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SHORELINE PROFILES OF SELECTED SITES ON LAKE TE ANAU

by J. IRWIN

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J. Irwin

INTRODUCTION

A detailed survey of profiles at selected shoreline positions on Lake Te Anau was carried out from 26 April to 6 May 1974. Previously available information was limited to general profiles measurable from a bathymetric chart on a scale of 1:63,360 and ten near-shore profiles. The survey was designed to provide detailed information on beach and near-shore gradients at selected localities, on the relation of extended transverse profiles of the underwater lake slope to above water lakeside slopes and to rock type; and to compare profiles off beaches with those where no beaches were developed.

This study was made to provide information to help with shoreline stability problems on the lake.

PREVIOUS WORK

In April 1970, 88 underwater profiles were measured at the southern shallow end of the lake from Lagoon Point on the east shore around the south end to Brod Bay on the west shore. The investigation was exclusive to this area and was to determine the area of lake bed that would be exposed at low lake levels. Measurements were taken with lead line to a depth of 650 ft above sea level and, at 31 of the 88, above water measurements were made to 670 ft above sea level. The water level at time of survey was between 662.4 ft and 664.0 ft above sea level (Irwin 1974b). These data are presented here together with data collected in June 1973 (Irwin 1974a). The general bathymetry of the lake as a whole has previously been charted (Irwin 1971).

FIELDWORK AND METHODS

Lake Level

All reference to lake levels with respect to hydro-electric purposes are stated in feet and tenths of a foot above mean sea level. To avoid confusion these units are retained. Metric units have been used for horizontal distances.

During the survey the lake level dropped from 661.13 ft above sea level to 660.73 ft above sea level (Table 1).

Measurements were made at 70 sites with lead line and with echo sounder. At 29 sites permanent 5 ft long steel posts were driven into the ground at the top of the beach close to the bush line. Numbered metal tags were attached to the top of each post and to a nearby tree (Table 1). Profiles measured with lead line in June 1973 are given in Table 2 (Irwin 1974a). The positions of the marker posts and profile positions were located on enlarged aerial photographs, and are shown in Figs 1-6 and 7(a-e).

Above Water-level Measurements

Heights along 28 of the profiles were measured at 5 m intervals to the nearest 0.1 ft from ground level at the marker post to water level along a bearing normal to the shoreline. No allowance was made for uneven slopes between measured points but generally beaches had even slopes with a few showing small steps of 0.5 to 1.0 ft caused by wave-cutting at varying lake levels.

Underwater Measurements

At all sites the underwater profile was measured on the same bearing as the above-water profile, both bearings being approximately normal to the shoreline. Horizontal distance from the shore was measured by a marked line connecting the boat to the shore. Lead-line soundings were taken from a small boat, and echo soundings from a power boat driven at constant speed.

Of the 70 profiles measured, 22 were measured by leadline to the nearest 0.5 ft at 5 m intervals along the transit line to a depth of over 30 ft; that is to approximately 630 ft above sea level. At 67 of the 70 profiles including 19 measured by lead line, profiles 200 m long were recorded using a Furuno F850 echo sounder with a sounding rate of 155 soundings per minute. The three remaining sites were situated on areas too shallow for the effective use of the echo sounder. At depths of less than about 6 ft the record was obliterated by the outgoing sound pulse. Echo sounder records are shown in Figs 8(a-g). Records of profiles taken by echo sounder on this lake in 1973 are shown in Irwin 1974a.

Beach and Underwater Sediments

Beach sediments of predominantly mud grade were collected at seven sites (Figs 2, 3 and 5).

Beach sediments were collected by hand and underwater sediments by pipe dredge along profile lines at three sites (Figs 5 and 6). At profile 59 (a shingle and sand area) samples were collected from the marker post and at 5 m intervals out to a distance of 60 m offshore. At profile 60 (a mud area) collections

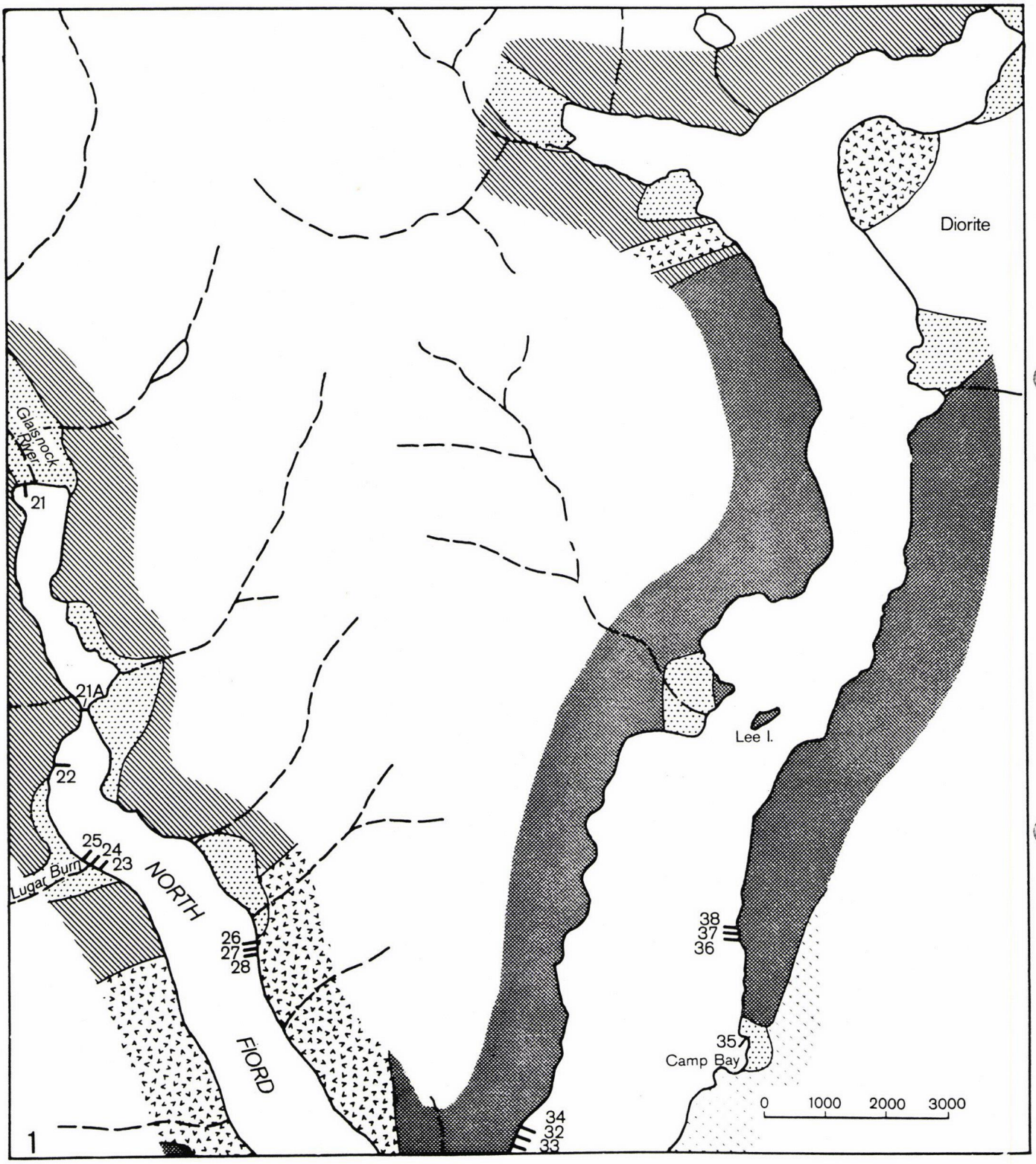


Fig. 1.

Figs 1 - 5. Lake Te Anau showing positions of shoreline profiles 1 - 10 1973, 1 - 67 1974, sediment sampling positions and surrounding shoreline geology.

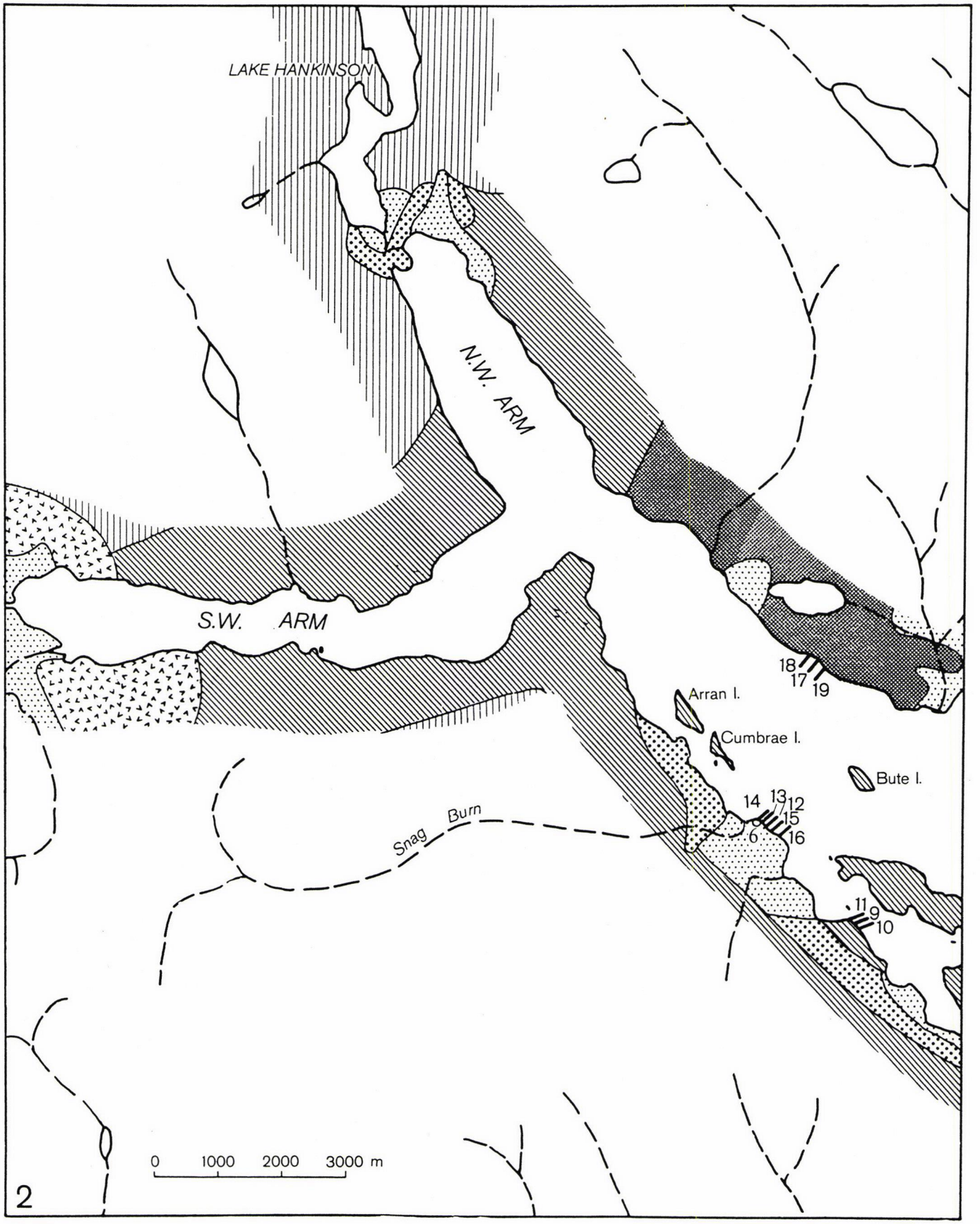

LAKE HANKINSON
N.W. ARM
S.W. ARM
Arran I.
Cumbrae I.
Bute I.
Snag Burn
18
17
19
14
13
12
15
16
6
11
9
10
0 1000 2000 3000 m
2

Fig. 2.

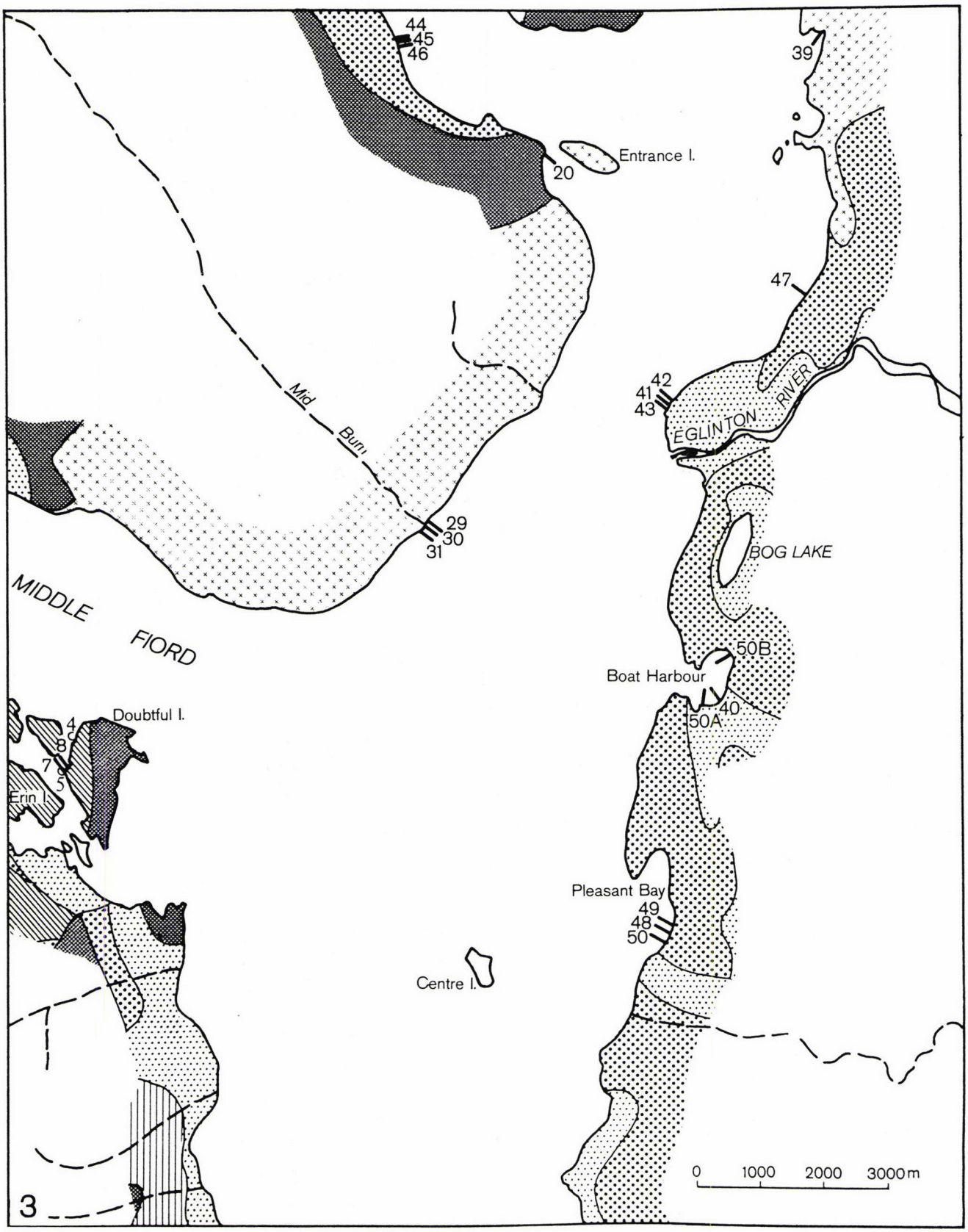

44
45
46
39
Entrance I.
20
47
42
41
43
EGLINTON RIVER
Mid Burn
29
30
31
BOG LAKE
MIDDLE FIORD
50B
Boat Harbour
40
50A
Doubtful I.
4
8
7
5
Erin
Pleasant Bay
49
48
50
Centre I.
0 1000 2000 3000m
3

Fig. 3.

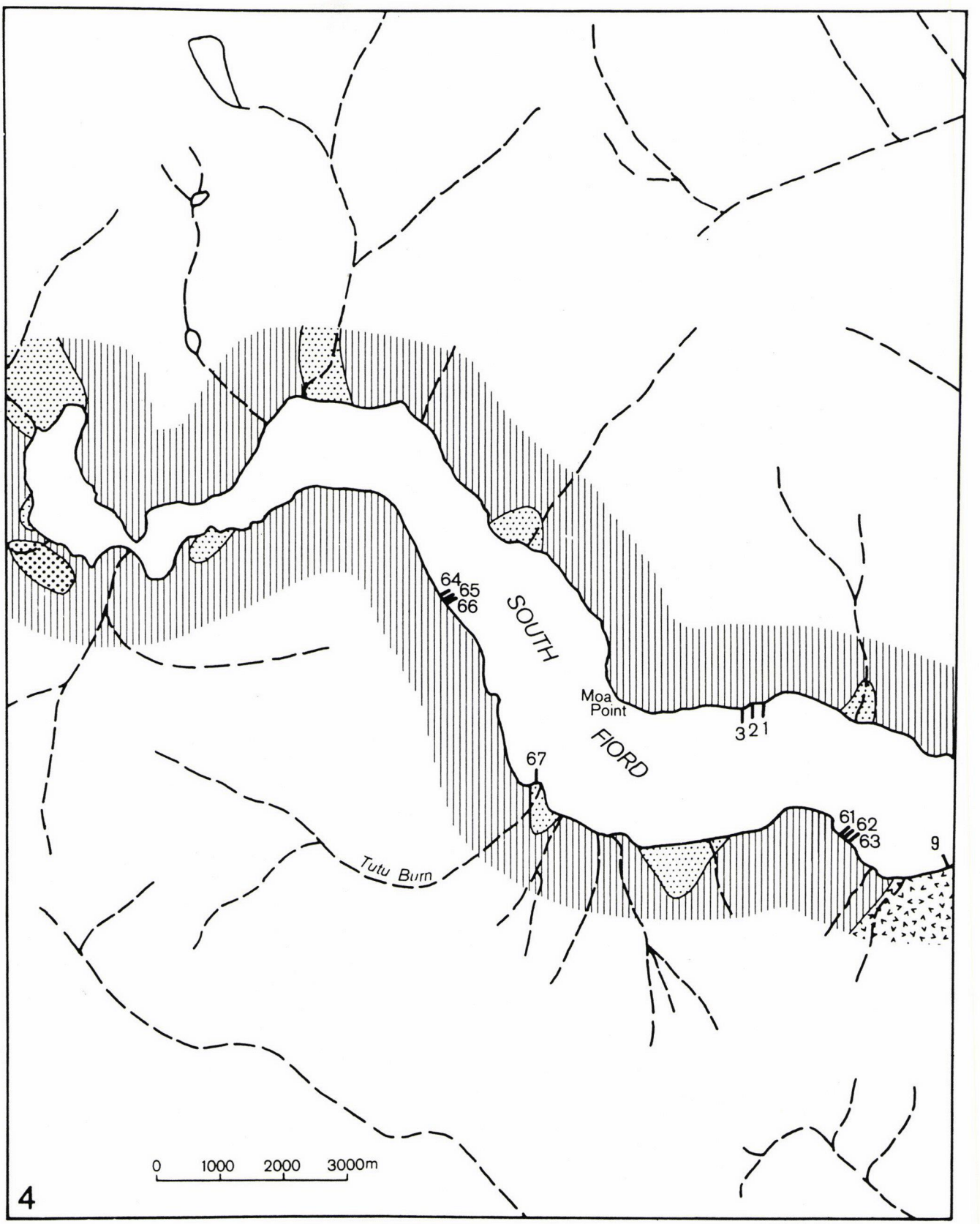

64
65
66
SOUTH
FIORD
Moa
Point
3
2
1
67
61
62
63
9
Tutu Burn
0 1000 2000 3000m
4

Fig. 4.

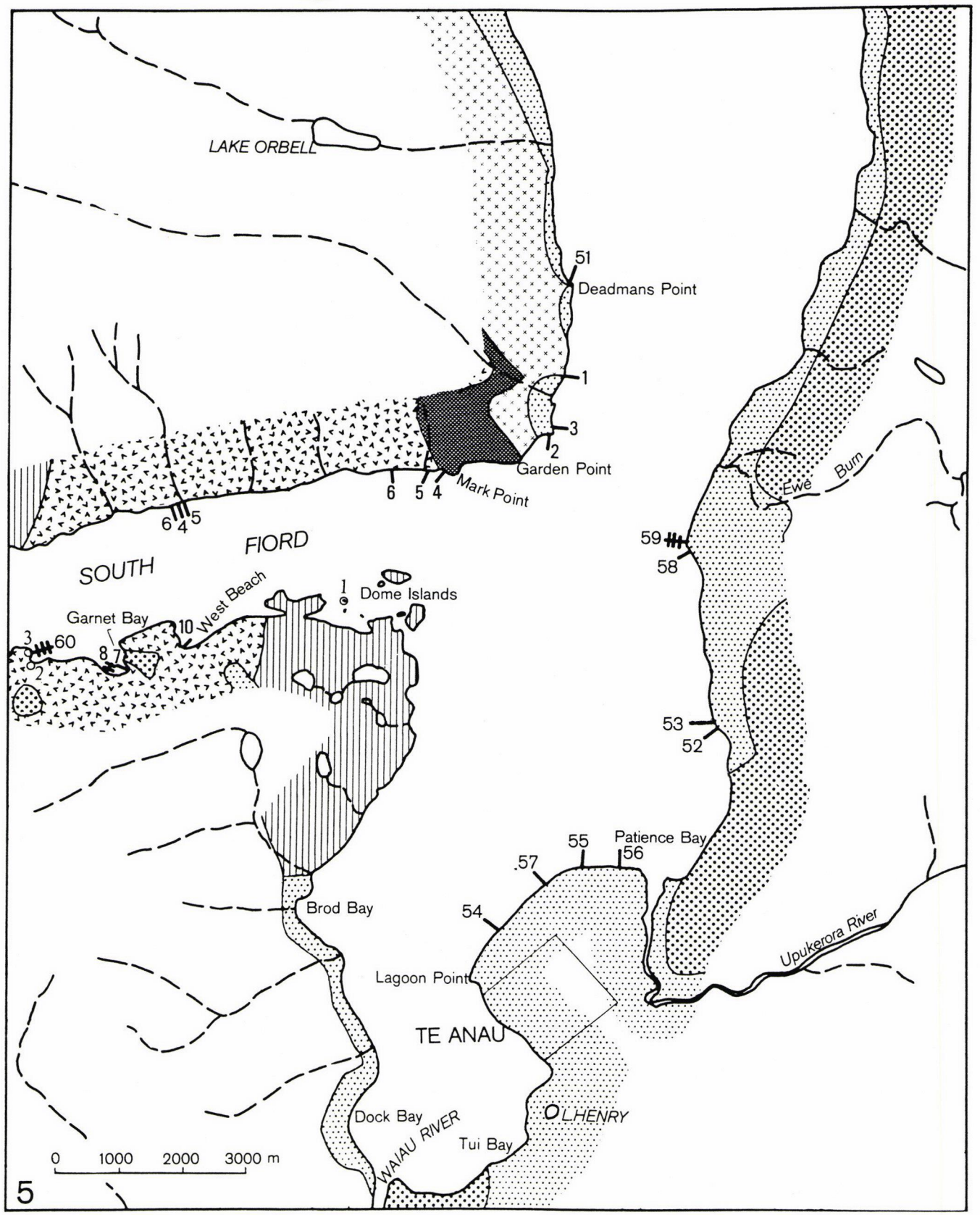

LAKE ORBELL
51
Deadmans Point
1
3
2
Garden Point
6 5 4
Mark Point
6 4 5
FIORD
SOUTH
Garnet Bay
3
60
2
8 7
10
West Beach
1
Dome Islands
59
58
Ewe Burn
53
52
55
Patience Bay
56
.57
54
Brod Bay
Lagoon Point
Upukerora River
TE ANAU
Dock Bay
WAIAU RIVER
Tui Bay
OLHENRY
0 1000 2000 3000 m
5

Fig. 5.

