Topography of the Liao-Tung Peninsula

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General Description

The backbone range of the Liao-tung Peninsula runs northeast to southwestward and consists of part of the mountain range running in the Sinian direction* (R. PUMPELLY).[1]** The shape of this peninsula is controlled by geologic structure. Since it deviates somewhat more to the north than in the Sinian direction proper, it is called the "Liao-tung direction."[2] The area has been investigated by many geologists[3-11] whose results have already been published, according to which granite, gneiss and quartzite predominate in the peninsula. Especially, the Sinian Ta-ho-shang-shan series[10] is distributed extensively in the beginning and terminal parts of this peninsula. No Tertiary sediments are found there, and the only Quaternary sediments are peat[26], which contains *Nelumbo* sp., and terrace gravel which is distributed sporadically. Fossils that are useful for age determination [index fossils] have not yet been found in the strata.

Here and there in this region, erosion surfaces exist which truncate the complicated geologic structures. These surfaces were once recognized as the ultimate plane of the eroded topography, which was called the "Liao-tung peneplane".[13,32]

The existence of an erosion surface in the Liao-tung Peninsula has already been reported by several geologists, namely Hanzō MURAKAMI[4] (1915; p. 3, 8, 12), Otoji AOJI[5] (1924; p. 3, 5), Susumu MATSUSHITA[3] (1930; p. 2), Toshio ŌTANI[11] (1933) and Heiichi TAKEHARA[32] (1934). It was also reported by students of topography, such as Jūji HANAI[13] (1928) and Masahide KAJIYAMA[14] (1932). The writer and the late Zenkyō IMAMURA[28] investigated the erosion surfaces in the northern part of the former Kuan-tung Province under the kind direction of Dr. Riuji ENDŌ.

BLACKWELDER[24] (1907; p. 86) once stated that "the topography of the preceding cycle was so completely removed that the original topographic forms were not preserved." However, remnants of an old flat surface came to be known by each of the investigators described above.

* In the direction of China.

** Numbers in parentheses designate corresponding references at end of translation.

1. Analysis of the erosion surfaces

It became clear that three planes had devoloped on the Liao-tung Peninsula, as a result of investigating the detailed classification and history of the topographic forms. Among these forms, the relatively complete surface of the P'i-tzu-wo peneplane, which is situated in the lowest position, 20 to 50 m above sea level, is preserved. The Kuang-ning-ssu peneplane exists 120 to 300 m above the P'i-tzu-wo peneplane, and is much more dissected. At the highest altitude, 300 to 400 m above present sea level, remnants of the Ping-shan peneplane, which occupies small areas, are distributed sporadically.

Using all 1:25,000 topographic maps (52 sheets), the author compiled restoration maps, with 50 m contour intervals, in which valleys 250 m wide are "buried" [E.N.; literal translation; probably meaning an imaginary topography for the purpose of coordination assuming that all valleys are 250 m wide and are filled with sediment]. Referring to these restoration maps and the geologic map,[5] 27 planes, each with remarkable features, were selected.

The 27 planes selected were divided into squares, 4 km per side, and several methods of geomorphometry were employed for each plane. For convenience, areas are designated a, b, c, etc. (see Fig. 1).

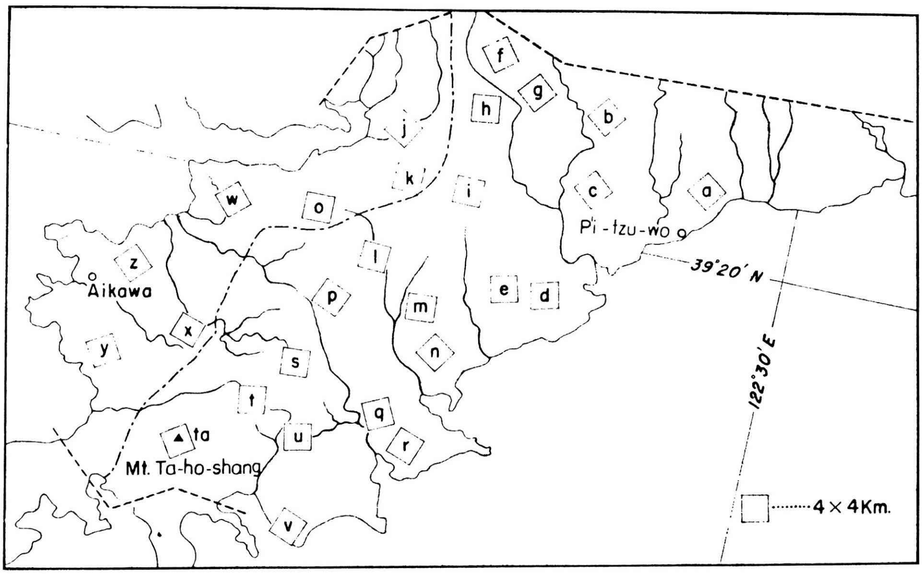

Fig. 1. Distribution Map of Measured Areas.

Prior to measurement, this region was divided into two parts, eastern and western, because each erosion plane included in the area to be measured is different. In addition, erosion surfaces are sometimes different, even if they were subjected to the same erosion during the same period. TAYAMA[22] indicated the following four causes for differential erosion; (1) difference in lithology, (2) difference in the stratigraphical sequence, (3) difference in meteorological conditions (especially in the amount of rainfall) and (4) inclination of plane.

Remarkable differences in this region are seen in lithologic features. Gneiss occurs extensively in the eastern area while Ta-ho-shang Shan quartzite crops out along the coast in the southern part. In the western part, Sinian and post-Sinian sedimentary rocks predominate. The rock formations of the western part and the gneiss group of the eastern part contact unconformably,[3)] and by thrust[23)] and normal faults. Consequently, the boundary line between these two rock groups was applied as the dividing line of this region, that is, between the eastern and western parts. However, Ta-ho-shang Shan and the area east of it were included in the eastern part, because it was found that the characteristics of the surface are similar to those of the eastern part when referring to a restoration map with a 50 m contour interval.

According to investigations on the structure of this region by Hanzō MURAKAMI,[4)] Otoji AOJI,[5)] Susumu MATSUSHITA,[7)] Mitsuo NODA[23)] and others, the region had been subjected to moderately complicated faulting and folding. However, since the movements were old, they may not be shown directly by topographic features at the present time. These were not recognized in the field work. Jūji HANAI[13)] states that any faults that truncated and displaced the dissected planes after their formation were not found either (see HANAI, 1928 and 1933, p. 358 and MATSUSHITA, 1930 p. 5).

It is assumed that the amounts of rainfall in these two areas are approximately the same because of their proximal location; therefore, as already described, this region was divided into eastern and western parts according to lithology alone. (see Fig. 1).

A. Erosion surfaces of the eastern part

1. *Classification of planes according to length of contour lines*

Gneiss is predominant in the eastern part of this region, except for several small areas. However, classification was made assuming that all areas were the same.

It is thought that these areas were very flat at the time the Liao-tung peneplane was completed. If this is true, it may be assumed that this plane was subjected to the same degree of dissection at the same time. If there are several planes in this region, it may also be assumed that the older plane was subjected to a higher degree of dissection than the younger plane. Therefore, if the degree of dissection (r_1) of each plane is measured, the number of planes and the relationship between new and old planes may be estimated.

As one method, the author measured the length of contour lines. If the conditions for erosion, except for the time factor, are the same throughout all areas, the length of the contour line in the unit area indicates not only the density of the valleys, which represents the degree of dissection, but also the degree of inclination of the surface formed during the same period in each area of measurement. Two

Table 1. Results of Measurement (50 m contour map)

	a						b						c						d						e					
S.R.	I	II	III	IV	V	VI	I	II	III	IV	V	VI	I	II	III	IV	V	VI	I	II	III	IV	V	VI	I	II	III	IV	V	VI
Σ	1.8	1.8	1.8	3.3	4.3	4.1	40.9	20.0	16.1	11.8	10.6	10.1	35.1	23.6	18.3	12.4	9.3	8.0	0.0	0.0	0.0	0.0	0.0	0.0	27.5	21.0	19.6	17.4	13.8	10.8
r_1	0.1	0.1	0.1	0.2	0.3	0.3	2.6	1.3	1.0	0.7	0.7	0.6	2.2	1.5	1.1	0.8	0.6	0.5							1.7	1.3	1.2	1.1	0.9	0.7
Δ							1.3	0.3	0.3	0.0			0.7	0.4	0.3	0.2									0.4	0.1	0.1	0.2		
r_2							2.0	0.7	0.4	0.1	0.1		1.7	1.0	0.6	0.3	0.1								1.0	0.6	0.5	0.4	0.2	
ha	50						100						70						40						70					
hm	20						50						50						20						40					
m_1	0.18						1.15						1.12												1.15					
m_2							0.66						0.72												0.54					
m_3							0.40						0.40												0.20					
L.C.	G						G						G						G						G					

	f						g						h						i						l					
S.R.	I	II	III	IV	V	VI	I	II	III	IV	V	VI	I	II	III	IV	V	VI	I	II	III	IV	V	VI	I	II	III	IV	V	VI
Σ	51.0	32.3	23.6	20.3	19.9	16.9	45.0	27.3	20.8	16.8	14.6	13.1	42.6	29.4	20.0	15.1	12.9	12.8	46.5	32.6	22.1	15.5	11.6	10.6	0.6	0.6	0.6	1.5	1.5	1.5
r_1	3.2	2.0	1.5	1.3	1.2	1.1	2.9	1.7	1.3	1.1	0.9	0.8	2.7	1.8	1.3	0.9	0.8	0.8	2.9	2.0	1.4	1.0	0.7	0.7	0.04	0.04	0.04	0.1	0.1	0.1
Δ	1.2	0.5	0.2	0.1			1.2	0.4	0.2	0.2			0.9	0.5	0.4	0.1			0.9	0.6	0.4	0.3								
r_2	2.1	0.9	0.4	0.2	0.1		2.1	0.9	0.5	0.3	0.1		1.9	1.0	0.5	0.1			2.2	1.3	0.7	0.3								
ha	150						150						130						170						50					
hm	70						50						50						60						30					
m_1	1.71						1.45						1.33						1.45						0.03					
m_2	0.72						0.78						0.88						0.90											
m_3	0.42						0.45						0.38						0.44											
L.C.	G						G						Ss, Sh, Cg						G						G					

