LATE QUATERNARY LANDSCAPE EVOLUTION IN THE WEST CAMEROON HIGHLANDS AND THE ADAMAOUA PLATEAU

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ABSTRACT : Landscapes of the West Cameroon Highlands and the Adamaoua Plateau and their changes in late Pleistocene and Holocene times have been investigated by means of regolith* stratigraphy with the aid of pollen-analytical and archeological works and radiocarbon dating. Both areas seem to have experienced similar environmental and landscape changes before mid-Holocene time. Most of thin angular-gravelly deposits underlain in part with indurated zone are considered to indicate the frequent occurrence of surface wash in drier savanna environment which was provided with the late Pleistocene climatic desiccation. The reddish fine-textured layer overlying the gravelly wash deposits is mostly considered to be the products of soil creep and some associated processes which were made possible in the early Holocene forest readvance due to climatic humidification. The remarkable forest clearance and, later, cultivation also, since, at latest, around 2,000 y.B.P. may have promoted the formation, maintenance or regeneration of somewhat humified topsoil layers/horizons in various places of the West Cameroon Highlands. In contrast to this, extensive burning and overgrazing have brought the expansion of shrub- and tree-savannas and severe denudation of topsoil layers/horizons particularly since the beginning of the 19th century in most areas of the Adamaoua Plateau. The above natural and man-induced environmental processes have produced the present both areas' landscape characteristics, i.e., the paucity of forest for rainfall and the too wide areal difference in comparison with the climatic difference.

I - INTRODUCTION

This paper presents an example of landscape evolution which incorporates both natural and man-induced environmental processes in humid tropical highlands in West Central Africa.

The present landscape of the West Cameroon Highlands and the Adamaoua Plateau is characterized by the paucity of forest although annual rainfall and the length of dry months seem to be adequate for the existence of forest in both areas. Moreover the difference in landscape between the two areas appears too wide in comparison with the climatic differences between them. In order to elucidate the above discrepancy between landscape and present climate in the two areas, both natural-environmental history and history of human impact on land are investigated by means of stratigraphic interpretation of geomorphological, palynological, and archeological evidences as well as radiocarbon dates.

II - REGIONAL SETTING

The West Cameroon Highlands and the Adamaoua Plateau take the form of a big horst-like massif mostly higher than 1,000m above sea-level, which separates the low plateau and lowland zones of South Cameroon and of the Benoue-Cross River basin (fig. 1). Underlain extensively by Precambrian basements, the massif is in many places composed of volcanic rocks ranging from Tertiary to Quaternary age, some of which form big mountains. Moreover, small volcanic cones and craters without marked cones presumably of late Pleistocene or Holocene age are concentrated in several zones.

Although the massif is generally accepted to be mostly located in the Sudano-Guinean Zone (fig. 1), it receives rather ample annual rainfall and has shorter dry season in normal year due to its high relief and the south-westerly monsoon from the Gulf of Guinea. Temperature of the massif is of course lower than that of the South Cameroon low plateau and the Benoue-Cross River basin, however, mean monthly temperature never falls below 18°C except on some high mountains over 2,000 m above sea-level. The climatic condition of the area is summarized in figure 2.

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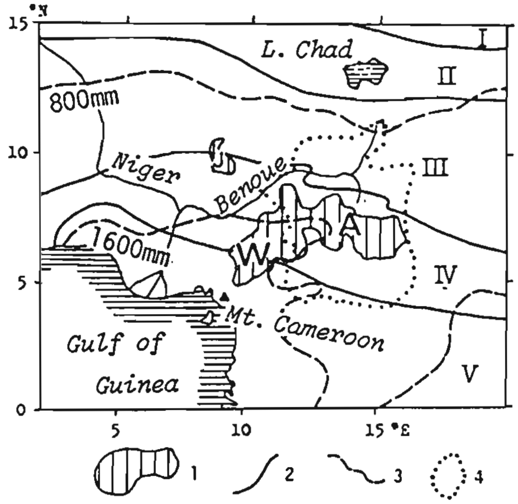

Figure 1 : Location of the study area in the climato-vegetational zonation of north central tropical Africa. A : Adamaoua Plateau : W : West Cameroon Highlands ; J : Jos Plateau ; I : Saharan zone ; II : Sahelian zone ; III : Sudanian zone ; IV : Sudano-Guinean zone ; V: Guineo-Congolian zone ; 1 ; Land over 1,000 m above sea level ; 2 : boundary of climato-vegetational zones ; 3 : isohyet of mean annual rainfall ; 4 : territory of Adamaoua Empire in the 19th century.

