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# THE HYDROLOGY OF THE UPPER FERGUS RIVER CATCHMENT, CO. CLARE

by

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ABSTRACT

The Fergus River springs have the largest catchment (115 km²) of any of the Burren resurgences, the drainage area reaching almost to Galway Bay in the north. The catchment has been delimited with reasonable accuracy using water tracing and computation of specific runoff values. The drainage system feeding to the Fergus springs, including the Fergus River Cave, may be of considerable antiquity and there is some evidence that part of the drainage to St Brendan's Well at Lisdoonvarna is being captured by the Fergus system.

## INTRODUCTION

The upper reaches of the Fergus River (upstream of Lough Inchiquin) drain both the shale lands to the south of Kilfenora and also, underground, a considerable part of the Burren plateau to the north and northwest of the river. Due perhaps to its peripheral location on the Burren and the fact that only one major cave system is known, the area has been neglected somewhat in terms of both speleological and hydrological research. Previous published studies have been concerned with the caves, particularly the Fergus River Cave (Patmore & Nicholson, 1965; Wilkins *et al.*, 1972), Vigo Cave (Hobbs & Nicholson, 1963) and the Kilcorney caves (Tratman, 1968; Hanna, 1968; Boycott *et al.*, 1983). This paper attempts to define and describe the upper Fergus area as a hydrological entity and to summarize work undertaken subsequent to the papers cited above.

## THE RESURGENCES OF THE UPPER FERGUS VALLEY

The Fergus River originates in Lough Fergus (Fig. 1) at 87 m O.D. on the impermeable Namurian strata and collects various tributaries, mainly from the south, before sinking underground at the contact with the limestone at the site called An Clab or Kiltoraght. The Fergus River only occupies a valley as such in the reach between An Clab and Killinaboy. Here a trench some 800 m wide and 30 m deep, oriented west to east and developed at the northern extremity of the Namurian outcrop, contains the river. Upstream of An Clab the valley form is obscured by numerous drumlinoid features, whilst downstream of Killinaboy the Fergus River is simply a conduit linking the various lakes that interrupt its course and it wholly lacks a valley. The sink at An Clab is entrenched some 3 m into the valley floor and the valley continues eastwards 15 m deep, cut into the shales and drift, dry except in severe floods. However this trench disappears after c. 150 m and for the next 700 m to the springs at Poulnaboe (S1 in Fig. 1) the valley is wide, flat-floored and occupied by many mounds and ridges of glacial deposits. It is difficult to envisage the Fergus River having flowed across this section of valley in post-glacial times, immature though both sink and rising appear.

