# INCEPTION AND SUBSEQUENT DEVELOPMENT OF CONDUITS IN THE CUILCAGH KARST, IRELAND

VOLUME II

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A thesis submitted to the University of Huddersfield
in partial fulfilment of the requirements for
the degree of Doctor of Philosophy

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# Table of Contents

Volume I

## Table of Contents

Volume I

## Table of Contents

Volume I

## List of Figures

Volume II

## List of Figures

Volume II

## List of Figures

## List of Figures

Volume II

## List of Figures

Volume II

## List of Plates

Volume II

## List of Plates

Volume II

## List of Tables

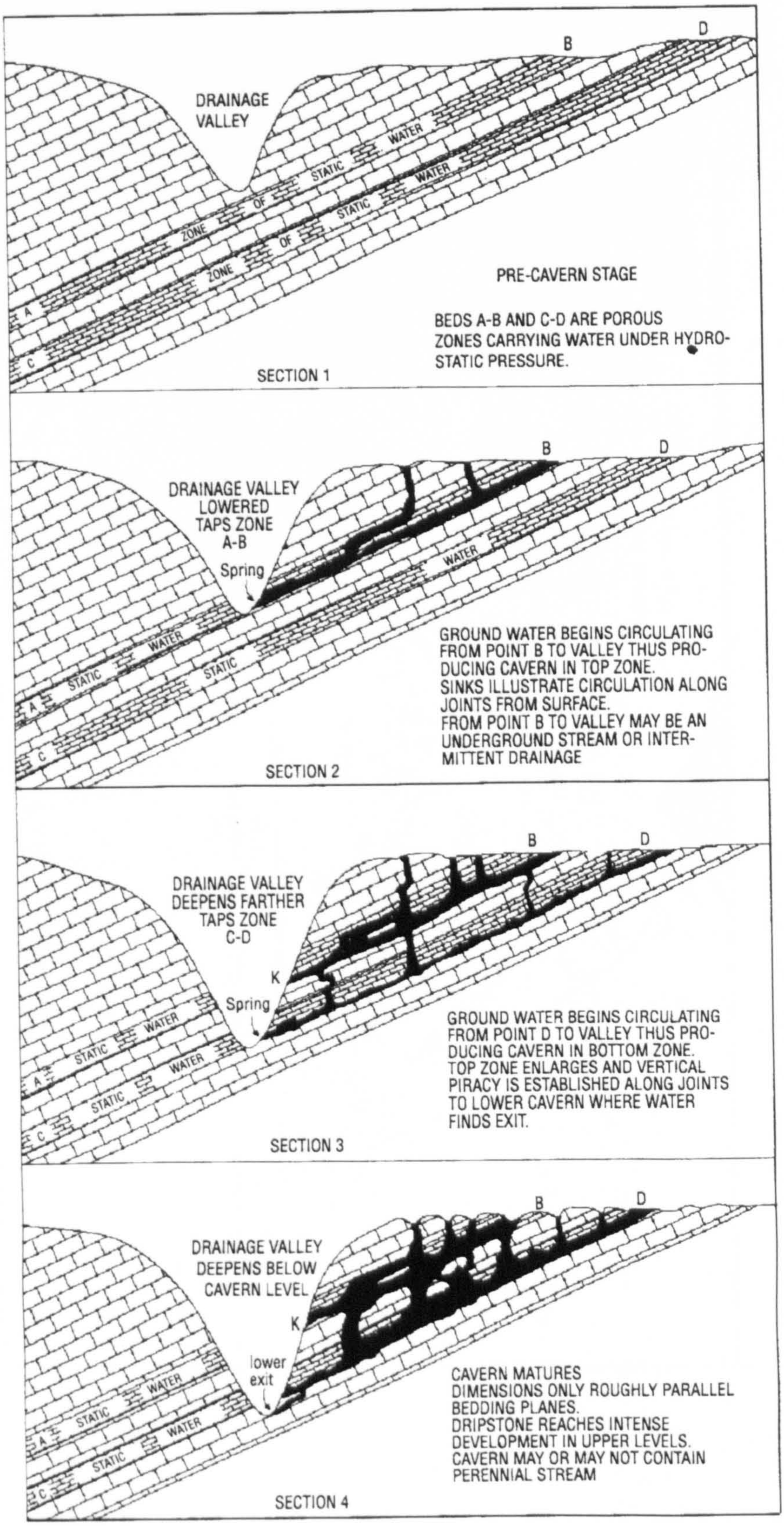



Figure 1. Sketch sections illustrating the origin and development of a large cavern by Gardiner (1935) (From Lowe, 2000).

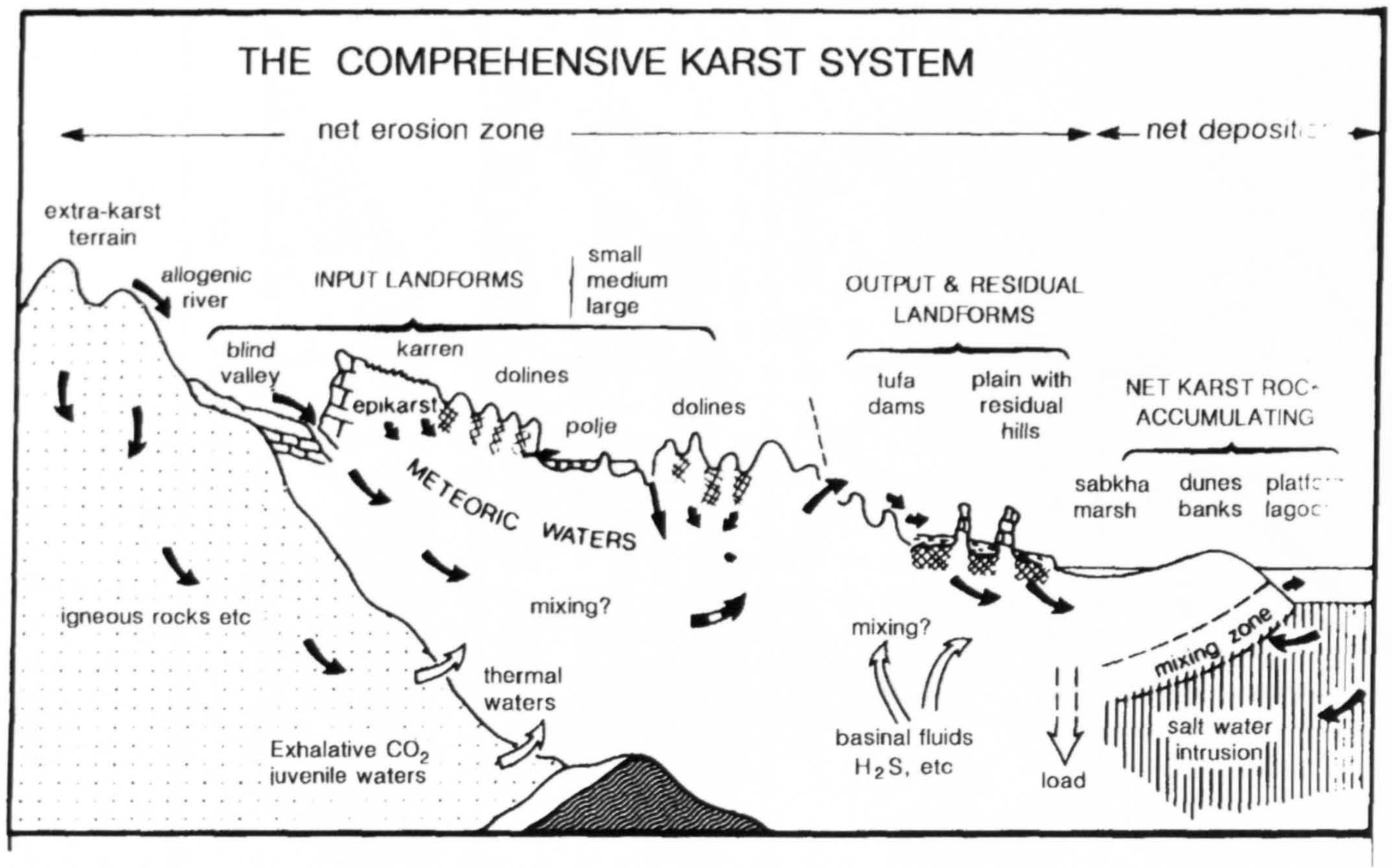



Figure 2. The comprehensive karst system (Ford and Williams, 1989).

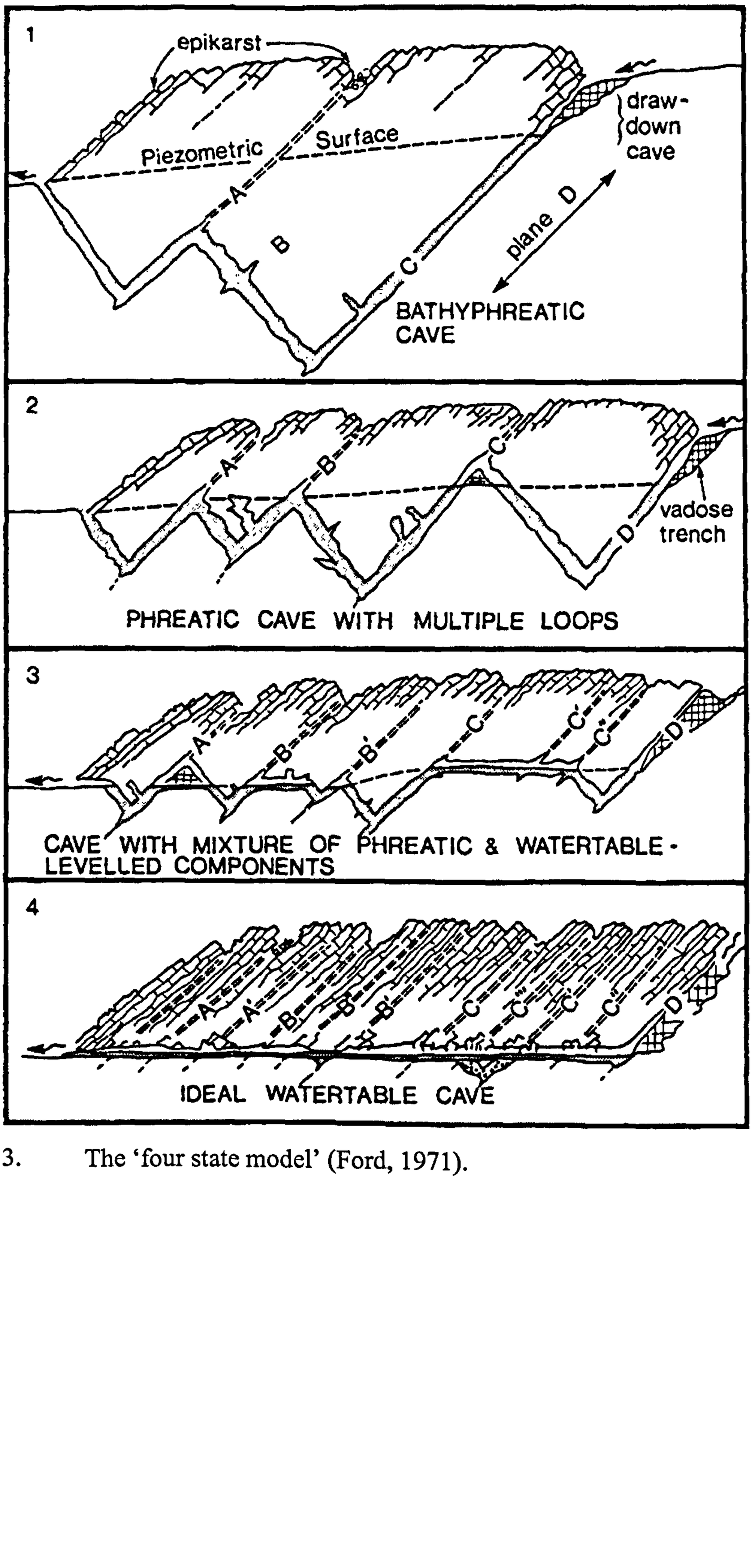



Figure 3. The 'four state model' (Ford, 1971).

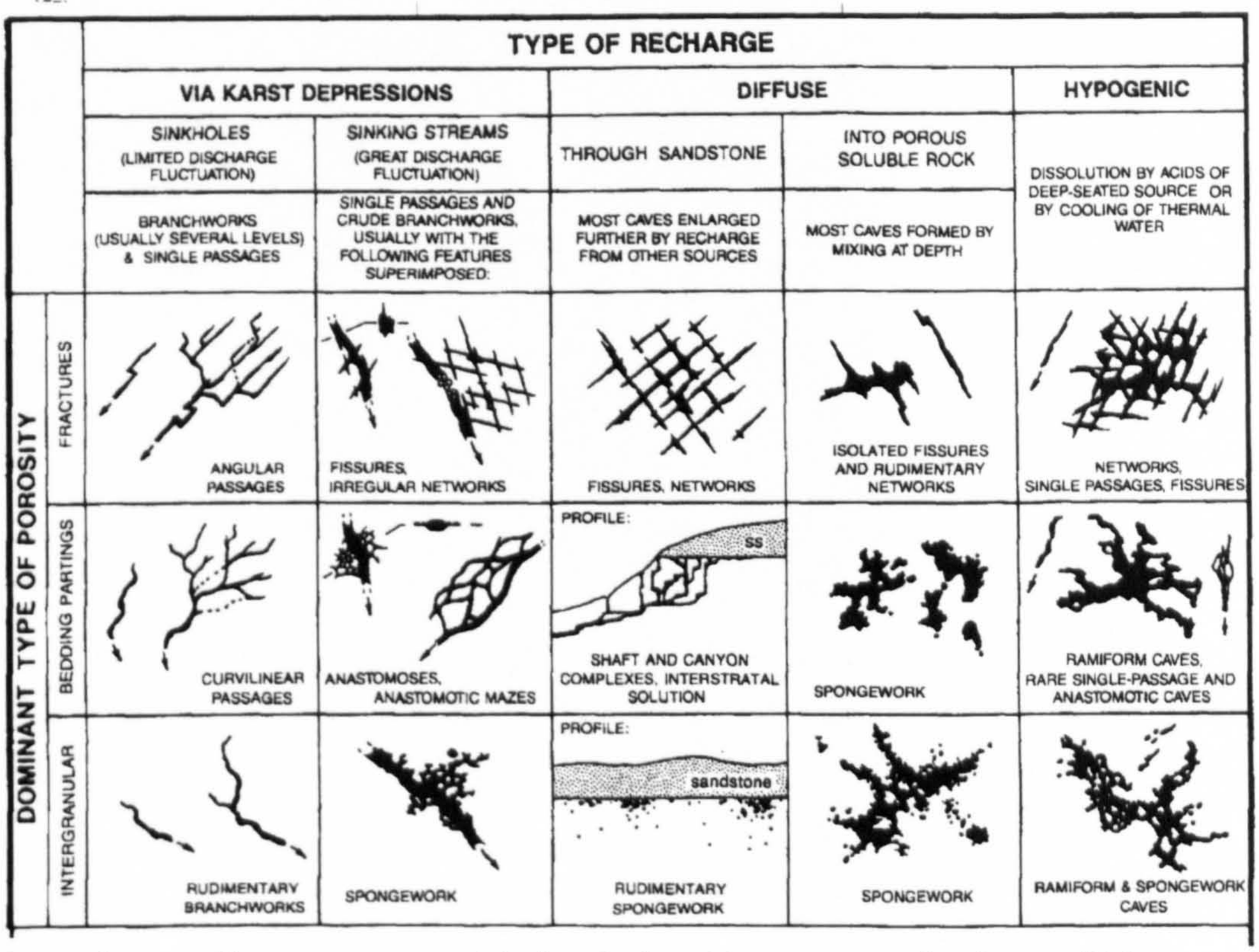



Figure 4. Cave patterns and their relationship to types of recharge (Palmer, 1991).

Simplified view of the life cycle of conduits/caves within a single "tier" of a typical carbonate succession, indicating:

① Terminology in common and informal use;
② Part of the terminology developed by Worthington (1991);
③ Terminology used by Lowe (1992a).

Elapsed **TIME**, increasing from left to right, is not to scale

| NO CONDUITS | ⟹ CONDUIT GROWTH ⟹ | TURBULENT THRESHOLD | ⟹ CAVE GROWTH ⟹ | OVERALL DECAY OF CAVES | NO CAVES |
|---|---|---|---|---|---|
| ① | INITIATION | | various phases of DEVELOPMENT | abandonment and eventual removal | ① |
| ② | INITIATION PHASE / LAMINAR FLOW NOTHEPHREATIC PHASE | | SYNGENETIC AND PARAGENETIC CONDUIT GROWTH PHASES | STAGNATION AND DESTRUCTION PHASES | ② |
| ③ | INCEPTION / GESTATION | | DEVELOPMENT | ABANDONMENT and DESTRUCTION | ③ |
| | true point of "cave" origin / Period of transitional change | Turbulent flow begins | Major growth phases | can be complex and multiphase | Host rock removed |

Figure 5. Selected examples of terms used to describe cave development phases. (Lowe, 2000).

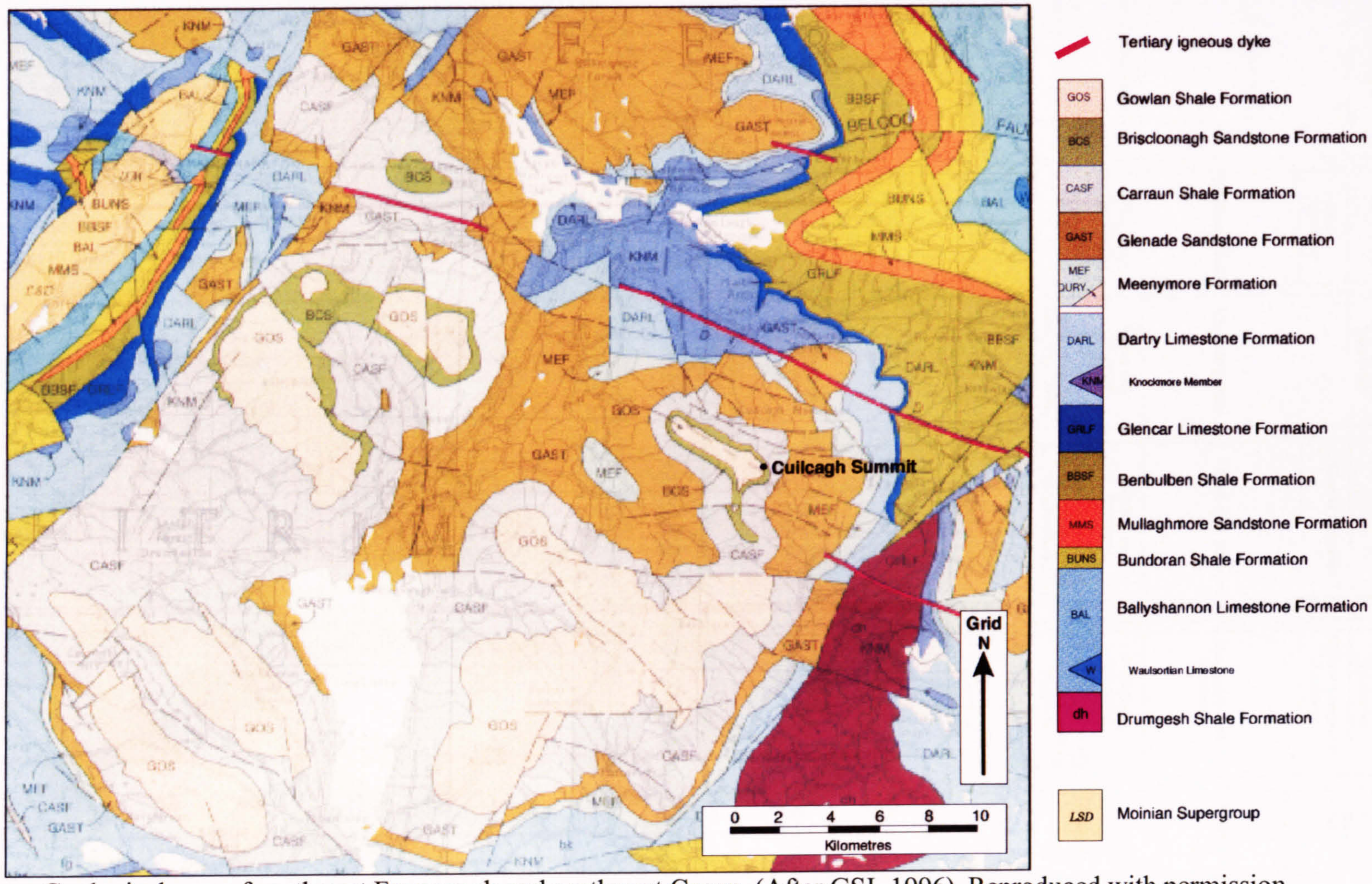



Figure 6. Geological map of southwest Fermanagh and northwest Cavan. (After GSI, 1996). Reproduced with permission.

| Symes and Wilkinson (1886) Wilkinson and Cruise (1886) Fermanagh | Oswald (1955) Sligo Syncline | Sheridan (1972) North-West Carboniferous Basin | Brunton and Mason (1979) Fermanagh | | GSNI (1998) | | Stages |
|---|---|---|---|---|---|---|---|
| Upper Limestone | Dartry Limestone | Upper (Dartry) Limestone | Dartry Limestone | DARTRY GROUP | Dartry Limestone Formation | | Asbian (part) |
| | Glencar Limestone | | Glencar Limestone | | Glencar Limestone Formation | | |
| Middle or Calp Limestone | Benbulben Shale | Upper Calp Shale | Benbulben Shale | | Benbulben Shale Formation | | Holkerian |
| Middle or Calp Sandstone | Mullaghmore Sandstone | Upper Calp (Macnean) Sandstone | Mullaghmore Sandstone | | Mullaghmore Sandstone Formation | TYRONE GROUP | Arundian |
| Middle or Calp Limestone | Bundoran Shale | Middle Calp Shale | Bundoran Shale (Upper) | | Bundoran Shale Formation | | |
| | | Lower Calp (Dowra) Sandstone | Dowra Sandstone | | | | |
| | | Lower Calp Shale | Bundoran Shale (Lower) | | | | |
| Lower Limestone | Ballyshannon Limestone including Basal Beds | Lower (Ballyshannon) Limestone | Ballyshannon Limestone | BALLYSHANNON GROUP | Ballyshannon Limestone Formation | | late Chadian |
| Lower Carboniferous Shale and Sandstone | | Basal Sandstones, Limestones and Shales | Basal Clastics | | undivided Tyrone Group | | early Courceyan (part) |

Figure 7. Nomenclature for the Dinantian sequence of the Northwest Basin of Ireland (GSNI, 1998). Crown copyright. Reproduced with permission.

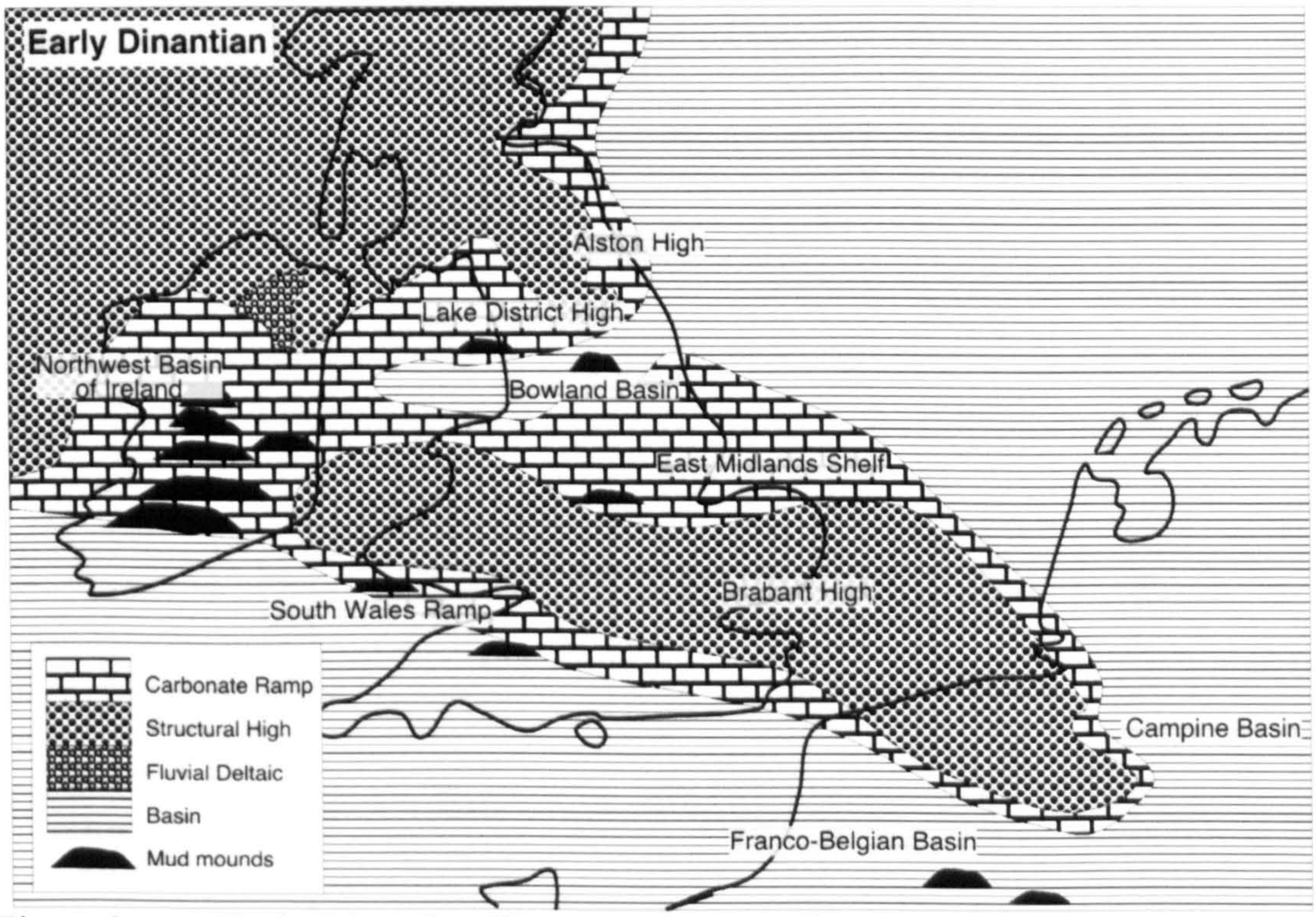



Figure 8. Early-Dinantian (Courceyan to Arundian stages) carbonate accumulations (After Bridges *et al.*, 1995).

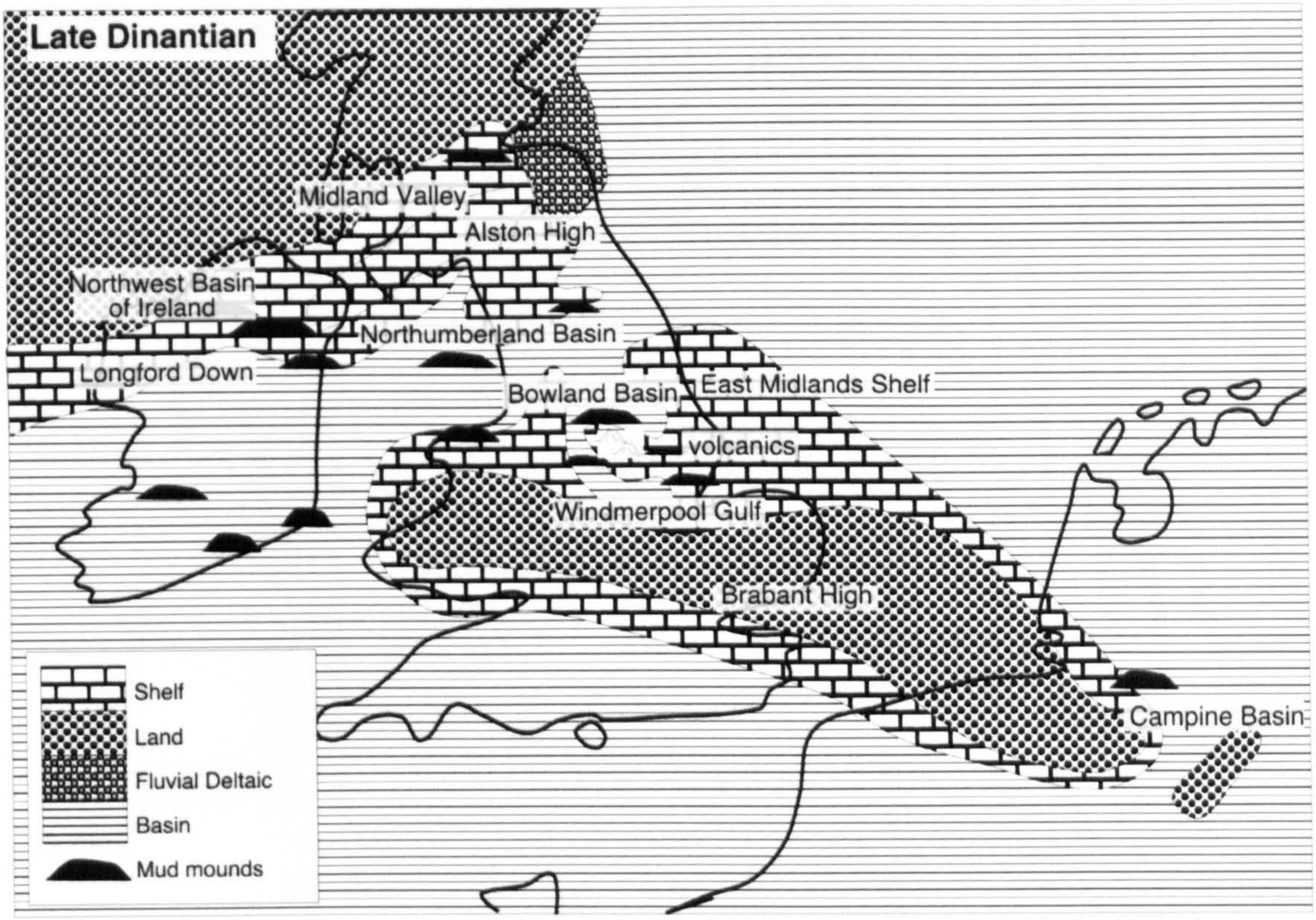



Figure 9. Late-Dinantian (Asbian-Brigantian) carbonate accumulations (After Bridges *et al.*, 1995.

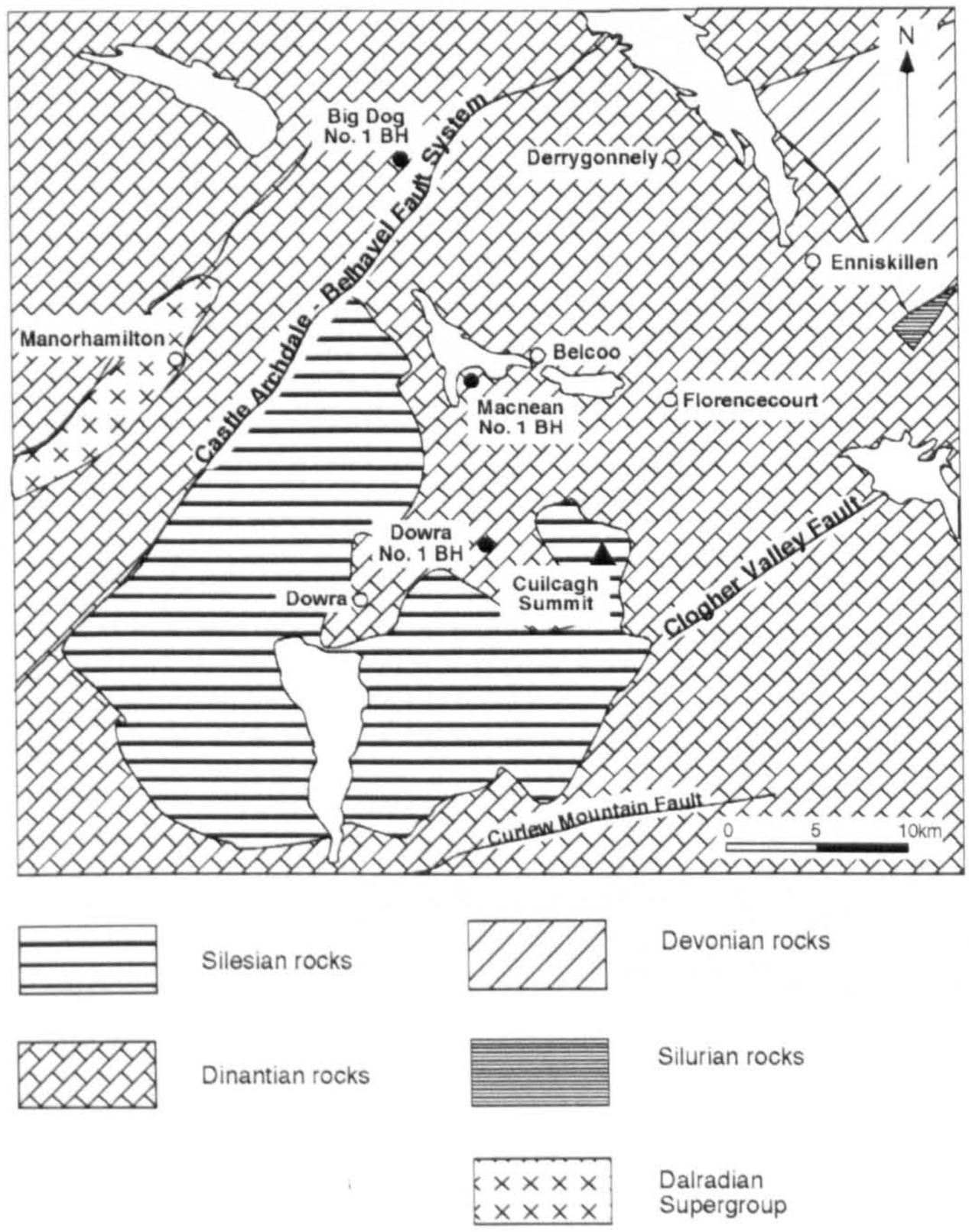



Figure 10. Generalised geology of the Lough Allen Basin. (Kelly 1996).

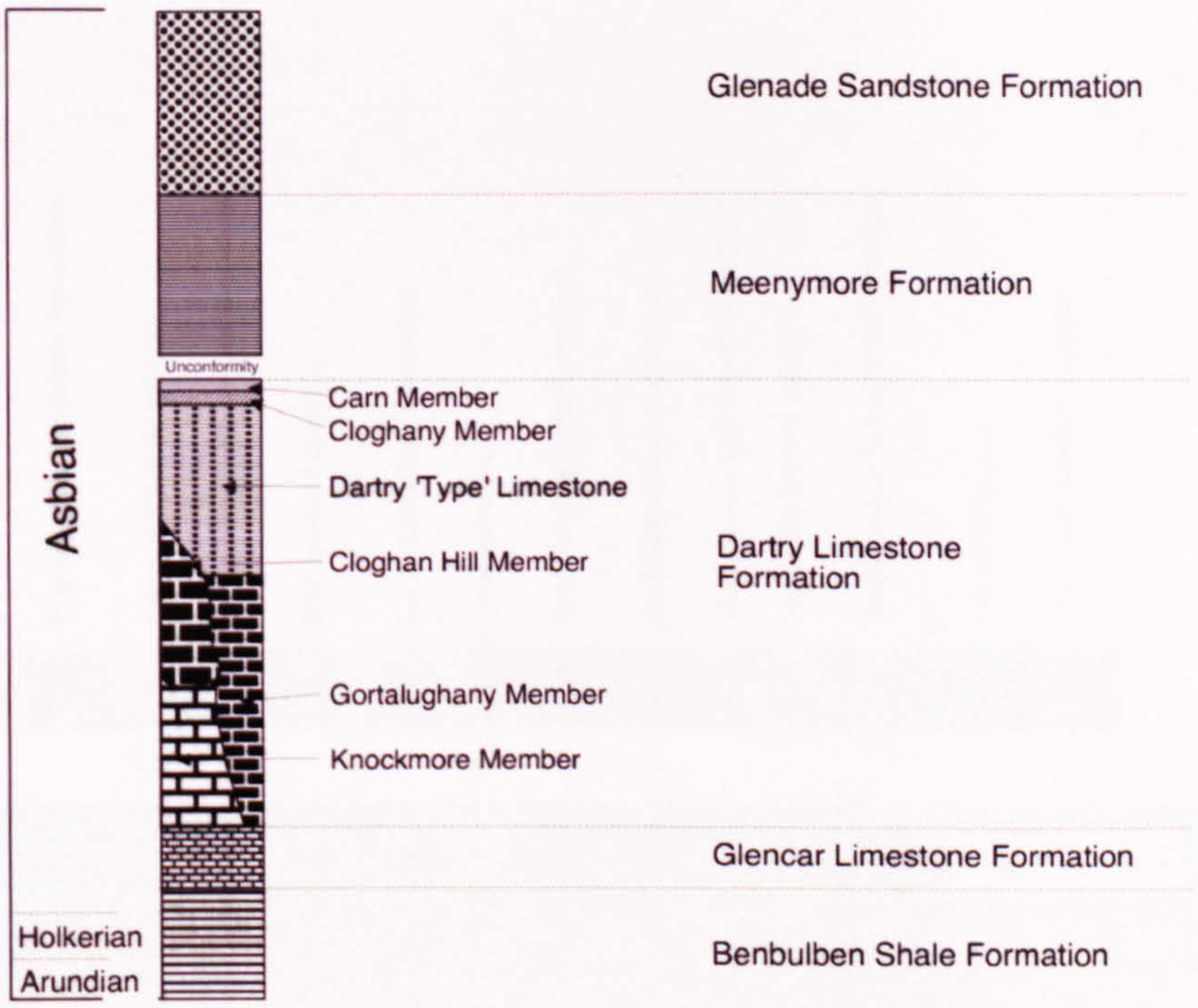



Figure 11. The subdivision of the Dartry Limestone Formation (After Kelly, 1996).

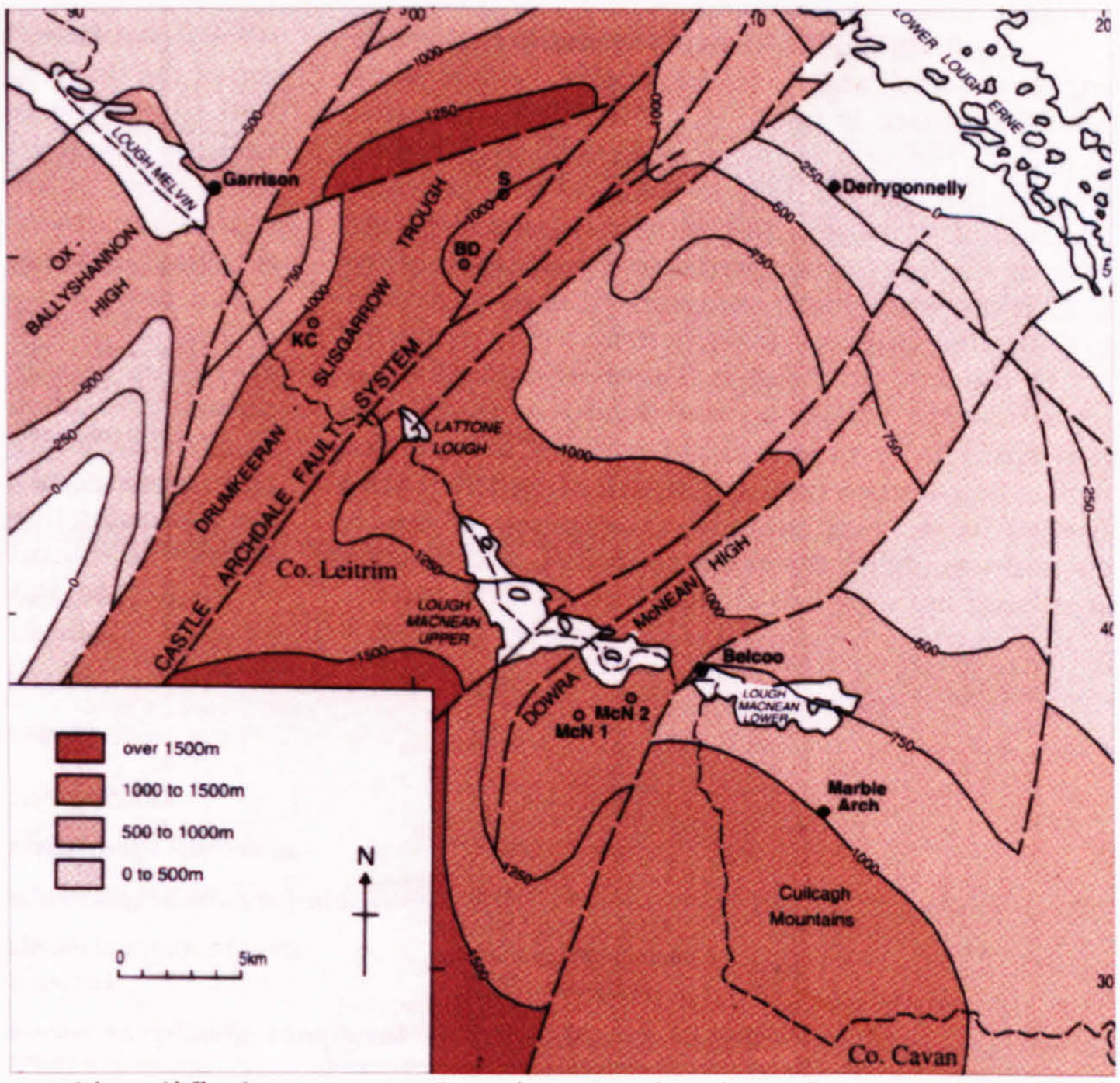



Figure 12. Simplified contours showing the depth to the top of the Ballyshannon Limestone Formation. Depths are shown in metres above seismic datum of +50 m OD. BD = Big Dog Borehole, KC = Kilco Cross Borehole, McN = MacNean Borehole and S = Slisgarrow Borehole (GSNI, 1998). Crown copyright. Reproduced with permission.

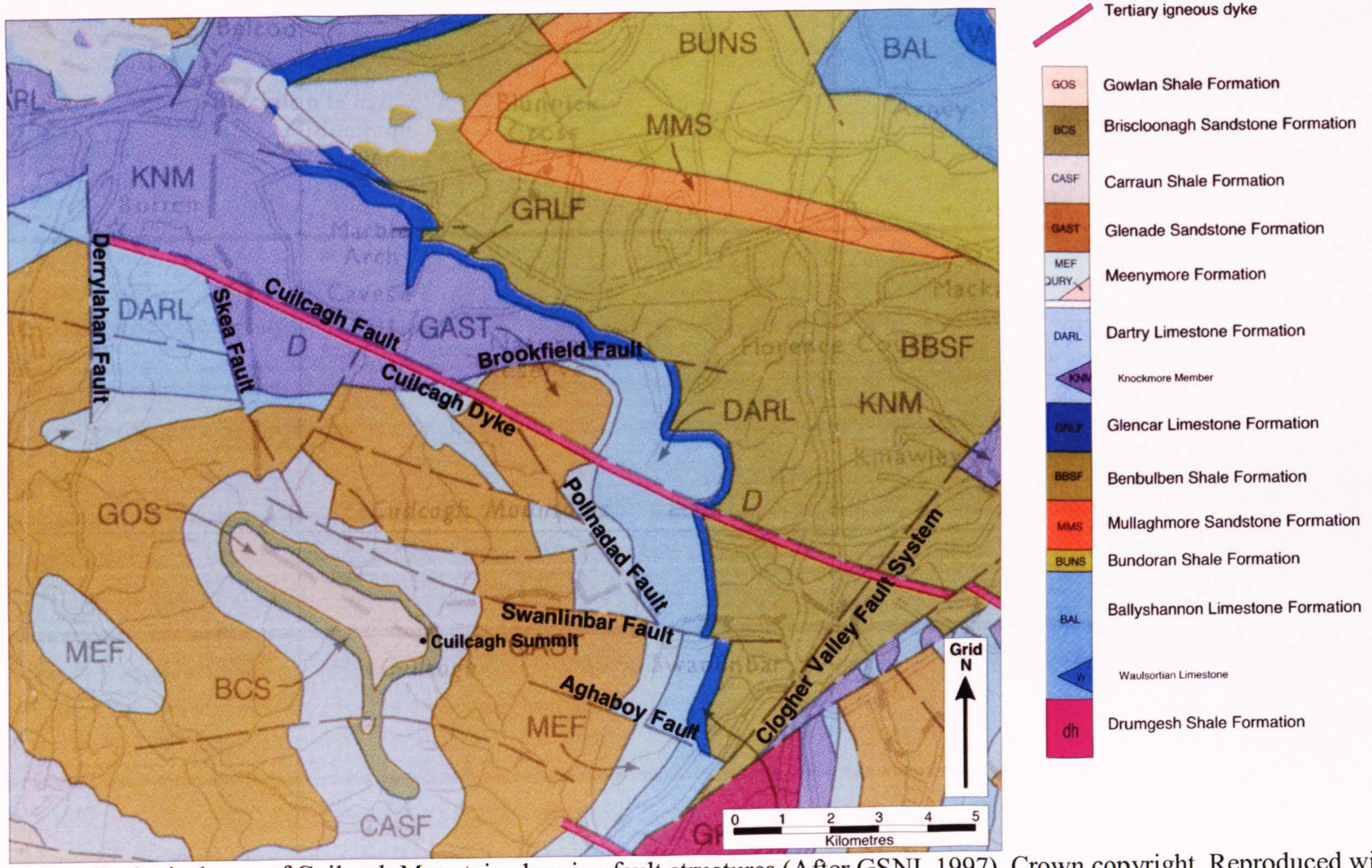



Figure 13. Geological map of Cuilcagh Mountain showing fault structures (After GSNI, 1997). Crown copyright. Reproduced with permission.

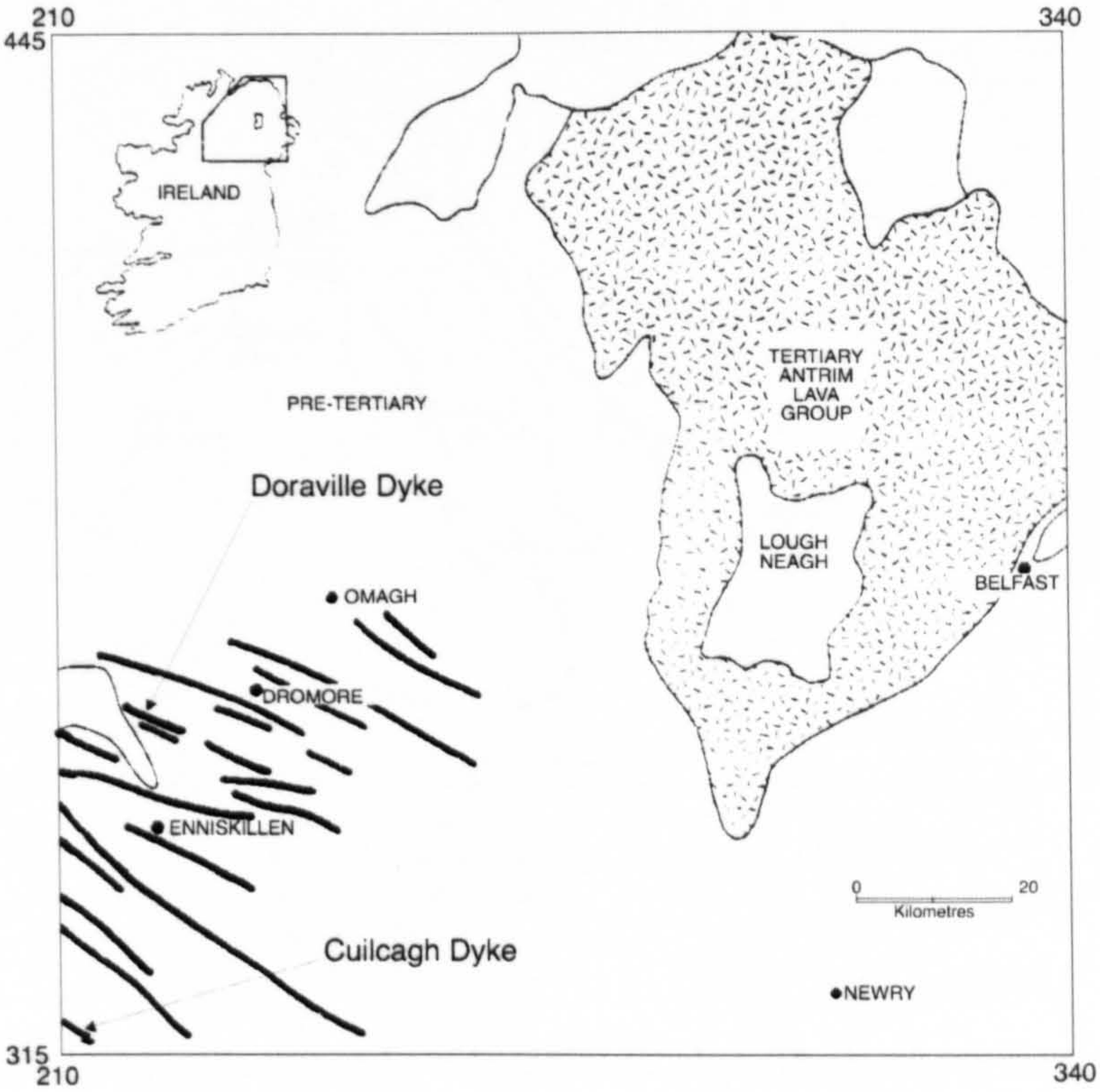



Figure 14. Part of the dyke swarm of southwest Fermanagh (Gibson & Lyle, 1993).