Table 1. (Continued)

m						
S.R.	I	II	III	IV	V	VI
Σ	24.0	19.8	16.9	14.9	11.5	11.0
r_1	1.5	1.2	1.1	0.9	0.7	0.7
Δ	0.3	0.1	0.2	0.2		
r_2	0.8	0.5	0.4	0.2		
ha	70					
hm	50					
m_1	1.02					
m_2	0.38					
m_3	0.16					
L.C.	G					

n						
S.R.	I	II	III	IV	V	VI
Σ	0.0	0.0	0.0	0.0	0.0	0.0
r_1						
Δ						
r_2						
ha	40					
hm	20					
m_1						
m_2						
m_3						
L.C.	G					

p						
S.R.	I	II	III	IV	V	VI
Σ	18.6	16.3	12.6	8.8	4.0	1.8
r_1	1.1	1.0	0.8	0.5	0.3	0.1
Δ	0.1	0.2	0.3	0.2		
r_2	1.0	0.9	0.7	0.4	0.2	
ha	100					
hm	60					
m_1	0.63					
m_2	0.64					
m_3	0.20					
L.C.	G					

q						
S.R.	I	II	III	IV	V	VI
Σ	0.6	0.6	0.6	0.6	0.6	0.6
r_1	0.04	0.04	0.04	0.04	0.04	0.04
Δ						
r_2						
ha	50					
hm	30					
m_1	0.04					
m_2						
m_3						
L.C.	G					

r						
S.R.	I	II	III	IV	V	VI
Σ	88.9	64.1	54.4	47.6	46.6	42.5
r_1	5.6	4.0	3.4	3.0	2.9	2.7
Δ	1.6	0.6	0.4	0.1		
r_2	2.9	1.3	0.7	0.3	0.2	
ha	320					
hm	50					
m_1	3.60					
m_2	1.08					
m_3	0.58					
L.C.	Q, Ssl					

s						
S.R.	I	II	III	IV	V	VI
Σ	41.8	28.0	20.8	13.1	12.5	10.4
r_1	2.6	1.8	1.3	0.8	0.8	0.7
Δ	0.8	0.5	0.5			
r_2	1.9	1.1	0.6	0.1	0.1	
ha	190					
hm	100					
m_1	1.33					
m_2	0.76					
m_3	0.38					
L.C.	G					

t						
S.R.	I	II	III	IV	V	VI
Σ	41.6	24.8	16.3	11.5	10.4	10.4
r_1	2.6	1.6	1.0	0.7	0.7	0.7
Δ	1.0	0.6	0.3			
r_2	1.9	0.9	0.3			
ha	170					
hm	110					
m_1	1.22					
m_2	0.62					
m_3	0.38					
L.C.	G					

u						
S.R.	I	II	III	IV	V	VI
Σ	93.5	59.1	35.6	29.8	26.0	23.8
r_1	5.8	3.6	2.2	1.9	1.6	1.5
Δ	2.2	1.4	0.3	0.3		
r_2	4.3	2.1	0.7	0.4	0.1	
ha	250					
hm	20					
m_1	2.77					
m_2	1.52					
m_3	0.86					
L.C.	G					

v						
S.R.	I	II	III	IV	V	VI
Σ	82.5	58.2	49.6	43.2	36.8	34.3
r_1	5.2	3.6	3.1	2.7	2.3	2.1
Δ	1.6	0.5	0.4	0.4		
r_2	3.1	1.5	1.0	0.6	0.2	
ha	270					
hm	50					
m_1	3.17					
m_2	1.28					
m_3	0.62					
L.C.	Q, Ls, Sh					

ta						
S.R.	I	II	III	IV	V	VI
Σ	124.6	107.9	86.1	72.2	66.6	66.6
r_1	8.7	6.7	5.4	4.5	4.1	4.1
Δ	2.0	1.3	0.9	0.4		
r_2	3.7	2.6	1.3	0.4		
ha	660					
hm	60					
m_1	5.43					
m_2	1.60					
m_3	0.74					
L.C.	Q					

Table 2. Results of Measurement (10 m contour map)

	a						b						c						d					
S.R.	I	II	III	IV	V	VI	I	II	III	IV	V	VI	I	II	III	IV	V	VI	I	II	III	IV	V	VI
Σ	67.5	47.6	37.8	35.9	28.9	25.4	120.9	82.0	62.1	53.0	47.4	45.7	126.5	82.3	59.4	45.2	36.1	32.2	60.6	46.9	39.1	34.0	30.0	24.4
r_1	4.2	3.0	2·3	2.2	1.8	1.6	7.5	5.1	3.9	3.4	3.0	2.9	7.9	5.1	3.7	2.8	2.3	2.0	3.3	2.9	2.4	2.1	1.9	1.5
Δ	1.2	0.7	0.1	0.4	0.2		2.4	1.2	0.5	0.4	0.1		2.8	1.4	0.9	0.5	0.3		0.9	0.5	0.3	0.2	0.4	
r_2	2.6	1.4	0.7	0.6	0.2		5.6	3.2	2.0	1.5	1.1		5.9	3.1	1.7	0.8	0.3		2.3	1.4	0.9	0.6	0.4	
m_1	2.52						4.13						3.95						2.43					
m_2	1.10						2.68						2.36						1.12					
m_3	0.52						1.12						1.18						0.46					

	e						f						g						h					
S.R.	I	II	III	IV	V	VI	I	II	III	IV	V	VI	I	II	III	IV	V	VI	I	II	III	IV	V	VI
Σ	93.9	68.3	52.4	41.4	33.1	28.3	230.1	161.5	116.4	97.6	88.9	79.5	185.2	121.8	97.2	83.1	75.9	70.4	174.5	129.4	79.1	83.8	75.0	74.4
r_1	5.9	4.3	3.3	2.6	2.1	1.8	14.4	10.1	7.2	6.1	5.6	5.0	11.6	7.6	6.1	5.2	4.7	4.4	11.0	8.1	6.1	5.2	4.7	4.6
Δ	1.6	1.0	0.7	0.5	0.3		4.3	2.9	1.1	0.5	0.6		4.0	1.5	0.9	0.5	0.3		2.9	2.0	0.9	0.5	0.1	
r_2	4.2	2.6	1.6	0.9	0.4		9.4	5.1	2.2	1.1	0.6		7.2	3.2	1.7	0.8	0.3		6.4	3.5	1.5	0.6	0.1	
m_1	3.33						8.07						6.60						6.78					
m_2	1.94						3.68						2.64						2.42					
m_3	0.84						1.88						1.44						1.28					

Table 2. (Continued)

	i						l						m						n					
S.R.	I	II	III	IV	V	VI	I	II	III	IV	V	VI	I	II	III	IV	V	VI	II	II	III	IV	V	VI
Σ	195.1	139.5	100.6	77.9	67.5	64.0	40.8	28.9	27.8	26.5	22.1	19.4	67.5	52.9	43.5	38.6	28.1	24.9	40.5	34.0	29.4	25.8	24.9	23.0
r_1	12.2	8.7	6.3	4.9	4.2	4.0	2.5	1.8	1.7	1.7	1.4	1.2	4.2	3.5	2.6	2.2	1.8	1.6	2.5	2.1	1.8	1.6	1.6	1.4
Δ	3.5	2.4	1.4	0.7	0.2		0.7	0.1		0.3	0.2		0.7	0.7	0.4	0.4	0.2		0.4	0.3	0.2		0.2	
r_2	8.3	4.8	2.1	0.7	0.2		1.3	0.6	0.5	0.5	0.2		2.4	1.7	1.0	0.6	0.2		1.1	0.7	0.4	0.2	0.2	
m_1	6.72						1.72						2.67						1.83					
m_2	3.22						0.62						1.18						0.52					
m_3	1.60						0.26						0.48						0.22					

	p						q						s						t					
S.R.	I	II	III	IV	V	VI	I	II	III	IV	V	VI	I	II	III	IV	V	VI	I	II	III	IV	V	VI
Σ	77.3	65.3	53.1	46.3	37.4	33.5	60.1	47.0	36.5	33.1	26.1	20.9	207.1	141.4	100.8	80.8	64.8	56.4	212.8	133.6	89.4	68.4	56.6	50.1
r_1	4.8	4.1	3.3	2.9	2.3	2.1	3.8	3.0	2.3	2.1	1.6	1.3	12.9	8.8	6.3	5.0	4.0	3.5	13.3	8.3	5.6	4.3	3.5	3.1
Δ	0.7	0.8	0.4	0.6	0.2		0.8	0.7	0.2	0.5	0.3		4.1	2.5	1.3	1.0	0.5		5.0	2.7	1.3	0.8	0.4	
r_2	2.7	2.0	1.2	0.8	0.2		2.5	1.7	1.0	0.8	0.3		9.4	5.3	2.8	1.5	0.5		10.2	5.2	2.5	1.2	0.4	
m_1	3.25						2.35						6.75						6.35					
m_2	1.38						1.26						3.90						3.90					
m_3	0.54						0.50						1.88						2.02					

methods were adopted for measuring the lengths of contours. One, restoration maps with 50 m contour intervals were made for the whole area, and the length of the contour lines included in the measured areas, 4 square km, which was determined previously, was measured during each stage of restoration; in the other method, the length of contour lines was measured from restoration maps which were made using a 10 m contour interval. The width of the valley buried during the restoration work and each stage of restoration are as follows:

The present topography .... 1st stage (I)*
Topography in which valleys 200 m wide were buried,
on the basis of the present topography .... 2nd stage (II)
Topography in which valleys 400 m wide were buried,
on the basis of the 2nd stage .... 3rd stage (III)
Topography in which valleys 600 m wide were buried,
on the basis of the 3rd stage .... 4th stage (IV)
Topography in which valleys 800 m wide were buried,
on the basis of the 4th stage .... 5th stage (V)
Topography in which valleys 1,000 m wide were buried,
on the basis of the 5th stage .... 6th stage (VI)

The results of measurement using the restoration map with a 50 m contour interval are given in Table 2. The meanings of the symbols used in these tables are as follows:

S.R. ..... Stage of restoration
Σ .... Sum of contour lengths in each measuring area (unit km).
r_1 .... $\frac{\Sigma}{s}$ Value of Σ divided by the measured area (16 sq. km), namely the average length (km) of the contour in 1 sq. km in each area.
Δ .... Difference between r_1 in each stage and its following stage of restoration; (I r_1–II r_1), (II r_1–III r_1), (III r_1–IV r_1), (IV r_1–V r_1), (V r_1–VI r_1) and so on.
r_2 .... Difference between r_1 in each stage of restoration (I to V) and r_1 of stage VI. (Exponent of dissection)
ah ...... Absolute height of the highest point in the present topography in each area (unit m).
mh ...... Mean height in each area (the longest contour within each area in the present topography) (unit m).
m_1 ...... Mean value of r_1 for all stages (unit km).
m_2 ...... Mean value of r_2 for all stages (unit km).
m_3 ...... Mean value of Δ for all stages (unit km).
L.C. ..... Rocks which constitute the foundation of each measured area (see references 3, 5, and 8).

