Chugoku Mountains as a Staircase Morphology

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Principal geomorphological features in the Chugoku Mountains, occupying almost whole the peninsula-like region of the most southwestern Honshu Island of Japan, are three levels of erosion surfaces and relief zones between them. Purpose of this paper is to study these features and some other minor features in relation and to generalize some principles of physical geomorphology in such a mountain area.

In this paper the Chugoku Mountains mean not only the Backbone Ridge Mountains but almost all mountain area in the Chugoku Region with exceptions of volcanic areas.

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To respectable Professor F. Tada this paper is dedicated.

1. Erosion Surfaces

One of the characteristics of morphogenesis in orogenic zone is that the mountain-building goes on before the cycle of erosion reaches at the ultimate stage, for the velocity of the former is faster than of the latter. It results multicyclic morphologies.

Erosion surfaces on mountain crests or on mountain flanks reported everywhere in Japan are symptoms of multicyclic morphologies, if carefully correlated and restored. The Chugoku Mountains are a typical example of the multicyclic morphology.

Among many students, Minoru Ooide (1912) was the first suggester of the multicyclic morphology of the Chugoku Mountains who thought the Kibi Highlands as an elevated peneplain and the Backbone Ridges as a residual mountain. Yanosuke Otuka (1937) made it more distinctive, who thought that the erosion surface of the Kibi Highlands denudating the Miocene beds is originated after the Miocene age and the Backbone Ridges without the Miocene beds was then already a land area. Geological studies following were more geological and parted from geomorphological studies.

Akira Watanabe (1950) divided the Kibi Highlands and the Backbone Ridges as separate physiographic divisions at the first time, before him they were not clearly divided. The Eastern Chugoku Mountains and the Kammuriyama Mountains in his division are the Backbone Ridges in the writer's division, and the Chugoku Highlands is the Kibi Highlands and the Iwami Highlands. Sohei Kaizuka (1950) defined another erosion surface, the Setouchi surface, apart from the Backbone Ridges and the Kibi Highlands.

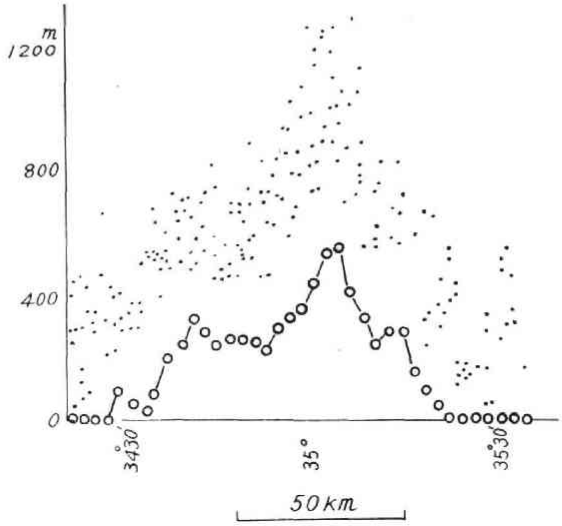

Fig. 1. Transverse profile of the Chugoku Mountains along 130°E longitude, clearly indicating the staircase morphology.
dot: summit circle: lowest point

The multicyclic morphology of the Chugoku Mountains is presented as a staircase morphology of three erosion surfaces.

The Backbone Ridge surface (Dogoyama surface, Higher surface) is a supposed surface restored from some residual summit flats.

The Kibi Highland surface (Middle surface) is wide-developed erosion surfaces northern and southern sides of the Backbone Ridges, and southern ones are called the Kibi Highlands and the Suho Highlands, and northern ones the Iwami Highlands.

The Setouchi surface (Lower surface) is an erosion surface fringing the Kibi Highland surface especially at its southern side. The writer proposes to enlarge the Kaizuka's definition to include the submarine erosion surface under the Seto Inlandsea, which is rather the core and the subaerial part is peripheral.

The making of the staircase morphology seems to be explained by Walter

Penck's Piedmont Stairs theory (1925). The process of mountain-building in the Japanese Islands has been favorable to make such Piedmont Stairs. It has been not continuous, with some ceasing ages which permitted to make erosion surfaces. Destructive agencies acted incessantly, but when the erosion surfaces elevated, they changed their action areal to linear, and the result was destruction of the erosion surfaces. Thus the Piedmont Stairs considered to be ubiquitous in the Japanese Islands have been destroyed mostly.

There have been the most favorable conditions to leave wide erosion surfaces in the Chugoku Mountains. One of the conditions is broadness of the mountain mass, which means gentleness of the mountain-building, and this facilitates the making of erosion surfaces and reversely makes the destruction difficult even when elevated. Another condition is that the elevation by the mountain-building has been not high, and from it come the same effects as the above condition. Recently reported pedimentation in this area (Akagi 1961, 1962) seems to promote the forming of erosion surfaces and moreover the semi-arid climate supposed from the pedimentation seems also to be favorable to make the erosion surfaces and to preserve it. And the rarity of post-Tertiary dislocation is a factor to retard the destruction.