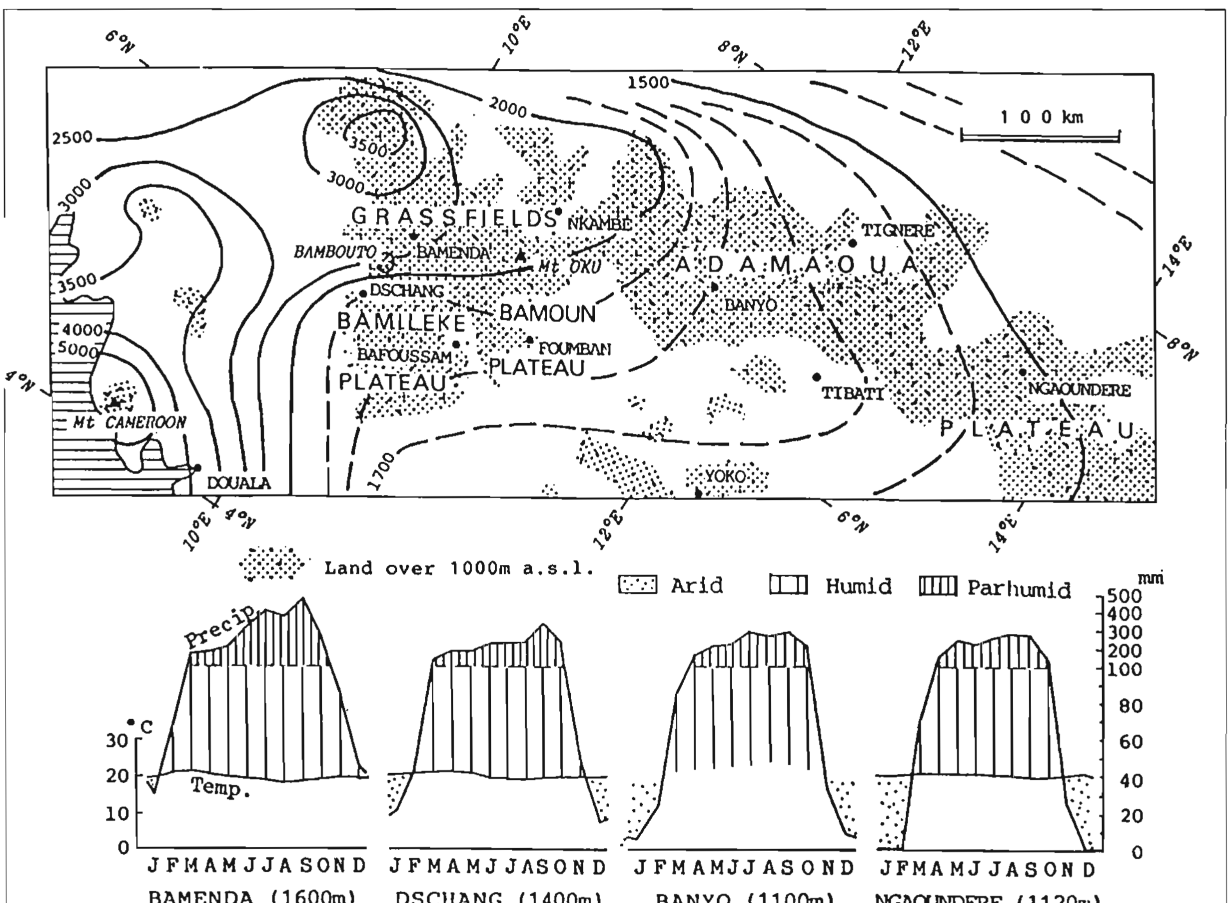

Figure 2 : Climatic conditions of the study area (adapted from Tamura, 1986a).

Figure 3 and table 1 demonstrate that, in south Asia, southeast Asia, and Tropical Australia, the rainforests exist under similar climatic conditions to that of the West Cameroon Highlands and the Adamaoua Plateau. Moreover, in Tropical America, Ogawa (1974) informs that evergreen monsoon forests of the same structure as typical tropical rainforest are distributed in the areas of similar rainfall conditions to that of Asia's monsoon forests. Although it should be of course taken into consideration that the relation between the atmospheric humidity and the rainfall and temperature is various in areas and West and West-Central Africa exposes to particularly desiccated atmosphere due to Harmattan in its "cool" dry season, the rough comparison as above suggests that the climatic condition of the West Cameroon Highlands and the Adamaoua Plateau may be able to provide the habitat for rainforest.

However, evergreen or semideciduous forests are rather rare, apart from afforestation made in this century, in the area studied. Their distribution is restricted to steep slopes particularly of valleys in some high mountains of the West Cameroon Highlands and in narrow valleys of the Adamaoua Plateau and the northeastern part of the West Cameroon Highlands (fig. 4). Although the paucity of forests is common to the West Cameroon Highlands and the Adamaoua Plateau, the Adamaoua's landscape which is dominated by grazed shrub- and tree-savannas and sporadic gallery forests in contrastive to the West Cameroon Highlands' landscape in which cultivated lands are extensive and almost tree-less grasslands and hedges surrounding farm plots are remarkable in the northern part (the Grassfields) and the southwestern part (the Bamileke Plateau) of the highlands, respectively. Letouzey (1979) classifies the actual vegetation of most parts of the Adamaoua Plateau and of the West Cameroon Highlands to the degraded form of the Sudano-Guinean savanna and to the submontane domestic landscape modified from the highland evergreen forests associated with the montane forests, respectively.

III - REGOLITH-STRATIGRAPHIC INFORMATION

The above description may suggest that the present landscape characteristics of the areas studied have been developed under a great influence of human activities, however, they cannot be free from natural environmental changes in longer times. Although the paleohydrological studies of lake-level provide excellent information in pure chronological investigation of natural environmental changes, particularly the change in aridity or humidity, it is somewhat inconvenient for detailed areal comparison of environment and its changes because the distribution of lakes is far from even. The inconvenience is supplemented by the stratigraphic investigation of earth surface material, e.g., soils, superficial deposits, and sedentary weathering products, which cover almost all over the interfluve landsurfaces. Both residual and transported loose or soft earthy material overlying solid bedrock is comprehensively called "regolith" according to a common usage (e.g., Ollier, 1975), and the term "regolith* stratigraphy" is applied to the above investigation (Tamura, 1984) in association with "soil stratigraphy" which means the use of pedological method in correlation of terrestrial sediment (Morrison, 1967).

Regolith-stratigraphic method consists of recognition of each regolith horizon or layer, interpretation of pedological and geomorphological processes concerning formation and interruption of each horizon/layer, and stratigraphic synthesis of those horizons/layers. Not only pure pedogenetic features but also the mode of occurrence of each horizon/layer should be remarked partly because some soil horizons are considered to have an aspect as a layer, a kind of terrestrial sediment, from the microgeomorphological viewpoint. Moreover a tropical soil profile frequently comprises not only rather thin horizons differentiated pedogenetically on pre-existing groundsurfaces but also both thick sedentary weathering zones and surface migratory layers which form groundsurfaces with themselves. The situation may be demonstrated in the adoption of other designation than ordinary A, B, C system to horizons/layers which constitute tropical soil profiles, e.g., CrW, CrT, CrG, and S by Nye (1954), M, S, and W by Watson (1962), and I, II, and III by Segalen (1969). In the present regolith-stratigraphic study, the migratory layers (abbreviated to M), the sedentary weathering zone (W), and the less weathered rock (R) are first discerned and each of them is further divided into several "regolith-stratigraphic units".

In the migratory layers of mostly ferrallitic soil profiles which prevail in the West Cameroon Highlands and the Adamaoua Plateau (Martin et Segalen, 1966 ; Vallerie, 1971), the following regolith-stratigraphic units are designated (Tamura, 1982).

Mh : the uppermost somewhat humic horizon or layer consisting of relatively loose and friable material of various texture ; frequently thin but gently thickening downslope and sometimes exceeds 1 m ; frequently having abrupt or clear boundary ; sometimes missing ; designated mostly as A (particularly A1) horizon in ordinary soil-profile

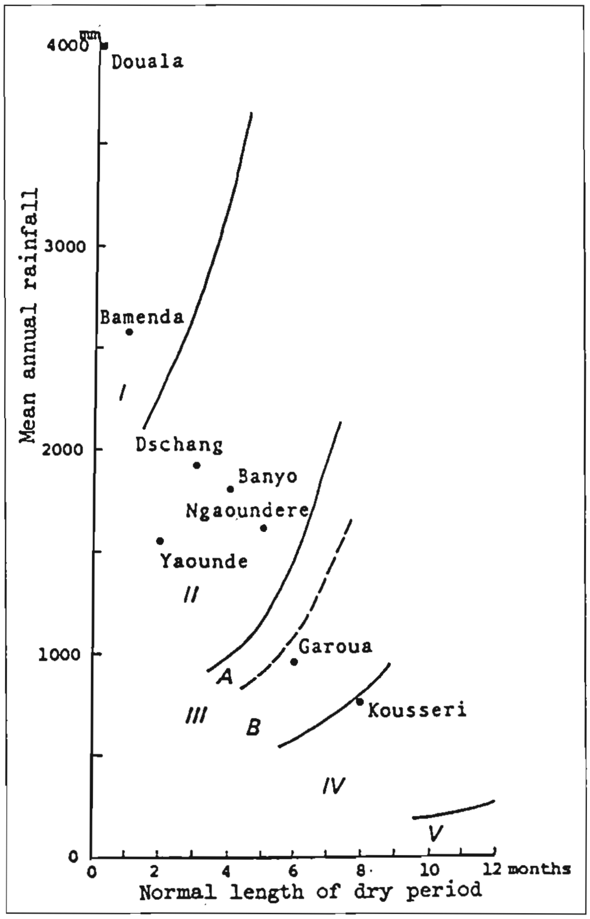

Figure 3 : Comparison of climatic condition represented by mean annual rainfall and length of dry season among South-Asian vegetation zones and several locations in Cameroon. I-V represent the vegetation zones in India, according to Walter, 1971. I : evergreen tropical rainforest ; II : semievergreen tropical rainforest ; III : monsoon forest (A : humid ; B : dry) ; IV : savanna (thorn scrub forest) ; V : desert.

