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A Study on Joints, developed in Tobong-san Area

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Abstract : Joint reflects the structure of the earth. And in many cases joints controls the developments of stream directions. In this studying area three joint sets are represented. One is concentrated to the north and the other is deviated 50°~60° from north to east and west. It is uncertain that the master joint set is a fault line, but the presence of the structural line is evident from the joint strike frequency. The Spearman's ϒ between joint patterns and the stream directions is about 0.73.

key word : *joint, stream, direction, joint set, master joint, fault, Spearman's ϒ*

Ⅰ. Introduction

Rocks are characteristically broken by smooth fractures known as joints. So that the analysis of systematic joints is necessary to know the present physical landscapes.

The purpose of this study is to show the joint patterns in Tobong-san area and the relationship between joint patterns and stream directions.

The studying area is a part of so called Chyuka-ka-ryŏng rift valley. The characteristics of the rift valley is well known is figure 2 which is the geomorphic cross-sections from Tobong-san (A: 736m) to Surak-san (B: 637m), Sorai-san (C: 227)

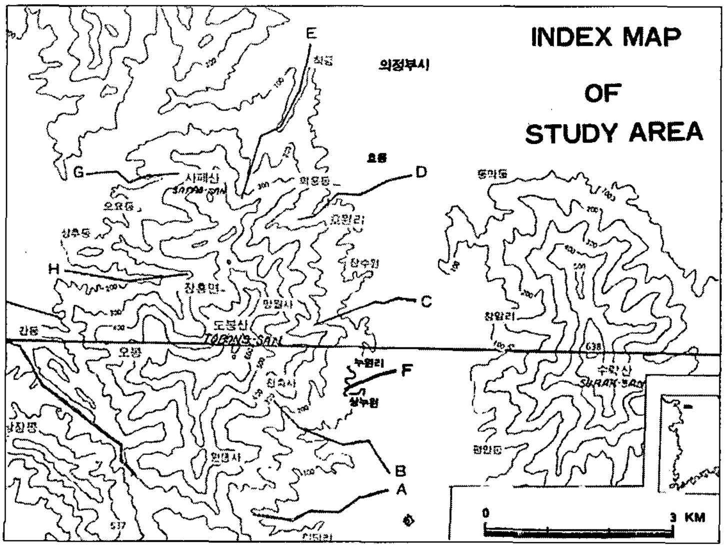

Fig. 1. Tobong-san Area.

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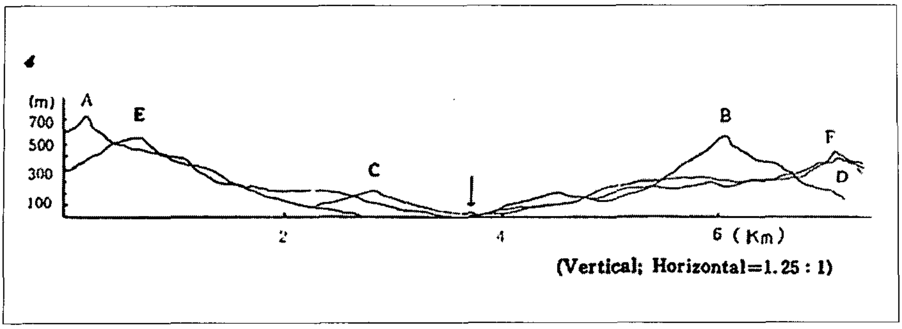

Fig. 2. Cross-section of the main points.

