Cullaun III, Co. Clare, Eire

(I.O.S. 6 in. to 1 mile, Clare, Sheet 5)

By

C. J. EATON AND B. B. PERRATT

INTRODUCTION

Cullaun III was discovered and first entered in 1953 by members of this Society, and a preliminary report was published in *Proceedings* (Acke 1954). In the summer of 1959 it was surveyed, using a steel reinforced tape and a hand-bearing compass, to that degree of accuracy required by the Cave Research Group grade 4–5. The passage widths and heights were estimated, and the depth of the cave was calculated from the dip of the beds and the amount of each drop in the roof level. The magnetic variation was taken to be 13·5° west. A desk calculator was used to convert the position of each station into eastings and northings, the zero being the entrance, which was accurately located by a surface survey. The plan was then drawn out on graph paper on a scale of 200 ft. to 1 in. On this scale it was impossible to represent the width of the cave, which averages 18–24 in., by the thickness of the lines, so the passage width should be taken from the sections, which were drawn at 5 ft. to 1 in. (*Plate* 2). As the limestone beds are nearly horizontal, and as the cave largely follows the dip slope, the gradient of the cave is so small as to make clinometer readings and a longitudinal section unnecessary. The plan and sections were reduced photographically for publication.

As there is no grid on the Irish Ordnance Survey 6 in. to 1 mile maps, and neither latitude nor longitude are marked, an arbitrary grid, commencing at the southwest corner of the sheet has been used to give the co-ordinates of the entrance on the map. The entrance is 8·6 in. east and 3·5 in. north.

The cave is essentially a single long canyon passage for practically its whole length. The stream occupies this passage. There are very few side passages and oxbows, and there are no passable tributary passages. The general direction of the cave is along the 196° major jointing. There are many stretches where a calcite-filled joint can be seen in the floor and roof, and it is obvious that the water chose to erode along these weaker parts, as has been noted repeatedly in other Clare Caves and also in the Mendips by Donovan (1949). The cave is typical of those formed in nearly horizontal strata that have suffered little tectonic disturbance, and is very similar to the other caves in the Cullaun series. A fluorescein test has shown that the water

