Pergamon

Journal of Structural Geology, Vol. 16, No. 12, pp. 1719 to 1721, 1994

0191-8141/94 $7.00+0.00

0191-8141(94)00064-6

Brevia

SHORT NOTES

Laboratory drilling of field-orientated block samples

W. H. OWENS

School of Earth Sciences, University of Birmingham, Edgbaston, Birmingham B15 2TT, U.K.

(*Received* 17 *January* 1994; *accepted in revised form* 5 *May* 1994)

Abstract—Corrections required to restore specimens to their field attitude are given, for specimens cored in the laboratory from a block arbitrarily orientated on the drill table.

INTRODUCTION

In palaeomagnetic or other studies orientated block samples are often collected in the field, for later coring in the laboratory. Directions measured in the core reference frame are subsequently rotated back to the field orientation of the sample. This note suggests a method of mounting block samples for laboratory drilling, which introduces a degree of flexibility over that usually employed, and describes the necessary rotations.

When collecting orientated block samples, it is standard procedure to mark up the sample in the field by drawing a horizontal strike line on a plane face and then recording the strike azimuth and the dip of this plane. Core specimens are usually taken from the block by mounting the block on a bench-press drill table with the sample reference plane horizontal, so that cores are drilled at right angles to the reference plane. Specimens can then be restored to their field orientation by two successive rotations: first, through the angle of dip about the horizontal strike line, and then through the strike azimuth about the vertical. The most frustrating step in this procedure is often that of setting the block on the drill table with its reference plane horizontal. This note describes the angular measurements and rotations necessary to recover the field orientation of the block, drilled, as before, through the reference plane, but for which the reference plane orientation is now arbitrary. This gives one the freedom to mount a block sample on the drill table in whatever orientation is most convenient. In that the reference plane now becomes a plane of measured orientation, rather than one that is 'near enough' (depending on one's patience or level of frustration) horizontal, the revised procedure may also be more accurate.

Alternatively, the increased flexibility allows one to core parallel to a particular direction of interest in a sample, or to take multiple cores in different orientations.

STRIKE, DIP AND PITCH

It is necessary to agree on a convention in which angular variables are specified unambiguously. The widely used 'clockwise' or 'right-handed' convention is adopted here (Fig. 1). Given a horizontal line on a

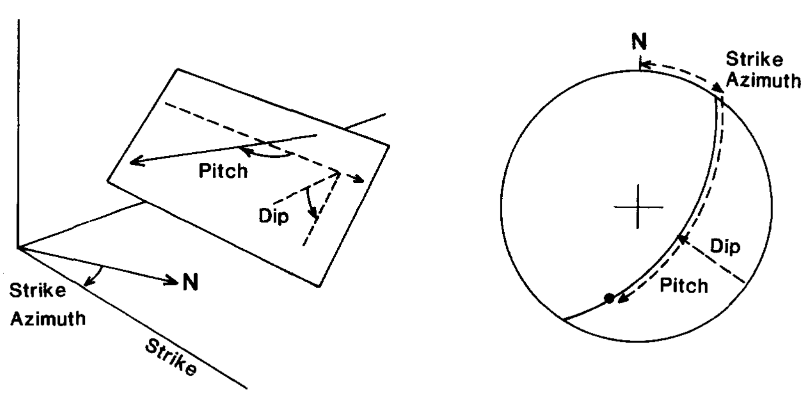

Fig. 1. The clockwise, or right-handed convention used for specifying strike, dip and pitch.

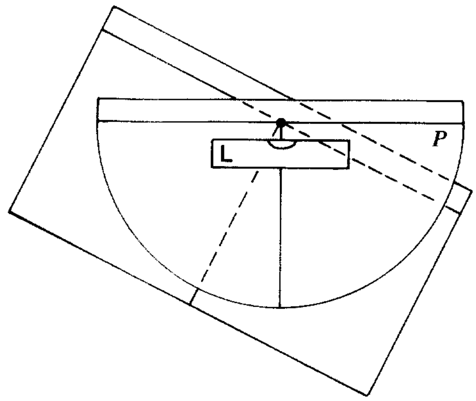

Fig. 2. A combined protractor and bubble (or carpenter's) level used to measure dip and pitch. The level L is attached to the protractor P, which is pivoted at X on to a rectangular plate.

dipping plane, the reference end (conventionally marked on the hand sample with an arrow) is taken as that from which one has to turn clockwise to look down dip (or that to which the thumb points if the right hand is placed on the plane with the fingers pointing down-dip). If a strike azimuth is specified, it is that of the reference end. The angle of dip is measured as positive if downward (0–90°: right way up; 90–180°: overturned). The angle of pitch of a line in the plane is measured in the (dipping) plane, from the reference end of the strike line as origin, and taken as positive if clockwise, looking into the face; if the line has a sense (i.e. is arrowed) the pitch can range over 360°.

Measurement of dip and pitch can be facilitated by the use of a simple device (Fig. 2). A bubble (or carpenter's) level is mounted on a protractor, parallel to its base (0–180° line). The protractor is pivoted at its origin on to a rectangular plate; the reference line runs through the pivot parallel to the edge of the plate and is read against the protractor scale.

