6. *Classification of Crustal Movements.*[*]

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Orogenic and epeirogenic crustal movements, as well as those caused by isostatic adjustments, are familiar expressions in geomorphology, geology, and geophysics. The following is merely a suggestion for their classification from the quantitative point of view.

The author examined their gradients with relation to (1) sea level, (2) rivers (chiefly antecedent rivers) as local base-levels, (3) erosion surfaces, and (4) deposition surfaces. In the cases of depositional and erosional surfaces, the increases in the gradient, instead of the gradient itself were calculated. The results are arranged in the following tables.

Table I. Orogenic Zones.

Locality	after	10^{-1}	10^{-2}	10^{-3}	10^{-4}
WITH RELATION TO SEA LEVEL:					
Yuzaki, Kii, Japan:					
outer part of Sandan Kabé	G. Imamura[1]		2·6		
inner part of Sandan Kabé	〃	0·77			
average gradient of Sandan Kabé	〃	0·63			
outer part of abandoned mine	〃		2·7		
inner part of abandoned mine	〃	1·6			
average gradient of abandoned mine	〃	0·62			
average gradient of the whole region	〃		5·4		
Eastern coast of Kitakami, Japan	R. Tayama[2]			3·7(?)	
Yaku Island, Japan	G. Imamura[3]		2·0		
Okusiri Island, Hokkaidô, Japan:					
III terrace	A. Watanabé[4]			1·3	
IV 〃	〃			1·2	
V 〃	〃			1·7	
VI 〃	〃				4·7

(*to be continued.*)

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[*] Communicated by C. Tsuboi.

[1] *Proc. Imp. Acad.*, 10 (1934), 483~485.

[2] *Tirigaku Hyôron*, 7 (1931), 337~362.

[3] *Tirigaku Hyôron*, 4 (1928), 237~247.

[4] *Tirigaku Hyôron*, 4 (1928), 298~309.

Table I. (*continued.*)

Locality	after	10^{-1}	10^{-2}	10^{-3}	10^{-4}
Riviera:					
Milazzien	Depéret[5], Caziot,[6] Maury[7], Boule[8], Denizot[9], etc.		1·8(?)		
Tyrrhénien, locality 1			1·0(?)		
〃 〃 2			1·7(?)		
WITH RELATION TO RIVER, AS LOCAL BASE-LEVEL:					
Hidi Kawa, Japan:					
K niveau, upper course	G. Imamura & Y. Mino[10]		2·5		
〃 lower course			1·6		
S niveau, upper course	〃		2·4		
〃 lower course	〃		2·4		
WITH RELATION TO EROSIONAL AND DEPOSITIONAL SURFACES:					
Western Sikoku, Japan	G. Imamura & Y. Mino[10]		4·3		
Eisernes Tor, Donau:					
locality 1	J. Cvijic[11]	0·57			
〃 2	〃		2·5		
〃 3	〃		4·9		
〃 4	〃		3·5		
〃 5	〃		2·2		
Elevated fans, Toyama plain, Japan:					
Kurobé Gawa, older fan	A. Watanabé[12]		4·0		
〃 younger fan (right bank)	〃		2·4		
〃 〃 (left bank)	〃		3·1		
Katakai Gawa, older fan	〃		1·1		
〃 younger fan (right bank)	〃		2·0		
〃 〃 (left bank)	〃		1·0		
Hayatuki Gawa, older fan	〃		0·77		
〃 younger fan (right bank)	〃		3·1		
〃 〃 (left bank)	〃		1·1		
Kamiiti Gawa, older fan	〃		2·0		
〃 younger fan	〃		2·0		
Jôganji Gawa	〃		0·74		

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5) *Bull. Soc. Géol. France*, 4 t.6 (1906), 207～230.

6) 7) *Bull. Soc. Géol. France*, 4 t.4 (1904), 420～431; t.5 (1905), 581～592; t.11 (1911), 177～189.

8) *Bull. Soc. Géol. France*, 4 t.4 (1904), 10～13.

9) *CR somm. Soc. Géol. France*, **17** (1924), 181～182.

10) *Tirigaku Nenpô*, **1** (1933), 25～50.

11) *Pet. Mit.* (Erg.), Nr. 160 (1908).

12) *Tirigaku Hyôron*, **5** (1929), 1～15.

Table II. Neo-Paläiden.

Locality	after	10^{-1}	10^{-2}	10^{-3}	10^{-4}
WITH RELATION TO SEA LEVEL:					
L'Esterel, Monastérien	Lutaux[13]			0·64(?)	
WITH RELATION TO RIVER, AS LOCAL BASE-LEVEL:					
Mosel, antecedent course	Oestreich[14]			1·7	
Rhein, antecedent course:					
locality 1	〃			2·3	
〃 2	〃			1·3	
〃 3	〃			[illegible]	
Basin de la Ourthe:					
Meuse	Fourmarier[15]			0·69	
Ourthe	〃			0·78	
Amblève	〃			0·86	
WITH RELATION TO DEPOSITIONAL SURFACE:					
Le Crau	Baulig[16]			1·3	

Table III. Regions of Isostatic Compensation.

Locality	after	10^{-1}	10^{-2}	10^{-3}	10^{-4}
WITH RELATION TO SEA LEVEL:					
Greenland, e-line:					
Southeast Greenland	Vogt[17]				1·2
Julianehaab	〃				0·76
Disco region	〃				0·93
West Scandinavia, tapes line:					
Oslo-Southland	Tanner[18]				2·1
Westland	〃				2·6
Northland	〃				2·7
Troms	〃				2·5
West Finnmark	〃				2·1
East Fenno-Scandinavia, tapes line:					
East Finnmark	〃				1·8
Kola	〃				1·3

(to be continued.)