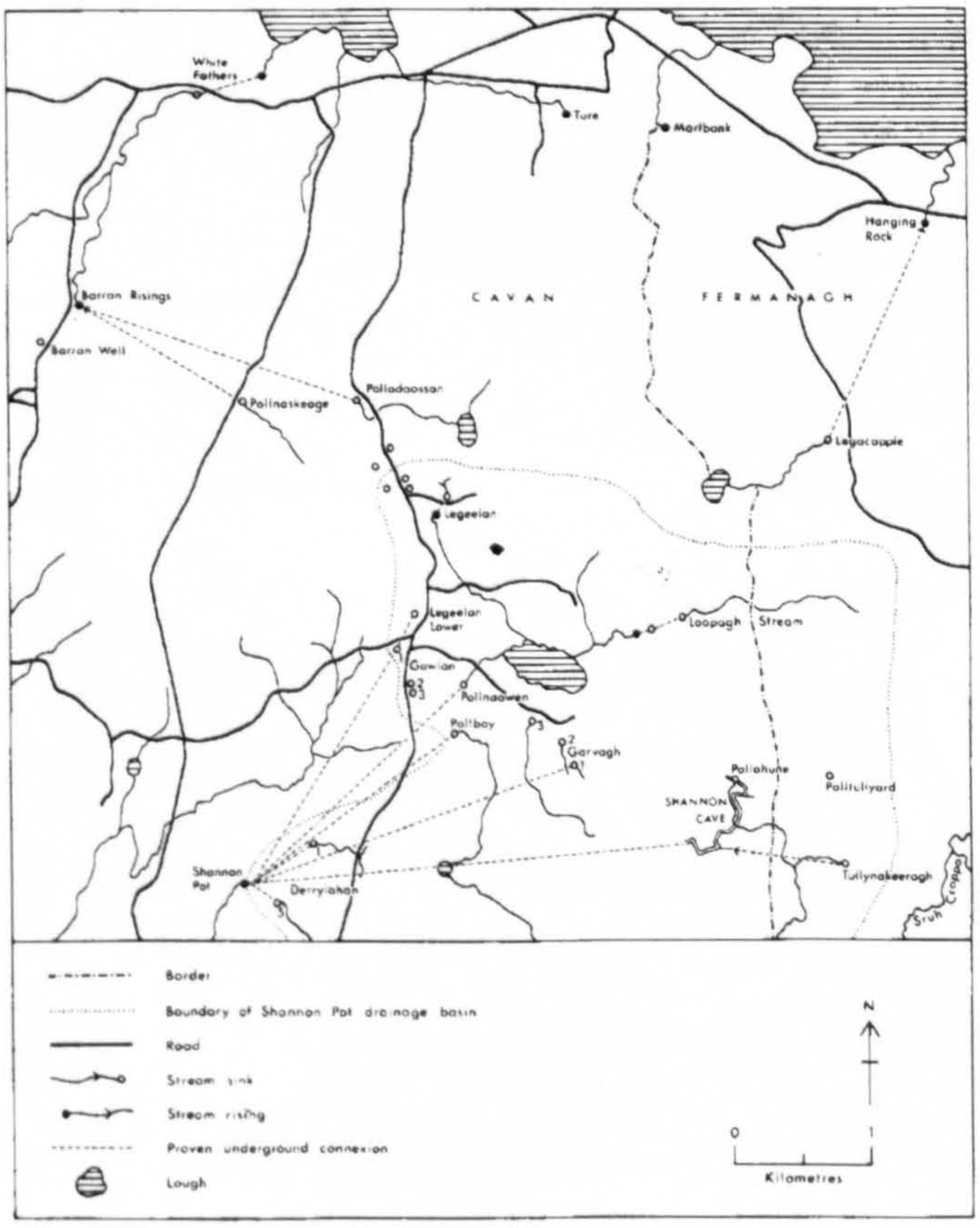



Figure 15. Summary of Gunn's water tracing experiments in the West Cuilcagh karst (Gunn, 1982).

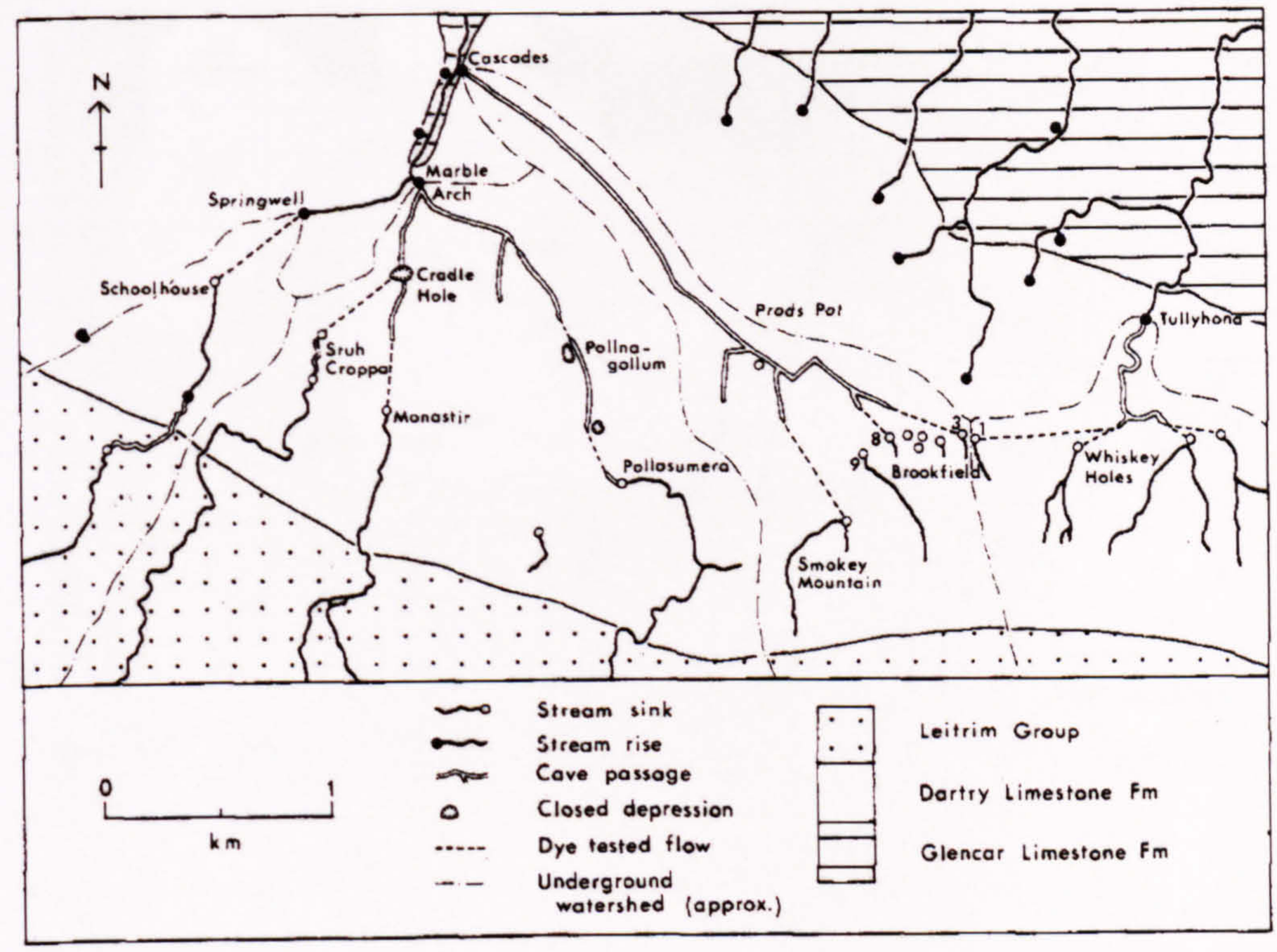



Figure 16. Summary of Gunn's water tracing experiments in the North Cuilcagh karst (Gunn, 1982).

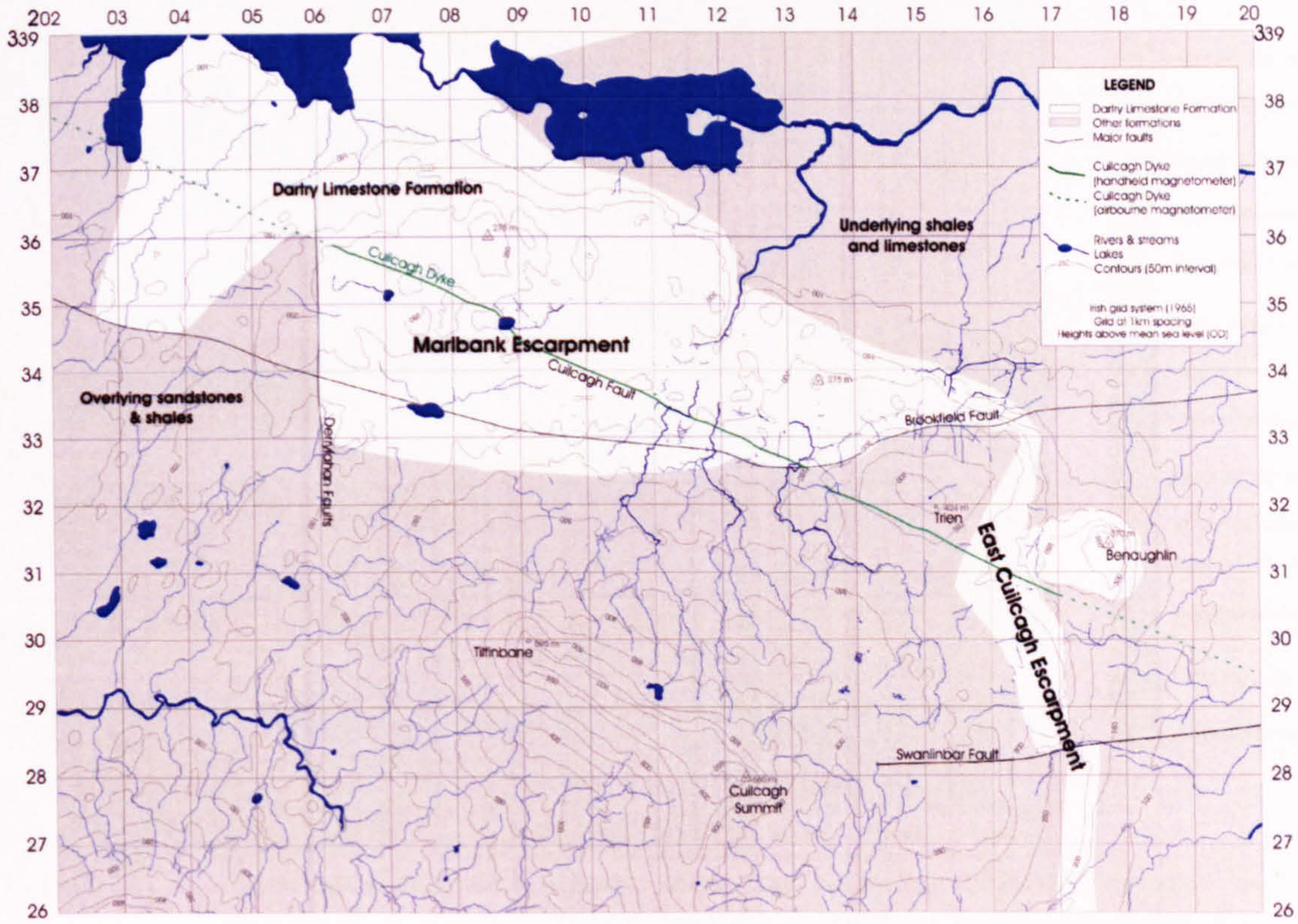



Figure 17. Outcrop of the Dartry Limestone Formation on Cuilcagh Mountain.

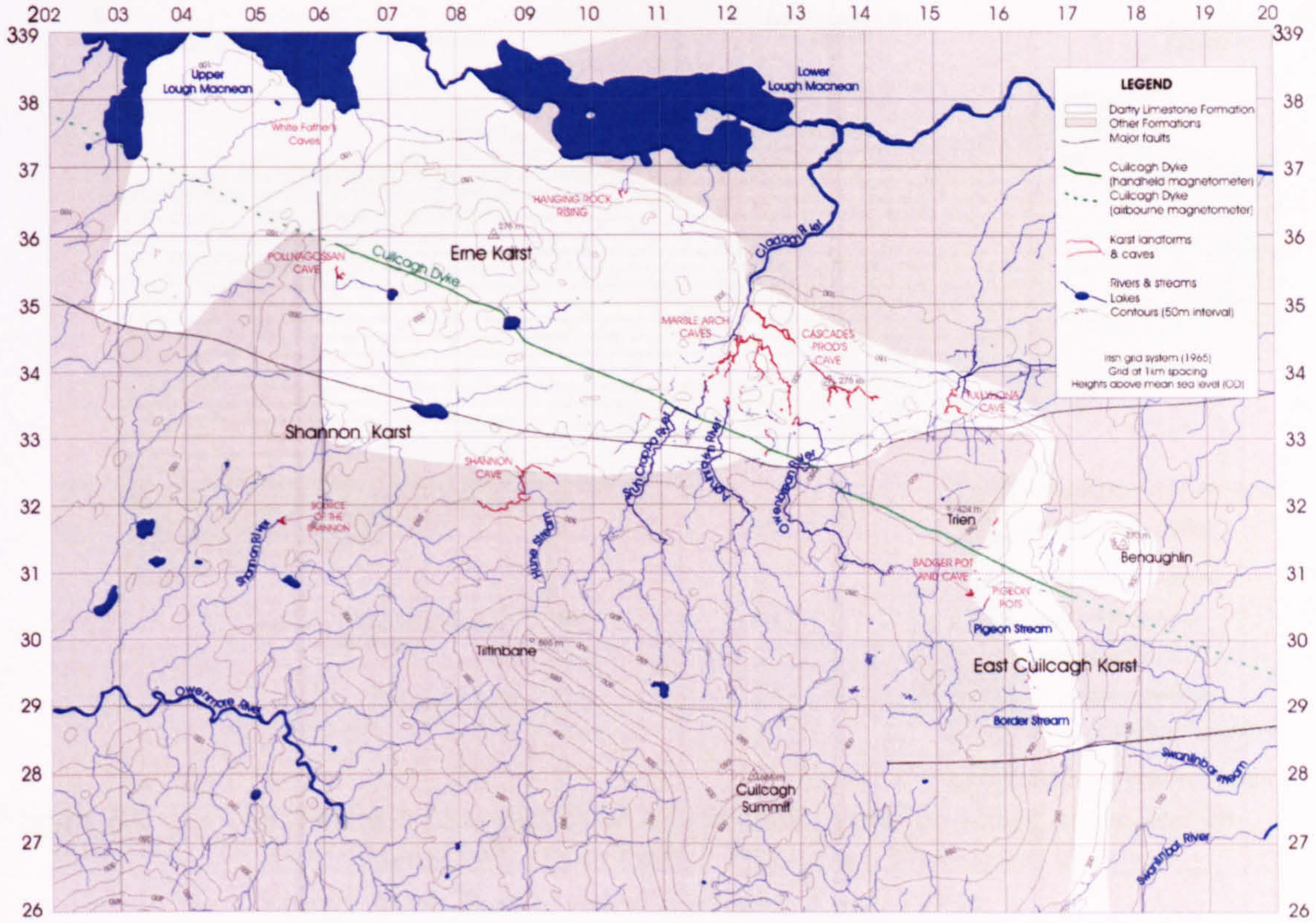



Figure 18. The East Cuilcagh, Erne and Shannon karst sub-areas of Cuilcagh Mountain.

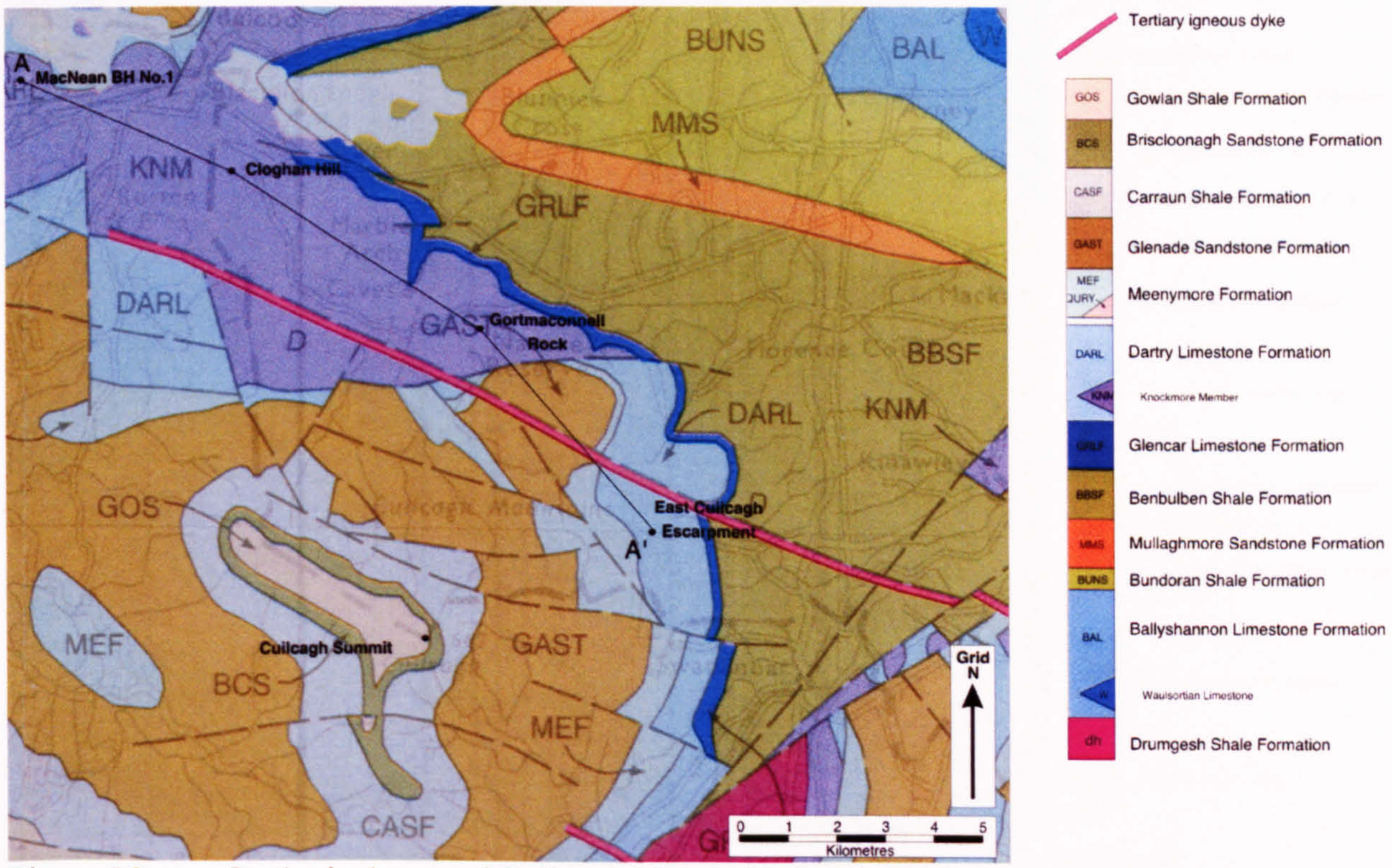



Figure 19. Geological map of Cuilcagh Mountain showing schematic cross section A-A' (Figure 20) (After GSNI, 1997). Crown copyright. Reproduced with permission.

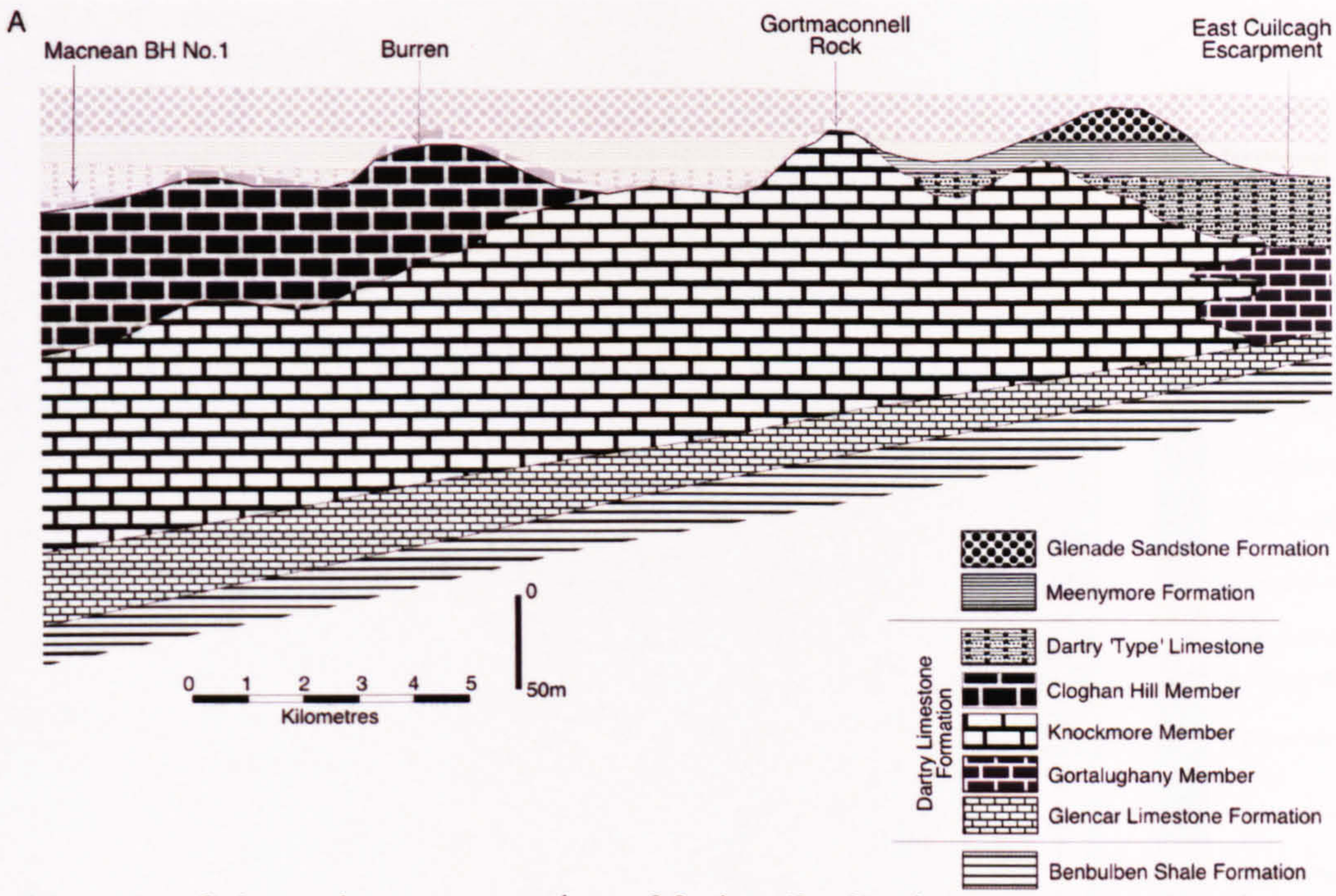



Figure 20. Schematic reconstruction of facies distribution along cross-section A-A' (Figure 19) of the Dartry Limestone Formation within the Lough Allen Basin. (Modified after Kelly 1989).

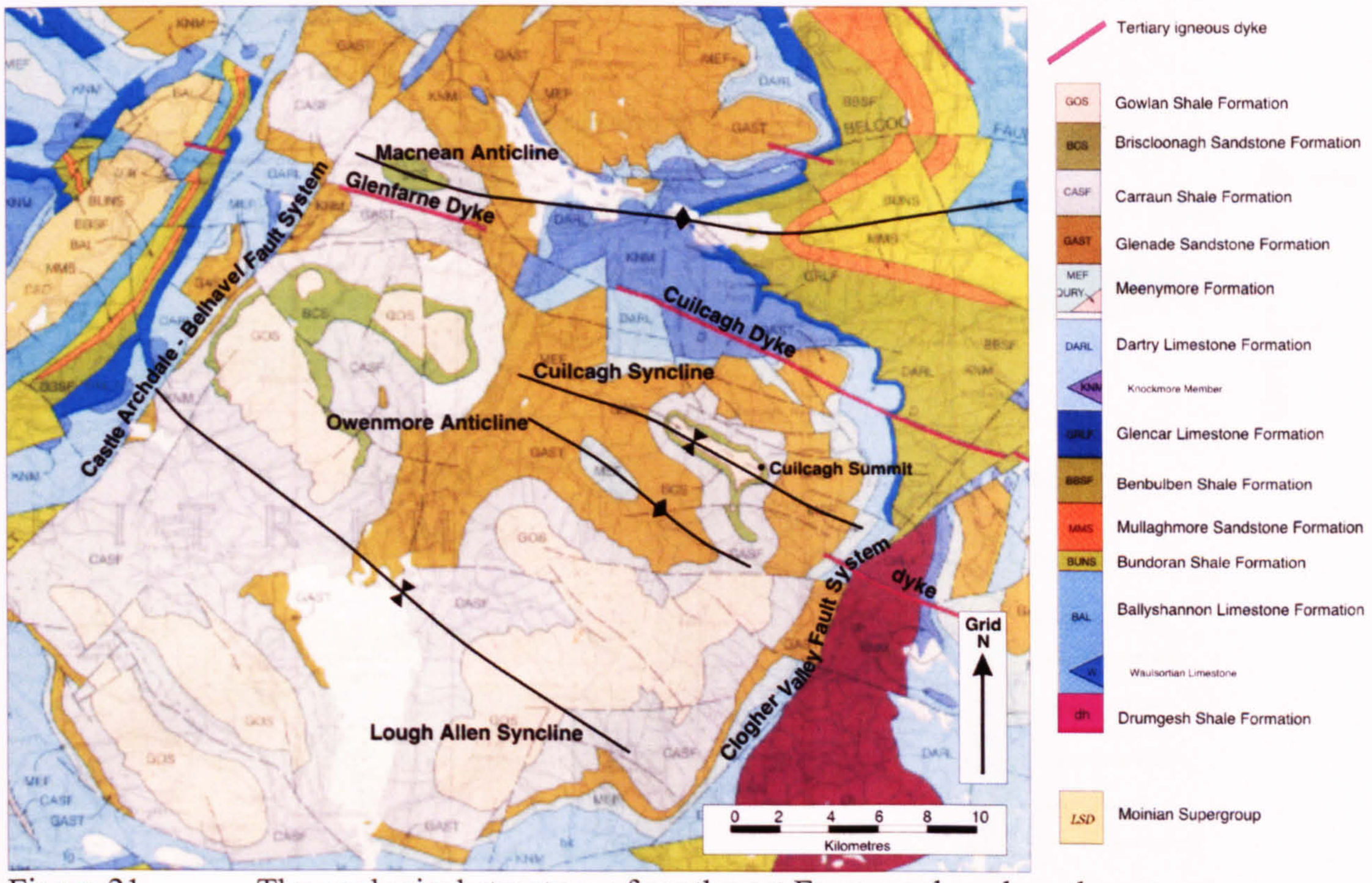



Figure 21. The geological structure of southwest Fermanagh and northwest Cavan (After GSI, 1996). Reproduced with permission.

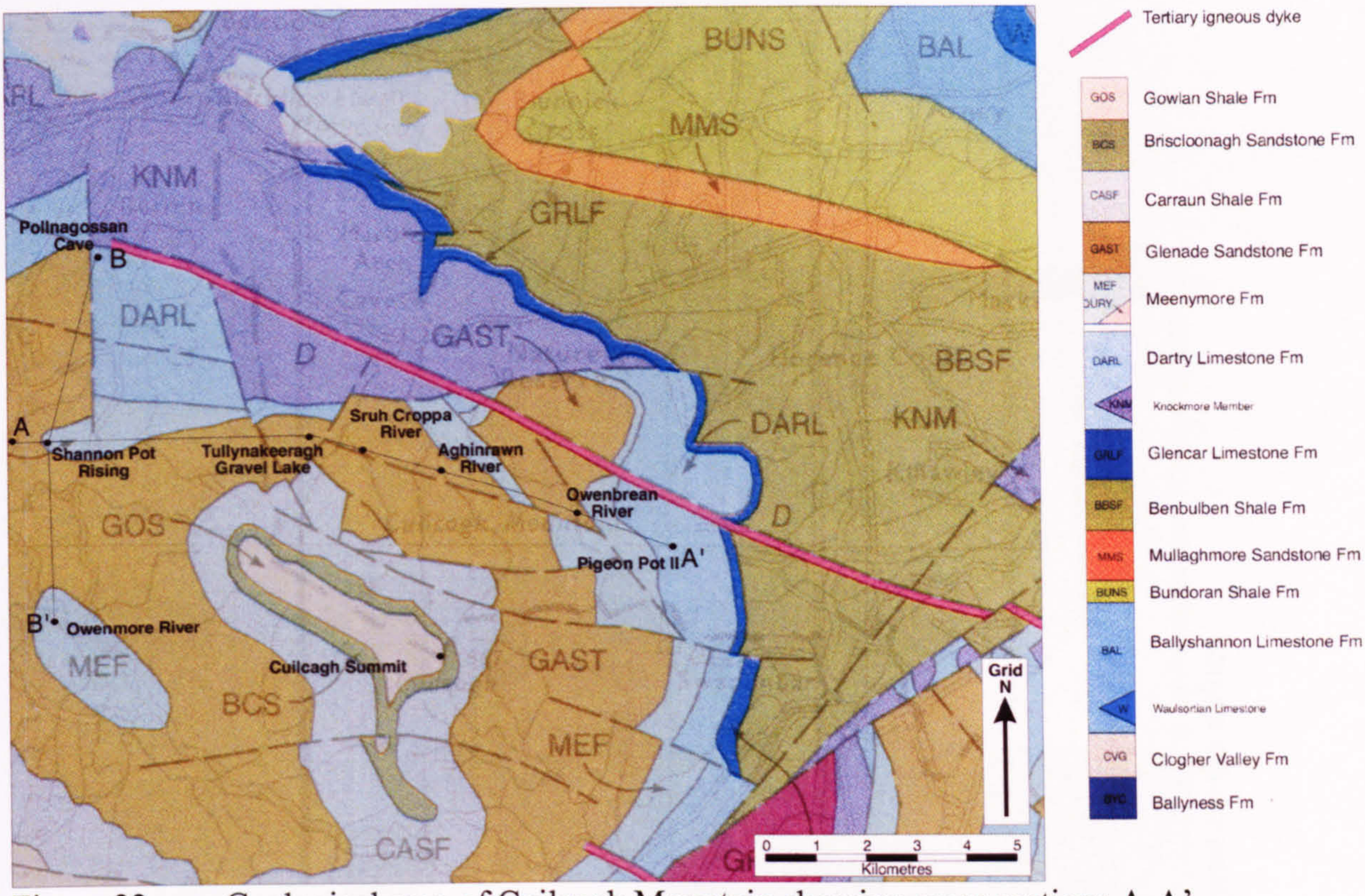



Figure 22. Geological map of Cuilcagh Mountain showing cross sections A-A' and B-B' (Figure 23) (After GSNI, 1997). Crown copyright. Reproduced with permission.

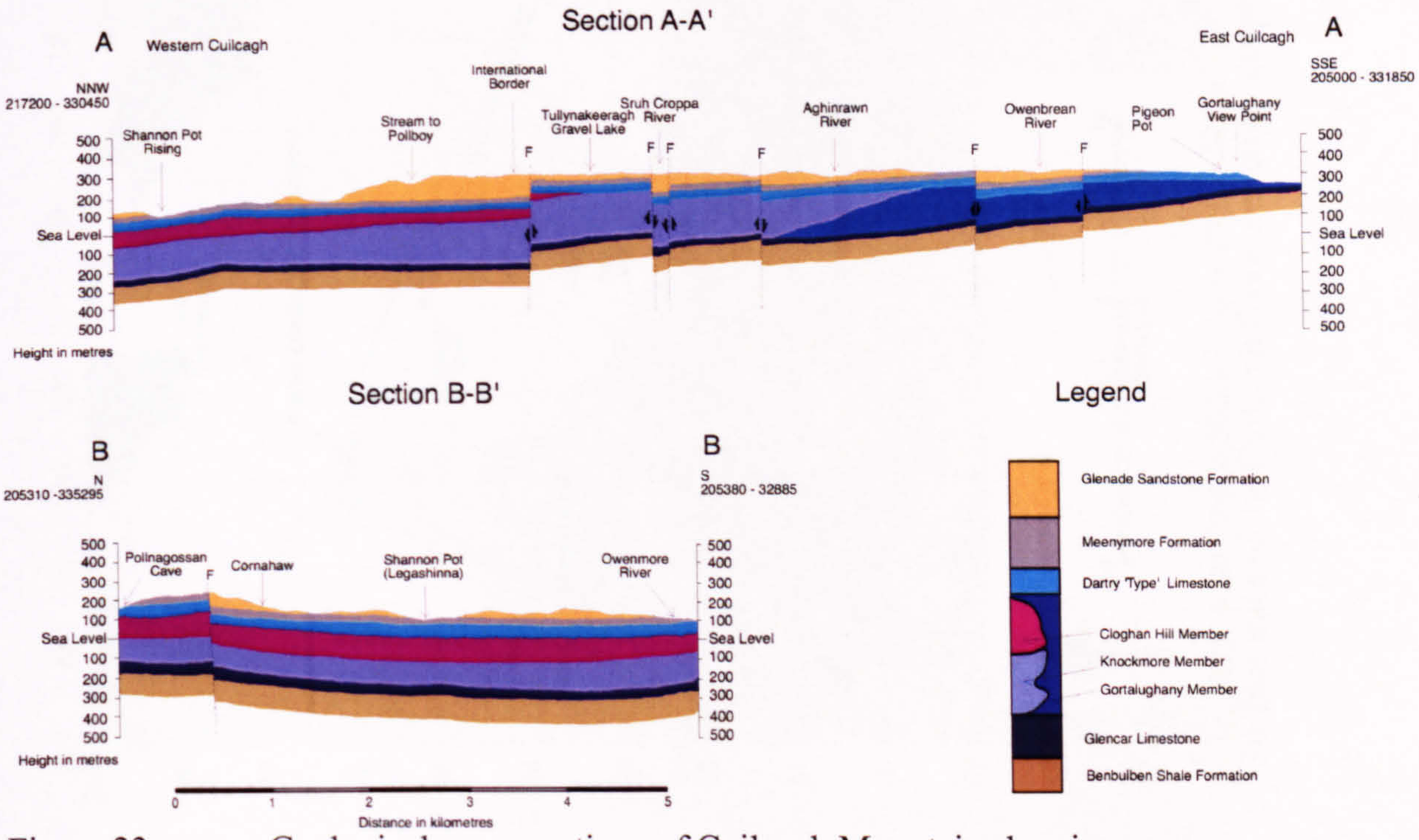



Figure 23. Geological cross-sections of Cuilcagh Mountain showing cross sections A-A' and B-B', (section transects marked on Figure 22).

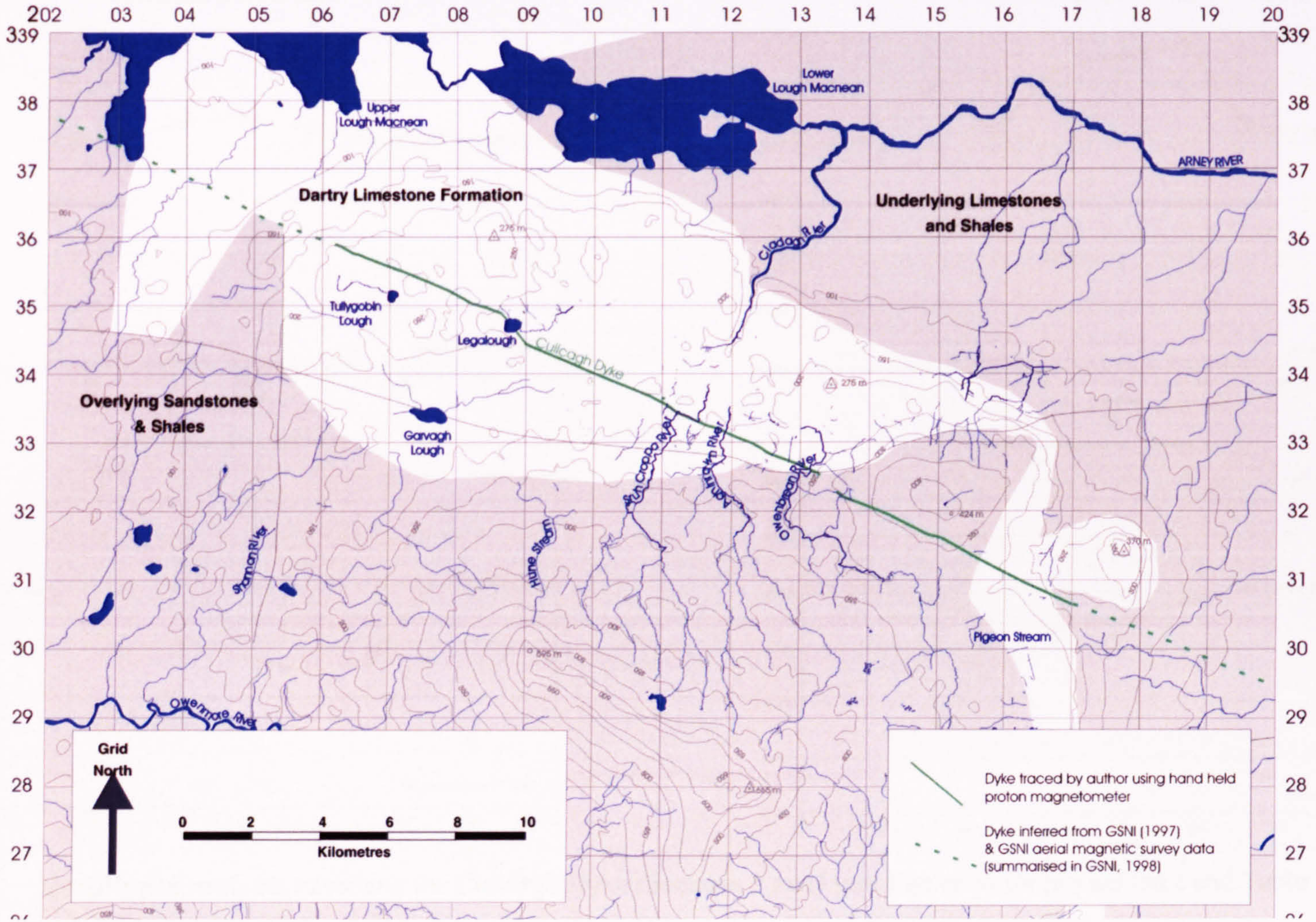



Figure 24. Surface trace of the Cuilcagh Dyke proven by geophysical surveying by the author.

**Chart 1. Cuilcagh Dyke - Transect 1**

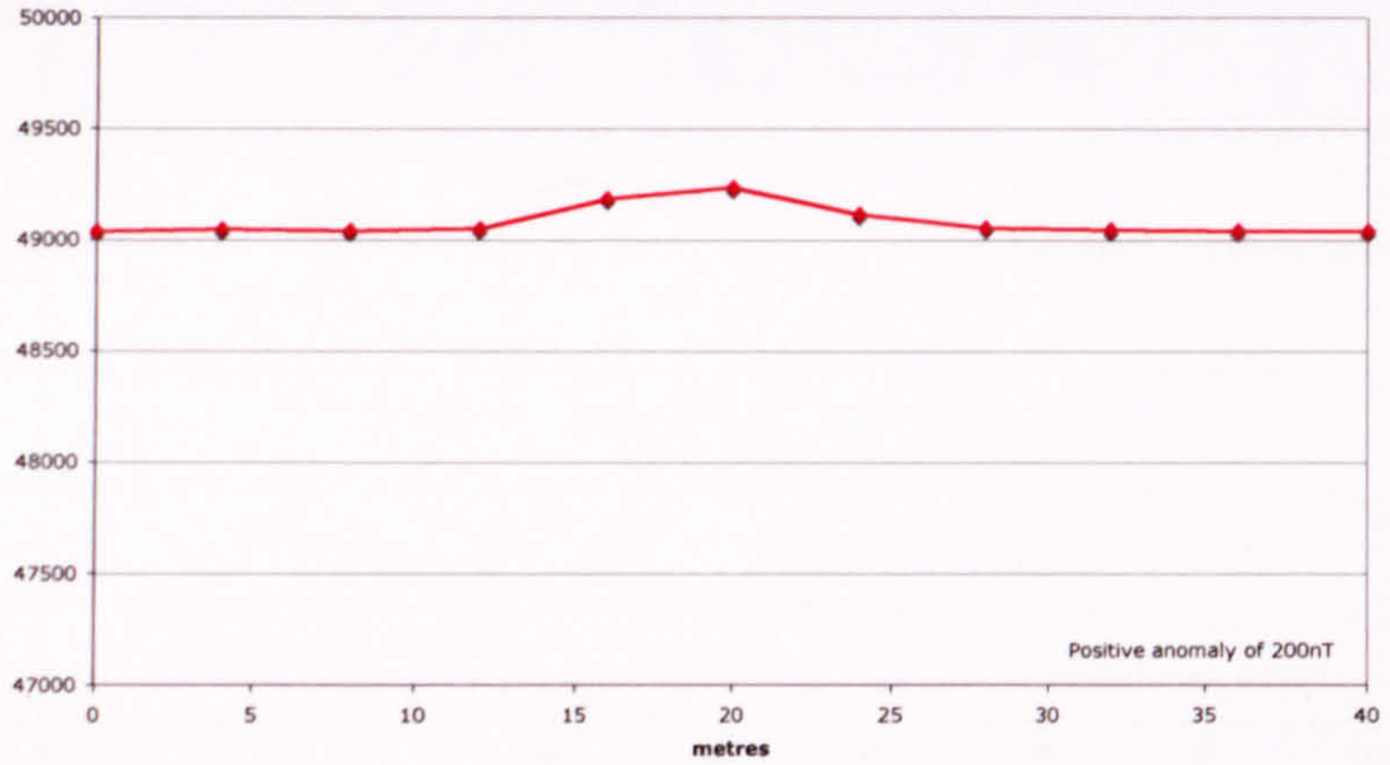



**Chart 2. Cuilcagh Dyke - Transect 2**

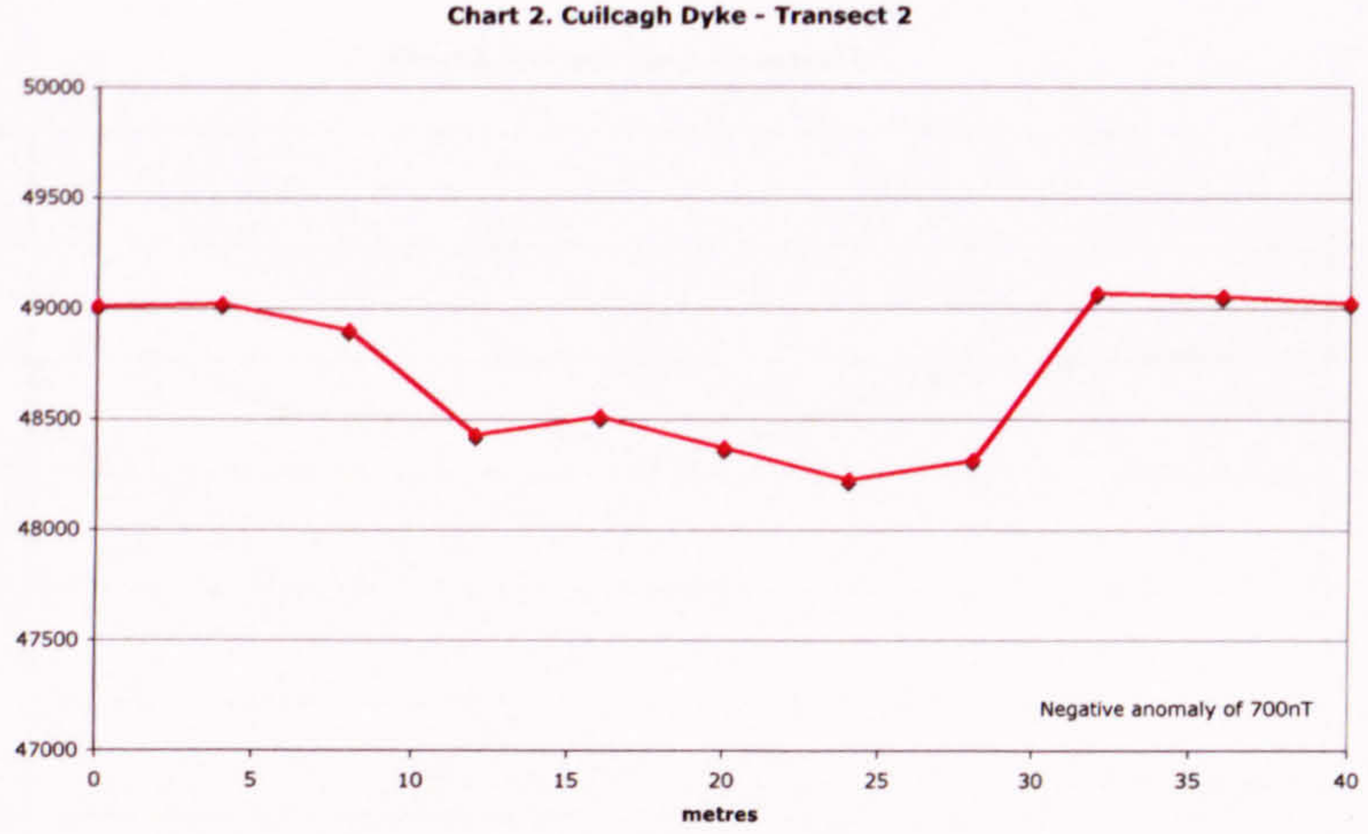



**Chart 3. Cuilcagh Dyke - Transect 3**

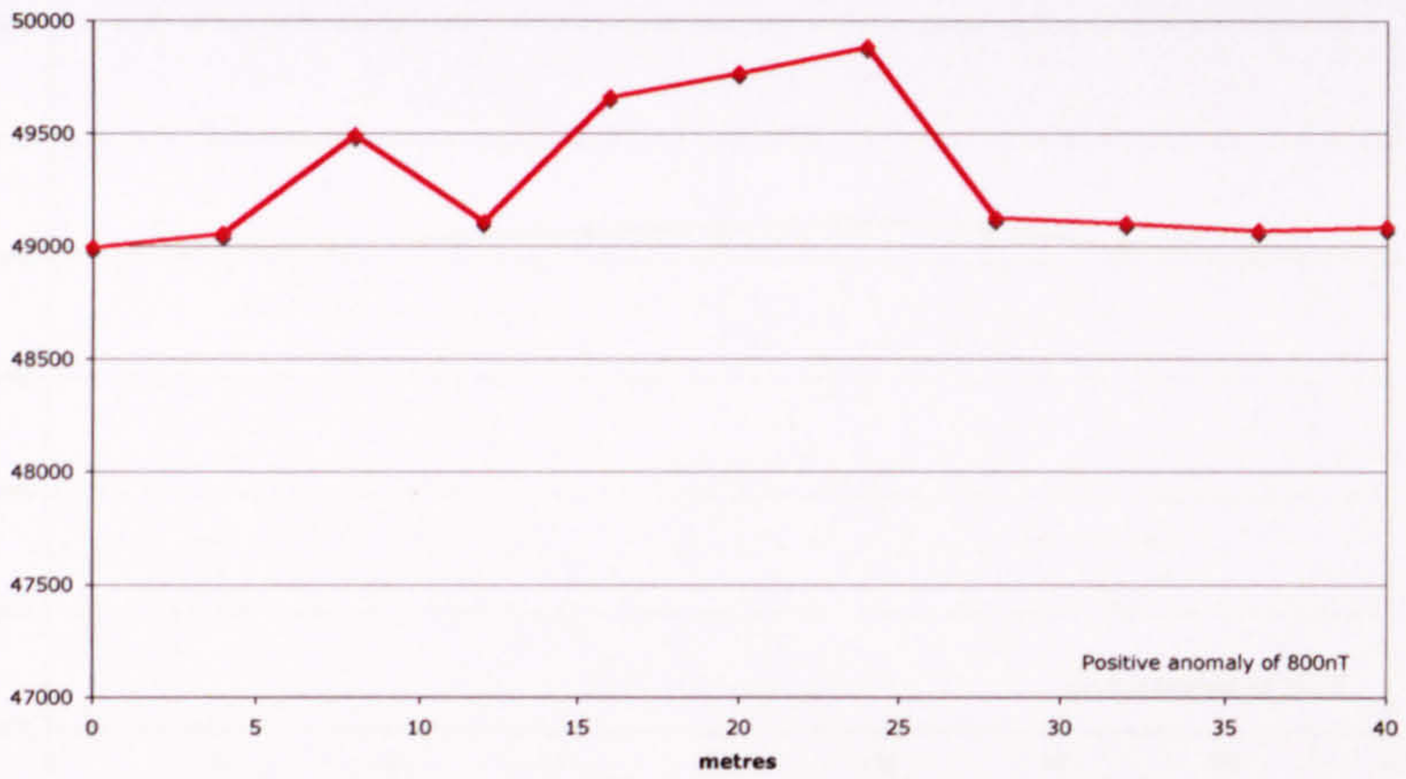



**Chart 4. Cuilcagh Dyke - Transect 4**

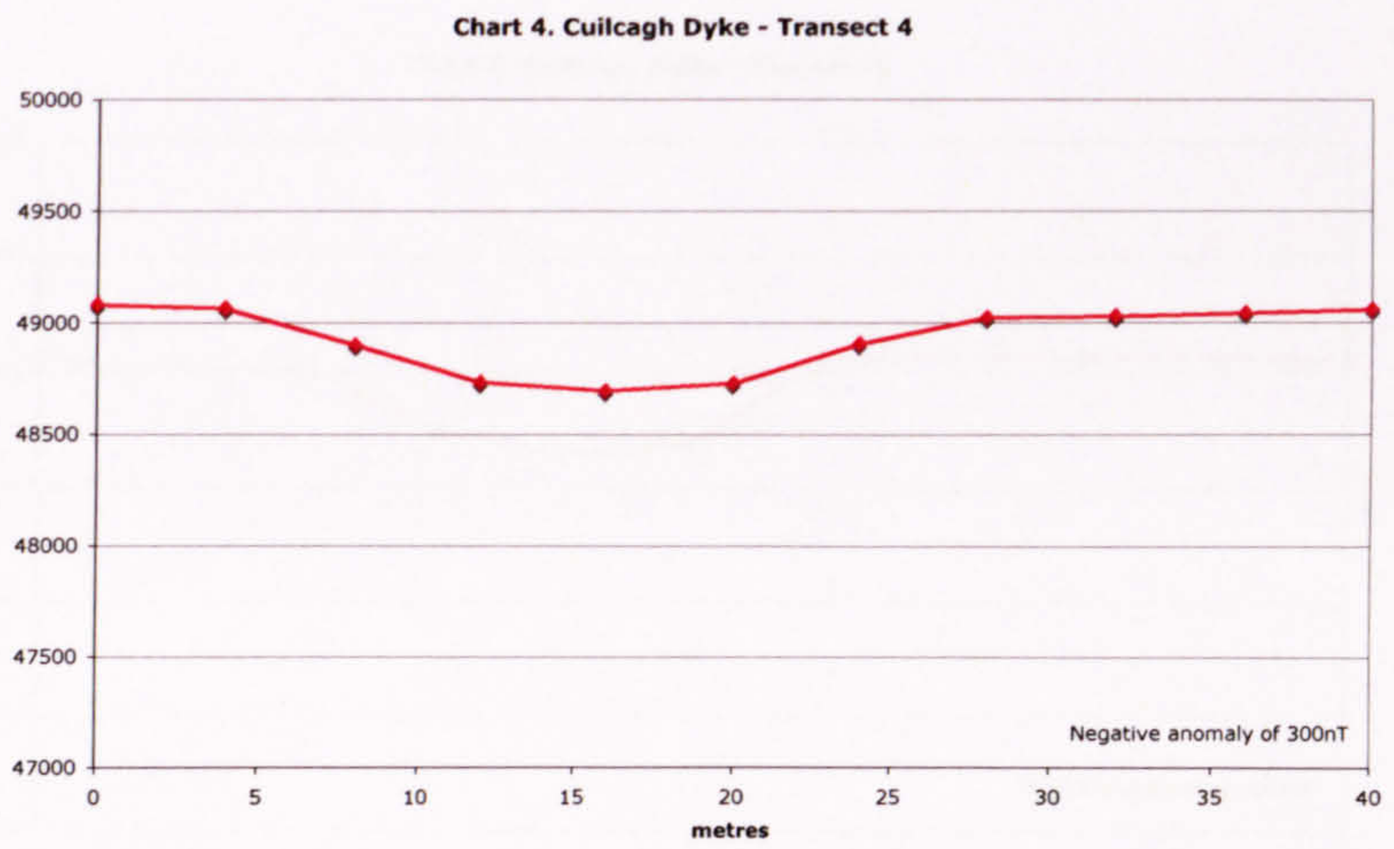



Figure 25. Geophysical sections traversing the Cuilcagh Dyke (Sections 1 to 4) (see Figure 24 for plotted trace and Table 7 for data).