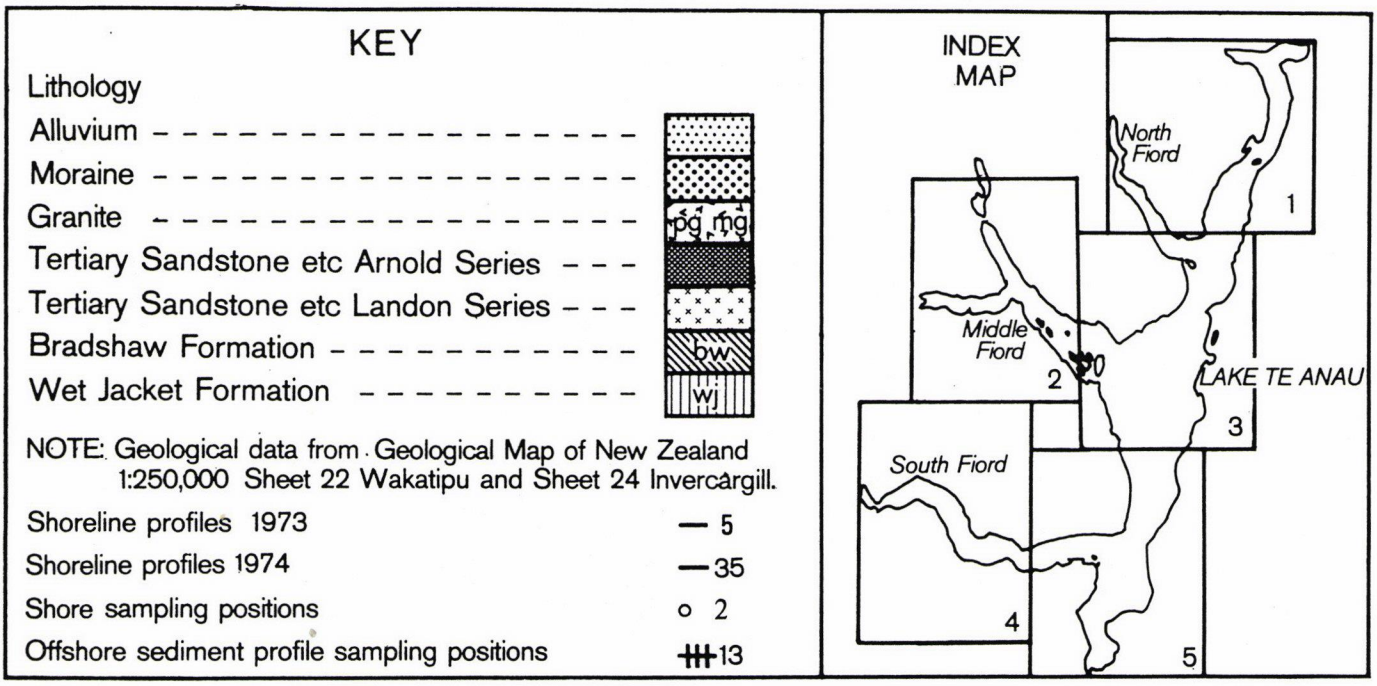


Fig. 6. Lake Te Anau Key and Index Map to Figs 1-5.

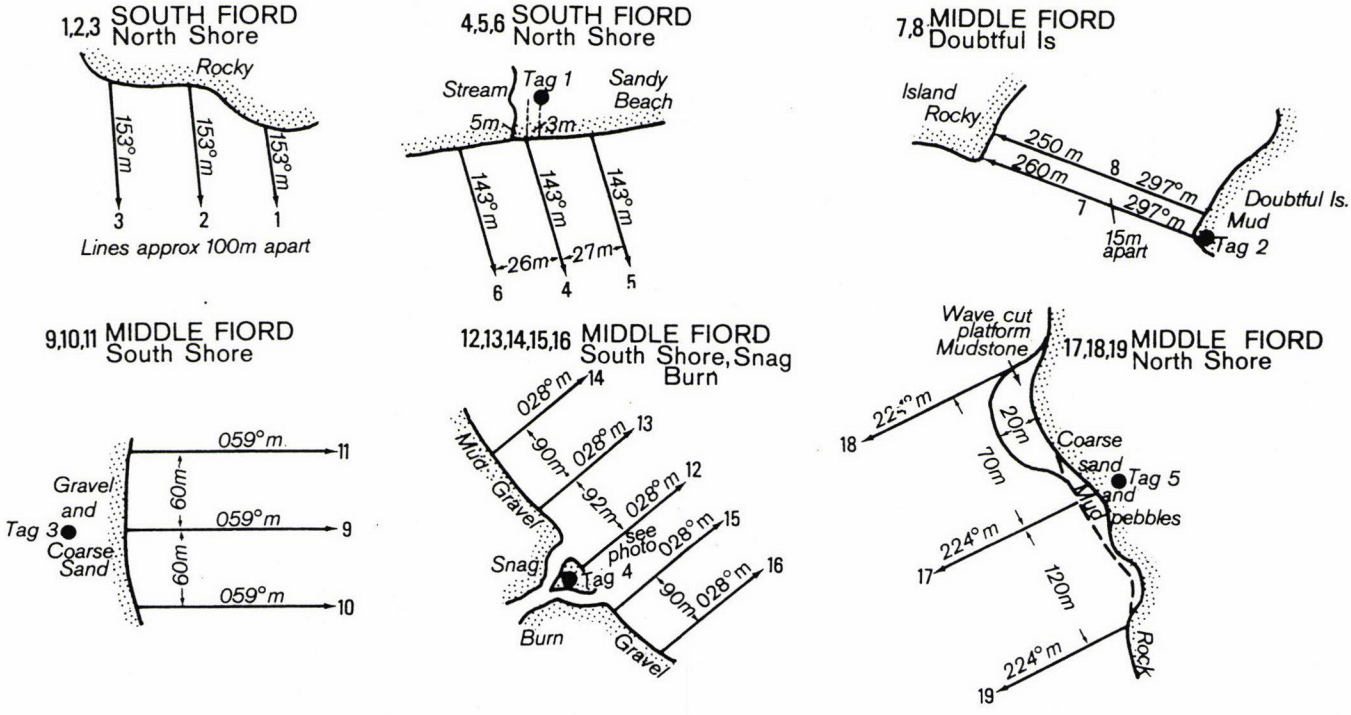


Fig. 7a.

Fig. 7a-e. Lake Te Anau, showing detail at shoreline profile positions 1-67 1974.

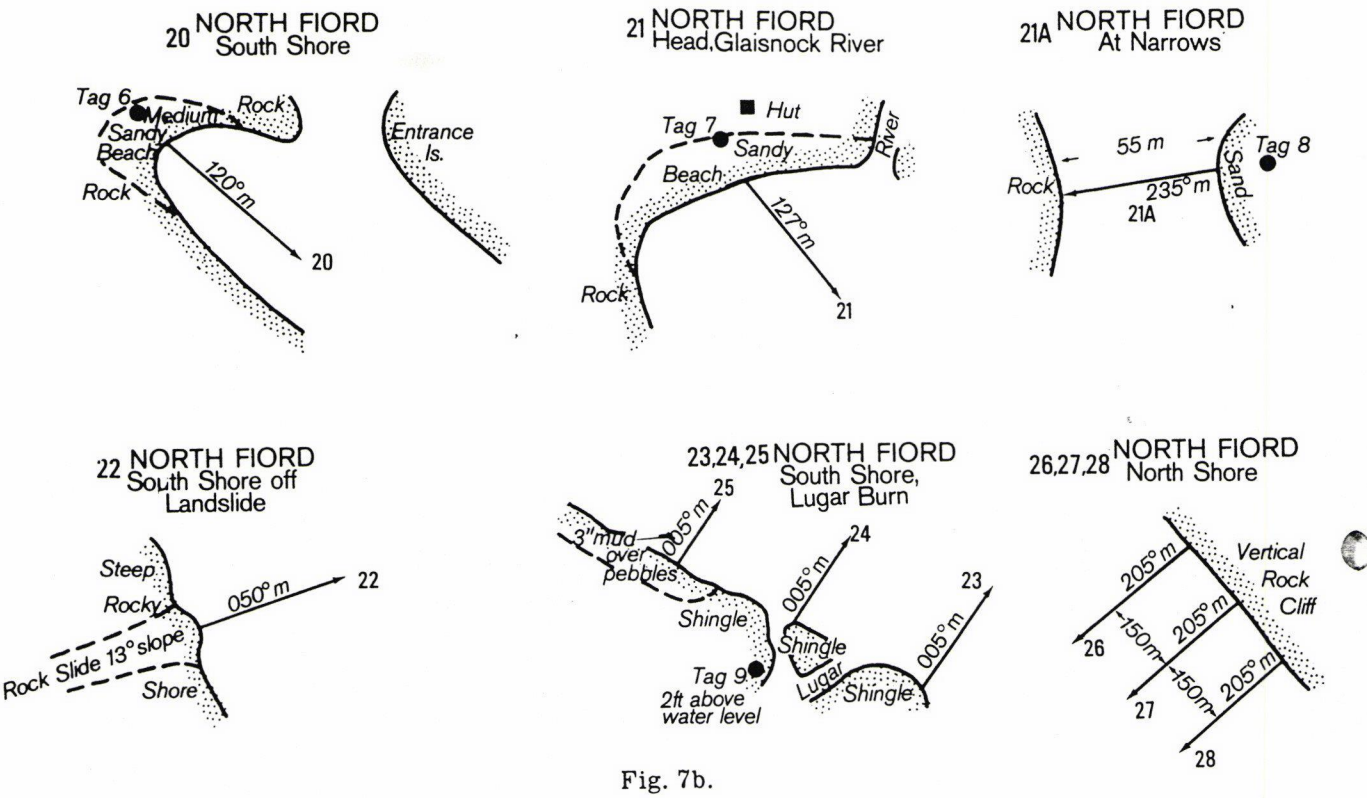

20 NORTH FIORD
South Shore
Tag 6
Medium
Rock
Sandy
Beach
Rock
120° m
20
Entrance
Is.
21 NORTH FIORD
Head, Glaisnock River
Hut
Tag 7
Sandy
Beach
River
127° m
Rock
21
21A NORTH FIORD
At Narrows
55 m
Tag 8
Rock
235° m
Sand
21A
22 NORTH FIORD
South Shore off
Landslide
Steep
Rocky
050° m
22
Rock Slide 13° slope
Shore
23,24,25 NORTH FIORD
South Shore,
Lugar Burn
25
3" mud
over
pebbles
005° m
24
005° m
23
Shingle
Shingle
005° m
Tag 9
2ft above
water level
Lugar
Shingle
26,27,28 NORTH FIORD
North Shore
205° m
Vertical
Rock
Cliff
150m
205° m
26
150m
205° m
27
28

Fig. 7b.

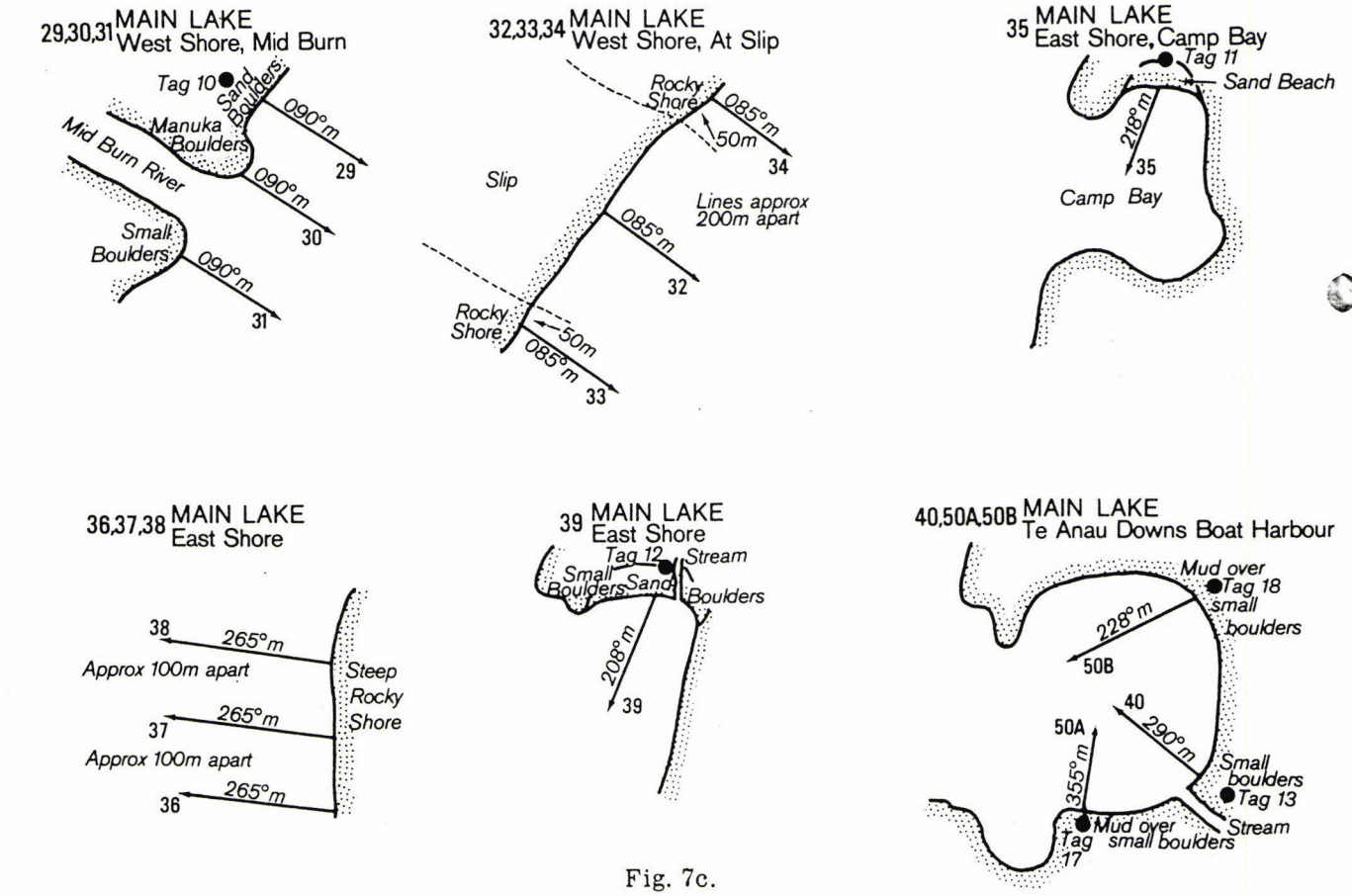
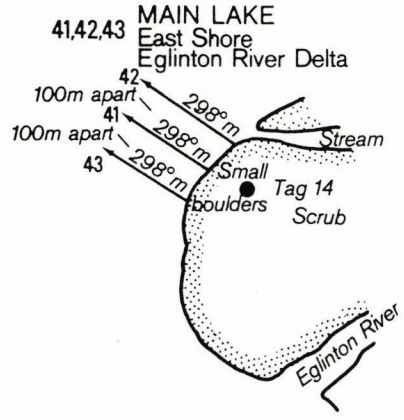
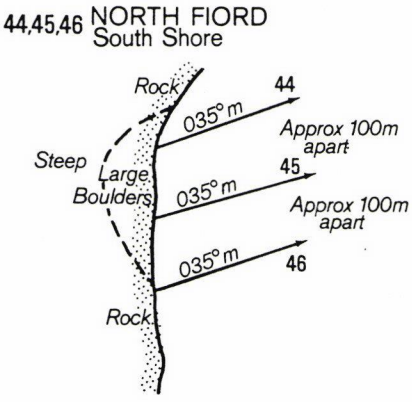
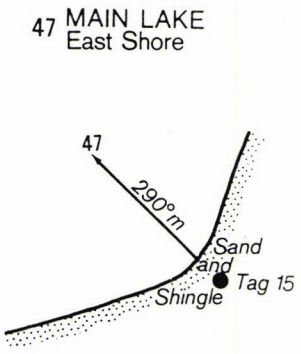
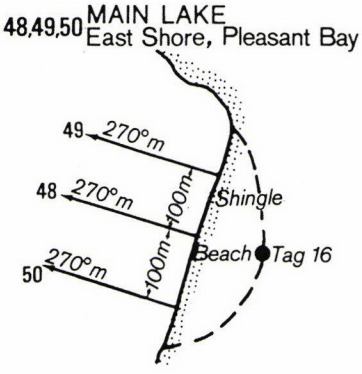

29,30,31 MAIN LAKE
West Shore, Mid Burn
Tag 10
Sand
Boulders
090° m
Manuka
Boulders
Mid Burn River
090° m
29
30
Small
Boulders
090° m
31
32,33,34 MAIN LAKE
West Shore, At Slip
Rocky
Shore
085° m
50m
34
Slip
Lines approx
200m apart
085° m
32
Rocky
Shore
50m
085° m
33
35 MAIN LAKE
East Shore, Camp Bay
Tag 11
Sand Beach
218° m
35
Camp Bay
36,37,38 MAIN LAKE
East Shore
38
265° m
Approx 100m apart
Steep
Rocky
Shore
37
265° m
Approx 100m apart
36
265° m
39 MAIN LAKE
East Shore
Tag 12
Stream
Small
Boulders
Sand
Boulders
208° m
39
40,50A,50B MAIN LAKE
Te Anau Downs Boat Harbour
Mud over
Tag 18
small
boulders
228° m
50B
40
290° m
50A
355° m
Small
boulders
Tag 13
Mud over
Tag
17
small boulders
Stream

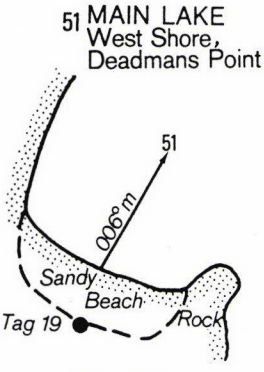
Fig. 7c.


41,42,43 MAIN LAKE
East Shore
Eglinton River Delta
42
100m apart
298° m
41
100m apart
298° m
43
298° m
Stream
Small boulders
Tag 14
Scrub
Eglinton River


44,45,46 NORTH FIORD
South Shore
Rock
035° m
44
Approx 100m apart
Steep
Large Boulders
035° m
45
Approx 100m apart
035° m
46
Rock


47 MAIN LAKE
East Shore
47
290° m
Sand and Shingle
Tag 15


48,49,50 MAIN LAKE
East Shore, Pleasant Bay
49
270° m
48
270° m
100m
Shingle
Beach
Tag 16
50
270° m
100m


51 MAIN LAKE
West Shore,
Deadmans Point
51
006° m
Sandy Beach
Rock
Tag 19

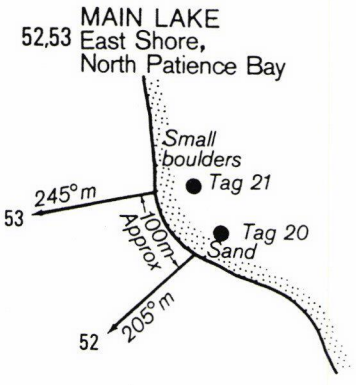
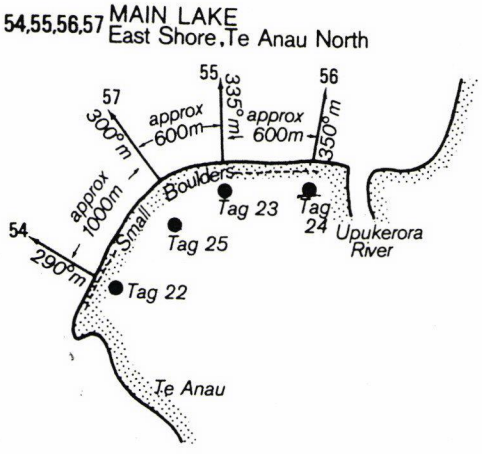
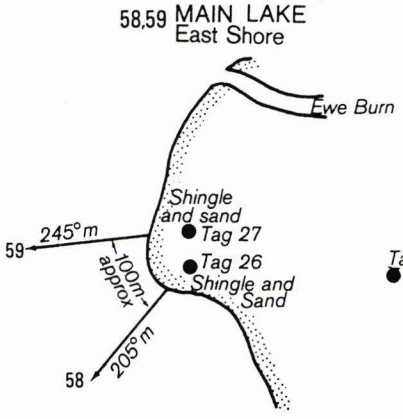
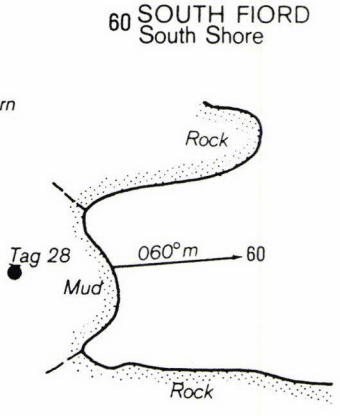
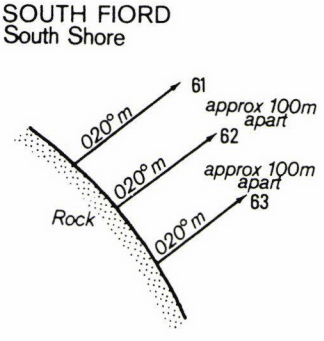

52,53 MAIN LAKE
East Shore,
North Patience Bay
Small boulders
Tag 21
245° m
53
100m Approx
Tag 20
Sand
205° m
52

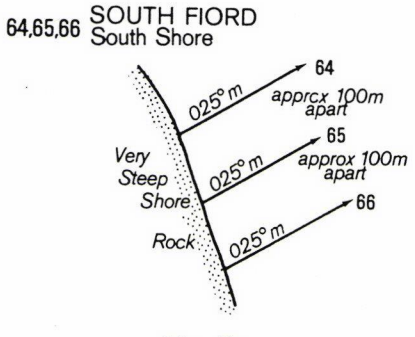
Fig. 7d.


54,55,56,57 MAIN LAKE
East Shore, Te Anau North
55
335° m
57
300° m
approx 600m
approx 600m
56
350° m
approx 1000m
Small Boulders
Tag 23
Tag 24
Upukerora River
54
290° m
Tag 25
Tag 22
Te Anau


58,59 MAIN LAKE
East Shore
Ewe Burn
Shingle and sand
Tag 27
245° m
59
Tag 26
Shingle and Sand
100m approx
205° m
58


60 SOUTH FIORD
South Shore
Rock
Tag 28
060° m
60
Mud
Rock


61,62,63 SOUTH FIORD
South Shore
020° m
61
approx 100m apart
020° m
62
approx 100m apart
Rock
020° m
63


64,65,66 SOUTH FIORD
South Shore
025° m
64
apprcx 100m apart
Very Steep Shore
025° m
65
approx 100m apart
Rock
025° m
66

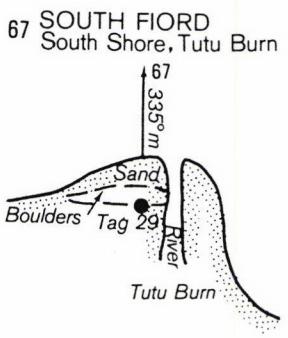

67 SOUTH FIORD
South Shore, Tutu Burn
67
335° m
Sand
Boulders
Tag 29
River
Tutu Burn

Fig. 7e.

TABLE 1. Lake Te Anau, 27 April - 4 May 1974. Profiles 1 - 67.