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13) *Rev. Géogra.*, t.12, f.1 (1924).

14) *Zeits. Geomorph.*, 2 (1926), 135~159.

15) *CR Cong. int. Géogra. Paris*, t.2 (1933), f.1, 90~108.

16) *Ann. Géogra.*, 36 (1927), 499~508.

17) 18) *Skr. Sval. Ishav.*, Nr. 60 (1933).

Table III. (*continued.*)

Locality	after	10^{-1}	10^{-2}	10^{-3}	10^{-4}
Carelia	Tanner				1·4
Baltic	〃				1·6
West Sweden	〃				2·0
Olonsay and Colonsay	Wright[19]			0·60(?)	
Islay	〃				1·5(?)

Table IV. Epirogenic Regions.

Locality	after	10^{-1}	10^{-2}	10^{-3}	10^{-4}
WITH RELATION TO SEA LEVEL:					
Atlantic coast of U.S.A., submerged shoreline	D. W. Johnson[20]				0·70(?)

In constructing these tables, attention was directed (1) to measuring the maximum gradient, and (2) to choosing such examples as occurred during approximately the same lapse of time; at any rate, the *order* of the length of time was made to be the same (say, 10^5 years). In these tables, such examples as in which the direction of the maximum gradient is uncertain, are indicated by question marks.

The above table and the accompanying frequency diagram show that the gradients are in the order of 10^{-2} in the so-called orogenic zones, 10^{-3} in the regions of "Neo-Paläiden," 10^{-4} in regions where isostatic adjustment is now going on. For epeirogenic movements, meagreness of data precludes me from coming to any conclusion.

If the total gradients during the supposed epoch are considered, and those examples covering longer periods are rejected, we shall then have a frequency curve for the orogenic zones as drawn with a dotted line in the accompanying figure. For other groups of crustal movements the curves remain unchanged.

These results show us that shorelines, once formed in almost horizontal situation, were afterwards so strongly

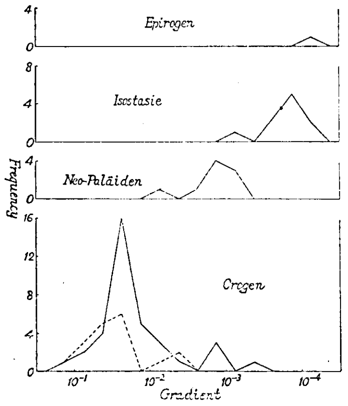

Fig. 1.

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[19] *Geol. Mag.*, 8 (1911), 97.

[20] The New England-Acadian Shoreline (1925), 299.

deformed by crustal movement that some of them attained a gradient of 10^{-1}. The author cannot accept Y. Ôtuka's opinion[21] that shorelines were *originally* made with such a strong gradient.

Along the coast of Kii Peninsula, the author[22] found a recent crustal movement with an average gradient of $5{\cdot}4\times10^{-2}$. This agrees well with the result obtained above, and suggests the existence of a kind of "Flexurküste" in the region in question.

In Japan, where crustal movements in the order of 10^{-2} prevail, it is rather difficult, not to say impossible, to find any indisputable geomorphological traces of *eustatic* changes of level.

6. 地殻運動の分類

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海岸段丘，河岸段丘(特に先行性流路に於けるもの)，堆積面，及び侵蝕面等の變位から地殼運動を求め，その gradient を定めた．これらの材料の内，海岸段丘は最も正しく地殼運動を示すものであり，その他のものは多少より不正確な結果を與へるものである．かくて 61 の觀測値を得てこれを頻度曲線にして見ると，造山帶は 10^{-2}, Neo-Paläiden 帶は 10^{-3}, アイソスタシーの地方は 10^{-4} の gradient を示すことが判る．

これらの測定値は 1) その最大傾斜の方向に測ることが必要であり 2) その運動した時間を知ることが大切である．幸にして傾斜方向は多くの場合に於て明かであり，二三疑はしいものは (?) を附けて區別した．時間は大略 10^5 年としてよいと思ふが，これよりも長いものは除外し，又この間に數回の運動をしたものはその傾斜の總和を出すことにして見ると，第1圖の頻度曲線の形は造山帶のものゝみが點線で書いたやうに變るが，その他のものは不變である．即ち上の結論はこれを變更する必要はない．

汀線は元來水平に近く形成されるものであるから，上述の gradient は形成後の地殼運動によると考へるを至當とする．かく考へれば各々の群に於て一つづゝ order が違ふことも無理なく說明されるけれども，大塚彌之助氏が昭和 9 年の 6 月及び 7 月の地震硏究所談話會で述べたやうに，汀線そのものが始から 10^{-2} のやうな大きな gradient で作られるとすれば，造山帶はそのまゝでよいとしても，Neo-Paläiden 帶，アイソスタシーの地方及び造陸帶では，その後一樣に gradient の減少が起り，然も一つづゝ order が違ふやうに減少しなくてはならないといふ事になり，甚しく不合理な結果となることは明瞭である．

本邦に於ては 10^{-2} が一般であるから，この樣な地方では汀線變化 eustatic changes of level の地形學的證據は求め難い．又世界各地で獨立に出した結果の order が合つて來ることは，地形學的方法で地殼運動を定めることが相當合理的であるといふことを示すものと思はれる．

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[21] An opinion expressed at the meetings of the Earthquake Research Institute, June 19 and July 3, 1934.

[22] G. Imamura, "Crustal Movements as indicated by an Elevated Shoreline near Yuzaki, Kii Peninsula, Japan," *Proc. Imp. Acad.*, **10** (1934), 483~485.