LATE PLEISTOCENE GEOCRYOLOGY OF THE BOGONG HIGH PLAINS

by

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A thesis submitted to Sydney University, Department of Geology and Geophysics, as partial fulfilment of requirements for the degree of Master of Science.

Submitted : May 1989

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Also I am indebted to Stan Walker and Richard Horbatt for their assistance in field surveying.

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All the following work in this thesis is my own work, unless otherwise acknowledged.

E. J. Minty
May 1989.

[Redaction]

ABSTRACT

The Bogong High Plains comprises fragmented, elevated surfaces (at 1600m to 1986m elevation), of low to moderate relief and contains relic cryogenic features including cryoplanation surfaces, blockstreams, block fields, block glacis and talus. No glacial features have been observed on the Bogong High Plains.

This thesis has examined the distribution of the cryogenic features and their lateral equivalents in the adjoining valleys of the Mitta Mitta and Kiewa Rivers, with a view to defining processes active in the late Pleistocene.

Three areas at Mt Nelse, Basalt Hill and Pretty Valley were targeted for detailed description and analysis of surficial geology. The cryogenic features defined from this study have been compared to those described in other studies of Alpine areas in south-eastern Australia.

Cryoplanation/blockfield terrain occurs on slopes of <20%, (11°),generally above 1600m. These surfaces are developed on exposed summit tops between 1600m and 1986m, and consist of low angle, broad, stepped, bedrock surfaces with shallow accumulations of blocks and gravelly loam fanning outwards.

Blockstreams are represented by block accumulations in drainage lines on slopes of 10° +5° at altitudes of 1 300m up to 1 800m and extending for up to 1km. Talus occurs below elevated bedrock scarps at similar altitudes on slopes > 30°. Both types of block accumulations require appropriately jointed bedrock and access to moisture. There is a preference of orientation of blockstreams and talus towards the south. Most large basalt blockstreams have a south-eastern aspect and this aspect coincides with maximum snowbank accumulation. Block glacii exist as relatively level, narrow accumulations of blocks marginal to basalt bedrock scarps, generally with a southerly aspect.

There are many slopes with significant block accumulations which appear to be hybrid blockstream/talus deposits on slopes between 15° and 30°.

Open block accumulations only survive as visible features where the blocks have reversed local relief. Most slopes are vegetated by heathland and/or snow gum woodland. Elevated vegetated slopes of >20% gradient have a distinct striped pattern oriented downslope. The vegetation stripes have probably been induced by etching of, or differential development of, gravelly slope deposits and soil which overlie relic sheets of blocks and cobbles of variable thickness. This striped terrain of > 20% gradient exists over an elevation range of 1400m to 1700m, with a preferred southerly aspect and is referred to as block slopes.

The relic status of block accumulations is evident from encroaching vegetation, insitu weathering and adjoining stratigraphy. Frost wedging and associated frost creep appear dormant and the shallow depth of seasonal frost prohibits gelifluction within the present climate.

The various relic block accumulations on the Bogong High Plains would have required colder conditions suggesting an approximate 5°C decrease in average temperatures during the late Pleistocene. The lateral equivalents of these deposits in the adjoining valleys are relic alluvial fans which would have required semi-arid conditions to accumulate and thereby suggest that the late Pleistocene climate was at least 50% drier as well as approximately 5°C colder than present.

SYNOPSIS

This thesis discusses the geomorphology and cryogenic alteration of the Bogong High Plains surface during the late Pleistocene.

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GLOBAL PERSPECTIVE OF S.E. AUSTRALIA

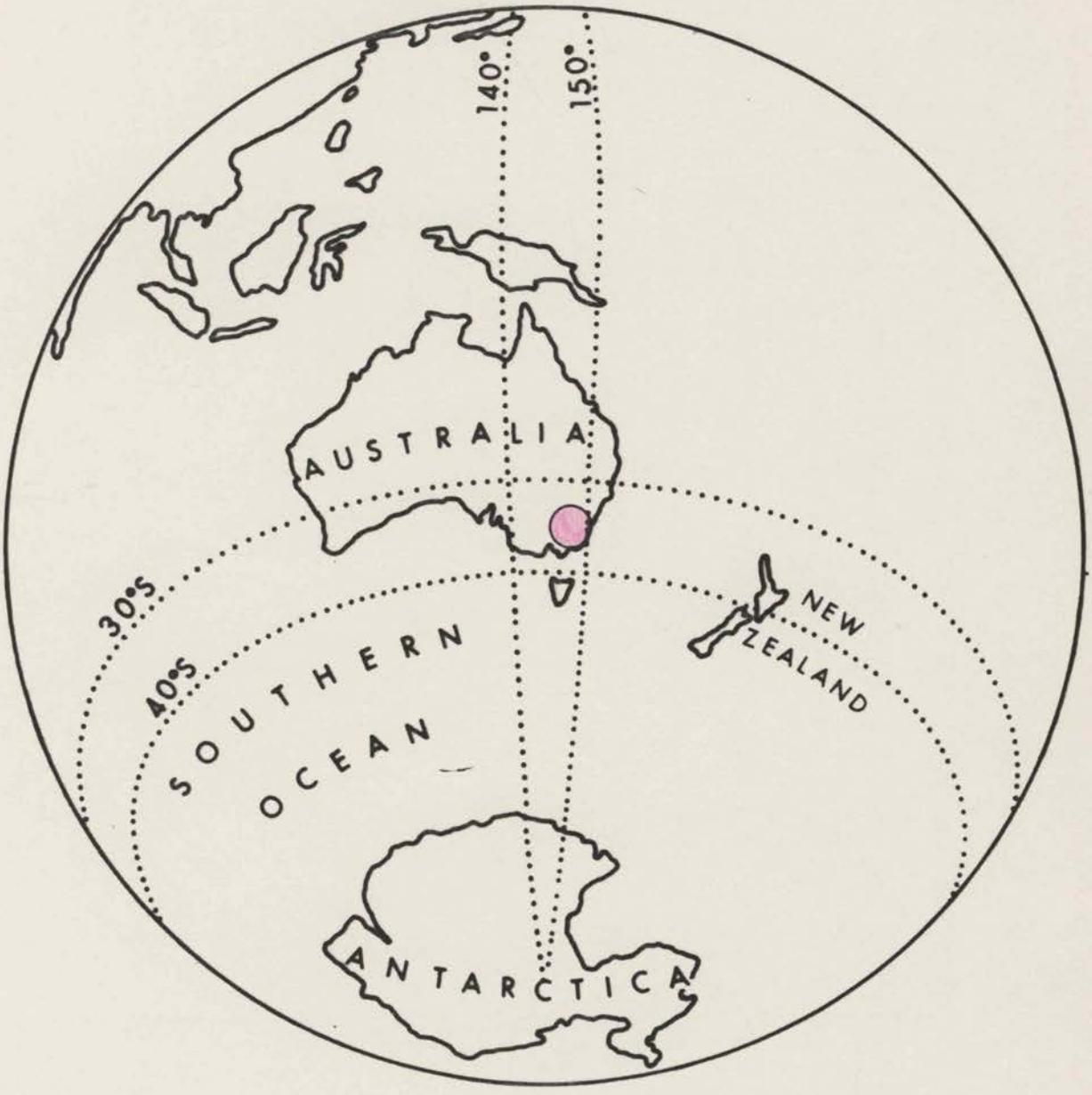
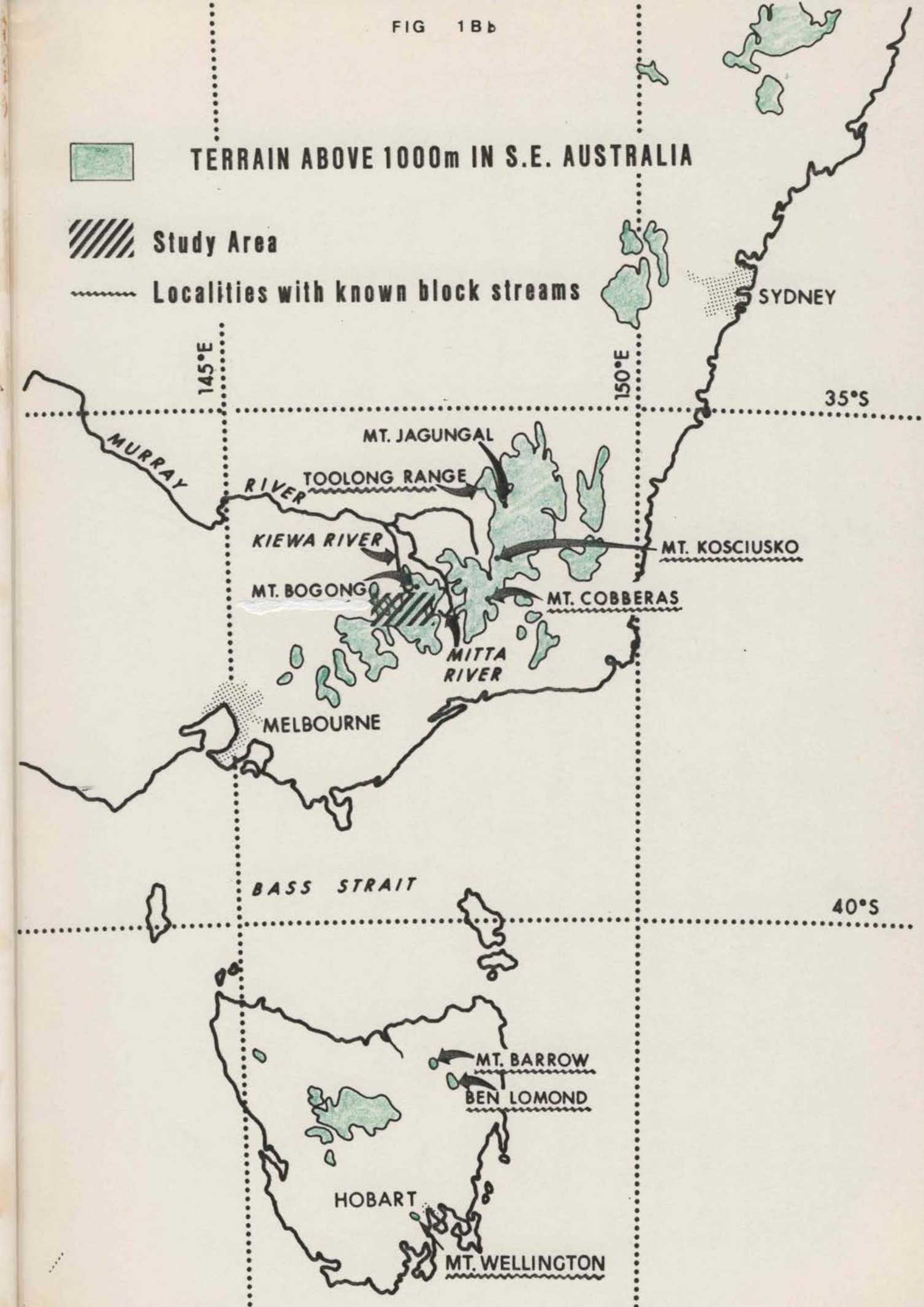


FIG 1Ba

FIG 1Bb


TERRAIN ABOVE 1000m IN S.E. AUSTRALIA
Study Area
Localities with known block streams
SYDNEY
145°E
150°E
35°S
MT. JAGUNGAL
MURRAY
RIVER
TOOLONG RANGE
KIEWA RIVER
MT. KOSCIUSKO
MT. BOGONG
MT. COBBERAS
MITTA
RIVER
MELBOURNE
BASS STRAIT
40°S
MT. BARROW
BEN LOMOND
HOBART
MT. WELLINGTON

SECTION ONE : INTRODUCTION

A) OUTLINE OF AIMS

B) DESCRIPTION OF GENERAL PHYSIOGRAPHY AND CLIMATE OF THE STUDY AREA

C) AN OVERVIEW OF THE GEOLOGICAL EVOLUTION OF THIS REGION AND CONCEPTUAL MODELS

D) AN OVERVIEW OF THE LATE PLEISTOCENE PROCESSES IN THE ALPINE TERRAIN OF SOUTHEASTERN AUSTRALIA

E) METHODOLOGY

SECTION ONE A: INTRODUCTION

OUTLINE OF AIMS

The aims of this thesis have been to:

i) Investigate the stratigraphy of surficial deposits of the Bogong High Plains and the adjoining valleys at the margins of the High Plains.

ii) Describe geomorphic surfaces on the Bogong High Plains and adjoining valleys.

iii) Investigate relations of present vegetation distribution to geomorphology and surficial stratigraphy on the High Plains in selected target areas.

iv) Interpret the stratigraphy and geomorphology with a view to defining the nature and extent of cryogenic processes on the Bogong High Plains during the late Pleistocene.

FIG 1Bc

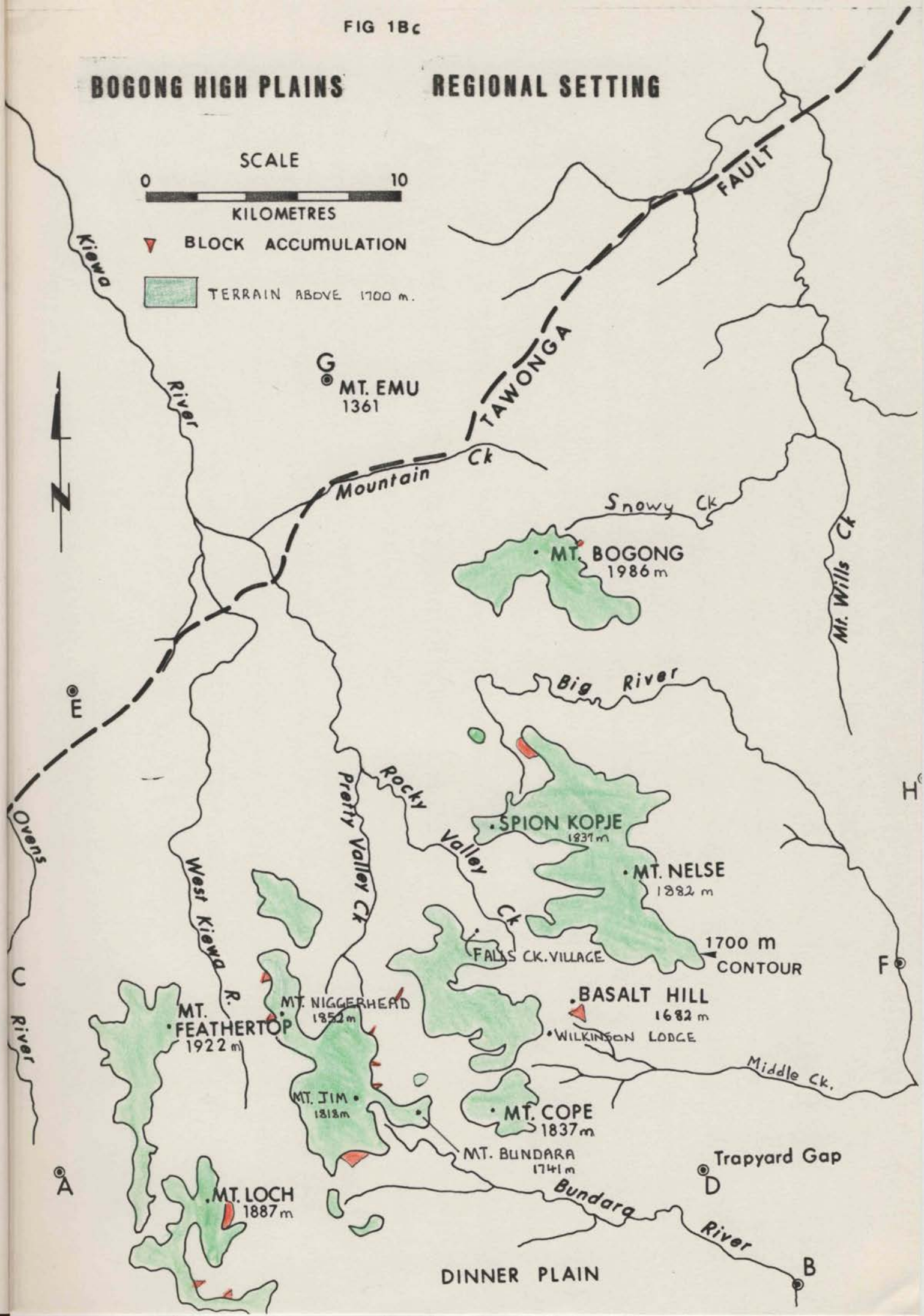

BOGONG HIGH PLAINS REGIONAL SETTING
SCALE
0
10
KILOMETRES
BLOCK ACCUMULATION
TERRAIN ABOVE 1700 m.
FAULT
TAWONGA
Kiewa River
G
MT. EMU
1361
Mountain Ck
Snowy Ck
MT. BOGONG
1986 m
Mt. Wills Ck
Big River
E
H
Rocky Valley Ck
Pretty Valley Ck
SPION KOPJE
1837 m
MT. NELSE
1882 m
Ovens
West Kiewa R.
FALLS CK. VILLAGE
1700 m
CONTOUR
F
C
River
MT. FEATHERTOP
1922 m
MT. NIGGERHEAD
1852 m
BASALT HILL
1682 m
WILKINSON LODGE
Middle Ck.
MT. JIM
1818m
MT. COPE
1837m
MT. BUNDARA
1741m
Trapyard Gap
A
MT. LOCH
1887 m
D
Bundara River
DINNER PLAIN
B

FIG 1Bd

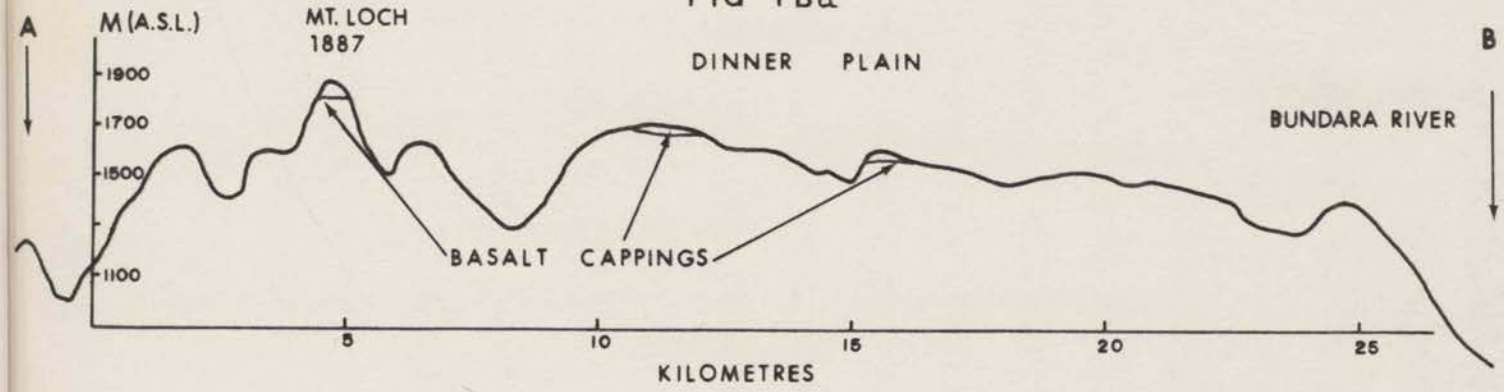


FIG 1Be

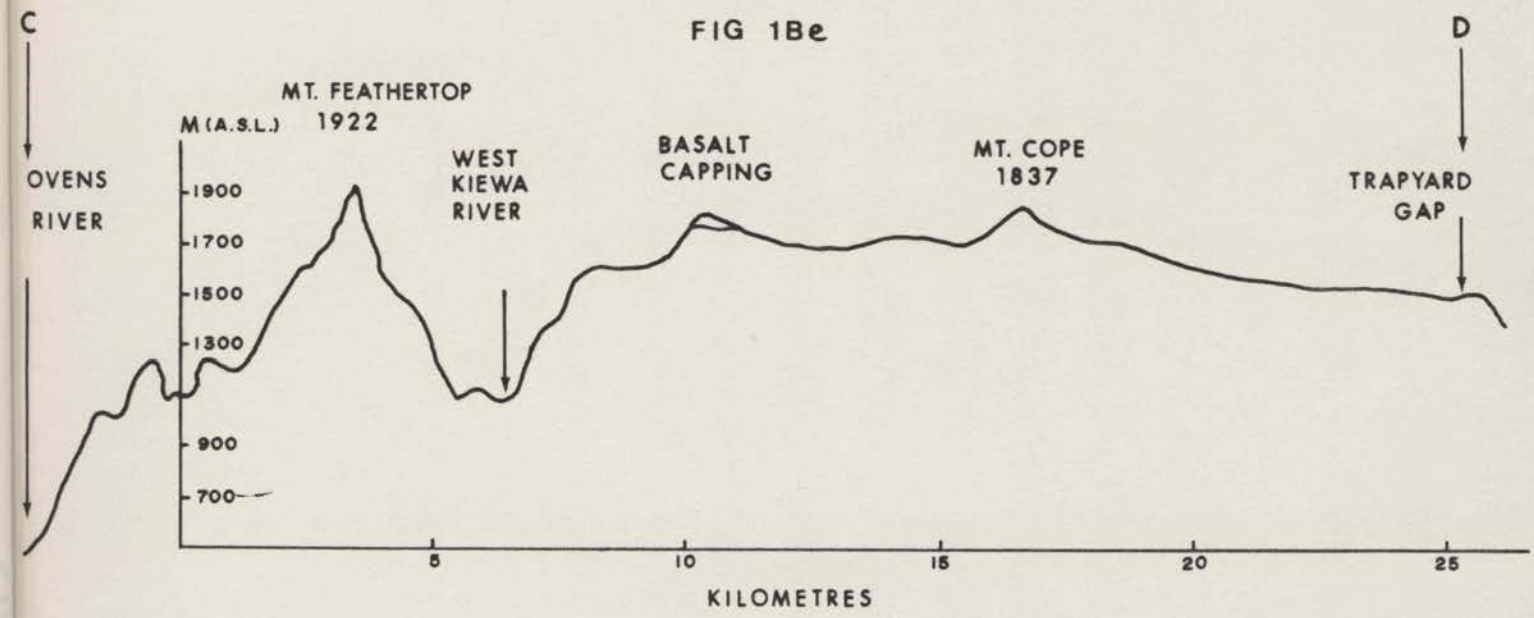


FIG 1Bg

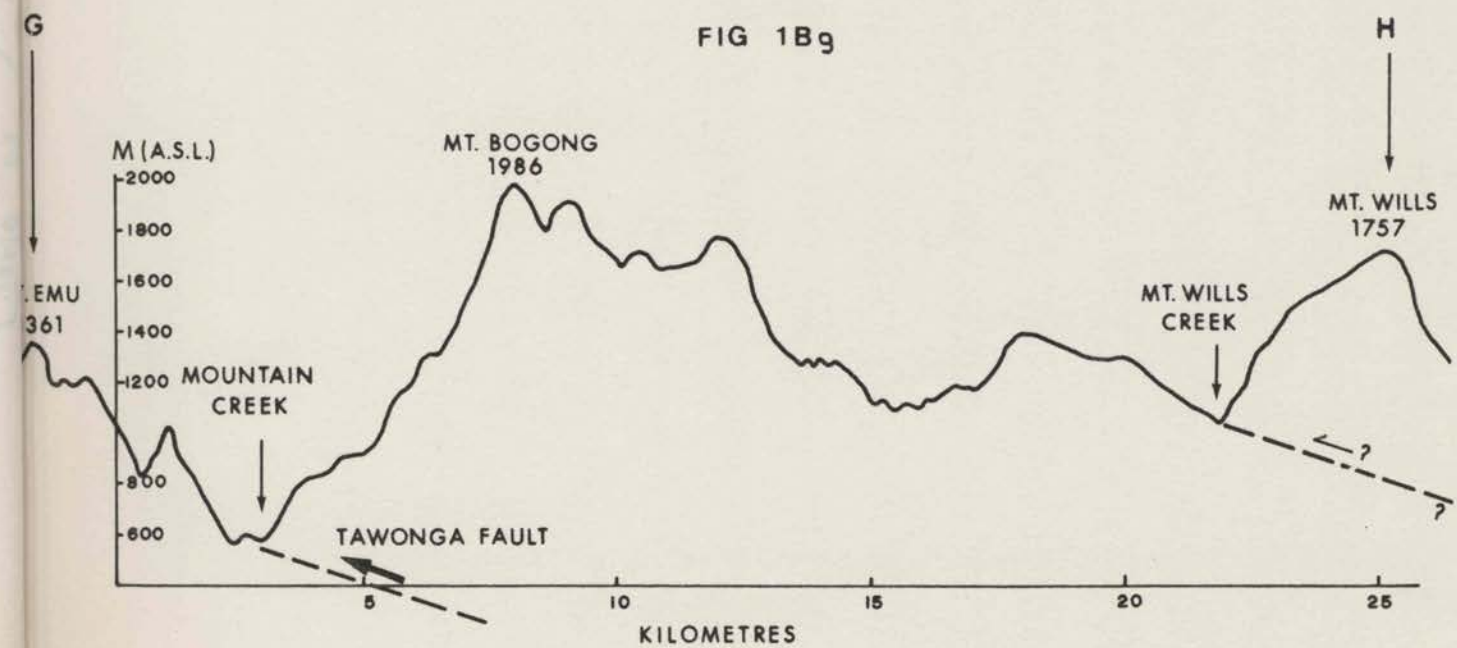
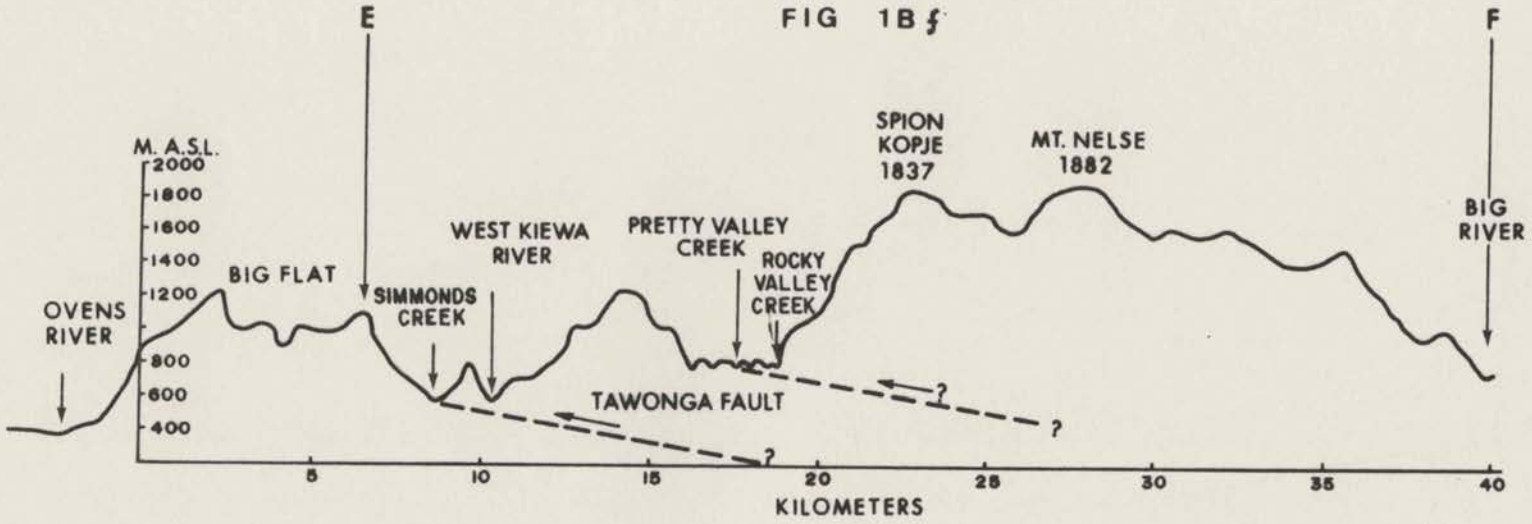


FIG 1B


E
F
M. A.S.L.
2000
1800
1600
1400
1200
800
600
400
OVENS RIVER
BIG FLAT
SIMMONDS CREEK
WEST KIEWA RIVER
PRETTY VALLEY CREEK
ROCKY VALLEY CREEK
SPION KOPJE 1837
MT. NELSE 1882
BIG RIVER
TAWONGA FAULT
?
?
?
5
10
15
20
25
30
35
40
KILOMETERS

SECTION ONE : B

DESCRIPTION OF GENERAL PHYSIOGRAPHY AND CLIMATE OF THE STUDY AREA

The region of prime interest in this study is the Bogong High Plains. Figures FiglBa, Fig 1Bb and Fig 1Bc, reveal the general location and relief of this region. The Bogong High Plains is an elevated area of land bounded by the West Kiewa River in the west; the Bundara River to the south; the Big River to the east and the lineaments of the Tawonga Fault line to the north. This is an area of approximately 900 square kilometres of which 150 square kilometres is elevated above 1600 m ASL and consists of an undulating surface comprising high grade metamorphic and granitic rocks and patches of almost horizontal surface comprising residual basalt flows.

The highest points of this elevated surface seem almost coplanar, averaging 1857m ASL and ranging from 1986m for Mt. Bogong in the north, to 1741 for Mt Bundara in the south.

Refer to photographs BG 382F27 and N 28286F15

The relative relief of this surface averages 63m measured from the highest points to their closest saddles, and varies from 21m on the basalt surface north of Mt. Jim to 132m adjacent to Mt. Nelse. See table 1.1 which summarises relief data referred to above.

This elevated terrain continues well beyond the Bogong High Plains, but is elsewhere only preserved in relatively small isolated plateaux or level lineaments of major ridge systems. Refer to Fig 1Bf which illustrates "Big Flat" and Fig 1Bg which illustrates Mt. Emu on the Eskdale Spur.

Climatic data are limited, but 7 years of daily observations at Wilkinsons Lodge (situated at G.R. 274161 Bogong 1: 100 000 NATMAP with an altitude approximately 1630m) and 24 years of daily observation at Falls Creek (G.R. 249200, Bogong 1:100 000 NATMAP with an altitude 1550m) are available (Mc Dougal, 1982.) These weather stations are both below the treeline and located on the eastern margin of the High Plains in the lee of the prevailing winds.

The above data indicate that average monthly temperature ranges from 12.3°C in January to -1.4°C in July. Precipitation, including snow and rain averages 2555mm per annum with monthly averages ranging from 96mm in February to 337 in August. The leeward location of these weather stations means that they collect a greater than average snow cover, which gives them relatively high precipitation rates.

The temperatures on the higher exposed portions of the Bogong High Plains should be considerably lower than the figures above, due to greater windchill. The temperatures in valleys such as Pretty Valley should also be lower than average due to the "frost hollow "effect.

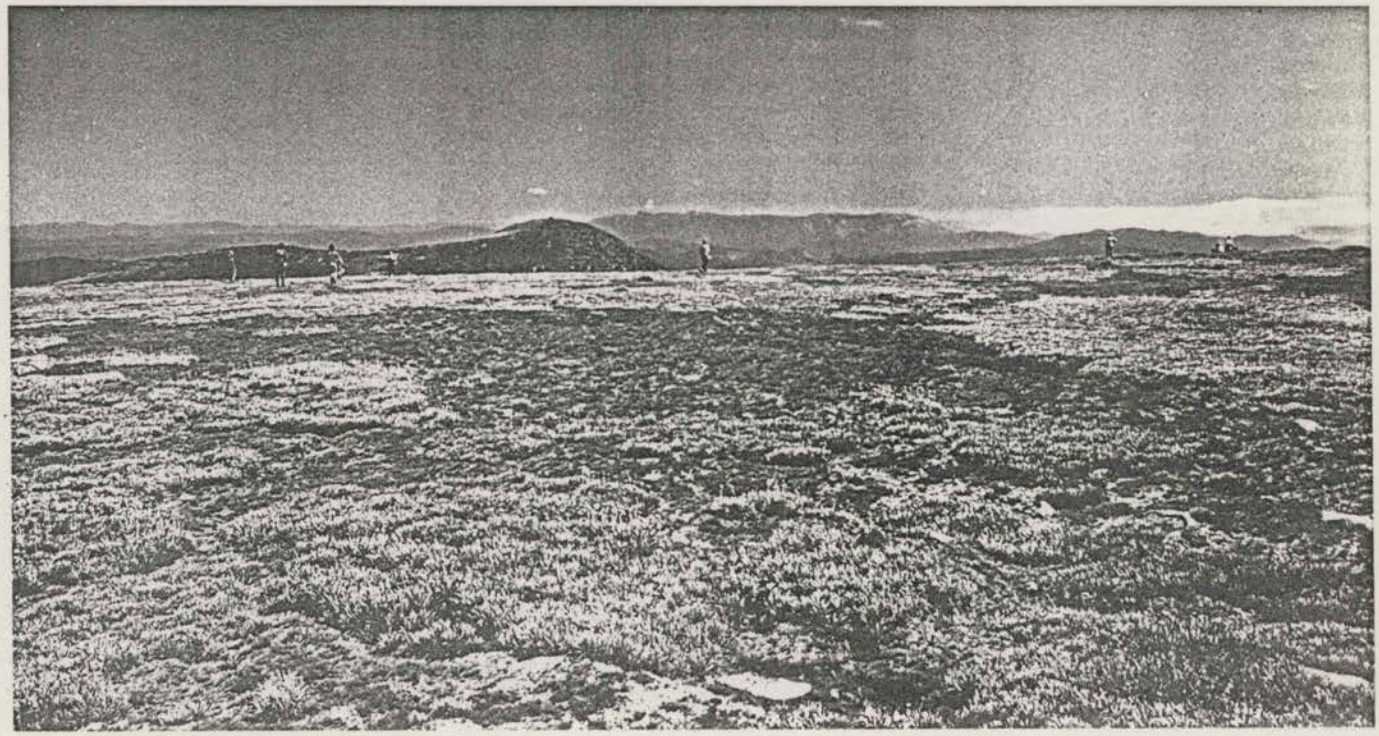
Table 1.1 Relief Data for High Points on the Mature Surface of the Bogong High Plains.

Elevated Feature	Elevation (m ASL)	Relative Relief (m)
Mt. Bogong	1986	76
Mt Bogong Central (G.R. 288237)	1974	64
Mt. Nelse North	1891	41
Mt. Nelse	1882	132
Mt. McKay	1849	79
Mt. Jim	1818	48
Mt. Bundara	1741	51
Mt. Cope	1837	87
Mt. Fainter North	1845	30
Mt. Fainter South	1883	53
Mt. Niggerhead	1852	102
Marm Point	1819	69
G.R. 189156	1831	21
G.R. 186124	1808	28
Rocky Knob	1797	87
Round Plain	1874	64

Mean altitude : 1857
Mean relative relief : approximately 63m

NOTE: G.R. denotes a grid reference from Bogong 1:100 000 NATMAP topographical map, where place names are not given for elevated features.

SECTION : 1B (continued)
PHOTOGRAPH BG 382F27
A view from Bogong Central (1974m) towards Mt. Buffalo in the central background.

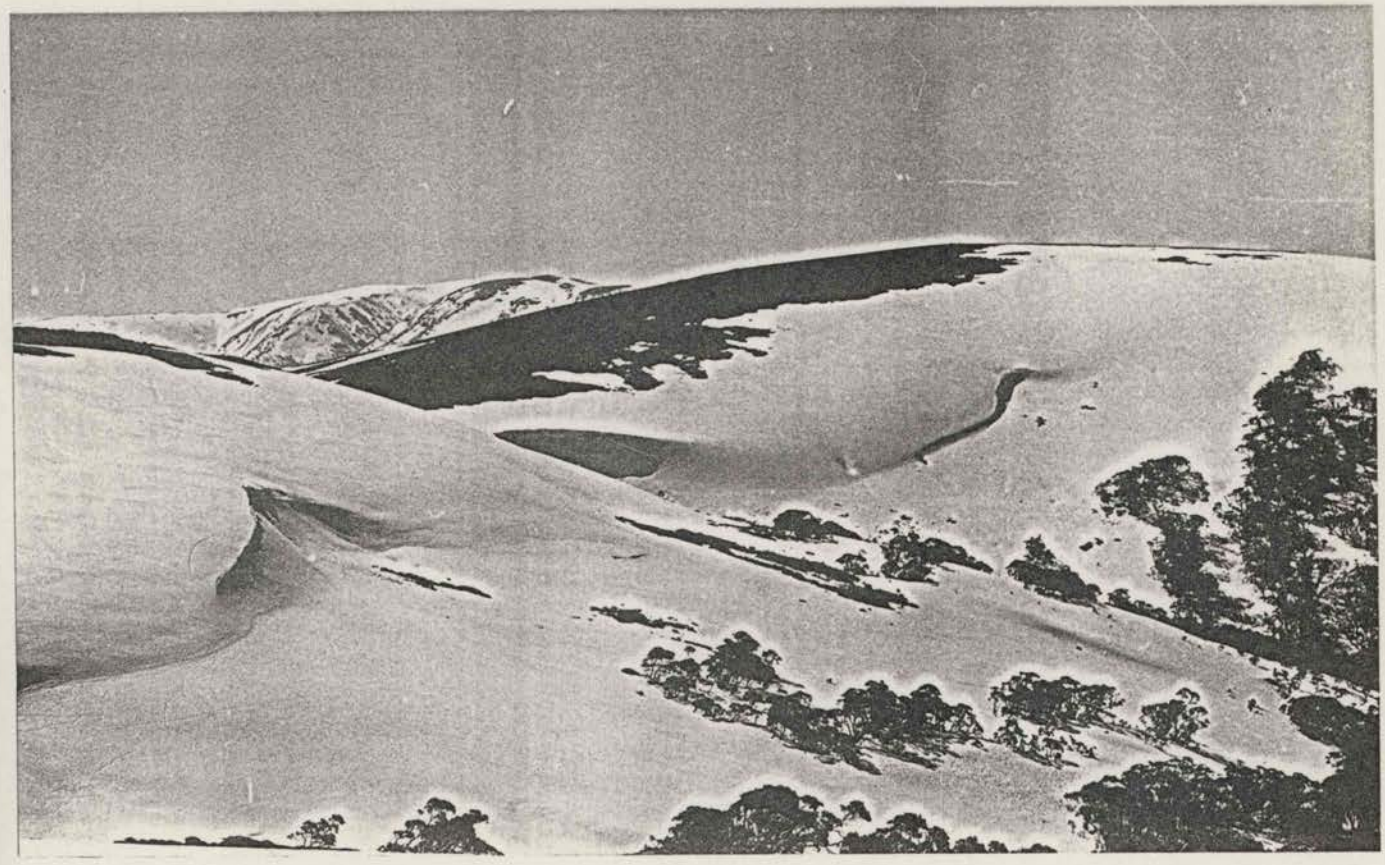


PHOTOGRAPH N 28286F15
A view from the saddle between Mt. Nelse and Nelse North looking northwest.



SECTION : 1B (continued)
PHOTOGRAPH N 41080F19

View towards Mt. Bogong from the east side of Mt. Nelse during the spring. The central nivation hollow is Warby Corner.



Relative humidity ranges from a monthly average of 67.2% in January to 86.8% in July. Average hours of sunshine range from 9.8 hours in January to 3.6 hours in July.

The prevailing wind is from the northwest, although the associated air mass is generally cool/cold maritime air moving in from the southwest off the Southern Ocean. The air masses may refract against the western margin of the Bogong High Plains to become northwesterly as they move over the high country.

The prevailing northwest wind direction has been recorded for 63% of daily observances over 7 years at Wilkinson's Lodge. The antiquity and consistency of this prevailing wind direction is reflected by:

i) location of snow gum clumps only on the northwest (windward) side of large tors in open woodland marginal to grassland/fenland valley floors. Good examples of this phenomenon are located near G.R. 287191 Bogong 1:100 000 NATMAP. Snow gums, Eucalyptus pauciflora, are sensitive to soil saturated by water. Large snow banks accumulate as lenticular plumes on the leeside of rock outcrops (>2m high) in open woodland. Spring thaw saturates the ground on the southeast or leeside of these rock outcrops which generally precludes the survival of snow gums.

ii) Location of most nivation hollows on slopes with a southeasterly aspect in the lee of prevailing winds. These hollows have taken thousands of years to develop and most probably formed in the Pleistocene. Refer to photograph N 41080F19.

iii) Present day snow patch zones have maximum frequency and accumulation on slopes with a southeasterly aspect and many occur at sites of relic nivation hollows which are completely revegetated and stable with respect to current climate.

Snow accumulates on the ground, above 1400m ASL, from June to September, with the spring thaw during October. Large drifts (>10m deep) accumulate on steep lee slopes and by September an average depth of 1 to 2 metres has accumulated over the whole Bogong High Plains, but with minimal cover on exposed, windward slopes.

The distribution of snow gums is a very useful indicator of frost accumulation over the undulating surface of the Bogong High Plains. Snow gum seedlings are sensitive to severe frost and avoid "frost hollows" with minimum spring temperatures of -7°C or less (Moore, 1958). Temperature profiles across open basins of the Bogong High Plains by the author support Moore's findings for the frost hollow effects.

Relative exposure (as measured by the windchill factor) and low average summer temperature, inhibits photosynthesis in snow gums. Costin et. al. (1979) identified the upper limit of snow gum woodland survival as corresponding to a 10°C mean monthly isotherm for the warmest month. In the Kosciusko region this corresponds approximately to the 1800 m contour and on the Bogong

High Plains it lies between 1750m and 1800m ASL . The region's vegetation has been mapped by McDougall (1982) on a series of published 1:15 000 color coded vegetation maps.

Frost action in the soil is restricted to minor areas of bare ground which occur on large snow patch zones above 1800m from January to May and on exposed summit tops from October to June. In these areas, needle ice is active and has been observed to form nets of sorted rock fragments on level ground acting to a depth of about 20cm. On steeper slopes of the bare snow patch zone, needle ice causes considerable erosion during the summer. Frost action is inhibited elsewhere on the Bogong High Plains by vegetation cover and by the seasonal snow cover.

The "Periglacial Domaine" defined by H.M.French (1976) is a region containing perennially frozen ground where mean annual air temperature is less than +3°C.

By comparison, the mean annual air temperature at Wilkinson's Lodge at 1630m ASL, is 5.3° C. Allowing a 1° C drop in maximum air temperature per 100m increase in altitude for dry air, produces an estimate of approximately 4.5° C mean annual air temperature at 1800 m ASL. Less than 20 square kilometres of the Bogong High Plains surface is above 1800 m .With the average summit height of 1857m for the most elevated portion of the High Plains, an estimate of mean annual air temperature at this altitude yields a value of 4.2° C (This does not take into account altitudinal variations in mean minimum temperatures as there are no data available.)

INTRODUCTION:SECTION ONE C

AN OVERVIEW OF THE GEOLOGICAL HISTORY OF THE REGION

PALAEOZOIC GEOLOGY

The rocks of this region are situated within the Omeo-Wagga metamorphic complex which is a belt of dominantly metamorphic and igneous rocks trending north west from Omeo to Wagga Wagga.

The stabilization of the Omeo-Wagga metamorphic complex was complete by the Carboniferous as a north moving Permian ice sheet polished, fluted and striated red gravelly sandstone of Carboniferous age at Moyhu (Craig and Brown, 1984) and pushed northwards elsewhere in southeastern Australia (Crowell and Frakes, 1971). At Moyhu, the glaciated rock surfaces dip 8° to the north and striations are tightly confined within a bearing of 350° -010° GB. Outliers of these late Palaeozoic glacial deposits are scattered widely elsewhere in Victoria and most outcrops are thin veneers of nearly undeformed and poorly consolidated sediment lying upon the undulating sub-Permian unconformity, (Crowell and Frakes, 1971).

The extent of this Permian surface further eastwards has not been closely examined but areas of low relief in the Dartmouth area may warrant further investigation.

The cratonisation of south-eastern Austrlia including the Omeo-Wagga metamorphic complex prior to the late Carboniferous marked the end of dramatic tectonic deformation for this region and also marked the start of a long period of denudation and isostatic adjustments as the deep rooted sialic crust emerged in reponse to "isostatic rebound" (Lambeck and Stephenson 1985).

MESOZOIC HISTORY

Since the Palaeozoic era, the only rocks laid down in the area of study are Cainozoic: Oligocene basalts with interbedded sediments and Pliocene to Holocene sediments. The Mesozoic Era seems to have been a period of erosion/ non deposition in this study area and over most of the Eastern Highlands.

Rifting apart of Antarctica and Australia produced basinal sediment traps along the Victorian coast in the early Cretaceous,(J.G. Douglas, et. al. 1976), which captured some of the erosion products from the pre-existing highlands to the north. The Murray basin did not trap sediment from the Highlands to the east until after the Mesozoic (Douglas et. al., 1976).

Jones and Veevers (1983), postulated that the Eastern High lands were initiated around 90 million years ago and the crestline subsequently migrated west from an initial location at the present coastline. In their assessment of Mesozoic stratigraphy, Jones and Veevers (1983) cite the absence of Late Cretaceous sediments after the Cenomanian (90 million years ago) in the Eastern Highlands as evidence for the initiation of the Eastern Highlands. Jones and Veevers seem to ignore the virtual absence of post-Permian sedimentary rocks over most of the Eastern Highlands, and they appear to ignore the Triassic period in particular in their stratigraphical consideration of the Mesozoic.

The absence of sediment within the Eastern Highlands prior to the Cretaceous (and after the Permian) cannot deny the possible existence of the Highlands prior to the Cretaceous.

The association of dispersed Jurassic mafic igneous rocks in the Eastern Highlands with mild uplift (Jones and Veevers, 1983) is speculative, and in the case of their Cainozoic scenario (Jones and Veevers, 1982), the "uplift" is yet to be proved.

Bishop (1982) in a review of ideas on ancient drainage in eastern N.S.W. presented the methodology behind two conflicting schools of thought on the evolution of this landscape. The "geological-approach" was vindicated over the "morphological approach". Most current workers utilise the geological approach which includes study of sedimentary structures in deep leads to retrace palaeocurrents, together with basalt flow fabric; sediment provenance of deep lead sediments; slope of basalt flow base and radiometric dating of basalt rock.

Bishop (1982) concludes that the gross parallelism between Triassic, Late Cainozoic and modern drainage directions and the lack of geological evidence for drainage direction in the period from the Triassic to the late Cainozoic certainly suggests that the modern drainage system may have considerable antiquity. Furthermore, Bishop, (1982), established that the antiquity of both west and east flowing river systems in Eastern N.S.W. implied the relative stability and antiquity of the axis of the Eastern Highlands.

The significance of the rifting of the Tasman Sea between 82 and 60 million years ago (Weissel and Hayes, 1977), on the morphology of the Eastern Highlands is brought into doubt by Speight (1985). In his study of the Tianjara Plateau near Ulladulla, Speight noted that Late Carboniferous and Permian shelf sediments have dips of about 2° which diminish from older to younger beds. Thus, neither Cretaceous rifting nor "uplift" has disturbed their attitude significantly.

Taylor's early Tertiary palaeo-geomorphic mapping (1985) in the Cooma Region has shown that river systems in the region have not changed their courses since at least the earliest Tertiary and the rivers are flowing at about the same relative positions in the topogrpahy as they were in the early Tertiary.

This and similar studies by Bishop (1985) in the Lachlan catchment demonstrate that post basaltic incision is not a reponse to rejuvenation but rather, the whole catchment has been uniformly downwasting at the same slow rate as the rivers have been incising.

Lambeck and Stephenson (1985) have put forward a mechanism of "erosional-rebound" to account for the longterm erosion since the Late Palaeozoic. Isostatic rebound occurs as erosion removes crustal overburden, but there is no growth in the total topography and absolute elevations decrease through time. Downcutting and backcutting by rivers does not NECESSARILY reflect dynamic uplift processes, if we accept Lambeck and Stephenson's (1985) model. Quantitative modelling by Lambeck and Stephenson working back through time, predicts a landscape with twice the present value of relief at 250 m.a..

Regional isostatic rebound should cause a broadening of the topography with time due to uplift of portions of the lowlands, which flanked the original Highlands, and due to continuing lowering of the landscape by erosion. This could account for the gently arched east-west profile of the Eastern Highlands and the accordance of their summits and plateau surfaces.

Furthermore, erosion of the Highland surface will cause reduced overburden on the rock beneath resulting in sheet jointing. This sheet jointing is most prevalent in granitic rocks, but is also apparent in the schist and gneiss of the Bogong High Plains where it has been exploited by cryogenic processes.

These sheet joints must have some influence in the longterm levelling of the landscape as they exist at some depth and their smooth, gently arched surfaces should have averaged out minor expressions of topographic relief on the surface. These same joint surfaces must influence the direction and rates of ongoing weathering and erosion so that the surface of the Highlands becomes broader, lower and flatter with time.

In "Geology of the Kiewa Area", Beavis (1961), notes that: "Sheeting was observed both in natural outcrops and in excavations, it is invariably accompanied by seams of decomposed rock. The sheeting was always subparallel to, and less steep

than, the natural surface. Where sheeting outcropped on steep slopes, it tended to control the stability with respect to sliding of such slopes.....Sheeting has developed independently of rock type, cutting across geological boundaries with little or no deflection."

In my opinion, the influence of sheeting has been unrecognised as a major influence on the development of the High Plains terrain. Refer to photograph W 882F3 which demonstrates surface sheeting and large scale levelling of the surface.

PHOTOGRAPH W 882F3

This photograph of granite on the Mt Wills ridge looks westwards towards the Bogong High Plains with the near level snowy heights of Mt. Nelse and Nelse North in the middle background. The foreground illustrates horizontal sheet jointing in granite with pot holes and rill weathering on the surface.



CAINOZOIC DEVELOPMENT

Our understanding of the history of the Eastern Highlands during the Cainozoic Era (65 m.a. to present), depends on our interpretation of the evidence. There are three main groups of evidence:

i) The stratigraphy and palaeogeography of the Highlands terrain during the Cainozoic,

ii) The stratigraphy and palaeogeography of the marginal basins during the Cainozoic. The Murray and Gippsland Basins are particularly relevant to the history of the Victorian Highlands,

iii) The stratigraphy of valley sediments at the margins of the highland terrain.

Three separate models are currently presented to account for the evidence available so far. These are:

MODEL 1 Cainozoic Tectonism, - involving periods of Highland uplift, volcanism and basin subsidence, alternating with periods of Highland settling accompanied by uplift of the adjacent basins. This model is proposed by Jones and Veevers, (1982), and Wellman (1978).

MODEL 2 The Eustatic Model, - proposes that global changes in relative sea level and intrabasinal isostatic adjustments associated with sediment loading have controlled the supply and preservation of sediment by changing base levels of erosion relative to the Highlands. (Brown, 1983).

MODEL 3 - proposes relative stability of the Highlands and long term erosion and isostatic rebound. Lambeck and Stephenson, (1985), Bishop, (1985), Taylor (1985), and Schmidt et. al (1984) support this hypothesis.

STRATIGRAPHY AND PALAEOGEOGRAPHY OF THE HIGHLANDS TERRAIN IN THE CAINOZOIC.

Most strata of early to mid Cainozoic time are preserved as deep leads beneath basalt flows or trapped behind localized fault blocks.

A multidisciplinary investigation of "Lake Bunyan" near Cooma, NSW (Tulip et. al., 1982) has so far revealed that lacustrine sediments (clays, silts, coals, diatomite, and marginal quartzose facies) developed behind a fault trap along the present course of the Murrumbidgee and Numarella Rivers. The palynological results of this study imply an age of 12 to 21 m.a.(late early to middle Miocene), and a palaeoecology of probable cool, temperate, poorly diversified rainforest. By comparison with other Miocene pollen flora from South-eastern Australia, which imply a subtropical rainforest palaeoecology, the Bunyan flora implies that the palaeogeography was elevated

and possibly in a rain shadow similar to today. Palaeozoic basement rocks underlie the Bunyan deposits and the lack of Mesozoic sediments gives an impression of relative elevation for this region in the Mesozoic. The Bunyan study supports the concept of relative stability of Highland terrain during and since the Miocene.

Miocene age determination is tentative due to the lack of pollen species which are known markers in other Tertiary sequences. Also, there are no direct relations with Eocene basalts in the Monaro area. However, the Bunyan study suggests that a similar multistrand approach to the Tertiary sediments interbedded with Oligocene basalts in the Bogong High Plains may yield valuable palaeo -ecological, -geomorphological, -climatic, data for the highland terrain as some of the mudstone and coal beds are in direct contact with some of the basalts.

An investigation of prebasaltic topography of the Northern Monaro by Taylor et. al. (1985) demonstrates that present and prebasaltic drainage systems of the northern Monaro are similiar. The pre-basaltic topography has substantial relief, (>200m), indicating that the drainage system was well developed prior to the Eocene. The coincidence of the present and pre-basaltic bedlevels of streams over most of the Northern Monaro implies that either this region has not been substantially uplifted since the Eocene, or these two rivers have not responded to a change in base level produced by "uplift" of the highlands. The authors (Taylor, et. al., 1985) see no evidence in the Highland terrain of the Monaro for uplifts in the Oligocene/Miocene and Pliocene as proposed by Jones and Veevers, (1982).

With respect to the Bogong High Plains, outcrop of Tertiary sediments is restricted to creek sections at the margins of basalt flows in the upper reaches of the High Plains Creek and Pretty Valley Creek, and a few isolated occurrences of waterworn, rounded, quartz pebbles below the base of the Basalt Hill flows. These are depicted as (Teo) on the Tallangatta Geological 1:250 000 plan, only for the High Plains Creek section. The marking of remaining Tertiary sediments on the Bogong High Plains, as (Tpe) in the Pretty Valley, Rocky Valley and other valley floors is erroneous in my opinion.

Pretty Valley Creek has developed along the eastern margin of the basalt flows which now form a small plateau in the south-western portion of the study area and centred on Mt. Jim. Mudstone and brown coal interbedded with basalt flows indicate a broad, gentle drainage depression existed here in the Oligocene. Partial damming by basalt flows possibly created a lacustrine/paludal depositional environment. The flow directions of basalt and related sediments has not been determined. Murray in a report of 1895 mentioned that the probable dip of deep leads beneath the Dargo High Plains was to the South-east. The basalt surfaces near Mt. Jim also dip gently towards the southeast at about 2°.

Block tilting could explain the reported asymmetrical valley profiles on much of the Bogong High Plains surface and the dominance of alluviation in north-west facing drainage basins

such as Pretty Valley when compared to mostly steeper south-east facing catchments such as High Plains Creek.

The 2° dip to the south-east may predate basalt extrusion and may in fact have been an important factor in the distribution of basalt flows. On the other hand, the low angle thrust of the Bogong High Plains over the Tawonga Fault could readily account for a dip to the south-east, as its direction of thrust is from the south-east.

An examination of regional structural patterns by Beavis (1961) demonstrated relationships between faults, dykes and joints. Joints were often parallel to or symmetrically arranged about main faults. Beavis ordered the structural data into four patterns based on certain structural assumptions (Spencer-Mead) patterns, and the assumption that each orogeny will develop its own characteristic fracture pattern. However, it was noted by Beavis (1961), that all of the fractures which could be produced by the late Tertiary "Kosciusko" deformation he envisaged, could also have been developed by earlier deformations.

Therefore the " Tertiary Kosciusko Uplift" event is neither necessary nor sufficient to explain the structural data exhibited by Beavis for the Bogong High Plains and adjacent terrain.

STRATIGRAPHY AND PALAEOGEOGRAPHY OF SEDIMENTS IN THE BASINS MARGINAL TO THE HIGHLANDS.

The Murray Basin has subsided slowly and gradually during the Tertiary (Paleocene to mid-Miocene) and again after the Late Miocene. (Gill 1970, Abele et. al. 1976). Brown (1983) states that the Cainozoic history of the Murray basin has been characterised by slow relative subsidence rates, low rates of sediment supply and minimal compaction rates.

Jones and Veevers (1982) recognise a lacuna at 10 m.a. to 7 m.a. (late Miocene) and associate it with a "recovery phase " involving tectonic settling of the Highlands and corresponding to mild uplifts of the Murray Basin. There are problems with both models.

Firstly, Brown has failed to account fully for the sediment that would continue to have been supplied by the Highlands during the late Miocene hiatus. Secondly, Jones and Veevers have failed to demonstrate that "uplift" has actually occurred in the Tertiary, let alone in association with episodes of smallscale basaltic volcanism in the Highlands, which they correlate neatly with episodes of sedimentation in the adjoining basins of the Murray, Otway, Bass and Gippsland. The correlation of episodes of sedimentation with relative changes in sea level is demonstrated in Brown's stratigraphic model of the Murray Basin, presented overleaf as fig. 1Ca

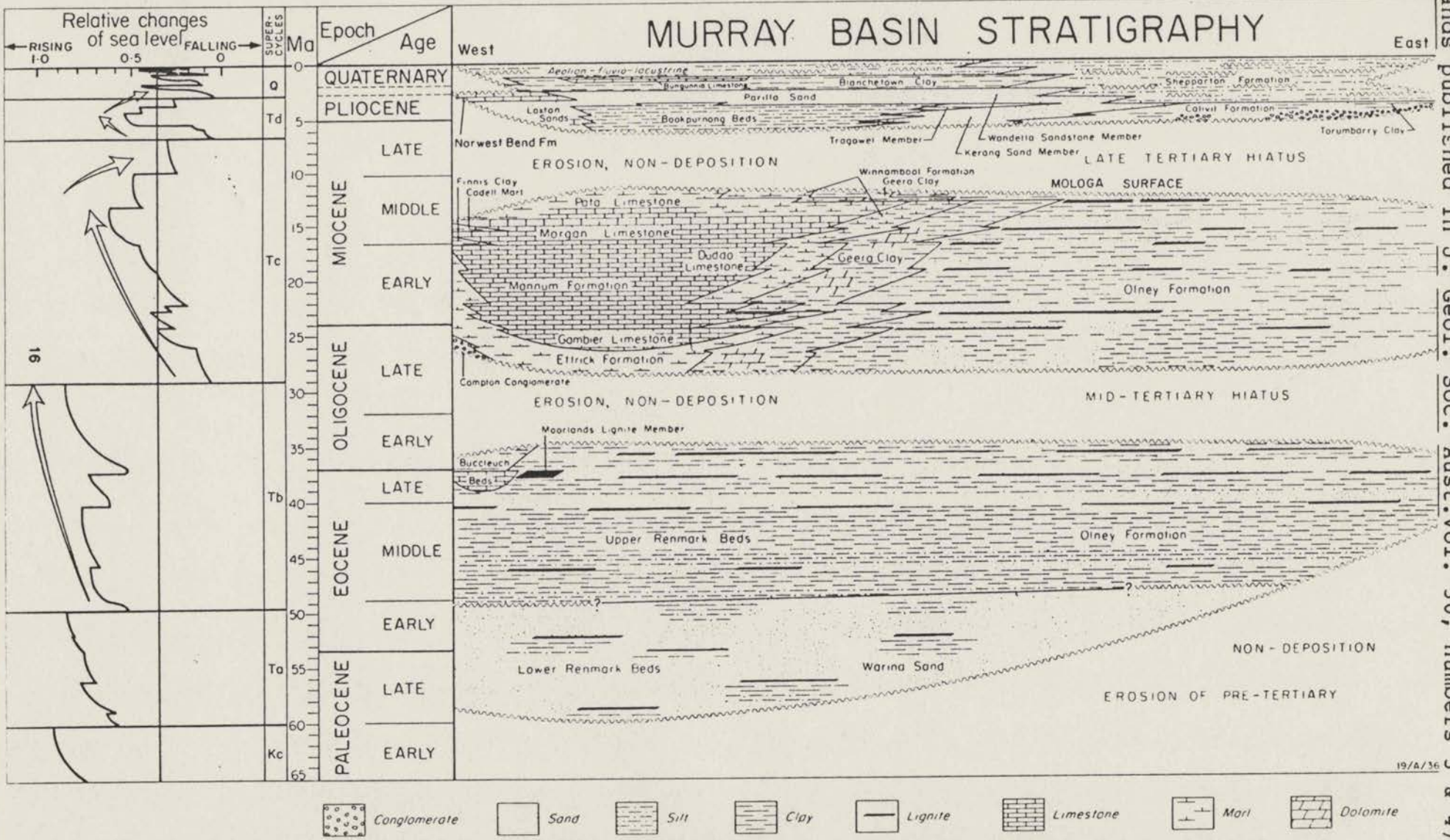


Fig. 1. Eustatic interpretation of Murray Basin stratigraphy. Modification of pre-existing stratigraphy in South Australia and Victoria (e.g., Ludbrook, 1961; Lawrence, 1975) based on examination of several thousand borelogs and numerous stratigraphic and biostratigraphic reports. Unpublished data supplied by the Geological Surveys of South Australia, Victoria and New South Wales, and by the Water Resources Commission of New South Wales as a contribution to the joint Commonwealth and State Murray Basin Hydrogeological Project. Relative changes in sea-level based on the relative coastal onlap curve of Vail et al. (1977).