Profile	Date	Geographical Position	Lake level	Measurement by Echo Sounder E/S	Measurement by Lead Line L/L	Tag Nos	Profile Bearing Shore-Lake (°M)	Slope ° (Beach and Underwater) By Lead Line Beach	By Lead Line 1st Slope	By Lead Line 2nd Slope	By Echo Sounder 1st Slope	By Echo Sounder 2nd Slope
1	24-7-74	South Fiord, north shore, 2.0 km east of Moa Point	661.13	E/S	-	-	153°				44 °	44 °*
2	"	" " " " " "	"	E/S	-	-	153°				36 °	36 °
3	"	" " " " " "	"	E/S	-	-	153°				40 °	40 °
4	"	South Fiord, north shore, opposite West Beach	"	E/S	-	1	143°	8½°			6 °	23 °
5	"	" " " " "	"	E/S	-	-	143°				23 °	23 °
6	"	" " " " "	"	E/S	-	-	143°				9½°	23 °
7	28-4-74	Entrance to Middle Fiord, Doubtful Is.	661.13	E/S	-	2	297°	5 °			4½°	26 °
8	"	" " " " " "	"	E/S	-	-	297°				9½°	25 °
9	"	Middle Fiord, south shore, 3.0 km west of Doubtful Is.	"	E/S	-	3	059°	7 °			7½°	13 °
10	"	" " " " "	"	E/S	-	-	059°				9½°	12 °
11	"	" " " " "	"	E/S	-	-	059°				<1 °	23½°
12	"	Middle Fiord, south shore, Snag Burn	"	E/S	-	4	028°	2½°			5 °	26 °
13	"	" " " " " "	"	E/S	-	-	028°				9½°	24 °
14	"	" " " " " "	"	E/S	-	-	028°				6 °	28 °
15	"	" " " " " "	"	E/S	-	-	028°				14 °	22½°
16	"	" " " " " "	"	E/S	-	-	028°				5½°	23 °
17	"	Middle Fiord, north shore, opposite Cumbrae Is.	"	E/S	-	5	224°				5 °	18 °
18	"	" " " " "	"	E/S	-	-	224°				4 °	18 °
19	"	" " " " "	"	E/S	-	-	224°				7 °	26 °
20	29-4-74	North Fiord, south shore, beach 0.5 km west of Entrance Is.	661.03	E/S	L/L	6	120°	7 °	6°	34½°†	6 °	13 °
21	"	North Fiord, head, Glaisnock River	"	E/S	L/L	7	127°	6 °	5°	31 °	6 °	28½°
21A	"	North Fiord at Narrows	"	E/S	L/L	8	235°	4½°	19°	29½°	-	-
22	"	North Fiord, south shore off landslide	"	E/S	-	-	050°				25 °	25 °
23	"	North Fiord, south shore, Lugar Burn	"	E/S	-	-	005°				30 °	30 °
24	"	" " " " " "	"	E/S	-	9	005°				23 °	23 °
25	"	" " " " " "	"	E/S	-	-	005°				2 °	23 °
26	"	North Fiord, north shore, 3.2 km SE of Lugar Burn	"	E/S	-	-	205°				43 °	26½°
27	"	" " " " "	"	E/S	-	-	205°				51 °	28 °
28	"	" " " " "	"	E/S	-	-	205°				55 °	34 °

29	30-4-74	Main lake, west shore, Mid Burn	"	E/S	L/L	10	090°	5½°	3½°	13°	5½°	15°	
30	"	" " " "	"	E/S	-	-	090°				5½°	15°	
31	"	" " " "	"	E/S	-	-	090°				5½°	15°	
32	"	Main lake, west shore, at slip 4.0 km SW Camp Bay	"	E/S	-	-	085°				50°	34°	
33	"	" " " " "	"	E/S	-	-	085°				49°	32°	
34	"	" " " " "	"	E/S	-	-	085°				30°	23°	
35	"	Main lake, east shore side Camp Bay North Beach	"	E/S	L/L	11	218°	7½°	2°	16½°	3°	19°	
36	"	Main lake, east shore, 2.0 km N Camp Bay	"	E/S	-	-	265°				49°	26°	
37	"	" " " "	"	E/S	-	-	265°				33°	17°	
38	"	" " " "	"	E/S	-	-	265°				26°	26°	
39	"	Main lake, east shore, Bay 2.2 km S of Camp Bay North Beach	"	E/S	L/L	12	208°	4½°	1½°	5½°	1½°	6½°	
40	"	Main lake, Te Anau Downs Boat Harbour S.W.	"	E/S	L/L	13	290°	2°	4½°	3°	4½°	2½°	
41	1-5-74	Main lake, east shore, Eglington River Delta	660.93	E/S	L/L	14	298°	2½°	2½°	23°	6°	23°	
42	"	" " " " "	"	E/S	-	-	298°				6½°	21½°	
43	"	" " " " "	"	E/S	-	-	298°				6°	22°	
44	"	North Fiord, shouth shore, 3.2 km N.W. of Entrance Is.	"	E/S	-	-	035°				21°	31°	
45	"	" " " " "	"	E/S	-	-	035°				20½°	33°	
46	"	" " " " "	"	E/S	-	-	035°				23°	37°	
47	"	Main lake, east shore N of Eglington River Delta, from centre of beach	"	E/S	L/L	15	290°	5½°	2½°	25½°	5½°	17½°	
48	"	Main lake, east shore, Pleasant Bay	"	E/S	L/L	16	270°	10½°	4½°	7½°	4°	4°	
49	"	" " " " "	"	E/S	-	-	270°				4°	4°	
50	"	" " " " "	"	E/S	-	-	270°				6°	6°	
50A	"	Main lake, Te Anau Downs boat harbour south side	"	-	L/L	17	355°	9½°	½°	1½°	-	-	
50B	2-5-74	Main lake, Te Anau Downs boat harbour northwest side	660.88	-	L/L	18	228°	3½°	1°	-	-	-	
51	"	Main lake, west shore, Deadmans Point	"	E/S	L/L	19	006°	7½°	7°	12½°	5°	16°	
52	"	Main lake, east shore, N Patience Bay	"	E/S	L/L	20	205°	6½°	10°	26°	8°	17°	
53	"	" " " " "	"	E/S	L/L	21	245°	7½°	3½°	24½°	9°	19°	
54	"	Main lake, east shore, Te Anau North	"	E/S	L/L	22	290°	6°	3°	21°	4½°	13°	
55	3-5-74	" " " " "	660.78	E/S	L/L	23	335°	3½°	3°	12½°†	2½°	24°	
56	"	" " " " "	"	E/S	L/L	24	350°	3½°	5°	23½°	4°	20½°	
57	4-5-74	" " " " "	660.73	E/S	L/L	25	300°	4°	1½°	22°	1½°	18°	
58	"	Main lake, east shore, 1.4 km S Ewe Burn	"	E/S	L/L	26	205°	8½°	7°	29°	7°	27°	
59	"	" " " " "	"	E/S	L/L	27	245°	7°	3½°	34½°	3½°	25°	

Pro-file	Date	Geographical Position	Lake level	Measurement by Echo Sounder E/S	Measurement by Lead Line L/L	Tag Nos	Profile Bearing Shore-Lake (°M)	Slope ° (Beach and Underwater) By Lead Line Beach	1st Slope	2nd Slope	By Echo Sounder 1st Slope	2nd Slope
60	"	South Fiord, south shore, 1.5 km W of Garnet Bay	"	E/S	L/L	28	060°	1½°	5½°	32 °	3 °	29 °
61	"	South Fiord, south shore, 3.5 km W of Garnet Bay	"	E/S	-	-	020°				47 °	24 °
62	"	" " " " "	"	E/S	-	-	020°				40 °	31 °
63	"	" " " " "	"	E/S	-	-	020°				44 °	25 °
64	"	South Fiord, south shore, 3.3 km N.W. of Moa Point	"	E/S	-	-	025°				37 °	37 °
65	"	" " " "	"	E/S	-	-	025°				41 °	41 °
66	"	" " " "	"	E/S	-	-	025°				44 °	44 °
67	"	South Fiord, south shore, Tutu Burn	"	E/S	-	29	335°	3½°			8½°	25½°

* Where there was no break in slope below water level on day of survey the same figure is given for both 1st and 2nd underwater slopes.

† Discrepancies between leadline and echo sounding results for 2nd underwater slopes arise from the occurrence of short extents of steep lake floor occurring locally at the termination of the leadline profile.

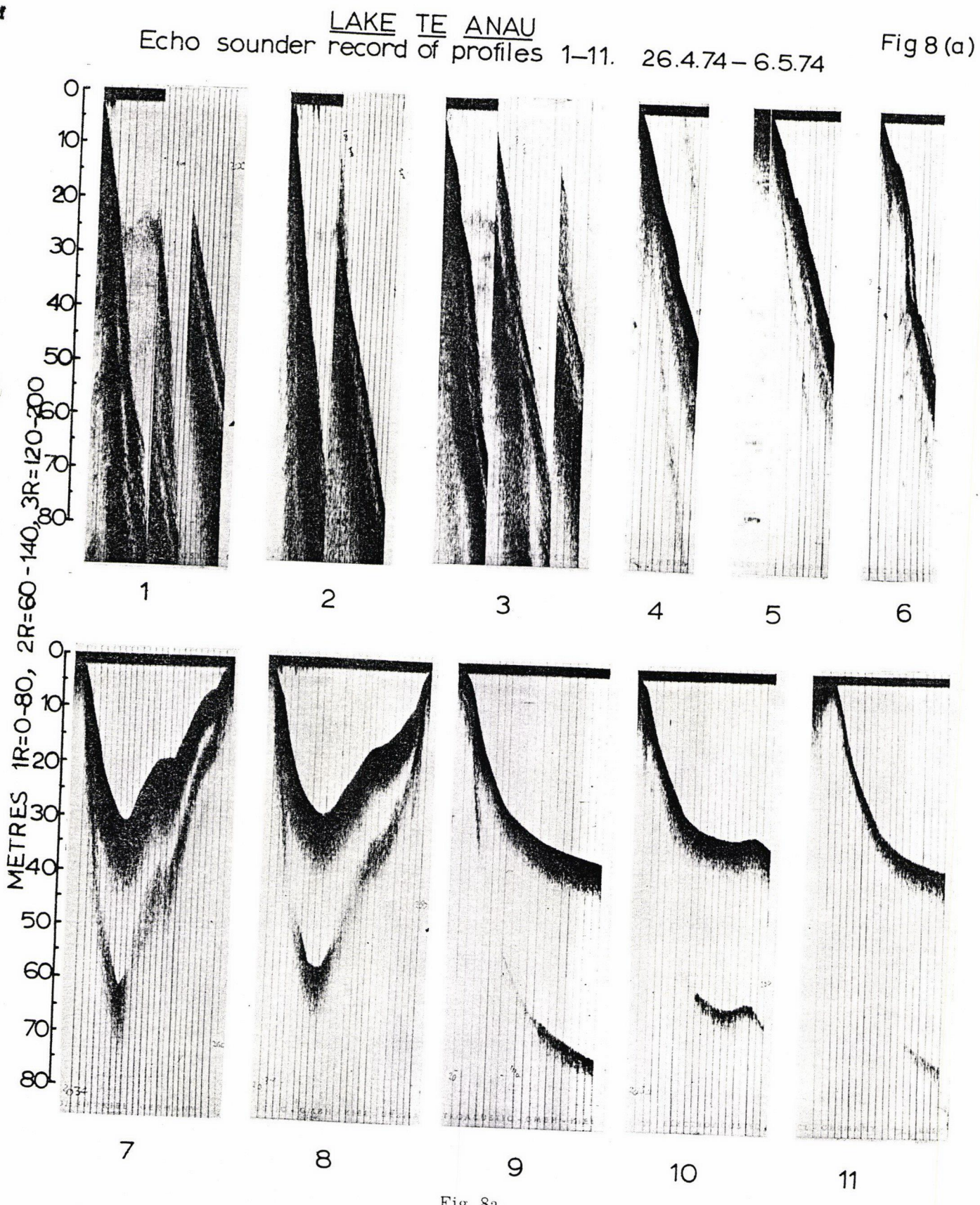


Fig. 8a.

Fig. 8a-g. Lake Te Anau. Echo sounder records of underwater profiles 1-67 April-May 1974. Records are marked at 10 m intervals out from the shore.

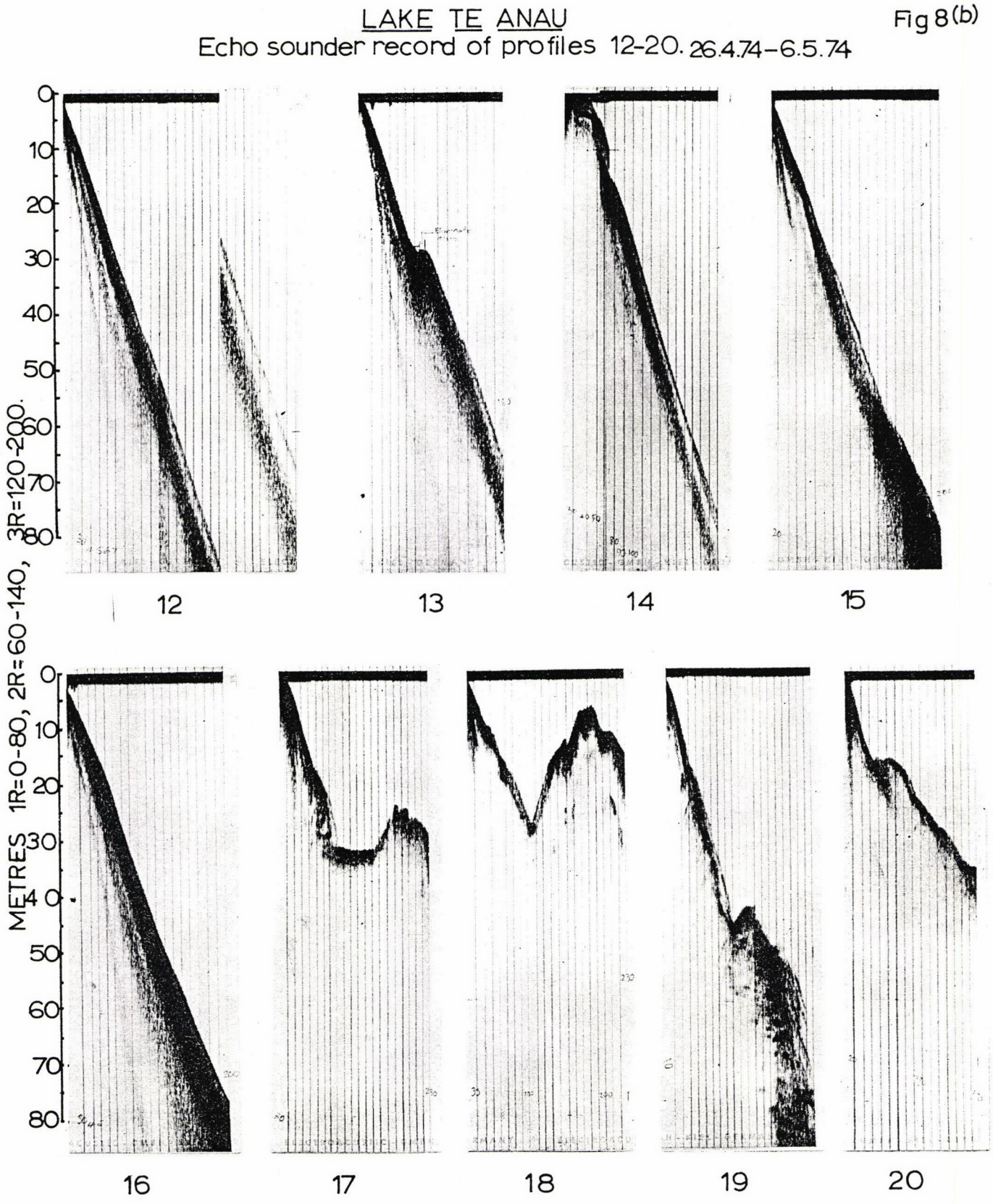

LAKE TE ANAU
Fig 8(b)
Echo sounder record of profiles 12-20. 26.4.74-6.5.74
METRES 1R=0-80, 2R=60-140, 3R=120-200.
0
10
20
30
40
50
60
70
80
12
13
14
15
16
17
18
19
20

Fig. 8b.

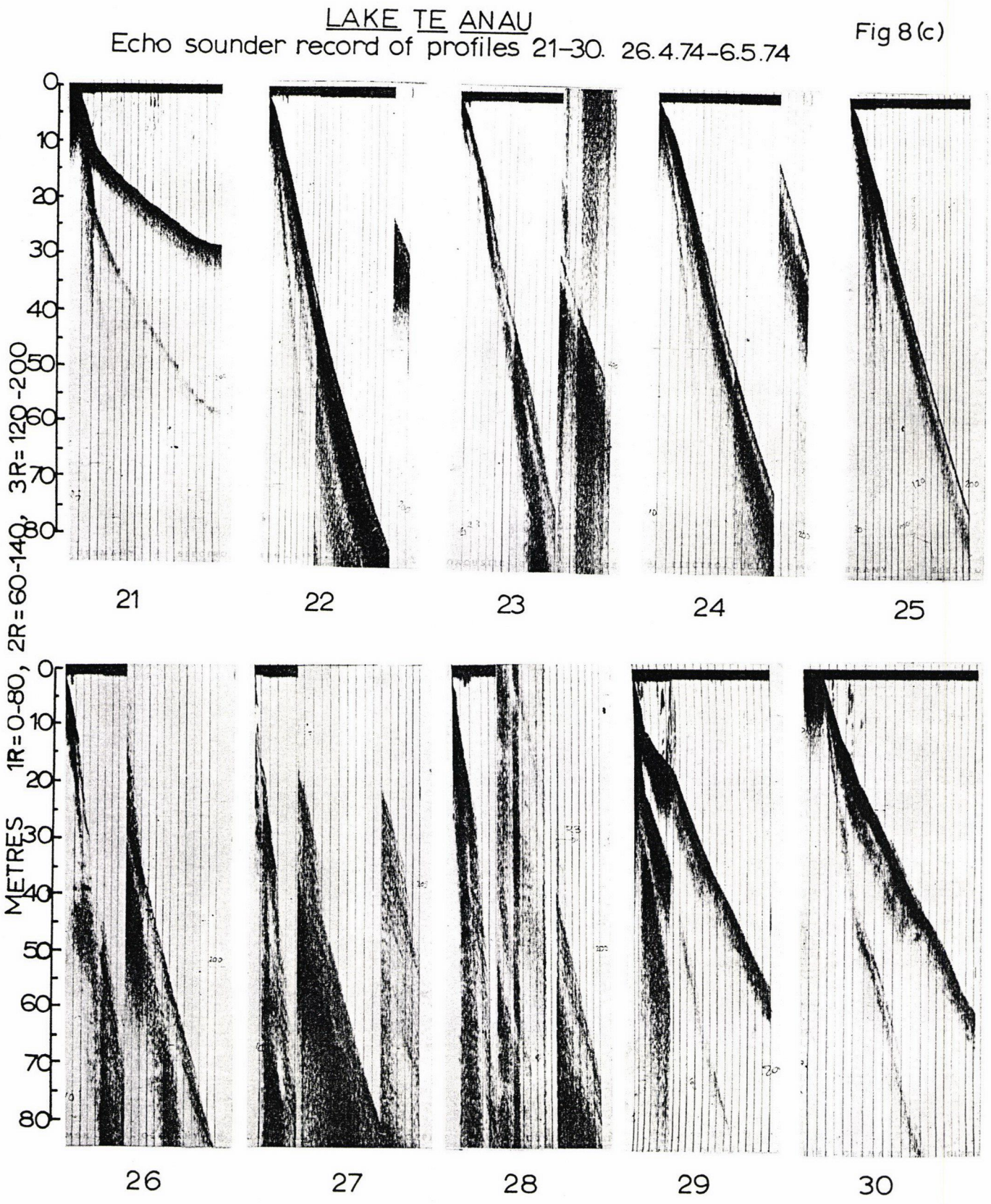

LAKE TE ANAU
Echo sounder record of profiles 21–30. 26.4.74–6.5.74
Fig 8(c)
METRES
1R=0-80, 2R=60-140, 3R=120-200
0
10
20
30
40
50
60
70
80
21
22
23
24
25
26
27
28
29
30

Fig. 8c.

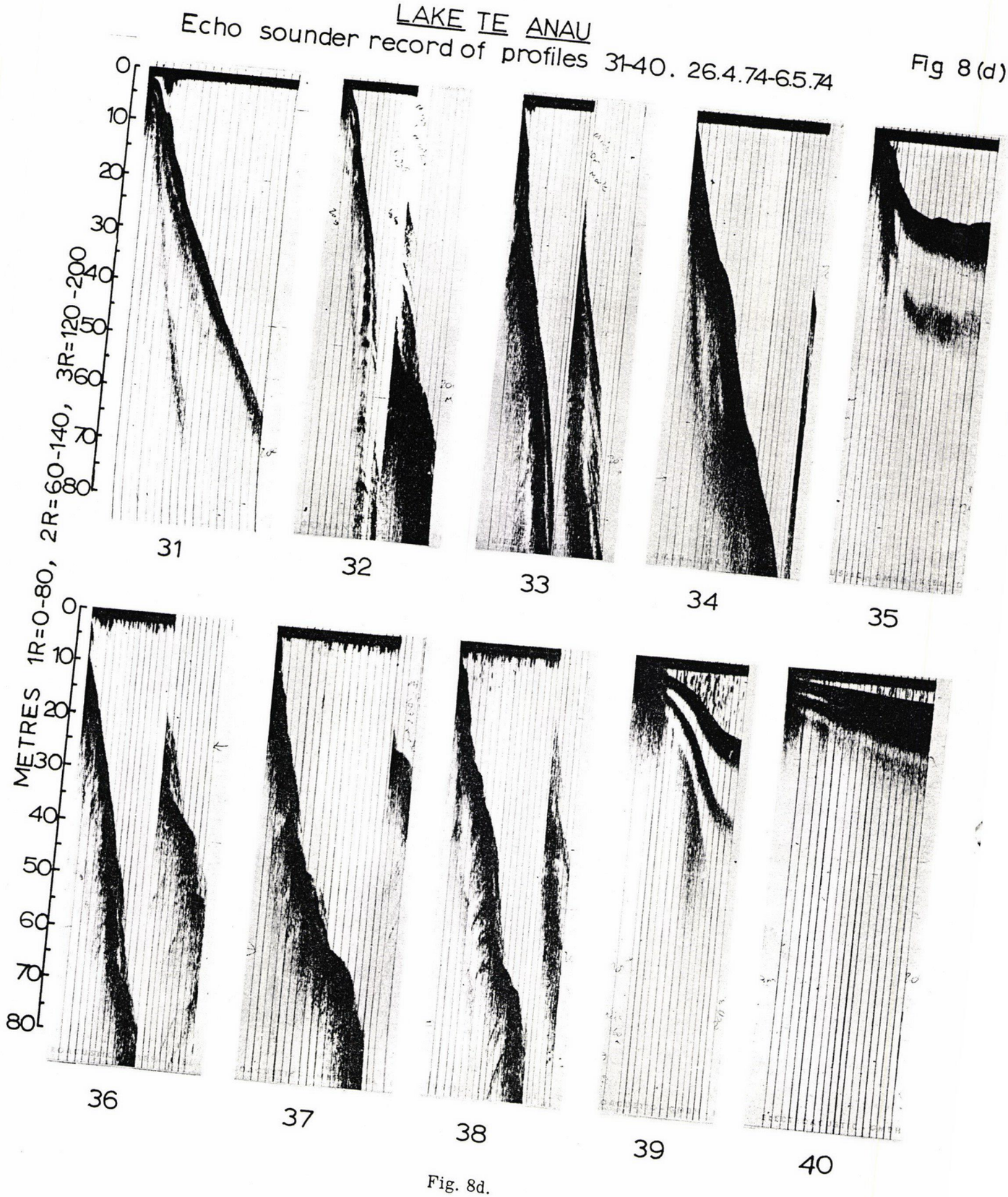

LAKE TE ANAU
Echo sounder record of profiles 31-40. 26.4.74-6.5.74
Fig 8 (d)
METRES
1R=0-80, 2R=60-140, 3R=120-200
0
10
20
30
40
50
60
70
80
31
32
33
34
35
36
37
38
39
40

Fig. 8d.