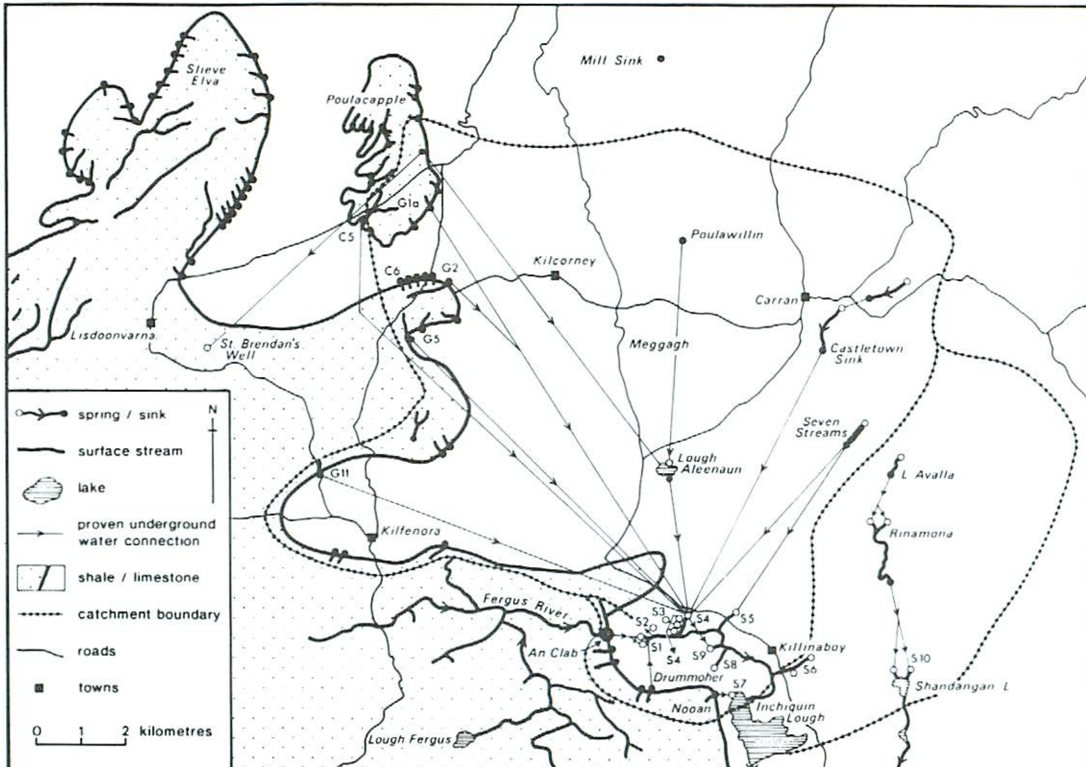


FIG. 1—THE HYDROLOGY OF THE FERGUS RIVER SPRINGS CATCHMENT

S1: Poulnaboe. S2: Ballycasheen Upper. S3 Ballycasheen Lower. S4: F.R.C. springs. S5: Buntober. S6: Killinaboy. S7: Boulder Pot. S8: Brian Boru's Well. S9: Elmvale, S10: Shandangan Lake. C5: Cullaun 5. C6: Poll-Cahermaan. G1a: Poll Cahermacnaghten. G2: Poulawillin. G5: Ballymahony Cave. G11: Poulballygoonaun.

*The Risings*

The Fergus River appears from one or more risings (dependent on stage) at Poulnaboe [S1] some 900 m east of An Clab. The middle rising at Poulnaboe consists of an extensive grid of small joint-controlled passages extending vertically some metres below the floor of the valley and with a water flow from the south. Some 100 m of passage have been explored at low stage (Boycott & Wilson, 1983). Low flow discharge at An Clab is about 6 litres/sec (l/s) and outflow at Poulnaboe about 7 l/s. The small discrepancy is accounted for by the waters of the small sinks, for example Drummoher Potholes, along the shale edge to the south which drain directly to Poulnaboe. However, Ecock (1981) reports that under high flow conditions much more water emerges from Poulnaboe than sinks at An Clab—he cites flows of 9.5 and 6.7 cumecs respectively. If this is the case then the difference in flows is far too great to be due to drainage from the shale margin to the south and implies that Poulnaboe is an overflow rising for the main body of groundwater discharging into the Fergus valley from the Burren plateau.

Downstream of Poulnaboe for some 2.5 km the river flow is augmented by water from a series of resurgences. In extreme drought all of these springs, Poulnaboe included, can dry, with the exception of Elmvale spring [S9] which then functions as the head of the Fergus River. The springs are numbered S1-S10 and are shown in Fig. 1. The values for flows given represent the average of 4–7 gaugings made between July and September 1987 and are indicative of low summer baseflow rather than drought condition flows. As with most resurgences in the Burren mean discharges are difficult to compute as flow regimes are so flashy (exceeding three orders of magnitude) and 'mean flows' are operative for only a small proportion of the year. Thus the values given for flows are intended to be of use for comparative rather than absolute purposes.

On the northern side of the valley are the springs of Ballycasheen Upper [S2] and Ballycasheen Lower [S3], both with low flows of c. 5 l/s and both issuing from the base of small cliffs some 250 m from the river. On the western side of the short tributary valley in which the Fergus River Cave is located, are a series of springs [S4] issuing from the bedding, again at the base of a small limestone cliff. Under flood flow conditions water resurges along almost the entire length of this scarp including the entrance to the Fergus River Cave, with total discharges exceeding 10 cumecs. Low flow (with only the lowest springs functioning) is c. 20 l/s.

Further east, near Roughan House is a series of springs collectively termed Buntober [S5], which rise from the drift covered area just beyond the south-eastern scarp of the Burren; low flow is c. 10 l/s. At Killinaboy is a similar group of springs [S6] (low flow 5 l/s) with successively higher level springs becoming active under wetter conditions.

There are three distinct springs on the south side of the Fergus valley. Of these much the largest is Elmvale [S9] (low flow c. 320 l/s), with water emerging from a 3 m high limestone cliff over a distance of some 80 m. Elmvale is fed by the same sources as springs S2-S5 but in order to reach Elmvale the waters must pass beneath the bed of the nearby Fergus River at very shallow depth. Presumably the drift and marl flooring the valley render the river bed impermeable in this vicinity, much as at the Turn Dub rising in Ribblesdale, North Yorkshire. To the south is Brian Boru's Well [S8] (low flow 35 l/s) which maintains a very uniform flow (flood discharge c. 75 l/s) and consistent chemical characteristics compared with the other springs of the area. No sources for this water are known.

Finally there is a small (2 l/s) spring discharging directly into Lough

Inchiquin from Boulder Pot [S7] and fed wholly by water from Nooan Pothole to the west.

*Rainfall : Spring Flow Relationships*

All of the springs respond rapidly to rainfall even during the summer months, lag times ranging from c. 10 hours at S4 to 48 hours at S8, but the nature of the response varies between springs. For example 39 mm of rain falling over a 72 hour period in September 1987 caused a tenfold increase in discharge at all springs excepting Elmvale ($\times 2$), Brian Boru's Well (20%) and Poulnaboe ($\times 100$). The last-mentioned trio of springs is also differentiated from the others in the area by the presence of abundant shale debris suggesting perhaps that there is a direct connection between An Clab and the three springs.

