellaneous landforms are those landforms that are not suitable for any (change of) use because of various reasons.

Escarpments, very steep slopes, are natural limitations to land use, and to access.
Built-up areas, such as towns, industrial complexes, waste dumps and mine tailings, etc., do no longer show the underlying morphology and soils and are also excluded from the classification. This does not apply to areas where houses are scattered on houselots and the original landscape structure is virtually unaltered.
Open water bodies also belong to the miscellaneous landforms.

STRUCTURE OF THE LEGEND

The legend is a hierarchic open system and identification of units proceeds from the highest level, through a number of choices to the lowest level. If any of the choices for subdivision cannot be made with the available information, the unit is not further subdivided.

Example: A* = Alluvial group, only lithology indicated
A*.1.2 = Broad alluvial valleys (no further subdivisions)
A*.1.2.1 = meanderbelt (subdivisions of A.*.1.2)
* indicates lithology.

For computer coding, do <u>not</u> use a full stop (.) between capital letter and lithology code, but do <u>always</u> use full stops after the lithology code and between numerical subdivisions.

Highest levels

At the highest level of the legend, physiographic groups are separated. The second level indicates lithology, according to predefined classes. In most land physiographic groups, the next subdivisions are by morphology and dissection. Exceptions are the Alluvial, the Marine, and the Peat Domes Group, which have been subdivided in a slightly different way.

In the text, the lithology has not been included in the code, but is indicated with *.

Associations

If two land forms are equally important in a certain landscape, use the codes of both units.
Example: A dissected acid tuff plain with broad, alluvial valleys (valleys cannot be separated on the map and cover 40-60% of the total) is coded I+A.

Associations can also given a single Group code. In that case, the constituting elements are described as facets in the Land Unit Description

Combinations

Some areas have been changed by intense human activity, e.g. leveling, building up, terracing. In such areas, where the human activity is a dominant feature, the letter X is added to the group code.
Example: Leveled area (large estate) in rolling plain: PX*.5.

Covers

In case of thin sedimentary covers over landscapes of different origin, use the lithological indication of the cover, preceding the morphological group.
Such covers are usually less than two or three meters thick. The landscape morphology is determined by the underlying material, the soil characteristics, however, by the cover. Outcrops of the covered material are common in those landscapes that are not flat.

Examples : thin andesitic cover over hilly landscape: aH*...
: fine alluvial cover over peat: fD...
: dacitic tuff cover over undulating plain in coarse sediments: dPq.3.
: thin peat cover on fine alluvial material: lAf..

Dominant lithology

The lithological codes of Technical Report 4 are a generalization. Lithology should be checked in the field and corrected accordingly. Dominant lithology should be given first (>50%). If dominant lithology is not known, codes as **df** and **fd** are the same and either should be chosen.

Lower levels

Land units are usually associated with specific *geologic material and lithology*. They are usually recognisable by genetically linked recurrent types of *drainage pattern*.
Uplands have generally been subdivided according to general landscape form (flat, undulating, rolling, etc), and further sub-division of land units according to *degree of dissection* allows stratification of the land into significant units with specific potential and erosion hazard.
In lowlands, subdivisions are based on *sedimentary patterns, drainage conditions and vegetation*.

If land units can be subdivided according to dominant soils, this can be effected at the lowest level, by adding an undercast character. This should only be used in large, rather homogeneous mapping units such as Piains, Acid Tuff Plains, etc.

> *Example*: Moderately dissected Rolling Acid Tuff Plain with areas dominated by Dystropepts and areas dominated by Tropudults (separable on map) can be subdivided into Id.5.2.a and Id.5.2.b.

> *Example*: A volcano has a lower slope area built up by two eruptions of similar lithology and dissection, but different age. The soils are Eutrandepts on the younger material, Dystropepts on the older deposit. The subdivision can be: Va.1.4.1a and Va.1.4.1b.

Examples of block-diagrams, cross sections and map-images of a number of physiographic groups and their Land Units are presented schematically. All drawings by T.Balsem.

Criteria for subdivision

Level I: PARENT MATERIAL / LITHOLOGY

Classes **Examples**

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o - no indication or intricate mixture of many rocks.

---

plutonic:

g - felsic/acid : granite, granite porphyry, pegmatite
r - intermediate : syenite, tonalite, granodiorite, diorite
m - mafic / basic : gabbro, dolerite (diabase), norite
x - undifferentiated/mixed plutonic rocks

---

ultramafic

s - ultramafic rocks : serpentinite, peridotite, pyroxenite, amfibolite

---

metamorphic(high):

n - gneiss
t - schist
y - undifferentiated/mixed metamorphic rocks

---

volcanic

a - intermediate & mafic tuffs : andesitic tuffs
b - intermediate & mafic lavas, basalts : basalt, lava's, andesite, phonolite
d - felsic/acid tuffs (ignimbrites) : dacite, rhyolite (liparite)
z - undifferentiated/mixed volcanic rocks

---

sedimentary/low metamorphic:

f - felsic fine : clays, silts, shales, claystone, mudstone, siltstone, diatomite (soft)
: slates, phyllites (hard)
q - felsic coarse : sands, gravels (soft)
: sandstone, quartzite, breccia, conglomerate (hard)
c - hard calcareous : limestone, marble, coral, limestone breccia
k - soft calcareous : marl, calcareous clays, calcareous tuffs, etc.
u - undifferentiated/mixed sedimentary rocks or sediments

---

organic sediments

l - organic sediments : coal, lignite (hard), peat, muck (soft)

RELIEF

Slope classes	:	amplitude (internal relief)
Flat < 3%	:	< 2 m (more over larger distances)
undulating 3 - 8%	:	0 - 50 m
rolling 8 - 16%	:	0 - 50 m
hillocky > 16%	:	10 - 50 m
hilly > 16%	:	50 - 300 m
mountainous > 16%	:	> 300 m

SLOPE (slopes classes according to Desaunettes, 1977 amended)

flat	0 - 3 %
gently sloping	3 - 8 %
sloping	8 - 16%
moderately steep	16 - 25%
steep	25 - 55%
very steep	55 - 75%
abrupt	> 75%

DISSECTION (drainage density)

Not dissected	: very large interfluves
Slightly dissected	: broad interfluves, shallow gullies
Moderately dissected	: mod. wide interfluves, mod. deep gullies
Strongly dissected	: narrow interfluves, deep gullies
Extremely dissected	: narrow ridges, very deep gullies badlands

Drainage density is similar to valley density (as used in the Land Unit Description; see Balsem & Buurman, 1990) or degree of dissection.
Dissection class, drainage density, and length of second or higher order drainage lines per unit area are related as follows:

Class	Dissection	Drainage density	Length of drainage lines
0.	not dissected	very low	: < 0.5 cm/cm^2 map (field: <0.5 km/km^2 at 1:100,000)
1.	slightly diss.	low	: 0.5-1.0 cm/cm^2 map (field: 0.5-1 km/km^2 at 1:100,000)
2.	moderately diss.	moderate	: 1.0-2.0 cm/cm^2 map (field: 1-2 km/km^2 at 1:100,000)
3.	strongly diss.	mod.high	: 2.0-4.0 cm/cm^2 map (field: 2-4 km/km^2 at 1:100,000)
4.	extremely diss.	high	: > 4.0 cm/cm^2 map (field: > 4 km/km^2 at 1:100,000)

MARINE

Boundaries according to maximum saline influence in rivers and other surface waters, to vegetation, and to morphology.

	EC water
Saline, brackish	: > 2 mS/cm (= 2 g NaCl/l) (= 2 mmhos/cm)

Saline soils: more than 4 mS/cm

Saline vegetations: *api-api* (Avicennia)
bakau (Rhizophora)
pedada (Sonneratia)
gelam (Melaleuca leucodendron)
ferns (Acrostichum aureum)
nipah (Nypa fructicans)
etc.

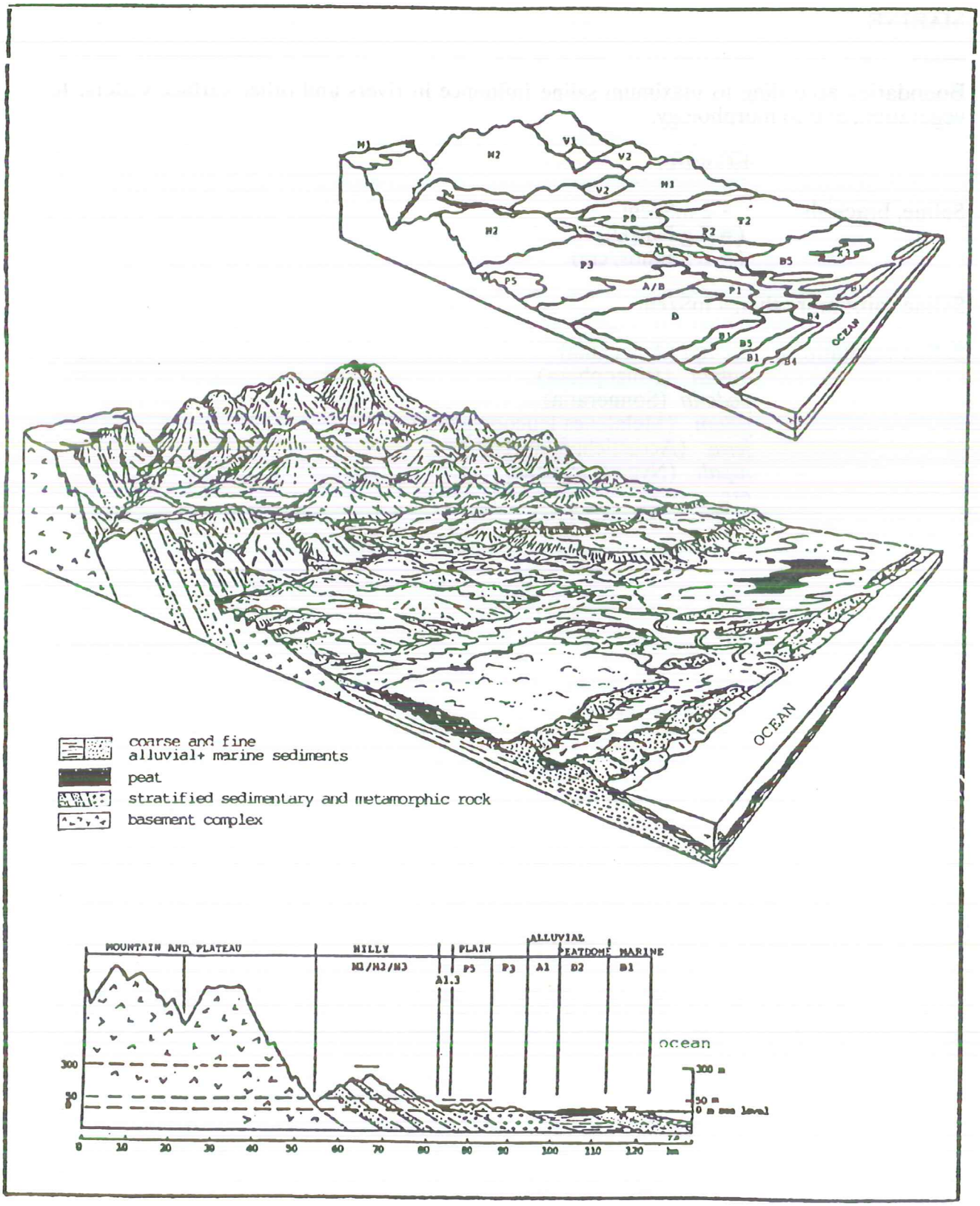


Figure 2. The main physiographic groups.

IDENTIFICATION OF PHYSIOGRAPHIC GROUPS

1. Large ombrogeneous (rainfed) peat bodies in the coastal plains, rising up to 10 m or more (above high water level of the adjacent rivers), marginally influenced by saline water. This unit excludes topogenic peat bodies with level or barely convex surface that occur in the backswamps of the Alluvial Group and that are subject to seasonal flooding due to their topographic position. Specific vegetation: peat forest.