LAKE TE ANAU

Fig 8(e)

Echo sounder record of profiles 41-50. 26.4.74 — 6.5.74

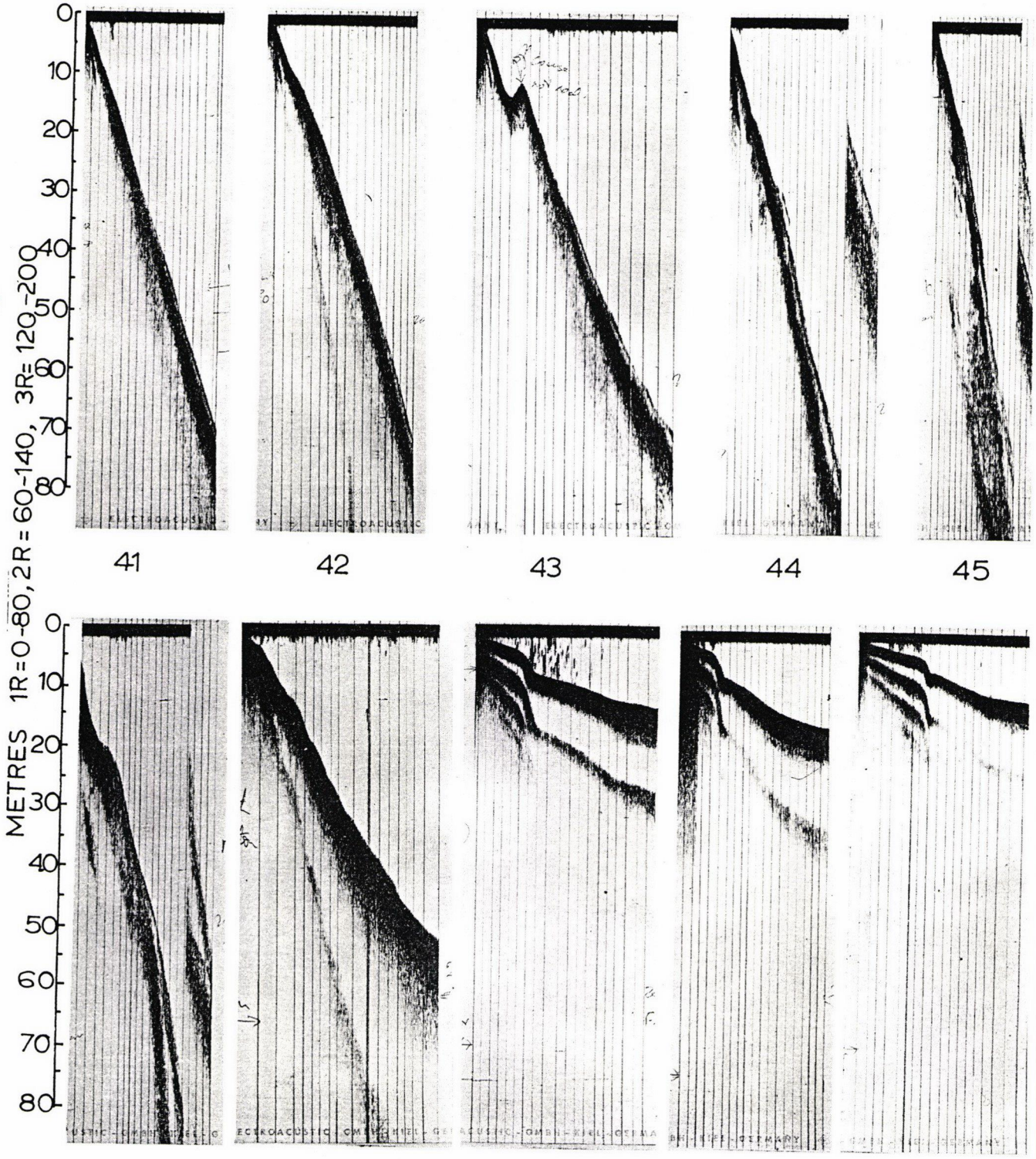


Fig. 8e.

LAKE TE ANAU

Fig 8(f)

Echo sounder records of profiles 51–61. 26.4.74–6.5.74

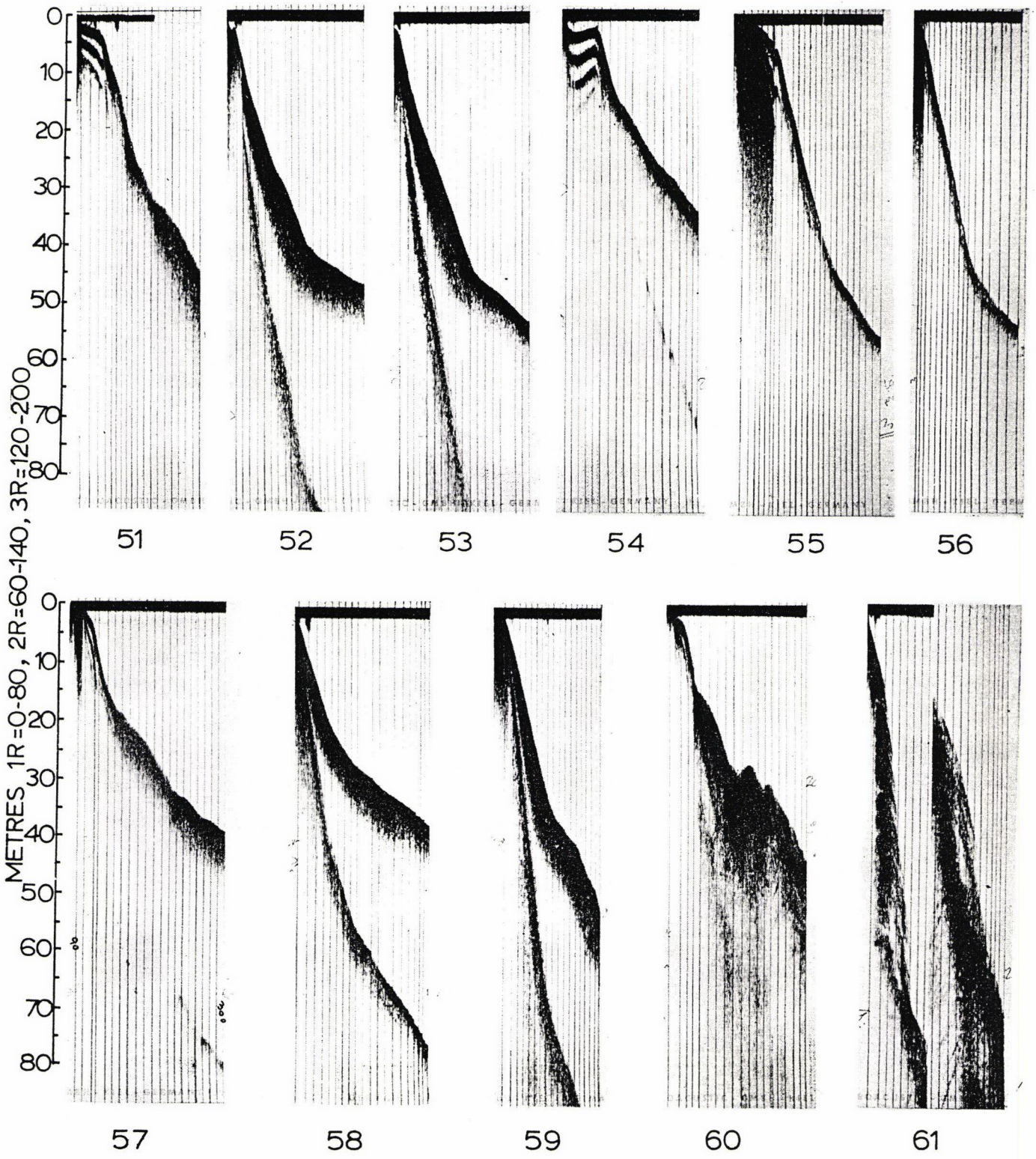


Fig. 8f.

were made at 10m intervals on the shore and out to a distance of 50m offshore. At profile 8((1973) a sandy beach) collections were made at 10m intervals on the shore and out to a distance of 60m offshore. Sediment descriptions are given in Table 3 (Figs 9a-c).

A survey was made of a shallow bay known as the Boat Harbour, at Te Anau Downs. The survey was carried out with a Ferrograph Inshore Graphic echo sounder on 2 May 1974 when the lake level was 660.88ft above sea level. Contours have been drawn at intervals of 0.5m (Fig. 10).

RESULTS

The Nearshore Detailed Profiles

The 22 profiles measured by lead line and a further 6 where beach gradients were measured and the 10 profiles surveyed in 1973 have been plotted with reference to a lake level of 661.0ft above sea level which is close to the average lake level for the period of survey (Figs 11a-g). Vertical distances are in feet and horizontal distances in metres on a vertical exaggeration of x 3.3. The ten samples measured on Lake Te Anau in June 1973 (Figs 12a-b) have been redrawn with reference to a lake level of 661.0ft above sea level and are included in the results.

The following properties have been examined.

1. Average beach gradients, from the top of the beach at the reference marker to the shoreline on the day of measurement. Thirty-eight profiles are examined including ten for June 1973.

2. Average first offshore gradients, measured from the shoreline to the first change in underwater slope which is well marked except at profiles 50A and 50B situated in Te Anau Downs Boat Harbour. Forty-eight first offshore gradients are examined including ten for June 1973.

3. Average second offshore gradients, measured from the break in slope down to 630ft above sea level. Forty-seven second offshore gradients are examined including ten for June 1973.

4. Depths of the break in slope between first and second offshore gradients have been noted below the 661.00ft above sea level point for the 48 profiles, and are listed in Table 4.

Beach Gradients

Twenty-one of the 38 beaches measured have average beach gradients of from 1 in 6 to 1 in 12, two

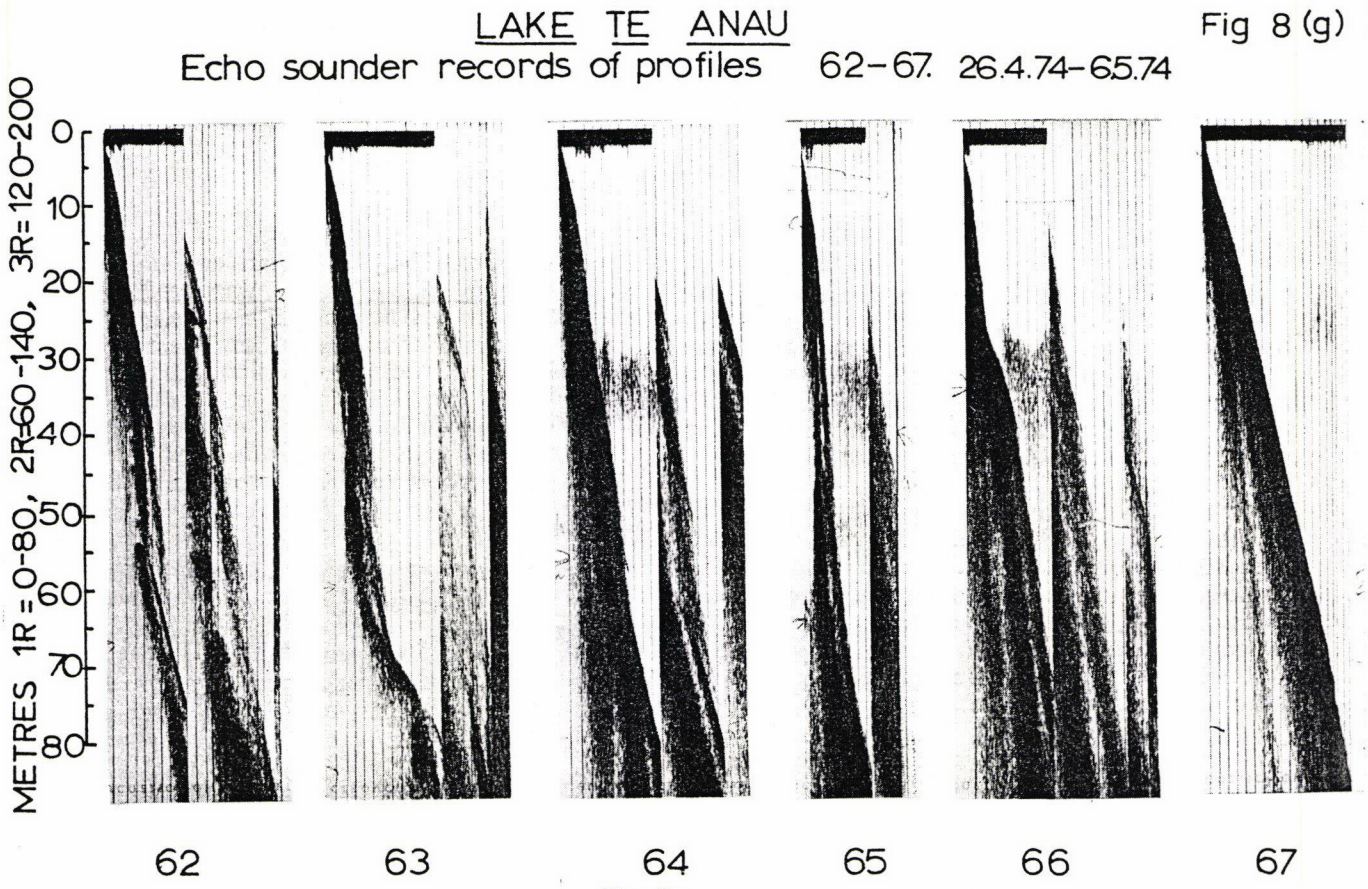


Fig. 8g.

TABLE 2. Lake Te Anau, 30 June 1973. Profiles 1 - 10.

No.	Date	Geographical Position	Lake Level	Tag Nos	(°M)*	Beach	Slope ° Measured by lead line 1st underwater	2nd underwater
1	30-6-73	Beach north of Trig B	663.8	86	093°	8½°	6 °	31½°
2	"	Trig B beach, south side	"	87	167°	6½°	3½°	31½°
3	"	Trig B beach, east side	"	88	082°	3 °	2 °	21½°
4	"	South Fiord north side Mark Point Beach	"	89	177°	6 °	5½°	25 °
5	"	South Fiord north side 1st beach west of Mark Point Beach	"	90	176°	5½°	6½°	20½°
6	"	South Fiord north side 2nd beach west of Mark Point Beach	"	91	149°	6½°	4 °	26½°
7	"	South Fiord south side Garnet Bay east beach	"	92	273°	5½°	9 °	12 °
8	"	South Fiord south side Garnet Bay west side	"	93	010°	2 °	6½°	17½°
9	"	South Fiord south side west of Garnet Bay	"	94, 95	308°	6½°	9½°	26½°
10	"	South Fiord south side west beach (Eastern Beach)	"	96, 97	348°	8 °	8½°	31 °

* Profile bearing shore to lake (°Magnetic)

profiles, 48 and 9 of 1973, have steep gradients greater than 1 in 6. Fifteen beaches have low gradients, less than 1 in 12 (profiles 12, 21A, 29, 39, 40, 41, 50B, 55, 56, 57, 60, 67 and profiles 2, 3 and 6 of 1973).

Underwater Gradients

The underwater gradients are divided into two groups. The first offshore gradient is an approximate extension of beach gradient though in many cases slightly less steep (Table 1). This characteristic is the same as for those profiles measured on Lake Te Anau in June 1973 and for 50 profiles measured on Lake Manapouri at the same time (Irwin 1974a).

The majority of the first offshore gradients are very steep to steep, 9 profiles being steeper than 1 in 8 and 24 between 1 in 8 and 1 in 16. Eight profiles have low gradients, 1 in 16 to 1 in 24, and seven very low gradients at less than 1 in 24. Six of the very low gradients measured in 1974 are either in small bays or off delta areas of the Eglinton or Upukerora Rivers on the east side of the lake.

The second offshore gradients measured from the usually distinct change in slope to the 630ft above

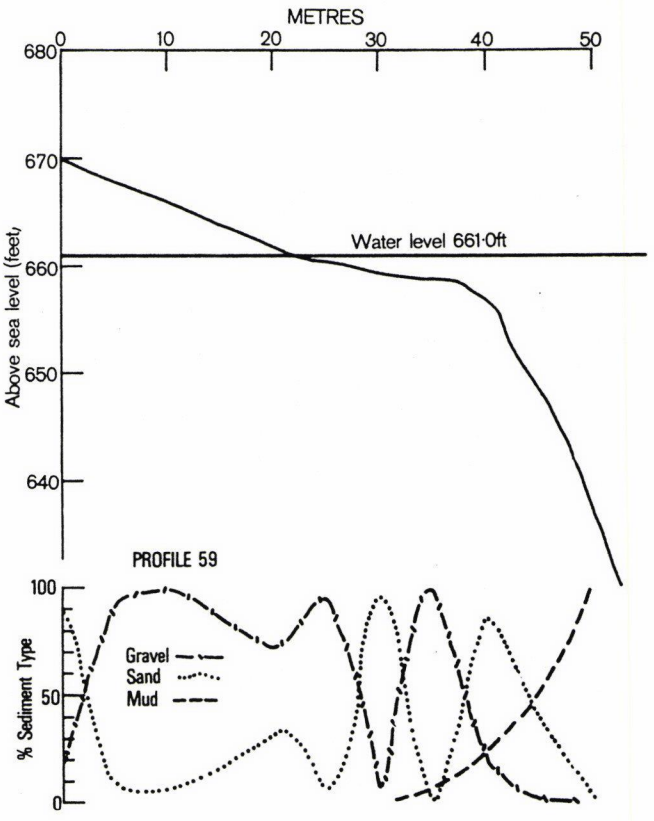


Fig. 9a.

Fig. 9a-c. Lake Te Anau. Sediment type profiles for profiles 59, 60 and 8 (1973). Positions shown in Fig. 5.

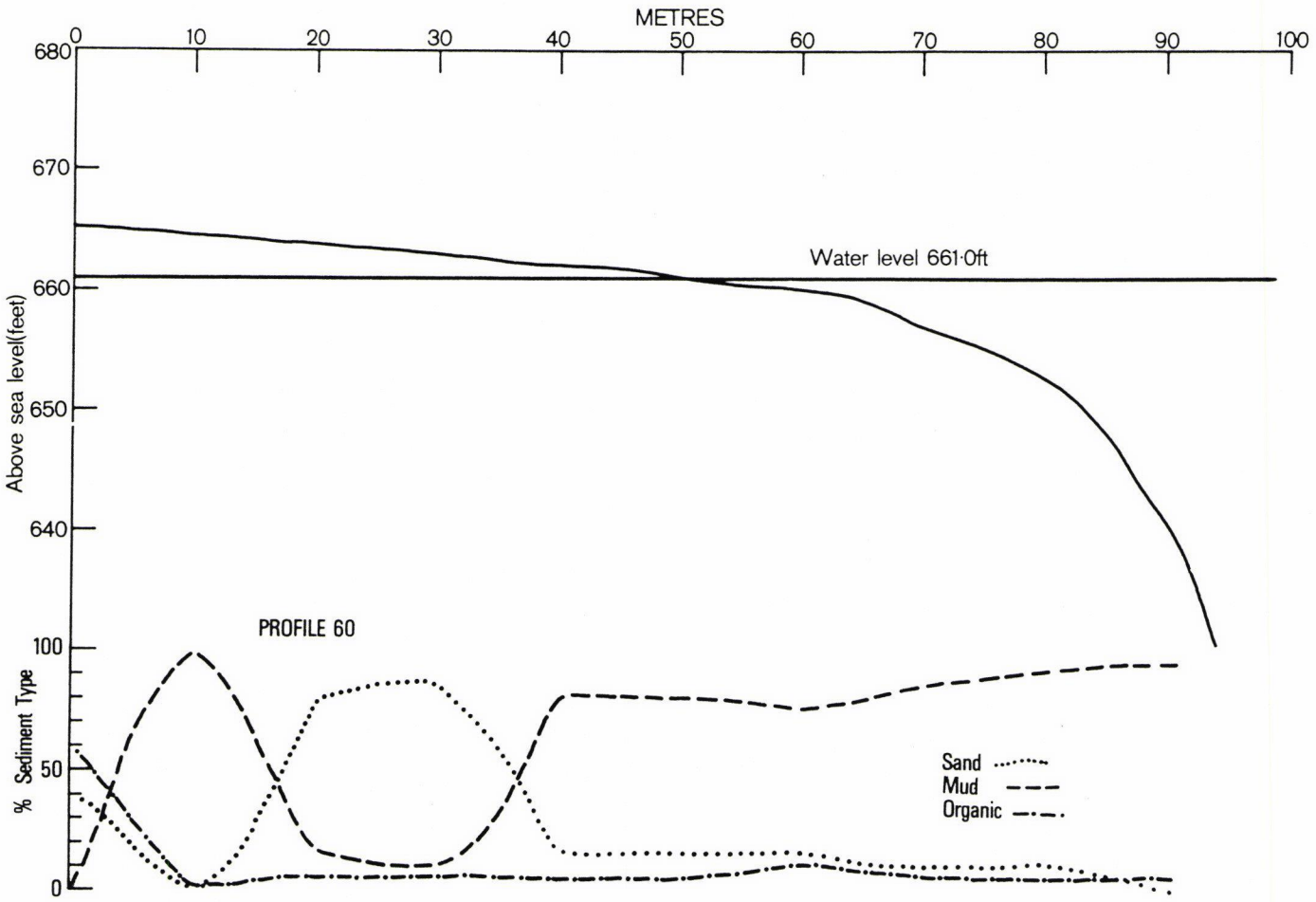


Fig. 9b.

sea level depth are steep, with 15 profiles having gradients greater than 1 in 2 and 23 profiles with gradients between 1 in 2 and 1 in 4. Only nine profiles have second offshore gradients which are comparatively low, 4 with gradients from 1 in 4 to 1 in 6 and 5 with gradients of less than 1 in 6. The lowest gradients measured in 1974 are all situated in bays on the east side of the lake. Most of the first and second offshore gradients are of even slope.

Depth of Break in Slope Between First and Second Offshore Gradients

The depth of the break in slope below the 661.00 ft above sea level depth ranged from 1.0 ft to 20.0 ft with an average depth of 7.0 ft for the 48 measurements made (Table 4).

Of the ten profiles measured in 1973 the break in slope of eight of these occurred between 6 ft and 9 ft below the level of 663.83 ft above sea level. To a level of 661.00 ft above sea level in 1974, i.e,, 2.83 ft lower, 22 of the 48 profiles have the break in slope between 3 ft and 6 ft (between 658 and 655 ft above sea level). Considering a depth of break in slope in a greater range, that is between 3 ft and 8 ft (between 658 and 653 ft above sea level), 31 of the 48 profiles fall in this group and a further 4 have a break in slope of less than 3.0 ft below 661.0 ft.

ANALYSIS OF THE SIXTY-SEVEN 200 m LONG ECHO SOUNDING PROFILES

The 67 profiles measured with echo sounder have been drawn on a natural scale in metres to the lake level on the day of the survey (*see* Table 1; Figs 13a-j).

Profiles off Alluvium and Moraine

(Hawera series (f, fb, h, hx, hb, mk)
(Wood 1960, 1962; McKellar 1973)

Twenty-eight underwater profiles were measured out to 200 m offshore, 4 from well developed beaches

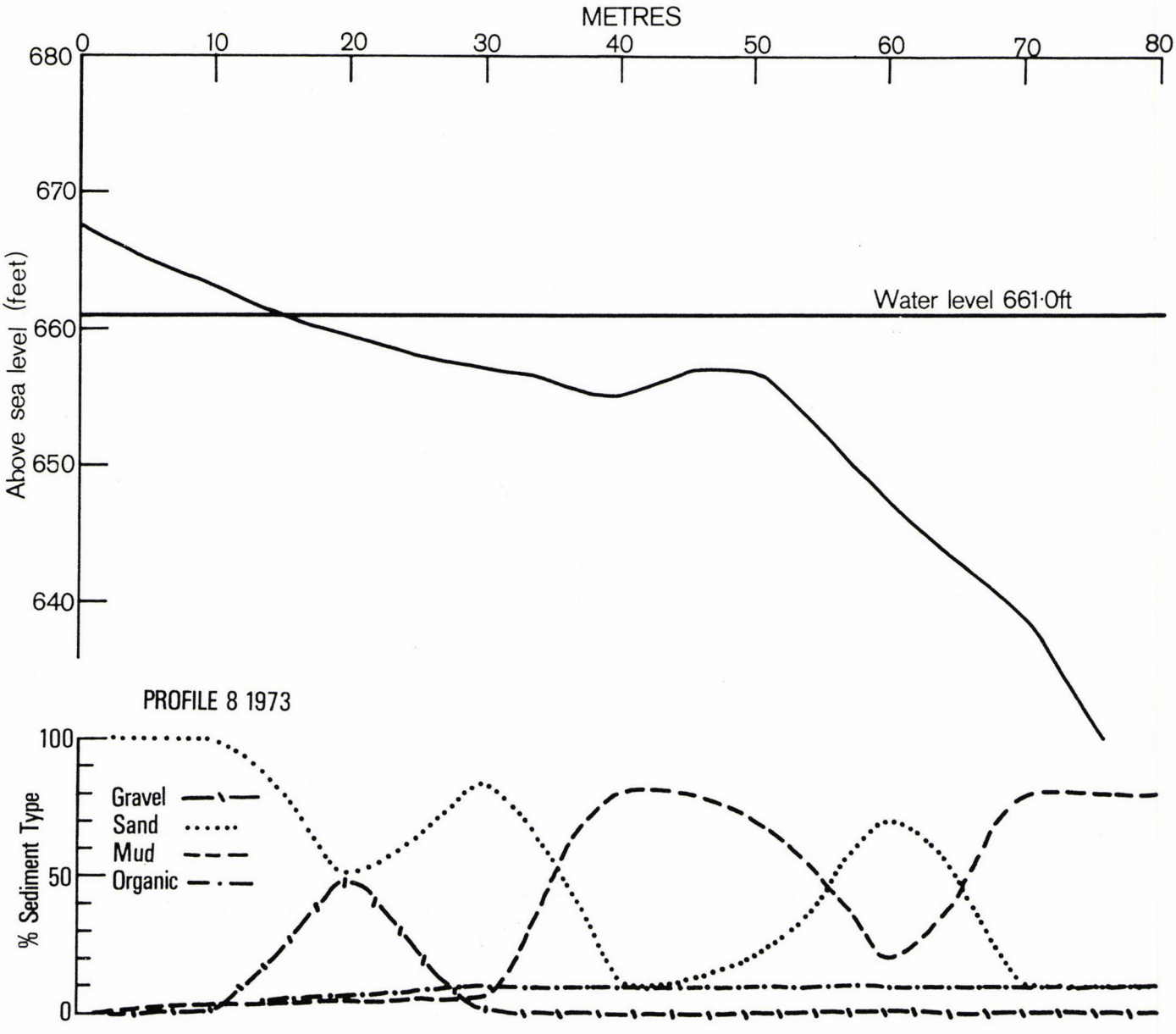


Fig. 9c.