Despite the rapid response time to rainfall, the Fergus springs (Poulnaboe excepted) are fed overwhelmingly by diffuse input recharge rather than by concentrated (stream sink) recharge. It is estimated that, irrespective of stage, diffuse recharge accounts for c. 95% of outflow from the springs. Even the largest of the sinking streams in the catchment, the Castletown River at Carran, contributes only 10% to the outflow from the springs associated with the Fergus River Cave during low and medium flows and thus less than 1% of total spring outflow.

*Downstream*

Between Lough Inchiquin and the Fergus estuary south of Ennis the channel of the Fergus has been greatly modified by drainage works. Originally the river used to sink in Lough Atedaun at Corofin, resurging in Dromore Lake. Now the river is engulfed in Lough Keagh, east of Atedaun, during low and medium flows and its whole course thereafter is partly karstic in character. Most of this area, though of great interest hydrologically and speleologically, is outside of the scope of this paper, the exception being the extreme eastern and southern fringe of the Burren (including Mullaghmore) and the adjacent lake-studded lowland, a part of which drains to the Fergus system—for example via the springs at Rinamona and Shandangan Lake [S10].

## THE CATCHMENT FOR THE UPPER FERGUS SPRINGS

*Rainfall Data*

An estimate of the size of the catchment area draining to the upper Fergus valley was made by comparing outflow at the springs with the input of effective precipitation per unit area of the Burren plateau. The 30 year mean annual precipitation was estimated to be 1,527 mm using area-weighted data from the rain-gauges at Corkscrew Hill, Ballyvaughan, Kilfenora, Corofin, Carran and Kinvarra. Potential evaporation data measured at University College Galway were used to derive effective precipitation, although it is likely that this overstates the evaporative loss for the Burren plateau with its cooler temperatures and limited surface/soil storage of water. Mean annual input of effective precipitation is thus estimated to be $1.071 \times 10^6 m^3/km$, equivalent to a specific runoff value of 34 $l/s/km^2$. Estimated mean discharge of the Fergus River upstream of Lough Inchiquin but excluding the inflow at An Clab derived from the shales is c. 3.9 cumecs (measurement by author 1984–88), assuming the specific runoff value computed above this would require a catchment area of some 115km$^2$ excluding the shale-floored portion

TABLE I—*Summary of water tracing experiments in the Fergus River catchment (springs and sinks are numbered as in Fig. 1 and the text)*

| Input Site | Date | Operator | Tracer used | Outlets Monitered + Results | Times of Travel Flow Rates (m/h) | Other Information |
|---|---|---|---|---|---|---|
| Castletown River Carran | 1953 | P. Williams | Fluorescein (9 kg) | S4—negative | (12 days monitoring) | |
| Castletown River Carran | 1967 | UBSS | Fluorescein? | S4—positive | 2–7 days<br>148 m/h | |
| Castletown River Carran | 1980 | K. Ecock | Fluorescein | S4—negative | (7 days monitoring) | |
| Castletown River Carran | 1987 | D. Drew | Leucophor PBS (5 l) | All springs<br>S4—positive<br>S9—positive<br>S2—positive<br>S3—positive | 65 hours = 110 m/h | Medium stage conditions |
| Vigo Cave | 1967 | UBSS | ? | Craggaunboy River—negative | (7 days monitoring) | |
| Cullaun Five (C5) | 1964 | UBSS | Fluorescein? | St Brendan's Well—negative | (3–4 days monitoring) | |
| Cullaun Five (C5) | 1968 | UBSS | Fluorescein | S4—negative | (11 days monitoring) | |
| Cullaun Five (C5) | 1970 | UBSS | Pyranine (200 g) | S4 + St Brendan's Well—negative | (11 days monitoring) | Low stage conditions |
| Cullaun Five (C5) | Aug. 1970 | UBSS | Pyranine (250 g) | S4—positive | 5 days = 94 m/h | Medium stage conditions |
| Doonyvarden (H8) | 1980 | K. Ecock | Fluorescein | S4—doubtful pos.<br>L. Aleenaun—doubtful pos.<br>S1—doubtful poss. | 50 hours = 230 m/h | Medium stage conditions |
| Doonyvarden (via H3 inlet) | 1988 | D. Drew | Fluorescein (2,500 g) | L. Alleenaun—pos.<br>S4—negative<br>St Brendan's Well—positive | 24 hours = 330 m/h<br><br>65 hours = 92 m/h | Medium stage at start of test, then major flood |
| An Clab | 1981 | K. Ecock | Fluorescein | S1—positive | 60 hours = 21 m/h | |
| Poulawillin (G2) | 1971 | UBSS | Pyranine (400 g) | S4—negative<br>S3—positive<br>S1—positive | 8 days = 49 m/h | Uncertain source of dye upstream of FRC tributary |
| Ballygoonaun (G11) | 1971 | UBSS | Pyranine (300 g) | S4—weak pos.<br>S3—negative | 14 days = 24 m/h | Very low stage conditions; river dried during the trace |
| Ballygoonaun (G11) | 1972 | UBSS | Pyranine (400 g) | S3—negative<br>S4—negative | 3–4 days? | Very high stage conditions |
| Poll Cahermacnaghten (G1a) | 1978 | UBSS | ? | S4—verbal evidence of weak pos. trace | 4 days = 110 m/h | Flood conditions |
| Kilcorney Cave (K1) | 1987 | UBSS | Rhodamine B (200 g) | Fergus R. downstream of S4—negative<br>S9—negative | (10 days monitoring) | |
| Ballymahoney (G5) | 1987 | D. Drew | Leucophor PBS (2 l) | S4—positive<br>S1—negative<br>S9—negative | 4 days = 92 m/h | |
| Lough Aleenaun Sinks | 1987 | D. Drew | Leucophor PBS (2 l) | S4—positive<br>S1—positive<br>S9—dubious pos. | 72 hours = 49 m/h | Major flood during the trace |
| Poulawillin/ Eanty Beg Sinks | 1987 | D. Drew | Fluorescein (1,000 g) | L. Aleenaun—weak pos. | 18 hours = 244 m/h | Major flood during the trace |
| Mill Sink Aillwee Hill | 1987 | D. Drew | Fluorescein | Ballyvaughan—neg.<br>Aillwee Cave—neg.<br>S4—negative<br>S9—negative | (9 days monitoring) | At least 4 other failed traces 1977–87 |
| Nooan Pothole | 1987 | D. Drew | Leucophor PBS (1 l) | S7—positive<br>S8—negative<br>S9—negative | 2 days = 17 m/h | |
| Seven Streams (Slievenaglasha) | 1987 | D. Drew | Leucophor PBS (5 l) | S4—positive<br>S5—positive<br>S6—negative<br>Rinamona—neg.<br>S9—weak pos.<br>Shandangan—neg. | 5 days = 58 m/h | |
| Dummoher Pothole | 1987 | D. Drew | Leucophor PBS (1 l) | S1—positive<br>S9—negative<br>S8—negative<br>S7—negative | 43 hours = 28 m/h | |
| Lough Avalla | 1988 | D. Drew | Leucophor (2 l) | Rinamona—pos.<br>Shandangan Lough—pos.<br>S5—negative<br>S6—negative | < 14 days<br>< 14 days | |

