Research Note

Statistical Significance of the Fold Test in Palaeomagnetism

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Summary

The significance of the change in direction dispersion on applying the fold test in palaeomagnetism is used as the criterion for deciding whether or not the fold test has statistical significance. A set of tables is compiled which can be used for quick application of the test.

In a recent paper Gough & Opdyke (1963) have used the standard "fold test" of Graham (1949) to suggest that the Lupata Alkaline Volcanics were more nearly horizontal when magnetized than they are now. This would also indicate that the thermoremanent magnetization has been stable since the displacement in these rocks occurred. As is usual in the application of Graham's fold test one observes that the value of Fisher's k, the estimate of the dispersion of the directions of magnetization (Fisher 1953), increased on restoring the strata to the horizontal. The increase in k merely indicates that the directions have become more closely grouped. In the case of the Lupata Volcanics the value of k increased from 162 to 339 after applying the fold test. In another case Irving & Runcorn (1957), in their study of the Torridonian Sandstone, also illustrate the increase in dispersion on restoring seven sites on a fold of Caledonian age to the horizontal. In this case the value of k increases from 4·4 to 25·5 after correcting for geologic dip. With this wide range of change in the value of k after applying the fold test, it may be of some interest to derive a simple test to decide at any given statistical level whether or not any particular change in k is significant.

The simplest test to use is that of Watson (1956) and Watson & Irving (1957) for the comparison of direction dispersions. One can use the ordinary methods for the comparison of variances to test whether the direction dispersions observed before and after the fold test differ from one another. One simply tests the hypothesis that the value k_1, the estimate of the dispersion before applying the fold test, and the value k_2, the estimate of the dispersion after applying the fold test, are drawn from the same population with direction dispersion κ.

If the two populations before and after applying the fold test have the same value for κ then as shown by Watson (1956):

$$\frac{k_2}{k_1} = \frac{\text{variance with } 2(N-1) \text{ degrees of freedom before folding}}{\text{variance with } 2(N-1) \text{ degrees of freedom after folding}}$$

where N is the number of directions of magnetization involved. The right-hand side of this equation has the variance ratio or f–distribution, and values of $f = k_2/k_1$ far from unity strongly suggest that the two populations do not have

the same direction dispersion. If the hypothesis has only 5 per cent significance it can reasonably be rejected and consequently one can assert that the fold test is therefore significant at the 95 per cent confidence limit.

The variance ratio or f-distribution for equal numbers of degrees of freedom have been tabulated below in Table 1 for various values of N, the number of directions of magnetization. These have been compiled with the use of standard statistical tables and are tabulated here for easy reference. Both 5 per cent and 1 per cent significance points are tabulated. These correspond to the 95 and 99 per cent confidence limits for the significance of the fold test.

Table 1

95 and 99 per cent confidence limits for the application of the fold test

N	k_2/k_1 at 95% limit	k_2/k_1 at 99% limit
2	19·0	99·0
3	6·39	16·0
4	4·28	8·47
5	3·44	6·03
6	2·97	4·85
7	2·69	4·16
8	2·48	3·70
9	2·33	3·37
10	2·22	3·13
11	2·12	2·94
12	2·05	2·79
13	1·98	2·66
14	1·93	2·55
15	1·88	2·47
16	1·84	2·38
17	1·81	2·32
18	1·78	2·26
19	1·75	2·20
20	1·72	2·15

To apply the test one simply calculates the ratio k_2/k_1 and compares this with the value opposite the appropriate N in Table 1. If the ratio k_2/k_1 is greater than the value tabulated at the significance level desired, then the fold test is significant at that level.

As examples three cases are given below in Table 2. These are the Lupata Volcanics of Gough & Opdyke (1963), the Torridonian Sandstone of Irving & Runcorn (1957) and the Bushveld gabbro of Gough & van Niekerk (1959).

Table 2

Examples of the significance of the fold test

Formation	N	k_1	k_2	k_2/k_1	*Significance of fold test*
Lupata Volcanics	7	162	339	2·09	No
Torridonian Sandstone	7	4·4	25·5	5·79	Yes at 99% level
Bushveld Gabbro	5	9·9	41	4·14	Yes at 95% level

The application of all statistical tests are limited to those cases which satisfy the assumptions made. In this case it is assumed that the distribution both before

and after applying the field correction is a Fisher distribution. This assumption may limit the cases in which this significance test can be applied.

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