Multiscale Landform Classification Study in the Hills of Japan: Part ? Device of a Multiscale Landform Classification System

著者	TAMURA Toshikazu
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Multiscale Landform Classification Study in the Hills of Japan:

Part I

Device of a Multiscale Landform Classification System

Toshikazu TAMURA*

1 Introduction

The method of classification and mapping of all landforms in an area has been developed chiefly in the field of applied geomorphology, particularly as an effectual means for integrated land resources survey. In other sciences, however, rational classification of objects is generally considered to be one of the principal subjects. In geomorphology also, landform classification must be established as one of the basic processes for scientific recognition of landform. The method is expected to be valid first for inventory of geomorphic problems of an area and finally for systematic representation of geomorphic characteristics of the area. Discussing some methodological problems which were preliminarily reviewed by Tamura (1980) this paper proposes a new framework of landform classification in order to promote comprehensive recognition of geomorphic characteristics of the hills as a type of areal geomorphic unit which composes active island arcs in the humid temperate zone. Actual application of the proposed system to several hills in the Japanese Islands will be made in Part II.

This study has been continued under impetus from many other studies in which I have participated at the Institute of Geography, Tohoku University and the Department of Geography, Tokyo Metropolitan University. I would like to express my gratitude to the members of staffs of the both institutions and other colleagues for many valuable suggestions, particularly to Prof. K. Nishimura of Tohoku University, now at Komazawa University, for continuing guidance and encouragement.

2 The characteristics and requisites of landform classification

In every physicogeographic science the objects can be classified according to both their intrinsic nature as "things" and their spatial occurrence as "regions". Classification or division as "regions" is generally accepted as a different process

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* Department of Geography, Tokyo Metropolitan University

from typological classification as "things" even in the case where areal discontinuity of the objects is not apparent.

In the case of soil study, for instance, the unit for field survey is *soil profile* which is usually composed of several soil horizons and regarded as a sample of each soil landscape (Hodgson 1978). Although they are three-dimensional entities soil profiles are treated as dimensionless "things" in the procedure of typological classification. Therefore, it follows that any typological unit of soil cannot have dimensions. Mapping typological soil units is considered to be delimitation of a kind of small "regions" is usually made according to areal distribution of respective soil landscapes from which soil profiles were selected and classified in the types. Soil-mapping units as "regions" sometimes do not coincide with soil-classification units as "things", partly because mapping scale is generally different from the scale of field survey and partly because soil landscapes often merge into one another. Spatial relationship of different soil units, *e.g.* catenary association first indicated by Milne (1935), is frequently considered not in the process of classification but in the procedure of mapping, though according to Bushnell (1942), Milne seems to have later considered to give some meaning as soil classification unit to *catena*.

More established concept of field-survey unit as soil profile mentioned above is *pedon* in the Comprehensive Soil Classification System in the United States (Soil Survey Staff 1960). Recently *pedon* is considered to be a sampling unit (Soil Survey Staff 1976) and *polypedon*, which includes several contiguous pedons within the same soil series, is called "soil individual" as a small segment of soil landscape (Johnson 1963). Preparation of the concepts of pedon and polypedon enables multicategorical classification of soils as "things" in the Comprehensive System. Particularly polypedon is important as a joint of classification which is a function of typology in essence, and mapping which is in the constraint of scale and spatial continuity/discontinuity. Even in the hierarchic system of Dokuchaevian pedology which is based on highly areal phenomena as zonal arrangement of environment in continental scale (*e.g.* Gerasimov and Glazovskaya 1960), the processes of descending soil classification is discriminated from procedure of soil-geographic regionalization which is made as a spatial organization of occurrence of classified soil units of various ranks, although it is considered that the hierarchy of soil classification corresponds generally to the dimension of areal occurrence of respective soil units.

Vegetation study is always begun with sampling of *stand* from vegetation landscape (Itow 1973). Although morphology and dimension are considered as attributes of any stand, cognition and systematization of plant communities in either classificatory approach as Zürich-Montpellier system (Braun-Blanquet 1964) or ordination approach (*e.g.* Whittaker 1973), is made through pure typology of stands which are in practice represented by quadrats in respective stands. Consequently plant communities are rather "things" than "regions" though any plant community is, as stated by Mueller-Dombois and Ellenberg (1974), unimaginable without the space it occupies. "Regions" represented on vegetation maps as to corresponding to respective plant communities are different in essence from typologically classified communities though both are often confused with each other because of settled-on-the-ground character of plant communities (Usui 1973). Each mapped "region" usually corresponds to a pattern or mosaic of communities which are combined recurringly (Mueller-Dombois and Ellenberg 1974). The above situation is understandable on analogy of soil study. Moreover it can be pointed out that stand is applied correspondingly with polypedon as a bridge between classification and mapping.