**Chart 5. Cuilcagh Dyke - Transect 5**

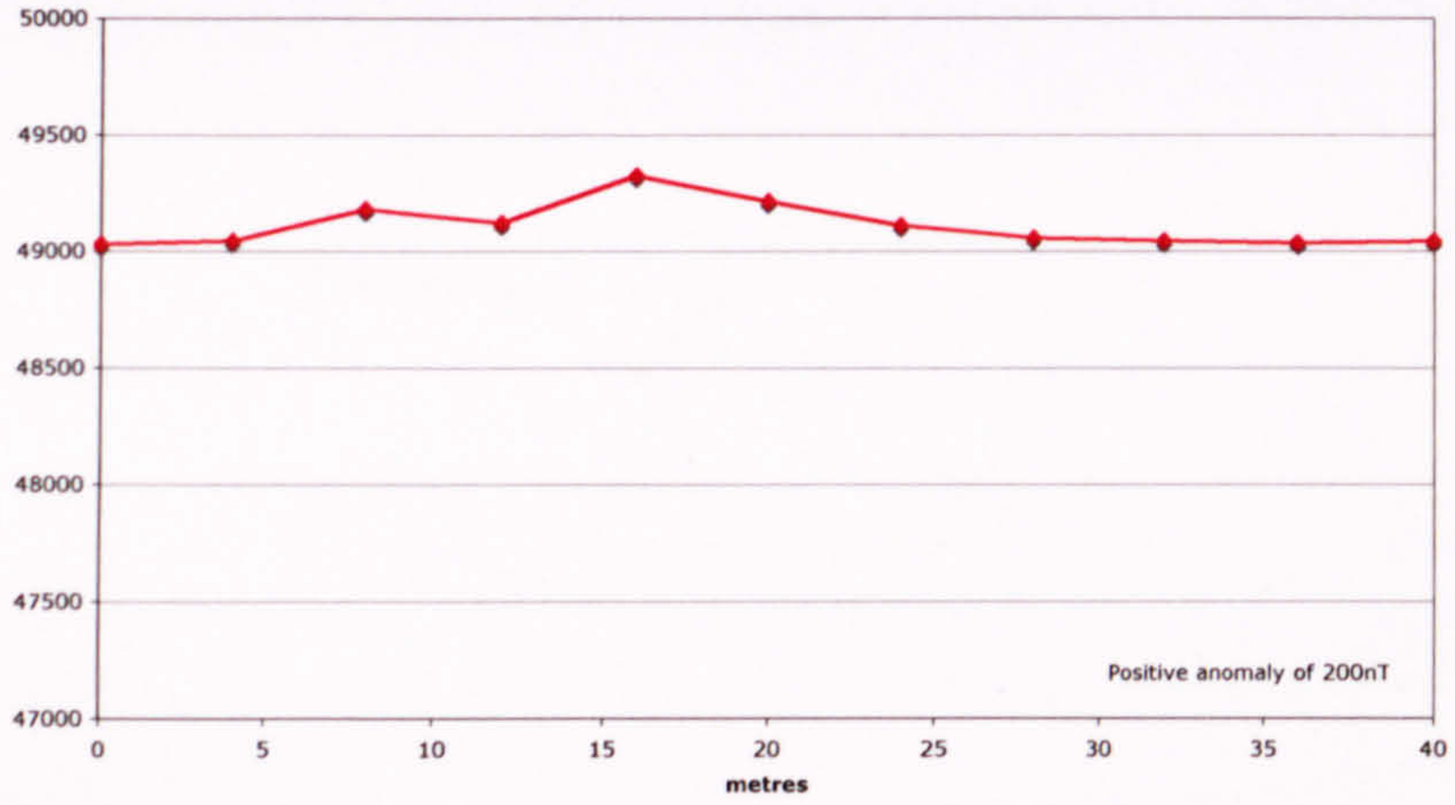



**Chart 6. Cuilcagh Dyke - Transect 6**

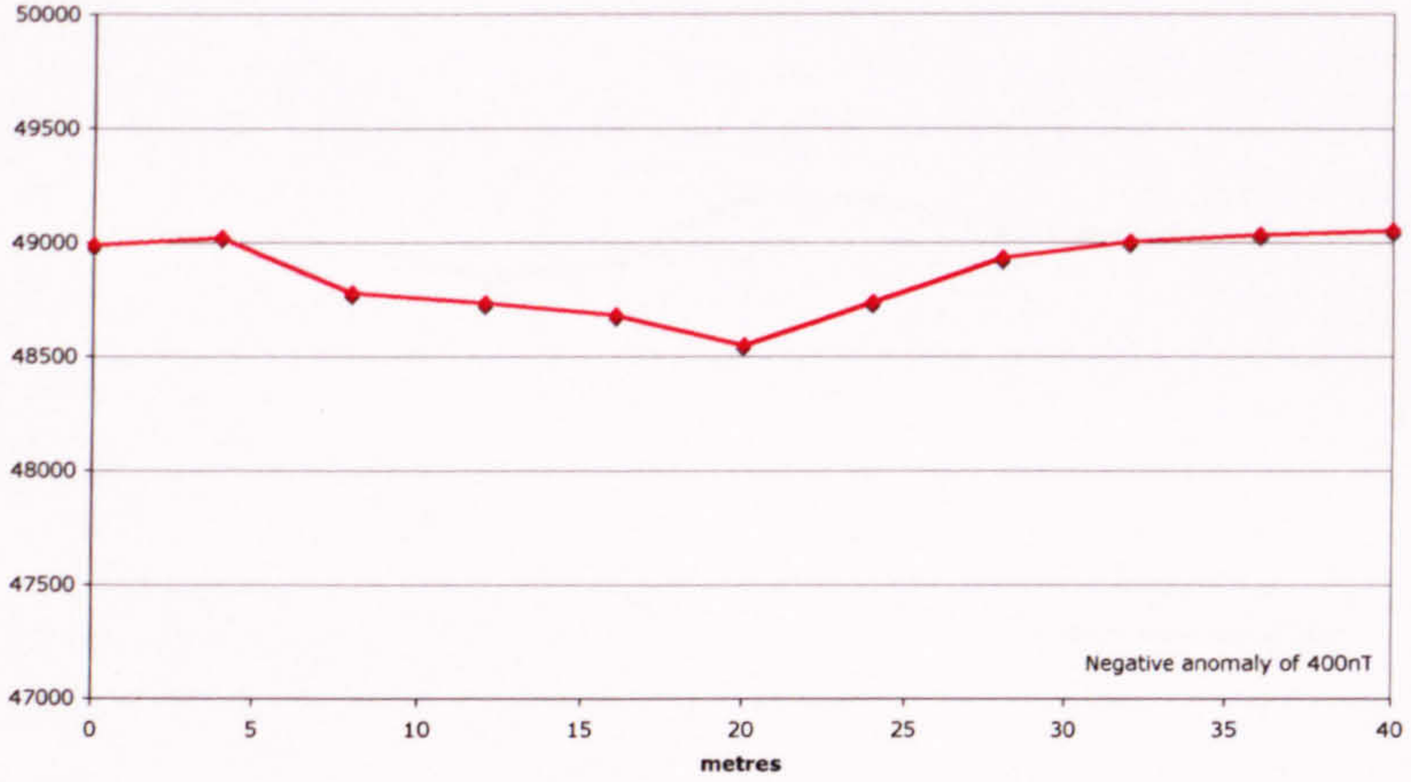



**Chart 7. Cuilcagh Dyke - Transect 7**

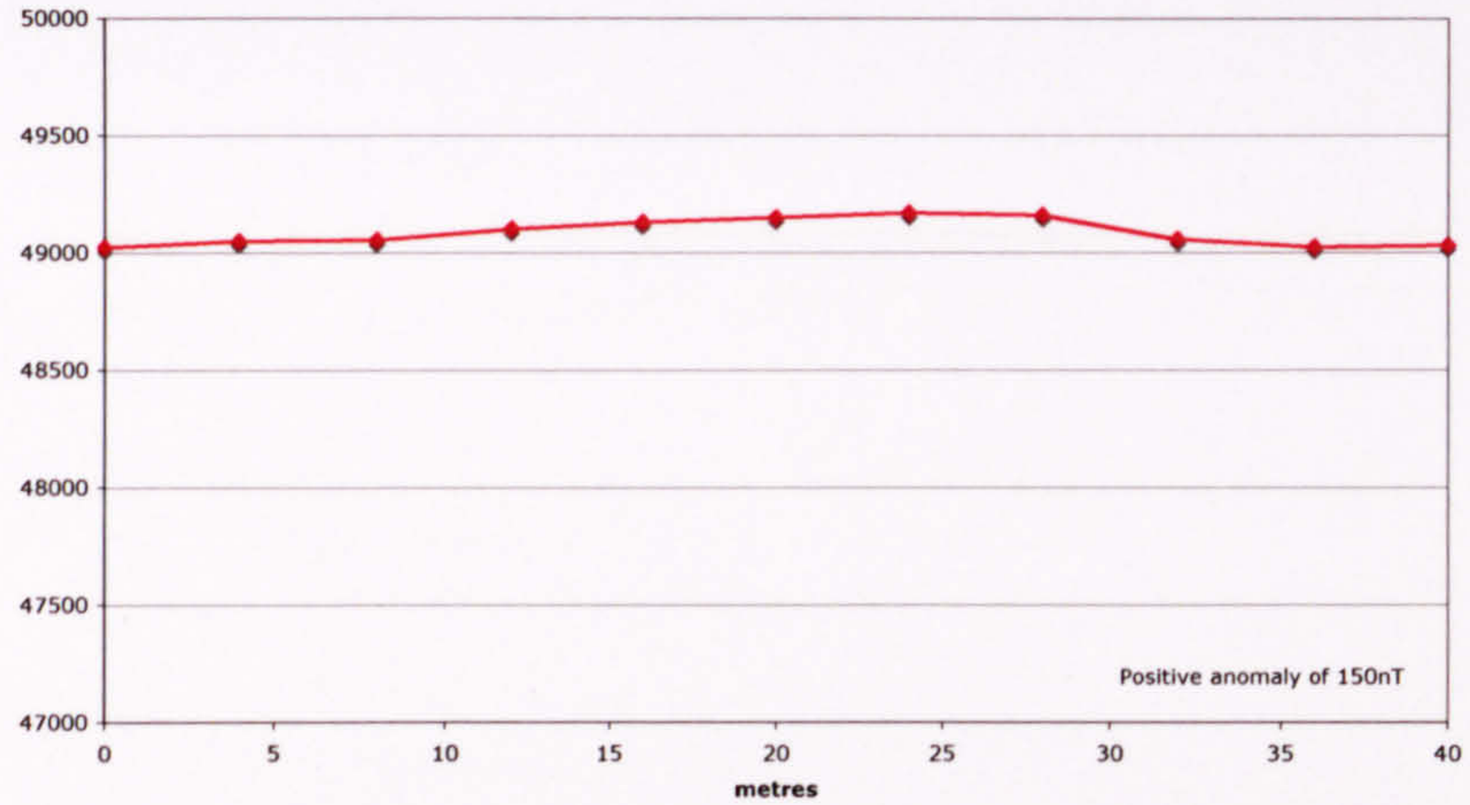



**Chart 8. Cuilcagh Dyke - Transect 8**

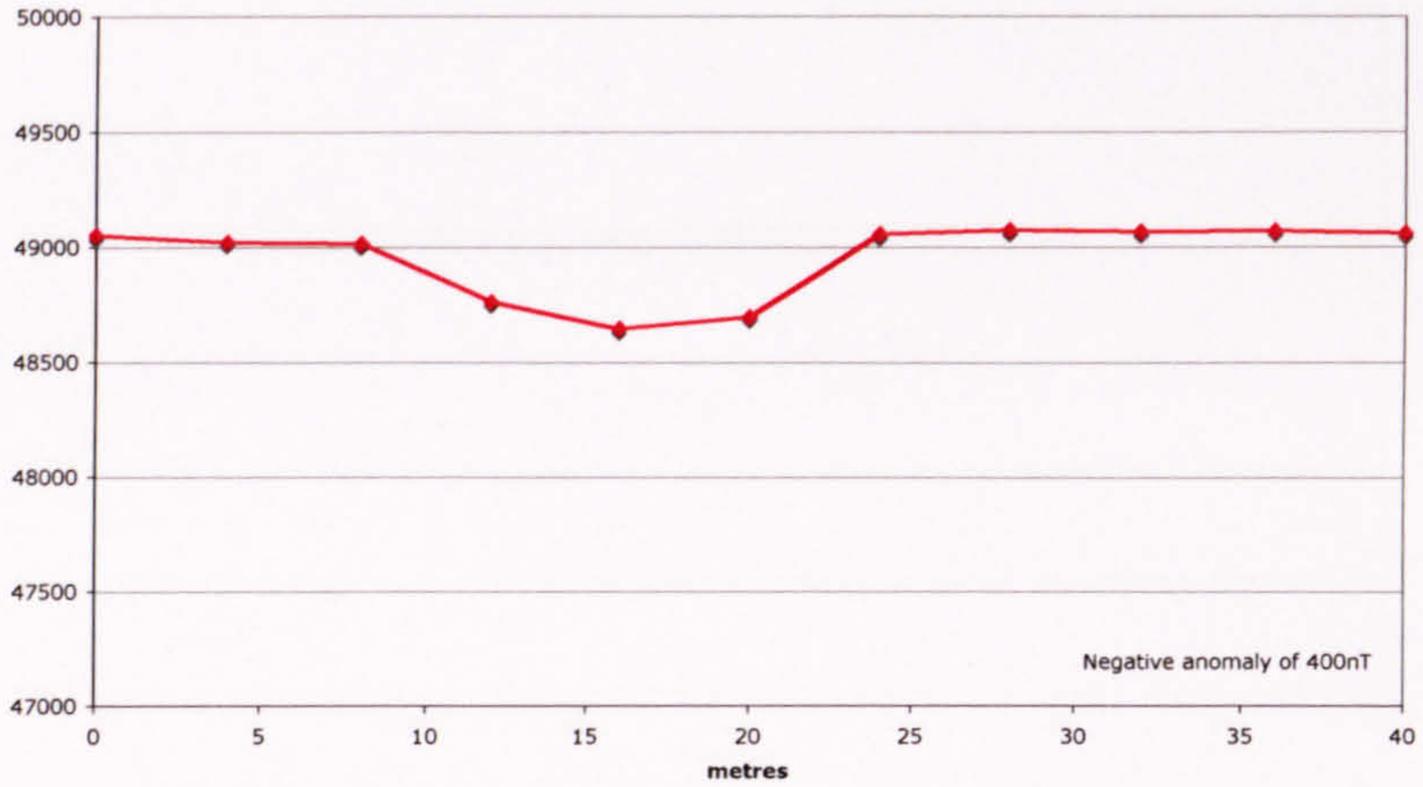



Figure 26. Geophysical sections traversing the Cuilcagh Dyke (Sections 5 to 8) (see Figure 24 for plotted trace and Table 7 for data).

**Chart 9. Cuilcagh Dyke - Transect 9**

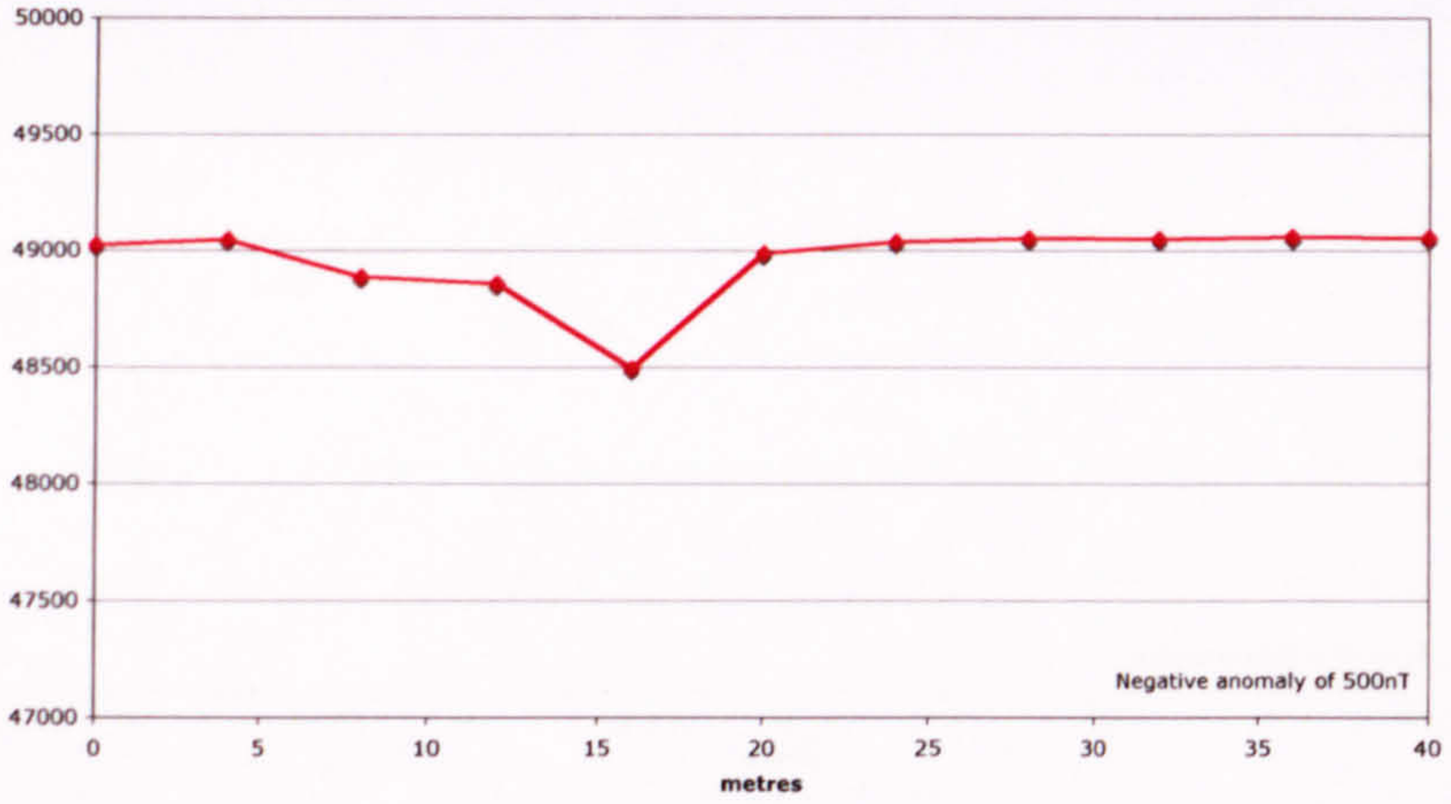



**Chart 10. Cuilcagh Dyke - Transect 10**

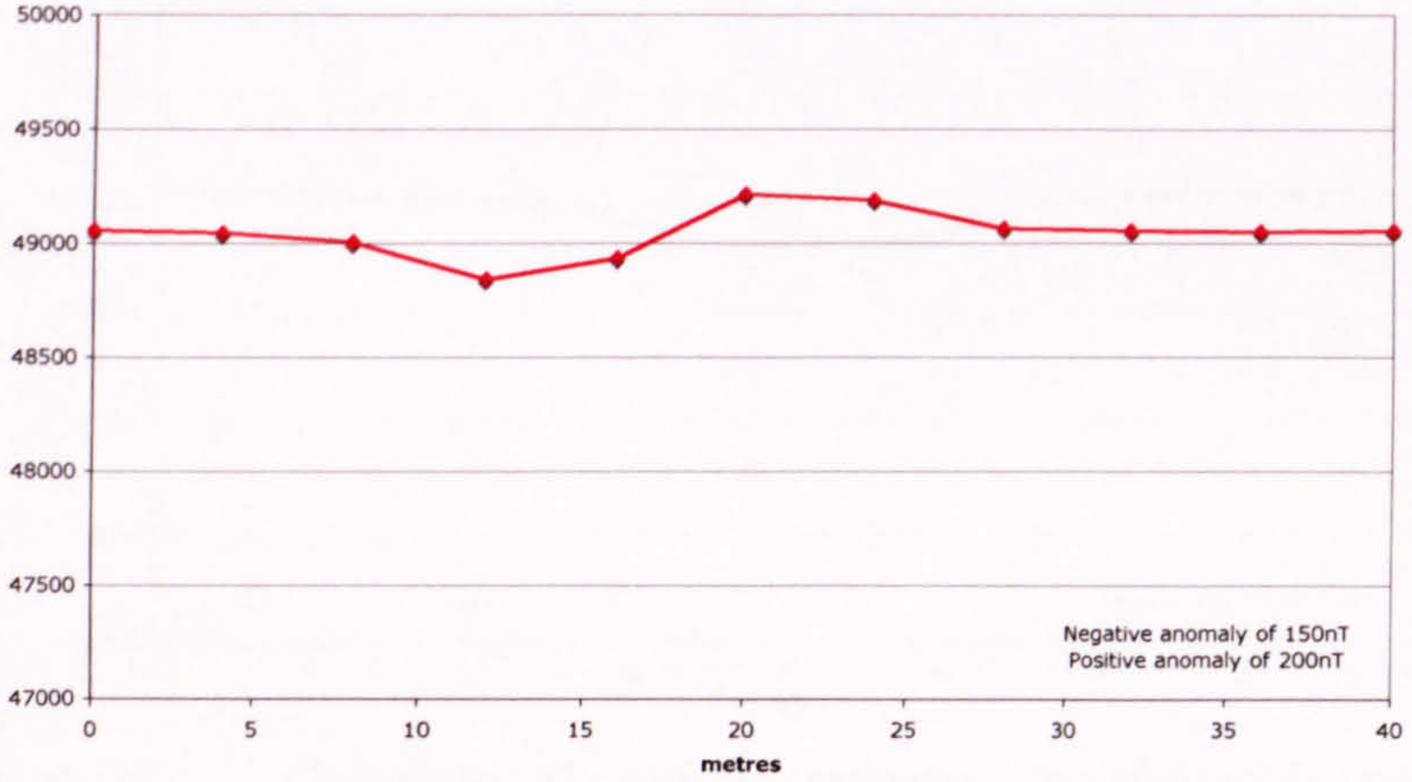



**Chart 11. Cuilcagh Dyke - Transect 11**

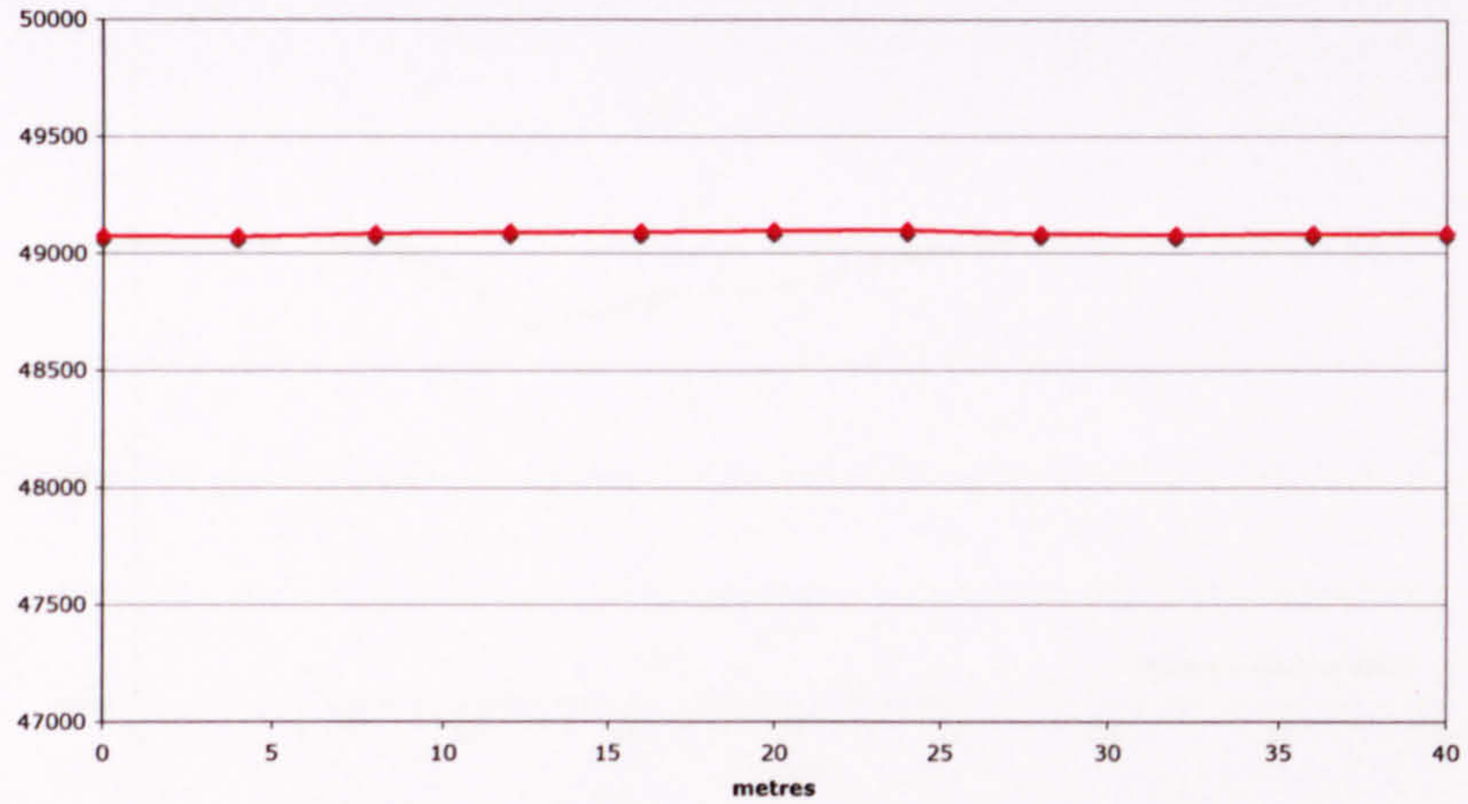



**Chart 12. Cuilcagh Dyke - Transect 12**

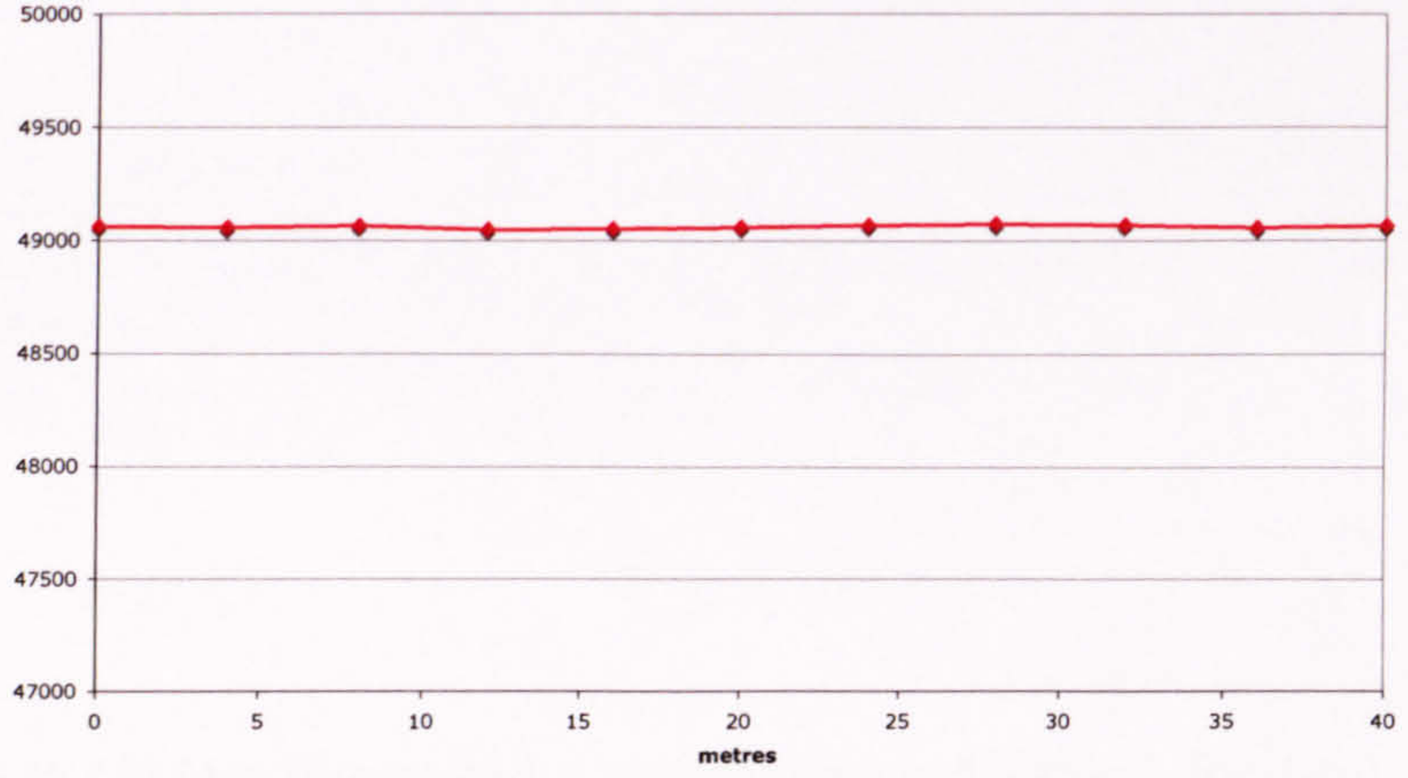



Figure 27. Geophysical sections traversing the Cuilcagh Dyke (Sections 9 to 12) (see Figure 24 for plotted trace and Table 7 for data.

**Chart 13. Cuilcagh Dyke - Transect 13**

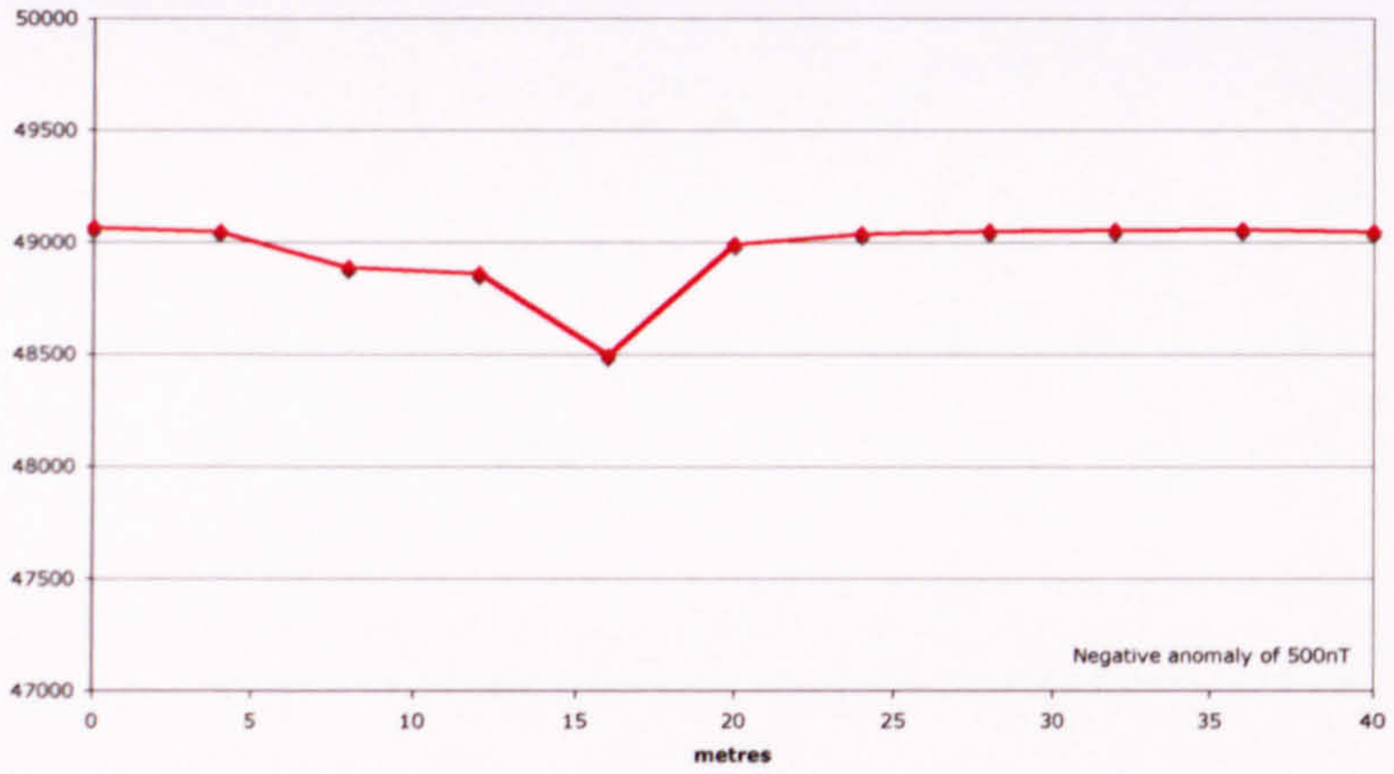



**Chart 14. Cuilcagh Dyke - Transect 14**

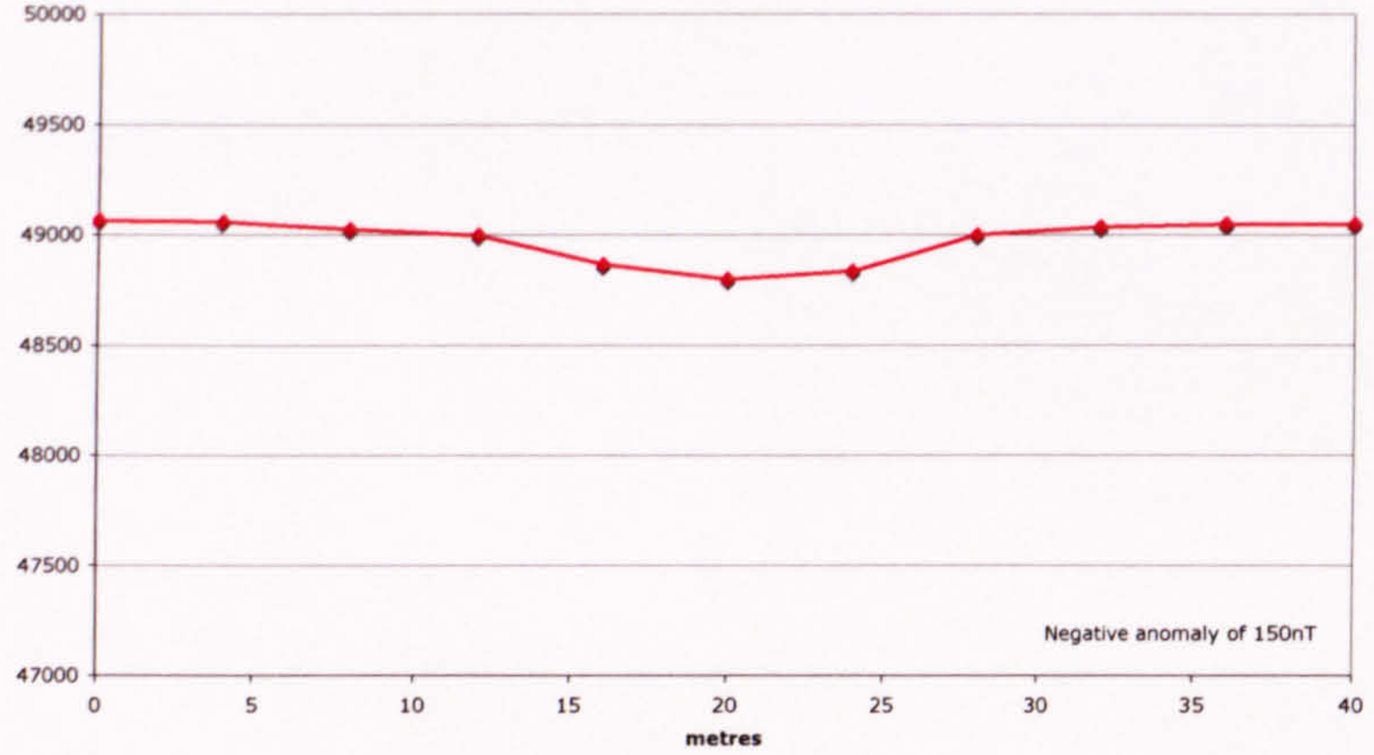



**Chart 15. Cuilcagh Dyke - Transect 15**

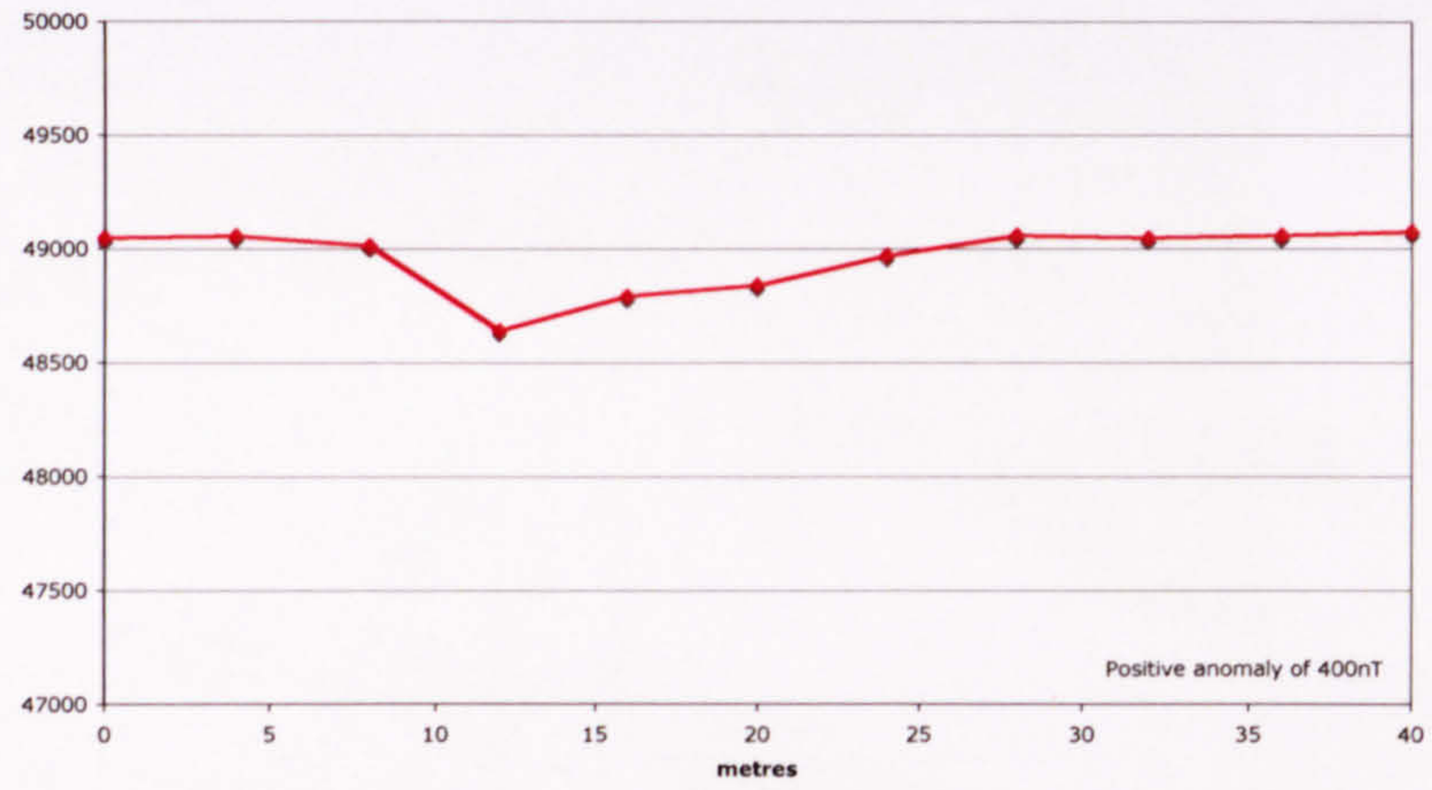



Figure 28. Geophysical sections traversing the Cuilcagh Dyke (Sections 13 to 15) (see Figure 24 for plotted trace and Table 7 for data).

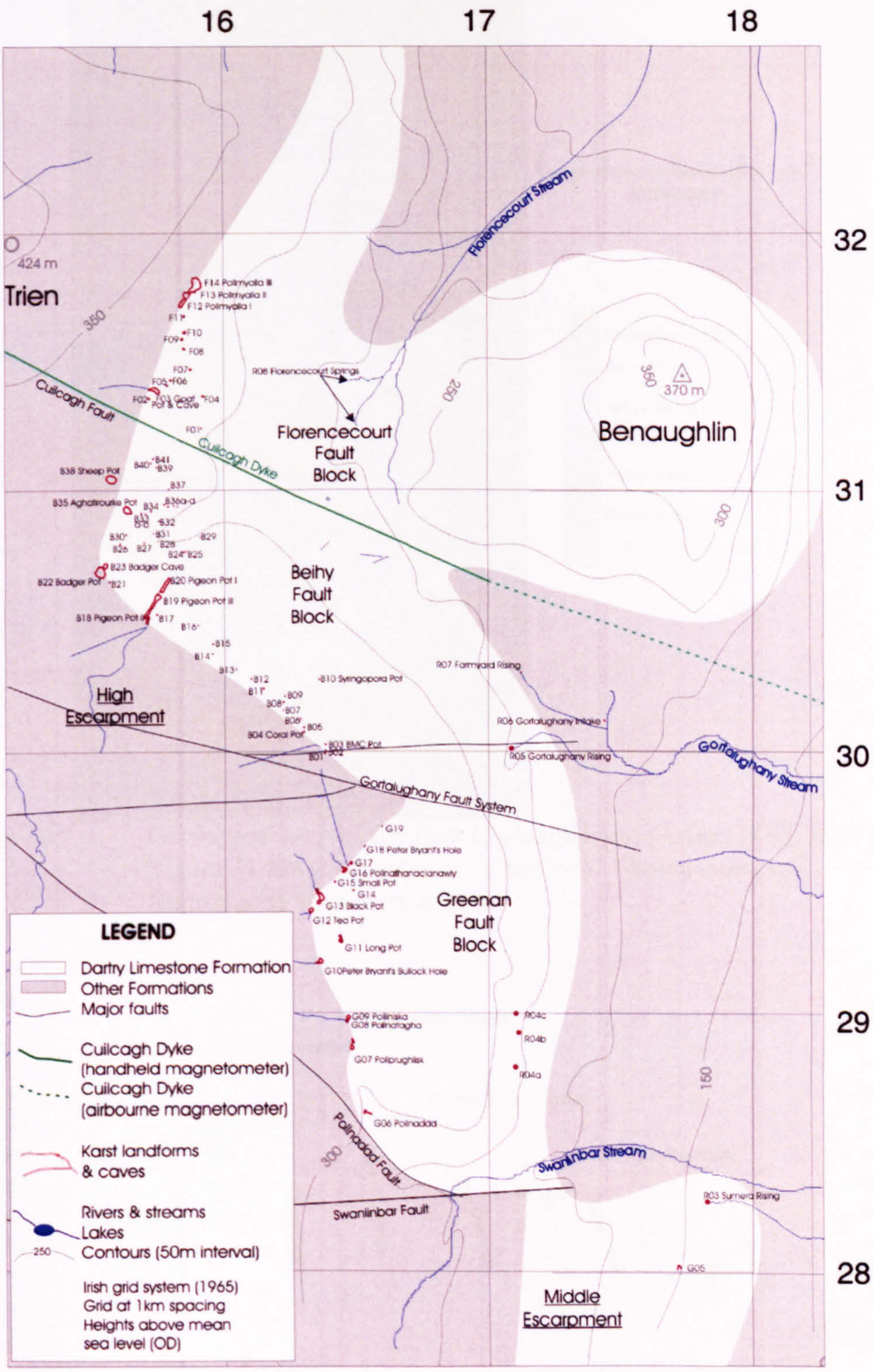



Figure 29. The distribution of karst landforms and caves in the East Cuilcagh Karst.

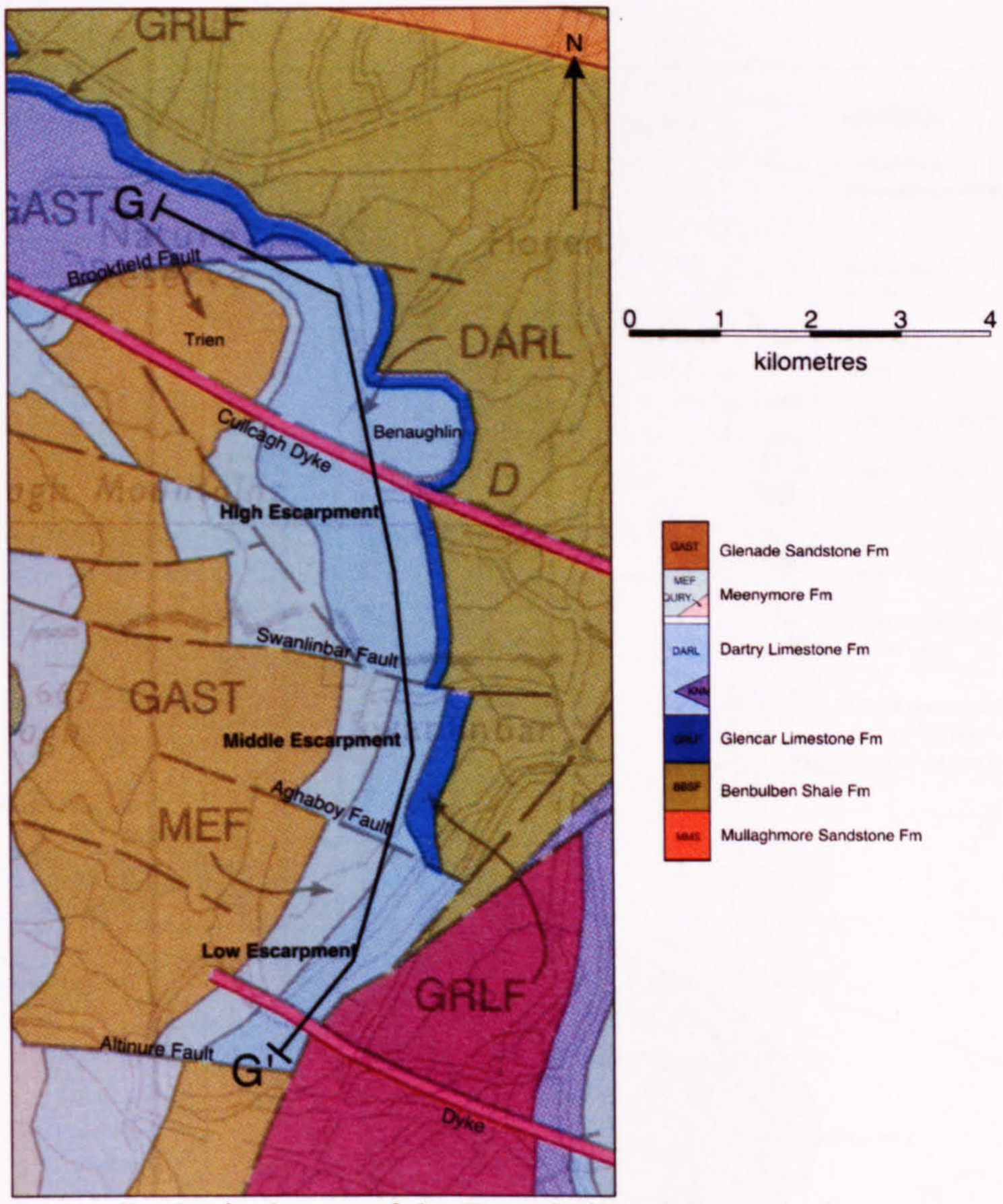



Figure 30. Geological map of the East Cuilcagh karst (After GSNI, 1997) (See Figure 31 for schematic cross-section). Crown copyright. Reproduced with permission.

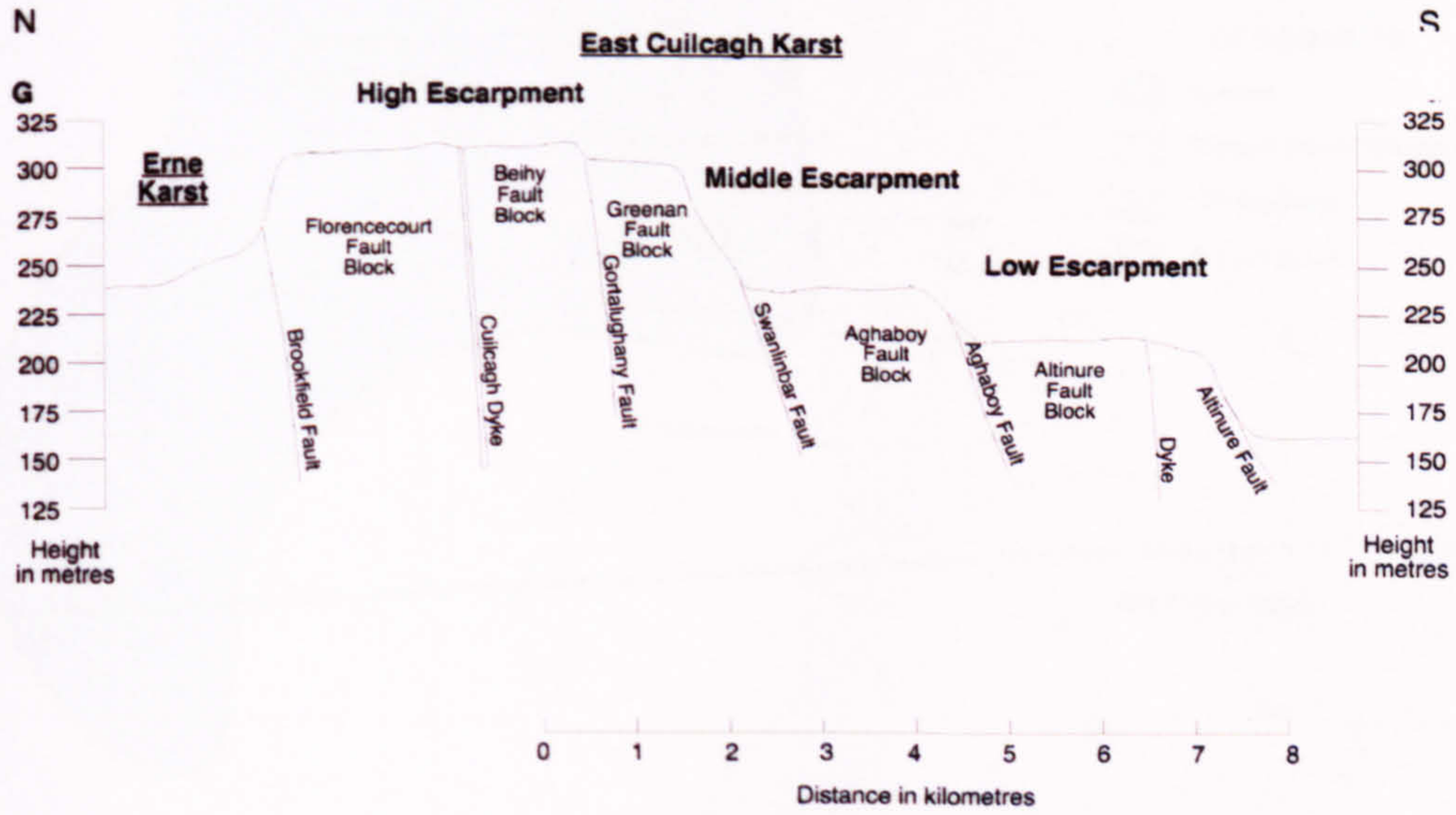



Figure 31. Schematic cross-section showing the fault block topography of the East Cuilcagh Escarpment (see Figure 30 for section plan).

