A SURVEY OF G.B. CAVE, CHARTERHOUSE-UPON-MENDIP

By J. H. Crickmay and R. A. Bendall, B.Sc.

G.B. Cave was discovered in November 1939 and a report, including a survey, was published in these *Proceedings* (Vol. V, No. 2) in 1944. Since that date, as a result of further explorations in the system and a series of excavations, several additional passages have been discovered. Two of these discoveries are of particular importance because they both provide routes from the First Grotto to the Gorge. The first route, the Mud Passage, was opened in July 1948 by digging 20 feet through a sand choke. This connection had been postulated when the first survey was made. It provides a very easy route into the Gorge. The second route, the Ooze, was penetrated later the same year. This passage was explored when the cave was first opened and found to be flooded. In 1948 the water level was sufficiently low to enable the passage to be followed. It led through a narrow fissure to the Gorge, entering it at a point 20 feet up on the west wall between the end of the Mud Passage and the Bridge. Most of the other discoveries have been side passages which were not noticed at the time of the original survey. In addition several small passages have been excavated in the lower parts of the cave.

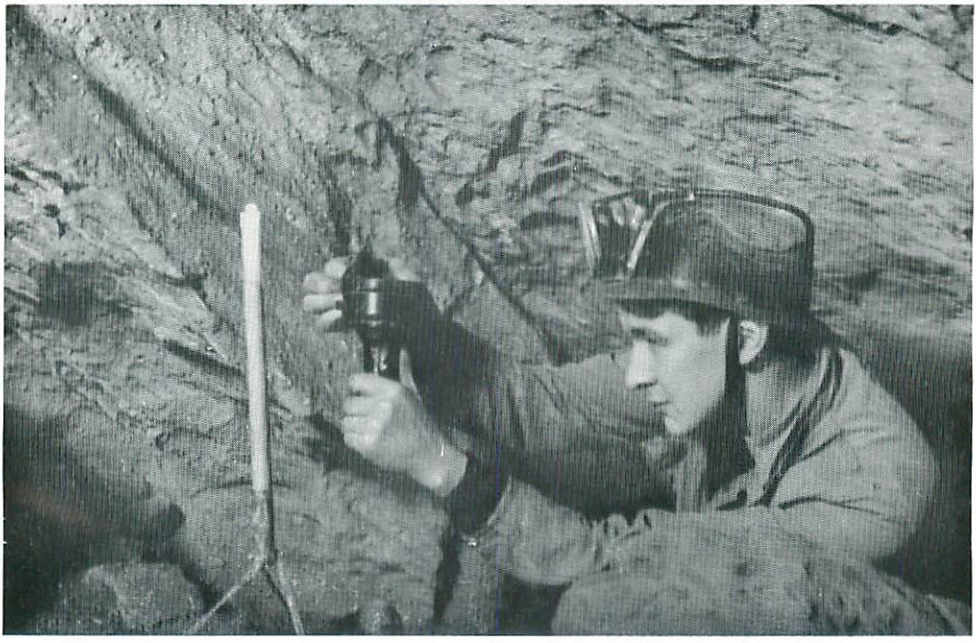
In November 1948 we decided that these new discoveries should be surveyed. It was decided to make an independent survey of the whole system with the greatest possible accuracy and also a survey of the surface detail in the vicinity. The two have been superimposed to show the correlation of the surface and underground detail. Since there were now three separate routes into the Gorge we had an excellent opportunity for investigating the accuracy of survey methods in a cave of this type, using simple equipment. We have also devised a satisfactory method of estimating beforehand the accuracy likely to be attained. The remainder of this paper is devoted to an account of the methods used and the results obtained. We hope that we have included sufficient detail for our work to be usefully compared with other surveys.

The Surface Survey

The surface survey was carried out in four stages.