Landform of former cycle is always chased by of later, and the destruction of former is the construction of later simultaneously. The Chugoku Mountains have been subject to destruction from around, and present destruction due to the present sea level as base level of erosion reaches somewhere through the Kibi Highland surface to the Backbone Ridges.

a. The Backbone Ridge surface

The Backbone Ridge surface is a supposed erosion surface restored from some residual summit flats and the similarity of summit heights of the Backbone Ridges.

That the summit heights of Mountains Dogo, Hiba, Sentsu are respectively 1279 m, 1268 m, 1142 m and distances between any two are over 10 km, makes easy to understand the similarity of summit heights of the Backbone Ridges. Comparing summit heights along the longitudinal axis of the Backbone Ridges about 250 km, they are included almost in 1400 m–600 m and more than half of them are in 1200 m–900 m.

Landscape of the summit of Mt. Dogo is an example of summit flats in the Backbone Ridges. Radiating valleys from the summit change their gradients at knickpoints bordering the summit and their shapes suddenly become V-type. The summit flat has 10 square km in area and between 1268 m and 950 m in height, that is 300 m relative height per 10 square km. Raised part of the summit flat seems like dome which is called Noro locally. Lithological difference between Noros and other parts means that Noro is a kind of Härtling, for instance the east-west directed Noro involving the top summit coincides with gabbro area surrounded by granite. It is notable that on the summit flat develop some surface features by human activity, which are ruins of sand-iron mining (Kannanagashi) and animal

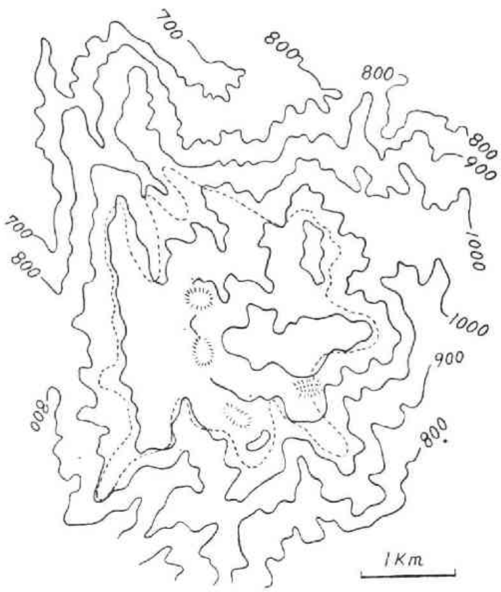

Fig. 2. Summit flat of Mt. Dogo.
broken line: boundary of summit flat dotted area: sand-iron mining scar

tracks. The summit flat belongs to the former cycle, and weathered soils are so thick that Kannanagashi, an artificial selective erosion, had been practiced, of which ruins look like scooped out troughs about 20 m deep. Because the summit flat has been used for the long time as grazing pasture, many animal tracks which are soil creep scars caused by cattle climbing, can be seen on slopes with adequate inclination and poor vegetation.

On the top of Mt. Hiba about 10 km west of Mt. Dogo are some summit flats not so wide as that of Mt. Dogo, which are overlain by basaltic lava flow (Imamura 1950). Thus, the summit flats show landscape of basalt mesa. Mt. Azuma and Mt. Ryuo, two of many peaks on Mt. Hiba have typical ones. The surface of basaltic lava flow is parallel with the summit flat and it is clear that the basaltic lava flowed there. Area of the basaltic lava flow is supposed to have been wider and continuous, but the erosion is more advanced than at Mt. Dogo, and most of the lava flow has been destructed. By the erosion, rim of the lava flow became vertical and bedrock became steep, not vertical, escarpment. As the lava flow destructed en bloc and the bedrock continuously, benchlike exhumed summit flat can be observed, for instance at the south end of Mt. Azuma basaltic mesa, and such a landscape is reported also at Matsuura area in northwestern Kyushu (Iwatsuka 1954).

The Backbone Ridge surface has generally considerable undulation, and raised part of it is named Noro as above mentioned, and sunken part is somewhere considered as intermontane basin, as examples Yawata basin and Kammuri basin in the west end of Hiroshima Prefecture. These basins are parts of an erosion surface and they are genetically erosion basins.