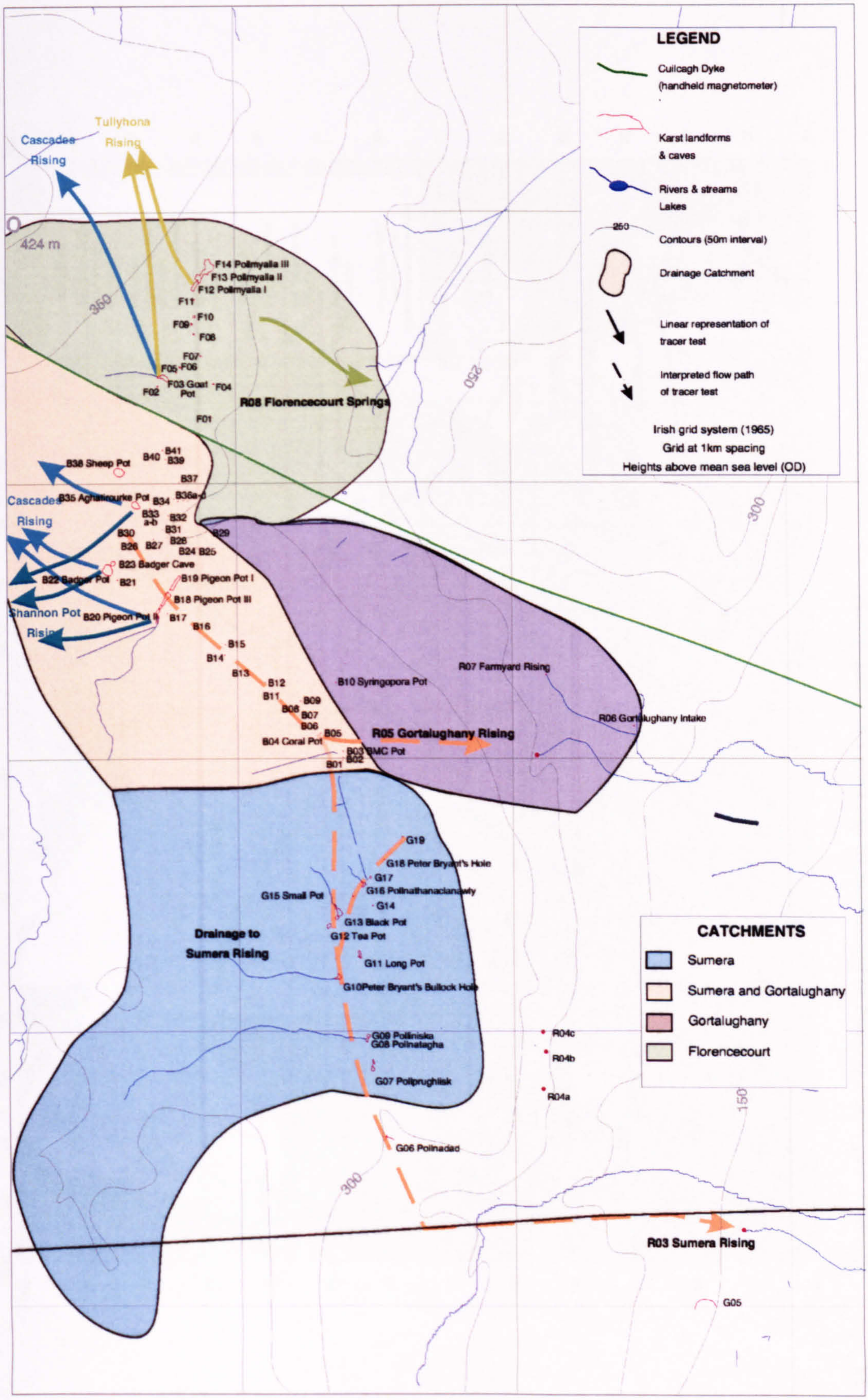



Figure 32. Summary of catchments to risings in the East Cuilcagh Karst.

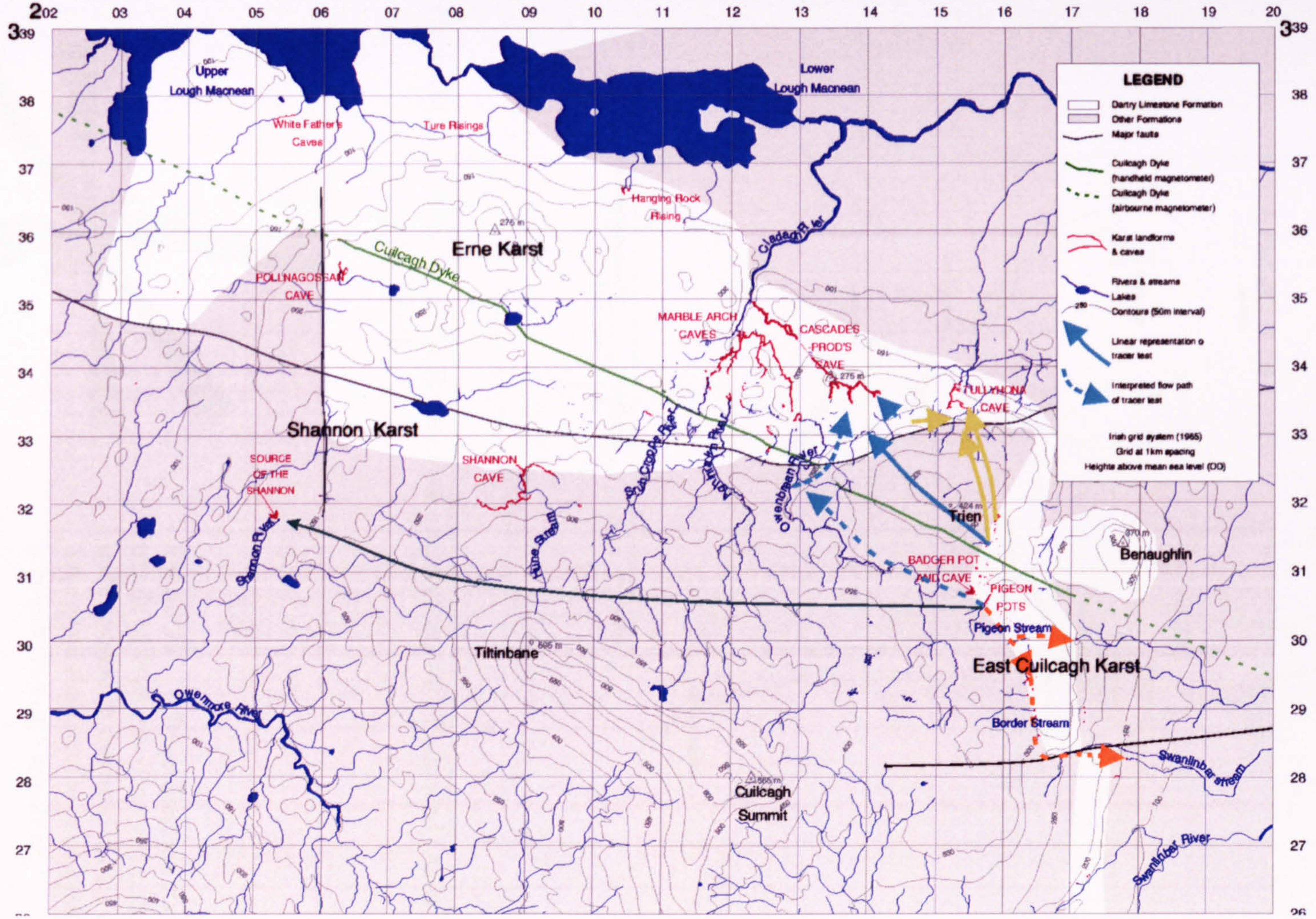



Figure 33. Summary of water tracing experiments in the East Cuilcagh Karst.

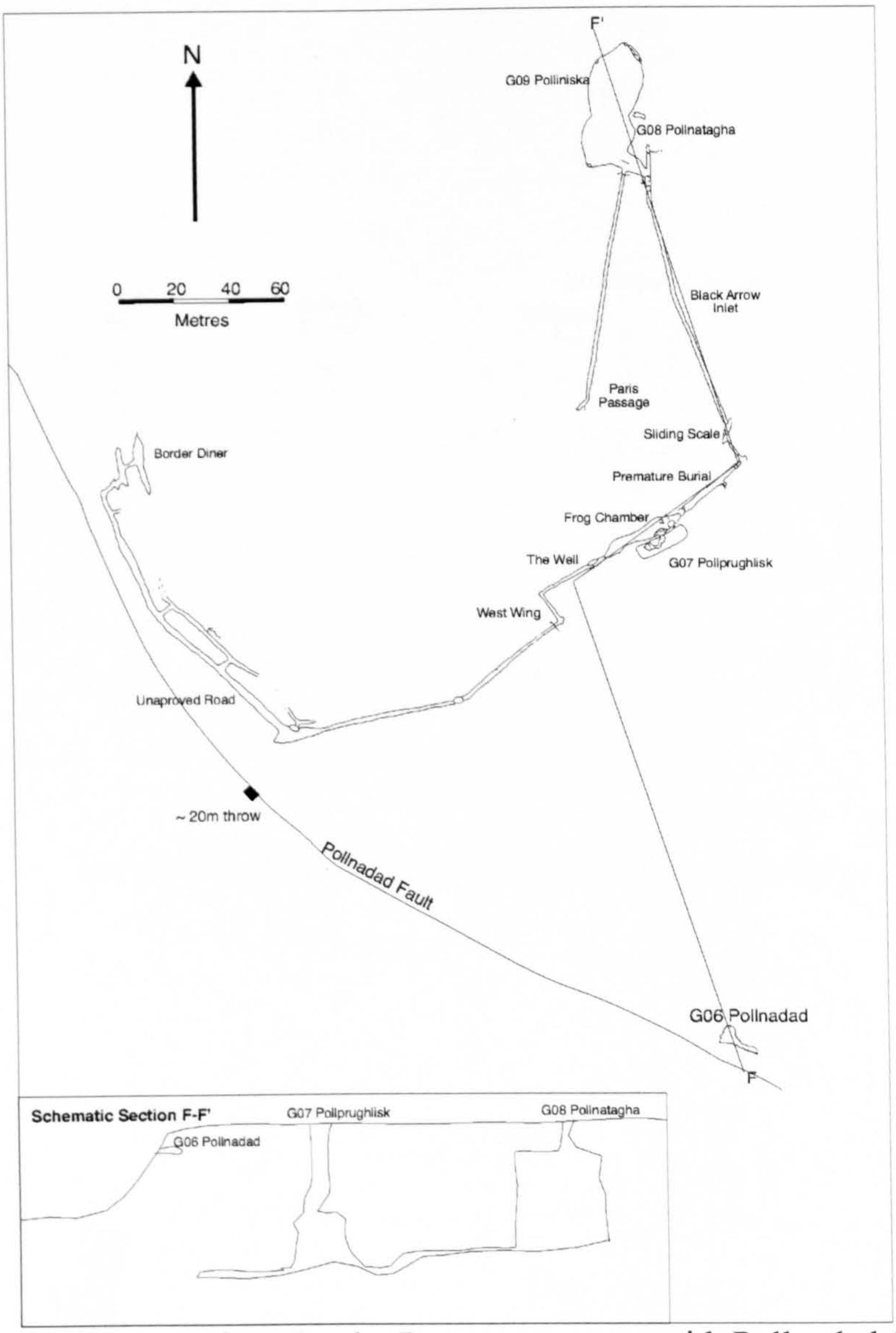



Figure 34. Survey of the Border Pots cave system with Pollnadad (After Jones *et al.*, 1997).

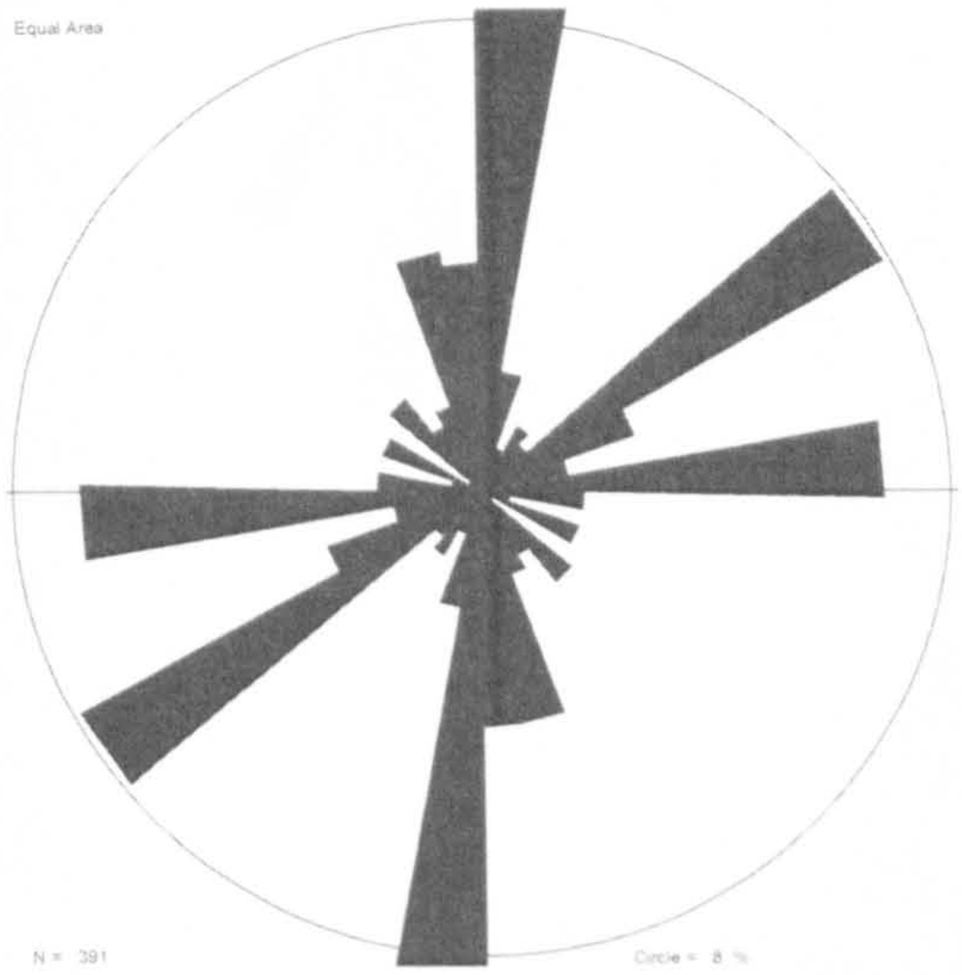



Figure 35. Rose diagram showing trends of fractures observed both underground in the Border Pots and over ground above the cave system (compiled using Stereonet).

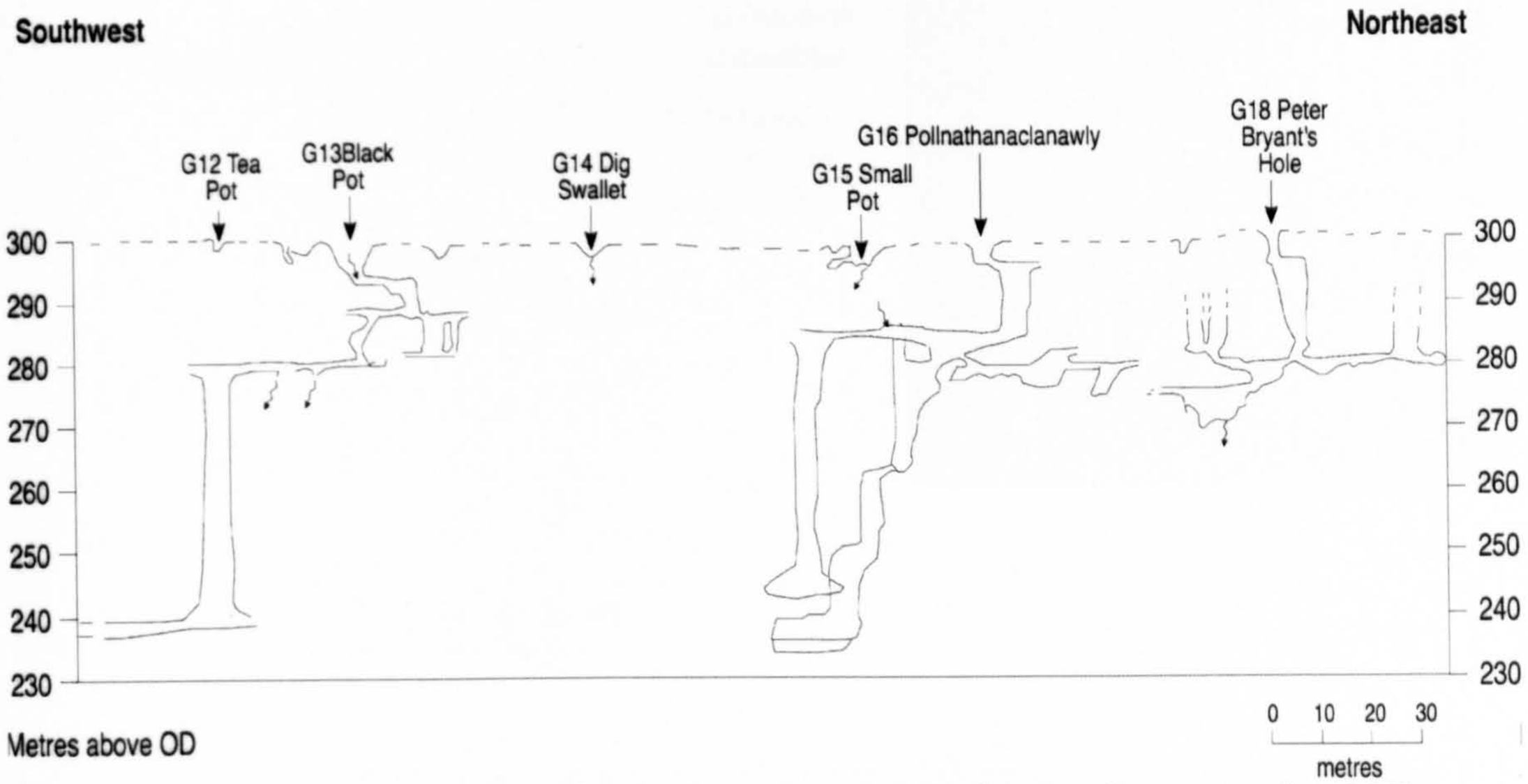



Figure 36. Survey of caves in the Peter Bryant's Hole area (Jones *et al.*, 1997).

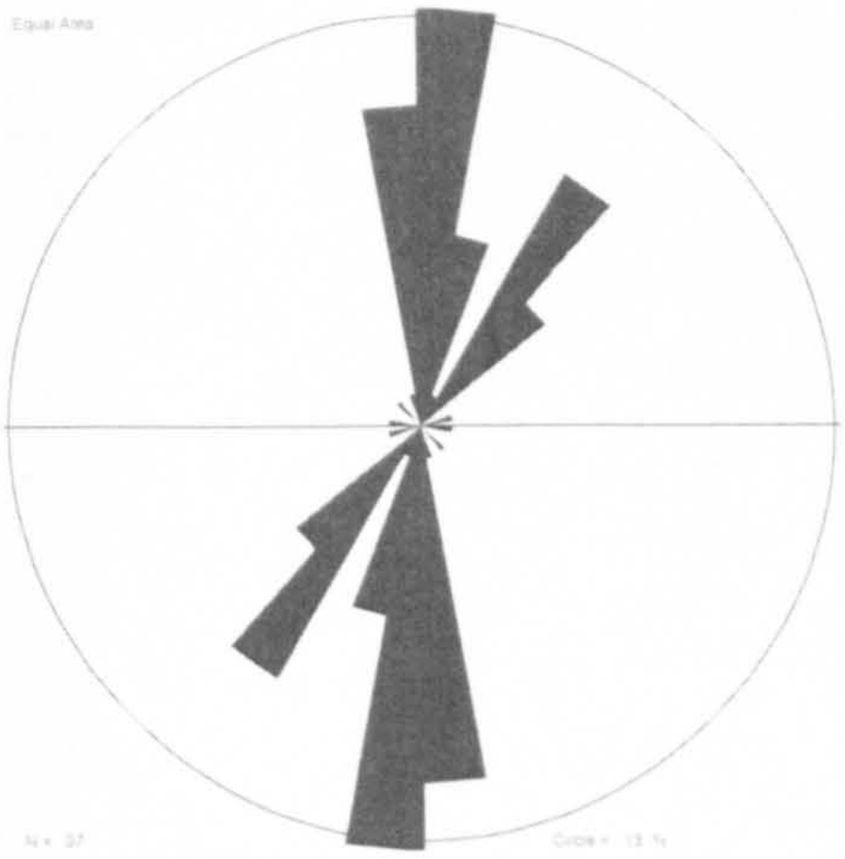



Figure 37. Rose diagram showing trends of fractures observed both underground in the caves in the area of Peter Bryant's Bullock Hole and over ground above the cave system (compiled using Stereonet).

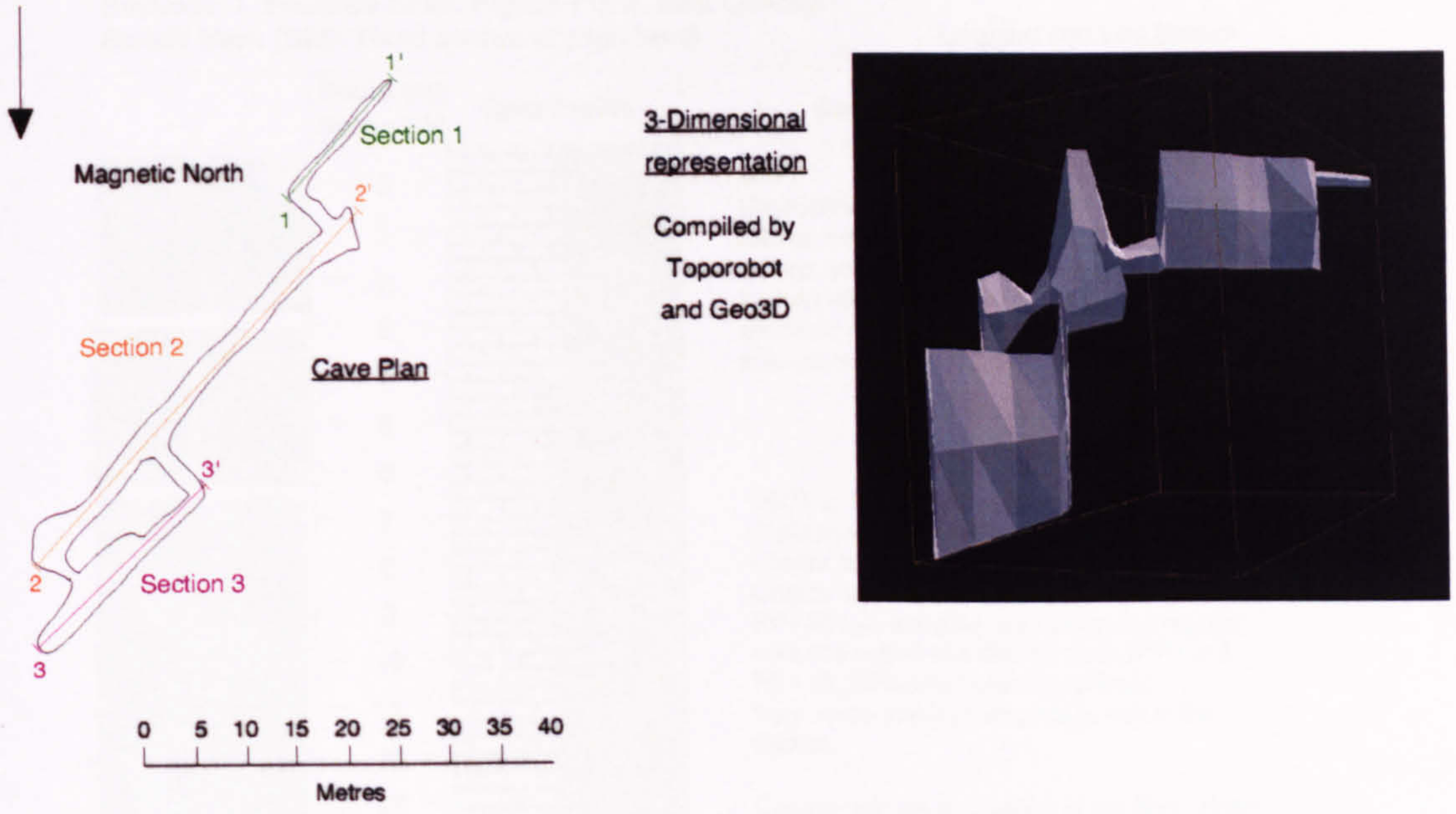



Figure 38. Plan section and generated 3D image of Pigeon Pot II compiled by the author (See Figure 39 for section view, which includes high level passages discovered off Section 3).

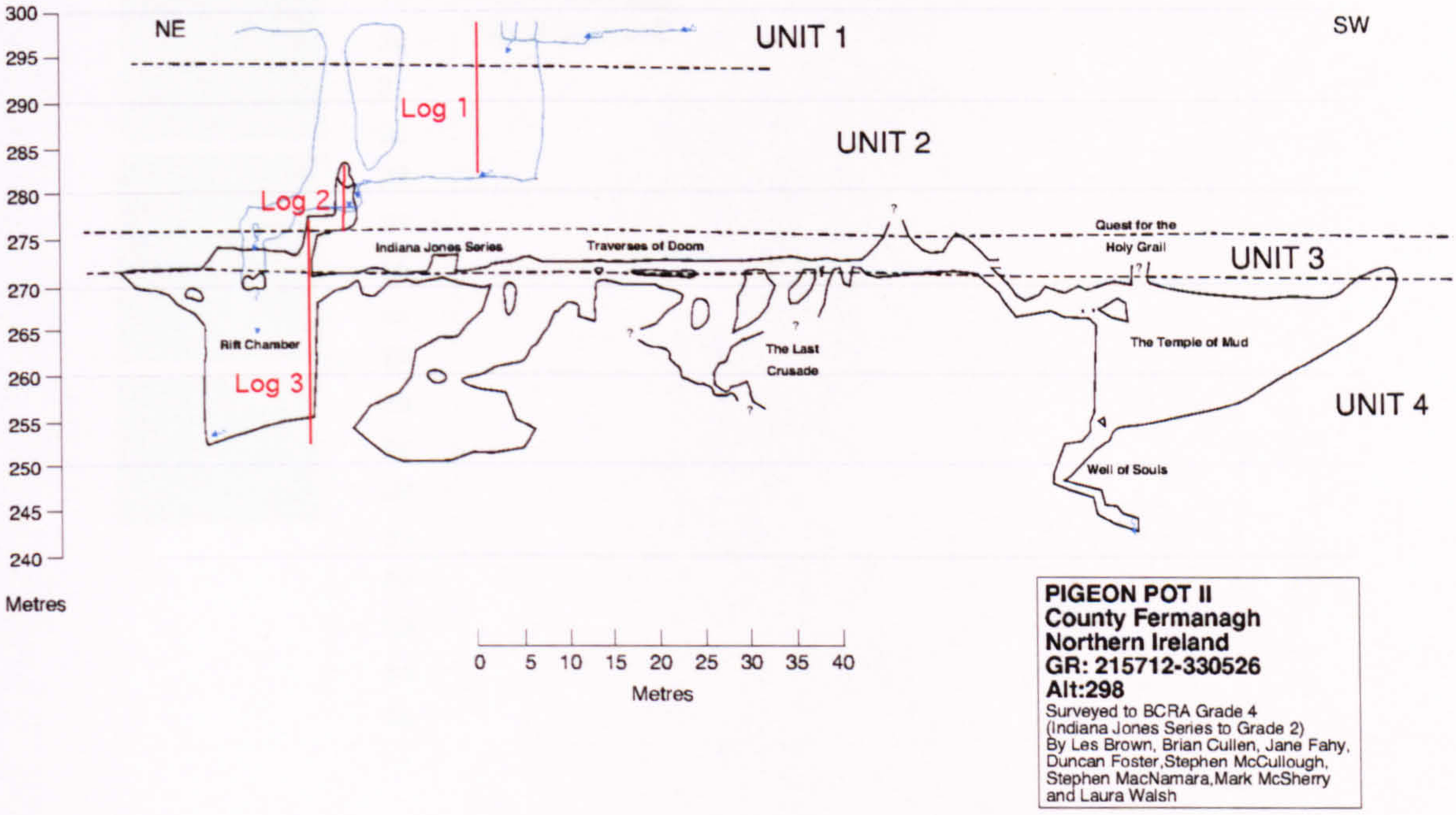



Figure 39. Section of Pigeon Pot II with geology annotated from geological logs 1, 2 and 3 (Figures 40, 41 and 42).

**Section:** 1. Entrance Shaft, Pigeon Pot II, East Cullcagh.
**Bench Mark (BM):** Fixed anchor at pitch head **Logged by**: Les Brown

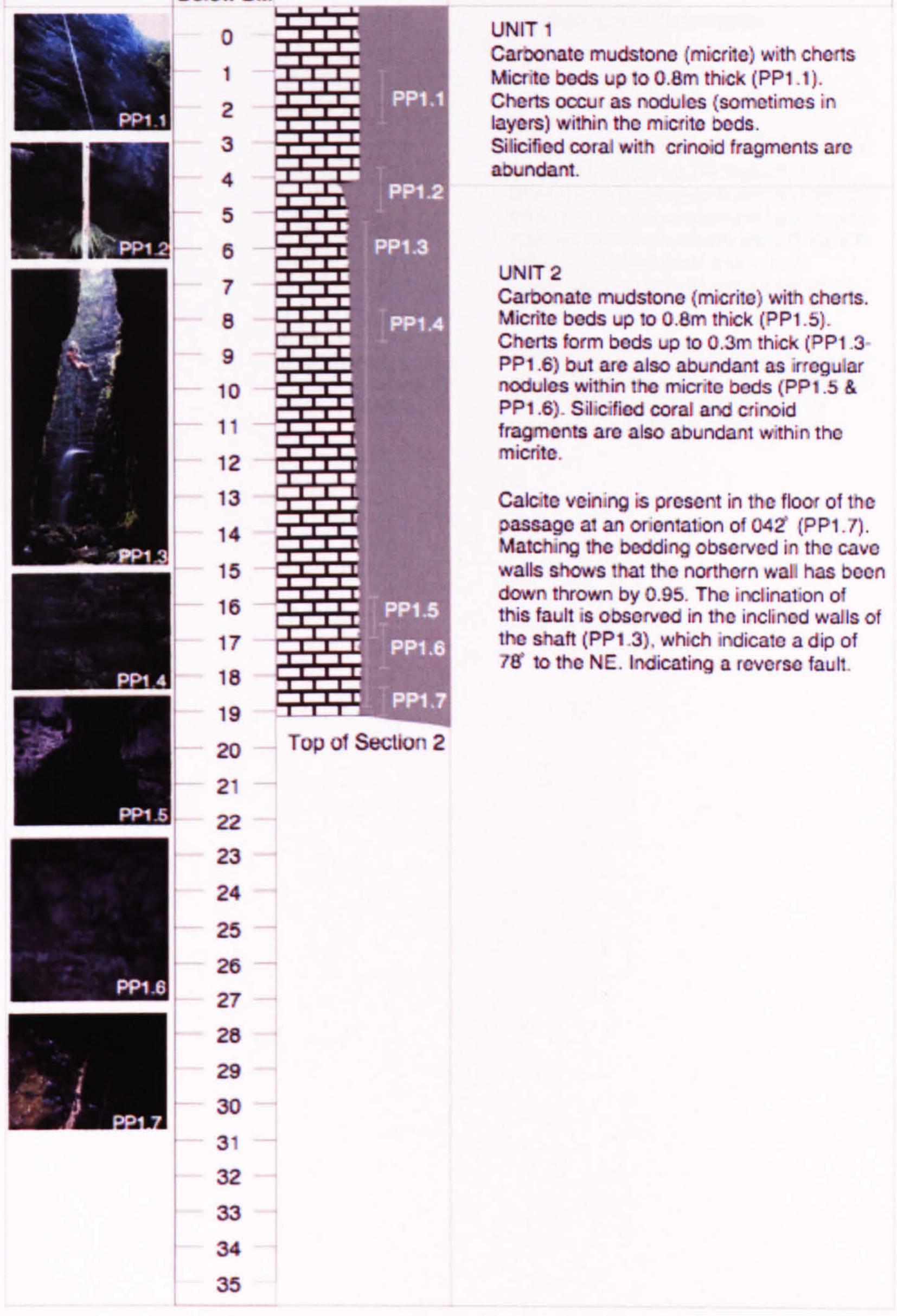
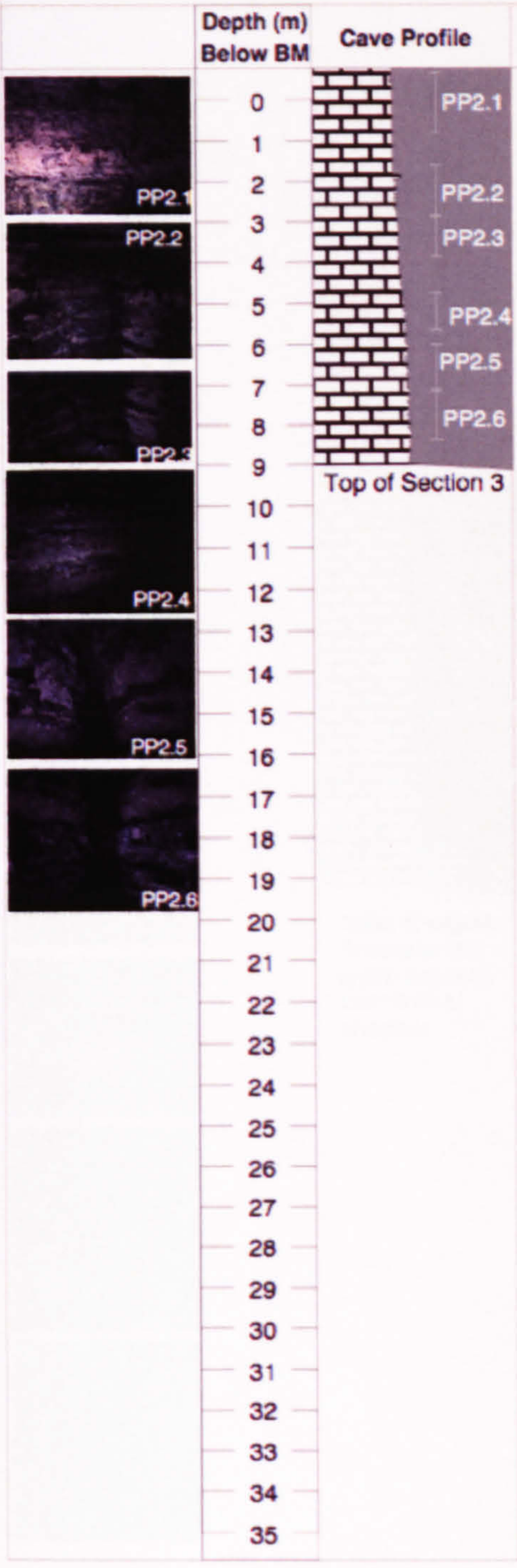



Figure 40. Geological log 1 of Pigeon Pot II entrance shaft (see Figures 38 and 39 for cave plan and section).

**Section:** 2. Entrance Rift to top of Lower Rift Chamber, Pigeon Pot II, East Cuilcagh.
**Bench Mark (BM):** Fixed anchor at pitch head **Logged by**: Les Brown




**Geological Description**

UNIT 2
Carbonate mudstone (micrite) with chert. Micrite beds up to 0.7m thick (PP2.1). Cherts form beds up to 0.4m thick (PP2.2-PP2.6) but are also abundant as irregular nodules within the micrite beds (PP2.2 & PP2.3). Silicified coral and crinoid fragments (are also abundant within the micrite.

Dissolution of the micrite leave the cherts prominent in the cave walls. Occasionally chert remains as a bridge straddling between the passage walls (PP2.3).

Figure 41. Geological log 2 of Pigeon Pot II entrance shaft (see Figures 38 and 39 for cave plan and section).

**Section:** 3. Lower Rift Chamber, Pigeon Pot II, East Cuilcagh.
**Bench Mark (BM):** Fixed anchor at pitch head **Logged by**: Les Brown

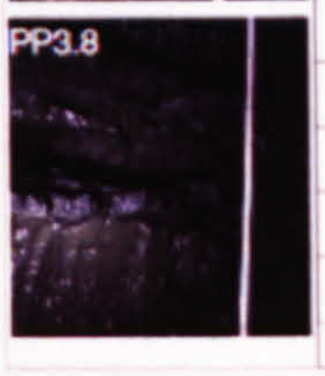
| | Depth (m) Below BM | Cave Profile | Geological Description |
|---|---|---|---|
|                 | 0<br>1<br>2<br>3<br>4<br>5<br>6<br>7<br>8<br>9<br>10<br>11<br>12<br>13<br>14<br>15<br>16<br>17<br>18<br>19<br>20<br>21<br>22<br>23<br>24<br>25<br>26<br>27<br>28<br>29<br>30<br>31<br>32<br>33<br>34<br>35 | PP3.1<br>PP3.2<br>PP3.3<br>PP3.4<br>PP3.5<br>PP3.6<br>PP3.7<br>PP3.8<br>Mass of angular limestone and chert boulders form floor of chamber | UNIT 3<br>Carbonate mudstone (micrite) with chert. Micrite beds up to 0.9m thick. Cherts form beds up to 0.4m thick but are also abundant as irregular nodules within the micrite beds (PP3.1). Silicified coral and crinoid fragments are also abundant within the micrite.<br><br>UNIT 4<br>Packstone with interbedded shale and chert. Micrite beds up to 0.5m thick (PP3.2). Cherts form thin beds up to 0.2m thick but are also abundant as irregular nodules within the micrite beds. Upper contact between micrite is gradual. However, lower contact is sharp (PP3.3).<br><br>UNIT 5<br>Carbonate mudstone (micrite) with chert The micrite forms beds that are typically 0.3-0.5m thick. However, one bed at the top of this unit is up to 1.4m thick (PP3.3 & PP3.4). This thick micrite bed also has prominent solution runnels just below the contact (PP3.2). A thin shaley horizon overlies the micrite, which appears to be highly weathered forming as distinctive negative feature in the cave wall, which can be follwed laterally. A high level passage extends from this shaft both SW and NE along this horizon.<br><br>Although micrite dominates this sequence, the chert form up to 30%. Generally the chert form beds up to 0.3m thick. Some chert beds are tabular (PP3.5), whilst others are irregular and wavy. Silicified coral and crinoid fragments are common within the micrite beds. |

Figure 42. Geological log 3 of Pigeon Pot II entrance shaft (see Figures 38 and 39 for cave plan and section).

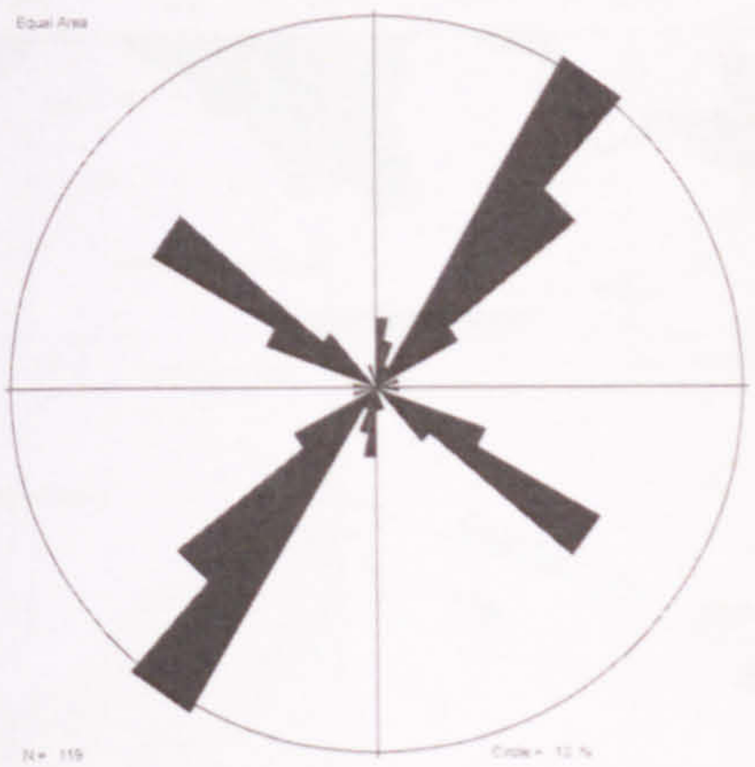



Figure 43. Rose diagram showing trends of fractures observed both underground in the Pigeon Pots and over ground above the cave system (compiled using Stereonet)

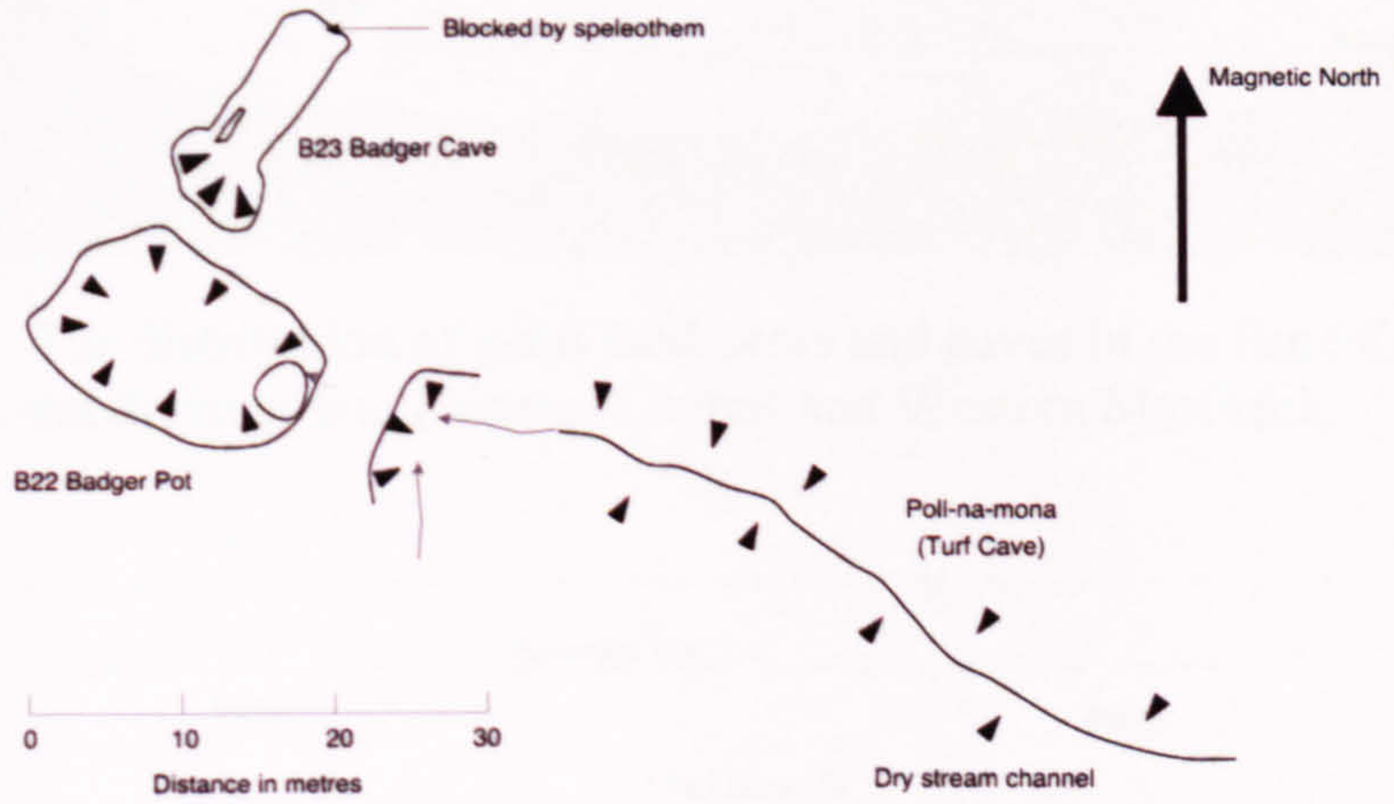



Figure 44. The location of Badger Cave and Badger Pot, with Poll-na-mona.

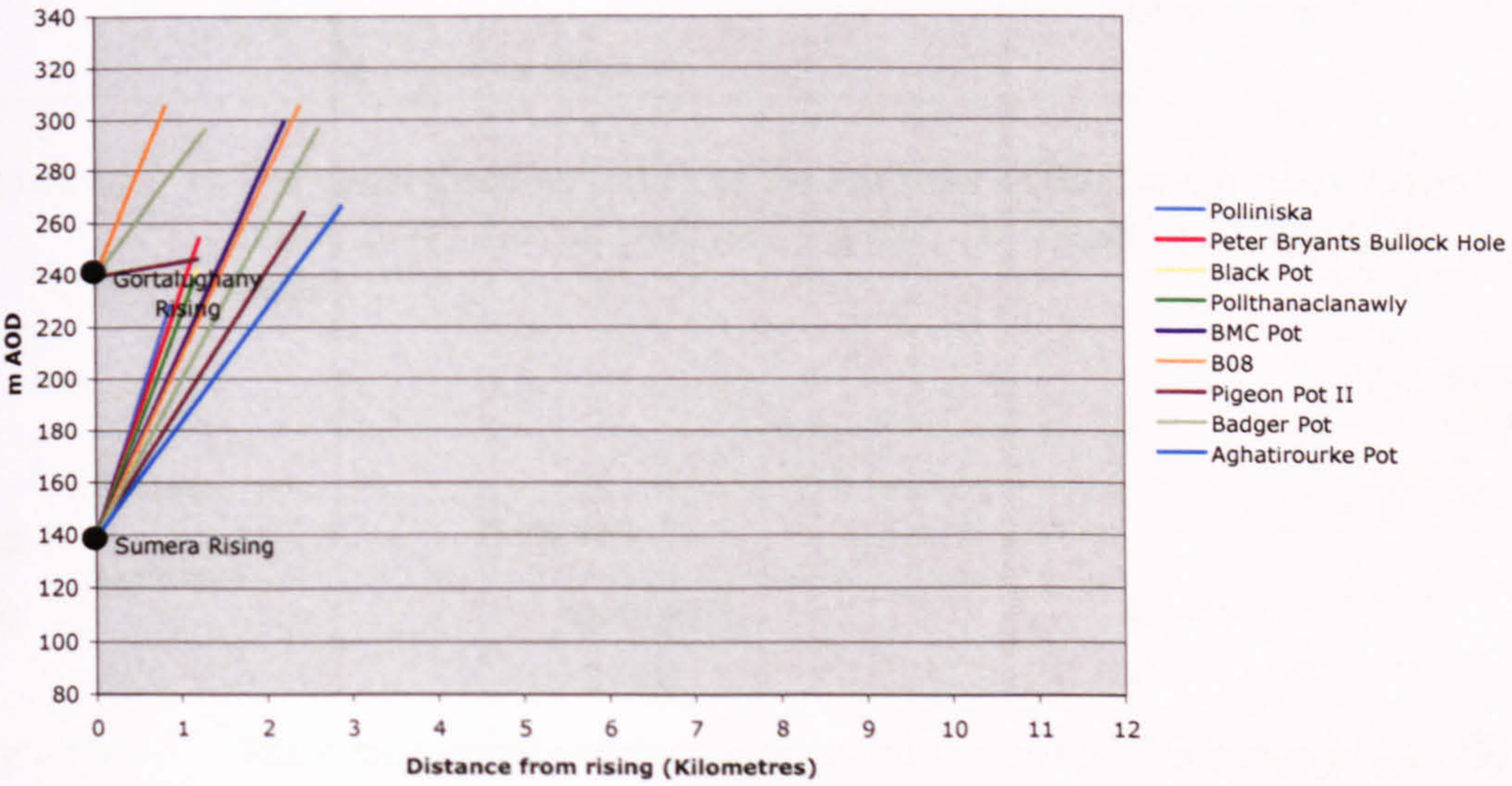



Figure 45. Linear gradients for sinks draining to Sumera Rising and Gortalughany Rising.

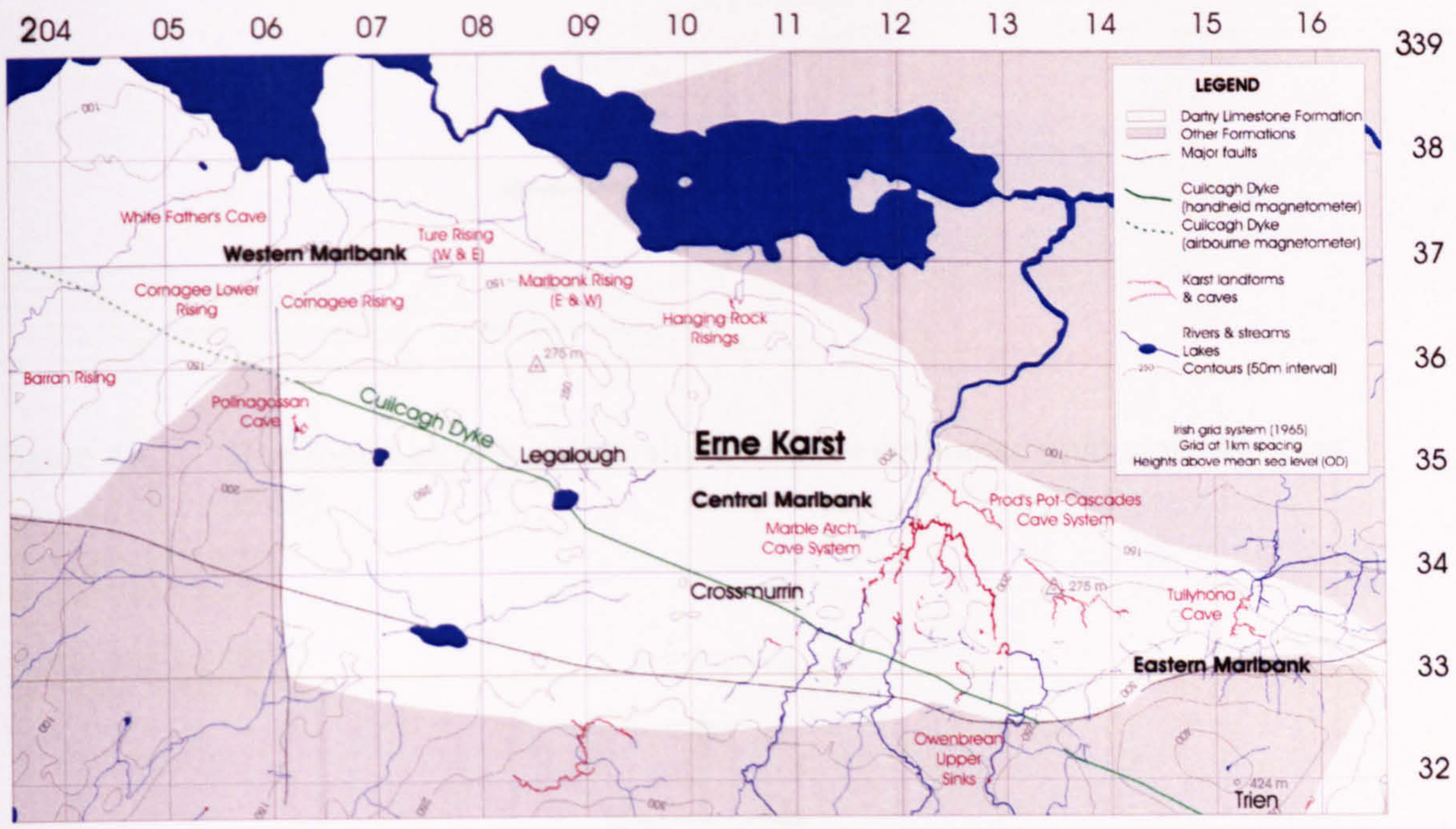



Figure 46. The distribution of karst landforms and caves in the Erne Karst, with subdivision into Eastern, Central and Western Marlbank.