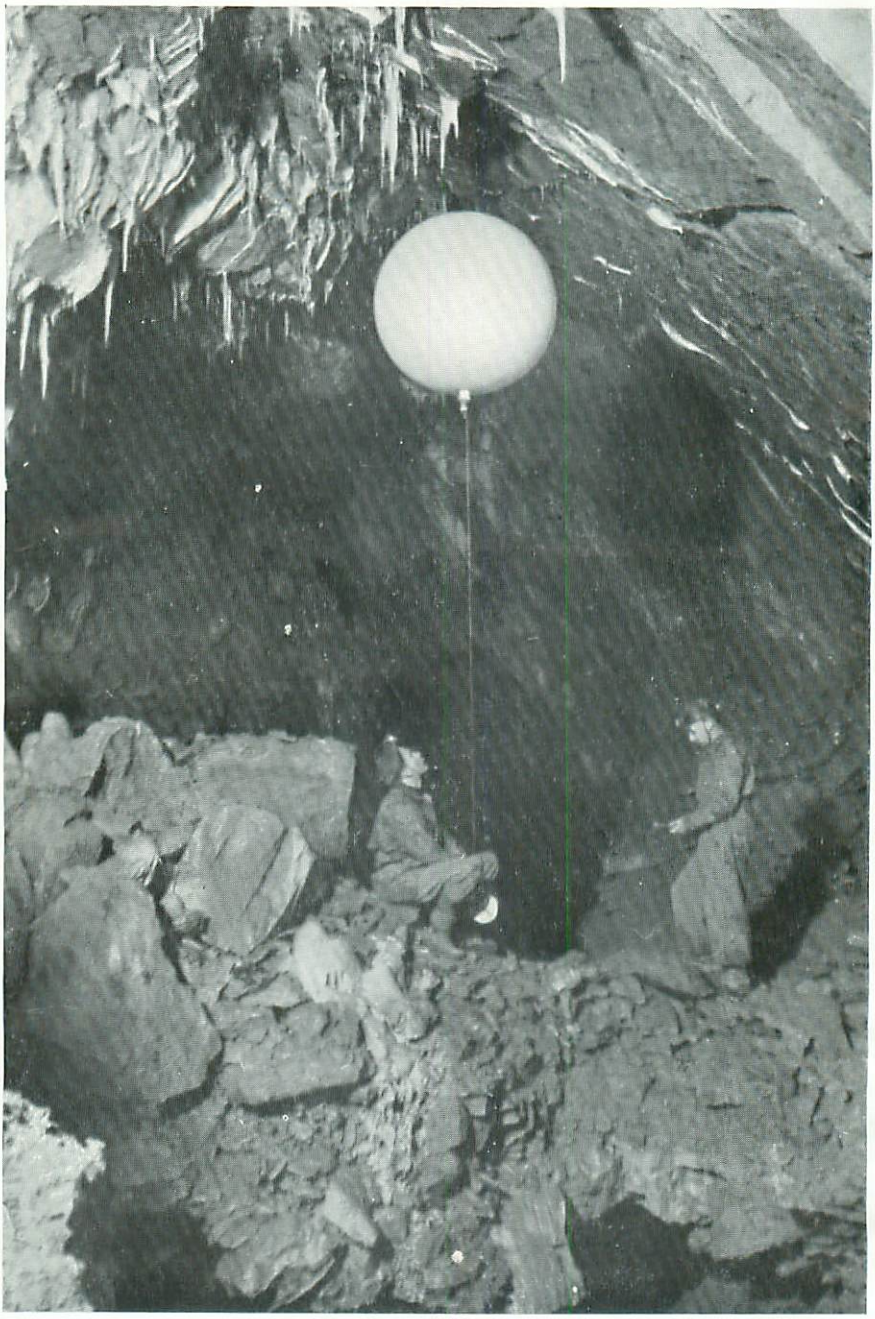
The National Grid co-ordinates of three well-defined hedge and wall junctions were scaled off the Ordnance Survey gridded 6 inch quarter sheets. A 600 foot base was measured along the metalled road which lies to the north of the

A The Astro-compass in use in small passage.



B The Hand-bearing compass in use in a cave.

Photographs by J. K. PITTS.



The balloon used for measuring the heights of the Gorge and Main Chamber in G.B. Cave.

G.B. CAVE

CHARTERHOUSE ON MENDIP

Surveyed by

UNIVERSITY OF BRISTOL
SPELÆOLOGICAL SOCIETY
1949 - 1950

Drawn by J.H. CRICKMAY & T.E.H. BENNETT

156 280 347 500 — 156 280 347 750 — 156 000 347 500 — 156 000 347 750

ENTRANCE
BM. 831·1
TYNING'S STREAM SWALLET
BM. 818·5
BM. 826·8 READ'S GROTTO
FIRST GROTTO
MUD PASSAGE
BOULDER CHAMBER
10' POT
DEVIL'S ELBOW
UPPER GROTTO
DOUBLE PASSAGE
WEST EXTN
EAST EXTN
GORGE
THE
GRUFFY FIELD
OOZE PASSAGE
RHUMBA ALLEY
WHITE PASSAGE
BM. 833·3
ART GALLERY
EAST PASSAGE
RIFT, 632 CHAMBER
BEDDING CHAMBER
LOOP
BRIDGE
GALLERY
BM. 828·8
THE GREAT SWALLET
MAIN CHAMBER
HALL
40' PITCH
BERTIE'S POT
OXBOW
LADDER DIG
UPPER SAND DIG
LOWER SAND DIG

I II III IV V VI VII IX X XI XII XIII

True North

Magnetic Variation 10° 30' W. June 1950

SCALE
0 10 20 30 Metres
0 50 100 Feet

site. This was used to fix four additional points by triangulation. The scheme was orientated from the co-ordinated junctions and computed on the National Grid.