Problems concerning classification and regionalization are thoroughly discussed in climatology (*e.g.* Knoch und Schulze 1954). It is often emphasized to distinguish climatic-type classification from climatic division which is made as areal representation of classified types (*e.g.* Maejima 1967; Yazawa 1980). It means that climatic types can be treated as "things" but, in most climatic classification systems, definition of climatic types is given only for the purpose of delimiting climatic regions. Any concept of the individual equivalent to polypedon in soils and stand in vegetation may not be established in climatic classification study. Although effort in mapping has been recently made in hydrology also (IASH and IAH 1962; Heindl 1971), it seems to be intended to only represent areal distribution of variable hydrologic elements and factors separately or overlaid on hydrological maps. The complication between typological classification of objects as "things" and representation of areal occurrence of classified units as "regions" do not yet become a serious problem in hydrological mapping.

In landform classification, on the other hand, processes of typological classification is hardly distinguished in general from procedure of regionalization. For instance, the clearly defined primary units or taxonomic "individuals", which are presented by Wright (1972) as an essential prerequisite to definite classification of landforms do not correspond with soil individuals as polypedons or stands in vegetation study but the smallest areal unit recognized geomorphologically. Rational areal association of contiguous "individuals" form a higher-class unit in the scheme of geomorphology-based land classification suggested by Wright (1972). It means that classification and regionalization are concurrent in his scheme. On different standpoint R.E. Murphy also stated in the lecture at Tohoku University in 1968 on his classification of the world landform (Murphy 1968) that landform classification must be classification of "regions" as well as of "things". The above situation is considered because areal shape and its arrangement are indispensable to recognition of surface morphology which is the most important attribute of landform. Therefore, a typological classification system of landforms cannot be free from a system of regionalization.

In the classification of "things" hierarchic systems are often adopted and they are called multicategory classification systems. The above-mentioned classification systems of soil and of vegetation are typical multicategory ones in which units of each rank are classified according to its category in either ascending or descending classification. Recently Kato (1977), comparatively investigating several soil classification systems, concludes that descending classification and ascending ones are applicable to the lower and the higher categories than the fundamental units named *soil types*, respectively. Such an idea of combining descending and ascending classification is adopted in the new classification system of Japanese soils proposed by Matsui (1978). Wright (1972) insists the necessity of establishing a strict ascending system, which is based on well-defined taxonomic individuals, for objective and truly applicable landform classification.

It is concluded from the consideration in the paragraph above and the immediately preceding one that any unit in the hierarchic system of landform classification must be both typological and areal, and that higher-class units must be not only a typological association but also an areal association of lower-class units in the system. The above characteristic of landform classification can be called *the parallelism of typological and areal hierarchy*. It is the logical basis of the trend that suitable mapping scale is smaller for higher-class units than for lower-class units. Moreover, it is advisable that the hierarchic system of landform classification is neither simply ascending nor descending. In other words, the fundamental unit should not be fixed to landform units of any particular class, in spite of the insistence by Wright (1972) as mentioned above. It is indicated in fact that landform units of each class can be recognized independently by taking notice of respective geomorphic characteristics in respective suitable scales even if neither association of lower-class units nor subdivision of higher-class units operate and that lower-class units sometimes cross boundaries of higher-class units. If such a system is established, recognition of landform units and both ascending and descending classification can commence from any class. The characteristic can be called *the flexible and reversible hierarchic classification without any fixed fundamental units.* It is inevitably derived from the parallelism of typological and areal hierarchy in landform classification.

3 A brief review of some landform classification systems

The characteristics and requisites of landform classification as mentioned above seem to be rather evident but often are not fully considered in some actual systems of landform classification. Although most of the classification systems which will be referred to below have their own purpose for general or specified land resource inquiry, the present discussion is focussed on the methodological aspects of them as geomorphic landform classification.