G—gneiss Ss—sandstone Q—quartzite Sh—shale
Ls—limestone Cg—conglomerate Ssl—siliceous slate

* Roman numerals used in tables designate each stage.

a. Classification by r_1. The value of r_1 obtained in this work is related to the density of valleys, representing the inclination of each stage of restoration. Classification of each measured area by the density of the valleys represented by r_1 is shown in Tables 3 and 4. In these tables, the values of r_1 for each stage of restoration are arranged in order of size, where δ is the difference between adjacent stages. The fact that δ is almost the same for any group of areas means that r_1 changes gradually, and that the areas are included in the same plane. On the contrary, the fact that δ suddenly shows a large value means that those two areas are included in different planes and the boundary is δ. In Tables 3 and 4, these points are marked by bold lines (called transformation points).

Looking at Table 3, a boundary line can be drawn between the plane of the sixth rank and the plane of the seventh rank in the order of dissection.

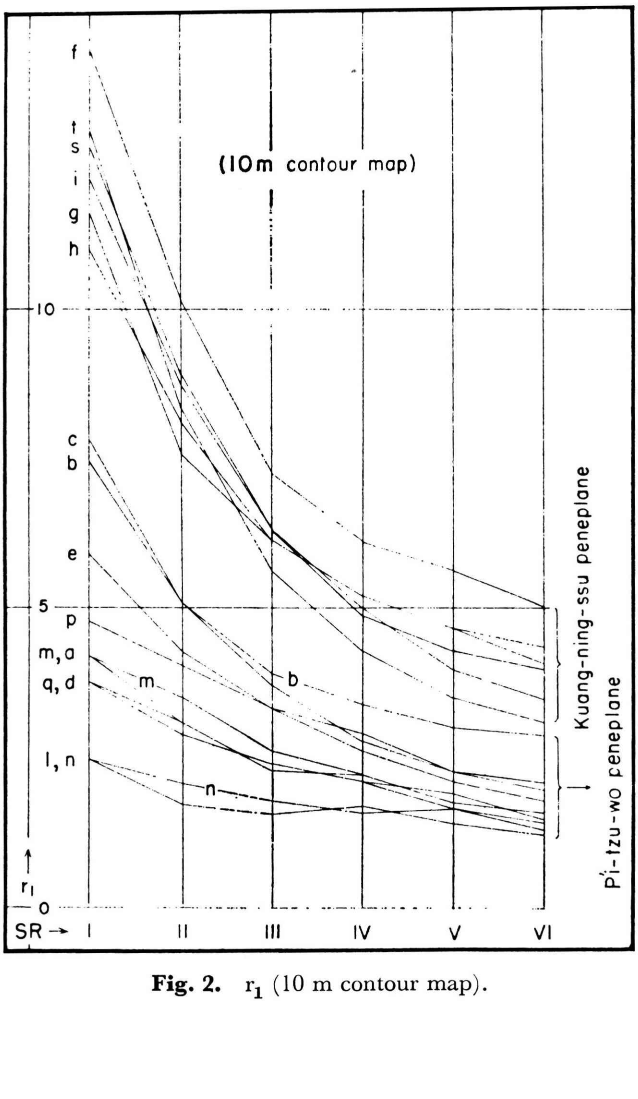

Fig. 2. r_1 (10 m contour map).

Table 3. r_1, δ (10 m contour map).

S.R.	Order of dissection	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
I	Area	f	t	s	i	g	h	c	b	e	p	a	m	d	p	n	l
	r_1	14.4	13.1	12.9	12.2	11.6	11.0	7.9	7.5	5.9	4.8	4.2	4.2	3.8	3.8	2.5	2.5
	δ	1.3 0.2 0.7 0.6 0.6 3.1 0.4 1.6 1.1 0.6 0.0 0.4 0.0 1.3 0.0															
II	Area	f	s	i	t	h	g	c	b	e	p	m	a	q	d	n	l
	r_1	10.1	8.8	8.7	8.3	8.1	7.6	5.1	5.1	4.3	4.1	3.5	3.1	3.1	2.9	2.1	1.8
	δ	1.3 0.1 0.4 0.2 0.5 2.5 0.0 0.8 0.2 0.6 0.4 0.0 0.2 0.8 0.3															
III	Area	f	i	s	g	h	t	b	c	e	p	m	d	a	q	n	l
	r_1	7.2	6.3	6.3	6.1	6.1	5.6	3.9	3.7	3.3	3.3	2.6	2.4	2.3	2.3	1.8	1.7
	δ	0.9 0.0 0.2 0.0 0.5 1.7 0.2 0.4 0.0 0.7 0.2 0.1 0.0 0.5 0.1															
IV	Area	f	g	h	s	i	t	b	p	c	e	a	m	d	q	l	n
	r_1	6.1	5.2	5.2	5.0	4.9	4.3	3.4	2.9	2.8	2.6	2.2	2.2	2.1	2.1	1.7	1.6
	δ	0.9 0.0 0.2 0.1 0.6 0.9 0.5 0.1 0.2 0.4 0.0 0.1 0.0 0.4 0.1															
V	Area	f	g	h	i	s	t	b	c	p	e	d	a	m	n	q	l
	r_1	5.6	4.7	4.7	4.2	4.0	3.5	3.0	2.3	2.3	2.1	1.9	1.8	1.8	1.6	1.6	1.4
	δ	0.4 0.0 0.5 0.2 0.5 0.5 0.7 0.0 0.2 0.2 0.1 0.0 0.2 0.0 0.2															
VI	Area	f	h	g	i	s	t	p	c	b	e	a	m	d	n	q	l
	r_1	5.0	4.6	4.4	4.0	3.5	3.1	2.1	2.0	1.9	1.8	1.6	1.6	1.5	1.4	1.3	1.2
	δ	0.4 0.2 0.4 0.5 0.4 1.0 0.1 0.1 0.1 0.2 0.0 0.1 0.1 0.1 0.1															

Figure 2 was plotted using the value of r_1 given in Table 3 as the ordinate and the stage of restoration as the abscissa. The figure shows that the six areas (group 1) that were advanced in dissection are different from the other ten areas (group 2), according to the shape of the curve. As described later, group 1 is a remnant of the Ping-shan peneplane and group 2 is part of the Kuang-ning-ssu peneplane.

Table 4 was compiled by arranging the values of r_1 derived from the 50 m contour map in order, beginning with the largest value. Transformation points were determined in the same way as previously, and the areas were divided into three groups.

From the results given in Tables 3 and 4, the twenty areas can be divided into four groups, each group belonging to a peneplane.

Table 4. r_1, δ (50 m contour map).

S.R.	Order of dissection	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
I	Area	ta	u	r	v	f	g	i	h	s	t	b	c	e	m	p	a	q	l	d	n
	r_1	7.8	5.8	5.6	5.2	3.2	2.9	2.9	2.7	2.6	2.6	2.6	2.2	1.7	1.5	1.1	0.1	0.0	0.0	0.0	0.0
	δ	2.0	0.2	0.4	2.0	0.3	0	0.2	0.1	0	0	0.4	0.5	0.2	0.4	1.0	0.1	0	0	0	
II	Area	ta	r	u	v	i	f	h	s	g	t	c	b	e	m	p	a	q	l	d	n
	r_1	6.7	4.0	3.7	3.6	2.0	2.0	1.8	1.8	1.7	1.6	1.5	1.3	1.3	1.2	1.0	0.1	0.0	0.0	0.0	0.0
	δ	2.7	0.3	0.1	1.6	0	0.2	0	0.1	0.1	0.1	0.2	0	0.1	0.2	0.9	0.1	0	0	0	
III	Area	ta	v	r	u	f	i	g	h	s	e	m	c	b	t	p	a	q	l	d	n
	r_1	5.4	3.1	2.7	2.2	1.5	1.4	1.3	1.3	1.3	1.2	1.1	1.1	1.0	1.0	0.8	0.1	0.0	0.0	0.0	0.0
	δ	2.3	0.4	0.5	0.7	0.1	0.1	0	0	0.1	0.1	0	0.1	0	0.2	0.7	0.1	0	0	0	
IV	Area	ta	r	v	u	f	g	e	i	h	m	c	s	b	t	p	a	l	q	d	n
	r_1	4.5	3.0	2.7	1.9	1.3	1.1	1.1	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.5	0.2	0.1	0.0	0.0	0.0
	δ	1.5	0.3	0.8	0.6	0.2	0	0.1	0.1	0	0.1	0	0.1	0	0.2	0.3	0.1	0.1	0	0	
V	Area	ta	r	v	u	f	g	e	h	s	b	i	m	t	c	a	p	l	q	d	n
	r_1	4.1	2.9	2.3	1.6	1.2	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.7	0.6	0.3	0.3	0.1	0.0	0.0	0.0
	δ	1.2	0.6	0.7	0.4	0.3	0	0.1	0	0.1	0	0	0	0.1	0.3	0	0.2	0.1	0	0	
VI	Area	ta	r	v	u	f	g	h	i	e	m	s	t	b	c	a	p	l	q	d	n
	r_1	4.1	2.7	2.1	1.5	1.1	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.6	0.5	0.3	0.1	0.1	0.0	0.0	0.0
	δ	1.4	0.6	0.6	0.4	0.3	0	0.1	0	0	0	0	0.1	0.1	0.2	0.2	0	0.1	0	0	