A line of levels was run between Tyning's Farm and Lower Farm with two loops to cover the area of the survey. Bench Marks were established along the road and in the vicinity of all swallets and shake holes. A complete detail survey of all surface features, including a number of prominent posts and trees, was carried out with a Gunter's chain. This was plotted on a gridded sheet. The whole was now transferred on to two sheets of tracing paper on which the plan was completed. Contouring at 5 foot vertical intervals and the supply of spot-heights at salient points was carried out using a plane table and Indian clinometer. All depressions which could definitely be identified as swallets or shake holes have been shown either by contour or by spot-heights. Rocky outcrops have been shown only when it is clear that they are natural features. No attempt has been made to show mine workings, except in the case of two lines of shafts which have exposed what appears to be a fault parallel to the Rift Chamber and Rhumba Alley. The fair drawing was then made on a scale of 1/500. (*Pl. XXV*).

The Cave Survey

We were able to start the underground survey from a well-fixed point at the Entrance, but after this we had to rely on polygon traverses. A normal surface traverse takes the straightest route between two fixed points and any linear or bearer error shows up as a co-ordinate misclosure. A polygon traverse, however, relies on only one fixed point and any error in fixing this point will not be apparent in the closure. Further disadvantages are that any cumulative error in measurement will merely affect the size of the polygon, and compensating errors will merely alter its shape. In each case the effects are not readily detectable.

Experimental Traverses

When we started the survey we possessed a W.D. liquid prismatic compass, a simple clinometer and a 100 foot metallic linen tape. We decided to make some experimental traverses and to draw them up on a scale of 1/200, using a scale and circular protractor. We estimated that it would be sufficient to measure bearings and vertical angles to the nearest degree and distances to the nearest 6 inches.

Two traverses were run from the Entrance to the Gorge, one via the Mud Passage and the other via the Old Route. Stations were selected at prominent positions on the floor and walls and marked by candles. Sights were taken through the candle flames. The same stations were used in the Entrance, First Grotto and Gorge. Bearings were taken in one direction only, either forward or back. When drawn up, the traverses showed a discrepancy near the Entrance and a misclosure of 3½ metres on the Gorge station. We assumed that the discrepancy was due to magnetic disturbance since an iron frame had been

cemented in the Entrance before the second traverse was made. We attempted to check the position of the Gorge station by running a traverse through the Ooze Passage. This had to be abandoned because the technique was not adequate for the bad physical conditions.

We now realised that drastic changes would be necessary in both our method and equipment if we were to attain greater accuracy. The chief fault in our work so far was that we had made no provision for checking the results. It is impossible to check any portion of a traverse if the exact positions of the stations are not known. We decided that in future all stations should be marked whenever possible—the permanent ones by aluminium rivets and the semi-permanent by chalk or paint.

It was also desirable to take both forward and back bearings. This had not been possible before because the W.D. prismatic compass could not be tilted when a large vertical angle was encountered. An R.A.F. hand-bearing compass was purchased. This instrument has a large prism with an open V sight and is read when held 2 to 3 feet from the eye. It can be read at considerable vertical angles (+ 30 degrees and − 60 degrees) without tilting the card. It is graduated in 2-degree divisions but by averaging forward and back bearings an accuracy of ± 0.5 degrees is possible. We decided that the selection of stations would be easier if the candles could be mounted on tripods and we therefore constructed some extensible ones out of Duralumin tubing. (*Plate XXIII B*).

By taking forward and back bearings it is possible to detect magnetic disturbance, but this does not mean that its effects can be eliminated. We wished to devise a method that would be independent of it. An R.A.F. astro-compass was adapted for use as a theodolite. The sight was constructed out of a copper tube with a cross-wire and pin-hole. On the surface this arrangement suffers from parallax but in a cave, sighting on to a candle, this is not noticeable. It was found preferable to a telescope because the damp atmosphere and inevitable dust from caving clothes tends to fog lenses easily. The instrument was used either on a small photographic tripod with a ball-joint mounting, or, whenever possible, on a large tripod. (*Plate XXIII A*). Tests on the surface showed that the instrument could be relied upon to measure included angles to 0.2 degrees and verticle angles to 0.5 degrees.

