

Methods for Collecting Oriented Rock Samples

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1. Introduction

Techniques commonly used for orienting rock samples for magnetic studies are described in Collinson *et al.* (1967). Following is a description of the methods currently employed by the rock magnetism group in the CSIRO Division of Mineral Physics and was prepared in response to requests from non-practising palaeomagneticians who may occasionally desire to obtain material suitable for magnetic properties investigations.

Samples may be collected in either block or drill-core form. The particular technique used is usually a matter of personal preference, though it is generally held that coring at the rock outcrop is more accurate and it does allow a field worker to avoid sampling near cracks and joints, i.e. preferentially weathered zones.

2. Field Drilling

Figure 1 shows the field-drill in operation. It consists of a lightweight two-stroke motor, generally of the type used to power a chain saw and a chuck which holds the diamond drill-bit: the bit is water cooled.

The commonest types of drill design used are (a) handset diamond bits and (b) a diamond matrix bit. The internal diameter of the bits is 25 mm. The arrangement shown in Figure 1 is based on a kit purchased from J. K. Smit of Toronto, Canada. After drilling to the depth required, generally 100-150 mm, the drill is carefully removed so as to leave the cored piece of rock *in situ*. An orienting tube is slid over the core and adjusted until the table is horizontal, checked with the bubble level — shown in Figure 2.

The table contains a fixed 0-360° scale and with the slitted rod positioned concentrically with the scale and perpendicular to the table, constitutes the sun compass. Since many rock types are sufficiently magnetic to appreciably deflect a magnetic compass, sample orientation must be carried out by means of a technique that does not depend on the direction of the earth's magnetic field. To complete the orientation the core must be scribed along its length via the slot provided in the orienting tube and the upward direction clearly marked. It is also good practice to take a magnetic bearing of the strike so that should the

occasional sun compass reading be unobtainable, then a good estimate of the local declination can be made for converting magnetic readings to true north readings. Details of the use of the sun compass are given in the appendix. The inclination of the core face (the plane perpendicular to the axis) is read directly from the clinometer scale.

3. Block Sampling

The block sampling method is a rapid way of collecting a limited number of oriented rock samples and relies on relatively unsophisticated and inexpensive field equipment. The size of the collection is limited by the sheer practicality of transporting a great weight of rock samples in the field. Much time is then required in the laboratory for drilling out cores and this also involves a reorientation of the blocks in the drill press. However block sampling may be the only practical way of obtaining suitable material, e.g. drill inaccessibility, drill-bit cooling water shortage, relatively unconsolidated rock, etc.

Two ways of orienting a block sample are (a) by marking the horizontal (strike) and dip line on a flat surface, or (b) if a flat face is not available, by a tripod arrangement where the feet in contact with the uneven surface form an isosceles triangle. Orienting equipment for these two systems is shown in the Figures 3 and 4. The table, used for flat faces, incorporates a sun compass (i.e. a fixed 0-360° scale and a concentric slot to house the slitted rod), a clinometer, and was originally designed with a built-in magnetic compass (Embleton and Edwards, 1973). The table is held horizontally (Figure 3A) and a strike direction marked on the rock surface. Both sun and magnetic compass azimuths are recorded. The table is then placed in a vertical position (Figure 3B) perpendicular to the strike line and the inclination of the face is marked and measured.

For orienting uneven faces a perspex table similar to that described above containing the sun compass, is hinged to a lower perspex plate. The hinge-line is parallel to the short side of an isosceles triangle formed by pointed brass legs themselves screwed into the lower perspex plate (Figure 4). At the rock face, the position of the lower plate is adjusted