Group 1: ta. . . . Ta-ho-shang Shan monadnock
Group 2: u, r, v. . . . Ping-shan peneplane
Group 3: f, g, h, i, s, t. . . . Kuang-ning-ssu peneplane
Group 4: b, c, e, m, p, a, q, l, d, n. . . . P'i-tzu-wo peneplane

b. Classification by r_2. Let r_1 of stage VI be the inclination of the original topography, assuming complete restoration of the original topography in the case of a valley 1 km wide being buried (the terminal topography of the former cycle). In this case, r_2, the difference between r_1 of stage VI and r_1 of each stage from I to V is taken as the index number showing the degree of dissection in each stage of restoration.[22] The index number of dissection, r_2, represents the old and new planes, as the degree of dissection is proportional to the time, assuming that factors other than time remain constant. Therefore, we can divide each area into groups according to the value of r_2. Tables 5 and 6 are obtained by arranging them in order, beginning with the largest, in the same way as r_1, which was described before. The values of r_2 on the restoration maps with 10 m and 50 m contour

Table 5. r_2, δ (10 m contour map).

S.R.	Order of dissection	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
I	Area	t	f	s	i	g	h	c	b	e	p	a	m	q	d	l	m
	r_2	10.2	9.4	9.4	8.2	7.2	6.4	5.9	5.6	4.2	2.7	2.6	2.6	2.5	2.4	1.3	1.1
	δ	0.8	0	1.2	1.0	0.8	0.5	0.3	1.4	1.5	0.1	0	0.1	0.1	1.1	0.2	
II	Area	s	t	f	i	h	b	g	c	e	p	m	q	a	d	n	l
	r_2	5.3	5.2	5.1	4.7	3.5	3.2	3.2	3.1	2.6	2.0	1.9	1.7	1.4	1.4	0.7	0.5
	δ	0.1	0.1	0.4	1.2	0.3	0	0.1	0.5	0.6	0.1	0.2	0.3	0	0.7	0.2	
III	Area	t	i	f	b	c	g	h	e	p	m	q	d	s	a	l	n
	r_2	2.4	2.3	2.2	2.0	1.7	1.7	1.5	1.5	1.2	1.0	1.0	0.9	0.8	0.7	0.5	0.4
	δ	0.1	0.1	0.2	0.3	0	0.2	0	0.3	0.2	0	0.1	0.1	0.1	0.2	0.1	
IV	Area	c	b	s	t	f	i	g	e	q	p	d	h	m	l	a	n
	r_2	1.8	1.5	1.5	1.2	1.1	0.9	0.8	0.8	0.8	0.8	0.6	0.6	0.6	0.5	0.4	0.2
	δ	0.3	0	0.3	0.1	0.2	0.1	0	0	0	0.2	0	0	0.1	0.1	0.2	
V	Area	b	f	s	d	t	c	g	e	q	a	i	m	n	l	p	h
	r_2	1.1	0.6	0.6	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1
	δ	0.5	0	0.2	0	0.1	0	0	0	0.1	0	0	0	0	0	0.1	

intervals are shown in Tables 5 and 6, respectively. This suggests that it is difficult to distinguish each group completely. Figure 3 (r_2 in Table 5) and Figure 4 (r_2 in Table 6) were drawn in order to distinguish the groups of areas. As these two

Table 6. r_2, δ (50 m contour map).

S.R.	Order of dissection	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
I	Area	u	ta	v	r	i	f	g	b	h	s	t	c	e	p	m	a	b	n	q	l
	r_2	4.3	3.7	3.1	2.9	2.2	2.1	2.1	2.0	1.9	1.9	1.9	1.7	1.0	1.0	0.8	0.0	0.0	0.0	0.0	0.0
	δ	0.6	0.6	0.2	0.7	0.1	0	0.1	0.1	0	0	0.2	0.7	0	0.2	0.8					
II	Area	ta	u	v	i	r	s	c	h	f	g	p	t	b	e	m	a	d	n	q	l
	r_2	2.5	2.1	1.5	1.3	1.3	1.1	1.0	1.0	0.9	0.9	0.9	0.9	0.7	0.6	0.5	0.0	0.0	0.0	0.0	0.0
	δ	0.4	0.6	0.2	0	0.2	0.1	0	0.1	0	0	0	0.2	0.1	0.1	0.5					
III	Area	ta	v	i	r	u	p	c	s	g	h	e	b	f	m	t	a	d	n	q	l
	r_2	1.3	1.0	0.7	0.7	0.7	0.7	0.6	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.3	0.0	0.0	0.0	0.0	0.0
	δ	0.3	0.3	0	0	0	0.1	0	0.1	0	0	0.1	0	0	0.1	0.3					
IV	Area	v	e	u	p	ta	t	c	g	i	r	f	m	b	h	s	a	d	n	q	l
	r_2	0.6	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
	δ	0.2	0	0	0	0	0.1	0	0	0	0.1	0	0.1	0	0	0.1					
V	Area	e	r	v	p	b	c	f	g	u	s	ta	t	i	m	h	a	d	n	q	l
	r_2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	δ	0	0	0	0.1	0	0	0	0	0	0.1	0	0	0	0	0					

figures were formed by plotting r_1 as the ordinate and the stage of restoration as the abscissa, the curve with the largest curvature is the oldest plane. That is, we can distinguish between the groups of areas through the figures.

The four curves of areas ta, u, r and v, based on Figure 4 because they do not exist in Figure 3, have larger curvatures than other curves.

Group 1: ta, u, v, r
Group 2: f, t, s, i, g, h

Sub-group 2: c, e
Group 3: a, b, d, p, q, m
Sub-group 3: l, n

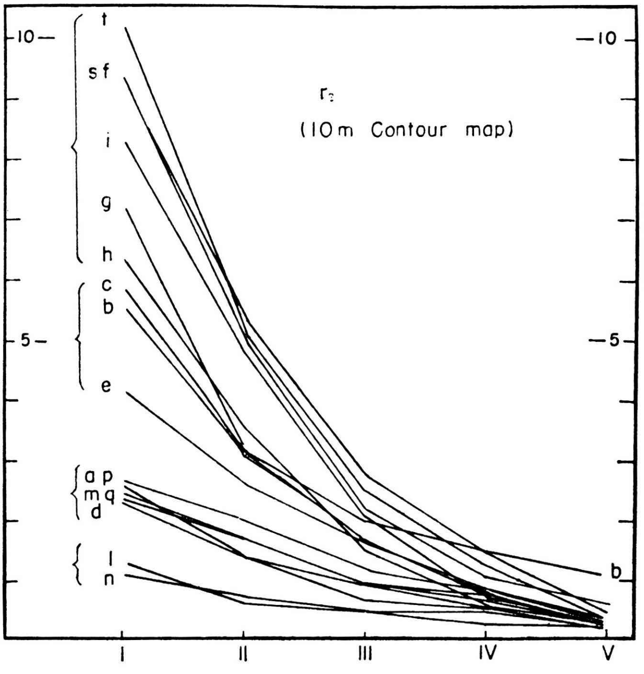

Fig. 3. r_2 (10 m contour map).

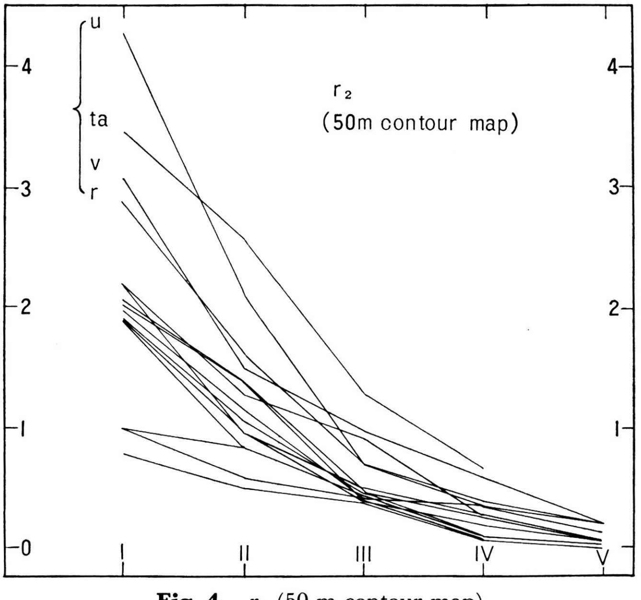

Fig. 4. r_2 (50 m contour map).

c. Classification by Δ. Δ is the difference between r_1 in each stage and its following stage of restoration. Therefore, the size of Δ is related to the curvature of r_2, and the old and new planes belonging to each area may be deduced from this relationship. Tables 7 and 8 are obtained by arranging Δ in order of size; Table 7 was based on the restoration map with a 10 m contour interval and Table 8 on the 50 m contour interval map. In these tables, the values of Δ to Δ_4 are the differences between the I and II, II and III, III and IV, and IV and V stages of restoration. Using these tables, Figure 5 was plotted using values of Δ as the ordinate and the stage of Δ as the abscissa. The following two groups can be seen in this figure.

Group 1: t, f, s, g, i, h, c, b

Group 2: e, a, q, d, p, l, m, n

Table 7. Δ_{1-4}, δ (10 m contour map).