It was now apparent that with the new instruments we could attain an accuracy of bearings which was far greater than we could possibly use with a protractor. The scale of the drawing up was also limiting the usefulness of more accurate distance measurements. We therefore decided to compute all our results and to make all measurements as accurately as possible. A rough calculation showed that in order to make our distance measurements comparable in accuracy to our bearing measurements, it would be necessary to measure to the nearest inch and to standardize the tape each day. We were now ready to start the final survey of the cave.

ENTRANCE PASSAGES

A traverse was run from the First Grotto to the Gorge using the astro-compass. Three sets of observations were taken at each station and in addition magnetic bearings were taken on long sights. The results agreed closely with the experimental traverses. It was subsequently found that the discrepancy between the two magnetic traverses was not due to magnetic disturbance but to an error in abstracting the data from the note book. We were now satisfied that a mean of the results gave the co-ordinates of the First Grotto station to within half a metre.

A similar traverse was run from the First Grotto to the Gorge via the Mud Passage and the results agreed closely with the magnetic traverse. We next ran a magnetic traverse via the Ooze but in spite of the fact that we were using the new equipment it misclosed by 5.2 metres. We therefore decided to re-survey the Old Route. When computed, this traverse gave a value for the Gorge station which agreed with those obtained from the Mud Passage traverses. Detailed comparison with the experimental Old Route traverse showed that there were no gross differences but the original traverse had accumulated three errors of 3½ metres, two of which were compensating. We now realised that in a passage of this type it is possible to accumulate a considerable error in a comparatively short distance. Since the Ooze passage is decidedly more difficult, and it had, in fact, taken six hours to survey 200 feet of it, the error in this traverse was quite explicable. We determined not to re-survey but to distribute this error.

We now accepted our results as determining the co-ordinates of the Gorge station. All stations were plotted on sheets of graph paper at a scale of 1/200. The detail of the passages was drawn in from notes made during the survey and the sheets were then taken down the cave in order to amplify and correct this.

GORGE AND MAIN CHAMBER

The comparatively large dimensions of the Gorge made it possible to use a chain of triangles. The astro-compass was used because it would result in greater accuracy. A scheme was worked out which ensured that every station could be observed from at least three others. All the distances were measured and all the stations permanently marked. Check bearings were taken with the prismatic compass. Triangulation was not used in the narrow portion of the Gorge between the Ooze and the Bridge, but here we had a polygon round the Art Gallery. The bottom of the Gorge below the Oxbow was surveyed by a magnetic traverse.

When the Gorge stations had been plotted the sheets were taken down the cave and the detail drawn in, using measured offsets from a tape stretched between the stations.