(21, 35, 52, 53), 19 from main river deltas (*see* Table 1) and 5 from main lake eastern shore sites where the surface rock is moraine (47, 48, 49, 50, 51).

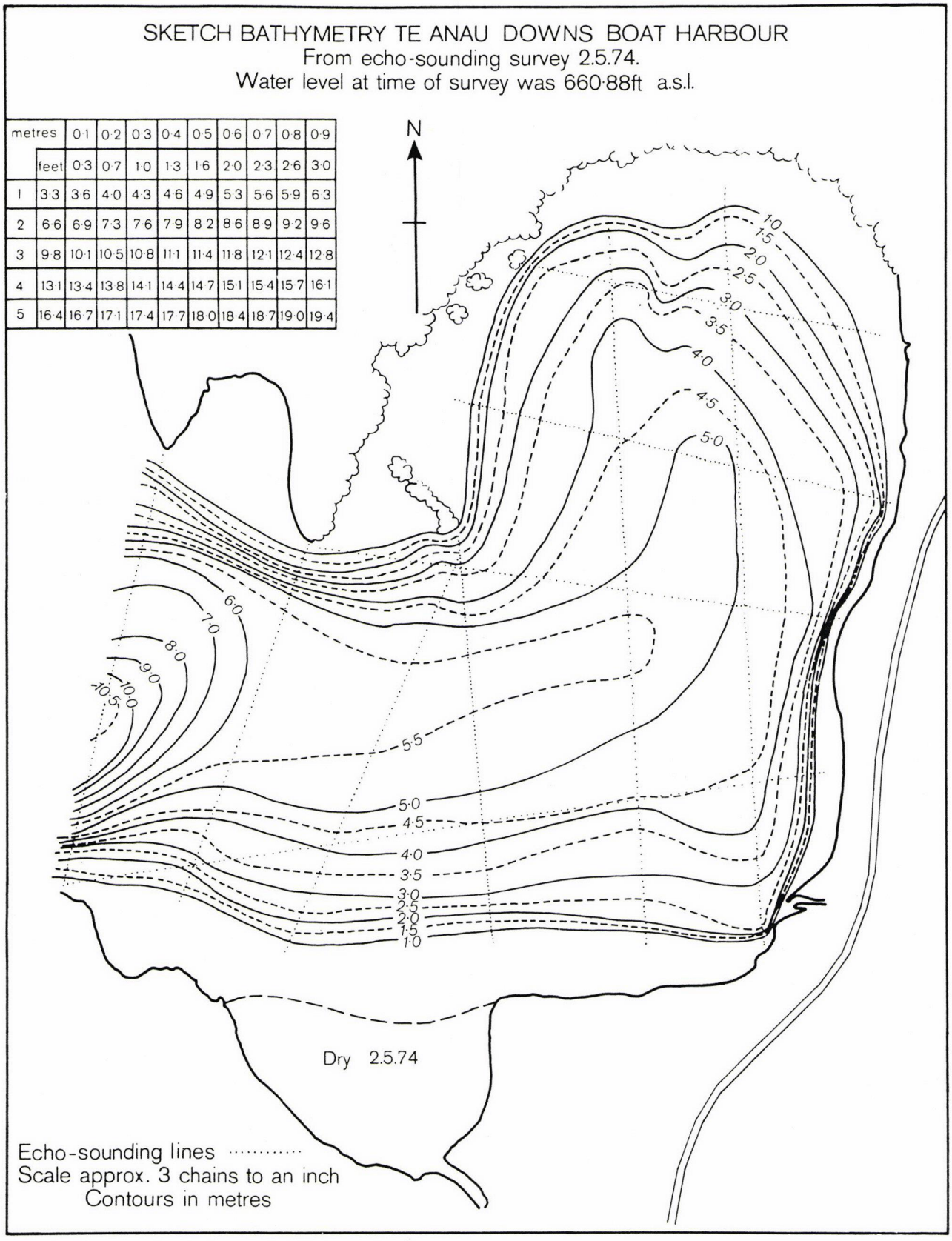
In most cases the above water slope was low 5-20° (Ralph Moir and Associates 1973) the initial underwater slope ranged from 1½° to 14° (av. 6° standard deviation 2.77), the following slope ranged from 7½° (in Camp Bay) to 30° (av. 20° standard deviation 5.21). The mean slope to 200 m offshore ranged from 4° to 30° with an average of 16° standard deviation 6.36.

Delta Profiles

Many of these profiles taken in groups at the one locality demonstrate that the underwater delta is limited in extent (for example, profiles 12 to 16 at Snag Burn, profiles 23 to 25 at Lugar Burn). The second underwater slope for these deltas represents the underwater angle of repose for the component materials and the dip of the foreset beds.

Comments

For the profiles developed off alluvial and moraine shores the initial slope averages only 6° and the following slope averages 20° with the mean slope to 200 m offshore averaging 16° and the above water slopes being generally less than 20°.



metres	0·1	0·2	0·3	0·4	0·5	0·6	0·7	0·8	0·9
feet	0·3	0·7	1·0	1·3	1·6	2·0	2·3	2·6	3·0
1	3·3	3·6	4·0	4·3	4·6	4·9	5·3	5·6	5·9	6·3
2	6·6	6·9	7·3	7·6	7·9	8·2	8·6	8·9	9·2	9·6
3	9·8	10·1	10·5	10·8	11·1	11·4	11·8	12·1	12·4	12·8
4	13·1	13·4	13·8	14·1	14·4	14·7	15·1	15·4	15·7	16·1
5	16·4	16·7	17·1	17·4	17·7	18·0	18·4	18·7	19·0	19·4

Fig. 10. Lake Te Anau. Sketch bathymetry of Te Anau Downs Boat Harbour from echo sounding survey.

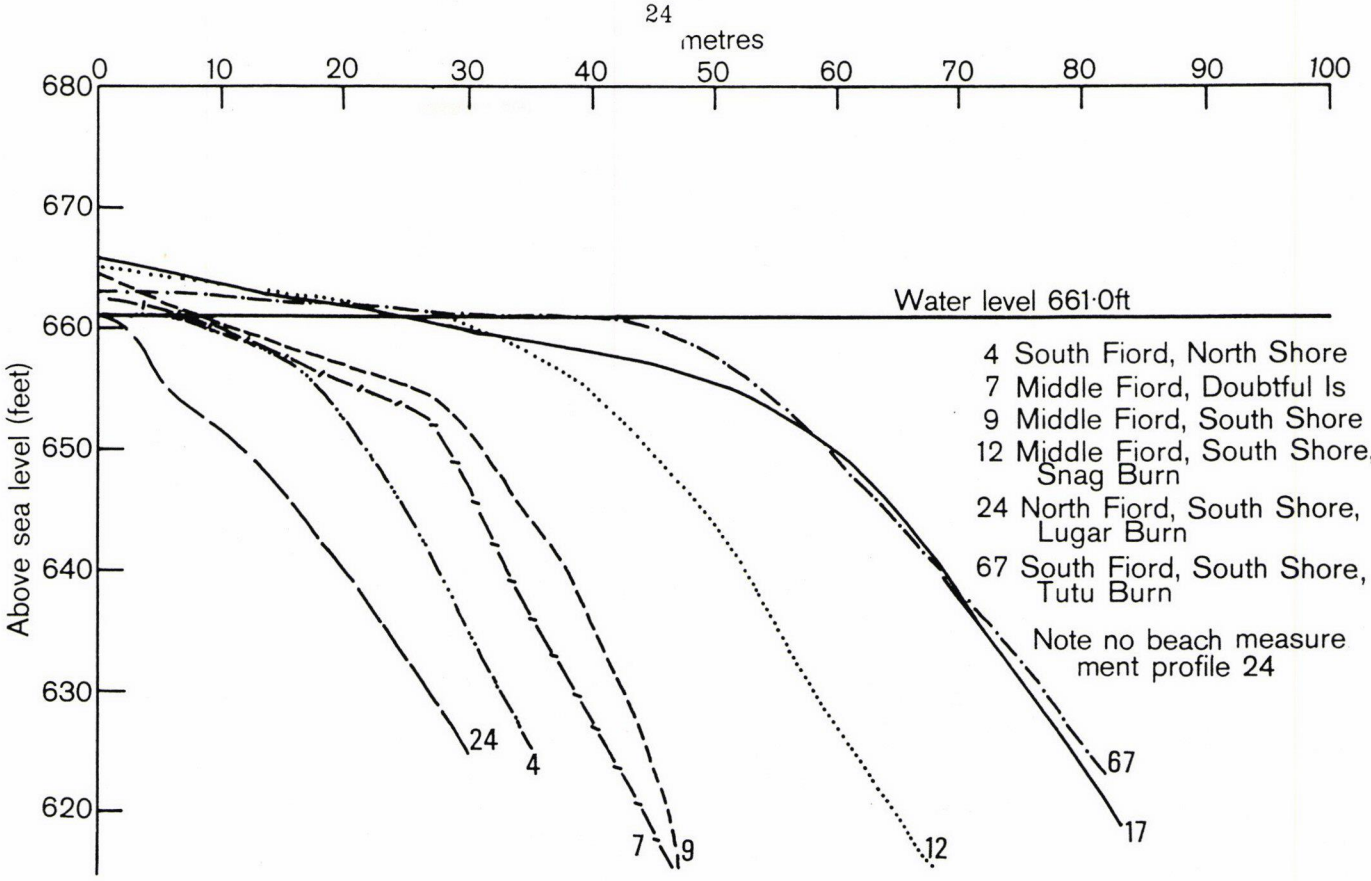


Fig. 11a.

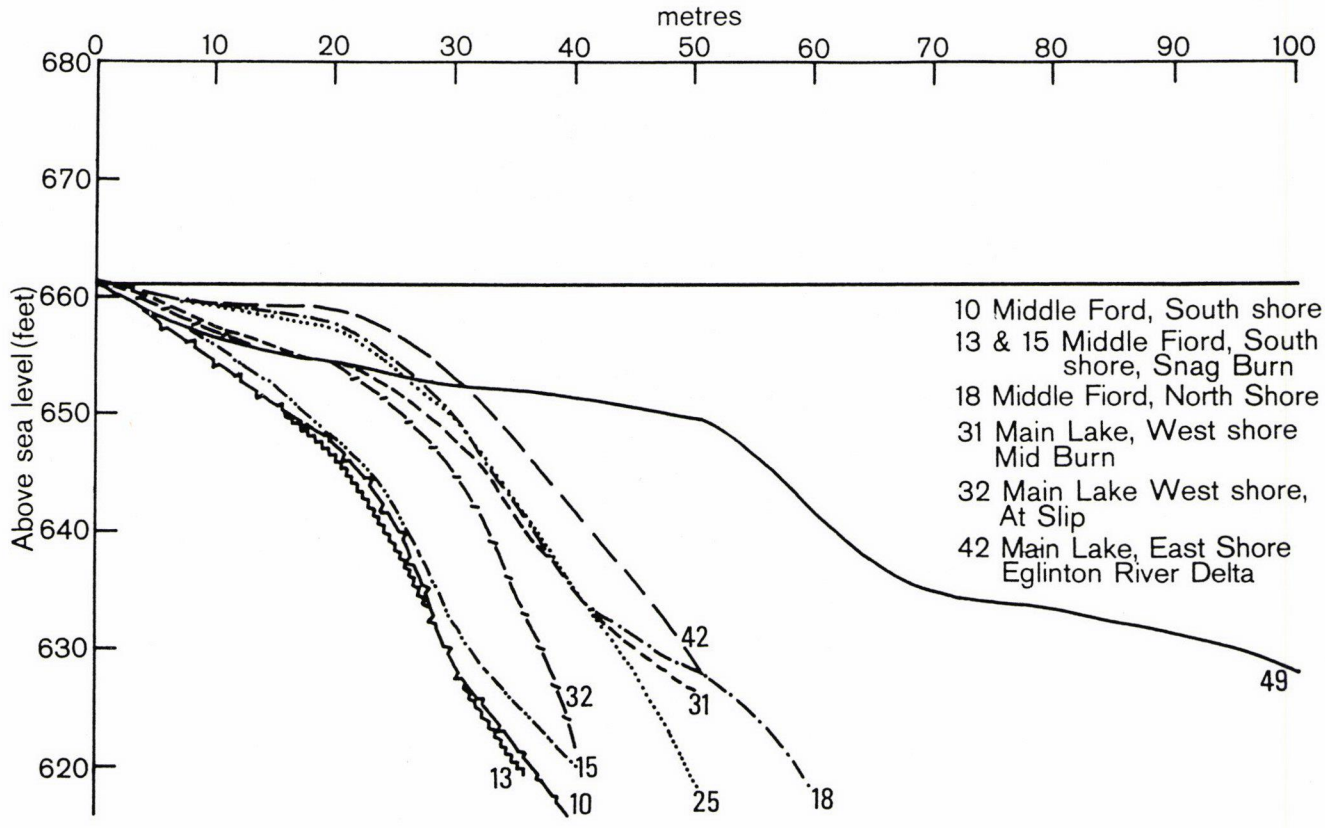


Fig. 11b.

Fig. 11a-g. Lake Te Anau Beach and underwater profiles measured by lead line and echo sounder; vertical exaggeration x 3.3. Position shown in Figs 1 - 5.

TABLE 3. Lake Te Anau, 29 April - 4 May 1974. Beach and underwater sediments from profiles 59, Stony Beach; 60, Muddy Beach, and 8 (1973, Sandy Beach) (*see* Fig. 5). Shore samples 1 - 7 (*see* Figs 2, 3 and 5).

Sample	Position	Cobbles and Pebbles	Pebbles	Maximum Size mm	Granule gravel	Very coarse sand	Coarse sand	Medium sand	Fine sand	Very fine sand	Mud	Organic	Colour (wet)	Wentworth Description
59-1	At marker post 27		10	30			80	10				Nil	Dark grey	
59-2	5 m from post 27		95	40		5						"	Medium grey	Gravel
59-3	10 m " " 27		100	55		Slight						"	" "	"
59-4	15 m " " 27		65	55	20	15						"	" "	Sandy gravel
59-5	20 m " " 27	65		70	5	10	20					"	" "	" "
59-6	25 m " " 27	95		70			5					"	" "	Gravel
59-7	30 m " " 27		5	30		40		55				"	" "	Sand
59-8	35 m " " 27	100		80								"	" "	Gravel
59-9	40 m " " 27				10	5		10	50		20	5	" "	Muddy sand
59-10	45 m " " 27								38		50	2	Medium grey brown	Fine sandy mud
59-11	50 m " " 27										100	-	" " "	Mud
60-10	At marker post 28								40			60	Light grey brown	Sand
60-9	10 m from post 28										98	2	" " "	Mud
60-8	20 m " " 28								40	40	15	5	Medium grey brown	Muddy sand
60-7	30 m " " 28							20	50	15	10	5	" " "	Sand
60-6	40 m " " 28								15		80	5	Light grey brown	Fine sandy mud
60-5	50 m " " 28									15	80	5	" " "	Very fine sandy mud
60-4	60 m " " 28								10	5	75	10	" " "	Fine sandy mud
60-3	70 m " " 28								10		85	5	" " "	" " "
60-2	80 m " " 28								5		90	5	" " "	Mud
60-1	90 m " " 28										95	5	" " "	"
8-3	At marker post 93						70		30			Nil	Light grey brown	Sand
8-2	10 m from post 93					5	70	25				"	" " "	"
8-1	20 m " " 93		30	50	20	30			20			"	Medium grey brown	Sandy gravel
8-4	30 m " " 93								85		5	10	Dark grey	Sand
8-5	40 m " " 93								10		80	10	Medium grey brown	Fine sandy mud
8-6	50 m " " 93							5	15		70	10	" " "	" " "
8-7	60 m " " 93									70	20	10	" " "	Very fine muddy sand
8-8	70 m " " 93									10	80	10	Light grey brown	Very fine sandy mud
8-9	80 m " " 93									10	80	10	Medium grey brown	Very fine sandy mud
1											100	-	Light grey brown	Mud
2									95		5	-	Dark grey brown	Sand
3								15	85			-	Light grey brown	"
4									10		90	-	Dark grey brown	Mud
5											100	-	Light grey brown	"
6								25	75			-	" " "	Sand
7								15	85			-	Medium grey brown	"

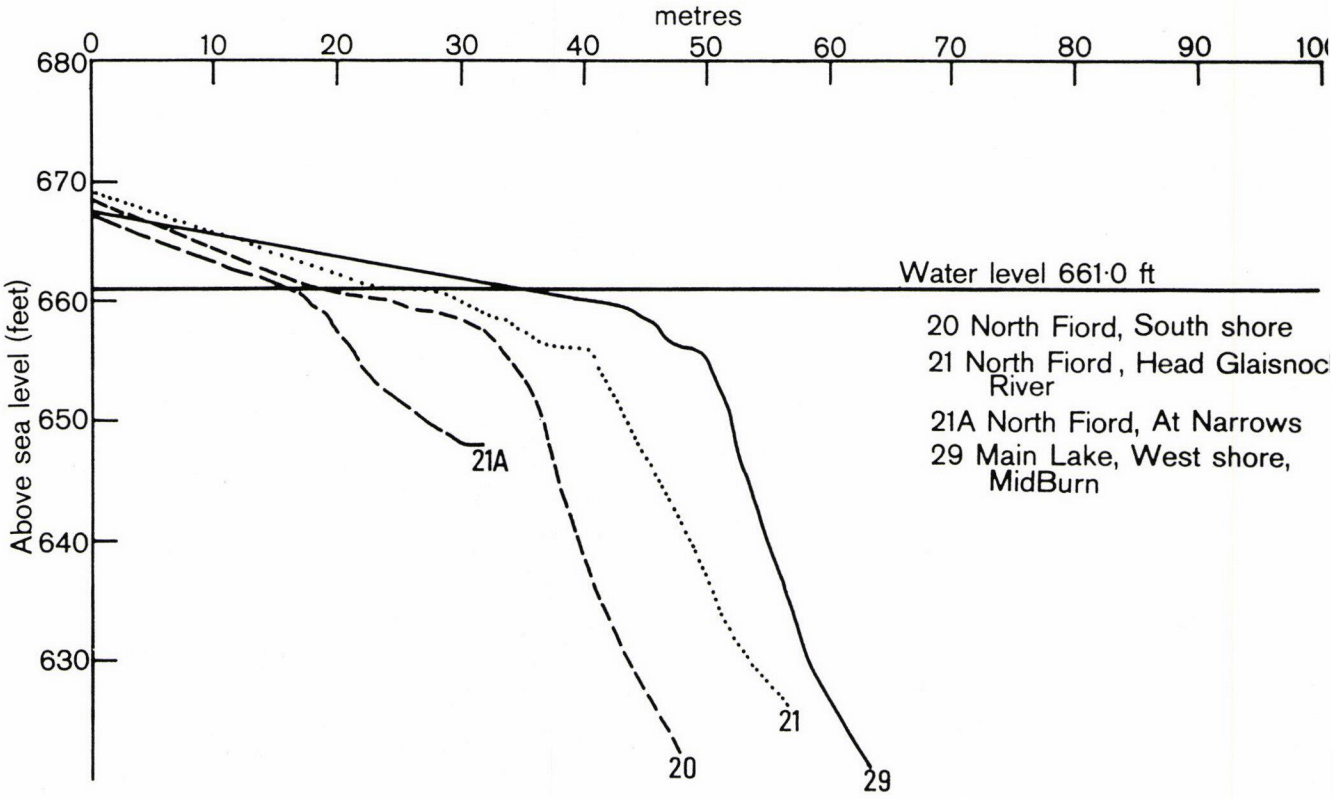


Fig. 11c.

SUMMARY OF GRADIENT CHARACTERISTICS OF THE 48 SELECTED PROFILES, 1973 AND 1974

Average Beach Gradients			
Steep gradient	Greater than 1 in 6 (9½°)	2 (1)	profiles Nos 48, (9)
Medium gradient	1 in 6 (9½°) to 1 in 12 (4¾°)	21 (6)	profiles Nos 4, 7, 9, 17, 20, 21, 35, 47, 50A 51, 52, 53, 54, 58, 59. (1, 4, 5, 7, 8, 10)
Low gradient	Less than 1 in 12 (4¾°)	15 (3)	profiles Nos 12, 21A, 29, 39, 40, 41, 50B, 55 56, 57, 60, 67 (2, 3, 6)
Average First Offshore Gradient			
Very steep gradient	Greater than 1 in 8 (7°)	9 (2)	profiles Nos 12, 21A, 52, 67, 10, 13, 15 (1, 10)
Steep gradient	1 in 8 (7°) to 1 in 16 (3½°)	24 (6)	profiles Nos 49, 31, 47, 9, 17, 20, 21, 24, 2 32, 40, 48, 51, 56, 58, 59, 60 (2, 4, 5, 6, 7, 9)
Low gradient	1 in 16 (3½°) to 1 in 24 (2½°)	8 (1)	profiles Nos 41, 47, 53, 54, 55, 18, 25, (3)
Very low gradient	Less than 1 in 24 (2½°)	7 (1)	profiles Nos 35, 39, 50A, 50B, 57, 42, (8)
Average Second Offshore Gradient			
Very steep gradient	Greater than 1 in 2 (26½°)	15 (3)	profiles Nos 4, 7, 20, 21, 21A, 29, 58, 59, 6 10, 13, 16 (1, 2. 10)
Steep gradient	1 in 2 (26½°) to 1 in 4 (14°)	23 (6)	profiles Nos 42, 31, 9, 12, 17, 24, 35, 41, 4 32, 52, 53, 54, 56, 57, 15, 25 (3, 4, 5, 6, 8, 9)
Low gradient	1 in 4 (14°) to 1 in 6 (9½°)	4 (1)	profiles Nos 51, 55, 67 (7)
Very low gradient	Less than 1 in 6 (9½°)	5	profiles Nos 40, 39, 48, 50A, 49

( ) indicates profiles measured in June 1973 and included in the total number

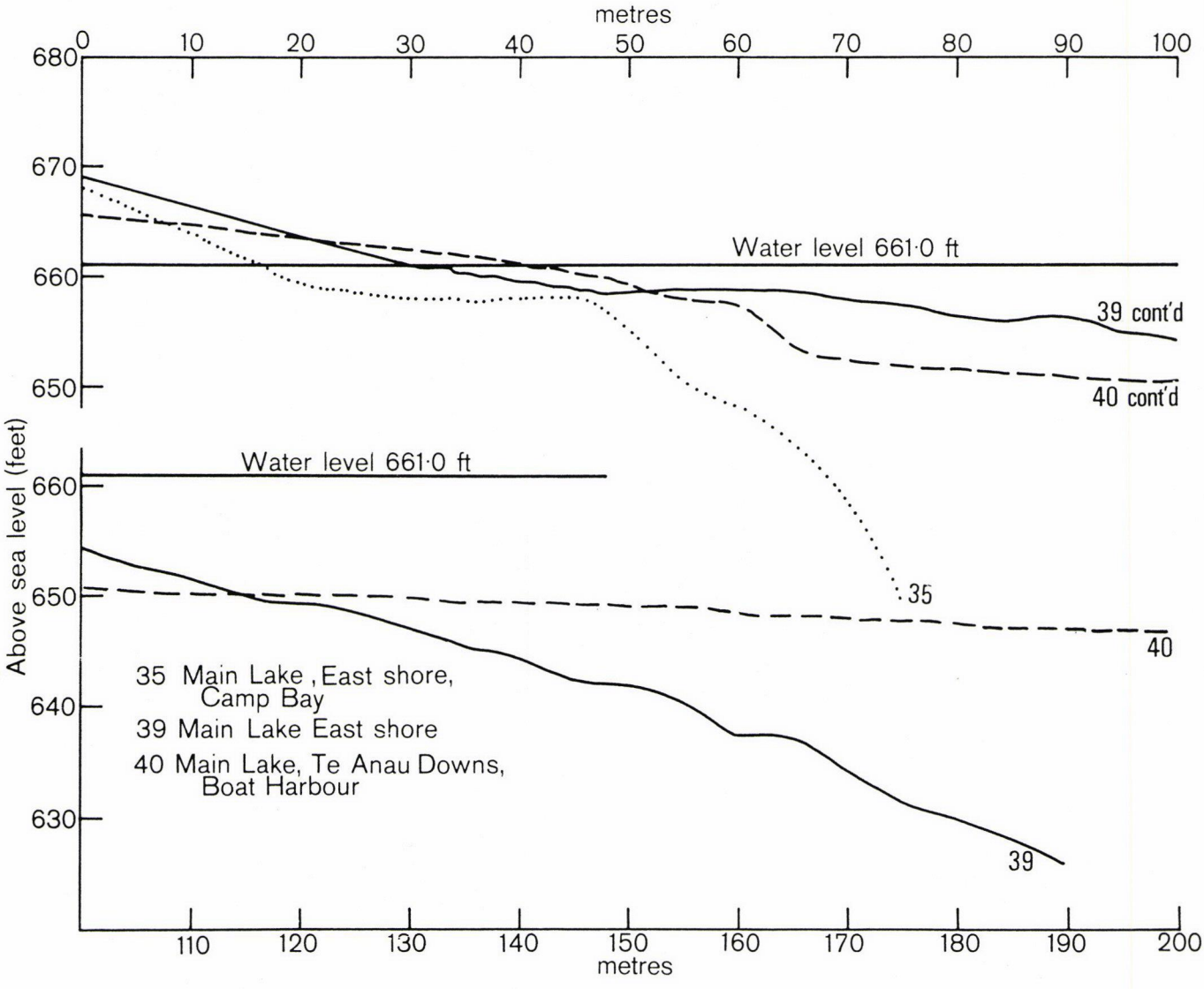


Fig. 11d.