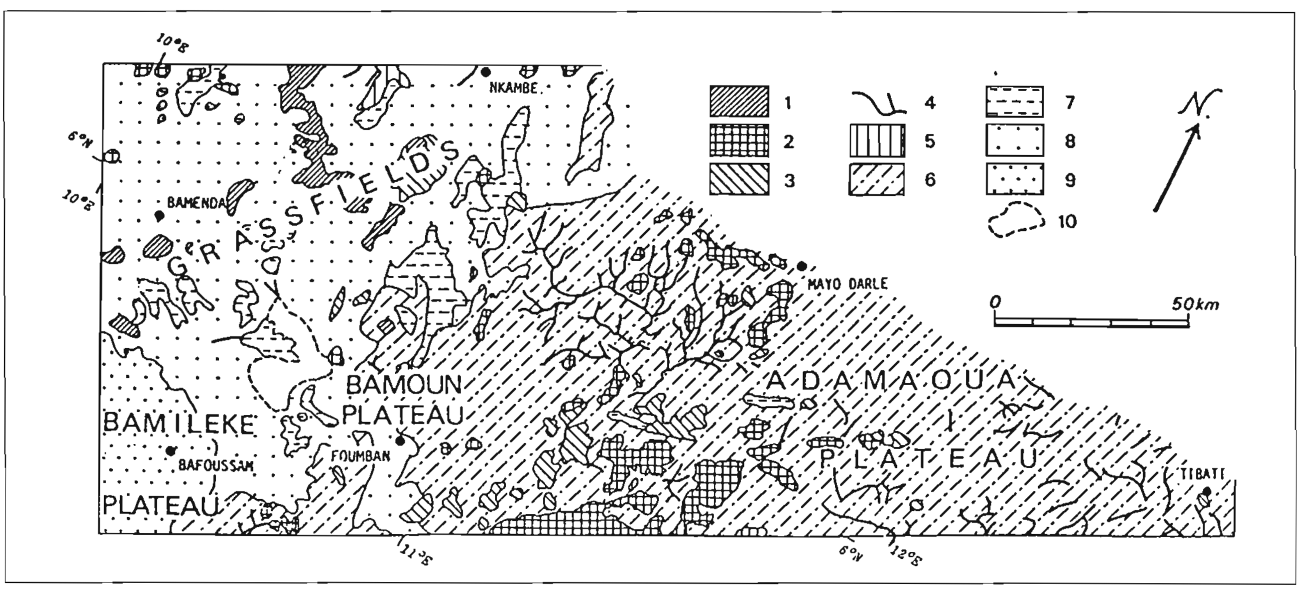

Figure 4 : Vegetation landscape of the principal area studied (adapted from the Pilot Project on Tropical Forest Cover Monitoring, 1978).

<table>
<tr><th rowspan="2">Annual sum of "h"(1)</th><th colspan="3">Vegetation zone</th><th rowspan="2">W. CAMEROON HIGHLANDS & ADAMAOUA</th></tr>
<tr><th>THAILAND(2)</th><th>BURMA(3)</th><th>AUSTRALIA(4)</th></tr>
<tr><td></td><td colspan="2">Tropical evergreen forest, including rain-forest and evergreen seasonal forest</td><td>Rain-forest</td><td rowspan="5">720 Bamenda
545 Dschang
415 Ngaoundéré</td></tr>
<tr><td>360</td><td>Tall deciduous forest or monsoon forest, completely deciduous on slopes (dry monsoon forest) and semi-evergreen on plains (moist monsoon forest)</td><td>Monsoon forest including Moist Teak Forest and dry Teak Forest</td><td>Forest</td></tr>
<tr><td>240</td><td>Prevailingly savanna forest, with dry monsoon forest on less arid habitats</td><td></td><td>Savanna</td></tr>
<tr><td>160</td><td rowspan="2"></td><td rowspan="2">Prevailingly Thorn Forest, with Indaing and Semi-Indaing forest on less arid habitats</td><td>Steppe</td></tr>
<tr><td>80</td><td>Desert and Semi-desert</td></tr>
</table>

Table 1 : Comparison of climatic condition represented by the annual sum value of Angström's humidity coefficient among the Southeast-Asian and Australian vegetation zones and several locations in the study area. 1 : The (monthly) humidity coefficient «h» is defined by Angström (1936) as :

$$h = 1.07^{-t} \times P,$$

where t and P are monthly mean temperature (°C) and monthly total precipitation (mm), respectively ; 2 : Ogawa et al. (1961) ; 3 : After Stamp (1924), cited in Ogawa et al. (1961) ; 4 : Imanishi and Kira 1953).

description in which the horizon is customarily conceived to have been formed solely by accumulation of humus in the same parent material as that of underlying horizon, however, the mode of occurrence of Mh as summarized above shows that in many profiles it has an aspect of a different surface migratory layer from underlying layers/horizons ; considered to have been formed in many cases with some kinds of deposition or disturbance, e.g., soil creep, airfall, and some biogenic and anthropic processes, which keep a pace with accumulation of ample humus.

Mc : relatively thick layer consisting of reddish silt or silt-loam ; having convex cross-sectional surface ; few to many granule- to cobble-size angular gravel ; considered to have been mostly moved by creeping assisted with activity of soil organisms ; perhaps designated partly as B horizon and partly as C horizon in ordinary system in which the unit may be hardly discriminated from sedentary weathering zone (Ws, see below); sometimes called "colluvion fine" by Francophone geomorphologists.

Mg : rather thin layer consisting mostly of granule- to cobble-size angular gravel ; sometimes undulating with an amplitude less than its thickness ; sometimes showing slightly concave cross-sectional form at its basal surface ; some of it is called "stone-line" ; considered to be mostly wash deposits but some other transportation processes may be concerned in its formation ; not including weathering products in situ, e.g., a disintegrated quartz vein, which mostly constitutes a part of Ws (see below).

Mi : indurated horizon of angular-gravelly deposits ; frequently comprising many fragments of formerly indurated zone.

The sedentary weathering zones, which may be almost equivalent to saprolite, are divided into the following two regolith-stratigraphic units (Tamura, 1982).

Wi : indurated horizon developed sometimes at the top of sedentary weathering zone ; equivalent to "cuirass" excepting that of gravelly-deposits origin (Mi).