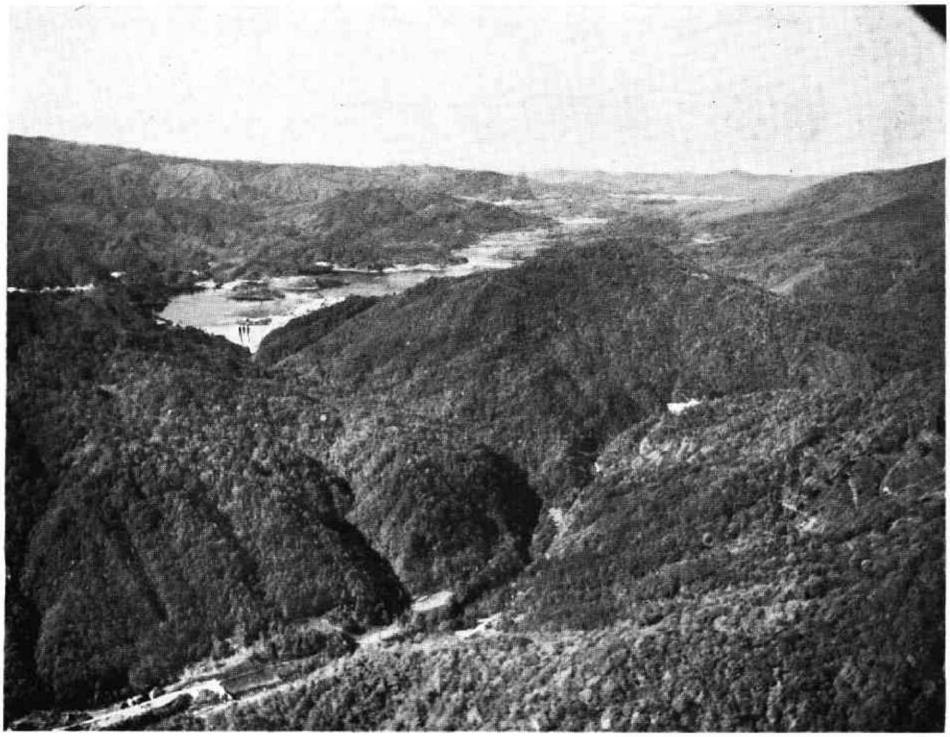

Fig. 3. Yawata basin, a part of the Backbone Ridge surface.

b. The Kibi Highland surface

The erosion surface well developed in Okayama and Hiroshima Prefectures was named Kibi Highlands by Takuji Ogawa (1906), of which landform was studied by Bunjiro Koto (1909), Minoru Ooide (1912), Tsutomu Ogura (1918, 1930), Takeo Kato (1922). And in 1930' many researches concentrated to solve the geomorphological problems of it. Masahide Sugiyama (1931, 1933) studied geomorphometrically summit level and valley level of the Kibi Highlands and regionally landform of the foot of Mt. Nagi. Studies of Yokichi Mino (1933a and others) aimed to subdivide the erosion surface and to correlate younger gravel beds and landform, and on the younger gravel beds was there Toshio Takeyama's study (1933) mainly to find some dislocation. Yanosuke Otuka (1937) explained the relation between the Backbone Ridges and the Kibi Highland surface as mentioned above.

Most of the studies on the Kibi Highland surface have researched especially in Okayama and Hiroshima Prefectures, where typically it developed, but about its delimitation and extention has been little known. That it extends to Tamba

Fig. 4. Mt. Noro with a wide summit flat, correlative to the Backbone Ridge surface, closely located to the Inlandsea.

Highlands in Hyogo Prefecture was already known, but the northern and western extention was not clear. The Suho Highlands and the Nagato Highlands in Yamaguchi Prefecture and the Iwami Highlands in Shimane Prefecture are all the correlative erosion surfaces of the Kibi Highland surface. It became clear by Akira Watanabe's physiographic division (1950) that the Backbone Ridges were separated east and west parts by the Go River gateway. And through this gateway the Kibi Highland surface continues to the Iwami Highland surface. Recently it was found by Yoshihiko Akagi (1958) that along the Hakubi railway-line the Kibi Highland surface extended to the San-in side and connected with the most eastern part of the Iwami Highland surface. To determine the continuity of the Kibi Highland surface, three procedures are practical. When the erosion surface directly continues, it is easy to determine the correlation. Insertion between the Backbone Ridge surface, the upper one, and the Setouchi surface, the lower one, is useful to determine the Kibi Highland surface, the intermediate one. And as the longitudinal profile of the river originating on the Kibi Highland surface has only one knickpoint (Nishimura 1962), it is not difficult to determine the Kibi Highland surface by investigating the longitudinal profiles.

In the western part of Hiroshima Prefecture the Kibi Highland surface separately intermingles with the mountain masses detached from the Backbone Ridges. The Toyohira Highlands in the north side of the Oota River is an example of such separated Kibi Highland surface and Mt. Noro is an example of such detached mountain mass of the Backbone Ridges.

Tracing the Kibi Highland surface westwards from the eastern part of Hiroshima Prefecture it comes to the Saijo basin and surrounding Kamo Highlands. The Kurose River draining the Saijo basin maintains the valley floor about 200 m in height, and it flows down abruptly at the Nikyu fall about 10 km from the mouth. The longitudinal profile clearly indicates the Kibi Highland surface and its edge, which is one of the most close limits to the Inlandsea (Fig. 8). At south and east of the Kurose River is a big mountain mass of Mt. Noro with a summit flat 4 km east to west, 3 km north to south in width. And it is higher than the general level of the Kibi Highland surface. Its top summit Zendanayama has 839 m in altitude and the relief of the summit flat is about 200 m. Considering the relative height to the Kibi Highland surface, the summit flat of Mt. Noro is correlative to the Backbone Ridge surface.

c. The Setouchi surface

Rolling surface around Ube in Yamaguchi Prefecture and at other places named the Setouchi surface by Kaizuka (1950) continues to the submarine erosion surface under the Suho-nada. Along the present coast some varieties such as sea cliff, drowned valley and coastal terrace are illustrated, which have been produced since post-Pleistocene age. At Pleistocene age, when the Inlandsea was dry, a wide erosion surface has been made which was the newly named Setouchi surface and some parts of them were left subaerial at the post-Pleistocene submergence. Of course the accurate shape of the submarine parts of the new Setouchi surface is not certain, but there must be an erosion surface restored from submarine rock floors. It is perhaps possible to subdivide the erosion surface some divisions according to the subsections of Pleistocene (Mogi, 1962).