In "detailed geomorphological mapping" which has been prevalent since the 1950's in the European Continental countries, typological classification of landforms is made on the basis of criteria concerning each aspect of landform, *viz.*, morphography, morphometry, morphogenesis and morphochronology, at the scale of 1:25,000 to 1:50,000 in general (Demek *et al.* 1972). The four aspects, among which morphogenesis and morphochronology are emphasized particularly in Polish and French systems (Klimaszevski 1956; Tricart 1962), and every landform in an area is classified independently and subsequently superposed on one another on a map. Therefore, a kind of systematic classification of landform as "things" is performed but classification as "regions" is rather difficult in the approach. Geomorphic regionalization is obliged to be made as spatial organization of various landforms which were classified typologically in detailed geomorphological mapping (Gellert in Demek *et al.* 1972). Such a situation is analogous to classification of soils, plant communities, *etc.* Recently I.G.U. Commission on Geomorphological Survey and Mapping that was developed from a group of scientists concerned with detailed geomorphological mapping commenced to establish an ascending hierarchic classification system on the occasion of compiling national- and continental-scale geomorphological maps (Demek 1976; Demek *et al.* 1978).

A kind of well-defined areal landform unit is presented in "morphological mapping" in the United Kingdom (Waters 1958; Savigear 1965). The approach is based on precise mapping of slope with special attention to slope discontinuities. It was developed from the idea of "ultimate units of relief" in the system of morphological regionalization by Linton (1951) and characterized by pure morphologic representation without genetic interpretation to which great importance is attached in detailed geomorphological mapping. The large scale geomorphological mapping system by Kugler (1965) in the German Democratic Republic is more similar in this respect to the British morphological mapping than to European detailed geomorphological mapping. The characteristic of morphological mapping ensures more objective classification but seems to make the approach insufficient for "geomorphological" landform classification. Moreover a hierarchic system of morphological units is not established in the approach, though it is derived from Linton's system (Linton 1951) in which seven classes of morphological regions are distinguished. I consider the morphological mapping to be a useful technique for recognition of the smallest landform units in sloping land (Tamura 1969, 1974a).

Linkage of lower- and higher-class areal landform units is theoretically elaborated and practically utilized in "land system mapping", which commenced in 1946 by the Division of Land Use Research and Regional Survey, Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia (Christian and Stewart 1952), as a kind of integrated land resources survey generally in smaller scale than those of "detailed geomorphological mapping" or "morphological mapping". The method has spread widely over the countries with vast unused and/or unsurveyed land (*e.g.*, UNESCO 1965; Brink *et al.* 1966; Bawden 1968; Thomas 1969). In this approach *land system* is recognized as an area composed of spatially recurring and genetically associated *land units*, each of which is an areal landform units formed by the same process in the same age. It was stressed in earlier publications on the approach that the spatial magnitude or scale of land system and land unit was not fixed and a set of land system and land units could be applied to any areal landform unit and its components, respectively (*e.g.*, Christian 1958), but later, in practice, the scale became fixed. For example, land unit in erosional landscape was defined as slope segment which was morphologically characterized with slope angle and location (Mabbutt and Stewart 1963), and lower category *site* was added as the smallest unit (Christian and Stewart 1968).

Although the approach of land system mapping based on the recognition of a kind of natural landscape unit with a hierarchic regional system was devised independently as a technique and methodology of reconnaissance resource survey in Australia (Christian and Stewart 1952, 1968), the root of such a concept can be traced back to Bourne (1931) and Unstead (1933) through Linton (1951). Moreover, similar concepts are presented and utilized in such land resource surveys in several countries as "land economic survey" as in Northern Michigan in the 1920's and 1930's, in which the idea of *land type* was developed by Veatch *et al.* (Barnes 1929; Veatch 1937; Davis 1969; *etc.*); reconnaissance survey and mapping of soil in East Africa since the 1930's in which the concept of *catena* was proposed by Milne (1935); and "landscape science" in U.S.S.R. (*e.g.* Solntsev 1962), *etc.* It is one of the common characteristics to all these approaches that a regional system of landform units is established on the basis of recurrent landscape pattern and its genetic interpretation. The characteristic is not only useful for efficient collection of land information available for any land-use purpose but also desirable for pure geomorphological landform classification that is regional as well as typological.

The "landscape approach" as above, as well as "genetic approach" as detailed geomorphic mapping, has a limitation concerning reproductivity or objectivity of classification and definition of fundamental unit (Mabbutt 1968; Wright 1972). Therefore, with a marked advancement of auto-scanning and data processing, the approaches may be replaced, as recommended by Mabbutt (1968), by "parametric approach" as a method of land resources survey, particularly the survey for some specific land-use purposes. However, singificance of landscape approach in pure geomorphic studies in a certain region deserves more attention though the approach has been provided for land resources survey. In this connection close association of landscape and genetic approaches is necessary.

A hypothetical model presented by Dalrymple *et al.* (1968) is a successful example of combination of landscape approach and genetic approach. They recognized nine landsurface units by precise observation of surface features, soil morphology and active processes. Because each unit is characterized by surface form and present-day processes, morphologic and morphodynamic description of total landsurface of a certain region is possible by the use of the model, although morphochronologic aspects seem to be not so fully considered in the model. Further elaboration of the model was made by Conacher and Dalrymple (1976) and its meaning as a process-response model of the earth surface was considered.