D PEAT DOMES GROUP

page 29

2. Other Landforms, due to recent (Holocene and Pleistocene, not folded) activity of lakes, meandering and braided rivers, and to slope processes (colluvium), excluding those parts where marine influence is dominant (not saline). These landforms mainly consist of the broad alluvial plains of the coastal areas, the river valleys in upland areas, colluvial deposits in fans and footslopes, lacustrine deposits, and river terraces.

A ALLUVIAL GROUP

page 21

3. Other recent and subrecent landforms due to marine and perimarine processes; saline and brackish environment (EC > 2 mS): beach ridges, swales, salt marshes, mudflats, mangroves, delta deposits, estuarine deposits (tidal salt water intrusion along rivers and creeks), dunes, coral reefs. This group does not include older, uplifted marine plains or terraces (salt leached).

B MARINE GROUP

page 25

4. Uplifted, eroded and dissected old coastal plains and abrasion terraces. Landforms are dissected, flat, horizontal, or gently inclined surfaces. These landforms have a large extent, subsoils usually consist of stratified marine deposits or eroded older (folded) rocks. The unit excludes river terraces and lacustrine terraces, which are included in A.

T MARINE TERRACE GROUP

page 43

5. Large plains consisting of (thick) acid volcanic tuffs with characteristic features, landforms and soils. The main acid tuffs in this group are: Palembang Formation (QTpv, Tpp, Tmp), former Lampung tuffs (Qhv) Ranau tuffs (Qrv) and others. These acid tuffs are also called 'ignimbrites'. Part of the tuffs was deposited in a shallow marine environment. The Toba Rhyolite is excluded from this unit.

I ACID TUFF PLAIN GROUP

page 37

6. Other plains, not predominantly formed in acid volcanic material. Regions of general uniform slope, comparatively level (slope <16%, amplitude less than 50 m), of considerable extent. Old landscapes: eroded and dissected; mainly consisting of variable, folded (pre-Quaternary) parent material. Excluding: Young Volcanic (V), Marine (B) and Alluvial (A) plains and Karst plains (K).

P PLAIN GROUP

page 37

7. Acid tuffs from the Toba eruption (Toba Rhyolite and related fissure eruptions), covering a range in altitude of 0 - 2000 m. Mostly long, homogeneous dissected slopes, infilled river valleys, plateaus. Thick acid tuff deposits, sometimes welded.

Q TOBA ACID TUFF GROUP
page 45

8. Other landforms that are due to recent and subrecent (Quaternary to Tertiary), dominantly intermediate to mafic, volcanic activity. Stratovolcanoes and eroded stratovolcanoes, lava flows, lava plateaus, lahars. Blockfaulted volcanic deposits are excluded (included in H, M). This group does not include the Toba Rhyolite (--> Toba Acid Tuff Group).

V VOLCANIC GROUP
page 49

9. Landforms predominantly developed in calcareous material. Usually with irregular morphology. Dissolution of soft calcareous material gives rise to less pronounced dissolution features than that of hard limestones. Relief is steeper and more irregular in tilted material than in horizontally bedded material. On hard limestones, soils are usually not continuous, but occur in pockets, pipes, etc. Soils are usually thin and of irregular thickness. Surface drainage is usually absent.

K KARST GROUP
page 39

10. Landforms made by orogenic and erosional processes, composed of hillocks and hills with a relief amplitude of 10 to 50 m or 50 to 300 meters; variable parent material . The unit includes structurally controlled patterns (oriented or random).

H HILLY GROUP
page 33

11. Mountains: large areas of land with a relief amplitude of more than 300m. Massive mountain chains, block mountains. Plateaus: elevated areas of comparatively flat, more or less dissected land, limited by an abrupt descent to lower land. This unit excludes Mountainous landforms due to recent volcanic activity (Volcanic Group) and the Toba Rhyolite (Toba Group).

M MOUNTAIN AND PLATEAU GROUP
page 41

12. Other landforms, not belonging to one of the previous, that either do not contain agricultural land or are strongly influenced by human activity. This group includes steep valleys, towns, lakes, leveled land, waste dumps, etc.

X MISCELLANEOUS GROUP
page 51

ADDITIONAL INDICATIONS

SAWAHS: Large complexes of irrigated rice; undifferentiated: tidal, irrigated as well as rainfed.

(////); not separate land unit

ESCARPMENTS: |||||

NARROW, STEEP SIDED VALLEYS: ||||||||

ROCKY TERRAIN: + + +
+ +

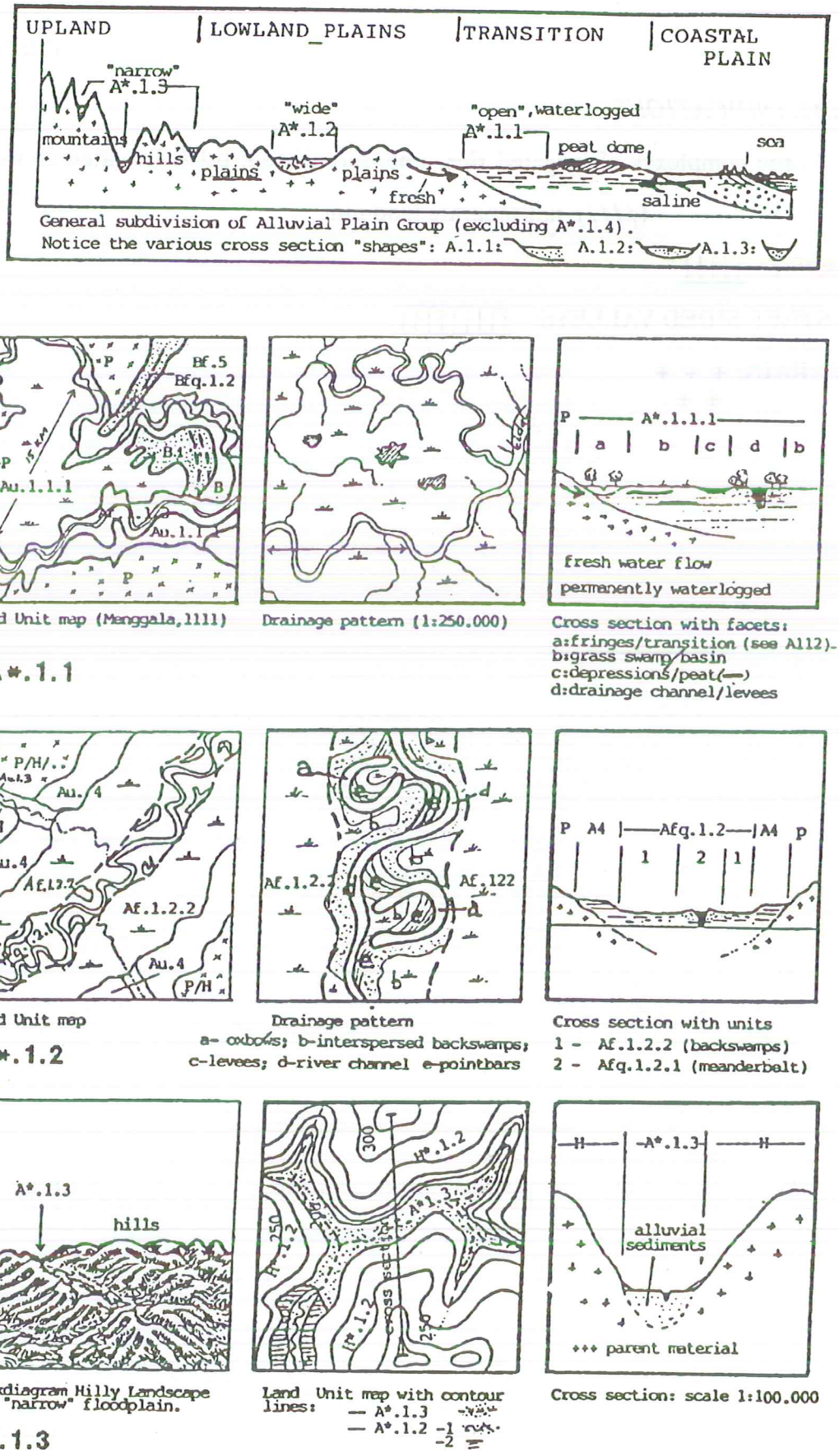


Figure 3. Examples of the Alluvial Group (A.1.1, A.1.2, A.1.3)

SUBDIVISION OF GROUPS

A ALLUVIAL GROUP

Figures 3 and 4.
lithology: *
dissection: @

A*.1 - Alluvial Subgroup
alluvium, valley systems, floodplains

A*.1.1 - Broad alluvial plain; (subrecent) transitional to marine, very poorly drained (Figure 3).

A*.1.1.1 - Swamps/swampy: open,low vegetation (mainly grasses).
A*.1.1.2 - Swamps/swampy:mixed vegetation (mainly swamp forest).
A*.1.1.3 - Riverbelts:mixed vegetation (single levees or complex of levees,scrolls, cut-offs, oxbows, etc.)
A*.1.1.4 - Elevated alluvial plain: cultivated/not cultivated

A*.1.2 - Flood plains of meandering rivers, non-saline complex.

A*.1.2.1 - Meanderbelt: levees, spillways, streamchannels, etc.
A*.1.2.2 - Backswamps, filled oxbow lakes, seasonally flooded

A*.1.3 - 'Narrow' valleybottoms occurring in upland (e.g. P, I,H,Q), but width does not allow further subdivision. (Figure 3).

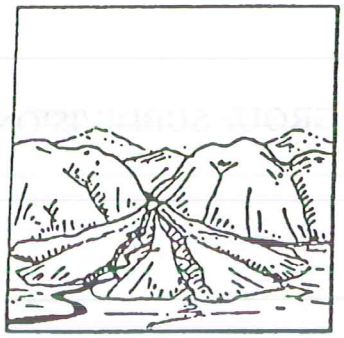
A*.1.4-Broad infilled graben (alluvial sediments)

A*.1.4.1 - Riverbelt
A*.1.4.2 - Floodplain and backswamps
A*.1.4.3 - Alluvial/colluvial fans along mountain slopes (faults)

A*.2 - Colluvial and Alluvial Fans
colluvial: deposits by mass wasting, accumulation.
alluvial: fans
(Figure 4)

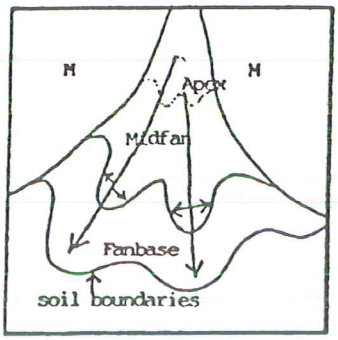
A*.2.1.@ - Flat
A*.2.2.@ - Undulating
A*.2.3.@ - Rolling
A*.2.4.@ - Hillocky

Level III : (dissection)
0 - not dissected
1 - slightly dissected
2 - moderately dissected
3 - strongly dissected
4 - extremely dissected

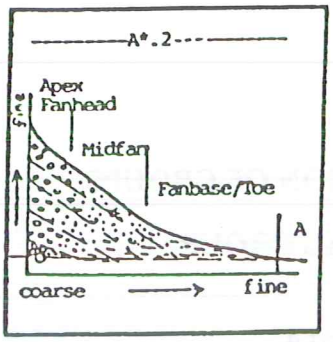


Single Alluvial fan

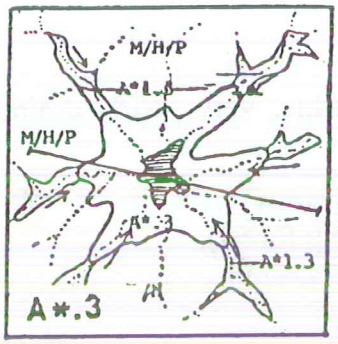
A*.2



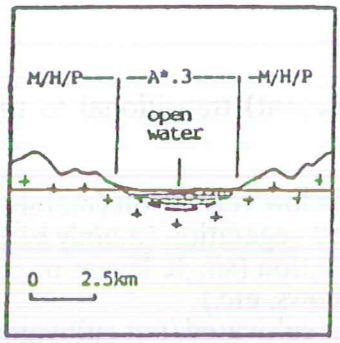
Differential sedimentation pattern:
↔ transverse textural gradient
↓ radial textural gradient



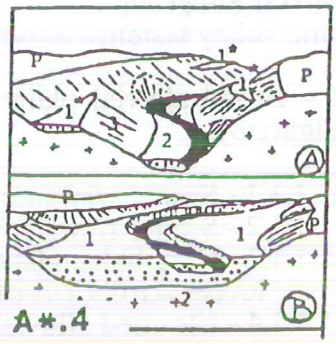
Radial cross section showing textural gradient



Map image showing Physiogr. Groups and centripetal drainage pattern.