Fig 1Ca : Murray Basin Stratigraphy (by C.M. Brown from Discussion: a Cainozoic history of Australia's Southeast Highlands published in J. Geol. Soc. Aust. Vol. 30, numbers 3 & 4)

. The "isostatic rebound" model could also associate mild scattered volcanism in the Highlands with tensional stress in the crust without the necessity of net increase in the topography during the Tertiary as implied by Jones and Veevers' (1982) tectonic model. The gentle subsidence of the Murray Basin could be accommodated by isostatic adjustment. If the sedimentary cycles have been motivated by external influences such as world sealevel fluctuations, then all the marginal basins should show similiar patterns of cyclic development and therefore the isostatic adjustments would have a common motivating force in the weight of the newly acquired sediments after each phase of accession.

The late Miocene hiatus and associated dissection of sediments in the eastern portion of the Murray Basin and lateritisation of the interfluves could be partly explained by a period of isostatic standstill or equilibrium, which assumes that adjustments had been completed in response to the previous marine transgression/regression cycle. Nonsubsidence of the surface in this late Miocene hiatus would help to explain the deep incision by rivers which is very evident in the north of the study area and which seems to have preceded the Pleistocene.

Brown's concept of sediment bypass of the basin due to lowering of base level by means of a rapid fall in sea level 6.6 m.a. assumes that the entire Murray River has rapidly adjusted its grade from its mouth back to its source in the Highlands PRIOR to the deposition of the Calivil Sands. Refer to Fig 1Ca.

The transgression of the marine Bookpurnong Beds and marginal Parilla Sand may be correlated with the very late Miocene- early Pliocene rise in sea level approximately 5 m.a. (Brown, 1983).

The Calivil Sands appear to be older than the transgressing Parilla Sands which Brown suggests have reworked the distal edges of the continental Calivil Sands formation.

Strong lateritisation is evident on late Tertiary surfaces in the Murray Basin and in the north of the study area. Macumber (1978) reported a set of weathered horizons in the Murray Basin as the "Mologa-Surface", which corresponds to lateritisation and non-deposition during the late Miocene.

The late Miocene climate in the Murray Basin and adjacent Highlands, probably had high (perhaps higher than present) precipitation levels. The co-existence of lateritised interfluves and high energy sediment of the Calivil Sands invokes strong chemical weathering, active stream incision and isolation of interfluves as well as stabilization of the interfluves by vegetation which would enhance the lateritisation processs on the interfluves. High precipitation levels and a stable vegetation cover would MINIMISE sediment supply from the Highlands, but the concentration of runoff in a dendritic network would maximise downcutting and only preserve the coarse clasts in such a high energy environment. These coarse clasts are in my view the Calivil Sands which often contain auriferous leads.

Small patches of elevated, lateritised late Tertiary sediments occur at the northern end of the present study area, near the margins of the Highlands.

At Tallangatta, at Ebden and near the Hume Weir these late Tertiary sediments occupy the higher terrain adjacent to the Mitta Mitta and Kiewa Rivers, whereas the Calivil Sands occupy the lowest portion of the landscape beneath the Shepparton formation in the valley floors. Refer to Fig 2Ba in Section 2B for details.

Finally with respect to the Calivil Sands, Jones and Veevers' (1982) interpretation that the Calivil Sand piedmont plain halted and reversed the marine transgression has been disputed by Brown (1983) and seems unlikely when one realises that the type section of the Calivil Sand is only 19m thick at Calivil, west of Echuca, (Abele et. al., 1986) and 0.7m in the Chiltern deepleads (Dunn, 1907).

The terrigenous finegrained sediments of the Shepparton Formation represent a lower energy alluvial outwash with increased sediment supply, when compared with the Calivil Sands.

The Shepparton Formation contains lateral and vertical discontinuities and its interpretation is best understood in terms of climatic factors. Climatic factors may not be adequately used in the analysis of relatively old sediments due to the lack of precision in describing and dating climatic variables and the averaging effects of short duration variations within long periods of the past. The Shepparton Formation however, reflects changes in sealevel and world climate associated with the Pleistocene Ice Age. The number of climatic/eustatic fluctuations associated with the late Pliocene/Pleistocene Ice Age is not resolved and is probably not fully understood for any one site.

STRATIGRAPHY OF VALLEY SEDIMENTS AT THE MARGINS OF THE HIGHLANDS

The Shepparton Formation is complex and is incompletely described, understood and mapped; especially along its proximal distribution at the edge of the Highlands. The type section at Kialla on the Goulburn River (Lawrence et. al., 1976) is insufficent to describe the Shepparton Formation which should be described as a time-stratigraphic unit encompassing rapid lateral facies changes, but representing the stratigraphy of the western margins of the Highlands and the adjacent Riverine plains from the late Pliocene and the duration of the Ice Age up to the conclusion of the last cold phase.

The boundary conditions at the base of the Shepparton Formation probably consist of an upward transition from the high-energy sedimentary depositional environments of the Calivil Sands with associated lateritised surfaces on the interfluves, through to a low-energy depositional environment. The clays and silts of the Shepparton Formation comprise fines from the distal

alluvial fan facies in the valleys, which have backfilled some of the incisions generated during the regime of the Calivil Sands. This is evident from gully fills in the upper reaches of the Kiewa and Mitta Mitta Rivers and by the reduction in grade of the present Ovens River between Harrietville and Bright, when compared to the steeply inclined auriferous gravels beneath (Kenny, 1925). Refer to Section 2B Parts 1 and 2.

Since the Pleistocene, the sediment supply has dwindled and the riverine activity has etched into the Shepparton Formation leaving behind at least two sets of inset terraces in response to greater eroding power of the rivers during the Holocene.

CONCLUSION TO STRATIGRAPHIC OVERVIEW.

Model 1, involving Cainozoic tectonism seems neither necessary nor sufficient to account for the stratigraphy of the Highland terrain, nor the Murray Basin. A combination of Model 2 and Model 3 which invokes long term stability and existence of the Highlands since Permian times with erosional losses dampened by isostatic adjustments and sedimentary cycles of marine transgression/regression essentially controlled by eustatic cycles seems to explain the stratigraphy.

The elevation of highland terrain by the Tawonga Fault, which has been active up until recent times, has been significant, but elevated terrain up to 1 200m ASL still continues north of this fault, which is seen as a complementary factor in the development of the Highlands rather than the primary cause.

INTRODUCTION : SECTION ONE D.

AN OVERVIEW OF LATE PLEISTOCENE PROCESSES IN THE ALPINE TERRAIN OF SOUTHEASTERN AUSTRALIA.

In 1886 James Stirling observed smoothed, planed rock outcrops and "erratics" on Mt. Bogong and also observed masses of boulders on the lower slopes of Mt. Bogong which he presumed to be moraine. Stirling had reservations about postulating the existence of extensive ice sheet glaciation during the Pleistocene due to uncertainties about Tertiary stratigraphy and structural history.

David (1908) presented evidence of general smoothing of rock surfaces, striated rock surfaces, roches moutonnees, erratics, terminal and lateral moraines, glacial lakes and tarns, U shaped valleys and hanging valleys from which he deduced the existence of a Pleistocene ice cap over 80 to 100 square miles in the Kosciusko area alone. David recognized the existence of at least two stages of glaciation, the succeeding stages being more localized around the relic cirques of the Kosciusko area.

David's work probably had a lot of influence on contemporary workers and was further reinforced by the work of Brown and Vallance (1947 to 1957) who postulated three stages of glaciation comprising ice cap, valley glaciation and cirque glaciation.

This hypothesis stimulated other workers to look for similar features elsewhere in the highlands of southeastern Australia.

Carr and Costin (1955), postulated the existence of a neve field on the Bogong High Plains which gave rise to cirque and valley glaciers contemporaneous with the early stage of glaciations at Kosciusko. The evidence for this included the existence of ground moraine at the head of Rocky Valley and the existence of erratics of quartz and granodiorite on the eastern side of Basalt Hill.

Beavis (1959) reappraised the boulder deposits near Langfords Gap at the head of Rocky Valley which Carr and Costin had interpreted as ground moraine. Beavis demonstrated by statistical analysis of joint patterns that the boulders had weathered insitu.

Furthermore, the present writer has demonstrated in this thesis, that the presence of quartz and granodiorite mixed with basalt blocks on the eastern side of Basalt Hill is consistent with cryogenic mass movement over the contact between the basalt and the underlying granodiorite and associated quartz veins to produce hybrid block accumulations close to their source rocks.

Costin (1962) suggested periglacial conditions had operated intensively in the past in the development of deep "lithosols" which include stony soils and open block accumulations on the High Plains of North-eastern Victoria. Costin (1962) further added that these lithosols complement the mildness or absence of glaciation on the Victorian High Plains.

Talent (1965) described rock rivers or block streams, stepped valleys with boulder cascades and amphitheatre-like valley heads on the Cobberas at the headwaters of the Indi and Buchan Rivers. These features and solifluction deposits near Mt. Hotham may be evidence for Pleistocene glaciation or periglaciation according to Talent (1965).

Alley (1981) proposed that periglacial features of differing ages are widespread in the southern Bogong High Plains. Alley postulated that the younger periglacial features occurred sometime after 3 700 years ago and that the older set predates 7 000 years ago. The basis for these dates was a carbon 14 dating of organic matter which accumulated behind a rampart at the head of a tributary of Pretty Valley Creek which Alley interpreted as a minor cirque moraine or nivation ridge. The present writer has examined the site and surveyed it in detail, producing longitudinal profiles (refer to Section 3C - Pretty Valley) and collected stratigraphic data which demonstrate that this feature is a rotational slip which has pushed up a rampart at its distal end. The C14 date of 3 700 years BP probably correlates with a wetter period during the Holocene which would have been conducive to mass movement of older frost riven regolith and the formation of this feature. The feature in question overrides a basalt blockstream which indicates the relative antiquity of the basalt blockstream. Other slips are evident around the margins of the basalt plateau centred on Mt. Jim, but the feature dated by Alley, is the freshest looking of these features.

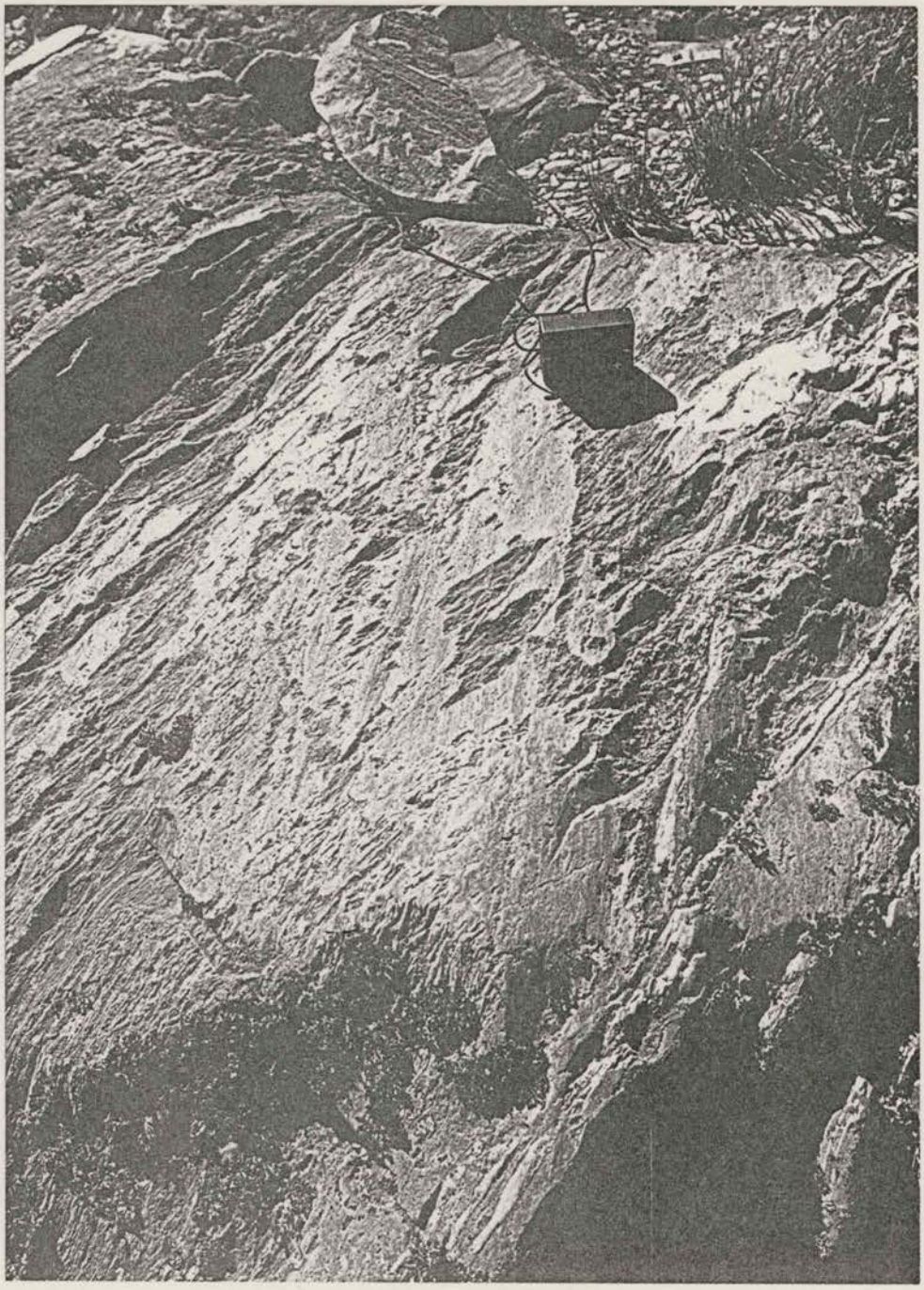
The present writer has found no evidence of glaciation anywhere on the Bogong High Plains but has described relic features interpreted as cryoplanation terraces, blockfields, block glacis, block slopes and block streams, which predate Holocene sediments and soils and would have required colder conditions that prevailing at present.

There is no evidence of ice sculpting or striation of rock masses anywhere on the Bogong High Plains. The active snow patch zones in the Mt. Nelse area, described in this thesis, demonstrate smoothing and polishing of bedrock exposed in these zones. Sculpting and striation of bedrock, however, was observed on small exposures in the axis of a steep reentrant below Club Lake in the Kosciusko area. Refer to photographs K 15386 F23 and K 15386F19, overleaf.

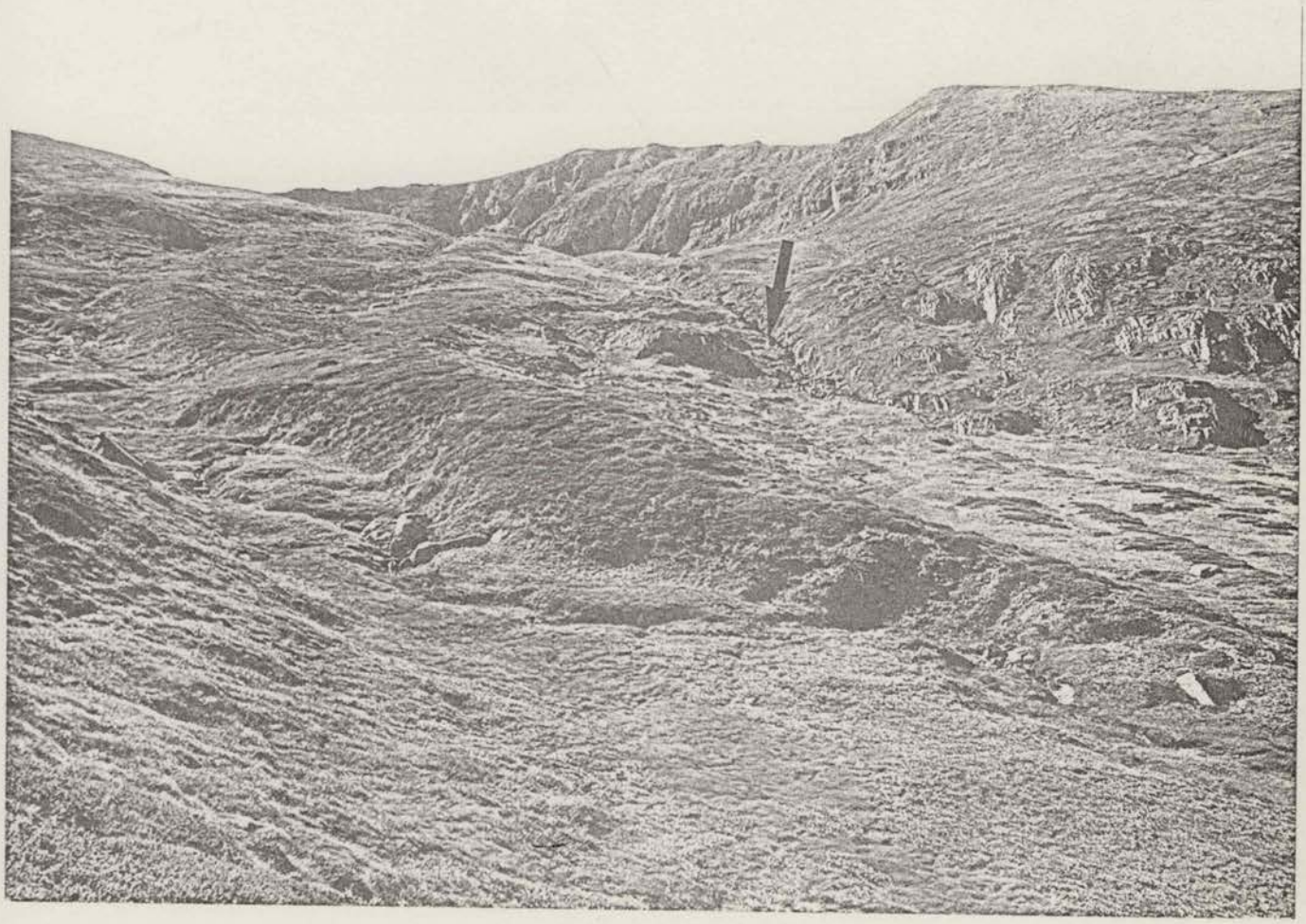
A terminal moraine bearing thermokarst exists 1.3km below Club Lake and is illustrated in photograph K. 1184F26. This example of glaciation is small scale , very localized and typical of the Kosciusko glacial features of the late Pleistocene. This example is mentioned in Section 3D of this thesis as a "rock glacier" and is compared to the cryogenic features of the Bogong High Plains.

A few features in the Kosciusko area previously described as relic glacial features appear to this writer to be nivational and restricted in extent to the immediate environs of relic permanent snow patch zones. Lake Cootapatamba on the southeastern flank of Mt. Kosciusko was previously described as a relic cirque. The
(continued on page 27)

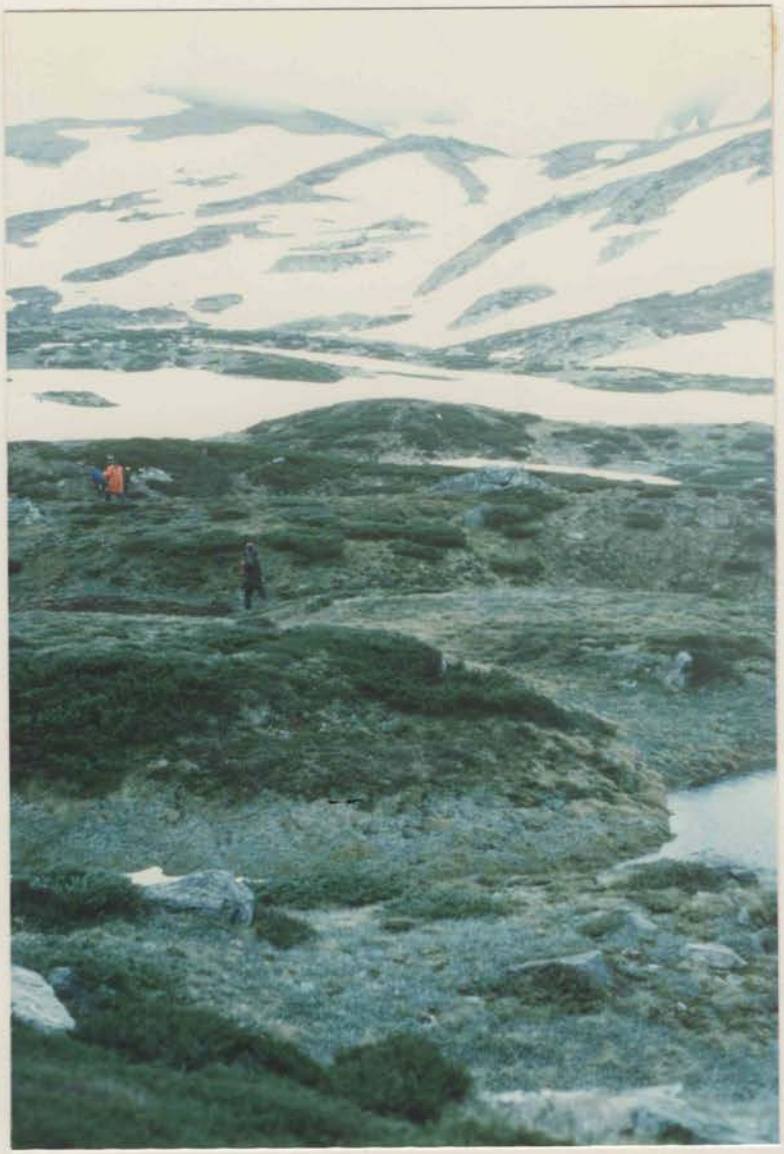
PHOTOGRAPH Ko 15386F19



This photograph shows polished facets on a metasediment outcrop in a steep reentrant below Club Lake. The position of the outcrop is shown by an arrow on photograph Ko 1536F21, overleaf. The polished surface reveals minor fluting of the bedrock surface but the sculpture is superficial as the rock ledge on which this exposure occurs has not been significantly changed in shape by the glacial action. In fact, the rock ledge continues laterally as a cryoplanation terrace.



This photograph is taken from a minor ridge looking north-west towards Carruthers Peak. Club Lake nestles at the foot of the south-east scarp below Carruthers Peak. The arrow denotes the position of the polished, striated pavement illustrated in photograph Ko 15386F19. The adjacent stepped terrain is typical of cryoplanation terrain. The rounded ridge in the midground is composed of angular detritus and probably represents a relic terminal moraine of a lateral lobe emanating from Club Lake. The valley of the reentrant below Club Lake is not U-shaped, and its sides appear to be convex rather than concave.



This photograph was taken during the spring thaw (November 1984) from the distal end of the Club Lake moraine. It demonstrates a hummocky surface with regular "kettle holes" or thermokarst. The photograph looks north-west towards Carruthers Peak (2140m). The peak is shrouded in cloud. The figures in the foreground give scale.

INTRODUCTION : 1D continued
PHOTOGRAPH Ko 1184F2



This photograph illustrates a view of Lake Cootapatamba taken from near Rawsons Pass looking south-west. The high ground containing the concave slope above the lake is a southeastern extension of Mt. Kosciusko, and its elevation behind the lake is approximately 2140m ASL. The spring thaw has delineated at least three concentric accumulations of blocky detritus downslope from the lake. These probably represent protalus ramparts derived from an adjacent permanent snow patch zone nestled into the concave slope on the flanks of Kosciusko. This photograph, taken 21st November 1984, demonstrates that block attrition appears to be relatively inactive on the steep blocky slope behind the lake.

INTRODUCTION : 1D continued
PHOTOGRAPH Ko 1184F6



This photograph demonstrates the stepped morphology of bedrock in the steep concave slope behind the lake. This photograph was taken opposite the distal moraine looking towards Lake Cootapatamba which is just visible in the midground. The height of the moraine is approximately 5m.

lake appears to be dammed by a set of low concentric ridges of coarse debris which are interpreted by this writer as protalus ramparts. This feature is illustrated in photographs K. 1184F2 and K. 118 4F6. Features such as rock glaciers and protalus ramparts in the Kosciusko region probably represent the optimal development of cryogenic features in southeastern Australia during the late Pleistocene and form the apex of a spectrum of cryogenic features which include cryoplanation terraces, blockstreams, blockfields and block glacis.

Galloway (1963) could find satisfactory evidence for only a limited cirque and valley head glaciation of about 50 square kilometres in the Kosciusko region.

Ritchie and Jennings (1955) doubted if glaciation has occurred at all on the adjacent Grey Mare Range. Peterson (1968) concluded that the Snowy Mountain cirques (Kosciusko region) are poorly developed because conditions were only marginal for glaciation.

The present writer, after numerous field checks in the Kosciusko region interprets the localization and small scale of "glacial" features to high altitude hollows with a southeasterly aspect as evidence of very limited glaciation. The dominant cryogenic processes have left a legacy of stepped profiles and blocky debris which are largely the result of frost action under drier, colder conditions than are prevalent today.

INTRODUCTION : SECTION ONE E

METHODOLOGY

The project was initiated with reconnaissance field trips to most features on the Bogong High Plains surface which were followed up by low altitude oblique aerial photography of many of the more remote features. This was coupled with an investigation of high altitude aerial photographs at various scales over the entire Bogong High Plains.

Target areas for detailed investigations were selected at Mt. Nelse, Basalt Hill and Pretty Valley as they presented a diverse range of rock types and features over an altitudinal range of 1400m to 1880m. These areas were also readily accessible by vehicle transport lasting one and a half hours and less than one hour of walking. Basalt Hill in particular offered many sections due to the presence of roads and aqueducts.

Detailed data were collected by specific site investigations and surveyed traverses in target areas. Several techniques of surveying profiles were attempted. Theodolite traverse using a borrowed Wild T2 proved slow, cumbersome and provided a higher order of accuracy than was necessary. Compass and tape profiles were rapid but not accurate for longer distances up to 1km. A telescopic level, tape and staff gave accurate data, but were difficult to use on steeply sloping, often very windy, terrain. An Abney clinometer mounted on a 1.5m stick and a tape and target stick, also 1.5m long provided a rapid, accurate means of deriving profiles and picking up small changes in slope. These profiles provided the framework to record and interpret surficial geology and vegetation.

The distribution of vegetation and surficial geology was presented on 1:15 000 vegetation maps produced by the Victorian Soil Conservation Authority (published 1982), now incorporated within the Ministry of Conservation Forests and Lands. This proved to be satisfactory for Basalt Hill and Pretty Valley but did not show the desired degree of detail for Mt Nelse which was mapped from 1:5 000 color aerial photographs and field traverses. The maps and overlays for Mt Nelse were drawn onto A3 paper at 1:5 000 and subsequently reduced down to A4 size (1:7 000).

The surveyed profiles have been presented at 1:1 000 scale on both vertical and horizontal axes. The profiles have been annotated from field notes. Photographs have been used liberally to illustrate stratigraphic sections and surficial features and their geological context. Photographs were taken over a time interval of ten years and individual photographs are numbered in a manner which indicates the target area, date and frame number. A log of photographs used in the thesis has been compiled and individual photographs are cross referenced to the original field notes.

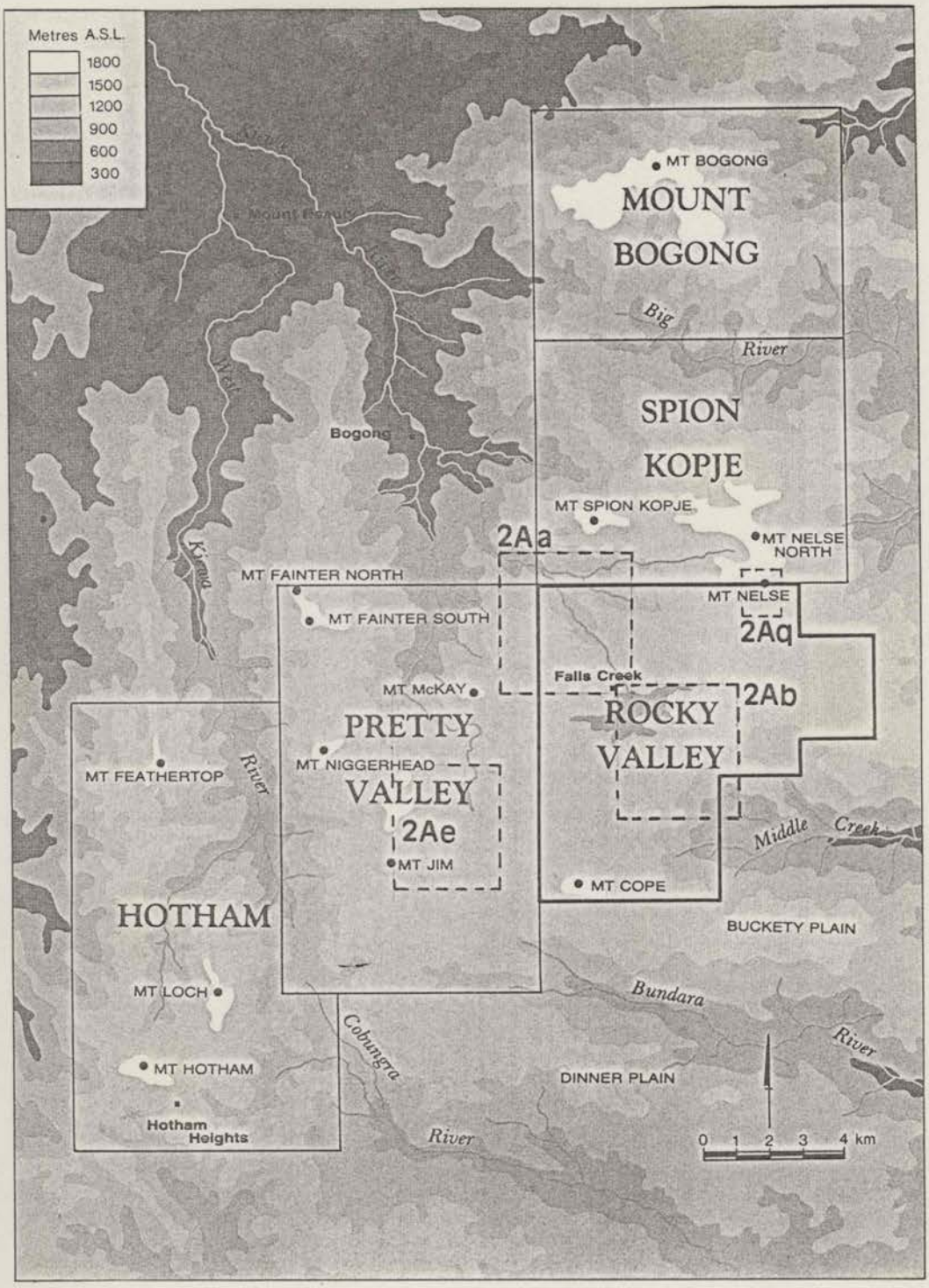


Fig 1Ea : Regional Map of Bogong High Plains Depicting Target Areas Described in Section 2A.

This map is taken from the Rocky Valley 1:15 000 Vegetation Map and is the index map to the series. The outlines of Figures 2Aa, 2Ab, 2Ae and 2Aq are shown by dashes. These cover : Fig 2Aa - Falls Creek/Howman Gap traverse (this links with traverse up the Kiewa River); Fig 2Ab - Basalt Hill target area; Fig 2Ae - Pretty Valley target area and Fig 2Aq - Mt Nelse target area.

Regolith was augered to test surficial stratigraphy along some surveyed profiles and grain size distribution was analysed for some of these samples. In addition, the very fine sand fraction of these samples was analysed by reflected light microscopy for clues to the processes of deposition.

Samples of regolith and sediment were taken at most exposures, especially along the valleys of the Mitta Mitta and Kiewa Rivers. These samples have been recorded , stored and in some cases examined further. Where more than one layer was exposed, the layers were described and numbered downwards from the surface.

The location of target areas on the Bogong High Plains which have been mapped in detail are shown on Fig 1Ea, which also depicts regional physiography with outlines of the series of 1:15 000 vegetation maps produced by the Soil Conservation Authority (1982). A perusal of Figures 1Bb and 1Bc should further demonstrate the location of target areas with respect to the region and to South-eastern Australia.

Portion of the Tallangatta 1:250 000 Geological Map has been reproduced in Fig 2Ba. This figure 2Ba presents an overview of sites sampled in the adjoining valleys of the Mitta Mitta and Kiewa Rivers. This figure should also be compared to Fig 1Ea in order to appreciate the range of stratigraphic sites samples and their relationship to the Bogong High Plains.

Reconnaissance field trips to : the Toolong Range, Mt. Jagungal, Mt Kosciusko and the Main Range, the Cobberas Range, Mt Hotham, Mt Loch, Mt Barrow (Tasmania)and Ben Lomond (Tasmania), were undertaken to collect data for comparision to the Bogong High Plains. These localities are shown on Fig 1Bb which depicts terrain and localiti es above 1 000m in South-eastern Australia.

SECTION TWO : STRATIGRAPHY

A) DESCRIPTION OF SURFICIAL DEPOSITS ON THE BOGONG HIGH PLAINS:

1. Falls Creek to Howman Gap
2. Basalt Hill
3. Pretty Valley
4. Mt. Nelse

B) DESCRIPTION OF SURFICIAL DEPOSITS IN THE VALLEYS OF THE MITTA MITTA AND KIEWA RIVERS LEADING UP TO THE BOGONG HIGH PLAINS :

1. Mitta Mitta
2. Kiewa

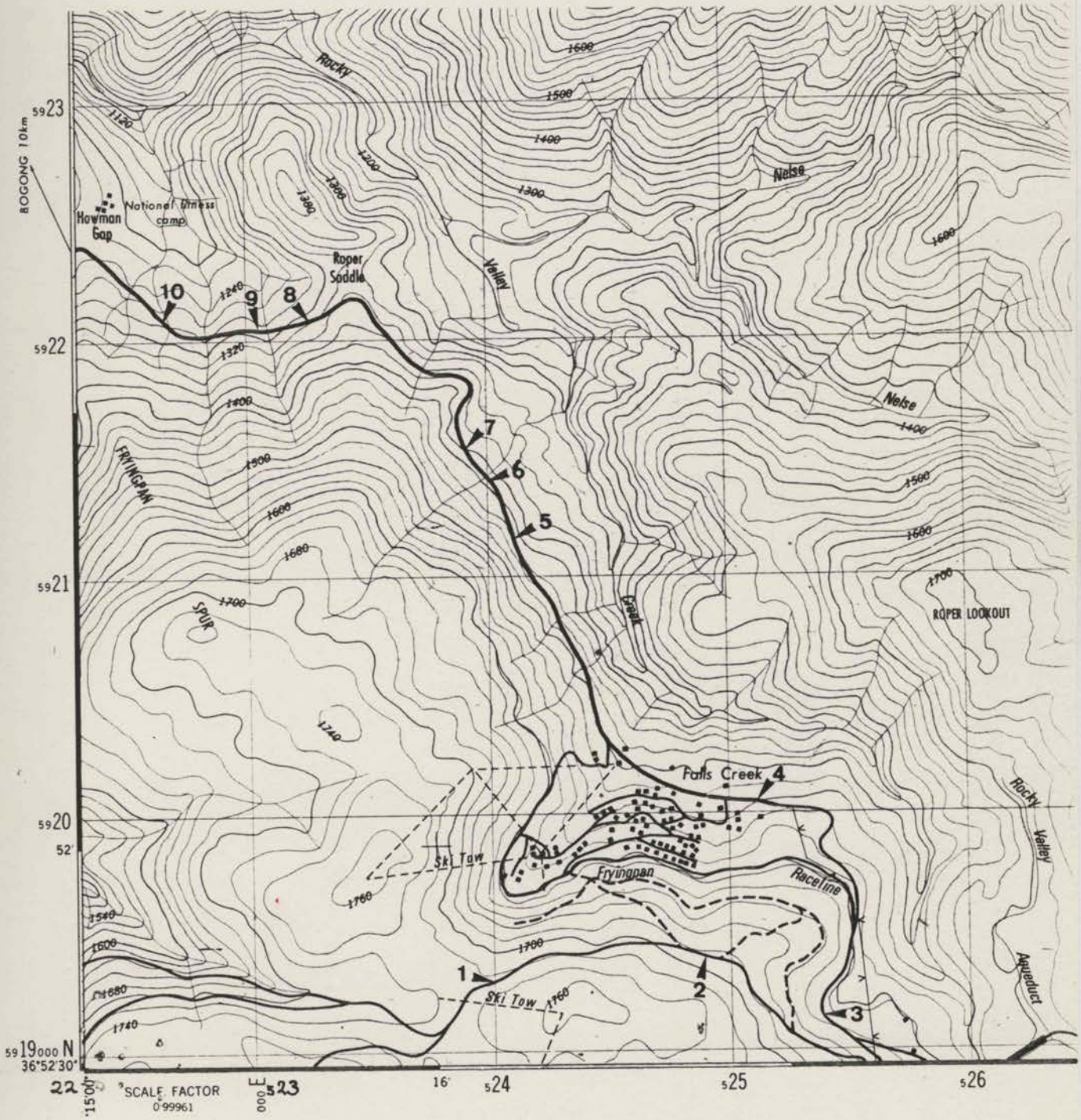
C) CORRELATION OF 2A AND 2B WITH AN INTERPRETATION OF THE TRANSITION OF DEPOSITS AND PROCESSES BETWEEN 2A AND 2B.

SECTION TWO : STRATIGRAPHY

A) DESCRIPTION OF SURFICIAL DEPOSITS ON THE BOGONG HIGH PLAINS

PART ONE: FALLS CREEK TO HOWMAN GAP

Fig 2Aa Section of Nelse map Showing Site Locations of Traverse From Falls Creek to Howman Gap.



SITE NUMBER :1
G.R. : 240193 Nelse 1:25 000 NATMAP
ELEVATION : 1730m
ASPECT : North
GEOMORPHIC SETTING : Upper slope on a spur, sloping 14° to the north, well drained.
VEGETATION : 100% cover of open heath, height less than 60cm.

Layer 1 : 30-40cm of dark orange brown stony loam. Stones from gravel to block size comprising 60% of bulk, are randomly orientated in a loose sandy silt matrix. Stones are light to moderately weathered gneiss of irregular platy shape. Larger, platy blocks exhibit a downslope orientation of their long axis. The top 15cm of layer 1 is moderately humified.

Layer 2 : A thickness of 30-40 cm. greenish to grayish brown gravelly silty sand regolith. Approximately 5% of the bulk of layer 2 is composed of very weathered pebbles and granules of gneiss. Stones are platy or irregular and generally less than 10mm, with a random distribution.

Bedrock : Not observed directly at site 1, but gneiss outcrops nearby.

SITE NUMBER : 2
G.R. : 249194 Nelse 1:25 000 NATMAP
ELEVATION : 1680m
ASPECT : North
GEOMORPHIC SETTING : Mid slope with gradient of 10°
VEGETATION : Open heath with height of $\leq$ 100cm. Tussocks and forbes occupy about 10% of cover.

Layer 1 : Approximately 20cm of dark brown, gravelly, organic loam.

Layer 2 : Approximately 30cm of orange brown, gravelly, sandy loam.

Layer 3 : Narrow band of stones, approximately 50cm below surface. Most stones are platy pebbles from 1 to 5 cm but there are large isolated blocks, 45cm across, associated with the stone line.

Layer 4 : 40cm to 50cm of orange brown loam with extremely weathered cobbles dispersed throughout.

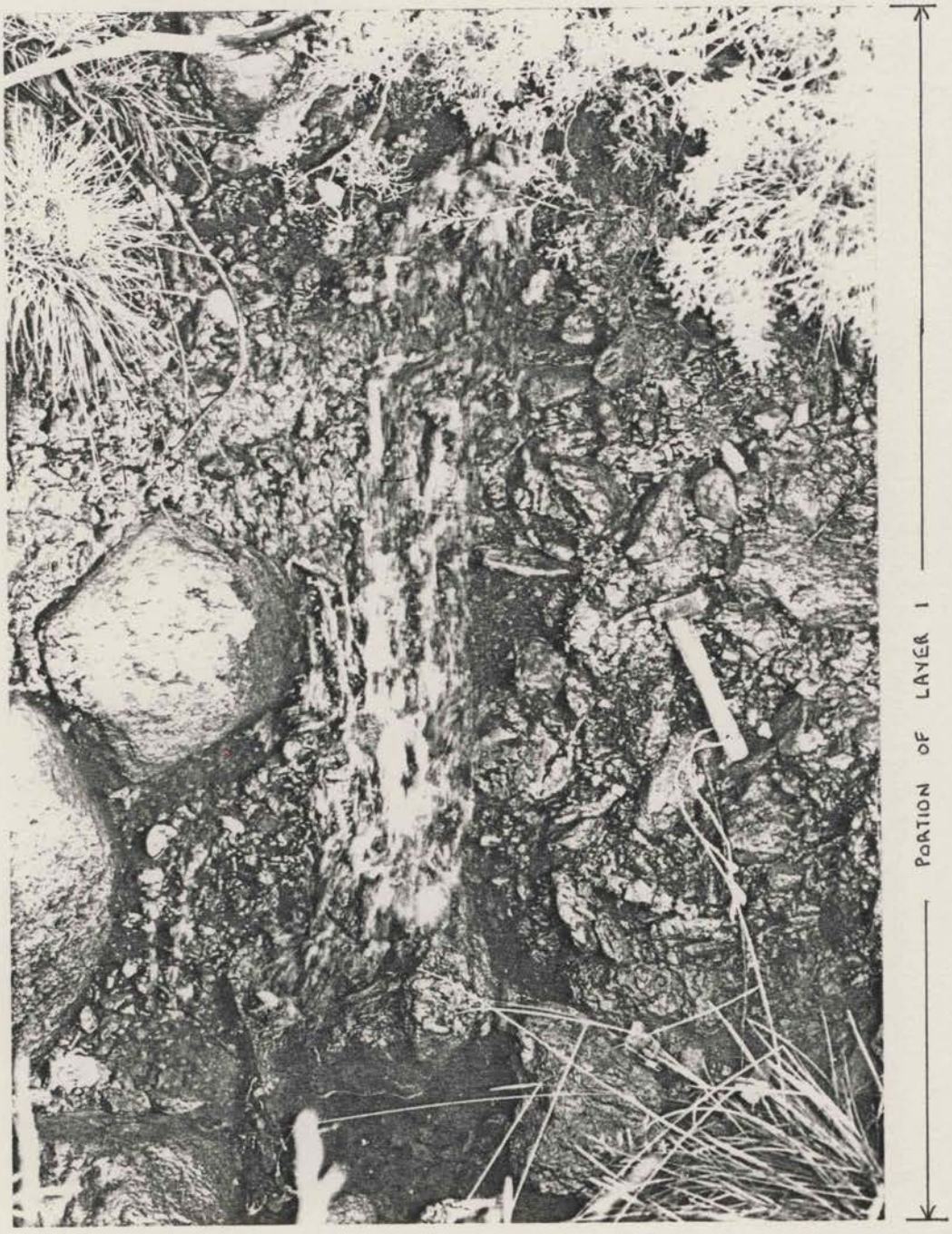
Layer 5 : Extremely weathered granodiorite bedrock.

SITE NUMBER : 3
G.R. : 254192 Nelse 1:25 000 NATMAP
ELEVATION : 1610m
ASPECT : East
GEOMORPHIC SETTING : Base of broad moderately sloping, concave drainage line, which rises 150m above site 3.
VEGETATION : Tall heath and open snow gum woodland.

Layer 1 : 1.5m deep section of large, rounded granodiorite tors, gneiss blocks and quartz cobbles, tightly packed with a matrix of pale orange brown silty, sandy gravel.

Layer 2 : Very weathered gneissic bedrock occurs nearby but was not directly observed in this section

Refer to photograph FC 3686F12.



SITE NUMBER : 4
G.R. : 251201 Nelse 1:25 000 NATMAP
ELEVATION : 1540m
GEOMORPHIC SETTING : Mid slope section on broad spur, sloping at approximately 13° or 23%.
VEGETATION : Tall heathland, open snow gum woodland.

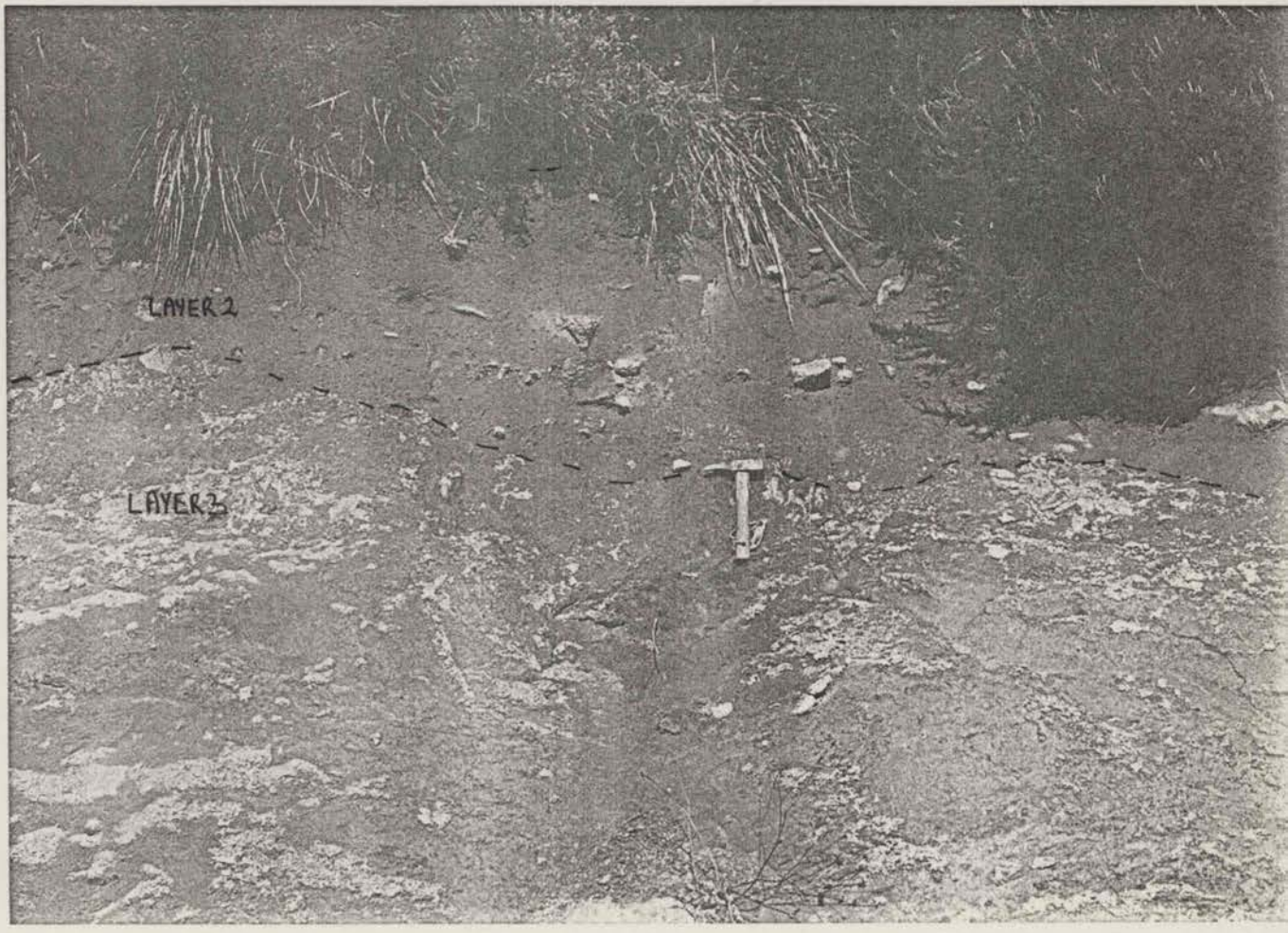
Layer 1 : 15cm of organic loam.

Layer 2 : Approximately 100 cm of mid brown gravelly silty sand with dispersed, slightly weathered blocks and cobbles, and some thin, weakly stratified, stone lines.

Layer 3 : Extremely weathered gneissic bedrock.

Refer to photograph FC 3686F13

This photograph demonstrates the weak stratification of platy cobbles parallel to the bedrock surface, which appears to have been shaved parallel with stone stratification. The hammer is located at the interface between layers 2 and 3. This is similar to gully fill stratification in Snowy Creek.



SITE NUMBER : 5
G.R. : 241212 Nelse 1:25 000 NATMAP
ELEVATION : 1440m
ASPECT : East
GEOMORPHIC SETTING : Near base of moderately steep slope of 50% or 26° on average, but attaining 34°.
VEGETATION : Tall heathland and closed snow gum woodland.

Layer 1 : Thin variable layer of humus.

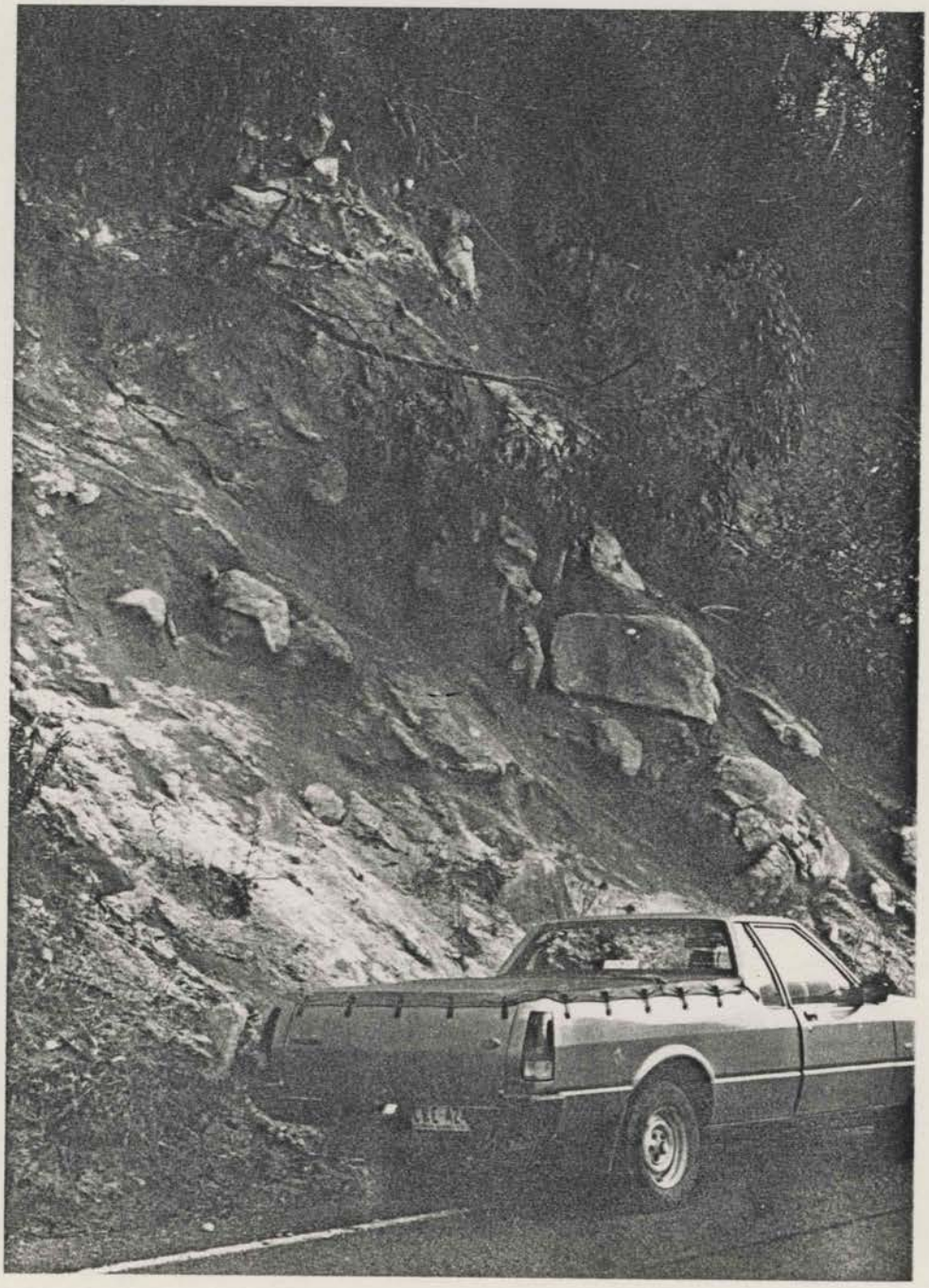
Layer 2 : Extremely weathered granodiorite with scattered, slightly weathered corestones, and a localized gully fill.

SITE NUMBER : 5 continued

Refer to photograph FC 3686F14

This photograph illustrates the 6m section of weathered grandiorite.

PHOTOGRAPH FC 3686F14

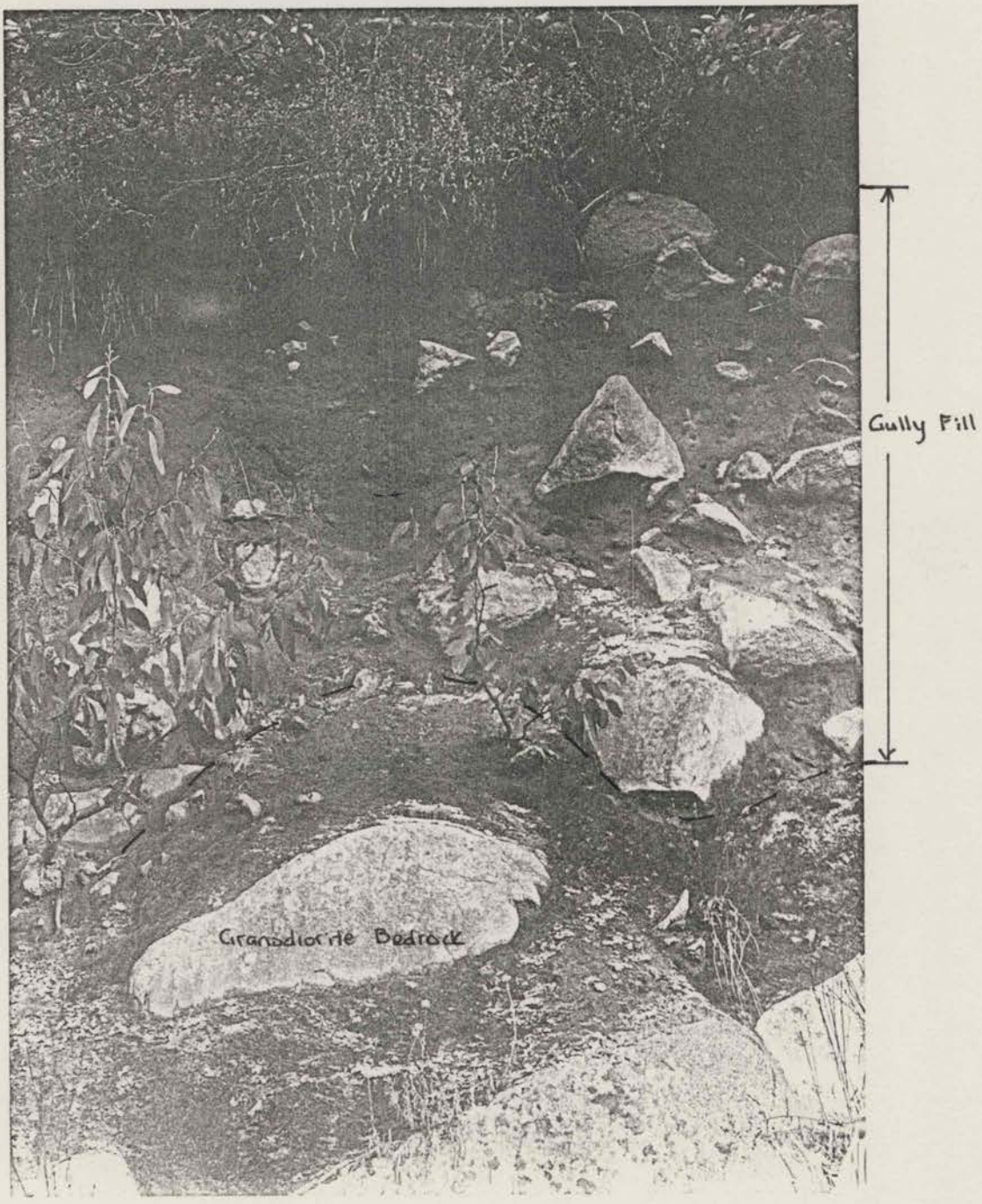


SITE NUMBER : 5 continued

Refer to photograph FC 3686F15

This photograph illustrates a minor gully fill within the weathered bedrock. The small gully fill comprises extremely weathered platy fragments and large rounded blocks of granodiorite with large irregular blocks and cobbles of gneiss in orange brown silty, gravelly sand. Maximum thickness is about 1.2m. The block accumulation in the gully fill is now unstable due to the road cutting.

PHOTOGRAPH FC 3686F15



SITE NUMBER : 6
G.R. : 240214 Nelse 1:25 000 NATMAP
ELEVATION : 1410m
ASPECT : North-east
GEOMORPHIC SETTING : Base of steep slope 38% or 21° which flattens out to 24% or 13°.
VEGETATION : Closed snowgum woodland.

Layer 1 : 20cm to 30cm of organic loam.

Layer 2 : Closed framework of granodiorite blocks in a matrix of orange brown gravelly sand.

SITE NUMBER : 7
G.R. : 239216 Nelse 1:25 000 NATMAP
ELEVATION : 1400m
ASPECT : East
GEOMORPHIC SETTING : Base of steep slope of 48% or 25°, which reduces to 23% or 13° below site 7.
VEGETATION : Closed snow gum woodland.

Layer 1 : Orange brown gravel with cobbles and blocks dispersed throughout. Several dark humus horizons occur within the top 1.2m of orange brown gravel.

Layer 2 : Approximately 1m of orange brown gravel with dispersed cobbles and blocks. Gravel and platy cobbles are weakly stratified.

Layer 3 : Very weathered gneissic bedrock.

SITE NUMBER : 8
G.R. : 233221 Nelse 1:25 000 NATMAP
ELEVATION : 1320m
ASPECT : North-west
GEOMORPHIC SETTING : Mid slope section of broad, open spur with average gradient of 40% or 22°. Local surface slope at exposure site is only 8°
VEGETATION : Closed alpine ash forest.

Layer 1 : Variable thickness (20cm to 100cm) of red gravel.

Layer 2 : Compact accumulation of granodiorite blocks sloping at approximately 18° to the west and less than 50cm thick. Blocks are moderately weathered to very weathered and friable. The blocks exist within an orange-brown, silty, sandy gravel matix.

Layer 3 : Orange brown, silty, sandy gravel matix approximately 50cm thick, sloping parallel to blocky layer at 18°.

Layer 4 : Extremely weathered granodiorite bedrock.

SITE NUMBER : 9
G.R. : 231220 Nelse 1:25 000 NATMAP
ELEVATION : 1290m
ASPECT : North
GEOMORPHIC SETTING : Mid slope section at the base of a steep slope of 38% or 21°.
VEGETATION : Closed Alpine Ash woodland.

Layer 1 : 50cm of very dark brown organic loam.

Layer 2 : Approximately 30cm of yellow brown loam.

Layer 3 : 20cm of dark brown humus with pieces of charcoal and weakly stratified blocks and cobbles.

Layer 4 : Red brown sandy, clayey silt with cobbles.

SITE NUMBER : 10
G.R. : 226221 Nelse 1:25 000 NATMAP
ELEVATION : 1270m
ASPECT : North-east
GEOMORPHIC SETTING : Minor gully within a broad mid slope with average slope of 35% or 19°.
VEGETATION : Closed Alpine Ash forest.

Layer 1 : Approximately 40cm of dark brown organic loam.

Layer 2 : Approximately 100 cm of yellow brown silty, sandy gravel

Layer 3 : Narrow band of blocks and charcoal above the underlying, extremely weathered granodiorite bedrock. Bedrock/ layer 3 interface is very irregular.