Parametric approach will serve to develop a more objective classification and regionalization in pure geomorphological studies if selection of landform attributes is appropriate to the studies or so comprehensive as to enable a flexible classification. In some experimental studies by Speight (1968, 1974, 1976), for example, a number of parameters are selected and operated not for pursuit of their direct correspondence to individual land attributes which they may be closely related to respective landuse purposes, but for explicit and efficient recognition of suitable landform units which represent certain suits of characteristic attributes.

Methodological framework of several kinds of geomorphic mapping which have been practiced as national and local governmental projects in Japan was given by Nakano (1952, 1955) and partially amplified by Nakano (1961), Agriculture, Forestry and Fisheries Research Council (1963), *etc.*, though there were somewhat similar preceding or contemporary ideas (*e.g.*, Tōki 1931; Asami 1951). The method, which is essential according to the genetic and landscape approach, is characteristic in that delimitation of small areal landform units and their regional association are considered more seriously than in the European detailed geomorphological mapping in which typological classification of genesis, age and morphology of individual landforms is the principal concern. If the Japanese method is improved in the following respects, it will be more suitable than the European detailedgeomorphological mapping for geomorphic recognition of landforms as "regions" as well as "things".

Genetic or quasi-genetic classification and empirical or temporizing classification are not superposed but paralleled in several kinds of geomorphic maps, published by national or local governments of Japan. In the classification of hilly or mountainous lands the criteria of classification are derived from only primitive morphometry and even simple morphotypologic classification of hillslopes is not made except in "the land condition maps" of a few selected areas. In the classification of landforms of plains genetic names are given but investigation of genesis is not always sufficient and morphodynamic or morphochronologic consideration are often defective. Nakano (1952, 1955, 1961) and Agr. For. and Fisher. Res. Council (1963) presented respective hierarchic classification systems of areal landform units, in which system *landform type* (Nakano 1952, 1955, 1961) and its equivalent *shôchikei* (Agr., For. and Fisher. Res. Council 1963) was dealt with as a fundamental unit and higher-class units were set up with association of lower-class units. Nakano (1961) made a correlation of the units of his system to those of Linton's (1951). The systematic hierarchic classification is, however, not completely realized in the mapping as some governmental projects, in which detailed classification in plains and rather rough classification in mountains and hills are intermingled on a sheet and rather empirical regionalization is made. The varieties of landform units and the empirical criteria for classification or division are stipulated by ministerial ordinance. It is surely effective for standardization of classification in areas distant from each other and by different surveyors, but on the other hand, it diminishes the flexibility of the classification.

The defects as above have been already criticized in part by, *e.g.*, Hatano (1971), Kadomura (1972, 1977) and Koizumi (1977), and some personal efforts to practice more rational classification and mapping have been done. For instance, Takeshita (1964) performed morphologic classification of slopes in low mountains and provided the meaning of slope units in the present-day and recent slope processes by soil morphologic investigation. Moriya (1972) also made morphologic classification and mapping of slopes in the different mountains and considered the evolutional sequence of the slope units in terms of landslides. In the valley-head areas in several hills Tamura (1969, 1974a, 1974b, 1978) recognized five or six *micro-landform* units which were delineated by a method of morphological mapping in on very large scale and proved their morphodynamic meanings by soil morphologic survey as well as observation of surface micro-features. The same name *micro-landform unit* was applied by Kadomura (1967) to the smallest component of alluvial lowlands. He recognized *landform regions* with a key of recurrent pattern of micro-landform units and inferred morphogenesis and morphochronology of the units. Combination of landscape and genetic approaches and application of hierarchic areal landform classification as above brought successful results in his study in which a new framework of photo-interpretative detection of soft grounds was proposed. It should be pointed out, however, that the fundamental unit was fixed to the micro-landform units in the system.

4 Proposal of a multiscale landform classification system

As desirable aspects for establishing more valid geomorphological landform classification system which is characterized by *the parallelism of typological and areal hierarchy* and *the flexible and reversible hierarchic classification* as outlined in Chapter 2., the following are drawn from the existing systems referred in Chapter 3.

a flexible hierarchic classification system of areal landform units in CSIRO land system mapping, especially in its earlier days;

delimitation of small areal landform units, especially of plains, and their regional association to higher-class units in the Japanese method;

a consistent interest in morphogenesis and morphochronology in European detailed geomorphological mapping especially of Poland and France; and

objective recognition of small pure-morphologic units especially of hillslopes in British morphological mapping.