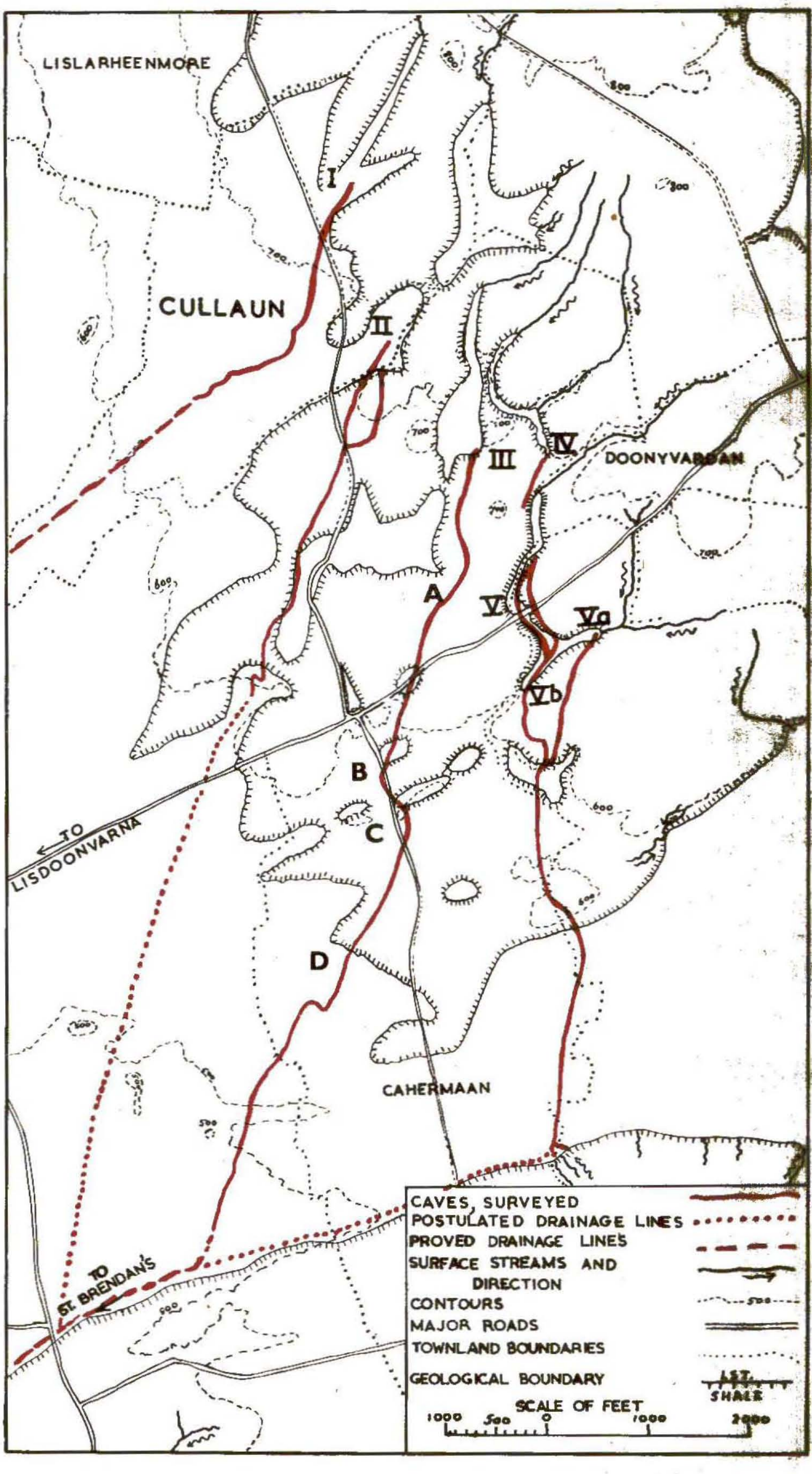


Fig. 12.—Map showing position of the Cullaun series of caves reproduced from the Ordnance Survey by the permission of the Minister for Finance, Republic of Ireland. Cave and geological data added by U.B.S.S.

eventually emerges at Lower St. Brendan's Well, although the water rises at Upper St. Brendan's Well in times of flood.

DESCRIPTION

Access to the cave is gained by entering a narrow rift surrounded by bushes on the eastern side of Cullaun III valley, at the southern end of a hollow in the valley floor. At this point the floor of the cave is 30 ft. below the valley floor and the cave proceeds in a south-southwesterly direction (*Fig.* 12, III; and *Plate* 2). The initial section is a simple canyon passage 10 ft. high and 18 in. wide, with a flat roof, although some wedged boulders necessitate crawling on the floor. After 10 ft. it is possible to stand and move sideways along a tightly meandering passage for 900 yds. The height varies between 8 ft. and 25 ft. in this section, but this is due to the varying slope of the floor, which is either greater or less than that of the roof formed by a bedding plane. The passage varies in width from 18 in. to 2 ft. and five stalactite barriers make crawling in the stream necessary. Just beyond the second of these barriers a large patch of limonite on the right (west) hand wall could indicate a local high concentration of iron pyrites in the shale above. Similar formations exist in other Cullaun Caves. There are three small tributaries in this section all entering on the right-hand side but none are passable. No relation with any surface features can be found for the first tributary which is 65 yds. from the entrance. The other two, 500 yds. and 550 yds. from the entrance respectively, probably connect with Calf Swallet (*Fig.* 12, A) although no fluorescein tests were done to prove this. There is also a single, impassable dry oxbow on the left-hand side, about 100 ft. long, and 600 yds. from the entrance. In times of high water the stalactite barriers in this section hold back the water, which in places reaches the roof. A row of helictites, 3 ft. above the floor, impede progress considerably along this first 900-yd.-long section.

For the next 100 yds., 900–1000 yds. from the entrance, until the First Meander Maze is reached, the passage is considerably higher, 20 to 25 ft., but remains 2 ft. wide. This section starts where two tributaries enter from either side down a common aven, 25 ft. high, which is too narrow to pass. This is a typical vertical feature of the second type (Ollier and Tratman 1956), At 40 and 60 yds. downstream of this point two small tributaries enter on the left-hand side. Both are impassable and coincide on the surface with an area of exposed limestone (*Fig.* 12, B). Several more stalactite curtains and flowstone on the walls make progress difficult.