SIDE PASSAGES AND FEEDERS

The Art Gallery, Loop and Oxbow were surveyed by magnetic traverses and

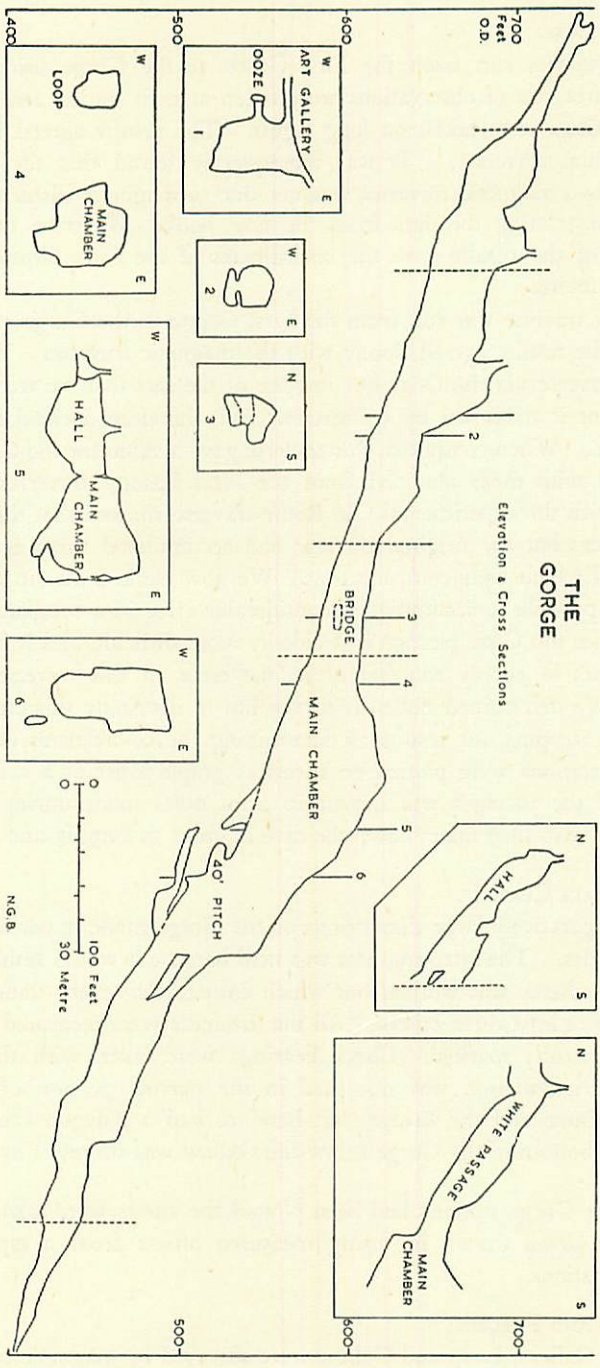

THE GORGE
Elevation & Cross Sections
400
500
600
700 Feet O.D.
W
E
N
S
ART GALLERY
OOZE
1
LOOP
MAIN CHAMBER
4
2
3
HALL
MAIN CHAMBER
5
6
BRIDGE
MAIN CHAMBER
40' PITCH
HALL
WHITE PASSAGE
MAIN CHAMBER
0
100 Feet
30 Metre
NGB

Fig. 33

closed back onto the Gorge stations in each case. Rhumba Alley was surveyed carefully as far as the size of the passage permitted and the White Passage was surveyed twice by different teams.

It remained to survey the various small passages. This was usually done at the same time as the detail. In most cases there was no check on the accuracy and in the Rhumba Alley and White Passage Extensions the constricted nature of the passages made it impossible to set up the tripods and survey accurately. In these passages sights were taken onto headlamps. As a check on the accuracy of this procedure a traverse was run through the Mud Passage using this rough and rapid method.

Elevation and Sections

We now decided to draw a series of sections which would illustrate the relation of the passages to each other and to the surface. These were drawn on a scale of 1/200 and projected onto a suitable bearing suggested by the plan. Portions of passages which do not actually lie on the line of projection have been indicated by a broken line for the sake of clarity. (*Figs.* 34–37.) The heights of the passages were either measured or estimated by comparison with a 10-foot telescopic measuring rod.

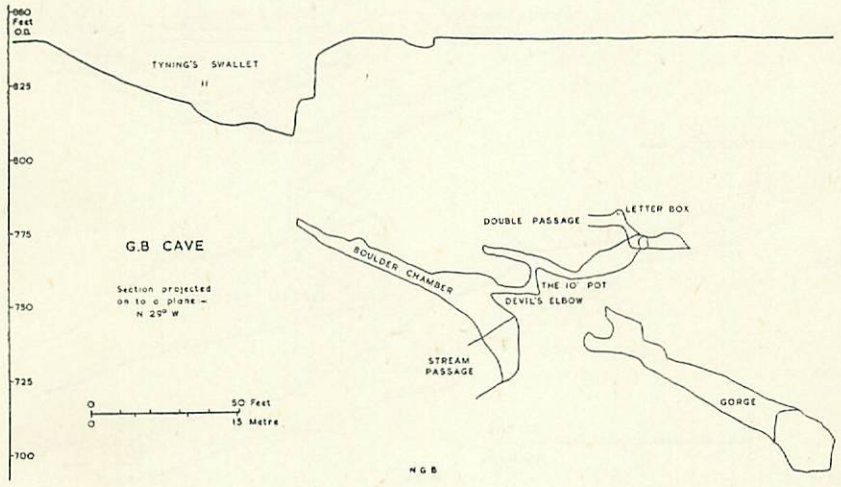


Fig. 34

We measured the heights of the Gorge and Main Chamber in detail, using a hydrogen-filled balloon. The measurements were taken at intervals along a tape stretched between the permanent stations. An extended elevation which follows the general course of the cave, usually in the direction of the dip or the strike, and typical cross-sections were then drawn. On this elevation changes in

direction have been indicated by a vertical broken line. The maximum height recorded was 75 feet in the middle of the Main Chamber. (*Fig.* 33).