Special attention to the matters as above brings forth an idea of multiscale landform classification.

Most systems for classifying any object are multicategory systems as mentioned in Chapter 2. In the case of landform classification, multicategory system is nothing but a multiscale one because of the parallelism of typological and areal hierarchy. If a multiscale system is established it will be also realized in the system that the landform units of each class can be recognized independently in respective suitable scale, that is the other characteristics of desirable landform classification. Recognition of landform units and both association and subdivision of them which have both genetic and areal bases will be able to be initiated from any class in the system.

The plan of multiscale landform classification will be proposed below with examples of landlforms of active island arcs in the humid temperate zones as the Japanese Islands. Although the consideration of the biggest forms as continental masses or morphoclimatic zones which are designated "the landforms of the first magnitude" by Fairbridge (1968) after Cailleux and Tricart (1956) cannot be performed by use of the examples because it does not affect the purpose of the present study so seriously. Tamura (1978) already presented a similar tentatively scheme. The hierarchy of scale in the multiscale system is framed of course according to spatial magnitude of the geomorphic units which belong to the scale and often the result corresponds to the units. It does not mean the adoption of descending classification that the following description commences from higher-class units. Any geomorphic unit of any scale is first noted in its morphologic features and subsequently recognized as an unit after morphogenic, morphostructural and morphochronologic investigations likewise in other geomorphic classification and mapping.

In the assemblage of island arcs as the Japanese Islands, geomorphic characteristics ranging over several arcs can be distinguished. The area in which the characteristics are realized is designated *the superarc-scale geomorphic units*. The areal grouping of five island arcs which compose the Japanese Islands into two arc systems by Sugimura and Uyeda (1973) presents examples of the units. The subordinate category is of course *the arc-scale geomorphic units* which correspond to individual island arcs. A kind of zonal arrangement of a trench, a non-volcanic outer arc and a volcanic inner arc, which are the essential components of island arcs and called the first-order topography of arc-trench system by Kaizuka (1975), seems to be not necessarily correlated to the units of the next category. The lesser units as outer-arc rises, mid-arc troughs, central ranges along volcanic fronts, *etc.*, which are referred to as the second-order topography by Kaizuka (1975), are designated *the subarc-scale geomorphic units*.

The regional-scale geomorphic units correspond to individual mountains or plains composing the subarc-scale units. The Ishikari Plain (so called Ishikari Lowland), the Kitakami Mountains, the Sendai Plain, the Kanto Mountains, the Kanto Plain, *etc.* provide examples of geomorphic regions delimited with regard to regional-scale units. They have areas of 10^4–10^3 km^2 and are presumed to have been formed by tectonic movements during 10^7–10^6 years in general.

Each plain consists of lowlands, uplands and, in places, hills. For example, the Kanto Plain, the Tokyo Lowland, the Musashino Upland, the Tama Hills, *etc.* are its constituents. Each mountain is recognized as a regional-scale geomorphic unit and is also composed of several branches, for instance, the Okutama Mountains as southeastern branches of the Kanto Mountains. Such lowlands, uplands, hills and mountains as above are designated as *intermediate-scale geomorphic units*. The location and features of each unit of the scale are considered to be the results of tectonic movements during 10^6–10^5 years although erosional and depositional modification of shorter duration is considerable especially in uplands and lowlands. Their areal extent, which is about 10^2–10^1 km^2, is likely to correspond to areal extent of "the groups" as lithostratigraphic units. It is reasonable that typological grouping of intermediate-scale unit in each regional-scale unit is frequently required as all the hills in a plain. But such grouping as above cannot form an individual unit in the multiscale landform classification system because it is the result of not areal but only typological classification.

The fundamental units in general morphochronologic studies at the scale of 1:25000 to 1:100000 are terrace surfaces which are often called geomorphic surfaces without a multiscale viewpoint. The equivalents to terrace surfaces are terrace scarps and valley floors in dissected uplands as intermediate-scale units. The terrace surfaces and their equivalents are designated *detailed-scale geomorphic units* in the mutiscale system. The corresponding landforms of the detailed-scale units in lowlands are alluvial fans, natural levee zones, lowlands in river mouths including deltas and emerged estuaries, and coastal lowlands. As the equivalents to them in the hills, which will be discussed in detail in the later chapters, Tamura (1976, 1977, 1978) listed hilltop gentle slopes, hillsides, small river terraces, hill-foot gentle slopes and valley floors. Most forms of the detailed-scale are often regarded as fundamental units in some preexisting landform classification systems, for instance, *the forms* in European detailed geomorphological mapping (*e.g.* Demek *et al.* 1972) and *the landform type* by Nakano (1952), but the concept of fixed fundamental unit is rejected in the multiscale system. To the formation of geomorphic characteristics of detailed-scale units, exogenic processes generally controlled by eustatic change of sea-level and climatic change during 10^5–10^4 years, as well as geomorphic locations or site conditions, are usually more significant than endogenic processes in the same or longer duration except for several forms directly or indirectly controlled by tectonic movements or volcanic activities, for example, fault scarps, alluvial fans on volcanic flanks, *etc.*