Layer 4 : Extremely weathered granodiorite.

SECTION TWO : STRATIGRAPHY

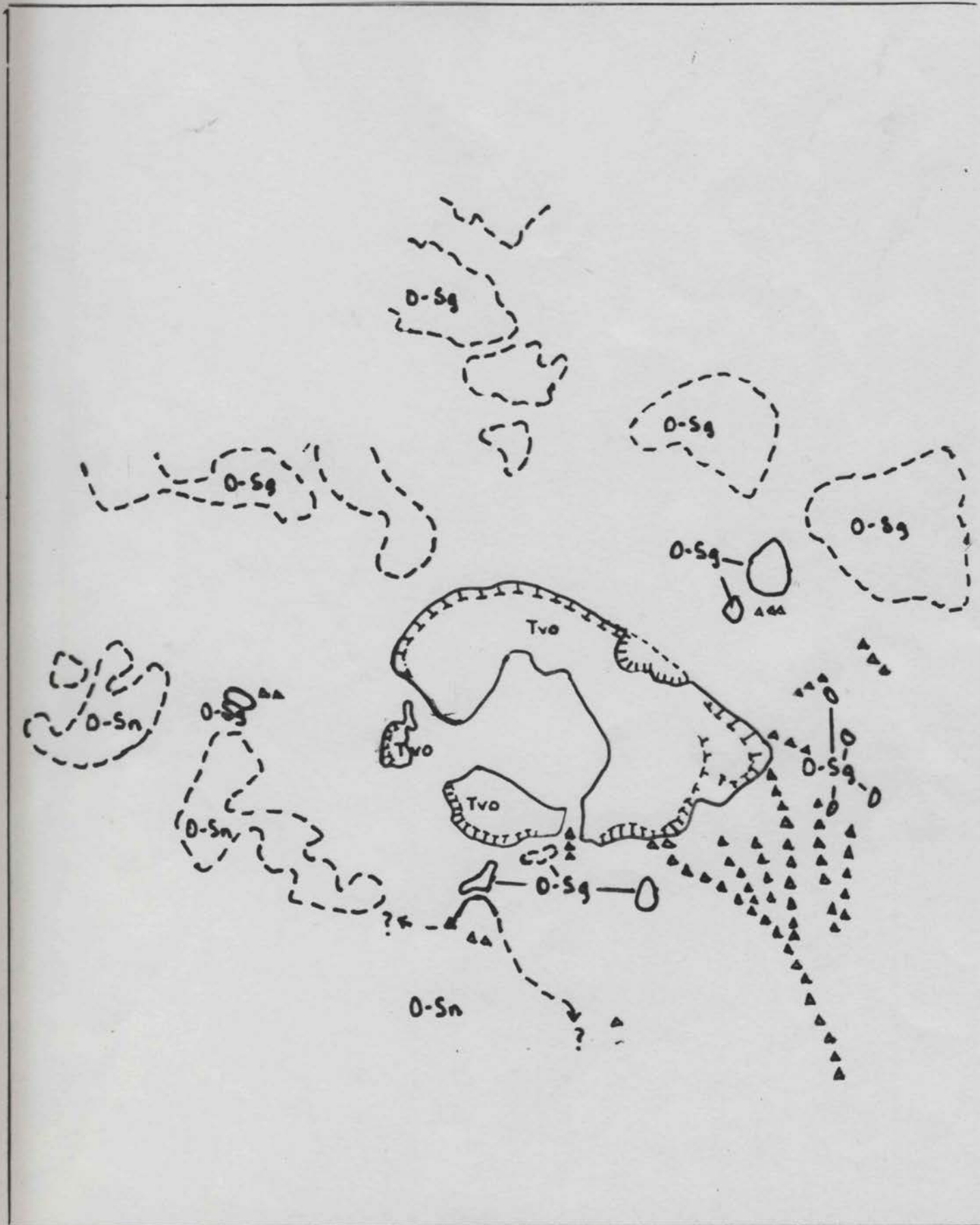
A) DESCRIPTION OF SURFICIAL DEPOSITS ON THE BOGONG HIGH PLAINS

PART TWO : BASALT HILL

The location of sites 1 to 32 is specified on portion of the 1:15 000 Rocky Valley Vegetation Map, Victorian SCA, and presented as Fig 2Ab with an overlay of Basalt Hill Geology.

The location of the Basalt Hill investigation area is shown on Fig 1E (a) (Section One)

BASALT HILL GEOLOGICAL OVERLAY



Tvo Basalt Outcrop

Basalt Scarp

O·Sg/O·Sn Outcrop

Inferred O·Sg/O·Sn Outcrop

Blocks

VEGETATION KEY Refer P109

Fig 2Ab BASALT HILL VEGETATION MAP With Locations of Stratigraphic Observations from Sites 1 to 32, incorporating Fig 2Ab, Basalt Hill Geological Overlay.

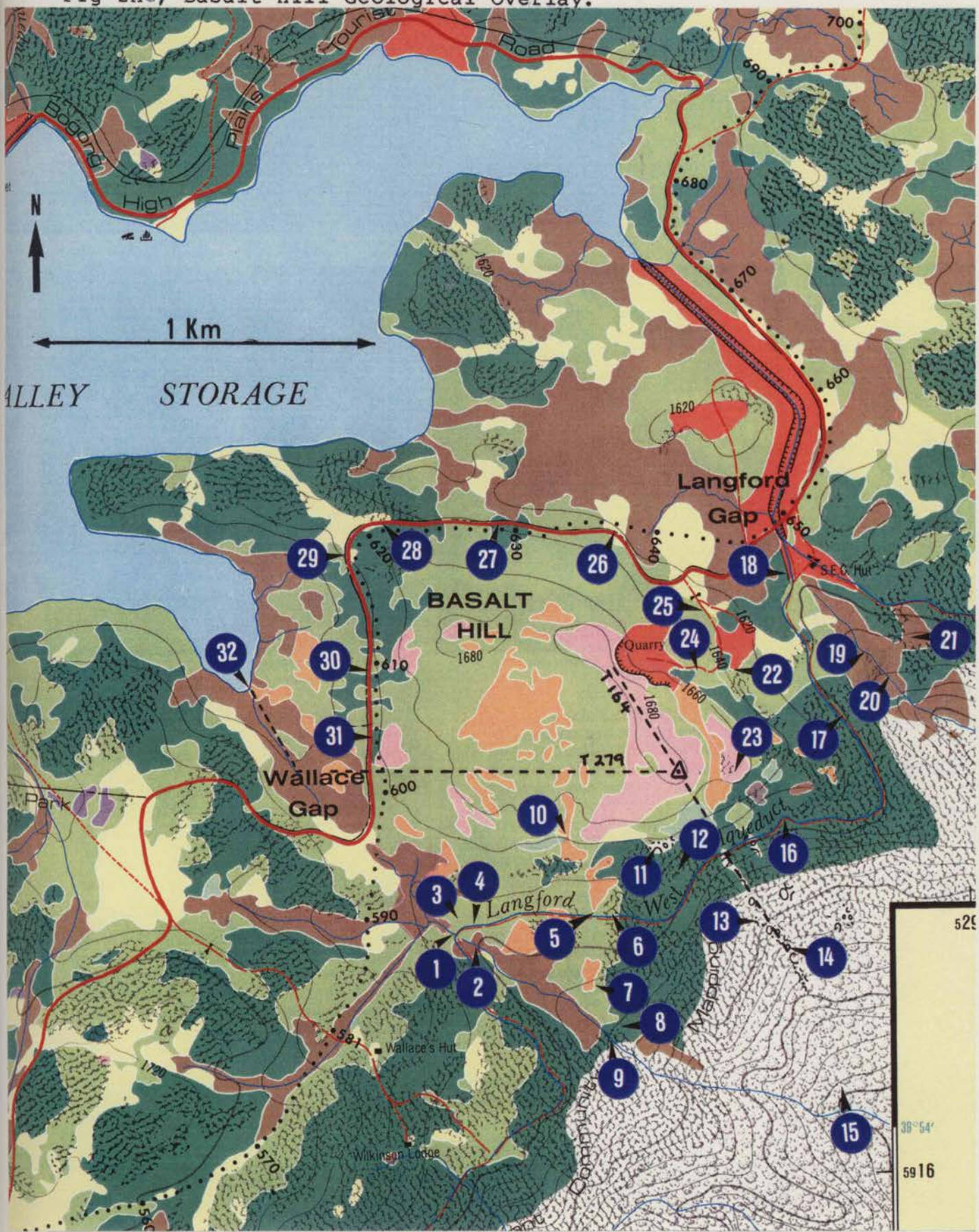
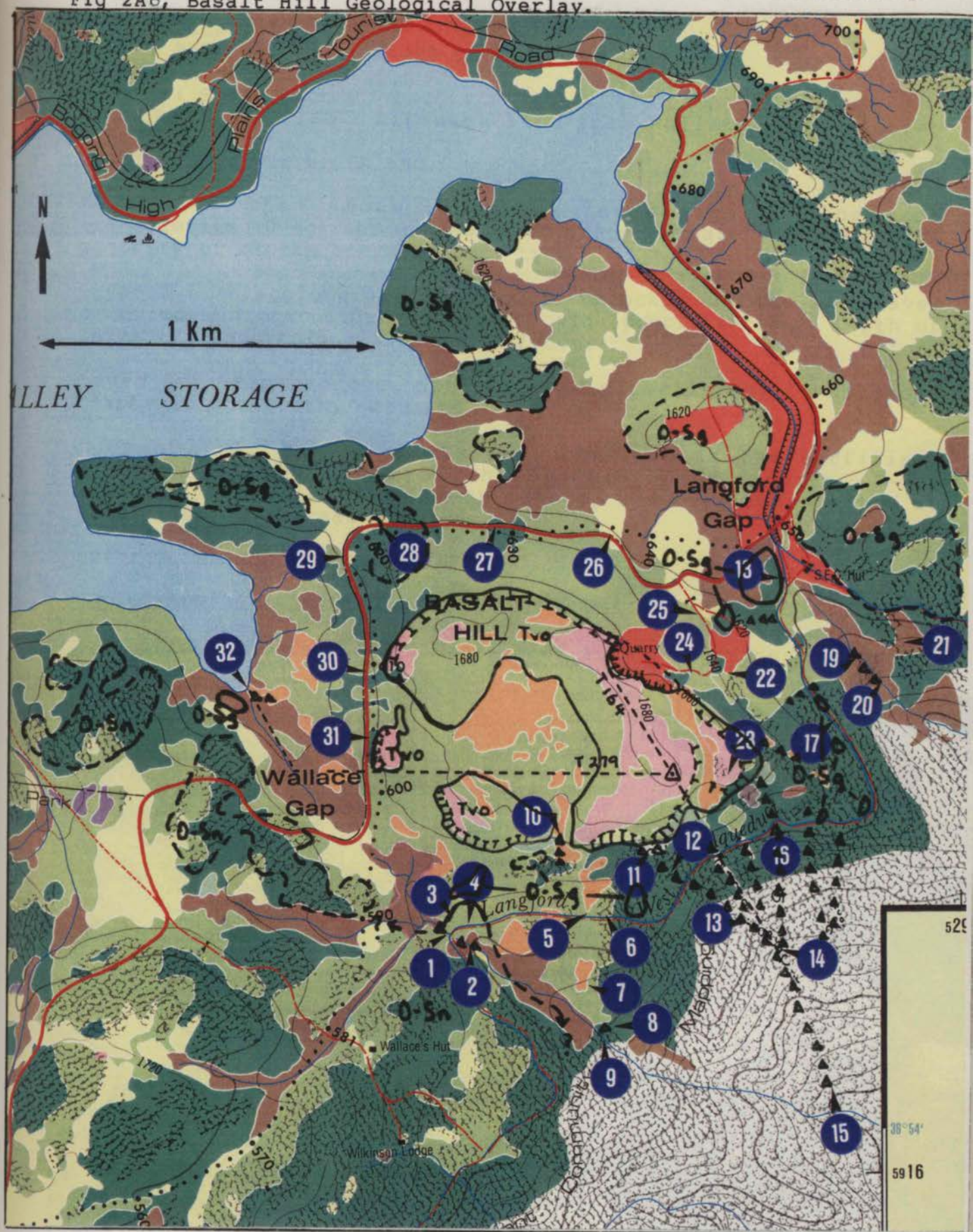


Fig 2Ab BASALT HILL GEOLOGICAL OVERLAY. Locations of Stratigraphic observations from Sites 1 to 32, incorporating Fig 2Ab, Basalt Hill Geological Overlay.



Tvo — Basalt Outcrop

O·Sg/O·Sn Outcrop

Blocks

Basalt Scarp

Inferred O·Sg/O·Sn Outcrop

VEGETATION KEY Refer P109

SITE NUMBER : 1
G.R. : 275167 Cope 1:25 000 NATMAP
ELEVATION : 1610m
ASPECT : South-east
GEOMORPHIC SETTING : Drainage line from Wallaces Gap, sloping 7.5%.
VEGETATION : Wet heathland.

Layer 1 : Open accumulation of large angular blocks of granodiorite (O-Sg) and gneiss (O-Sn), approximately 1m deep. The majority of blocks are O-Sg rock type.

Layer 2 : An agglomerate of irregular blocks, cobbles and gravel cemented and consolidated by iron oxide precipitation. Depth of layer (2) uncertain > 30cm and < 100cm.

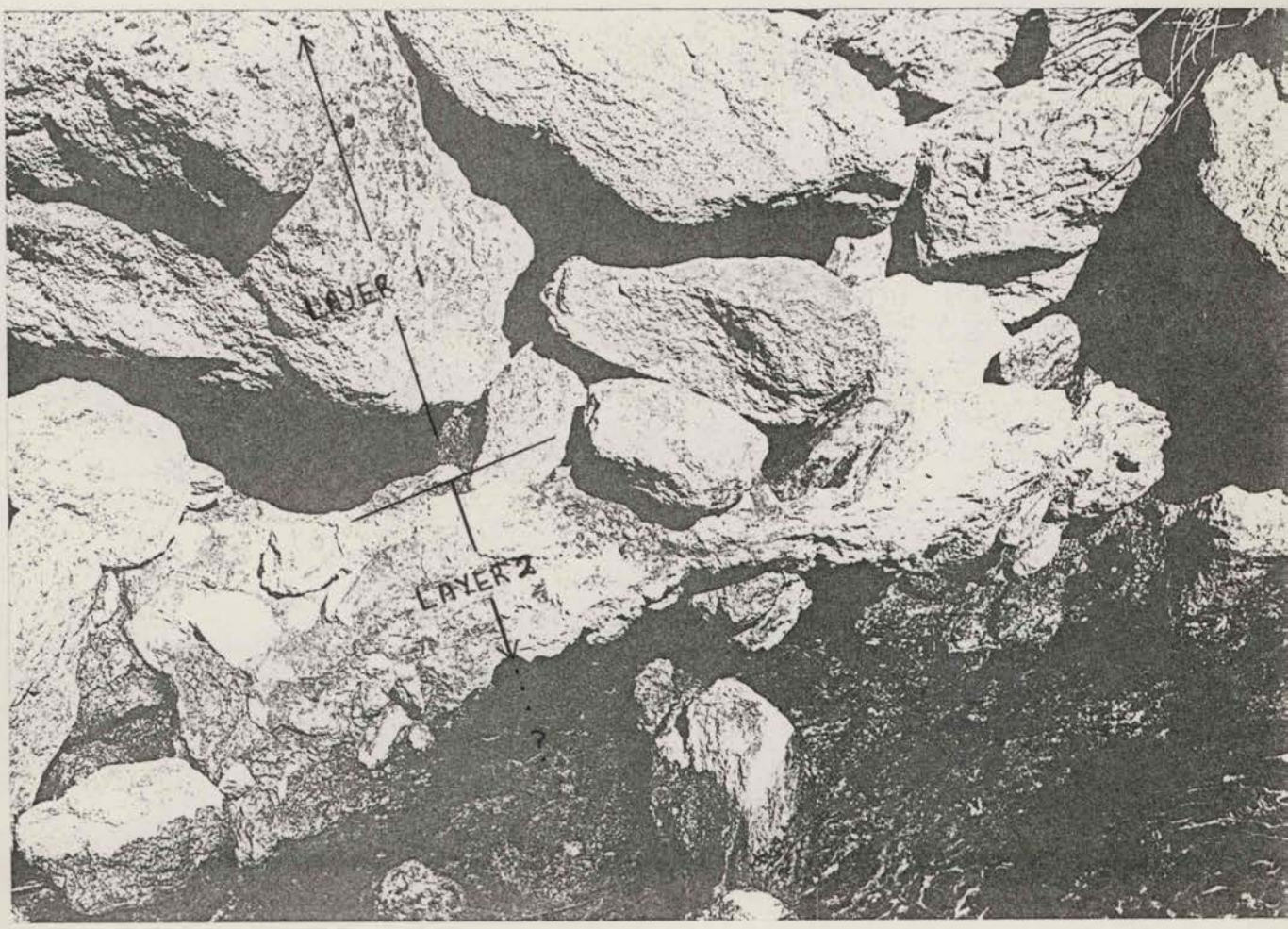
Layer 3 : O-Sn bedrock. Not observed directly but it outcrops nearby to the south, east and north.

Comment : No basalt clasts were observed in the surficial material to the south of this point. Granodiorite, O-Sg, material has overridden O-Sn outcrop and been transported at least 100m downstream to site 2.

Refer to photograph BH 18384F17

PHOTOGRAPH BH 18384F17

This photograph shows details of site 1 exposure in aqueduct.



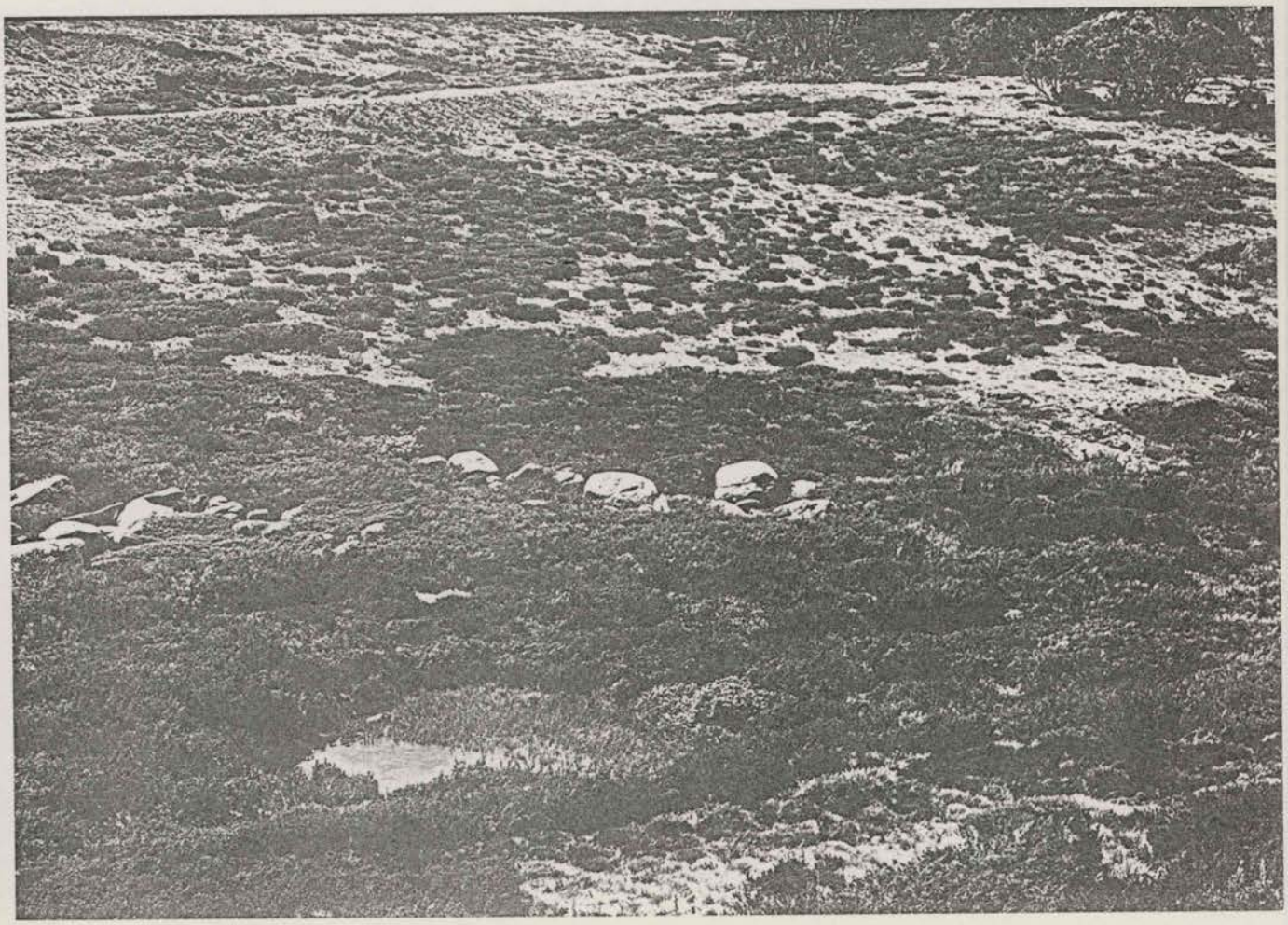
SITE NUMBER : 2
G.R. : 276167 Cope 1:25 000 NATMAP
ELEVATION : 1600 m
ASPECT : South-east
GEOMORPHIC SETTING : Drainage line approximately 60m downstream of site 1, and sloping about 7%.
VEGETATION : Bog

Layer 1 : Accumulation of large granodiorite O-Sg blocks in drainage line. Large blocks have maximum dimensions of approximately 3m.

Comment : No other layers observed beneath layer 1. Bedrock O-Sn outcrops upstream and downstream of the block accumulation.

Refer to photograph BH 18384F14 below.

This photograph looks northwards, with the site 2 granodiorite block accumulation in the midground and the aqueduct track heading east in the background.

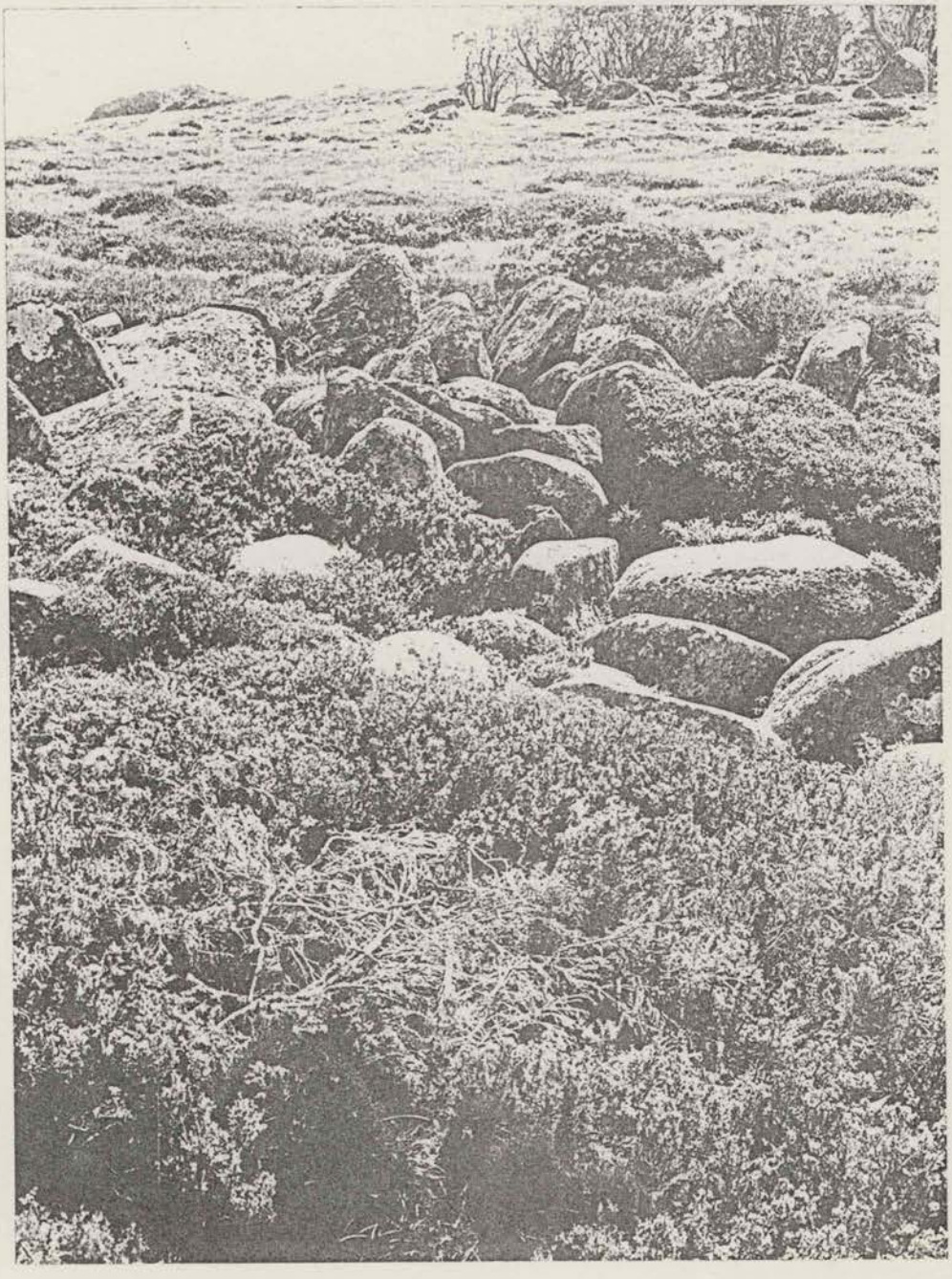


SITE NUMBER : 3
G.R. : 275168 Cope 1.25 000 NATMAP
ELEVATION : 1610m
ASPECT : South-east
GEOMORPHIC SETTING : Distal end of vegetated blockfield sloping 13% and adjacent to drainage line, just north of site 1.
VEGETATION : Open heath and becoming closed wet heath near drainage line.

Layer 1 : Open structured accumulation of large granodiorite blocks, partially vegetated by wet heathland. Maximum dimension approximately 2m at site 3.

Comment : The granodiorite forms tabular blocks with well rounded corners and edges, and the blocks stack with an imbricate texture.

Refer to photograph BH 18384F18 below.

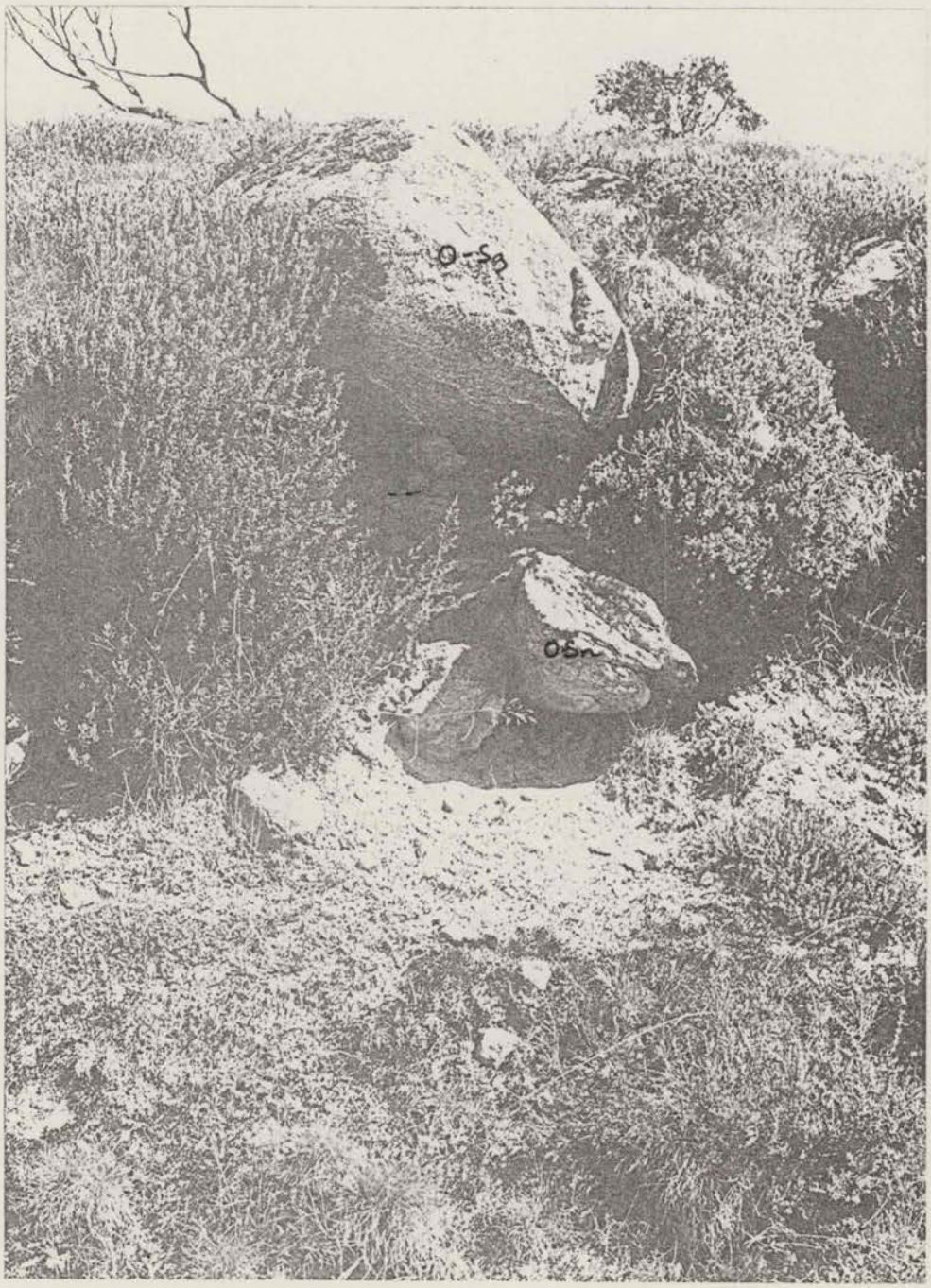


SITE NUMBER : 4
G.R. : 276167 Cope 1:25 000 NATMAP
ELEVATION : 1610m
ASPECT : South
GEOMORPHIC SETTING : Aqueduct cutting through mid slope of blockfield with slope approximately 11%.
VEGETATION : Open heathland.

Stratigraphy is shown in 3 photographs over a 50m section of the aqueduct.

Refer to photograph BH 18384F16

Large granodiorite block (O-Sg) overrides smaller gneissic blocks (O-Sn).



SITE NUMBER : 4 continued

Refer to photograph BH 18384F19

Granodiorite (O-Sg) and basalt (Tvo) blocks at the surface are partially obscured by vegetation and overlie smaller blocks and cobbles of granodiorite and basalt in a gravel, sand, silt matrix. Total depth of exposure is 1m.



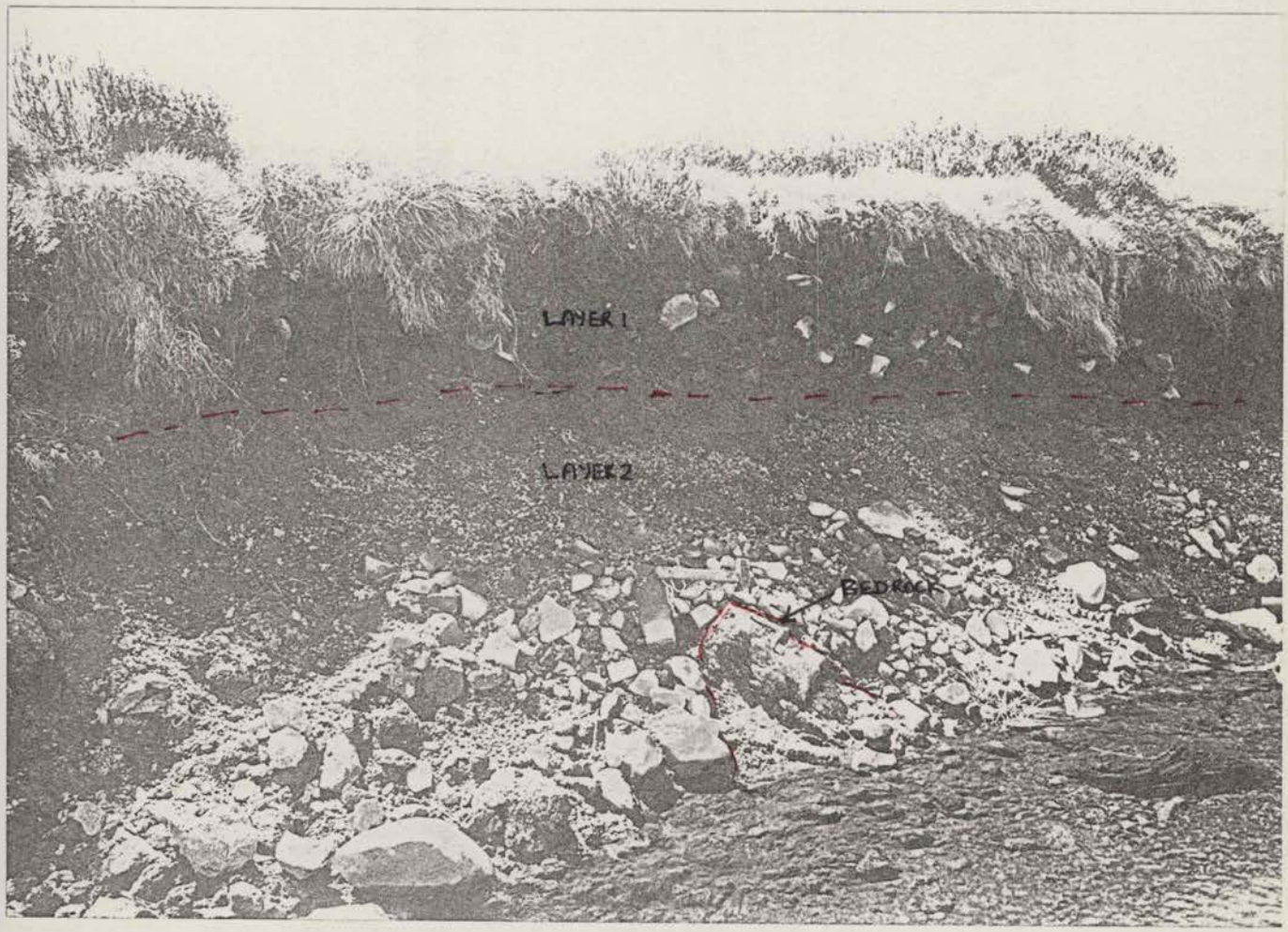
SITE NUMBER : 4 continued

Refer to photograph BH 18384F20

Layer 1 : 50cm to 60cm of close packed basalt blocks infilled with alpine humus.

Layer 2 : 30cm to 40cm of extremely weathered bedrock (regolith) mixed with cobbles of basalt near upper surface.

Layer 3 : Bedrock. Weathered gneiss (O-Sn) is exposed and visible below pick.



SITE NUMBER : 5
G.R. : 278167 Cope 1.25 999 NATMAP
ELEVATION : 1610m
ASPECT : South
GEOMORPHIC SETTING : Distal section of broad vegetated sheet of blocks (blockfield) sloping at approximately 10% and emanating from a drainage line out the southern scarp of Basalt Hill. The blockfield terminates below the aqueduct as a terrace with a riser $\leq$ 1m.

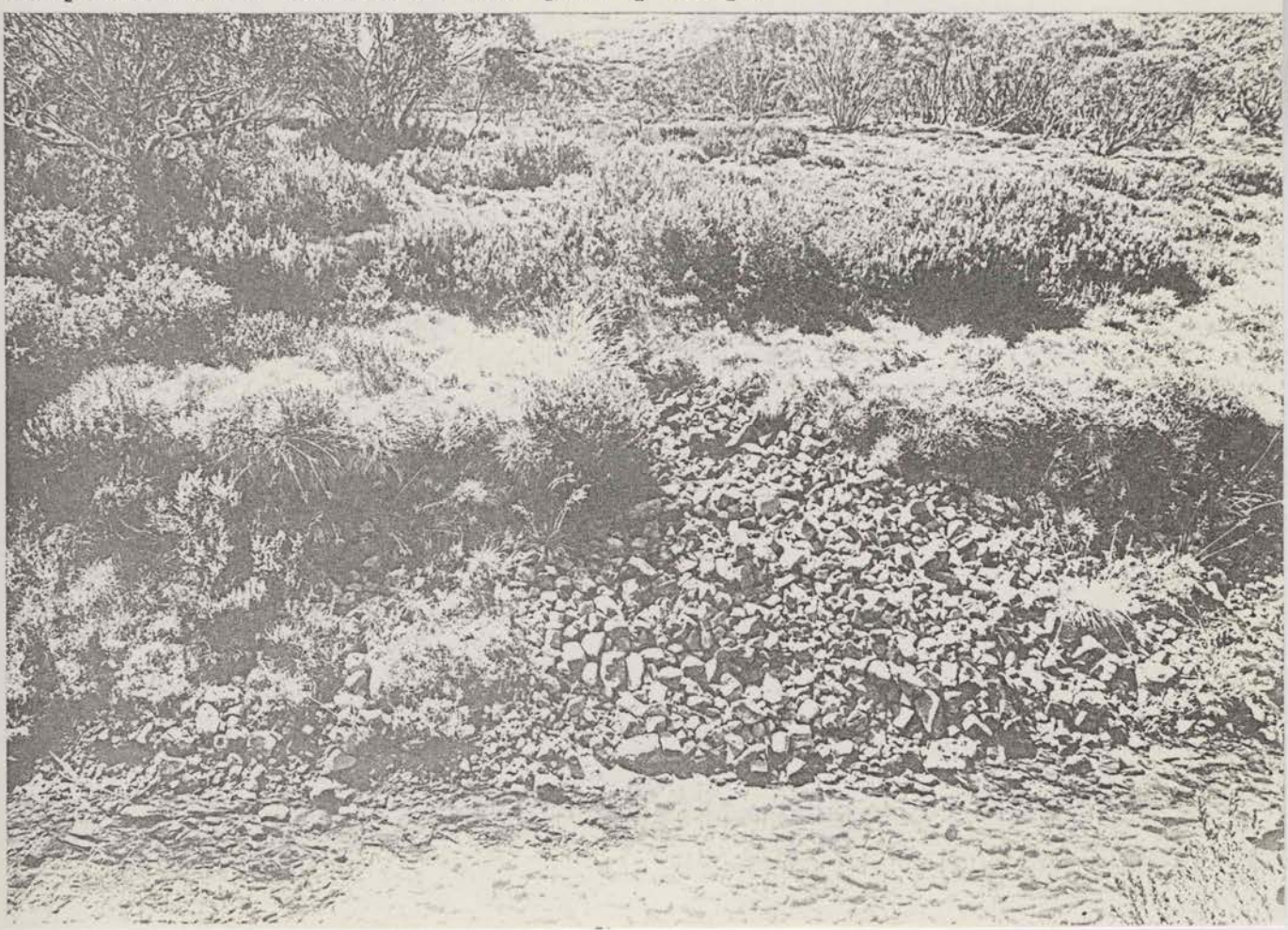
The surface of this south facing slope is striped. The downslope stripes are vegetation patterns visible on aerial photographs and they carry 500m south from the basalt scarp.

The exposure, partly illustrated in photograph BH 18384F21, reveals a mass of close packed basalt blocks over a width of 70, to 80m with a small drainage line in the central portion of the exposure.
VEGETATION : Open heath.

Layer 1 : 60cm thickness of loose blocks, infilled with alpine humus. The blocks are angular and relatively fresh with a thin weathering rind $\leq$1mm.

Layer 2 : basalt blocks and cobbles cemented by limonite. Basalt clasts in this saturated zone are more altered with conversion of all phenocrysts to red clay - variable thickness.

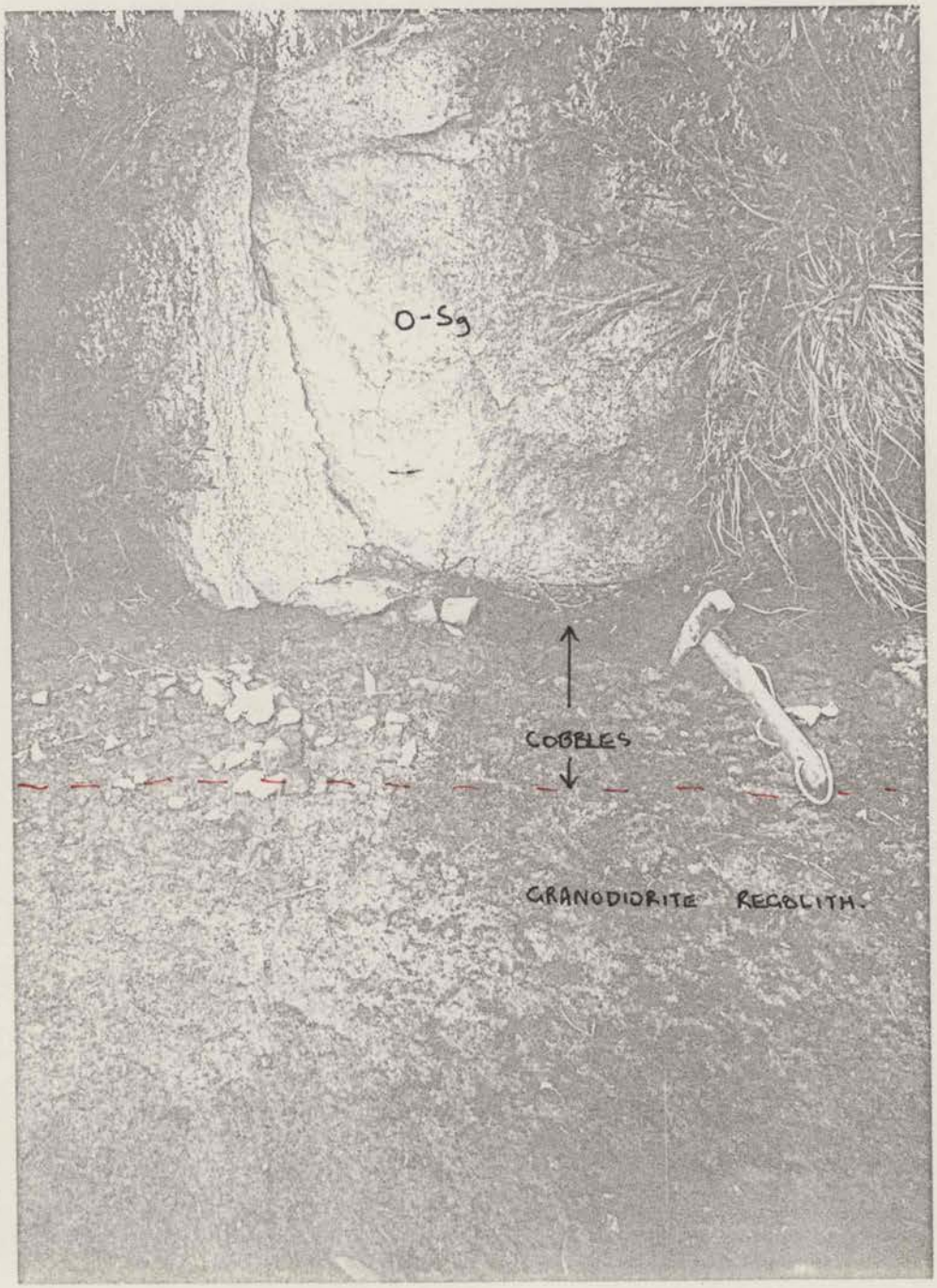
Comment : Bedrock not directly observed at this site but it is granodiorite (O-Sg). The thickness of the block layer tapers off away from the drainage line; and thereafter the blocks are dispersed in a matrix of red gritty clay.



SITE NUMBER : 6
G.R. : 279167 Cope 1:25 000 NATMAP
ELEVATION : 1610m
ASPECT : South
GEOMORPHIC SETTING : Gently sloping flank of a broad spur of granodiorite bedrock, with gradient approximately 10% towards the south.
VEGETATION : Open snow gum woodland, with open heathland ground cover.

Refer to photograph BH 18384F1

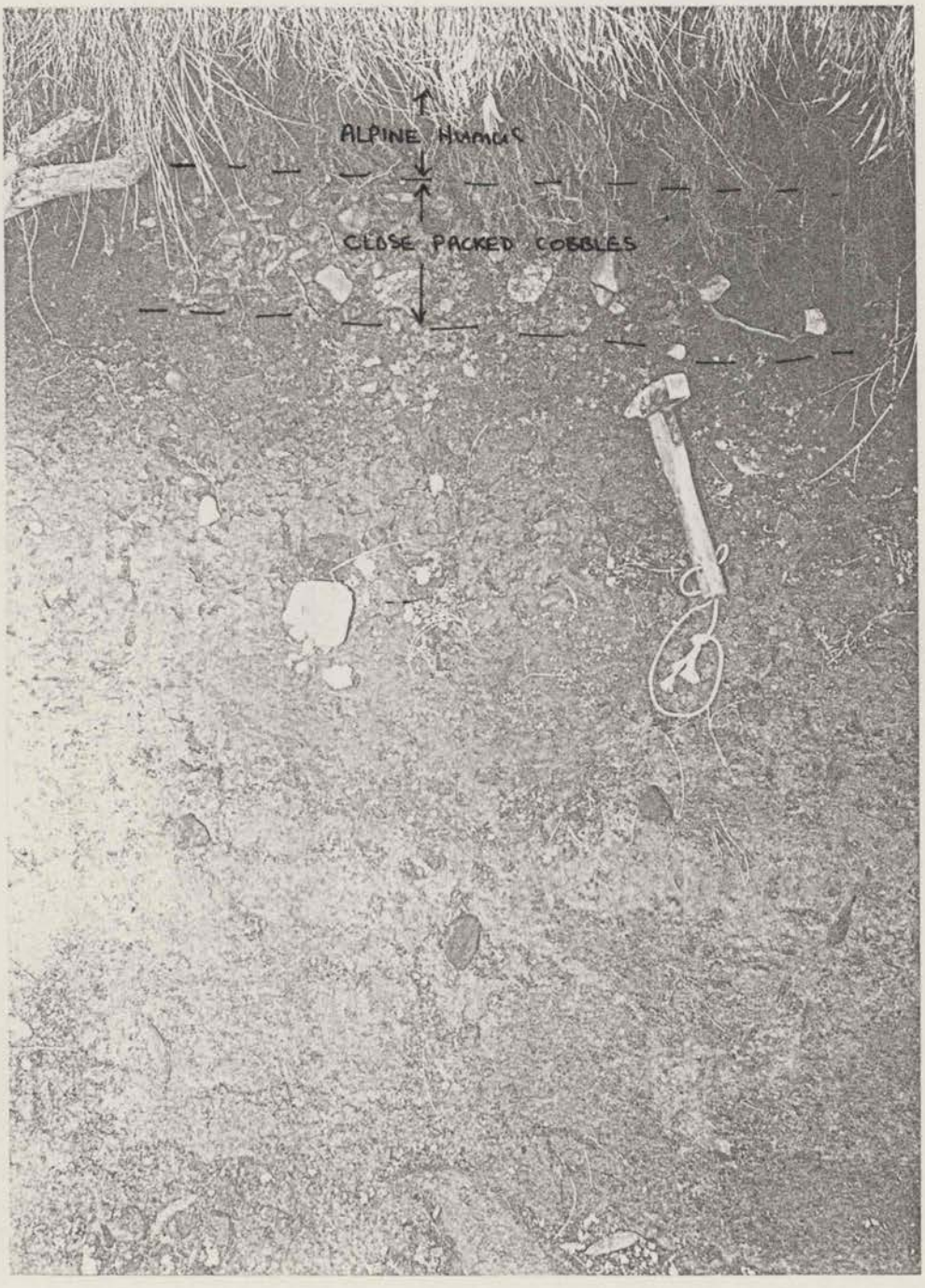
Large granodiorite block overlies a layer of cobbles (mainly basalt), approximately 30cm thick. Below this is a gravelly regolith. Below this, but not visible is extremely weathered granodiorite bedrock.



SITE NUMBER : 6 continued

Refer to photograph BH 18384F4

About 20 cm of dark alpine humus overlies a layer of close packed weakly stratified basalt/granodiorite cobbles with a gravelly sand matrix about 30 cm thick which overlies a layer of gravelly silty sand with dispersed cobbles, of thickness about 90cm with extremely weathered granodiorite bedrock below.

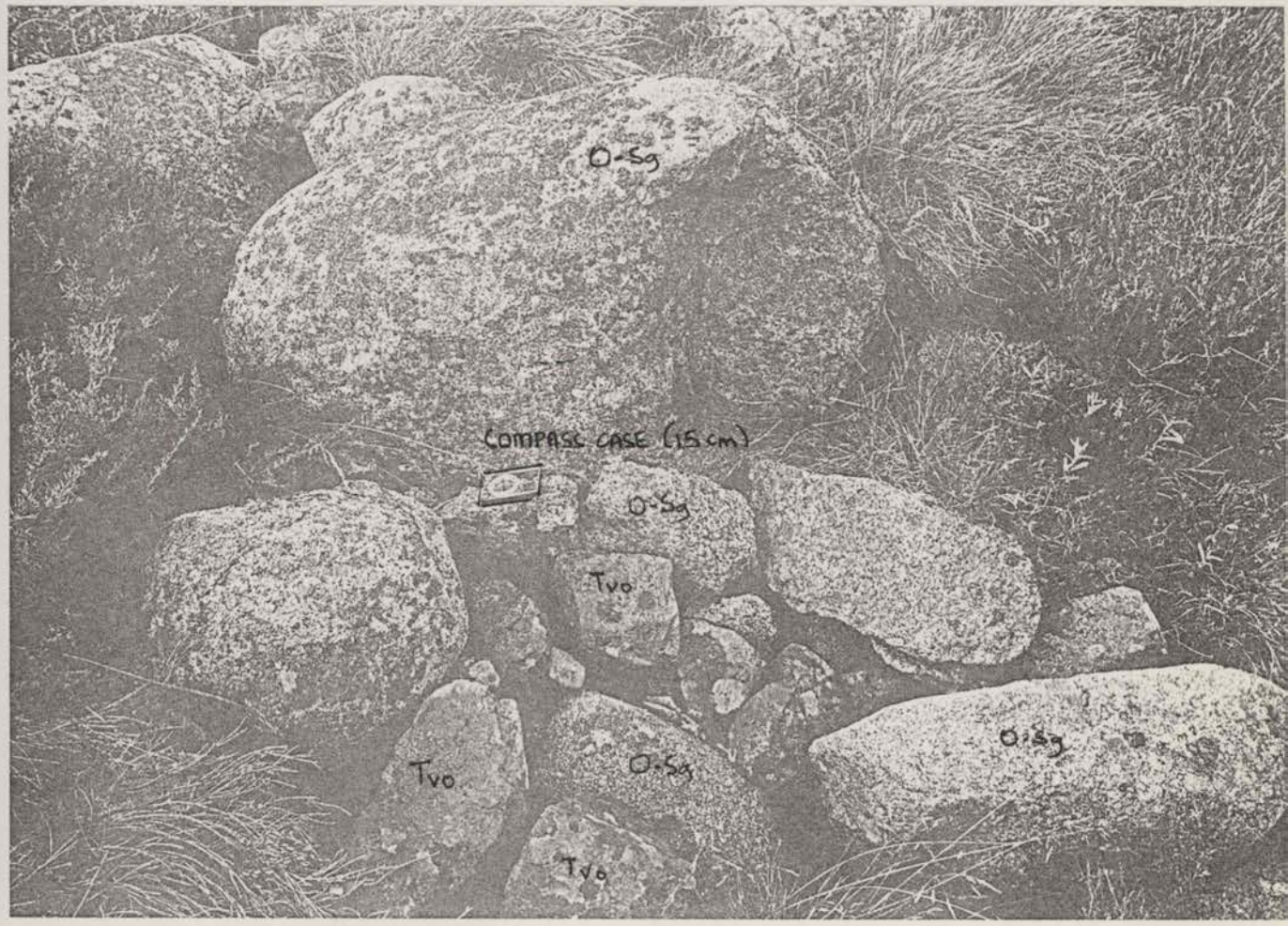


SITE NUMBER : 7
G.R. : 278165 Cope 1:25 000 NATMAP
ELEVATION : 1580m
ASPECT : South-south-east
GEOMORPHIC SETTING : Minor drainage line with a broad block field sloping approximately 15% towards the south-south-east.
VEGETATION : Open heath and grassland

Exposures in drainage line are illustrated in the following photographs.

Refer to photograph BH 3482F2

Large granodiorite blocks from 50cm to 100cm across, override and intermix with smaller basalt blocks.

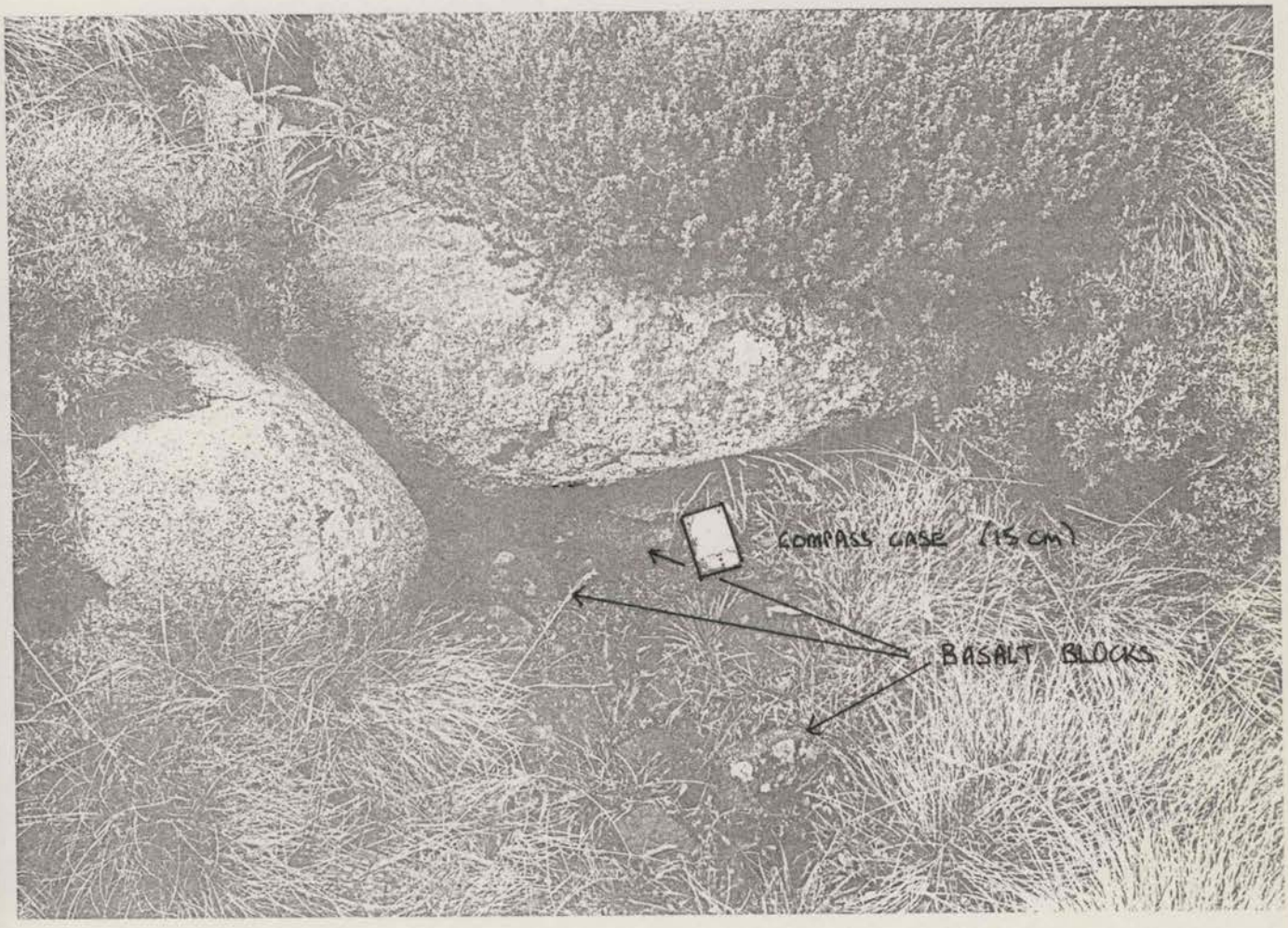


PHOTOGRAPH BH 3482F2

SITE NUMBER : 7 continued

Refer to photograph BH 3482F3

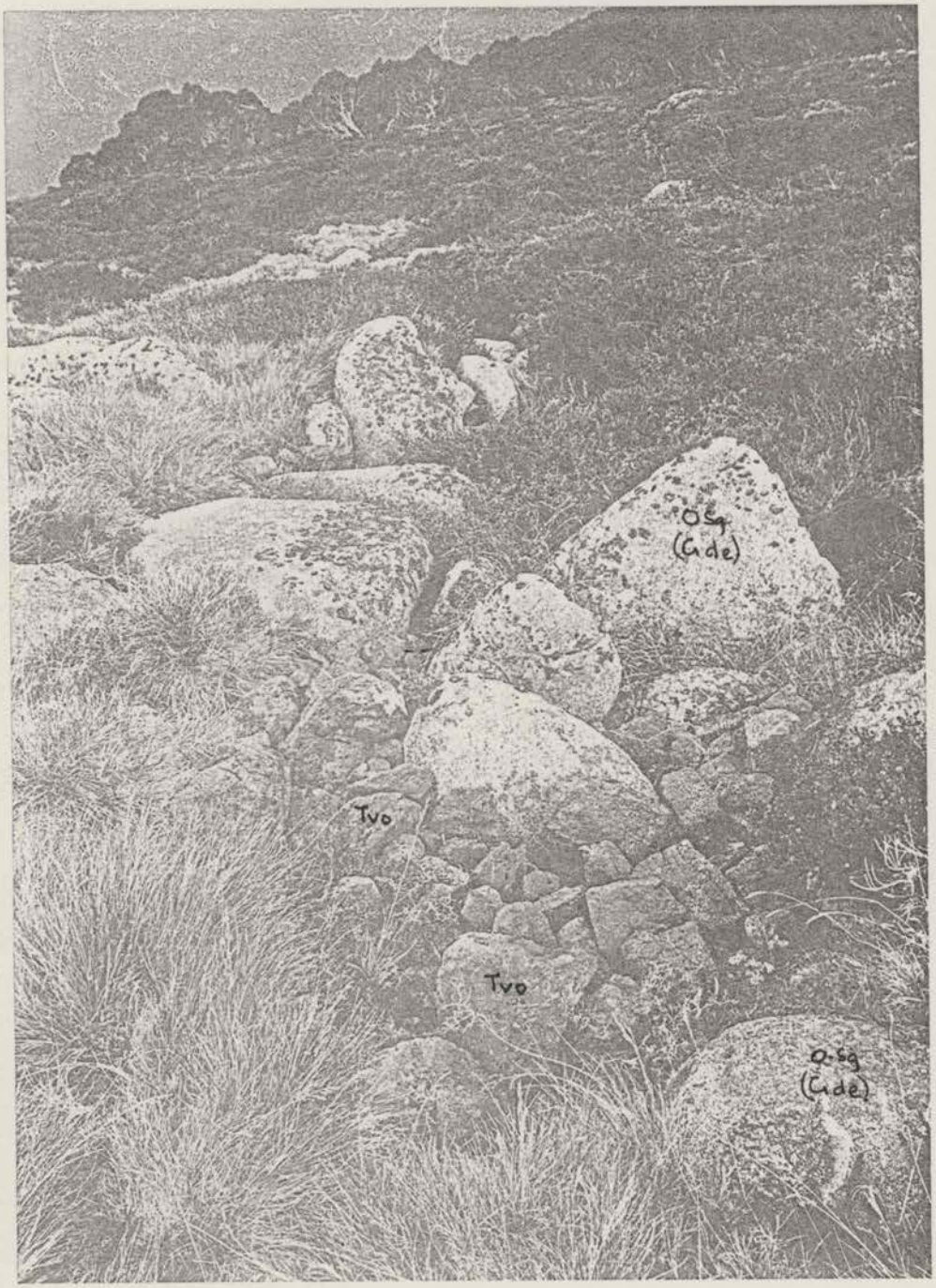
This photograph further demonstrates the mobilization of large granodiorite blocks which have overridden smaller close packed blocks of basalt.



