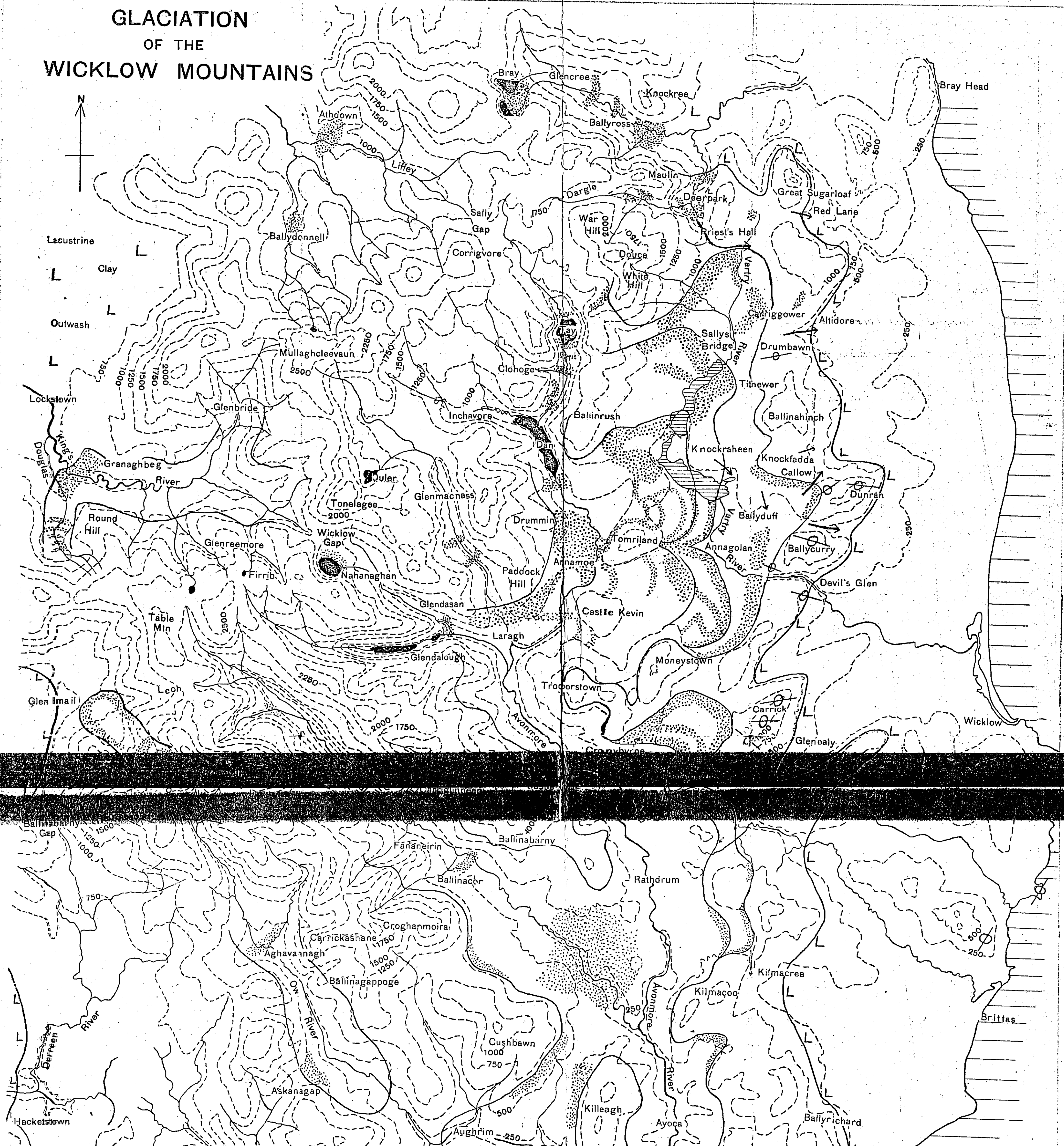
F.M. Synge



FARRINGTON.—GLACIATION OF WICKLOW MOUNTAINS.

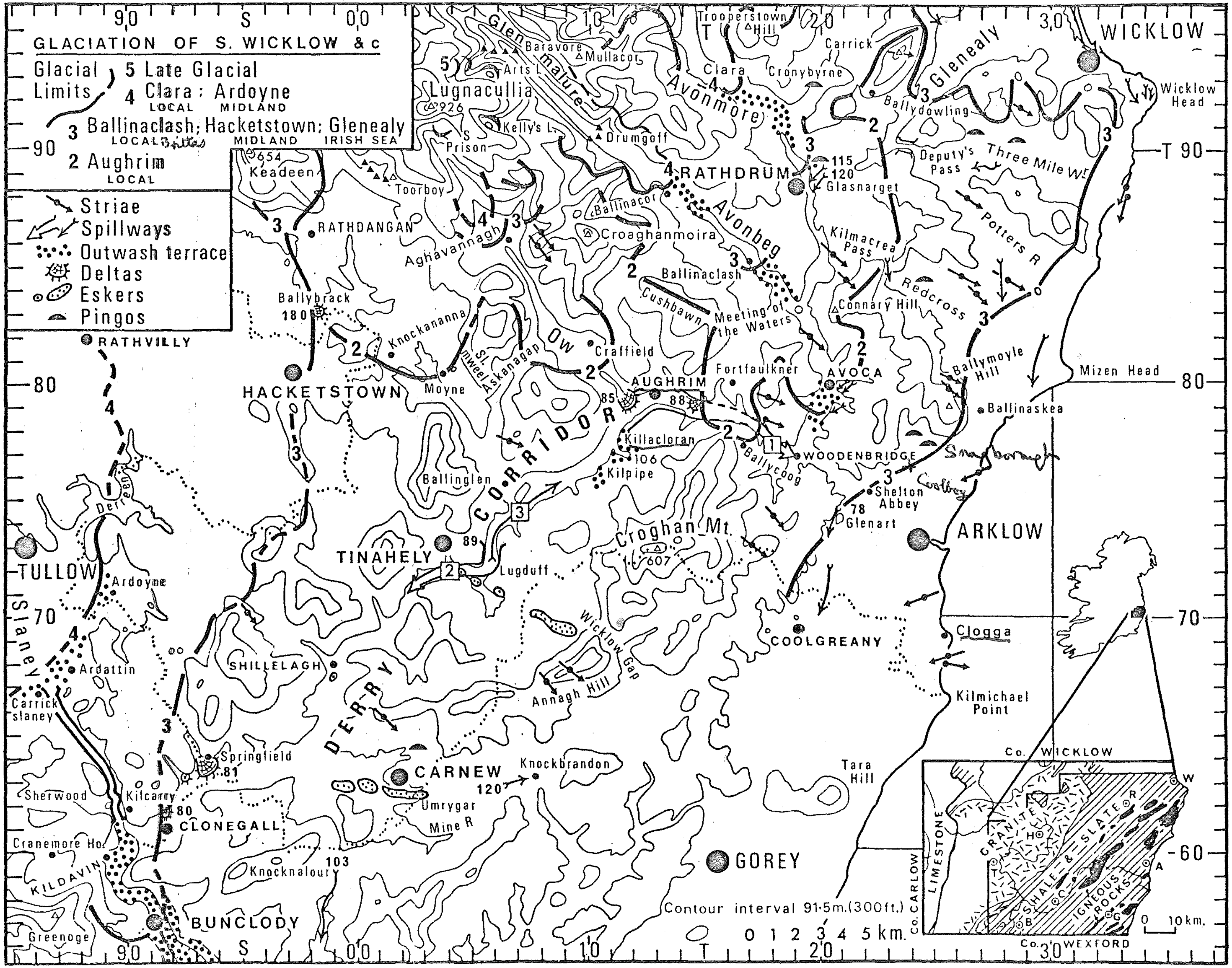
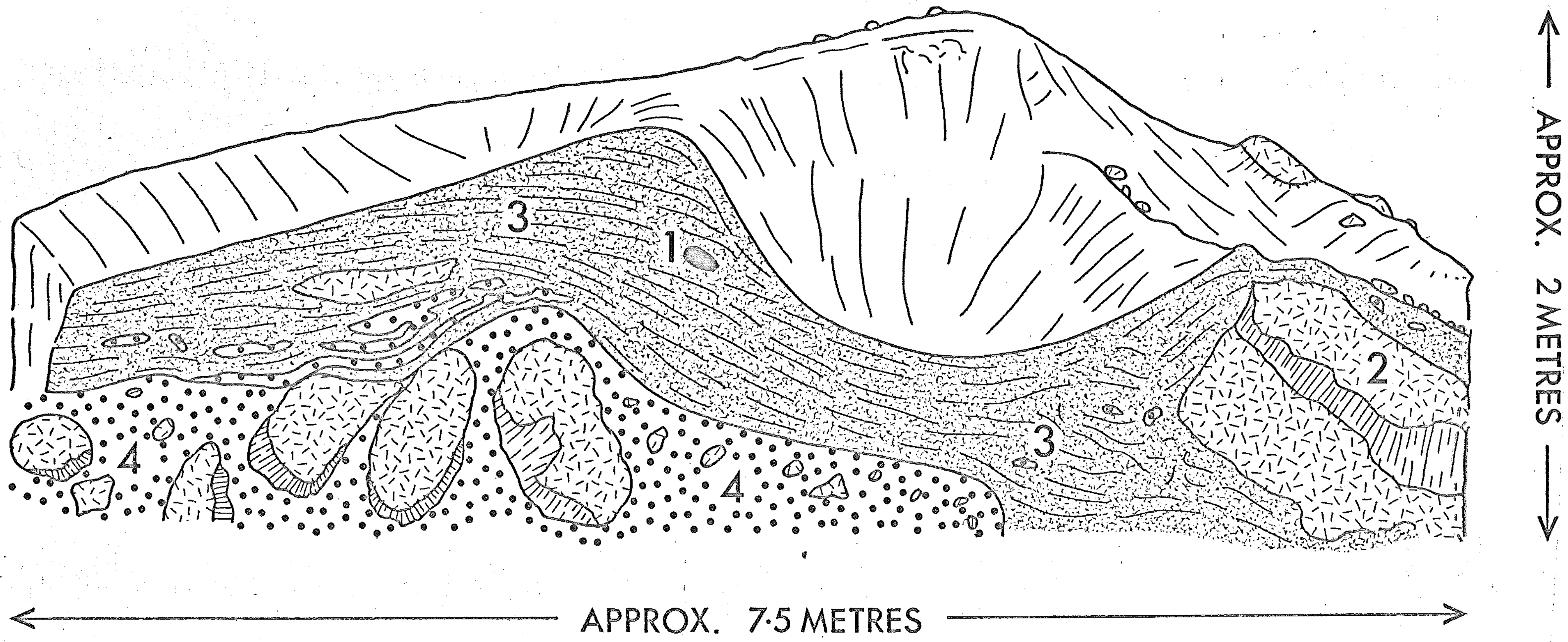
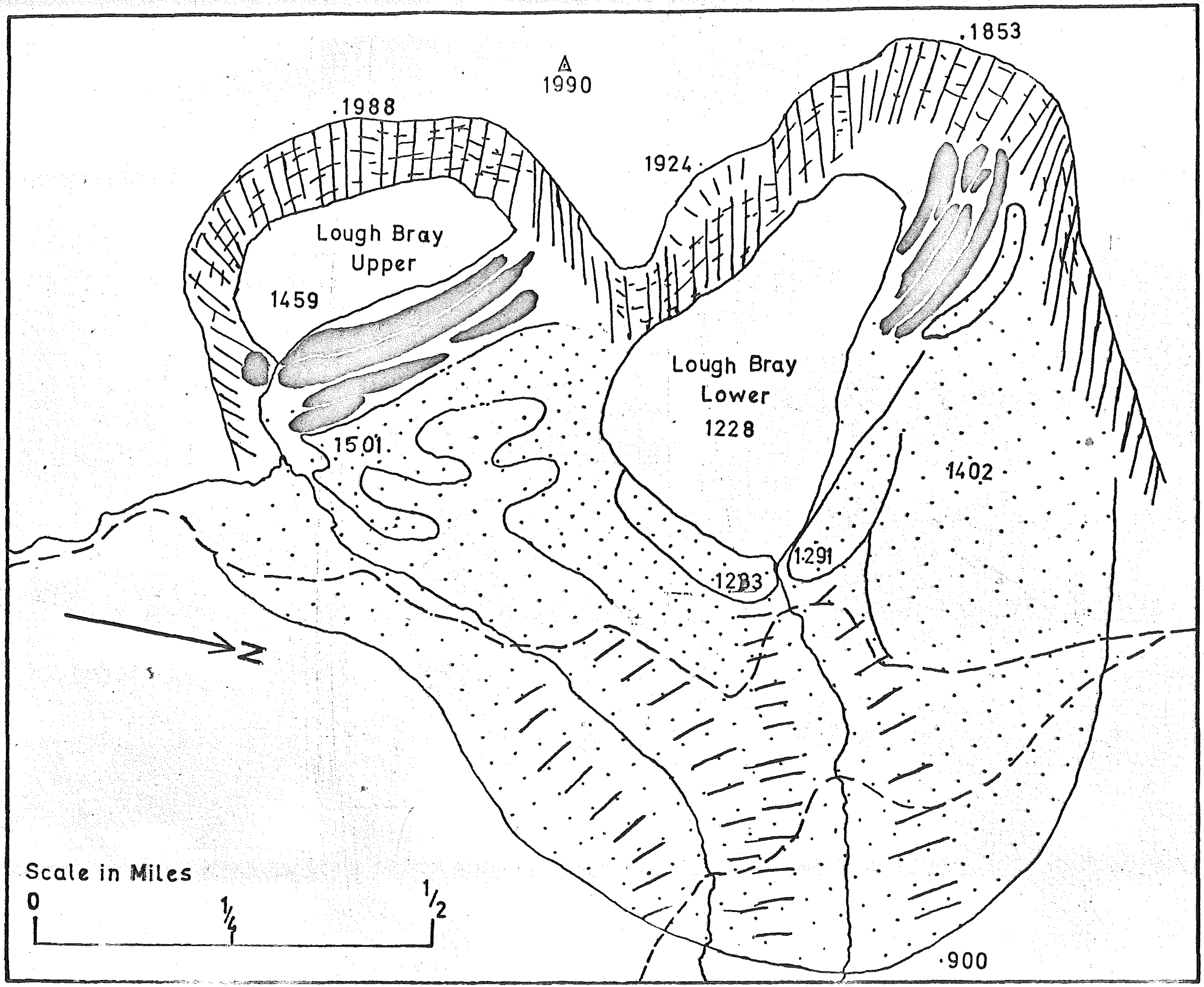

GLACIATION OF S. WICKLOW &c
Glacial Limits
5 Late Glacial
4 Clara ; Ardoyne
LOCAL MIDLAND
3 Ballinaclash; Hacketstown; Glenealy
LOCAL MIDLAND IRISH SEA
2 Aughrim
LOCAL
Striae
Spillways
Outwash terrace
Deltas
Eskers
Pingos
WICKLOW
RATHDRUM
AUGHRIM
AVOCA
WOODENBRIDGE
ARKLOW
HACKETSTOWN
TINAHELY
TULLOW
RATHVILLY
SHILLELAGH
CARNEW
CLONEGALL
BUNCLODY
GOREY
COOLGREANY
CORRIDOR
DERRY
Croghan Mt.
Contour interval 91·5m.(300ft.)
0 1 2 3 4 5 km.
Co. WICKLOW
Co. WEXFORD
Co. CARLOW
LIMESTONE
GRANITE
SHALE & SLATE
IGNEOUS ROCKS