Comparing three erosion surfaces, the higher has smaller area in turn if approved the new Setouchi surface, and it seems to be rational because the higher has been suffered longer destruction.

2. Relief Zones

As mentioned above, landscape of the Chugoku Mountains is a staircase morphology, and there are two bordering zones between any two steps, upper bordering zone and lower. At these bordering zones lower erosion surface interfingers to upper erosion surface, and maximum relief appears, therefore they can be called relief zones.

Where the Kibi Highland surface is close to the Inlandsea, the relief zone is presented by many islands in the Inlandsea, some of which were already landtied or landlocked.

Traversing the relief zone from the upper erosion surface to the lower, in not so long distance all stages of cycle of erosion are observable. The upper erosion surface is corresponding to the initial surface and the lower to the ultimate surface, and young, mature and old stages are involved in the relief zone.

On the stages of cycle of erosion will be here some critiques developed. As the stages are qualitatively defined, the limits of stages are in vague. It seems possible to define the stages clearly and definitely by using a geomorphological quantity varying with the progress of cycle of erosion. And as the geomorphological quantity Reliefenergie is one of the most fittest, for it is considered to augment from the young stage to the mature stage and to reduce from the mature stage to the old stage. But thinking in detail the maximum value of Reliefenergie has a duration. Where there is enough altitude, after the maximum Reliefenergie is once realized, summit descending and valley floor descending take place simultaneously. As the inclination of mountain flank or valley wall is regarded as constant within a certain limit the values of summit descending and valley floor descending coincide and thus the maximum Reliefenergie continues. Where is not enough altitude, before the initial surface disappears valley floor descending reaches to limit and valley floor begins to widen, and in these circumstances already the maximum Reliefenergie is realized and continuing.

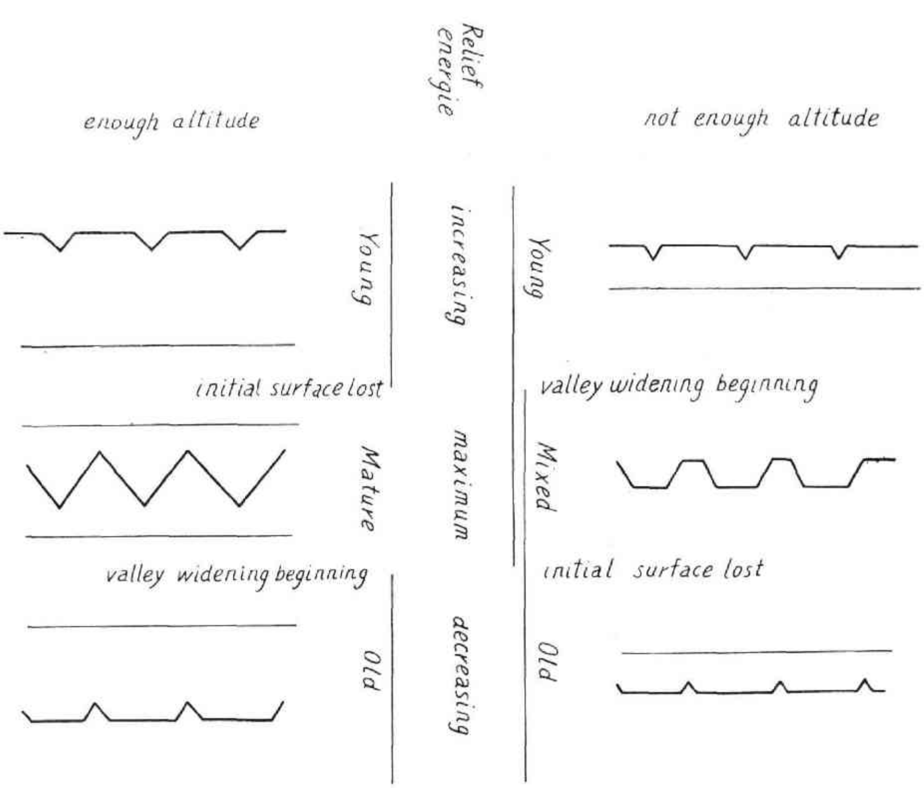

Fig. 5. Stages defined by Reliefenergie sequence.

It is proposed here to divide the stages of cycle of erosion, using the duration of the maximum Reliefenergie, that is to say, to define the young stage corresponding with Reliefenergie increasing, the old stage corresponding with Reliefenergie decreasing and the mature stage or the mixed stage corresponding with the maximum Reliefenergie duration where the mixed stage is in case of not enough altitude.