SITE NUMBER : 7 continued

Refer to photograph BH 3482F4

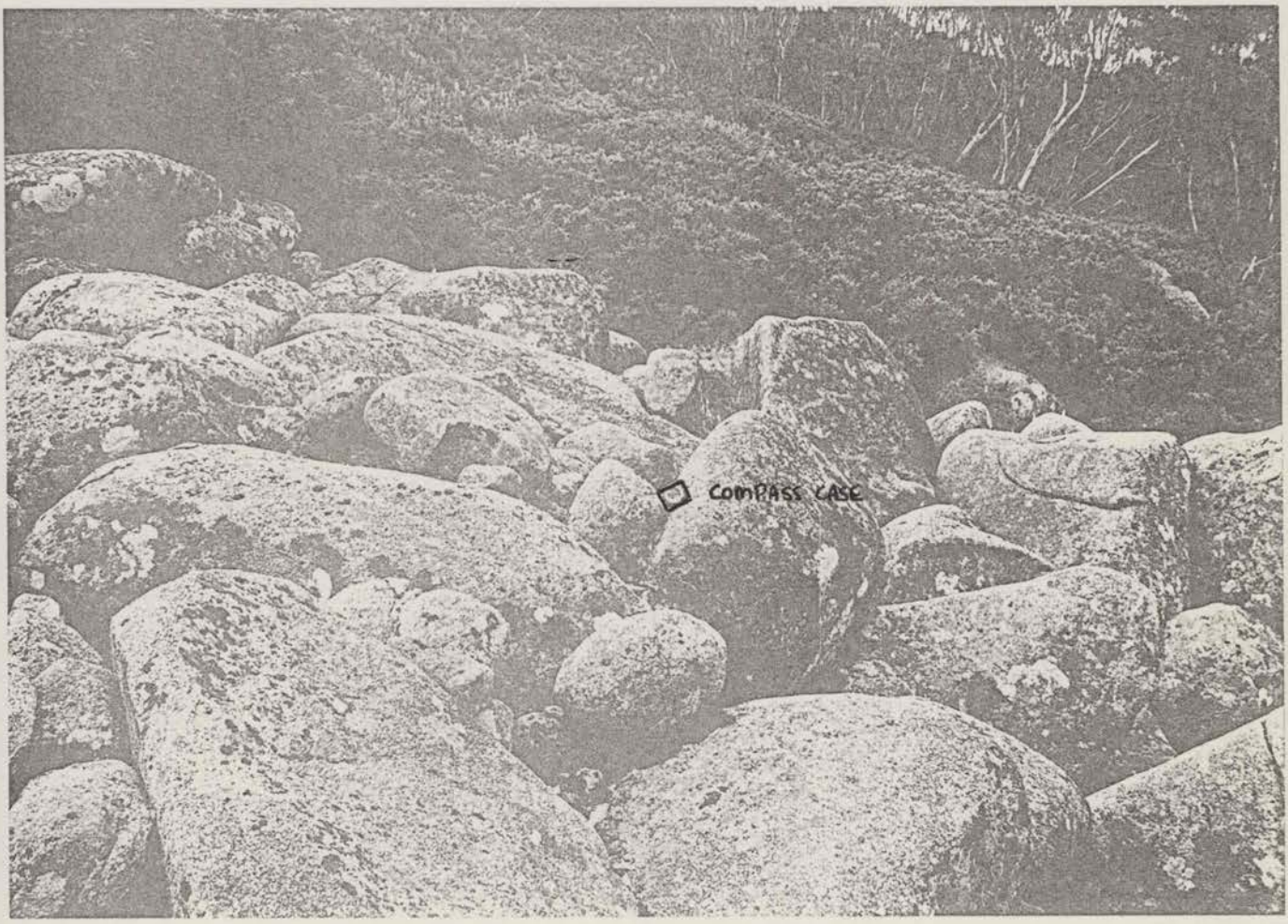
This photograph also demonstrates the intermixing of granodiorite and basalt blocks. The basalt blocks diminish in size and quantity further downslope.



SITE NUMBER : 8
G.R. 280164 Cope 1:25 000 NATMAP
ELEVATION : 1560m
ASPECT : South-east
GEOMORPHIC SETTING : Vegetated block slope, with gradient of 25%, and increasing downslope.
VEGETATION : Tall closed heathland, predominantly Podocarpus heath.

Refer to photograph BH 3482F8

This photograph demonstrates portion of the block layer in this block slope. The blocks are almost entirely granodiorite, with maximum dimensions of approximately 2m. The compass case is 15cm. The blocks have an imbricate texture suggesting a fluid transport, during the latter part of their mobilization. Thickness is not readily determined but is estimated at approximately 2m. Bedrock was not observed, but it could be O-Sg or O-Sn.



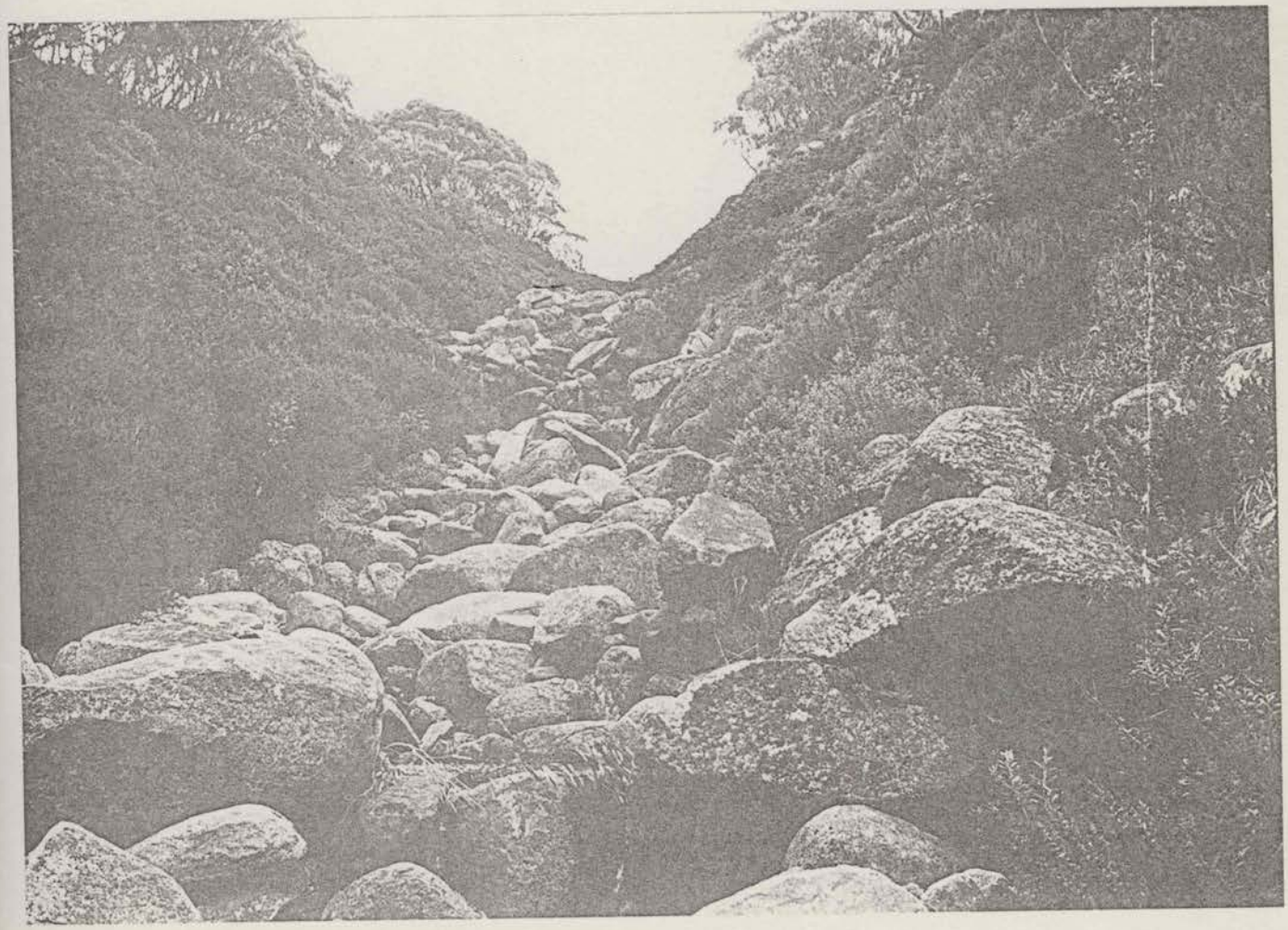
PHOTOGRAPH BH 3482F8

SITE NUMBER : 9
G.R. : 280163 Cope 1:25 000 NATMAP
ELEVATION : 1560m
ASPECT : South-east
GEOMORPHIC SETTING : Deeply incised reentrant below nick point in creek draining south-east from Wallaces Gap.
VEGETATION : Tall closed heathland and open snow gum woodland.

Refer to photograph BH3482F11

This photograph demonstrates partial infilling of the creek, adjacent to blockslope. Block accumulation in creek may post date emplacement of blockslope and may be due to undercutting of the blockslope by the creek during the Holocene. The deposit of blocks in the creek differs from cryogenic "blockstreams" in that most cryogenic blockstreams have positive relief with respect to the adjoining terrain.

This creek section also demonstrates that the blockslope is a veneer of large blocks $\leq$ 2m thickness, but details of the substrate were not discernible.



PHOTOGRAPH BH 3482F11

SITE NUMBER : 10
G.R. : 278170 Cope 1:25 000 NATMAP
ELEVATION : 1640m
ASPECT : South-south-west
GEOMORPHIC SETTING : Linear accumulation of basalt blocks forming a short, sharp rampart (< 1m relief) at its distal margins. The block accumulation is located within a drainage line which dissects the basalt scarp on the south side of Basalt Hill. Snow patch zones occur adjacent to this block accumulation as deep snow accumulates against the south and south-east facing escarpments.

Refer to photographs : BH 482F5, BH 482F6, BH 1083F1, BH 1083F2, BH 1083F8 and Fig 2Ac.

VEGETATION : Surrounding vegetation is grassland and open heath.

STRATIGRAPHY : The block accumulation has a sharply defined margin around most of its perimeter and overall has a slightly raised relief relative to the adjacent terrain. The margins form steep ramparts with relief of 1m to 2m where the block accumulation has encroached against the drainage line. This feature is noted on the plane table plan, Fig 2Ac.

The surface of the block accumulation has 2 sets of conical and linear depressions which range in depth from 60cm to 100cm. The absence of these pits below the A-B line across the feature suggests some mass movement has taken place after emplacement of the blocks. There is a slip-like feature revealed in the longitudinal section through this portion of the block accumulation, below the A-B line. It is possible that the mass of blocks has slipped on or with its substrate down a natural step in the topography.

The longitudinal section also reveals that the terrain along the drainage line is steplike with benches, probably of bedrock, sloping at 6° to 10° with short risers between the benches sloping 20° to 30°. The adjacent bedrock has basal joints dipping 30° towards 210° GB and vertical joints along 030° GB. The block accumulation is only a veneer of depth 1m$\pm$ 0.5m. The substrate beneath was sampled near the toe and appears to be an orange brown, clayey, silty gravel with a significant proportion of basalt cobbles. Similar material occurs as layer 2 beneath alpine humus top soil behind and above the adjacent snow patch zone to the west of this feature.

The size of the basalt blocks is similar to the columnar blocks in adjacent basalt bedrock, with columns 10cm to 20cm across and basal fractures 10cm to 30cm apart. The blocks have not altered much since emplacement as their edges show little or low curvature and they have a weathering rind < 0.5mm thick. Blocks have a pitted surface texture due to weathering and removal of olivine phenocrysts. Strong alteration of olivine was evident up to 5mm below the surface of basalt blocks.

The blocks in the block accumulation at site 10 are fairly uniform, competent blocks. Micropetrological analysis of one block from site 10 indicates that it is very similar in

composition, fabric and degree of alteration to insitu basalt sampled in layers 1, 2, and 3 on Basalt Hill, being samples BHL1, BHL2 and BHL3. The rock appears to be a limburgite with dominantly euhedral to subhedral olivine phenocrysts up to 3mm in a matrix of fine plagioclase laths intergranular olivine and a very fine groundmass of olivine, augite, plagioclase, magnetite and dark brown intersertal glass (palagonite). The olivine phencrysts show alteration along subparallel fractures to Iddingsite and some olivine phenocrysts appear to have central portions occupied by antigorite. The sample at site 10 also has isolated spherulitic xenoliths or xenocrysts of olivine, magnetite surrounded by volcanic glass. The fine laths of plagioclase show little alteration in all samples examined.

The fine grained intersertal fabric of this basaltic material and its location in an open block accumulation above groundwater probably accounts for the minimal physical and chemical change to the blocks since their emplacement. It also suggests that the blocks within the block accumulation at site 10 have never been buried or filled by a fine grained mineral matrix, as this would have accelerated chemical alteration. Examples of accelerated chemical weathering are evident in the basalt clasts of layer 2 at site 5, where the whole mass of the cobbles is extremely altered and can be broken with the fingers.

The original matrix, if any, may have been ice, or ice lenses may have formed beneath portions of the block accumulation as patchy permafrost which later melted and produced the conical pits and linear depressions which are now relics. Refer to Fig 2Ae and the photographs. The view points of the photographs relative to the block accumulation are marked on Fig 2Ac, Plane Table Plan.

Although the block accumulation at site 10 appears to be a discrete linear feature in the drainage line, it is possible that this feature is a composite feature resulting from the accumulation of blocks at the distal margins of permanent snow patch zones located in the flanks of the drainage line and against the adjacent basalt scarp. This concept is illustrated in a locational sketch as part of Fig 2Ac. Seasonal snow patches occur today on the western side of the block accumulations, as evidenced by photographs : BH 1083F1, BH 1083F2 and BH 1083F8.

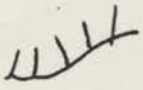
However, there is little or no current block movement in the block accumulation or in the adjoining basalt scarps, as evidenced by the lichens covering the upper surfaces of all blocks including bedrock in the vicinity. Furthermore, the adjoining terrain is well vegetated at present and the sheets of cobbles and blocks which were mobilized downslope in the past now occur as layer 2 beneath an alpine humus. Also, freezing of the ground surface is limited in the present climate to the top 10cm to 15cm and that is only apparent in the bare stony pavements near the summit of basalt Hill.

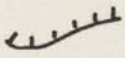
It is envisaged that the sheet of basalt blocks and cobbles which extend about 1km south of the the basalt outcrop at site 10 was moved by slow gradual frost heave mechanism. Blocks have been selectivley retained in the vicinity of snow patch

zones to produce features such as the block accumulation at site 10 which in my opinion is a composite block glacis. Photographs BH 482F5 and BH 482F6 further demonstrate the distribution of this block glacis. The steep ramparts within this feature are adjacent to seepage lines, as depicted in the plane table plan and these seepage lines may have removed a snow/ice matrix within the blocks, thereby increasng the internal friction and halting any creep of the block accumulation from the adjoining snow patch zones, during the period of accumulation.

Fig 2Ac LEGEND
Legend for Plane Table Plan of Block Accumulation at Site 10 and Accompanying Longitudinal and Transverse Sections.


Outline of block accumulation


Steep rampart


Convex rim


Conical pit


Linear pit

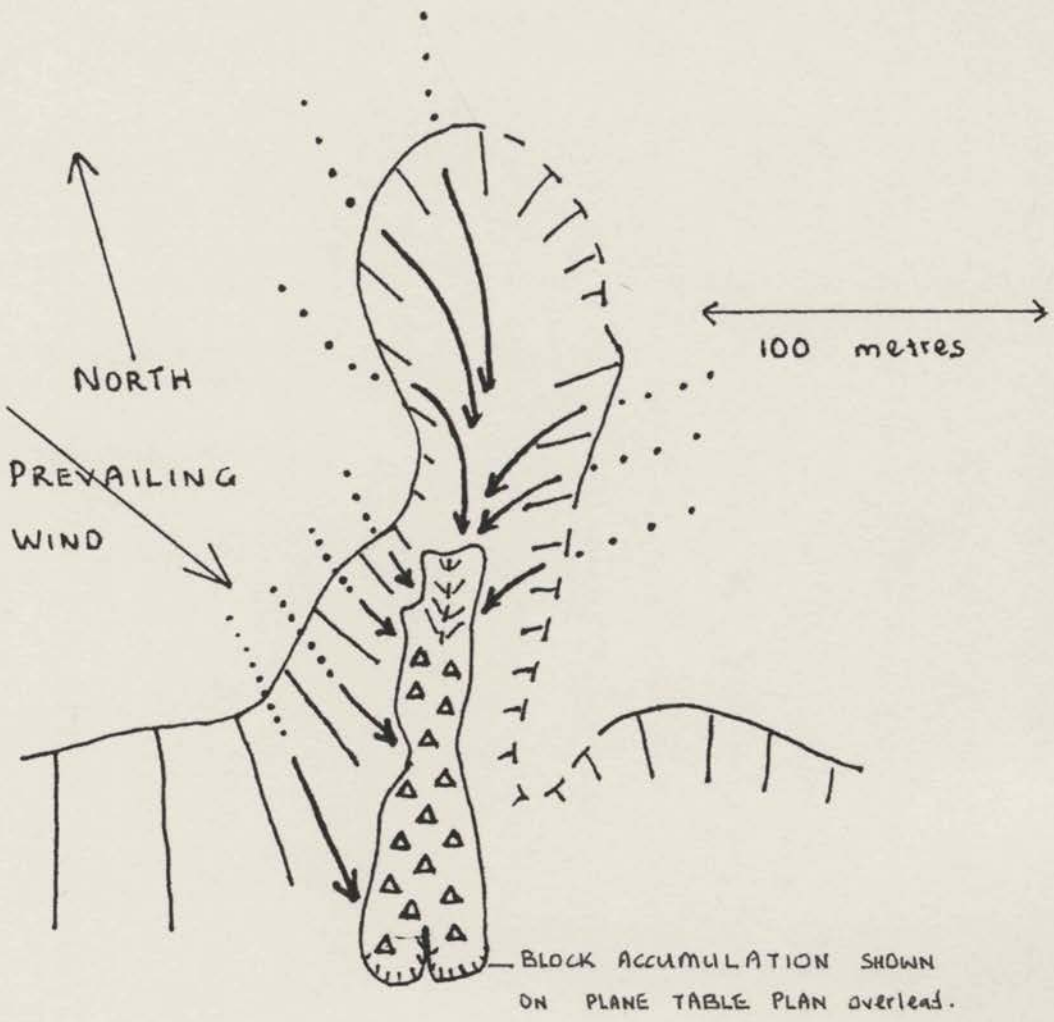

Drainage line


Open structured block accumulation


Viewpoint of photograph as numbered (n).

SITE NUMBER : 10 continued

Fig 2Ac LOCATIONAL SKETCH of Site 10.



Legend for Fig 2Ae Locational Sketch of Site 10.

Well defined scarp

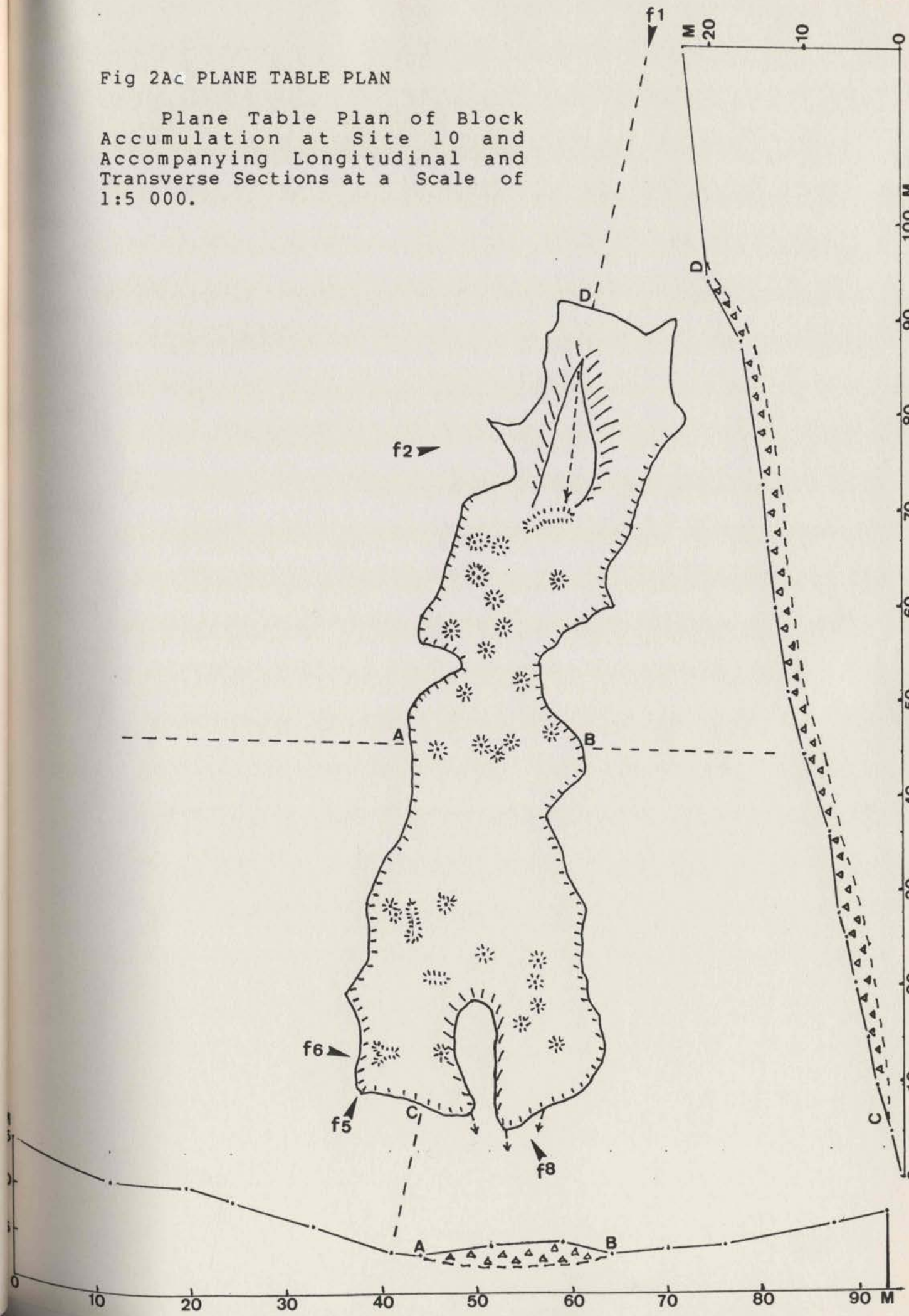
Gradual change in slope

Block accumulation

Probable paths of block mobilization

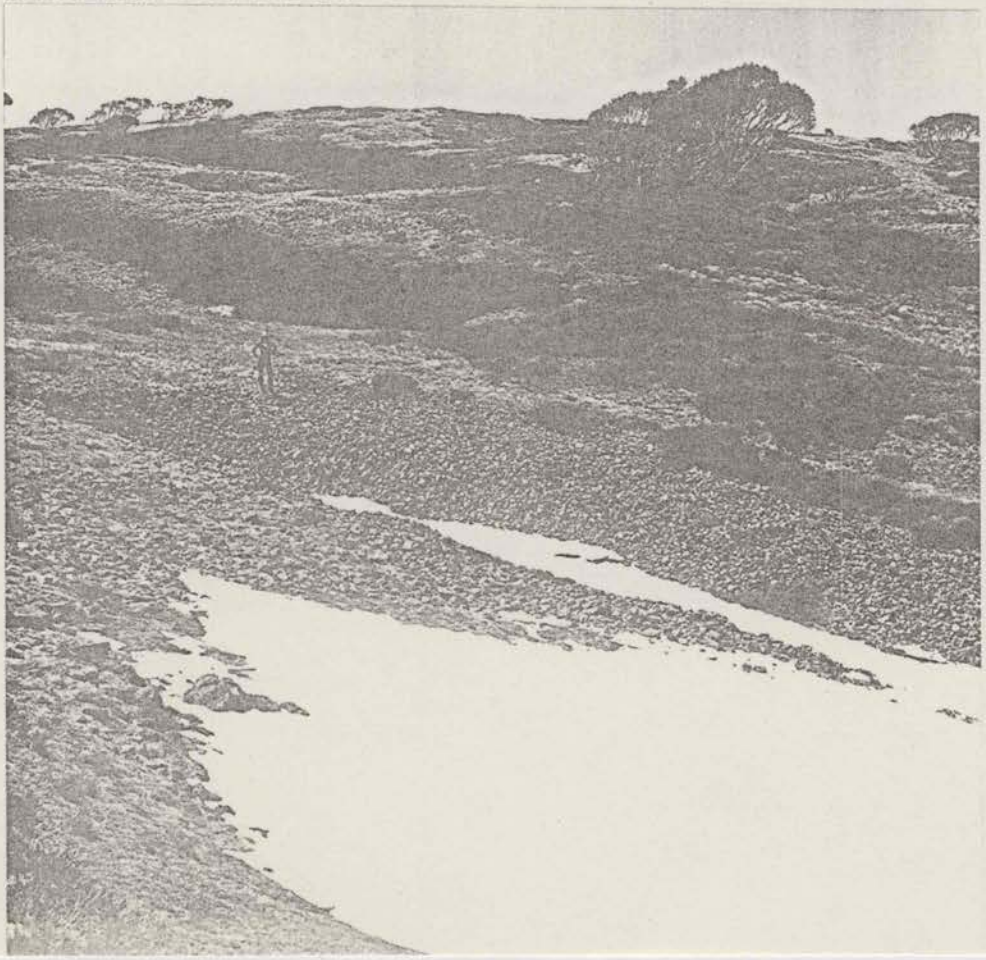
Fig 2Ac PLANE TABLE PLAN

Plane Table Plan of Block Accumulation at Site 10 and Accompanying Longitudinal and Transverse Sections at a Scale of 1:5 000.

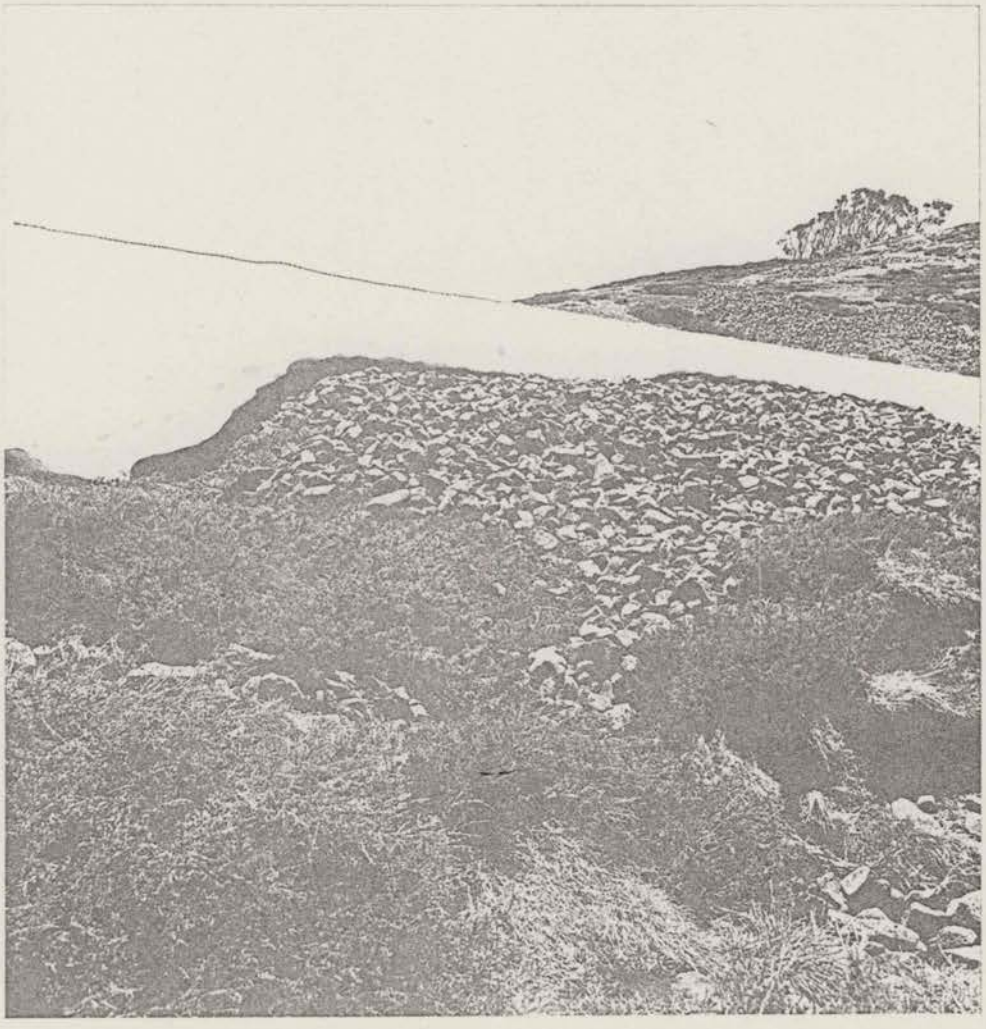


SITE NUMBER : 10 continued
PHOTOGRAPHS BH 1083F1 (top) and BH 1083F2 (bottom)

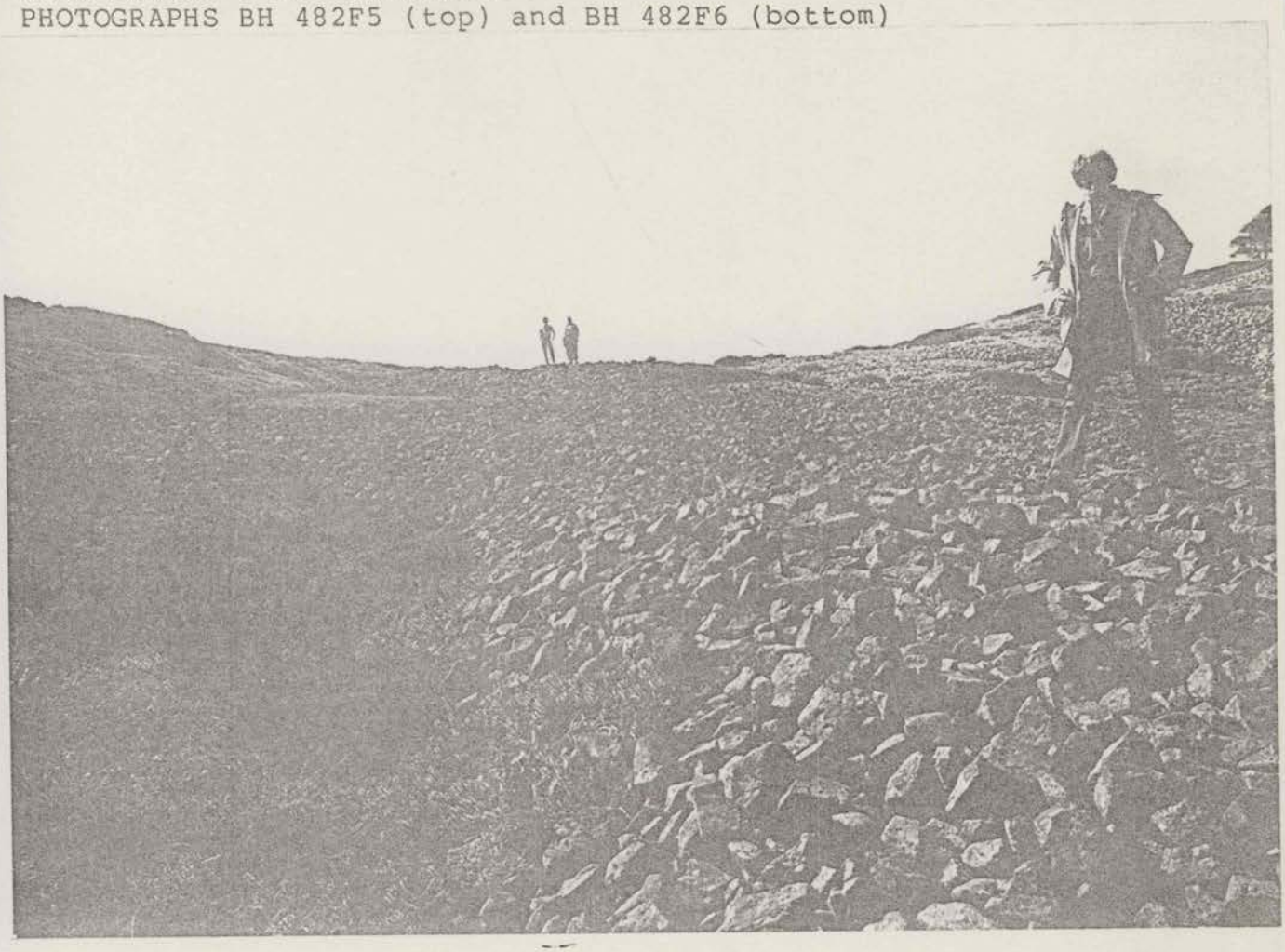


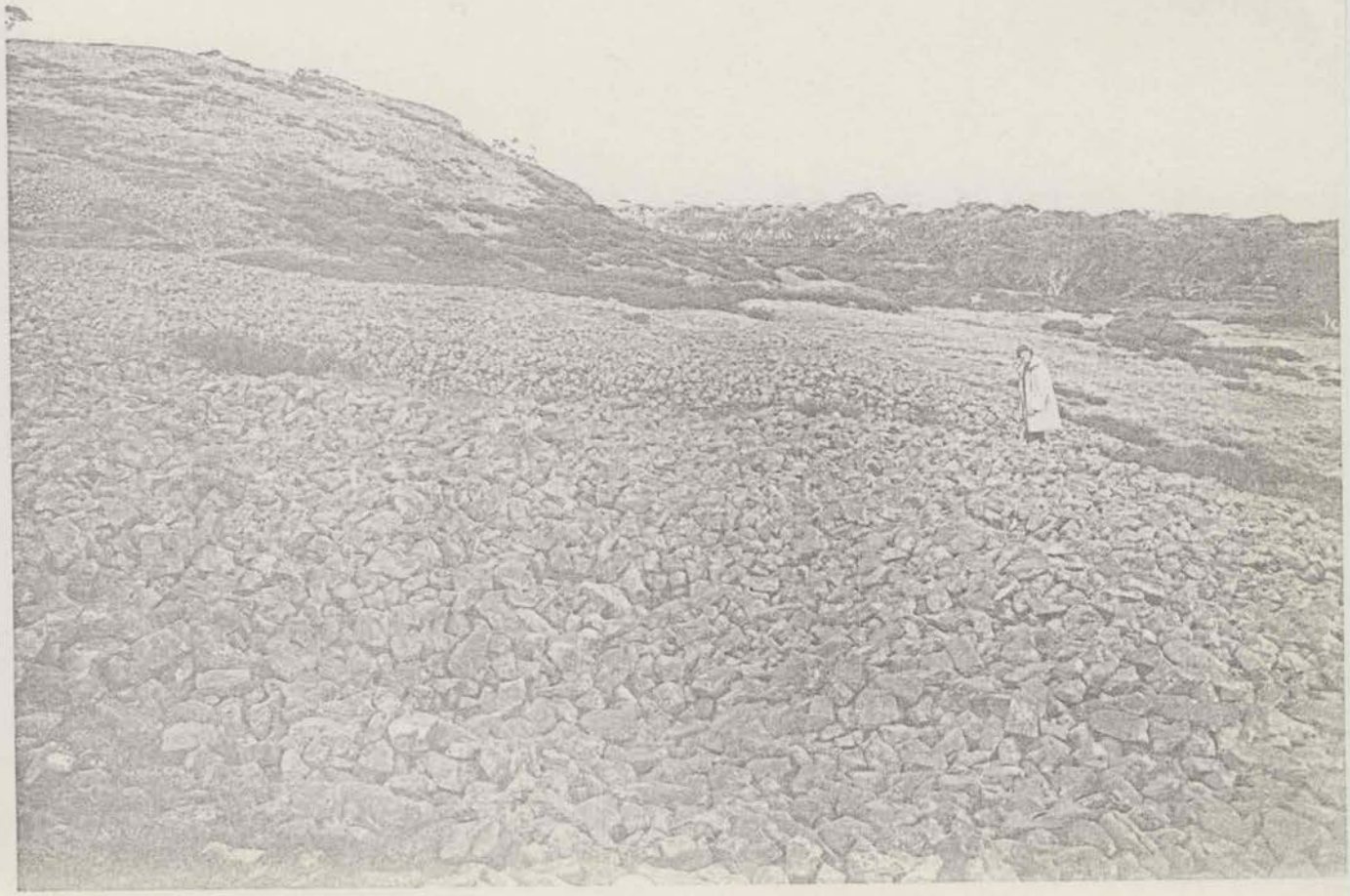


SITE NUMBER : 10 continued
PHOTOGRAPH BH 1083F8



SITE NUMBER : 10 continued
PHOTOGRAPHS BH 482F5 (top) and BH 482F6 (bottom)

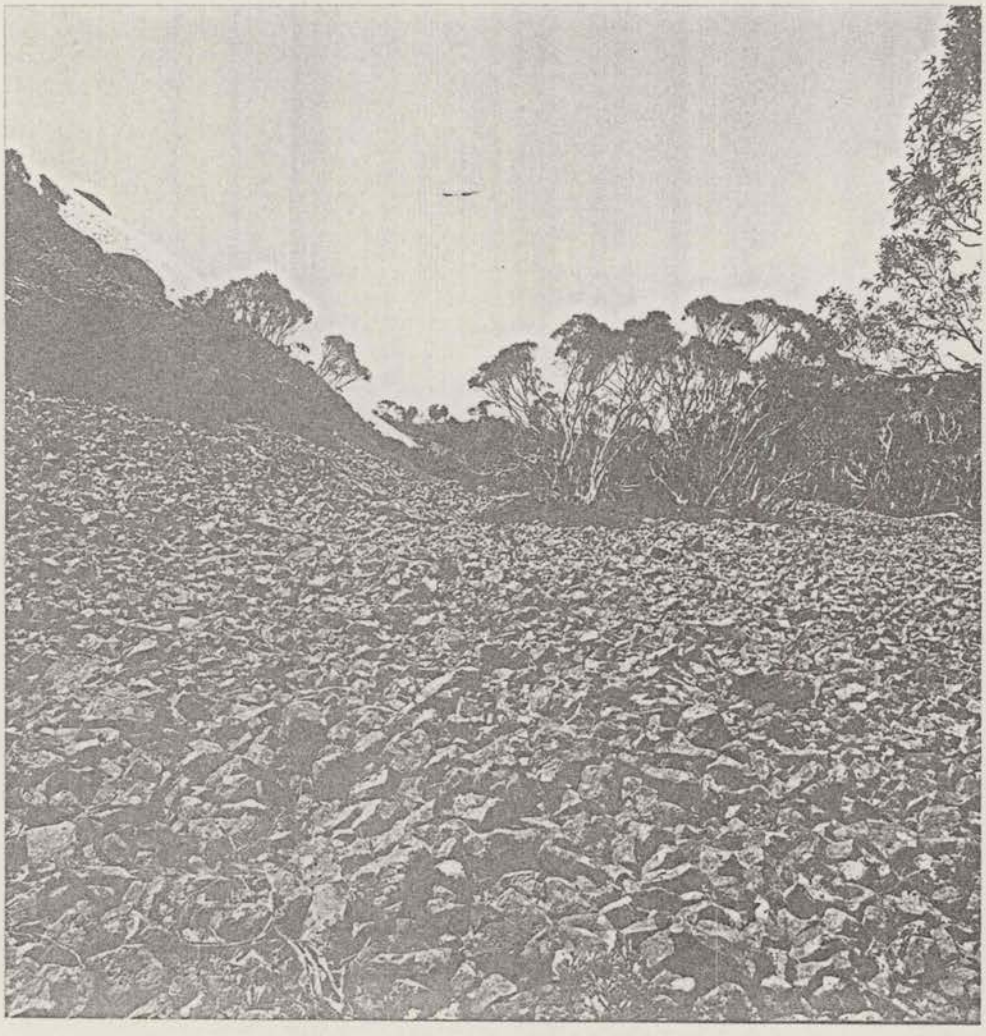




SITE NUMBER : 11
G.R. 280170 Cope 1:25 000 NATMAP
ELEVATION : 1640m
ASPECT : South-south-east
GEOMORPHIC SETTING : A near level accumulation of basalt blocks fringing the margins of the basalt scarp. This feature could be described as a block glacis.
VEGETATION : The block glacis is essentially unvegetated, except for lichens and some snow gums, with tall heath at the fringes.
COMMENT : Site 11 is marked on Fig 2Ab as a block accumulation.

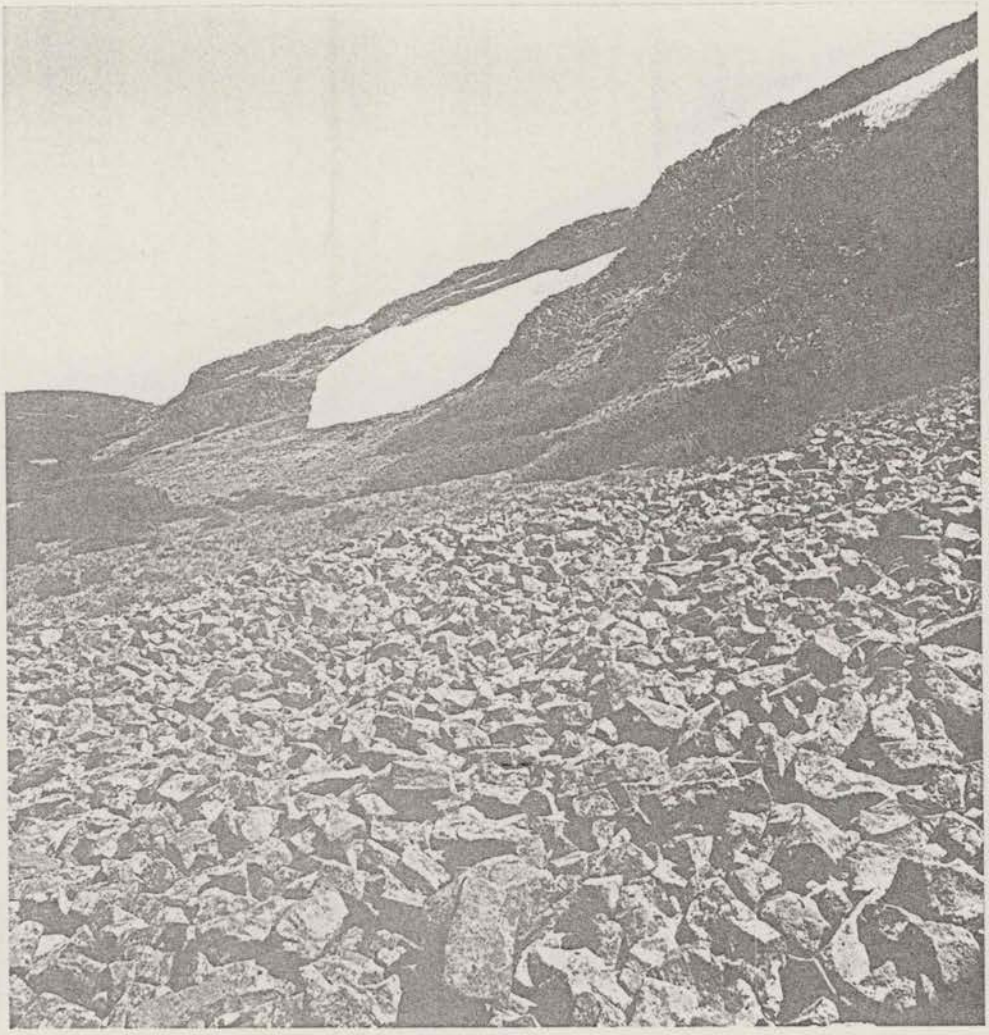
Refer to photograph BH 1083F10

This photograph views site 11 from its southern margin in a north-east direction parallel with the long axis of the accumulation and the basalt scarp. Dimension of site 11 block glacis are approximately 100m x 40m. A late spring residual snow bank can be seen against the basalt scarp to the north of site 11. It also has a south-east aspect. The block accumulation at site 10 forms a level deposit marginal to the foot of the basalt scarp, which is very different from normal talus. The block accumulation is also peppered with conical pits and shallow depressions (thermokarst), similar to site 10. The deposit terminates at its distal margins in a well defined ramp with less than 1m relief.



SITE NUMBER : 11 continued

PHOTOGRAPH BH 108F9



SITE NUMBER : 11 continued

Refer to photographs BH 1083F11 and BH 1083F9

Photograph BH 1083F11 is taken from below the distal margin at eye level with the upper surface of the block accumulation and facing north-west towards the basalt scarp. The level surface and distinct marginal ramp in the foreground of this photograph are evident. There is a thin veneer of scree over the steeply sloping bedrock scarp which has about 30m relief. The attitude of the scarp is controlled by jointing as revealed in photograph BH 1083F9; which looks south-west from site 11. The basal jointing in the basalt scarp dips approximately 30° to 40° towards the south.



SITE NUMBER : 11 continued

Refer to photograph BH 1083F12

A few large slabs of basalt have rolled off the edge of the scarp in recent time as evidenced by photograph BH 1083F12 where a chunk about 2m long and 1.5m thick rests on the block accumulation after having rolled down the scarp. It was probably loosened by weathering along basal joints and vertical megajoints. This massive chunk is in contrast to the uniform mass of small blocks beneath it and further illustrates that frost wedging of individual basalt columns is not a competent process in the present climate.

PHOTOGRAPH BH 1083F12

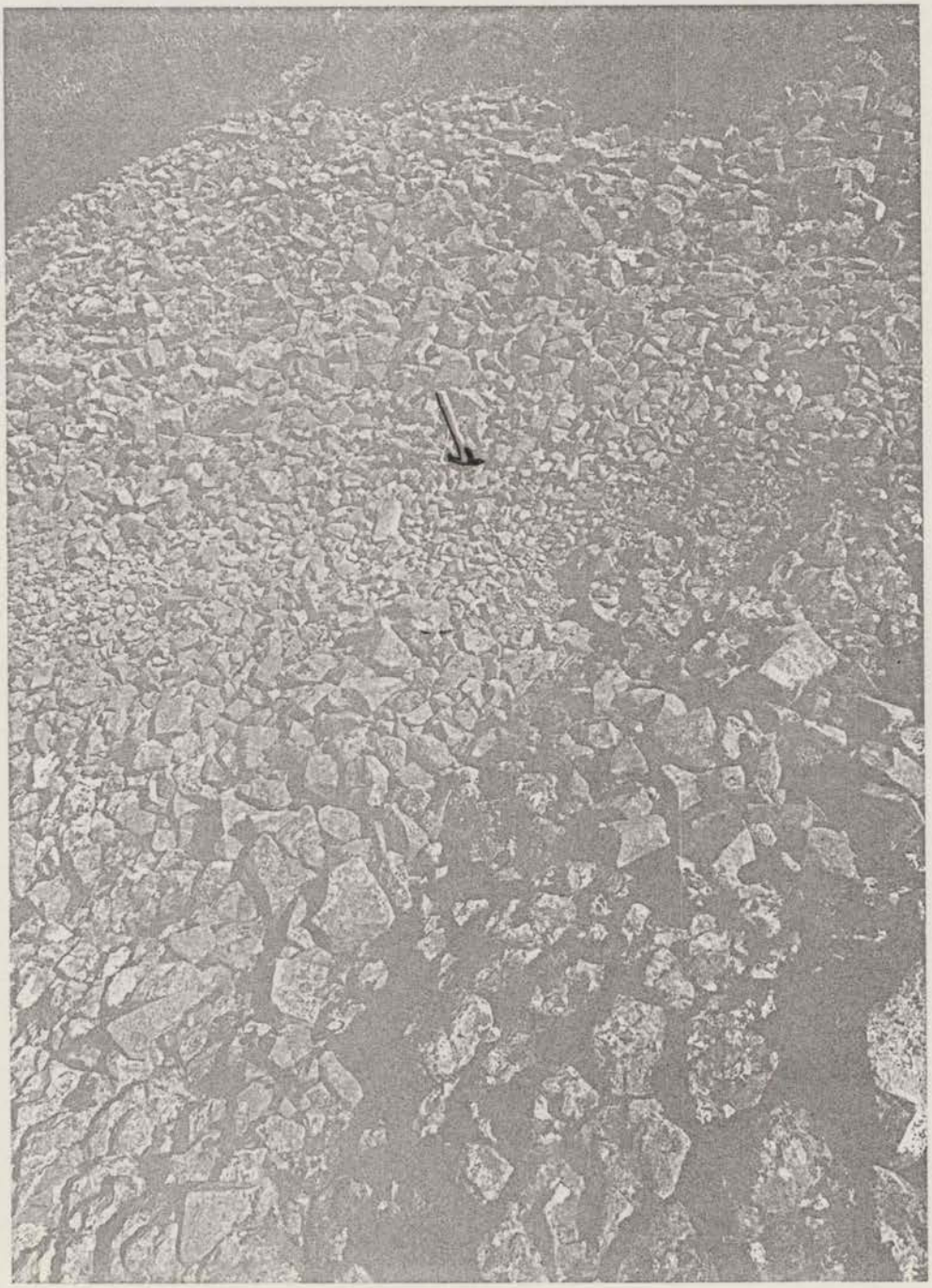


SITE NUMBER : 11 continued

Refer to photograph BH 3384F2

There is some evidence of shallow frost sorting. Photograph BH 3384F2 illustrates a line of basalt cobbles within a veneer of basalt blocks on the scarp above site 11. The hammer demonstrates scale. Solid outcrop occurs in the lower right hand corner of this photograph.

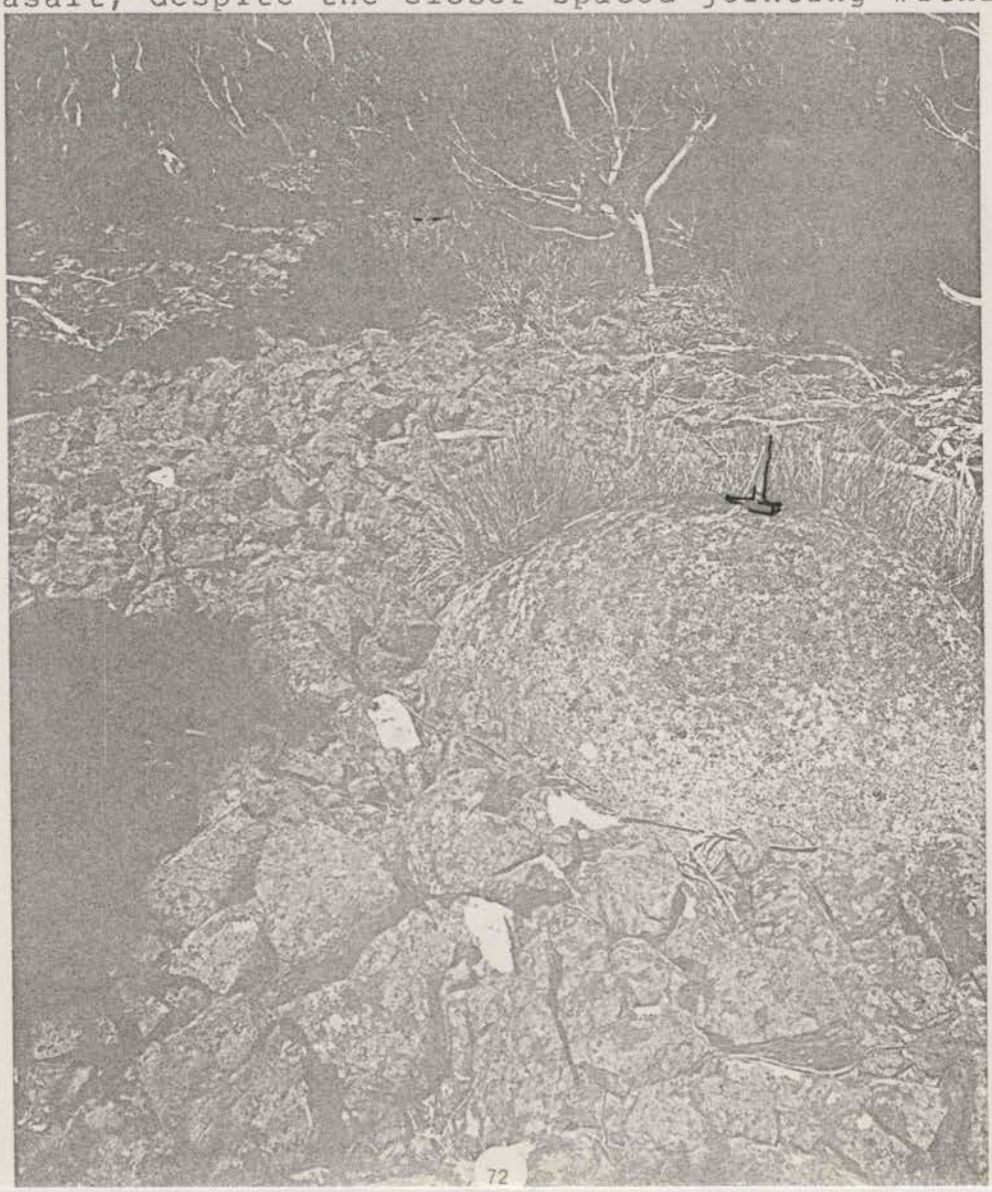
BH 3384F2



SITE NUMBER : 12
G.R. 281169 Cope 1:25 000 NATMAP
ELEVATION : 1610m
ASPECT : South-east
GEOMORPHIC SETTING : Partially vegetated blockfield on a 10% to 20% slope.
VEGETATION : Tall closed heath and open snow gum woodland

Refer to photograph BH 3384F3

This photograph demonstrates the character of this type of block accumulation. It is a close packed veneer of relatively uniform, competent basalt blocks over granodiorite bedrock. The large rounded tor with the hammer perched on top is granodiorite and it may be a loose tor or insitu bedrock. There is no evidence of thermokarst near this site which suggests more downslope movement for the blockfield accumulation compared to the relatively static block glacis at sites 10 and 11. The degree of rounding of the granodiorite is in contrast to the angular basalt blocks which have retained their joint faces with only a small degree of rounding at the edges. This contrast in block habit between the granodiorite and basalt is most probably related to crystal fabric in the parent rock. The coarse intergranular texture of the granodiorite allows a faster rate of chemical alteration of the rock mass than the fine grained, glassy basalt, despite the closer spaced jointing within the basalt.



SITE NUMBER : 13
G.R. : 284167 Cope 1:25 000 NATMAP
ELEVATION : 1510m
ASPECT : South-east
GEOMORPHIC SETTING : Upper portion of steeply sloping block accumulation on a concave portion of slope ranging from 50% gradient at top to 20% near lower margin.
VEGETATION : The surface of the block accumulation is mostly unvegetated.

Layer 1 : This block accumulation could be classifed as a block slope. It is situated within a drainage line and could also be described as a blockstream except that its gradient is steeper than generally accepted. This block accumulation has infilled the drainage line below a major step in the topography. Talus deposits generally form below large bedrock scarps but this deposit begins just below a flattening of the local terrain.

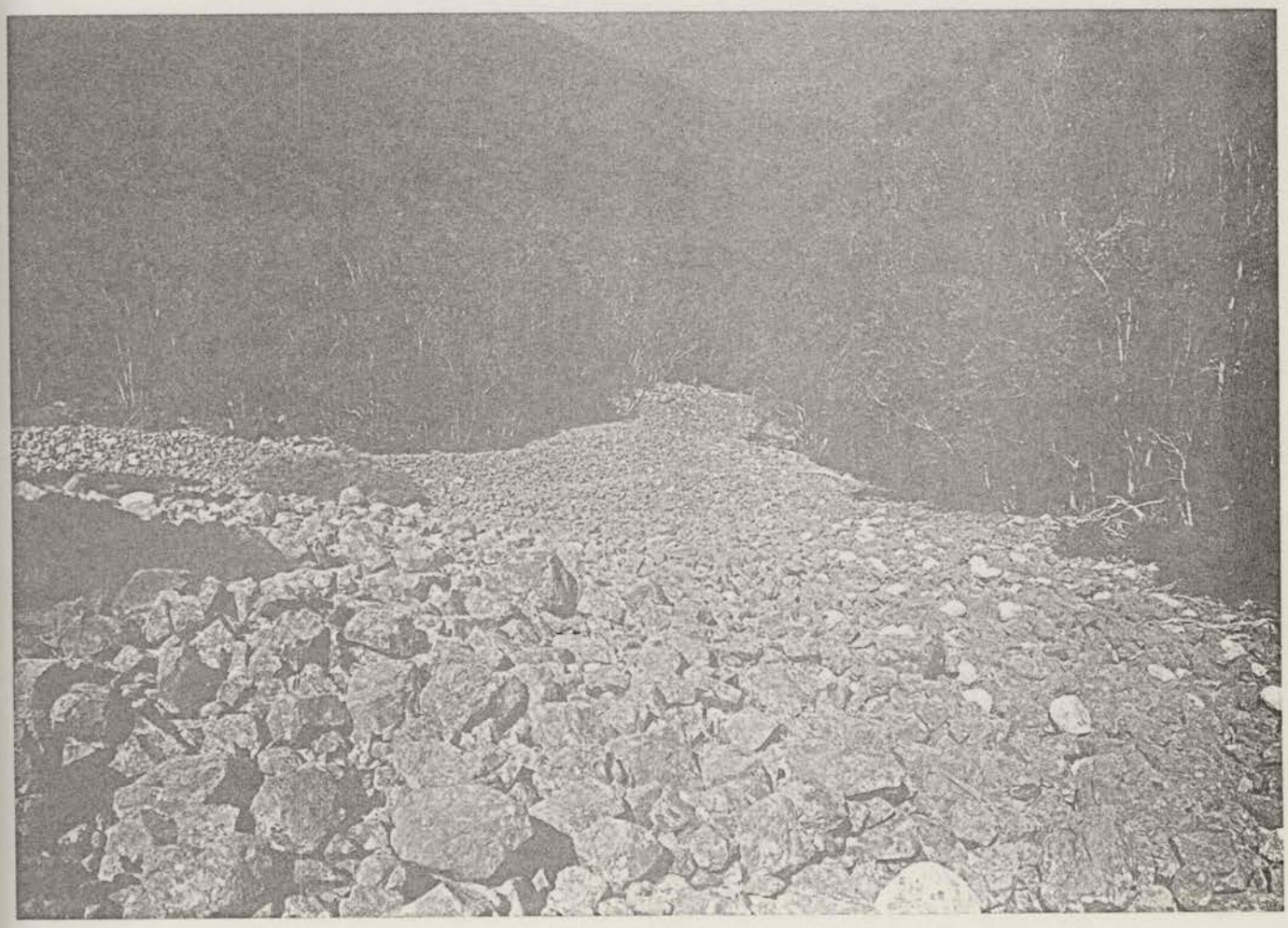
Refer to photograph BH 3384F6

This photograph looks downslope from site 13 down approximately 200m of blockslope in a southeasterly direction. The block accumulation widens as another drainage line containing a high proportion of large granodiorite blocks merges from the central left of the picture. The surface of this basalt block deposit has 3 large transverse terracettes or wrinkles, visible in the centre of the photograph, which appear to be part of a rotational slip. The right-hand, western margin of this deposit has a peppering of pale, granodiorite blocks on the surface of what is essentially a basalt blockslope.

These granodiorite blocks appear to have been contributed from the sides. Although this basalt blockslope is approximately 500m beyond insitu basalt outcrop, most of the material appears to have been contributed from the adjoining slopes rather than moving directly and continuously down the drainage lines. The block accumulations seem to be discrete and separate accumulations within individual drainage lines, defined by small ramparts or rims at their distal edges. Many of them are associated with arcuate depressions which may have been active snow patches within this steep, stepped terrain. There are no obvious pits or depressions in this blockslope surface on steep sections in the vicinity of site 13.