S.R.	Order of dissection	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
I	Area	t	f	s	g	i	h	c	b	e	a	d	q	l	p	m	n
	Δ_1	5.0	4.3	4.1	4.0	3.5	2.9	2.8	2.4	1.6	1.2	0.9	0.8	0.7	0.7	0.7	0.4
	δ	0.7	0.2	0.1	0.5	0.6	0.1	0.4	0.8	0.4	0.3	0.1	0.1			0.3	
II	Area	f	t	s	i	h	g	c	b	e	m	p	a	q	d	n	l
	Δ_2	2.9	2.7	2.5	2.4	2.0	1.5	1.4	1.2	1.0	0.9	0.8	0.7	0.7	0.5	0.3	0.1
	δ	0.2	0.2	0.1	0.4	0.5	0.1	0.2	0.2	0.1	0.1	0.1		0.2	0.2	0.2	
III	Area	i	s	t	f	c	g	h	e	b	p	m	d	q	n	a	l
	Δ_3	1.4	1.3	1.3	1.1	0.9	0.9	0.9	0.7	0.5	0.4	0.4	0.3	0.2	0.2	0.1	0.0
	δ	0.1		0.2	0.2			0.2	0.2	0.1		0.1	0.1		0.1		
IV	Area	s	t	i	p	c	f	g	h	q	a	b	e	m	l	d	n
	Δ_4	1.0	0.8	0.7	0.7	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.3	0.2	0.0
	δ	0.2	0.1		0.2					0.1				0.1	0.1	0.2	

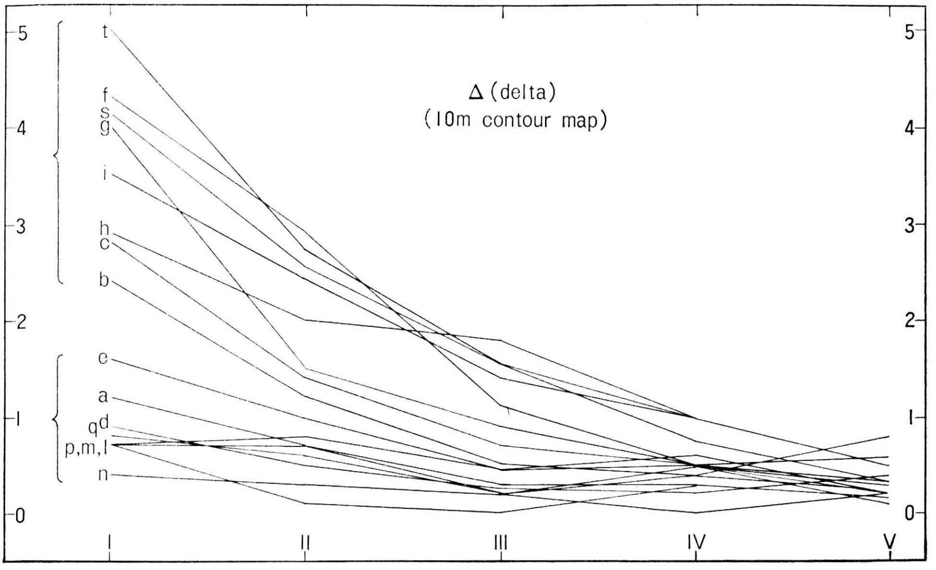

Fig. 5. Δ (10 m contour map).

In order to examine the four areas u, v, r and ta, which are not included in these groups, Table 8 was compiled from the restoration map with a 50 m contour interval. This table shows that the four areas should be included in group 1, and the value of Δ is larger than the area included in group 2. Adding these four areas:

Group 1: ta, u, v, r, t, f, s, g, i, h, c, b

Group 2: e, a, q, d, p, l, m, n

2. *Classification of planes by absolute height*

As older planes remained at higher altitudes, under the assumption that no crustal movement took place since the end of the preceding cycle in this region, it is believed that higher planes should be older than lower ones. To classify planes, the highest point (one point) within each area was applied to the height of the area (the height of the plane at the end of the preceding cycle). Table 9 was obtained by arranging the highest points in order of size; transformation points, at which remarkable changes in height can be seen, are marked by bold lines. The following six groups were found:

Group 1: ta

Group 2: r

Group 3: v, u

Group 4: s, i, t, f, g, h

Group 5: b, p

Group 6: c, e, m, a, q, l, d, n

3. *Classification of planes by relief*

a. Classification by growth curves. A circle with a radius of 1,500 m was used to measure the relief. Concentric circles, whose centers are three peaks at

Table 8. Δ_{1-4}, δ (50 m contour map).

S.R.	Order of dissection	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
I	Area	u	r	v	b	f	g	ta	t	h	i	s	c	e	m	p	a	d	n	q	l
	Δ_1	2.2	1.6	1.6	1.3	1.2	1.2	1.1	1.0	0.9	0.9	0.8	0.7	0.4	0.3	0.1	0.0	0.0	0.0	0.0	0.0
	δ	0.6		0.3	0.1		0.1	0.1	0.1		0.1	0.1	0.3	0.1	0.2	0.1					
II	Area	u	ta	i	r	f	h	v	s	t	c	g	b	p	e	m	a	d	n	q	l
	Δ_2	1.5	1.3	0.9	0.6	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0
	δ	0.2	0.4	0.3	0.1					0.1		0.1	0.1	0.1		0.1					
III	Area	ta	s	h	i	r	v	b	c	u	p	t	f	g	m	a	e	d	n	q	l
	Δ_3	0.9	0.5	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0
	δ	0.4	0.1				0.1					0.1			0.1		0.1				
IV	Area	ta	v	i	u	c	g	e	m	p	f	h	r	a	b	d	n	q	l	s	t
	Δ_4	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	δ		0.1		0.1					0.1				0.1							

optional positions in each area, in order of decreasing height, were drawn with radii of 0.5, 1.0 and 2.0 km. The differences in height between the centers of the circles (peaks) and the lowest points were obtained in turn from the small to the large circle. Then the average values for the differences in height between these three circles (relief) were calculated for each area and each kind of circle. By plotting the area of the circle as the ordinate and the relief as the abscissa, the relative curve between the relief and the area of the circle was obtained, as shown in

Figure 6. This curve[12] is represented by the equation $y=A(1-Bx)$, and is called a growth curve: x is the area (dimension), y the relief energy, B a constant (less than 1) and A is the limiting value of y.

This shows that the rate of relief decreases remarkably at a 1,500 m radius; therefore, the circle with a radius of 1.5 km was used for measuring the relief in this region. As seen in the figure, the growth curves may be grouped. It is true that low relief signifies a small degree of dissection, and such a plane is a newer one. Group 1 is the oldest and group 3 the newest (the above statement is con-

Table 9. Highest Points within Measured Areas.

Order of dissection	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Area	ta	r	v	u	s	i	t	f	g	h	b	p	c	e	m	a	q	l	d	n
ah	660	320	270	250	190	170	170	150	150	130	100	100	70	70	70	50	50	50	40	40
δ	340	50	20	60	20		20		20	30		30			20			10		
Group	1	2	3		4						5		6							

Table 10. Summary of Eastern Part.

Group	Gr. 1	Gr. 2 Ping-shan P.			Gr. 3 Kuang-ning-ssu P.						Gr. 4 P'i-tzu-wo P.									
Order of dissection	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Δ (delta)	ta	u	v	r	t	f	s	g	i	h	c	b	e	a	q	d	p	l	m	n
r_1	ta	u	r	v	f	g	h	i	s	t	b	c	e	m	p	a	q	l	d	n
r_2	ta	u	v	r	f	t	s	i	g	h	c	e	a	b	d	p	q	m	l	n
ah	ta	r	v	u	s	i	t	f	g	h	b	p	c	e	m	a	q	l	d	n
Growth curve	ta	r	v	u	f	g	i	h	s	t	c	b	e	i	g	m	a	p	d	n
Relief	ta	u	v	r	h	g	i	t	f	s	l	n	d	a	q	m	e	p	c	b
Average relief	ta	r	v	u	t	s	i	g	c	b	f	h	p	e	m	q	a	d	n	l

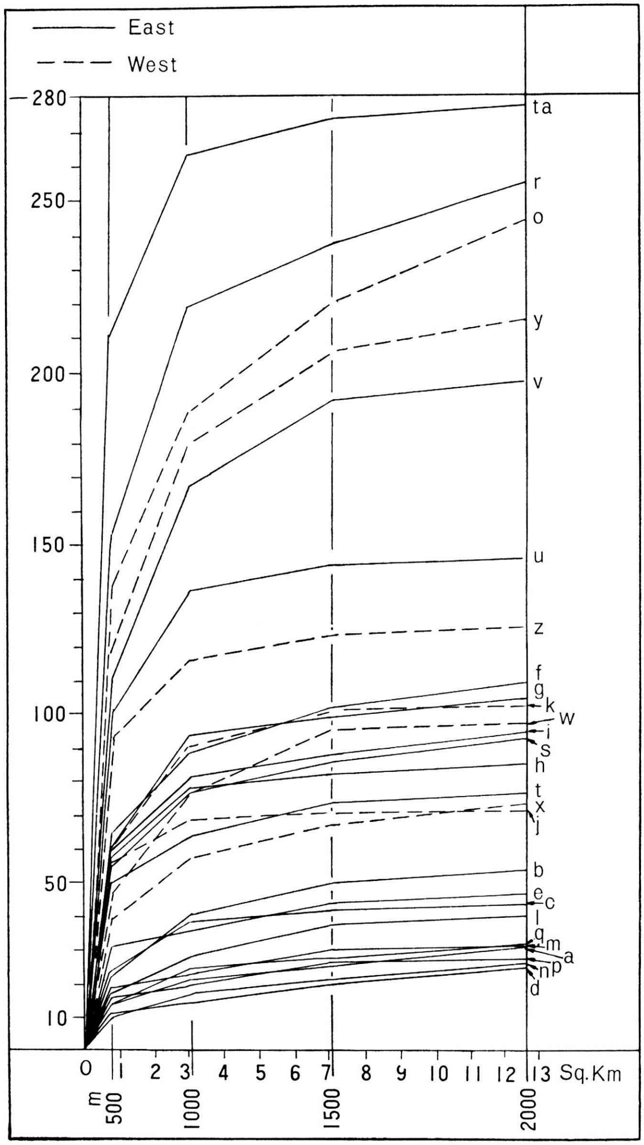

Fig. 6. Growth Curves—Eastern and Western Parts.