of the basin upstream of An Clab. Mean discharge of the Fergus River downstream of Lough Atedaun is some 5.1 cumecs (again excluding flow generated upstream of An Clab) and this increased discharge would require a further 35km$^2$ of catchment area—presumably including the extreme eastern flank of the Burren and a part of the adjacent lowlands. Although it is possible to sketch the likely configuration of the Fergus catchment given this estimate of its overall size, its accurate delimination can only be achieved using the data from extensive water tracing experiments.

*Water Tracing Results*

A summary of the water tracing experiments known by this author to have been undertaken to the Fergus springs is given in TABLE I. It is not possible to be sure of the degree of reliability that can be ascribed to the traces undertaken by others, but if the author has doubts this is remarked upon in the text. The proven trace lines are shown diagrammatically in FIG. 1, and these allow the limits of the Fergus catchment to be defined with reasonable confidence.

(*a*) The eastern catchment of the area draining to the springs upstream of Lough Inchiquin extends northeastwards from Killinaboy and parallels the eastern flank of Slievenaglasha, the sink at Seven Streams being the easternmost trace undertaken. No water was traced to the Killinaboy spring and still further east, the trace from Lough Avalla to Rinamona and Shandangan Lake suggests that the extreme eastern flank of the Burren drains directly to the lakes of the lowlands.

(*b*) The northern boundary of the basin is the least well delimited. Only the Castletown River at Carran and the small sinks in the northern extension of the Meggagh depression (Poulawillin area) have been traced to the Fergus springs—the last mentioned via Lough Aleenaun. However, the northernmost extension of the Fergus drainage remains uncertain. Repeated attempts over some ten years to trace the considerable stream sinking at Mill Sink near the summit of Aillwee Hill have been unsuccessful despite the fact that possible discharge points were monitored in the Fergus valley, at local springs on Aillwee Hill, in Aillwee Cave and from boreholes in the Ballyvaughan valley. Thus it is assumed that these waters discharge via submarine springs in the Ballyvaughan area and so the Fergus/Galway Bay drainage divide lies to the south of Mill Sink.

(*c*) The western and southern part of the Fergus springs basin is presumed to correspond to the surface catchments of the series of small streams developed on the Namurian strata which sink underground at the limestone contact and which have been traced to the Fergus springs. In the north-west of the area the divide is between water flowing to the Fergus and water flowing to St. Brendan's Well near Lisdoonvarna. All of the water traces undertaken in this region have produced ambiguous or, at the least, less than definitive results (swallets H3, H8, C5, G1a, G2, G5, G11).