SITE NUMBER : 13 continued

PHOTOGRAPH BH 3384F6



SITE NUMBER : 14
G.R. : 285166 Cope 1:25 000 NATMAP
ELEVATION : 1450m
ASPECT : South-east
GEOMORPHIC SETTING : Toe or distal edge of basalt block accumulation in drainage line below site 13. The distal margin is marked by a step rampart about 2m above the adjacent terrain. The termination of the block accumulation coincides with a local reduction in slope from 55% to approximately 30% prior to the terminal rampart which slopes at 57%. The surface behind the rampart is pitted with conical depressions 2m wide and 1m deep.
VEGETATION : This block accumulation is mostly unvegetated.

Refer to photograph BH 3384F8

This photograph is taken from below site 14 looking upwards towards the north-west at the basalt rampart. Note that granodiorite blocks have accumulated along the western margin of the basalt accumulation to its full depth and that there is an underlying and ongoing accumulation of granodiorite blocks in the drainage line which continues through the foreground and downstream below site 14. This accumulation is probably contemporaneous with the basalt block accumulation but has been overridden near its proximal end by the basalt block slope. The granodiorite appears more weathered than the basalt which is mostly due to its coarse fabric and also in part to the proximity of denser taller vegetion at lower elevations which dissipates organic matter onto the blockslope and accelerates chemical weathering.

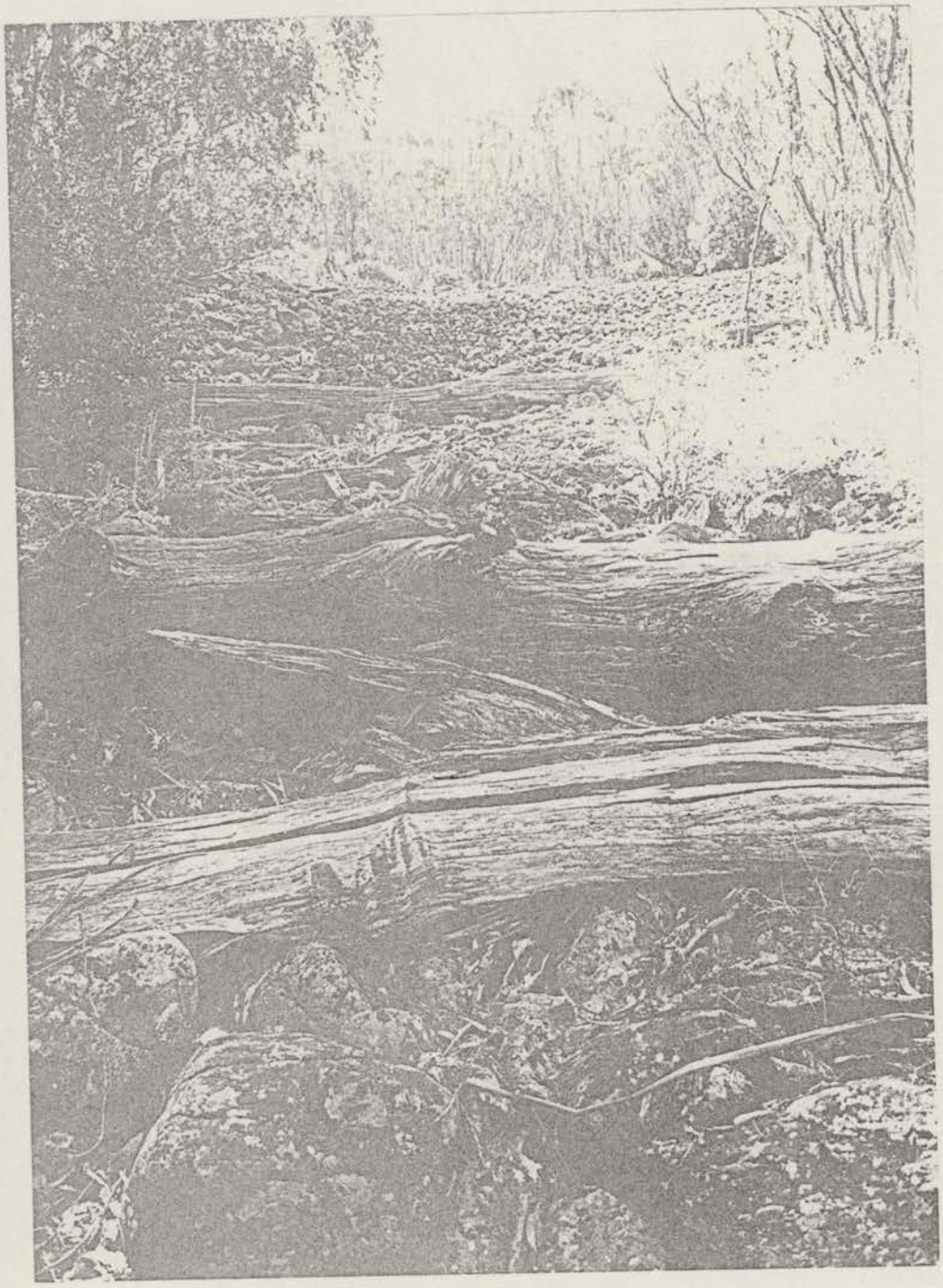
The weathering rind, size and shape of basalt blocks at site 14 near the toe of the basalt slope are very similar to all other sites tested (site 11, 12, 13). The degree of alteration in a sample thin-sectioned from site 14 (slide N17343) demonstrates a close resemblance to slide N17448, being insitu basalt of layer 4 near the base of the basalt scarp. The texture is porphyritic (olivine) with an intergranular fine grained matrix of augite, antigorite, plagioclase and magnetite. There is some alteration of olivine phencrysts along fractures to Iddingsite and there is some reddish brown straining around olivine phencrysts but there is very little other alteration.

The uniformity and minimal physical or chemical alteration of the basalt blocks in this deposit suggests a process of emplacement which did not involve burial in soil or prolonged wetting of the blocks in transit away from their source. Futhermore, the similarity of surface outcrops on the scarp to blocks at the toe of the basalt blockslope in degree of weathering and alteration suggests that the blocks in the block slope have remained above the water table since emplacement. Water can be heard percolating though the base of the block accumulation along most if its course.

In addition to lichens on the upper surfaces of blocks in this basalt block accumulation there appears to be slightly deeper etching of the uppermost surfaces of basalt blocks compared to vertical sides or undersides. This suggests that the deposit has been static for a long time.

SITE NUMBER : 14 continued

PHOTOGRAPH BH 3384F8

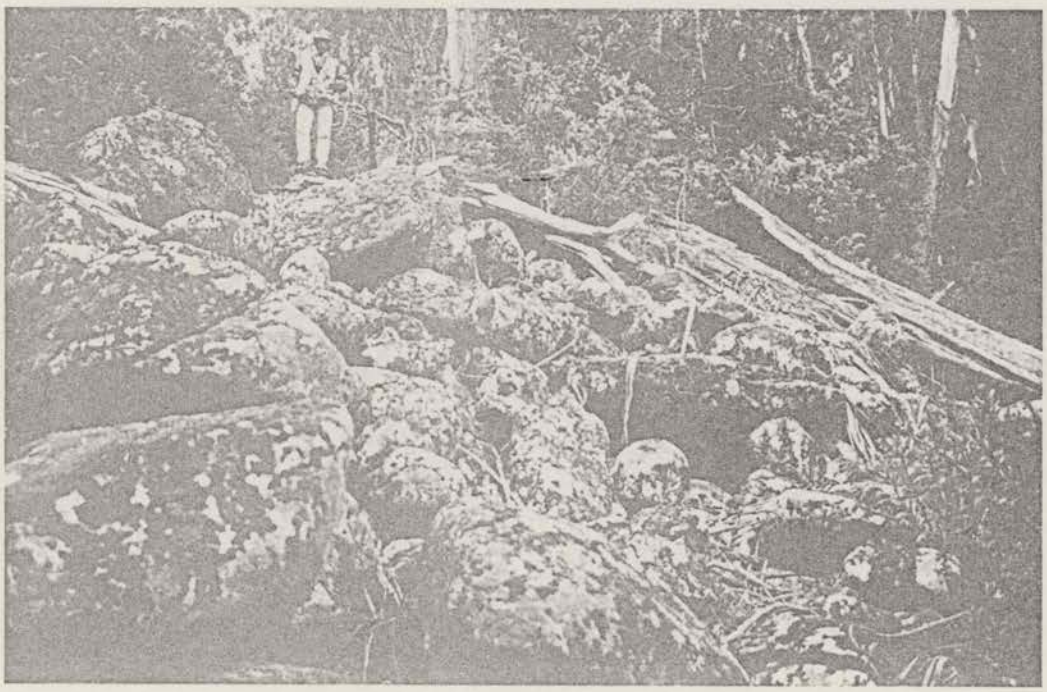


SITE NUMBER : 15
G.R. : 287162 Cope 1:25 000 NATMAP
ELEVATION : 1300m (approximately)
ASPECT : South-south-east
GEOMORPHIC SETTING : An accumulation of roughly imbricate granodiorite blocks occurs in a drainage line The local slope of the drainage line is approximately 35% and decreasing downslope.
VEGETATION : Closed Alpine Ash forest.

Refer to photograph BH DB186F1

Layer 1 : This comprises a weakly imbricate accumulation of large granodiorite blocks approximately 5m high at its distal end, and terminating in a steep rampart. The absence of basalt blocks in this accumulation further demonstrates that most of the block movement was down the valley slopes and that the drainage line has acted as a focus for the accumulation of blocks rather than a corridor of transport.

PHOTOGRAPH BH DB186F1



SITE NUMBER : 16
G.R. : 284170 Cope 1:25 000 NATMAP
ELEVATION : 1600m
ASPECT : South-east
GEOMORPHIC SETTING : Small reentrant in a slope with gradient of 17%. A cutting in the service road adjacent to the Langford West Aqueduct reveals a small section through a basalt block accumulation in the drainage line.
VEGETATION : Tall closed heath and open snow gum woodland .

Layer 1 : 1.5m thick accumulation of tightly packed basalt blocks partly infilled with humus and partly vegetated. There are a few quartz and granodiorite blocks within this accumulation suggesting that granodiorite outcrops upstream of site 16.

Layer 2 : Approximately 0.5m of basalt and quartz gravel and cobbles in a pale orange brown silty sandy grit matrix. Most of the clasts are angular and competent although smaller platy clasts of basalt are very weathered. There were no indications of bedding or stratification.

The gritty material is probably decomposed granodiorite with much muscovite and some feldspar grains 1mm to 2mm in size exist in the matrix. This layer 2 material may be typical of the substrate beneath the basalt block accumulations elsewhere.

SITE NUMBER : 17
G.R. : 285174 Cope 1:25 000 NATMAP
ELEVATION : 1600
ASPECT : North-east
GEOMORPHIC SETTING : Mid slope section of a broad slope with a local gradient of 27% and located in a road cutting adjacent to the aqueduct.
VEGETATION : Tall closed heath and open snow gum woodland.

Layer 1 : 30cm dark, organic loam

Layer 2 : Approximately 100cm of close packed granodiorite blocks 10cm to 50cm with minor amounts of basalt in a matrix of brown gravelly mineral soil. Blocks become more dispersed near the base of layer 2.

Layer 3 : Extremely weathered, insitu granodiorite bedrock.

COMMENTS : The block accumulation of layer 2 exposed north-west and south-east of site 17 contains a mixture of rock types and varies in its development. Near minor drainage lines, layer 2 comprises close packed blocks to 1m thickness, but in the vicinity of spurs, layer 2 changes to isolated blocks in a brown gravelly mineral soil matrix. Most of the slope with a north-eastern aspect between the basalt scarp and the aqueduct could be regarded as vegetated blockfield, as gradients are mostly close to or less than 20%.

SITE NUMBER : 18
G.R. : 285177 Cope 1 :25 000 NATMAP
ELEVATION : 1610m
ASPECT : East
GEOMORPHIC SETTING : Broad, gently sloping saddle. Site 18 comprises a cutting through granodiorite bedrock adjacent to the aqueduct.
VEGETATION : Disturbed ground at Langfords Gap, with a covering of short open heath.

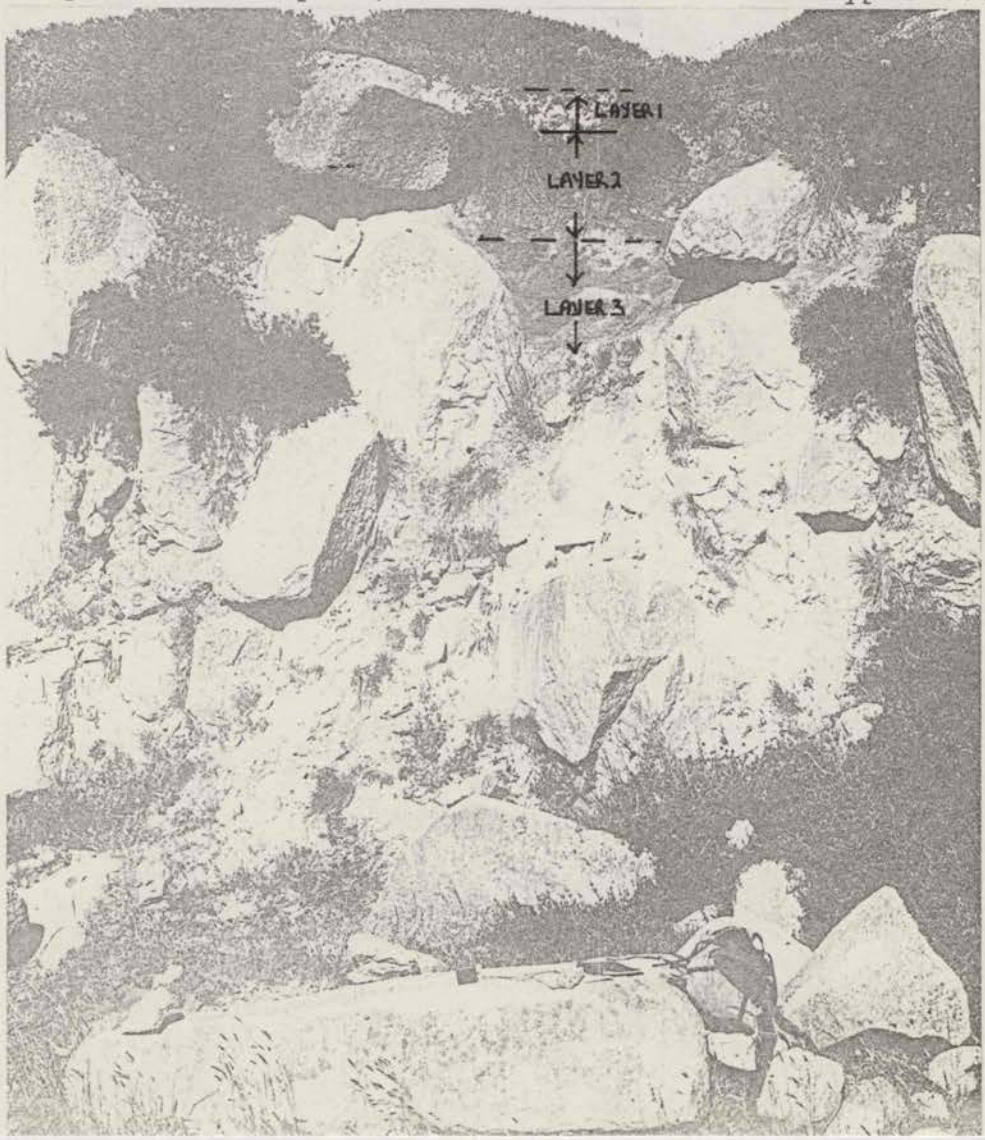
Layer 1 : Dark humus soil 10cm to 20cm deep. Isolated granodiorite clasts occur within this layer but NO basalt clasts were observed.

Layer 2 : Brown mineral soil and granodiorite floaters, 50cm to 100cm thick.

Layer 3 : Insitu granodiorite core stones surrounded by insitu granodiorite grus.

Refer to photograph BH 5284F2

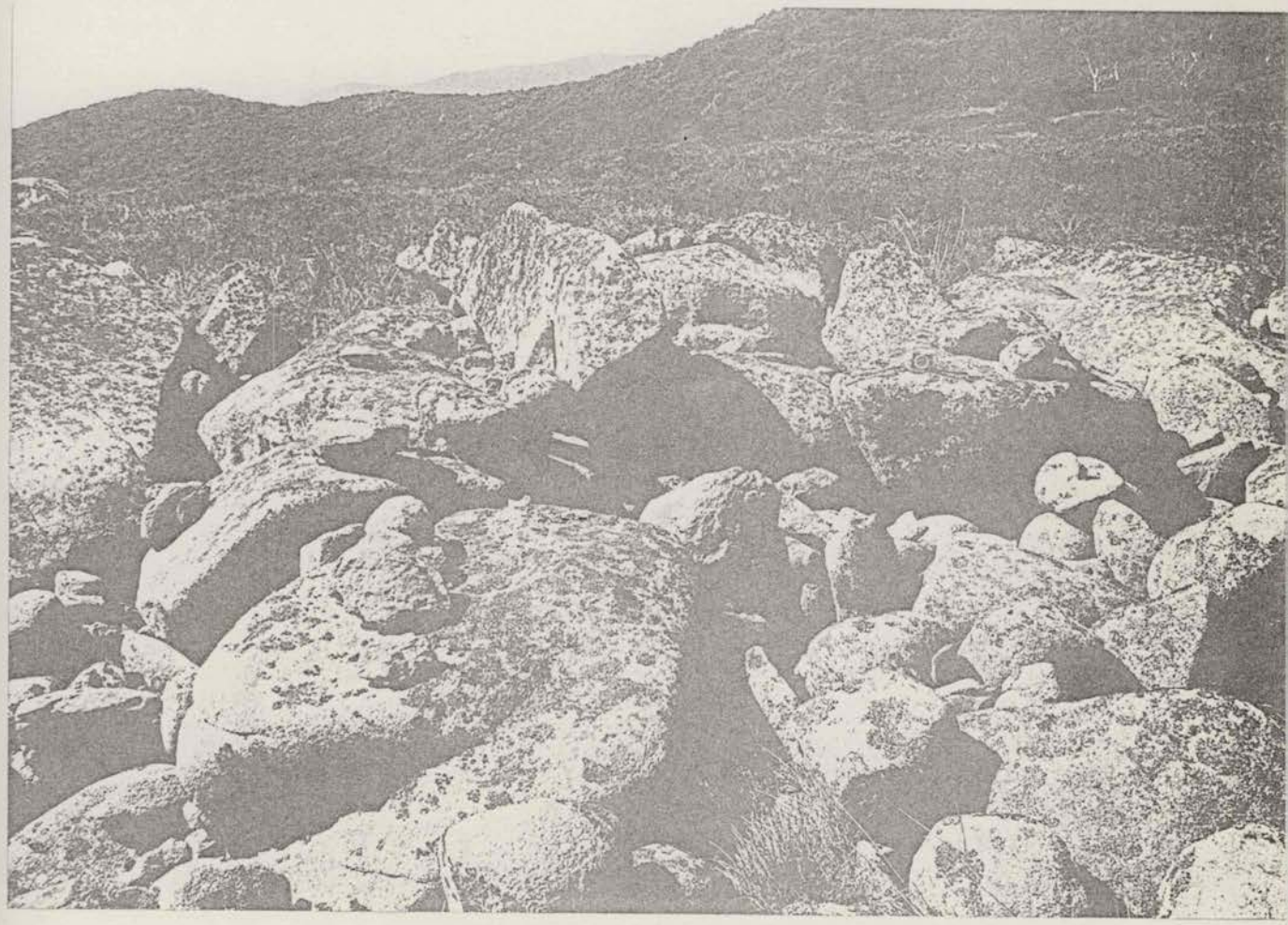
Total height of cutting is approximately 4m. The absence of basalt clasts at this site further demonstrates that mobilization of clasts is away from spur lines towards drainage lines and is so localized that it precludes large scale glacial action, as a mechanism for regolith transport, which would mix rock types over a wide area.



SITE NUMBER : 19
G.R. : 286175 Cope 1 :25 000 NATMAP
ELEVATION : 1570m
ASPECT : South-east
GEOMORPHIC SETTING : Block accumulation exposed in central drainage line of valley draining south-east from Langfords Gap. The local slope averages 13%.
VEGETATION : Bog.

Refer to photograph BH 5284F3

This photograph demonstrates the hybrid character of this block accumulation. Blocks are dominantly granodiorite with dimension 20cm to 400cm and scattered blocks of basalt from 10cm to 40cm and a few quartz blocks, 30cm to 40cm. This demonstrates that the source of this material was from the south-west which corresponds to the north-east flanks of Basalt Hill.

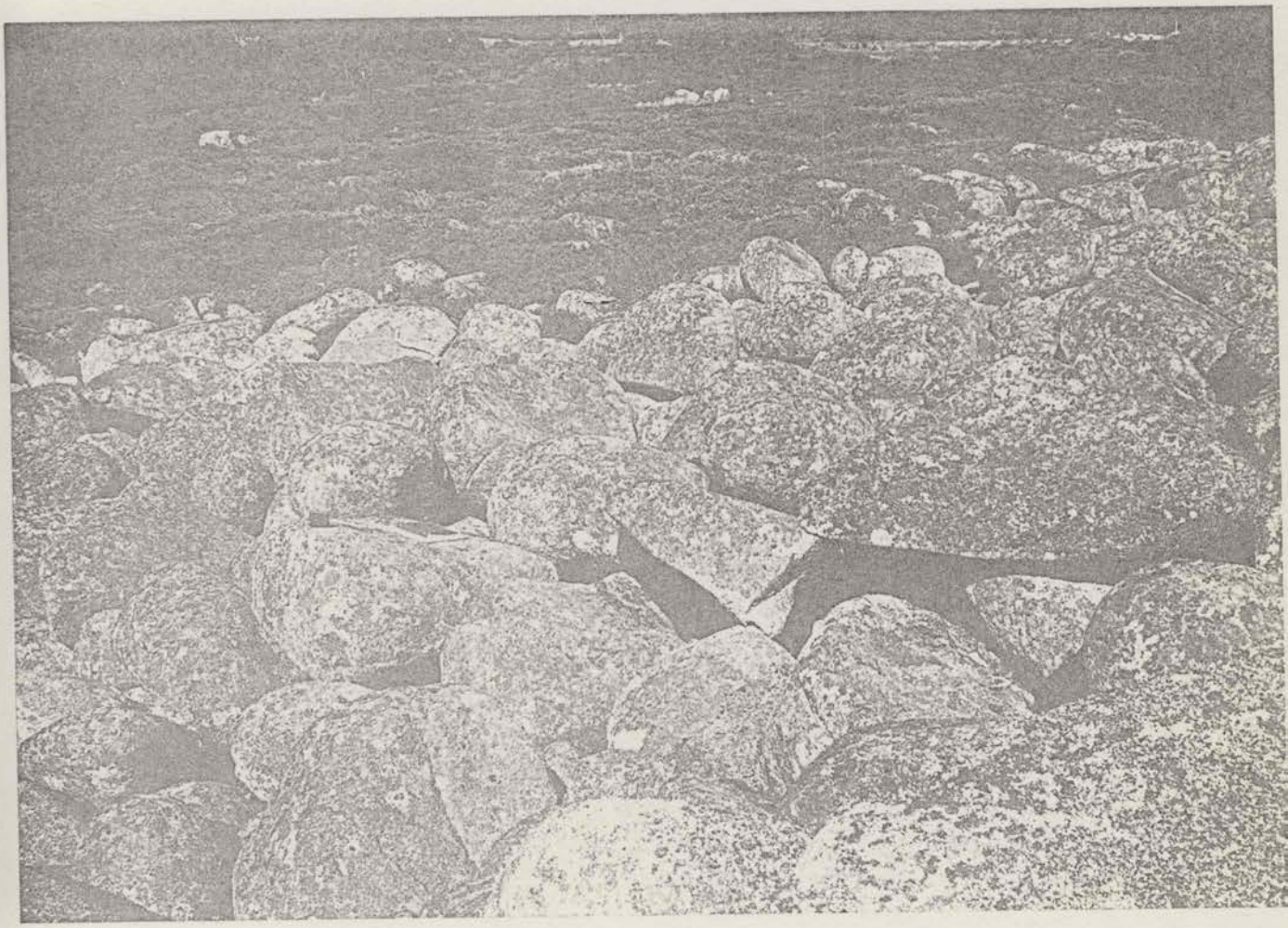


SITE NUMBER : 19 continued

Refer to photograph BH 5284F4

This photograph looks across the mid-section of site 19, towards the south-west and demonstrates the imbricate fabric of the large granodiorite blocks which suggests some form of mass movement of the whole block accumulation near this site, even if such movement may have been small in extent. It might also explain why the block accumulation appears slightly higher than the adjacent terrain to the north-east, whereas the terrain to the south-west appears to be continuous vegetated blockfield. This suggests that a sheet of blocks has migrated downslope from the north-east flanks of the Basalt Hill and terminated in the vicinity of the drainage line. Some additional form of mass movement along the distal margin of this sheet of blocks has produced the imbrication and thickened the deposit as blocks override other blocks in the vicinity of the drainage line.

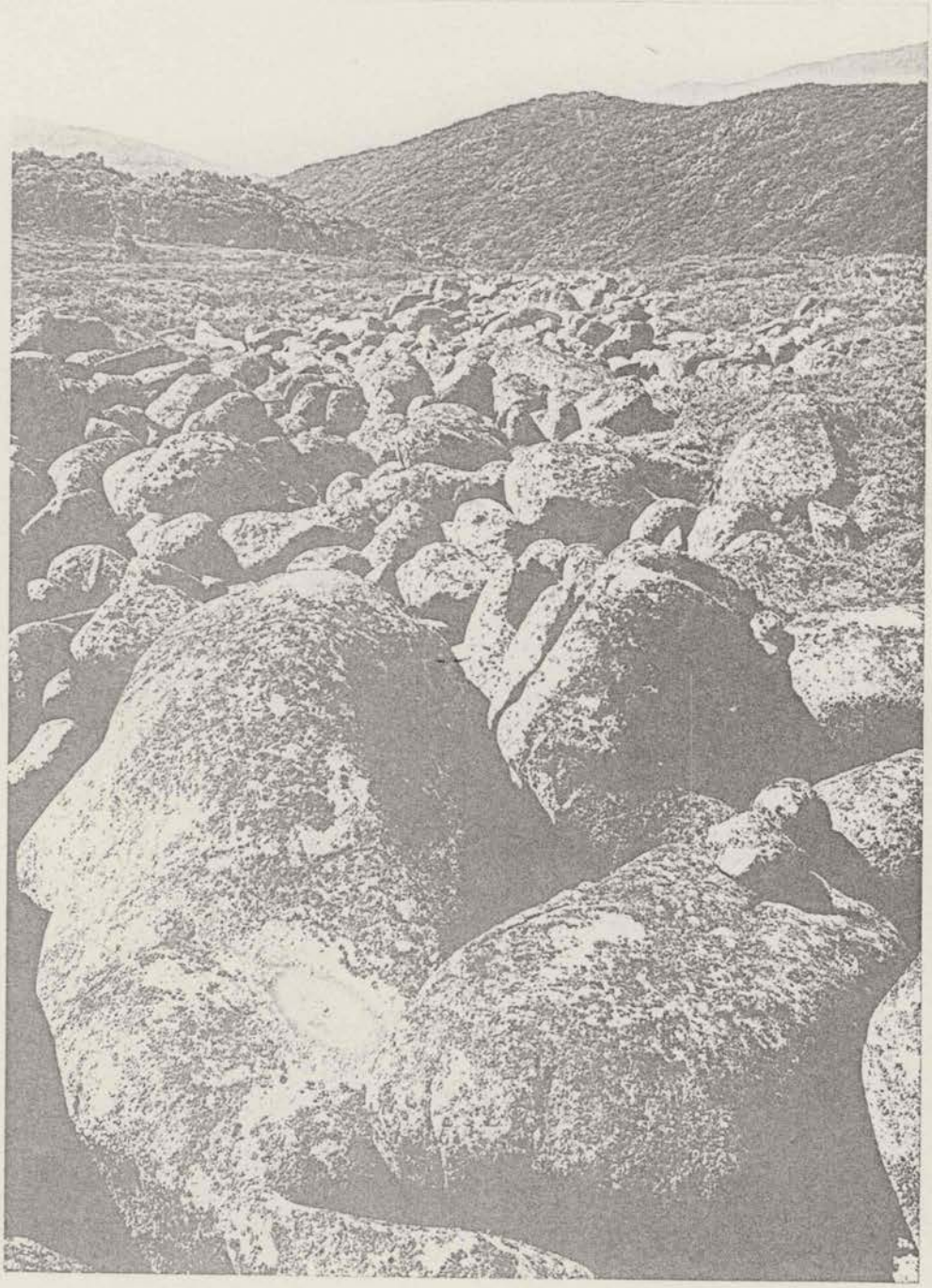
PHOTOGRAPH BH 5284F4



SITE NUMBER : 19 continued

Refer to photograph BH 5284F5

This photograph was taken from the mid-section of the block accumulation at site 19, and looks downslope in a south-easterly direction. The slope continues at approximately 9° or 16% for a further 100m, then declines sharply to greater than 30° or 60% where the drainage line decends through a knickpoint in the granodiorite.



SITE NUMBER : 20
G.R. : 288173 Cope 1:25 000 NATMAP
ELEVATION : 1575m
ASPECT : South-east
GEOMORPHIC SETTING : Knickpoint in drainge line below site 19. The slope changes rapidly from 9° to >30°
VEGETATION : Tall closed heath.

Refer to photograph BH 5284F6

This photograph looks across the knickpoint towards the north. Granodiorite bedrock is exposed in the drainage line. A vegetated blockfield occurs on the north side of the creek. This vegetated granodiorite blockfield appears to be less than 2m thick where it abuts against the drainage line. Vegetation stripes observed from aerial photographs suggest this material has migrated downslope from the north and north-west. The termination of the site 19 block accumulation is just visible in the upper left hand corner of the photograph.



SITE NUMBER : 21
G.R. : 289174 Cope 1:25 000 NATMAP
ELEVATION : 1580m ± 20m
ASPECT : South
GEOMORPHIC SETTING : Portion of a broad convex slope with upper gradient at approximately 20% and lower gradient at approximately 50%.
VEGETATION : bog, and tall closed heath.

Refer to photograph BH 5284F7

This photograph looks north towards site 21 which comprises a partially vegetated blockslope. Large tabular blocks of granodiorite can be observed over much of this slope. Thicker accumulations in drainage lines have probably inhibited the complete vegetation of this slope. It is estimated that these blocks form a veneer about 1m deep. This terrain appears to have a downslope striped pattern when viewed on high altitude aerial photographs. It is assumed that the vegetation patterning postdates and records the flow patterns of downslope mass movement, as most surficial deposits on the High Plains, especially block accumulation, appear to be stable and static.



SITE NUMBER : 22
G.R. : 283176 Cope 1:25 000 NATMAP
ELEVATION : 1635m
ASPECT : North
GEOMORPHIC SETTING : Upper portion of blockfield sloping approximately 20% to the northeast. This slope abuts against the northern scarp of Basalt Hill and exhibits a downslope striped patterning, particularly with respect to the snow gums.
VEGETATION : Disturbed ground marginal to open heath.

Refer to photograph BH 19284F1

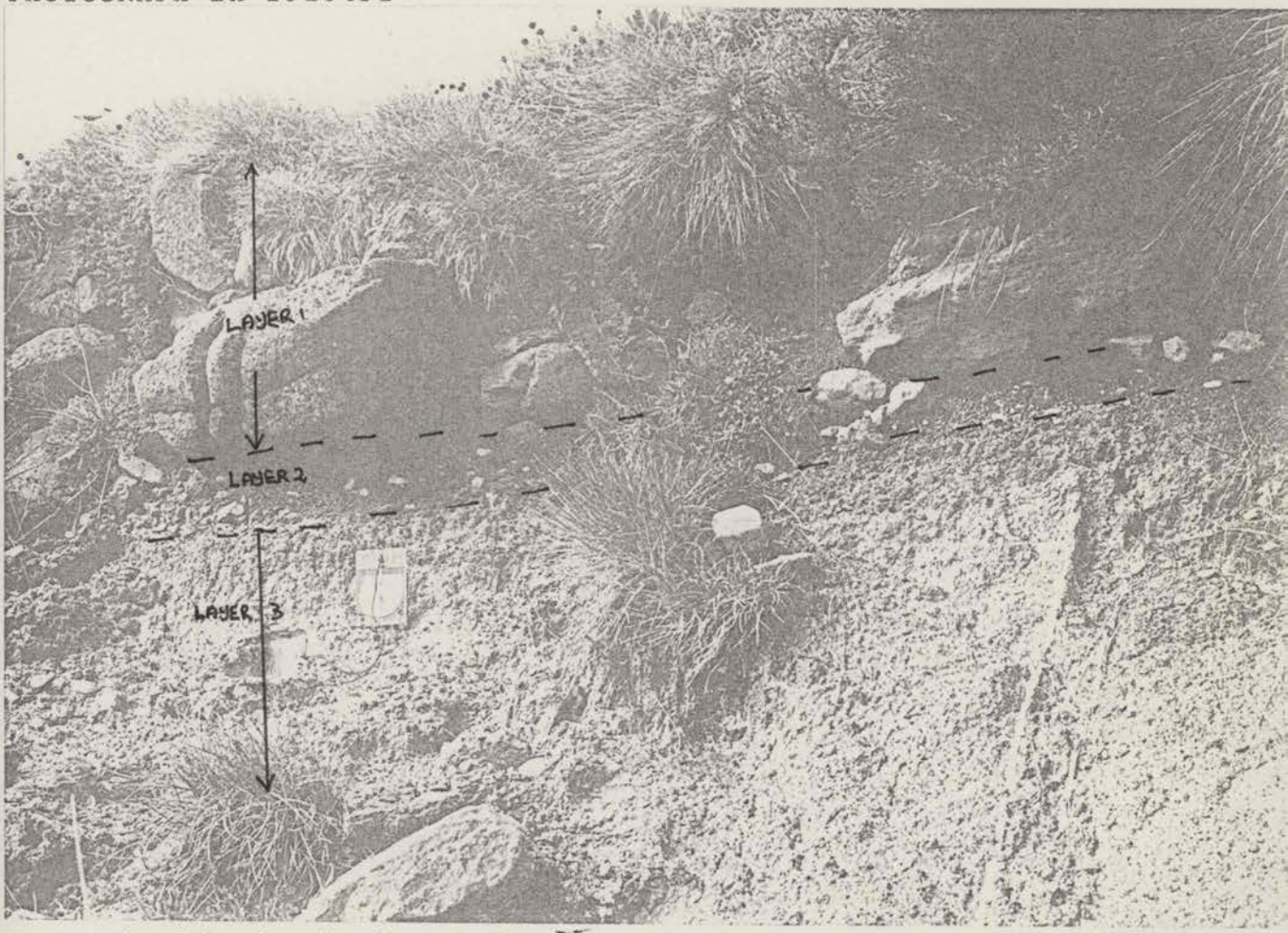
Layer 1 : 30cm to 40cm of basalt blocks in a matrix of organic loam.

Layer 2 : 10cm of fine gravel and irregular basalt cobbles.

Layer 3 : pale reddish brown, insitu, weathered granodiorite.

NOTE : The surface at this site is disturbed in places. The basalt blocks within this section exhibit well developed differential and rill weathering. Surface phenocrysts have produced pits 5mm into the surface and rills have cut 5cm into the basalt blocks. The weathering of these blocks suggests that they have been within a mineral matrix and have experienced much chemical weathering due to their contact with ground moisture.

SITE NUMBER : 22 continued
PHOTOGRAPH BH 19284F1



The blocks in layer 1 are much more weathered than blocks insitu, or blocks in open non-vegetated accumulations. The rill-type weathering, commonly associated with limestone, demonstrates that these blocks have beeen in a soil matrix, and motionless, for a considerable period of time.

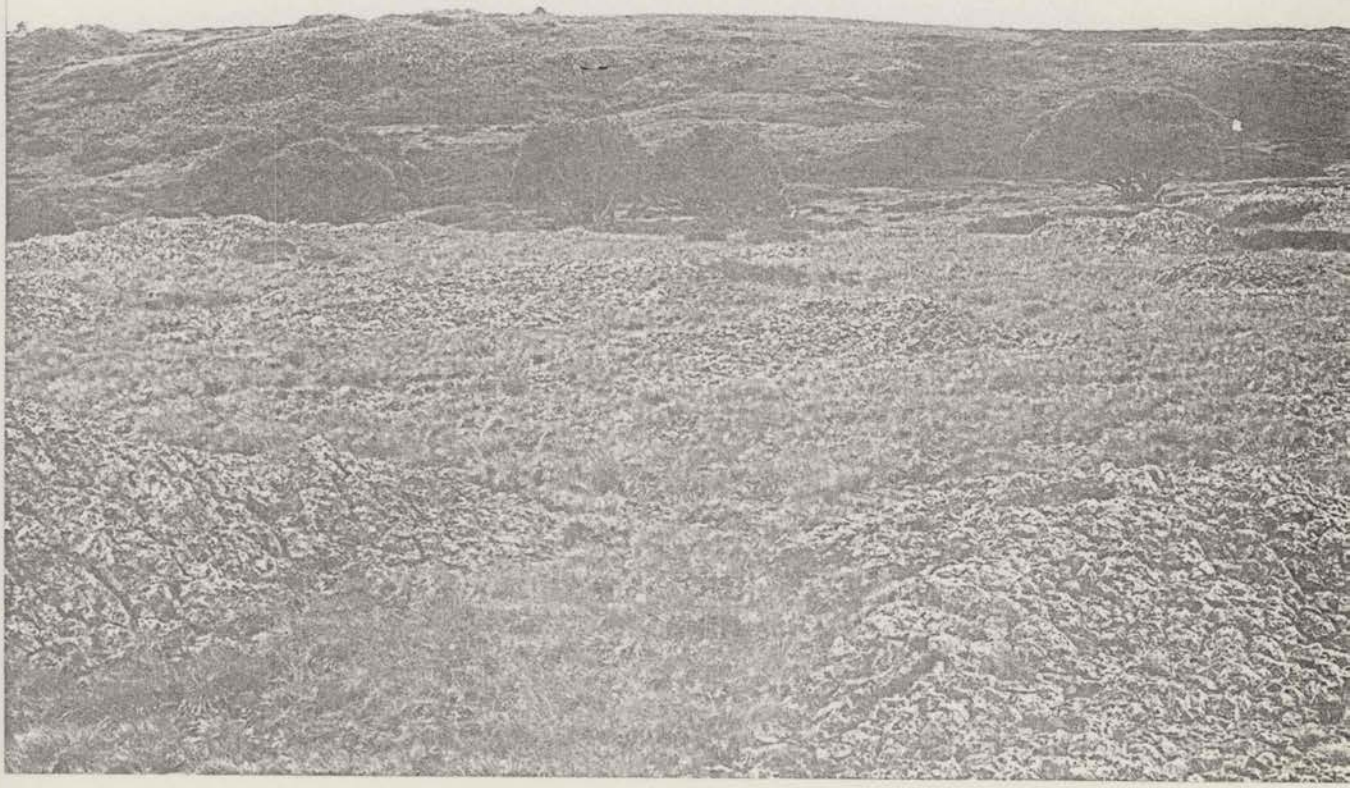
The gravelly layer 2 may have been the original substrate when these blocks were mobilized away from the adjacent basalt scarp approximately 100m to the south. The organic loam which surrounds and overlies the blocks is probably Holocene.

SITE NUMBER : 23
G.R. : 282172
ELEVATION : 1670m
ASPECT : near horizontal
GEOMORPHIC SETTING : Portion of basalt bedrock corresponding to level 3 within the basalt bedrock. This surface is dissected by minor drainage lines which drain eastwards.
VEGETATION : partial vegetation of rocky grassland

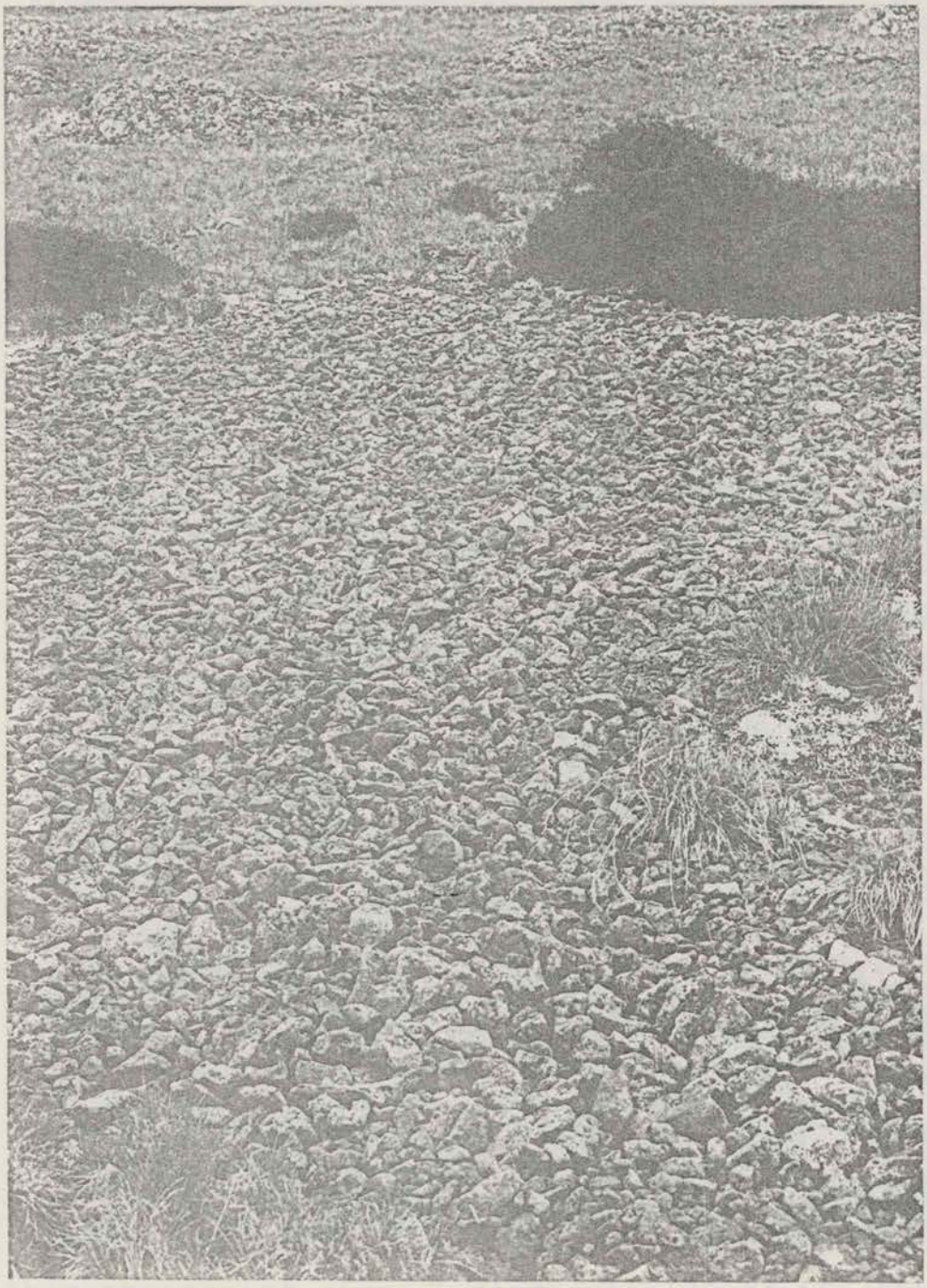
Refer to photographs BH 19284F2, BH 19284F3, BH 19284F4 and BH 20486F13, and diagram Fig 2Ad.

The photograph BH 19284F2 gives an overview of the surface near site 23. The summit cairn on level 1 is visible in the background. Basalt bedrock outcrops in the foreground as rounded stacks which are bounded by vertical megajoints striking 095° GB and 223° GB, and near horizontal basal joints. The intervening ground between the basalt stacks is partially vegetated but contains a thin veneer of frost sorted gravel and cobbles.

PHOTOGRAPH BH 19284F2



SITE NUMBER : 23 continued
PHOTGRAPH BH 19284F3



Photograph BH 19284F3 gives an overview of the thin patchy frost sorted regolith which occurs on near horizontal ground. The compass in the midground is about 7cm in diameter.

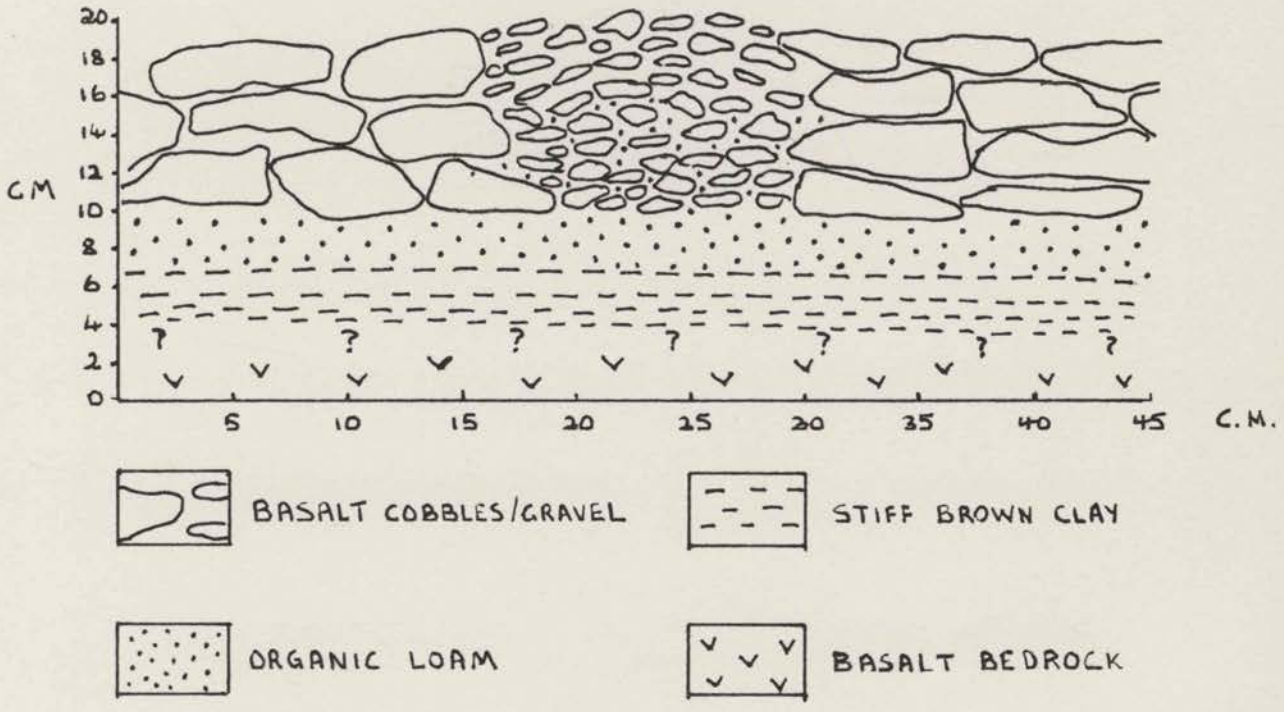
SITE NUMBER : 23 continued
PHOTOGRAPH BH 19284F4



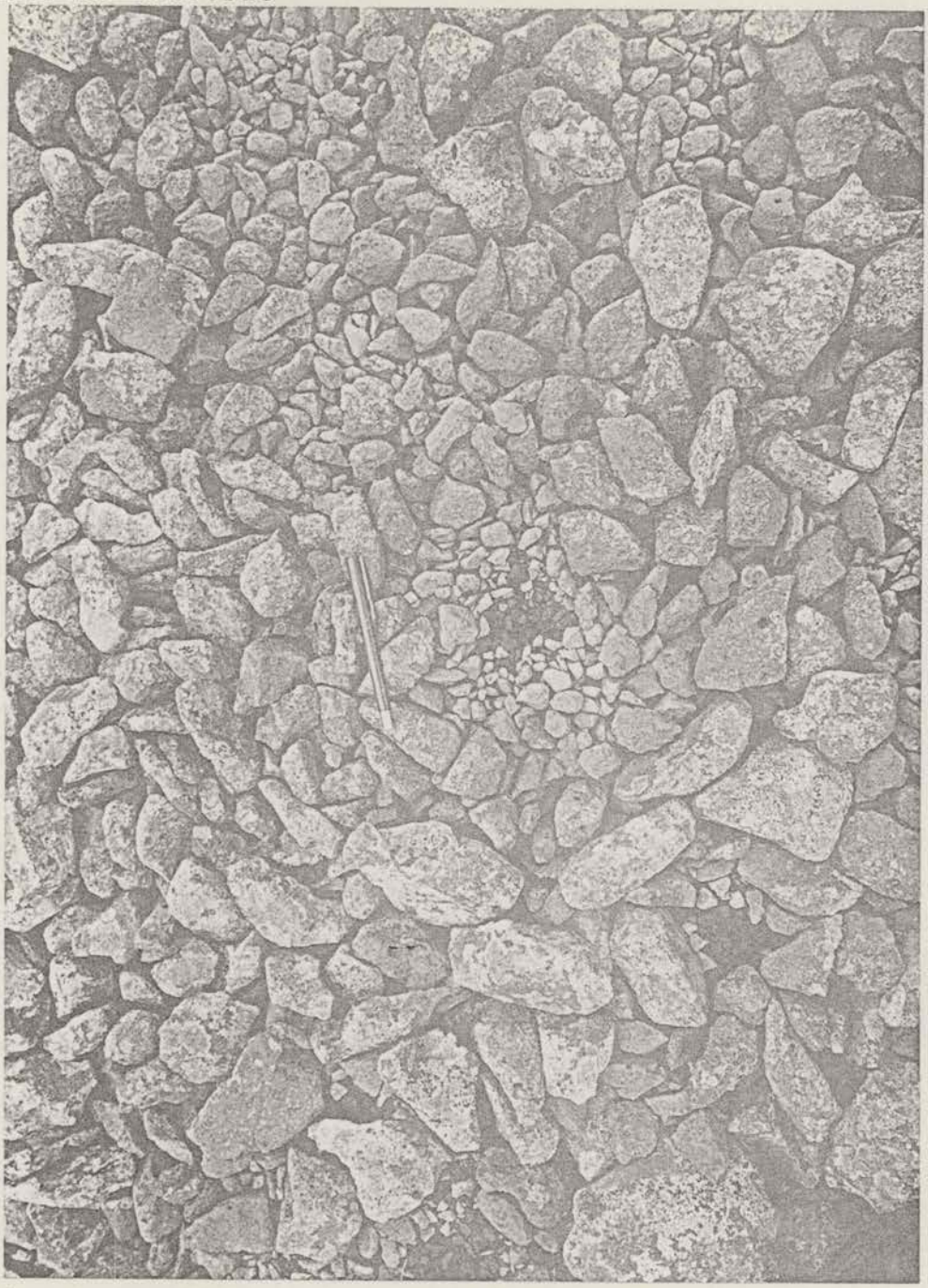
This photograph gives a close up view of the frost sorted surface at site 23, which could be described as a set of small sorted nets. The surface profile is illustrated in Fig 2Ad below.

SITE NUMBER : 23 continued

Fig 2Ad Cross-section of Frost Sorted Circle on Basalt Hill



SITE NUMBER : 23 continued
PHOTOGRAPH BH 20486F13

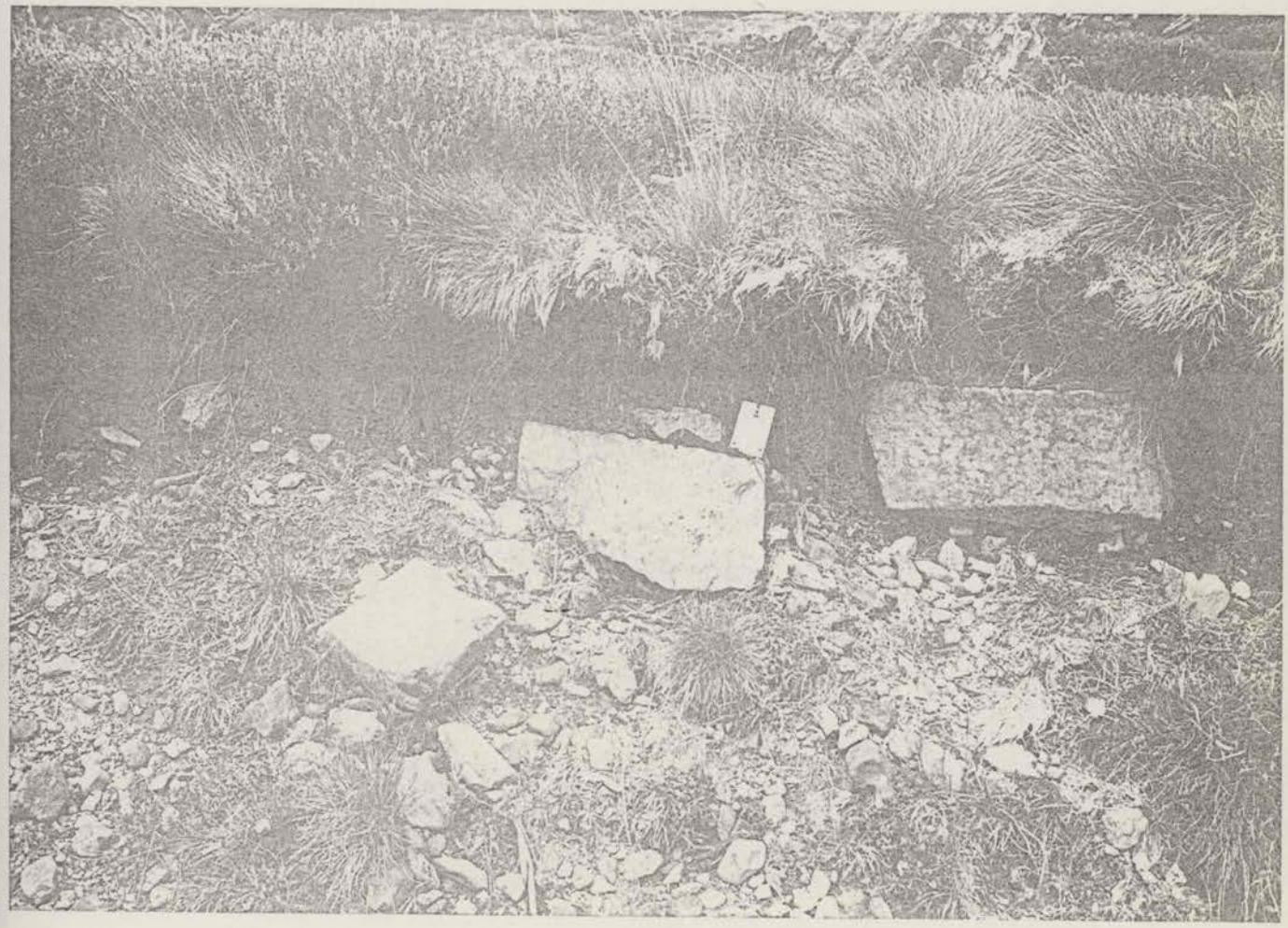


This photograph (taken 24th April 1986) reveals small sorted circles and stripes on near level ground near site 23. The dark, damp patches in the central portion of the circles were caused by the melting of needle ice. Needle ice was observed on 1st June 1986 to be heaving the central portions of these sorted circles up in a mound, which could be responsible for pushing or rolling the larger cobbles outwards and thus creating the patterning.

The pen is 13cm long.

SITE NUMBER : 24
G.R. : 283174 Cope 1:25 000 NATMAP
ELEVATION : 1650m
ASPECT : north
GEOMORPHIC SETTING : proximal edge of vegetated block field sloping about 16% away from adjacent basalt scarp.
VEGETATION : complete cover of open heath.

Refer to photograph BH 19284F16



This photograph of a partly obscured road cutting reveals isolated, angular blocks of basalt in a matrix of dark brown gravelly loam soil about 30cm deep. The blocks are resting on and within a layer of basalt gravel and cobbles with a light brown silty sand matrix.

The compass is about 10cm long.

SITE NUMBER : 25
G.R. : 282176 Cope 1:25 000 NATMAP
ELEVATION : 1630m
ASPECT : North-east
GEOMORPHIC SETTING : Mid slope section of a lobate blockfield which extends northwards from the basalt scarp with a gradient of 14% near site 25.
VEGETATION : site 25 and most of the lobate blockfield is characterized by tussock grassland.

Layer 1 : depth 0-10cm - dark fibrous organic loam. Good crumb structure, very few stones present.

Layer 2 : depth 10-20cm - moist orange brown sandy silt pentrated by heath roots.

Layer 3 : depth 20-50cm - weakly stratified cobbles and gravel in an orange brown sandy silt matrix. The cobbles are mainly basalt with minor amounts of granodiorite. Basalt clasts vary in length from 1cm to 15cm with a modal size of 4-5cm. The basalt cobbles which are moderately weathered but competent, form 60% of the bulk of this layer.

Layer 4 : depth 50-90 cm (variable) - pale orange brown granodiorite mineral soil.

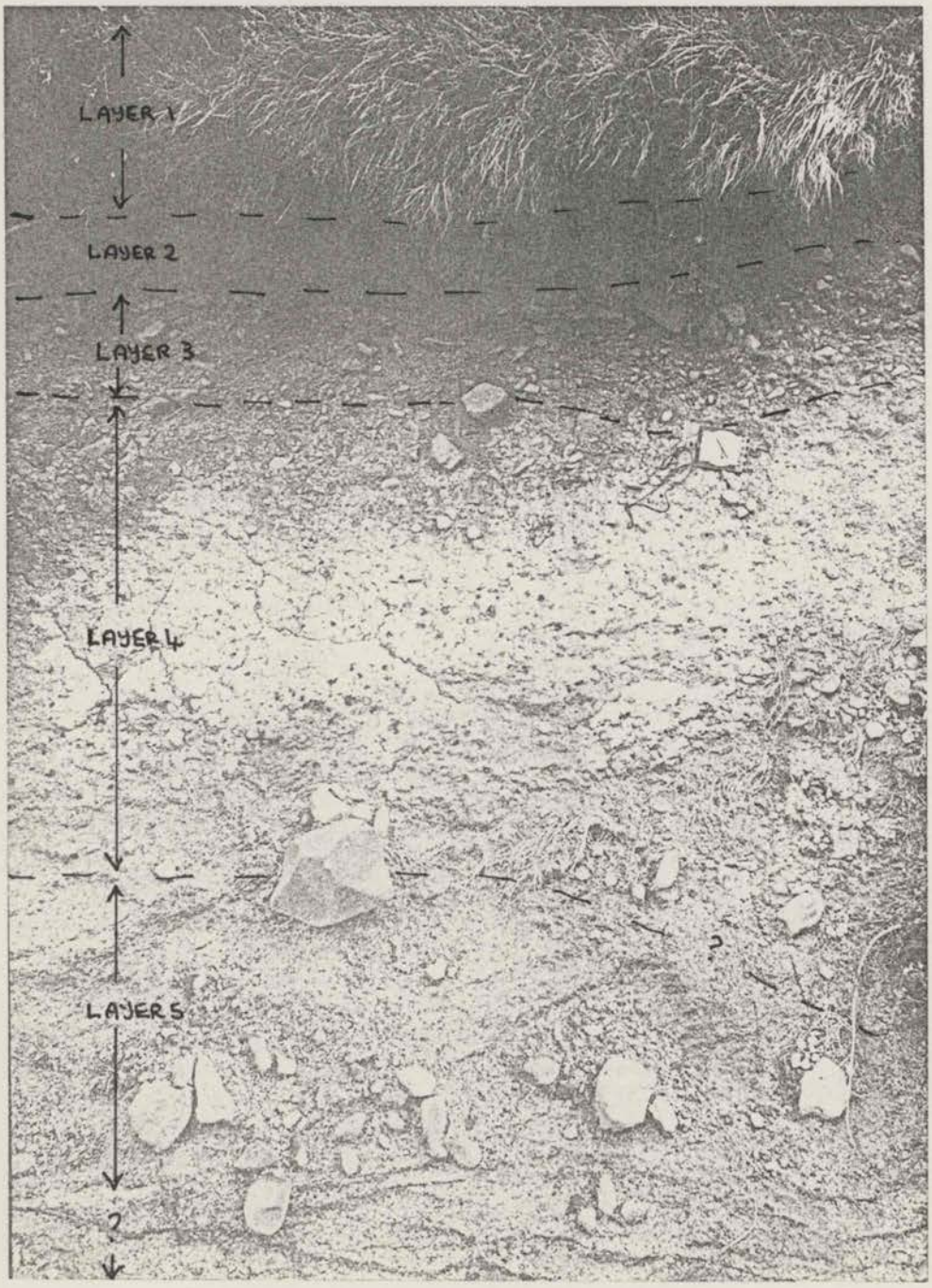
Layer 5 : Remainder of exposure below 90cm exhibits relic rock fabric and constitutes extremely weathered insitu granodiorite. Fresh granodiorite corestones outcrop in a few places along this section.