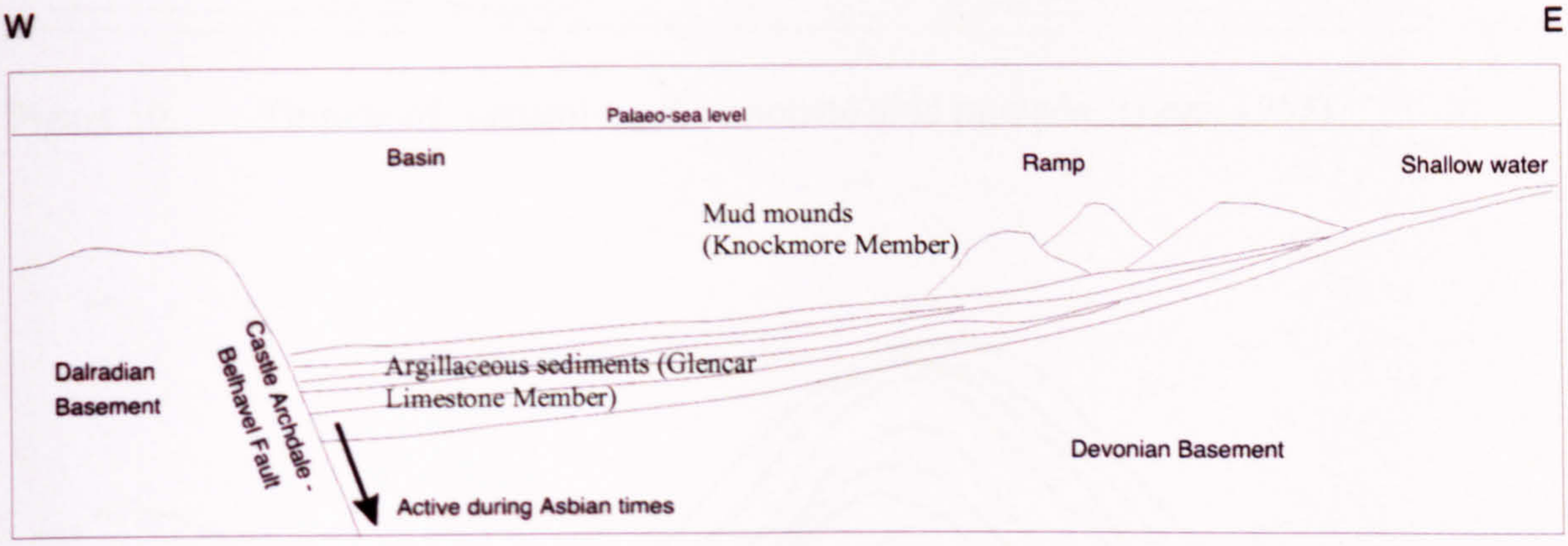



Figure 47. The generalised structure of the sea floor of the Lough Allen Basin during Early-Asbian time (see Figure 1 for extent of Lough Allen Basin).

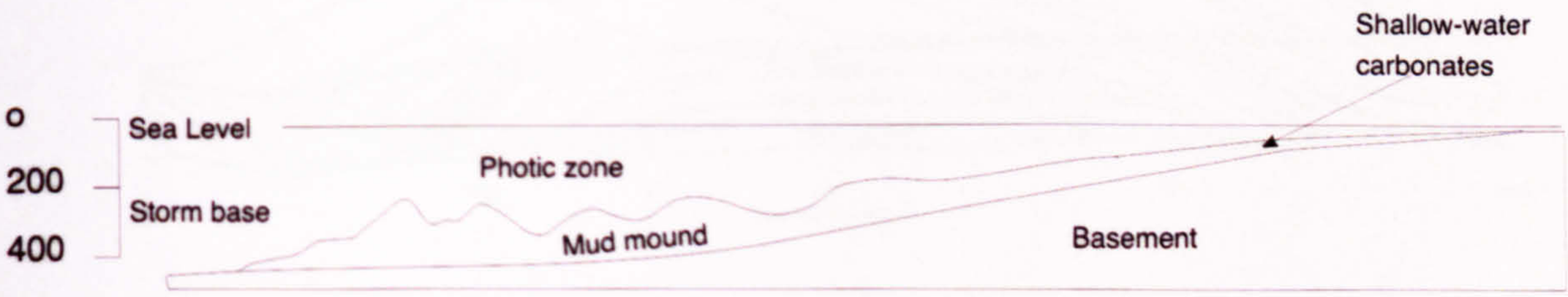



Figure 48. The depositional setting on the carbonate ramp (Bridges *et al.*, 1995).

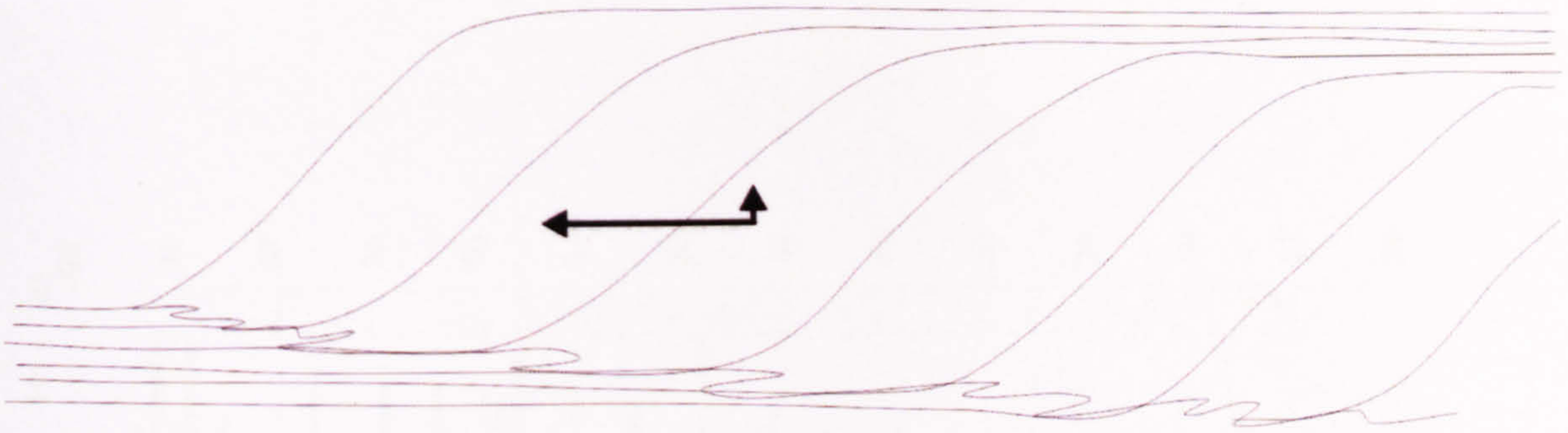


Figure 49. Horizontal growth of laterally extensive carbonate mud mounds (Lees, 1963).

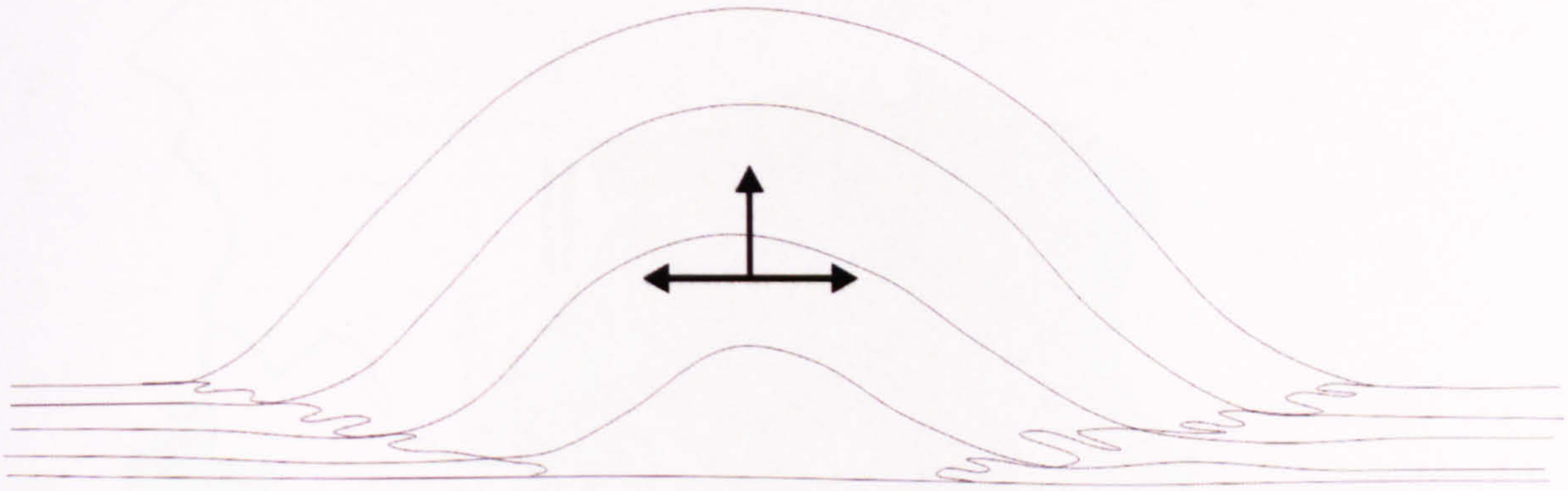


Figure 50. Growth of 'vertical-type' carbonate mud mounds. (Lees, 1963).

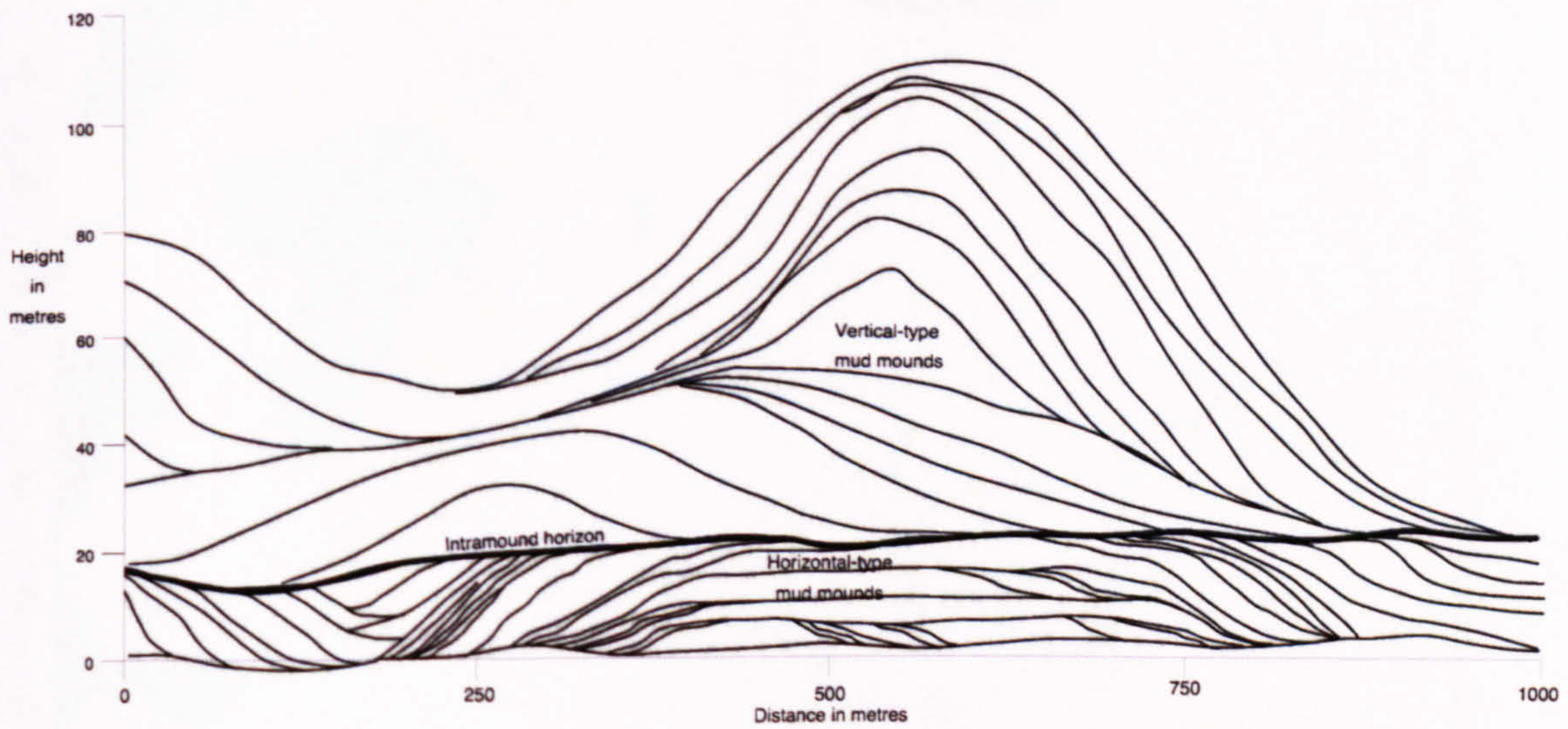



Figure 51. Schematic diagram showing the authors interpretation of the Knockmore Member mud mound complex. The interpretation is based upon observations in underground, in Skreen Hill I passage of Marble Arch Cave (see Figure 63 for cave survey), and over ground on Skreen Hill, which forms the topography above the cave system.

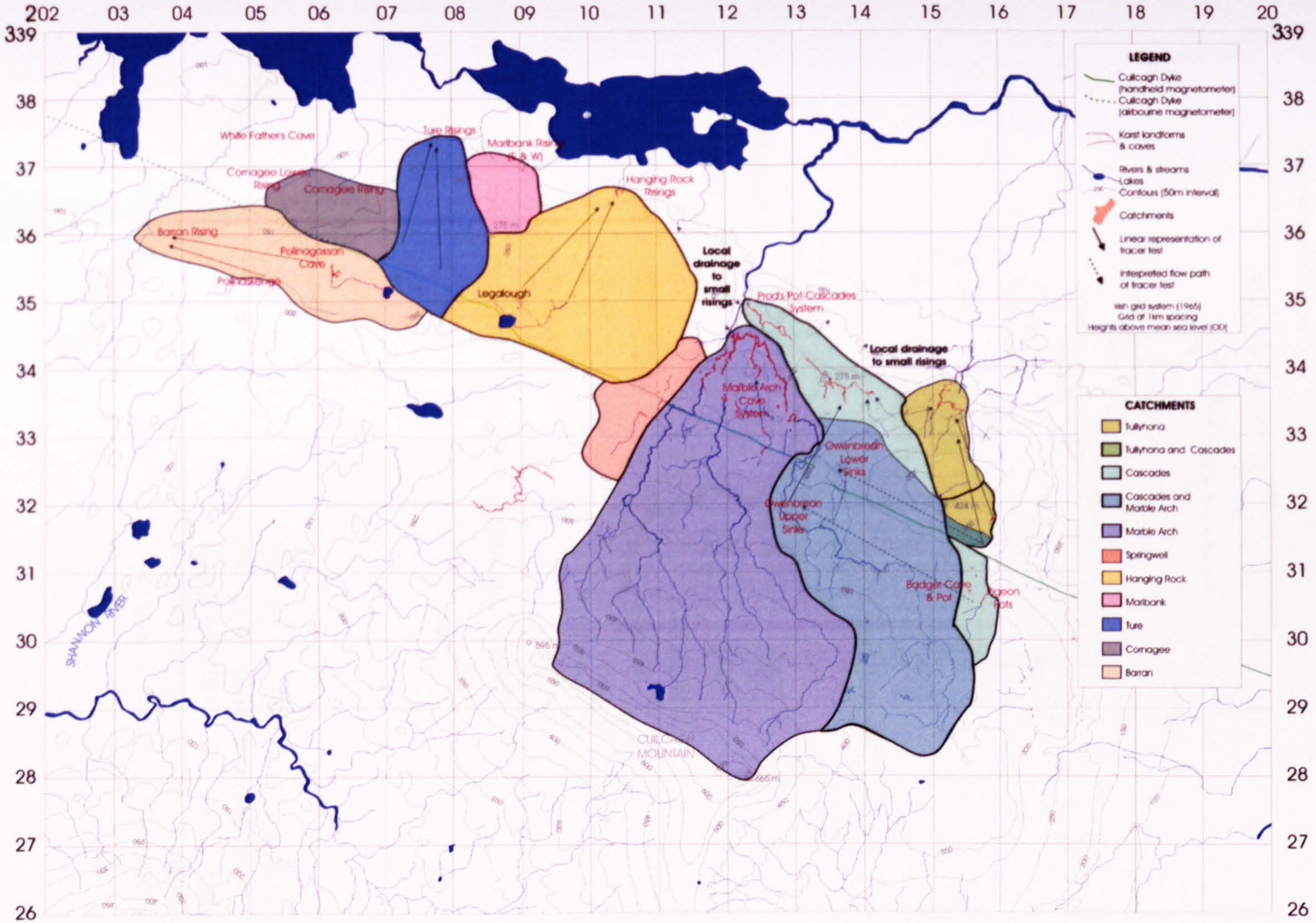
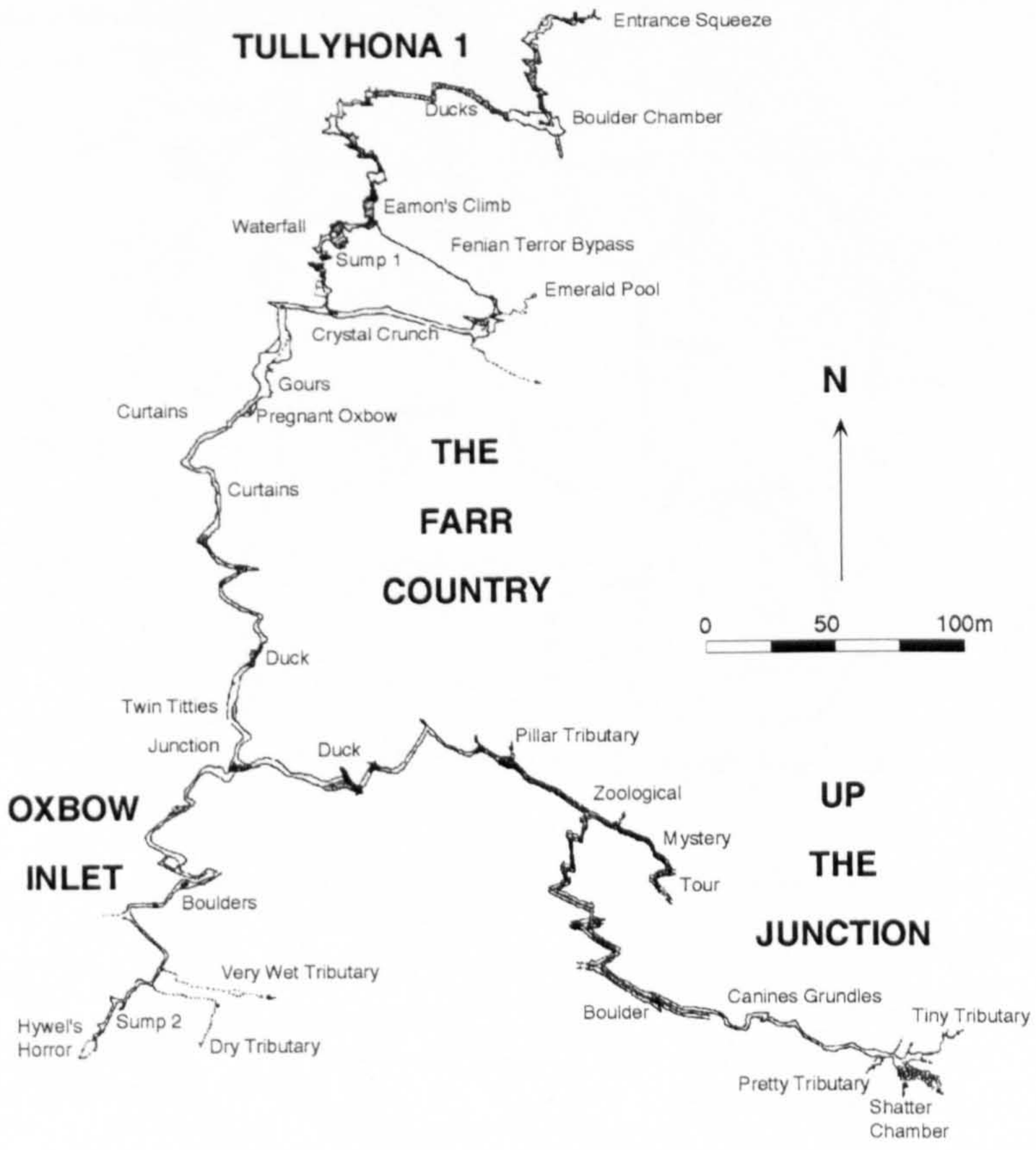



Figure 52. Drainage catchments of the Erne Karst.




# TULLYHONA RISING CAVE

## Co. Fermanagh
## GR H 1533 3373

Surveyed to BCRA Grade 3
by The Reyfad Group
G. LI. Jones, H. Ball, M. Neill,
D. Atkinson and G. Burns

Tullyhona 1 surveyed by P. & S. O'Reilly

Figure 53. Survey of Tullyhona Cave (Jones *et al.*, 1997).

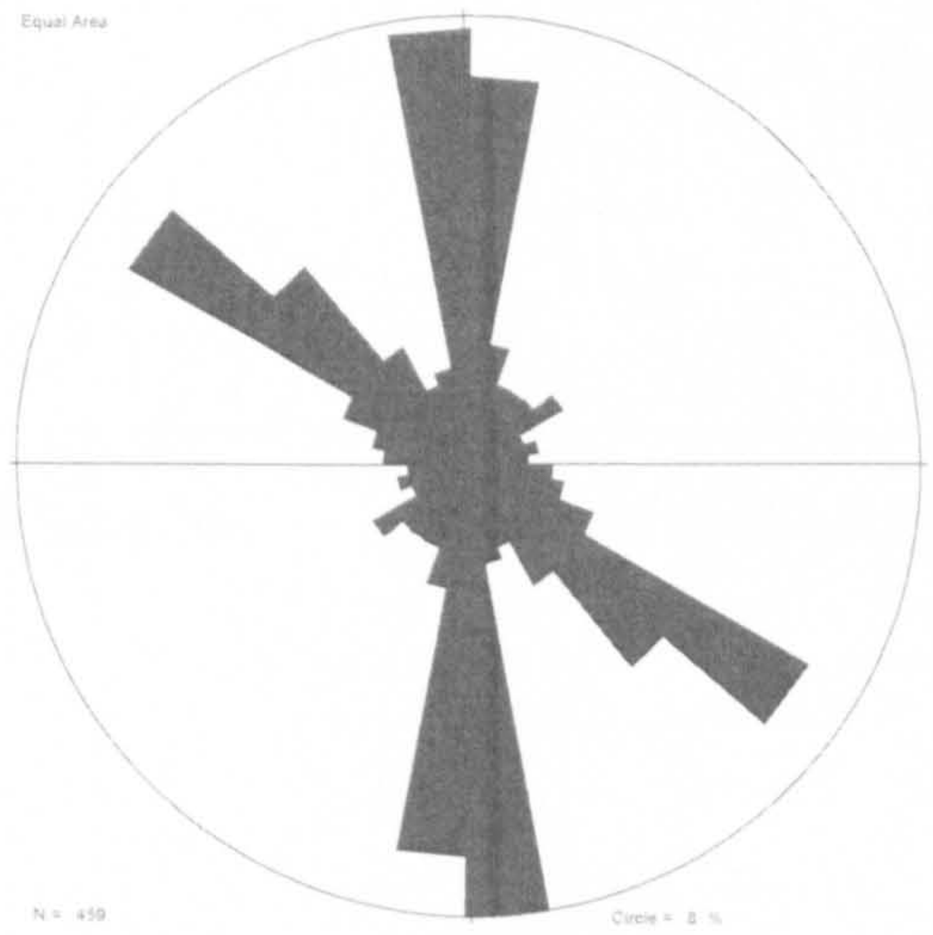



Figure 54. Rose diagram showing trends of fractures observed both underground in the Tullyhona Rising Cave and over ground above the cave system (compiled using Stereonet).

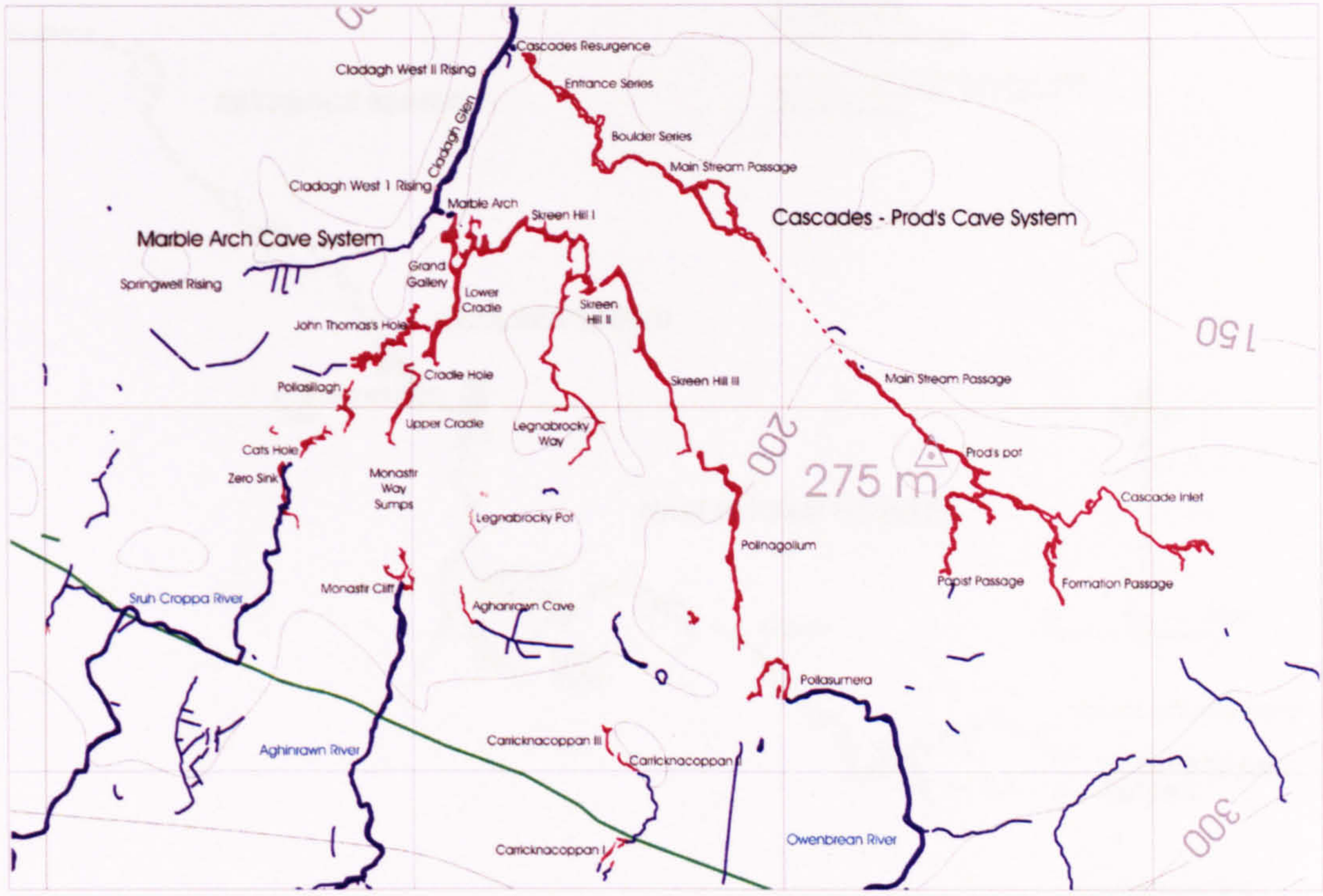



Figure 55. The caves and landforms of the Central Marlbank, of the Erne Karst.

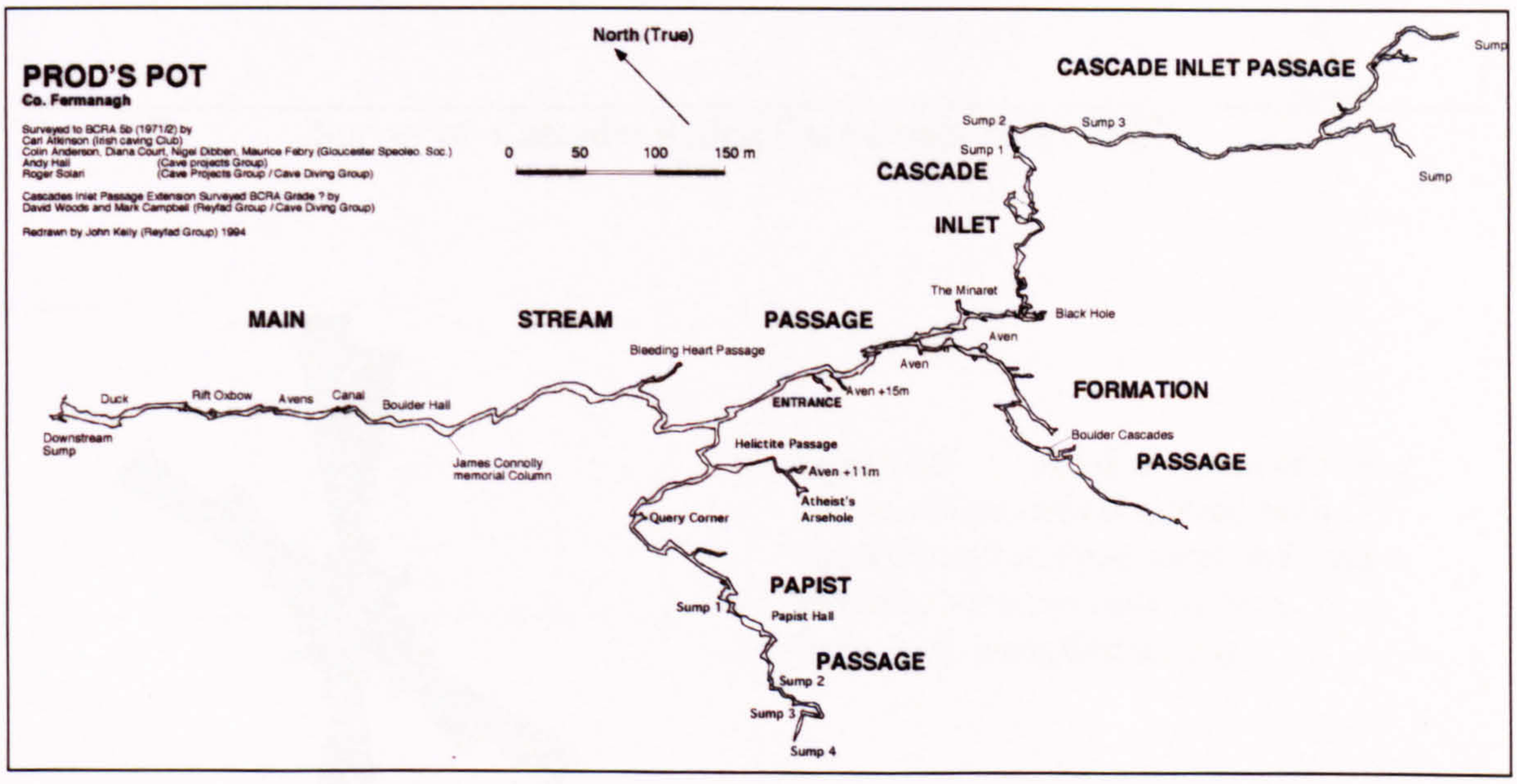



Figure 56. Survey of Prod's Pot (Jones *et al.*, 1997).

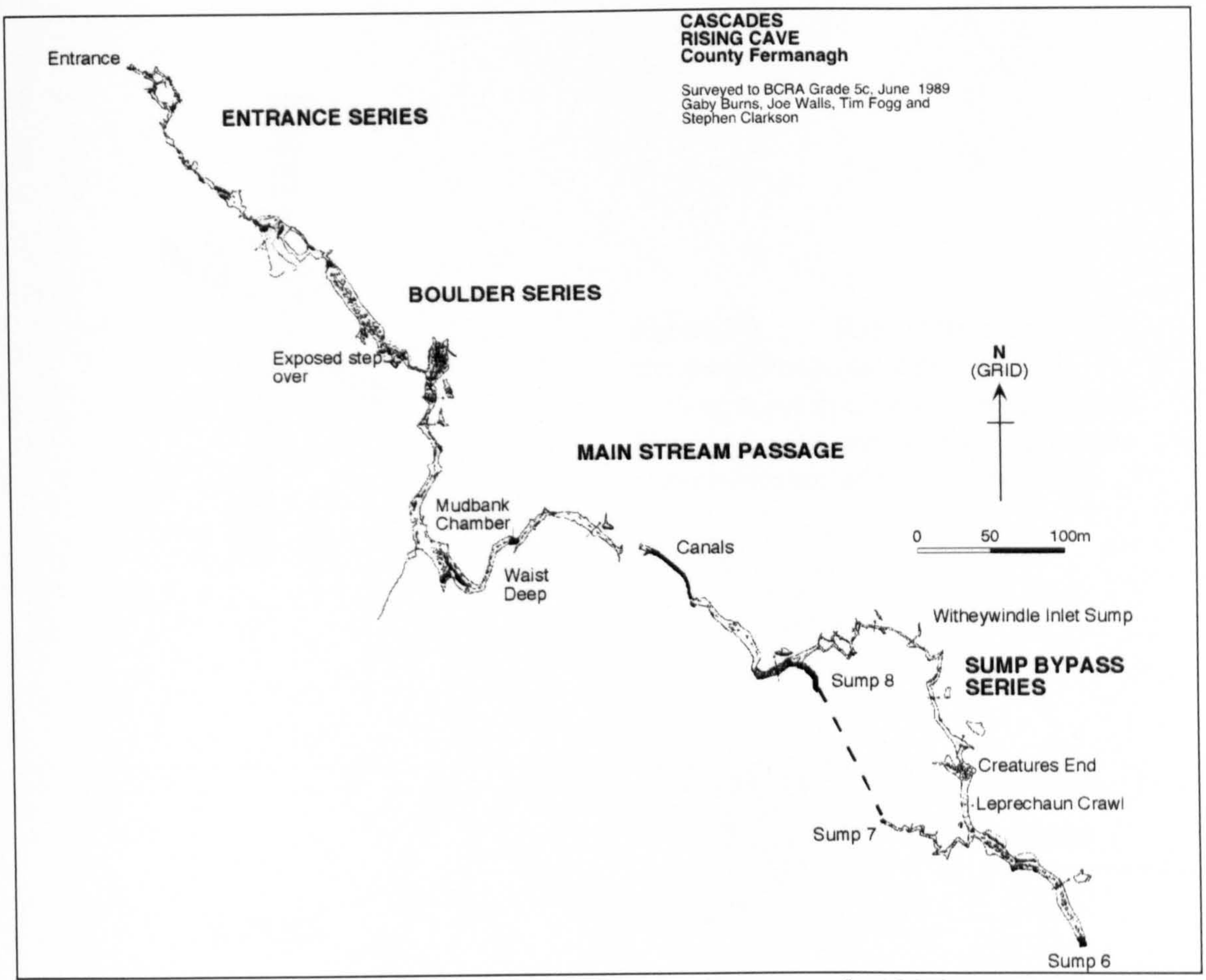



Figure 57. Survey of Cascades Rising Cave (Jones *et al.*, 1997).

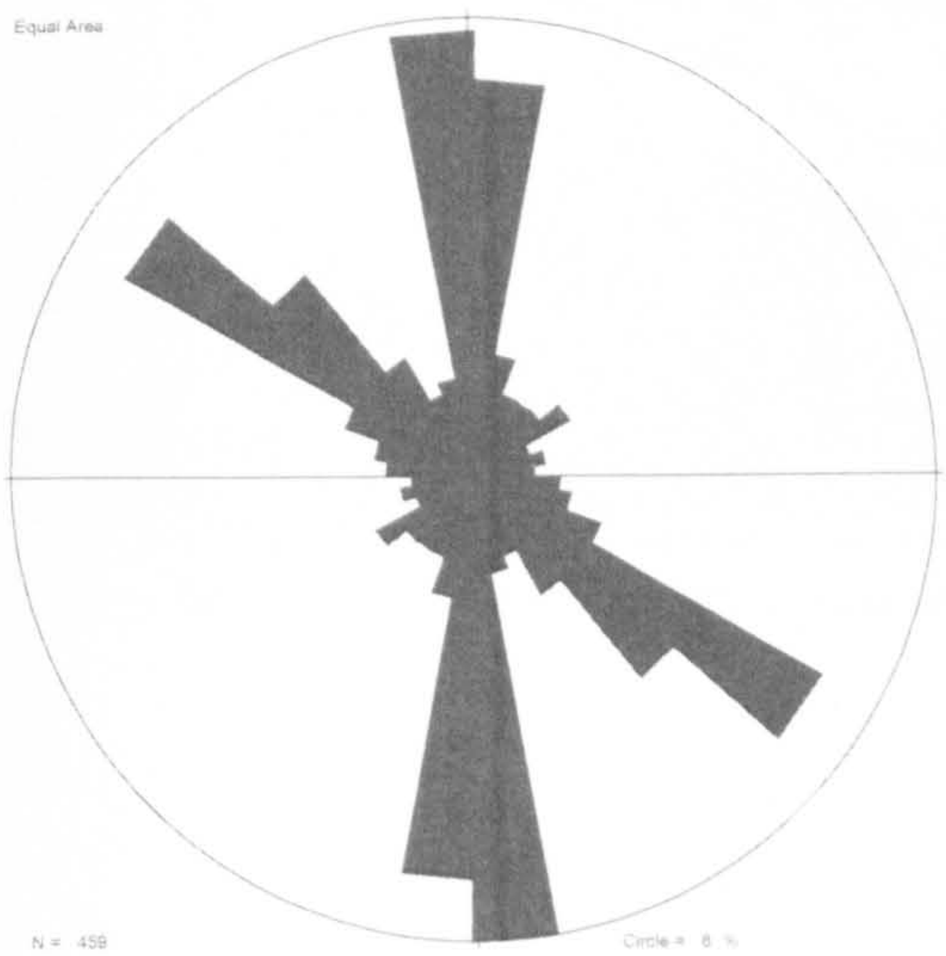



Figure 58. Rose diagram showing trends of fractures observed both underground in Prod's Pot and over ground above the cave system (compiled using Stereonet).

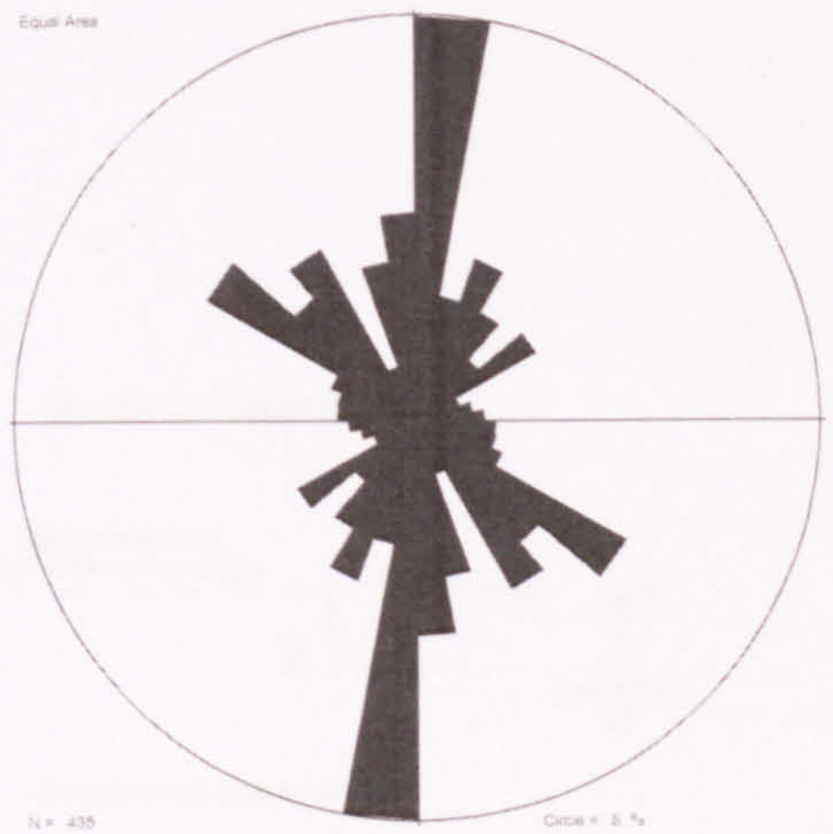



Figure 59. Rose diagram showing trends of fractures observed both underground in Cascades Resurgence Cave and over ground above the cave system (compiled using Stereonet).

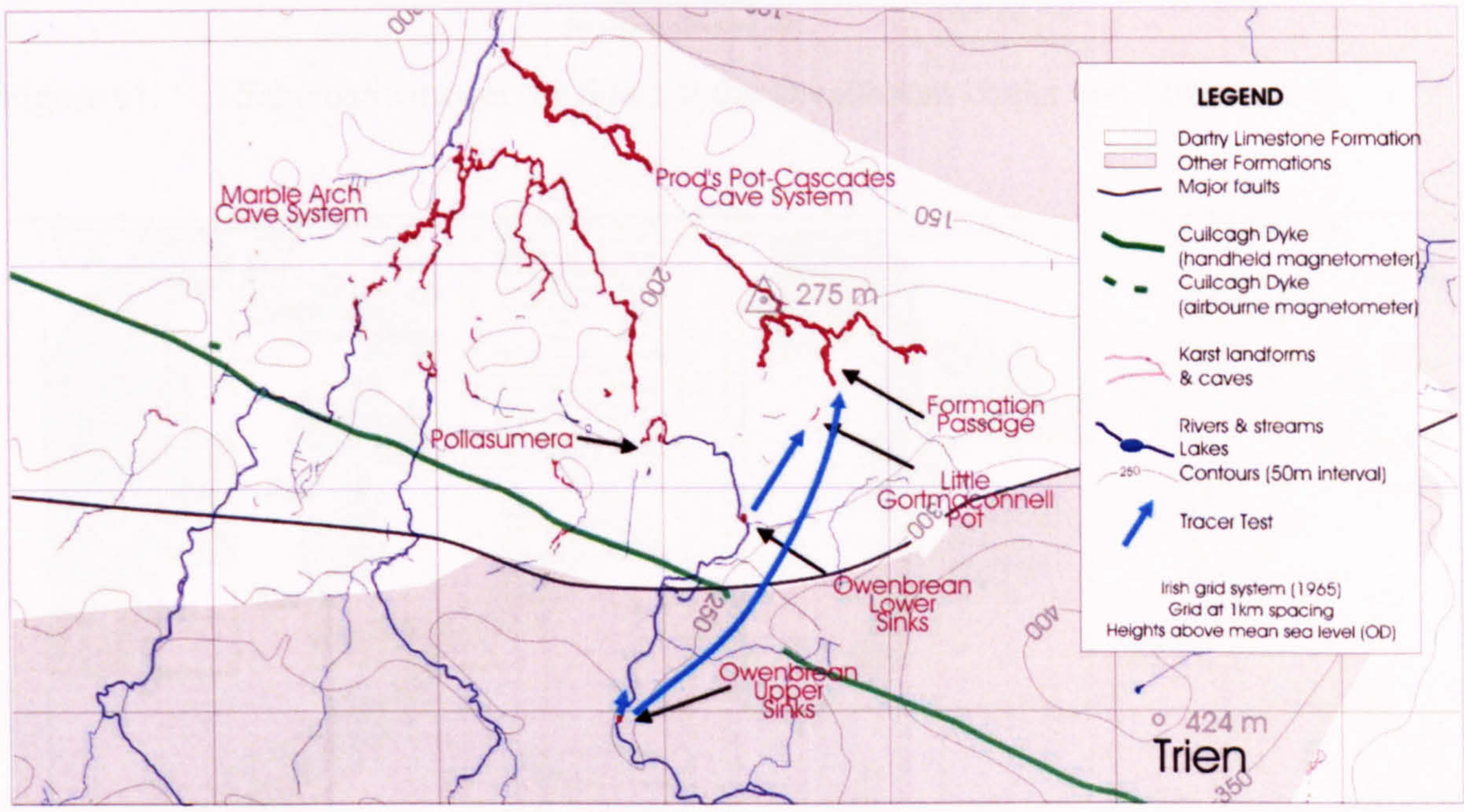
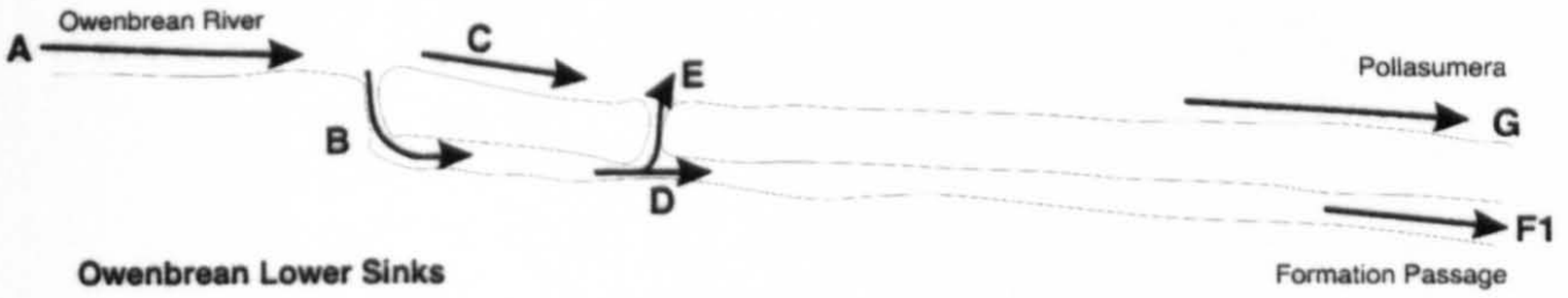


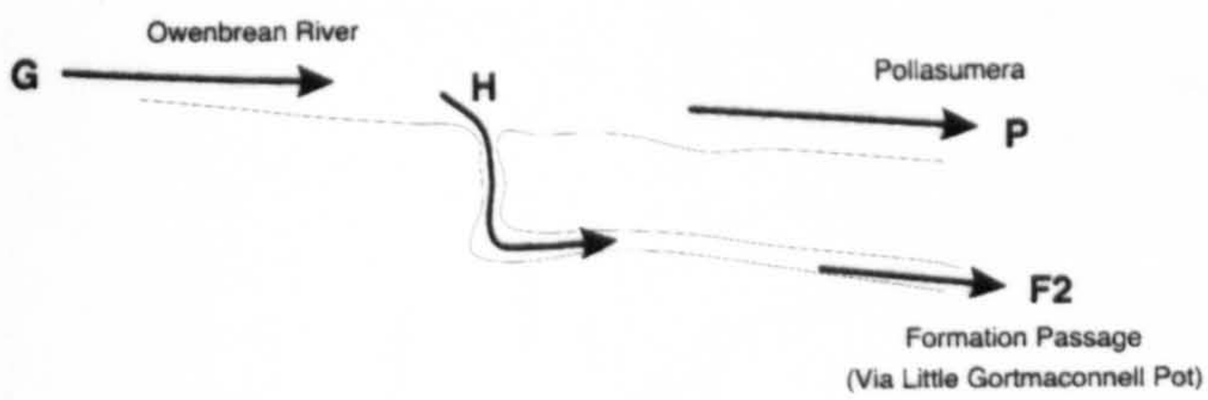

Figure 60. The Owenbrean Upper and Lower Sinks.

**Key**
A=Surface flow upstream of Upper Sinks
B=Conduit capacity of Upper Sinks
C=Excess surface flow from Upper Sinks
D=Conduit capacity to F1
E=Conduit capacity of rising
F(1&2)=Conduit system draining to Formations Passage, Prod's Pot
G=Surface flow immediately downstream of Upper Sinks
H=Conduit capacity of Lower Sinks
P=Surface flow to Pollasumera

**Owenbrean Upper Sinks**




**Owenbrean Lower Sinks**




**Owenbrean Upper Sinks**
1. If A≤B then C =0
2. If A>B then C =(A-B)
3. If B≤D then E=0
4. If B>D the E=(B-F1)
5. G=C+E

**Owenbrean Lower Sinks**
1. If G≤H then P=0
2. If G>H then P=(G-H)

Figure 61. Schematic model for flows at the Owenbrean Upper and Lower Sinks.

