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FRONT COVER

Our cover photograph shows a BBC Outside Broadcast television camera, fitted with an Evershed servo-controlled Angenieux zoom lens, used in Westminster Abbey at the wedding of H.R.H. Princess Alexandra and the Hon. Angus Ogilvy.

Photograph by kind permission of the Dean and Chapter of Westminster Abbey and with the help and co-operation of the BBC.

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Figure 1

Cave Surveying in Northern Spain

THE final report of the Oxford University Expedition to Northern Spain reveals another interesting application of the Megger Earth Tester Series 1. In this case, the instrument was used to trace the positions and depths of potholes and underground caves in the Picos de Europa mountains, near the biscay coast of Spain.

After a preliminary survey of caves in Westmorland to obtain practice in the methods to be used, the expedition crossed the Channel and travelled by road through France and across the Pyrenees to the town of Cangas de Onis, some 12 miles from the final base.

The expedition had the twofold object of research into the geomorphology of the mountains and archaeological investigations of the underground rock carvings and cave paintings. Many caves and potholes were explored and surveyed using prismatic compass, clinometer and metallic tapes. The course of the caverns was followed on the surface, and the depth of the passage below ground was calculated at each survey station. These calculations were used to test formulae applicable to the use of the Megger Earth Tester in depth surveys, by comparing the results of geophysical survey methods and direct-survey work at selected points.

The particular caverns in which the expedition was interested lie beneath a region of bare limestone rock, weathered into a characteristic 'clint surface', as is often the case in Britain. The vegetation consists of short turf, small trees, and in places dense scrub. To help in moving the Megger Earth Tester and electrode leads across this difficult country a suitably-padded slotted-angle frame was made up, and carried as a rucksack.

VEGA DE LA CUEVA (VALLEY of the CAVE)
28 AUGUST 1961. Possible extension of P1 (POZO PALOMERU)