Supplementary categories are sometimes required between the intermediate-scale geomorphic units and the detailed-scale units and between detailed-scale units and micro-scale units. They are preparatory designated *the semidetailed-scale geomorphic units* and the *subdetailed-scale geomorphic units*, respectively. Examples in the hills will be shown in Part II.

The lowest category of the present system is *the microscale-geomorphic unit.* The micro-landform units defined by the author (Tamura 1969, 1974a, 1977, 1978b) in valley-head areas in hills, *viz.*, crest slopes, side slopes, head hollows, head floors and channelways, and ordinarily called micro-landforms in lowlands, *e.g.*, natural levees, inter-levee basins, s (saad) and ridges, *etc.*, are examples of the units of the scale. The equivalents of them in uplands have not been fully investigated but the original terrace surfaces and shallow depressions which are similar to head hollows may correspond to the units. Although relic forms of 10^4 years ago may be included, most of units of the scale are considered to be direct results of recent erosion and deposition except some micro-scale units of tectonic origin as fault trenches, *etc.*

The recognition of smaller units than the micro-scale geomorphic units is not always impossible. For example, the author referred the micro-morphological units which were recognized with the application of morphological mapping (*e.g.* Waters 1958) to extremely intensive scale as 1:500 or more (Tamura 1969). Some micro-features due to solution of limestone are smaller geomorphic units than micro-scale units.

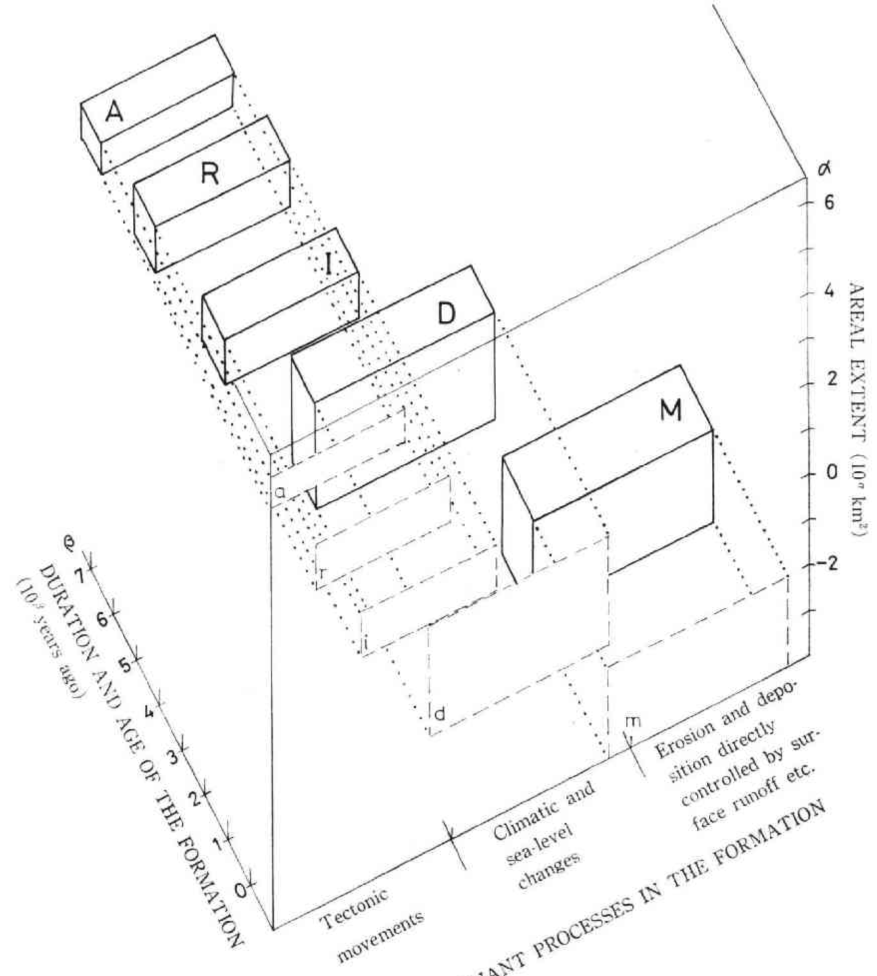

Fig. 1 Range of space, the formative ages and processes of geomorphic units of respective scales.
A: Arc-scale geomorphic units, R: Regional-scale g.u., I: Intermediate-scale g.u., D; Detailed-scale g.u., M: Micro-scale g.u.
a, r, i, d and m are shadows of A, R, I, D and M, respectively, projected on the plane of 10^{-1} years ago.