The results obtained from many of the Poulacapple and Knockavoarheen swallet traces together with the fact that Doonyvarden Cave was traced to the Fergus River and, under high stage conditions, to St. Brendan's Well, may indicate that some or all of these streams drain only to the Fergus River under low stage conditions, but have overflow routes to their original resurgence at St. Brendan's Well at high discharges. In this context it might be noted that at the further points of exploration in Cullaun Five, Gragan

West and Cahermacnaghten the route divides into two poorly developed bedding passages—the streamway continuing down-dip to the south (Fergus River) and the dry or normally dry route trending west towards St. Brendan's Well. Similarly Poulawillin (G2) trends west-south-west, away from the Fergus Springs over its explored length, yet it has been traced to the Fergus Springs.

FIGS. 1 and 3 show the catchment boundary positioned according to the results of the water tracing and incorporating an area corresponding to the value generated by the specific runoff data. The approximate flow rates for the traced steams range from 17 to 330m/h. Comparisons between sites are of dubious value as underground flow rates are very dependent on stage; however, there seems to be a correlation between increasing flow rate and a more dominantly north to south flow route, expressed as the ratio between the distance north or south and east or west from sink to rising ($r^2 = 0.572$). In effect routes with a high dip component allow faster flow rates than those with a significant strike component.

## HYDROLOGY OF THE MAJOR CLOSED DEPRESSIONS

The limestone plateau portion of the Fergus springs catchment is dissected by a series of valleys and closed depressions. The valleys are dry apart from small springs and sinks but the largest of the closed depressions (Carran, Meggagh, Kilcorney and Aleenaun) are all hydrologically active to some extent. The large depressions are described in order of increasing 'hydrological activity'.

### *Kilcorney*

The Kilcorney depression floods less frequently than any of the others and with less predictability. There are conflicting views as to the mode of flooding (Boycott *et al.*, 1983) but it seems that the cave conduits beneath or to the south of the depression are unable to cope with the largest flows (presumably due to partial infilling by sediments) and water backs up, ultimately being discharged at the surface via the Cave of the Wild Horses. Both flooding and recession can occur within a few hours. The lowest point of the depression is at some 103 m O.D. but evidence from drilling suggests that the bedrock floor is at an elevation of less than c. 50 m O.D. in at least a part of the hollow. It may be that all of the caves, including the entrance and the lowest series of the Cave of the Wild Horses, are truncated conduits opening out on the partially buried cliff face of the very deep depression.

### *Meggagh*

The Meggagh depression is separated from Kilcorney to the west by a low col. Drift and other infill seems relatively shallow (1–10 m where sections reaching to bedrock are exposed). There are numerous small perennial springs and sinks both in the upper part of the depression (Poulawillin—Eanty Beg) and in the lower (Poulcarry) part of the declivity. This water drains to the Fergus River via Lough Aleenaun. During wet conditions a lake is formed in the lower depression and may persist for several weeks.

### *Carran*

The Carran depression is the largest of the four (area c. 7.5 km$^2$) and functions hydrologically in a manner similar to Meggagh. Unlike Meggagh, however, the Carran depression maintains a perennial stream which rises at the north-eastern extremity of the hollow and, after sinking and rising once more, becomes the Castletown River before its terminal sink at the southern end of the depression. The infill of sediments is more than 4 m thick and the presence of 0·4 m of marl (Crabtree, 1982) indicates that the depression formerly contained a perennial lake. At present a lake forms in the lower half of the depression whenever inflow from the springs exceeds the limited capacity of the sinkhole; a lake is present for some 6–9 months of the year. Groundwater levels in the depression are some 80–100 m below the surface and thus in no sense is the lake a watertable feature.

*Lough Aleenaun*

Lough Aleenaun occupies the western extremity of a large hollow formed where an extensive dry valley network originating on Slievenaglasha debouches into a shallow east-west oriented hollow to the northeast of Leamanah Castle. The exact position of the lake is determined by an elongate drift mound blocking the south-westerly outlet to the depression. A lake is present for some 75% of the year, its extent varying considerably according to rainfall (Fig. 2). The lake can fill to a depth of 3–4 m within 12 hours of rain commencing, and typically response time to individual rainfall events is c. 6–8 hours. The lake can empty completely if no rain falls for a 10 day period. Lough Aleenaun functions in a manner similar to that of lowland turloughs (Coxon, 1987), filling from a series of springs (all on the northern side of the lake), and emptying from a large number of small sinks around the periphery of the lake. At higher stage conditions successively more springs come into operation, the highest located some 6–7 m above the turlough floor. It is not possible to measure inflows at high stage levels but discharge probably exceeds 5 cumecs. All of the inflowing water comes from the north and flows in enlarged bedding planes. Water issues from the foot of the scarp that forms the northern side of the lake for at least 1 km further to the east, almost certainly held up by the chert-rich beds of the Lower Faunal Zone which outcrops here (see the following section), and it is only the presence of the drift mound that has caused the lake to be impounded.