FIGURE 1

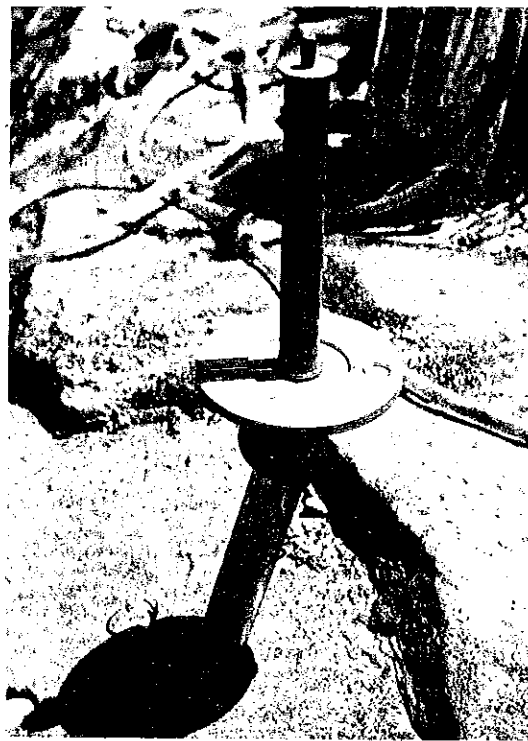


FIGURE 2



FIGURE 3a

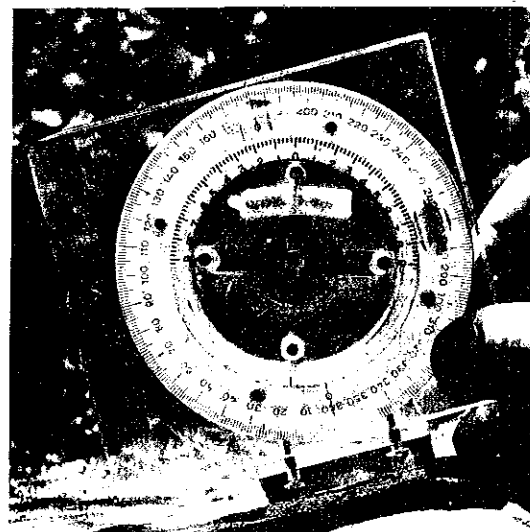


FIGURE 3b



FIGURE 4

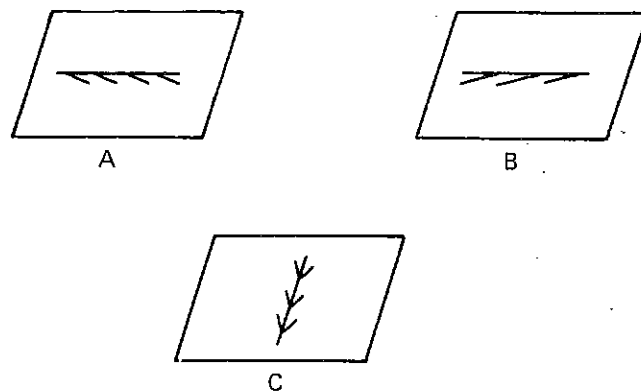


FIGURE 5

FIGURE 1

The field sampling drill in operation — also shown is the pressurised water can.

FIGURE 2

Core orienting tube in position over an unbroken core sample, showing the sun compass table, levelling bubble, sun compass tube, clinometer scale beneath the table and the orienting slit in the tube with a brass scribe in position.

FIGURE 3

Orientating table for orienting flat faces on block samples. In position A it is shown as used for making a sun compass reading for the azimuth and in position B for measuring the inclination of the face.

FIGURE 4

The tripod arrangement for orienting uneven surfaces. The sun compass tube is shown in position and the inclination of the plane is read from the clinometer scale shown at the side of the instrument.

FIGURE 5

Schematic representation of sample orienting techniques. The planes shown may be an actual rock sample face, the plane contained by the points of the legs of the orienting tripod or the plane perpendicular to the long axis of a cored sample. A: the zero angles of the sun and magnetic compass scales are set to the left; B: zero is set to the right and C: zero is set in the direction down dip.

and the sun compass table is tilted until the bubbles indicate it is horizontal. Then the positions of the feet are marked on the sample surface with a dot and ringed for clarification. The straight line (in 3-space) joining the dots which define the short side of the triangle represents a horizontal (strike) direction. The dip of the plane (analogous to the core face) is defined by the points of the three legs and is read from the clinometer scale.

4. Orienting Conventions

The foregoing description of the mechanics of sample collecting and orienting techniques omits reference to the conventions for measuring azimuths and dip angles. Basically there are two convenient ways of describing the orientation of a plane in 3-space (a) measure the azimuth of the horizontal line (strike) on the face of the plane and the true dip of the plane, or (b) measure the azimuth of the true dip direction and the dip value. Figure 5 illustrates schematically the application of these two systems. Although the data processing systems currently in use in the Division can accommodate field measurements following any of these orienting conventions, the field orienting equipment has been standardized using the convention shown in Figure 5A. This is employed both for describing the attitude of an individual sample (either a block or drill core) and the structural (e.g. bedding) attitude within a geological unit.