The above-mentioned respects on geomorphic units of each scale in the mutiscale system are illustrated in Fig. 1 in the form modified from the diagram which was used by Haggett *et al.* (1965) for comparison of regional studies in their areal scale, time-span and range of subject treated. Any unit in the multiscale system as presented above is both typological and areal. For example, valley floors in the hills and not-dissected alluvial fans in the lowlands are typologically similitudes as origin, age and material and situated in the same position in morphogenesis and morphochronology, because both are Holocene fluvial depositional forms of detailed-scale but are associated in different units according to their respective areal coherent in intermediate-scale classification.

The parallelism of typological and areal hierarchy is also realized in the system. Higher-class units of the system occupy broader areas with more complex composition and are characterized by more comprehensive genesis and chronology than lower-class units. For example, the hills which include depositional forms of the Holocene as valley floors and erosional forms since the late- or mid-Pleistocene as hillsides are generally recognized as erosional and structural or tectonic forms of the mid- or early-Pleistocene as a whole.

Moreover, the system enables both ascending and descending classification of landforms from any scale unit according to the purpose of classification. For some kinds of morphotectonic consideration, subdivision of the arc-scale geomorphic units into the subarc- and regional-scale units will be appropriate. In tranditional morphochronologic studies recognition of detailed-scale units and their association in the intermediate- and sometimes the regional-scale units have been practiced without comprehending its multiscale nature. In morphodynamic interpretation of micromorphologic characteristics of hillslopes by Tamura (1969, 1974a), the micro-scale units are directly recognized in a part of the intermediate-scale units without regard to the detailed-scale unit. It is a matter of course that initial recognition of any scale geomorphic unit and subsequent association or subdivision of it is made in respective appropriate mapping scales. In general mapping scales of 1:500 to 1:2,500, 1:10,000 to 1:100,000, 1:200,000 to 1:500000 and 1:1000000 to 1:2000000 seem to be appropriate to investigate the geomorphic units of micro-, detailed-, intermediate- and regional-scales, respectively. In some cases boundaries of higher-class units are not followed but crossed with lower-class units. For example, valley floors being crossed with boundaries of mountains and hills in intermediate-scale classification are not always divided with the boundaries in detailed-scale classification, and crest slopes as micro-scale units are frequently crossed with boundaries of hilltop gentle slopes and hillsides, both of which are detailed-scale units. Despite that classification of geomorphic units can be made independently in any scale, the hierarchy of units of different scales is

Table 1 A tentative correlation of hierarchic

Tamura (this paper)	Tamura (1978)	Tamura (1974a 1969)	Agr., For. & Fish. Res. Council (1963)	Nakano (1961)	Nakano (1952, 1955)	Kadomura (1967)	Speight (1976)	Thomas (1969)	Brink et al. (1966)	Christian & Stewart (1968)
Superarc-scale geomorphic units				Landform division						
Arc-scale geomorphic units	*Kyodai-chikei*			Landform province						
Subarc-scale geomorphic units	*A-kyodai-chikei*			Landform sub-province						
Regional-scale geomorphic units	*Daichikei*		*Daichikei*	Landform section	Landform area			Landform region	Land region	
Intermediate-scale geomorphic units	*Chūchikei*		*Chūchikei*	Landform association	Landform group		Landscape type (Land system)	Landform system	Land system	Land system
Semidetailed-scale geomorphic units				Landform series	Landform family Landform series	Landform regions	Landform pattern region	Landform complex Unit landform	Land facet	Land unit
Detailed-scale geomorphic units	*Shōchikei*		*Shōchikei*	Landform type	Landform type	Micro-landform units		Facet		
Micro-scale geomorphic units	*Bichikei*	Micro-landform units	*Bichikei*	Parts	Parts		Landform element	Site	Land element	Site
		Micro-morphological units								

* Supplemented by Linton.