TYPICAL STEP-TRAVERSE OVER CAVE

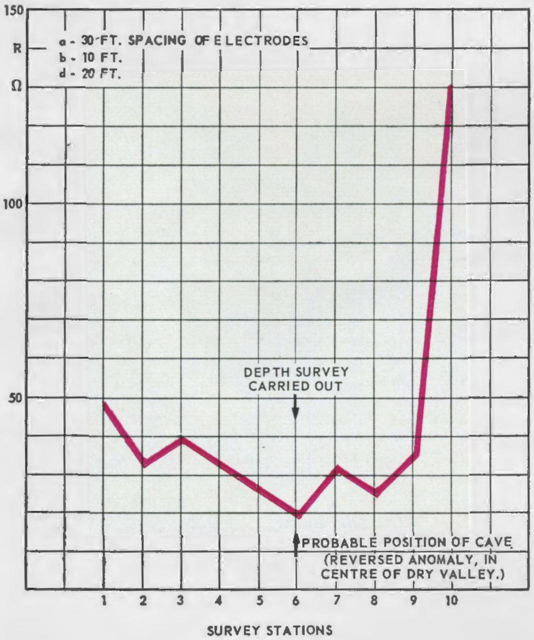

Figure 1

TYPICAL DEPTH SURVEY OVER CAVES

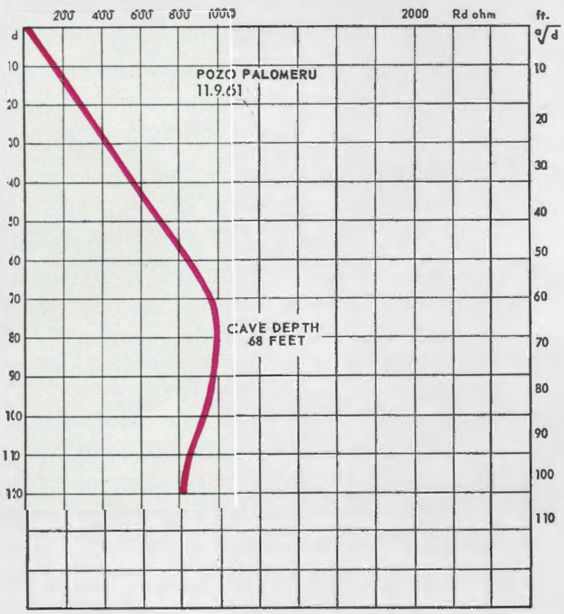

Figure 2

The Earth Tester and four 100-yd. reels of wire were carried on the frame, each wire being brought out from the centre of its reel and terminated by a crocodile clip which could be connected to flying leads attached to the instrument terminals. The electrode ends of the wires were terminated by large battery clips, which occasionally became entangled in the vegetation, but this was not found to be a serious limitation. The electrodes themselves were half an inch in diameter and had case-hardened points. They were satisfactory in both rocky and marshy conditions.

Several geophysical surveys were made with the Earth Tester, each survey comprising two types of tests. The first test used fixed electrode-spacing in a series of step traverses to locate the position of a known or suspected underground cave, and for the second test variable-electrode spacing was adopted to determine the depth of the cave below ground.

The best results were obtained over the pot-hole designated P.1. (Pozo Palomeru), where an underground survey was first undertaken in the main passage, from which a surface survey enabled the depth of the passage to be known accurately at a number of points.

Resistivity surveys were then undertaken at several points and enabled comparisons to be made between the two sets of results.

In depth testing by the resistivity method, the depth of the anomaly, i.e. the sudden change in earth resistivity, is found by expanding the distance between the electrodes so that the current between the C electrodes reaches a greater depth at each increase of spacing. A graph is drawn as in Figure 2, which shows the depth of the anomaly as the maximum point of the curve. However, the problem of interpreting results lies in estimating the depth reached by the current with each electrode spacing. When the electrodes are equally spaced this depth can be taken as approximately equal to the distance between two electrodes. Several methods have been evolved for finding a more accurate interpretation of the true depth than that given by h=a, and in the case of the Oxford survey team, comparisons with the accurate ground survey led to the adoption of a correction factor which then gave accurate depth figures from the resisitivity method.

The distance between the current electrodes and between the potential electrodes was termed 2a and 2b respectively, so that a and b became the distances of the current and potential electrodes from the centre point, or assumed meter position, of the line of electrodes. The actual distance between the electrodes (a – b) was termed d, and it was found that by multiplying a by $\sqrt{\alpha}$, where $\alpha = b/a$, an accurate determination of depth was obtained. In a typical case, as shown in Figure 2, the centre point of the curve, and therefore the depth of the cave, appears at $h = d = 80$ ft. Multiplying a by $\sqrt{\frac{b}{a}}$ gives $120 \times \sqrt{0{\cdot}33}$, or 69·3 feet, which is very close to the surveyed depth of 68 feet.

$$b = 40 \text{ ft}, \; a = 120 \text{ ft}, \; d = a - b = 80 \text{ ft},$$

$$h = a\sqrt{\alpha} = 69{\cdot}3 \text{ ft}.$$

In some cases the separation of the current electrodes could not be increased because of rocky ground. This was overcome by increasing the separation of the potential electrodes while maintaining the current electrodes at constant separation. When this is done the resistance measured on the Earth Tester is no longer proportional to the resistivity of the ground ρ

since $$\rho = \frac{\pi a(1 - \alpha^2)}{2\alpha} R$$

and is a function of α. A quick method of calculating in the field, given R and α was needed, and the problem was overcome by modifying a slide rule. Values of the expression

$$\frac{2\alpha}{\pi(1 - \alpha^2)}$$

were calculated for all possible values of α.

Figure 3. A member of the expedition "reeling-in" over difficult country.

The corresponding values of α were marked along the top fixed scale of the slide rule opposite the calculated values of the above expression. By setting the value of a on the upper sliding scale against α, the value of ρ is read off on the sliding scale below R on the fixed scale. From this it is a simple matter to calculate the depth reached ($a\sqrt{\alpha}$) on the slide rule.

The methods adopted were regarded as a useful way of confirming the presence of a cave at a given point, and of finding new caves or confirming the presence of existing ones.

Acknowledgment
The editor wishes to thank Mr. John D. Wilcock, the Caving Organiser and Geophysicist of the Expedition, for his assistance in the preparation of this article.