firmed in the eastern part of this region, and the growth curves for the western part have the same values as those for the eastern part).

b. Classification by frequency of relief. To obtain the relief, one area (16 sq. km) was covered with a net of 500 meter mesh. Placing the center of the 1.5 km (radius) circle described above on a point of intersection of the net, the difference between this crossing point (the center of the circle) and the lowest point within the circle were determined as the relief at this point. As a result, 81 relief values were obtained for one area. The curve of relief and frequency was made by plotting the relief as the ordinate and the frequency obtained in each area as the abscissa. The fact that the curve with a higher inclination is nearer the ordinate means that the plane is flatter, and the curve that has a lower inclination and stretches toward the abscissa means that the plane is in a higher degree of dissection. Figure 7 was constructed by arranging each area in order from flat areas to

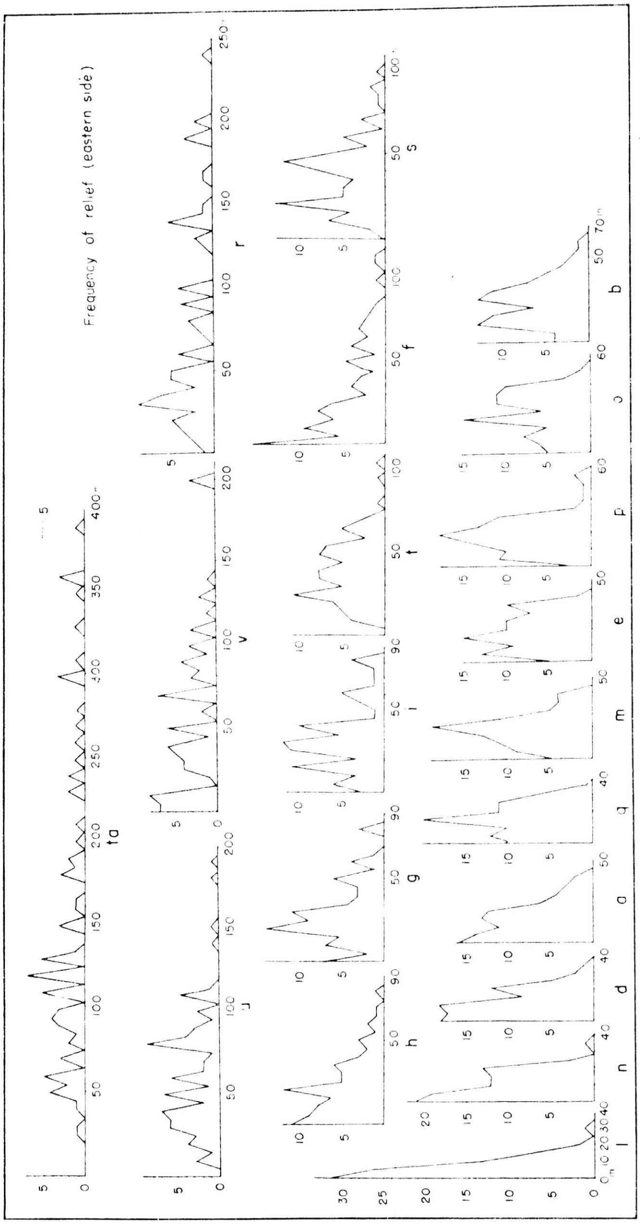

Fig. 7. Frequency of Relief.

areas with a higher degree of dissection. From the figure, the following four groups were found.

Group 1: ta
Group 2: u, v, r
Group 3: h, g, i, t, f, s
Group 4: l, n, d, a, q, m, e, p, c, b

Group 1 has the largest relief, and group 4 the smallest; that is, group 4 is of the youngest plane which was subjected to the lowest degree of dissection.

c. Classification by average relief. As described previously, 81 values of relief were obtained for each area. We obtained the arithmetical mean, and let it be the average relief of that area. A curve was obtained by arranging these values in order and plotting them as the ordinate and the relief as the abscissa, as in Figure 8.

Group 1: ta
Group 2: r, v, u
Group 3: t, s, i, g, c, b, f, h, p, e, m, q, a, d, n, l

4. *Summary of the eastern part*

The results of measuring, by various methods, the erosion surfaces of the eastern part distinctly confirmed that each area does not belong to one simple plane, as described above. Table 10 summarizes the results. Four groups were found using the means of distinction most common to each measuring method. On the map, the area belonging to group 4 is named the P'i-tzu-wo peneplane by the author and others.[28] The six areas in group 3 are included in a plane surface at a higher altitude than the P'i-tzu-wo peneplane, and in a higher degree of dissection. This is the Kuang-ning-ssu peneplane whose center is around Kuang-ning-ssu station

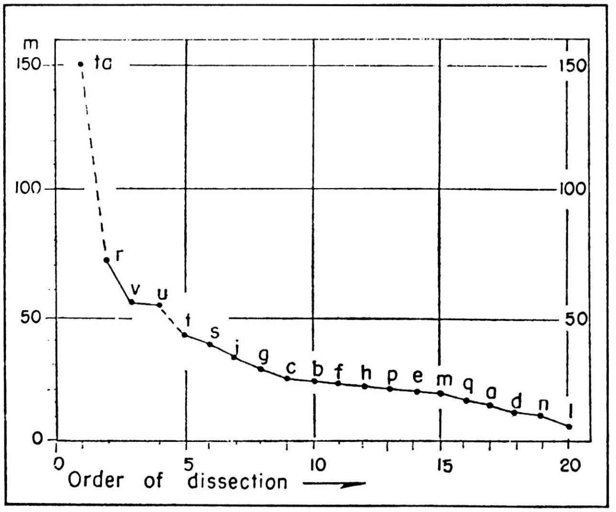

Fig. 8. Average Relief.

of the Chin-fu Railway. As shown in Table 10, this is distinguished from groups 2 and 3 by distinct boundaries and is not included in the same plane.

The second group (u, v, r) consists of areas which belong to the Pingshan plane[3] or the Ping-shan peneplane.[28] This shows greater dissection than the former peneplane, and is recognized only from its remnants, as shown in the table.

The fourth group (ta) was isolated in all methods of measurement, and is 200~300 m higher in absolute height than the Ping-shan peneplane; none compare with it. This already existed as a monadnock when the Ping-shan peneplane was completed, and is called the Ta-ho-shang Shan monadnock from the name of the mountain that exists in this area.

The heights of these peneplanes were obtained from Table 9, considering that the height of the highest peak in area a is near that of the original topography of the preceding cycle, to which that area belongs. According to Table 9, the Ping-shan peneplane is more than 250 m high, the Kuang-ning-ssu peneplane more than 130 m high and the P'i-tzu-wo peneplane more than 40 m high.

B. Erosion surfaces of the western part

Classification of the erosion surfaces of the western part was carried out in the same way as for the eastern part.

Table 11 summarizes each measured area classified by the various methods described above. All areas are classified into two groups; the first group is part of the Ping-shan peneplane and the second part of the Kuang-ning-ssu peneplane.

Table 11. Summary of Western Part.

Group	Gr. 1 Ping-shan P.		Gr. 2 Kuang-ning-ssu P.				
Order of dissection	1	2	3	4	5	6	7
Δ (delta)	y	o	k	x	w	j	z
r_1	y	o	k	z	x	w	j
r_2	y	o	k	x	w	z	j
ah	o	y	k	w	z	x	j
Growth curve	o	y	z	k	w	x	j
Relief	y	o	k	w	x	z	j

2. Distribution of erosion surfaces

The previous description shows that among the 27 areas measured, ta is the monadnock of Ta-ho-shang mountain and the other 26 areas are the products of peneplanation that occurred three times as follows.

1. Ta-ho-shang monadnock: ta
2. Ping-shan peneplane: u, v, r, y, o
3. Kuang-ning-ssu peneplane: t, f, s, g, i, h, k, x, w, j, z
4. P'i-tzu-wo peneplane: c, b, e, a, q, d, p, l, m, n

Figure 9 shows the distribution of each erosion surface on the restoration map with a 50 m contour interval, referring to the classification of these areas. In order to make the distribution of these three peneplanes more clear, Figure 10 was constructed.

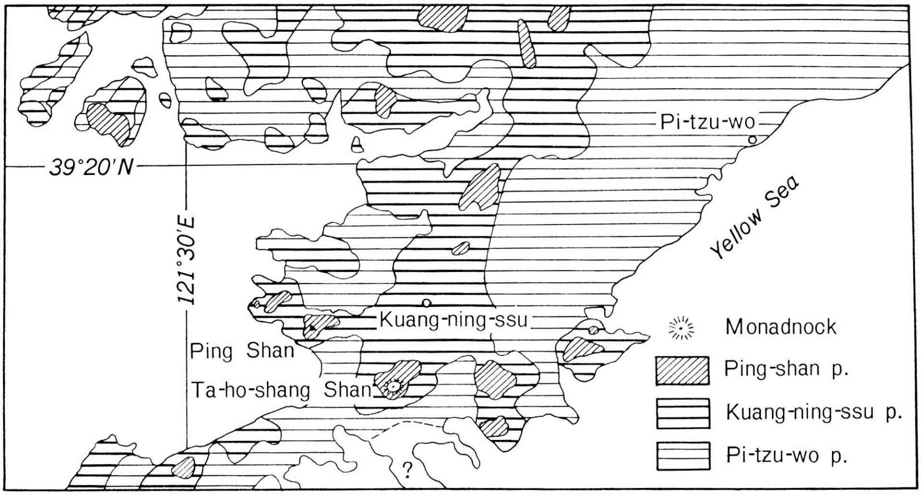

Fig. 9. Distribution of Erosion Surfaces (based on 50 m contour restoration map).