Figure 5

5



1 *Clay ball with plant remains*
2 *Ice-pushed granite block*
3 *Ice-pushed lake clays*
4 *Granite till*


.1853
1990
.1988
1924
Lough Bray
Upper
1459
Lough Bray
Lower
1228
1501
1402
1291
1233
Scale in Miles
0
1/4
1/2
900

(Fig.4)

15B

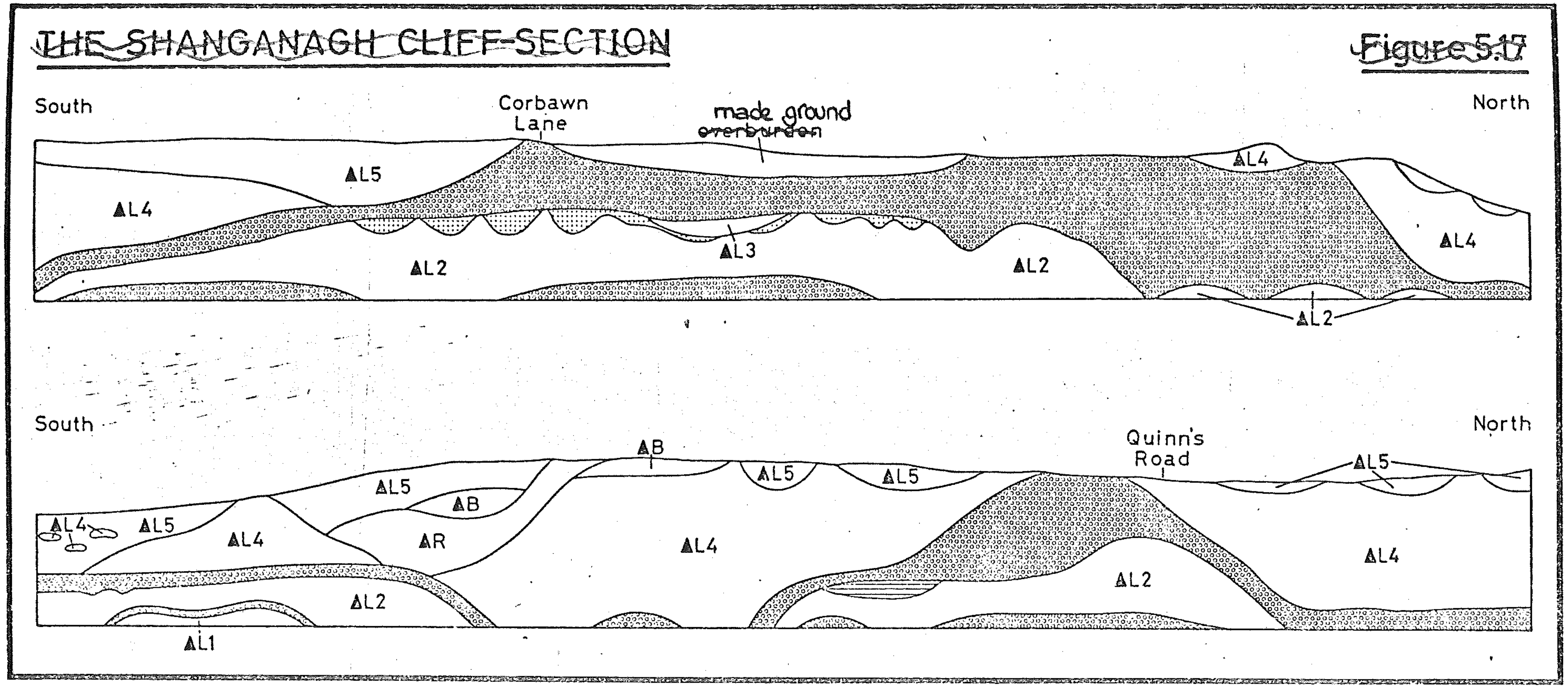
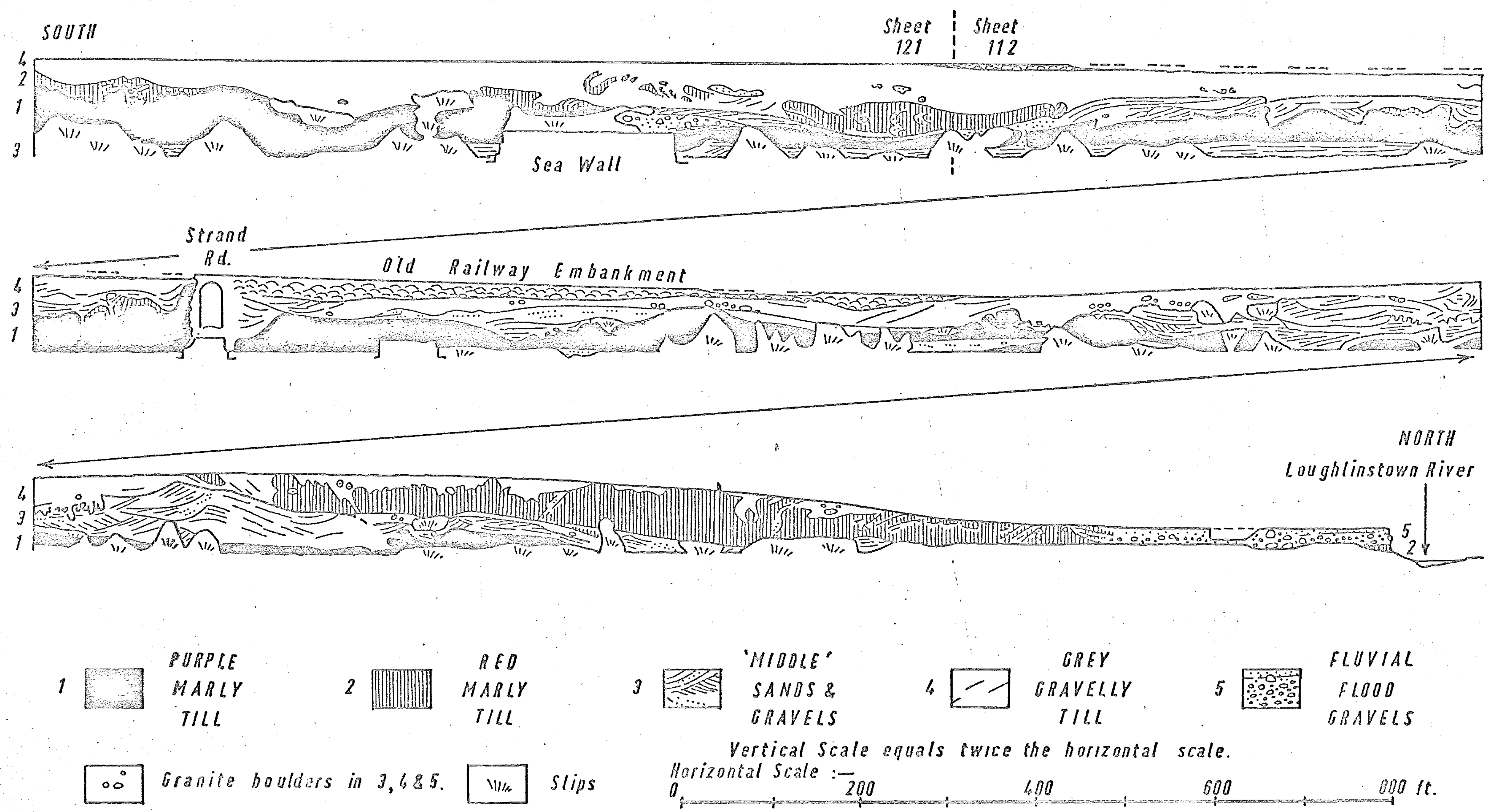


Figure 1 - The glacial stratigraphy in Shanganagh and adjoining townlands, south-east County Dublin


SOUTH
Sheet 121
Sheet 112
Sea Wall
Strand Rd.
Old Railway Embankment
NORTH
Loughlinstown River
1 PURPLE MARLY TILL
2 RED MARLY TILL
3 'MIDDLE' SANDS & GRAVELS
4 GREY GRAVELLY TILL
5 FLUVIAL FLOOD GRAVELS
Granite boulders in 3, 4 & 5.
Slips
Vertical Scale equals twice the horizontal scale.
Horizontal Scale :—
0
200
400
600
800 ft.

main moraine – 300' thick
– little basin, essentially
moraine dammed.

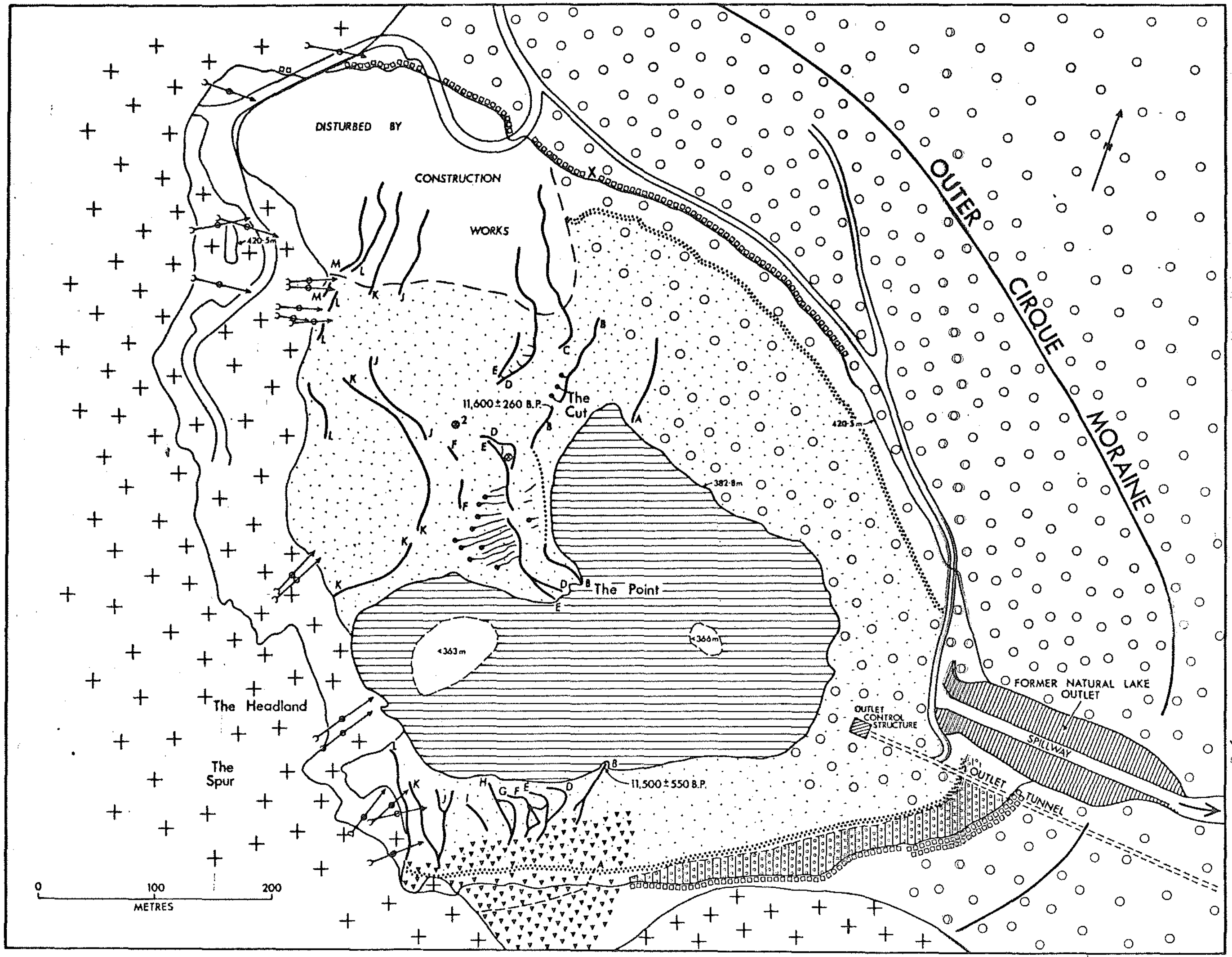
12A

(17) outer moraine

(16)

(15)