METHOD OF COMPUTING THE RESULTS

The traverses were first drawn up directly from the note book, using a scale and circular protractor. This was done as soon after the surveying as possible, since it served as a check on booking errors. All the data was then abstracted for computation.* The measured distances were corrected for tape shrinkage and converted to metres. The magnetic bearings were corrected to grid bearings. The traverses were then computed. A calculating machine and five-figure tables were used throughout.

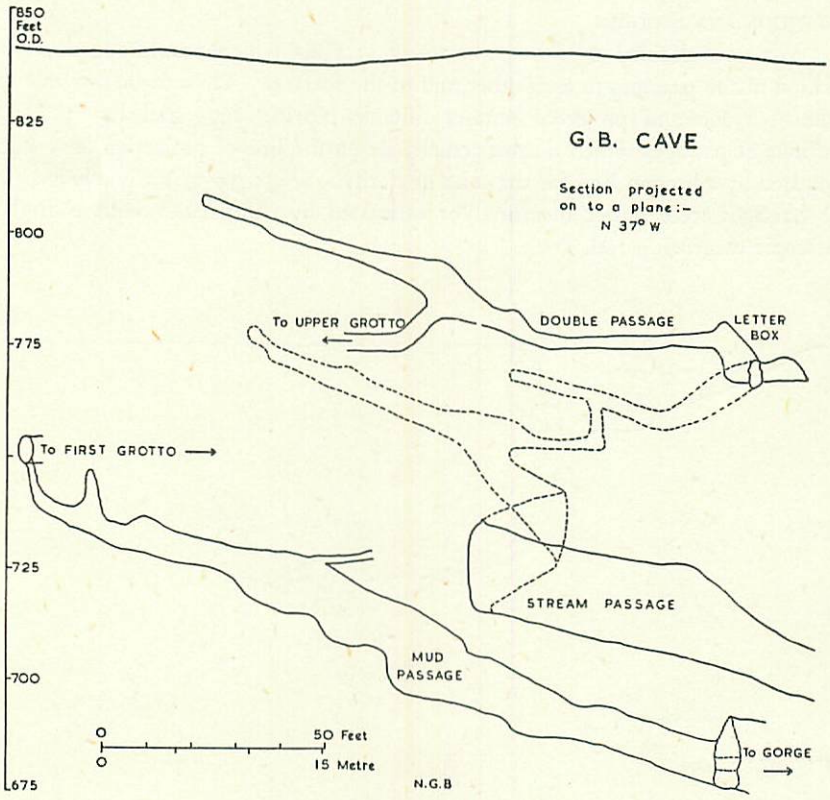


Fig. 35

The accuracy of the various traverses was estimated according to the following method. The average length of the legs in each was calculated from the total length (using plan distances) and the number of stations. The probable

* For details of the methods of computation see "Notes on the Minor Trigonometrical Work of the Ordnance Survey." H.M.S.O. 1933. Section 7: or any standard work on traverse computation.

error due to inaccuracy of bearings was then considered, it being assumed that astro-compass bearings were accurate to 0.2 degrees and magnetic bearings to 1.0 degrees. The error due to the tape and inclinometer had also to be considered. Even though the tape was read to the nearest inch and always compared with a standard after each day's survey, it was impossible to gauge its condition and the amount of tension applied for any particular reading. We assumed that our plan distances were correct to 3 inches, except in the experimental traverses for which we estimated 6 inches. These two errors are always at right angles and can never compensate. They were, therefore, added vectorially and expressed as the diagonal error per leg. The diagonal error was multiplied by the square root of the number of stations to give the probable error in the traverse. The proportion which this bears to the total length of the traverse was then calculated.

For the co-ordinates of the First Grotto station the values obtained from the astro-compass traverse and the second magnetic traverse were meaned according to the estimated accuracy of each traverse. The errors were then distributed according to the length of the legs. For the Gorge station the value obtained from the Ooze traverse was discarded and a weighted mean taken from the values given by the two Mud Passage traverses and the second traverse via the Old Route. The errors were then distributed. In the Gorge and Main Chamber the triangles had been fully observed and fully measured. Each triangle was solved separately and mean values accepted for the three sides. A number of stations, forming a conveniently short route through the Gorge, were then selected and treated as a line traverse. The remainder of the stations were then computed by bearing and distance from those already accepted. The values obtained for these additional stations served as a check for errors in computing. The Art Gallery, Loop and Oxbow were computed as polygons. The two White Passage traverses were meaned. The side passages were computed and the uncorrected co-ordinates accepted, since there was no means of ascertaining the errors. The fair drawing of the plan was then made on a scale of 1/500 and super-imposed on the surface map. (*Plate XXV*).