Acknowledgements

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References

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Appendix

The Sun Compass

A table containing a fixed 0-360° scale with a perpendicular and concentric rod, or tube providing a columnated slit, constitutes a convenient and rapid technique for measuring azimuths with respect to true north. To use the compass, the table is set horizontally with the scale zero pointing in the required direction according to the conventions shown in Figure 5. The sun's shadow angle (or narrow beam columnated through the slit), the time of day to the nearest minute and the date are recorded. Unless the azimuth with respect to true north is required at the sampling site, this is all of the information that needs to be recorded in the field. A detailed description of the procedure for reducing the sun compass data to yield azimuthal directions is covered by Creer and Sanver (1967). Alternatively, if an HP 25 hand calculator (or similar instrument) is available, then given the site geographical coordinates (to the nearest 0.1°) and using the following programme, developed by Dr. P. W. Schmidt from an earlier version by Dr. C. E. Barton (1978), the azimuth can be quickly calculated at the site thus reducing the chances of error. The constants which appear in the equations, and their definitions are available in the *Air Almanac* and the *Astronomical Ephemeris*.

Definition of symbols:

- ϕ_F Longitude of sampling site (0°-360°, positive east)
 λ_F Latitude of sampling site (90° to -90°)
 ϕ_Z Time zone longitude (0-360°)
 ϕ_S Longitude of sun
 T Time of day expressed in minutes
 α Sun compass shadow angle reading (0-360°)
 Γ Azimuth of sun's shadow
 λ Sun's azimuth
 θ True north azimuth of required orientation direction

The sun compass programme for calculating a true north azimuth is based on the following equations.

1. N = days elapsed during year since JAN 1.
i.e. JAN 1 = day 0
2. R = Right ascension of mean sun
= position of sun on JAN 1 + $\frac{360}{365.24}$ N
= 279.9 + 0.98565N
3. A = Equation of time/4
= $\frac{-229.183}{4}$ [EQ' - $\tan^2 \left(\frac{\text{OBLIQUITY}}{2} \right) \sin 2R]$
where EQ' = 2.Eccentricity. sin (R - Perihelion)
∴ A = 2.4572 sin (2R) + 1.9163 sin (282.37 - R)

4. $D = \text{Declination of sun } (-23.45 \leq D \leq 23.45)$
 $= \tan^{-1} [\tan (\text{OBLIQUITY}) \sin (R-A)]$
 $= \tan^{-1} [0.43274 \sin (R-A)]$
5. $H' = \phi_F - \phi_Z + \frac{T}{4} + A$
 where $H_F = \text{Local hour angle at the site} = \phi_F - \phi_S$
 $= H' - 180$
6. $\gamma = \tan^{-1} \left[\frac{\sin H'}{\cos \lambda_F \tan D + \sin \lambda_F \cos H'} \right]$

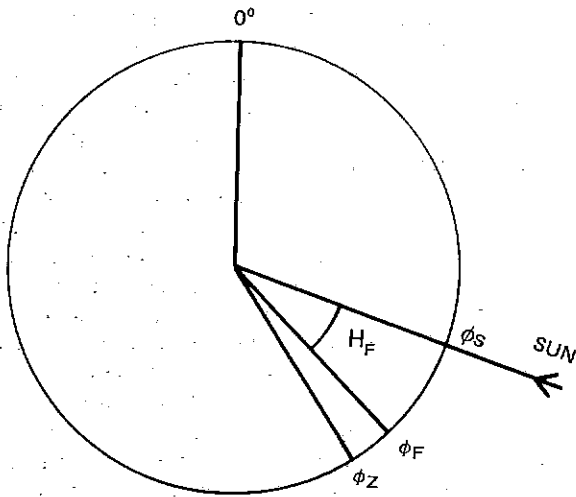


Figure A1(a) Relationship between the local hour angle (H_F), the meridian containing the field site (ϕ_F) and the meridian containing the sun (ϕ_S). 0° represents the Greenwich Meridian

7. $\Gamma = \gamma + 180$ if $\lambda < D$ (i.e. for all latitudes south of Capricorn)
 or $\Gamma = \gamma$ if $\lambda > D$
8. $\text{AZIMUTH } \theta = \Gamma - \alpha$

Sun Compass Programme for HP25C:

Step (Line)	Operation (Key Entry)	Step	Operation
01	RCL1	26	STO 7
02	X	27	R/S
03	RCL 0	28	RCL 0
04	+	29	$x \Rightarrow y$
05	STO 6	30	4
06	2	31	÷
07	X	32	+
08	fsin	33	fsin
09	RCL2	34	flast x
10	X	35	f cos
11	RCL4	36	RCL 1
12	RCL6	37	f sin
13	-	38	X
14	f sin	39	RCL7
15	RCL3	40	RCL1
16	X	41	fcos
17	+	42	X
18	↑	43	+
19	↑	44	÷
20	RCL6	45	$g \tan^{-1}$
21	-	46	1
22	CHS	47	8
23	f sin	48	0
24	RCL5	49	GTO27
25	X		

Steps 46-49 are valid for $\lambda < D$ (equation 7.)

For $\lambda > D$ substitute the following

step	Operation
46	0
47	0
48	0

N.B. $\lambda < D$ always for sites south of Tropic of Capricorn.

Enter the following constants in the respective storage registers:

$R_0 : 279.9; R_1 : 0.98565; R_2 : 2.4572; R_3 : 1.9163;$
 $R_4 : 282.37; R_5 : 0.43274.$

Programme operation is illustrated using the following examples:

Date	Site Coords.	Shadow Angle	Time (EST)	Magnetic Compass Reading
15 Mar 1978	$151.1^\circ \text{E},$ 33.7°S	345°	1055	214°
15 Mar 1978	$151.1^\circ \text{E},$ 33.7°S	025°	1057	172°

Procedure. Key in N, (here = 73), R/S : Display = $\tan D$ (here = -0.04), and the calculation is stopped at step 26. Then key in, \downarrow , ϕ_F (here = 151.1°), $+$, ϕ_Z (here = $150^\circ = \text{E.S. Time Zone}$), $-$, STO 0, λ_F (here = -33.7°), STO 1, T (here = 655), R/S. On completion, the display = 180° . Following equations 7 and 8, this must be added to λ to first give Γ and by subtracting the shadow angle we get θ , the required azimuth.

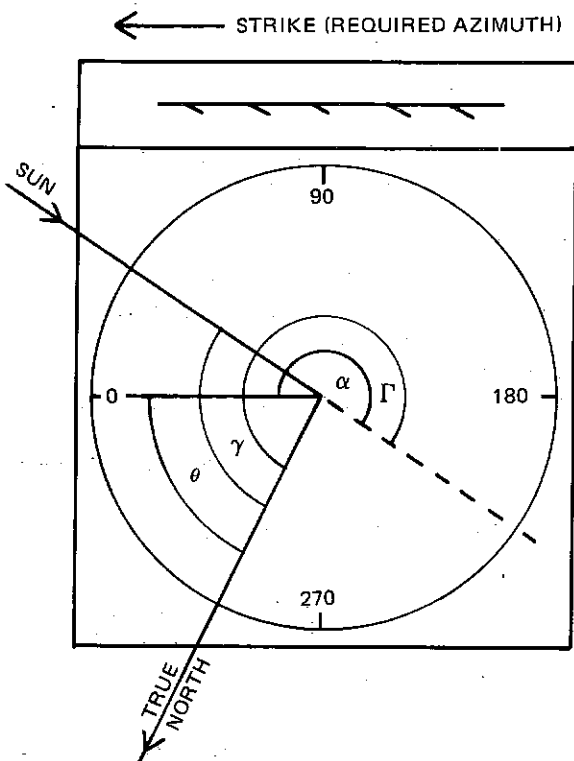


Figure A1(b) Measured and calculated parameters referred to the sun compass scale — conventions used by CSIRO Division of Mineral Physics.

Key in, +, α (here = 345°), - : Display = -133.44 . The positive angle is obtained by adding 360° . Key in, 360° , +, and the final display = 226.56° .

The magnetic compass reading was 214° and the local declination at that site is approximately 12° E.

For all subsequent calculations on that day i.e. N is constant, and at that locality i.e. ϕ_F , λ_F and ϕ_Z are constant, the programme loop from step 27 only is used. (N.B. R_0 and R_1 are corrupted after the first calculation and must be re-entered for a new day (N) or new ϕ_F and λ_F).

To proceed; clear the display and enter the next T (here = 657), R/S and on completion of the calculation simply key in +, α , - . The display is 185.78° and already positive.

A careful orientation should be accurate to $\pm 1^\circ$, consequently azimuths and dips are only taken to the nearest degree.