Profiles off Tertiary Rocks

(Landon series (L, Ld-w, Lwh))
(Arnold series (A))

(a) *No beach developed*

A group of three profiles on the eastern shore of the main lake north of Camp Bay, 36, 37, 38, is backed by steep country (slopes recorded as 80°). The initial underwater slope ranges from 26° to 49° (av. 36°), the following slope ranges from 17° to 26° (av. 23°) and the average of the mean slopes to 200 m offshore is 26°.

On the west shore of the main lake north of North Fiord the superficial rocks have slipped into the lake leaving a large bare slip face approximately 300 m wide. The above water slope is recorded as 40°. The mean underwater slopes out to 200 m offshore on three profiles 200 m apart at this point range from 25° to 35° (av. 30°).

(b) *With beach*

One group of three profiles and a single profile exhibit an initial underwater slope averaging 6° followed by a second slope averaging 19°. The mean slope to 100 m offshore averaged 14° and the above water slope is recorded as 60°.

Comments

The abovewater slopes in these rocks range from 40° to 80°. However the mean underwater slope to 200 m offshore averages 28° for the no beach profiles and for profiles offshore from beaches, 14°.

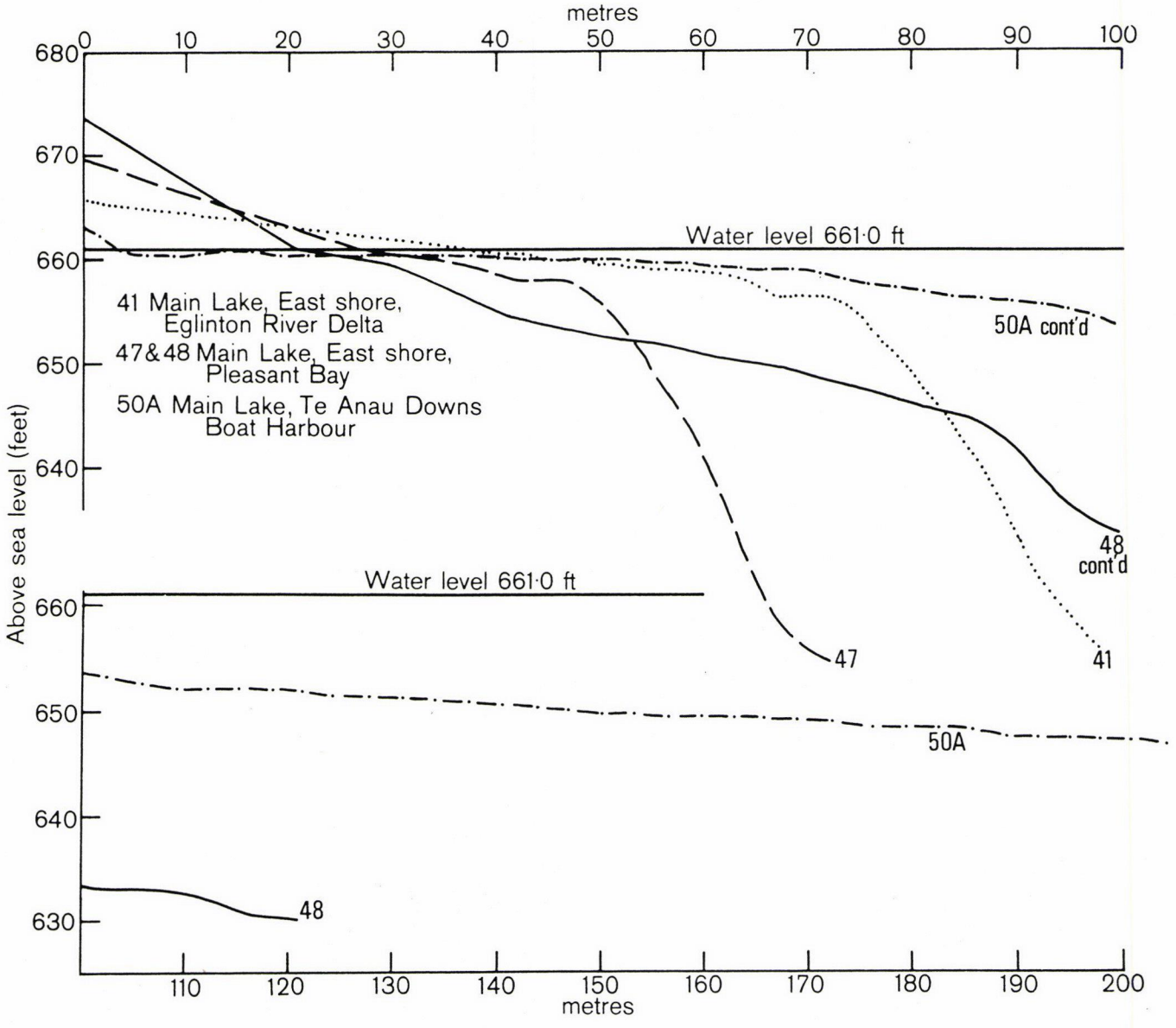


Fig. 11e.

Development of Shore Platform

In an area of mudstone shoreline (Middle Fiord north shore 17, 18, 19) small shore platform, 15 m wide, is developed terminating shoreward in a small ramp of debris at the foot of a near vertical cliff. Lakeward, the wave-cut surface of this platform forms at least the upper part of the initial underwater slope which here averages 5° and extends distances ranging from 5 to 30 m offshore from the lake edge at the time of survey.

Profiles off Bradshaw Formation

((bw) dominantly gneiss, *see* Wood 1960)

(a) *No beach developed*

One group of three profiles (South Fiord, south shore 61, 62, 63) was measured out to 200 m offshore. The profiles were concave with an initial slope of 40-47° down to 70 m depth followed by a 24-31° slope. The above water slope is recorded as 45°. The mean slope to 200 m offshore is 35°.

(b) *With beach*

A group of five profiles were measured in the vicinity of Doubtful Island, Middle Fiord south shore, two off a mud beach with an initial underwater slope averaging 7°, followed by a slope of 25° with a mean slope to 100 m offshore of 17°. Three (9, 10, 11) were off a gravel beach, with an initial underwater slope of averaging 6°, followed by a slope of 12 to 33°, with a mean slope to 200 m offshore of 11°.

These five profiles are so located that they cannot be compared to main fiord situations.

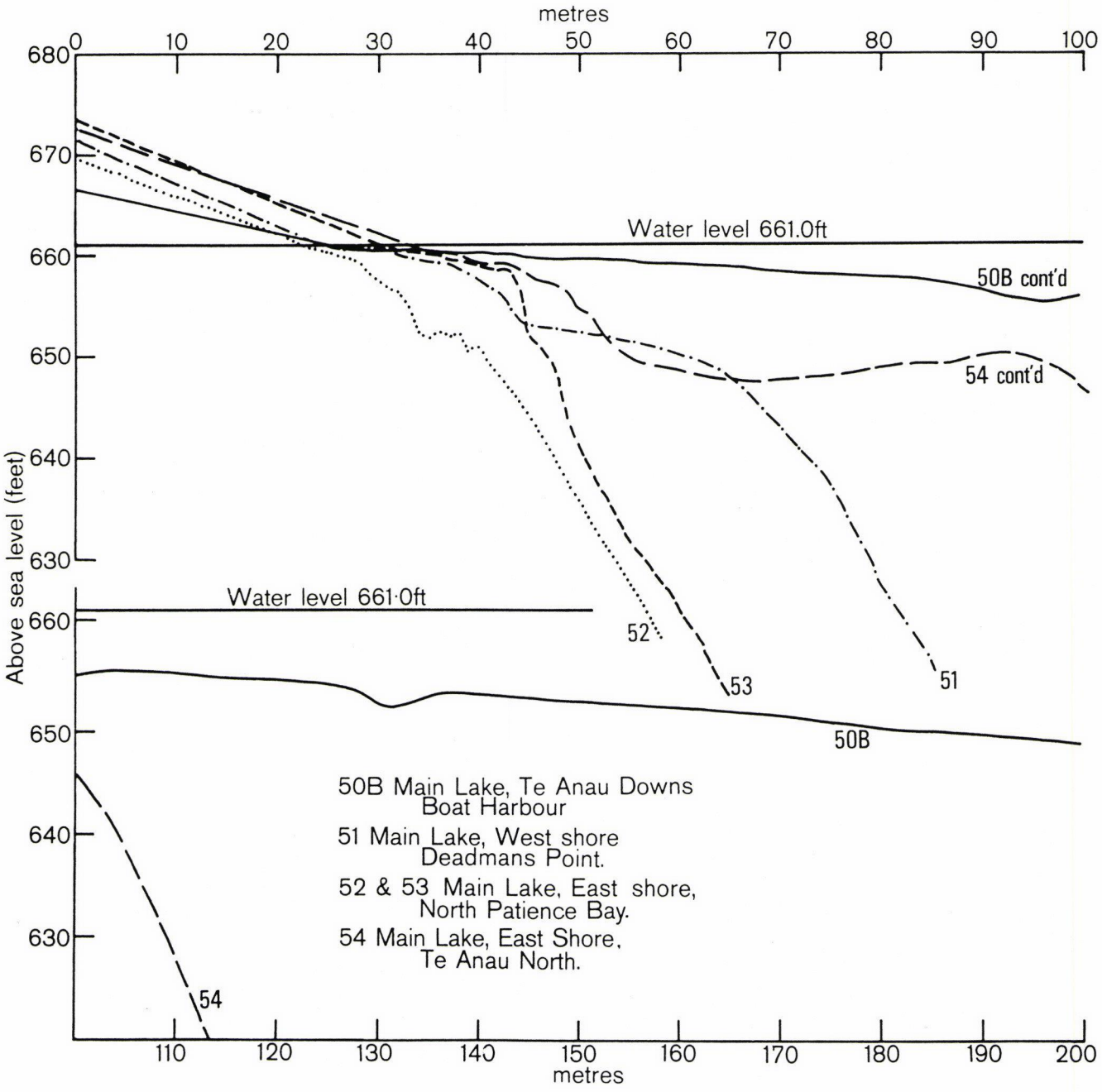


Fig. 11f.

At a steep (13°) gully (North Fiord south shore, 22) the slope to 200 m offshore was even and 25°. An above water slope of 25° is recorded for this area.

Comments

The above water slopes in gneiss areas range from 20° to 45° and the mean underwater slopes to 200 m offshore from 25 to 35°.

Profiles off Wet Jacket Formation

((wj) gneiss and schist (*see* Wood 1960))

(a) *No beach developed*

Two groups of three profiles were measured out to 200 m. The first group (South Fiord, north shore 1, 2, 3) had a relatively even underwater slope averaging 40° out to 200 m offshore with above water slopes averaging 45°.

The second group (South Fiord, south shore 64, 65, 66) had a similar more or less uniform slope averaging 41° out to 200 m offshore, but with above water slopes recorded as 80°.

Comments

The underwater slopes in this terrain out to 200 m offshore, average 40°: on the other hand the above

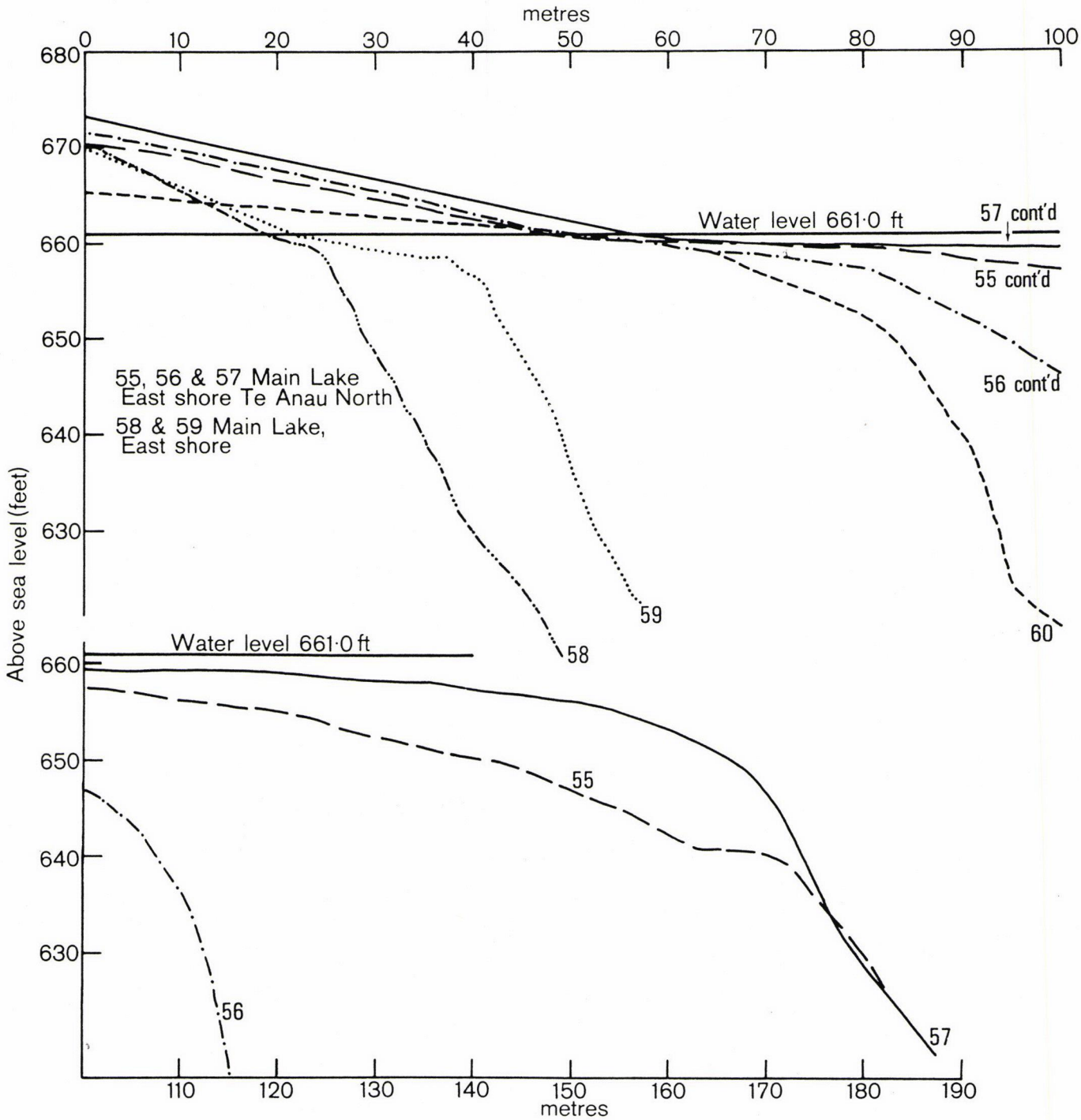


Fig. 11g.

water slopes at the measured localities have been recorded as varying between 45 and 80°.

Profiles off Granite Terrain

(Pomona (pg); Murchison (mg))

(a) *No beach developed*

Two groups of three profiles were measured out to 200m offshore. One group (North Fiord, north shore 26, 27, 28) had a concave profile with an average initial slope (to about 100m) of 50° and a second slope averaging 30°. The slope above lake level is recorded as 60°. The mean slope of the three lines out to 200m offshore is 45°.

The second group (North Fiord, south shore 44, 45, 46) had a convex profile with an average slope of 22°

Summary of mean angles of slope of groups of 200 m long echo sounding lines for rock types

Rock type		Above Water Slope	Initial mean u/w Slope	Second mean u/w Slope	Mean Slope to 200 m Offshore
Pomona and Murchison Formation					
(granite)	No beaches	60°	50°	30°	45° (to 100 m only)
		50°	22°	34°	29°
	Beaches	45°	-	-	23° (to 100 m only)
Wet Jacket Formation					
(gneiss & schist)	No beaches	45°	-	-	40°
		80°	-	-	41°
Bradshaw Formation					
(dominantly gneiss)	No beaches	45°	44°	27°	35°
	Beaches	25°	7°	25°	17° (to 100 m only)
		25°	6°	16°	11°
		25°	-	-	25°
Tertiary	No beaches	80°	36°	23°	26°
		40°	43°	30°	31°
	Beaches	60°	6°	19°	14°
Alluvium and Moraine	Beaches	5-20°	6°	20°	16°

down to 30 to 50 m depth and an average second initial underwater slope of 34°. The mean slope to 200 m offshore is 29°. The fiord walls here are recorded as being 50°.

(b) *With beach*

One group of three profiles measured off a small sandy beach (South Fiord, north shore 4, 5, 6) have a slope (to 100 m) that averages 23°. The fiord walls behind are recorded as being 45°.

Profile 60 in South Fiord (south shore) was measured in a small cove and is not representative of the main fiord situation.

Comments

The above water slopes range from 45 to 60° and the mean underwater slope to 200 m offshore ranges from 23 to 45°. The slopes of the beach profiles below water are less (23°) than either of the measured groups where there was no beach.

TABLE 4. Lake Te Anau. Depth of break in slope between first and second offshore gradients for 38 selected profiles 1974, and for profiles 1-10, 1973.

No.	Date	Depth of break in slope (ft)
1	1973	3.0
2	"	7.0
3	"	3.5
4	"	5.0
5	"	5.0
6	"	3.0
7	"	20.0
8	"	4.0
9	"	5.0
10	"	9.5
4	1974	4.0
7	"	8.0
9	"	6.5
10	"	13.0
12	"	6.0
13	"	14.5
15	"	8.5
17	"	8.0
18	"	3.5
20	"	4.0
21	"	5.0
21A	"	8.0
24	"	1.0
25	"	4.0
29	"	5.0
31	"	6.5
32	"	6.5
35	"	3.0
39	"	6.0
40	"	6.0
41	"	5.0
42	"	3.0
47	"	3.0
48	"	16.0
49	"	11.5
50A	"	2.0
50B	"	12.75
51	"	8.0
52	"	10.0
53	"	2.5
54	"	11.0
55	"	20.0
56	"	14.0
57	"	8.0
58	"	2.0
59	"	4.0
60	"	9.0
67	"	4.5

Beach and Underwater Sediments

(a) The sediments of three profiles off beaches that are developed in sand, muddy sand, and gravel respectively may be compared (Figs 10a-c, Table 3). Along profile 8 (sand beach) the sand is dominant to just below the water level where gravel rises to nearly 50%. As the water deepens gravel effectively

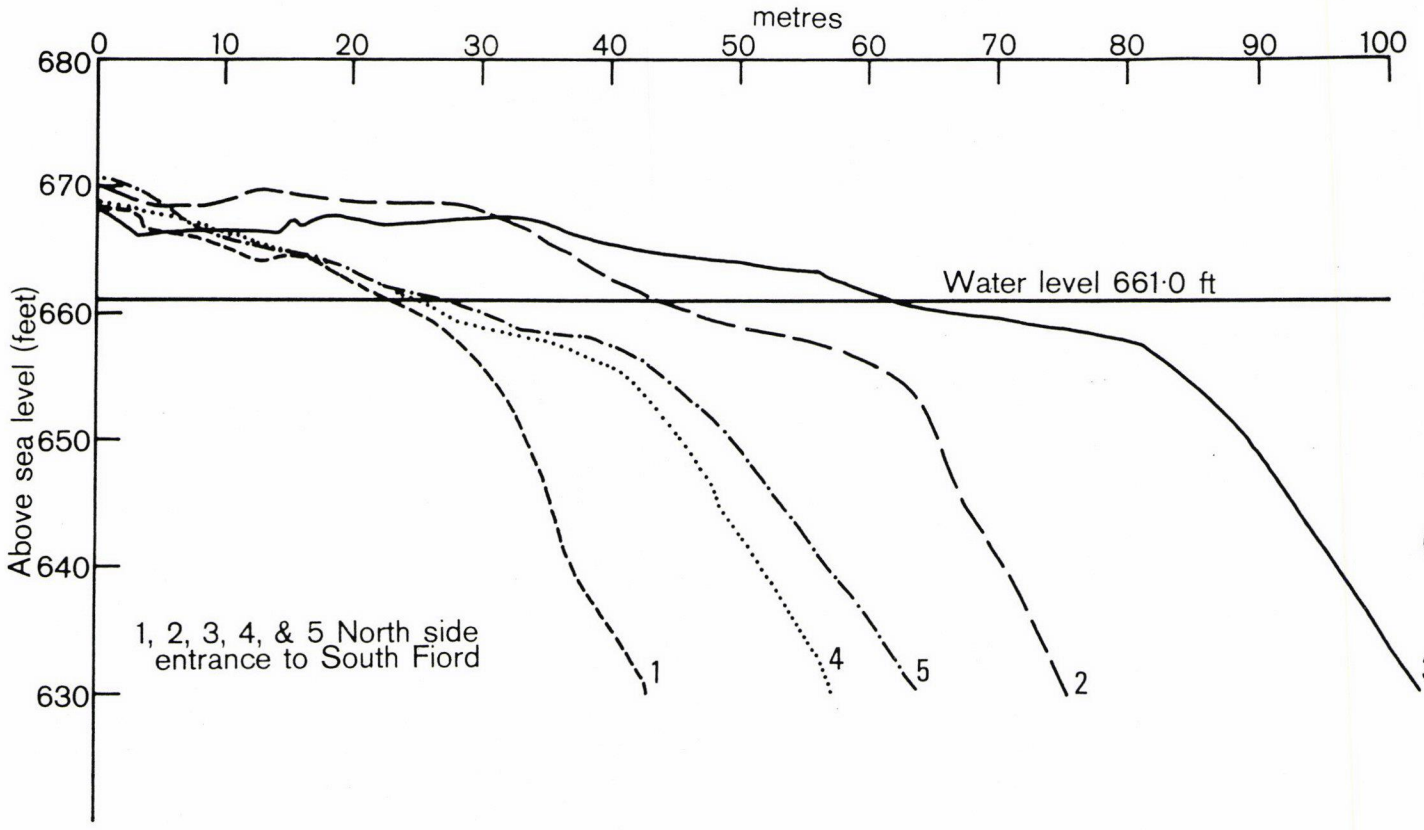


Fig. 12a.