Hitherto the stages of cycle of erosion were considered on fluvial series and on mountain series, sometimes the latter series were presented as areal series, and the dual series like these are sometimes not matched with actual progress of landscape, or inconsistent of stages between both series.

Of the progress on mountain series definite delimitation can be practised only at the vanishment of the initial surface, which is ordinarily considered as the border between young stage and mature stage. And of the progress on fluvial series definite delimitation can be practised only at the beginning of valley floor widening, which is commonly considered as the border between young and mature stages. Definite limits of both series can not take place at the same time, and then it becomes necessary to consider both series as other sequences like common principles. Even in this case it would be better to divide two stages respectively than to divide three stages, for there is only one definite limit in any series.

The system proposed above is applicable for area including both mountain and valley, and introduced by other criteria. But some comparing is possible between two systems, ordinary system and newly proposed system. Where there is enough altitude, the young stage in mountain series is just the young stage in the new system, and the mature and the old stages in the valley series become the old stage in the new system. Others are included in the mature stage in the new system. Where there is not enough altitude, valley widening that is only definite limit in the valley series begins before initial surface loss that is only definite limit in the mountain series, and therefore between both phenomena the mixed stage is defined and before it is the young stage and after it is the old stage.

Meaning of enough altitude and not enough altitude must be explained here, as these are of regional peculiarity. When the initial surface loss precedes the valley widening, the area is considered to have enough alititude, and at reversed case the area has not enough altitude.

Therefore in the new system of stages, the serial progress of landscape of an area passes a couple of way, the mature stage and the mixed stage according to the altitude the area has.

In the relief zones of the Chugoku Mountains most areas are in the mixed stage and it means the areas without enough altitude. Initial surfaces are not yet lost and valley widening has begun. And thus the erosion surfaces interfinger each other. Along the lower Nuta River near Mihara City subaerial part of the Setouchi surface remains on both sides, and south of this broad valley surmounts a mountain with a summit flat more than 400 m in height and 2 km in length, 1 km in width, where is a village named Hata. This summit flat is a detached part of the Kibi Highland surface. Landform of the area is a clear evidence for the diminishing of the Kibi Highland surface and the forming of the Setouchi surface. On the coastal area of the Inlandsea separated parts of the Kibi Highland surface can be seen, and the summit flat of Mt. Yuka in the Kojima Peninsula or the bedrock surface overlain by volcanic lava on the Iwai Island seem to be examples of those.

If the initial surface completely lost, the area comes into the old stage. In the relief zone of the Chugoku Mountains changing landforms in the old stage are well observed.

In the young stage and the mature stage fluvial action is the most active agency and constant inclination of mountain flank or valley wall is maintained. But in the mixed stage and in the old stage the situations are others entirely, when as the river acts no more always directly at the foot of mountain or of valley wall, slope development by other agencies must be considered and the constancy of the inclination of mountain flank or valley wall is no more maintained. Loss of the initial surface means generally widening of river drainage, for the initial surface is not always drained radially.

Runoff on the mountain flank became the main agency to develop the slope after the valley widening began, of which action is generally most active on the midway of the flank, for the absorption in the lower deposital part weakens the action and thus the slope becomes generally concave. Convexity and concavity of a slope are serial representations of mountain flank before and after the beginning of valley widening, and not always possible to be combined with upheaval and depression, which seem to be only promoting factors.

Morphological development in the old stage goes on uncontinuously. The upper part of the concavity of the mountain mass oftentimes consists of bare rock undergone of erosion, weathering and soil washing-out. In the relief zone of the Chugoku Mountains, especially in that between the Kibi Highland surface and the Setouchi surface, the bare rock capped hill can be seen. Devastated vegetation and bare rock summit are accelerating each other, but such bare rock summits appear also in the vegetation covered mountains. After a while the bare rock summit abruptly destroyed and rock blocks crumble down or flow down as rock flow. The mountain lost its top becomes anew convex-topped hill and then its slopes begin to recover the concave form.

Observing the independent hills in the old stage along the coastal area of the Inlandsea, several phases of the above process can be found. Serially arranged the hills near Onomichi and in Mukaijima Island and the low mountains around Hiroshima, morphological development of the old stage terrain will be easily understood.

It is already the erosion surface if the morphological development of the old stage terrain advances out of a certain limit.

3. Pedimentation

Pediment, which assisted the making of erosion surface in the Chugoku Mountains, coincides with the Onuka Morphology (Mino 1939) on the whole. It occurs in the relief zone as a frontal planation of the lower erosion surface to the mountain mass supporting the higher erosion surface. Sometimes it cuts granitic bed to the foot of backscarp of more resistant rocks such as Paleozoic or porphyritic rocks. At present it is cut by ravines or gullies and deposit on it is weathered, therefore it is no more developmental.