The First Meander Maze, 1000 yds. from the entrance, starts where a small impassable tributary enters on the left hand-side. The maze consists of a complex series of dry oxbows, some of which are 40 ft. high and 3 ft. wide. This maze is 200 ft. long and finishes at the start of a shattered zone 400 yds.

long where the stream runs through a T-shaped passage 7 ft. high. The First Meander Maze was probably formed by water entering from the surface through various open joints none of which are passable by spelaeologists. For the next 550 yds., until the Second Meander Maze is reached, the passage is T-shaped 6 ft. high and 8 ft. across the arms of the T. Just before the Second Meander Maze the stream cuts down into the floor and it is necessary to traverse in the roof for nearly 30 ft., some 6 ft. above the stream. The second maze consists of three separately meandering passages, one above the other, continuing for 50 yds. Beyond this maze the character of the cave changes: it is wider and it is now possible to walk normally. There is no visible tributary to account for this but it is possible that one enters somewhere in the second maze. The maze lies under a dry valley which crosses the cave on the surface with two exposed patches of limestone one on either side of the cave (*Fig.* 12 C). The passage now straightens and has a T-shaped section, 2 ft. 6 in. wide and 12 to 15 ft. high. Between here and the end of the cave the roof drops to a lower bed four times, finishing 32 ft. lower. At one point it is necessary to climb over a number of large flakes which have fallen from the roof, but otherwise progress is easy.

At a point 2800 yds. from the entrance the stream disappears in the floor down an aggressively scalloped passage too small to follow. The original passage continues straight on, the floor rising 3 ft. over a series of gour pools. After these it winds along a channel 2 ft. deep cut in the floor of a bedding plane passage 20 ft. wide and 2 ft. high. Beyond this, through a stalactite grill and two gour pools 3 ft. deep, the passage slopes down to meet the stream in the terminal chamber. This chamber, 3050 yds. from the entrance, is 20 ft. long and 10 ft. wide with a flat roof 6 ft. high and marks the end of the grade 4–5 survey. The stream leaves the chamber in a bedding plane passage 18 in. high and 10 ft. wide. This section was surveyed at C.R.G. grade 2 for 200 ft., to where the passage bifurcates, both passages turning and sloping down to the east. Both are 2 ft. high and 30 in. wide, the first one taking all the water in the cave on the occasion of our visit. They are both viciously scalloped and further progress was thought unwise on this occasion. It is hoped to make a second attempt in 1960.

DEPTH OF THE CAVE

The limestone in this local region dips $1\frac{1}{2}°$ at $184°$. If the cave roof was formed by the same bed during the whole of its journey to Upper St. Brendan's Well, where it is unroofed, it would finish 240 ft. lower than at the entrance. Observations on the roof show that it drops seven times along the surveyed part, with a total drop of 54 ft., so that by calculation, the roof of the cave at the rising is 294 ft. below the roof at the entrance. By ordinary surface survey methods, the difference between these two heights is found to be about 300 ft., which indicates that the assumptions are correct and a similar calculation can be used to find the depth at any point. The depth below the surface at the main shale-limestone boundary at the southern end of the Poulacapple ridge (*Fig.* 12, D) is about 50 ft. and had it not been for the cave roof dropping to lower beds the cave would have come to the surface. For the first half of the cave, the roof must be very near the surface, and indeed, the shale above the limestone actually forms the roof in one place in the topmost meander in the First Meander Maze.