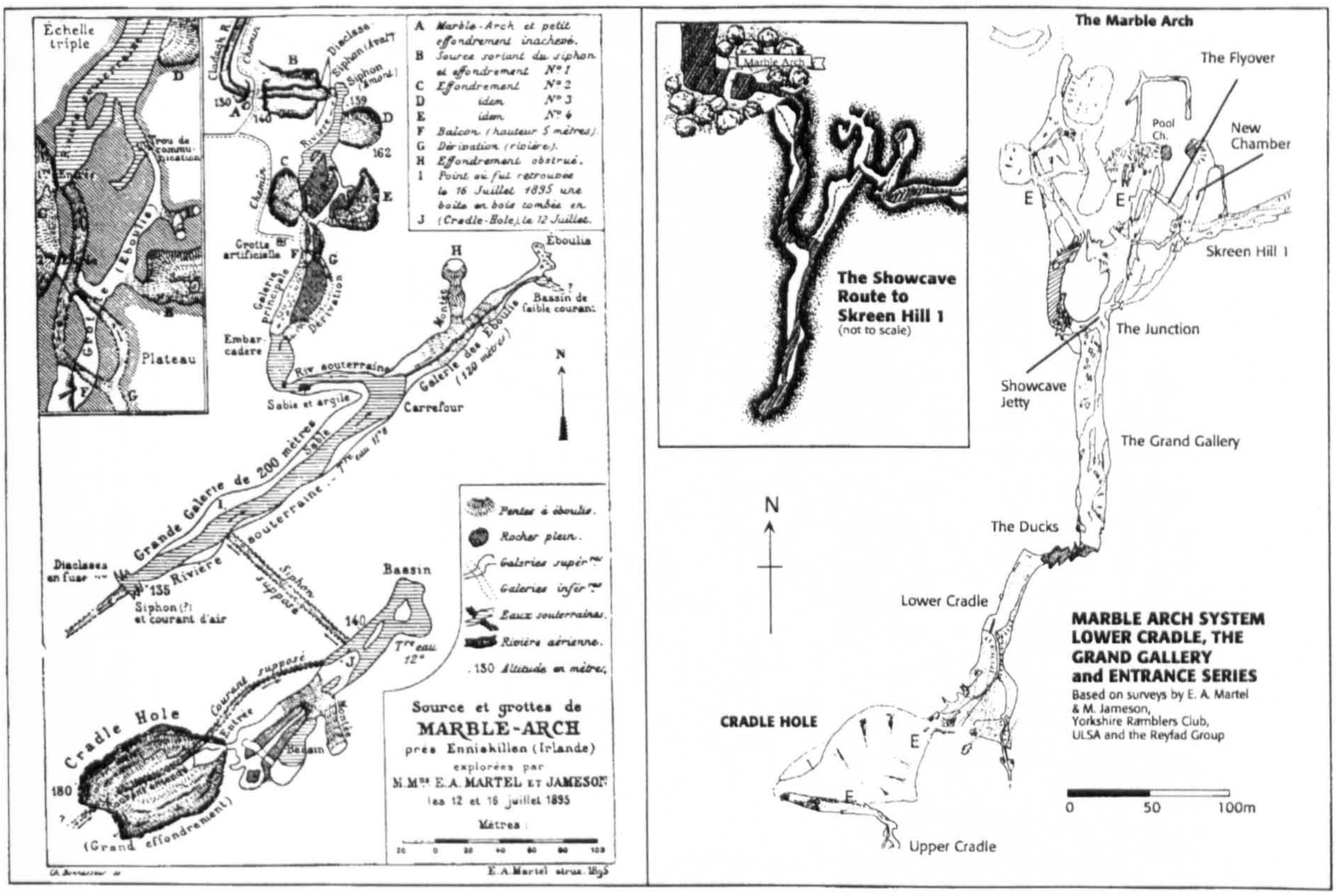



Figure 62. Survey of the Marble Arch Cave by Martel (1895) and the modern survey of the same passages (Jones *et al.*, 1997).

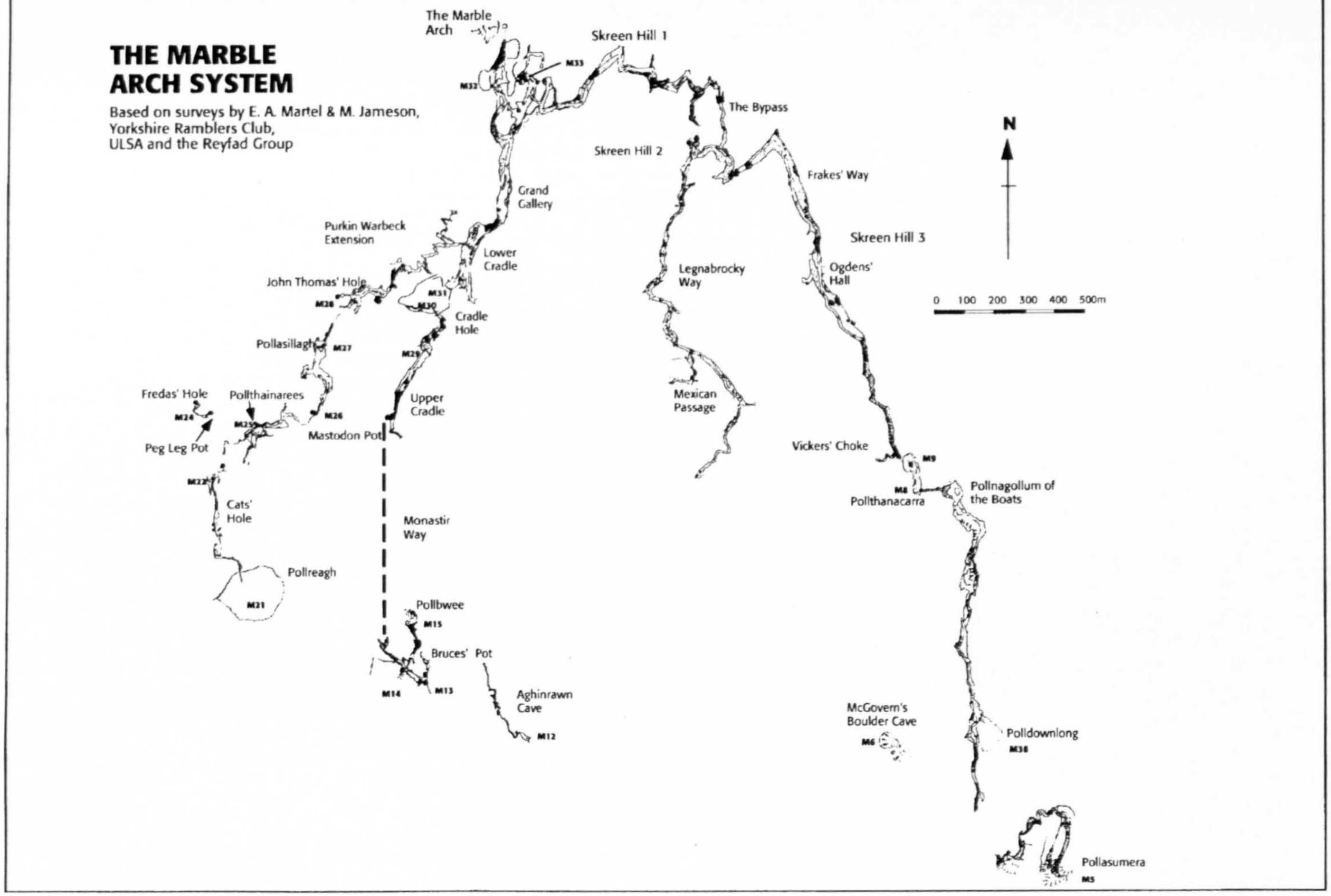



Figure 63. Survey of Marble Arch Cave (Jones *et al.,* 1997).

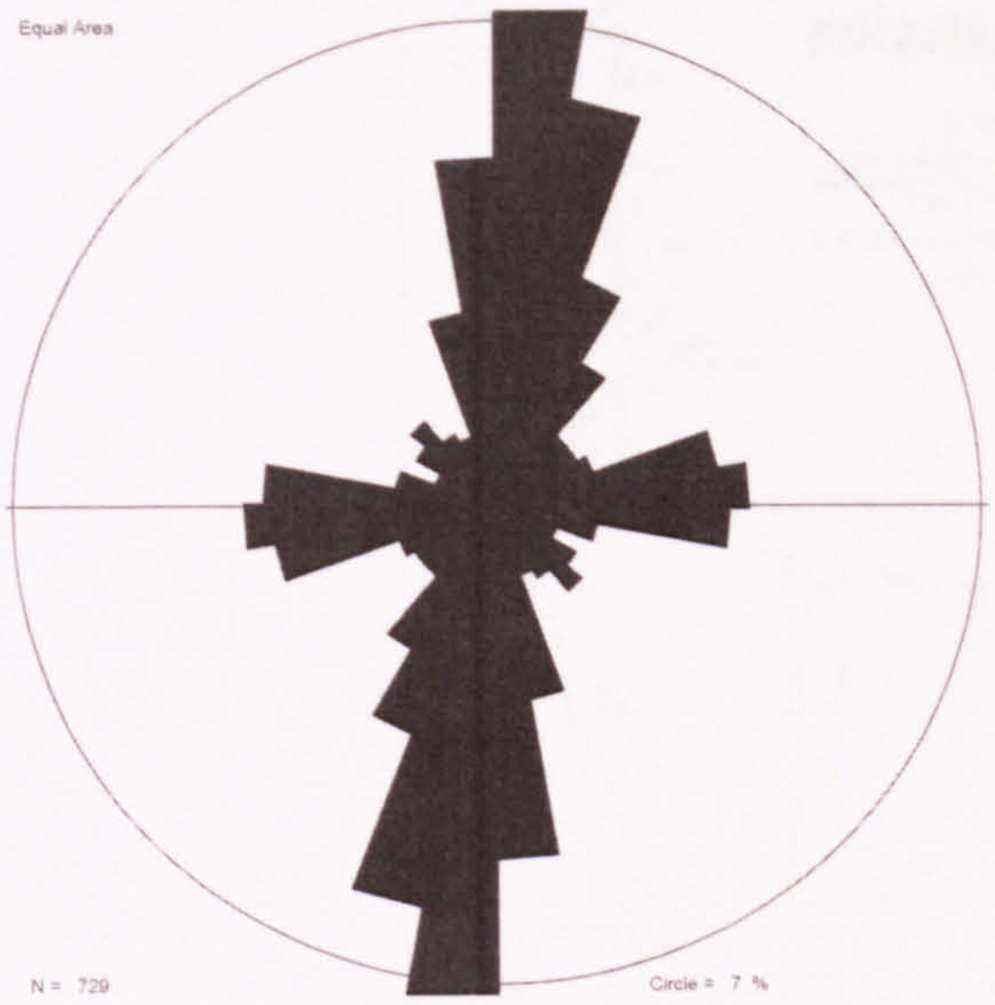



Figure 64. Rose diagram showing trends of fractures observed both underground in Marble Arch Cave System and over ground above the cave system (compiled using Stereonet).

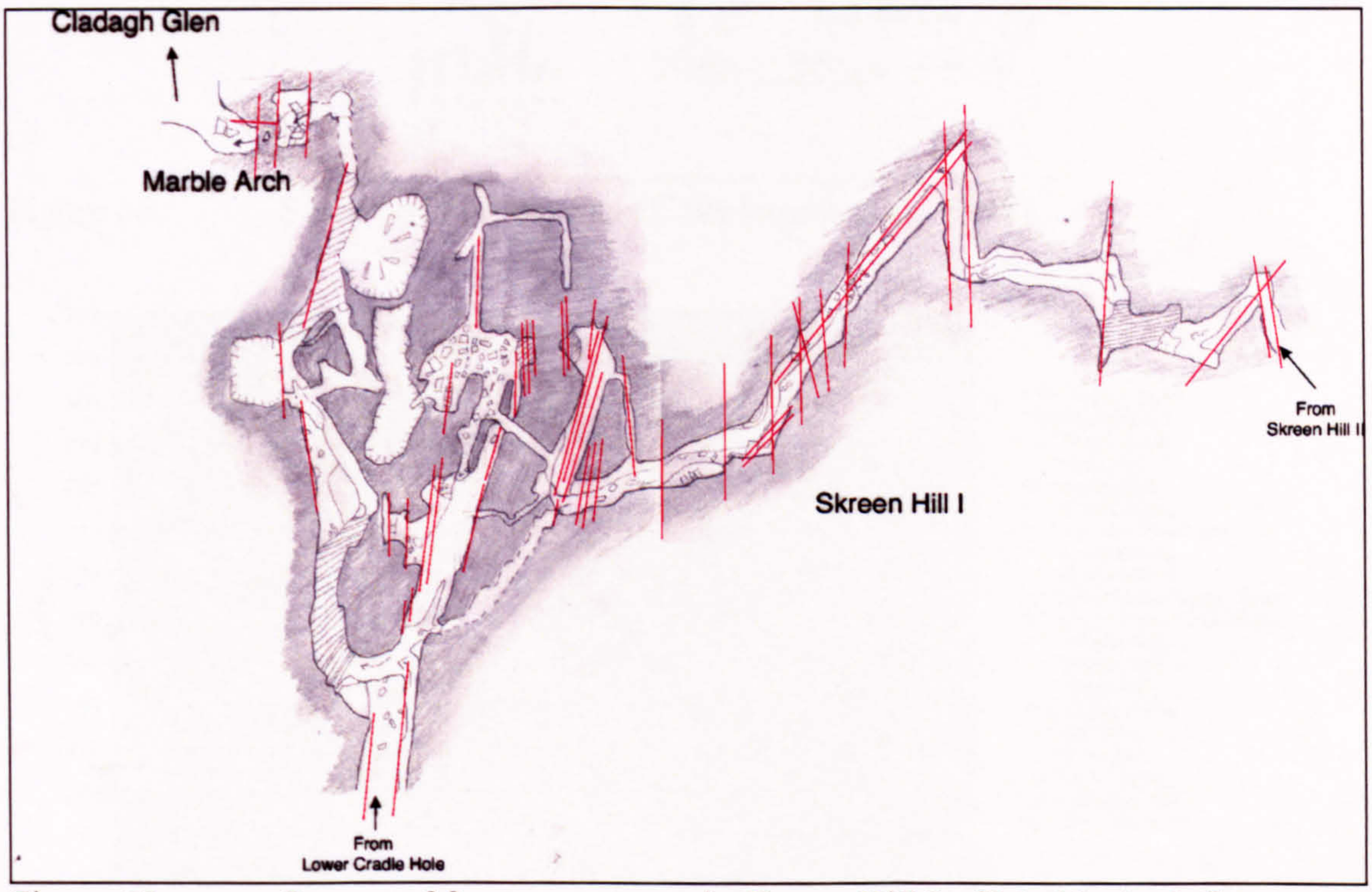



Figure 65. Survey of fracture patterns in Skreen Hill I of Marble Arch Cave.

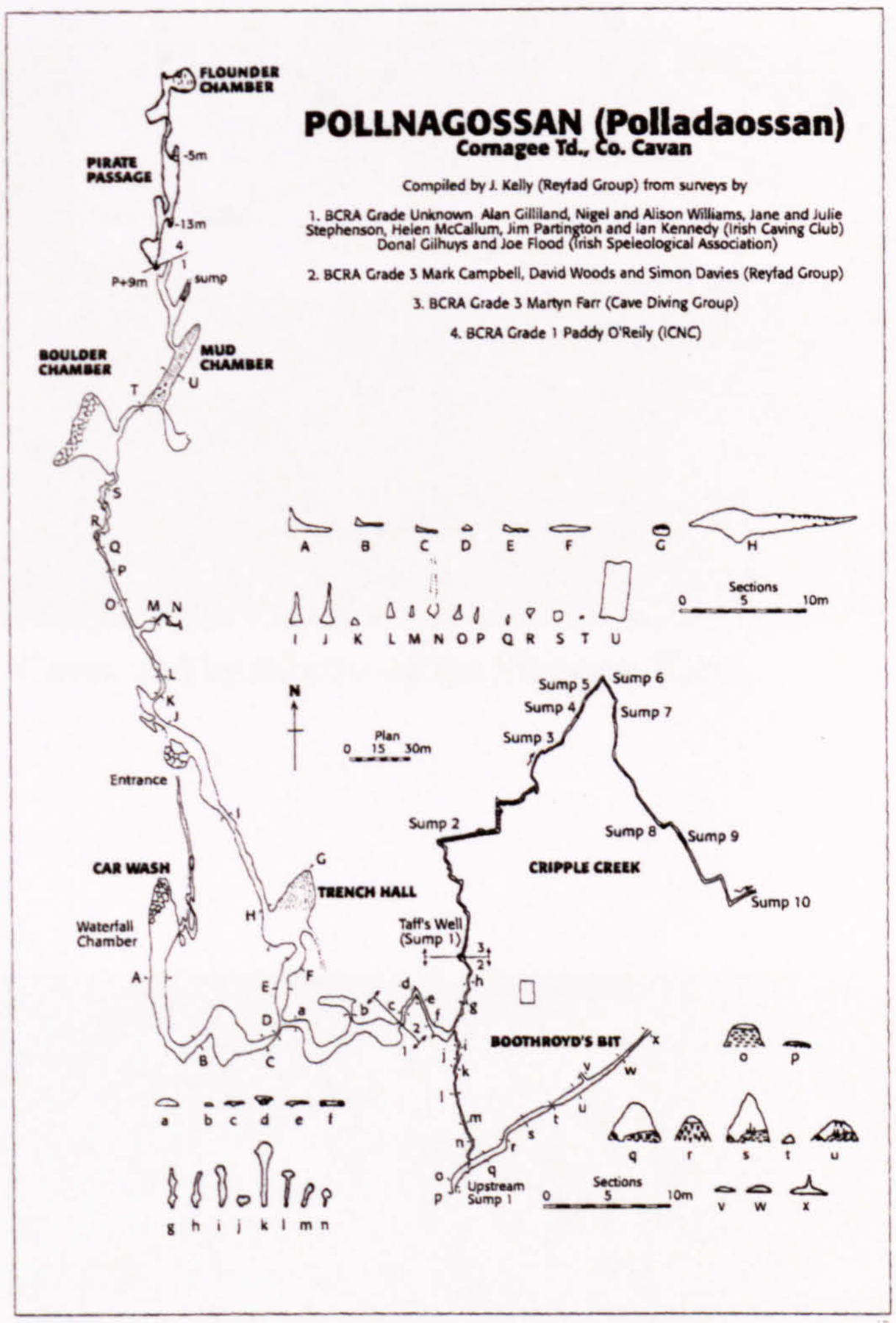



Figure 66. Survey of Pollnagossan Cave (Jones et al., 1997).

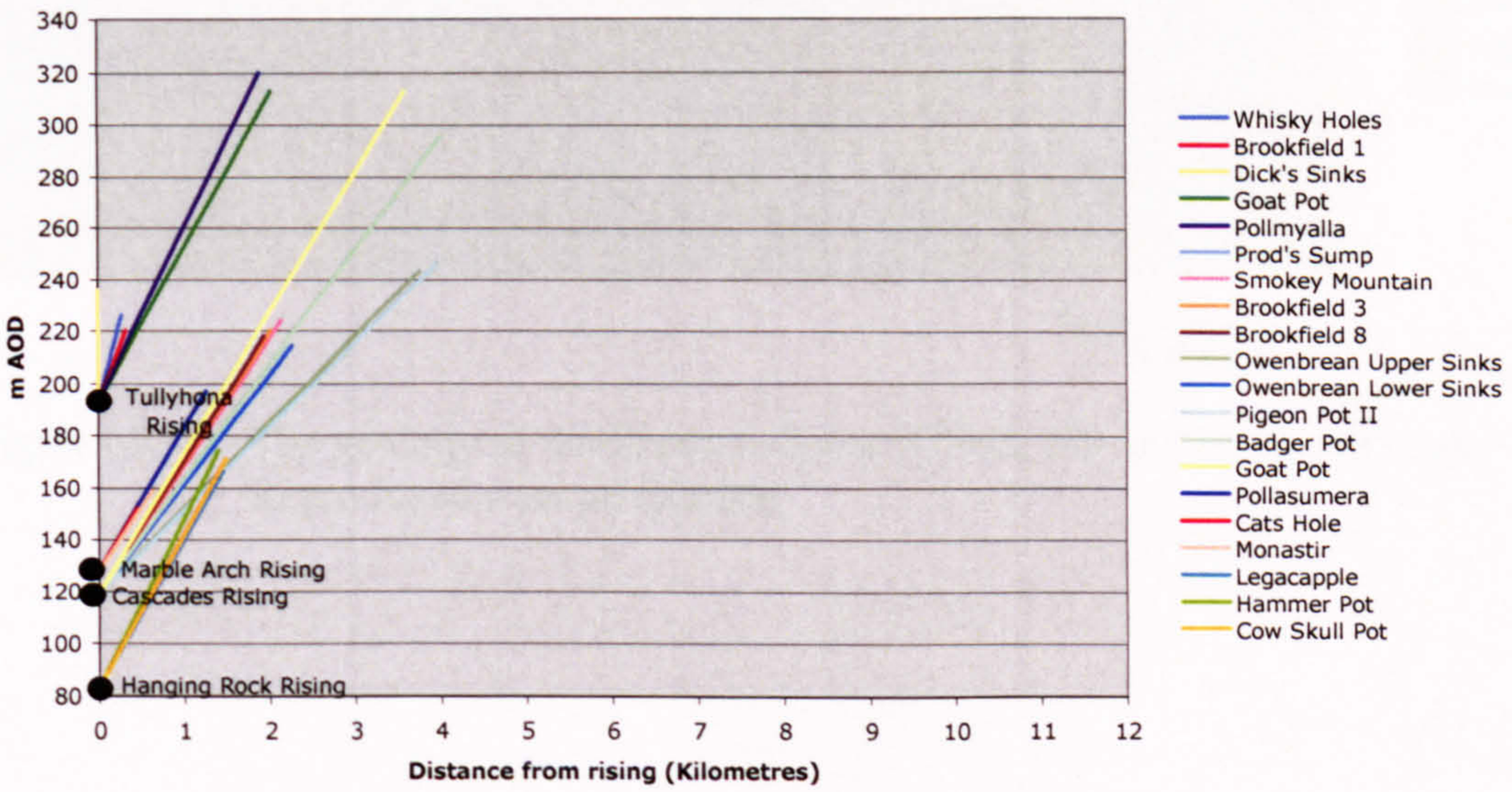



Figure 67. Linear gradients from sinks to risings in the Erne karst.

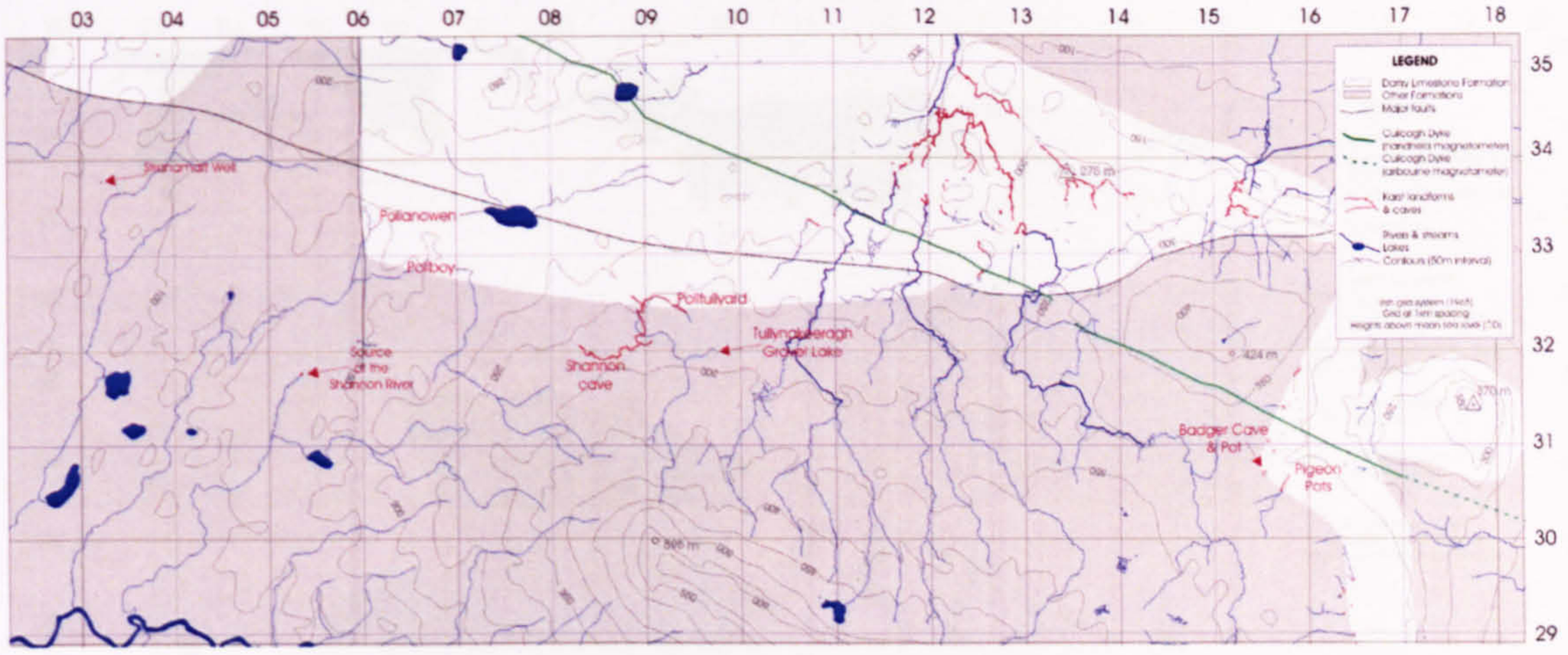



Figure 68. Caves and landforms of the Shannon Karst.

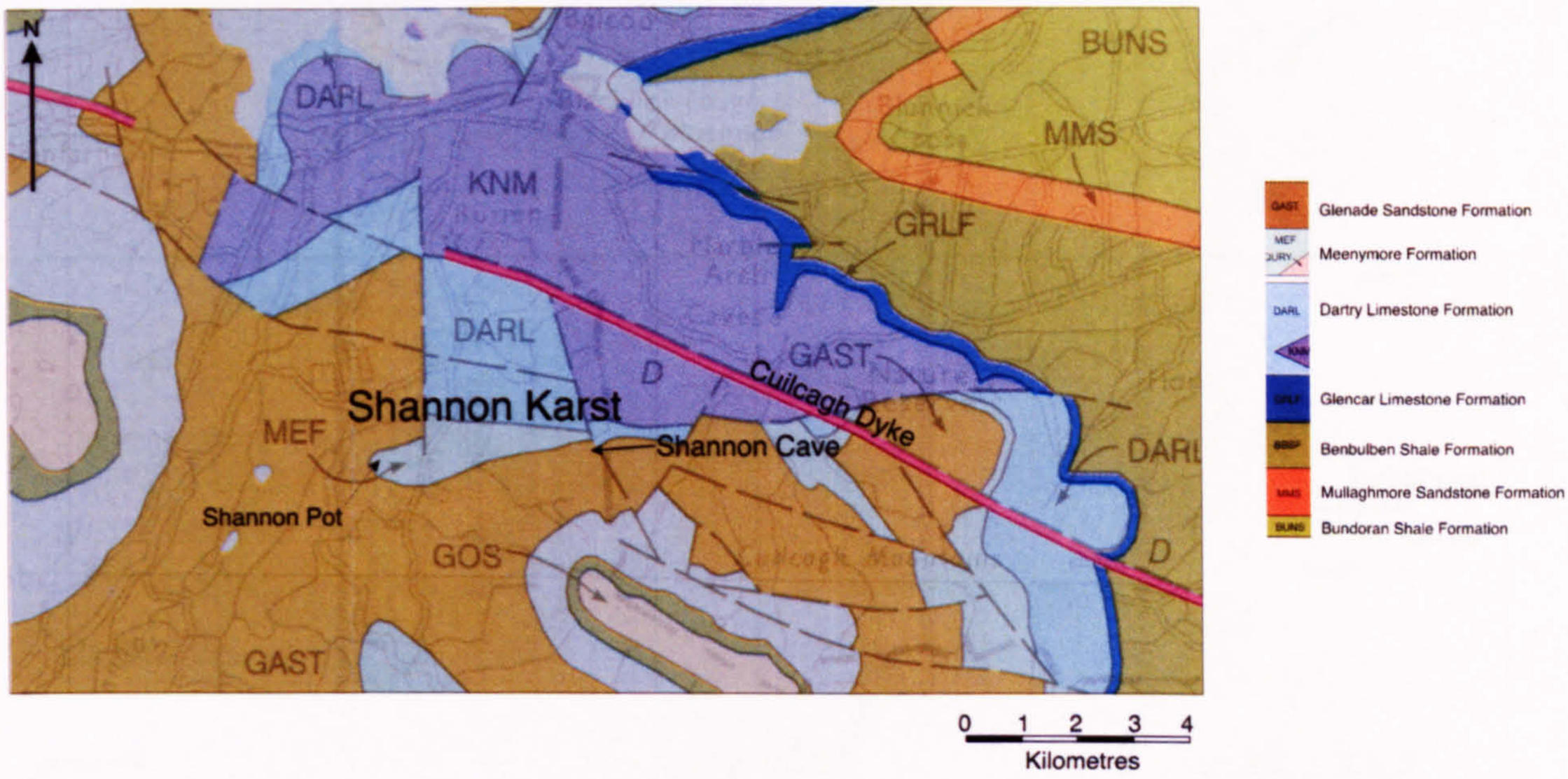



Figure 69. The geology of the Shannon Karst (GSNI, 1997). Crown copyright. Reproduced with permission.

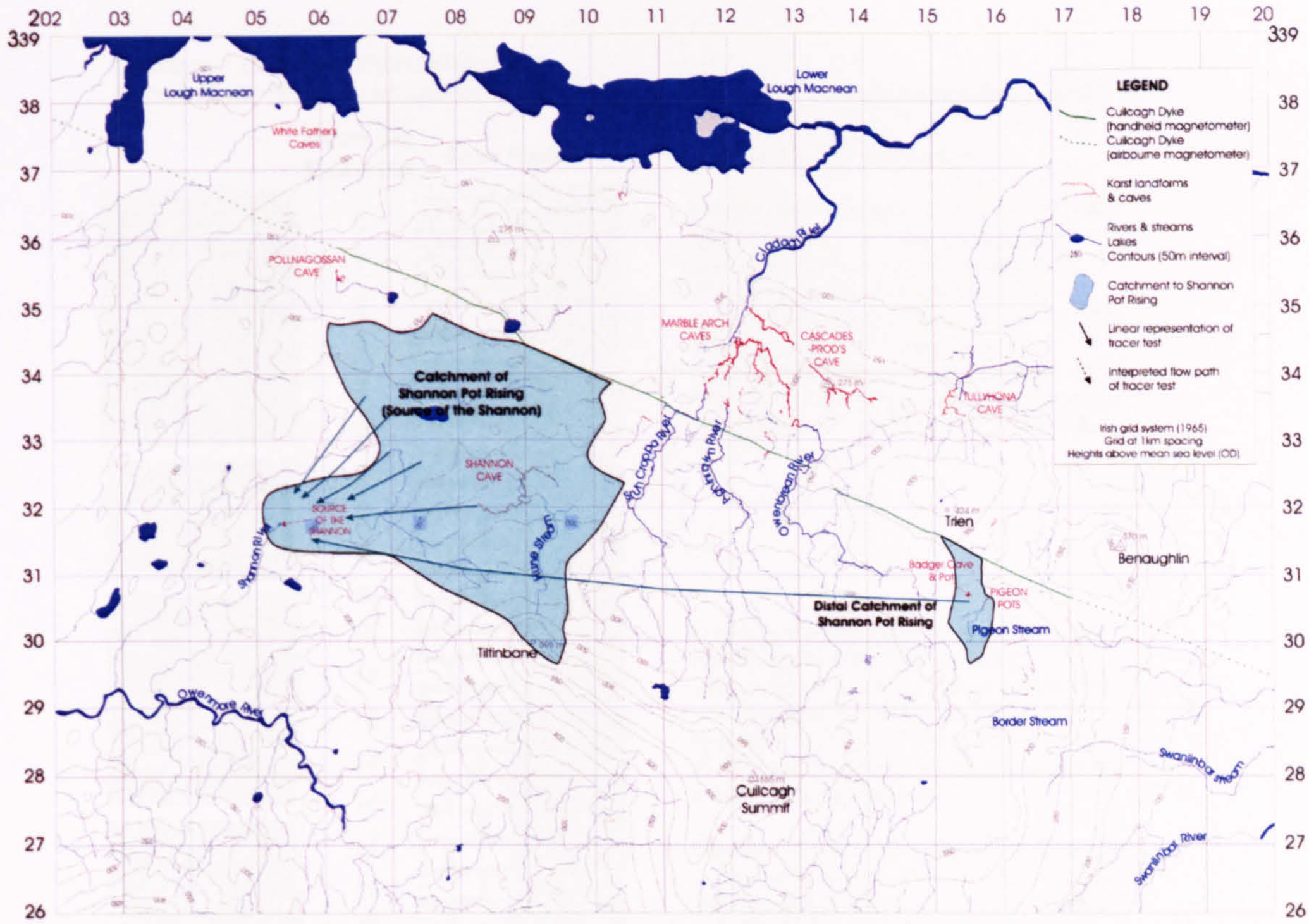



Figure 70. Drainage catchments of the Shannon Karst.

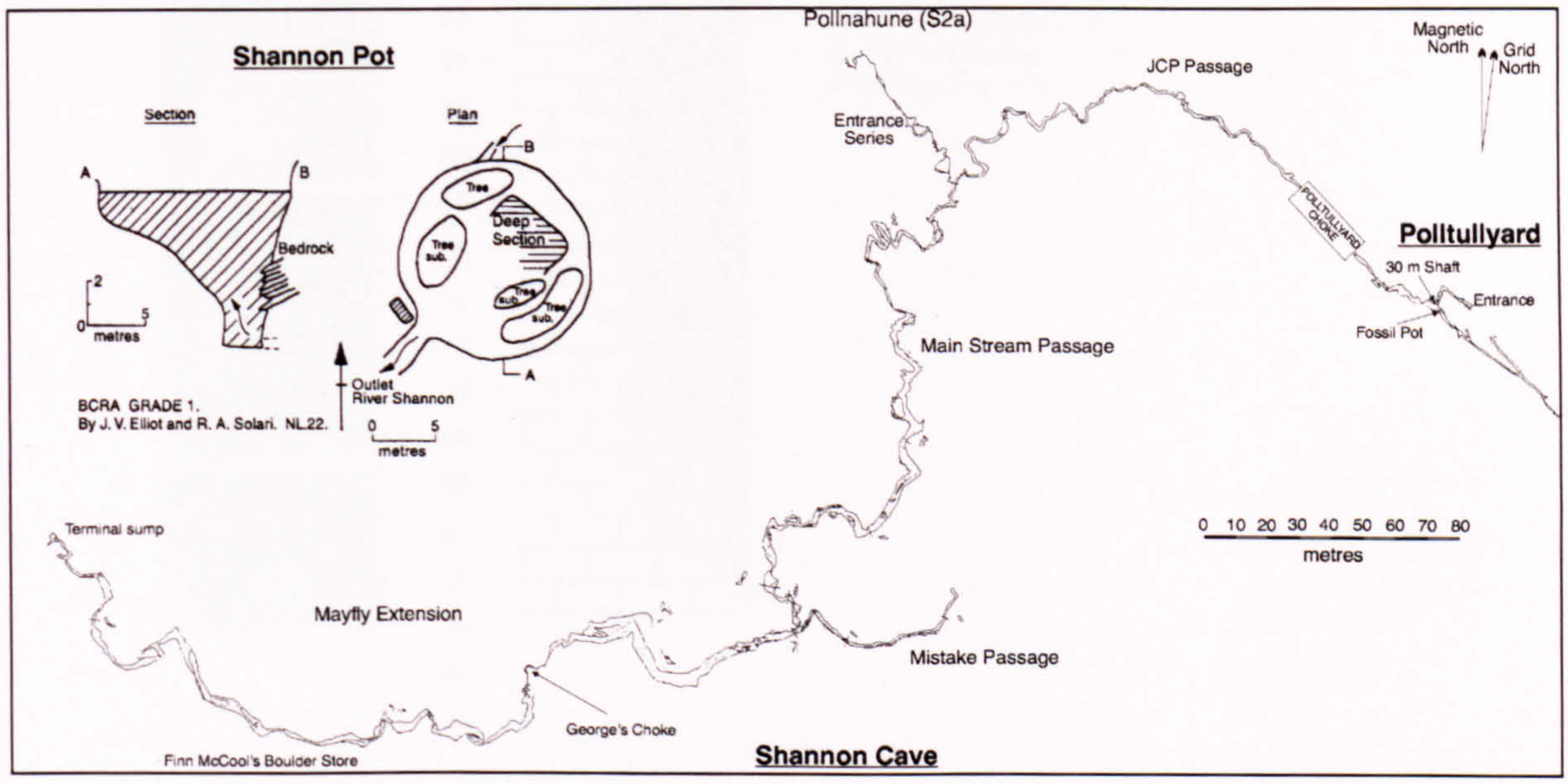



Figure 71. Survey of Shannon Cave, Polltullyard (Jones *et al.*, 1997) and Shannon Pot Rising (after Elliot and Solari, 1972).

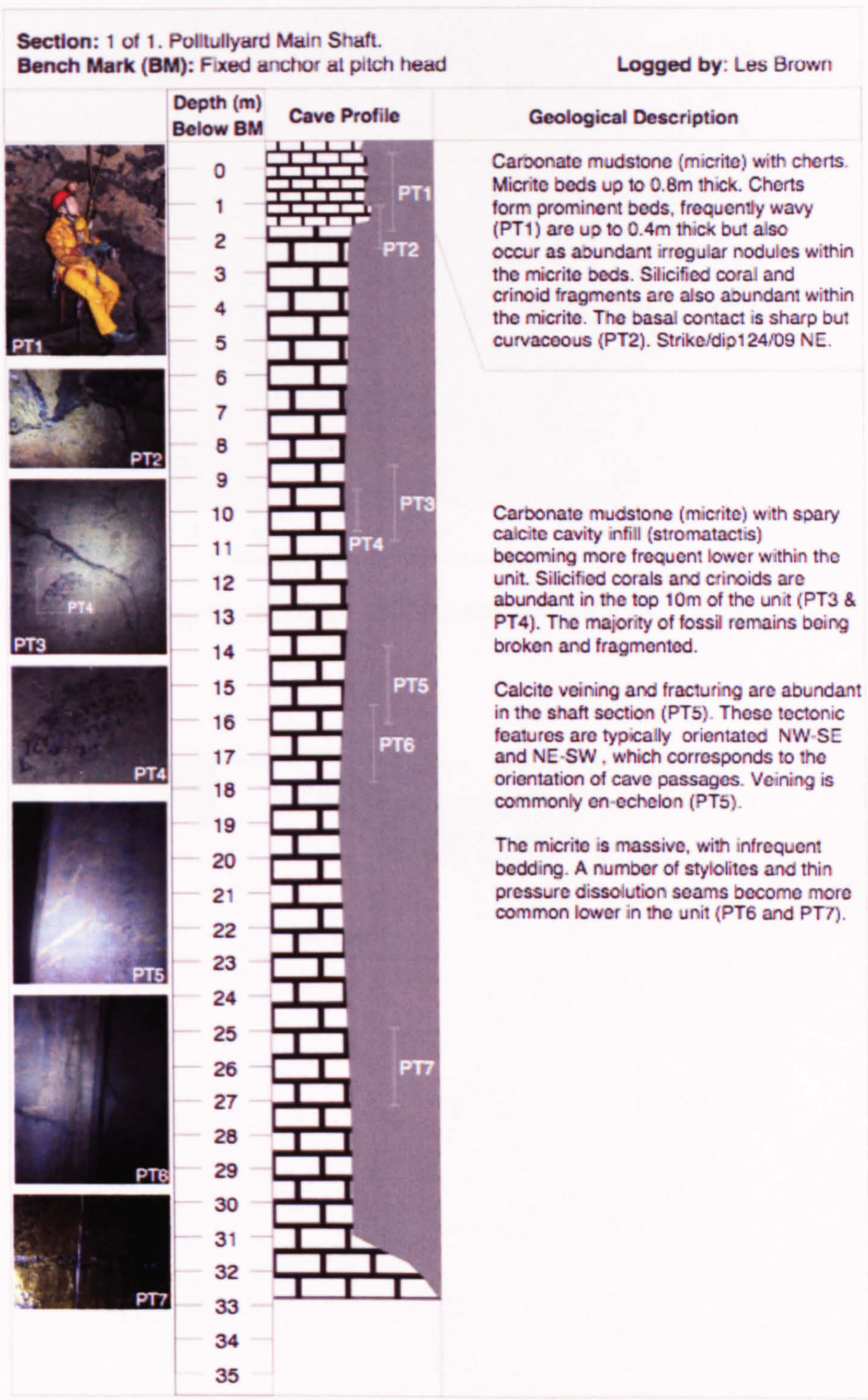



Figure 72. Geological log of Polltullyard (see Figures 71 for cave plan and section).

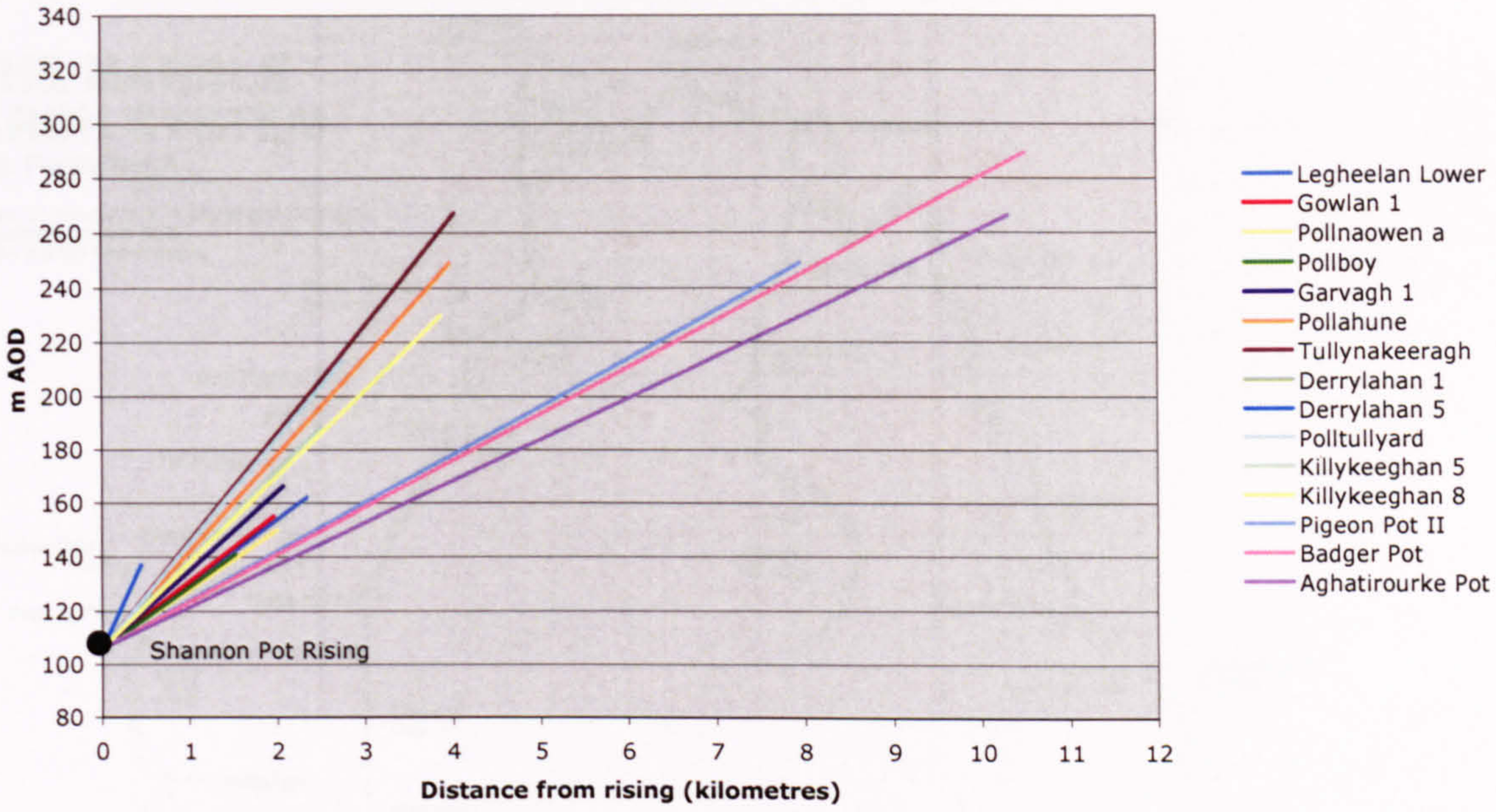



Figure 73. Linear gradients from sinks to risings in the Erne karst.

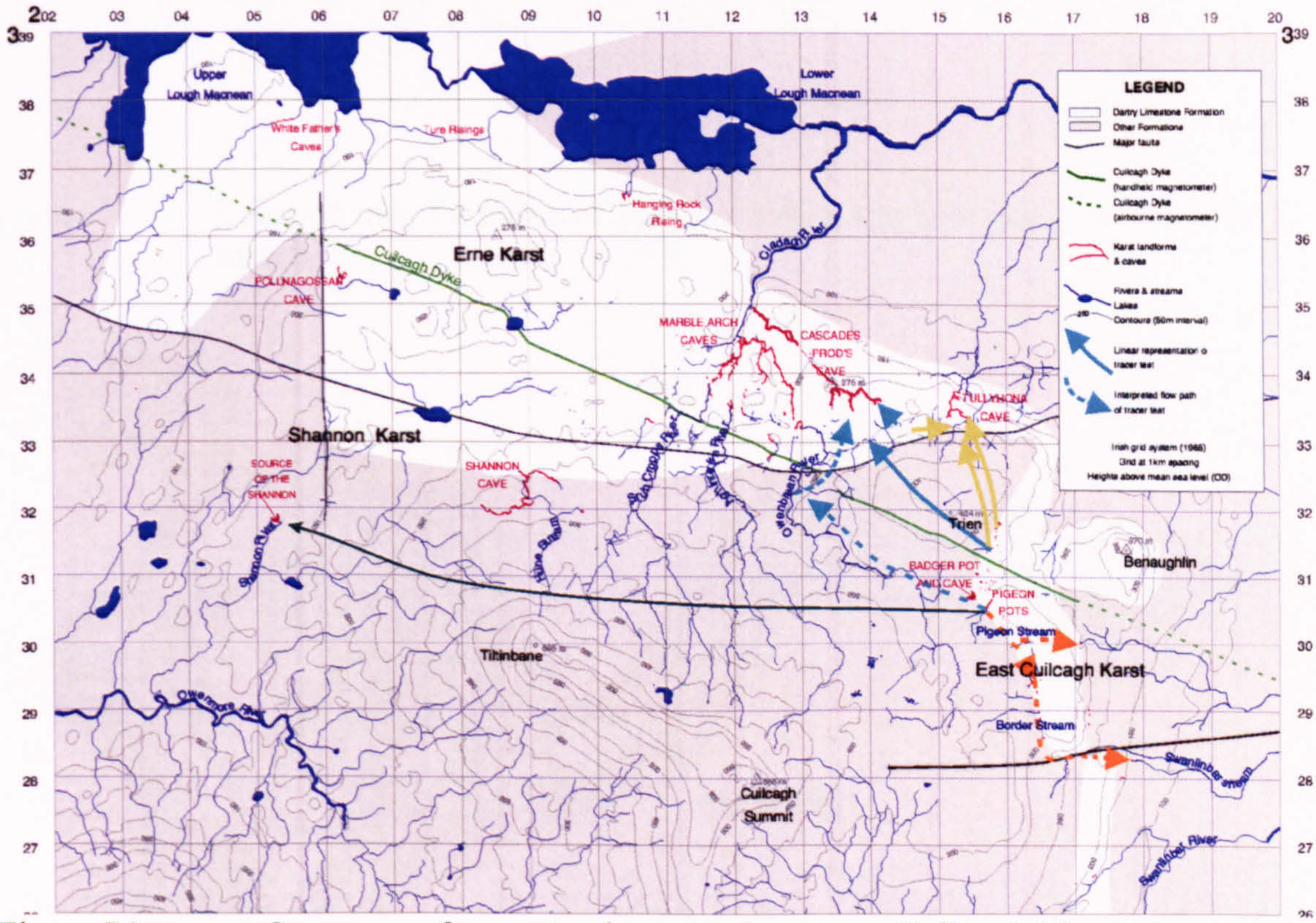



Figure 74. Summary of water tracing experiments on Cuilcagh Mountain.

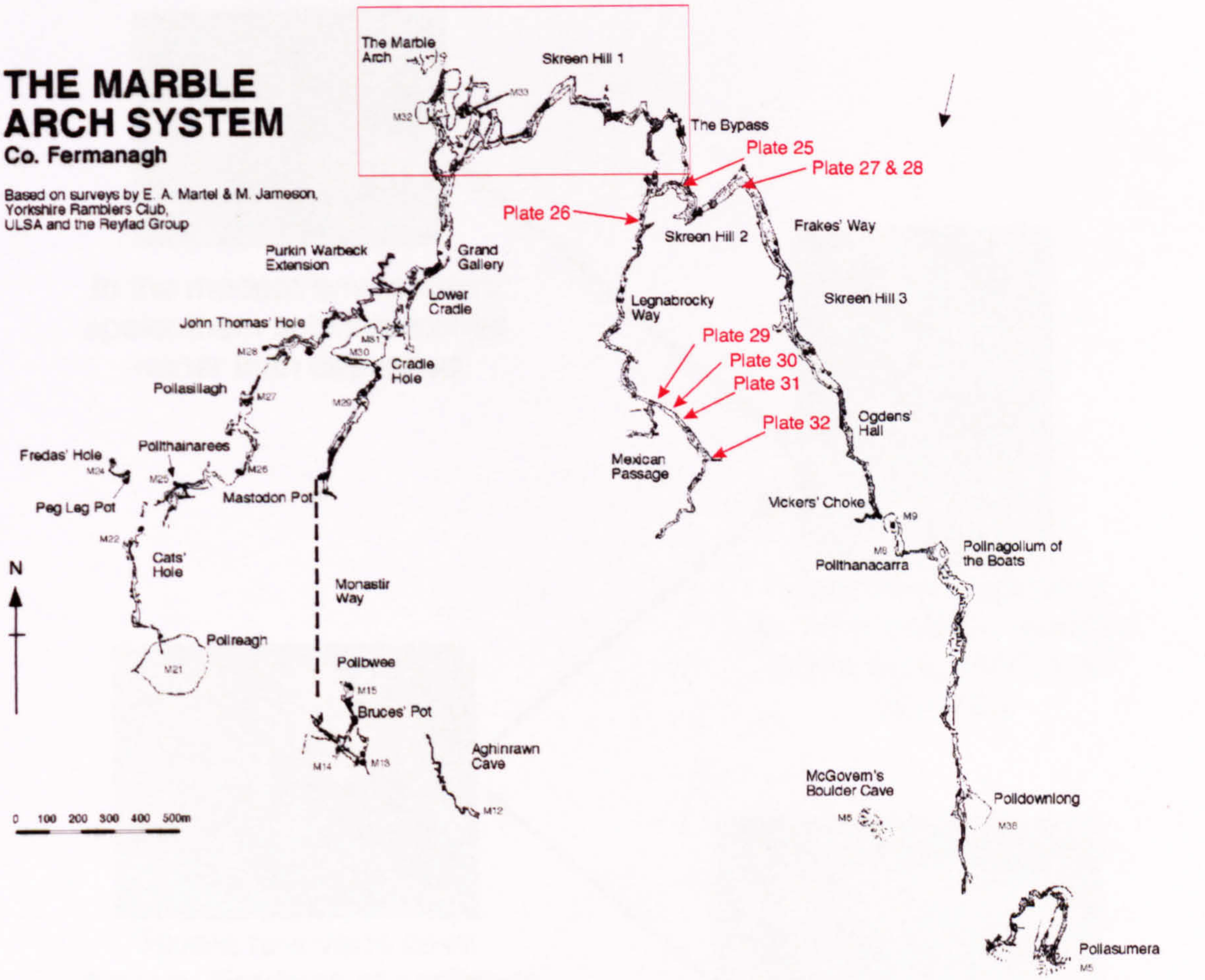



Figure 75. Location map for plates of sites in Marble Ach Cave (see Figure 76 for insert).