Ws : strongly weathered but not indurated zone ; generally fine texture ; sometimes retaining structure of original rock decomposed completely ; sometimes containing very coarse material such as jointed blocks, corestones, and exfoliation plates of original rock particularly in the profile of weathered granitic, gneissic and migmatitic rocks ; mostly designated as C horizon and partly B horizon in ordinary soil-profile description.

Figure 5 shows an idealized profile which consists of above-mentioned regolith-stratigraphic units. R, Ws, and Wi, as well as Mi, should be further subdivided in the study of deep-weathering profile development.

According to the stratigraphic arrangement and the mode of occurrence of regolith-stratigraphic units in respective regolith profiles, most profiles observed in the West Cameroon Highlands and the Adamaoua Plateau

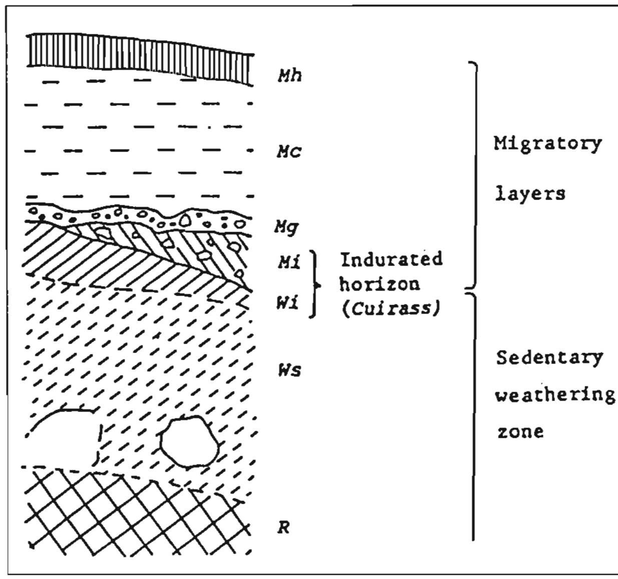

Figure 5 : An idealized regolith profile (Tamura, 1986). See the text for abreviation.

are classified to the "regolith-profile types" (fig. 6) (adapted from Tamura, 1986a). In the case of profiles containing Wi, the following four types are discernible (Hereafter, the symbol "*" indicates occasional occurrence of the horizon/layer).

I1 : Mh/Mc/Mg/Wi/Ws/R ; I2 : Mc/Mg/Wi/Ws/R ; I3 : Mc*/Mi/Wi/Ws/R ; I4 : Wi/Ws/R.

The profiles without Wi are similarly classified as follows.

N1 : Mh/Mc/Mg/Ws/R ; N2 : Mc/Mg/Ws/R ; N3 : Mh/Mg/Ws/R ; N4 : Mh/Mc/Ws/R ; N5 : Mh/Ws/R ; N6 : Mg/Ws-R.

Not only the arrangement of regolith-stratigraphic units but also the mode of their occurrence, particularly their relation to landforms, should be taken into consideration in the typification of regolith profiles. Several units which compose some profile types occur in particular topographic location and are lacking in other topography as illustrated diagramatically in figure 8. Particularly on the profiles which have developed on granitic, gneissic, or migmatitic rocks, the difference in regolith profile according to topographic location is remarkable, and the following three types are discerned.

G1: Mh*/Mc/Mg*/Ws/R
(In this profile types, R takes a form of corestone in Ws and sometimes exposes as rock domes on slope).

G2: Mh*/Mc/Mg/Ws/R
(R is exposed on crestslope frequently as a tor and Mg is mostly derived from breaked quartz vein in R situated in upper position).

G3: Wi'/Ws (Upper slopes)
Mc/Mg/Ws/R (Lower slopes)
(Ferric concretion (Wi') in the uppermost part of Ws on crestslope or upper sideslope are deposited on middle-sideslope surface and covered by Mc on lower sideslope).

The series of regolith-profile types presented above, particularly I and N series, demonstrate that the deposition of Mg, which was followed by that of Mc and sometimes preceded by induration (the formation of Wi and/or Mi), occurred on gently to moderately sloping land almost throughout the West Cameroon Highlands and the Adamaoua Plateau irrespective of difference in bedrock geology. Similar sequence of events is indicated by regolith profiles reported in the forest zone of the South Cameroon Plateau (Kadomura et al., 1986). Although so various processes have been mentioned on the formation of stone-lines as summarized in table II (Tamura, 1975), most layers designated as Mg in the present study are considered of surface origin, mostly wash deposits, buried subsequently by several processes which may involve biological activity, on the evidence of their mode of occurrence as illustrated diagramatically in figures 5, 6, and 7.

At the same time the above series are indicative of differential truncation of regolith profiles which follow the formation of Mc and Mh. Semidetailed field observation reveals that profiles of the I1, N1, and N5 types are frequently occurred in the Bamileke Plateau and the Grassfields in contrast to that the I2, N2, N3, and N6 type profiles are dominant in the Adamaoua Plateau.

The above regolith-stratigraphic facts are considered the results of the following sequence of environmental changes.

1 Deep ferrallitic weathering (formation of Ws) and induration (formation of Wi, partly Mi) in part, which may have proceeded in long time of tropical climate involving many wet and dry phases.

2 Frequent occurrence of surface wash (formation of Mg), which may have been provoked by torrential rains on bare or very sparsely vegetated land. Tropical climate having distinct long dry season is indicated.

3 Predominance of soil creep associated with ferrallitic weathering (formation of Mc) and activity of soil organisms, perhaps chiefly termite. Such processes are effective in perhumid tropical environment.

4 Formation of somewhat humic surface layer/horizon (Mh) by slow movement of inorganic material and/or ample organic-matter supply on relatively stable groundsurface. This process may have been less evident in the Adamaoua Plateau.

5 Occurrence of denudational processes by which Mh, and sometimes Mc also, were removed. These processes were more active in the Adamaoua Plateau than in the West Cameroon Highlands particularly the Bamileke Plateau where Mh and Mc are frequently preserved from truncation.

IV - TEPHROCHRONOLOGICAL, PALYNOLOGICAL AND ARCHEOLOGICAL EVIDENCES ASSOCIATED WITH RADIOCARBON DATES

Regolith-stratigraphic reconstruction of landscapes changes as made in the preceding chapter must be supported and supplementd with other evidences of paleoenvironments and chronology.