EVOLUTION OF THE CAVE

By

B. B. PERRATT

All the valleys that have ever fed water into Cullaun III are shallow, V-shaped, have interlocking spurs, and contain no glacial drift on their sides, whereas the top of Poulacapple is covered with drift. Upstream of the present entrance, the cave runs under a dry valley, and the cave is unroofed at various parts along this section. Downstream of the present entrance, the cave runs under the same dry valley for a while, and then leaves it. There is no real blind-valley as is so common on Mendip and in Yorkshire. The cave itself, which still takes the stream that formed it, contains no glacial deposit at all, and had it ever been covered by a large thickness of ice, the roof is so near the surface, that even the narrowness of the cave could not have stopped the roof collapsing at several places just below the present entrance. Also, during the permafrost period, that must have followed the retreat of the ice, there must have been a phase of alternate freezing and thawing and if the cave had been present, then it would have contained frozen water which would have caused shattering due to the enormous pressure exerted by freezing water. Although shattering is seen in the cave roof it is only at certain places, where it can be explained in other ways, and is by no means common. The facts cited can only mean that the cave is post-glacial and post-permafrost.

Charlesworth (1928) and Wright (1937) have concluded that the most recent terminal moraine in this area is the "Newer Drift", which stretches across the southern part of County Clare. This moraine has been correlated with Würm II of the Alps. An absolute date for any part of the ice age is very difficult to determine. Zeuner (1945) has concluded that the climax of Würm II was about 72,000 years ago, and the climax of the Scottish Readvance was about 22,100 years ago. During the Scottish Readvance, however, the Clare area must have been under periglacial conditions, and as there is no loess in the region, it must have been in the Tundra belt. This means that during this period the ground was frozen for most of the year, and all the water must have run off in surface streams, which eroded the present valleys. As has been said before, had the cave been formed before the permafrost condition set in during the Scottish Readvance, the pressure exerted by the freezing of the water would have caused considerable shattering, followed by collapse. When the Newer Drift ice retreated, the whole of the top of Poulacapple was covered by a layer of shale, but, by the end of the periglacial period caused by the Scottish Readvance, patches of limestone were exposed at various points in the valleys, and at these points the water could go underground. These patches could not have been exposed any earlier than 20,000 years ago, and their exposure might be as recent as 10,000 years.

Except for the end of the cave and for a short distance about one-third of the way along there is no evidence of phreatic water action. The roof is normally smooth, and the walls near the roof have no scalloping on them, which means that the water was soon flowing very smoothly and the phreatic period of formation in this cave was very short. It is probable that paraphreatic conditions existed soon after the start of formation (Tratman 1957 (a)). As soon as the patches of limestone were exposed on the surface and the periglacial conditions had passed, the cave started to form, and more and more water sank into the ground as the cave became larger, until vadose conditions supervened. Formation continued under these conditions and produced the scalloping in all the lower parts of the cave walls.

The question that now arises is; could the cave possibly have been formed in less than 20,000 years ? The following calculations show the average annual rainfall needed for formation to have taken place under corrosion (solution) by carbonic acid alone. Corrasion is considered to have played an insignificant part, and while it must be admitted that there is an abundance of local high concentrations of iron pyrites in the shale above the limestone, Renault and Queffélec's (1959) view that sulphuric acid plays a part in cave formation is neglected, as it is probable that calcium sulphate, being almost insoluble, would form a coating that would prevent further action by the sulphuric acid. Indeed, organic acids from the peat probably played a more important part than sulphuric acid. Thus carbonic acid alone is considered in the calculation. Another factor that could have been important is that the solubility of calcium carbonate increases with decrease in temperature, due to the increase in solubility of carbon dioxide at lower temperatures; but it is difficult to determine the temperature of the water in the past, so this too has been ignored. Swinnerton (1932) states that approximately 500 parts by weight of calcium bicarbonate can be expected to be dissolved in 1,000,000 parts by weight of water under conditions similar to these; his information came from analyses by Matson (1909). As has been pointed out by Tratman (1957 b) a vadose cave will always have a ready supply of carbon dioxide, to replenish that used to give bicarbonate ions, so it is unlikely that the water will ever be saturated with calcium bicarbonate.

$$CaCO_3 + H_2O + CO_2 \rightleftharpoons Ca(HCO_3)_2$$

The molecular weights of calcium carbonate and calcium bicarbonate are respectively 100 and 162 and the density of limestone is 2·7. This means that 10^6 parts by volume of water will dissolve about 115 parts by volume of calcium carbonate. The volume of Cullaun III is quite easy to calculate as the cave is so simple, and a reasonably accurate estimate is 343,000 cub. ft. The total volume of water needed to dissolve this is approximately 3×10^9 cub. ft., which is 150,000 cub. ft. per annum for 20,000 years. The catchment area for the headwaters can be determined within fairly close limits and is about 300,000 sq. ft., or a little more than 8 acres. Of course, more water will come into the cave at points along its length, but this quantity is small compared with that derived from the headwater area. Assuming that 60 per cent of the rainfall enters the cave, the average annual rainfall needed to provide this 150,000 cub. ft. of water would be about 10 in.