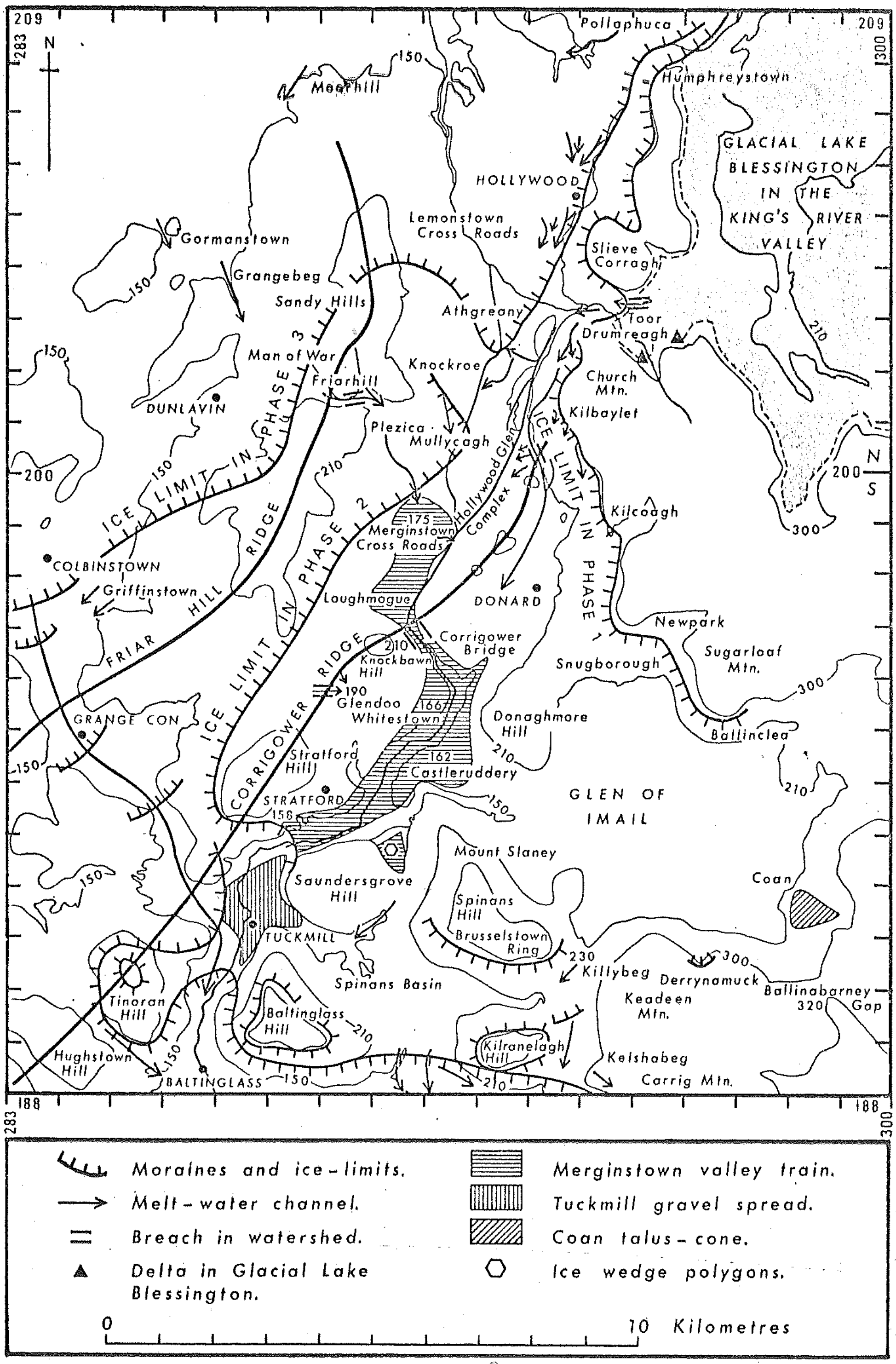
14 } Wedge in
13 } Gravels
@ Towerlands



LOWERED LAKE WATER | LOW WATER SAND BEACH | LAKE SILTS AND CLAYS | ICE-LAKE PLATFORM | ICE-PUSHED GRANITE BLOCKS

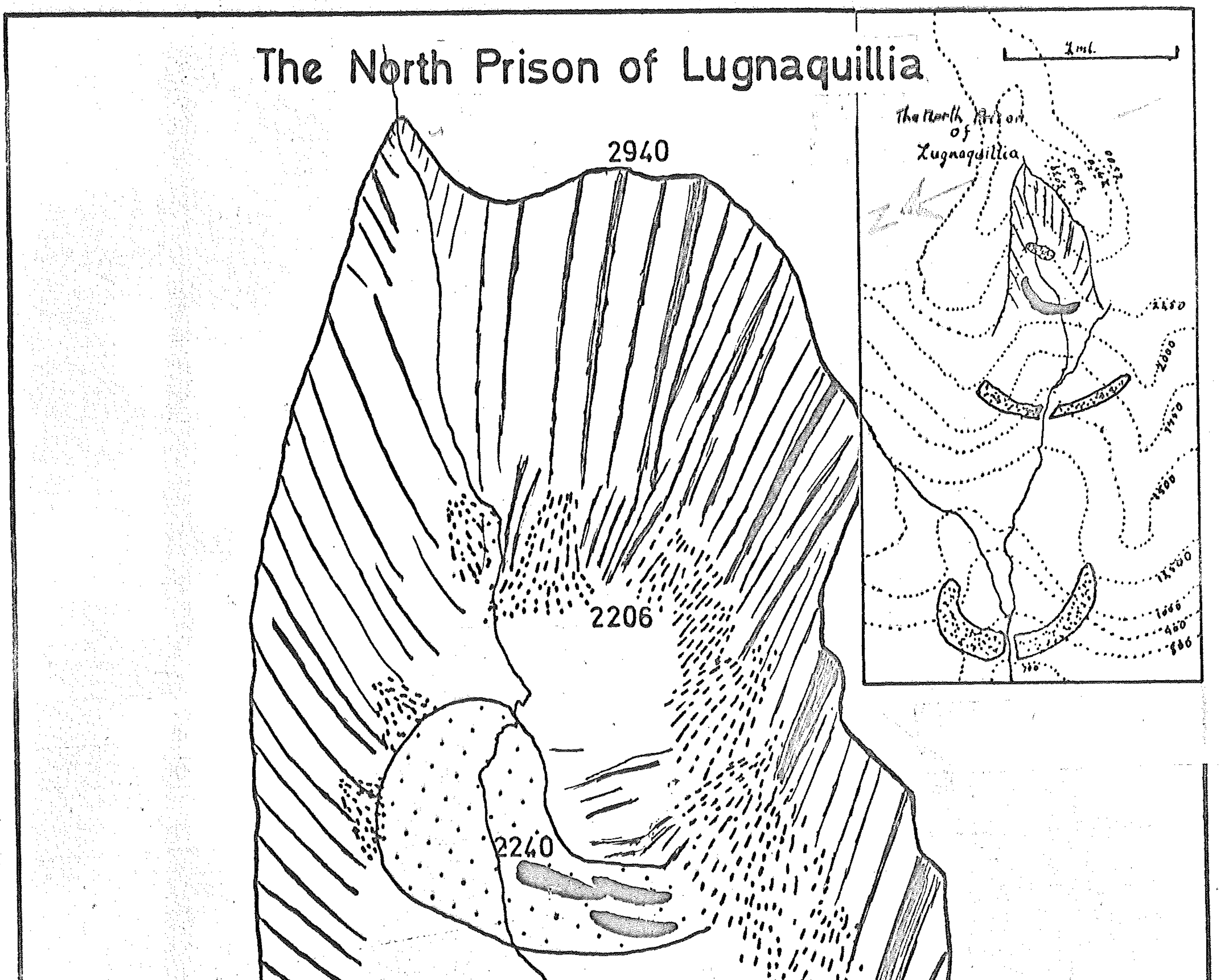
INNER CIRQUE MORAINES | GRANITE BOULDERS AND FLUTED RIDGES | GRANITE SCREES | STRIAE | GRANITE SANDS AND GRAVELS | GRANITE

10



Pollaphuca
Humphreystown
Meerhill
GLACIAL LAKE BLESSINGTON IN THE KING'S RIVER VALLEY
HOLLYWOOD
Lemonstown Cross Roads
Gormanstown
Grangebeg
Slieve Corragh
Sandy Hills
Athgreany
Toor
Drumreagh
Man of War
Knockroe
Church Mtn.
Friarhill
DUNLAVIN
Kilbaylet
Plezica
Mullycagh
ICE LIMIT IN PHASE 3
ICE LIMIT IN PHASE 2
ICE LIMIT IN PHASE 1
Hollywood Glen Complex
Kilcoagh
Merginstown Cross Roads
FRIAR HILL RIDGE
COLBINSTOWN
Griffinstown
Loughmogue
DONARD
Newpark
Corrigower Bridge
Knockbawn Hill
Sugarloaf Mtn.
Snugborough
Glendoo
Whitestown
Donaghmore Hill
Ballinclea
GRANGE CON
CORRIGOWER RIDGE
Stratford Hill
Castleruddery
STRATFORD
GLEN OF IMAIL
Mount Slaney
Saundersgrove Hill
Coan
Spinans Hill
TUCKMILL
Brusselstown Ring
Killybeg
Derrynamuck
Spinans Basin
Ballinabarney Gop
Tinoran Hill
Keadeen Mtn.
Baltinglass Hill
Kilranelagh Hill
Hughstown Hill
Kelshabeg
BALTINGLASS
Carrig Mtn.
Moraines and ice-limits.
Melt-water channel.
Breach in watershed.
Delta in Glacial Lake Blessington.
Merginstown valley train.
Tuckmill gravel spread.
Coan talus-cone.
Ice wedge polygons.
0
10 Kilometres

Figure 10

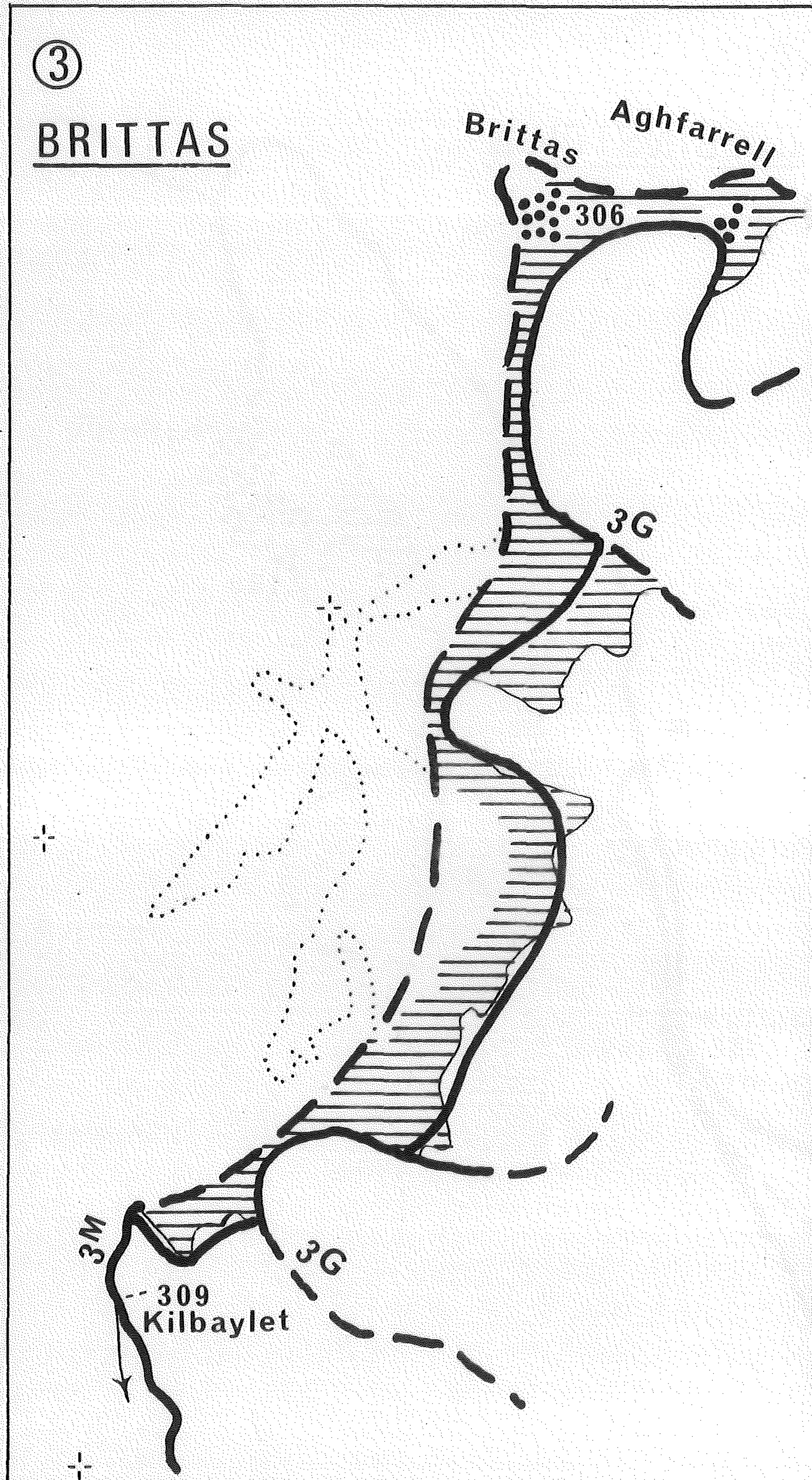

The North Prison of Lugnaquillia
2940
2206
2240
2114
1/4 Mile
The North Prison of Lugnaquillia

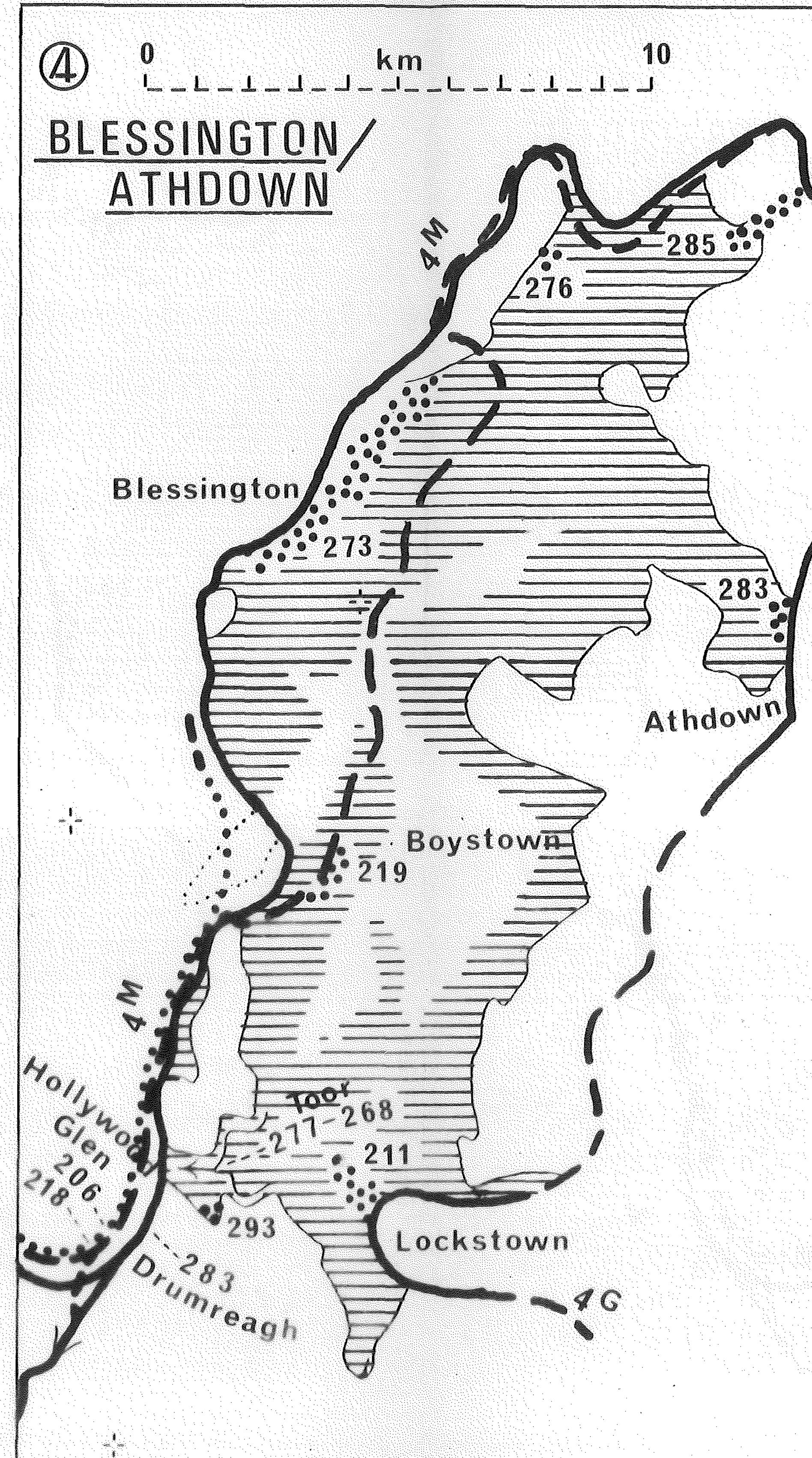
(Fig. 11)

