10. *Notes on the Fracture System developed in the Setogawa Group.*

By Isamu MURAI,

Earthquake Research Institute.

(Read Oct. 21, 1947.—Received June 20, 1949.)

There are various fractures or cracks in any rocks, and it may be possible to consider that such fractures are the traces of ruptural failure produced by the crustal movement. Some geologists have already suggested that it may be possible to obtain some available information about the mechanism of rock deformation under a systematic and detailed investigation of such fractures. The fracture fabric of intensely deformed rocks, however, is so complicated that it seems to be very difficult to analyse the mechanism of fabric. In this report, the writer may show a trial of statistical treatment applied to the study on such apparently complicated fracture fabric.

The Setogawa Group, which is distributed along the Nirazaki-Sizuoka Tectonic Line, is a sedimentary group composed mainly of shale or clayslate and sandstone. The geological age of this group is assumed to belong in an early epoch of the Tertiary, and it has been suffered from intensive deformations and disturbed complicatedly by countless faults.

The writer tried to analyse the fracture system developed in the Setogawa Group by a statistical research, and could obtain several interesting results. Some arguments about these results may be written in the following.

1. *Outline of folding*—From the result of the statistical investigation about the orientation of bedding planes, it is clarified that their position is generally vertical, but gently inclined strata are distributed locally. (cf. fig. 1.)

2. *Fracture fabric*—Diagrams of poles to fracture planes, which are sampled at random out of the whole structure in the Setogawa Group, seem to show no significant preferred orientation at a glance. (cf. fig. 2, 3 & 4.) If all of the fractures are orientated entirely at random, that is, in any direction of the whole space the probability of appearance of pole to fracture plane is equal, the number of sections (f) which are classified by the number of poles (k) in them may follow to Poisson's distribution: $f=e^{-m}\frac{m^k}{k!}$,

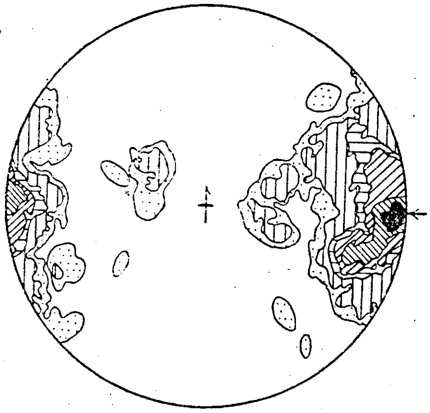

Fig. 1. Diagram (1% diagram) of 190 normals to the bedding planes of the Setogawa Group, measured at Hayakawa-Iri District, Yamanasi Prefecture. Contour interval: (12–10)–8-6-4–2–1–0%.

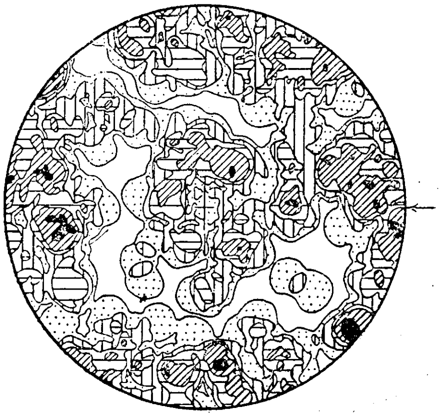

Fig. 2. Diagram (1% diagram) of 205 poles to the fracture planes in the Setogawa Group, measured at Umegasima-Mura, Abe-Gun, Sizuoka Prefecture. Contour interval: (3.5-3)–2-1.5-1-0.5-0%.

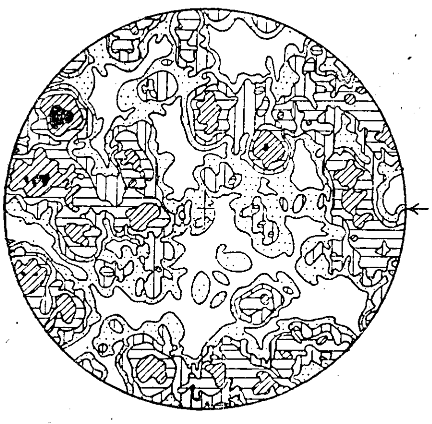

Fig. 3. Diagram (1% diagram) of 288 poles to the fracture planes in the Setogawa Group, measured at Ôkôti-Mura, Abe-Gun, Sizuoka Prefecture. Contour interval: (4-3)-2-1.5-1-0.5-0%.