SITE NUMBER : 25 continued

Refer to photographs BH 19284F18 and BH 2586F18

Photograph BH 19284F18 (below) gives an overview of the section. layer 1 is obscured by tussock grass, but layers 2, 3, 4 and the weathered bedrock are visible. The character of layer 3, cobbles and gravel, shows considerable variation in stratification and thickness along this road section near site 25.

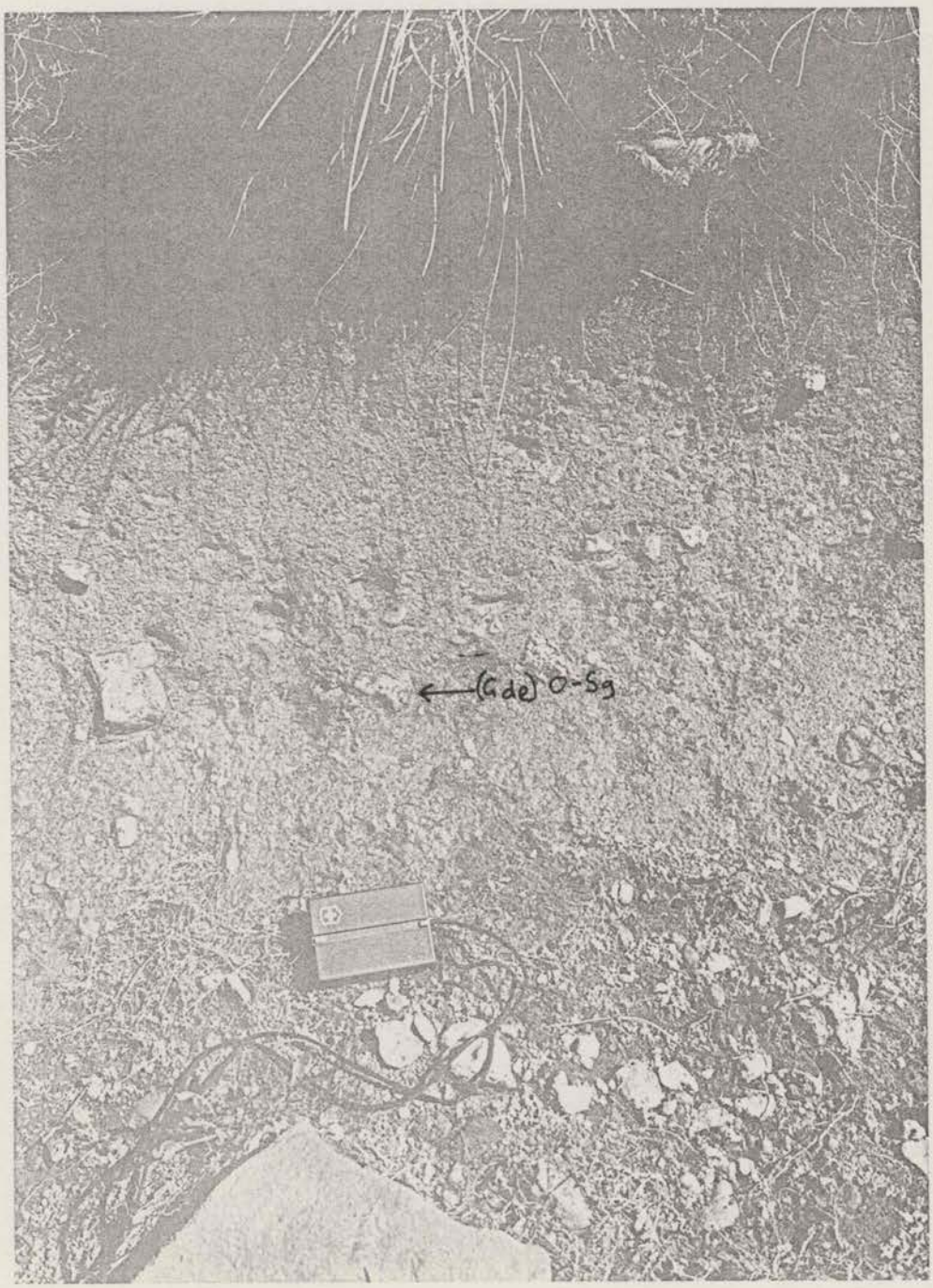
PHOTOGRAPH BH 19284F18



SITE NUMBER : 25 continued
PHOTOGRAPH BH 2586F18

This photograph shows a very weakly stratified layer 3 comprising mostly basalt clasts, but a granodiorite clast 2cm in diameter is visible in the centre of the photograph.

The compass is 6.5 cm long.



SITE NUMBER : 26
G.R. 278178 Cope 1:25 000 NATMAP
ELEVATION : 1625m
ASPECT : North-east
GEOMORPHIC SETTING : Site 26 is located within a lobate vegetated blockfield sloping at approximately 12° to the north-east, with well-defined convex margins at its distal end. The distal end flattens out.
VEGETATION : Most of the blockfield is vegetated by tussock grassland, but some of it continues into an alpine bog.

Layer 1 : depth 0-25cm - dark, friable organic sandy loam

Layer 2 : depth 25-50cm - basalt blocks mostly larger than 15cm with a weathering rind approximately 2mm thick. Matrix is an orange brown gravelly loam.

Layer 3 : depth 50-110cm - orange brown gravel with dispersed basalt cobbles. The basalt cobbles are platy to tabular and moderately weathered and comprise 10% of bulk. Stratification is weak to absent. Most of the gravel appears to be derived from granodiorite.

Layer 4 : below 110cm - moderately weathered granodiorite bedrock.

SITE NUMBER : 27
G.R. : 275178 Cope 1:25 000 NATMAP
ELEVATION : 1640m
ASPECT : North
GEOMORPHIC SETTING : Simple, vegetated blockfield slope with local gradient of 18%, located below a well defined bedrock bench of granodiorite.
VEGETATION : Tall heath, but close to open heath.

Layer 1 : depth 0-30cm - dark organic loam, matted with root fibres. No stones present.

Layer 2 : depth 30-60cm - dark, quartz gravel loam.

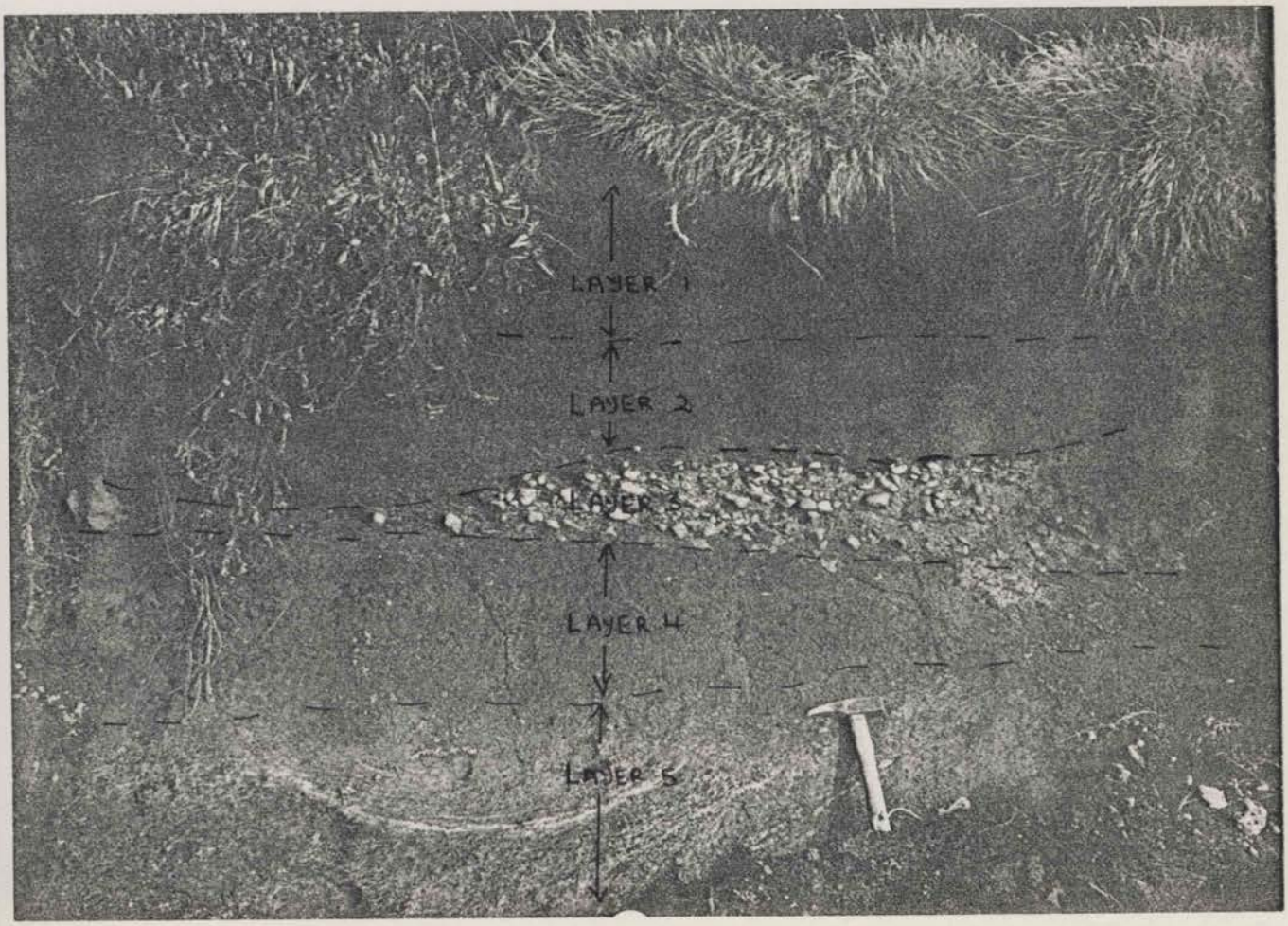
Layer 3 : depth 60-80cm - light colored, close packed basalt cobble layer. Cobbles are slightly weathered with rinds 2mm to 3mm deep.

Layer 4 : depth 80-120cm - pale brown extremely weathered granodiorite regolith.

Layer 5 : below 120cm - extremely weathered insitu granodiorite.

Refer to photograph BH 2586F20

This photograph, below, reveals most of the layers reported. The pick is 25cm long. Note the gneissic fabric preserved in layer 5. Also note the cracks penetrate layer 1, 2, 3, and 4 but not 5. The close packed cobbles of layer 3 appear to lens out to the left of the photograph.



SITE NUMBER : 28
G.R. : 273178 Cope 1:25 000 NATMAP
ELEVATION : 1650m
ASPECT : North
GEOMORPHIC SETTING : Site 28 is located just north of the axis of a long spur trending westwards from Basalt Hill. This spur is mostly granodiorite bedrock with much outcrop exposed. The slope angle is 5° towards the northwest. The surface of this spur appears to be stepped.
VEGETATION : tall closed heath and snow gum woodland.

Layer 1 : depth 0-20cm - thin layer of alpine humus.

Layer 2 : depth 20-50cm ?? - layer of coarse angular basalt blocks with well preserved joint faces and slight to highly rounded edges. Columnar fragments are 40cm to 70cm long and 20cm wide.

Layer 3 : below 50cm?? - extremely weathered granodiorite bedrock.

SITE NUMBER : 29
G.R. : 272178 Cope 1:25 000 NATMAP
ELEVATION : 1650m
ASPECT : West
GEOMORPHIC SETTING : gentle slope of 5° or 9%, near saddle in westward trending spur adjacent to site 28.
VEGETATION : Open heath

Layer 1 : depth 0-20cm - dark fibrous organic loam with isolated moderately weathered basalt blocks which appear to rest on layer 2 below.

Layer 2 : depth 20- 35cm - close packed layer of waterworn quartz cobbles in a gravelly loam matrix. A few basalt cobbles occur amongst the quartz cobbles.

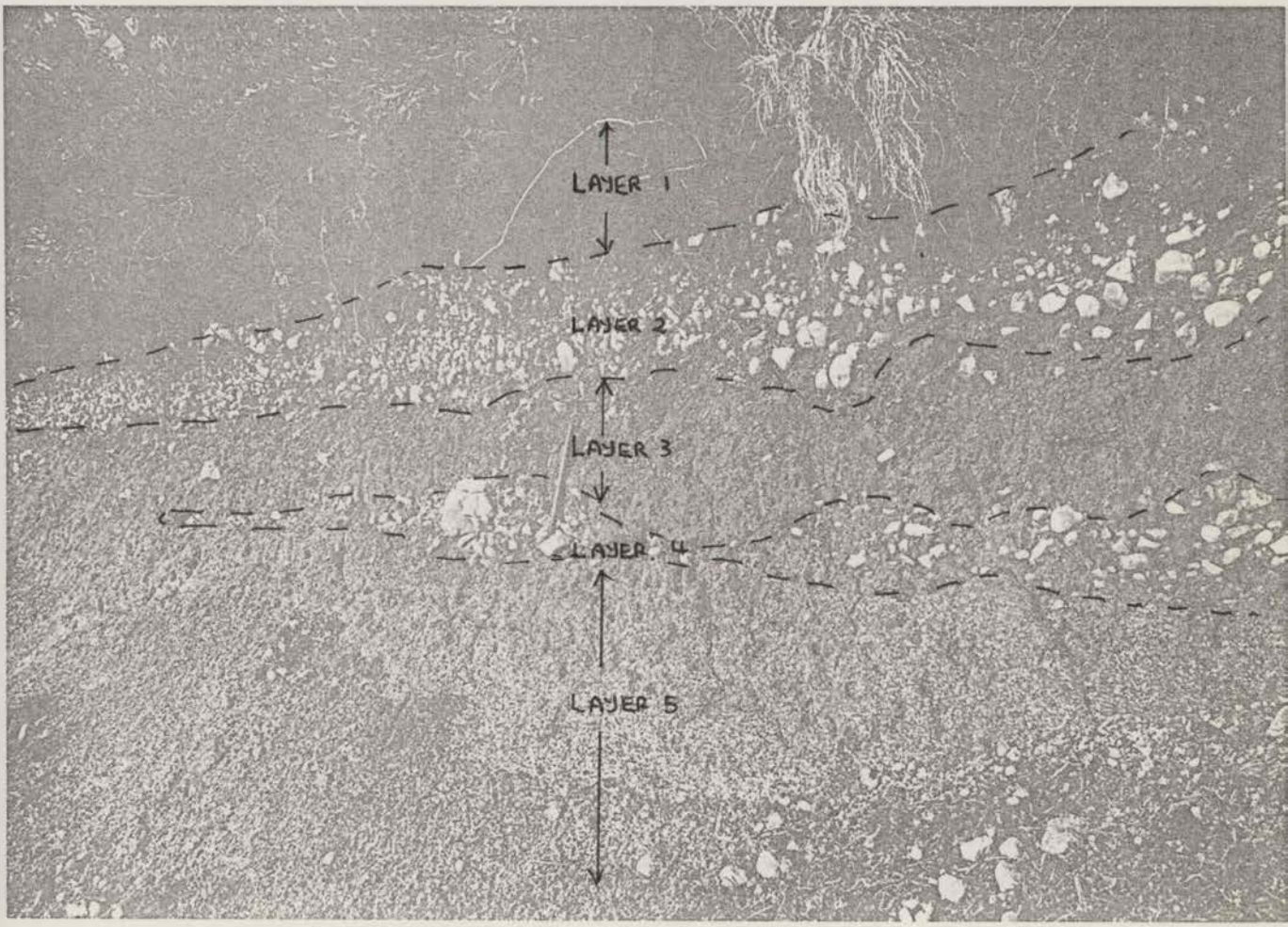
Layer 3 : depth 35- 55cm - brown gravelly loam with dispersed pebbles of quartz.

Layer 4 : depth 55-65cm - thin discontinuous layer of closepacked quartz pebbles and cobbles resting on extremely weathered granodiorite bedrock.
Layer 5 : below 65cm - extremely weathered granodiorite bedrock.

SITE NUMBER : 29 continued
Refer to photographs BH 2586F21 and BH 2586F17.

PHOTOGRAPH BH 2586F21

This photograph demonstrates the section described. The pen is 14cm long, and its lower end is near the break between layer 4 and bedrock. Note the relic fabric in the almost decomposed insitu granodiorite.

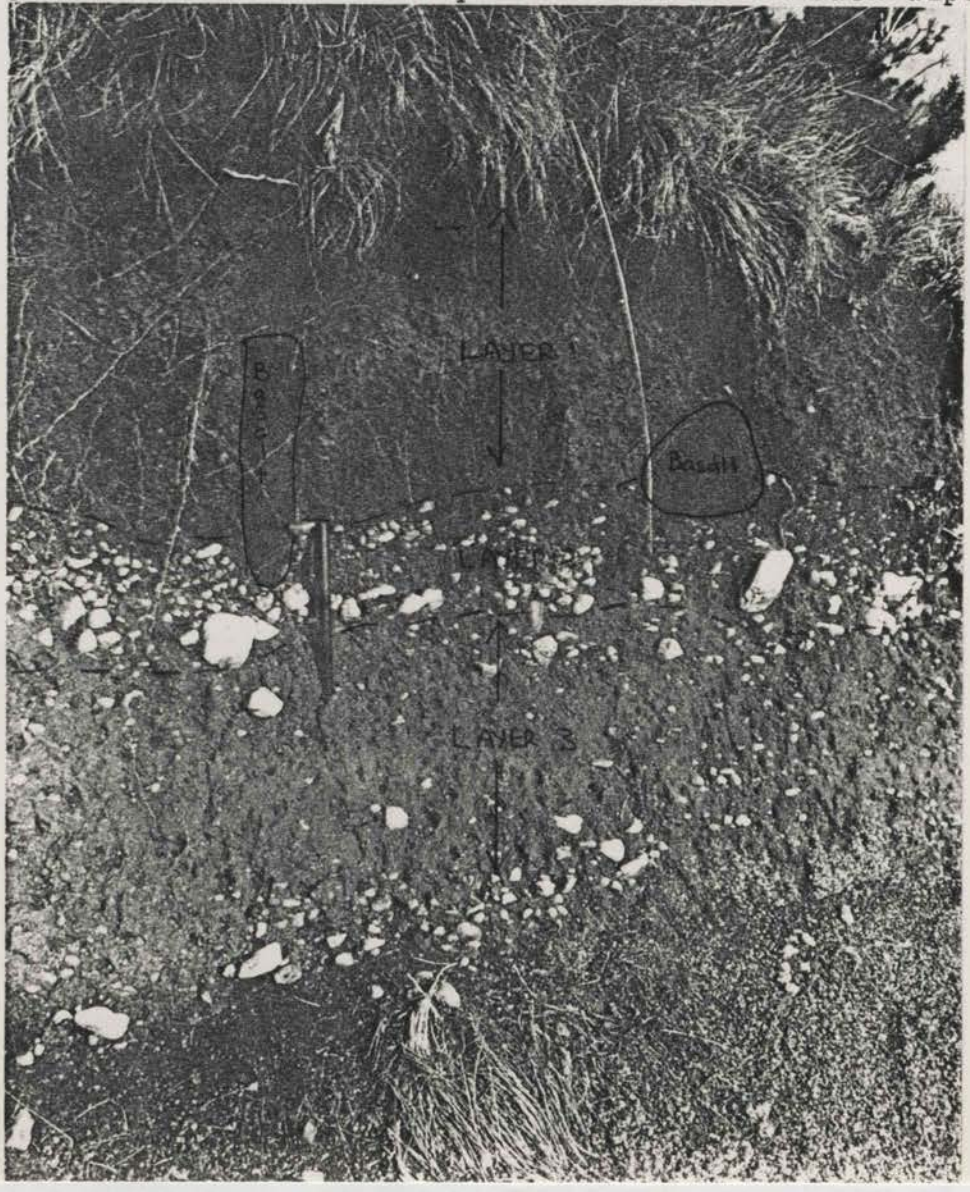


SITE NUMBER : 29 continued
PHOTOGRAPH BH 5487F17

This photograph demonstrates that some basalt blocks have migrated down from the gentle spur line of average gradient 8% or 5° for approximately 300m and become incorporated on and partially within layer 2. These blocks are moderately rounded at the edge and they seem moderately weathered as well, suggesting that they have been within a mineral matrix for some time and have experienced accelerated chemical weathering compared to blocks on the surface.

The quartz clasts are slightly to moderately rounded. This degree of rounding and polishing could not be explained by 300m of downslope movement. It is probable therefore that these pebbles and cobbles have been derived from the old Tertiary surface which existed prior to the extrusion of the basalt. They probably represent clasts from streams which dissected that old granodiorite surface. Quartz clasts would be the only common component of the granodiorite which could be expected to survive the > 30 million years since the extrusion of the basalt.

These clasts have been remobilized downslope prior to the Holocene (assuming that Layer 1 is a Holocene soil), and they occupy a similar position in the surficial stratigraphy to the close packed basalt cobble layers elsewhere beneath alpine humus soil.



SITE NUMBER : 30
G.R. : 272175 Cope 1:25 000 NATMAP
ELEVATION : 1630m
ASPECT : West
GEOMORPHIC SETTING : Upper slope with gradient 17% and situated less than 100m from the basalt scarp.
VEGETATION : open heath merging with tall closed heath.

Layer 1 : depth 0-20cm - dark gravelly loam

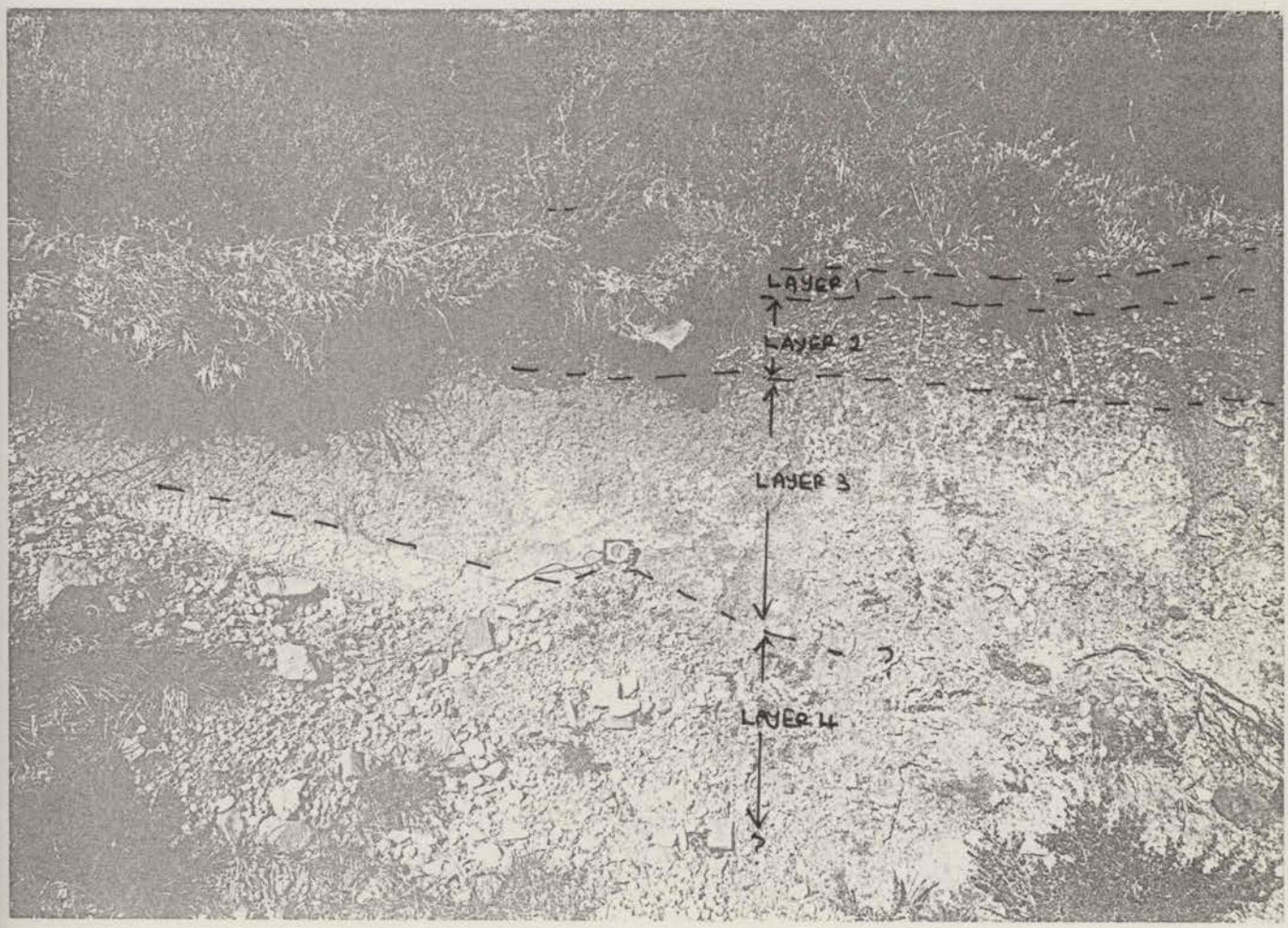
Layer 2 : depth 20-50cm - close packed layer of basalt and quartz cobbles and pebbles with isolated angular basalt blocks in a gravel matrix.

Layer 3 : depth 50-150cm?? - pale brown granodiorite regolith

Layer 4 : below 150cm ?? - insitu extremely weathered granodiorite.

Refer to photograph BH 3384F13 (below)

This photograph illustrates the section at site 30.



SITE NUMBER : 31
G.R. : 272173 Cope 1:25 000 NATMAP
ELEVATION : 1630m
ASPECT : West
GEOMORPHIC SETTING : upper level slope of a vegetated blockfield with gradient approximately 6° or 11% and situated less than 100m from the basalt scarp.
VEGETATION : tall closed heath

NOTE : In an adjacent drainage line the reentrant has been filled with a considerable thickness (>1.5m) of cobbles and pebbles dispersed in a clay silt gravel matix and overlain by a close packed layer of pebbles, cobbles and blocks about 20cm thick.

Layer 1 : depth 0-20cm - gravelly organic loam

Layer 2 : depth 20-40cm - close packed slightly stratified pebbles and cobbles. Clasts mostly competent, slightly weathered basalt with a 2mm rind and irregular, platy and round habit.

Layer 3 : below 40cm - gravelly pale brown granodiorite regolith or relic soil. Exact depth unknown.

PHOTOGRAPH BH 5487F16



SITE NUMBER : 32
G.R. 269174 Cope 1:25 000 NATMAP
ELEVATION : 1500m
ASPECT : West
GEOMORPHIC SETTING : Distal end of a lobate vegetated concave blockfield sloping at about 6° at the proximal end to 4° near the distal end and emanating from a broad drainage line through the southwest corner of Basalt Hill.
VEGETATION : tussock grassland bordered by an alpine bog.

Layer 1 : broad partially vegetated sheet of predominantly basalt blocks. Granodiorite blocks and tors become predominant in and to the south of the adjacent drainage line. Thickness is at least 30cm and water percolates through the base of the blockfield.

Layer 2 : 10cm to 20cm thickness of close packed gravel, pebbles and cobbles. Overlying blocks are revealed in an eroded lakeside bank.

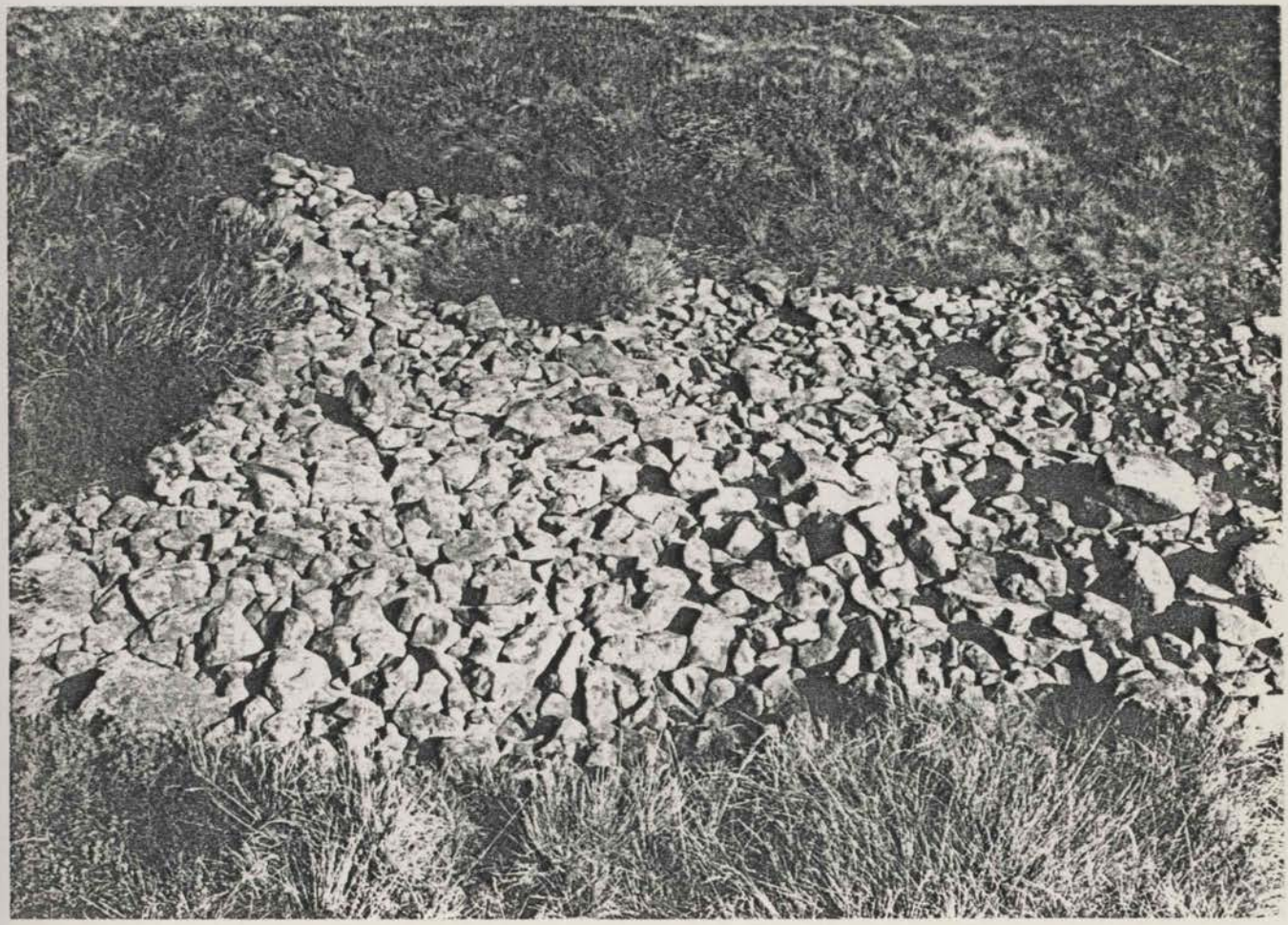
Layer 3 : regolith from underlying granodiorite bedrock. Gneiss of unit O-Sn outcrops on the hill to the south-west.

SITE NUMBER : 32 continued

Refer to photographs BH 5487F11, BH 5487F13 and BH 5487F14

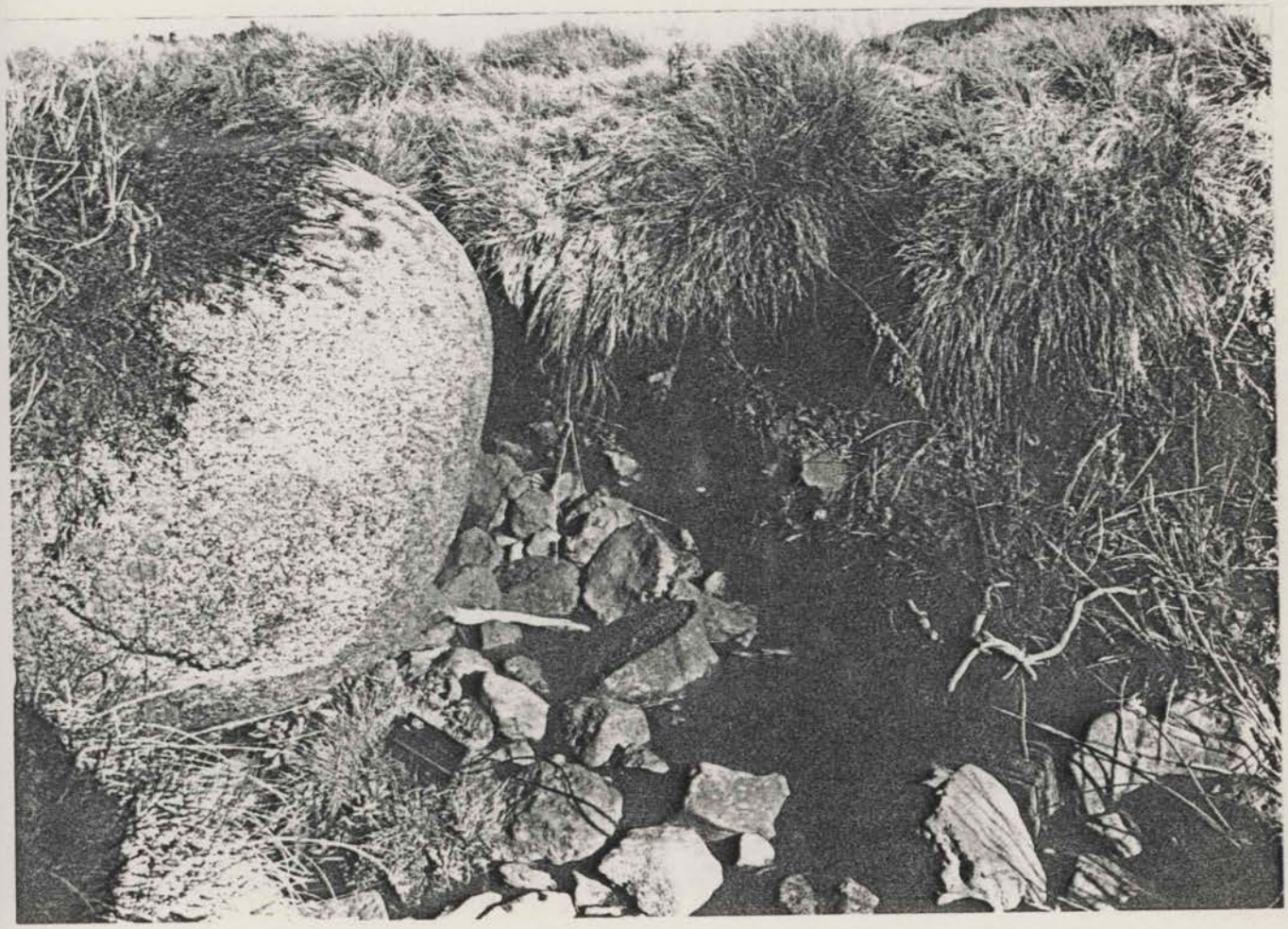
Photograph BH 5487F11 demonstrates portion of the partially vegetated blockfield at site 32. These blocks are angular and competent and have resisted vegetation and soil accumulation because they are of a significant thickness (>30cm), and they lie in the drainage line without impeding water flow. Tussock grass and heath has overgrown most of the blockfield on this broad slope below Basalt Hill, and may suceed in vegetating the blocks illustrated if enough fines can accumulate. A 6.5cm compass case to the rear of the blocks gives scale. These basalt blocks are located approximately 500m west of the edge of the basalt scarp and overlie extremely weathered granodiorite bedrock.

PHOTOGRAPH BH 5487F11



SITE NUMBER : 32 continued
PHOTOGRAPH BH 5487F14

This photograph demonstrates a large granodiorite block overlying smaller basalt blocks where the drainage line near site 32 exits through the eroded lakeside bank. Undercutting may have dislodged the granodiorite block. The compass case is 6.5cm long.



SITE NUMBER : 32 continued
PHOTOGRAPH BH 5487F13

This photograph demonstrates portion of the eroded lakeside bank adjacent to site 32. Layer 1 is dark organic loam 15cm thick. The underlying layer 2 is a compact layer of gravel, pebbles and cobbles of basalt, grandiorite and quartz. Although NOT well demonstrated here, a compact layer of blocks about 30cm thick overlies the gravel pebbles and cobbles.



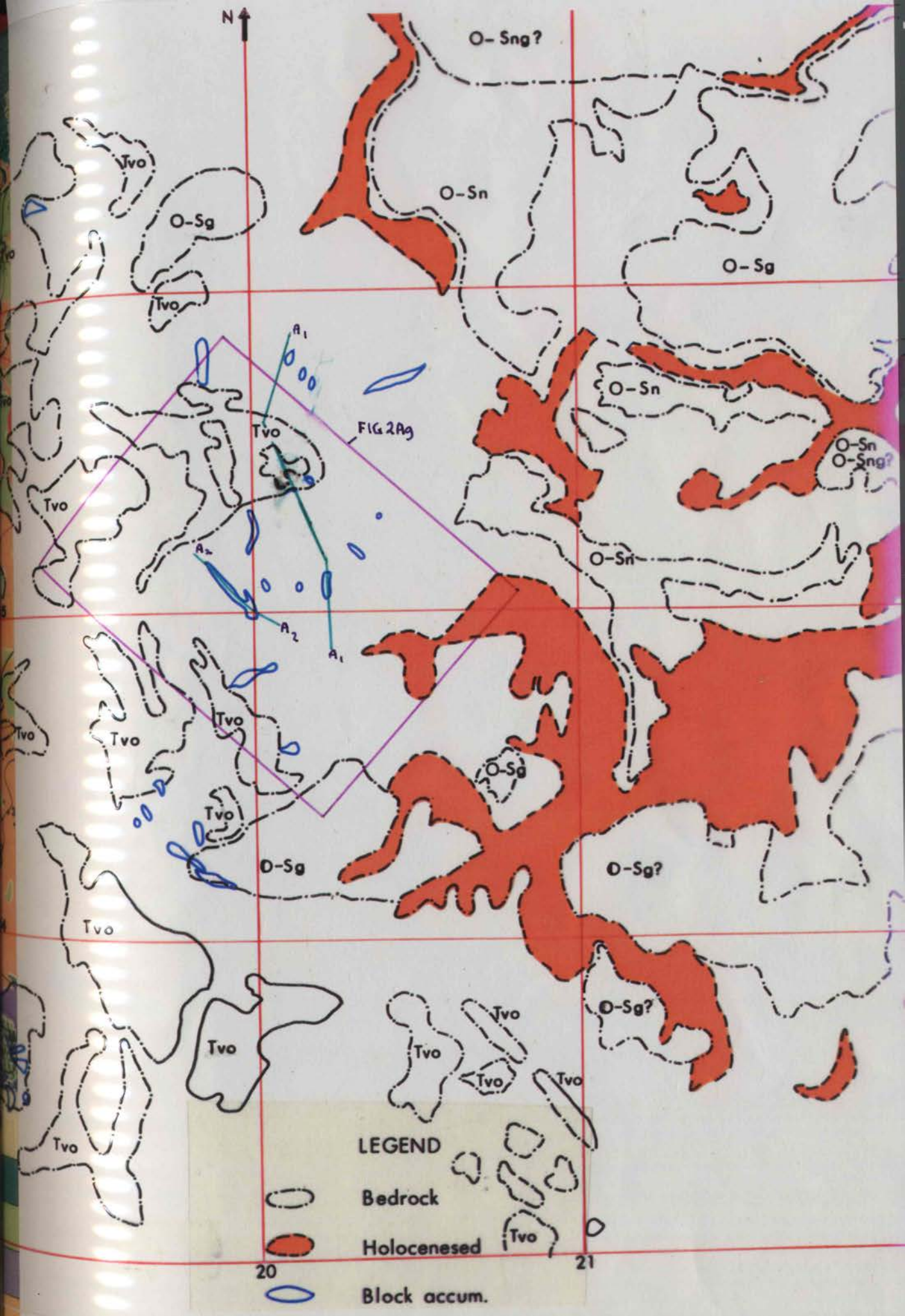
SECTION TWO : STRATIGRAPHY

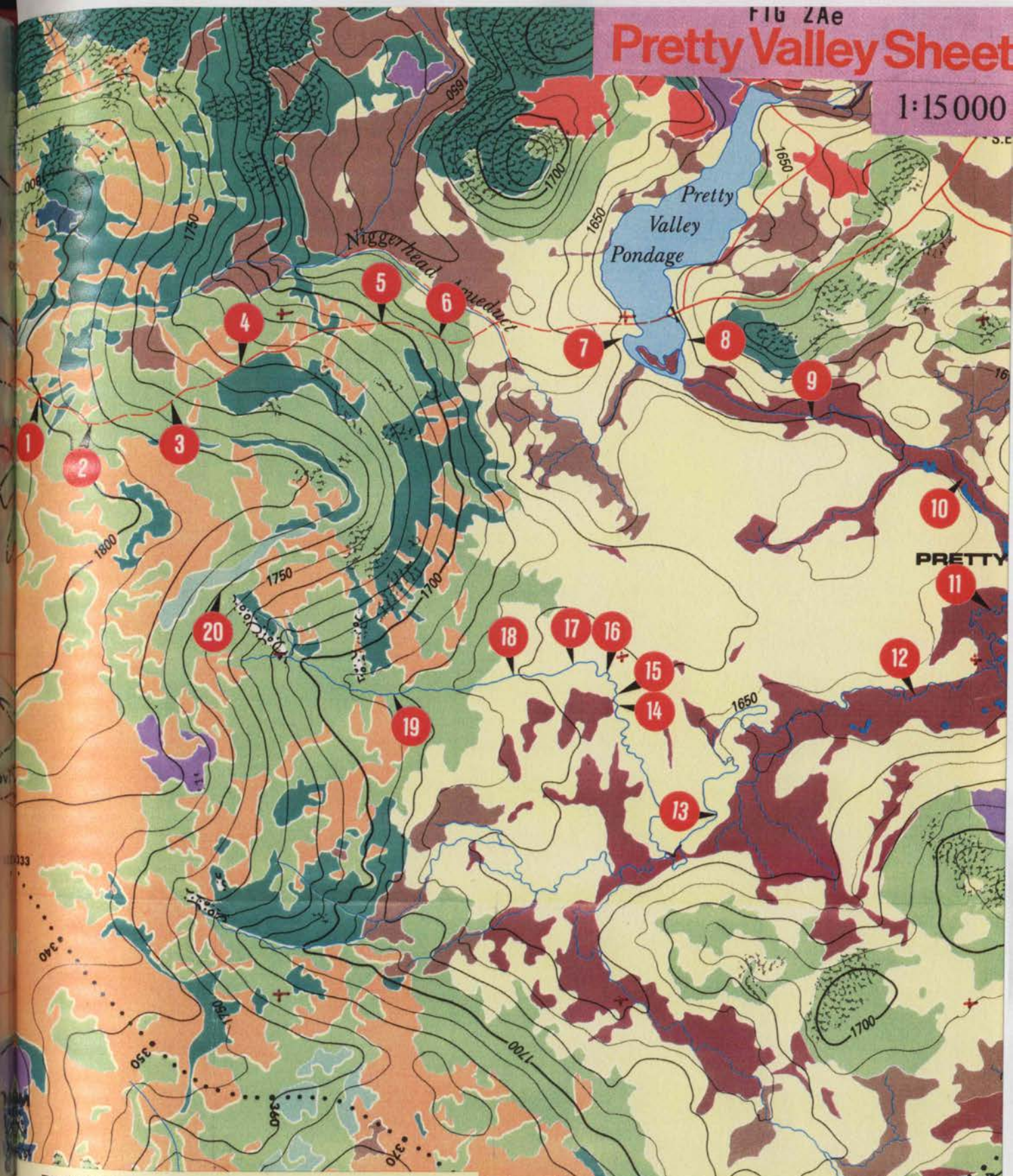
A). DESCRIPTION OF SURFICIAL DEPOSITS ON THE BOGONG HIGH PLAINS

PART THREE : PRETTY VALLEY

All grid references in this section refer to Bogong 1:100 000 NATMAP Sheet 8324. Vegetation descriptions utilise plant communities described on the Pretty Valley 1 : 15000 Vegetation Map, unless otherwise stated.

Refer to Fig 2Ae for the location of Pretty Valley stratigraphic sites.


N
O- Sng?
O-Sn
O-Sg
Tvo
FIG 2Ag
A1
A2
O-Sn
O-Sng?
O-Sg?
20
21
LEGEND
Bedrock
Holocenesed
Block accum.



DESCRIPTIVE NOTES

Closed heathland — Dense stands of tall shrubs, often with sparse understorey, occurring near and below treeline.

Open heathland — Short shrubs, rarely dense, with inter-shrub spaces comprising herbs and grasses.

***Kunzea* heathland** — Shrubs, usually prostrate, growing in dense, layering mats. Mainly on gentle slopes and often on summits.

***Poa costiniana* tussock grassland** — Grassland of dense tussocks and small, periodically water filled depressions occurring in areas underlain by basalt.

***Poa hiemata* tussock grassland** — Grassland with many inter-tussock spaces containing herbaceous species, mainly on gentle slopes of metamorphic rock type.

Short turf snowpatch — Short herbs and grasses (non-tussock) occurring on sheltered sites of relatively late snowmelt (melt usually complete by early December).

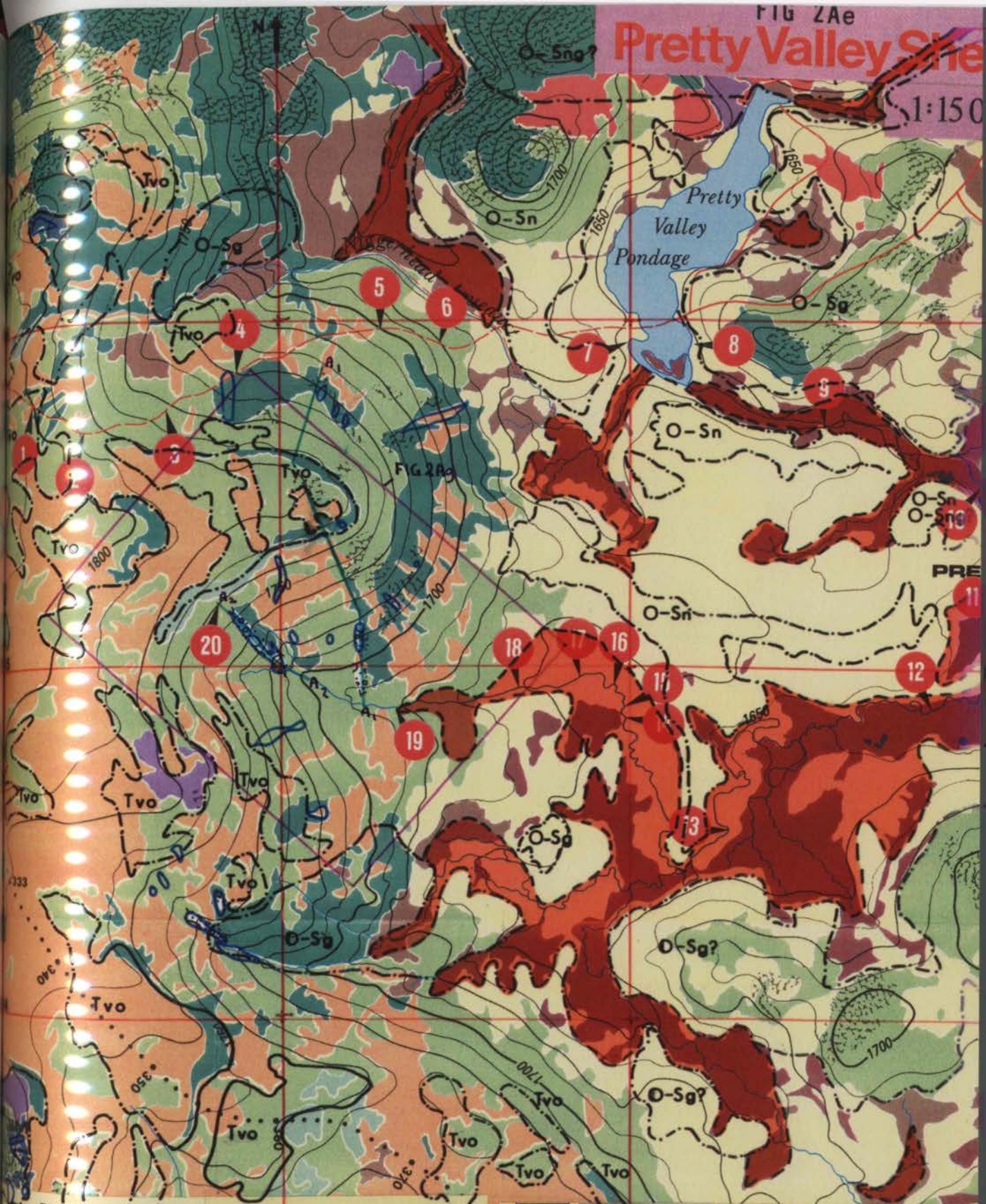
Late-lying snowpatch — On moderate to steep slopes, the lower parts comprising tussock grasses and the upper portions *Celmisia asteliifolia* — sheltered sites of late snowmelt (melt usually complete by mid-January).

Bog — Normally composed of a mossy (*Sphagnum*) layer with a sparse to dense shrub cover and interspersed with pools. Permanently wet sites.

Relic bog — A mosaic of dwarf heathland, deep pools and moist depressions — confined to floor of Pretty Valley. Intermittently wet sites.

Disturbed areas — Some of these have been revegetated with introduced plants.

Rocky grassland — On sparsely vegetated rocky sites, predominantly basaltic outcrops. Grasses, herbs and short shrubs are confined to spaces between rocks.


FIG 2Ae
Pretty Valley She
1:150
O-Sno?
Pretty Valley Pondage
O-Sn
O-Sg
Tvo
FIG 2Ag
O-Sn
O-Sn
O-Sn
O-Sn
O-Sg
O-Sg?
O-Sg?
1650
1700
1800
1750
1700
1700
1650
1700
1700
1700
1650
1700
1700
1700

SITE NUMBER : 1
G.R. : 193158
ELEVATION : 1800m
ASPECT : North-north-east
GEOMORPHIC SETTING : Gentle well drained slope of gradient 4°.
VEGETATION : Poa grassland.
STRATIGRAPHY :

Refer to Photograph PV 4586F8.

Layer 1 : 30cm thick. Dark, friable organic loam.

Layer 2 : 60cm thick. Peat changing from black at the base to mid brown at the top. Charcoal fragments were present within the peat.

Layer 3 : 70cm thick. Irregular tightly packed basalt clasts up to about 7cm in a fine orange brown matrix. All clasts were very weathered basalt and the clasts comprised about 80% of the bulk, but did not exhibit internal stratification.

PHOTOGRAPH PV 4686F8

This photograph illustrates site 1 and demonstrates a sharp junction between layers 2 and 3.



SITE NUMBER : 2
G.R. : 195157
ELEVATION : 1780m
ASPECT : North-east
GEOMORPHIC SETTING : Well drained bench sloping 10°.
VEGETATION : Short wet heath, on locally saturated site.
STRATIGRAPHY :

Refer to Photograph PV 4586F9.

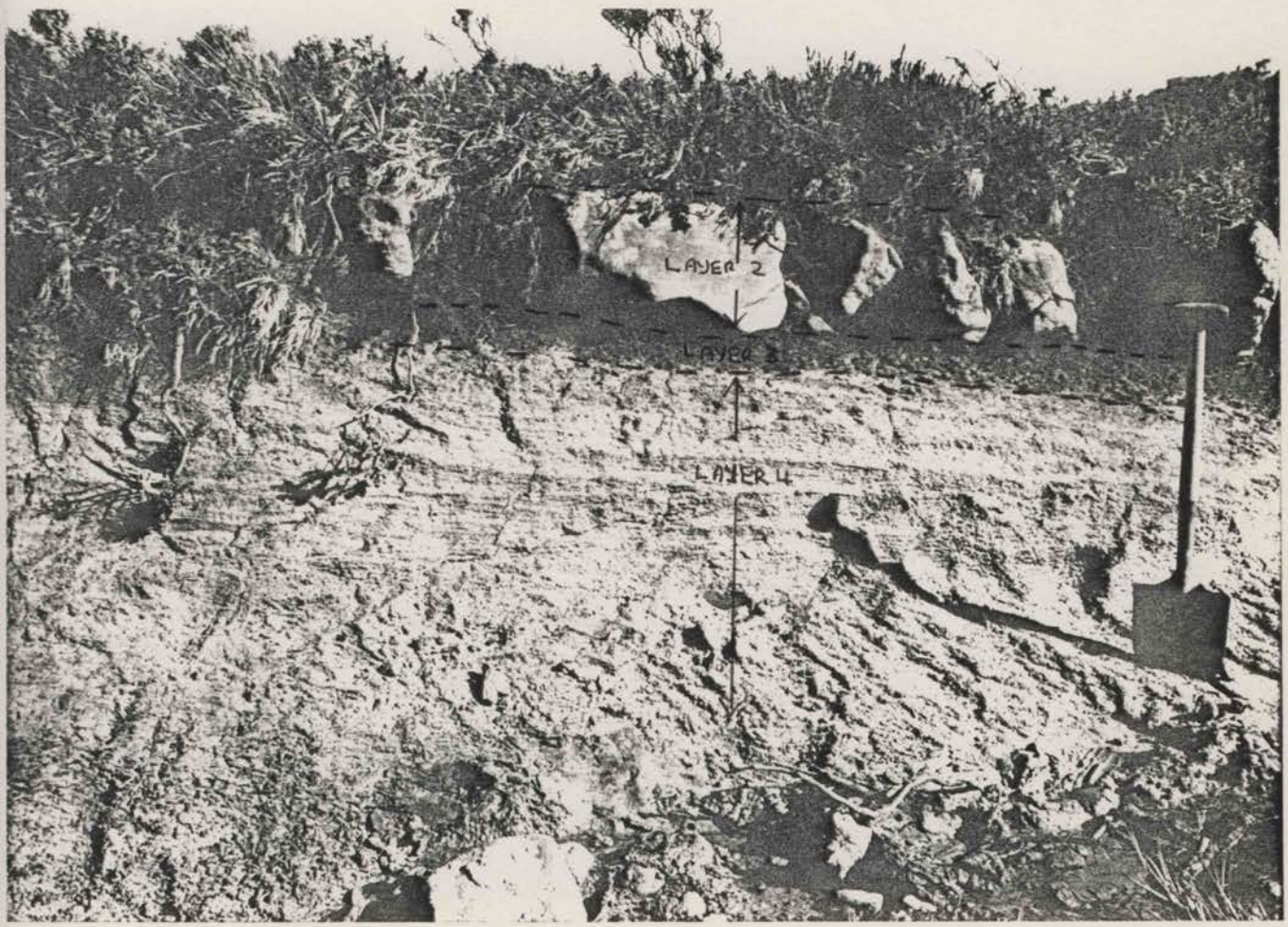
Layer 1 : 20cm-40cm thick. Organic loam (Alpine Humus).

Layer 2 : 40cm-50cm thick. Tightly packed basalt blocks (10cm-60cm) in a matrix of humified gravelly loam.

Layer 3 : 50mm-75mm thick. A layer of fine gravel comprising pebble of quartz and basalt in a silty sandy matrix.

Layer 4 : It appears to be a sediment but is probably extremely weathered gneissic bedrock.

PHOTOGRAPH PV 4586F9



SITE NUMBER : 3
G.R. : 197158
ELEVATION : 1760m
ASPECT : North
GEOMORPHIC SETTING : Simple mid slope section sloping 10°.
VEGETATION : Poa grassland.
STRATIGRAPHY :

Refer to Photograph PV 4586F12

Layer 1 : 10cm thick. Organic loam

Layer 2 : 30cm thick. Basalt blocks in a matrix of organic loam, but resting upon a tightly packed gravel layer entirely made up of basalt pebbles from 2mm-20mm. Layer 2 is similar to the frost sorted pavement described at Basalt Hill site 23 in Section 2A part 2.

Layer 3 : 90cm thick. Weakly stratified irregular to platy basalt cobbles in a fine orange brown matrix.

Layer 4 : Extremely weathered metamorphic (O-Sn) bedrock.

PHOTOGRAPH PV 4586F12

This photograph demonstrates the 1.5m section described. The pen lies at the boundary between layers 3 and 4.



SITE NUMBER : 4
G.R. : 199158
ELEVATION : 1740m
ASPECT : North
GEOMORPHIC SETTING : Block accumulation in a drainage line sloping at 14% towards 350° GB.
VEGETATION : Tall closed heath.
STRATIGRAPHY : Partially vegetated accumulation of basalt blocks in drainage line. The head of the "blockstream" is at the base of the basalt escarpment to the south.

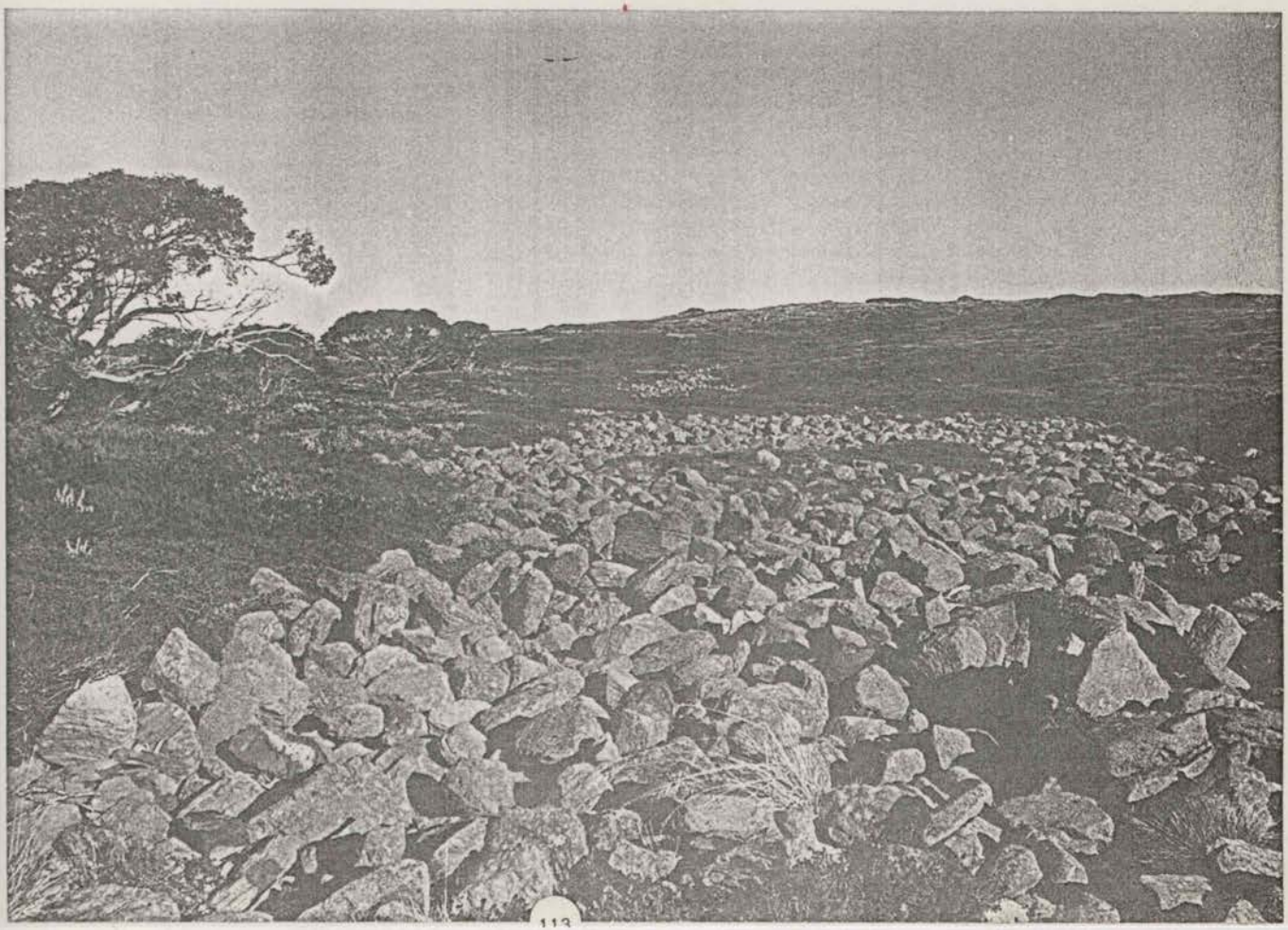
Refer Photograph PV 4586F13.