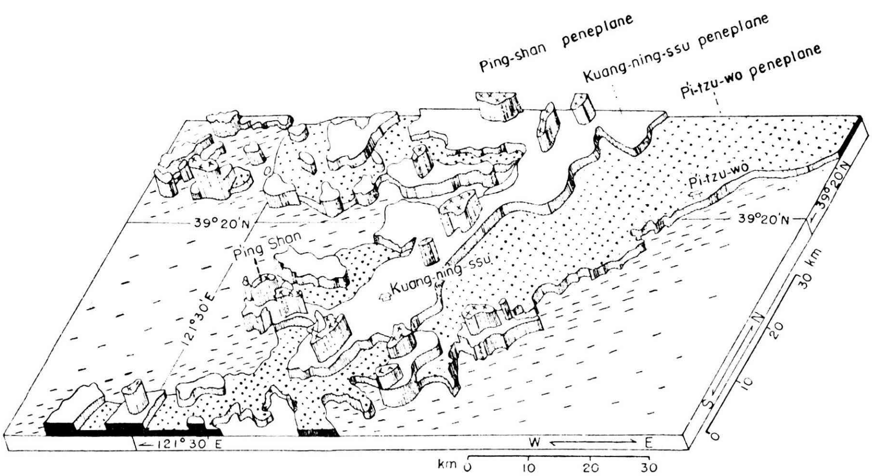

Fig. 10. Distribution of Ping-shan, Kuang-ning-ssu and P'i-tzu-wo Peneplanes.

A. P'i-tzu-wo peneplane

The P'i-tzu-wo peneplane is roughly 20 to 50 m above sea level and is quite extensive in this region. The center is located at P'i-tzu-wo in the eastern part of this region, and the peneplane is traceable east and west.

B. Aikawa plane

On the P'i-tzu-wo peneplane, a comparatively lower plane, 10 meters above sea level, exists mainly along the shore-line. This plane can be distinguished from the P'i-tzu-wo peneplane through field examination.

C. Kuang-ning-ssu peneplane

As shown in Figure 10, remnants of the Kuang-ning-ssu peneplane occupy most of the central part of this region, and extend north-northeast to south-southwest. It is quite extensive in the region centered at Kuang-ning-ssu, 120 to 200 meters above sea level.

D. Ping-shan peneplane

Remnants of the Ping-shan peneplane are found at an altitude of 300 to 400 meters, and is scattered in various places, assuming the shape of monadnocks in the field. A typical remnant of the Ping-shan peneplane is Ping Shan, rising north of Chin-chou station, on the top of which exists a flat plane with dolines. It has attracted the interest of geologists from early times[8,32] (Fig. 11).

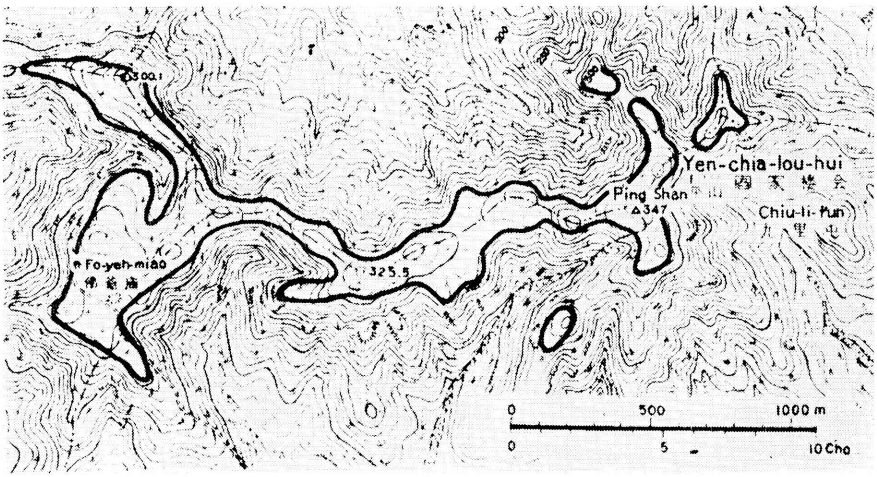

Fig. 11. Topographic Map of Ping-shan Peneplane (monadnock-like terrace).

E. Ta-ho-shang Shan monadnock

The Ta-ho-shang Shan monadnock rises higher than any other peak on the Ping-shan peneplane that is scattered as a monadnock-like terrace.* This moun-

* The monadnocks, like Ta-ho-shang Shan monadnock, are distributed in the northern part of the Liao-tung Peninsula. However, topographic maps of the northern district had not yet been published at the time when the author carried out measurements in this region.

tain already existed as a monadnock, more than 340 meters higher than the Ping-shan plane, at the time when the plane was completed.

3. Transformation point of the river valley

In the longitudinal section of the river in the middle of the Liao-tung Peninsula,

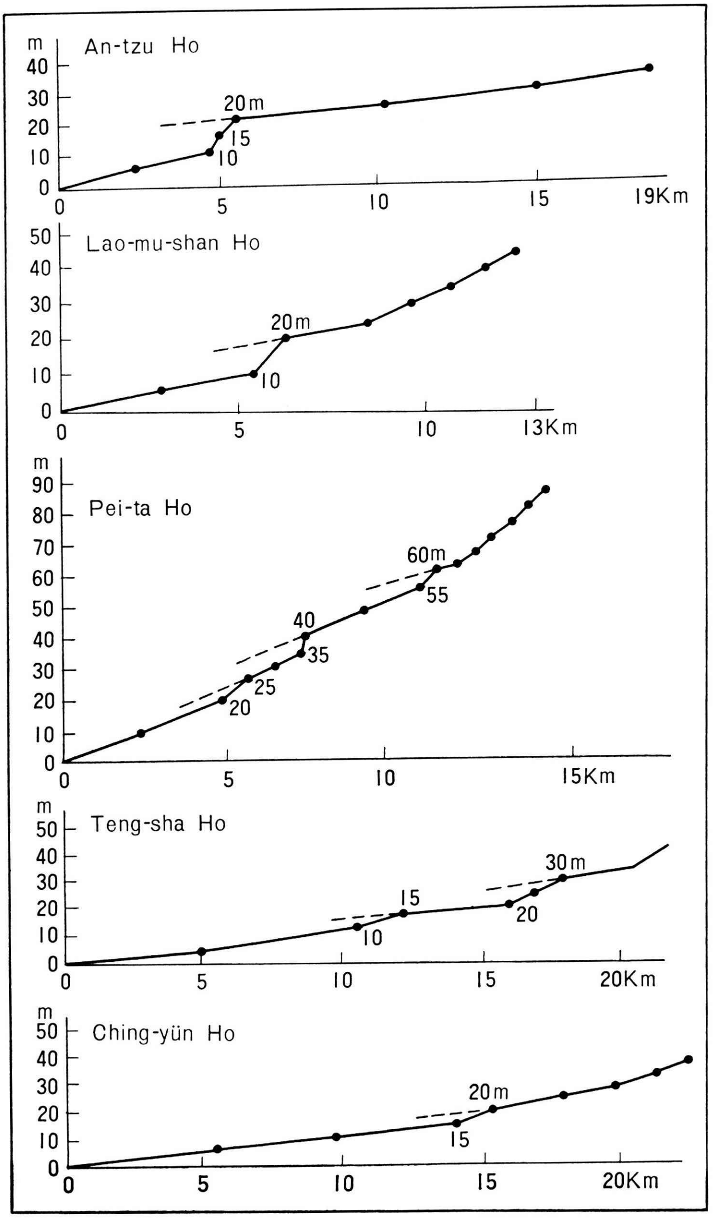

Fig. 12. Longitudinal Profiles of Rivers and Anomalies of the Profiles of Equilibrium.

transformation points where rapids occur are found. From the longitudinal sections of fifteen rivers, such anomalies in the profiles of equilibrium were discovered for many. Figure 12 shows one example. Figure 13 was constructed by plotting the Wendepunkts* on the map. One series of transformation points exists 10 to 20 meters above sea level; when connected on the map they almost parallel the coast line at the upper streams about five kilometers from the coast line. The lines connecting the Wendepunkts at 30 to 40 meters and 50 to 60 meters approximately parallel the main watershed of the peninsula. Therefore, they are distributed symmetrically along both sides of the watershed of the peninsula.

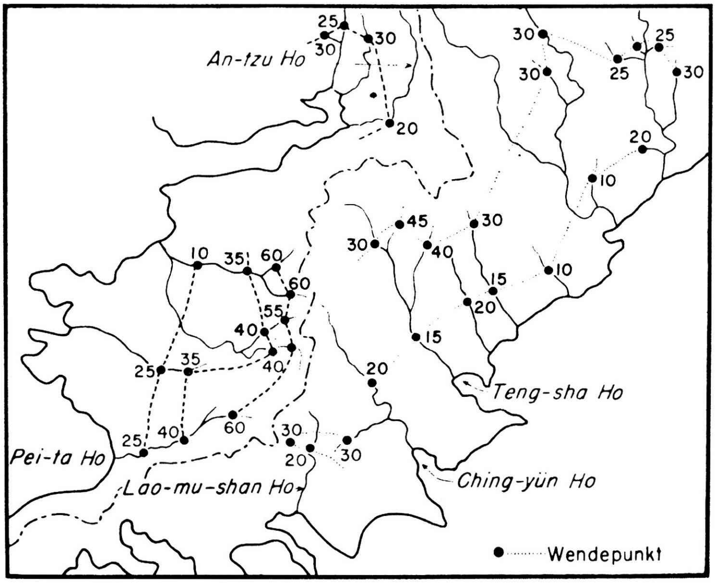

Fig. 13. Distribution of Wendepunkts.