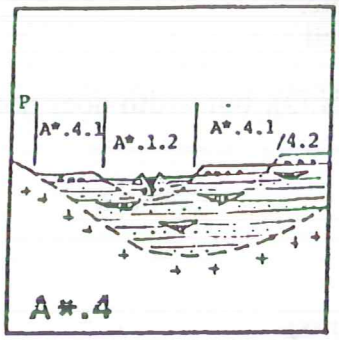


Schematic cross section A*.3

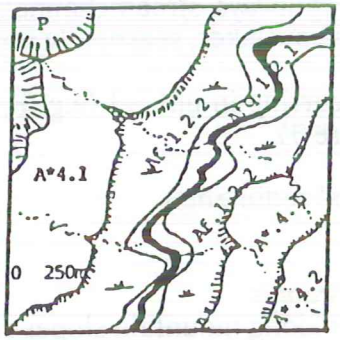


River terraces:
A: bedrock terraces developed by uplift and re-incision
B: alluvial terraces as a result of sedimentation
1: alluvial terrace (thick)
1*: incision terrace with thin alluv.cover
2: floodplain (recent)
3: valley slope

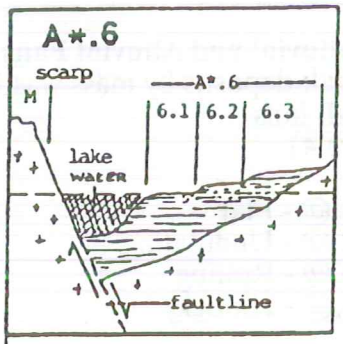
* (A) will occur in uplands and areas with active tectonic movement.
* (B) will normally occur in LOWLANDS.



Cross section through a Lowland riverplain with broad terraces.

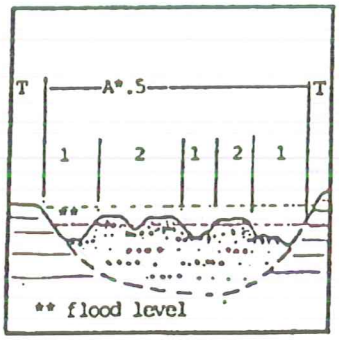


Land Unit map
Note that older terraces (normally higher positions) are more dissected



Cross section through a number of lacustrine terraces.

Detailed map image with simple subdivision:
1 - riverchannel
2 - bars/sand banks or "braids"



Cross section showing channels and braids.

Figure 4. Examples of the Alluvial Group (A.2 - A.6)

A*.3 - Closed Alluvial Basins
low upland areas without drainage, no marine influence (Figure 4).

A*.3.1 - discarded
A*.3.2 - closed basin, depression
A*.3.3 - swamp or marsh
A*.3.4 - lacustrine plain (recent)
A*.3.5 - ancient lake bottom

A*.4 - River Terraces Subgroup
terraces along rivers (Figure 4).

A*.4.1.@ - flat
A*.4.2.@ - undulating
A*.4.3.@ - rolling

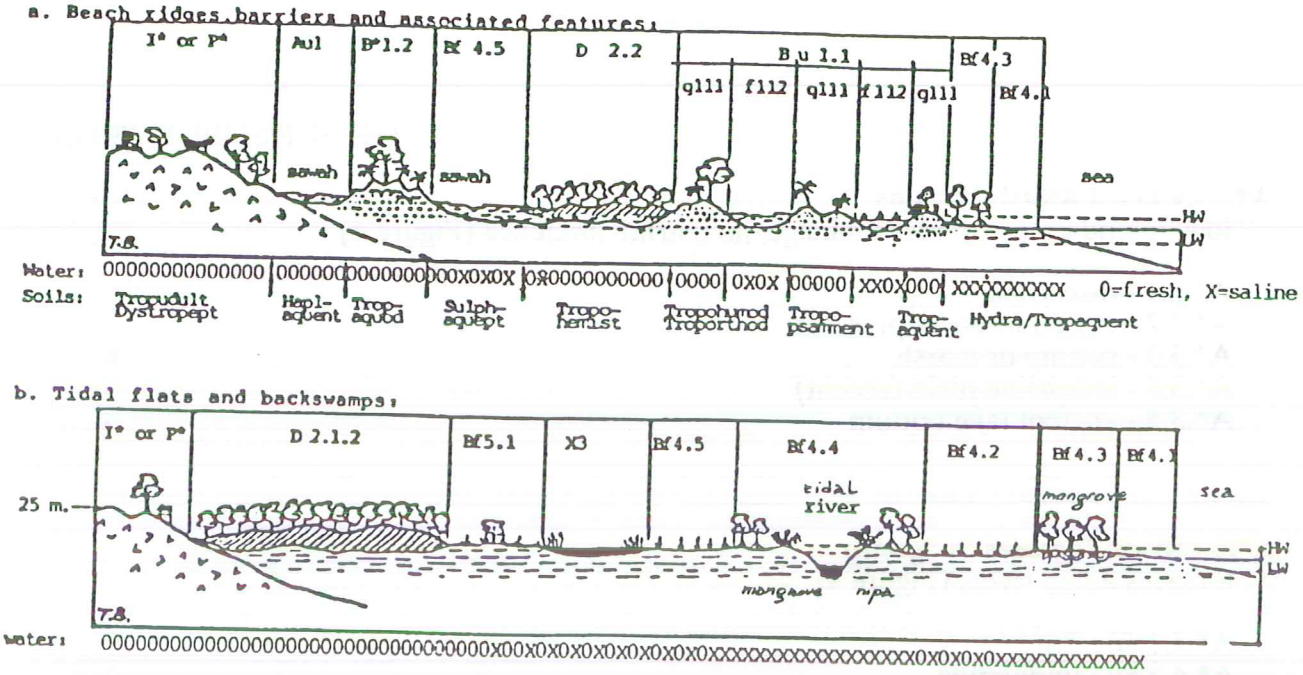
Level III : (dissection)
0 - not dissected
1 - slightly dissected
2 - moderately dissected
3 - strongly dissected
4 - extremely dissected

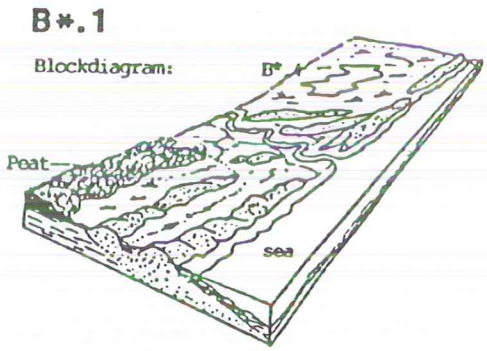
A*.5 - Floodplains of Braided Rivers
undifferentiated.

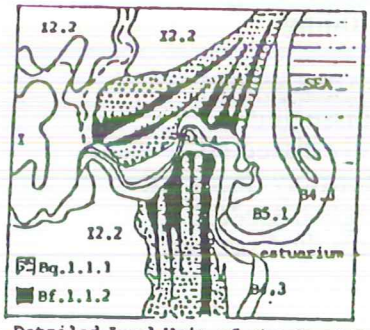
A*.6 - Lacustrine Terraces
terraces representing former lake bottom levels

A*.6.1.@ - flat
A*.6.2.@ - undulating
A*.6.3.@ - rolling

Level III : (dissection)
0 - not dissected
1 - slightly dissected
2 - moderately dissected
3 - strongly dissected
4 - extremely dissected







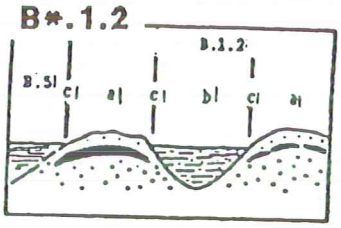
Detailed Land Unit of the Soputih river mouth (Lampung,1111).

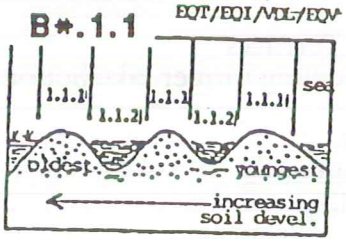
Facets and soils B*.1.2:

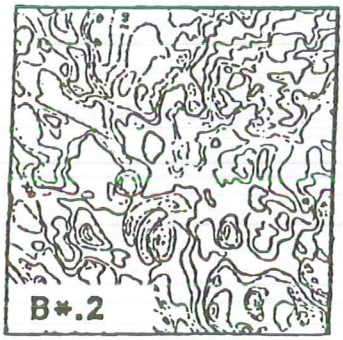
a - eroded/levelled ridges: ESZ/SHT/SOA/MR
b - swale (ripened clay/peat/gley): IQT/IQS/EQT
c - transition (gley,layered): SQT/EQS

Facets and soils B*.1.1:

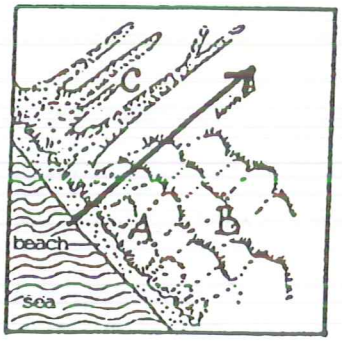
Bq.1.1.1- ridges(sand):EST/ESZ/EQS
Bf.1.1.2- swale(clay/unripe): EQT/EQI/MDL/EQM





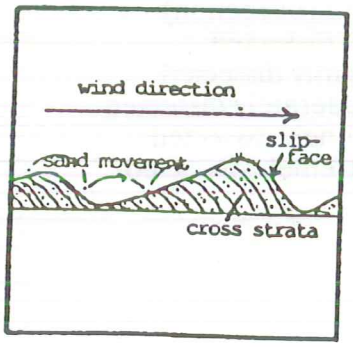


Topographical map with contour lines, transverse dunes(1:50.000) (from Strahler,1969)



Some kinds of dunes based on form:

A - beach dunes
B - transverse dunes
C - longitudinal dunes



Cross section with simple parallel cross-strata.

Figure 5. Examples of the Marine Group: beach ridges and dunes.
5a. Beach ridges, barriers and associated features. 5b. Dunes

B MARINE GROUP

Figures 5 and 6.
lithology:*

B*.1 - Beach ridges, barriers, swales and associated features e.g. swales (recent, subrecent, ancient) (Figure 5a).

B*.1.1 - Complex of beach ridges and swales, repetitive (young)
B*.1.1.1 - ridges
B*.1.1.2 - swales

B*.1.2 - Complex of eroded beach ridges and filled-in swales, old seashores

---

B*.2 - Dunes

B*.2.1 - Flat sandy deposits

B*.2.2 - Undulating relief

B*.3 - Coral reef and coral flat

B*.3.1 - Recent reef and flat

B*.3.2 - Uplifted reefs and flats

B*.4 - Tidal flats
Tidal lats along shore and estuaries, clayey, non-ripe, tidal influence, saline (Figures 5b).