** Modified by Fairbridge (1968)

preserved as a whole. For instance, the characteristics of hills as intermediate-scale units are found in valley floors in the hills even if they resemble valley floors in the uplands. Flexible and reversible classification of landforms is also accepted in the system as mentioned above.

The multiscale landform classification system is different in the above respect from the previously proposed hierarchic systems of landform classification, some of which were referred to in Chapter 3. It is debatable to correlate several scales of the multiscale system to respective classes of the previous systems. Only a tentative correlation of them is presented in Table 1.

systems of landform classification

<table>
<tr><th colspan="3">Christian and Stewart (1952)
Christian (1958)</th><th>Linton
(1951)</th><th>Bourne
(1931)</th><th>Veatch
(1937)</th><th colspan="2">Gellert
(in Demek et al. eds. 1972)</th><th>Cailleux & Tricart
(1956) **</th><th>Yoshikawa et al.
(1973)</th><th>Nishimura
(1968)</th></tr>
<tr><td rowspan="3">(very extensive scale)</td><td rowspan="4">(moderately intensive scale)</td><td rowspan="6">(very intensive scale)
?</td><td>Major division</td><td rowspan="4">?</td><td rowspan="2">Division</td><td rowspan="3">(Hierarchy of form) *</td><td>(Hierarchy of region)</td><td>Landform of 2nd magnitude</td><td>Global morphology</td><td rowspan="3">Major landform</td></tr>
<tr><td>Province</td><td rowspan="2">Morpho-region</td><td rowspan="2">3rd magnitude</td><td rowspan="2">Major relief (in narrow sense)</td></tr>
<tr><td>Sub-province</td><td rowspan="2">Physio-graphic unit</td></tr>
<tr><td>Land system</td><td>Section</td><td>Form group</td><td>Morpho-macrochore</td><td>4th magnitude</td><td>Meso-relief</td><td rowspan="4">Meso-landform
?</td></tr>
<tr><td rowspan="2">Land unit
?</td><td rowspan="2">Land system</td><td rowspan="2">Tract</td><td rowspan="2">Region
?</td><td rowspan="4">Unit</td><td rowspan="4">Form complex</td><td>Morpho-mesochore</td><td rowspan="2">5th magnitude</td><td rowspan="7">Minor relief</td></tr>
<tr><td rowspan="3">Morpho-microchore</td></tr>
<tr><td rowspan="10"></td><td rowspan="5">Land unit
?</td><td rowspan="5">Land system</td><td rowspan="4">Stow</td><td rowspan="4">?</td><td rowspan="3">6th magnitude</td></tr>
<tr><td rowspan="4">Minor landform</td></tr>
<tr><td rowspan="3">Land type</td><td rowspan="4">Form</td><td rowspan="2">Morphotop group</td></tr>
<tr><td rowspan="3">7th magnitude (kilo-metric)</td></tr>
<tr><td rowspan="3">Site</td><td rowspan="3">Site</td><td rowspan="2">Morphotop</td></tr>
<tr><td rowspan="5"></td><td rowspan="2">Land unit
?</td><td rowspan="2"></td><td rowspan="4">Micro-topography</td><td rowspan="4">Micro-landform</td></tr>
<tr><td rowspan="4">Form parts</td><td rowspan="4"></td><td rowspan="2">Minor-forms less than 1 km^2</td></tr>
<tr><td rowspan="3"></td><td rowspan="3"></td><td rowspan="3"></td><td rowspan="3"></td></tr>
<tr><td rowspan="2">Micro-geomor-phology</td></tr>
<tr><td></td><td></td></tr>
</table>

Summary

General characteristics and requisities of the framework of landform classification have been investigated in order to utilize the method of landform classification, which had been developed chiefly in the field of applied geomorphology, as the basic procedure for pure geomorphic recognition of landform. *The parallelism of typological and areal hierarchy* and *the flexible and reversible hierarchic classification* have been pointed out as principal requisites after a critical review of pre-existing methods of landform classification and geomorphic mapping. A multiscale landform classification system has been proposed to satisfy the requisites especially

in active island arcs in the humid temperate zone as the Japanese Islands. The system consists of *superarc-*, *arc-*, *subarc-*, *regional-*, *intermediate-*, *detailed-* and *micro-scales* and a few incidental scales as *semidetailed-* and *subdetailed-scales* are set in some cases. The range of space, the formative ages and processes of geomorphic units of respective scales are diagramatically illustrated and the scales are tentatively correlated to respective classes of previously established landform classification systems. Further consideration and examination of the multiscale landform classification system will be practiced in Part II with actual application of the lower categories than regional-scale geomorphic units of the system to pure and applied geomorphological studies in several hills of the Japanese Islands.

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