The heights of all the stations were then calculated in feet. Since they depended only on the distance and vertical angle measurements the results were meaned according to the length of the traverses, it being assumed that all the vertical angle measurements were equally reliable. The errors were distributed according to the length of the legs.

THE RESULTS

The errors in all the polygons and duplicated passages are listed in the accompanying table page 185. They indicate that the position accepted for any station on a main traverse is accurate to at least one metre. It is probable that equal accuracy has been achieved in all the side passages except the Rhumba

Alley and White Passage Extensions. Here the rough method of survey has probably introduced an error of not more than two metres. The discrepancy between the heights obtained from the two White Passage traverses was found to be due to a 1.5 degree zero error in the clinometer. This was not serious enough to affect the plan distances.

The comparatively inferior accuracy in the earlier traverses can be attributed largely to the inexperience of the surveyors. It is unfortunate that this occurs in the more important passages but in any case the accuracy is sufficiently good for us to place full confidence in our results. Of the other traverses, the accuracy agrees well with that expected, except that the Loop polygon and the White Passage traverses are far better than expected. This may be due to errors com-

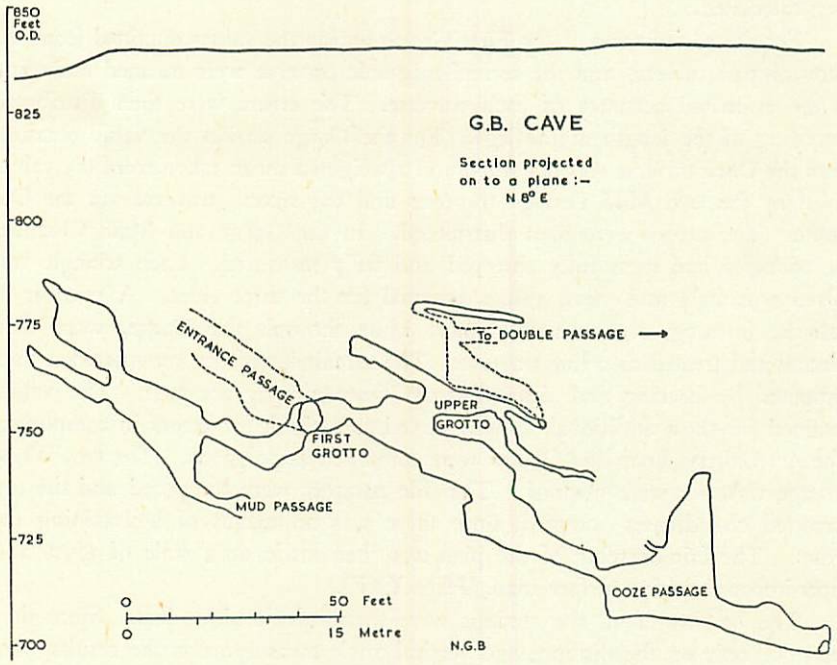


Fig. 36

pensating and giving a false impression of the accuracy, or we may have gained sufficient experience for our bearings to be more accurate than the estimated one degree.

We should like to emphasize that the results quoted are those which were accepted after the traverses had been carefully checked for all obvious errors. Every discrepancy was thoroughly investigated and if necessary a portion of the traverse was re-surveyed. In all cases gross errors were easily found and corrected.

They were usually due to booking errors or mistakes in computing. All sources of cumulative or systematic error had to be considered and allowed for. We have already mentioned tape corrections which were very important and varied considerably. In one instance wet conditions produced a shrinkage of as much as 1 foot in 100 feet (9 inches in the first 50 feet and 3 inches in the second). Errors in reading the astro-compass were also cumulative. We had evidence of this in the last leg of the Mud Passage traverse where the error had added up to 2 degrees. This was detected by comparison with the check magnetic bearings. The use of