Groundwater levels in the vicinity of Lough Aleenaun are some 20 m below the surface of the ground even during winter. The sinkholes are usually developed in some 0.1–0.7 m of drift as small collapses, and often lie in lines oriented along the east-west jointing. As water levels in the lake rise, so higher level sinks become functional until an equilibrium between inflow and outflow is achieved. As at Carran, marl is present in the Lough Aleenaun depression implying that formerly it was a permanent lake—the bevelled cliff to the west of the lake suggesting a former water level some 2 m above the present high water level. The waters derive from the area between south-eastern Poulacapple and the Meggagh depression to the north as shown on Fig. 1, and the sinking waters reappear both at the Fergus River Cave springs and at Elmvale rising. It seems likely that the routes feeding to Lough Aleenaun are shallow and that flow velocities are high as the springs throw out considerable quantities of coarse sediment under flood conditions. This sediment is sub-angular to rounded, 0.2–2 mm in diameter and composed of carbonate material (33%), chert (15%), sandstone (25%) and quartz-conglomerate (27%). No exotic material, e.g. granite, was found and the sediment could be interpreted as a reworked version of the drift infill found in many of the caves of the area—for example the Poulcarry Caves of the Meggagh depression.

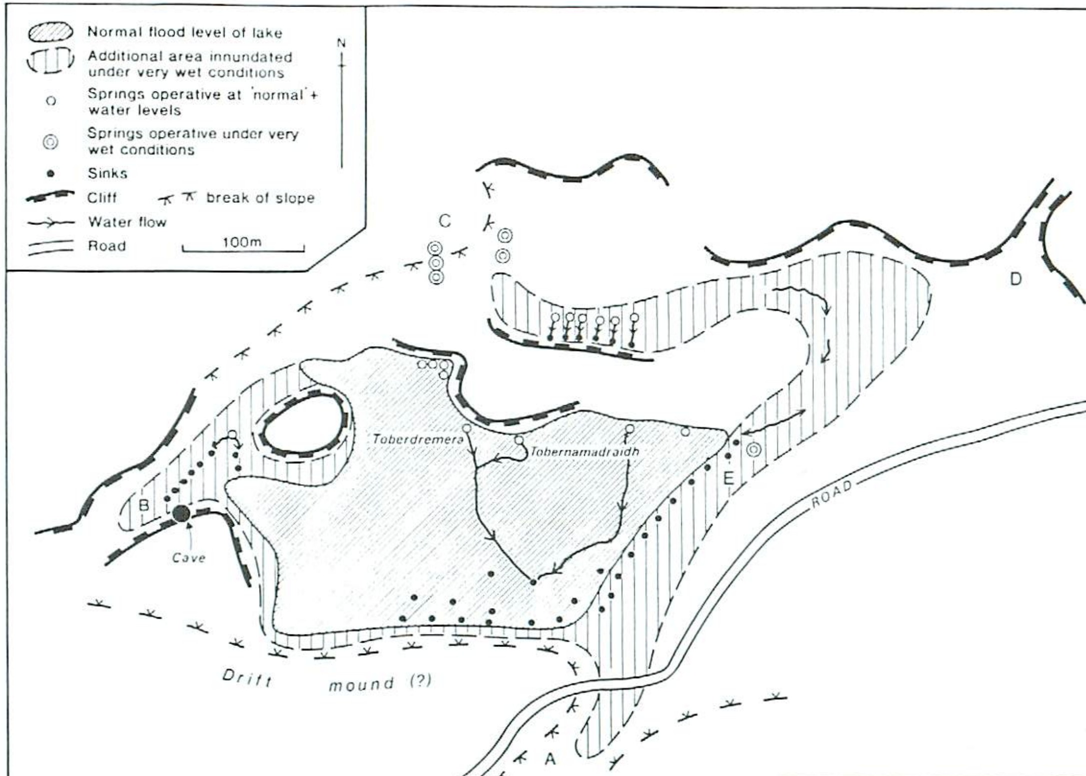


FIG. 2—HYDROLOGY AND MORPHOLOGY OF LOUGH ALEENAUN

A: trench, partly in drift. B: fragment of gorge. C: lower limit of dry valley network originating on Slievenaglasha. D: area of limestone pavement.