Many regolith profiles in some areas of the West Cameroon Highlands contain pyroclastic deposits (tephras) ejected from adjacent volcanoes. Apart from fine tephra material intermingled in Mh, visible coarse tephra layers, mostly scoriaceous, are frequently distributed around respective craters. Among them, a scoria layer which is originated from Lake Baleng, about 7 km north of Bafoussam in central Bamileke, can be traced within the area about 10km to the west of its source (fig. 7) and provides a useful key bed in stratigraphic correlation of regolith profiles. The reconstruction of environmental sequence on the basis of

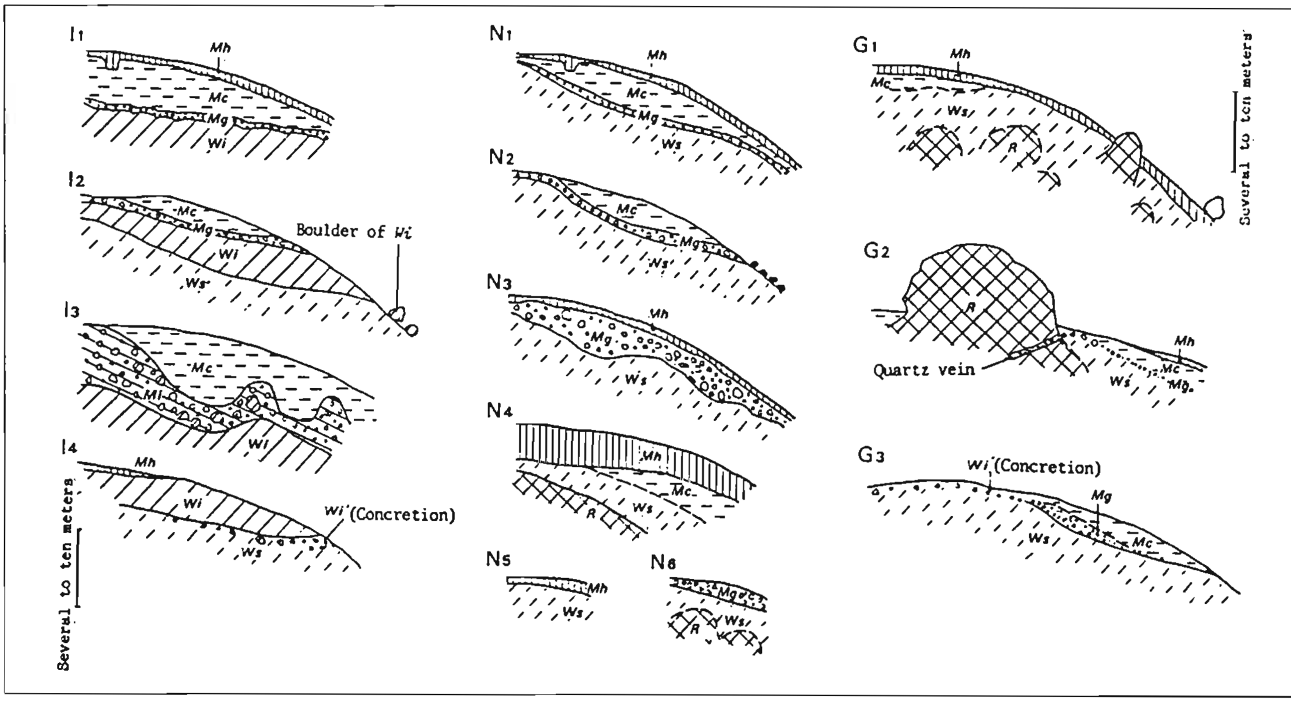

Figure 6 : Regolith-profile types and their series (adapted from Tamura, 1986a). See the text and figure 5 for abreviation.

Microgeologic or geomorphic processes	a	Wind action	Surface origins	fossil
	b	Rapid massmovement		
	c	Streamflow		
	Od	Surface wash		
	Oe	Soil creep		
Pedologic processes in the profile	Of	Activity of soil organisms (especially of termite)	Subsurface origins	fossil / active
	g	Neoformation of secondary quartz		
	h	Weathering in sity		

(O : processes referred frequently)

Table II : Already-referred processes concerning stone-line formation (Tamura, 1975).

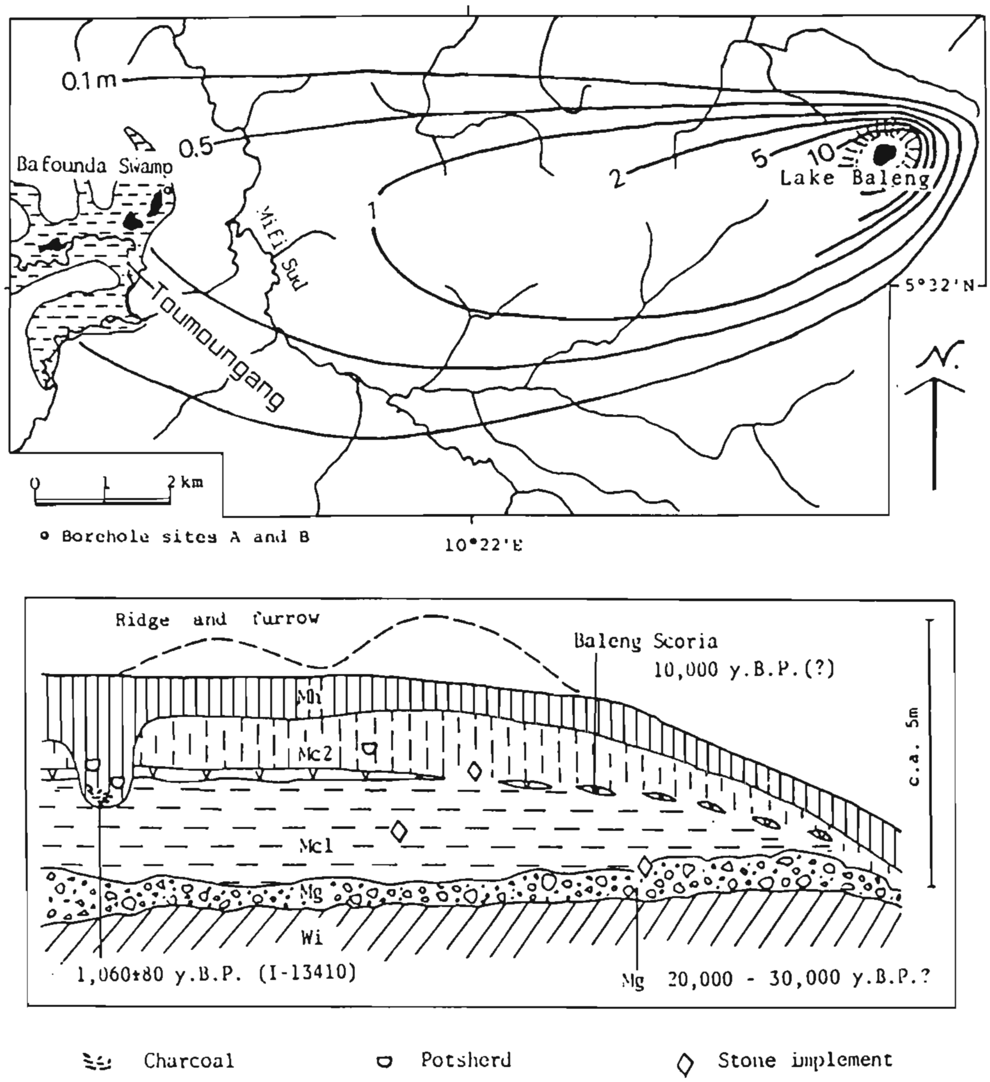

Figure 7 : Isopach map of the Baleng Scoria (top) and standard regolith stratigraphy containing the scoria layer (bottom) in the northern Bafoussam area (after Tamura, 1986a).

stratigraphy in which identification and correlation of key tephra layers are the principal procedure is called tephrochronology after Thorarinsson (1944) (cited from Thorarinsson, 1981).