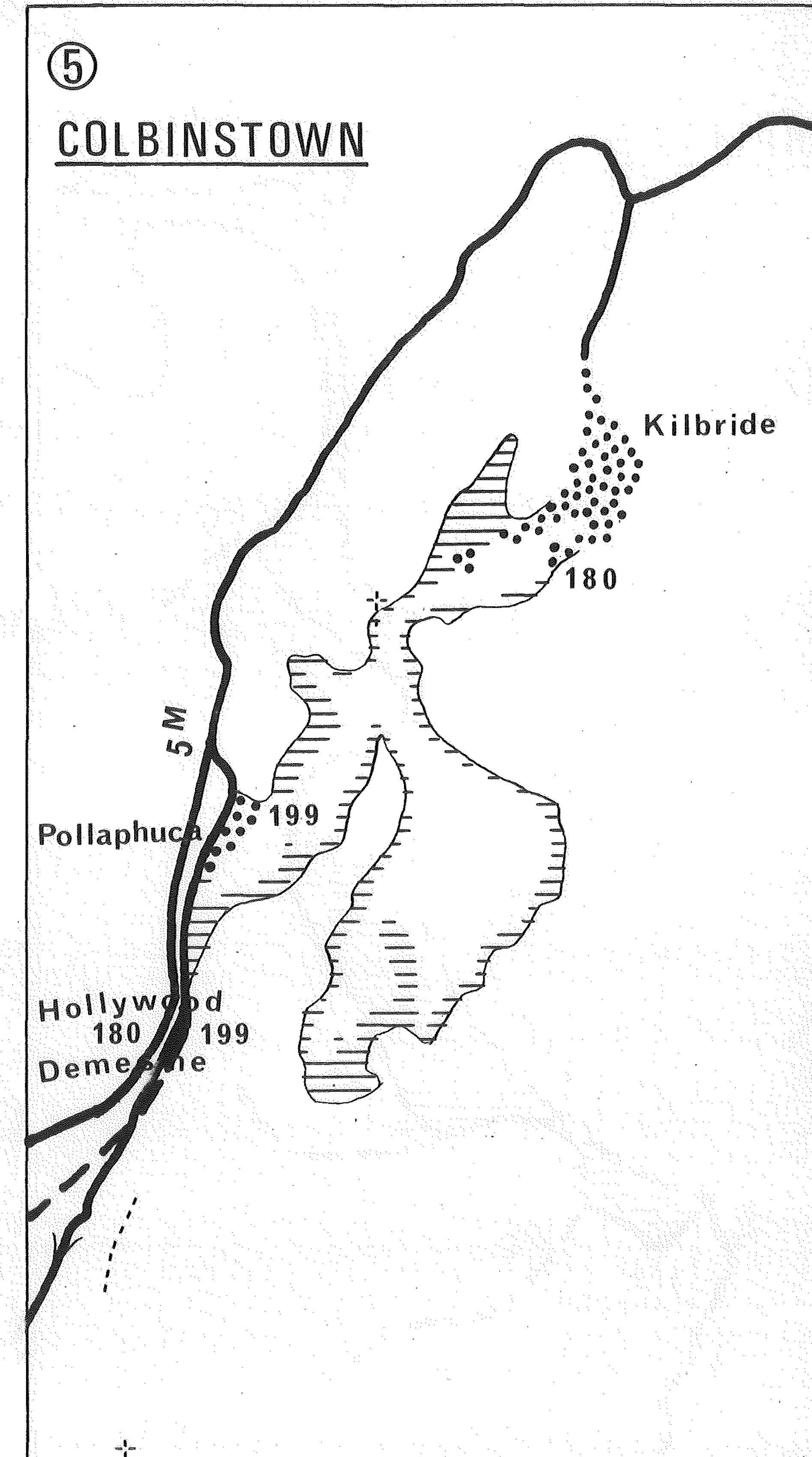
TABLE 1. The formally-defined stratigraphic units in the Pleistocene succession of County Dublin

Group	Formation/ Glaciation[1]	Member	Grid reference[2] of type-site
Leinster	Glenasmole (Athdown)	Castlekelly Gravel	106203
	Dublin (Midland General)	Glassamucky Varved Clay	104210
		Piperstown Gravel	106230
		Cloghran Till	177443
		Jordanstown Till	188574
		Damastown Till	140571
	Brittas (Brittas)	Aghfarrell Gravel	053215
	Irish Sea (Eastern General) [+(?)inland ice-sheet]	Rush Till	270558
		Oldbawn Till	099266
		Loughshinny Till	272571
		Balheary Till	185484
	Slievethoul (Enniskerry)	None differentiated	0122 (type area)

1 Terms used by Farrington (1957a) are given in parentheses
2 All occur within sub-zone 0 of the Irish National Grid

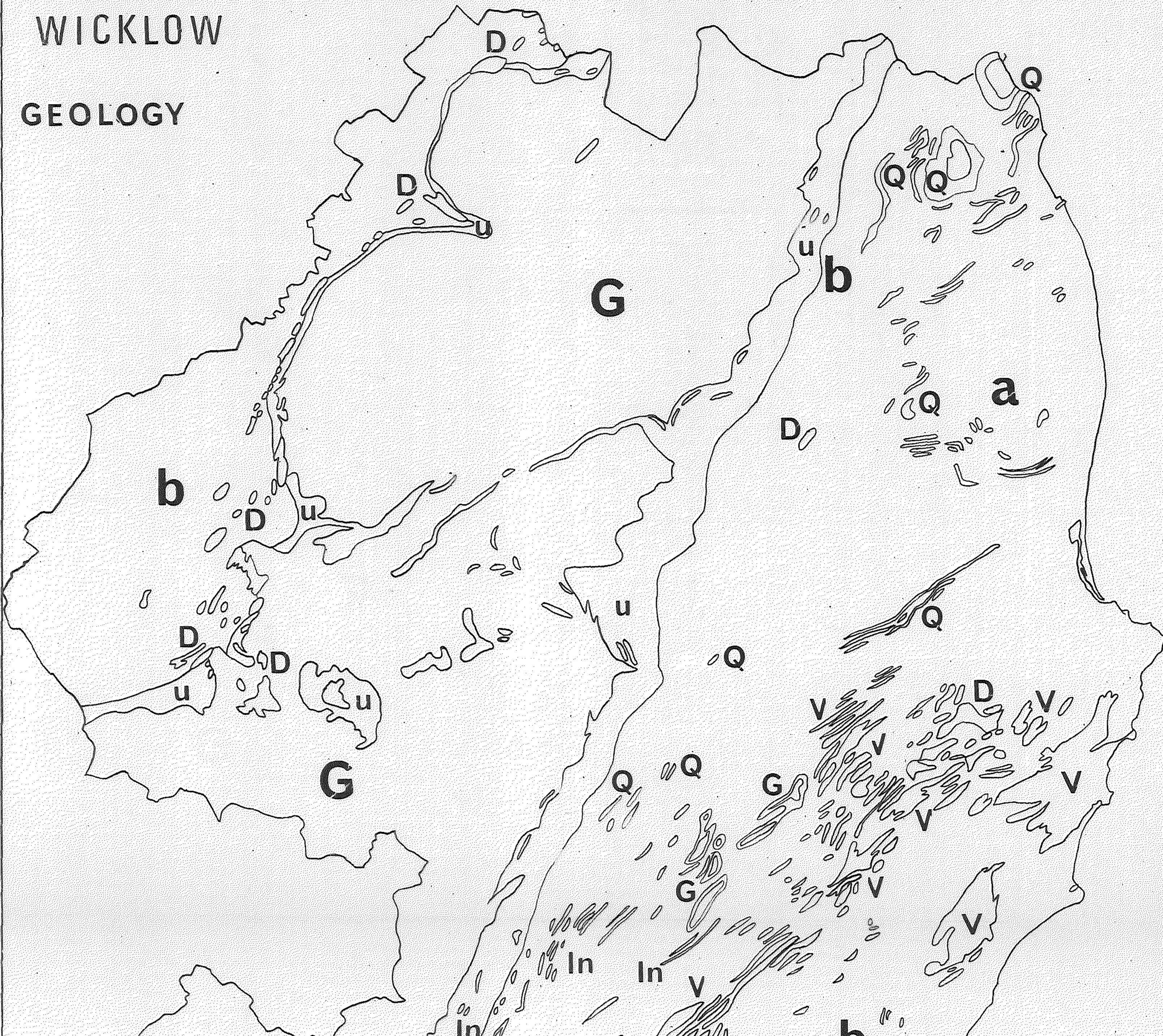

3
BRITTAS
Brittas
Aghfarrell
306
3G
3G
3M
309
Kilbaylet

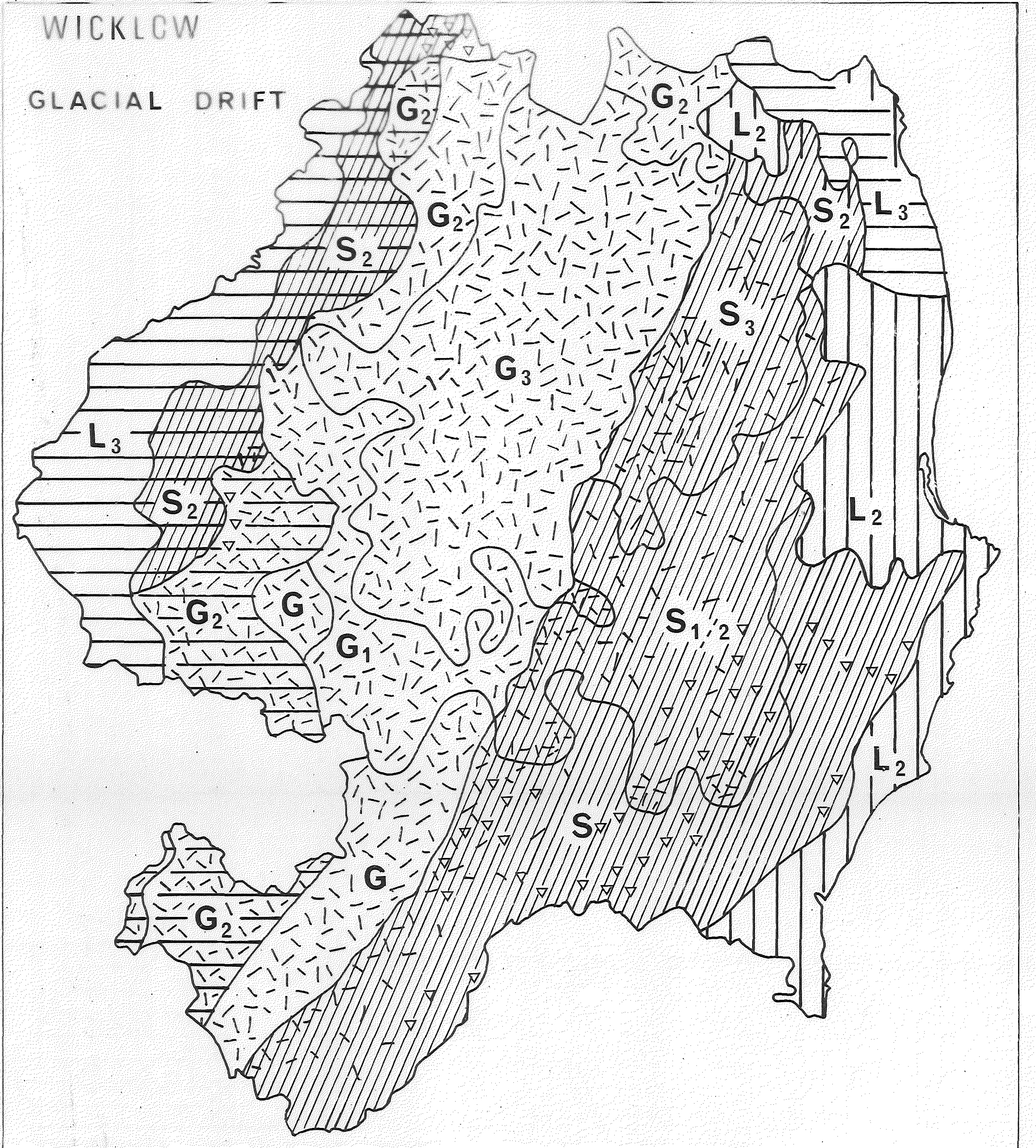

4
0
km
10
BLESSINGTON/
ATHDOWN
4M
276
285
Blessington
273
283
Athdown
Boystown
219
4M
Hollywo
Glen
206
218
Toor
277-268
211
293
283
Drumreagh
Lockstown
4G