B*.4.1 - Tidal mud flat along seashore: bare, no vegetation.

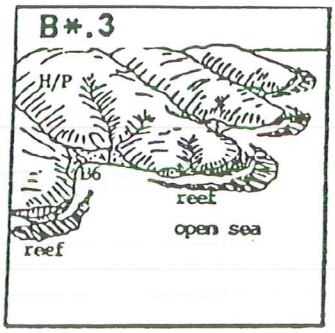
B*.4.2 - Marshy tidal flat behind shore: low, open vegetation, mainly grasses.

B*.4.3 - Tidal flat along seashore: mangrove vegetation.

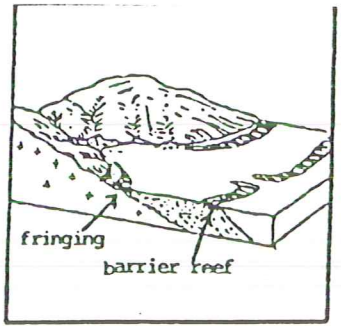
B*.4.4 - Estuarine flats along major rivers: Nipa and/or mangrove vegetation.

B*.4.5 - Flats above storm level: elevated, older flat, partly ripened, cultivated.

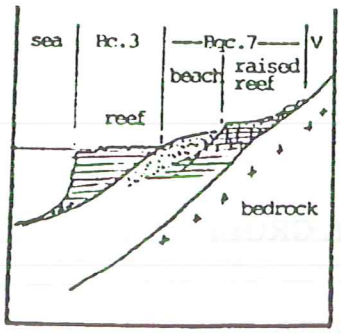
B*.4.6 - Artificially drained flats along estuary: cultivated,mainly tidal rice.



Fringing reefs are widest in front of headland (H/P), absent near river delta's/mouths.
(from Strahler, 1969)



Barrier reefs are separated from the mainland by shallow lagoons.
(from Strahler)

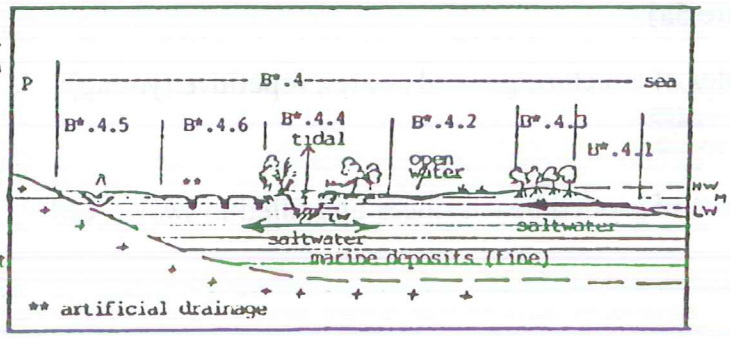


Cross section of a fringing reef.

B*.4

Schematic cross section and subdivision of unit B*.4: "tidal flats"

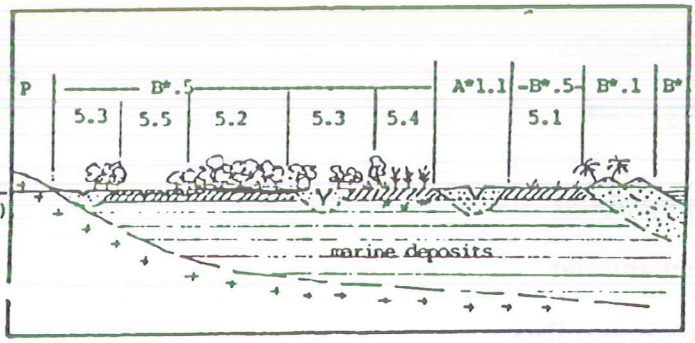
Note: tidal flats normally occur along coasts with little wave and current action. The angle of the river gradient is low and the shelf is shallow.



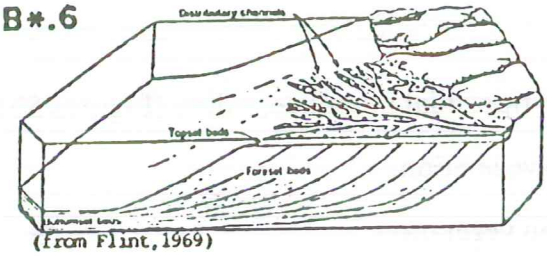
B*.5

Schematic cross section and subdivision of unit B*.5: "coastal backswamps"

Note: broad coastal backswamps develop if drainage is blocked (very flat relief) and if sedimentation (due to emergence) keeps pace with subsidence.



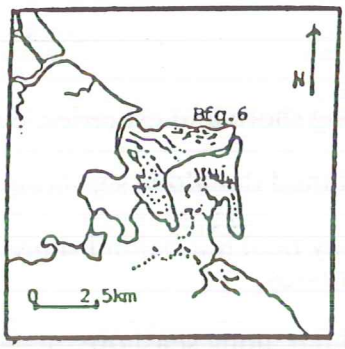
B*.6



(from Flint, 1969)

Delta's (s.s.) are not very common along the shores of Sumatra. Normally they are small and show relicts of former coastal development.

Note: Definition (Flint, 1969): general term for a body of sediment deposited by a stream flowing into standing water of a lake or the sea.



Example of an pointed arcuate or cuspate delta: Aceh Arakunda river, 0621.
(interpretation from radar)

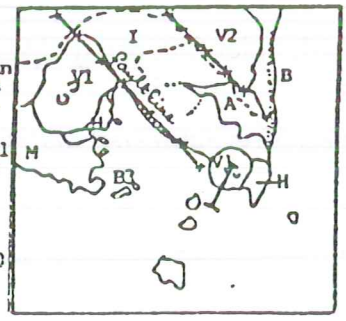
B*.7

B7-Narrow Coastal plains:

In fact these units can contain almost any kind of subdivision since it is a matter of scale.

In most cases however it concerns narrow (1-2 km) coastal deposits along mountain ranges and volcanoes near shore.

Example of B*7 along the Rajabasa volcano (Lampung, 1110) with possible facets.
(see also introduction B).



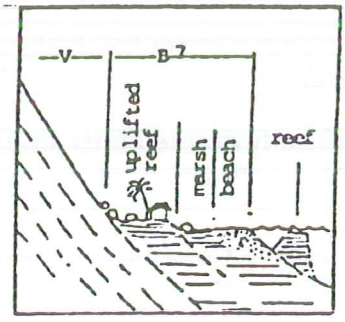


Figure 6. The Marine Group: reefs, tidal flats, backswamps, and deltas.

B*.5 - Backswamps; mixed vegetation, not tidal, clayey, mainly *un*ripe sediments possibly sulfidic, shallow (<2.00 m) peat. Transitional to D and A*.1.1., fresh to brackish. (Figure 6).

B*.5.1 - Low, open swamp vegetation: dominantly grasses and/or shallow peat cover and open water bodies.

B*.5.2 - Mixed freshwater swamp forest and peat forest (no peat dome).

B*.5.3 - Mixed levee forest along rivers and tributaries.

B*.5.4 - Swamp vegetation with gelam trees, transition to B.5.1.

B*.5.5 - Cultivated backswamps (including former peat domes).

B*.6 - Delta deposits
further subdivision to be considered

B*.7 - Narrow coastal plains
undifferentiated, sandy-calcareous, eroded, sometimes combined with small fans.

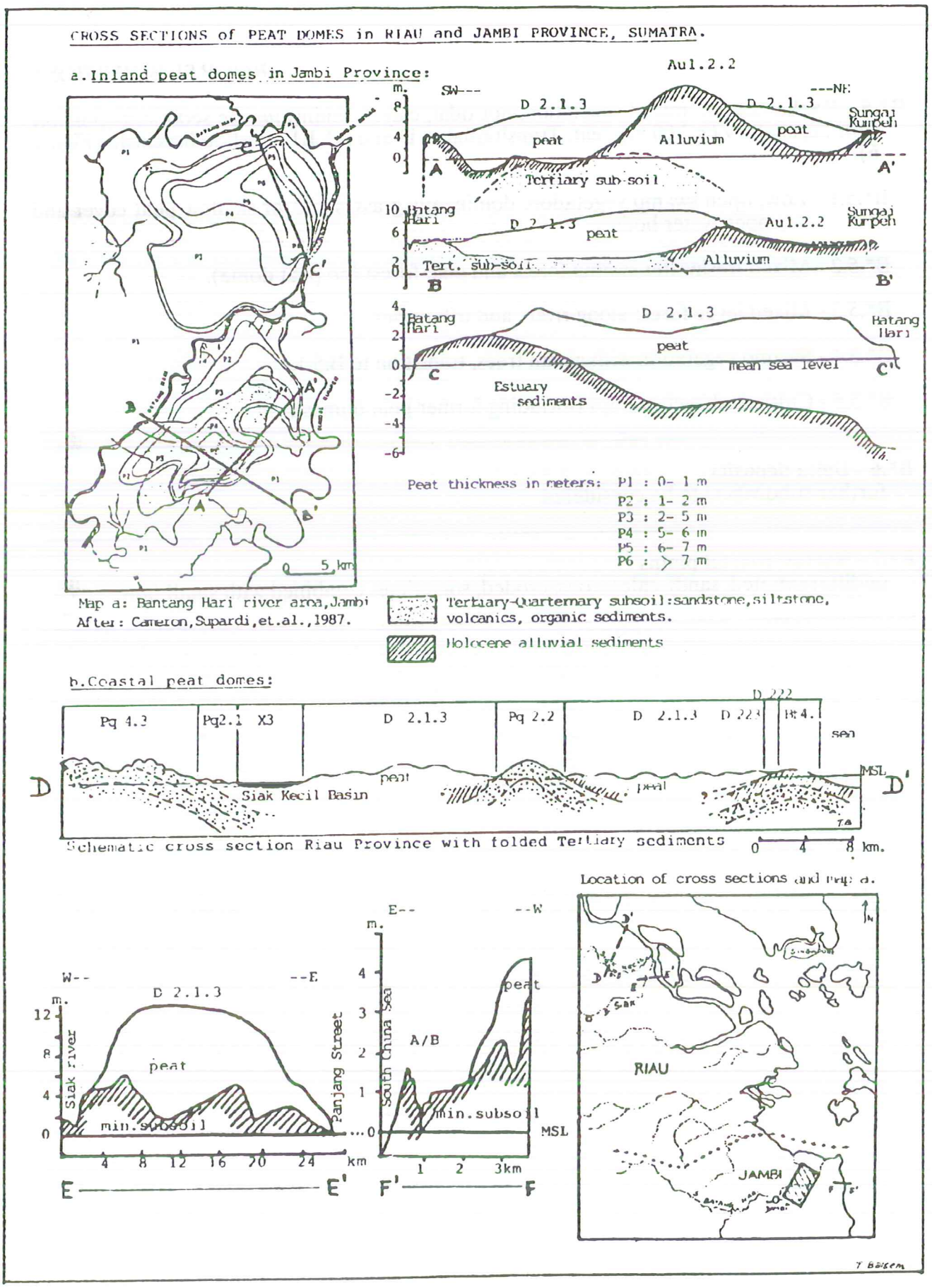


Figure 7. Cross sections of Peat Domes in Riau and Jambi provinces, Sumatra.
7a. Inland peat domes in JAMBI province. 7b. Coastal peat domes.

D PEAT DOMES GROUP

Figures 7 and 8.

Level I: (nutrient status & reclamation)
D.1 Eutrophic peat domes (no subdivisions as yet)
D.2 Oligotrophic peat domes

D*.1 - Eutrophic peat domes
Mainly topogenous, groundwater dependent, shallow peat, C content >12(-18)%, Bulk Density >0.2, Total Ash >30%

--Subdivision as D.2.