PROCEDURE

A field-orientated block is marked up with arrowed strike lines on its reference plane. Place the block on the drilling table, to be drilled vertically. Measure (with strict regard to convention) the angle of dip of the reference plane and the pitch in this plane of the strike line (to avoid mistakes it is useful to record the angles measured on a sketch). Drill through a strike line and trace, through its intersections with the core, lines on the sides of the core to preserve the core reference frame (x along reference line, z into core) for the individual, sliced specimens.

In the core reference frame (Fig. 3a) the azimuth of strike of the as-drilled reference plane can be calculated from the measured dip δ_d and pitch ϕ_d:

$$\tan \beta_d = -\tan \phi_d \cos \delta_d. \qquad (1)$$

The sample can now be returned to its field orientation by three successive rotations. Alternative sets of rotations can be devised. Of the two described below the first is, perhaps, easier to visualise and forms a basis for calculating the required rotation matrix (Fortran program available). The second set of rotations is suitable for a stereographic solution. (The two should produce the same result—a useful test.)

Rotations—sequence of Fig. 3

Referring to the sequence of operations illustrated in Fig. 3:

(1) Rotate about P_d, the pole to the as-drilled reference plane, anticlockwise (looking out along the axis) through the measured angle of pitch (rotation of $-\phi_d$; Figs. 3a & b). This returns the strike line to horizontal.

(2) Rotate about the strike line, through an angle equal to the difference of field and as-drilled dips of the reference plane (rotation of $\delta_f - \delta_d$; Figs. 3b & c). This returns the reference plane to its field dip.

(3) Rotate about the vertical, through an angle equal to the difference of the field azimuth of strike and the azimuth of the as-drilled reference line pitch (rotation of $\alpha_f - \beta_d$; Figs. 3c & d). This returns the strike line to its field azimuth.

If $\mathbf{R}_1$, $\mathbf{R}_2$ and $\mathbf{R}_3$ are the matrices describing the successive rotations, the resultant rotation matrix is:

$$\mathbf{R} = \mathbf{R}_3\, \mathbf{R}_2\, \mathbf{R}_1. \qquad (2)$$

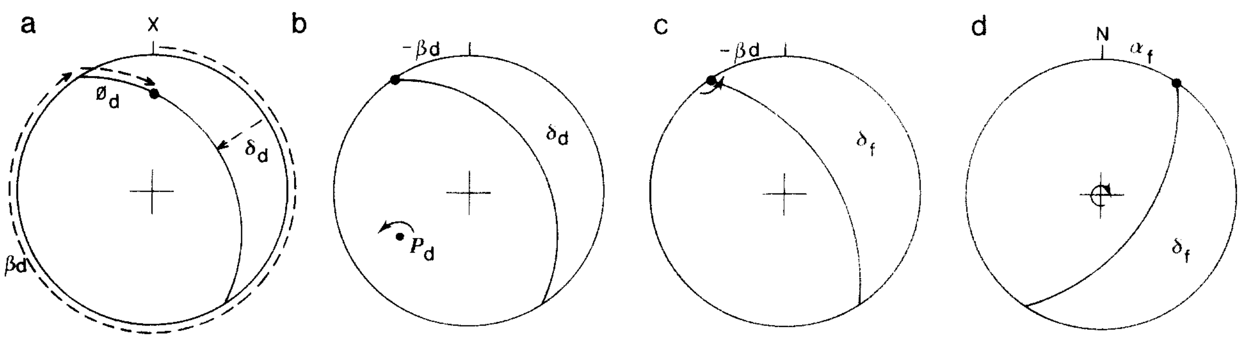

Fig. 3. The successive rotations required to recover the field orientation. Orientation in the field is specified by the strike and dip of a reference plane: in the figure the strike line is marked as a filled circle, P_d is the pole to the reference plane. (a) Core as drilled; (b) after rotation about the pole to the as-drilled reference plane to restore the strike line to horizontal; (c) after rotation about the strike line to restore the field dip; (d) after rotation about the vertical to restore the field strike azimuth. In (b)–(d) arrows indicate the rotation leading to that step.

Rotations—stereographic solution

(1) On a sheet of tracing paper draw as a great circle the reference plane, dipping as drilled.

(2) Mark off the pitch of the reference line along the great circle.

(3) Rotate the paper until the reference line lies in the vertical north–south plane of the net, with its arrow direction pointing north. Relative to the net the paper is now in the core-axis frame (Fig. 3a).

(4) Plot the measured vector (e.g. remanence direction) in the core-axis frame.

(5) Rotate the as-drilled reference plane back to horizontal about its strike (i.e. take out the dip of the plane); rotate the measured vector and the reference line with it. By this stage the field reference line has been returned to the horizontal.

(6) About the reference line rotate the reference plane, and with it the previously rotated vector, from the horizontal through the field dip. The reference plane now has its correct dip.

(7) Rotate the paper until the reference line points in the direction of field strike relative to the net. The reference plane and the measured vector now have their field orientation.

Acknowledgements—My thanks to Graham Borradaile and an anonymous reviewer for detecting shortcomings in the original manuscript: I hope this version is better.