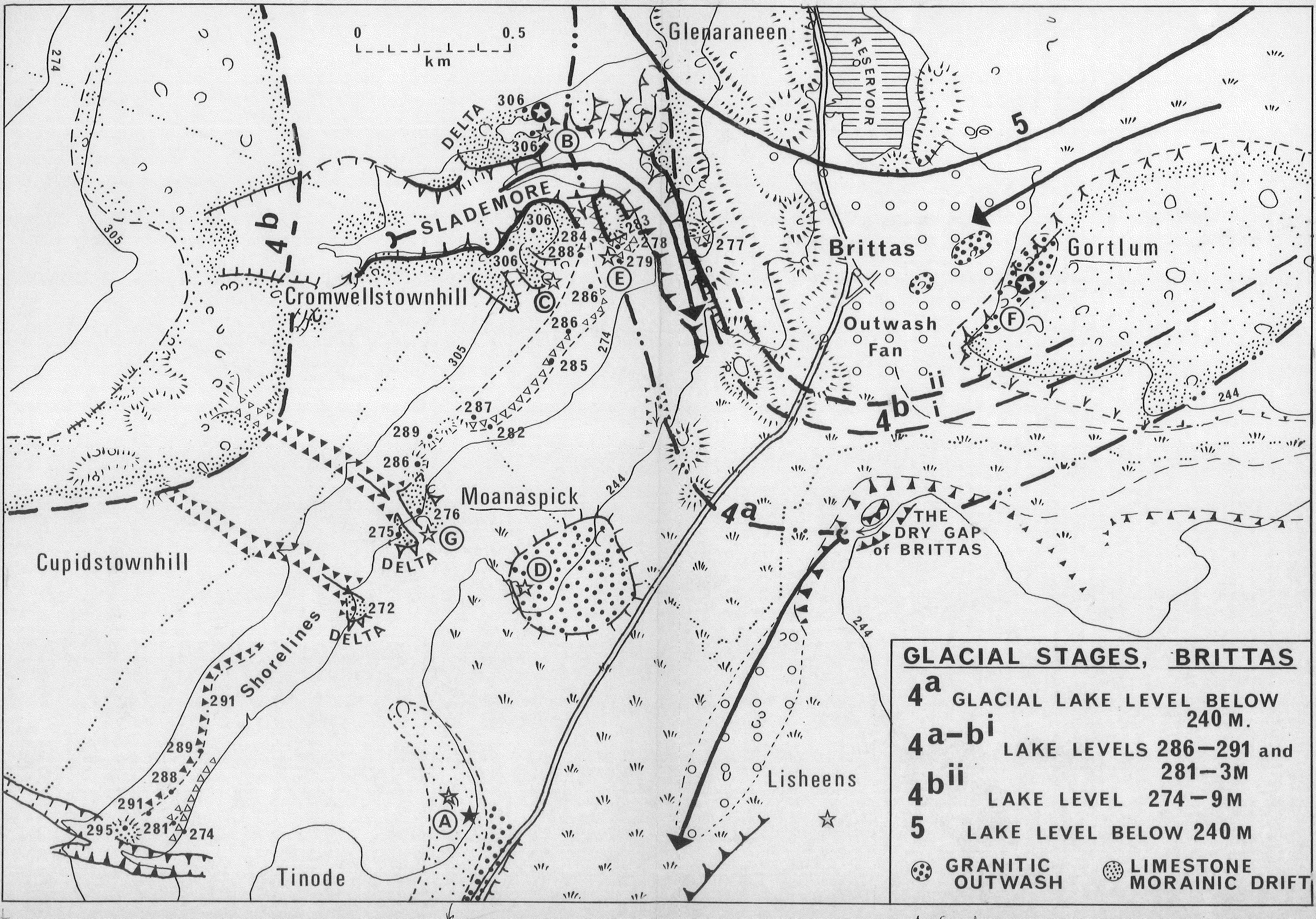

5
COLBINSTOWN
Kilbride
180
5M
Pollaphuca
199
Hollyw d
180
199
Deme ne

WICKLOW

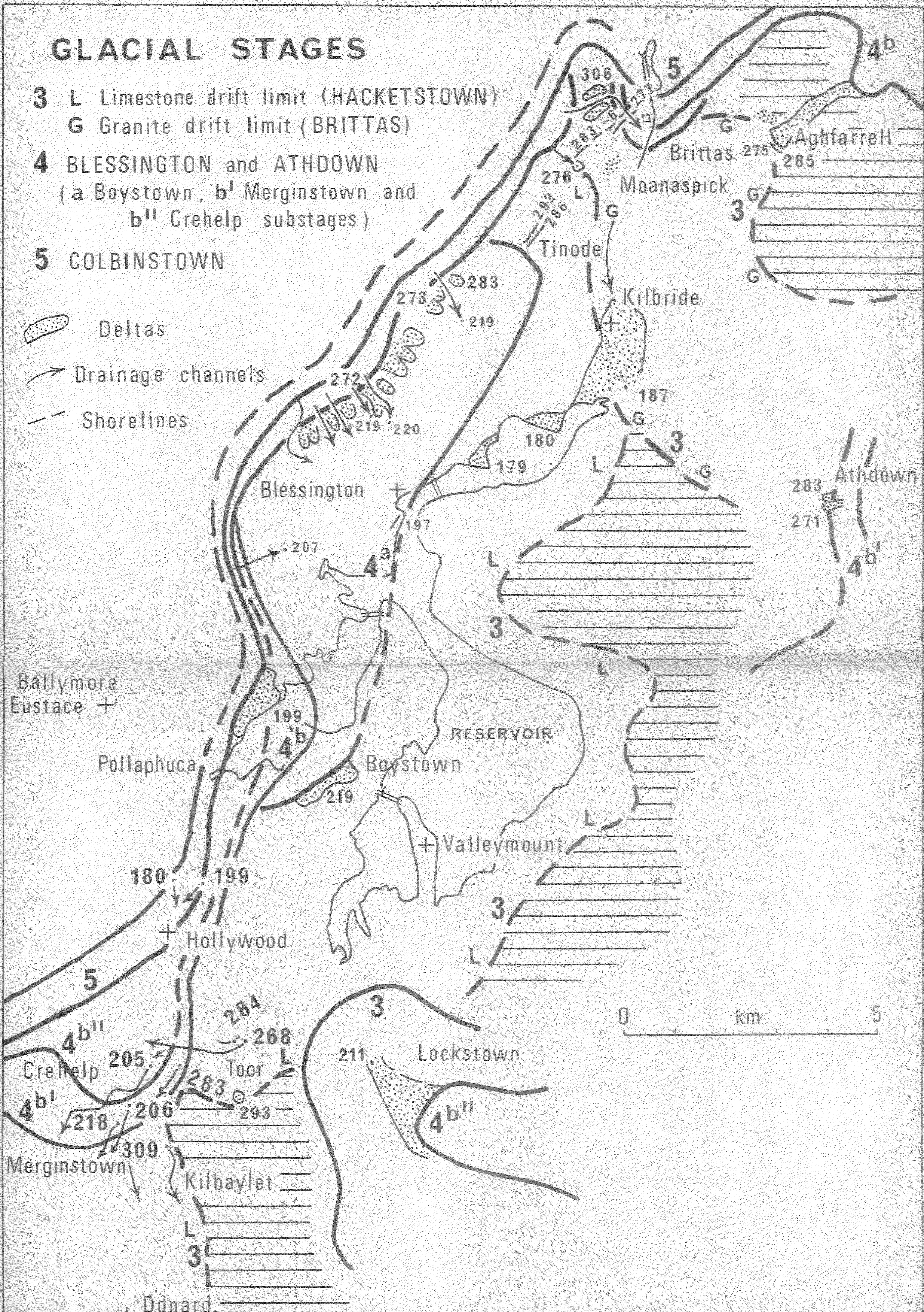
GEOLOGY

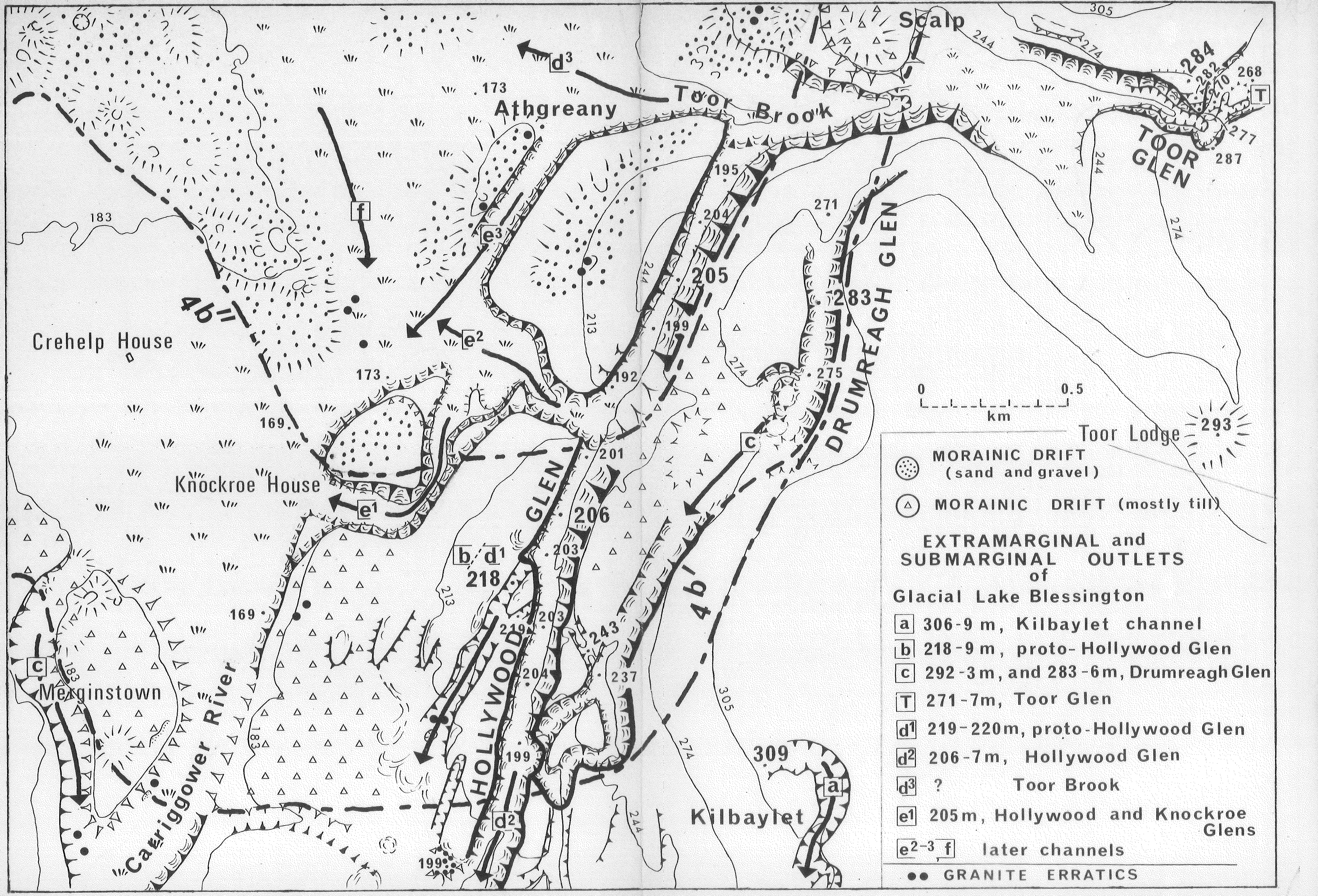


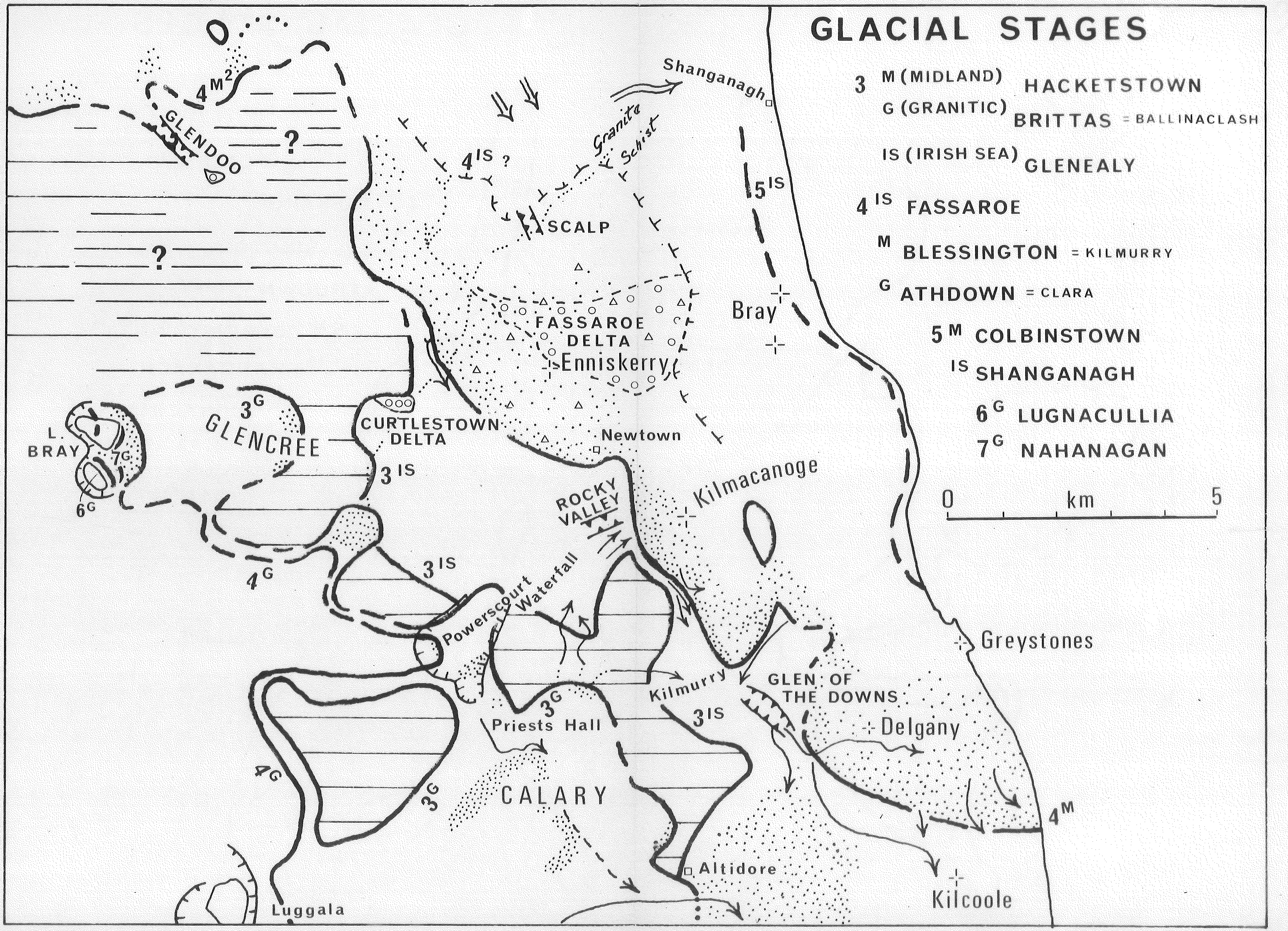

WICKLOW
GLACIAL DRIFT
G2
G2
L2
G2
S2
L3
S2
S3
G3
L3
S2
L2
G2
G
G1
S1 2
L2
S
G
G2


0
0.5
km
Glenaraneen
RESERVOIR
5
DELTA
306
306
B
SLADEMORE
306
284
288
306
283
278
279
E
277
Brittas
Gortlum
4b
Cromwellstownhill
C
286
286
274
305
285
Outwash
Fan
F
ii
4b
i
244
287
289
282
286
276
275
G
Moanaspick
244
4a
THE
DRY GAP
of BRITTAS
Cupidstownhill
DELTA
D
272
DELTA
Shorelines
291
289
288
291
295
281
274
A
Tinode
Lisheens
244
274
305
GLACIAL STAGES, BRITTAS
4a GLACIAL LAKE LEVEL BELOW 240 M.
4a–bi LAKE LEVELS 286–291 and 281–3M
4bii LAKE LEVEL 274–9M
5 LAKE LEVEL BELOW 240M
GRANITIC OUTWASH
LIMESTONE MORAINIC DRIFT

☆ Gravels


GLACIAL STAGES
3 L Limestone drift limit (HACKETSTOWN)
G Granite drift limit (BRITTAS)
4 BLESSINGTON and ATHDOWN
(a Boystown, b' Merginstown and
b'' Crehelp substages)
5 COLBINSTOWN
Deltas
Drainage channels
Shorelines
5
4b
306
277
Brittas
Aghfarrell
275
285
283
276
Moanaspick
292
286
Tinode
Kilbride
273
283
219
272
219
220
187
180
179
Blessington
197
207
4a
Athdown
283
271
4b'
RESERVOIR
Ballymore
Eustace
199
4b
Pollaphuca
Boystown
219
Valleymount
180
199
Hollywood
284
268
Toor
4b''
205
Crehelp
283
293
206
218
4b'
309
Merginstown
Kilbaylet
211
Lockstown
0
km
5
Donard


Scalp
305
244
274
284
282
270
268
T
d3
Toor Brook
173
Athgreany
TOOR GLEN
277
287
244
274
f
195
183
271
204
e3
244
DRUMREAGH GLEN
205
283
4b''
213
Crehelp House
e2
199
173
192
274
275
0
0.5
km
169
Toor Lodge
293
201
c
MORAINIC DRIFT (sand and gravel)
Knockroe House
e1
MORAINIC DRIFT (mostly till)
GLEN
206
EXTRAMARGINAL and SUBMARGINAL OUTLETS of Glacial Lake Blessington
b d1
203
218
4b'
a 306-9 m, Kilbaylet channel
169
213
203
b 218-9 m, proto-Hollywood Glen
219
243
c 292-3 m, and 283-6 m, Drumreagh Glen
c
183
204
237
T 271-7 m, Toor Glen
Merginstown
HOLLYWOOD
River
305
d1 219-220 m, proto-Hollywood Glen
183
Carriggower
274
d2 206-7 m, Hollywood Glen
199
309
d3 ? Toor Brook
a
Kilbaylet
e1 205 m, Hollywood and Knockroe Glens
d2
244
e2-3, f later channels
199
GRANITE ERRATICS


GLACIAL STAGES
3 M (MIDLAND) HACKETSTOWN
G (GRANITIC) BRITTAS = BALLINACLASH
IS (IRISH SEA) GLENEALY
4 IS FASSAROE
M BLESSINGTON = KILMURRY
G ATHDOWN = CLARA
5 M COLBINSTOWN
IS SHANGANAGH
6 G LUGNACULLIA
7 G NAHANAGAN
0 km 5
Shanganagh
Granite
Schist
GLENDOO
4 M2
4 IS ?
SCALP
5 IS
Bray
FASSAROE DELTA
Enniskerry
CURTLESTOWN DELTA
Newtown
3 G
GLENCREE
L. BRAY
7G
6G
3 IS
ROCKY VALLEY
Kilmacanoge
4G
Powerscourt Waterfall
Greystones
Kilmurry
GLEN OF THE DOWNS
Delgany
Priests Hall
CALARY
3G
4M
Altidore
Kilcoole
Luggala

E Watson

Field Guide

to

THE QUATERNARY OF THE WICKLOW DISTRICT

Compiled by

Francis M. Synge

Geological Survey of Ireland

with written contributions from E.A.Colhoun and P.G.Hoare

Leaders

F. M. Synge, G. F. Mitchell, W. P. Warren and P. G. Hoare

EXCURSION GUIDE for field meeting arranged to demonstrate the Quaternary Geology of County Wicklow in Ireland

for

the QUATERNARY RESEARCH ASSOCIATION, May 15 - 19, 1975

During the thirty years preceding 1966 the detailed field observations of the late Dr. Farrington in Wicklow laid the foundations for the comprehensive stratigraphy of the Irish Quaternary adopted at the present time. According to his evidence two successive ice sheets enveloped the lowlands both to the west and east of the Wicklow Hills. At the same time local glaciers that grew up in these uplands attained a phase of maximum advance on three occasions - before the earlier lowland ice sheet had reached its greatest extent; after it had retreated somewhat; and also after the second or last lowland ice sheet had started to wane. By 1948 Farrington recognized these five distinct glacial episodes throughout southeast Ireland, naming them thus:-

ATHDOWN	Mountain Glaciation, or last significant advance.
MIDLAND	General " " " , from northwest (Irish Midlands).
	_____ weathering horizon _____
BRITTAS	Mountain Glaciation.
EASTERN	General " " ", from northeast (Irish Sea).
ENNISKERRY	Mountain " " ".