There is no evidence available to show that this area, during the period under consideration, has ever had a lower rainfall than at present, even in Boreal times. The rainfall is now 40–60 in. each year, and if the lower figure is taken, this would provide more than four times the annual amount needed to form the cave in 20,000 years, so there is ample margin to allow for any underestimate for the volume of the cave, or for an overestimate of the time available or for an overestimate in the solubility of calcium carbonate under these conditions.

While it is obvious that the preceding calculation is very approximate it does show that it is possible for a cave the size of Cullaun III to be formed in less than 20,000 years, and possibly in as little as 5,000 years. This idea of rapid formation has already been expressed in more general terms for the Clare Caves, first by Acke (1954) and subsequently by Ollier and Tratman (1956). It is obvious that much more work needs to be done on the rate of solution of limestone in caves and particularly by vadose cave streams.

Finally, the discussion and the conclusions reached about the rate of formation of Cullaun III are specifically related to that cave and that cave only. Nevertheless, what has been said about Cullaun III may reasonably be deemed to be applicable to all the caves of the Cullaun series and to most, but not all, of the other caves in north-west Clare. It may even be applicable to cave systems elsewhere, provided that the general conditions of geology, geography and rainfall are approximately the same.

ACKNOWLEDGEMENTS

We should like to record our thanks to the other members of the Society on the 1959 Eire Expedition, and especially to Dr. E. K. Tratman for much helpful criticism in the preparation of this paper. The combined efforts of the party resulted in the survey of this difficult cave being completed in two days, a total of 170 man-hours. We would also like to thank Mr. and Mrs. D. O'Callaghan of the Castle Hotel, Ballynalachen, for their unfailing kindness in dealing with cavers coming and going at all times, and in all sorts of odd clothes.

REFERENCES

Proc. = *Proceedings, University of Bristol Spelæological Society*

ACKE, P. R., 1954, "The Cullaun Series of Caves", *Proc.*, Vol. 7, No. 1, 7–22.

CHARLESWORTH, J. K., 1928, "The Glacial Retreat from Central and Southern Ireland", *Q.J.G.S.*, Vol. 84, 293–342.

DONOVAN, D. T., 1949, "The Geology of Rod's Pot", *Proc.*, Vol. 6, No. 1, 72–75.

MATSON, G. C., 1909, "Water supply Paper 233", *U.S. Geol. Survey*, 42–43.

OLLIER, C., and TRATMAN, E. K., 1956, "The Geomorphology of the Caves of North-west Clare", *Proc.*, Vol. 7, No. 3, 138–158.

RENAULT, P., and QUEFFÉLEC, C., 1959, "Au Sujet du Role de la Pyrite dans le Cavernement", *Grottes et Grouffres*, No. 22, 17–21.

SWINERTON, A. C., 1932, "The Origin of Limestone Caverns", *Bull Geol. Soc. Am.*, Vol. 43, 663–693.