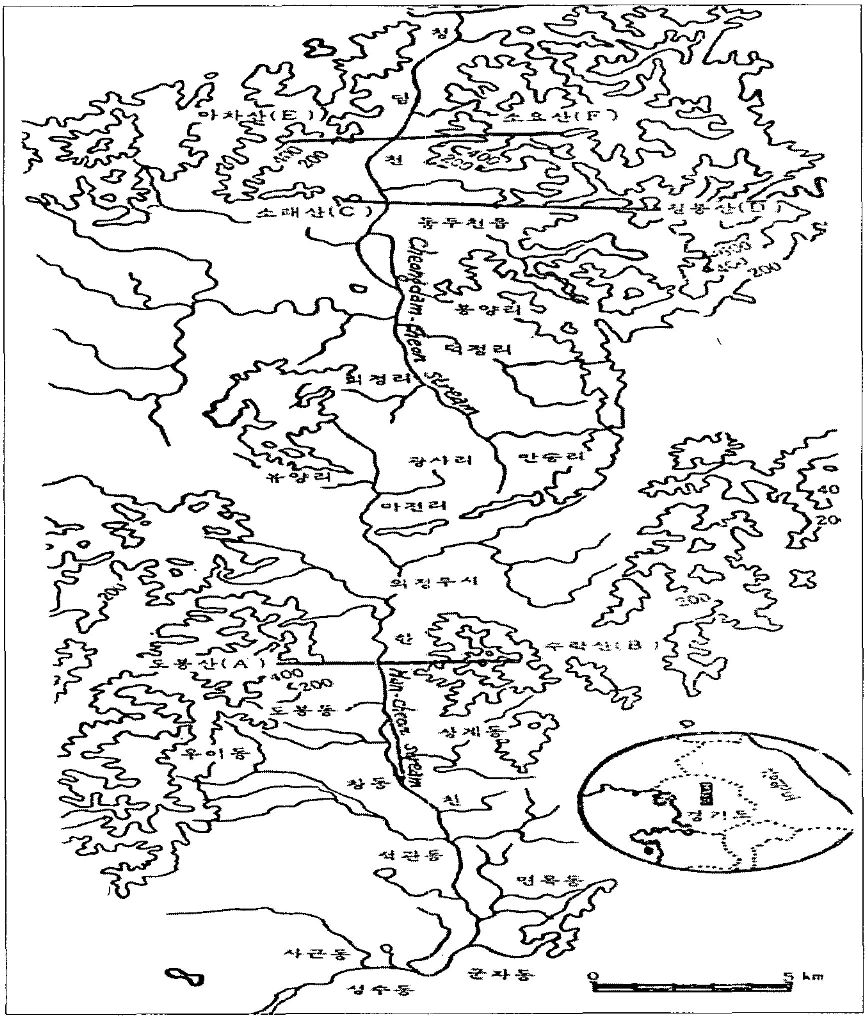

Fig. 3. Han-cheon and Cheong-dam-cheon stream area.

to Chilbong-san (D: 506m), Macha-san (E: 587m) to Soyeo-san (F: 535m). But the whole rift valley is not formed in same process.

The outline of the studying area is illustrated in figure 1 and 3.

Table. 1. Strikes frequency (East)

Strike / f	N1E ~ N10E	N11E ~ N20E	N21E ~ N30E	N31E ~ N40E	N41E ~ N50E	N51E ~ N60E	N61E ~ N70E	N71E ~ N80E	N81E ~ N89E	N1W ~ N10W	N11W ~ N20W
f	12	4	4	2	11	15	22	18	3	43	13
%	5.36	1.79	1.79	0.89	4.92	6.80	8.90	8.33	2.23	19.46	5.90

Strike / f	N21W ~ N30W	N31W ~ N40W	N41W ~ N50W	N51W ~ N60W	N61W ~ N70W	N71W ~ N80W	N81W ~ N89W	NS	EW	Σf
f	1	8	10	10	10	14	3	15	4	224
%	0.45	3.57	4.46	4.46	4.46	6.26	1.35	6.80	1.79	100

Table. 2. Strike frequency (West)

Strike / f	N1E ~ N10E	N11E ~ N20E	N21E ~ N30E	N31E ~ N40E	N41E ~ N50E	N51E ~ N60E	N61E ~ N70E	N71E ~ N80E	N81E ~ N89E	N1W ~ N10W	N11W ~ N20W
f	5	4	9	9	6	10	12	15	6	10	13
%	3.22	2.62	4.33	4.33	2.98	6.12	7.28	9.02	2.98	6.12	7.86

Strike / f	N21W ~ N30W	N31W ~ N40W	N41W ~ N50W	N51W ~ N60W	N51W ~ N70W	N71W ~ N80W	N81W ~ N89W	NS	EW	Σf
f	10	6	11	3	11	14	1	9	8	172
%	6.12	2.98	6.69	2.04	6.69	8.44	0.89	4.33	4.95	100

Ⅱ. Methods

The field data is obtained from April, 1968 to July and July, 1973 to September. Outcrops are measured along the stream valley. In the outcrops, strikes and dips of joints were measured. joint observation is followed by K.E. Lowe's[1] methods.

In Tobong-san area, total 792 values are obtained from 238 outcrops. And to know the differenciation between east slope and west slope medians and deviations are calculated. Stream directions are measured on the map and the field checking is added. In Han-chon, Cheongdam-cheon stream areas total 397 joints are measured in 191 outcrops.

There are 274 joint values in 130 outcrops from Ham-cheon stream area and 123 joint values in 61 outcrops from Cheongdam-cheon stream area. In the stream 191 joint values are observed.