Hitherto the glacial episodes in the mountains had not been considered. A simple tripartite division of the Irish drifts prevailed - Lower Boulder Clay; a shelly clay with few stones derived from sediments in the Irish Sea, Middle Sands and Gravels, interpreted as outwash produced during the decay of the Irish Sea Ice; and Upper Boulder Clay, a stony clay derived from ice from the northwest. This concept was largely based on the coastal section examined at Shanaganagh (between Killiney and Bray) by J.R. Kilroe in 1903 for the Geological Survey of Ireland.

The later realisation that the youngest ice sheet was both less extensive than the older one, and was separated from it in time by an interglacial period of temperate climate inspired scientists to subdivide the drift succession into two major units - the Newer and Older Drifts of the literature of the time. The southern limit of the younger drift sheet was clearly identified on morphological grounds (Charlesworth, 1928) crossing Ireland from the foothills south of Dublin to the Shannon estuary; apart from a few minor details its position and course as mapped by Charlesworth has been onfirmed by subsequent work.

In the absence of interglacial deposits containing fossil evidence of the 'Last Interglacial', Farrington suggested that the weathering of the drifts that preceded his Midland General deposits belonged to this episode. On the other hand the Athdown deposits were considered to be much younger, and correlated with the Late Glacial stage (i.e. Zone III of the pollen sequence). This view had to be abandoned when it was realised that a number of the cirque moraines lying well within the Athdown limit had all the characteristics of a significant readvance(Farrington, 1966).

Subsequent work being carried out by the Geological Survey in Wicklow has confirmed Farrington's fivefold sequence. In the course of this work the writer has had occasion to check a great many of Dr. Farrington's field observations and has always found them to be accurate and reliable. But because of the great many new exposures now available, certain of his glacial stages - particularly the Brittas and Athdown - have been repositioned in east Wicklow. Such alterations are of a minor nature (compare his map, fig. 1, with fig. 2). It should be pointed out that the detailed story of the succession was based on stone counts round Brittas (1942) from 15 samples and round Enniskerry (1944) from 83 samples - a technique of drift separation well in advance of its time.

Since 1966 such scientific techniques have become more general in Quaternary research in Ireland. Along with stone counts, Dr. P.G. Hoare has recently succeeded in subdividing and classifying the tills of County Dublin by means of carbonate analysis, colour classification and pebble orientation. Similar work has been carried out in Meath and Louth (McCabe, 1973). These techniques have rather surprisingly established that the upper tills of the classic Shanganagh cliff section all originated from the Irish Sea, not from the Midlands as was previously believed.

Another advance in knowledge was made in 1969 with the discovery of lenses of organic matter caught up and embedded in the youngest suite of cirque moraines revealed when the level of Lough Nahanagan was lowered during the construction of a hydroelectric pump storage station. The organic matter in these moraines gave two finite ^{14}C dates, 11500±550 and 11600±260 years B.P., thus preving the reappearance of small glaciers in the Wicklow uplands during the Late Glacial (Colhoun and Synge, et al., in preparation).

According to the inter-relationship of ice marginal lake outlets across south Wicklow (Synge, 1973), the earliest phase of the Midland General Glaciation was contemporaneous with a large Irish Sea (Eastern General) glacial and the local Brittas ice cap, but postdated the earliest and greatest expansion of the local ice. This latter advance previously ascribed to the Athdown stage, is termed Aughrim from the locality where it is most clearly demonstrated.

Near Wexford the terminal zone of the Irish Sea glacier mentioned above incorporates masses of estuarine mud containing pollen having close affinities to that of the Last or Ipswichian Interglacial (Colhoun and Mitchell, 1971). This drift appears to be younger than that of similar type on the coast of county Cork (Mitchell, 1972), but possibly older than the upper Irish Sea drifts of Dublin. Evidence for a distinct readvance of the Irish Sea glacier <u>later</u> than that of the main Midlandian advance from the northwest is somewhat problematic at the moment.

The distribution of pingos in southeast Ireland also supports the contention that the Irish Sea drift of east Wexford falls into the Last or Midlandian Glaciation. These periglacial landforms stud the older drift surface that lies outside that limit. (Mitchell, 1973). In south Wicklow such pingo fields appear to be truncated by the same Irish Sea drift, but extend within the Aughrim limit. From the foregoing it is apparent that Farrignton's weathering horizon cannot be as old as the Last Interglacial. Its persistent occurrence at the same stratigraphical horizon does, however, suggest a widespread climatic amelieration between the Brittas and Midland advances during the middle part of the Last Glacial Period.

Important in any reassessment of the succession is the position of the coastal wave-cut paltform underlying most of the Irish drifts. Hitherto this platform has always been regarded as predating all Irish drifts (Wright and Muff, 1904: Farrington, 19 ; Mitchell, 1972). New evidence suggests that this strict adherence to the basic 'law of superposition' must now be questioned; the ease with which boulder clay can flow or slump down a slope and bury the original surface had not been appreciated before. If the platform predates a glacial episode it should bear the signs of glacial erosion; but if, on the other hand, glacial ice had never overrun the platform, only the signs of wave erosion should be apparent. All along the east coast, north of the very southeast tip of Ireland the platform falls in the former category - being strongly ice moulded and striated. But along the south coast, as far west as the entrance to Cork Harbour no vestige of any sign of glacial erosion could be found on its surface. In other words the platform has not been glaciated outside the limits of the Last or Midlandian Glaciation, and therefore properly belongs to the period of the Last (Ipswichian) Interglacial.

The above view is completely at variance with the stratigraphy worked out for the south of Ireland based on pollen dated sites of Hoxian age at Newtown and Kilbeg in Co. Waterford and Baggotstown in Co. Limerick (Mitchell, 1972). This stratigraphy may be presented thus -

Munsterian Glaciation	Midland ice from north (Ballyvoyle and Bannow tills). Irish Sea ice from east (Ballycroneen till).
Gortian Interglacial	Courtmacsherry Beach and Gortian orogenic beds.
<u>glaciation</u>	Erratics (in the Courtmacsherry beach).
	Marine wave cut platform

The oldest till observed on the Wicklow coast was first recognized at Clogga as a compact deposit with erratics of Leinster granite. Farrington (1954) showed that it was associated with ice from the northwest, and unlike the overlying Irish Sea drift, entirely non-calcareous. He equated it with his E-niskerry Mountain Glaciation and also placed it stratigraphically above the nearby marine cut rock platform which occurs nearby. The inland extension of this till however, as a weathered surface deposit right across south Wicklow in association with a very consistent NW-SE striae pattern show that it belongs to an early general, not local, glaciation (Synge, 1973).

Recent exposures show that the gravel layer separating the Clogga till from the overlying Irish Sea drift, rests on a planated surface. This surface appears to be laterally continuous with the rock platform - a striated surface associated with the overlying Irish Sea till. The gravel layer is derived entirely from the lower till and local rock; it has the appearance of a beach deposit. The suggestion is made here that the gravel layer and the platform belong to the Ipswichian Interglacial and intervene between the Clogga till and the overlying Irish Sea drift.

On the west side of the Wicklow Hills attempts have been made to work out the intimate relationship between the oscillations of margin of the general ice sheet and those of the local glaciers during the Main Midlandian. By means of the precise levelling of the deltas and outlets of a large ice dammed lake, Glacial Lake Blessington, in the valley of the upper Liffey some eight water levels were identified.

The following succession has been worked out for Wicklow (based on work in west Wicklow; the east Wicklow correlatives are shown in brackets) -

	GLACIATION	Midland ice	Local ice	Irish Sea ice
7.	Late Glacial	-	NAHANAGAN	-
6.	Late	-	LUGNACULLIA	-
5.	MIDLANDIAN	COLBINSTOWN	?	Shanganagh (= Balheary, Rush and Loughshinny tills of P.G. Hoare)
4.	Main	BLESSINGTON (Ardoyne)	ATHDOWN (Clara)	?
3.	Early	HACKETSTOWN	BRITTAS (Ballinaclash)	(GLENEALY)
2.		-	AUGHRIM	-
	1.5 - 4.0 m (O.D. Newlyn) beach and platform (? IPSWICHIAN)			
1.	MUNSTERIAN	(CLOGGA)	-	(further offshore) = Ballycroneen of G.F. Mitchell.

The present survey of Co. Wicklow for the Geological Survey includes field mapping on the 1/10560 scale with standard grid sampling of till and/or fluvioglacial deposits for stone counts every 8 sq. km. Significant fluvioglacial deltas, outwash terraces and lake shorelines are instrumentally levelled from beachmarks. Air photographs are also checked as an aid to feature mapping, but have not turned out to be very useful in this particular country.

This tour has been arranged to demonstrate the basis of the Quaternary succession in County Wicklow. For location the Ordnance Survey ½-inch to 1 mile (I:126720) Topographic Sheets 16 and 19 are recommended. For central Wicklow the special 1 inch to a mile (I:63,360) 'Wicklow District' map is very useful.

All stops listed below are indicated on the Route Map (fig. 2). This map, also showing the limits of the main glacial stages should be compared with fig. 3 (Solid Geology) and fig. 4 (Drift Geology).

<u>1st day</u> - <u>To sites featuring the older part of the succession</u> (Figs. 2,5).
<u>Route</u> - Woodenbridge-Avoca-Snugberough-Coolboy-Arklow-Clogga-Coolgreany-Aughrim-Coats Bridge-Woodenbridge.

1. <u>AVOCA</u> (T207 800)
Terrace of glacial outwash gravel associated the terminus of the

Avonmore Glacier during the Aughrim glacial episode. A suite of marginal drainage channels defines the margin of the ancient ice lobe.

2. SNUGBOROUGH (T241 774)
Pingo developed on the surface of the Clogga drift, an earlier glacial deposit of Munsterian age.

3. COOLBOY (T250 748)
Section in one of the terminal moraine ridges of the Irish Sea Glacier of the Glenealy stage. Note the characteristic erratics, limestone, flint and marine shell fragments.

4. CLOGGA (T252 692)
An important section, the type site of the Clogga till, extends along the south shore of the bay -

4c Irish Sea till with few stones
4b Laminated sand, silt and clay beds
4a Stony Irish Sea till derived from underlying till.
3 Gravel bed derived from underlying till
2 Planated till surface.
1 Very stony (Clogga) till.

Moving south horizons 1-3 are truncated by 4a, and surface 2 merges with a marine rock cut platform developed upon steeply dipping slates. Striae ranging from NNE-SSW to E-W occur on the platform. Small pockets of Clogga till survive and seem to have slumped upon the wave cut platform before the arrival of the overlying Irish Sea till. The two tills are quite different - the Clogga till contains granite but no flint, shells or limestone and is non-calcareous (the thin surface layer below 3 has become calcareous through percolation downwards from 4a). The Irish Sea tills contain flint, shells and limestone and highly calcareous below a zone of leaching.

Farrington (1954) pointed out that the lower till was quite fresh, and therefore indicative of no obvious unconformity in the succession.

It is suggested here, however, that a phase of marine erosion intervened between 1 and 4 and removed the weathered surface of the Clogga till, and deposited a gravel beach (3). This episode is considered to correspond with the Ipswichian Interglacial.

5. COOLGREANY (T182 700)
Ice marginal kame gravels associated with the inland margin of the Irish Sea Glacier (Glenealy stage).

6. KILLADORAN (T120 779).
Glacial gravels deposited during wastage of the Clogga ice. Some erratics of silicified limestone from the west occur.

7. Roddenagh Bridge, AUGHRIM (T115 790)
Deltaic deposits at 85m associated with glacial outwash from the Ow Glacier during the maximum of the Aughrim stage. The delta was deposited in a lake impounded in the Derry Corridor by the terminal lobe of the Avonbeg Glacier. This lake drained west to the Slaney valley.

During the succeeding cold period widespread frost-heaving disturbed the upper beds of the delta. At this time the Derry Corridor was impounded at its west end by Midland ice and ice marginal deltas were deposited at 80 and 81m near Clonegall. These levels accord with that of the Lugduff col, already lowered some eight metres by the earlier drainage west during the Aughrim stage. This evidence thus suggests that the limit of the Midland ice during the Hacketstown stage postdates the Aughrim advance of the local ice.

8. and 9 <u>Coats Bridge, AUGHRIM</u> (T142 789 & T145 789).
Deltaic deposits at 88m are associated with glacial outwash from the Avonbeg Glacier whose snout impounded the lake mentioned above, at this point. This delta lies just west of a mass of till containing large blocks of granite; this is interpreted as a terminal moraine.

<u>2nd. day</u> - <u>Featuring the relationship between the local glaciers and the main icesheet during the period of the main Midlandian stages</u>. (fig 7).

Route - Woodenbridge-Rathdrum-Laragh-Roundwood-Luggala-ScallyGap-Athdown-Aghfarrell-Moanaspick-Blessington-Boystown-Lockstown-Toor-Hollywood Glen-Knockroe-Donard-Snugborough-Ballinabarny-Aughavannagh-Askanagap-Aughrim-Woodenbridge.

10. <u>LUGGALA</u> (O 169 075)
Overdeepened glacial trough which was the main discharge route for local ice spreading out to the Calary plateau. During the latter stages of glaciation hanging cirques developed on the west side of this trough, associated with arcuate moraines.

29 L. Tay.

11. <u>ATHDOWN</u> (O 067 142)
(fig.6) Terminal moraine of a local ice cap during the Main Midlandian. The outermost moraine is associated with the highest level of Glacial Lake Blessington at 283m - the <u>highest outwash terrace</u> at this place. This contradicts the previous assumption that the lake level had already fallen before the local ice had advanced to this point.

~~30~~ 28

12. AGHFARRELL (O 054 218)
(fig.7) Delta at 285m associated with limestone rich outwash from Midlandian ice sheet abutting against the north edge of the Dublin Hills at Ballinascerney. This deposit fills a trench cut through fluvioglacial mounds of granite sand that mark the edge of the local Brittas advance.

13. <u>MOANASPICK</u> (O 026 206)
(Fig.8) Mounds of granitic gravels and sands mark the Brittas limit. They abut against a ridge of weathered limestone drift (?Hacketstown stage). Further west up the slope a small delta of limestone gravel lies at the lower end of a small drainage channel leading from a moraine on the ridge summit higher up. This delta front at 272m. lies below shoreline at 286^{o}-9m.

In this classic area three distinctive drift types have been recognized, an early limestone drift (3^M), a local drift (3^G), and a younger limestone drift (4^M). All these are referable to different phases of the Midlandian Glaciation. Farrington believed that the earlier limestone drift came from the northeast; however the characteristic erratics of flint are extremely rare, but they do occur with shell fragments at Slademore. The deposition of this earlier limestone drift suggests that Irish Sea ice, Midland ice and local ice all merged in this area. But the younger limestone drift is associated with both low and high levels of the ice dammed Lake Blessington and fresh landforms (fig. 8).