The scoria layer, named the Baleng Scoria (Tamura, 1984), is intercalated in Mc outside the source volcano, and Mc is thus divided into Mc1 below the Baleng Scoria and Mc2 above it in the northern Bafoussam area (fig. 7). The volcano takes a form of small cone 100m high composed mostly of the scoria and has a crater about 800m across, filled presently with water. The sideslopes of the cone and the crater are not at all dissected by gullies. Although the rate of dissection in volcanic cones must vary according to morphoclimatic conditions, the feature as above suggests that the volcanic cone of Baleng is never older than 1×10^4 years upon comparison with the relation between the erosion ratio and the duration of erosion in 17 volcanic cones in Japan (Suzuki, 1969). It gives an estimate of date of Mc1 and Mc2 as around the early Holocene and middle Holocene, respectively (Tamura, 1984).

Near the western margin of the Baleng Scoria area is situated a swamp named the Bafounda Swamp, about 1,310m above sea-level (Tamura, 1984). It is filled with clayey sediments which was supplied mostly as suspended load in floodwater of a river called the Toumoungang (fig. 7). Two cores of soft clayey sediments have been sampled by the use of a Hiller-type borer on a meadow which emerges in the dry season in the northeastern part of the swamp. As shown in figure 8, a black clay layer which occurs 150-165cm from the surface at Site A and 160-200cm at Site B separates the lower gray clay layer, which color indicates that it is reduced, and the upper brownish clay layer which contains an intercalated reddish brown clay layer considered to have been removed from neighboring hillslopes.

Provisional pollen analysis of Site B sample shows that the lower gray clay and the lower half of the black clay have quite different pollen assemblage from that of the upper brownish clay. The former two layers and the latter are thus designated Pollen Zone I and II, respectively, in figure 8 (Tamura, 1984). Radiocarbon date of slightly humic clay which is intercalated at 112-130cm from the surface in the upper clay layer at Site A is 2,040+/-130 y.B.P. (TH-1175) (Tamura, 1986a). It shows that the abrupt change of vegetation, which includes sudden disappearance of *Podocarpus* and some other pollen types, took place around 2,500-2,900 y.B.P. in association with the change of lithofacies.

Among the trees belonging to the genus *Podocarpus*, only *Podocarpus latifolius (=P. milanjianus)* is presently recognized in the West Cameroon Highlands, particularly in forest patches situated in some valleys in the high montane zones including the flank of Mt. Bambouto (Letouzey, 1968 ; see also Maley et al., p. 336 in this book), which forms a part of the Toumoungang catchment area. According to Hamilton (1982), the pollen diagrams reported from the East African montane forests, where *Podocarpus latifolius* presently takes more humid habitat than that of *Podocarpus gracilior*, displays that *Podocarpus* pollen rises markedly in Late Pleistocene time and declines in Early Holocene time. The rise and decline are interpreted to be correspond to decrease and increase in humidity, respectively. A less significant rise of *Podocarpus* pollen since 3,000 or 2,000 y.B.P. in the highlands of Kenya and Uganda and the coast of Lake Victoria is also atributed to slightly increased aridity (Hamilton, 1982).

At Barombi-Mbo, a crater lake 300m above sea-level, situated about 60km north-northeast of Mt. Cameroon and 130km southwest of the Bafounda Swamp, Maley and Brenac (1987) report a marked change in the occurrence of pollen of some montane taxa and evergreen-forest taxa during recent 28,000 years and indicate the extension of montane condition to lowland in a relatively dry and cool climate in latest Pleistocene time. Based on the above evidence, they discuss the presence of a forest refuge in West Cameroon in the last great arid period. The same pollen diagram shows almost continuous occurrence of small number of *Podocarpus* at least throughout Holocene time except the latest recent in relatively stable semideciduous forest taxa. Intermittent occurrence of small number of *Podocarpus* pollen from about 6,000 y.B.P. to near present is reported by Richards (1986) at another crater lake, Mboandong, about 120m above sealevel, situated in the northern foot of Mt. Cameroon and about 200km southwest of Bafounda. On the other hand Gramineae and *Elaeis guineensis* increase since about 2,400 y.B.P. and 2,000 y.B.P., respectively, at Mboandong. The latter evidences would appear the beginning of forest clearance and cultivation (Richards, 1986).

In central Bamileke area, the bottom of Mh sometimes takes a form of depression several meters across and a few meters deep (I1 and N1 in figure 6), which resembles a garbage pit observed presently in the garden of farmhouses of the area. Mh which fills pit-shaped depressions frequently contains many potsherds and charcoal fragments. Radiocarbon date of 1,060+/-80 y.B.P. (I-13140) has been obtained from charcoal collected from the depth of 2.4-2.5m in Mh which fills a pit 2.8m deep located about 8km west-northwest of Bafoussam (fig. 7) (Tamura, 1984). Most potsherds contained in Mh are fragments of large unglazed pots

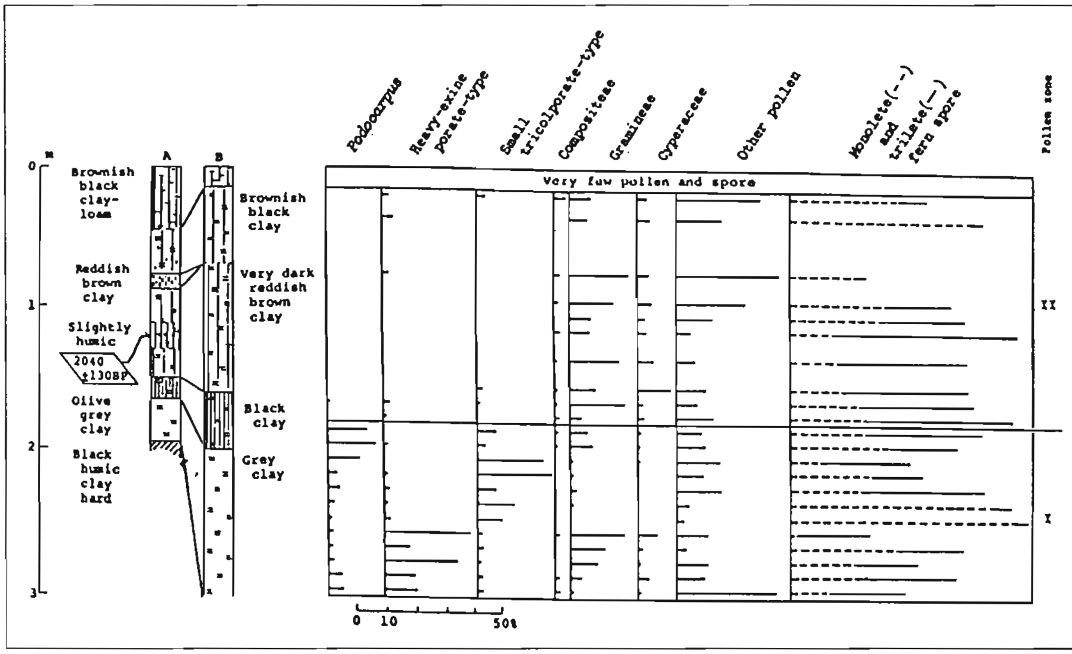

Figure 8 : Pollen diagram of the Bafounda Swamp deposits (added to Tamura, 1984).