Y. Akagi (1962, 1963) reported on the genesis of pediment as follows. Aridity is the most important factor for pedimentation and lithological difference is the second one. In arid region prevails sheet erosion because of the scarcity of stream system and pedimentation is too powerful to ignore the lithological difference, but where aridity is not enough pedimentation is subject to the lithological difference, and the Chugoku Mountains comes under the latter condition. The writer agrees with the opinion.

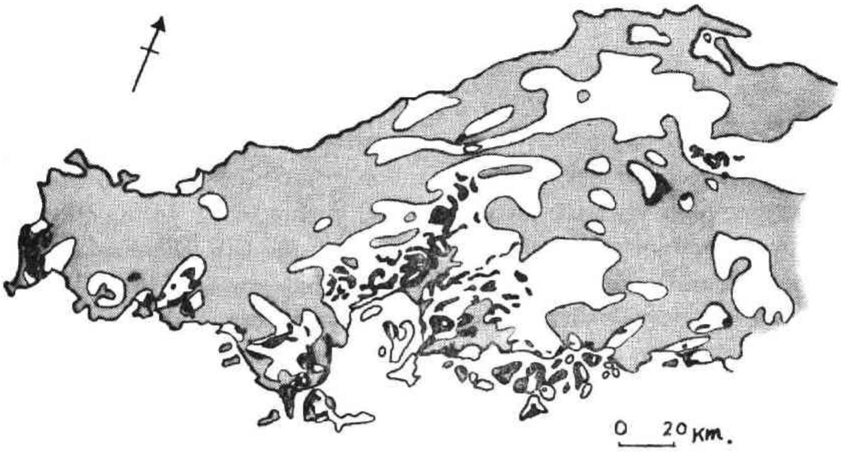

Fig. 6. Distribution of granitic rocks and pediments.

The Chugoku Mountains is not in so arid region that stream system can not develop sufficiently. However it was arider than now, when the Japanese Islands was tied with continent or the Inlandsea was an intermontane basin because of the lowering of sea level in the Pleistocene glacial age. Otherwise the wide exposure of granitic rock with remnants of Paleozoic rock as roof pendant is also a favorable condition for pedimentation.

Thus the pedimentation in the Chugoku Mountains occurred in selected places only, that can not be called universal pediplanation which L.C. King recognized in South Africa or Brazil (1951, 1956). In this area the peneplanation has acted the major role to make the erosion surface and the pediplanation had some subordinate effect.

Exogenic agencies are ultimately the agenices to the planation, and the mode of planation changes according with the agencies. Glacioplanation, Cryoplanation, Peneplanation and Pediplanation are thought as tentative kinds of the planation and appear to have respective areas. Recent studies on the Japanese landform proved the traces of Cryoplanation (Suzuki 1960, Wako 1963) and Pediplanation, so that the location of the Japanese Islands was once, probably in the Pleistocene age, partly in the Cryoplanation area or in the Pediplanation area. The boundary of the past Cryoplanation area or the past Pediplanation area is not yet certain, but it is sure that the Chugoku Mountains was involved in the Pediplanation area.

4. Intermontane Basin

Between the erosion surface by peneplanation and the peneplain there are many unsolved processes, but at least the peneplain is a limitting case of the erosion surface by peneplanation. The erosion surfaces in the Chugoku Mountains should not be called peneplain.

Actual relief on the erosion surfaces in the Chugoku Mountains is over 50m per square km. Really the landscape is a typical "ridge and ravine" (Hack 1960). The writer named the part of ridge Noro which means the round top ridge locally in this area. In the part of ravine sometimes occur intermontane basins.

Nogaihara west of Hatsukaichi, Hiroshima Prefecture, is one of such intermontane basins. It is 5 km west of Hatsukaichi and its basin floor lies at 600 m above sea level. Surrounding rolling slopes are of the Kibi Highland surface, and on the basin wall remain soil creep scars. At the discharge point the basin wall becomes steeper and has rock blocks rolled down on the slope, which seem to have been the cause of damming up. But the sediment is so thin that the bedrock exposes somewhere along the draining streamlet. By the damming up occurred some marshes and marshy vegetation. The basin is not of tectonic origin but of erosional and the damming up is mere temporal happening or additional process.

Kammuri and Yawata basins near the western boundary of Hiroshima Prefecture are also erosional basins. The basin floor of Kammuri basin is covered by 1 m thick sand and surface soil directly on the bedrock. The thickness of sediment on the Yawata basin is about 10m assured by the resistivity survey and the bedrock floor is a kind of erosion surface. Yawata basin suffered once damming up at any place downstreams and became a lake, of which lacustrine beds remain as lacustrine terraces. Therefore Yawata basin has a nature of sedimentary basin partly. Accurately it is identified as an exhumed erosional basin.

