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SHORT NOTES

A note on sand dyke orientations

GRAHAM J. BORRADAILE

Department of Geology, Lakehead University,
Thunder Bay, Ontario, Canada P7B 5E1

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Abstract—The techniques of the statistics of directional data are applied to the orientations of sand dykes and bedding in strata unaffected by significant penetrative tectonic strain or compaction. From the records of the orientations of both bedding and sand dykes in 578 individual cases it is shown that the mean bedding-dyke dihedral angle for each group of dykes recorded in the literature ranged from 87.7 to 89.6°. The hypothesis is accepted that these dykes tended to form perpendicular to bedding. This has beneficial implications for their use as strain markers in compaction studies and in tectonic strain analysis.

THE ANGULAR relationships of parts of certain sedimentary structures may be sufficiently consistent to allow their use as strain markers. In this regard I have been working on the application of sand dykes of the types which were formed by the downwards infilling of fissures, the so-called neptunian dykes. Statistics on the original orientations of such features are also of value to sedimentologists in distinguishing between genetic models for sedimentary structures. For example, did sand dykes merely infill cracks orthogonal to bedding, or were they injected hydraulically in some different attitude? (See Eisbacher 1970, Hiscott 1979, Young 1968 for discussions along these lines.)

In the literature frequent reference is made to sand dykes being perpendicular to bedding in the undeformed state. (A computer listing of more than 60 papers referring to the relationships between bedding and some kind of sand dyke is available from the author). Unfortunately only a few authors described examples that were convincingly undeformed and few of those presented dips and strikes of bedding and sand dykes. Their data are summarized in Table 1. However, a misleading impression is given when we try to summarize their information using inappropriate statistics. Consider the following trivial example. Bedding is horizontal. One sand dyke dips to the E at 80°. Another dips W at 82°. What is the average dihedral angle between dykes and bedding? The arithmetic mean, 81°, is clearly misleading; the vector mean is 87°W. The choice of such arithmetic and inappropriate reference directions will cause an underestimate of the dihedral angle between dykes and bedding. Furthermore, when the azimuths of dips are not just west or east but range over 360° it is necessary to use the techniques of Mardia (1972).

For the data I examined (Table 1), inappropriate arithmetic averaging gives mean dyke-bedding dihedral angles as low as 66°, and several authors summarized their results in this way. However, applying the methods appropriate to directional data (Mardia 1972, pp. 218–222, 258–262) we observe that for horizontal beds, the mean dyke dips, $\bar{\beta}$, are very close to 90°. Furthermore using an α-value of 0.05 we can determine the 95% cone of confidence about the pole to bedding. This in indicated as β_{95} in the table. For the hypothesis of perpendicularity of dykes with bedding $\bar{\beta}$ should exceed β_{95}. Thus the hypothesis of perpendicularity is accepted for the first six data groups in the table. The seventh data group fails this hypothesis test by a narrow margin. However, the authors responsible included orientations of known sand-sills in their sample which increased the variance.

Table 1

Source	Number of dykes	Mean dyke-dip relative to horizontal beds $\bar{\beta}$	95% confidence limit about pole to bedding β
Alwin (1970)	76	88.6	88.3
Duncan (1964)	53	89.2	88.3
Hayashi (1966)	39*	87.7	86.6
Ivaschenko (1978)	114	89.6	86.1
Kato (1979)	51	89.0	83.4
Kharkovska (1972)	22	85.8	82.3
Smyers (1970)	223†	89.6	89.7
Smyers & Peterson (1971)	(10)‡	86.0	—

β_{95} is the 95% confidence limit for the dyke-bedding dihedral angle. $\bar{\beta}$ must exceed this for the hypothesis of orthogonality of dykes and bedding to be accepted.

* Representative sample of 10,000 dykes.

† The author included sand-sills in this sample but did not distinguish them from the dykes.

‡ Data not given. The authors presented 'averages' for the ten groups of data.

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