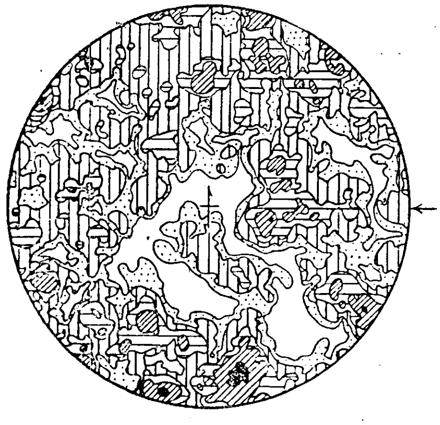

Fig. 4. Diagram (1% diagram) of 341 poles to the fracture planes in the Setogawa Group, measured at Ôkôti-Mura, Abe-Gun, Sizuoka Prefecture. Contour interval: (4-3)-2-1.5-1-0.5-0%.

when the whole area of diagram (which is made by using the equal area projection net) is divided into scores or hundreds of equal area sections. Then, it is possible to ascertain the significance of preferred orientation by comparing the observed frequency (f) with the expected frequency (F) of such number of sections. The degree of deviation of f from F is examined

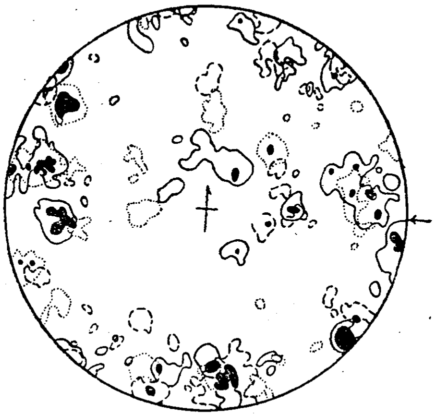

Fig. 5. Collective diagram of Fig. 2, Fig. 3 and Fig. 4, indicating the area of more than 2% and 3% concentration.

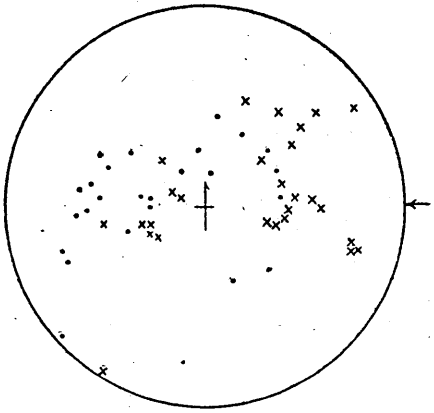

Fig. 6. Diagram of poles to the fracture planes which seem to belong in (hOl) fracture set. (•: shearing fracture, ×: vein.)

by χ^2-test for goodness of fit.[1] The writer divides the whole diagram into 156 equal area sections, and calculates the value of observed χ^2: $\chi_0^2=\Sigma\frac{(f-F)^2}{F}$, then obtains the value of probability $\{\chi^2>\chi_0^2\}$ from Fisher's χ^2-table. (cf. table I.) The null hypothesis, that these diagrams show entirely random orientation of all poles, is not denied by this statistical test, and the significance of preferred orientation is not ascertained. But in the collective diagram of these three diagrams, maxima or submaxima of each partial diagram have a tendency to cluster in several points in the diagram. (cf. fig. 5.) Then, the writer tried to calculate the indices of dispersion $\chi^2=\frac{\sum_{i=1}^{N}(k_i-m)^2}{m}$ about the numbers of poles in the equal area sections corresponding each other. In this case, he divides the whole diagram into 70 equal area sections. If all poles of these partial diagrams are orientated entirely at random, the frequency distribution of such indices of dispersion may be approximately similar to χ^2-distribution with number of degrees of freedom: $\nu=N-1$. Then the difference tween the distribution of observed frequency and that of expected frequency of χ^2 is examined by χ^2-test for goodness of fit, and the probability $\{\chi^2>\chi_0^2\}$ is obtained from χ^2-table. (cf. table II.) This time, the difference between them is highly significant, and it is ascertained that the