	Stone Counts at -	Limestone	Chert	Palaeozoics	Granite	Moanaspick Limestone Chert
A	Drift 3^M TINODE (Till)	7%	12%	61%	-	0.6:1
	" 3^M " (Gravel)	4	1	34	-	4:1
C	" 3^M BRITTAS LITTLE(")	11	22	47	-	0.5:1
B	" 3^M SLADEMORE (Gravel)	23	22	49	-	1:1
	" 3^G TINODE (Gravel) (off map just S of A)	2	10	14	60	0.2:1
D	" 3^G MOANASPICK(")	-	7	21	57	--
F	" 3^G GORTLUM* " ")	-	1	51	47	--
14	" 4^{aM} TINODE (")	23	31	29	-	0.7:1
G	" 4^{bM} MOANASPICK(")	39	10	46	-	4:1
E	" 4^{bi} BRITTAS (")	-	32	56	-	---
F	" 4^{bii} LITTLE GORTLUM* (Till)	12	6	81	1	2:1

* samples from Farrington, 1942.

In spite of local variations due to differences in the source of meltwater streams, the major groups are clear. The second sample seems misplaced - it could be a shoreline deposit derived from the Moanaspick delta (4^{bM}).

Fluctuations of the levels of Glacial Lake Blessington are clear from the map (fig. 8). -

306 -8 m. Highest level. Delta at Slademore associated with lake formed as the Early Midlandian ice 4^M withdrew from the Brittas ice. The pounded water escaped south into Glen of Imaal by the Kilbaylet channel (fig. 7).

201 -8m. During maximum advance of the Main Midlandian ice (4^a) the lake level was low; marginal delta at Boystown and marginal channel at Brittas.

288-293 m. Shoreline at Tinode. Outlet being cut at Drumreagh Glen. (fig. 9).

281- 6 m. Ice margin at Brittas diverted the Slademore channel south. Shoreline at Brittas and Tinode. Delta at Aghfarrell and Athdown. Outlet 283 m at Drumreagh.

271 - 9m. Ice margin $4^{b''}$ at Brittas. Deltas at Moanaspick, Blessington, and Athdown. Outlet eventually cut down to 268 m at Toor.

211 -9m. Lower limit of channels at Blessington. Outlet ?

194 -9 m. Delta at Pollaphuca. Outlet, upper channel, Hollywood Demesne.

178-185 m. Delta at Kilbride. Outlet, lower channel, Hollywood Demesne.

14. TINODE (O 008 182)
Terminal subaqueous moraine at limit of the Blessington advance.

15. BLESSINGTON (N 978 161)
Massive delta at 272 -4m. built out from a till end-moraine,fed by esker-like kames.

16. BURGAGE(N= 982 131).
Varved clays deposited close to the ice margin of the Blessington stage.

17. BOYSTOWN(N 975 087)
Ice marginal delta at limit of Blessington stage at 205 m.

18. LOCKESTOWN(N 993 024)
Local moraine at Athdown age associated with delta at 211 m. The more massive Brittas moraine stands further downstream.

19. TOOR(N 951 035)
Evidence of col breaching by lake outlet at 277 m. Shoreline at 283 m. In the distance the ruins of Teer Lodge stand on a small stream delta at 293 m., the highest lake level.

20. HOLLYWOOD GLEN (N 891 037)
Viewed from the Blessington stage moraine at Scalp. A submarginal outlet of L. Blessington excavated along a zone of weakness down to a col at 205 m.

The outlets of Glacial Lake Blessington

Detailed mapping carried out by the Geological Survey in the vicinity of Hollywood Glen and Toor suggest a more complex story than envisaged by Farrington and Mitchell in 1973. Briefly, these authors came to the conclusion that the entire sequence of channels were cut by submarginal drainage during the first phase of the Midlandian Glaciation; with the exveption of the lowest or Knockroe Channel, which was cut during the oscillation of the ice margin in the third phase (fig 10).

This investigation suggests that channels were cut in this area during each of the three phases of glaciation, each of which was represented by a significant readvance of the ice margin. An important feature of the evidence is the presence of the same low level (218-9m) of Glacial Lake Blessington both before and after the high levels (284 -6m. and 272 -6m.) attained during a very significant advance of the Midland ice. As the low level is some 14m above the highest part of the floor of the deepest channel, Hollywood Glen, it must predate the excavation this cut to its present level.

During phase I of the Midlandian ice advance the ice limit reached about 310 m marked by a concentration of chert and silicified limestone. This drift is more weathered than those of the younger readvance; although the weathering in part depends on location and textural differences it must also be related to age, because during phase II the presence of fresh limestone is much more widespread. The margins of this drift sheet are represented by a marginal channel intaking at 309m at Kilbaylet. There is no evidence of any widespread ice dammed lake at this time. At the time the Toor col was buried by Midland ice which merged with the local ice further east. Ponded water, impounded between the two ice masses early during deglaciation is represented by the ice marginal delta at 306m at

Slademore near Brittas; presumably this marks the time when marginal drainage passed south along the Kilbaylet channel. With further deglaciation westwards a series of submarginal channels were formed radiating from Hollywood Glen which had only been excavated to a col at 218m by the time this ice had disappeared. Somewhat later the ice margin stood along the southern part of the Carriggower channel and poured delta gravel into a marginal lake impounded in the Glen of Imaal at Castleruddery. This was previously interpreted as an outwach terrace extending south from an ice margin at Merginstown along the Carriggower valley. However, new exposures at Whitestown show that the gravels were deposited as a kame terrace along the ice margin.

This stage of glaciation postdates an expansion westwards of the local ice, represented by large quantities of granite boulders, and in places an underlying deposit of drift containing much granite but no limestone. This spread of granite boulders is very thick opposite the entrance to the Glen of Imaal, and can be traced as far as Dunlavin. In the area at present being described they were observed at Merginstown, Crehelp, and Athgreany (fig. 9).

During the next advance the Midland ice moved southeast instead of east, and deposited a clear ice marginal feature at Boystown associated with a marginal lake at 219m which discharged through Hollywood Glen (channel 'b' in fig. 9). Later the ice margin pushed further east in the Hollywood area, but retreated from Boystown to Blessington further north as the lake level rose accordingly to a maximum stand at 292m, represented by a shoreline at Tinode and a small delta at Toor Lodge and a submarginal outlet above Hollywood Glen, at Drumreagh. Here a small defile has been etched down to 283m. By the time the outlet had been cut down to this level ice marginal deltas were deposited by Midland ice at Aghfarrell and Blessington, and by local ice at Athdown, and the shoreline formed at Tinode and the Toor col.

As the ice sheet decayed the lake level dropped until the Toor col was exposed and notched by the outlet torrent. There is no evidence that this is a subglacial cut - it has all the signs of being a normal channel carrying an enormous quantity of water., it was eroded by migrating waterfalls at three diffent levels - 277m, 268m and a very raw cut (the 'Jackdaw's Glen'; Farrington, 1934) a few metres lower. The above levels can be matched as deltas and shorelines at various places on the margins of the former lake. The outlet torrent first passed submarginally along the valley of the Toor Brook to Athgreany; there cannot have been passage along Hollywood Glen at this time, because the later drainage of the ice lake corresponds with a consistent level of 219-220m in the Blessington area - this level corresponds with an old col above Hollywood Glen at 218m (channel d^1 in fig.). After drainage had ceased through Toor Glen, it passed south along the west side of the morainic dump at Scalp. At this time the southern part of Hollywood Glen was being deepened along a structural zone of weakness; the new channel d^2 thus replaced d^1. Drainage later broke out to the west through a low part of the western wall of the channel ('e^2'). A subsequent readvance diverted the drainage south cutting the Knockroe channel.

21. KNOCKROE (N927 024).
    View of the above channel and the moraine at Crehelp which caused the diversion of the mettwaters.

22. SNUGBOROUGH (S 952 963)
    Marginal delta formed as Midland ice was retreating from the Hacketstown

limit. Note depth of decalcification. This deposit laid down in Lake Imaal formed when the Midland Ice withdrew from the front of the local ice at Leitrim. Lake outlet at Killybeg channel.

The rock ridge to the west (of Palaeozoic sediments) is covered with granite blocks and denotes a moraine of local ice emplaced before the arrival of the Midland ice. Cirque moraines on Lugnacullia, in the North Prison(mapped by W. Warren) indicate much later phases of glaciation (fig. 11).

23. BALLINABARNY (S486 902).
Thick local till in the gap, probably medial moraine of Brittas age between Imaal and Toorboy glaciers. A curious little dry gully runs northeast from the gap entrenched in the moraine.

24. AGHAVANNAGH (T 060 860)
Terminal moraine of the Ow Glacier at the Aughrim stage. This moraine has lost its topographic form; only the large granite blocks remain.

Continue past the outwash at Roddenagh Bridge to Aughrim and Woodenbridge.

3rd. day - Cirque and Valley Glaciation in the Lugnaquillia-Table Mt. Massif.

Route - Woodenbridge-Carty's Corner-Ballinaclash-Greenan-Drumgoff-Baravore-Drumgoff-Laragh-Lough Nahanagan-Glendalough-Clara-Rathdrum-Woodenbridge.

26. BALLINACLASH (T 172 848)
(fig 5) Outwash terrace and terminal moraine of the Avonbeg valley glacier during the Brittas stage.

27. GREENAN (T 146 877).
Outwash terrace emanating from terminal moraine at Ballinacor; position of snout of Avonbeg galcier during the Athdown atage.

28. DRUMGOFF (T 106 907)
Recessional moraine, Avonbeg glacier. Local moraine at Car Park.

29. BARAVORE (T 066 943)
Here a large morainic ridge west of the main valley (Glenmalur) may be a medial moraine developed between ice descending the main valley and ice from Lugnaquillia. This tributary Baravore valley is of great interest as it is associated with a low level cirque with a clear series of moraines at 370m - the lowest fresh cirque moraines in East Ireland. A higher cirque at Arts Lough (490m) is fronted by a larger moraine. It is suggested that both cirques were occupied by ice during Zone III.

30. LOUGH NAHANAGAN (T 078 903)
(fig12) Excavations made in connection with the construction of a hydroelectric pump storage station at this site revealed suite of every clear terminal moraines beneath the surface of a cirque lake. Dr. E.A. Colhoun, now at Department of Geography, University of Tasmania has prepared the following note -

From the mapping and field study of the inner cirque moraines it is possible to draw some general conclusions on the nature of this lateglacial episode of glaciation at Lough Nahanagan.

The completely uneroded character of the morainic ridges which for the most part are draped with a blanket of lake clays and organic muds indicates that the moraines have been entirely preserved in their original forms of deposition beneath the waters of the cirque lake since their time of formation in the ice-lake. The extremely fresh topography with the narrow, sinuous, sharp-crested, asymmetric, steeply sloping and intersecting characteristics of the inner moraine ridges clearly distinguishes them from the massive, curved plan and convex cross-profile form of the outer cirque moraine which is much more denuded and represents a subaerially formed moraine; the product of a much larger glacier that occupied the entire cirque basin at a time considerably before the development of the inner moraine series. It is believed that the inner moraine series represent sublacustrine moraines similar to some of the sublacustrine moraines described from Baffin Island by Goldthwait (1951) and by Andrews and Smithson (1966). It is of note that the inner cirque moraines nowhere occur above the shorelines of either the former ice-lake or the succeeding cirque lake, nor did they occur within the zone influenced by wave action. Andrews and Smithson consider that the sublacustrine moraines of the Isortoq and Rimrock valleys similarly did not extend above the shorelines of the glacial lakes concerned; an observation which parallels the Loughnahanagan situation so precisely that it can hardly be fortuitous. The sublacustrine origin of the Lough Nahanagan moraines is supported by the observations that many of the steep distal slopes of the block moraines appear to have been formed simply by the sliding or dumping of large blocks off a steep, probably cliffed ice margin. This suggestion of sinuous cliffed terminii to the two cirque galciers is supported by the marked absence of outwash deposits of sand and gravel on the floor of the ice-lake or adjoining the distal slopes of the block moraines appear to have been formed simply by the sliding or dumping of large blocks off a steep, probably cliffed, ice margin. This suggestion of sinuous cliffed terminii to the two cirque glaciers is supported by the marked absence of outwash deposits of sand and gravel on the floor of the ice-lake or adjoining the distal slopes of the moraines. The predominance of granite blocks with some sand in many of the moraines and the contemporaneous development of laminated ice-lake clays in addition to the pre-existing clays of the lake floor indicates that there was mainly erosion, transport and deposition of coarse blocky granite debris and fine rock flour by the cirque glaciers.

The steep proximal slopes of most of the moraines are ice-contacts and are associated with minor re-entrant ridges. The intrusion of large granite boulders into and the deformation of the lake clays on the proximal sides of several moraines indicates that most of the ridges are push-moraines. The occurrence of grooved drift in which many of the ridges terminate in large boulders, similar to those shown beyond the terminus of the Woodworth Glacier in the Tasnuna Valley, Alaska by Flint (1957), on and behind several of the moraines indicates that the steep gradient cirque flowed rapidly forward to their terminal positions throughout the period of their existance. The presence of the large granite boulders on the upstream side of the clay ridges shows that the ice failed to transport the largest boulders forward at the same rate as either the ice or finer detritus and that the weight of the ice mass squeezed the basal load of the glacier that was mainly derived from late clays into the basal ice furrows created by the boulders. This inferred rapid flowage of the glaciers is supported by the strongly ice-moulded and striated character of the granite at the base of the cirque headwall and the absence of granitic debris on its surface.

The three series within the inner cirque moraines have been largely differentiated on the dominant composition of the moraine material and the proximity of the ridges to each other. This differentiation largely reflects the relationship between glacial erosion, glacial deposition and glacial intrusion and disturbance of pre-existing laminated lake clays. In the outer series, series I, the moraines are formed chiefly of ice-pushed lake clays. The relative scarcity of granitic debris indicates that the glacier overrode and deformed a thick deposit of lake clay but did not remove it from the lake basin. Only in moraine B of the central group were underlying granitic moraine deposits revealed and nowhere in this part of the basin was granite bedrock observed. The second series of moraines consists of a mixture of granite blocks, sand and clay and represents the mixing of freshly eroded and ice transported granite from the cirque headwall with lake clays which already mantled this part of the basin floor. The third series of moraines chiefly consist of granite blocks which occur peripherally beyond the ice-moulded granite rock at the foot of the headwall. Though some clay occurs in the matrices of the moraines and more clay lightly mantles some of the moraines the dominance of large granite blocks indicates that the floor and headwall were subject to strong glacial erosion. Even though the inner moraines can be divided into three series it is clear from their fresh morphology, pattern of arrangement and structure that they all belong to one episode of very active cirque glaciation which was quite short lived.