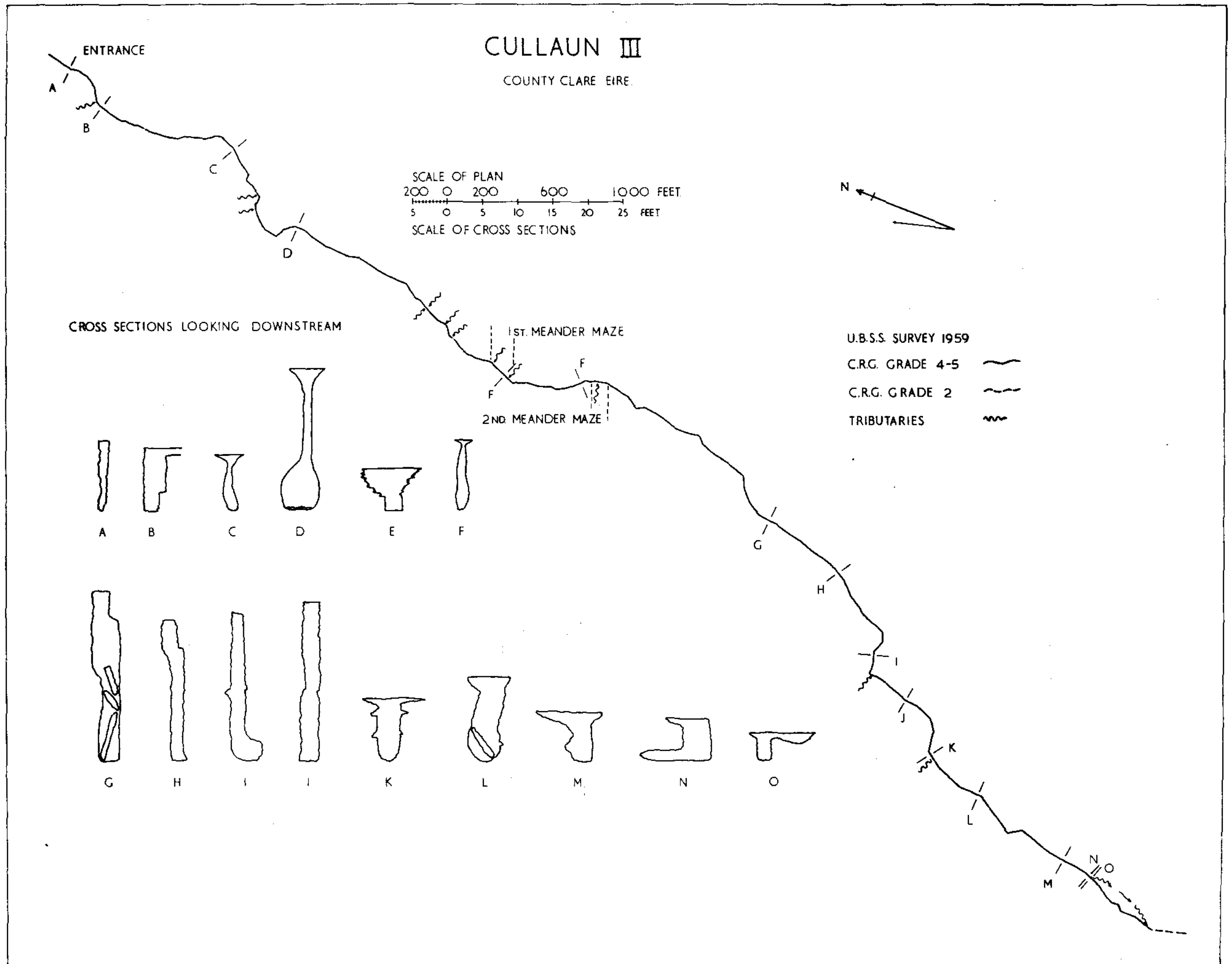
TRATMAN, E. K., 1957a, "A Nameless Stream", *Cave. Res. Grp. N.L.* No. 68, 6.

— — 1957b, "Some Problems of Solution in Caves under Vadose Conditions", *Trans. Cave Res. Grp.*, Vol. 5, No. 1, 53–59.

WRIGHT, W. B., 1937, "The Quaternary Ice Age", 2nd Ed., Macmillan.

ZEUNER, F., 1945, "Dating the Past", p. 145, Methuen.

PLATE 2


CULLAUN III
COUNTY CLARE EIRE
ENTRANCE
SCALE OF PLAN
200 0 200 600 1000 FEET
5 0 5 10 15 20 25 FEET
SCALE OF CROSS SECTIONS
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CROSS SECTIONS LOOKING DOWNSTREAM
1ST. MEANDER MAZE
2ND. MEANDER MAZE
U.B.S.S. SURVEY 1959
C.R.G. GRADE 4-5
C.R.G. GRADE 2
TRIBUTARIES
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