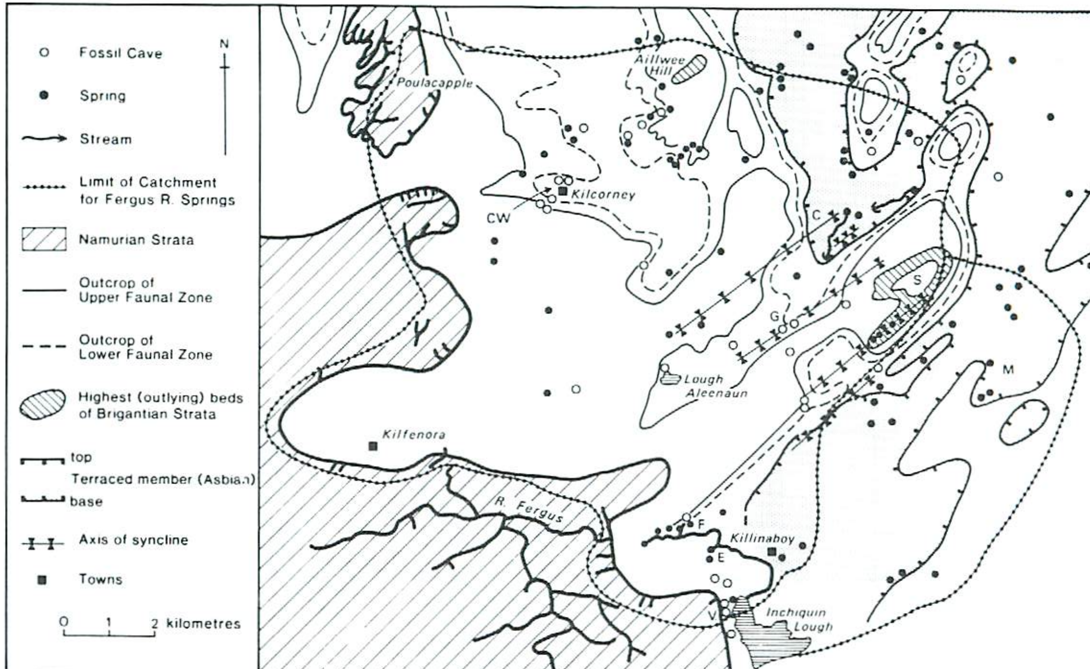


FIG. 3—SPRINGS, CAVES AND SELECTED ASPECTS OF LITHOLOGY AND GEOLOGICAL STRUCTURE, FERGUS RIVER AREA
C: Carran. CW: Cave of the Wild Horses. E: Elmvale springs. F: Fergus River Cave. G: Glencurran Cave. M: Mullaghmore. S: Slievenaglasha. V: Vigo Cave.

Thus all of the large closed depressions are 'windows' in the underground drainage network of the area, intercepting a part of the predominantly north to south flow of water.

## GEOLOGICAL INFLUENCES ON THE HYDROLOGY AND CAVES

FIG. 3 shows those aspects of the geology of the Fergus catchment which are regarded as relevant to its hydrology, whilst FIG. 4 shows details of the succession in the uppermost formations of the Carboniferous Limestone. The geological information presented here is derived from McDermott (pers. comm.) of the Geological Survey of Ireland and from Daly (1977).

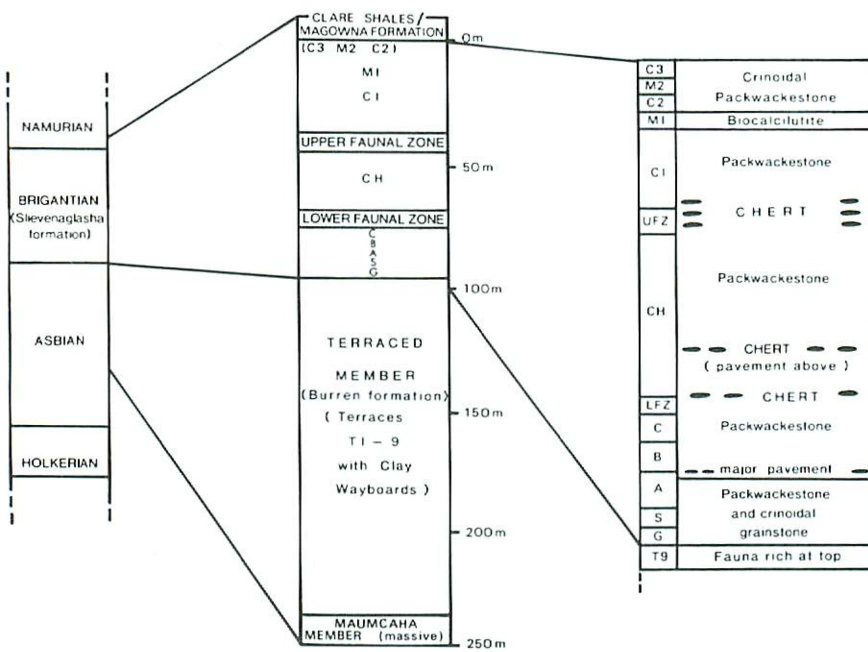


FIG. 4—STRATIGRAPHY OF THE UPPER BEDS OF THE CARBONIFEROUS LIMESTONE IN THE BURREN

### *Lithology*

The greater part of the area is underlain by the highest beds of the limestone—the Slievenaglasha Formation (Brigantian). Only in the north and east is the topmost part (Terraced Member) of the underlying Burren Formation (Asbian) exposed. FIG. 3 shows the approximate outcrop locations for the major chert-rich group of beds within the Slievenaglasha Formation (Upper and Lower Faunal Zones) and the fauna-rich topmost bed of the Burren formation (unit T9). In addition the location of the highest beds of the limestones (i.e. immediately beneath the Namurian) strata is shown where they occur as 'outliers' from the main shale cover; this includes an area on Aillwee Hill and on Slievenaglasha.