This photograph illustrates the blockstream. The total depth and nature of underlying material was not discernible. The view is south from site 4.

The blockstream is composed of columnar fragments of basalt derived from the low basalt escarpment in the background. The blocks are angular and include irregular, prismatic and platy blocks, all of which are derivatives of the primary columnar jointing. The edges of the blocks are slightly rounded and the surviving joint faces are etched by differential weathering of minerals along flow lines.

The edges of this partially vegetated accumulation are raised relative to the groundsurface at the valley sides. Estimated thickness of this block accumulation is approximately <1m. Insitu weathered basalt outcrops on the road 20m east of the blockstream at site 4.

PHOTOGRAPH PV 4586F13



SITE NUMBER : 5
G.R. : 202160
ELEVATION : 1 700m
ASPECT : North
GEOMORPHIC SETTING : Simple slope of 8° or 14% towards the north.
VEGETATION : Open heath bordering on Poa Grassland.
STRATIGRAPHY :

Refer to Photograph PV 4586F14

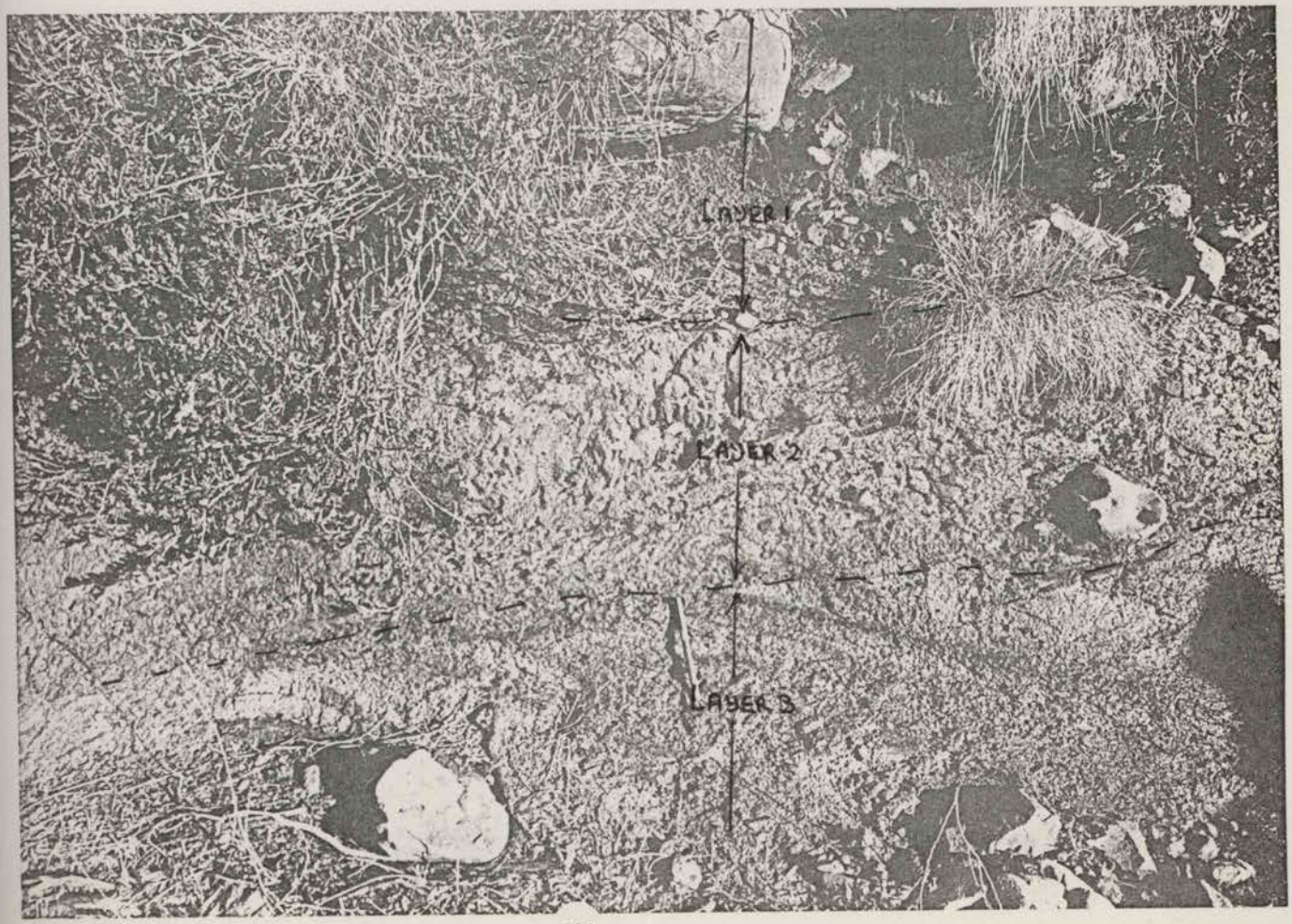
Layer 1 : 40cm thick. Tightly packed basalt blocks in an organic gravelly loam matrix.

Layer 2 : 40cm thick. Weakly stratified, angular and platy basalt clasts up to 10cm, in a pale orange brown gravelly matrix. Layer 2 is very stiff and partially consolidated by iron precipitations. Iron oxide concretions occur at the interface of layers 2 and 3.

Layer 3 : Soft banded material, probably insitu, extremely weathered gneiss or granodiorite. Relic joints are evident in this material.

The photograph below demonstrates the weak strafication within layer 2 and the banding in layer 3. The pen top is close to the junction of layers 2 and 3. The stratification of platy clasts in layer 2 suggests that this material has been fluid in the past as a series of discrete shallow flows.

PHOTOGRAPH PV 4586F14



SITE NUMBER : 6
G.R. : 204160
ELEVATION : 1680m
ASPECT : North-east.
GEOMORPHIC SETTING : Simple slope of 12° below a bench.
VEGETATION : Open heath - 30cm-40cm high.
STRATIGRAPHY :

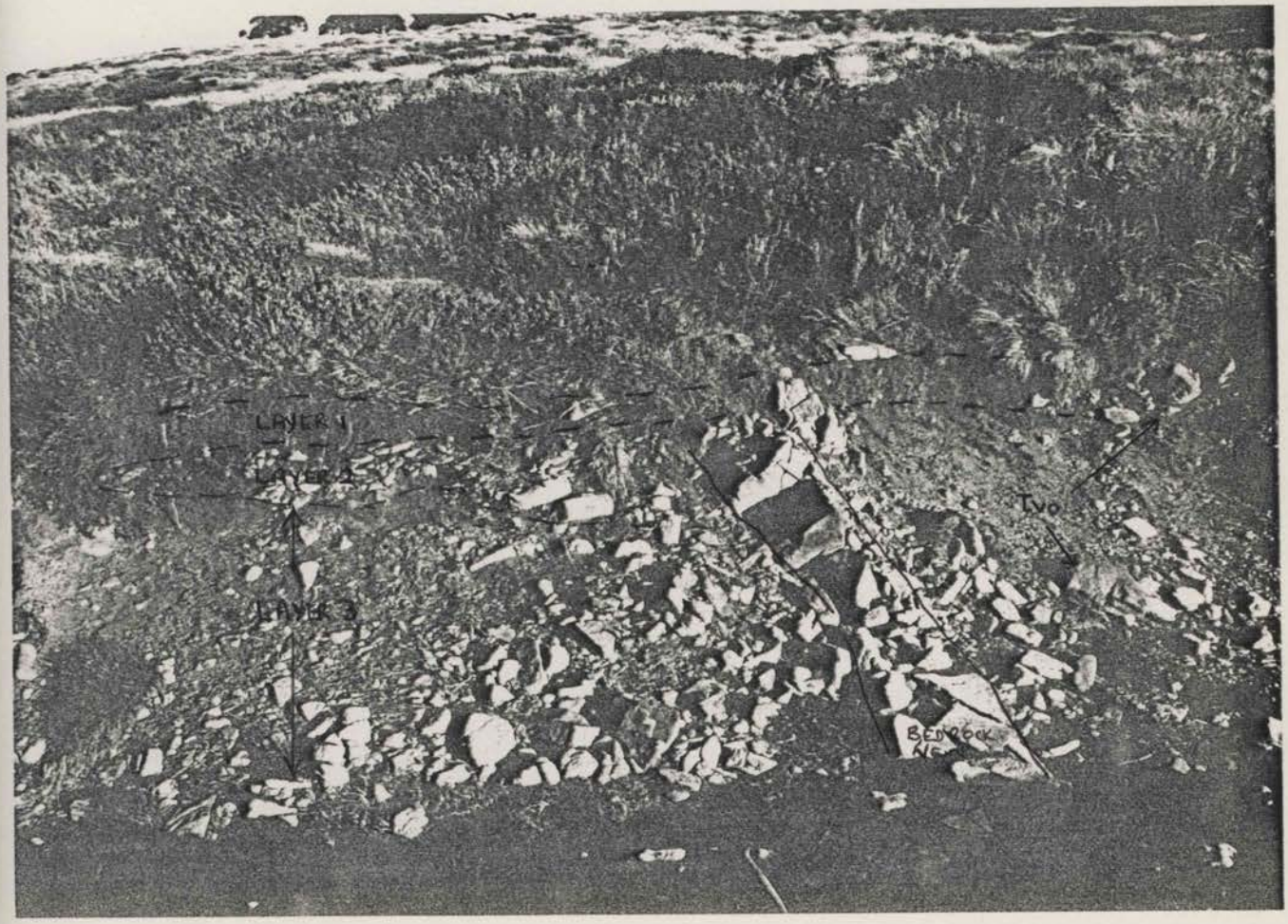
Refer to Photograph PV 4586F16

Layer 1 :20cm thick. Organic gravelly loam.

Layer 2 : 30cm thick. Local granitic rock fragments derived from an adjacent vein and arranged in a well stratified layer downslope of the parent material. Four large basalt blocks have migrated this far downslope as the exposure upslope of the vein outcrop demonstrates. See the photograph below.

Layer 3 : Pale orange brown gravel. Gravel clasts are mainly weathered basalt with some angular quartz pebbles and a few granitic pebbles.

PHOTOGRAPH PV 4586F16



SITE NUMBER : 7
G.R. : 210159
ELEVATION : 1640m
ASPECT : East
GEOMORPHIC SETTING : Base of short slope of 25% or 14°, adjacent to Pretty Valley Pondage.
VEGETATION : Poa grassland.
STRATIGRAPHY : Site 7 is a 1.6m exposure.

Layer 1 : 20cm thick. Dark brown loam.

Layer 2 : 60cm thick. Angular clasts of quartz and gneiss dispersed in a matrix of orange brown silty sandy gravel. Very few blocks were present. No basalt clasts were observed and the gneissic clasts were cobble size or smaller and extemely weathered.

Layer 3 :80cm thick. Mid brown sandy clay overlying insitu gneisic bedrock.

Layer 4 : Gneissic bedrock probably Unit (O-Sn).

SITE NUMBER : 8
G.R. : 212159
ELEVATION : 1640m
ASPECT : West
GEOMORPHIC SETTING : Base of a simple slope of approximately 25% or 14° sloping towards the west, close to the edge of Pretty Valley Pondage.
VEGETATION : Poa grassland
STRATIGRAPHY :

Refer to Photograph PV 30586F1.

Layer 1 : 20cm-25cm thick. Organic loam.

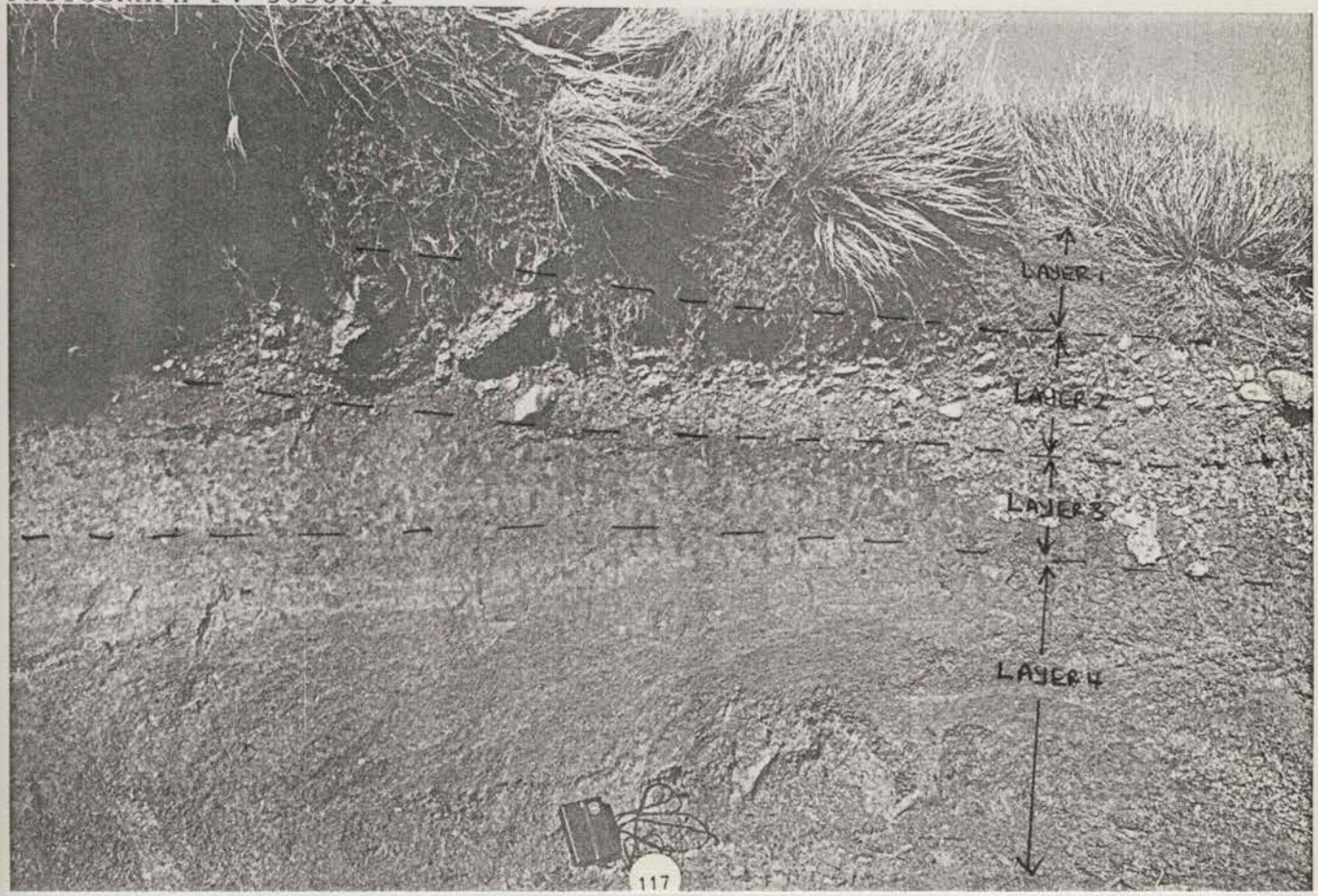
Layer 2 : 15cm-20cm thick. Pebbles, cobbles and blocks in a silty sandy matrix. Platy pebbles are stratified, with no sign of rounding or polishing. Clasts are moderately weathered gneiss or quartz. No basalt clasts were evident.

Layer 3 : 20cm thick. Orange brown mineral soil. No large clasts. Similar in appearance to the insitu extremely weathered bedrock below, but it does not possess relic foliation or stratification.

Layer 4 : 50cm thick. Extremely weathered gneissic bedrock possesing a relic foliation comprising alternating bands of light limonitic yellow brown and darker bands.

The photograph below, demonstrates the weakly stratified (imbricate) clasts of layer 2 and the diffuse boundary between layers 3 and 4 which implies a lack of movement and perhaps long term weathering for layer 3.

PHOTOGRAPH PV 30586F1



SITE NUMBER : 9
G.R. : 215157
ELEVATION : 1638m
ASPECT : N.A.
GEOMORPHIC SETTING : 50cm high alluvial terrace adjacent to Pretty Valley Creek.
VEGETATION : Tussock, sedge and swamp heath, but mapped as relic bog on 1:15 000 Vegetation Map.
STRATIGRAPHY :

Layer 1 : 15cm thick. Organic sandy silt loam.

Layer 2 : 25cm thick. Loose, unconsolidated gravelly sand. This sediment appears to be devoid of internal stratification other than a reduction in particle size towards the top.

Layer 3 : Peat. Mid brown in upper sections and dark in lower sections.

SITE NUMBER : 10
G.R. : 221155
ELEVATION : approximately 1645m
ASPECT : N.A.
GEOMORPHIC SETTING : A 1m high alluvial terrace adjacent to Pretty Valley Creek.
VEGETATION : Relic bog community.
STRATIGRAPHY :

Layer 1: 50cm thick. Brown silt. This material is a recent stone free accretion.

Layer 2 : 50cm thick. Dark peat.

SITE NUMBER : 11
G.R. : 221152
ELEVATION : approximately 1646m
ASPECT : N.A.
GEOMORPHIC SETTING : A 50cm high alluvial terrace adjacent to Pretty Valley Creek.
VEGETATION : Relic bog community.
STRATIGRAPHY :

Layer 1 : 40cm thick. Fine sandy silt in the creek bank. The silt has a vertical columnar structure, with columns 15cm-20cm wide and 40cm-50cm high.

Layer 2 : Brown fibrous peat occurs just below the water line and appears to be stratified.

SITE NUMBER : 12
G.R. : 218149
ELEVATION : 1648m
ASPECT : N.A.
GEOMORPHIC SETTING : A 1.2m alluvial terrace adjacent to Pretty Valley Creek
VEGETATION : Tussock grassland.
STRATIGRAPHY :

Refer to Photograph PV 11186F10.

Layer 1 : 20cm-30cm thick. Organic loam.

Layer 2 : Variable thickness of brown sandy silt with a very diffuse boundary between layers 1 and 2.

Layer 3 : Approximately 1m thick. Laminations of peat interbedded with gravelly sand.

Layer 4 : Variable thickness. Stratified cobbles.

Layer 5 : Extremely weathered bedrock.

A sample of peat from layer 3 was analysed for pollen by Helene Martin, School of Botany, University of N.S.W.. H.A. Martin's report states " This type of assemblage suggests a Recent or contemporary age. All of the plants are the type which would be found in the region today. The most common pollen groups, Gramineae and Compositae indicate open grasslands or herbfields typical of the region today."

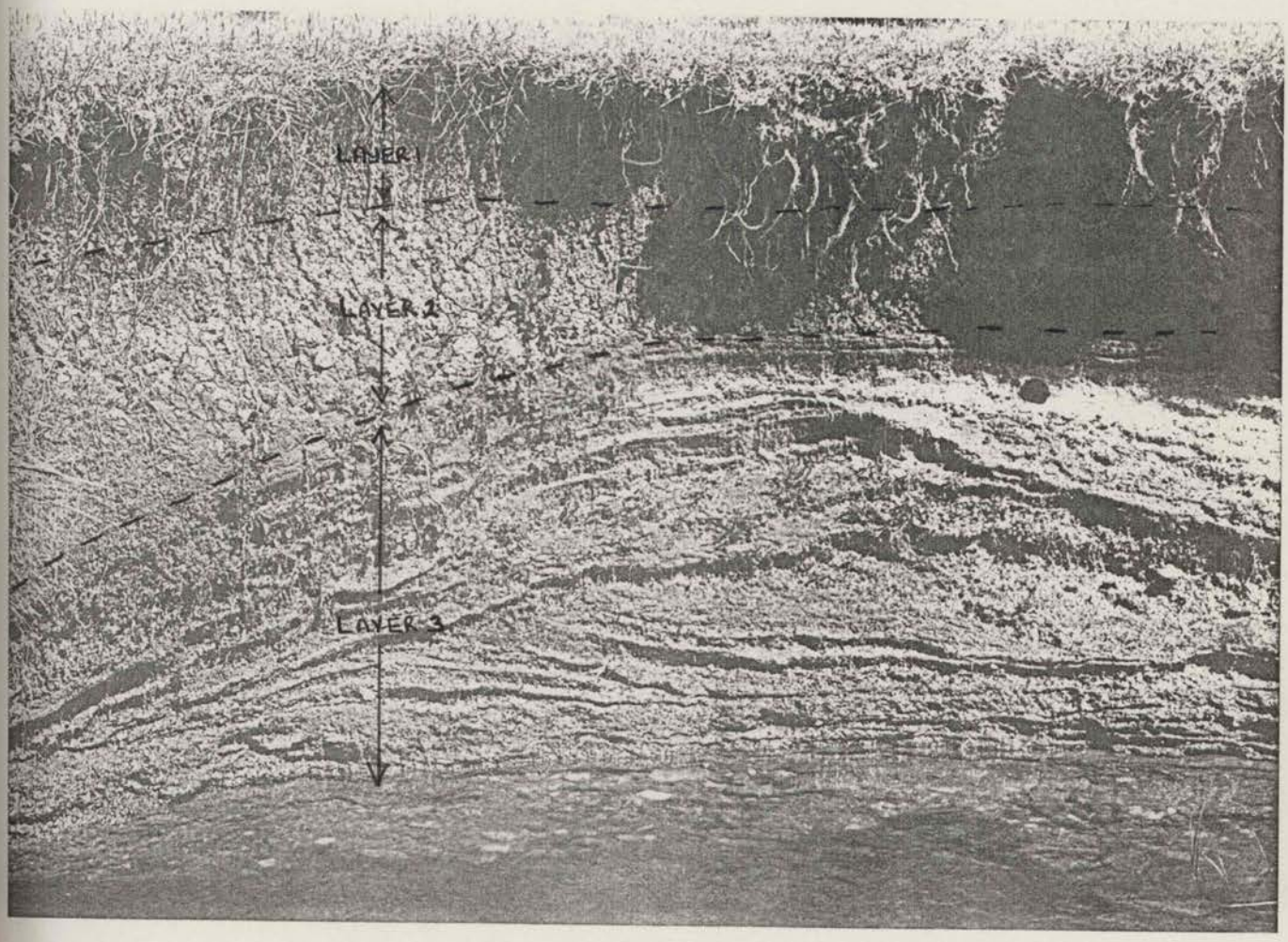
The fact that the peat is now relic and is overlain by organic loam which supports grassland instead of bog or fen communities suggests that there has been significant climatic and or hyrologic changes during the Holocene.

It would appear that the original peat beds have been reworked and redeposited with poorly sorted, angular gravels during a flash flood. These laminated, interbedded gravelly peats are common along Pretty Valley Creek which suggests a widespread change in stream dynamics and a change in the erodibility of the peat bog communities possibly brought about by a period of aridity with erratic but occasionally very heavy rainfall.

In places the laminated peat is intercalated with the brown sandy silt (of layer 2, site 12), with which it may be synchronous.

SITE NUMBER : 12 (continued)
PHOTOGRAPH PV 11186F10

This photograph demonstrates layers 1, 2 and 3 at site 12. The reworked peat of layer 3 is laminated and displays current bedding.



SITE NUMBER : 13
G.R. : 213145
ELEVATION : 1650m
ASPECT : N.A.
GEOMORPHIC SETTING : Small alluvial terrace adjacent to Pretty Valley Creek.
VEGETATION : Short tussock grassland.
STRATIGRAPHY :

Layer 1 : 25cm of dark brown organic loam.

Layer 2 : 20cm lens of orange-brown silty gravel.

Layer 3 : 40cm of interstratified gravel and peat.

The peat seems to disappear or lens out at regular intervals along the creek and orange brown sandy silt dominates as the major component with organic loam above and extremely weathered bedrock below.

SITE NUMBER : 14
G.R. : 210149
ELEVATION : 1655m
ASPECT : N.A.
GEOMORPHIC SETTING : Small irregular terrace adjacent to Pretty Valley Creek.
VEGETATION : Tussock grassland.
STRATIGRAPHY : Site 14 is a 1.3m creek bank section.

Refer to composite Photograph PV 1686F4/F5

Layer 1 : 20cm-30cm thick. Brown organic loam.

Layer 2 : 60cm-90cm thick. Interstratified sand and sandy peat in a series of current bedded lenses. The lower 40cm is dominantly dark fibrous peat.

Layer 3 : approximately 30cm thick. Tightly packed cobbles below the creek waterline. The clasts comprise gravel, cobbles and blocks of quartz and basalt in a silty sand matrix. The modal size is cobble.

NOTE : Basalt clasts were not recorded downstream from this point. The irregular blocks within layer 3 indicate minimal transport by water.

The composite photograph PV 1686F4/F5 (overleaf) demonstrates a 4m wide strip of creek embankment which exposes layers 1 and 2. Some of the cobbles of layer 3 are just visible below the water line.

SITE NUMBER :14 (continued)
COMPOSITE PHOTOGRAPH PV 1686F4/F5



SITE NUMBER : 15
G.R. : 210149
ELEVATION : 1655m
ASPECT : N.A.
GEOMORPHIC SETTING : Small irregular creek terrace against Pretty Valley Creek.
VEGETATION : Tussock grassland.
STRATIGRAPHY : Site 15 is a 1m section.

Layer 1 : 20cm thick. Organic loam.

Layer 2 : > 20cm thick. Stratified sand lens, containing organic matter.

Layer 3 : Composite layer approximately 60cm thick comprising pale grey mottled clay with columnar structure which lenses out and is onlapped by lenticular stratified peat and sand. Thin lenses of gravel also occur within the stratified peat.

Layer 4 : 20cm-30cm lens of resistant, tightly packed cobbles with a silty sandy gravelly matrix. Layer 4 is exposed below the water line.

Layer 5 : Dark clayey material, probably extremely weathered bedrock.

SITE NUMBER : 16
G.R. : 209150
ELEVATION : 1655m
ASPECT : N.A.
GEOMORPHIC SETTING : Irregular terrace adjacent to Pretty Valley Creek.
VEGETATION : Tussock grassland.
STRATIGRAPHY :

Layer 1 : 10cm-15cm thick. Dark organic loam.

Layer 2 : 50cm thick. Brown sand with stratification of organic matter and sand. No pebbles or gravel apparent in this layer.

Layer 3 : 5cm-10cm thick. Thin seam of cobbles and gravel of quartz and basalt.

Layer 4 : 40cm thick. Orange clay merging into grey gravelly sand. This may represent relic extremely weathered gneissic bedrock.

SITE NUMBER : 17
G.R. : 208150.
ELEVATION : 1658m
ASPECT : N.A.
GEOMORPHIC SETTING : Irregular terrace adjacent to Pretty Valley Creek.
VEGETATION : Tussock grassland.
STRATIGRAPHY :

Layer 1 : 40cm thick. Organic loam with small percentage of quartz and basalt pebbles.

Layer 2 : 15cm thick. Blocks cobbles and gravel in a sandy matrix. 5m further upstream layer 2 becomes more massive and well cemented in a yellow brown matrix but it is humified in its upper portions.

Layer 3 : Grey well structured clay material, probably extremely weathered insitu bedrock.

This site is different from previous sites downstream, in that it does not contain peat or reworked peat or gravelly alluvium . The reworked peat and sandy gravelly alluvium of layer 2 and 3 at site 12, 13, 14, 15 are interpreted as alluvial fan outwash from the valley immediately the margin of the basalt plateau rising 180m above site 17

Site 17 appears to be beyond the margin of this alluvial cone and the diminished development of stratified peat/gravel in layer 2 at site 16 supports a thinning of the alluvial cone at its north eastern distal margin. The alluvial cone slopes at 5% or 3° to the southeast and may have diverted the creek draining this valley.

Site 12 and 13 probably include accretions of alluvium from other tributaries of Pretty Valley Creek in addition to the previously mentioned tributary along which the traverse continues.

SITE NUMBER : 18
G.R. : 207149
ELEVATION : 1660
ASPECT : East
GEOMORPHIC SETTING : Small alluvial terrace at the mouth of a steep tributary of Pretty Valley Creek and within the alluvial cone refered to at site 17.
VEGETATION : Tussock grassland.
STRATIGRAPHY :

Refer to Photograph PV 1686F10.

Layer 1 : 20cm thick. Organic loam.

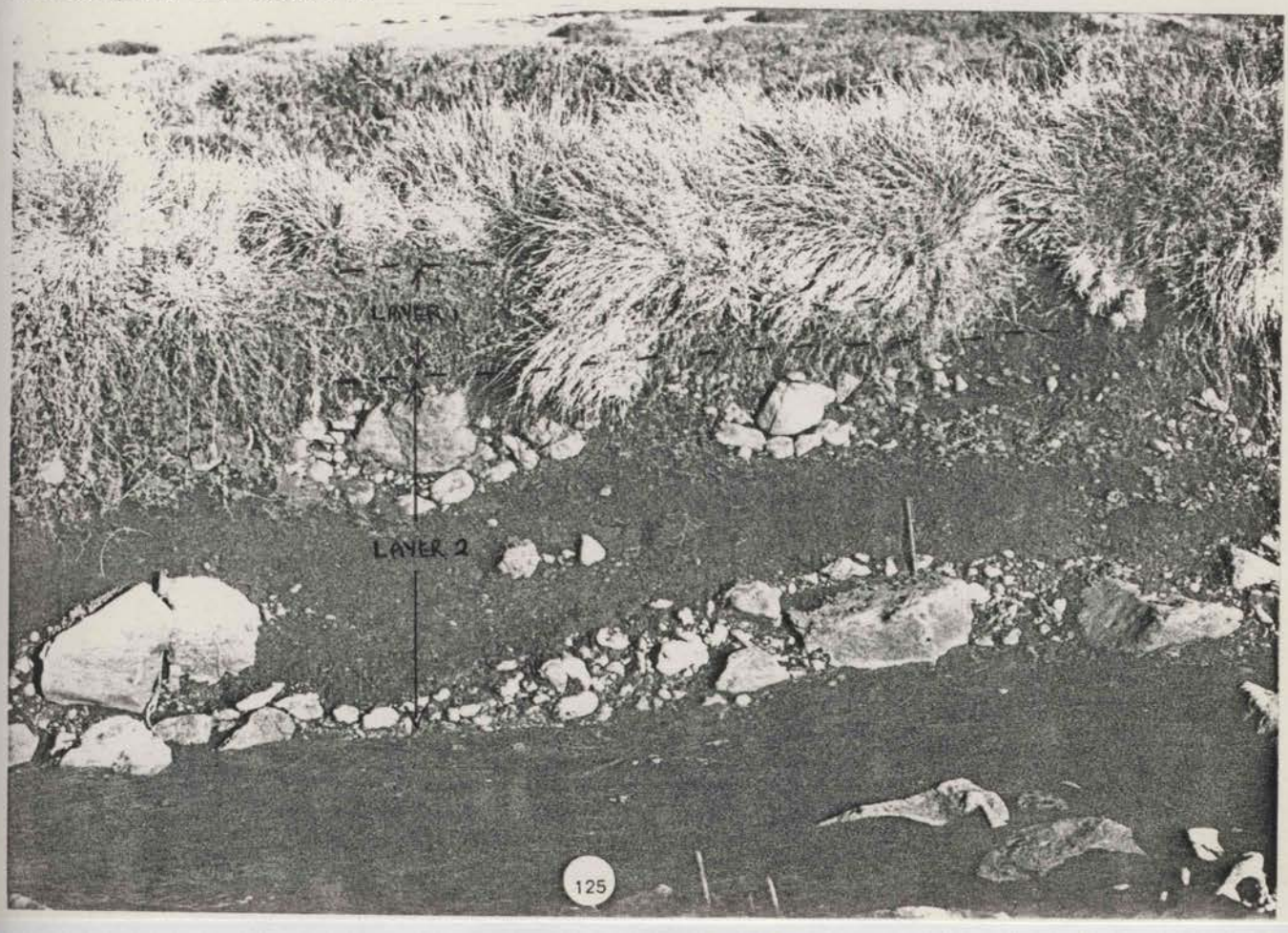
Layer 2 : 40cm-50cm thick. Comprises lenses of bouldery gravel and gravelly silty sand containing organic matter.

The blocks in this section are relatively small and generally less than 20cm in maximum dimensions. There is much organic matter in the matrix of layer 2. Layer 2 probably represents a stream flood deposit near the fan head. This deposit probably represents a reworking of relic frost sorted debris on the steep slopes along the margins of the basalt plateau during the Holocene.

Layer 2 of site 18 is probably synchronous with layer 2 at sites 12 to 16.

The blocky alluvial terrace observed at site 18 appears to continue upstream for 300m. The creek has dissected this material to a depth of approximately 2m.

PHOTOGRAPH PV 1686F10



SITE NUMBER : 19
G.R. : 203149
ELEVATION : 1680m
ASPECT : East
GEOMORPHIC SETTING : Irregular terrace at margins of the creek sloping 4° or 6% towards the east.
VEGETATION : Short open heath.
STRATIGRAPHY :

Refer to Photograph PV 1686F11

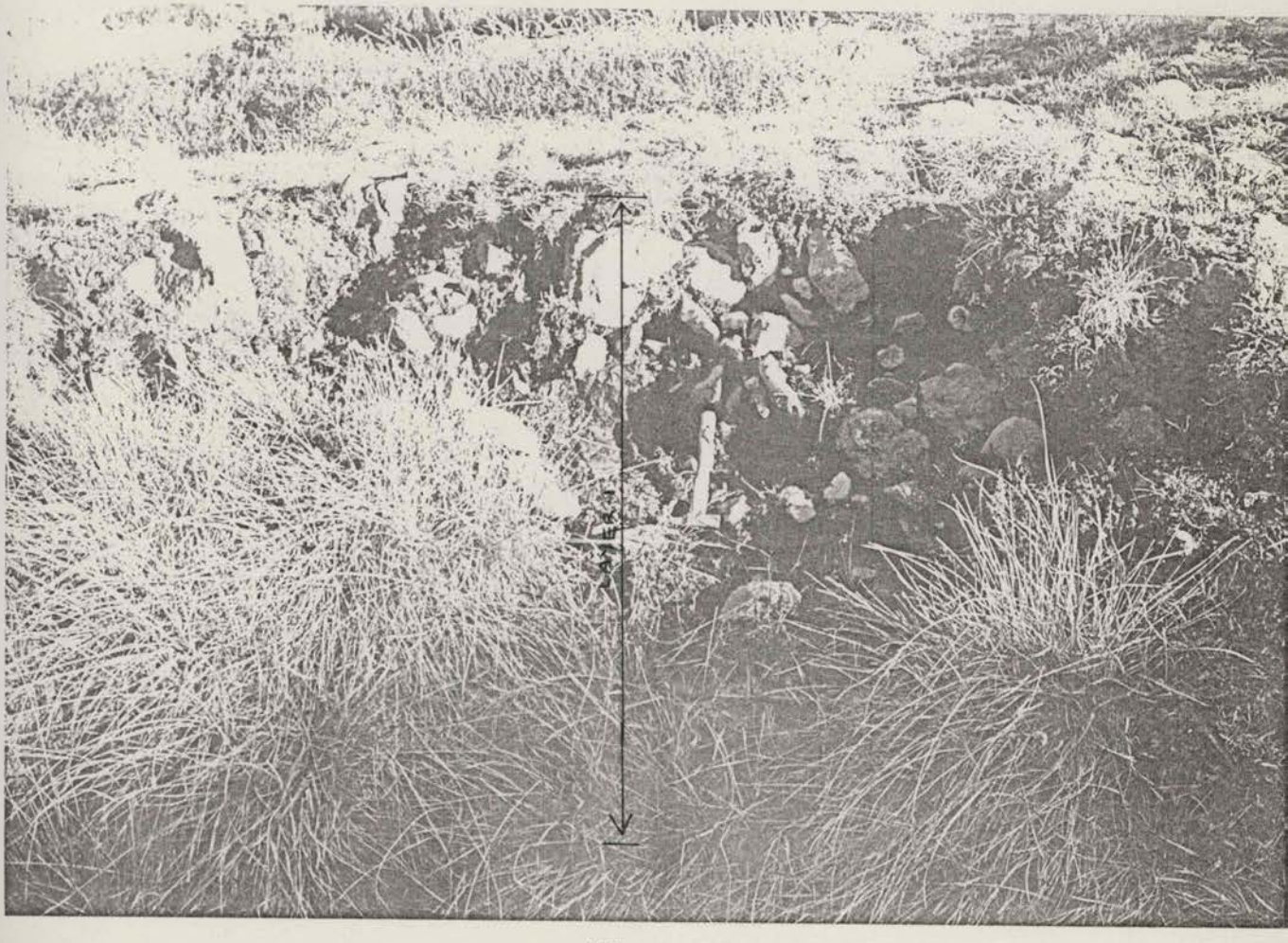
Layer 1 : 1.8m exposure of basalt blocks in a dark humified gravelly loam matrix.

Layer 2 : A small exposure of cobbles in a yellow brown silty sandy matrix. (not shown in photograph)

Site 19 is located 100m below a large step in the terrain which corresponds to an insitu layer of basalt. Several basalt block streams appear to terminate just below this basalt step, and above site 19.

The basalt block accumulation has probably been reworked and dissected by alluvial action but suggests selective down slope transport of blocks by frost creep across the surface of the adjacent valley sides during the last cold phase of the Pleistocene. Block movement today on these surfaces is minimal due to the resistant cover of heath and tussock grassland.

PHOTOGRAPH PV 1686F11



SITE NUMBER : 20
G.R. : Approximately 197153
ELEVATION : 1770m
ASPECT : South-east
GEOMORPHIC SETTING : This feature is a recent mass-movement (earthflow/landslide) at the head of a tributary of Pretty Valley Creek on a slope of about 10% or 6°.
STRATIGRAPHY : This is best represented on a profile surveyed through this feature using a theodolite. Four longitudinal sections were surveyed. Traverse 4 is represented as Fig 2Ah and traverse 3 as Fig 2Ai.

A plan of the scarp and rampart produced by this earthflow is contained in Fig 2Ag, which is a geomorphic outline overlying a 1:4 000 aerial photograph (3478-231).

Layer 1 : 10cm-50cm thick. A thin brown mineral soil or recent accumulation of peat in saturated depressions behind the distal rampart. Some of this material was sampled by Dr. N. Alley (1980) and yielded a C14 date of 3 700 y.B.P. (personal communication).

Layer 2 : Variable thickness of basalt blocks in a gravelly silty sand matrix.

Layer 3 : Bedrock. Green mudstone which oxidises to brown on exposure to air.

Refer to figure 2Ag which is an overlay of geomorphic interpretation on aerial photograph 3478-231.The following features are shown by numbers on this overlay which includes the earthflow/landslide feature at the head of Pretty Valley Creek:

1) Earthflow backwall (site 20)
2) Earthflow rampart (site 20)
3) Proximal end of blockstream overrun by earthflow rampart.
4) Distal end of blockstream/block glacis exhibiting thermokarst.

Refer to Photographs PV 481F13, PV 481F8, and PV 481F21.
PV DBF37 , PV DBF7, PV 1182 F 6 , PV 1182 F 9
INTERPRETATION : A blocky regolith of angular blocks accumulated on this stepped terrain during the late Pleistocene due to frost shattering and surface creep of the larger clasts. This blocky regolith became unstable due to impeded drainage caused by the green mudstone of layer 3 beneath, and an earthflow ensued. The rampart was formed as the leading edge of the earthflow slowed and was bulldozed by material behind. The earthflow movement scraped pieces of green mudstone from the insitu outcrop and a few slivers of this material are visible in a small creek section through the leading edge of the rampart.

Basalt bedrock exposed in the scarp or backwall of this feature at site 20 is represented in photograph PV 481F13. It demonstrates sharply defined sections of columnar jointing. In contrast the blocks exposed in the blockstream which has been overrun by the rampart near its northern end, are noticeably more weathered with deep rills and pits caused by chemical weathering

FIG 2A j

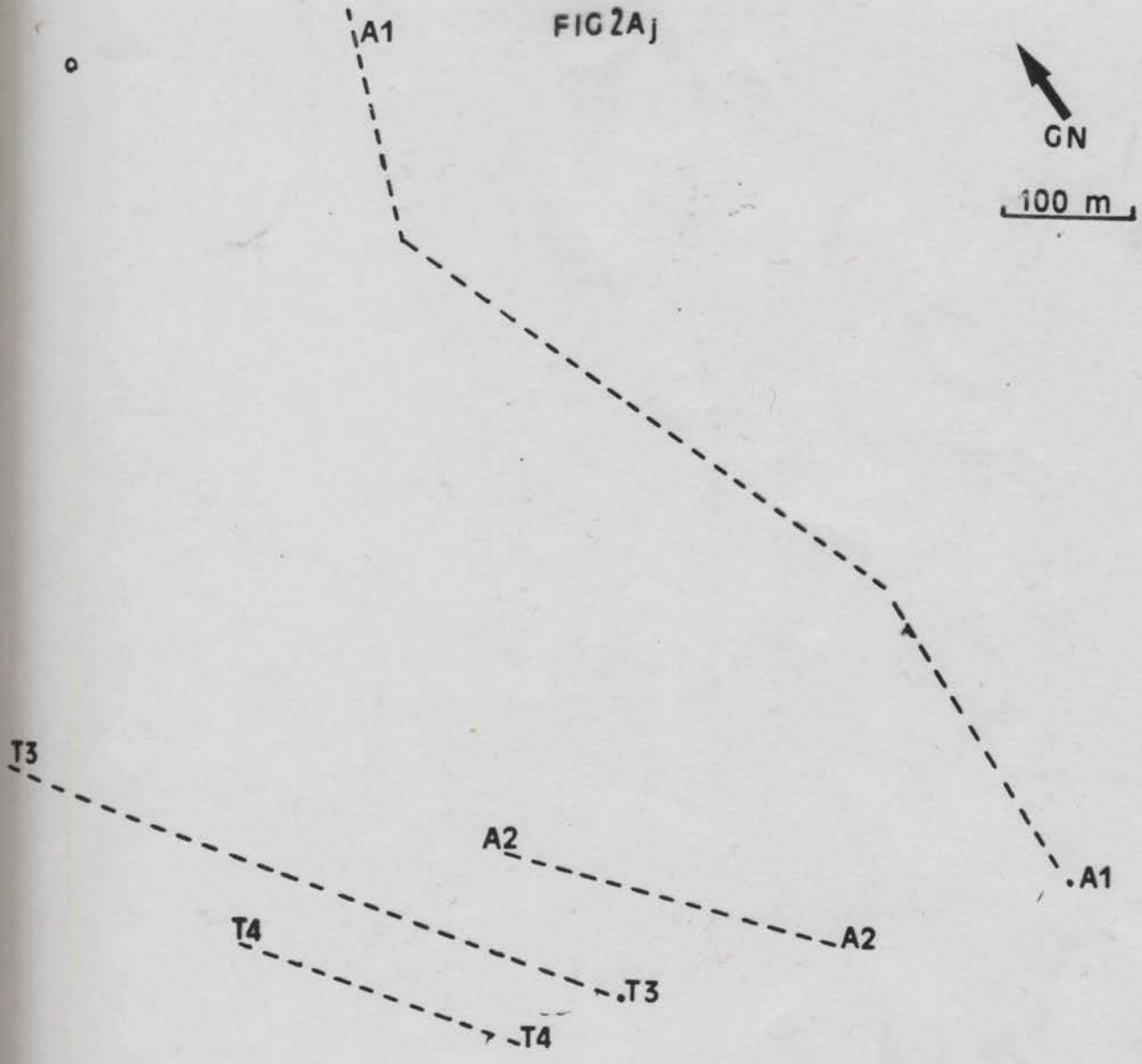


FIG. 2Ag

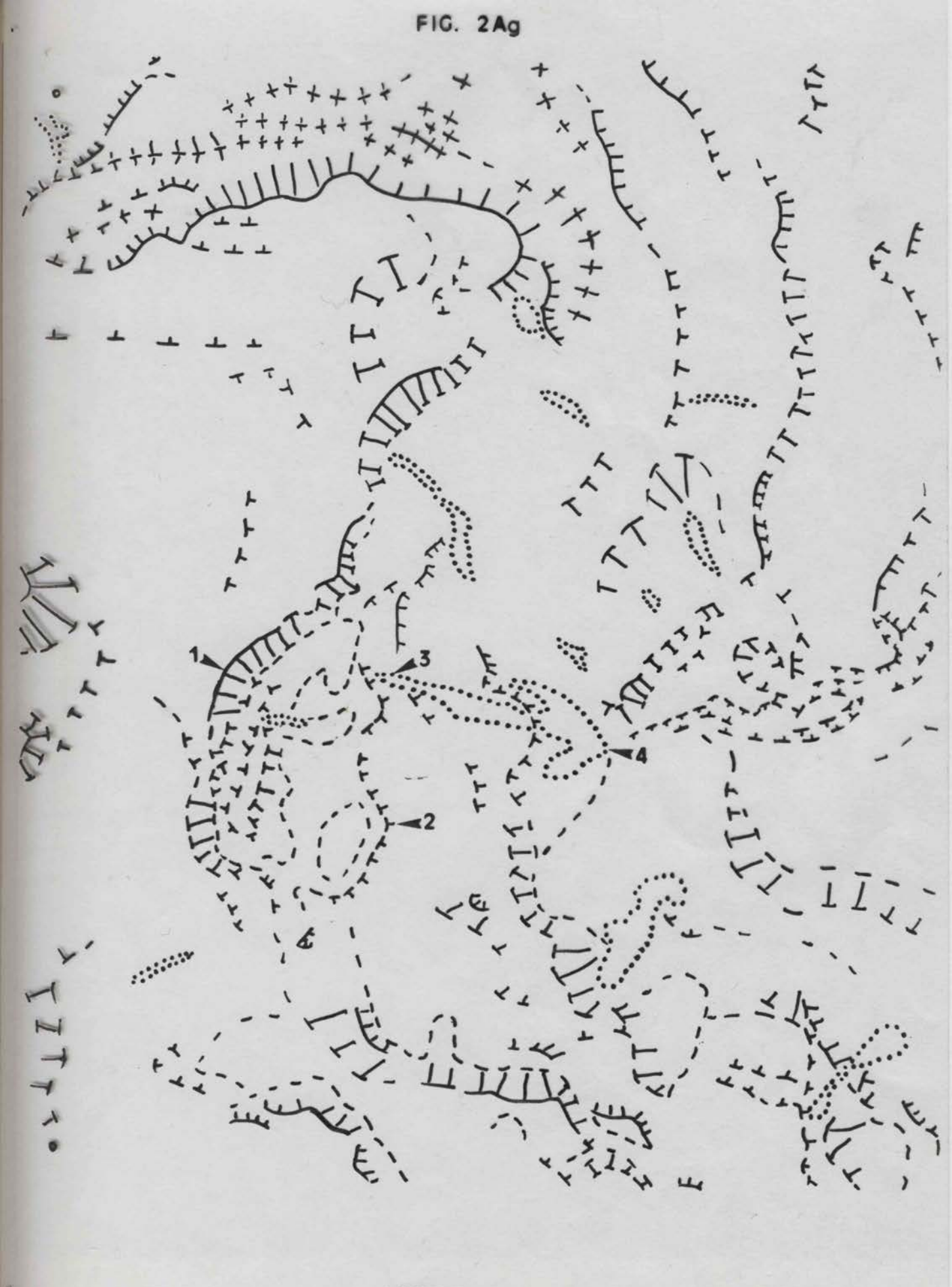

1
2
3
4
LEGEND
CLEARLY DEFINED SCARP
DIFFUSE CHANGE IN SLOPE
BLOCK ACCUMULATION

FIG 2Af



T3 - Traverse 3 presented as Fig 2Ai
T4 - Traverse 4 presented as Fig 2Al
Al- Surveyed Section presented as Fig 3Ce in Section 3C
A2 - Surveyed Section presented as Fig 3Cf in Section 3C

FIG. 2Ag



LEGEND

CLEARLY DEFINED

DIFFUSE

BLOCK ACCUMULATION

CHANGE IN SCARP SLOPE

T3 - Traverse 3 presented as Fig 2Ai
T4 - Traverse 4 presented as Fig 2A1
A1- Surveyed Section presented as Fig 3Ce in Section 3C
A2 - Surveyed Section presented as Fig 3Cf in Section 3C

FIG. 2Ag



LEGEND

CLEARLY DEFINED SCARP

DIFFUSE CHANGE IN SLOPE

BLOCK ACCUMULATION

T3 - Traverse 3 presented as Fig 2Ai
T4 - Traverse 4 presented as Fig 2Al
A1- Surveyed Section presented as Fig 3Ce in Section 3C
A2 - Surveyed Section presented as Fig 3Cf in Section 3C

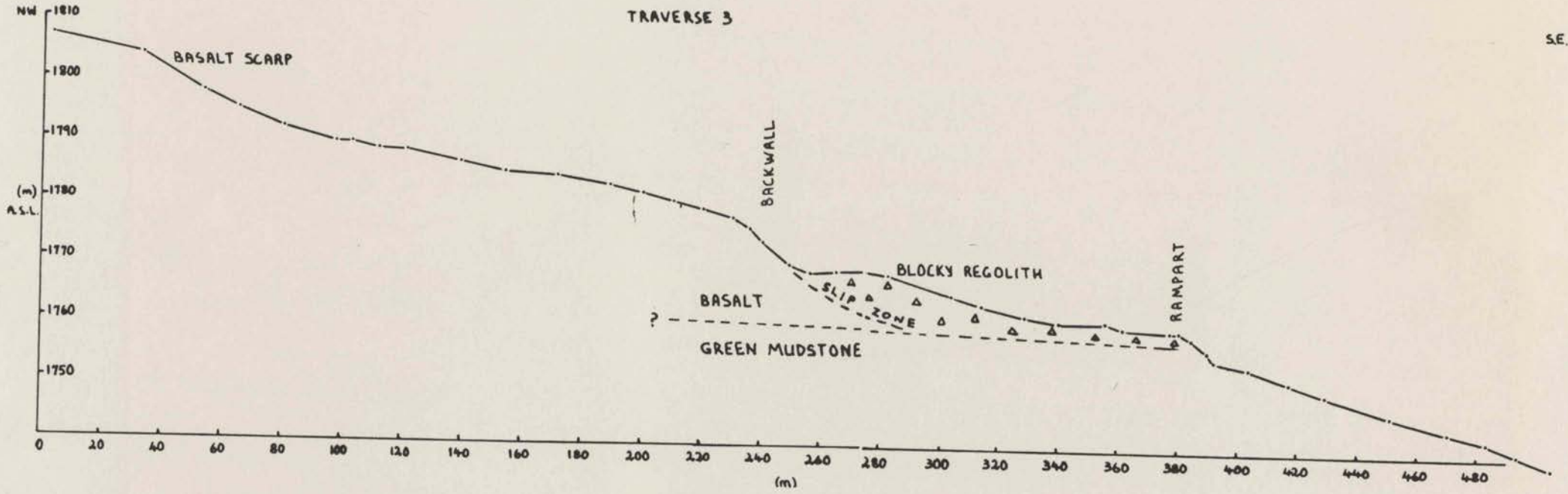
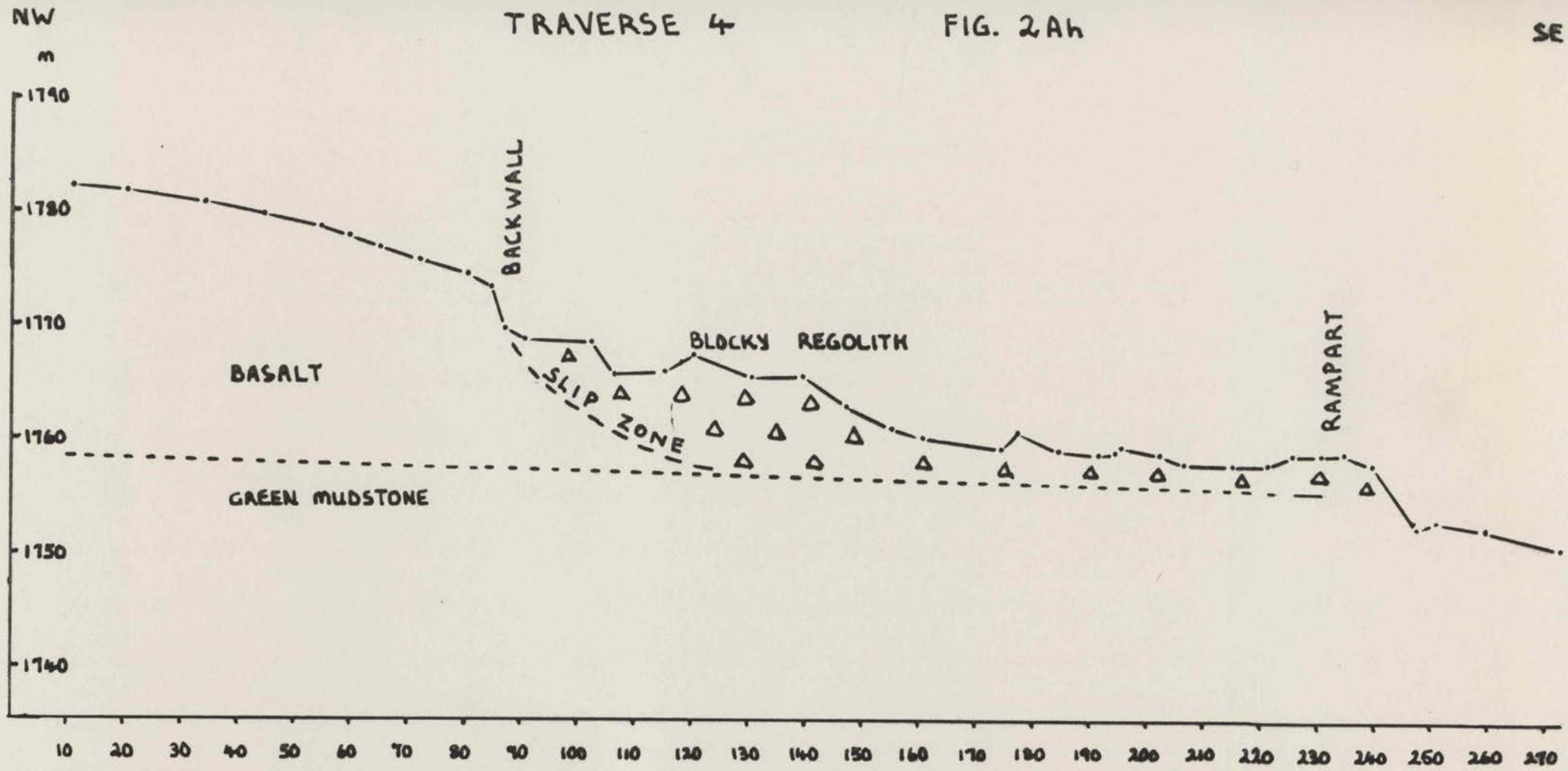

TRAVERSE 3
NW
SE
1810
1800
1790
1780
1770
1760
1750
(m) A.S.L.
BASALT SCARP
BACKWALL
BLOCKY REGOLITH
SLIP ZONE
RAMPART
BASALT
?
GREEN MUDSTONE
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
(m)

FIG. 2A i



TRAVERSE 4

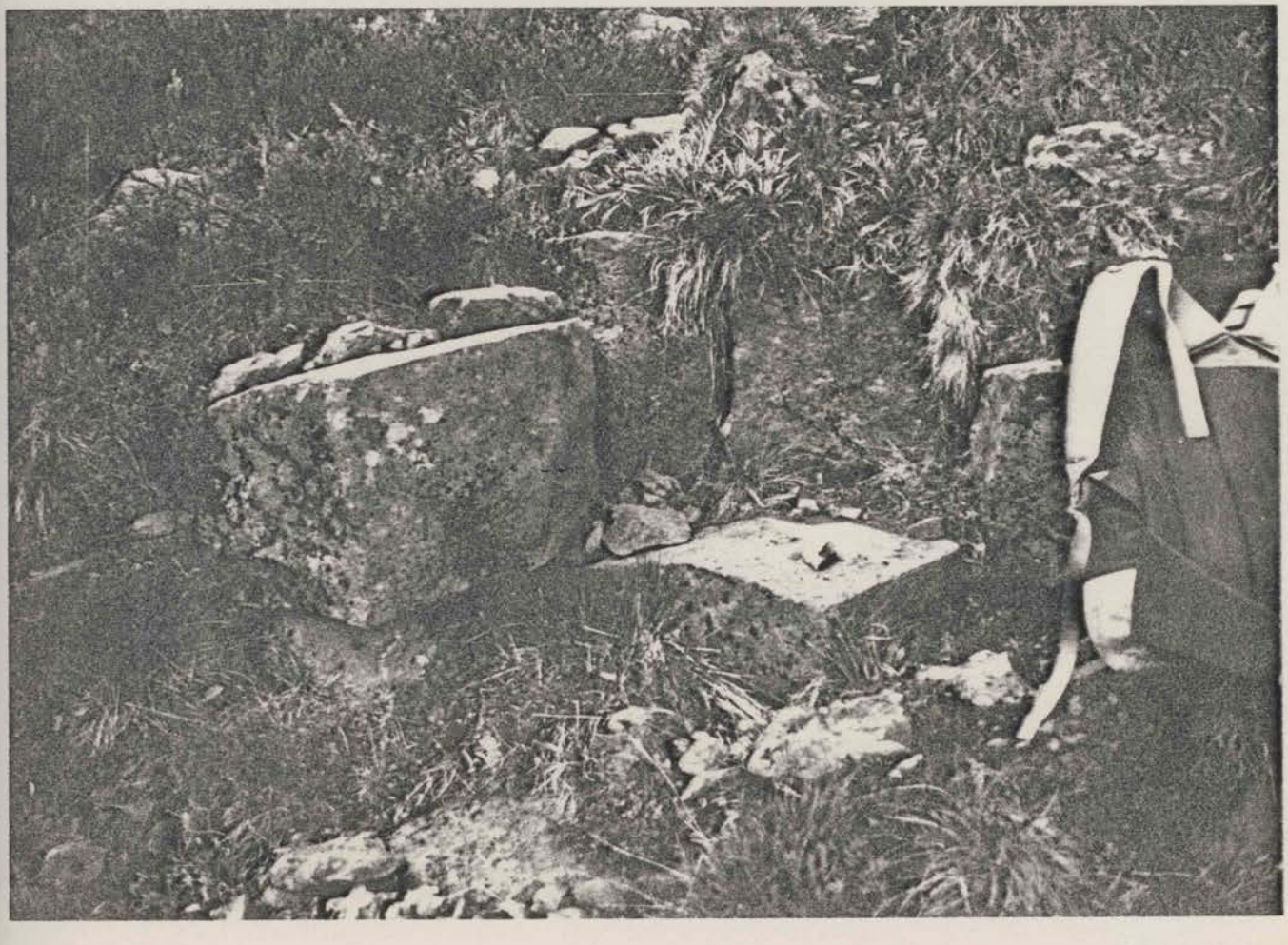
FIG. 2Ah

despite their present position above the soil and corroding groundwater. This is illustrated in photograph PV 481F8.

Further down at the toe of this "blockstream" the block accumulation terminates but the relic surface possesses a set of hollows interpreted as thermokarst. This is demonstrated in photograph PV 481F21. Note that the blocks are progressively more weathered at the toe of the blockstream than they are at the head, and are considerabley reduced in size when compared to their parent columns, illustrated in photograph PV 481F13.

The relative freshness of the insitu blocks revealed at the backwall of the earthflow at site 20 when compared to the blockstream below suggests, independently of the C14 date mentioned earlier, that the earthflow post-dates the blockstream and is infact relatively recent.