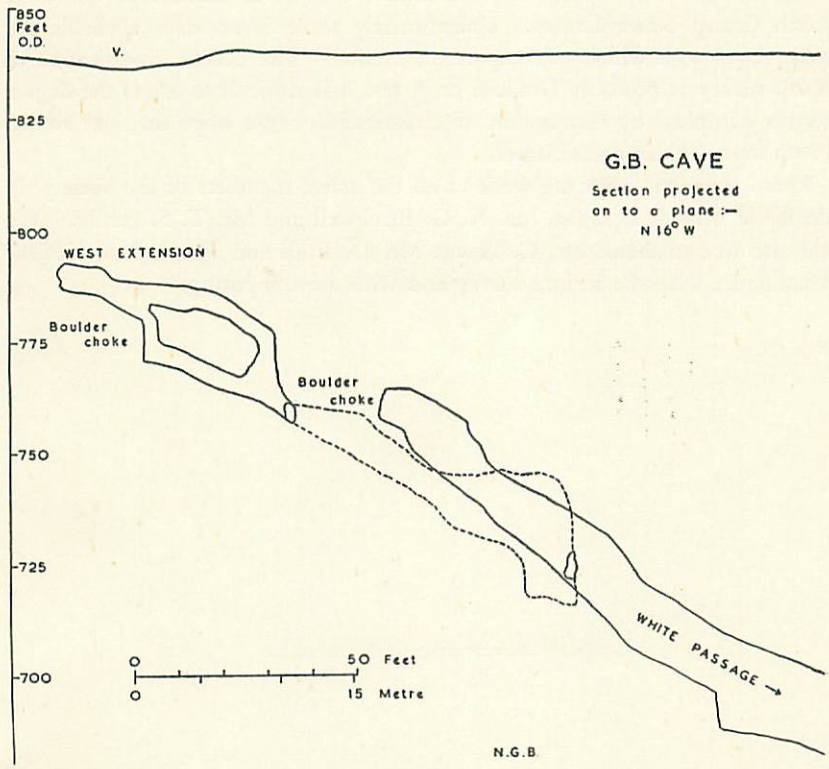


Fig. 37

the astro-compass proved a dubious advantage in line traverses for this reason. It was extremely valuable, however, when magnetic disturbance was suspected or when a large vertical angle was encountered. The other disadvantages of this instrument were that it was very tedious to use in small passages and very difficult to mount rigidly on a mud or gravel floor. It proved to be ideal for use in the Gorge. The magnetic compasses had to be standardised regularly to ensure

that the correct magnetic deviation was being applied. This was different for the two compasses.

The practice of computing results enabled us to have a permanent record of the station heights and co-ordinates which is independent of drawing errors and paper distortion. It also made it easier to assess the errors and to distribute them. The drawings of the traverses before they were computed served as a check on the computation. In any case it was found necessary to compute every traverse twice in order to avoid mistakes.

With reference to the results of other cave surveys which are available, we found good agreement with the observations of various authors of the Cave Research Group News Letters. Unfortunately there is no data available for Mendip Caves with which to compare our results. The C.R.G. classification of the G.B. survey is probably Grade 6 or 7, but it is difficult to assess the degree of accuracy implied by this system of classification. We hope that our results will help to make this point clearer.

This survey has been the work of all the active members of the Society, in particular of Miss J. I. Light, Mr. N. G. Blackwell and Mr. T. S. Zeally. We should also like to thank Mr. C. Lewis, Mr. D. Finn and Mr. J. Lowndes for their assistance with the surface survey and with the computing.

TABLE OF RESULTS OF THE G.B. SURVEY

Traverse	*Number of Stations*	*Length in Metres*	*Accuracy Estimate*	*Error in Eastings*	*Error in Northings*	*Diagonal Error*	*Height Error* (Feet)	*Accuracy Obtained*
ENTRANCE PASSAGE								
Astro-compass - -	7	40	1/211	+0.12	+0.18	0.22	+0.8	1/182
Magnetic - - -	6	44	1/86	−0.28	−0.42	0.50	−2.0	1/88
MUD PASSAGE								
Astro-compass - -	12	83	1/307	−0.45	+0.21	0.48	+0.2	1/173
Magnetic - - -	14	83	1/120	+0.72	+0.43	0.84	+0.6	1/99
Rough Magnetic - -	12	83	1/42	+4.04	−1.70	4.38*	−8.3*	1/19
OLD ROUTE	28	152	1/224	+0.77	−0.51	0.93	−1.8	1/163
OOZE PASSAGE	17	85	1/173	+4.93	−1.82	5.20*	+1.1	1/16
ART GALLERY	10	121	1/180	−0.70	+0.32	0.77	+0.08	1/158
LOOP	14	174	1/215	−0.08	+0.33	0.34	−0.71	1/510
OXBOW	10	107	1/178	−0.57	−0.43	0.71	+1.8	1/150
WHITE PASSAGE								
First Traverse - -	9	77	1/185	−0.20	−0.20	0.28	0	1/275
Second Traverse - -	9	77	1/185	+0.20	+0.20	0.28	+6.7*	1/275

* These results were not used in the final calculations.