D*.2 - Oligotrophic peat domes
Mainly ombrogenous, rainwater dependent, deep peat, C content >12(-18)%, Bulk Density <0.2, Total Ash <10%

D*.2.1-Freshwater peat domes, natural condition

D*.2.1.1: thickness <0.5 m
D*.2.1.2: thickness 0.5 - 2 m
D*.2.1.3: thickness >2 m

D*.2.2-Peat dome fringes with tidal/saline influence, natural condition.

D*.2.2.1: thickness <0.5 m
D*.2.2.2: thickness 0.5 - 2 m
D*.2.2.3: thickness >2 m

D*.2.3-Cultivated, logged peat domes with compacted/deminished peat layers.

D*.2.3.1: thickness <0.5 m
D*.2.3.2: thickness 0.5 - 2 m
D*.2.3.3: thickness >2 m

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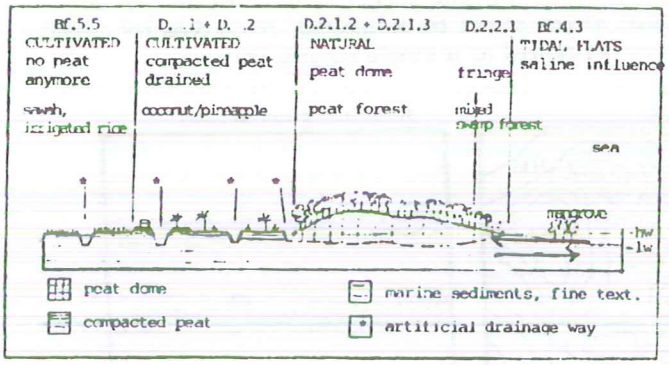
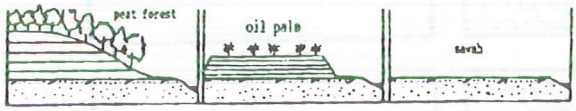


Example of a cross section of a partly cultivated and artificially drained Peat Dome.
The classification of a seperate unit for cultivated Peat Domes is justified, not only because extensive dome areas in Riau, Jambi and Sumsel are being cultivated, but mainly because the completely changed land use possiblities and suitability.

3 stage of development of peat dome



A. natural condition → B. cultivated condition drained, compacted → C. after 20 years of cultivation

D .2.1----------D .2.3---------Bf.5.5

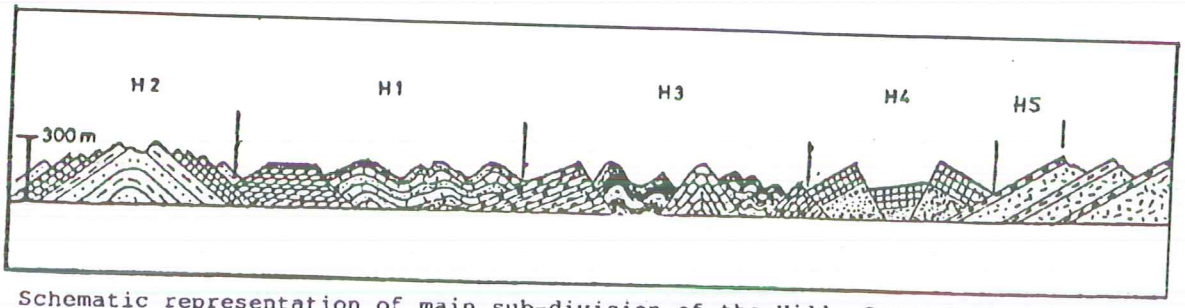
three stages of development of a Peat Dome: natural-cultivated/drained/compacted and completely disappeared.
For chemical and fysical characteristics of the various soils we refer to e.g.: Driessen and Pernadhy Sudewo, 1977. (see table below).

Silica contained in the upper 20 cm layers of forest peats from Kalimantan ("P") and Sumatra ("JDP").[x]

profile		SiO_2 (kg/ha)	Total ash (kg/ha)	100.SiO_2 / total ash
P10	deep central dome peat under mixed sw. forest	5,892	9,070	65%
P11	deep central dome peat cleared 16 years ago; cropped 3 times	1,671	6,570	25%
P5	ditto; cropped 16 times	983	4,340	23%
JDP5	mod. deep fringe peat under mixed sw. forest	14,958	17,500	85%
JDP7	ditto; cleared 2 years ago, never cropped	11,873	17,180	69%
JDP6	ditto; cleared 30 years ago, continuously cropped	4,401	16,000	28%

x) Table presented at the Soils and Rice Symposium, Manila, 20 - 24 September 1977.

Figure 8. Three stages of reclamation of a peat dome



Schematic representation of main sub-division of the Hilly Group. Notice that sub-groups H2 and H5 overlap; H2= seperate monoclinal slopes cannot be delineated, scale does not permit this, H5= monoclinal slope is large enough to be delineated as a single mapping unit.

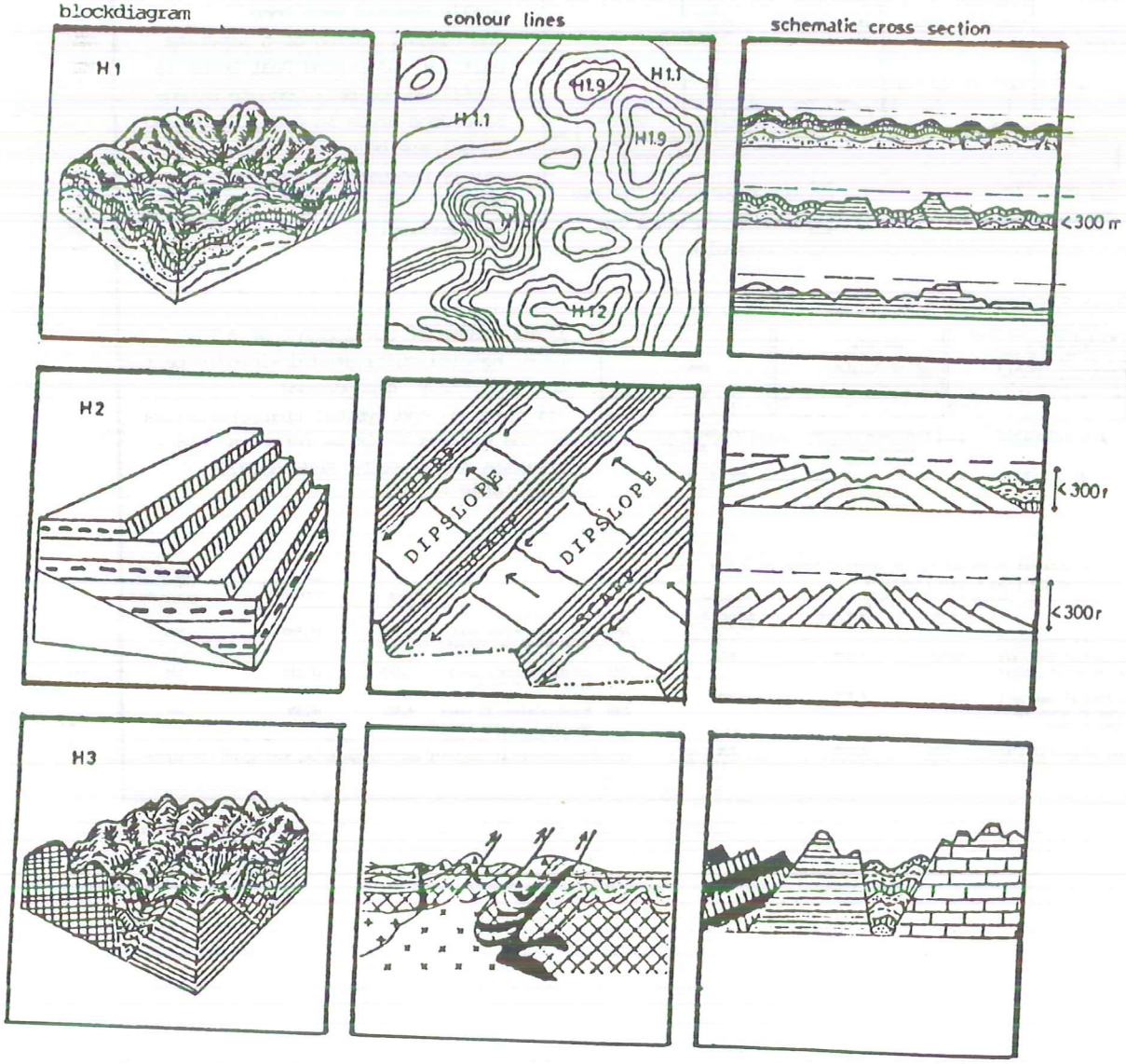


Figure 9. The Hilly Group: random hills, aligned patterns, complex hills (H1 - H3)

H HILLY GROUP

Figures: 9, 10
lithology: *
dissection: @.

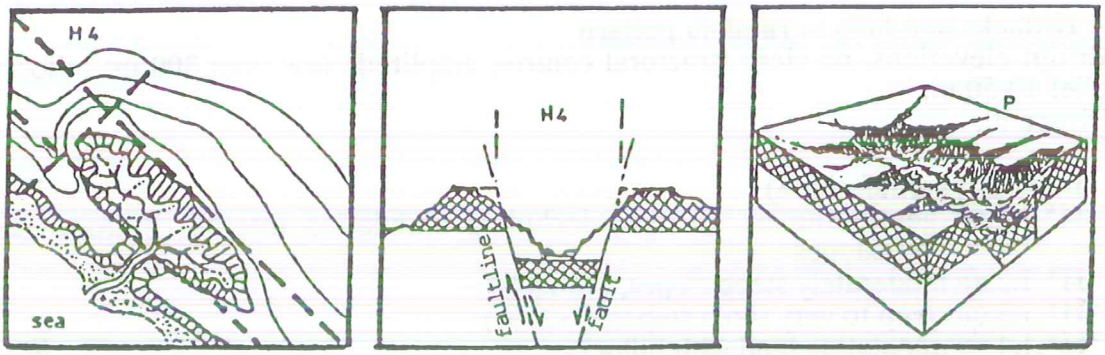
Level I: (lithology)

Level II: (relief)

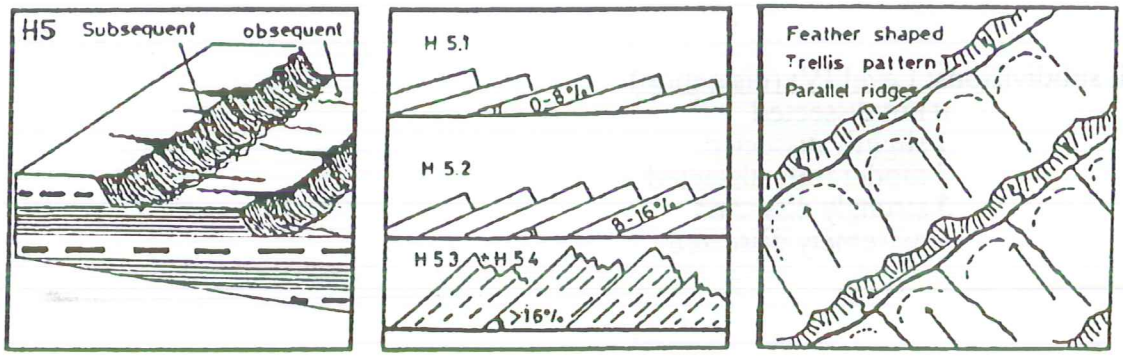
H*.1 - Hillocks and hills in random pattern
Abrupt elevations, no clear structural control, amplitude less than 300 m; hillocks: relief 10-50 m.
(Figure 9).

