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N.C. & M.R.S.
STANDARDS OF CAVE SURVEY

J.M. Dickinson

Shortly after the formation of the Society, a meeting was held to discuss the laying down of a standard underground survey method to be used by the members of the Society. After much thought and trial in the field, the following method has been accepted. Using a prismatic compass graduated to 30 minutes of arc and reading to the nearest 10 minutes, mounted on a strong metal tripod.

The compass is set up at station 1 and a foresight is taken to Sta. 2, which is a candle or small electric light mounted on a similar tripod to that of the compass. The fore distance is measured by a steel tape to the nearest inch. Now the compass is detached from the tripod at Sta. 1 and mounted onto the tripod at Sta. 2. A back sight is taken to Sta. 1 and the back distance measured. While the tape is stretched out offsets are taken at right angles from the tape to the cave walls every four to six feet. As this is being done a third tripod is set up at Sta. 3 in readiness for the next foresight. The readings are booked in-a waterproofed note book as the following example:-

Sta. 5				
	B/S	256°	F/S	75°
	B/D	56.75	F/D	56.5

The offsets are booked either in sketch form or as a column of figures; it is a matter of personal preference as to which method is used. All readings are plotted by the use of total co-ordinates obtained from the mean of the angles and distances given in the field notes.

Of course, this method of cave surveying is as open to criticism as are all the other methods. We are well aware of the terrible conditions in which cave surveyors work and that in some passages it is [7] hardly possible to take a foresight, let alone to back sight. Steel tapes do tend to become unreadable in muddy conditions and refuse to be wound back into their cases; the answer to the latter is for the tape man to carry some clean rags. Although steel tapes can be difficult to deal with, the resulting accuracy of the measurements is well worth the effort, being far more accurate than marked cords, ladders, or plastic clothes lines when spring balances are attached.

In cave surveying all distances should be taken as being horizontal; this point should be remembered by the men holding the ends of the tape at all times, although the ideal method is to use an Abney Level to measure the slope of the passage, thus constructing an elevation of the cave at the same time.

When using an Abney Level the actual or horizontal length of the passage can easily be calculated by the formulae, H = MD. Cos a, where H = horizontal distance, MD = Measured distance on slope, a = Angle of slope.

The angular reading taken on the average prismatic compass is known as an azimuth or whole circle bearing. That is to say the compass card is divided into 360 degrees clockwise from 0 to 360°. Therefore, in order to facilitate calculations it is better to reduce these bearings to Quadrant bearings. A quadrant being 90°, obviously there are four quadrants in a whole circle, therefore an Azimuth bearing of 285° expressed as a quadrant bearing will be 360° – 285° = 75°. Being in the fourth quadrant, the bearing is expressed as N75°W. Likewise an Azimuth of 200° being in the third quadrant, would be 200° – 180° = S20°W. To plot a magnetic survey to true north it is necessary to allow for the magnetic declination. This may be found on the Ordnance Survey map of the district, in which the cave lies. The necessary information is given to bring the magnetic variation up to date. When the angle of declination is known the original compass bearings can be changed to true bearings by the following rules. First change the Azimuths to Quadrant bearings, then, if the declination is to the West, add the declination angle to the bearings in the North-West and South-East quadrants and subtract it from bearings in the North East and South-West quadrants. If the declination [8] is to the East, subtract it from North-West and South East bearings and add it to North-East and South-West bearings.

The only way to plot a survey with any claims to accuracy is by the method of total co-ordinates. By this method the skeleton of the survey is mapped out, not by the usual protractor and rule but by horizontal and vertical points calculated from a known meridian. The point of the first survey station is selected and a meridian drawn through it, usually representing true North. If the system to be drawn out is extensive it will be found advantageous to construct a series of squares or “graticules” of say 1000 ft square, from which the co-ordinates can be measured. The graticules must be drawn with the utmost care or the accuracy of the whole survey will be affected. In calculating the co-ordinates of a station the mean angle and distance is taken from the foresights and back sights in the field notes. The Vertical and Horizontal ordinates are calculated from the quadrant bearings and the length of the station in question. The algebraic signs of the vertical ordinates are taken as being plus when counted from north to east and north to west or in the 1st and 4th quadrants, being minus when counted from the South-West and South-East or in the 2nd and 3rd quadrants. Likewise the horizontal ordinates are plus in the 1st and 2nd quadrants and minus in the 3rd and 4th quadrants. Take as an example the following three legs of a cave survey.