Point-diagrams[2] and contour-diagrams[3] are represented the strikes and dips in Tobong-san area. To know the relationship between joint strikes and stream directions, Spearman's γ is applied.

The maps used in this study is 1:25,000 and 1:50,000 topograpphic maps published in 1966 and 1973.

Ⅲ. Synthetic Analysis

1. Strikes in Tobong-san area.

Table 1 and 2 represents the strike frequency in east and west slopes. 224

Table. 3. Strikes changed into angles.

SLOPE \ ANGEL	f	0~9	10~19	20~29	30~39	40~49	50~59	60~69	70~79	80~89	90~99
E	f	5	14	10	10	10	8	1	13	43	27
	Σf	5	19	29	39	49	57	58	71	114	141
W	f	5	14	11	3	11	6	10	13	10	14
	Σf	5	19	30	33	44	50	60	73	83	97

SLOPE \ ANGEL	f	100~109	110~119	120~129	130~139	140~149	150~159	160~169	170~180
E	f	4	4	2	11	15	22	18	7
	Σf	145	149	151	162	177	199	217	224
W	f	4	9	9	6	10	12	15	10
	Σf	101	110	119	125	135	147	162	172

Table. 4. Dip distribution (East slope)

QUADRANT ANGLE	NW%		NE%		SE%		SW%		NxE%	
0~10	0	0	0	0	0	0	0	0	-	-
11~20	0	0	0	0	0	0	0	0	-	-
21~30	0	0	0	0	1	0.45	0	0	-	-
31~40	0	0	0	0	3	1.35	0	0	-	-
41~50	0	0	1	0.45	1	0.45	0	0	-	-
51~60	0	0	4	1.79	8	3.57	2	0.89	-	-
61~70	3	1.35	16	7.14	8	3.57	10	4.46	-	-
71~80	12	5.36	24	10.71	19	8.46	21	9.38	-	-
81~89	3	1.35	12	5.36	25	4.16	16	7.14	-	-
90	-	-	-	-	-	-		-	9	4.02
Σf	18	8.06	57	25.45	65	29.01	49	21.87	9	4.02

QUADRANT ANGLE	NS├%		NS┤%		NxW%		EW┬%		Σf	
0~10	0	0	0	0	-	-	0	0	0	0
11~20	0	0	0	0	-	-	0	0	0	0
21~30	0	0	0	0	-	-	0	0	1	0.45
31~40	0	0	0	0	-	-	0	0	3	1.35
41~50	0	0	0	0	-	-	1	0.45	3	1.35
51~60	1	0.45	0	0	-	-	1	0.45	16	7.15
61~70	1	0.45	1	0.45	-	-	1	0.45	40	17.87
71~80	3	1.35	2	0.89	-	-	2	0.89	83	37.04
81~89	3	1.35	1	0.45	-	-	0	0	60	26.81
90	0	0	1	0.45	8	3.57	0	0	18	8.04
Σf	8	3.57	5	5.24	8	35.7	5	2.24	224	100

joints in east slopes and 172 joints in west slope are treated. Strikes represented in point diagram and contour-diagrams.

are changed into angles in table 3. In the formula, Table. 5. Dip distribution (West slope)

QUADRANT ANGLE	NW%		NE%		SE%		SW%		NxE%	
0~10	0	0	0	0	0	0	0	0	-	-
11~20	0	0	0	0	0	0	0	0	-	-
21~30	0	0	0	0	0	0	0	0	-	-
31~40	0	0	1	0.58	2	1.16	0	0	-	-
41~50	0	0	2	1.16	1	0.58	2	1.16	-	-
51~60	2	1.16	6	3.48	5	2.91	5	2.91	-	-
61~70	5	2.91	7	4.07	7	4.07	2	1.16	-	-
71~80	5	2.91	19	11.05	23	13.37	5	2.91	-	-
81~89	6	3.48	17	9.30	19	11.05	4	2.32	-	-
90	-	-	-	-	-	-	-	-	4	2.32
Σf	18	10.46	52	29.64	57	33.14	18	10.46	4	2.32