1) WINCHELL, HORACE: *A new method of interpreting fabric diagrams, Am. Min.*, Vol. 22 (1937) p. 15–37.

positions of poles in each diagram are not randomly orientated and have a tendency to cluster in several points in the diagram.

3. *Mechanism of fracture fabric*—It is difficult to recognize accurately the details of mechanism of such a fracture system ascertained by the statistical research as mentioned above. About some of these fractures, however, outline of their character may be recognized. The most distinct and penetrated ones are as follows:

(The general position of strata is taken as (*ab*) plane of the fabric co-ordinate, and the direction of strike of strata is taken as *b*-axis, in this case.)

(a) *(h0l) fracture set:* This is a pair of two fracture planes. Most of the faults of this fracture set seem to be normal faults. The direction of displacement along such fault planes may generally be perpendicular to the direction of strike of the fault plane. This fracture set is developed fairly homogeneously throughout the whole area between Sizuoka and Nirazaki. It may be possible to consider that the penetrating effect of this fracture set may have resulted in such unique structure of the Setogawa Group as mentioned above. (cf. fig. 1) Calcite and quartz veins are developed along the fracture planes of this set. (cf. fig. 6 & 7.)

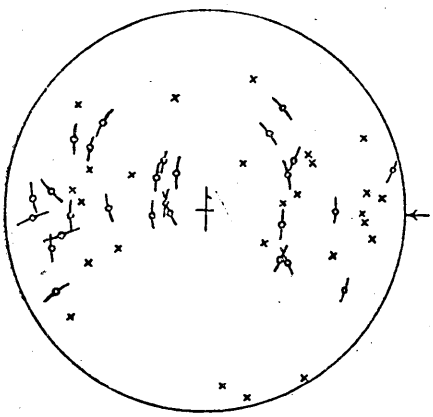

Fig. 7. Diagram of lineations and poles to slickensided surfaces upon which such lineations rest, measured at Hayakawa-Iri District. (o: direction of lineation, ×: pole to slickensided surface.)

Table I.

	$Pr.\ \{\chi^2 > \chi_0^2\}$
Fig. 2	$0.70 > P > 0.50$
Fig. 3	$0.50 > P > 0.30$
Fig. 4	$0.50 > P > 0.30$

(b) *(0kl) fracture set:* About the mechanism of this fracture set the writer could not obtain any information.

(c) *(010) fracture set:* This is not so distinct as (*h0l*) fracture set. The direction of lineation upon the slickensided surface which seems to belong in this fracture set is generally horizontal.

The detailed argument about the whole structure of the Setogawa Group may be reserved for another opportunity.

Table II.

χ^2	Expected frequency of χ^2 F		Observed frequency of χ^2 f		$\frac{(F-f)^2}{F}$
0. — 0.0201	0.4	8.2	0	19	14.22
0.0201 — 0.0404	0.4		1		
0.0404 — 0.103	1.2		3		
0.103 — 0.211	2.1		6		
0.211 — 0.446	4.1		9		
0.446 — 0.713	4.1	12.3	6	16	1.11
0.713 — 1.386	8.2		10		
1.386 — 2.408	8.2	20.5	6	6	10.21
2.408 — 3.219	4.1		0		
3.219 — 4.605	4.1		0		
4.605 — 5.991	2.1		0		
5.991 — 7.824	1.2		0		
7.824 — 9.210	0.4		0		
9.210 — 13.815	0.4		0		
13.815 — ∞	0.0		0		
Total	41.0		41		25.54

$\chi_0^2 = 25.54$ $\nu = 2$ $Pr.\{\chi^2 > \chi_0^2\} < 0.0001$