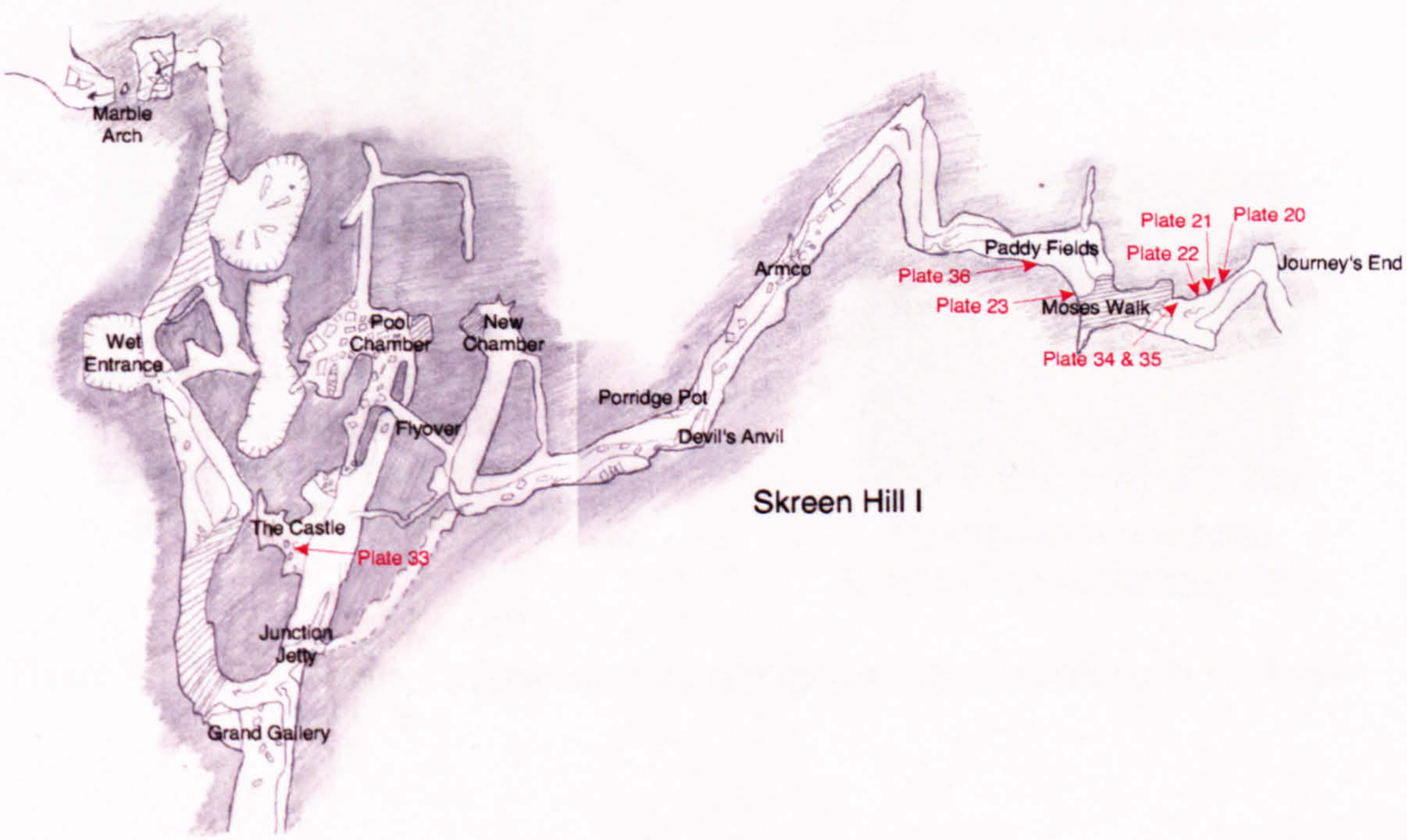
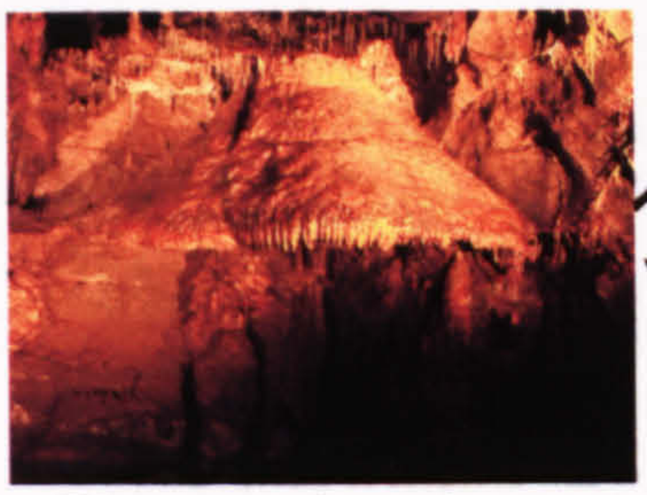



Figure 76. Location map for plates of sites in Skreen Hill I of Marble Ach Cave.

In the modern environment speleothem is being eroded rather than deposited

Spelethem deposited in more isolated reaches of the cave. MAC 1 &3 32-4.5ka



Rivers re-invade cave system. Erodsion of sediment fil and speleothml

Spelethem deposited over course sediment fill.

Fluvio-glacial sediment deposited in cave. High energy environemnt which rodes speleothem.Partially filling the system with gravel and cobble fill.

Spelethem deposited MAC4 & 6 (>350ka-200ka)

Figure 77. Summary of the sequence stratigraphy of cave sediments in Marble Arch Cave.

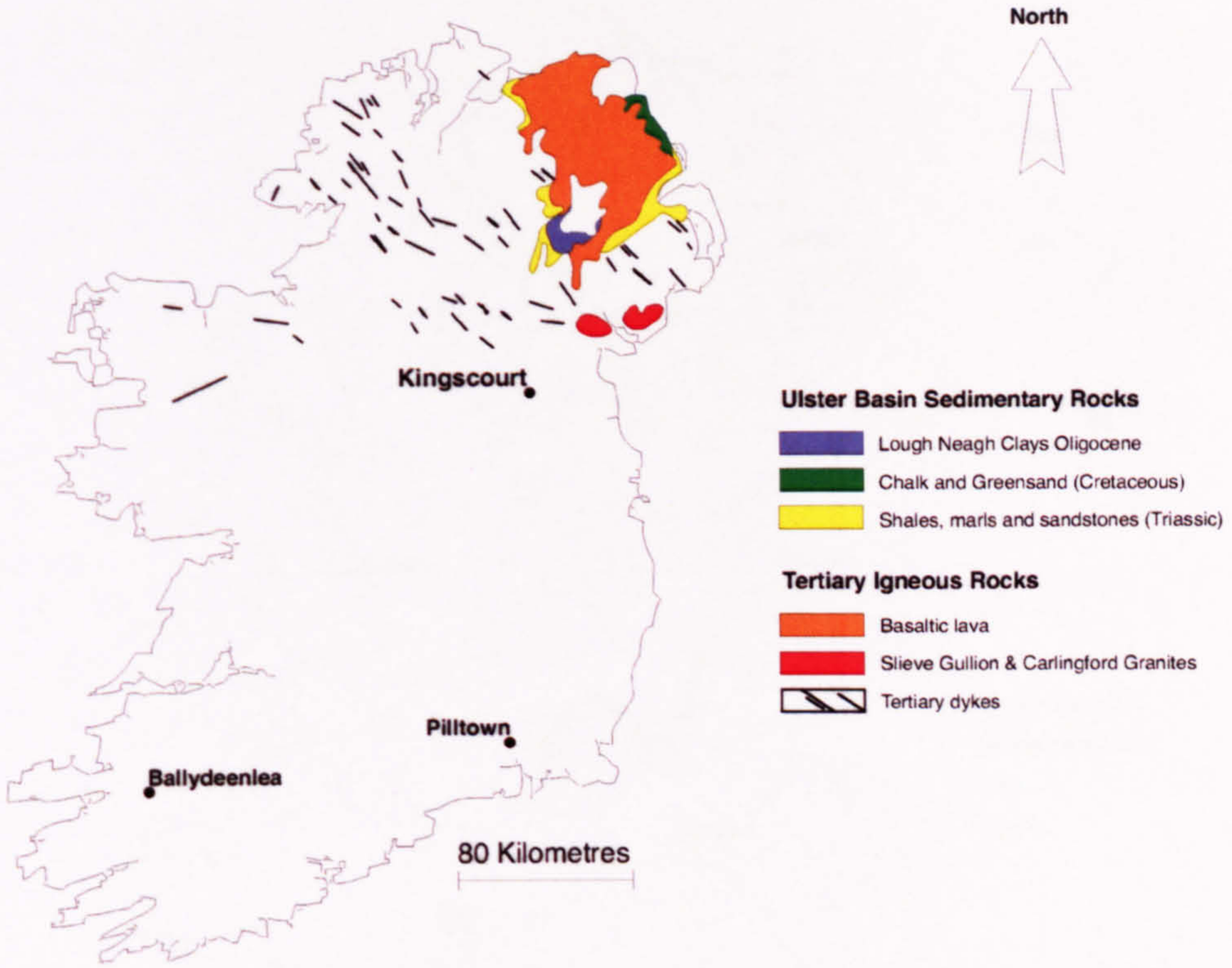



Figure 78. The Mesozoic and Cainozoic rocks sequence of Ireland (After GSNI, 1997). Crown copyright. Reproduced with permission.


Figure 79. The distribution of the Palaeogene and Neogene palaeokarst sediments in Ireland (Modified after Naylor, 1992).


Figure 80. The distribution of glacial landforms within the Irish landscape (Warren, 1985) (see Figure 81 for details of insert).

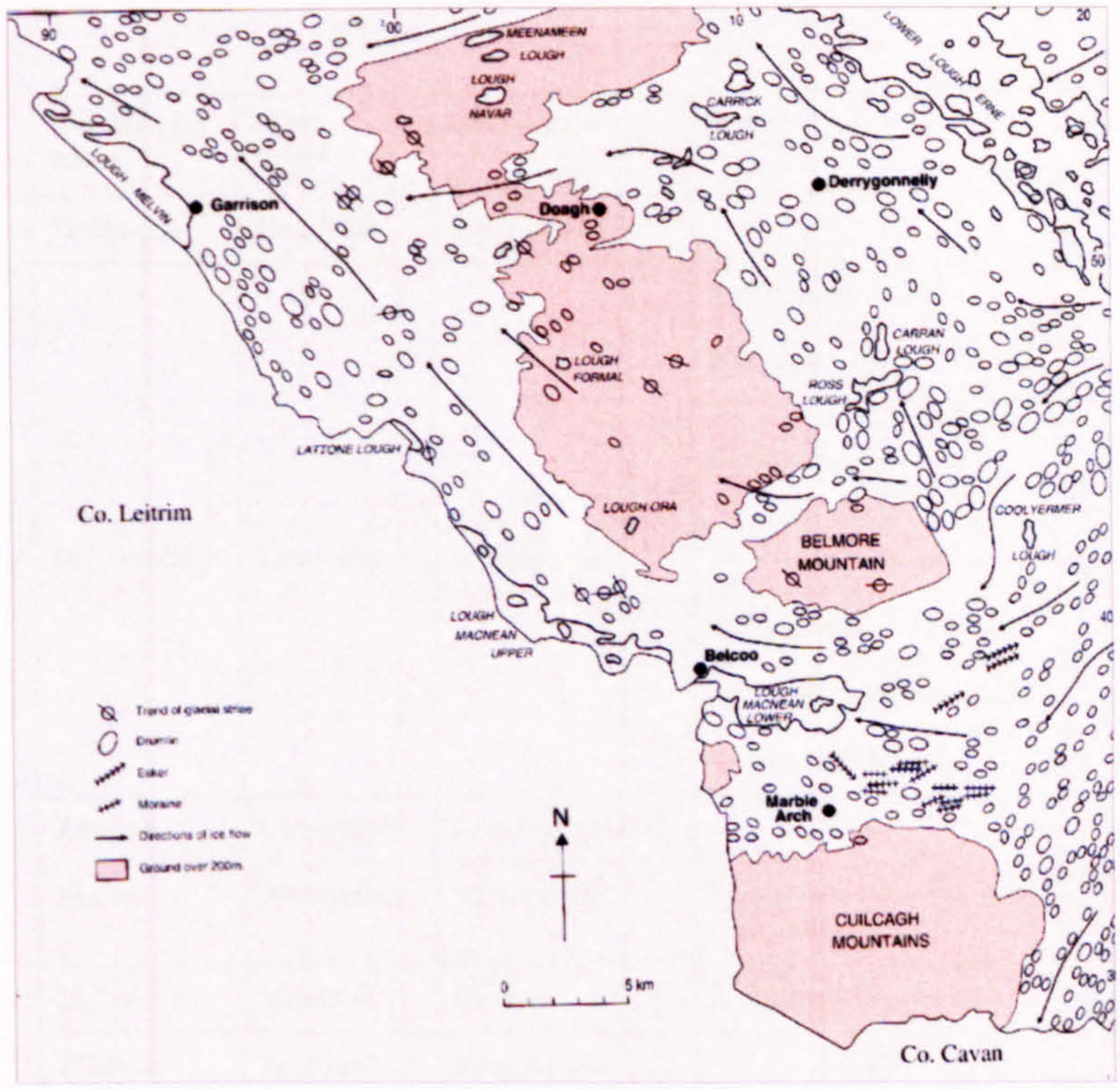



Figure 81. Distribution of glacial landforms in southwest Fermanagh (GSNI, 1998). Crown copyright. Reproduced with permission.

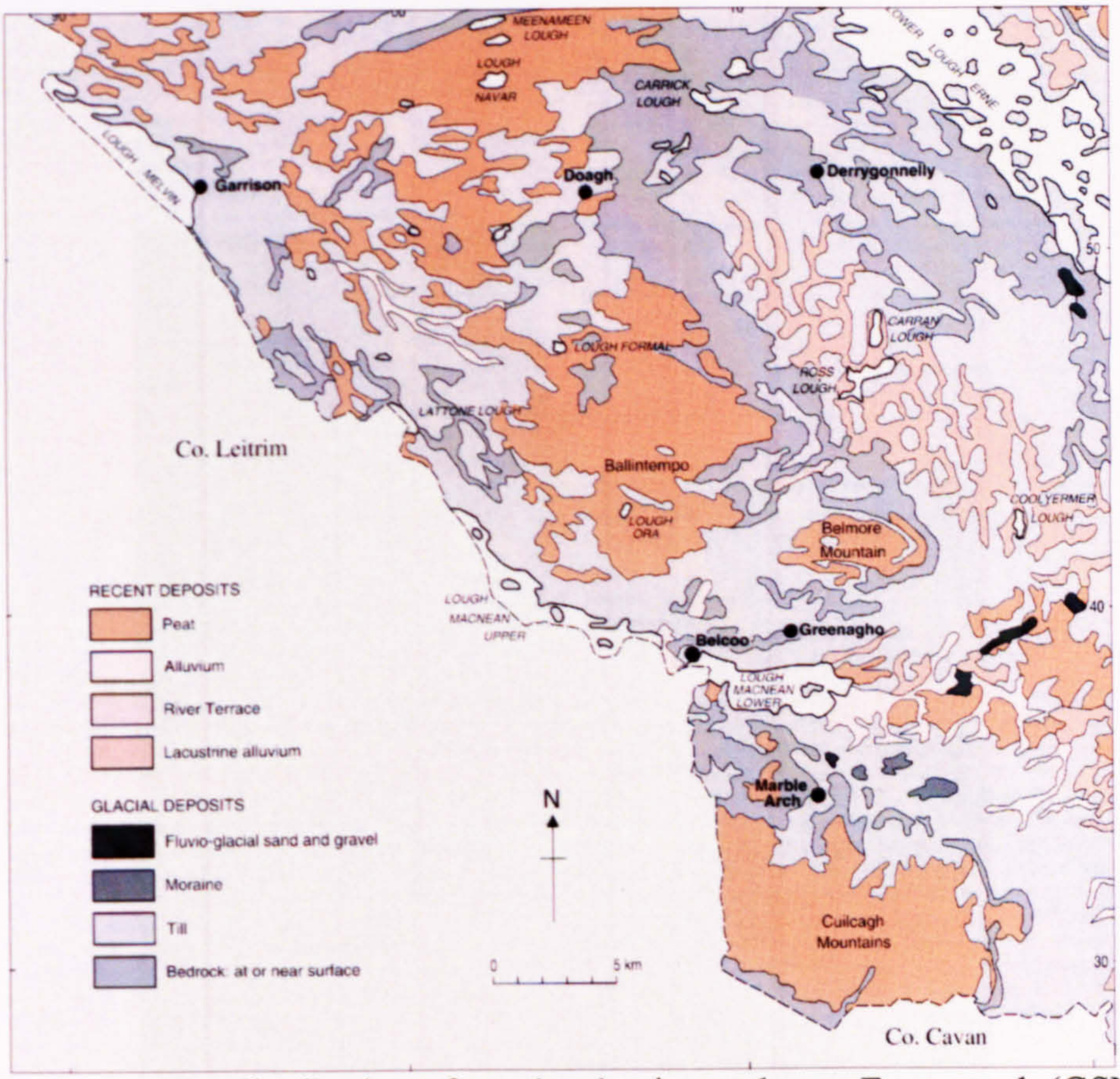



Figure 82. The distribution of overburden in southwest Fermanagh (GSNI, 1998). Crown copyright. Reproduced with permission.

| NW Europe stages | British stages | Irish stages | Events |
|---|---|---|---|
| Holocene | Flandrian | Littletonian | |
| Weichselian | Devensian | Midlandian | Nahanagan stadial |
| | | | Woodgrange Interstadial |
| | | | Drumlin phase<br>Glenavy Stadial<br>Main phase |
| | | | Derryvree Interstadial |
| | | | Hollymount Cold Phase |
| | | | Aghnadarragh Interstadial |
| | | | Fermanagh Stadial |
| Eemian | Ipswichian | Last Interglacial | ? |
| Saalian | Wolstonian | Munsterian | ?Stadia with Scottish and Irish influence |
| Holsteinian | Hoxnian | Gortian | Benburb Interglacial |
| Elsterian | Anglian | Pre-Gortian | ? |

Figure 83. Irish glacial stratigraphy (GSNI, 1998). Crown copyright. Reproduced with permission.

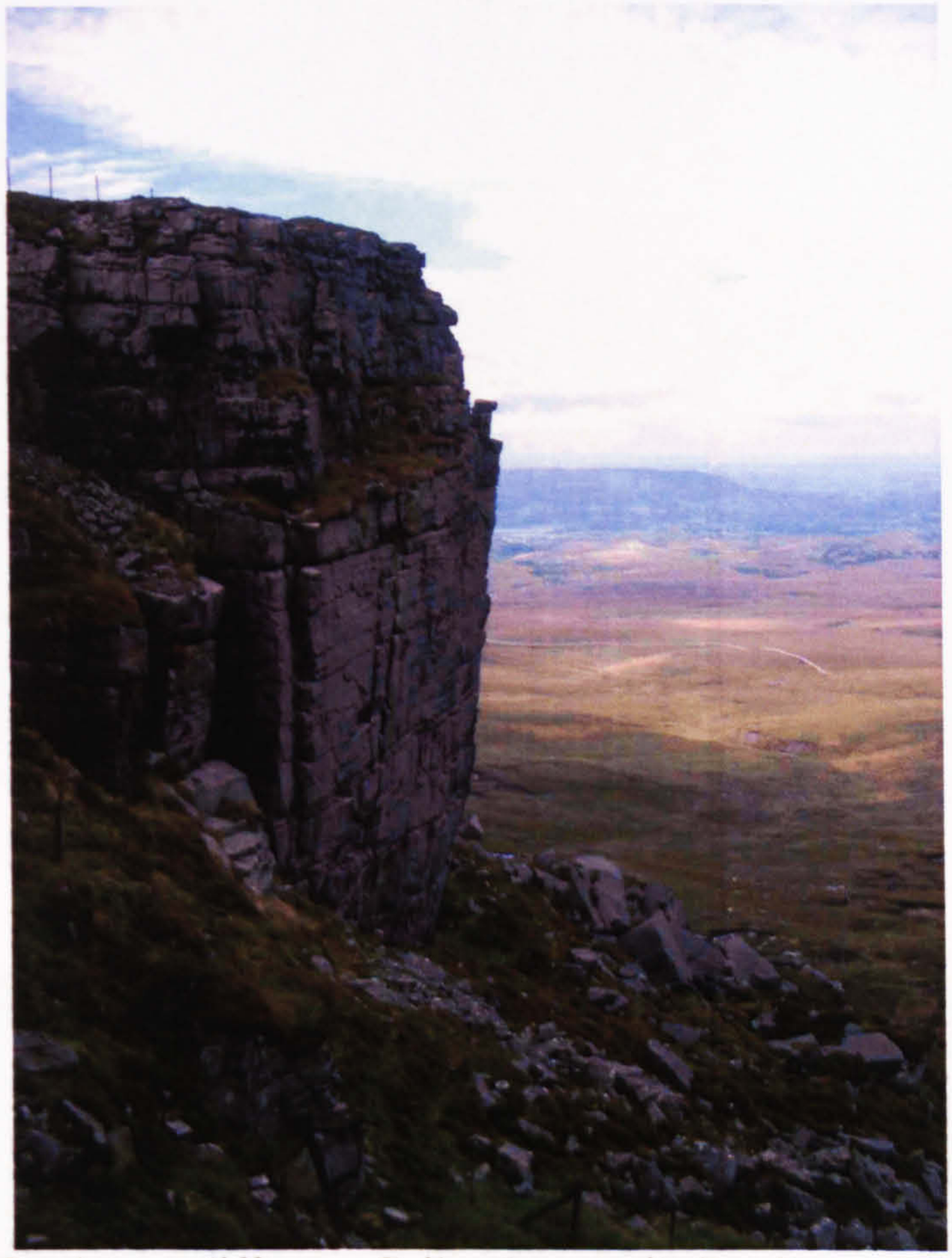


Plate 1. Sandstone cliffs near Cuilcagh summit. (Les Brown).

Plate 2. The mud mound topography of the Marlbank Escarpment. (Richard Watson).

Plate 3. A vertically extensive mud mound from the Knockmore Member of the Dartry Limestone Formation. Limekiln Hill, Marlbank. (Les Brown).

Plate 4. The well-bedded limestones with chert bands of the Gortalughany Member, Gortalughany Quarry, East Cuilcagh. (Les Brown).

Plate 5. Limestone pavement showing the dip slope located at the top of the Dartry Limestone Formation on the East Cuilcagh Escarpment. (Richard Watson).

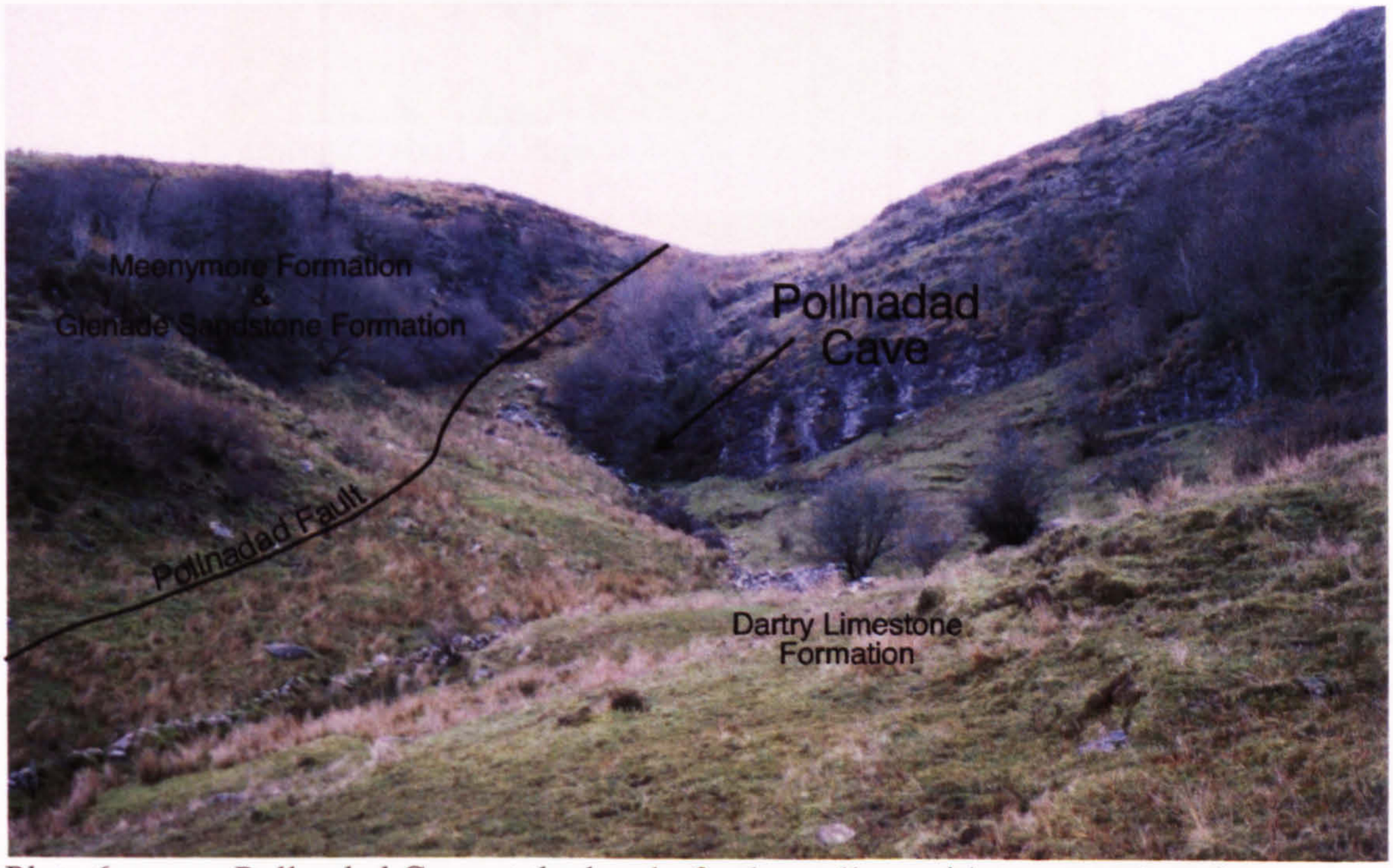



Plate 6. Pollnadad Cave at the head of a dry valley, with annotated geology. (Les Brown).

Plate 7. Entrance shaft of Pigeon Pot II. (Garret Devitt).

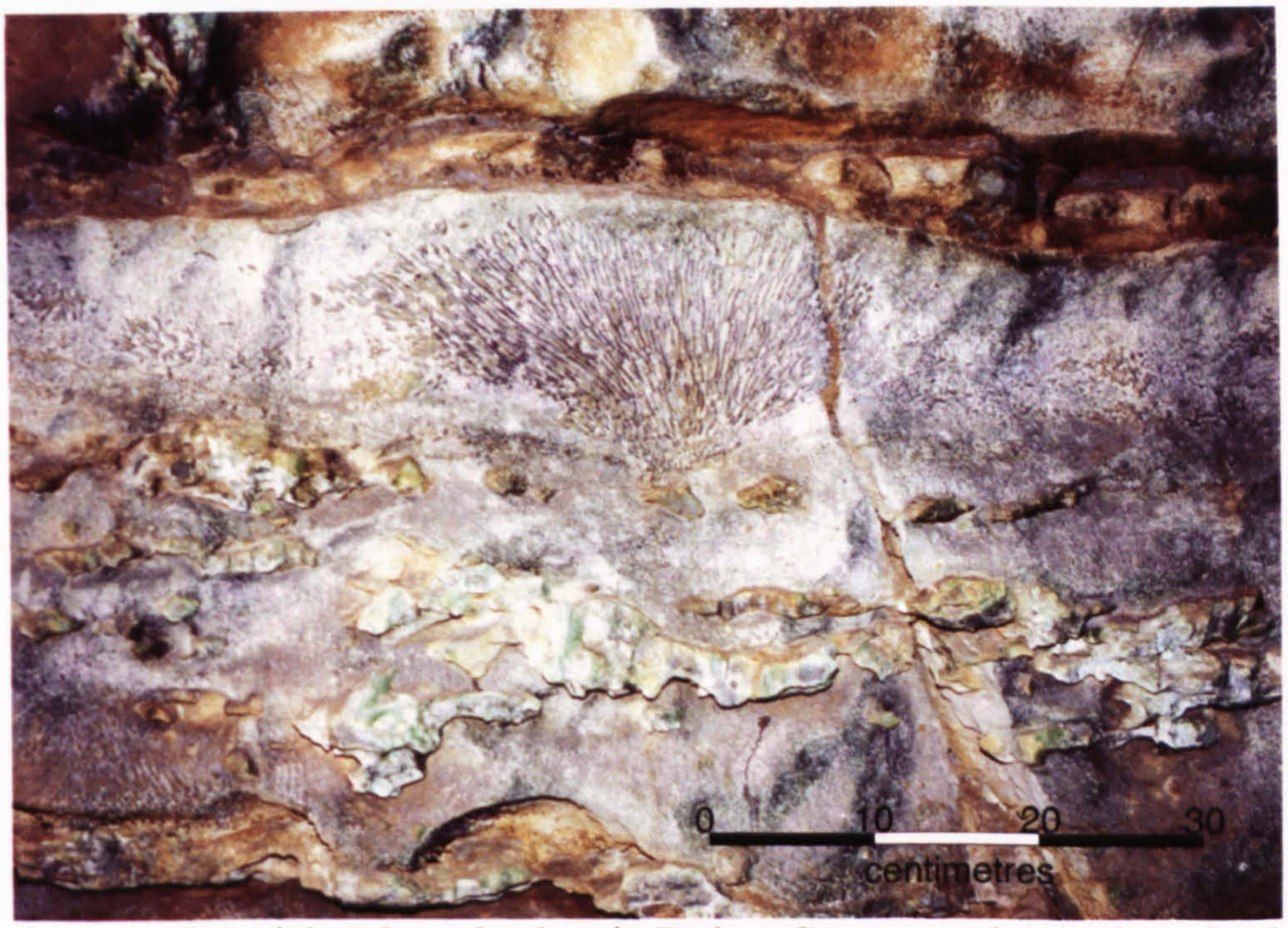



Plate 8. Colonial *siphonodendron* in Badger Cave, a marker horizon for the top of the Dartry Limestone Formation. (John Gunn).

Plate 9. Speleothem in Badger Cave. (John Gunn).

Plate 10. Half tube in roof of Badger Cave. (John Gunn).

Plate 11. Sample of intramound horizon taken from Skreen Hill I of Marble Arch Cave, showing the relative abundance of shell fragments and ferric iron. (John Gunn).


Plate 12. The stromatactis structure commonly found within the vertical-type mud mounds. Showing shelter cavities associated with bryozoa and final stage blocky calcite spar. (John Gunn).

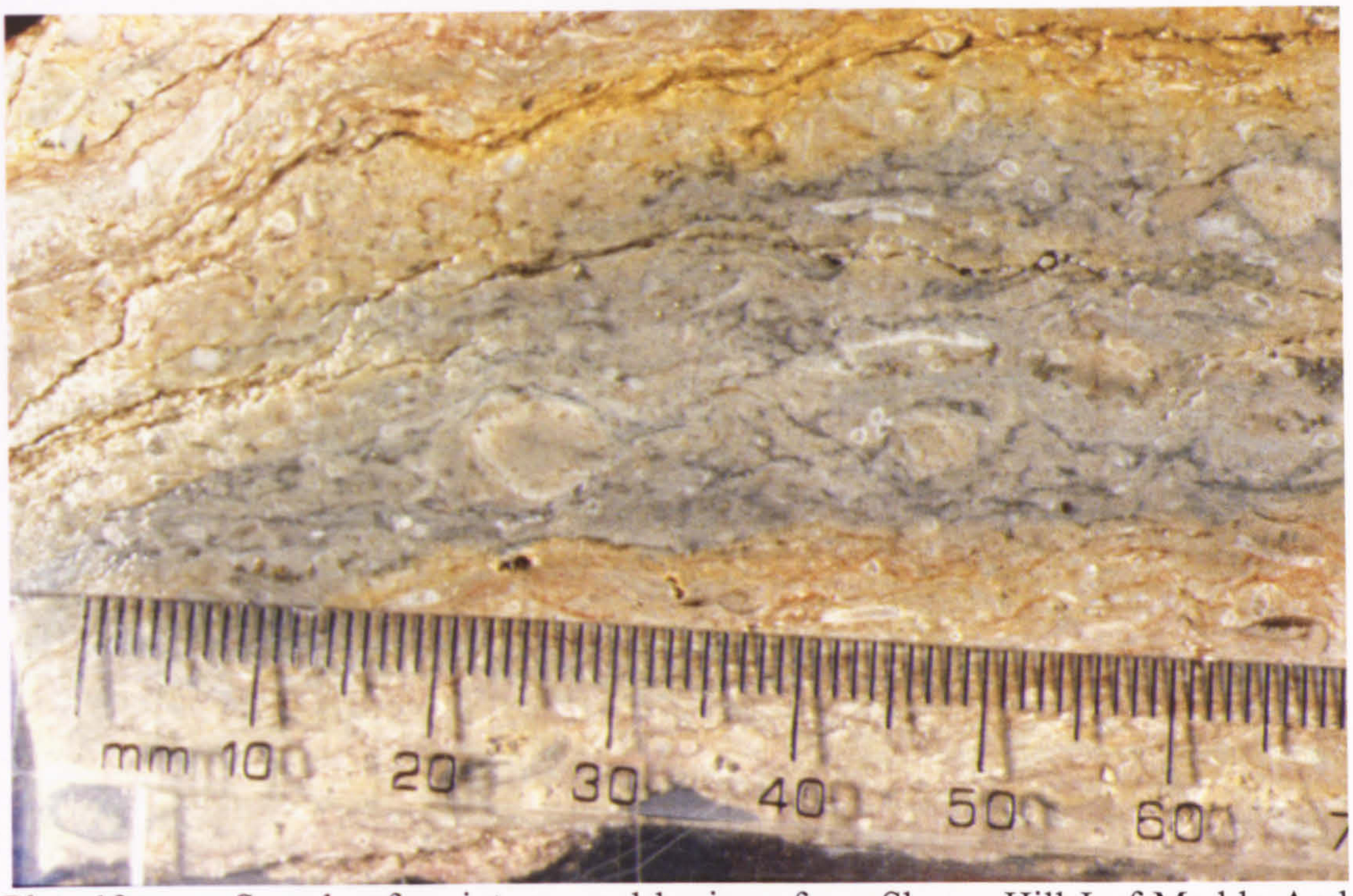



Plate 13. Sample of an intramound horizon from Skreen Hill I of Marble Arch Cave, which shows the development of pressure dissolution within the unit. (John Gunn).


Plate 14. Dolomitisation of micrite where stromatactis cavities exist gives the rock a gnarly texture. (John Gunn).


Plate 15. Cascades Rising showing the thinly bedded nature of the Glencar Limestone Formation. (John Gunn).

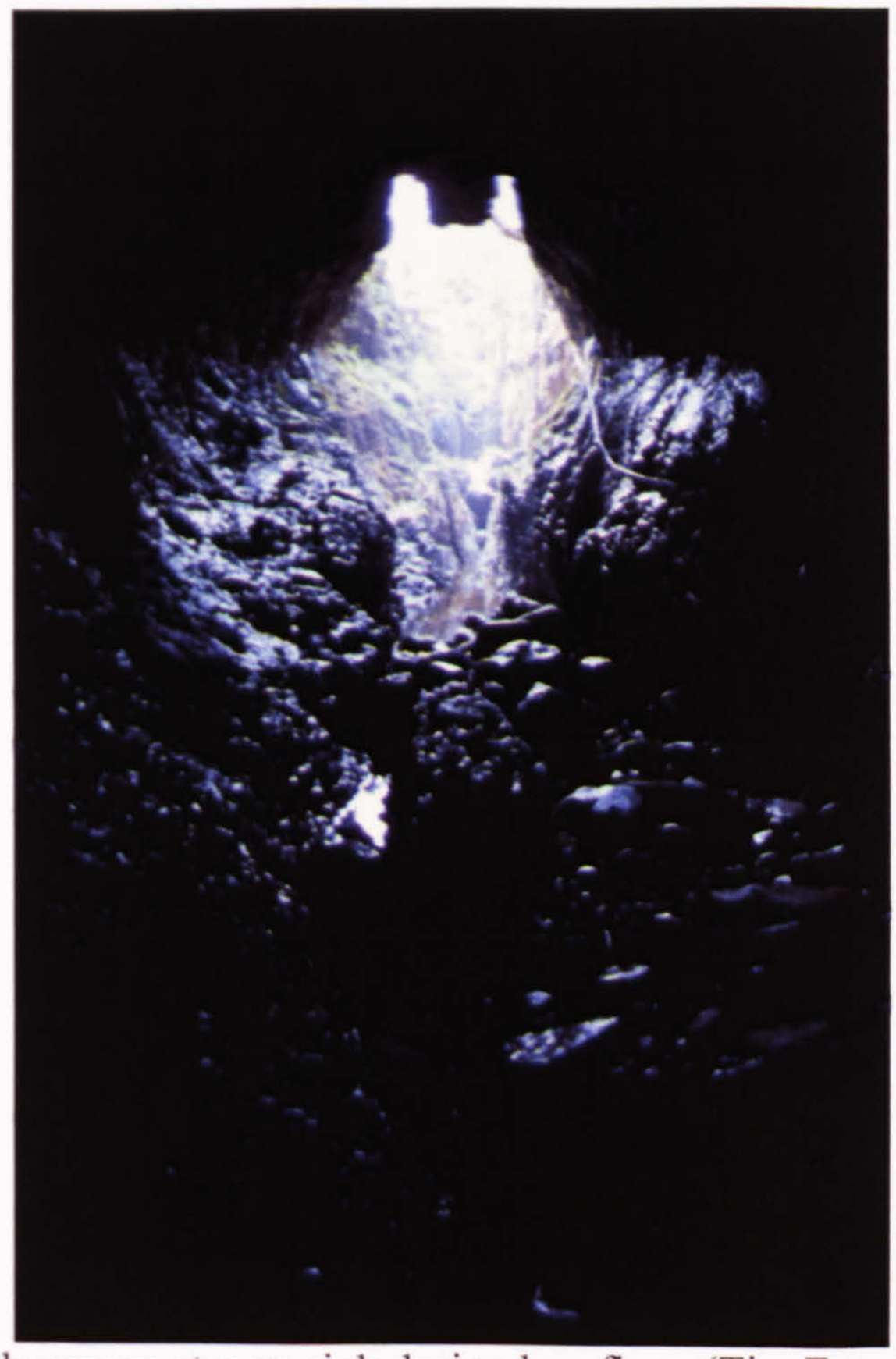


Plate 16. Pollasumera stream sink during low flow. (Tim Fogg).

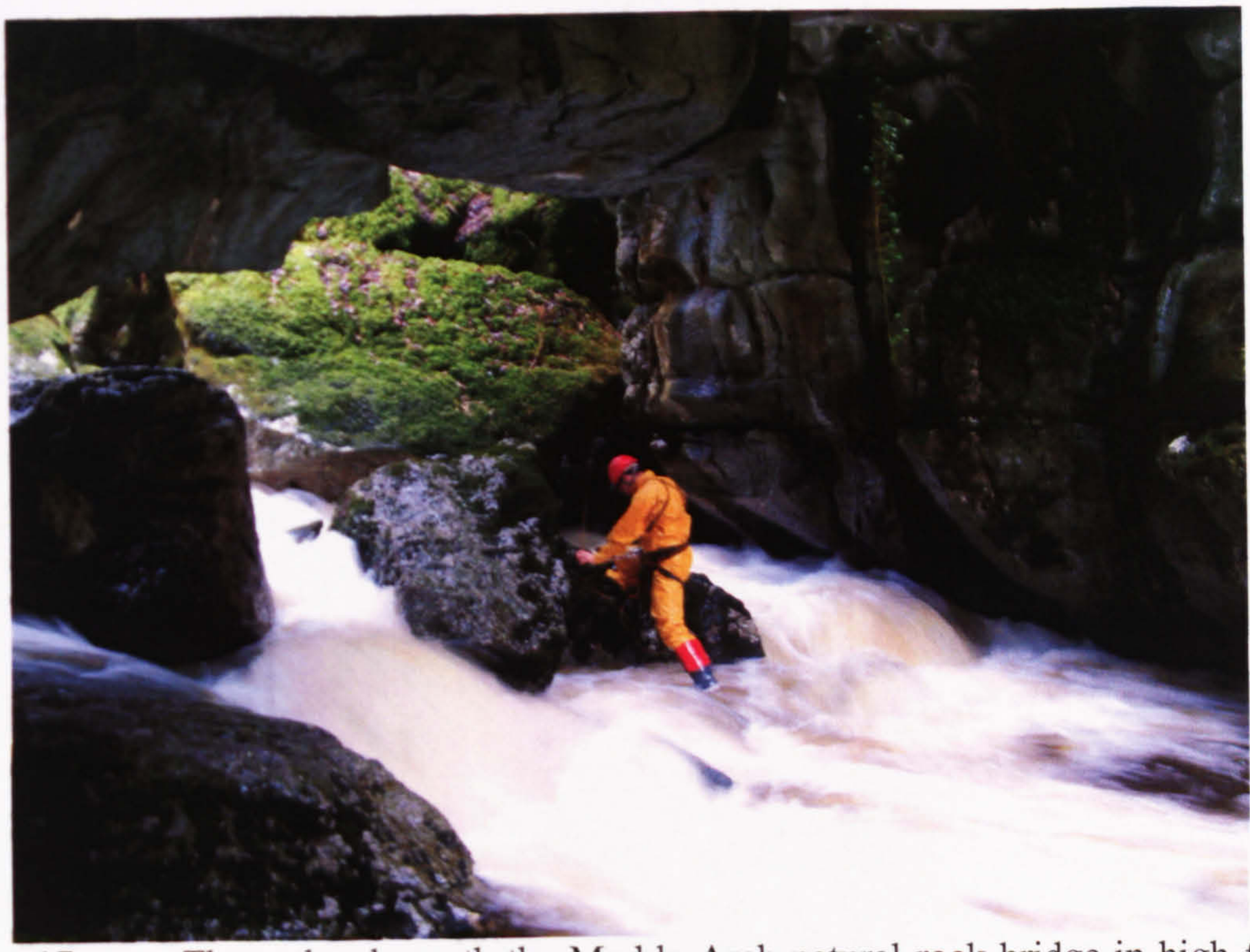


Plate 17. The author beneath the Marble Arch natural rock bridge in high flow conditions. (Laura Walsh).

Plate 18. The Dartry 'Type' Limestone at the top of the 33m shaft in Polltullyard. (Les Brown).

Plate 19. Bifurcation of the Hune Stream. Left hand stream drains to Pollnahune and right hand stream to Tullynakeeragh Gravel Lake. (Les Brown).

Plate 20. Soft sediment slumping in the Knockmore intramound at Journey's End of Skreen Hill I, Marble Arch Cave (see Figure 75 for location). (Les Brown).

Plate 21. Speleothem deposition from seepage draining from the Knockmore intramound on the up dip side of Skreen Hill I, Moses Walk in Marble Arch Cave (see Figure 75 for location). (Les Brown).

Plate 22. Speleothem deposition from seepage draining from the Knockmore intramound on the up dip side of Skreen Hill I, Moses Walk in Marble Arch Cave (see Figure 75 for location). (Les Brown).

Plate 23. The Knockmore intramound on the down dip side of Skreen Hill I, Moses Walk in Marble Arch Cave (see Figure 75 for location). (Les Brown).

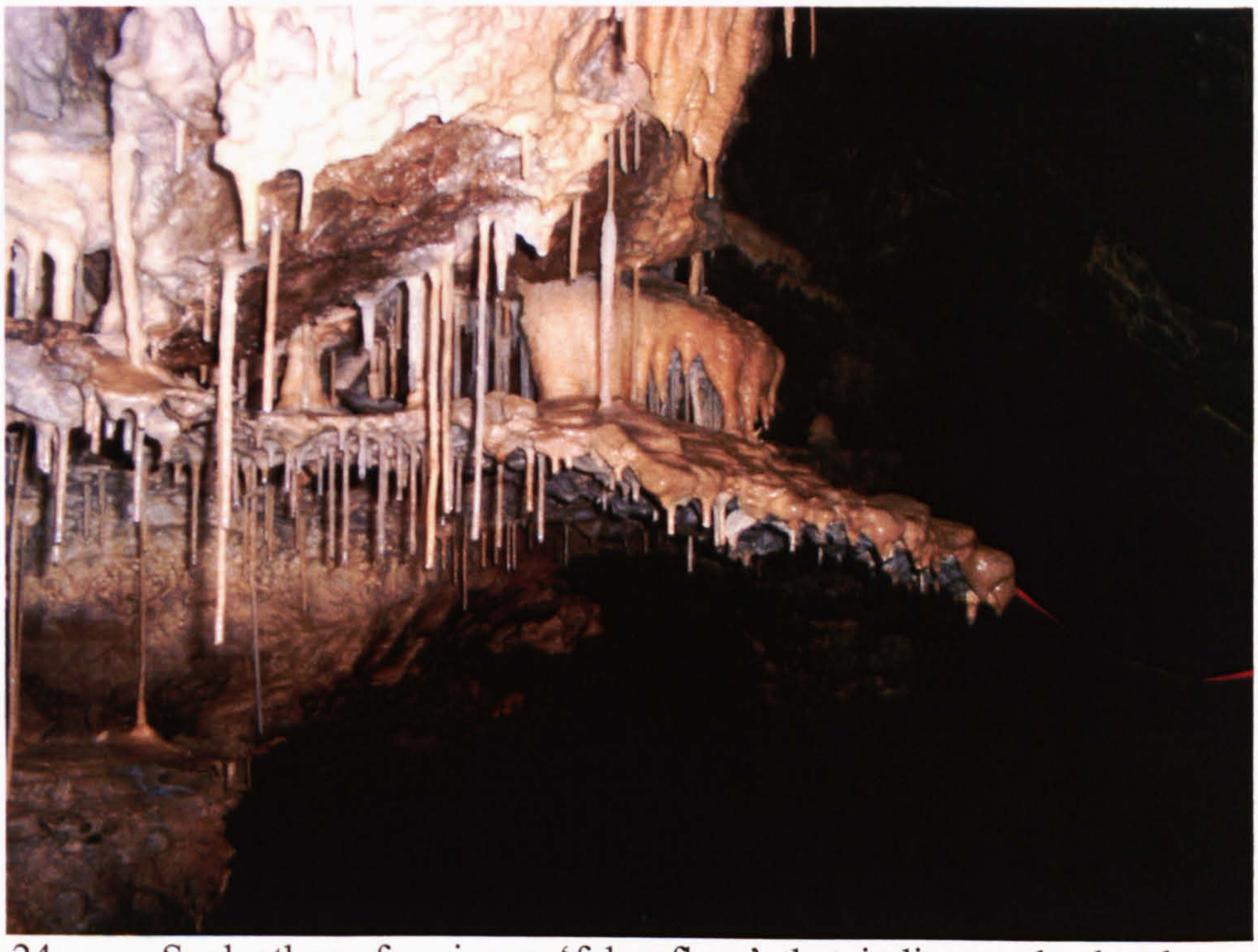


Plate 24. Speleothem forming a 'false floor' that indicates the level to which sediment had filled the passage, Legnabrocky Way, Marble Arch Cave (see Figure 76 for location). (Les Brown).

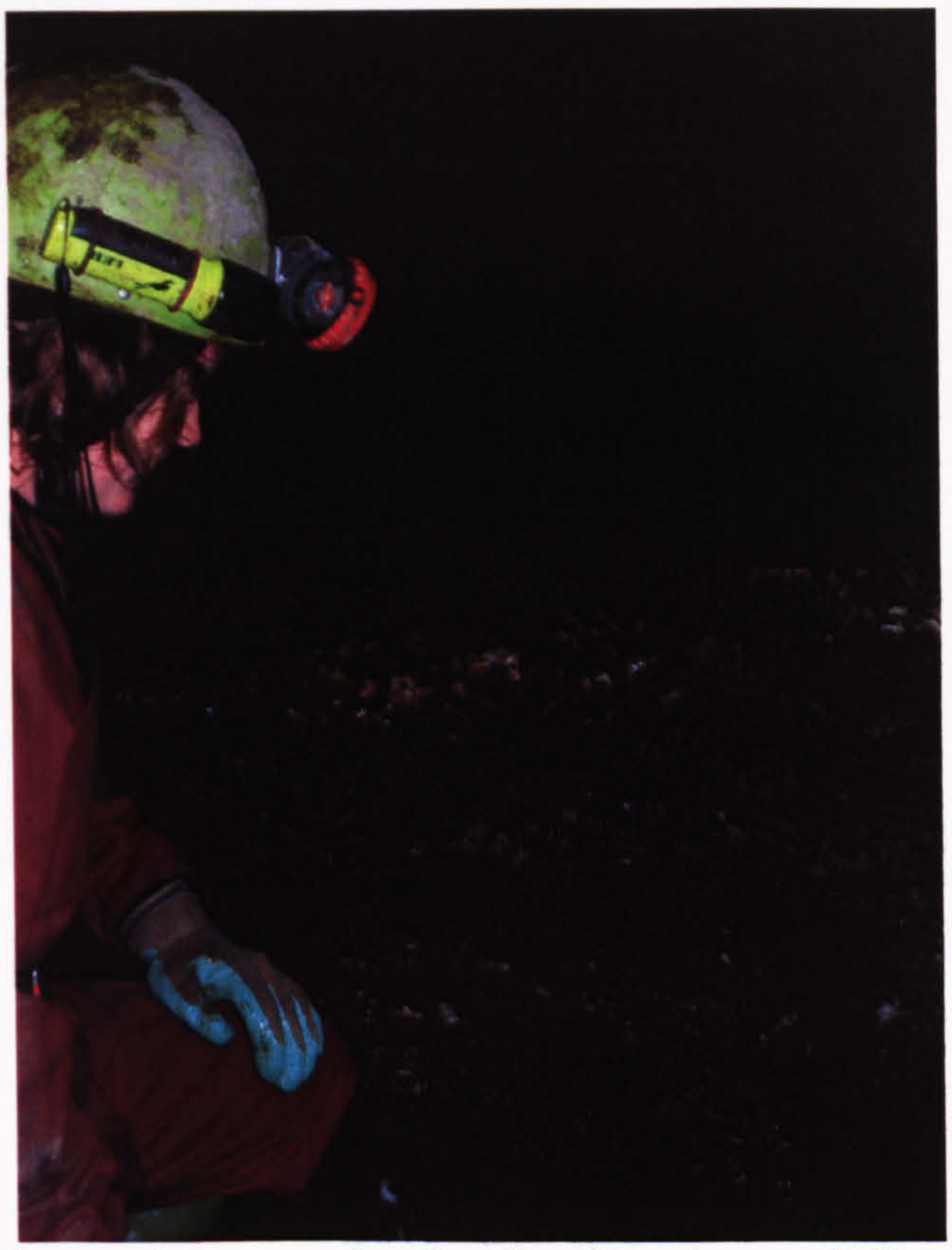


Plate 25. Rock step between the Sand's Chamber and Skreen Hill II records 0.75m of stream incision since Cascades and Marble Arch Cave became separated (see Figure 76 for location). (Les Brown).

Plate 26. Cemented cobbles preserved beneath flowstone, Skreen Hill II (See Figure 76 for location) (Les Brown).

Plate 27. Location of sample MAC1, Skreen Hill II, Marble Arch Cave. Stalactite had been displaced and was lying on side covered in fine-grained sediments (see Figure 76 for location). (Les Brown).

Plate 28. Speleothem sample MAC3 (left) in Skreen Hill II, Marble Arch Cave. Fine sand covers the base of the stalagmite (see Figure 76 for location). (Les Brown).

Plate 29. Sample MAC4. Broken speleothem in partially consolidated fluvio-glacial till, Legnabrocky Way, Marble Arch Cave (see Figure 76 for location). (Les Brown).