These anomalies are not thought to be the results of stream piracy. The Wendepunkts in the eastern part are distributed over, and cut, the P'i-tzu-wo peneplane and the Aikawa plane, and the foundation rocks consist of the same gneiss, but faulting, warping or volcanic activity after completion of the P'i-tzu-wo peneplane are not thought to have been the cause of Wendepunkts. Consequently, they may be attributed to either crustal movement, positive to land and negative to sea, or a change in climate after the completion of the P'i-tzu-wo peneplane. There are two steep terraces in the vicinity of Ta-lien (Dairen) to Port Arthur which were formed chiefly by uplift of the land from the sea,[17)] and in the same way, the distribution of Wendepunkts is thought due to uplift of the land. That is, slight uplift took place after the completion of the Aikawa plane, and each river on the aikawa plane flowed rapidly to the mouths of rivers. These points where rapids

* Where stream rapids occur as the result of rejuvenation of the river; named Wendepunkt by SOKOL (R. SOKOL, Geol. Rundschi, 12, p. 123–228, 1921).

occurred gradually receded upstream while they continued to cut the Aikawa plane, and it is believed that these points are distributed as shown in Figure 13.

The transformation point of each river flowing into the Yellow Sea exists 20 to 50 m from the mouth of the river, distributed at an altitude of about 60 m above sea level, and is even seen in the interior to the vicinity of the southern end of Chi-lin (Kirin), Province in the northern part.[31]

4. Periods of peneplanation

Cenozoic deposits are scanty in this region. As a matter of course, there were few deposits in the period when peneplanation occurred, and deposits regarded as an interpeneplanation stage do not exist. Therefore, we must estimate the age of peneplanation in this region, referring to the data obtained for each place of circumference.

A. Ping-shan stage

It is known from earlier times that the flat plane at the top of Ping Shan can be traced halfway up Ta-ho-shang Shan. Susumu MATSUSHITA[8] called it an imaginary flat plane, which corresponds to the Ping-shan peneplane named by IMAMURA and the author.[28] At the present time, remnants of this peneplane are recognized at an altitude of 350 to 400 m, and Ta-ho-shang mountain, more than 660 m high already existed as a monadnock at that time. Remnants of the Ping-shan peneplane can be traced to the northern part of the Liao-tung Peninsula. Tracing this to the east, the Roppyakuzan plane in Korea, named by Teiichi KOBAYASHI,[18] is found. This is the peneplane that was completed in the middle of the Miocene Epoch, and it is known that the uncompleted peneplane existed before that time.

In China, the Yen-shan crustal movement occurred in the latter part of the Mesozoic Era, which then elapsed into quiet for a long time. This erosion period corresponds to the Pei-tai stage, named by B. WILLIS,[24] and the whole area of North China was subject to peneplanation at that time. A flat-topped crest on Pei-tai mountain, the highest mountain of the Wu-tai Shan reported by B. WILLIS, is 3,080 m high. Afterward, it became known that the lower plane such as Hsi-shan of Pei-p'ing (Peking) and the truncated plane in the porphyry massif east of Chang-chia-kou correspond to the Pei-tai peneplane.

BERKEY and MORRIS[25] believe that the Pei-tai peneplane may be correlated with the Khangai (Hang-ai) peneplane in Mongolia, which is about 3,000 m high. Since the Himalayan orogenic movement appeared in the stage next to the Pei-tai period in North China, faulting and folding structures were formed and volcanic activity occurred; a good example is found in Nan-ling in South China. The period is called the Nan-ling stage. It is believed that the Pei-tai peneplane was destroyed by this crustal movement and the height of some peneplane in North China was also changed.

Remnants of the Pei-tai peneplane, which was completed in the period of Pei-tai dissection, can be seen over a very wide area throughout North China, Mongolia and Korea. The Ping-shan peneplane is a remnant, which is thought to have been completed in the middle Miocene.

B. Kuang-ning-ssu stage

After completion of the Ping-shan peneplane, there was again calm in the Tang-hsien stage during the Nan-ling stage of crustal movement in North China, and the Pei-tai peneplane was subject to erosion. The plane that reaches a height of 90 to 120 meters at present in Tang-hsien, west of P'ei-ping, is the peneplane that was completed at the end of this period, and was traced by B. WILLIS to a height of 1,000 to 1,500 meters within the circumference of Pei-tai mountain of Wu-tai Shan. During this erosion period, fluviatile gravels and red clays were deposited on the lowland. This period is called the Pao-te stage. L. von LOCZY[27] reported that the river beds of this Pao-te stage contain Pliocene fossils in Kan-su Province. BERKEY and MORRIS[25] thought that the Mongolian peneplane, about 2,000 meters high in Mongolia, was formed in the T'ang-hsien stage. In Korea, this is the piedmont lowland[18], which was formed in the Pliocene. Sand and gravel beds occur at an altitude of more than 50 meters at Kangdong near the eastern margin of the Nangnang (Rakuro) peneplane, and an apparent nonuniformity exists between this plane and the lower one. A plane that is situated between the Roppyakuzan and Kishyu planes (P'i-tzu-wo plane) occurs over a wide area in the basin of Il-ha-myön, Tok-ch'on-gun in the northern part of P'yong-an-nam-do. That is, in the Pliocene, peneplanation occurred over the whole region of eastern Asia, and the Kuang-ning-ssu peneplane resulted.

After completion of the Kuang-ning-ssu peneplane, there came the Ma-lan stage through the Fen-ho dissection stage, San-men stage (deposition period of lacustrine and red clay), and Ching-shui dissection stage. The Ma-lan stage is the period when loess accumulated in North China and red clay[18] was deposited in Korea. In Mongolia, the Pang-kiang[25] period of dissection can be correlated with this stage. In the Liao-tung Peninsula, beds of loess-like clay, or red clay, cover the Kuang-ning-ssu plane in the vicinity of Chou-chia-kou at the northern foot of An-tzu Shan northwest of Ta-lien (Dairen), that is, the bed of red clay that accumulated after completion of the Kuang-ning-ssu peneplane is believed to have been dissected in the next stage from the fact that it did not accumulate on the P'i-tzu-wo peneplane.

The Manchurian plain is a vast flat surface which is thought to have resulted from erosion. The part of the plain covered with loess is found only in high-altitude regions, and the foundation plain on which the loess accumulated is thought to be a plain that was completed before the Ma-lan loess accumulated. Such a vast plain developed not only in the region of this plain, but it also connects with the Kuang-ning-ssu peneplane in the Liao-tung Peninsula. This is thought to be a product of the peneplanation that occurred over the whole of eastern Asia in the Tang-hsien stage; on the contrary, the Manchurian plain, not being covered with the loess, is distributed at altitudes lower than the former, and is considered to be connected with the P'i-tzu-wo peneplane.

C. P'i-tzu-wo stage

In North China, the Pan-chiao dissection stage followed the Ma-lan loess-accumulation stage. In this period, the loess beds were dissected and the gravel beds accumulated at lower levels; that is in the period between the Diluvial and Alluvial epochs. During this period in Korea, the surrounding peneplane (Kisyu plane), in the region of the western coast, was completed. The plane that forms part of the above-mentioned plane and is especially well developed on the banks of the above-mentioned plane and is especially well developed on the banks of the Tae-dong River in P'yeongyang is called the Rakuro peneplane. It corresponds to the Musashino plane (M plane)[20] in the vicinity of Tokyo, Japan.[18] The Pan-chiao stage is recognized as the Pang-kiang dissection stage in Mongolia,[25] and corresponds to the P'i-tzu-wo stage of construction in the Liao-tung Peninsula.

D. Aikawa plane

Uplift of the land has taken place since the completion of the P'i-tzu-wo peneplane. In the Liao-tung Peninsula, a slight depression occurred in the marginal part, and a peat bed accumulated in the vicinity of Pu-lan-tien, and the low plane in the vicinity of the shoreline, that is now a salt field, was completed. In Korea, a peat bed of this period was also found. These are deposits which were laid down after the completion of the P'i-tzu-wo peneplane, and the inundated flood plain that resulted from the slight depression in the marginal part of the continent. It seems that the low plane, which is cultivated in the Aikawa village, is quite typical. The peat bed in the vicinity of Pu-lan-tien was deposited recently in view of the fact that it contains *Nelumbo* sp., which is a semi-fossil that still has the ability to germinate. The plane, which is lower than the Rakuro peneplane and 3 to 10 m above sea level, occurs on the coast of the Taedong River in Korea.Typical development of this plane is found in Choni, south of P'yeongyang City, and is called the Souri plane[29] by the author.

Slight uplift of the land followed, resulting in lower terraces, and causing transformation points in rivers.

5. History of topographic development

In conclusion, the history of topographic development will be given in the following correlation table.

Table 12. Correlation Table

	North China	Liao-tung Peninsula	Korea
Recent	Present stage (dissection, alluvium)	Slight uplift {wendepunkt, Aikawa plane} Slight subsidence (Peat)	Slight uplift (Souri plane) Slight subsidence (part of peat bed)
		(slight uplift)	(Slight uplift)
	Pan-chiao stage {dissection, valley gravel}	Pi-tzu-wo Peneplane (20–50 m)	Rakuro Peneplane (20–50 m)
Pleistocene	Ma-lan stage (Loess)	(Red clay in Chou-chia-kou)	(Aqueous löess, red clay) Flood of yellow sea
			(Subsidence)
	Chin-shui stage {dissection, rock terrace}		
	(Warping)	(Uplift of Peneplane)	(part of lava-flow, Uplift with slight tilting)
	San-men stage (Fluvio-Lucustrine condition, San-men Series)		
Pliocene	(Slight Warping)		(Saikiho marine Formation)
	Fen-ho stage {Gorge-cutting, Flood plane}		(Subsidence of Tusima Basin)
	(Fold, Fault, Tilt)		(Up & Down Warping)
	Pao-te stage (Gravel bed—Pliocene fossils) Red clay	Kuang-ning-ssu Peneplane (120–200 m)	Piedmont lowland
			(En-niti series)
	Tan-hsien stage (dissection of plane and lava plateau)	(dissection)	
Oligo-Miocene			(subsidence of Eastern coast-region)
	Nan-ling stage {volcanism, fault, fold} (Himalayan Orogeny)	(faulting)	fault (low relief)
	Pei-tai stage Peitai Peneplane	Ping-shan Peneplane (300–400 m) Ta-ho-shang-shan Monadonock	Roppyakuzan Plane Transgression (*Mya, Vicarya* Bed) Monadnocks

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