The great importance of the chert-rich beds in influencing underground water routes is apparent. All of the caves carrying sinking streams from the shale edge remain perched above the cherts of the Upper Faunal Zone for their explored lengths—all becoming impenetrable bedding caves when the cherty beds are reached. The majority of the springs in the Fergus valley, including the Fergus River Cave and Lough Aleenaun, are developed above the cherts of the Lower Faunal Zone. On the plateau itself the Seven Streams of Slievenaglasha flow on the Upper Faunal Zone cherts, finally sinking underground only where the cherts are breached. To some extent the location of small seepage springs shown in FIG. 3 is related to the chert layers; however, the thick clay wayboards that occur between the units of the Terraced Member of the Burren Formation are a more common location for the numerous small seepage springs and sinks in the north and the east of the area. For example the springs in the northern part of the Carran depression are located at the T7/8 and T6/7 junctions, whilst the Castletown River sink itself is at the top of unit T9.

*Structural Geology*

Stratal dips are not shown in FIG. 3 as over much of the area, and in particular the central region south of Kilcorney-Meggagh, dips are very low and highly variable. Nevertheless the regional dip is to the south and, as was indicated earlier, most of the underground flow is down-dip in the bedding planes. In the south-eastern part of the catchment the limestones are folded into a series of monoclines oriented northeast-southwest and the axes of these folds are shown in FIG. 3. It is probable that there is a degree of localization of groundwater flow along these monoclines and the overall trend of the structures is towards the Fergus River valley. The Castletown River sink at Carran is developed in a monocline with dips to the south-east of 30°. Similarly the series of sinks and risings of the Seven Streams on Slievenaglasha are along the axis of a monocline with dips of 30° to the north-west. Wilkins *et al.* (1972) noted dips of 6–8° to the west in the further reaches of the Fergus River Cave and it may be that the cave follows a syncline in its downstream section at least.

*Palaeohydrology; the Fossil Caves*

Hydrologically active caves are confined to those occupied by the streams sinking at the shale/limestone boundary—with the exception of the partly fossil Fergus River Cave. The great majority of the catchment consists of limestone plateau and few caves are known. The location of the plateau caves is shown in FIG. 3 and detailed by Self (1981). Although the caves are mostly small truncated fragments of conduit, quite unrelated to present day topography, they demonstrate a marked geological control. In particular the axes of the monoclines are favoured sites as are the chert-rich limestone beds. For example the upper Kilcorney caves are developed above the Upper Faunal Zone cherts whilst Glencurran Cave is located at the base of a monocline and within the cherts of the Lower Faunal Zone. However Glencurran Cave remains an anomaly in terms of the hydrology and fossil caves of the Fergus catchment. Its location suggests that it must inevitably be intersected by the drainage from the Castletown River sink to the Fergus springs yet its original function is unclear. It consists of a phreatic tunnel with a cross-sectional area of more than 40 $m^2$, leading south-eastwards away from the valley in which the entrance is located. Its fill, of rounded cobbles, sands and silt is unlike that of any other Burren cave and presumably consists of reworked glacial or fluvio-glacial material. Even less readily explicable is the series of fossil caves of which Vigo Cave is the largest and best known, developed at the shale contact in the steep scarp above the western shore of Lough Inchiquin and presumably formed when the shale cover extended north and east over what is now the Fergus valley.

## CONCLUSIONS

1. The catchment for the Fergus River springs is much larger (115 km$^2$) than that for any of the other Burren springs, extending very close to the southern shore of Galway Bay near Ballyvaughan. Underground flow routes are predominantly dip-controlled, presumably allowing the waters to follow single bedding partings for considerable distances.

2. There is some evidence to suggest that the Fergus system may be capturing some of the drainage to St. Brendan's Well, particularly the eastern (strike-oriented) component.

3. If this capture is indeed taking place it might be supposed that the resurgences of the Fergus valley are a relatively recent development, perhaps in response to the creation of an outlet for underground waters flowing south when glacial deepening of what is now the Fergus valley took place. However, there is evidence that the Fergus drainage system is of much greater antiquity than Holocene times. The Fergus River Cave shows signs of partial infilling, block collapse, re-invasion by streams and finally abandonment with further deposition (Patmore & Nicholson, 1965), whilst a stalagmite in a high level chamber some 160 m into the cave has been dated by D. C. Ford of MacMaster University using uranium-thorium series dating, to more than 350,000 years bp (a date of 'reasonable' validity). Kilcorney Caves and Vigo Cave also are clearly of some antiquity and are associated with the Fergus drainage system. It may be that the most recent phase of karstification is represented by the phreatic mazes at the lowest parts of Drummoher and Nooan Pots and at Poulnaboe and possibly also the conduits feeding to Elmvale rising.

4. Glencurran Cave differs in size and form from other caves in the area and its relationship to the main drainage to the Fergus springs remains unclear. Further work might be well worthwhile at this site.

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