The outer cirque moraine at Lough Nahanagan represents the maximum known extent of glacier ice at the head of Glendasan during the last glacial stage and has long been correlated with Farrington's Athdown Mountain Glaciation (Farrington, 1944). That such a correlation is correct is supported by the two ^{14}C dates from the ice-deformed lake clays within this moraine of 11,600 and 11,500 B.P. and the degraded nature of the moraine surface. It has been suggested that cirque glaciers reformed in some of the deep cirque basins of Achill Island (Farrington, 1953), in the Nephin Beg Range (Synge, 1963; 1969) and on Lugnaquilla in the Wicklow Mountains (Farrington, 1966) but none of the moraines attributed to this stage of glaciation, envisaged as having taken place during Pollen Zone III times, have been dated in Irlenad. The evidence from Lough Nahanagan clearly proves that renewed glaciation occurred after 11,500 B.P. probably approximately during the period 11,000 to 10,000 B.P. The inner Lough Nahanagan cirque moraines therefore may be correlated with the cirque moraines of North Wales which have been dated by pollen analysis to Pollen Zone III times (Manley), and with the Loch Lomond Readvance in Scotland which has been dated by pollen analysis to Zone III times (Donner, 1957). Recent ^{14}C dates from many sites at or near the limit of the Loch Lomond Readvance indicate that ice was present until after 11,750 B.P. (Sissons, 1967; Peacock, 1971). The close agreement of these ^{14}C dates and the subsequent deposition of organic lake muds that contain a complete Flandrian pollen profile indicates that the Lough Nahanagan inner cirque moraines were formed during the climatic deterioration which caused the Loch Lomond Readvance and renewed cirque glaciation in the Lake District and North Wales during Pollen Zone III times.

31. <u>GLENDALOUGH</u> (T 112 964)

This deeply cut valley is associated with valley glaciation down the Avonmore. The monastic settlement stands on a delta associated with drainage down Glendasan into a lake impounded by dead ice in the valley at Laragh. Frost wedges have been observed in the surface layers of the deltaic deposits. Once the ice dam had collapsed, a long narrow lake remained occupying the glacial rock basin. This lake was later divided in two by an alluvial fan.

32. CLARA (T 161 925)
The southern terminus of valley kames, equated with the Athdown limit. A large outwash terrace starts at this point and can be traced down the Avonmore valley to Woodenbridge.

33. RATHDRUM (T 194 893)
An earlier glacial limit (Brittas) represented by a kame terrace containing contorted glacial gravels, and much fine sediment. The deposit is considered deltaic and associated with a lake impounded in the Avonmore valley by a dam of Irish Sea ice at Shelton Abbey causing the outflow to cut a marginal channel at Glenart. In a like manner another marginal lake impounded in Glenealy drained south by the dry rock cut channels entering the Avonmore valley from the north just east of the morainic deposits mentioned above (the western one is followed by the main road T7 and the railway). Immediately outside this moraine limit the clear remains of a pingo was observed.

4th. day - Woodenbridge-Ashford-Kilmartin-Newtownmountkennedy-Ballremon Commons-Powerscourt Waterfall-Lough Bray Upper-Curtlestown-Enniskerry-Newtown-Bray-Shanganagh-Killiney-Dublin.

34. GLENEALY (T 244 934)
Lateral and terminal moraines of Irish Sea glacier.

35. KILMARTIN (O 267 057)(O 275 029)
Submarginal drainage channels cut in rock, associated with lateral zone of Irish Sea glacier (Glenealy advance).

36. NEWTOWNMOUNTKENNEDY (O 267 057)
Large dry valley cutting directly east towards the coast. This carried drainage from the local ice on the Calary plateau (Athdown stage) unimpeded across the coastal plain.

37. KILMURRY (O 246 123)
(fig.13) Terminal moraine marking readvance of the Midland ice from northwest, (Blessington stage). Outwash made use of the older dry gap of Glen of the Downs.

38. BALLYREMON COMMONS (O 212 107)
Terminal moraine of local plateau or piedmont glacier. Its relationship to the dry Priests Hall channel from Powerscourt Deerpark places it with the Brittas stage. This channel intakes at 275m, the same height as the Curtlestown delta, built into a lake in Glencree by marginal drainage of the Irish Sea Ice (Glenealy stage). Farrington maintained that the northern part of this channel drained to Powerscourt, from local ice on the plateau, while the channel sloping east was postglacial cut by normal drainage through the moraine.

39. POWERSCOURT WATERFALL (O 197 123)
A fine arcuate moraine associated with an outwash apron extends below the foot of the waterfall. This is regarded as the snout of a glacial in the upper Dargle of Athdown age. The Brittas limit is further downvalley at Bahana.

40. LOUGH BRAY UPPER (O 144 152)
A fine suite of moraines occur across the lip of the two Lower Bray cirques. A very massive moraine 1 km broad is regarded as the equivalent of the Athdown stage. A very fresh double moraine perched on the inner edge of the older morainic pile impounding the upper lake probably represents the Zone III stage. In the lower cirque similar moraines emerge from the lake halfway along the northern shore. As in the case of Lough Nahanagan the ice only occupied the inner part of the cirque. The map (fig. 14) is compiled from the field observations of W.P. Warren.

41. CURTLESTOWN (O 189 168)
Ice marginal deltaic deposits probably associated with a dam of Irish ice that once impounded a lake in Glencree during the Glenealy stage.

42. Round ENNISKERRY (O 224 176)
Seven distinct drift deposits were identified by means of stone counts (Farrington, 1944) - 'C' - the youngest deposit, a terrace of outwash gravel, bordering the main valley, of variable composition; limestone 25%-50%, limestone/chert ratio below 7:1, granite 10%-25%; no shell fragments. 'B', gravel, and 'D', a reddish brown till associated with the hummocky drift of the general ice from the Midlands.

Limestone in 'B', 50%-70%	;	in 'D', 45%-65%
Limestone/chert, over 7:1	;	" " , over 7:1
Granite below 5%	;	" , granite below 7%
Shells, striated stones	;	shells

The shells are believed to have been picked up from the previous drift from the northeast. These deposits are seen at site 43, at NEWTOWN (O 232 161).

'A' Gravel, the Fassaroe delta, a large deposit extending east from Glencullen along the valley of the Dargle. This delta is thought to have extended from a local galcier into a lake impounded by Irish Sea ice. But the high percentage of limestone present does not accord with the presence of local ice - could it not represent a stage in the advance of the ice than later overwhelmed it? The complete absence of shell fragments would have to be explained - Limestone 32%-55%, Limestone/chert below 7:1, Granite, below 5% and no shells.

'G' Gravel, The local 'moraine' thought to be associated with this delta is completely weathered, Limestone 3%-13%, Limestone /chert under one; Granite 26%-80%; no shells.

The position of this 'moraine' very close to the edge of till 'D' suggests that it might be the outer edge of the younger ice sheet.

'E' Till, a typical 'stoneless' Irish Sea till extends south of the limit of the 'D' till (4^M in fig. 13).

'F' Till is a local granitic deposit beneath 'E'.

A very significant break in the succession occurs between the Glenealy stage ('E' or 3^{IS}) and the Delgany stage ('D' or 4^M). All the large rock cut drainage channels, Glen of the Downs, the Rocky Valley, and the Scalp are associated with the retreat of the earlier ice advance. During the later advance and retreat meltwaters completely failed to utilise the Scalp.

44. SHANGANAGH, County Dublin (O 161 224). Description supplied by Dr. P.G. Heare. (Refer to fig. 15a. Fig. 15b, drawn by FMS is included for comparison.

One of the most extensive coastal drift sections in eastern Ireland is the continuous exposure trending southwards from Killiney Bay, County Dublin, to the boundary between Counties Dublin and Wicklow, a distance of 4km. Several nineteenth century geologists desceibed a three-fold sub-division of the drift in south-east County Dublin. The succession was considered to consist of a Lower Boulder Clay at the base, overlian by a bed of shelly marine sand and gravel (the Middle Drift), with, at the top, an Upper Boulder Clay. This tripartite interpretation of the stratigraphy has recently been restated (Mitchell et al., 1973; Bowen, 1973).

It is suggestdd that all the horizons in these cliffs may have been deposited during a complex episode of advances and withdrawals of a single (Irish Sea) ice-sheet, possibly of Munsterian (Wolstonian) age. No material dating from the Midlandian (Devensian) Cold Stage is thought to occur.

The Pleistocene succession in the townlands of Shanganagh, Cork Little and Cork Great rests on Lower Palaeozoic strata at depth. The cliffs are up to 14m high in the central part of the section but decline both to the north and south. In general the beds are well exposed but to the south of Quinn's Road (263216), in particular, slumping has obscured certain parts of the cliffs. Elsewhere the steepness of the exposure makes close inspection of the stratigraphy either dangerous or impossible.

Many of the units occur throughout the greater part of the section and the gravels especially show considerable lateral changes in calibre. It is not possible to discuss in detail all these variations and only the predominant characteristics of each stratum are described.

Bedrock is not seen at any point along the cliffs but forms the prominent headlands of Killiney Hill to the north and Bray Head to the south.

The oldest exposed deposit occupies a limited outcrop towards the southern end of the section. It is a dark brown (10YR 3/3.5 according to the Standard Soil Color Chart notation) till (till 1) which is at least 1.8m thick but nowhere is the base seen. Fabric analysis suggests that the ice responsible for its deposition advanced form the north north- east (18.9°). Corresponding data from the other tills in the section, with one apparently anomalous exception, indicate a subsequent southerly shift in the centre of ice dispersal.

Till 1 is separated by an extremely sharp junction from an overlying fluvioglacial gravel which normally occurs at the base of the exposed succession. The extent of this bed suggests that the ice probably withdrew completely from the area following the accumulation of till 1.

The gravel is succeeded by till 2 which in many respects resembles till 1. It is up to 61.m thick to the south of Corbawn Lane (261224) and usually dark brown (10YR 3/3). The till contains pockets and lenses of sand and fine grade gravel and the base is frequently rubbly and poorly defined. Pebble orientations at seven sites indicate that the ice advanced from between north north-east and east north-east (30.1-78.1°).

The top of till 2 has been eroded by meltwater and is often highly irregular, especially immediately north and south of Corbawn Lane. Many of the 'basins' probably extend as channels for considerable distances inland and a few may be seen in three dimensions. These features, which are up to 2-3m deep, are filled with current-bedded sand and, less commonly, fine grade gravel deposited in flowing water. However, a large basin in a stratigraphically similar position south of Quinn's Road is occupied by finely laminated silt and sand suggesting accumulation in ponded water.

The sand is almost invariably overlian by outwash gravel, but a rubbly brown (7.5YR 4/3) till(till 3) separates the two beds north of Corbawn Lane and records a temporary advance of the ice. The till crops out over a distance of 100m and attains a maximum thickness of 2.4m. Locally it rests idrectly on, and extends as 'dykes' into, till 2. A stone orientation count suggests ice movement from the north north-east (26.3°).

The medium and coarse grade outwash gravel which overlies the sand is up to 10m thick south of Quinn's Road. Current bedding foresets frequently dip towards the south. Where it rests on till 2 the junction is sharply defined. The calibre of the material is extremely variable but there is a general decrease to the south. The morainic gravel overlying till 2 south of Corbawn Lane represents a local increase in grade of this unit and possibly records a still-stand of the Irish Sea ice-sheet as it withdrew towards the north and east.

The next youngest bed, till 4, is exposed intermittently throughout the section and is up to 11m thick. It is usually brownish grey (7.5YR 4/1) to dark brown (7.5YR 3/3). This unit is the least homogeneous of the tills and, although typically silty and almost stone free, encloses numerous pockets of sand and gravel; large granite boulders occur towards the top of the till. Fabric analysis indicates that the ice advanced across the area from the east (87.5° and 87.6°).

To the south of Quinn's Road, till 4 is overlain by a brown(7.5YR 4/4-4/6) till (till 5) which is up to 3m thick. It has a sandy texture, is relatively stone free and is locally separated from till 4 by a sharp junction.

Till 5 is succeeded by a rubbly black brown (10YR 2/2) till (till 6) which attains a maximum thickness of 7.3m and passes southwards into a much less stony, dark brown facies. The contact between tills 4 and 6 is clearly defined but is diffuse where till 6 rests on the gravel overlying till 2.

Three adjacent sets of stone orientation counts were made on till 6. Two display well-developed peaks (84.5° and 145.0°); the other shows a bimodal arrangement of values at 50° and 140°. The mean of 145.0° may appear to lend support to the claim that the upper part of the Shanganagh sequence was deposited by the south-easterly advance of the Midlandian ice-sheet (Mitchell et al., 1973; Bowen, 1973). However, the figure of 84.5° is consistent with an association with the Irish Sea ice, as is the preferred orientation from the overlying till 8 (mean = 81.2°).

A second brown (7.5YR 4/4) till (till 7), which is up to 4.6m thick, apparently fills a depression in the surface of till 6. The relationship between these two beds is not altogether clear, but at all the other sites in County Dublin where a similar situation occurs they are thought to have accumulated during the same ice-advance (Hoare, 1975). Two till fabrics were measured: one indicates ice movement from the north (6.7^{o}); the other contains no single well-defined peak.

An eighth till-sheet (till 8) occupies the upper part of the section throughout much of the exposure south of Corbawn Lane. It is dark brown (10YR 3/3), locally up to 7.3m thick, rubbly and has a sandy matrix. The till overlies gravel at several places with an ill-defined junction. The contact between tills 4 and 8 is usually indistinct but is occasionally a sharp erosional surface. At the southern end of its outcrop, till 8 contains irregular-shaped masses up to 9m long of the silty till 4. Till 8 was apparently deposited by ice which advanced from the east (81.2^{o}).

Two pockets of fine grade outwash gravel, at least 1.8m deep, overlie till 4 near the northern limit of the section. Long bulbous tongues of this material, approximately 0.5m thick, extend into the till at a low angle. It is not possible to reach this bed and its age is uncertain.

Whilst the Dublin (Midlandian) ice-sheet clearly advanced across the area, it only left striae to record its former passage. North-west to south-east coursing striations have been recorded from Killiney Hill, Dalkey Island and Bray Head. Till of ~~Munsterian~~ Midlandian age underlies the level area west of Carrickmines (226241) but does not persist farther east. This patchy distribution of the till is a common phenomenon in County Dublin and has also been noted in eastern Counties Louth and Meath (McCabe, 1973). No satisfactory explanation has yet been proposed.

The following sequence of events at Shanganagh may be tentatively reconstructed:

i) advance of the Irish Sea ice-sheet and the accumulation of till 1

ii) complete withdrawal of the ice from the area accompanied by the production of outwash and morainic gravel.

iii) readvance of the ice-sheet and the deposition of till 2

iv) a further deglaciation of the area; till 3 suggests a minor oscillation of the ice-margin.

v) a westward readvance of the ice-sheet and the accumulation of till 4

vi) the deposition of till 5

vii) tills 6 and 7 probably accumulated during the same advance

viii) the youngest deposit in the section which it is thought may be linked with reasonable confidence to the Irish Sea Glaciation is till 8

The age of the gravel which overlies till 4 at the northern end of the outcrop is not known.

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Key to fig. 3. (Compare with fig. 2).

(1) GEOLOGY

a - Cambrian Shales, Slates, Schists and Sandstones.
b - Ordovician and Silurian " " " " "
D - Intrusive Igneous rocks including Greenstone (Diorite and Dolerite) and
In - microgranite
G - Granite
u - Mica-Schist
Q - Quartzite
V - Volcanics

Key to fig. 4.

(3) GLACIAL DRIFT

L - Limestone drifts L_2 Irish Sea drift. L_3 Midland drift
S - Shale-Slate-Schist-Sandstone drifts (from the Cambro-Silurian rocks)
S Clogga drift. $S_{1/2}$ Aughrim and Brittas drift.
S_2 Hacketstown stage. S_3 Athdown stage.
G - Granite drifts G Clogga drift. G_1 Aughrim drift. G_2 Hacketstown/Brittas
G_3 Athdown stage.

(N.B. - Note intermixture of drift types shown by the combination of symbols - Limestone (horizontal lines for midland drift and vertical lines for Irish Sea drift): Cambro-Silurian rocks (diagonal shading); Granite ('needles'); Volcanics and other igneous rocks (triangles).

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