Plate 30. Speleothem sample MAC6 in Legnabrocky Way, Marble Arch Cave. Large slab of broken flowstone embedded in the stream floor. Sample is partially covered by well-rounded sandstone boulders (see Figure 76 for location). (Les Brown).

Plate 31. *'Mud towers'* formed in very fine grained sediments, Legnabrocky Way, Marble Arch Cave (field of view = *0.6m).* (See Figure 76 for location). (Les Brown).

Plate 32. Fine grained sediments, Legnabrocky Way, Marble Arch Cave (see Figure 76 for location). (Les Brown).

Plate 33. 'The Castle' a relict rim stone pool speleothem in Marble Arch Cave (see Figure 75 for location). (Les Brown).

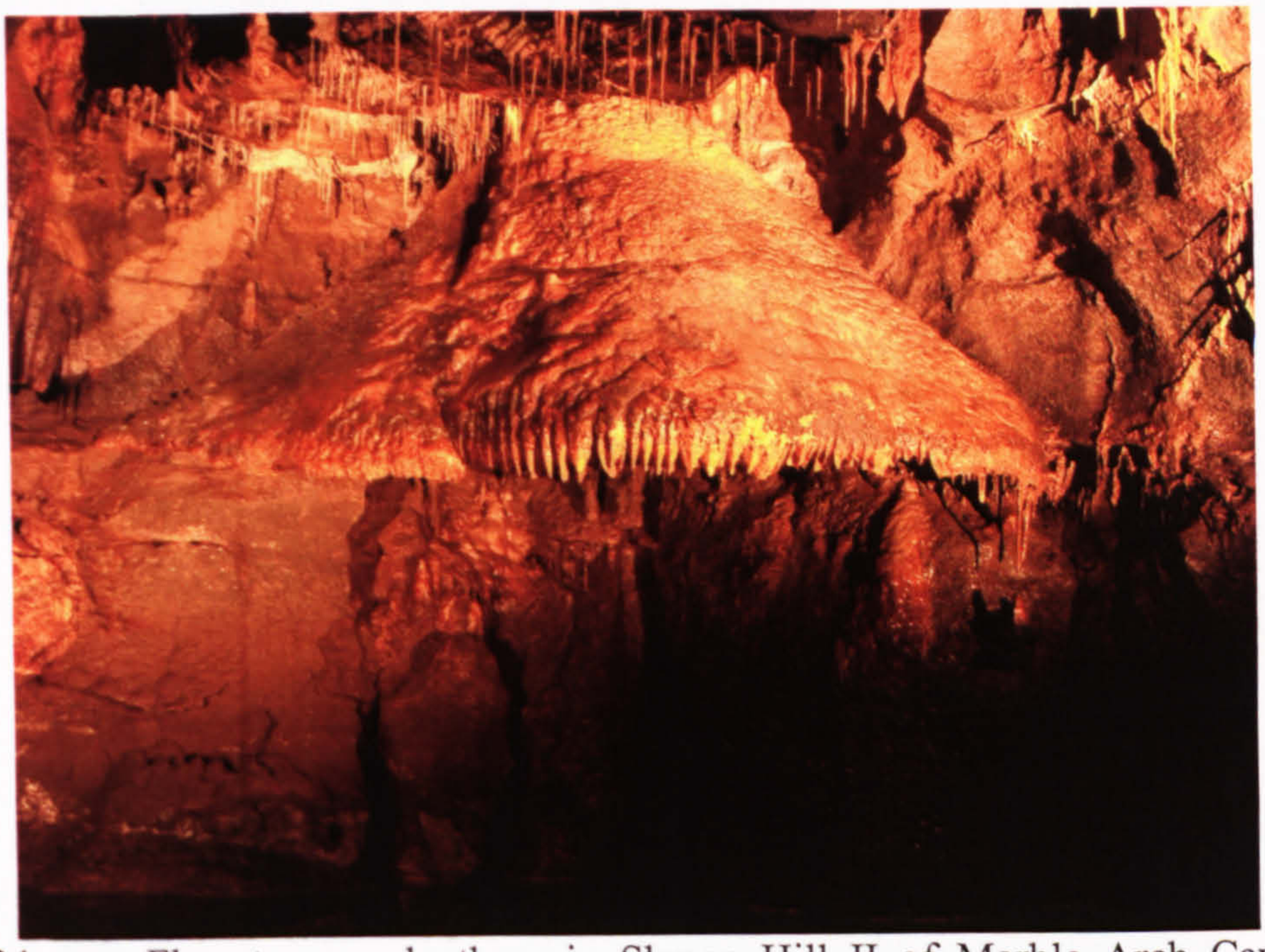


Plate 34. Flowstone speleothem in Skreen Hill II of Marble Arch Cave (see Figure 75 for location). (Les Brown).

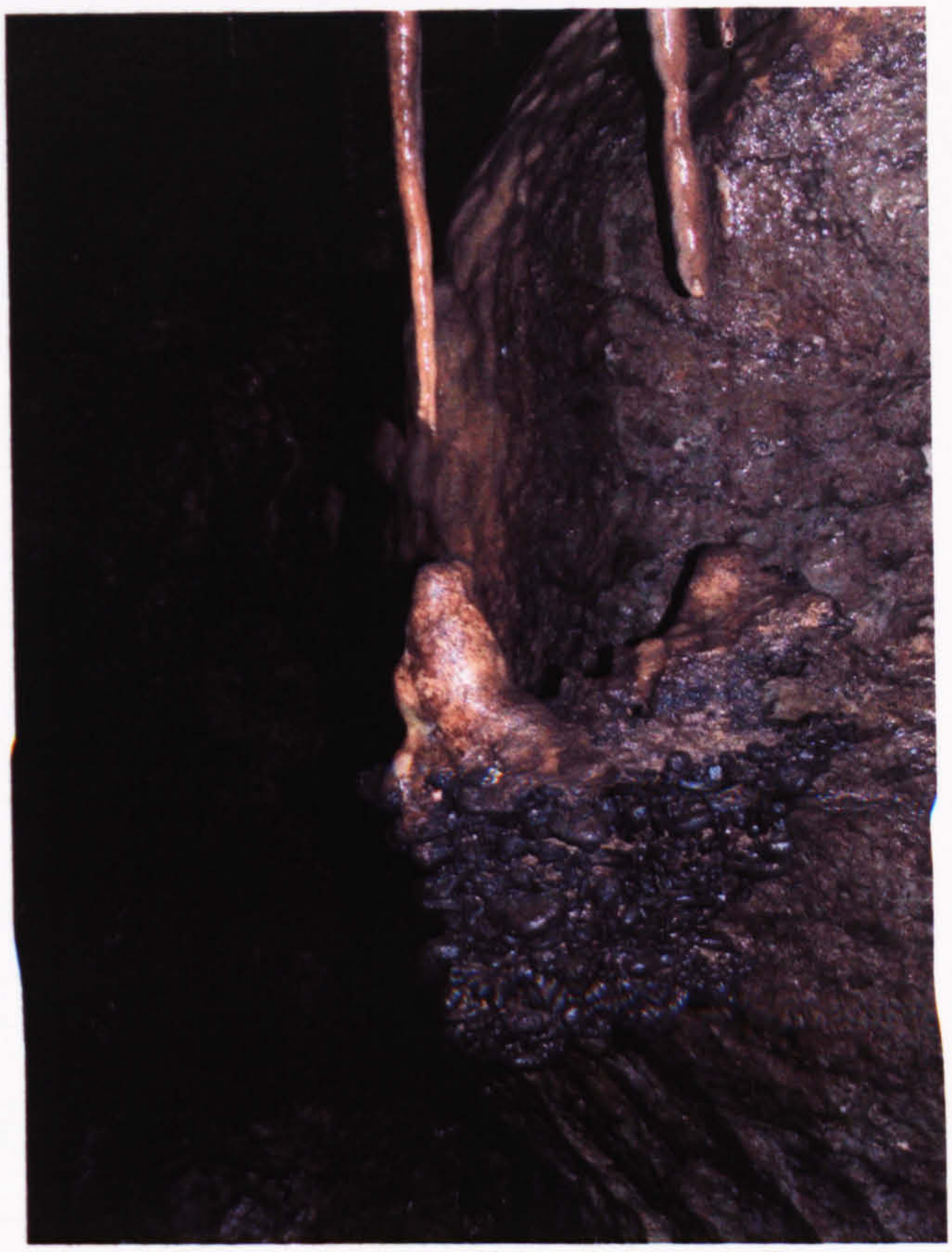


Plate 35. *Remnant* of partially consolidated gravel fill beneath flowstone (Plate 34). (Les Brown).

Plate 36. 'The Paddy Fields' a rim stone pool speleothem with embedded sandstone boulders, Skreen Hill I of Marble Arch Cave (see Figure 75 for location). (Les Brown).

| Rising to drainage system | Sinks traced to rising | Grid reference (Irish Grid, 1964) | Altitude (m AOD) | Depth of cave (m) | Average linear velocity (m/h) | Linear sink-rising gradient (m/km) |
|---|---|---|---|---|---|---|
| **R03 Sumera Rising (GR:217842-328253, Alt 139m)** | | | | | | |
| | G08 Polliniska [8] | 216460-328969 | 298 | 70 | - | 102 |
| | G13 Black Pot [8] | 216540-329467 | 302 | 60 | 30 | 86 |
| | B03 B.M.C. Pot [8] | 216384-330027 | 305 | 6 | - | 72 |
| | B16 Pollthanaclanawly [8] | 216448-329539 | 301 | 63 | 30 | 85 |
| | B18 Pigeon Pot II [8] | 215712-330526 | 298 | 52 | 45 | 51 |
| | B22 Badger Pot [8] | 215543-330670 | 301 | 5 | 50 | 60 |
| **R05 Gortalughany Rising (GR: 217126-330024, Alt: 239m)** | | | | | | |
| | B18 Pigeon Pot II [8] | 215712-330526 | 298 | 52 | 20 | 41 |
| | B22 Badger Pot [8] | 215543-330670 | 301 | 5 | 25 | 33 |
| **R06 Gortalughany Intake Rising (GR: 216437-330438, Alt 239m)** | | | | | | |
| | B18 Pigeon Pot II [8] | 215712-330526 | 298 | 52 | <20 | 46 |
| | B22 Badger Pot [8] | 215543-330670 | 301 | 5 | <20 | 39 |
| **R07 Gortalughany Farmyard Rising (GR: 216837-330637, Alt 243m)** | | | | | | |
| | B18 Pigeon Pot II [8] | 215712-330526 | 298 | 52 | <20 | 52 |
| | B22 Badger Pot [8] | 215543-330670 | 301 | 5 | <20 | 40 |

Notes [1] Brodrick (1908); [2] Wynn (1956); [3] Holgate (1954); [4] Devoy and Orr (1970); [5] Jones (1974), p.92; [6] Gunn (1982); [7] Gunn (1996); [8] Gunn *pers. comm.*, (1998).

Table 1. Summary of all water tracing experiments on the East Cuilcagh Escarpment by previous authors.

| Rising to drainage system | | Grid reference | Altitude | Depth of | Average linear | Linear sink-rising |
|---|---|---|---|---|---|---|
| | Sinks/cave passage traced to rising | (Irish Grid, 1964) | (m AOD) | cave (m) | velocity (m/h) | gradient (m/km) |
| **T1 Tullyhona Rising (GR:21533-33373, Alt 193m)** | | | | | | |
| | Whiskey Holes [5] (Via oxbow Inlet) | 21503-33335 | 238 | 12 | 77 | 120 |
| | Brookfield 1 [6] (Via oxbow Inlet) | 21457-33338 | 220 | - | 50 | 83 |
| | Dicks Sinks [8] | 21545-33332 | 236 | - | - | - |
| | F03 Goat Pot [8] | 215717-331390 | 328 | 15 | <30 | 59 |
| **C1 Cascades Rising (GR: 21228-33498, Alt 119m)** | | | | | | |
| | Downstream Sump 1 in Prods Cave [4] | - | - | - | 260 | - |
| | Smokey Mountain [6] | 21396-33372 | 231 | 7 | 120 | 49 |
| | Brookfield 3 [6] | 21453-33339 | 220 | - | 260 | 50 |
| | Brookfield 8 [6] | 21421-33339 | 218 | - | 300 | 51 |
| | Owenbrean Upper Sinks [8] | 212782-331986 | 243 | - | >80 | 33 |
| | Owenbrean Lower Sinks [8] | 213298-327740 | 214 | - | - | 42 |
| | B18 Pigeon Pot II [7 and 8] | 215712-330526 | 298 | 52 | 78 | 32 |
| | B22 Badger Pot [7 and 8] | 215543-330670 | 301 | 5 | 75 | 44 |
| | F03 Goat Pot [7 and 8] | 215717-331390 | 328 | 15 | - | 54 |
| **M33 Marble Arch Rising (GR: 2121-3344, Alt: 128m)** | | | | | | |
| | Sruh Croppa (Cats' Hole) [4] | 21166-33374 | 169 | 17 | >34 | 53 |
| | Pollasumera [5] | 21302-33319 | 197 | - | 320* | 55 |
| | Monastir [1] | 21195-33350 | 159 | - | 32 | 49 |
| **H1 Hanging Rock Rising (GR: 21045-33663, Alt 83m)** | | | | | | |
| | Legacapple [6] | 20965-33496 | 166 | - | 150 | 57 |
| **Ture Main Rising (GR: 20783-33735, Alt: 83m)** | | | | | | |
| | Legnaveagh Sink [8] | 20767-33553 | 218 | - | - | 60 |
| | Super Star Pot [8] | 20730-33735 | 209 | - | - | 58 |
| **Barran Rising 1 (GR: 20418-33596, Alt: 77m)** | | | | | | |
| | Pollnagossan [6] | 20625-33528 | 208 | 15 | 50 | 58 |
| | Pollnaskeoge [6] | 20544-33527 | 171 | - | - | 49 |

Notes [1] Brodrick (1908) [2] Wynn (1956); [3] Holgate (1954); [4] Devoy and Orr (1970); [5] Jones (1974), p.92; [6] Gunn (1982); [7] Gunn (1996); [8] Gunn *pers. comm.*, (1998).

Table 2. Summary of all water tracing experiments to risings on the northern part of the Marlbank Escarpment by previous authors.

| Rising to drainage system | | Grid reference | Altitude | Depth of cave | Average linear | Linear sink-rising |
|---|---|---|---|---|---|---|
| | Sinks traced to rising | (Irish Grid, 1964) | (m AOD) | (m) | velocity (m/h) | gradient (m/km) |
| **Shannon Pot Rising (GR:205406 331814, Alt 106 m)** | | | | | | |
| | Legeelan Lower [6] | 206788-333698 | 164 | 2 | 120 | 24 |
| | Gowlan 1 [6] | 206767-333556 | 157 | 2 | 130 | 25 |
| | Pollnaowen [6] | 206890-333224 | 154 | 4 | 240 | 22 |
| | Pollboy [6] | 206979-332827 | 149 | 8 | (80-250) | 23 |
| | Garvagh 1 [6] | 207776-332879 | 167 | 1 | 60 | 29 |
| | Pollnahune stream sink [6] | 209447-332410 | 252 | 3 | <90 | 36 |
| | Tullynakeeragh [6] | 209767-331887 | 276 | 9 | 105 | 40 |
| | Derrylahan 1 [6] | 205979-332012 | 128 | 2 | 50 | 60 |
| | Derrylahan 5 [6] | 205521-331809 | 138 | 1 | 140 | 70 |
| | Polltullyard [8] | 209441-332418 | 261 | 48 | - | 39 |
| | Killykeegan 5 [8] | 209415-332810 | 189 | 1 | - | 33 |
| | Killykeegan 8 [8] | 210231-332185 | 236 | 6 | - | 32 |
| | B18 Pigeon Pot II [7 and 8] | 215712-330526 | 298 | 48 | 100 | 20 |
| | B22 Badger Pot [7 ad 8] | 215543-330670 | 301 | 5 | 85 | 22 |

Notes [1] Brodrick (1908) [2] Wynn (1956); [3] Holgate (1954); [4] Devoy and Orr (1970); [5] Jones (1974), p.92; [6] Gunn (1982); [7] Gunn (1996); [8] Gunn *pers. comm.*, (1998).
Note that multiple traces have been undertaken from some sinks.

Table 3. Summary of all water tracing experiments to risings on the southern part of the Marlbank Escarpment by previous authors.

| | Sampling during low flow (22nd-24th January 1997) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Temp °C | pH | Cond. µS/cm | $HCO_3$ mg/l | Cl mg/l | $NO_3$ mg/l | $SO_4$ mg/l | Ca mg/l | Mg mg/l | Na mg/l | K mg/l | Fe mg/l | Sr mg/l | $\partial^{13}C_{PDB}$ | $\partial^{34}S_{CDT}$ |
| **East Cuilcagh Karst** | | | | | | | | | | | | | | | |
| Aghaboy Springs (R02) | 7.60 | 8.23 | 322 | 155 | 9.8 | 0.8 | 4.6 | 55.1 | 4.3 | 6.5 | 0.3 | 0.1 | 0.15 | -12.7 | 9.2 |
| Sumera Rising (R03) | 7.10 | 7.11 | 167 | 60 | 7.2 | 1.2 | 7.7 | 22.6 | 2.6 | 5.8 | 2.0 | 0.1 | 0.33 | n/s | n/s |
| Gortalughany Intake (R06) | 8.30 | 7.64 | 352 | 165 | 9.9 | 0.0 | 5.6 | 55.1 | 4.3 | 6.5 | 0.3 | 0.1 | 0.15 | -12.7 | 9.2 |
| **Erne Karst** | | | | | | | | | | | | | | | |
| Tullyhona Rising | 7.10 | 8.31 | 245 | 105 | 9.1 | 0.8 | 4.5 | 34.4 | 2.2 | 7.3 | 1.0 | 0.3 | 0.29 | -18.7 | 6.6 |
| Cascades Rising | 8.20 | 8.07 | 257 | 127 | 8.6 | 0.0 | 4.8 | 36.5 | 5.1 | 5.4 | 0.9 | 0.1 | 0.27 | n/s | n/s |
| Marble Arch Rising | 5.00 | 7.87 | 108 | 54 | 7.3 | 0.4 | 6.2 | 12.7 | 1.9 | 6.6 | 0.5 | 0.3 | 0.15 | n/s | n/s |
| Inlet into Moses Walk | 8.50 | 7.87 | 467 | 239 | 8.3 | 3.0 | 3.9 | 77.7 | 5.4 | 6.7 | 0.5 | 0.1 | 0.15 | -14.5 | 14.5 |
| Cladagh West | n/s | n/s | n/s | n/s | n/s | n/s | n/s | n/s | n/s | n/s | n/s | n/s | n/s | n/s | n/s |
| Cladagh West 1 | 8.50 | 8.33 | 426 | 207 | 13.8 | 6.6 | 7.2 | 68.5 | 15.5 | 7.7 | 1.0 | 0.1 | 0.15 | n/s | n/s |
| Cladagh West 2 | 9.10 | 7.91 | 400 | 196 | 12.1 | 4.5 | 5.1 | 65.6 | 11.1 | 6.4 | 0.5 | 0.1 | 0.14 | n/s | n/s |
| Hanging Rock Main Rising | 8.60 | 7.39 | 416 | 196 | 11.7 | 5.2 | 5.2 | 70.9 | 2.6 | 8.2 | 2.9 | 0.1 | 0.18 | -16.5 | 10.0 |
| Ture Main Rising | n/s | n/s | n/s | n/s | n/s | n/s | n/s | n/s | n/s | n/s | n/s | n/s | n/s | n/s | n/s |
| Ture East | 9.00 | 7.07 | 607 | 249 | 19.2 | 8.8 | 8.8 | 77.9 | 3.4 | 10.9 | 0.9 | 0.1 | 0.28 | -15.0 | 4.4 |
| Ture West | 8.30 | 7.82 | 549 | 271 | 11.7 | 17.1 | 4.4 | 113.2 | 1.6 | 6.2 | 1.1 | 0.1 | 0.18 | n/s | n/s |
| Marlbank West | 9.30 | 7.27 | 535 | 322 | 13.2 | 8.5 | 5.7 | 94.7 | 5.3 | 7.5 | 0.9 | 0.1 | 0.44 | -15.7 | 7.6 |
| Marlbank East | 6.40 | 8.20 | 566 | 328 | 14.7 | 10.5 | 10.3 | 86.6 | 4.0 | 9.5 | 0.8 | 0.1 | 0.38 | n/s | n/s |
| Barran Rising 1 | 7.70 | 7.42 | 254 | 95 | 15.9 | 1.0 | 5.4 | 35.6 | 6.1 | 8.3 | 0.7 | 0.2 | 0.11 | -23.3 | 9.2 |
| Barran Rising 2 | 7.40 | 6.73 | 427 | 206 | 13.9 | 1.3 | 6.4 | 71.4 | 2.4 | 8.9 | 1.7 | 0.4 | 0.17 | n/s | n/s |
| Barran Rising 3 | 6.00 | 7.04 | 710 | 322 | 19.0 | 0.0 | 5.2 | 88.2 | 3.0 | 22.9 | 3.4 | 0.1 | 3.30 | -16.0 | 38.3 |
| **Shannon Karst** | | | | | | | | | | | | | | | |
| Shannon Pot Rising | 6.80 | 7.38 | 209 | 62 | 10.7 | 1.6 | 5.8 | 23.7 | 2.2 | 7.3 | 1.0 | 0.3 | 0.29 | -18.7 | 6.6 |

Table 4. Chemical analyses of emergent waters from karstic risings in the Cuilcagh uplands during low flow conditions (Based on unpublished work by Neil Webber, Limestone Research Group, University of Huddersfield).

| | Sampling during high flow (24th-26th May 1996) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Temp °C | pH | Cond. µS/cm | $HCO_3$ mg/l | Cl mg/l | $NO_3$ mg/l | $SO_4$ mg/l | Ca mg/l | Mg mg/l | Na mg/l | K mg/l | Fe mg/l | Sr mg/l | $\partial^{13}C_{PDB}$ | $\partial^{34}S_{CDT}$ |
| **East Cuilcagh Karst** | | | | | | | | | | | | | | | |
| Aghaboy Springs (R03) | 9.90 | 7.74 | 275 | 148 | 8.8 | 2.1 | 3.5 | 55.0 | 2.0 | 4.7 | 0.4 | 0.2 | 0.14 | -12.3 | 12.4 |
| Sumera Rising (R04) | 7.80 | 6.92 | 126 | 51 | 6.0 | 0.9 | 5.2 | 19.0 | 2.4 | 4.2 | 0.6 | 0.3 | 0.23 | n/s | n/s |
| Gortalughany Intake (R06) | 8.20 | 7.60 | 313 | 172 | 10.5 | 0.6 | 5.4 | 60.0 | 4.2 | 5.0 | 0.4 | 0.1 | 0.26 | -12.5 | 11.2 |
| **Erne Karst** | | | | | | | | | | | | | | | |
| Tullyhona Rising | 8.20 | 7.80 | 265 | 107 | 7.3 | 1.0 | 4.0 | 34.0 | 3.9 | 4.6 | 0.5 | 0.3 | 0.11 | n/s | n/s |
| Cascades Rising | 9.20 | 7.99 | 182 | 84 | 6.9 | 1.3 | 3.5 | 27.0 | 3.6 | 4.2 | 0.5 | 0.3 | 0.36 | n/s | n/s |
| Marble Arch Rising | 8.90 | 7.21 | 68 | 36 | 5.2 | 0.4 | 3.2 | 10.0 | 1.2 | 3.6 | 0.5 | 0.7 | 0.02 | n/s | 4.0 |
| Inlet into Moses Walk | 8.20 | 7.16 | 317 | 161 | 7.7 | 7.0 | 4.0 | 59.0 | 3.8 | 5.0 | 0.6 | 0.3 | 0.19 | -15.6 | 8.8 |
| Cladagh West | 9.10 | 7.91 | 442 | 261 | 13.5 | 7.8 | 13.8 | 78.0 | 6.2 | 7.6 | 1.0 | 0.1 | 0.45 | -13.1 | -2.5 |
| Cladagh West 1 | 11.90 | 8.26 | 343 | 176 | 14.8 | 6.6 | 8.4 | 62.0 | 4.9 | 6.9 | 0.9 | 0.1 | 0.26 | n/s | n/s |
| Cladagh West 2 | 10.00 | 8.20 | 358 | 207 | 12.7 | 5.3 | 4.4 | 66.0 | 4.5 | 5.9 | 0.6 | 0.2 | 0.23 | n/s | n/s |
| Hanging Rock East Rising | 8.70 | 7.38 | 401 | 227 | 10.9 | 5.0 | 5.6 | 82.0 | 3.9 | 6.4 | 0.9 | 0.3 | 0.36 | -15.3 | 6.7 |
| Ture Main Rising | 8.50 | 7.42 | 310 | 167 | 13.0 | 4.1 | 6.9 | 58.0 | 3.1 | 6.5 | 0.7 | 0.2 | 0.23 | n/s | n/s |
| Ture East | 9.50 | 7.04 | 529 | 287 | 17.0 | 10.8 | 9.1 | 104.0 | 4.9 | 8.4 | 0.8 | 0.2 | 0.46 | -15.4 | 2.3 |
| Ture West | 9.30 | 7.30 | 488 | 276 | 13.5 | 18.1 | 4.6 | 99.0 | 3.1 | 6.0 | 1.0 | 0.3 | 0.29 | n/s | n/s |
| Marlbank West | 9.30 | 6.94 | 409 | 232 | 12.7 | 11.0 | 5.0 | 73.0 | 3.5 | 5.8 | 1.3 | 0.2 | 0.30 | -16.1 | 7.9 |
| Marlbank East | 8.50 | 7.83 | 370 | 203 | 15.5 | 6.8 | 6.6 | 78.0 | 4.2 | 6.6 | 0.5 | 0.2 | 0.24 | n/s | n/s |
| Barran Rising 1 | 8.30 | 7.03 | 260 | 143 | 12.7 | 1.5 | 6.6 | 48.0 | 3.4 | 7.2 | 2.1 | 0.6 | 0.17 | -14.2 | 10.7 |
| Barran Rising 2 | 7.90 | 7.55 | 254 | 124 | 14.2 | 1.2 | 5.9 | 51.0 | 3.0 | 6.7 | 0.8 | 0.3 | 0.15 | n/s | n/s |
| Barran Rising 3 | 9.40 | 7.35 | 619 | 326 | 19.3 | 0.0 | 6.4 | 54.0 | 6.8 | 13.5 | 1.6 | 0.3 | 2.34 | -13.7 | 30.6 |
| **Shannon Karst** | | | | | | | | | | | | | | | |
| Shannon Pot Rising | 8.20 | 7.37 | 187 | 98 | 9.4 | 1.4 | 5.8 | 29.0 | 3.1 | 5.6 | 0.8 | 0.5 | 1.19 | -14.7 | 17.9 |

Table 5. Chemical analyses of emergent waters from karstic risings in the Cuilcagh uplands during high flow conditions (Based on unpublished work by Neil Webber, Limestone Research Group, University of Huddersfield).

| Field measurements (January 1997) | | |
|---|---|---|
| Site | Temperature [1] | Conductivity [2] |
| | °C | µS/cm |
| | | |
| Aghaboy Rising | 7.5 | 56 |
| Pollnagollum Aghaboy | 7.6 | 47 |
| Gortalughany Rising | 7.7 | 150 |
| Gortalughany Intake | 8.2 | 370 |
| | | |
| Cascades Rising | 8.2 | 257 |
| Formations Passage | 10.6 | 297 |
| Cascade Inlet | 7.6 | 114 |
| Papist passage | 9.5 | 207 |
| Prods Downstream Sump | 8.3 | 174 |
| | | |

1 Measurements taken using a mercury thermometer
2 Measurements taken using a Jenway conductivity meter

Table 6. Additional field measurements taken during low flow (January 1997) to complement Table 4 and 5.

| Location | Grid Reference | | Magnetic | Anomaly |
|---|---|---|---|---|
| Reference | Northing | easting | tN | nT |
| 1 | 206249 | 335838 | 48867 | -193 |
| 2 | 206391 | 335778 | 49182 | 122 |
| Transect 1 | 206546 | 335753 | 49223 | 163 |
| 3 | 206694 | 335646 | 48338 | -722 |
| 4 | 206865 | 335605 | 48081 | -979 |
| Transect 2 | 207068 | 335515 | 48368 | -692 |
| 5 | 207290 | 335424 | 48095 | -965 |
| 6 | 207521 | 335348 | 49882 | 822 |
| Transect 3 | 207734 | 335250 | 49764 | 704 |
| 7 | 207966 | 335146 | 49121 | 61 |
| 8 | 208204 | 335043 | 49112 | 52 |
| 9 | 208441 | 334927 | 49177 | 117 |
| Transect 4 | 208654 | 334870 | 48729 | -331 |
| 10 | 209131 | 334377 | 49119 | 59 |
| 11 | 209432 | 334243 | 49127 | 67 |
| Transect 5 | 209669 | 334118 | 49211 | 151 |
| 12 | 209924 | 334033 | 49179 | 119 |
| 13 | 210136 | 333967 | 48833 | -227 |
| Transect 6 | 210412 | 333799 | 48549 | -511 |
| 14 | 210603 | 333757 | 48871 | -189 |
| 15 | 210965 | 333608 | 48890 | -170 |
| Transect 7 | 211219 | 333417 | 49146 | 86 |
| 16 | 211411 | 333332 | 48842 | -218 |
| 17 | 211538 | 333268 | 48876 | -184 |
| Transect 8 | 211750 | 333226 | 48697 | -363 |
| 18 | 211942 | 333098 | 48860 | -200 |
| 19 | 212153 | 333036 | 48645 | -415 |
| Transect 9 | 212362 | 332963 | 48987 | -73 |
| 20 | 212569 | 332831 | 48698 | -362 |
| 21 | 212754 | 332742 | 49199 | 139 |
| Transect 10 | 212951 | 332682 | 49213 | 153 |
| 22 | 213201 | 332574 | 49258 | 198 |
| 23 | 213238 | 332526 | 49231 | 171 |
| Transect 11 | 213328 | 332430 | 49095 | 35 |
| Transect 12 | 213387 | 332367 | 49058 | -2 |
| Transect 13 | 213470 | 332307 | 48987 | -73 |
| 24 | 213848 | 332121 | 48728 | -332 |
| 25 | 214331 | 331935 | 48699 | -361 |
| Transect 14 | 214984 | 331638 | 48796 | -264 |
| 26 | 215493 | 331354 | 48903 | -157 |
| 27 | 215839 | 331186 | 48748 | -312 |
| Transect 15 | 216238 | 330995 | 48837 | -223 |
| 28 | 216742 | 330773 | 48945 | -115 |
| 29 | 217342 | 330507 | 48729 | -331 |

Table 7. Magnetic data from measurement of the Cuilcagh Dyke from Burren Forest to East Cuilcagh using a proton magnetometer.

| | Easting (m) (Irish Grid, 1965) | Northing (m) (Irish Grid, 1965) | Elevation (m) Above OD (Irish Datum, 1965) |
|---|---|---|---|
| **Lower and Middle Escarpment** | | | |
| **Risings** | | | |
| R01 Aghaboy Rising | 217156 | 326425 | 167 |
| R02 Aghaboy Springs | 217496 | 328460 | 147 |
| **Landforms 'A' series** | | | |
| A01 Pollnagollum Aghaboy | 217000 | 326445 | 223 |
| **Upper Escarpment** | | | |
| **Greenan Fault Block** | | | |
| **Risings** | | | |
| R03 Sumera Rising | 217842 | 328253 | 139 |
| R04a rising (27) | 217232 | 328806 | 254 |
| R04b rising (28) | 217251 | 328942 | 255 |
| R04c rising (29) | 217232 | 329013 | 259 |
| **Landforms 'G' series** | | | |
| G05 Quarry Crowbar caves | 217700 | 327970 | 178 |
| G06 Pollnadad | 216569 | 328622 | 293 |
| G07 Pollprughlisk | 216485 | 328871 | 297 |
| G08 Polliniska | 216460 | 328969 | 298 |
| G09 Pollnatagha | 216473 | 328988 | 298 |
| G10 Peter Bryant's Bullock Hole | 216362 | 329194 | 302 |
| G11 Long Pot | 216440 | 329275 | 300 |
| G12 Tea Pot | 216330 | 329400 | 301 |
| G13 Black Pot | 216540 | 329467 | 302 |
| G14 Dig Swallet | 216488 | 329467 | 301 |
| G15 Small Pot | 216454 | 329537 | 300 |
| G16 Pollthanaclanawley | 216448 | 329539 | 301 |
| G17 | 216596 | 329715 | 311 |
| G18 Peter Bryant's Hole | 216531 | 329636 | 309 |
| G19 | 216597 | 329689 | 310 |
| **Beihy Fault Block** | | | |
| **Risings** | | | |
| R05 Gortalughany Rising | 217126 | 330024 | 239 |
| R06 Gortalughany Intake Rising | 217437 | 330438 | 239 |
| R07 Gortalughany Farmyard Rising | 216837 | 330637 | 243 |
| **Landforms 'B' series** | | | |
| B01 | 216382 | 329994 | 307 |
| B02 | 216383 | 330004 | 303 |
| B03 BMC Pot | 216384 | 330027 | 305 |
| B04 Coral Pot | 216303 | 330075 | 305 |
| B05 | 216303 | 330092 | 307 |
| B06 | 216289 | 330125 | 308 |
| B07 | 216224 | 330158 | 311 |
| B08 | 216224 | 330189 | 311 |
| B09 | 216230 | 330210 | 311 |
| B10 Syringopora Pot | 216392 | 330210 | 317 |
| B11 | 216149 | 330240 | 311 |
| B12 | 216102 | 330278 | 304 |
| B13 | 216044 | 330315 | 304 |
| B14 | 215955 | 330377 | 306 |
| B15 | 215958 | 330414 | 305 |

Table 8(1). Grid References and elevations for karst landforms on the East Cuilcagh Escarpment.

| | Easting (m) (Irish Grid, 1965) | Northing (m) (Irish Grid, 1965) | Elevation (m) Above OD (Irish Datum, 1965) |
|---|---|---|---|
| B16 | 215902 | 330485 | 305 |
| B17 | 215744 | 330530 | 303 |
| B18 Pigeon Pot II | 215712 | 330526 | 298 |
| B19 Pigeon Pot III | 215750 | 330584 | 297 |
| B20 Pigeon Pot I | 215779 | 330634 | 298 |
| B21 | 215561 | 306657 | 300 |
| B22 Badger Pot | 215543 | 330670 | 301 |
| B23 Badger Cave | 215538 | 330705 | 300 |
| B24 | 215846 | 330762 | 294 |
| B25 | 215855 | 330765 | 295 |
| B26 | 215603 | 330771 | 295 |
| B27 | 215698 | 330799 | 290 |
| B28 | 215748 | 330811 | 296 |
| B29 | 215908 | 330824 | 299 |
| B30 | 215627 | 330833 | 300 |
| B31 | 215732 | 330838 | 300 |
| B32 | 215752 | 330888 | 301 |
| B33a | 215687 | 330908 | 287 |
| B33b | 215704 | 330907 | 290 |
| B34 | 215724 | 330917 | 294 |
| B35 Aghatirourke Pot | 215628 | 330928 | 294 |
| B36a | 215772 | 330948 | 293 |
| B36b | 215786 | 330941 | 293 |
| B36c | 215809 | 330945 | 295 |
| B36d | 215822 | 330942 | 297 |
| B37 | 215793 | 331001 | 289 |
| B38 Sheep Pot | 215571 | 331047 | 292 |
| B39 | 215745 | 331085 | 289 |
| B40 | 215724 | 331100 | 292 |
| B41 | 215734 | 331117 | 301 |
| **Florence Court Fault Block** | | | |
| **Risings** | | | |
| R08 Florence Court Risings | 21650 | 33140 | 230 |
| **Landforms 'F' series** | | | |
| F01 | 215915 | 331237 | 316 |
| F02 | 215717 | 331353 | 318 |
| F03 Goat Pot | 215717 | 331390 | 328 |
| F04 | 215785 | 331405 | 321 |
| F05 | 215799 | 331425 | 319 |
| F06 | 215922 | 331362 | 315 |
| F07 | 215874 | 331446 | 320 |
| F08 | 215852 | 331547 | 325 |
| F09 | 215844 | 331585 | 327 |
| F10 | 215853 | 331611 | 330 |
| F11 | 215851 | 331671 | 329 |
| F12 Pollmyalla I | 215844 | 331710 | 327 |
| F13 Pollmyalla II | 215859 | 331747 | 326 |
| F14 Pollmyalla III | 215926 | 331789 | 329 |

Table 8 (2). Grid References and elevations for karst landforms on the East Cuilcagh Escarpment.

| Trace Ref: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date: | 26/03/1996 | 26/03/1996 | 10/07/1996 | 10/07/1996 | 06/09/1996 | 06/09/1996 | 27/07/1997 | 27/07/1997 | 24/01/1998 | 24/01/1998 | 30/04/1998 | 30/04/1998 | 15/05/1998 | 15/05/1998 |
| Injection Point: | Black Pot | Pollthana- | Goat Pot | Peter Bryant | Pollmyalla I | Peter Bryant | Aghatirourke | Pollmyalla II | Pigeon Pot | Badger Pot | Hammer | Sheep Skull | Sheep | B08 |
| | | clanawley | | Bull' Hole | | Hole | Pot | | II | | Pot | Pot | Pot | |
| **East Cuilcagh Karst** | | | | | | | | | | | | | | |
| Aghaboy Rising | - | - | - | - | - | - | - | - | - | - | | | - | - |
| Aghaboy Springs | - | - | - | - | - | - | - | - | - | - | | | - | - |
| Sumera Rising (Upper) | + | + | - | + | - | + | + | - | + | + | | | + | + |
| Sumera Rising (Lower) | + | + | - | + | - | + | + | - | + | + | | | + | + |
| Gortalughany Spring A | - | - | - | - | - | - | - | - | - | - | | | - | - |
| Gortalughany Spring B | - | - | - | - | - | - | - | - | - | - | | | - | - |
| Gortalughany Spring C | - | - | - | - | - | - | - | - | - | - | | | - | - |
| Gortalughany Rising (Upper) | - | - | - | - | - | - | + | - | + | + | | | + | + |
| Gortalughany Rising (Lower) | - | - | - | - | - | - | + | - | + | + | | | + | + |
| Gortalughany Intake Rising | - | - | - | - | - | - | + | - | + | + | | | + | - |
| Gortalughany Farmyard Rising | - | - | - | - | - | - | - | - | - | - | | | - | - |
| Florencecourt Springs | - | - | - | - | + | - | - | - | - | - | | | - | - |
| | | | | | | | | | | | | | | |
| **Erne Karst** | | | | | | | | | | | | | | |
| Tullyhona Rising | - | - | + | - | + | - | - | + | - | - | - | - | - | - |
| Cascades Rising | - | - | + | - | + | - | + | - | + | + | - | - | + | - |
| Marble Arch Rising | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Cladagh West 1 | | | | | | | | | | | - | - | | |
| Cladagh West 2 | | | | | | | | | | | - | - | | |
| Springwell Rising | | | | | | | | | | | - | - | | |
| Hanging Rock Rising | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Marlbank Rising (East) | | | | | | | | | | | + | + | | |
| Marlbank Rising (West) | | | | | | | | | | | + | + | | |
| Ture | | | | | | | | | | | - | - | | |
| Cornagee Lower | | | | | | | | | | | - | - | | |
| Cornagee | | | | | | | | | | | - | - | | |
| Barran Rising 1 | | | | | | | | | | | - | - | | |
| Barran Rising 2 | | | | | | | | | | | - | - | | |
| Barran Rising 3 | | | | | | | | | | | - | - | | |
| | | | | | | | | | | | | | | |
| **Shannon Karst** | | | | | | | | | | | | | | |
| Shannon Pot Rising | - | - | - | - | - | - | - | - | + | + | - | - | - | - |

Risings with + and - denote those monitored during each trace  + = Positive dye recovery, indicating hydraulic connection with the stream sink  - = No dye recovery, indicating isolation from the stream sink

Table 9. Summary of water tracing experiments carried out during this research project. Showing stream sink where dye was injected and those risings where monitoring was undertaken.

| Rising to drainage system | | Grid reference | Altitude | Depth of | Average linear | Linear sink-rising |
|---|---|---|---|---|---|---|
| | Sinks traced to rising | (Irish Grid, 1964) | (m AOD) | cave (m) | velocity (m/h) | gradient (m/km) |
| **R03 Sumera Rising (GR:217842-328253, Alt 139m)** | | | | | | |
| | G08 Polliniska [8] | 216460-328969 | 298 | 70 | - | 102 |
| | G10 Peter Bryants' Bullock Hole [Author] | 216362-329194 | 302 | 48 | - | 94 |
| | G13 Black Pot [8 and Author] | 216540-329467 | 302 | 60 | 30 | 86 |
| | G18 Peter Bryant's Hole | 216531-329689 | 310 | 21 | - | 92 |
| | B03 B.M.C. Pot [8] | 216384-330027 | 305 | 6 | - | 72 |
| | B16 Pollthanaclanawly [8 and Author] | 216448-329539 | 301 | 63 | 30 | 85 |
| | B18 Pigeon Pot II [8 and Author] | 215712-330526 | 298 | 52 | 45 | 51 |
| | B22 Badger Pot [8 and Author] | 215543-330670 | 301 | 5 | 50 | 60 |
| | B35 Aghatirourke Pot [Author] | 215628-330928 | 294 | 28 | - | 44 |
| | B38 Sheep Pot [Author] | 215571-331047 | 292 | 29 | - | 44 |
| | B08 | 216224-330189 | 311 | 2 | - | 72 |
| **R05 Gortalughany Rising (GR: 217126-330024, Alt: 239m)** | | | | | | |
| | B18 Pigeon Pot II [8 and Author] | 215712-330526 | 298 | 52 | 20 | 41 |
| | B22 Badger Pot [8 and Author] | 215543-330670 | 301 | 5 | 25 | 33 |
| | B35 Aghatirourke Pot [Author] | 215628-330928 | 294 | 28 | - | 28 |
| | B38 Sheep Pot [Author] | 215571-331047 | 292 | 29 | - | 44 |
| | B08 | 216224-330189 | 311 | 2 | - | 104 |
| **R06 Gortalughany Intake Rising (GR: 216437-330438, Alt 239m)** | | | | | | |
| | B18 Pigeon Pot II [8 and Author] | 215712-330526 | 298 | 52 | <20 | 46 |
| | B22 Badger Pot [8 and Author] | 215543-330670 | 301 | 5 | <20 | 39 |
| | B35 Aghatirourke Pot [Author] | 215628-330928 | 294 | 28 | - | 27 |
| | B38 Sheep Pot [Author] | 215571-331047 | 292 | 29 | - | 44 |
| **R07 Gortalughany Farmyard Rising (GR: 216837-330637, Alt 243m)** | | | | | | |
| | B18 Pigeon Pot II [8 and Author] | 215712-330526 | 298 | 52 | <20 | 52 |
| | B22 Badger Pot [8 and Author] | 215543-330670 | 301 | 5 | <20 | 40 |
| **R08 Florence Court Risings (GR: 21650-33140, Alt: 230m)** | | | | | | |
| | E248 Pollmyalla 1 [Author] | 215844-331747 | 327 | 14 | <10 | <10 |

Notes [1] Brodrick (1908); [2] Wynn (1956); [3] Holgate (1954); [4] Devoy and Orr (1970); [5] Jones (1974), p.92; [6] Gunn (1982); [7] Gunn (1996); [8] Gunn *pers. comm.*, (1998).

Table 10. Summary of all water tracing experiments in the East Cuilcagh Karst.

| Rising to drainage system / Sinks/cave passage traced to rising | Grid reference (Irish Grid, 1964) | Altitude (m AOD) | Depth of cave (m) | Average linear velocity (m/h) | Linear sink-rising gradient (m/km) |
|---|---|---|---|---|---|
| **T1 Tullyhona Rising (GR:21533-33373, Alt 193m)** | | | | | |
| Whiskey Holes [5] (Via oxbow Inlet) | 21503-33335 | 238 | 12 | 77 | 120 |
| Brookfield 1 [6] (Via oxbow Inlet) | 21457-33338 | 220 | - | 50 | 83 |
| Dicks Sinks [8] | 21545-33332 | 236 | - | - | - |
| F03 Goat Pot [8 and Author] | 215717-331710 | 328 | 15 | <30 | 59 |
| F12 Pollmyalla I [Author] | 215844-331747 | 327 | 6 | <20 | 67 |
| F13 Pollmyalla II [Author] | 215859-331747 | 326 | 7 | <20 | 67 |
| **C1 Cascades Rising (GR: 21228-33498, Alt 119m)** | | | | | |
| Downstream Sump 1 in Prods Cave [4] | - | - | - | 260 | - |
| Smokey Mountain [6] | 21396-33372 | 231 | 7 | 120 | 49 |
| Brookfield 3 [6] | 21453-33339 | 220 | - | 260 | 50 |
| Brookfield 8 [6] | 21421-33339 | 218 | - | 300 | 51 |
| Owenbrean Upper Sinks [8] | 212782-331986 | 243 | - | >80 | 33 |
| Owenbrean Lower Sinks [8] | 213298-327740 | 214 | - | - | 42 |
| B18 Pigeon Pot II [7, 8 and Author] | 215712-330526 | 298 | 52 | 78 | 32 |
| B22 Badger Pot [7, 8 and Author] | 215543-330670 | 301 | 5 | 75 | 44 |
| F03 Goat Pot [7, 8 and Author] | 215717-331390 | 328 | 15 | - | 54 |
| **M33 Marble Arch Rising (GR: 2121-3344, Alt: 128m)** | | | | | |
| Sruh Croppa (Cats' Hole) [4] | 21166-33374 | 169 | 17 | >34 | 53 |
| Pollasumera [5] | 21302-33319 | 197 | - | 320* | 55 |
| Monastir [1] | 21195-33350 | 159 | - | 32 | 49 |
| **H1 Hanging Rock Rising (GR: 21045-33663, Alt 83m)** | | | | | |
| Legacapple [6] | 20965-33496 | 166 | - | 150 | 57 |
| Hammer Pot [Author] | 21015-33477 | 174 | 22 | 80 | 65 |
| Cow Skull [Author] | 20971-33459 | 174 | 3 | 50 | 59 |
| **Ture Main Rising (GR: 20783-33735, Alt: 83m)** | | | | | |
| Legnaveagh Sink [8] | 20767-33553 | 218 | - | - | 60 |
| Super Star Pot [8] | 20730-33735 | 209 | - | - | 58 |
| **Barran Rising 1 (GR: 20418-33596, Alt: 77m)** | | | | | |
| Pollnagossan [6] | 20625-33528 | 208 | 15 | 50 | 58 |
| Pollnaskeoge [6] | 20544-33527 | 171 | - | - | 49 |

Notes [1] Brodrick (1908) [2] Wynn (1956); [3] Holgate (1954); [4] Devoy and Orr (1970); [5] Jones (1974), p.92; [6] Gunn (1982); [7] Gunn (1996); [8] Gunn *pers. comm.*, (1998).

Table 11. Summary of all water tracing experiments to risings in the Erne Karst.

| Rising to drainage system<br>Sinks traced to rising | Grid reference<br>(Irish Grid, 1964) | Altitude<br>(m AOD) | Depth of cave<br>(m) | Average linear<br>velocity (m/h) | Linear sink-rising<br>gradient (m/km) |
|---|---|---|---|---|---|
| **Shannon Pot Rising (GR:205406 331814, Alt 106 m)** | | | | | |
| Legeelan Lower [6] | 206788-333698 | 164 | 2 | 120 | 24 |
| Gowlan 1 [6] | 206767-333556 | 157 | 2 | 130 | 25 |
| Pollnaowen [6] | 206890-333224 | 154 | 4 | 240 | 22 |
| Pollboy [6] | 206979-332827 | 149 | 8 | (80-250) | 23 |
| Garvagh 1 [6] | 207776-332879 | 167 | 1 | 60 | 29 |
| Pollahune stream sink [6] | 209447-332410 | 252 | 3 | <90 | 36 |
| Tullynakeeragh [6] | 209767-331887 | 276 | 9 | 105 | 40 |
| Derrylahan 1 [6] | 205979-332012 | 128 | 2 | 50 | 60 |
| Derrylahan 5 [6] | 205521-331809 | 138 | 1 | 140 | 70 |
| Polltullyard [8] | 209441-332418 | 261 | 48 | - | 39 |
| Killykeegan 5 [8] | 209415-332810 | 189 | 1 | - | 33 |
| Killykeegan 8 [8] | 210231-332185 | 236 | 6 | - | 32 |
| B18 Pigeon Pot II [7,8 and Author] | 215712-330526 | 298 | 48 | 100 | 20 |
| B22 Badger Pot [7, 8 and Author] | 215543-330670 | 301 | 5 | 85 | 22 |

Notes [1] Brodrick (1908) [2] Wynn (1956); [3] Holgate (1954); [4] Devoy and Orr (1970); [5] Jones (1974), p.92; [6] Gunn (1982); [7] Gunn (1996); [8] Gunn *pers. comm.*, (1998).

Table 12. Summary of all water tracing in the Shannon Karst.

| Description | U (ppm) | sU (±) | $^{234}U/^{238}U$ | s $^{234}U/^{238}U$ (±) | $^{230}Th/^{234}U$ | s $^{230}Th/^{234}U$ (±) | $^{230}Th/^{232}Th$ | Age (ka) | s Age | –s Age | Corrected age (ka) | s Age | –s Age |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MA 1/1, base | 0.145 | 0.004 | 1.359 | 0.047 | 0.492 | 0.03 | 2.38 | 70.95 | 6.02 | 5.73 | 32.56 | 9.04 | 8.86 |
| MA 1/9, top | 0.073 | 0.003 | 1.448 | 0.074 | 0.255 | 0.035 | 10000 | 31.42 | 5.06 | 4.86 | | | |
| MAC 3 base | 0.068 | 0.003 | 1.382 | 0.063 | 0.121 | 0.015 | 12.1 | 13.9 | 1.88 | 1.85 | 12.29 | 2.09 | 2.06 |
| MAC 3 top | 0.073 | 0.003 | 1.407 | 0.085 | 0.106 | 0.019 | 2.36 | 12.03 | 2.34 | 2.3 | 4.56 | 3.77 | 3.75 |
| MAC 4A base | 0.056 | 0.002 | 1.369 | 0.071 | 0.96 | 0.053 | 31.4 | 244.81 | 53.21 | 37.16 | 240.79 | 53.68 | 37.58 |
| MAC 4B top | 0.042 | 0.001 | 1.3857 | 0.04081 | 0.9846 | 0.03061 | 10.0196 | 264.15 | 33.05 | 26.14 | 251.02 | 34.05 | 27.05 |
| MAC 6A | 0.032 | 0.002 | 1.4521 | 0.11174 | 0.9282 | 0.06437 | 25.5263 | 214.99 | 48.58 | 34.96 | 210.16 | 49.21 | 35.54 |
| MAC 6B | 0.024 | 0.001 | 1.2774 | 0.07477 | 1.0789 | 0.072 | 21.2222 | >350 | | | | | |
| MAC 6C | 0.03 | 0.002 | 1.3866 | 0.11523 | 1.0966 | 0.06982 | 3.1127 | >350 | | | | | |

Table 13. Results from uranium series dating of speleothem samples collected from Marble Arch Cave (see Plates 27-30, and Figure 75)