Sta. A. 50 ft @ 75° Sta.B. 25 ft @ 169° Sta. C. 15 ft @ 230°. Let V = Vertical and H = Horizontal co-ordinates required. and L = Length measured. Then Sta. A 750 = N 75°E therefore the sign of V and H is in this case positive and H = L CosA = 50ft x Sin 75° = +48.294 ft. V = L CosA = 50 ft

x Cos 75° = + 12.949 ft. Using the same formula for the other stations we have Sta. B H = +4.7708 ft v = -24.549 ft and Sta C. H = 11.499 ft V = -9.6412 ft.

To draw out these co-ordinates, select Sta. A and draw a meridian through it. Measuring V on the meridian, above or below Sta. A according to the sign, locate H by measuring to the East or West of the meridian according to the sign with a parallel ruler.

[9]

This forms a rectangle, a diagonal line from Sta. A to the opposite corner of this rectangle will lie at the angle measured by the compass and be the same length as that measured in the cave. This is checked by a protractor and rule. Sta. C is located by adding the co-ordinates of Sta. A algebraically to those of Sta. B. The calculations for the coordinates are more easily carried out by the use of 5 or 7 figure logs. The layout of the calculations is as follows:

Sta. A 50 ft @ 750

Log 50ft	1.69897
Log Sin 75°	1.98494
	1.68391
H @ Sta. B =	+48.294 ft

Quadrant Angle N 75° E

	1.69897
Log Cos	1.41300
	1.11197
V @ Sta. B	+12.949 ft

Sta. B 25 ft @ 169° Q.A. S 11° E

1.39794	1.39794
1.28068	1.99195
0.67854	1.38989
+ 4.771	– 25.459 ft
H @ B = + 48.294	V @ B = + 12.949 ft
H @ C = + 89.065	V @ A = - 12.510 ft

Sta. C 15 ft @ 230° Q.A. S 50° E

1.17609	1.17609
1.88425	1.80807
1.06034	0.98416
- 11.499 ft	– 9.641 ft

H @ C = +89.06 ft V @ C = – 12.510 ft
H @ D = +77.56 ft V @ D = – 22.151 ft

If one has the use of a calculating machine it is as well to check these results using the natural Sines and Cosines.

[10]

Local magnetic attraction may at some time be encountered during a cave survey, the method of detecting this attraction is as the following example.

Suppose that the foresight from Sta.23 to Sta.24 is N 85° E and that the back sight from Sta.24 to Sta.23 is S75° 30' W. If the compass has been read accurately there must be local attraction at either Sta. 23 or 24. Otherwise the back sight from Sta.24 would have been S 85° W. Select an intermediate point, say half way between Sta.23 and 24. Set up the compass and take a back sight on to Sta.23, it will usually be found that the bearing just taken agrees with one of the bearings taken from Sta.23 or 24. If the bearing taken from the intermediate point to Sta.23 is S 85° W then the local attraction is at Sta.24 and vice-versa. The point for this check should not be taken too near either of the stations in question, otherwise the needle may be disturbed by the attraction at either of the stations.

The question of what scale the plan should be drawn at depends largely on what the plan is required to illustrate. It is a sound practice to adopt a standard set of scales to be used for all plans. We have adopted a scale of 1 : 1000 and its multiples as our standard. This is an excellent scale to use when plotting by co-ordinates as it simplifies the operation.

When the outline of the cave has been drawn, all details such as nature of floor, formations, water flow, etc. are filled in. The standard Cave Research Group symbols should always be used to avoid confusion.

We hope that this brief outline of our methods will be found to be of use to other cave surveyors and will help to raise the standard of cave plans produced in England.

[11]