made of gritty clay and scored folded-line patterns probably by stamping of comb on their surfaces. Moreover Mc2 in the northern Bafoussam area commonly contains small unidentified potsherds as well as stone implements which are sometimes made of volcanic rock and very elaborated. These artifacts demonstrates human activity in Holocene time and its intensification around, at latest, 1,000 y.B.P. which may have accompanied with cultivation. Apart from the elaborated tools, rather crude large implements made of quartz occur in Mc1 and rarely in Mg in central Bamileke. Similar implements, which were found in lower part of Mc and Mg in southern Adamaoua (Kadomura, 1982a) and the South Cameroon Plateau (Hori, 1982), are typologically identified as mostly of Upper Lupemban to Final Lupemban industries in Latest Pleistocene time (Omi and Kato, 1982 ; Omi et al., 1984).

In the Grassfields, Shum Laka rock shelter, 13km southwest of Bamenda, yields microlithic industry associated with bones of forest animals from the lowest layer which has been radiometrically dated about 8,800 y.B.P. (Maret, 1982 ; Nkwi and Warnier, 1982). This means that the area was covered by or adjacent to forest in which hunting was active in early Holocene time. Large basalt tools occur above the layer dated about 7,000 y.B.P. at the same site. They are associated with or followed by pottery decorated with comb stamping, which is related to the radiocarbon date about 6,000 y.B.P. (Maret, 1982). The stone implements and pottery seem to have close connection with respective similar artifacts contained in Mc2 in northern Bafoussam area, although further typological investigation is necessary.

Maret (1982) reports that the iron smelting sites about 1,400 to 400 y.B.P. have also been found in the Grassfields. Moreover undated slag is spread over various forests in the Grassfields (Nkwi and Warnier, 1982). They indicate landscape changes induced by the mining of indurated horizons, Wi and Mi, and the consumption of wood in those days.

V - APPARENT IMPACT OF GRAZING AND CULTIVATION ON LAND

The greater part of the Adamaoua Plateau is very sparsely populated and utilized principally for grazing at present. The compilation of peopling history such as Mohammadou (1978), Njeuma (1978), Boutrais (1978), and Kadomura (1984) reveals that the presently occupying cattle raising people, Fulani (Foulbé-Mbororo), invaded the Adamaoua Plateau around the beginning of the 19th century (fig. 1). The Fulani's invasion, which is associated with intense raiding, provided a decline of farming population and the extension of grazing land burned every dry season in the Adamaoua Plateau and the adjacent areas to the south.

There have been various discussions about the human influence on the formation of shrub- and tree-savanna spread presently over the plateau (e.g., Letouzey, 1968 ; Boutrais, 1974 ; Hurault, 1975). In any case it is evident that the above-mentioned event in the beginning of the 19th century was followed with marked changes in both mode and intensity of human impact on land. The frequent occurrence of truncated regolith profiles which lack Mh and sometimes Mc also (e.g., I2, N2, N3, and N6 types in figure 6) in the Adamaoua Plateau, as described in Chapter 3, seems to have to be investigated in close relation to both pre- and post-Fulani's invasion human activities on land, although the influence of minor climatic fluctuations should not be ignored.

In contrast to Adamaoua, the West Cameroon Highlands are densely inhabited mostly by cultivators. Many archeological and linguistic investigations suggest that the highlands have been occupied by cultivators during thousands of years (e.g., Warnier, 1984 ; Dongmo, 1984). The evidences represented in Chapter IV reinforce and make more precise the discussion as above. Not only cultivation but also grazing is practiced in various places of the West Cameroon Highlands including the Grassfields, however, the present landscape of the area characterized by paucity of forests is not considered the consequence of grazing by existing cattle-raising people. Because the northern part of the West Cameroon Highlands was already called the Grassfields or "das Grasland" by early Europeans colonists in the late 19th century, previous to the arrival of pastoral Fulani (Mbororo) to the Highlands from Nigeria in the early 20th century, who began grazing without severe conflict in vacant areas such as high rugged lands and swampy lands (Bawden and Langdale-Brown, 1961 ; Dongmo, 1984).

The long history of cultivation, which embraces many times of introduction of new crops and techniques as well as new domestic animals, must be investigated for the elucidation of landscape formation in the West Cameroon Highlands. Particularly some cultivation practice prevalent to the area, e.g., the formation and maintenance of hedges characteristic to Bamileke's agricultural landscape (Morin, 1979 ; Dongmo, 1980), are remarked in reference to landsurface management. As mentioned in Chapter III the regolith-profile types having relatively thick Mh (e.g., I1, N1, and N4), which seems in general to reduce the occurrence of erosive overland flow, are frequently observed in the West Cameroon Highlands, particularly the Bamileke Plateau.

VI - RECONSTRUCTION OF LANDSCAPE AND ITS CHANGE

This chapter intends to reconstruct the study-area's landscapes of respective ages on the basis of regolith-stratigraphic synthesis of the materials presented above and with reference to many reports on paleoenvironment of the area and its surroundings.

Tephrochronological and archeological evidences in central Bamileke area indicate Mc to have been mostly deposited in earlier time of Holocene age. Considering that the perhumid tropical environment is favorable for the development of lithofacies that Mc shows as mentioned in Chapter III, it is inferable that forests existed in those days. The inference is clearly concordant with the results obtained from Shum Laka site which has been presented in Chapter IV. Moreover the currently accepted view of Tropical African paleoenvironments admits the early Holocene humid climate which is recognized as the significant high-level phase with increase of arboreal pollen in many tropical lakes, including Lake Chad and Lake Bosumtwi, in the time between c. 10,000 and 5,000 y.B.P. with some variation (e.g., Maley, 1987 ; Street-Perrott et al., 1985 ; Kadomura, 1982b ; Servant et Servant-Vildary, 1980 ; Pastouret et al., 1978).

Mg is considered to have been mostly deposited in latest Pleistocene time because it is overlain by Mc, most of which is considered the deposits of Holocene age as mentioned above. Possibly Lupemban-type stone implements contained in Mg support the chronological inference. Rather sparse vegetation cover and seasonally concentrated rain, which are effective for the frequent occurrence of surface wash, are reconstructed as the environment of those days. It means drier savanna environment as that seen presently in the Sahelian or the Sahelo-Sudanian zone. It is concordant with the general trend of climatic desiccation of the tropics around 20,000 to 15,000 y.B.P. (e.g., Maley, 1987; Street-Perrott et al., 1985 ; Kadomura, 1982b ; Servant et Servant-Vildary, 1980 ; Pastouret et al., 1978). Most of Mi, Wi and Ws represent various periods of drier and of wetter climate preceding to latest Pleistocene age.