Level III: (relief, slope)
H*.1.1.@ gentle slopes, (0-15%) including undulating interhill bottoms and footslopes
H*.1.2.@ moderately steep slopes, (16-25%)
H*.1.3.@ steep to very steep slopes, (>25%)
H*.1.4.@ undulating land with hillocks
H*.1.5.@ rolling land with hillocks
H*.1.6.@ hillocks in rolling pattern
H*.1.7.@ interhill flat or undulating to rolling area
H*.1.8.@ isolated hillocks, hills or knobs, erosion remnants.
H*.1.9.@ summit areas and plateaus

For all subdivisions: Level IV: (dissection)
0 not dissected
1 slightly dissected
2 moderately dissected
3 strongly dissected
4 extremely dissected



Tectonic valley: example from sheet Tanjungkarang (1110). Note: along the Great Barisan Fault many similar valleys can be detected. Soils will have different properties because sediments have not been transported over long distances as is the case with most alluvial sediments (A). When subdivision is possible and relief consists mainly of alluvialland they should be classified as A*.1.4.!!!



Monoclinal Slopes: large units that can be delineated as single mapping units, see further ID.

Figure 10. The Hilly Group: tectonic valleys and monoclinal slopes (H4 - H5)

H*.2 Parallel, elongated ridges and structural slopes from bedded rocks with vertical or subvertical dip. Internal drainage parellel to elongation. (Figure 9).

Level III: (relief, slope)
H*.2.1.@ gentle slopes,footslopes (< 16%)
H*.2.2.@ moderately steep slopes (16 - 25%)
H*.2.3.@ steep and very steep slopes (25 - 75%)
H*.2.4.@ very steep abrupt slopes (> 75% ;scarps)
H*.2.5.@ undulating land with hillocks
H*.2.6.@ rolling land with hillocks
H*.2.7.@ hillocks in rolling pattern
H*.2.8.@ interhill undulating to rolling area
H*.2.9.@ isolated hillocks hills or knobs (erosion remnants)

H*.3 Complex hilly relief and special features

Level III: (relief, slope)
H*.3.1.@ gentle slopes (< 16%)
H*.3.2.@ moderately steep slopes (16 - 25 %)
H*.3.3.@ steep slopes (> 25 %)
H*.3.4.@ summit areas : flat to undulating
H*.3.5.@ summit areas : rolling, hillocky

H*.4 Tectonic Valleys

H*.5 Monoclinal slopes

Level III: slope
H*.5.1.@ gently sloping (3-8%)
H*.5.2.@ sloping (8-16%)
H*.5.3.@ moderately steep (16-25%)
H*.5.4.@ steep to very steep (> 25%)

For all subdivisions: Level IV: (dissection)
0 not dissected
1 slightly dissected
2 moderately dissected
3 strongly dissected
4 extremely dissected

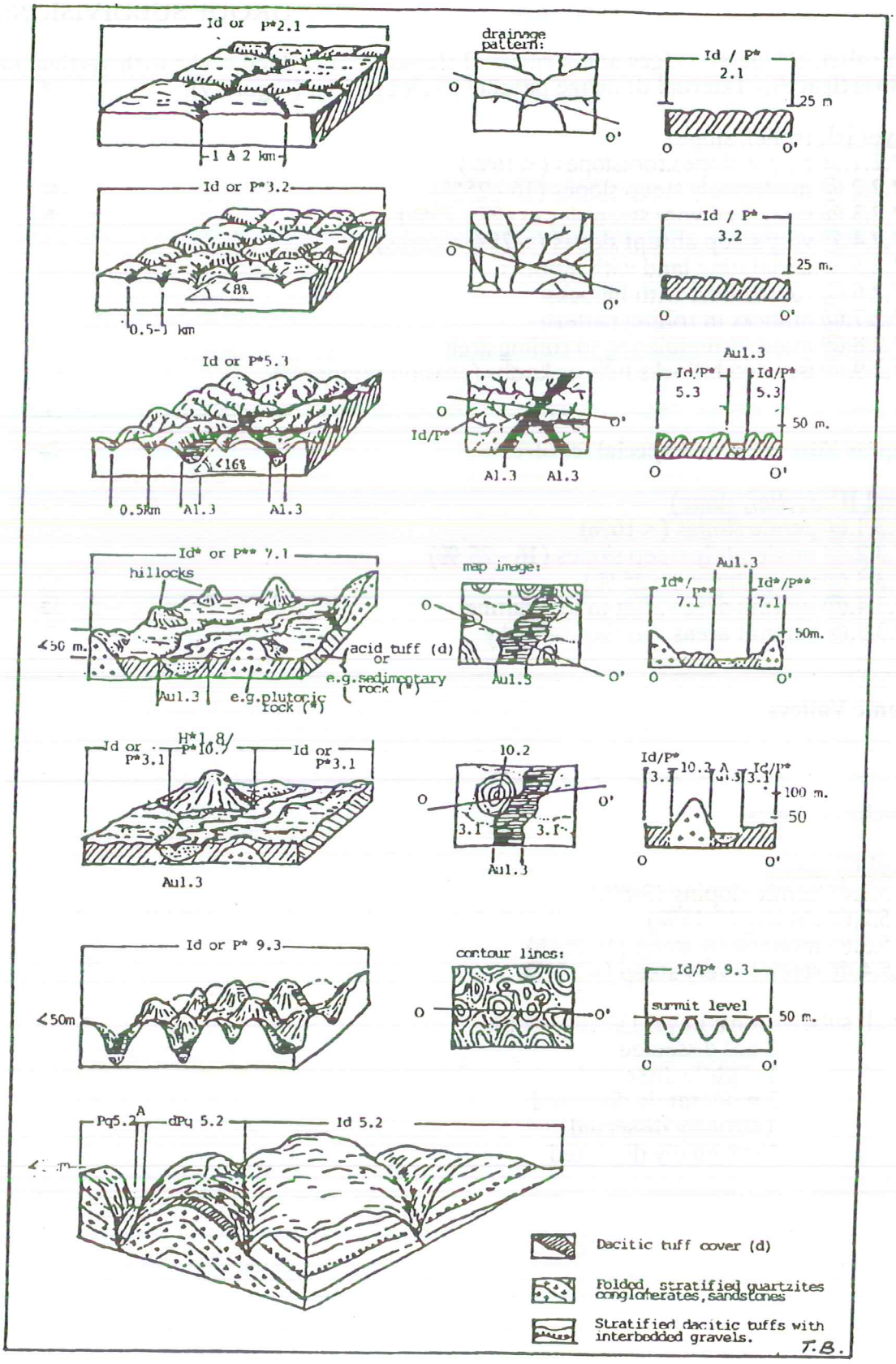


Figure 11. Examples of the Plain and Acid Tuff Plain groups

I ACID TUFF PLAIN GROUP

Figure 11.
lithology: *
dissection: @

Level I: (lithology)

Level II: (relief)
I*.1.@ - flat plain
I*.2.@ - flat to undulating plain
I*.3.@ - undulating plain
I*.4.@ - undulating to rolling plain
I*.5.@ - rolling plain
I*.6.@ - flat with hillocks
I*.7.@ - undulating with hillocks
I*.8.@ - rolling with hillocks
I*.9.@ - hillocky plain
I*.10.@ - erosion remnants, residual hills and hillocks

Level III: (dissection)
0 - not dissected
1 - slightly dissected
2 - moderately dissected
3 - strongly dissected
4 - extremely dissected

P PLAIN GROUP

Figure 11.
lithology: *
dissection: @

(excluding young volcanics, young marine + alluvial plains, acid tuff plains, plains in Toba Acid Tuff Group, karstic plains, marine terraces, mountain plateaus) (Figure 11).

Level I: (lithology)

Level II: (relief, landform)
P*.1.@ - flat plain
P*.2.@ - flat to undulating plain
P*.3.@ - undulating plain
P*.4.@ - undulating to rolling plain
P*.5.@ - rolling plain
P*.6.@ - flat with hillocks
P*.7.@ - undulating with hillocks
P*.8.@ - rolling with hillocks
P*.9.@ - hillocky plain
P*.10.@ - erosion remnants, residual hills and hillocks

Level III: (dissection)
as under I

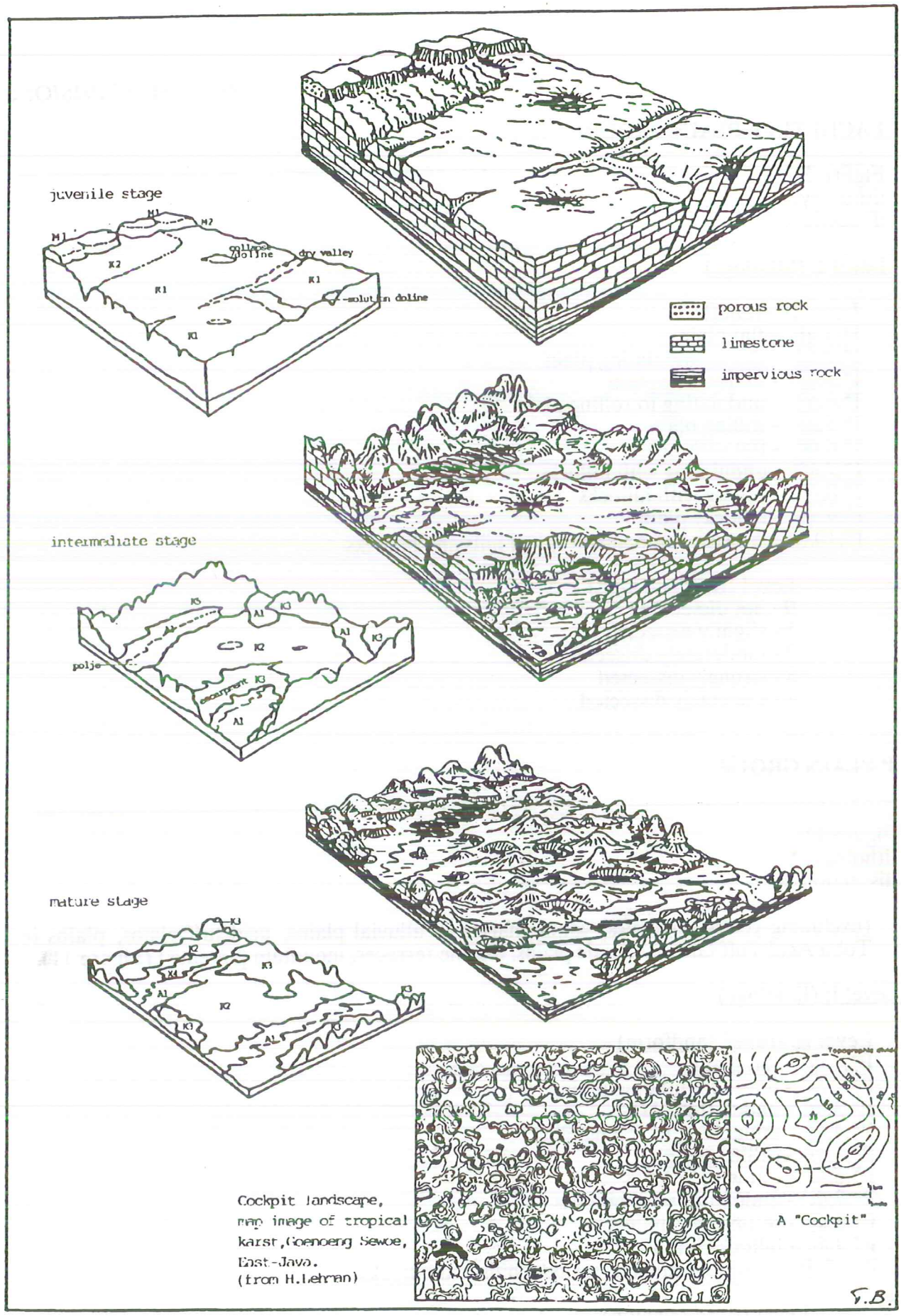


Figure 12. Development stages in the Karst Group.

K KARST GROUP

Figure 12.
lithology: *
dissection: @

K*.1.@ Karstic plain/plateau/terrace, flat to undulating relief, gentle slopes (<8%).

K*.2.@ Undulating to rolling karstic plains, gently sloping to sloping (3-16%).

K*.3.@ Karstic hills and hillocks, moderately to steep slopes (16-55%)

K*.4.@ Horizontally bedded chalk.