Saijo basin in the central Hiroshima Prefecture has two heterogeneous parts,

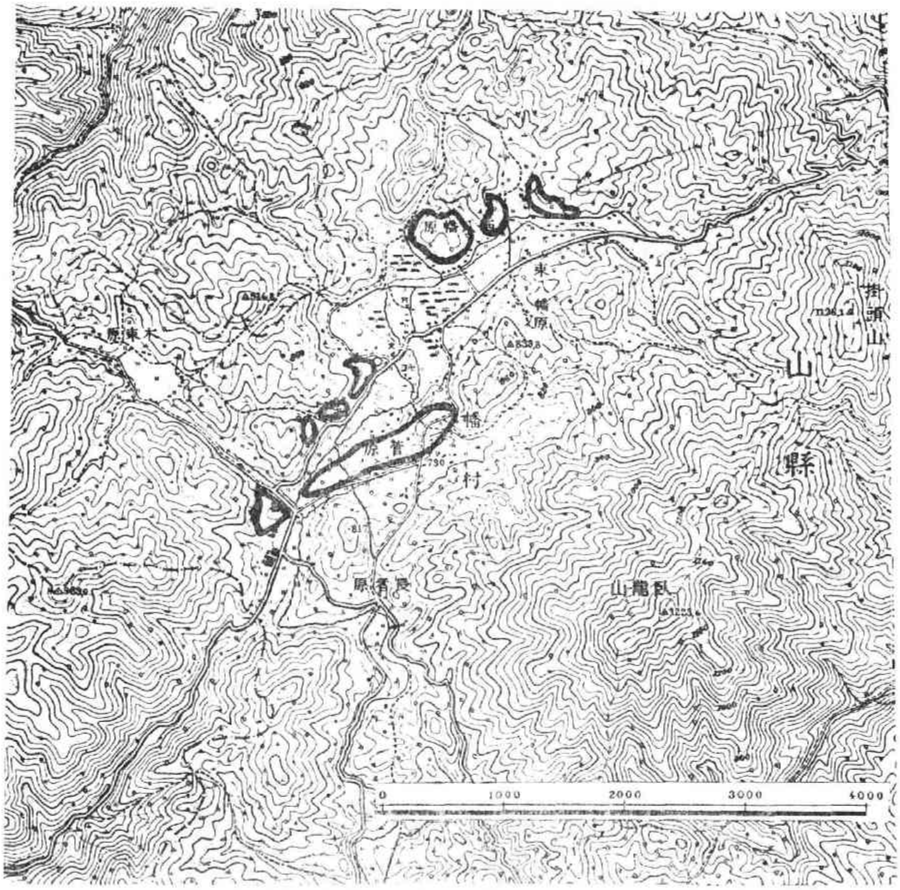

Fig. 7. Yawata basin, lacustrine terrace and marsh.

erosional basin in northern half and sedimentary basin in southern half. The east west line through the top of Mt. Kagami surmounting in the basin center is the boundary line of two parts. In the northern half about 5m thick deposital veneer covers the bedrock and the bedrock surface is the erosional basin surface which continues to the eastwards neighboring Shiroichi basin clearly indicating the erosional basin feature by dissection. In the southern half of the Saijo basin over 30 m thick sediment called Saijo lacustrine bed fills in. The lacustrine bed is dissected by the Kurose river and its tributaries and the top surfaces make plateau feature. The Kurose river and its tributaries have abrupt change of height in their longitudinal profiles at the boundary line of two parts of the Saijo basin, and there are such falls as Azumako fall and Takeshi fall. Plateau feature composed of the Saijo lacustrine bed continues downstream to the Kurose area

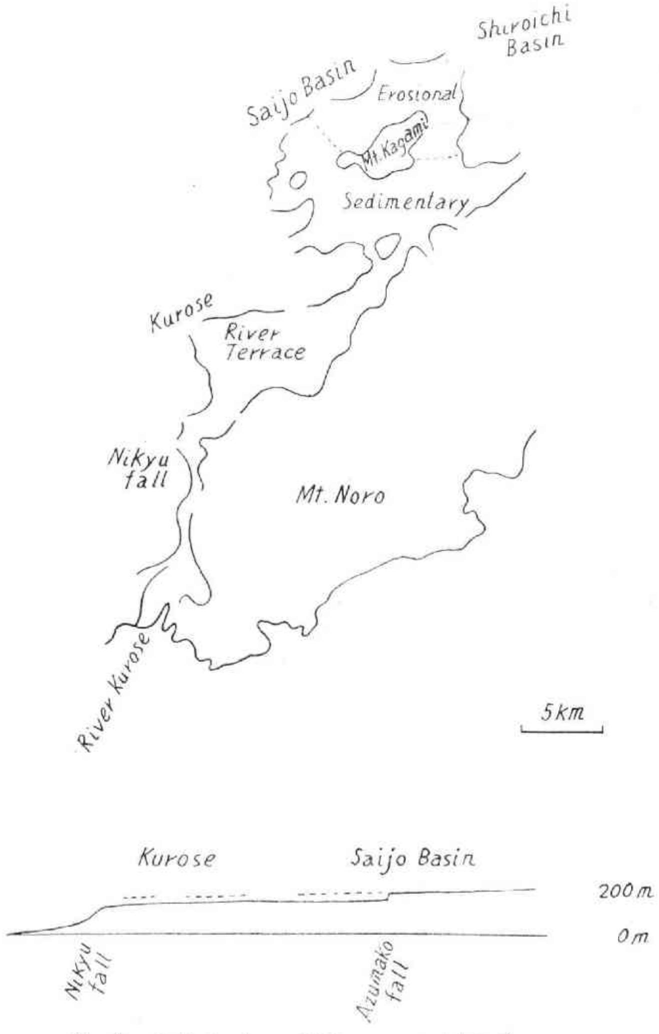

Fig. 8. Saijo basin and Kurose area(above).
River Kurose: Longitudinal profile (below).

where it becomes wide river terrace.