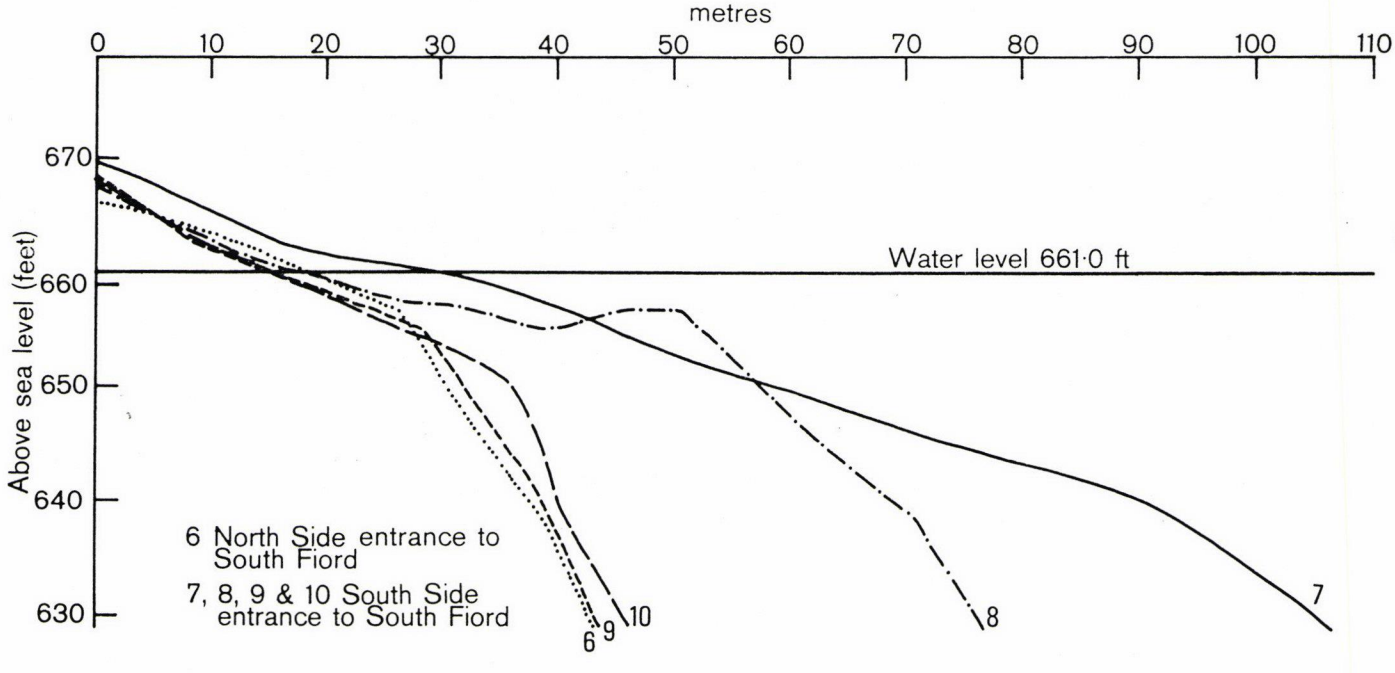


Fig. 12b.

Fig. 12a-b. Lake Te Anau Beach and underwater profiles measured by lead line on June 1973; vertical exaggeration x3.3. Positions shown in Figs 1 - 5.

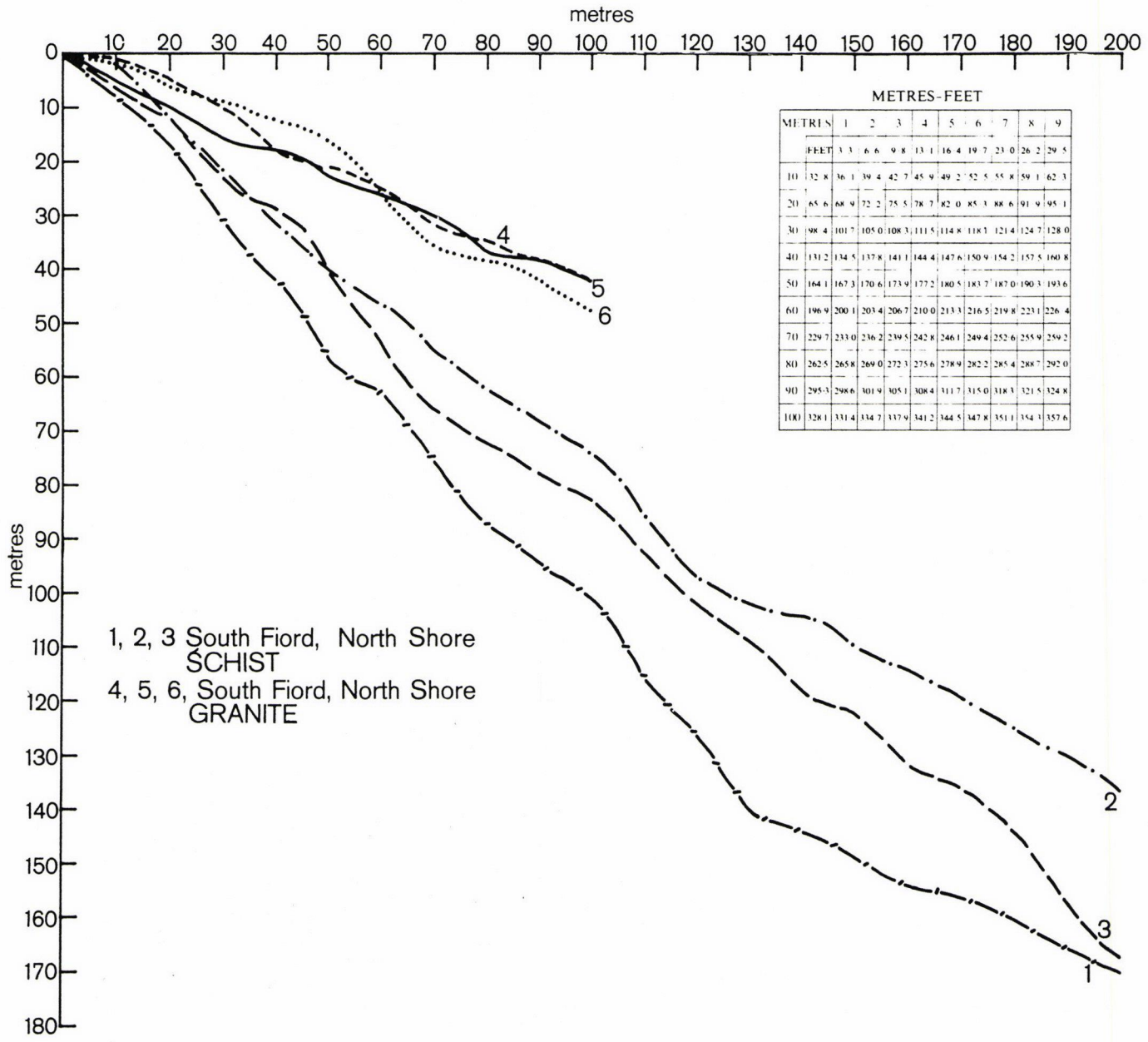


Fig. 13a.

Fig. 13a-j. Lake Te Anau underwater profiles measured by echo sounder; drawn at natural scale. Positions shown in Figs 1-5.

disappears at 15m from shore and at water level 657.0ft from this point lakeward sand and mud alternate as dominants.

Along profile 60 (muddy sand beach), no gravel was sampled. Sand and mud alternate as dominants out to the water level, below which mud is dominant.

Along profile 59 (gravel beach), gravel is dominant out to the water level and alternates with sand as dominant to about 20m offshore, water level 651.0ft where mud becomes dominant.

All three profiles demonstrate the high variability of inshore sediment grade, which can be seen to be common where sediment has accumulated. It is notable that each profile ends in muddy sediments.

(b) At numerous places around the lake shores fine grained sand and mud beach sediments are developed. Field analyses were made at seven localities (Figs 1-6). At three sites (1, 4, 5) the sediments were almost exclusively mud. At the remainder, fine sand dominated (75-95%) over sand grade and no mud was present.

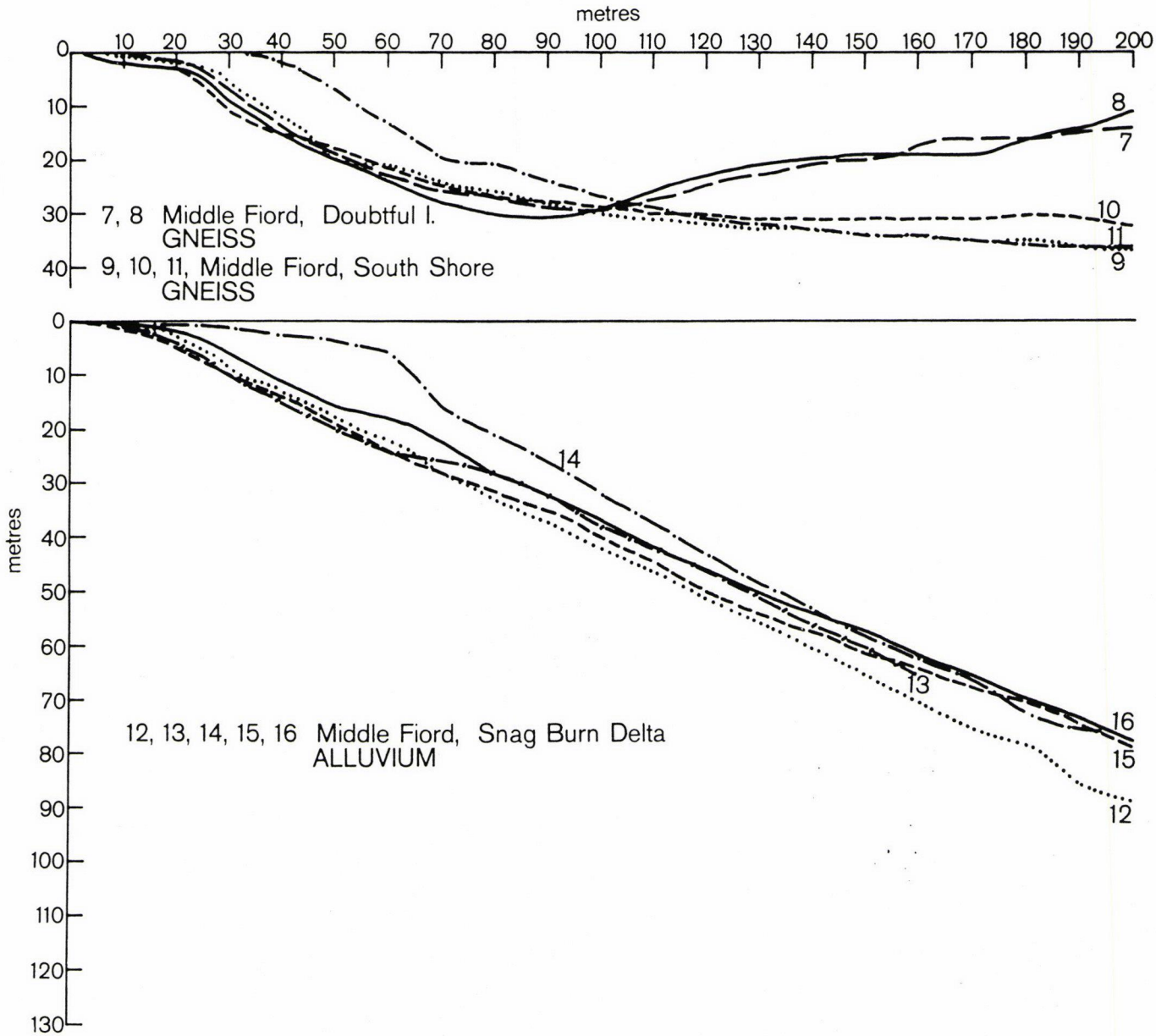


Fig. 13b.

Of the seven localities, one (profile 14 sample 6) was situated on the growing front of the Snag Burn Delta in Middle Fiord at a site clearly supplied with present day sediments. The sediment consisted of 75% fine sand and 25% medium sand.

One site (sample 1) was on a small rocky islet near the entrance to South Fiord with no present source of sediment. The rocky surface was covered with morainic debris ranging in size from small boulders down to mud (silt and clay) grade deposits, all at about lake level.

At one site in South Fiord (profile 60, samples 2 and 3) the muddy fine sand sediments were laid down over a wide extent in a relatively sheltered position and extended above and below lake level. At a further sheltered site in Middle Fiord (profiles 7 and 8, samples 4 and 5) the shore sediments extended similarly above and below water level and were dominantly mud with up to 10% of fine sand.

At the last site in Middle Fiord (profile 17, sample 7) the sediment near the lake level was 85% fine sand and 15% medium sand. A purely local source existed in the relatively soft Tertiary mudstones in which the beach at this point was cut.

DISCUSSION

Depth of Nearshore Break in Slope

Sixty-four per cent of the 48 profiles considered on

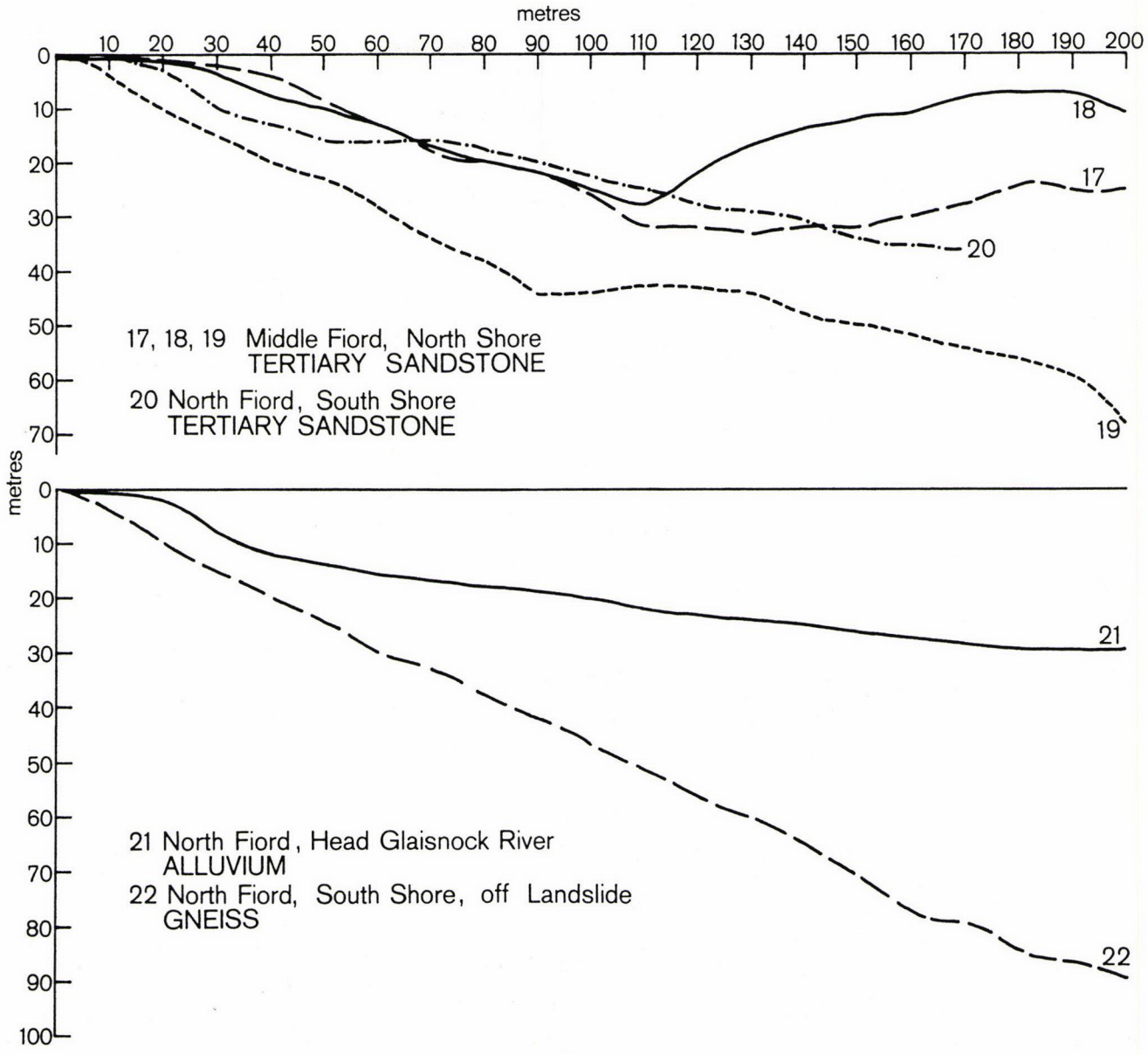


Fig. 13c.

Lake Te Anau had a depth of break in slope between 3 ft and 8 ft below lake level when measured (Table 4).

At 80% of the 50 profiles measured on Lake Manapouri in 1973 the depth of the end of the first offshore gradient, that is the depth of the break in slope between first and second offshore gradients, ranged from 6 ft to 11 ft below lake level when measured (Irwin 1974a). The majority of profiles on each lake had depths of break in slope which fell within this 5 ft range.

The average lake level for Lake Manapouri is considered to be approximately 581.0 ft above sea level (Andrews and McKellar 1973), and the average lake level of Lake Te Anau from long term records is 663.0 ft above sea level (Irwin 1974b). The majority of profiles have a break in slope on Lake Manapouri between 571 and 576 ft above sea level (Irwin 1974a) and between 653 and 658 ft above sea level on Lake Te Anau. As the break in slope is between 5 and 10 ft below the average lake level of each lake this suggests that the profiles measured are equilibrium profiles that have developed over the natural range of lake levels.

Variations of Underwater Slope with Rock Type

The mean slope to 200 m offshore in areas without

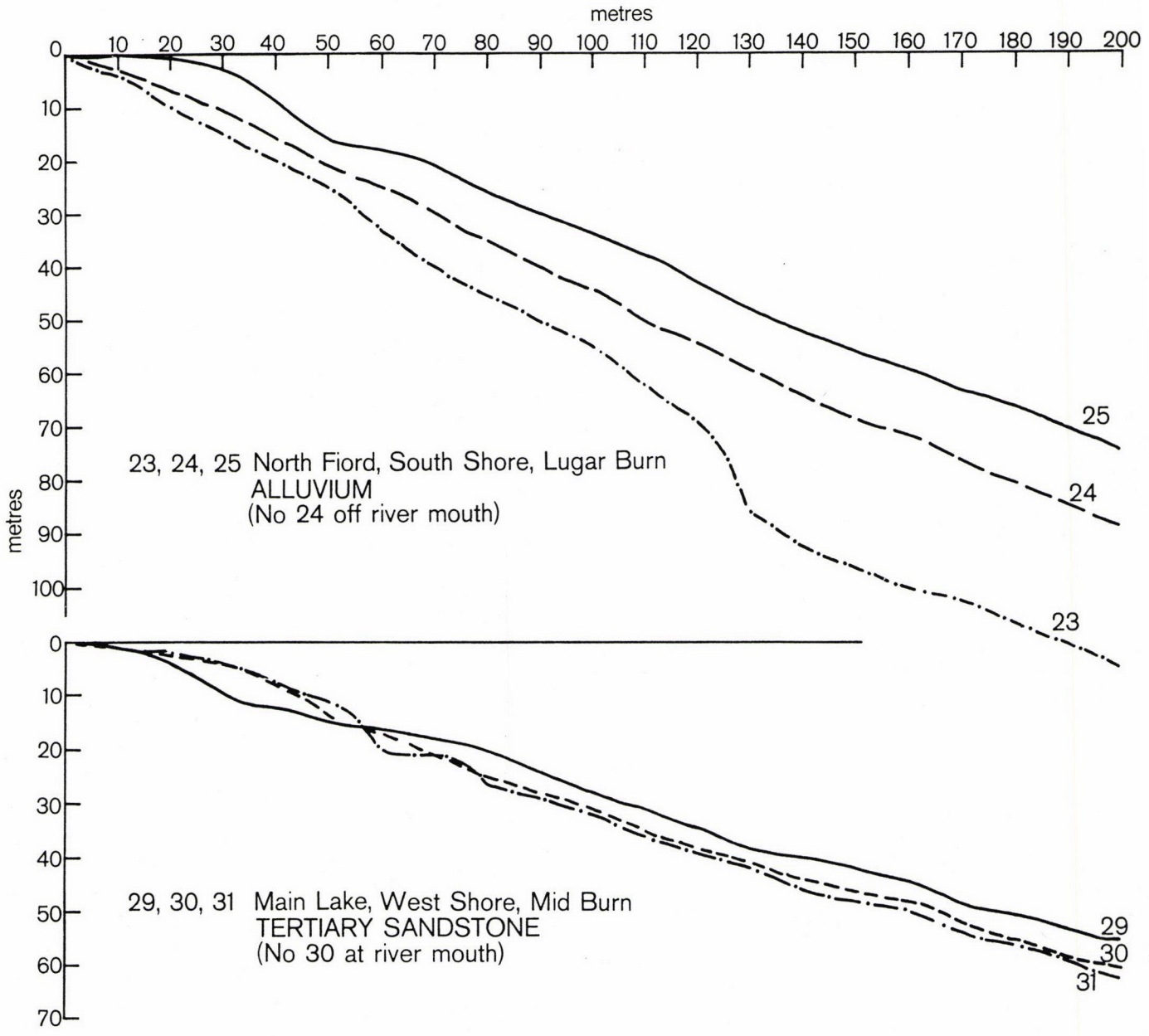


Fig. 13d.

beaches is least in the profiles off Tertiary shorelines (26 and 31°). The slope ranges from 23 to 45° in hard rock terrain (granite, schist and gneiss).

Where beaches were developed in all rock types, the mean slope to 200 m offshore was significantly less (range 11 to 25°) than in areas where beaches were not developed.

Variation of Underwater Slopes with Above Water Slopes

The mean underwater slope to 200 m offshore is in general steeper where the lake sides are steeper when profiles off areas without beaches are considered. Where beaches are developed the mean underwater slopes are less and the above water slopes are also less.

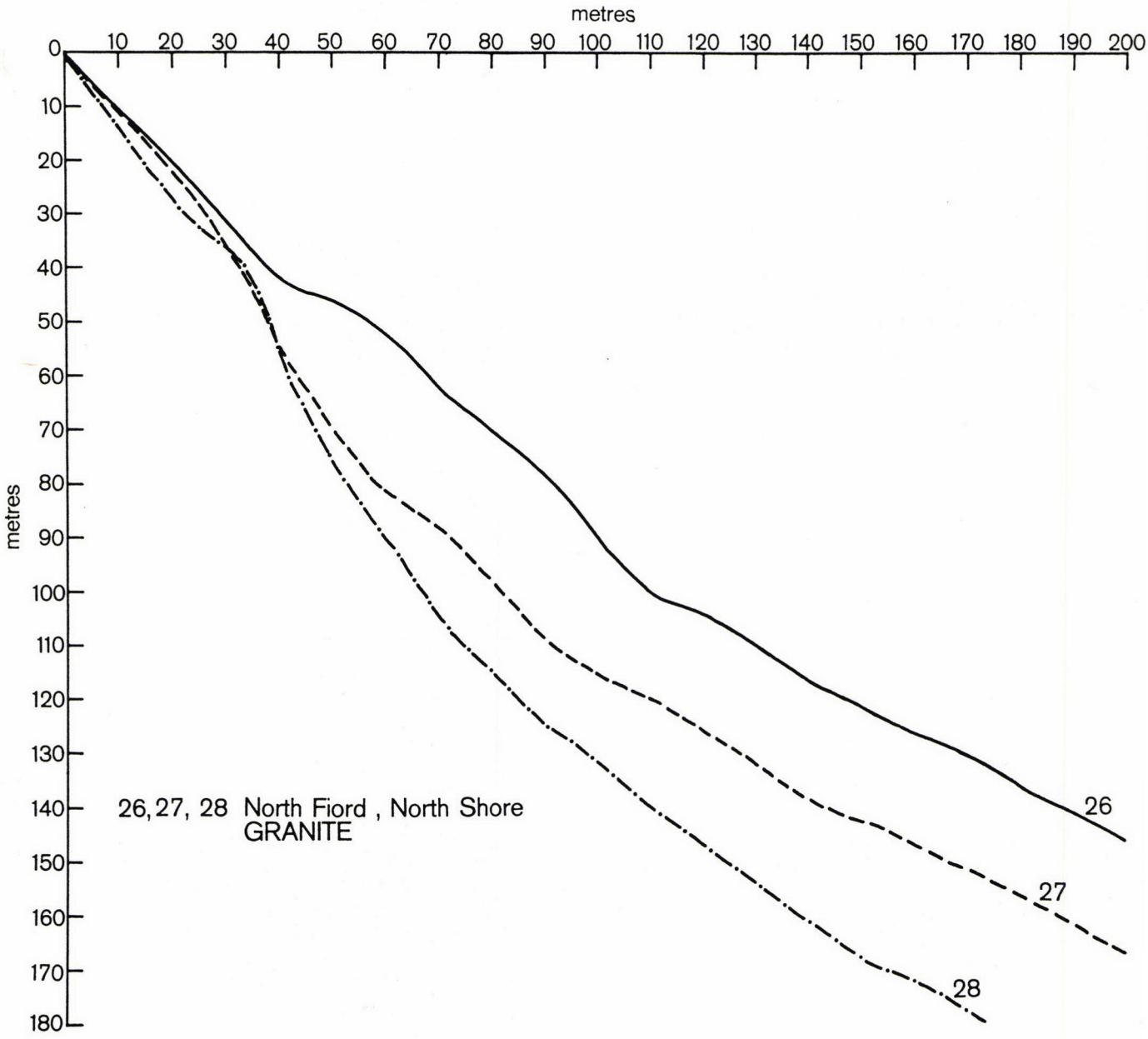


Fig. 13e.