K*.5.@ Karstic mountains, steep to very steep slopes (>25%).

Level III: (dissection)
0 - not dissected
1 - slightly dissected
2 - moderately dissected
3 - strongly dissected
4 - extremely dissected

NB: subdivision of the Karst group has to be amended for other areas.

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M MOUNTAIN AND PLATEAU GROUP

Figure -
lithology: *
dissection: @

Blockmountains, Massifs, Chains.

Level I: (lithology, parent material of top layer)

Level II: (landform)

M*.1 Plateaus (surrounded by other M units or escarpment)

Level III: (relief)
M*.1.1.@ flat to undulating
M*.1.2.@ rolling
M*.1.3.@ hillocky

M*.2 Mountains

Level III: (relief)
M*.2.1.@ gentle to moderately steep slopes, footslopes (<25%)
M*.2.2.@ steep to very steep slopes (25-75%)
M*.2.3.@ abrupt slopes (>75%)
M*.2.4.@ talus slopes, fans

M*.3 Intramontane Plain (erosive, no alluvial sediments)

Level III: (relief)
M*.3.1.@ flat to undulating
M*.3.2.@ rolling
M*.3.3.@ hillocky.

For all subdivisions:
Level IV: (dissection)
0. not dissected
1. slightly dissected
2. moderately dissected
3. strongly dissected
4. extremely dissected

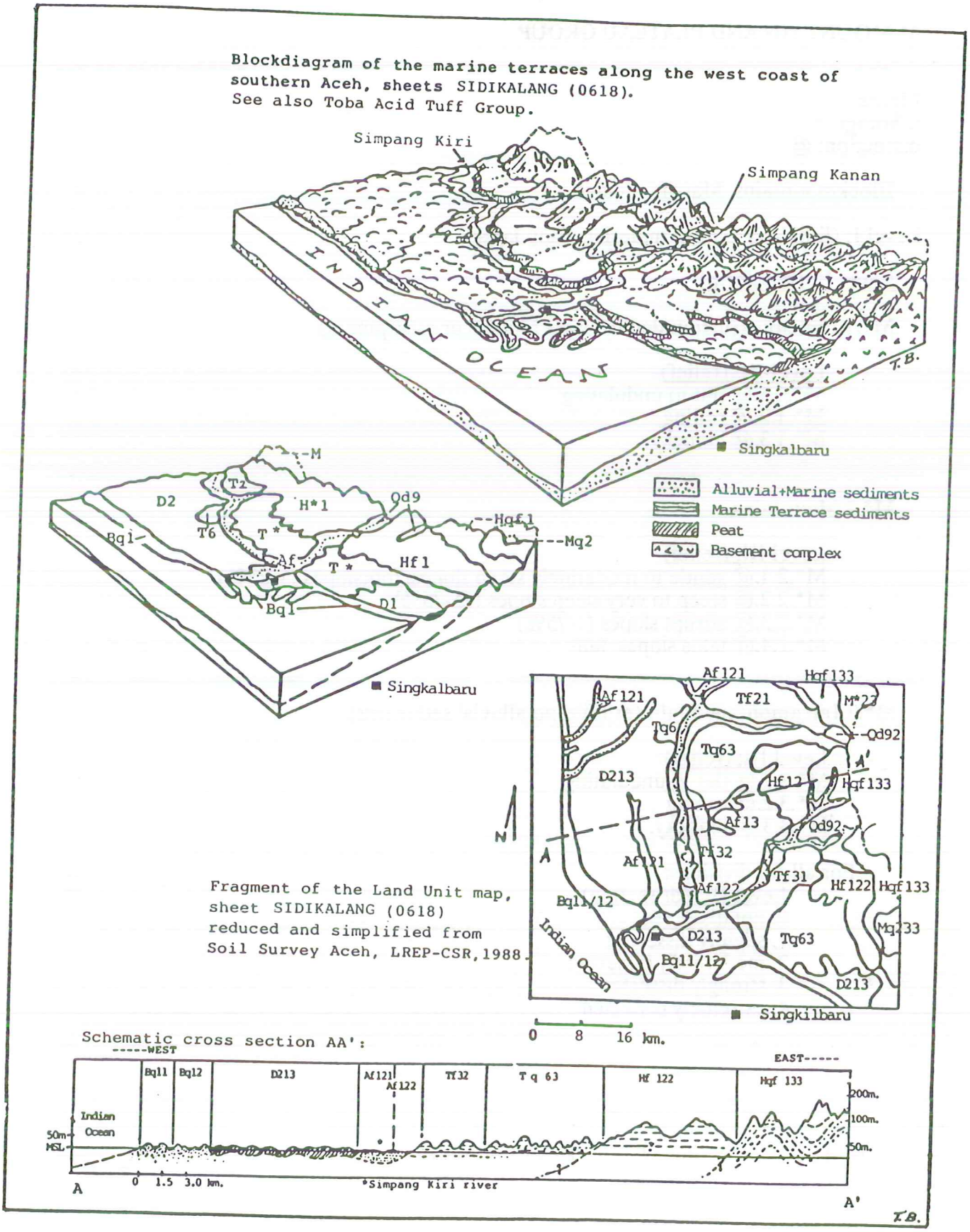


Figure 13. Examples of the Marine Terrace Group

T MARINE TERRACE GROUP

Figure 13.
lithology: *
dissection: @

Level I: (lithology)

Level II: (relief)

T*.1.@ - flat
T*.2.@ - undulating
T*.3.@ - rolling
T*.4.@ - flat with hillocks
T*.5.@ - undulating with hillocks
T*.6.@ - rolling with hillocks
T*.7.@ - hillocky
T*.8.@ - erosion remnants, outcrops, residual hillocks, hills

Level III : (dissection)

0 - not dissected
1 - slightly dissected
2 - moderately dissected
3 - strongly dissected
4 - extremely dissected

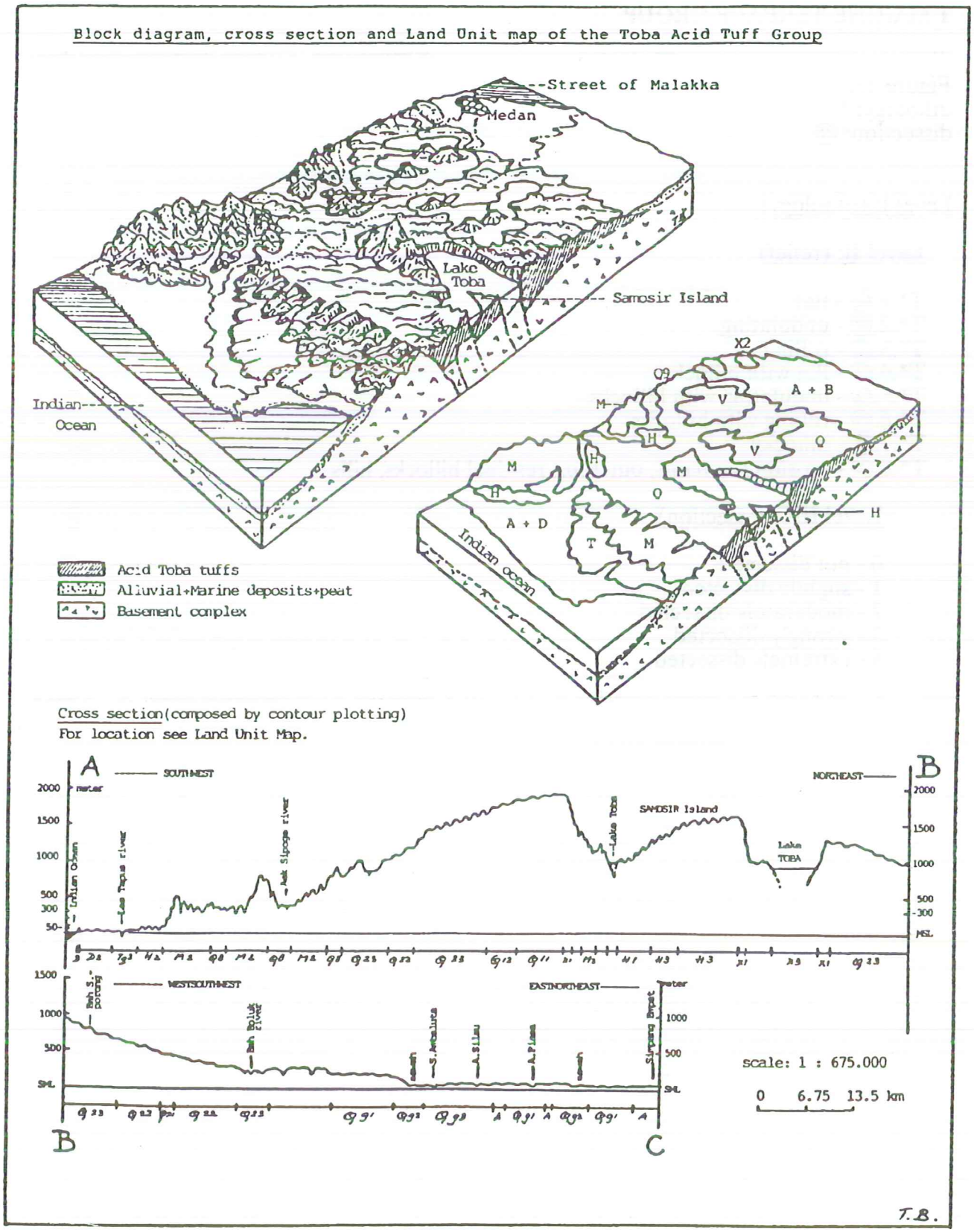


Figure 14. Examples of the Toba Acid Tuff Group

Q TOBA ACID TUFF GROUP

Figures 14 and 15.
lithology: *
dissection: @

Ignimbrite deposits of the Toba eruption, irrespective of position

Level I: (lithology)

Level II: (morphology)

Q*.1. Highlands (above 500-700 m, plateaus, upper slopes, valley fills, and related upland features

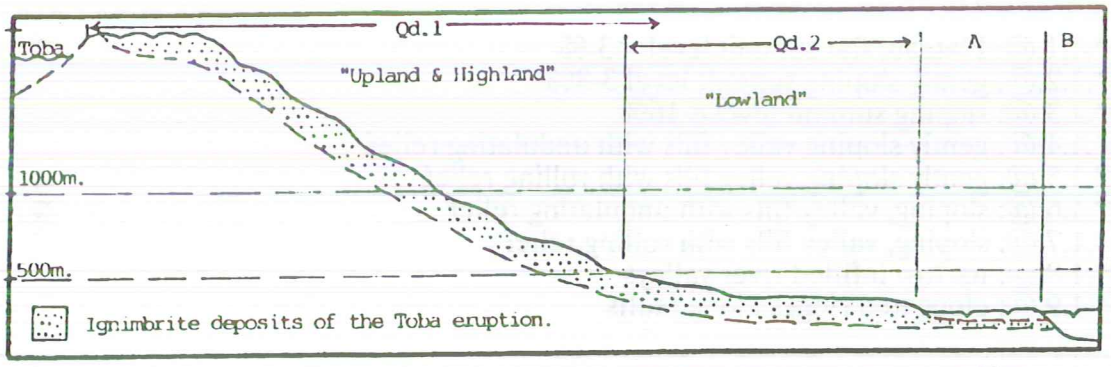
Q*.1.1.@: Plateau, flat summit level <3 %
Q*.1.2.@: gently sloping summit level 3-8%
Q*.1.3.@: sloping summit level 8-16%
Q*.1.4.@: gently sloping valley fills with undulating relief
Q*.1.5.@: gently sloping valley fills with rolling relief
Q*.1.6.@: sloping, valley fills with undulating relief
Q*.1.7.@: sloping, valley fills with rolling relief
Q*.1.8.@: narrow infilled river valleys
Q*.1.9.@: elongated ridges along faults

Q*.2 - LOWLANDS (+ <500-700m): lower slopes, plains, footslopes and fans.