The process of morphogenesis in the Saijo basin will be explained as follows, first the erosional basin at the level of the northern half was made, next the erosional basin at the level of the southern half encroached the former, and these erosional basins are results of twice maintenances and an abrupt change between of the local base level of erosion, which occurred at the Nikyu gorge quartz porphyry zone. And then landslide or avalanche at the northern slope of Mt. Noro dammed up the discharge and Paleo-Saijo lake appeared, in which the Saijo lacustrine bed deposited. As four plant fossil beds are found in the lacustrine bed, the damming up seems to have occurred step by step five times. Thereafter the waste of damming up has been removed gradually and the Kurose river's erosion has revived.

The erosional basin develops not only by the lateral erosion but by slope development and the discharging ability that removes the waste is the factor to decide the size of the basin. And the pedimentation favored with the lithological conditions somewhat accelerated the making of erosional basin.

Yagami basin in Shimane Prefecture occupies the upstream area of the Yagami river, a tributary of the Go river. The basin is on the level of the Iwami Highland surface and has 200–400 m altitude above sea level. The basin floor is of granite and the basin wall is of quartz porphyry and such a contrast was favorable for pedimentation. The landform of basin floor is dissected by the rejuvenated stream erosion and destructed by the sand-iron mining, but the pediment surface can be restored from the remained. Yagami basin is an erosional basin chiefly by the pedimentation. Onuka basin in northeastern Hiroshima Prefecture and Kadonoue basin in northwestern Okayama Prefecture are the same kind of basin (Mino 1939, 1942, Akagi 1960, 1961).

There are also sedimentary basins in the Chugoku Mountains. The making of

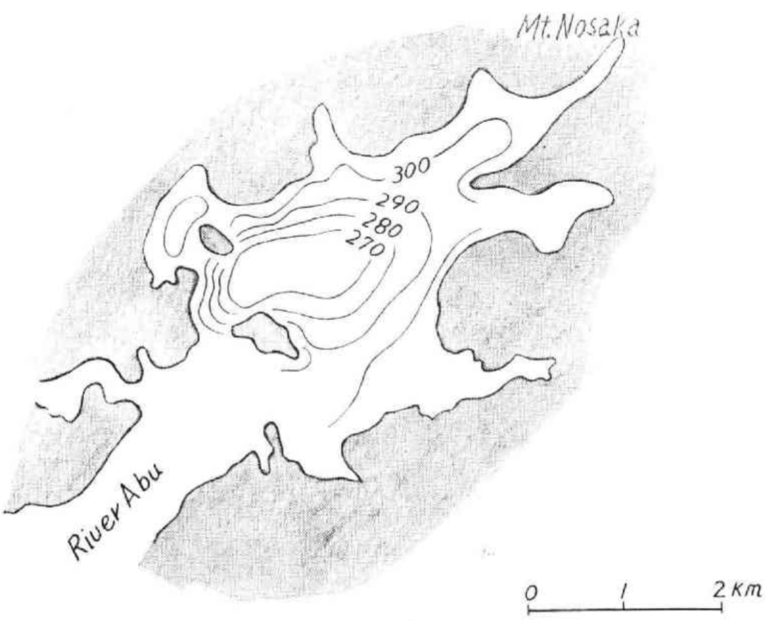

Fig. 9. Subsurface form of Tokusa basin.

Tokusa basin in the upstream area of the Abu river in northeastern Yamaguchi Prefecture is already explained (Nishimura 1962). It is a dammed up basin by volcanic accident and the thickness of sediments is over 30 m ascertained by resistivity survey.

At Takasaka area north of Mihara City remains Pleistocene sedimentary bed including lignite bed on the 200–300 m high hill tops correlative with the Kibi Highland surface. The sedimentary bed is dissected to the bedrock by the Buttuji river and its tributaries, and exposes about 30 m thick section, by which synclinal basin structure can be traced. This area seems to have been a lake basin but its morphological sequence is not yet certain.

Tsuyama basin and Miyoshi basin are the largest intermontane basins in the Chugoku Mountains, both situated between the Backbone Ridges and the Kibi Highland surface and consisting partly of the Miocene bed. Before the formation of the Kibi Highland surface these basins existed and suffered the Miocene transgression. The Miocene bed was preserved through the formation of the Kibi Highland surface. But at the upheaval of the Kibi Highland surface the Miocene bed began to be eroded by the rejuvenated river erosion and the basin morphology is resurrected, because of the weakness of the Miocene bed against the lateral erosion. Thrust faults found in the northern side of both basins have only modified the morphology and never made it.

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