Angle of Repose of Sediments on Beaches and Deltas

From the 200m long echo sounder lines the initial underwater slope for beach areas developed off all rock types averages 6° (range in 35 examples 1 to 14°). This is the approximate average slope of the previously above water beach zone as determined from the majority of the 38 lead line measured beaches.

From the 200m long echo sounding lines off beaches the second underwater slope - the angle of repose of the foreset beds ranges from 7.5 to 30° and averages 20°. Comparing the second underwater slope measured off beaches by lead line in 1974, 15 profiles have slopes greater than 28°, 23 slopes between 14° and 28°, 4 slopes between 14 and 10°, and 5 with slopes of less than 10°.

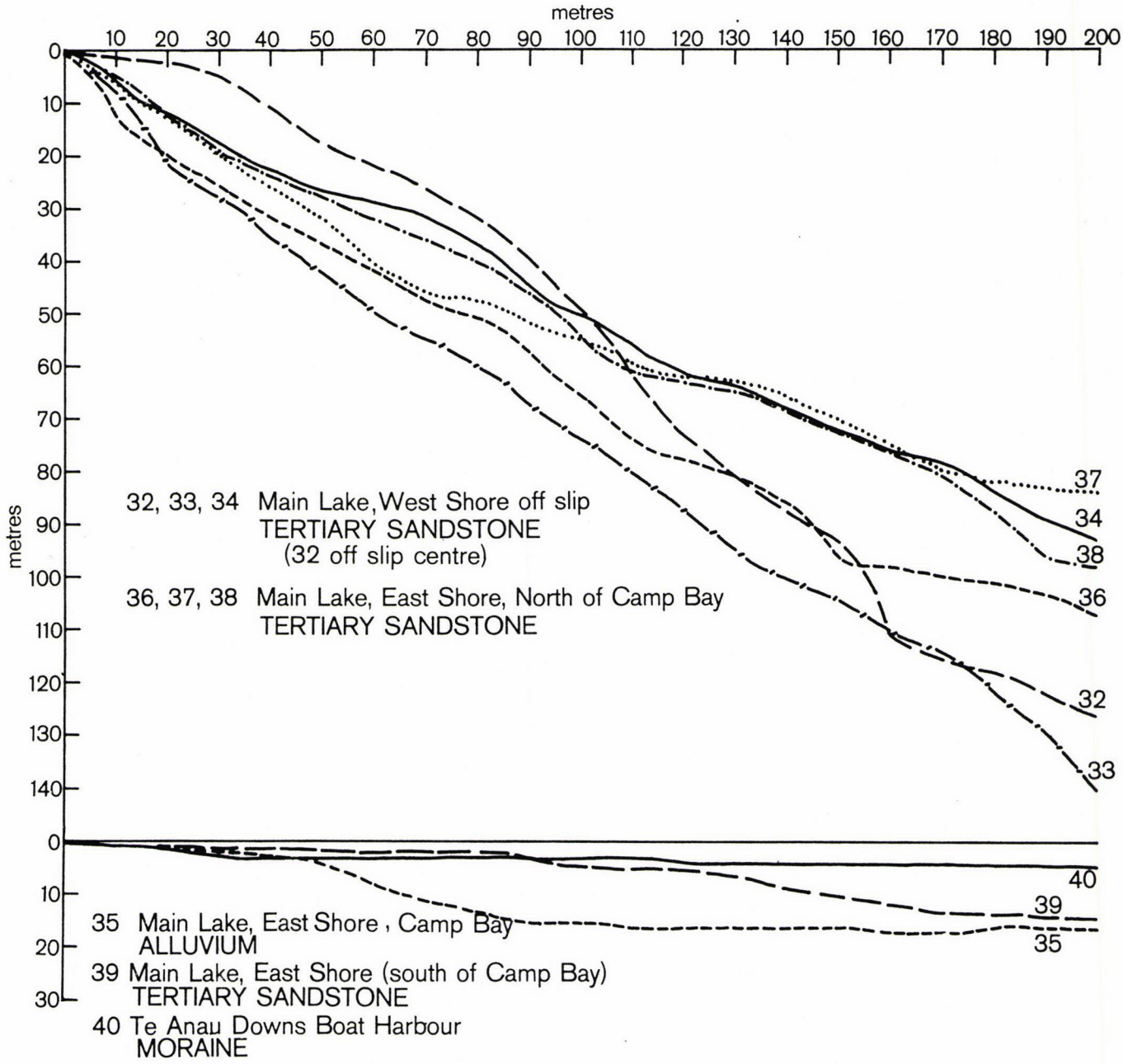


Fig. 13f.

Large Delta

It is of interest to compare the slopes of the topset beds of the larger deltas: Glaisnock Burn 6°; Eglinton River average 6°; Snag Burn average 5°; and the equally consistent foreset slopes of 28.5; 22 and 24.7° respectively.

It is clear that beach slopes and delta topset beds in the alluvial materials derived from the parent rock in the Te Anau area are the same and approximately 6°. Similarly the mean angle of repose of foreset beds and second underwater slopes off beaches is 20°.

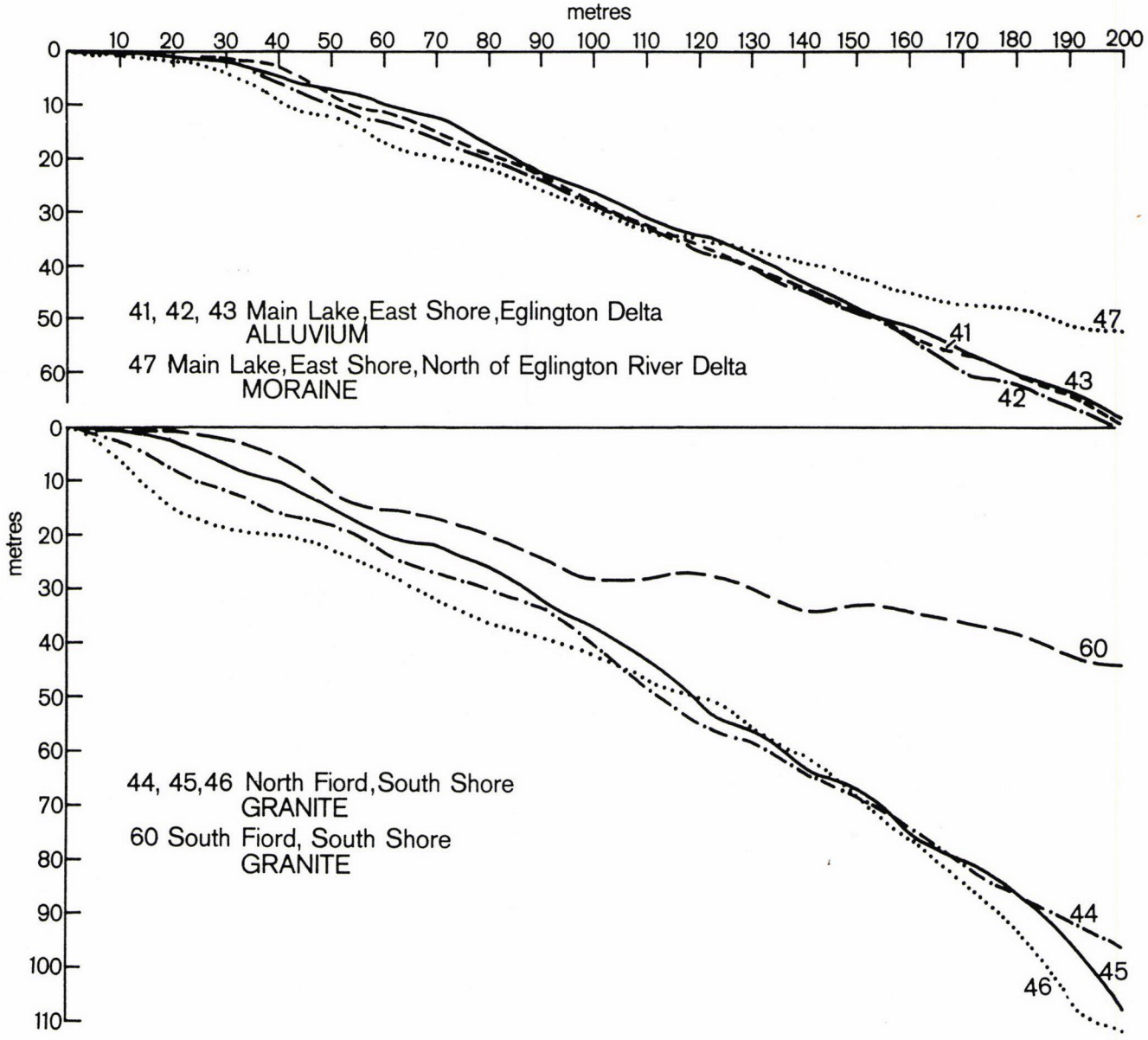

metres
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
0
10
20
30
40
50
60
41, 42, 43 Main Lake, East Shore, Eglington Delta
ALLUVIUM
47 Main Lake, East Shore, North of Eglington River Delta
MORAINE
47
41
43
42
metres
0
10
20
30
40
50
60
70
80
90
100
110
60
44, 45, 46 North Fiord, South Shore
GRANITE
60 South Fiord, South Shore
GRANITE
44
45
46

Fig. 13g.

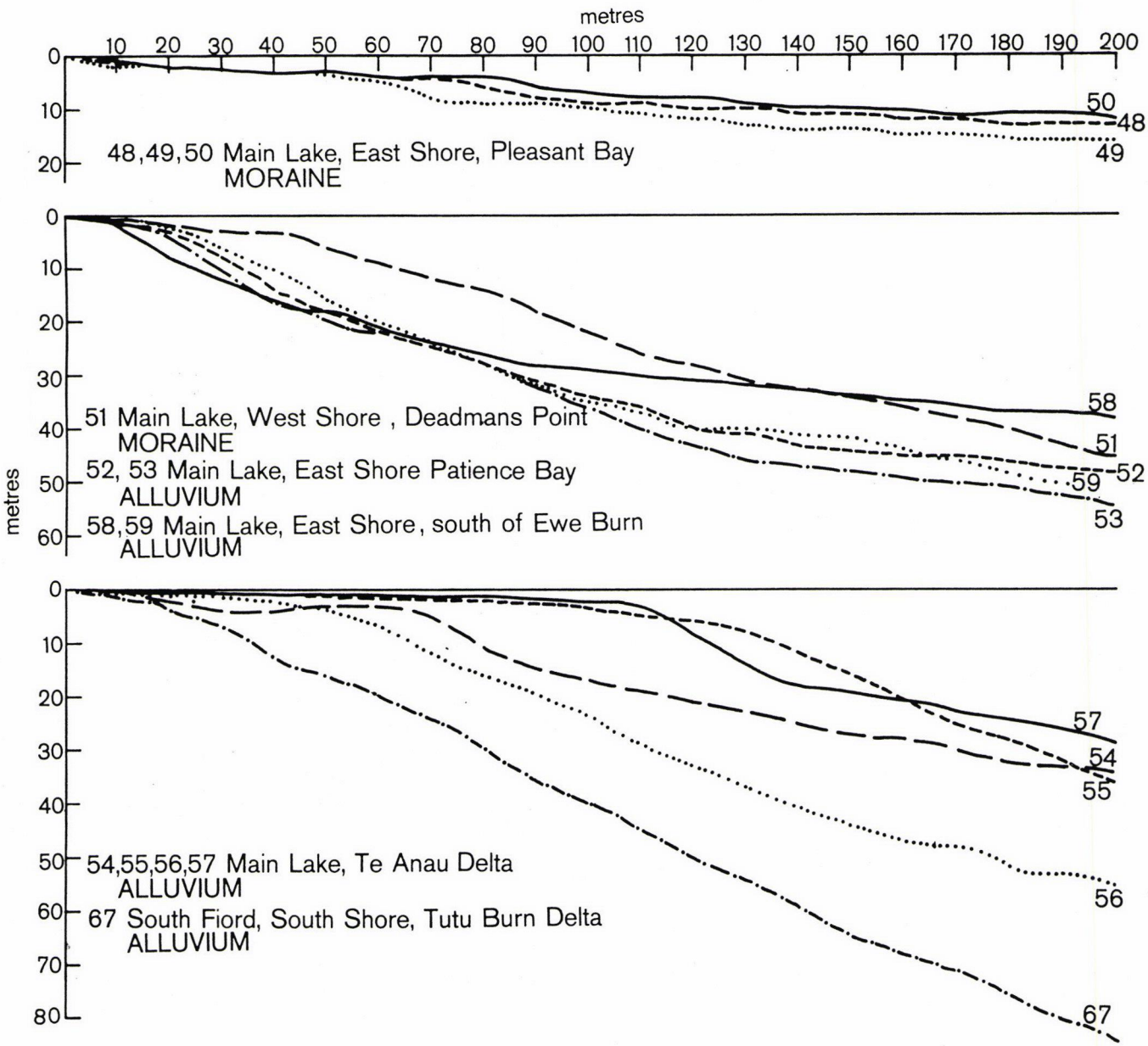

metres
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
0
10
20
48,49,50 Main Lake, East Shore, Pleasant Bay
MORAINE
50
48
49
metres
0
10
20
30
40
50
60
51 Main Lake, West Shore , Deadmans Point
MORAINE
52, 53 Main Lake, East Shore Patience Bay
ALLUVIUM
58,59 Main Lake, East Shore, south of Ewe Burn
ALLUVIUM
58
51
52
59
53
0
10
20
30
40
50
60
70
80
54,55,56,57 Main Lake, Te Anau Delta
ALLUVIUM
67 South Fiord, South Shore, Tutu Burn Delta
ALLUVIUM
57
54
55
56
67

Fig. 13h.

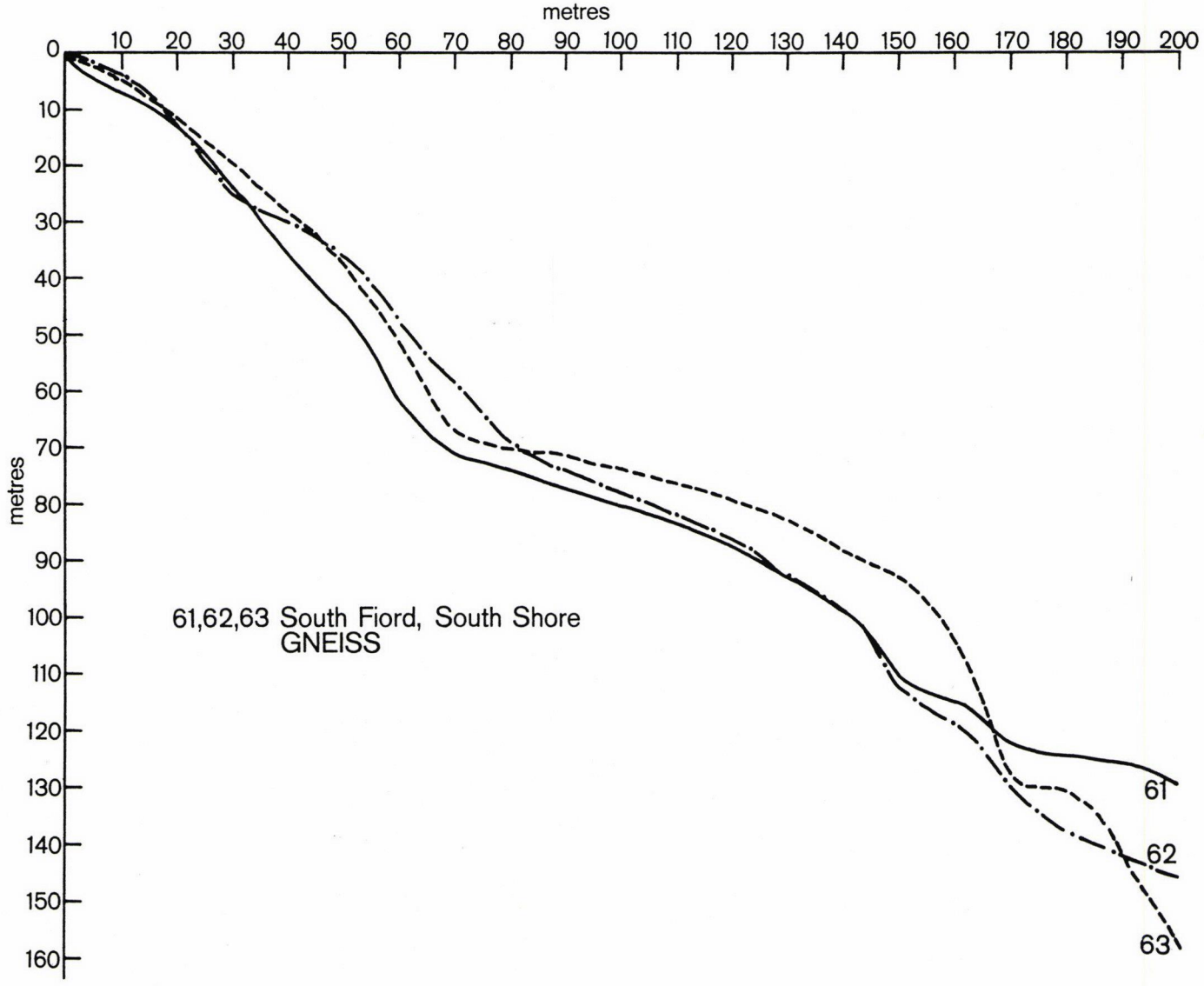

metres
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
metres
61,62,63 South Fiord, South Shore
GNEISS
61
62
63

Fig. 13i.

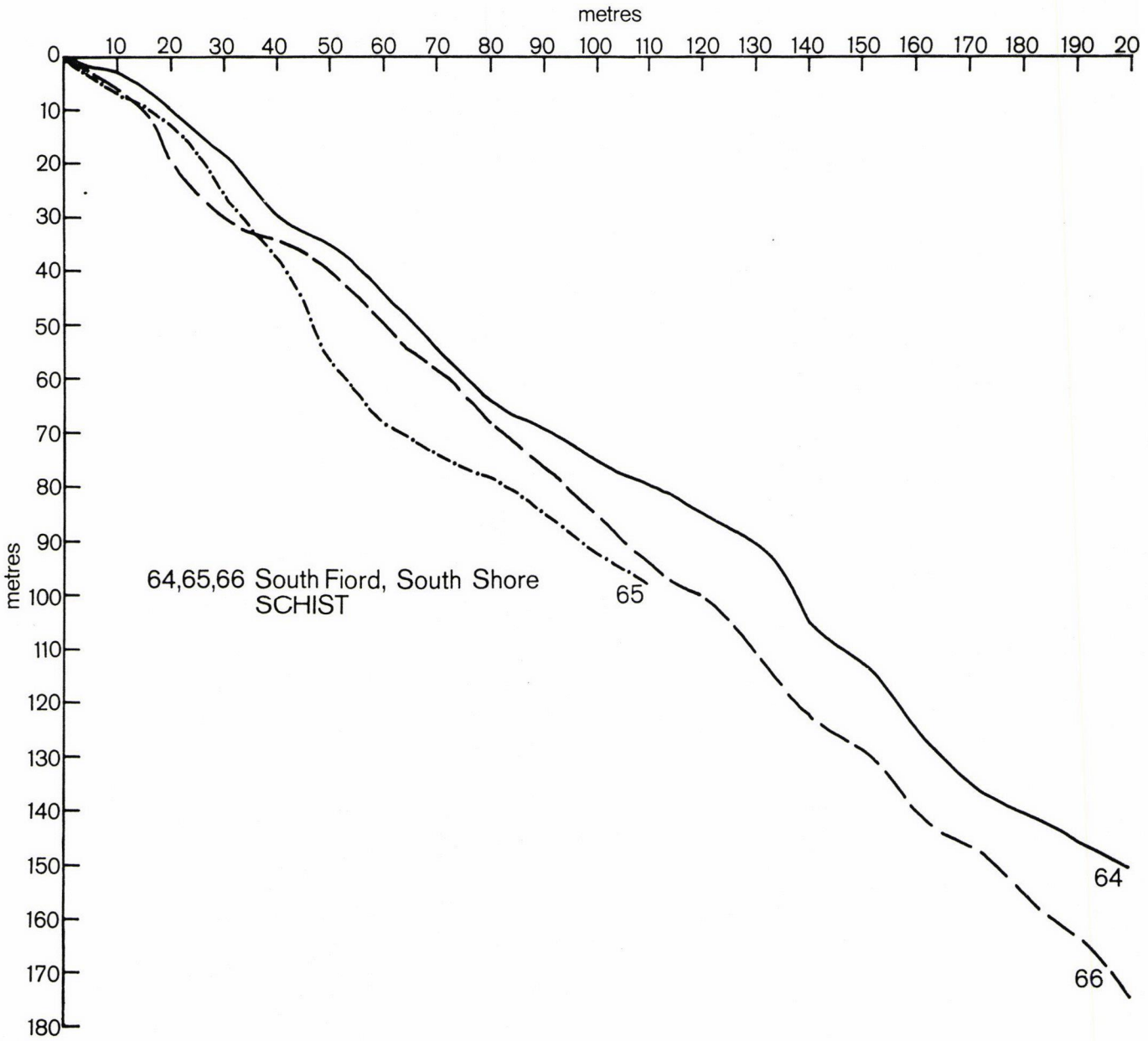


Fig. 13j.

Origin of Fine grained Sediments

Clearly there are various origins for these relatively fine grained sediments, and they do not equate with the Damsite Formation of Lake Manapouri (Irwin 1974a) in either grade or probable mode of emplacement.

The closest analogue is to be found in the sheltered sites (4 and 5) at the entrance to Middle Fiord where the sediment is predominantly mud. However at the equally sheltered sites (2 and 3) in South Fiord the sediments are dominantly fine sand.

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REFERENCES

ANDREWS, P.B.; McKELLAR, I.C. 1973: Lake Manapouri - Shoreline stability and the effects of lowered lake levels. *Rep. N.Z. geol. Surv.* : 12 pp.

IRWIN, J. 1971: Lake Te Anau. Provisional Bathymetry 1:63,360. *N.Z. oceanogr. Inst. Chart, Lake Series.*

IRWIN, J. 1974a: Shoreline profiles of selected sites on Lakes Manapouri and Te Anau. *NZOI oceanogr. Fld Rep. 1* : 22 pp.

IRWIN, J. 1974b: Report on bathymetric survey of nearshore zone, the south end of Lake Te Anau. *NZOI oceanogr. Fld Rep. 3* : 8 pp.

MOIR, RALPH and ASSOCIATES, 1973: Lake Te Anau shoreline survey. Unpublished Report. Ralph Moir and Associates, Invercargill.

McKELLAR, I.C. 1973: Te Anau-Manapouri district 1:50,000. *N.Z. geol. Surv. Misc. Series Map 4.*

WOOD, B.L. 1960: Fiord (1st Ed.), 1:250,000. *N.Z. geol. Surv. Sheet 27.*

WOOD, B.L. 1962: Wakatipu (1st Ed.), 1:250,000. *N.Z. geol. Surv. Sheet 22.*

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