QUADRANT ANGLE	NSㅏ%		NSㅓ%		NxW%		EWㅜ%		Σf	
0~10	0	0	0	0	-	-	0	0	0	0
11~20	0	0	0	0	-	-	0	0	0	0
21~30	0	0	1	0.58	-	-	0	0	1	0.58
31~40	0	0	0	0	-	-	0	0	3	1.74
41~50	1	0.58	0	0	-	-	0	0	6	3.48
51~60	0	0	1	0.58	-	-	2	1.16	21	12.20
61~70	1	0.58	1	0.58	-	-	0	0	23	13.37
71~80	2	1.16	1	0.58	-	-	2	1.16	57	33.14
81~89	0	0	0	0	-	-	3	1.74	49	27.89
90	0	0	1	0.58	6	3.48	1	0.58	12	10.96
Σf	4	2.32	5	2.90	6	3.48	8	4.64	172	100

$Mdn = l + i\left\{ \frac{\frac{N}{2} - cumf_1}{fm} \right\}$ the median of the wast slope is 95 ° 56'. And the Q is 42 ° 37'.

In the east slope 43(19.46%) joint strikes are revealed between N1 ° W~N10 ° W, 22(8.93%) joint strikes are between N61 ° E~N70 ° E, 18(8.33%) joint strikes are between N71 ° E~N80 ° E. The ratio of above three intervals is 36.72%.

In the west slope the highest percentile is 9.02% between N71 ° W~N80 ° W and the lowest is 0.89% in N81 ° W~N89 ° W. 8.44% is represented in N71 ° W~N80 ° W, 7.86% is in N11 ° W~N20 ° W. The ratio of above three intervals in the west slope is 24.54%. Strikes in the east slpoe is more concentrated than the west slope.

To know the statistical analysis meadians and quadrant deviation is applied. Strikes in the west the median is 98 ° 31' and the Q is 47 ° 27'. This means that the strikes frequency in the west is weaker than the east slope.

2. Dips in Tobong-san area.

Table 4 show the dip distributions in the east slope. The interval is separated in 10 ° and the frequency is treated in quadrant. NSㅓ, NSㅏ and EWㅜ are treated specially,

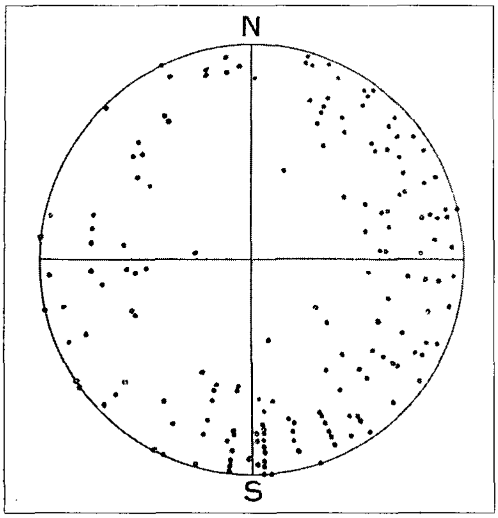

Fig. 4. Point diagram of 172 joints in the west slope of Tobong-san area.

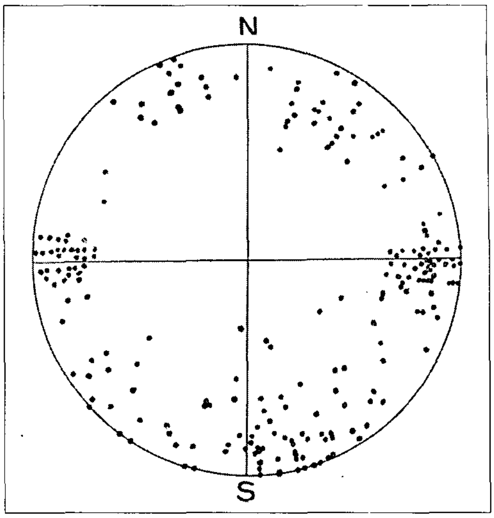

Fig. 5. Point diagram of 224 joints in the east slope of Tobong-san area.

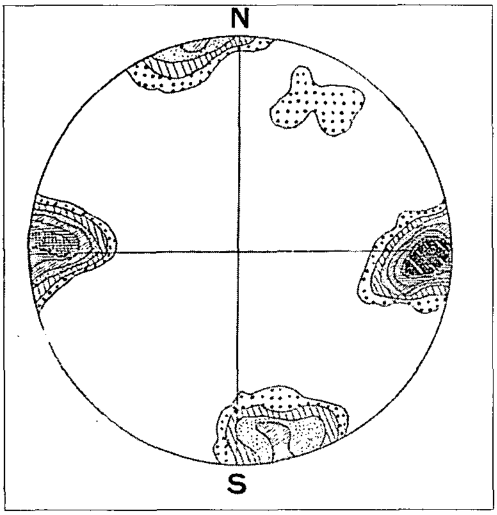

Fig. 6. Contour-diagram of fig. 4.