The existing Mh is, in some places, considered to have been formed by slow movement, disturbance, or accretion of earth material as well as accumulation of humus or humification in the time which follows the formation of Mc in the places. Palynological and archeological evidences found in Mh in cental Bamileke area suggest that forest clearance and agricultural activities began at latest around 2,500 or 2000 y. B.P. and are intensified around 1,000 y.B.P. The pollen records at Mboandong crater lake and some iron-smelting remains in the Grassfields support the suggestion. Those human activities on land are expected to have induced both the development of Mh and the denudation.

Actually Mh is better preserved in the West Cameroon Highlands, and many regolith profiles in the Adamaoua Plateau have fragmentary Mh on the upper sideslopes. It suggests that the formation of Mh proceeded in both the West Cameroon Highlands and the Adamaoua Plateau, although it may have been more active in the former area, and that the more severe denudation followed on it in the latter area. The relatively poor development of Mh in Adamaoua may be partly due to a worse supply of fine tephra and somewhat drier climate than the West Cameroon Highlands. However, the most significant factors which provide the difference in development and preservation of Mh between the two areas are the continuation of intense but rather careful cultivation in the West Cameroon Highlands and the extensive grazing associated with burning since the early 19th century in Adamaoua.

The latter activity induces surface wash which accelerates denudation. Particularly on lower sideslopes and in shallow troughs around gully-heads, not only Mh but also Mc is frequently denuded to expose Mg and, in extreme cases, Wi or Mi, which hinder for short grasses to take roots on (Tamura, 1986b). It is considered to be closely related to the fact that bush- and tree-savannas prevail in the Adamaoua Plateau in contrast to the Grassfields where predominant gramineous grasses take roots on Mh and avoid the invasion of trees.

In the colonial age and after the independence also, landscape of the West Cameroon Highlands and the Adamaoua Plateau has been considerably altered with modern human activities such as plantations, ranching, afforestation, mining, and various construction works. Such types of landscape reorganization are, however, phenomena beyond the scope of present discussion.

VII - CONCLUDING REMARKS

The following history of landscape evolution is given as a conclusion of the above discussion (fig. 9).

Significant difference in landscape can not have been recognized between the West Cameroon Highlands and the Adamaoua Plateau in latest Pleistocene and early Holocene times. Drier savanna environment which was characterized by concentrated rain after marked long dry season prevailed in latest Pleistocene time. It provided gravelly surface wash deposits, which were underlain in part with indurated zone of the products of former environment. Human occupancy did not influence the landscape so effectively in those days. In contrast forest environment readvanced due to climatic humidification in early Holocene time. Soil creep associated frequently with biogenic processes and ferrallitic weathering having proceeded under the condition produce finetextured surface layer underlain with former wash deposits.

Since mid-Holocene time human action on land, which includes forest clearance and, later, cultivation also, has become remarkable. It promotes the formation of somewhat humic and porous plowed horizon/layer which is effective for diminishing the occurrence of surface wash and, on the other hand, induces surface wash due to degradation of vegetation. In various places of the West Cameroon Highlands, particularly gently undulating central Bamileke and a part of the Grassfields, diminution of the surface wash occurrence is dominant. Although forests have been extensively replaced by domestic landscape, humified topsoil layers/horizons have been maintained or effectively regenerated by both some kinds of local cultivation practices and the suitable supply of fine tephra in the greater part of the West Cameroon Highlands.

In contrast to this, extensive burning and overgrazing have brought the expansion of shrub- and tree-savannas and severe denudation of top-soil layers/horizons particularly since the early 19th century in most areas of the Adamaoua Plateau. It has been followed with the exhumation of the products of Pleistocene paleoenvironments, i.e., gravelly wash deposits and indurated zones, both of which have conditioned for further sprawl of bush. Moreover decrease in cultivating population of the plateau may have made more difficult to maintain or regenerate plowed top-soil layer.

Thus similar climatic/environmental changes since, at latest, late Pleistocene time and areally differential human impact on land since mid-Holocene time, particularly during recent 200 years, have produced the present landscapes, which have both similarity and areal contrast, of the West Cameroon Highlands and the Adamaoua Plateau. Formation and destruction of regolith profiles are the result of changing landscape and, at the same time, prepare a condition for the subsequent change in landscape. Further investigation is necessary for the study of changes in both climate and human activity and

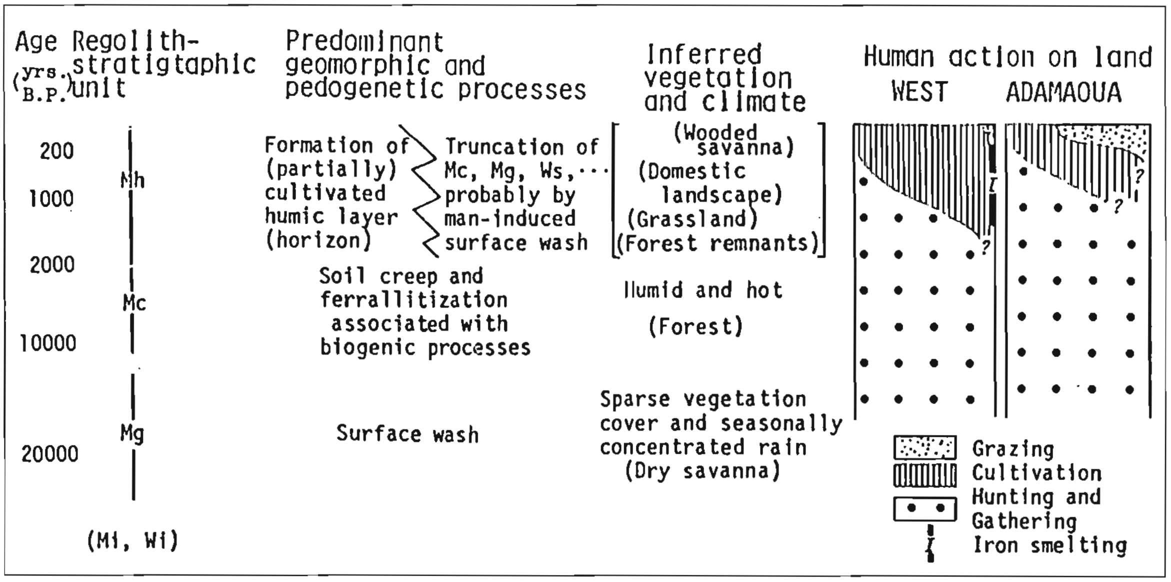

Figure 9 : Environmental and landscape changes in the West Cameroon Highlands and the Adamaoua Plateau. See figure 5 for the abreviation of regolith-stratigraphic units. Lateral changes in each column indicates areal variation (adapted from Tamura, 1988).

their influence to landscape in the times from the beginning of agriculture and iron smelting to the 18th century.

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