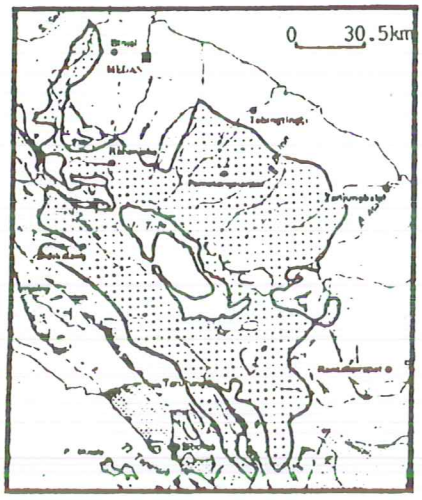
Q*.2.1.@: gently sloping
Q*.2.2.@: flat
Q*.2.3.@: infilled river valleys

Level III: (dissection, for both Q1 and Q2))

0 - not dissected
1 - slightly dissected
2 - moderately dissected
3 - strongly dissected
4 - extremely dissected



Schematic cross section and sub-division of the TOBA ACID TUFF GROUP (Q), eastern section.



The main sub-division into "Highlands" and "Lowlands" is based on the fact that the acid tuff deposits cover a range in altitude of 0 - 2000 m. over long, homogeneous slopes, at several places interrupted by surfacing older deposits (Palaeozoic & Miocene basement and volcanics) or covered by Holocene alluvial deposits in the Lowlands(A). For sub-soil lithology, see transects of geological maps (e.g. 0618 and 0718).

: silicic effusives, air flow Rhyodacite, Toba tuff welded in part, Pleistocene age (Qvt, associated: Qvtsa, Qvtsu, Qvpb).

Fragment of the (Provisional) Geological map of Sumatra, scale 1:2.500.000, published by BAKOSURTANAL.

Figure 15. Main subdivision of the Toba Acid Tuff Group

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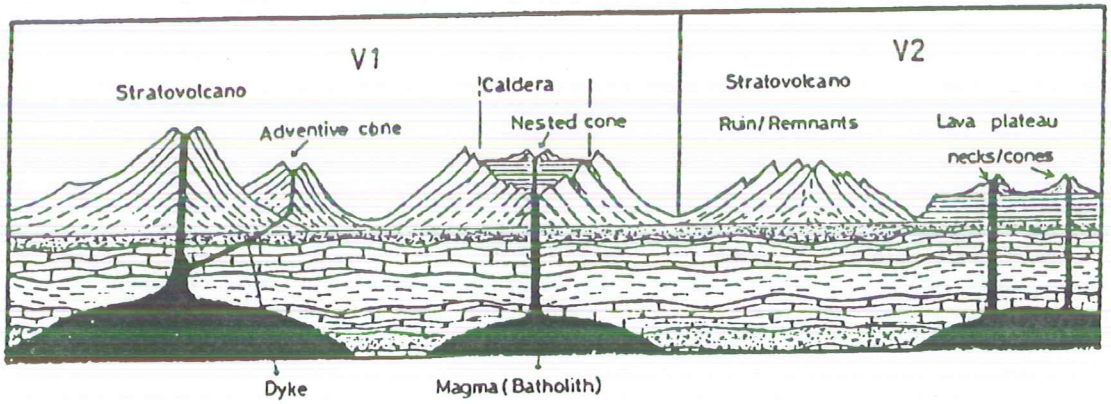
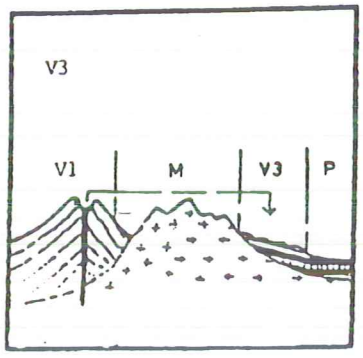


Main sub-division of the Volcanic Group. Note: the identification and subdivision of V1 and V2 is mainly based on physiography. If the topography shows clearly a "stratovolcano shape" the unit must be classified as V1. All other features should be classified as V2 or V3.



Fluvio-volcanic Fans: fan shaped bodies disconnected from the main volcanic source, normally a stratovolcano.

For more examples see e.g. Verstappen (1973).

Figure 16. Main subdivision of the Volcanic Group

V VOLCANIC GROUP

Figures 16 and 17.
lithology: *
dissection: @

Level I: (lithology)

Level II: (relief)

V*.1 Stratovolcanoes and associated features characteristic symmetric cone shaped landforms resulting from repeated eruptions of pyroclastics and short lava flows from a central vent.

V*.1.1.@: Crater, caldeira
V*.1.2.@: Upper slopes (>25%)
V*.1.3.@: Middle slopes (16-55%)
V*.1.4.@: Lower slopes, includ. footslopes + valley bottoms (<16%)
V*.1.5.@: Lava flows (young)
V*.1.6.@: Lahars (young)
V*.1.7.@: Outcrops
V*.1.8.@: Eroded spurs (of large flows)
V*.1.9.@: Caldeira floor

V*.2 Volcanic plains, eroded volcanoes
(lava) plateaus and eroded older volcanoes

V*.2.1.@ : flat plain or plateau
V*.2.2.@ : undulating plain
V*.2.3.@ : rolling plain
V*.2.4.@ : flat with hillocks
V*.2.5.@ : undulating with hillocks
V*.2.6.@ : rolling with hillocks
V*.2.7.@ : hillocky
V*.2.8.@ : erosion remnants
V*.2.9.@ : lahars (old)
V*.2.10.@: hills
V*.2.11.@: mountains

V*.3.@ Fluvio-volcanic fans
disconnected from the main body of the volcano; subdivision as volcanic plains and plateaus

For all subdivisions:

Level IV:
0 not dissected
1 slightly dissected
2 moderately dissected
3 strongly dissected
4 extremely dissected

---

* lahar: **young features:** prominent relief, badly sorted material, boulders, shallow soils
old features: (eroded) included in V*.1.3 and V*.1.4.

lava flow: **young flows:** prominent relief, escarpments, flow lines
old flows: included in V*.1.2, V*.1.3, V*.1.4.

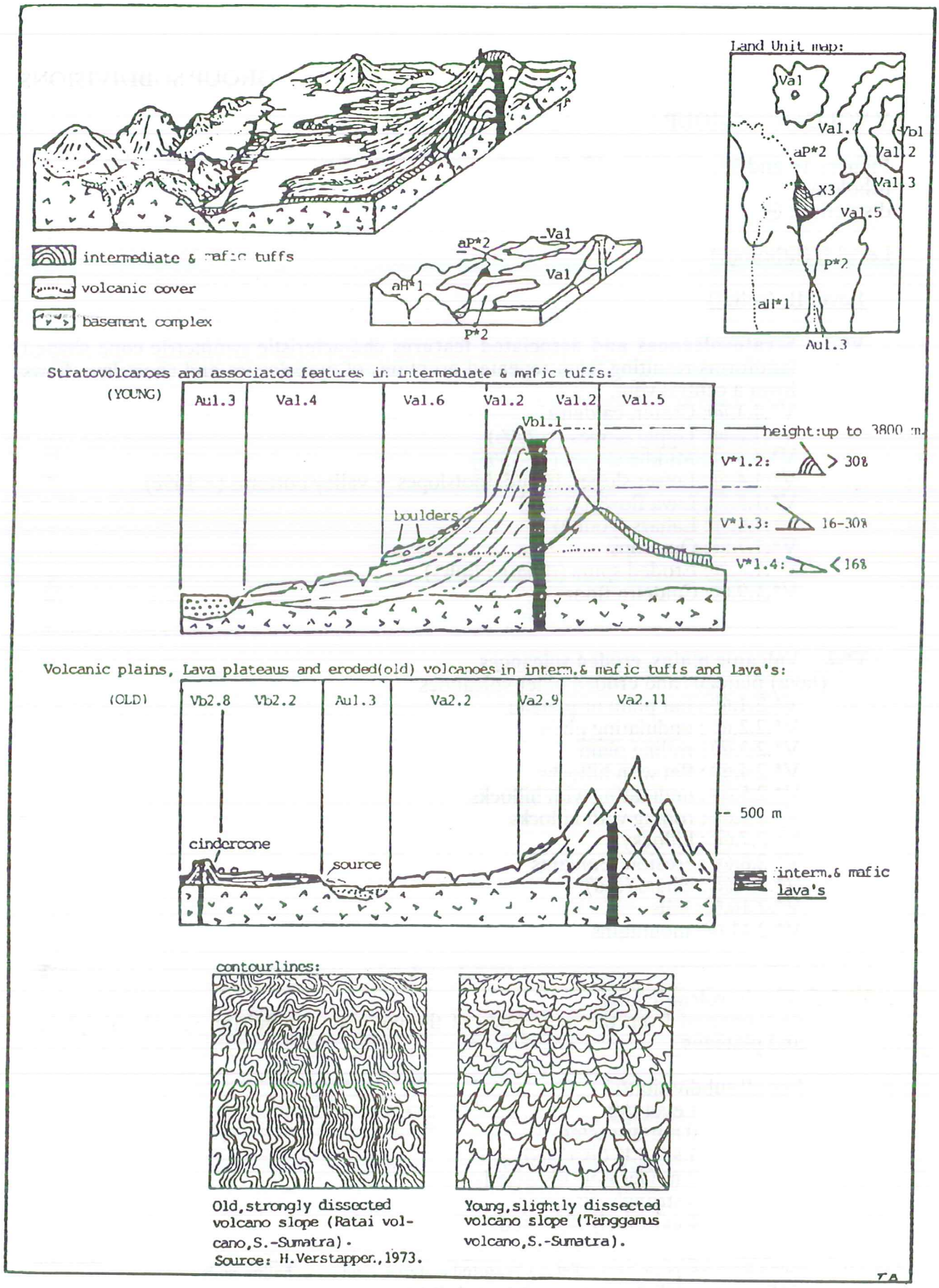


Figure 17. Examples of the Volcanic Group

X MISCELLANEOUS LAND UNITS

Areas that have been extensively changes by human activity (towns, mines, dumps), and non-land areas (water bodies).

The addition of the symbol X to other land unit codes indicates **levelling.**

X1. Steep, erosive river valleys or single slopes without major colluvial or alluvial deposits general slope > 25% but frequently > 75%.

X2. Major settlements, towns, built-up areas, industrial areas.

X3. Lakes, crater lakes, etc.

X4. Open water bodies of rivers, tidal channels, etc.

X5. Mine tailings and waste dumps.

X6. Fishponds (mainly coastal, *tambak*).

ADDITIONAL SYMBOLS

Additional symbols for specific features may be added.
Such symbols are not mapping units.
Specific features can include e.g:
- escarpments
- rocky land, rock outcrops (including "tors")
- deeply incised (narrow) river valleys, canyons.
- permanently water logged land

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Appendix A. Distance between contours in relation to slope classes

General slopes of landscapes can be deduced from distances between contours in reliable topographic maps.

The available 1:250,000 scale topograhic maps have a contour interval of 100m, those at scale 1:50,000 of 25m.

The following table lists the distances between contours for various situations and two map scales. At scale 1:250,000, 500 metres equals five contours. At scale 1:50.000, 250 metres equals ten contours.

Slope %	Slope angle	Scale 1:50000		Scale 1:250.000	
		25 m	250 m	100 m	500 m
3	1.7°	17 mm	166 mm	13.3 mm	66.6 mm
8	4.6°	6.3 mm	62.5 mm	5.0 mm	25.0 mm
15	8.5°	3.3 mm	33.3 mm	2.7 mm	13.3 mm
30	16.7°	1.7 mm	16.6 mm	1.3 mm	6.7 mm
55	28.8°	0.9 mm	9.1 mm	0.7 mm	3.6 mm
75	36.9°	0.7 mm	6.7 mm	0.5 mm	2.7 mm