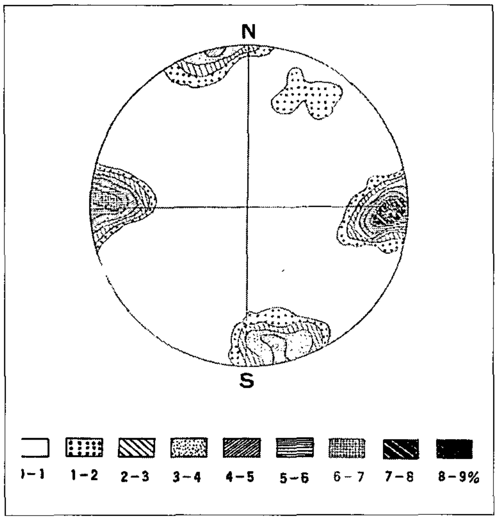

Fig. 7. Contour-diagram of fig. 5.

and NxE, NxW means dip in 90 ° . The highest frequency is in SE quadrant, 65(29.01%) dips and NE quadrant 25.45%, SW quadrant 21.87%.

The median of dip is 76 ° 24', and Q is 7 ° 42'. This means that dips of the east slope developed in high angles and the range of dispersion is not large.

Table 5. represented the dips in west slope. The highest frequency is SE quadrant in 33.41% and NE quadrant is 29.64%. Median is 76 ° 6' and Q is 9 ° 13'.

3. Analysis in Diagrams.

In general, joints are plotted in maps and diagrams to clarify the distribution patterns. In this paper point-diagrams and contour-diagrams are applied.

Table 6. The process of Spearman's γ in Han cheon area (N=17)

STRIKE or DIRECTION	Jx	Sy	Rx	Ry	d	d2	cf
5˚~14˚	13		8	3.5	4.5	20.25	
15~24	14		9	3.5	5.5	30.25	
25~34	3	2	1	8.5	7.5	56.25	
35~44	20	7	13.5	10	3.5	12.25	
45~54	15	11	10.5	13	2.5	6.25	
55~64	15	18	10.5	14	3.5	12.25	
65~74	26	25	15	16.5	1.5	2.25	
75~84	44	21	17	15	2	4	
85~94	32	25	16	16.5	0.5	0.25	
95~104	20	10	13.5	12	1.5	2.25	
105~114	11	8	7	11	4	16	
115~124	4	1	2.5	7	4.5	20.25	
125~134	7	2	4	8.5	4.5	20.25	
135~144	9	-	5.5	3.5	2	4	
145~154	17	-	12	3.5	8.5	72.25	
155~164	9	-	5.5	3.5	2	4	
165~175	4	-	2.5	3.5	1	1	
T	263	130		- -	-	289=Σd2	

Fig. 4, 5 show the strike distribution patterns in east and west slopes. Figure 6, 7 show the contour-diagrams fromspoint-diagrams.

This type of diagrams can be used in faults, dikes etc. But there are many problems in these diagrams to represent the joints correctly. The concept of D-D diagrams[4] is published but there are still many problems.

4. Relationship between joins and the Han-cheon stream direction.

To know the relationship between joint strikes and the Han-cheon stream directions, Spearman's γ is applied. Table 6 shows the processes of the Spearman's γ.

Jx means the joint frequency in outcrops and Sy means the stream direction. Rx means the rank of Jx in each intervals, Ry means the rank of stream direction frequency in the stream. D means the |Rx|-|Ry|. Spearman's γ is

$$\gamma = 1 - \frac{6\sum d^2}{N(N^2-1)} = 1 - \frac{6\times 289}{17(17^2-1)}$$
$$= 1 - \frac{1734}{4896} = 1 - 0.354 \fallingdotseq 0.646$$

Therefore the Spearman's γ between the Hancheon stream and joint strikes is about 0.65[5]

5. Relationship between joints and the cheongdam-cheon stream direction.

Figure 8 represent the joint strike frequency distributions and figure 9 means the stream direction distributions in the Cheongdam-cheon stream.

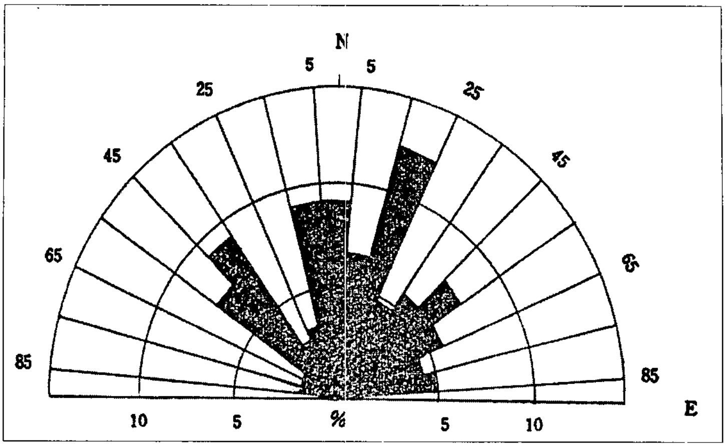

Fig. 8. Joint strike frequency distribution in Cheongdam-cheon stream. (T=123)

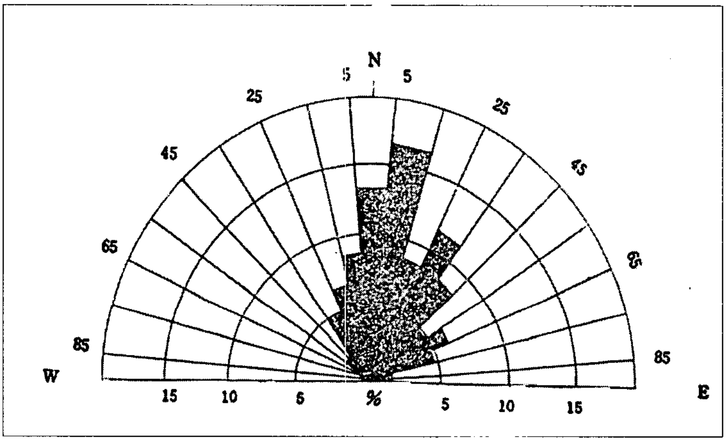

Fig. 9. Stream direction frequency distribution in cheongdam-cheon stream. (T=61)

Among the total joint strikes, 12.3% is in N16°E~N25°E and 8.9% is in NS, N1°E~N5°E, N1°W~N5°W and N6°W~N15°W.

And the other hand 16.4% of the total stream direction frequency is in N6°E~N15°E and 13.2% is in N1°E~N5°E and 11.5% is in N26°E~N35°E. So the three intervals mark the 41.1%[6]

The Spearman's γ in Cheongdam-cheon stream is 0.65[7] Therefore, the coefficient between the joint strikes and the stream direction is 0.65.

6. Relationship between joints and the stream direction.

To know the relationship between joint strikes and the stram directions, total 397° joint strikes and 191 stream directions were measured. Spearman's γ of the studying area is 0.734[8].

In general, jointing is the most important process to weathering in granite area[9]

It maybe thought that in Hancheon and Cheongdam-cheon stream area, jointing is antecedent and the weathering is proceeded and after then stream is unloading the weathering materials.

Ⅳ. Conclusions

The following conclusions are obtained from the analysis of the joint distributions in Tobongsan area and the relationship between joint strikes and stream directions in Hancheon and Chengdam-cheon stream.

1) In Tobongsan area, the distribution of the joint strikes of the east slope is more concentrated than west slope.

2) In Tobongsan area, the dips of joints developed in both east and west slope represented in high angle and the dispersion is not high but the east slope is steeper than the west slope.

3) In Tobongsan area, the direction of the joint strike is the most frequency in N4° W~N5° E which is corresponded with the direction of NNE-SSW. And this means the presence of the structural line.

4) In Hancheon stream area, the joint consist the master joint set concentrated to the north and the Spearman's γ is 0.65.

5) In Cheongdam-cheon stream area. the joints developed in three major sets and the Spearman's γ is 0.65.

6) In the studied area, the Spearman's γ between the joint strikes and the stream *directions is 0.73.*

As a whole the joint patterns in the studying area are three sets, one is concentrated to the north and two are separated by 50° ~60° in the opposite directions from the north. It may not be asserted confirmedly that the the master joint as a fault line exists because of deficiency of data, but it can be possibly agreed that there is a structural line through this studying area judging from the strike concentration. And so this study comes to the conclusion that there is amount of correlation between the joint patterns and the stream directions.

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2) Billings, M.P., Structural Geology, Prentice Hall, Inc. Engle wood Cliffs, N.J., Charles E. Tuttleco., Tokyo, Japan, 1966, pp. 108~111.
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4) Kim, Joo Hwan, "A concept of D-D diagram as a structural geomorphology analysis method." 1975.
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