PHOTOGRAPH PV 481F13



SITE NUMBER : 20 (continued)
PHOTOGRAPH PV DB 185F37

This photograph looks up the tributary valley of Pretty Valley Creek with the uppermost two surfaces comprising insitu basalt layers. Below these is the earthflow visible in the centre of the photograph.



PHOTOGRAPH PV DB 185F7

This photograph demonstrates the rampart of the earth flow at site 20, looking south-west across its upper surface.



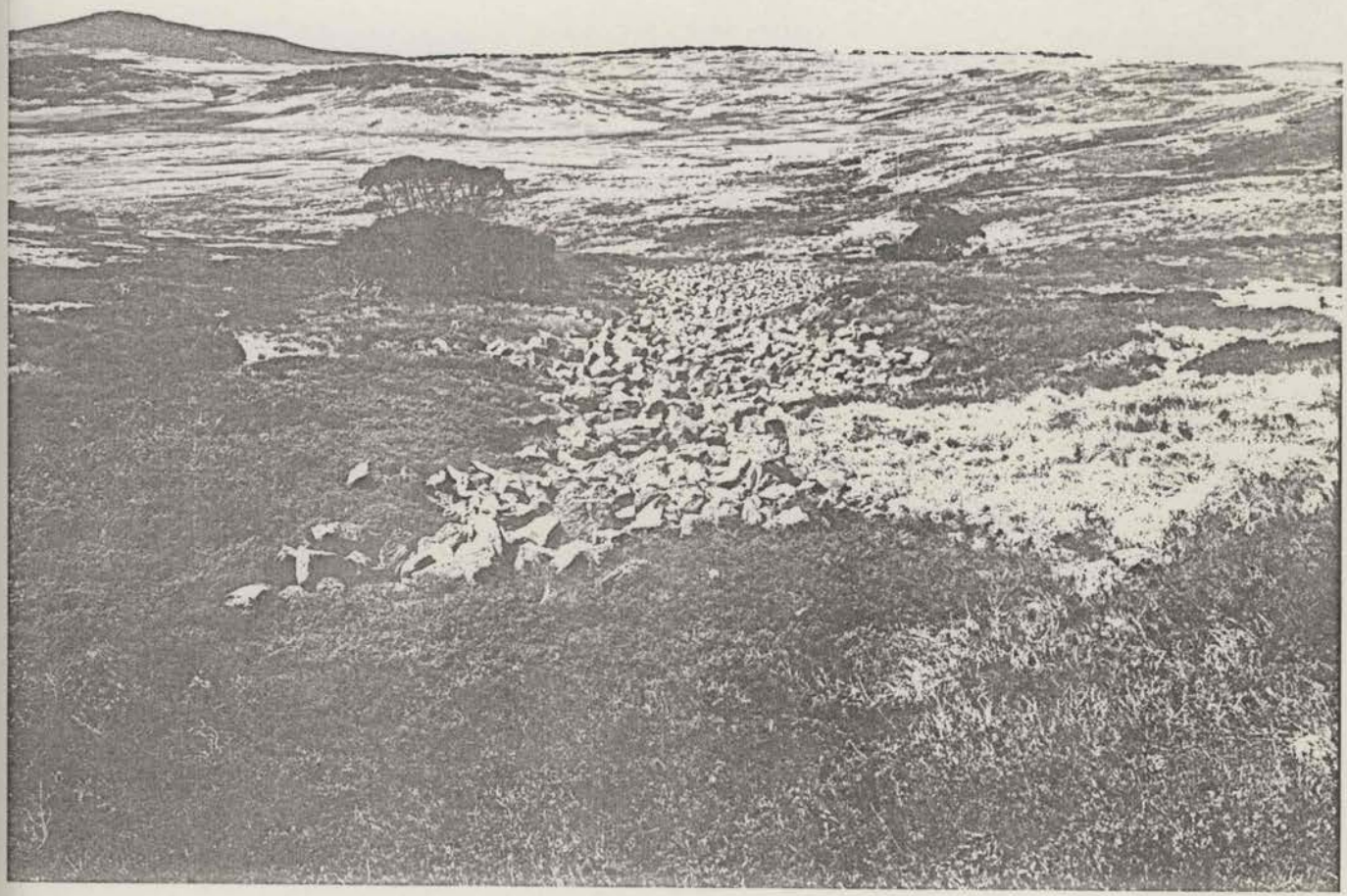
SITE NUMBER : 20 (continued)
PHOTOGRAPH PV 1182F9



SITE NUMBER : 20 (continued)
Refer to Photographs PV 1182F6, PV 1182F9

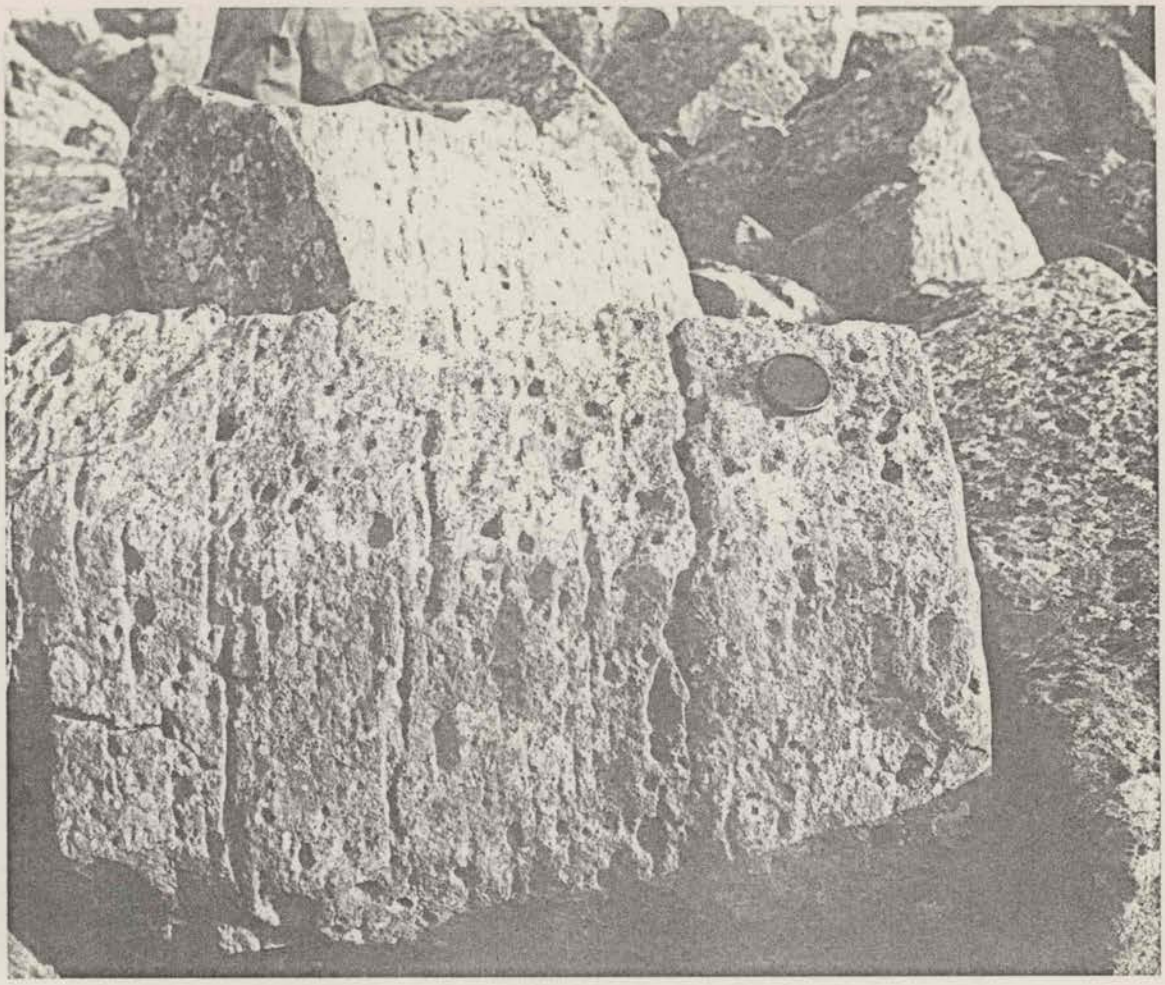
The blockstream which appears to have been overrun by the earthflow rampart is illustrated in photograph PV 1183F6. The backwall is illustrated in photograph PV1182F9 which demonstrates the preference of late lying snow for slopes with a south-east aspect.

PHOTOGRAPH PV 1182F6

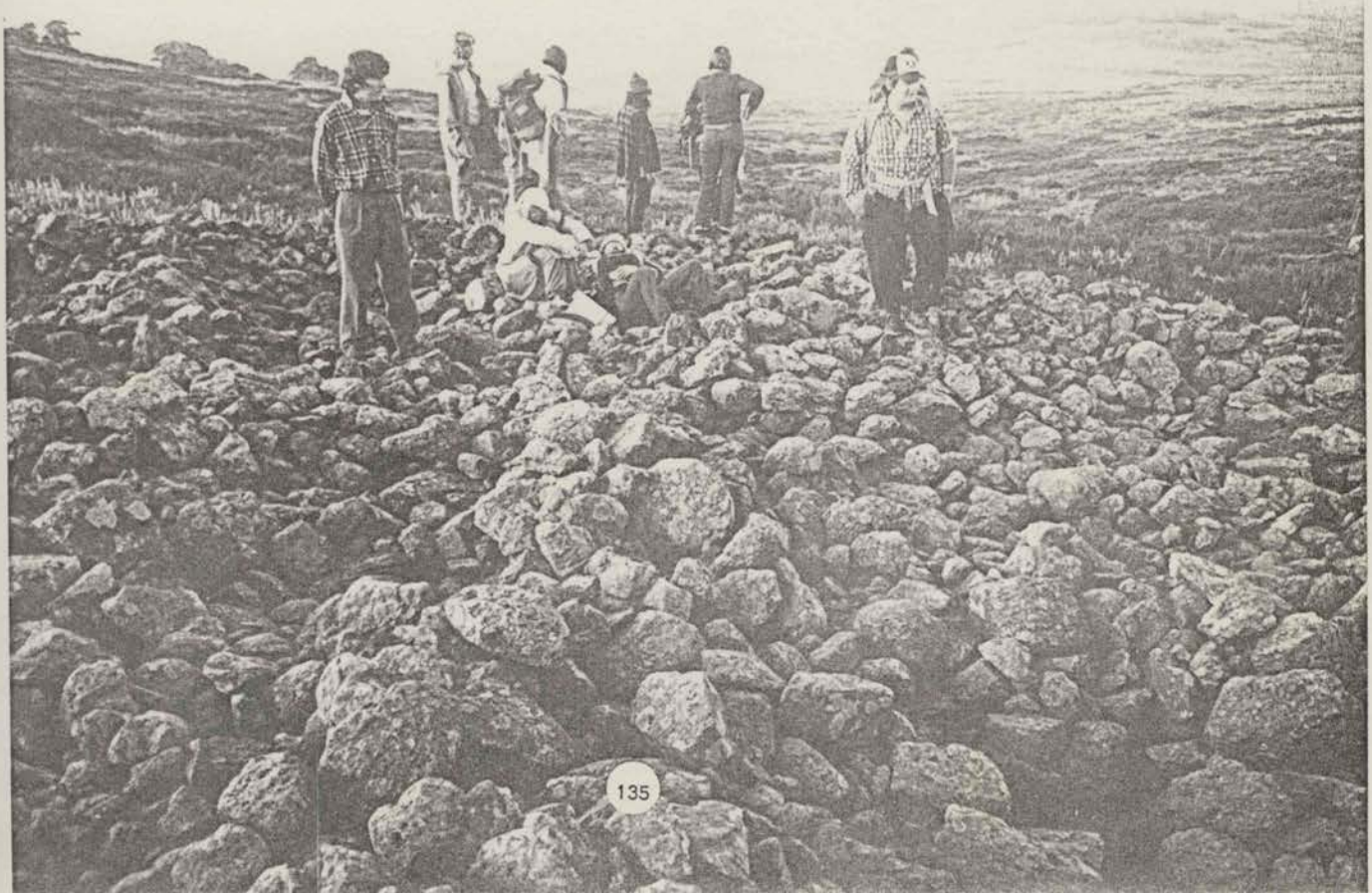


The figure in foreground gives scale.

SITE NUMBER : 20 (continued)
PHOTOGRAPH PV 481F8



PHOTOGRAPH PV 481F21



SECTION TWO : STRATIGRAPHY

A). DESCRIPTION OF SURFICIAL DEPOSITS ON THE BOGONG HIGH PLAINS

PART FOUR : MT. NELSE

The stratigraphic sites are depicted on Fig 2Aq which is a 1:7 000 plan of bedrock and bedrock close to surface as inferred from aerial photography. In addition, drainage lines and 20m contours are included with positions of the traverses described in Section 3C. Bedrock outcrop is coded brown and bedrock inferred close to the surface is coded yellow. Point 5 is the summit of Mt. Nelse, to the east of which the Nelse snow patch zone is outlined.

Fig 2Ar is an overlay to Fig 2Aq and depicts structural vegetation units which are defined on pages 190 and 191.

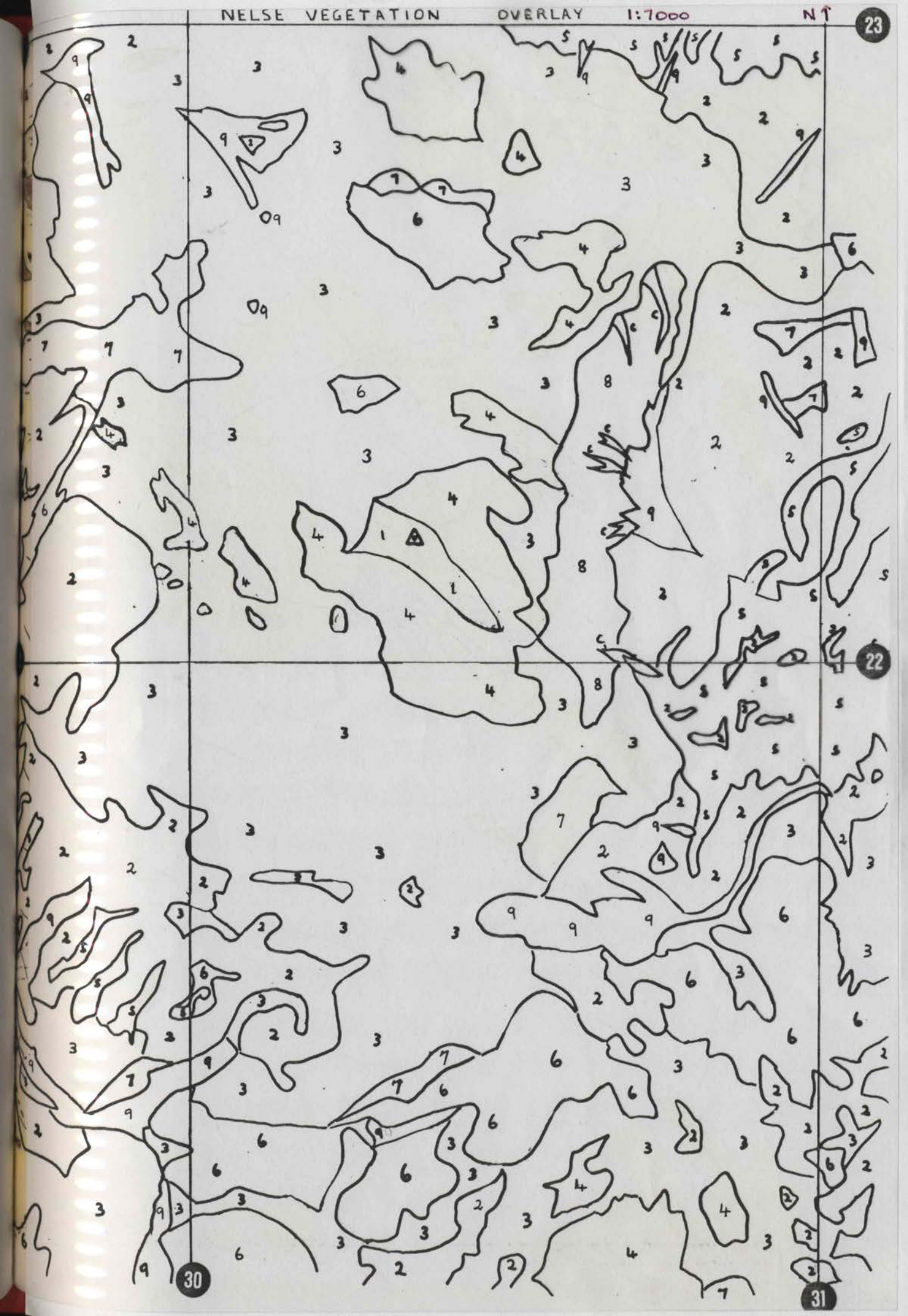
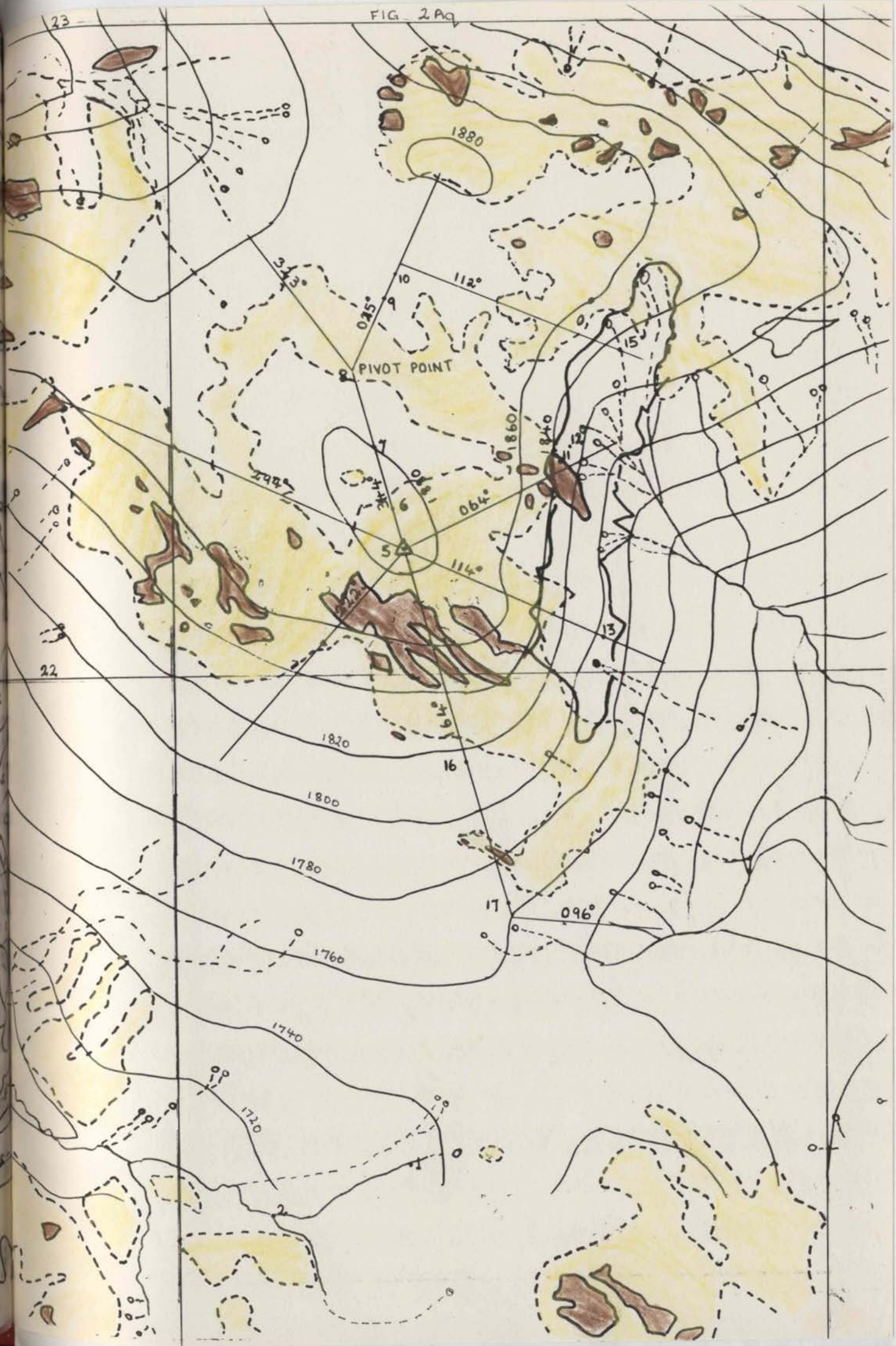
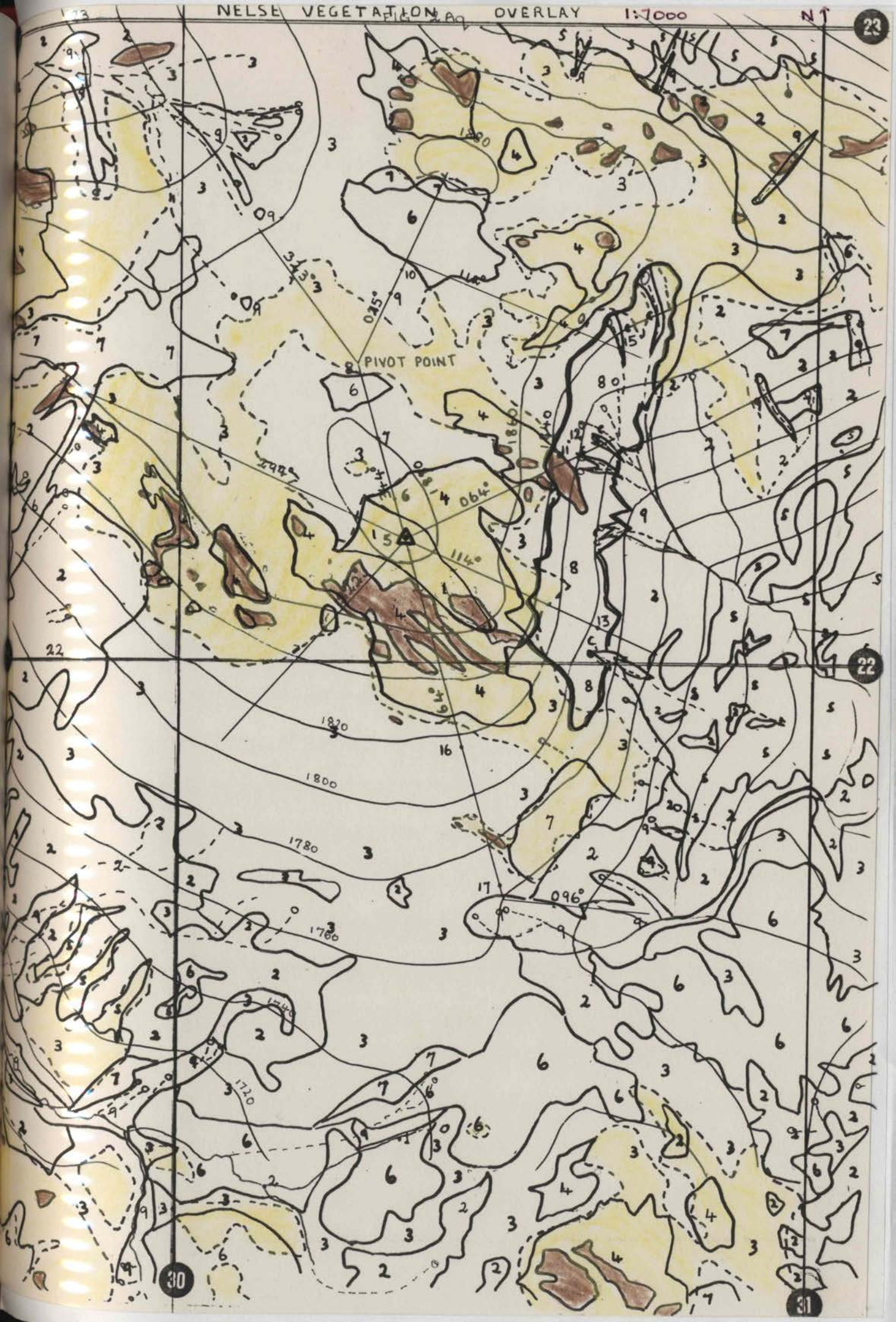

NELSE VEGETATION OVERLAY 1:7000
NT
23
22
30
31

FIG. 2Aq


23
1880
343°
10
112°
025°
9
15
PIVOT POINT
8
1860
1840
7
294°
088°
064°
6
5
114°
13
22
164°
1820
16
1800
1780
17
096°
1760
1740
1720
2


NELSE VEGETATION OVERLAY 1:7000
N
PIVOT POINT
064°
114°
096°
1800
1780
1760
1820
1740
1720
22
23
30
31

SITE NUMBER : 1
G.R. : 302212 Nelse 1:25 000 NATMAP
ELEVATION : 1725m
ASPECT : South-west
GEOMORPHIC SETTING : Head of a small drainage line below a well defined, arcuate, seasonal snow patch zone. The feature at site 1 is a small slump in alpine humus soil on a slope of 6°.
VEGETATION : Poa tussock grassland.

Refer to the diagram below, Fig 2As.

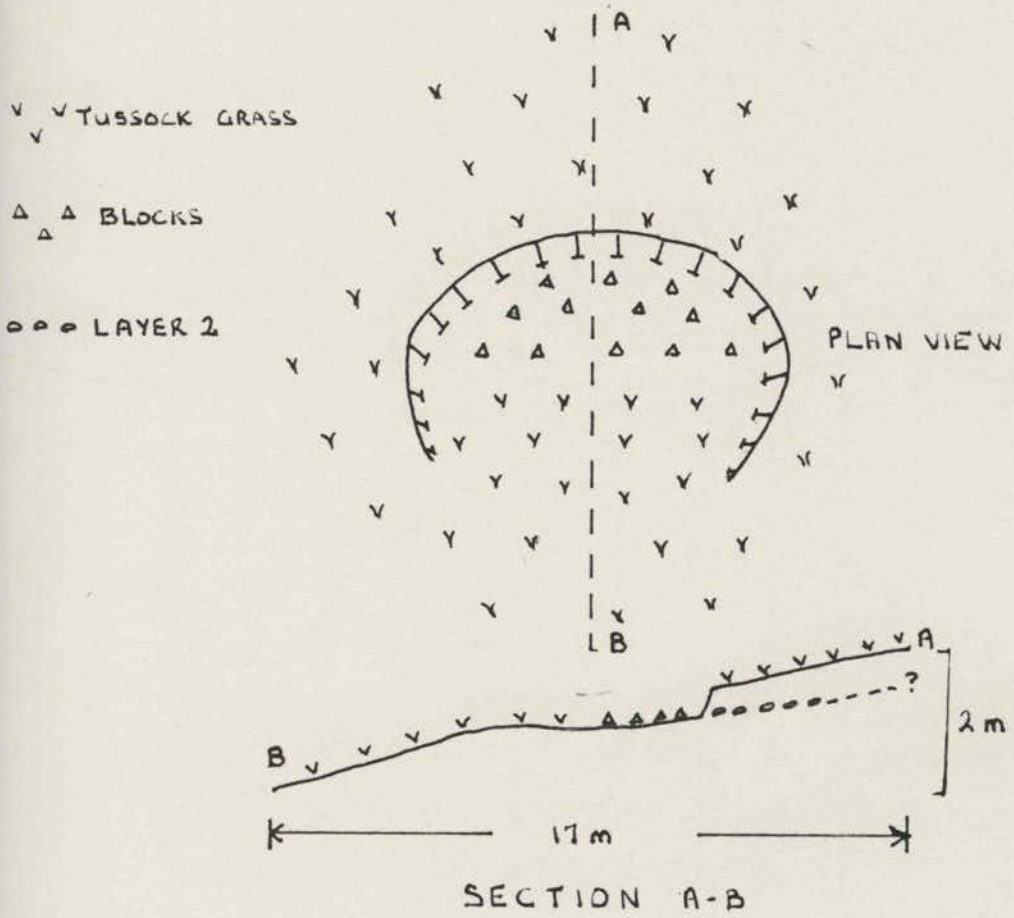


Fig 2As Plan and Section Through Site 1, Mt Nelse.

Layer 1 : 40cm of alpine humus soil comprising a dark organic gravelly loam.

Layer 2 : Thin layer of weakly stratified pebbles, cobbles and blocks below the alpine humus soil. These stones are left as residuals on the slip surface.

COMMENT : This feature demonstrates the relative instability of vegetated slopes on relatively gentle gradients in the vicinity of seasonal snow patch zones.

SITE NUMBER : 2
G.R. : 298212 Nelse 1:25 000 NATMAP
ELEVATION : 1710m
ASPECT : West
GEOMORPHIC SETTING : Creek cutting in upper section of Nelse Creek, adjacent to an alluvial-colluvial flat. Local creek gradient is 10%.
VEGETATION : Poa tussock grassland.

Layer 1 : Depth 0-60cm, 60cm of dark grey organic gravel-loam.

Layer 2 : Close packed layer of blocks 30cm to 50cm thick. Blocks are platy and weakly-stratified and from 20 to 50cm long.

Layer 3 : Orange colored, slightly consolidated, weakly-stratifed unit of angular platy pebbles and cobbles, 2cm to 5cm long in a gravel sand silt matrix. Cobbles are moderately weathered but still competent.

INTERPRETATION : Layer 1 is interpreted as a recent accretion of fine gravelly hillwash and organic matter. Layer two is probably the upper portion of a relic frost sorted colluvium, while layer 3 can be interpreted as the lower portion of the relic colluvium which may have migrated down the southern flanks of Nelse by frost creep and come to rest in the axis of this valley.

SITE NUMBER : 3
G.R. : 294219 Nelse 1:25 000 NATMAP
ELEVATION : 1740m
ASPECT : South-west
GEOMORPHIC SETTING : Drainage line on the southwestern slope of Mt Nelse, averaging 23% gradient and rising 140m above site 3. Site 3 is a small 1m waterfall in the drainage line.
VEGETATION : Alpine bog.

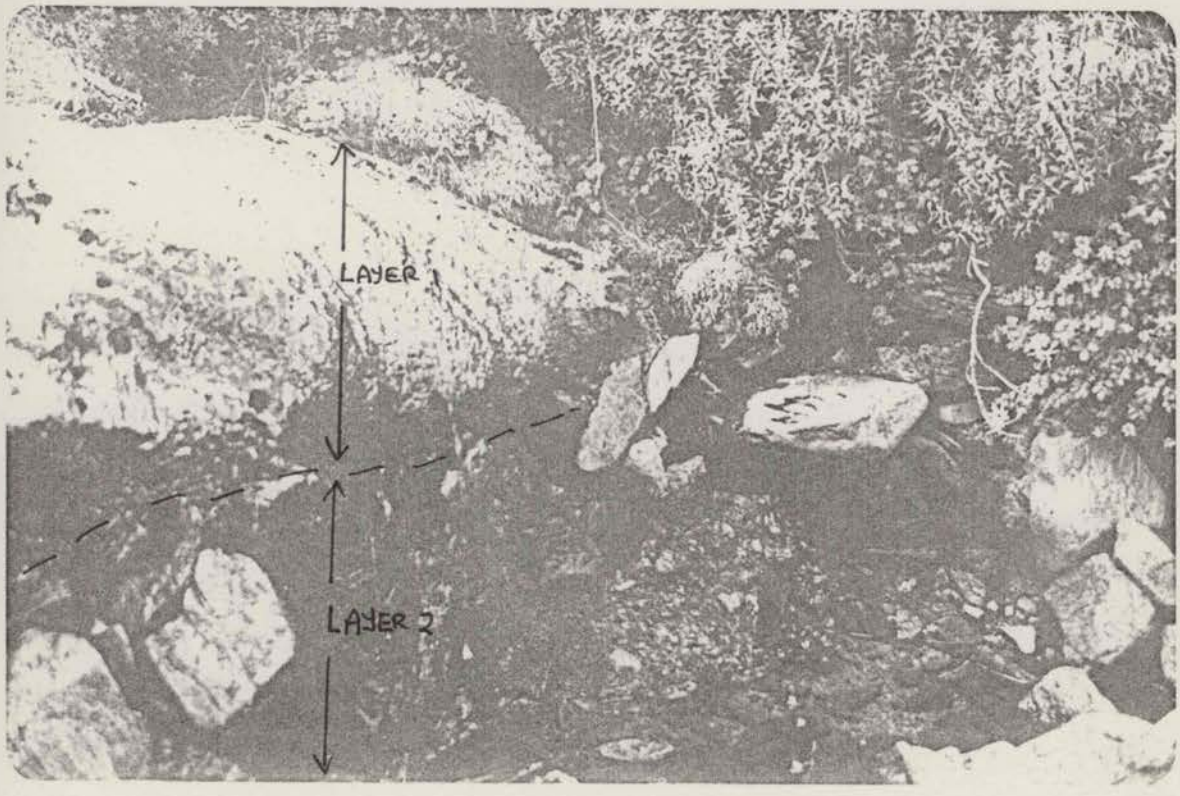
Layer 1 : 0-50cm depth - Peat with an accumulation of grit at its base

Layer 2 : 50cm-100cm depth - Large platy blocks, 20cm to 40cm long in a matrix of orange gravel, sand and silt. Blocks appear imbricated.

Layer 3 : below 100cm - Dispersed platy pebbles and cobbles in an orange gravel sand and silt matrix.

COMMENT : The peat from layer 1 (site 3) was examined by Helene Martin of the University of New South Wales on May 4th 1987, and her analysis of spores and pollen concluded that this assemblage is of recent or contemporary age with a high percentage of sedges which suggests a swampy environment, such as the adjacent alpine bog.

Refer to photograph N 386F2
PHOTOGRAPH N 386F2



SITE NUMBER : 4
G.R. : 293221 Nelse 1:25 000 NATMAP
ELEVATION : 1780m
ASPECT : South
GEOMORPHIC SETTING : An eroded section of the drainage line in the upper reaches of the creek passing by Edmondson's Hut. Local slope is 20%.
VEGETATION : Minor patches of wet heath as islands on a stony pavement, with adjacent grassland.

Layer 1 : discontinuous layer of peat about 20cm thick

Layer 2 : A continuous layer of blocks, cobbles, pebbles and gravel forming a stony pavement where the overlying peat has been eroded away.

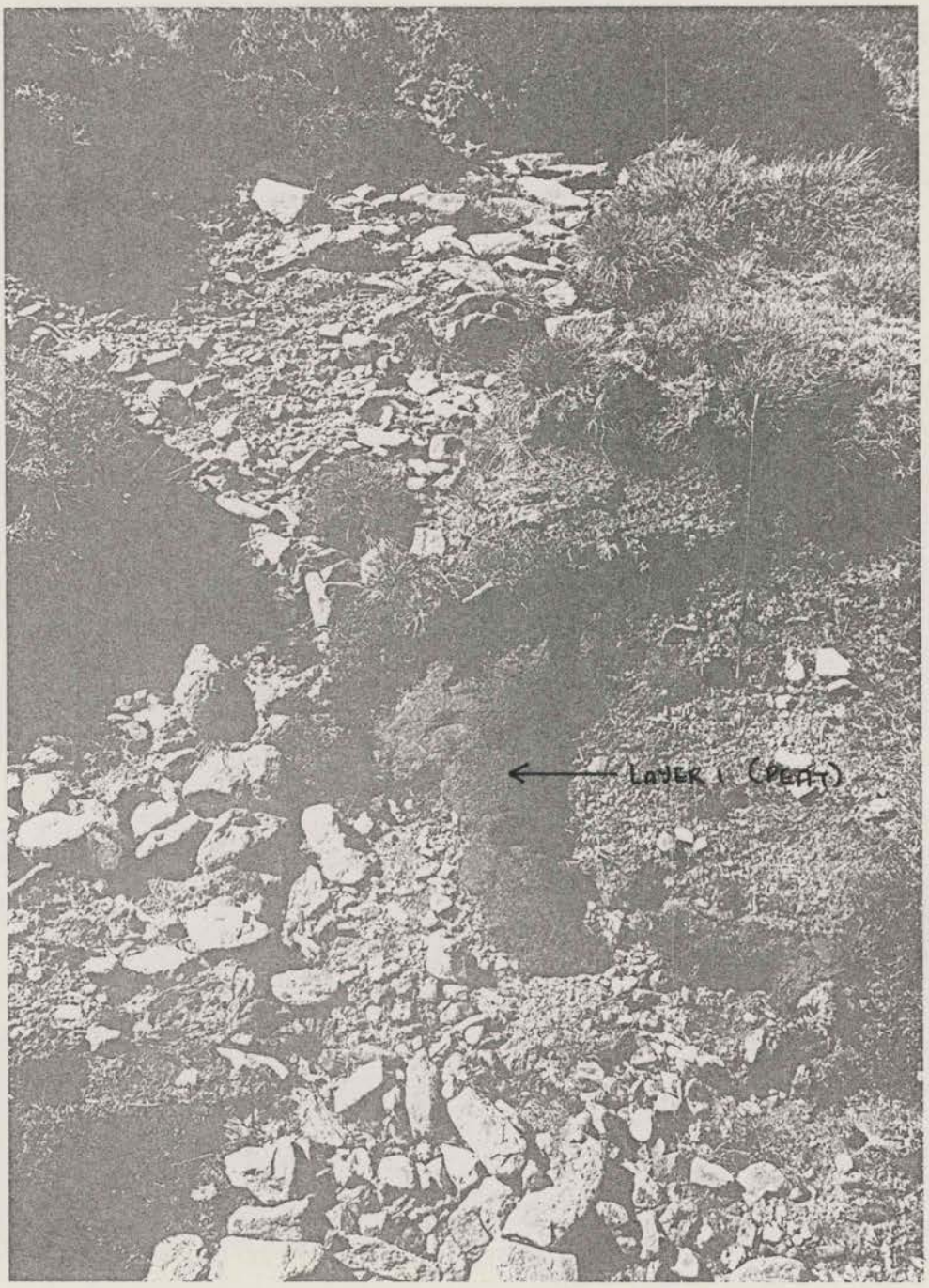
Refer to photographs N4486F3, N4486F2, N4486F4 and N 181080F5.

PHOTOGRAPH N 4486F3



This photograph views upstream along portion of the eroded drainage line in a north-westerly direction.

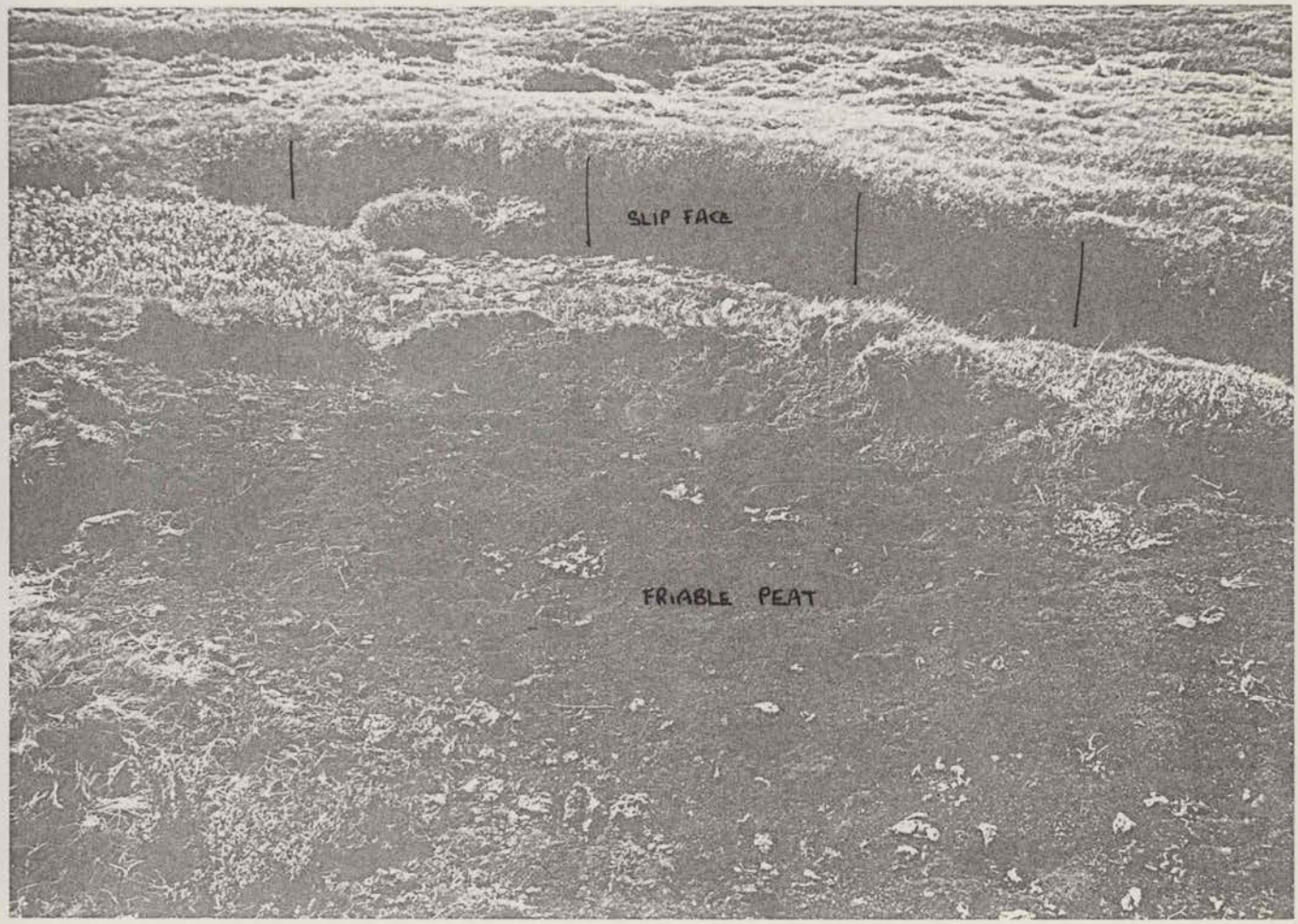
SITE NUMBER : 4 continued
PHOTOGRAPH N 4486F2



This photograph reveals a portion of the previous photograph and demonstrates an isolated remnant of peat underlain by cobbles and overlain by tussock grass. The adjacent grassland overlying the peat, suggests that the local alpine bog has regressed in very recent times. The tracks and dung of cattle are evident in this scene and they often forage in alpine bog communities during the summer. Cattle tracks could possibly have drained moisture away from the bog community and caused erosion and subsequent encroachment by tussock grassland.

SITE NUMBER : 4 continued
PHOTOGRAPH N 4486F4

This photograph is of the grassland adjacent to site 4. It reveals a slump in the relic peat overlain by the tussock grassland. The peat is soft and friable and has been broken up by cattle in the slump zone. This region has been grazed by domestic animals for over 130 years.



SITE NUMBER : 4 continued
PHOTOGRAPH N 181080F5

This photograph is of an equivalent site on the eastern side of Mt Nelse near G.R. 305215 at the head of Johnstons Hut Creek. Again, humified peat has been eroded exposing a stony pavement of blocks. The humified peat is up to 60cm thick and implies changes to the local hydrology, some of which may be man induced.



SITE NUMBER : 5 (Mt Nelse summit)
G.R. : 302221 Nelse 1:25 000 NATMAP
ELEVATION : 1882m
ASPECT : near horizontal
GEOMORPHIC SETTING : Summit area of Mt Nelse. Broad, near level to <2° slope. The surface is partially vegetated bedrock with a thin, patchy veneer of blocks.
VEGETATION : Partial vegetation by shortKunzea Heathland and minor amounts of Ewartia -Microphylla dwarf heathland.
STRATIGRAPHY : The summit is mostly solid outcrop occurring as low relief sheets. Jointing is complex, with a dominant basal jointing and strong foliation within the rock. The surface contains a stony pavement of platy, slightly imbricate cobbles and blocks. Grevillea australis (Alpine Grevillea) grows prostrate over blocks on the surface. Bare patches are susceptible to needle ice and eluviation and deflation, resulting in a small scale patterning of the surface. Beneath the stony pavement and above bedrock is up to 30cm of gravelly loam ranging from dark brown near surface to orange brown against bedrock.

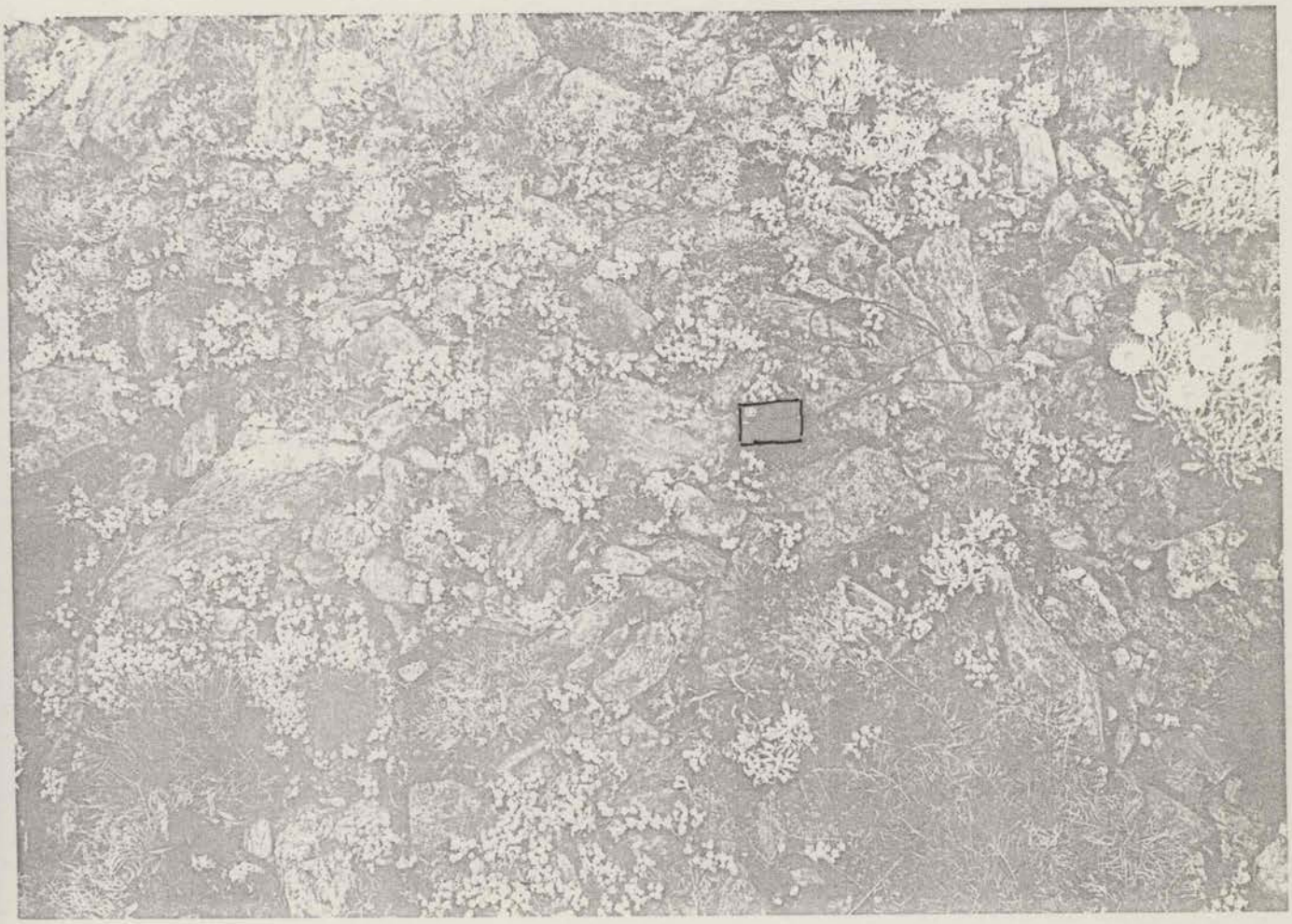
Refer to photographs N 28286F5, N 28286F8, N 28286F9, N 28286F18 and N 28286F16, and diagram Fig 2At.

PHOTOGRAPH N 28286F5

The summit trig mast of Nelse is visible in the background. The rock in the foreground demonstrates many joint planes but with a dominant basal joint which dips to the south-east. The compass is 6.5cm long. The absence of lichen on the block surface beneath the compass indicates that a piece of rock has broken off the top of this block and rolled downslope recently.



SITE NUMBER : 5 continued
PHOTOGRAPH N 28286F8



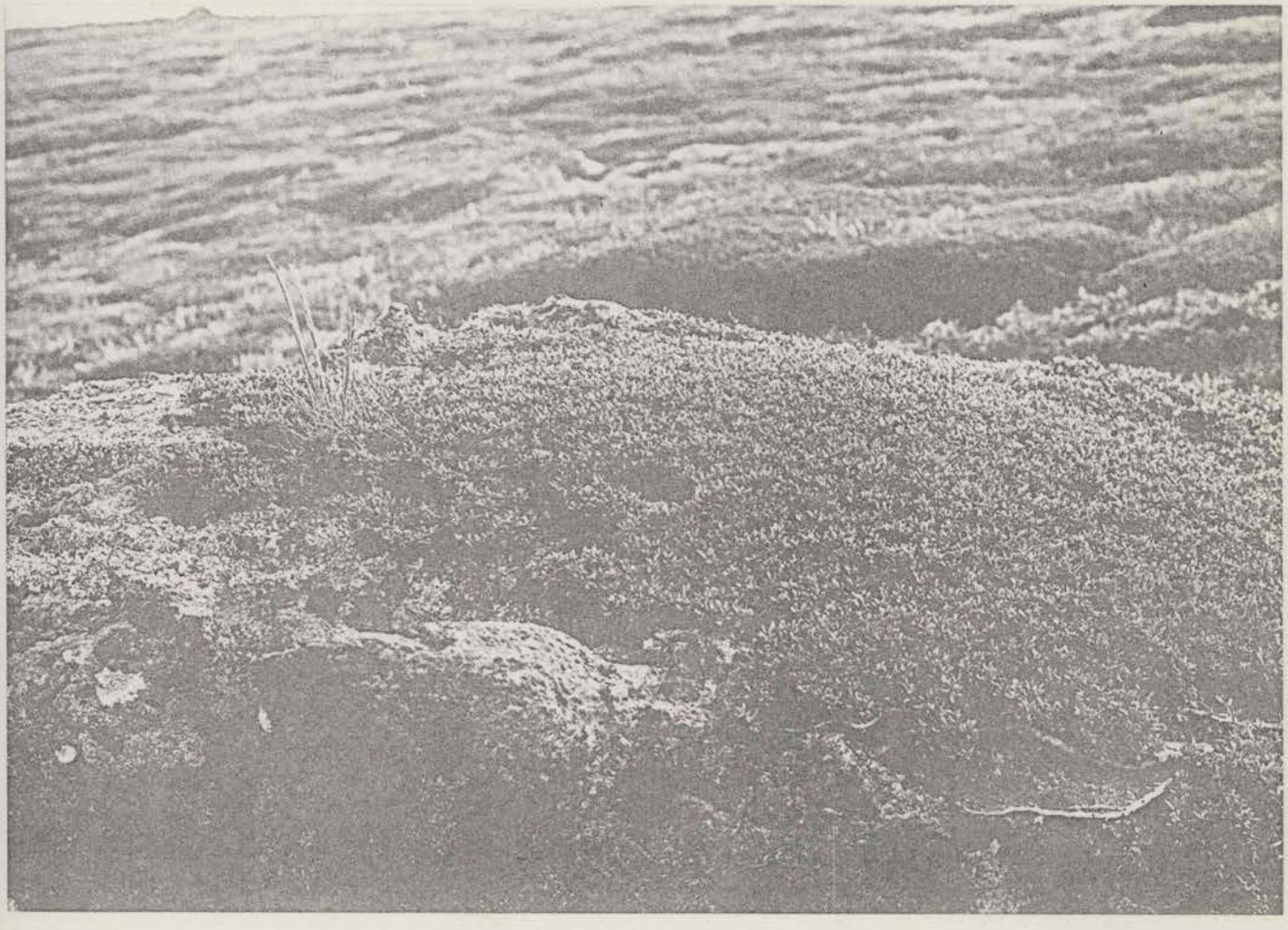
This photograph demonstrates close packed stony pavement and associated sparse, feldmark style vegetation of Ewartia nubigena. The Ewartia is actually a component of the dwarf heathland.

SITE NUMBER : 5 continued
PHOTOGRAPH N 28286F9

This photograph demonstrates imbricate texture on a very gentle slope near the summit. These blocks and cobbles may be moving slowly downslope under the action of needle ice. The ground is spongy during the autumn due to residual needle ice.



SITE NUMBER : 5 continued
PHOTOGRAPH N 28286F18



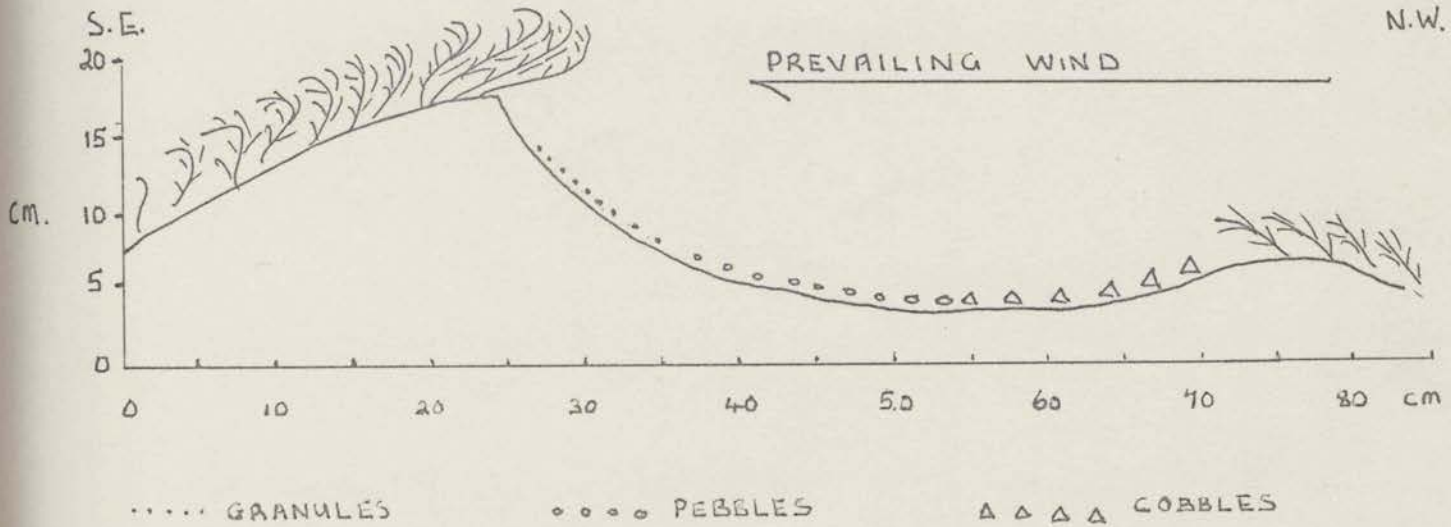
The wind sculpted habit of Grevillia australis encroaches on a surficial block near the summit. The prevailing wind direction is north-westerly, from right to left in this photograph.

SITE NUMBER : 5 continued
PHOTOGRAPH N 28286F16



Wind deflation and elluviation have created this small patterned terrace on bare ground on gently sloping terrain on the east side of Mt. Nelse. A cross sectional diagram, Fig 2At, is drawn below. The prevailing wind is from right to left. This may be a natural mechanism of recolonising bare ground after it was damaged earlier this century by overgrazing, bushfires and drought.

Fig 2At Section Showing Wind Sorting and Recolonization of Bare Ground.



SITE NUMBER : 5 continued
PETROFABRIC SUMMARY OF NELSE BEDROCK

Four samples of insitu bedrock at points 100m apart across the strike of the bedrock were thin sectioned and examined. Two of the samples, N2 and N5 were similar and appear to be quartz biotite schist. Long foliated envelopes of coarse biotite enclosed knots of fine grained quartz and biotite. Small amounts of fine grained kyanite occur within the quartz-biotite knots and isolated anhedral crystals of fine staurolite occur occasionally within the coarse biotite blades. There was also a peppering of fine subhedral magnetite. Minimal alteration of the biotite was evident. Isolated sections of coarse, foliated biotite appear to be altered to chlorite along cleavage planes.

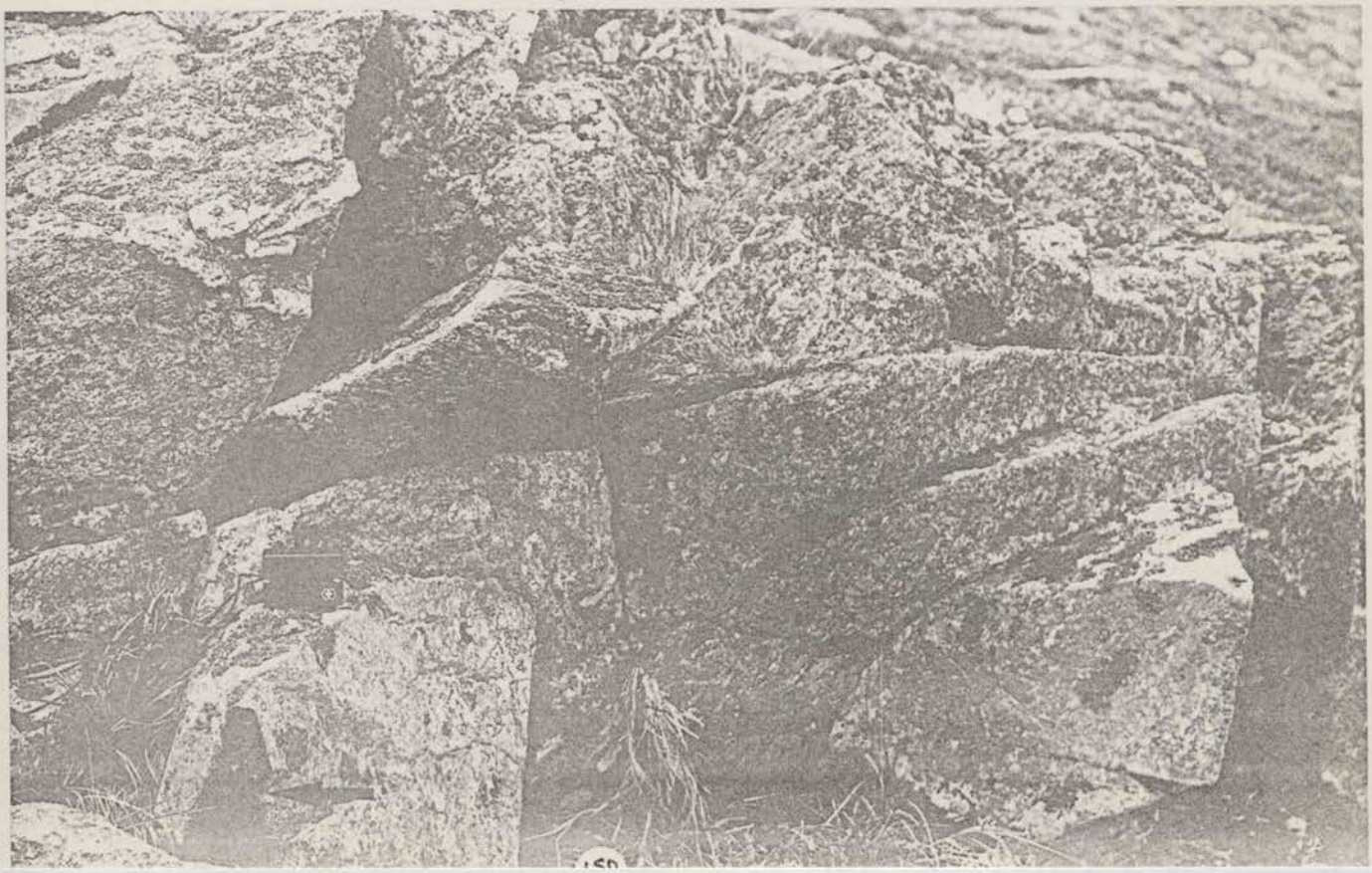
The other samples,N3 and N4, were less foliated and more hornfelsic in hand specimen. These samples were quartz biotite cordierite schist with less massive aggregates of biotite than samples N2 or N5. Again there was minimal alteration of biotite but the cordierite was altered along parallel fractures to sericite.

The microfabric of these metamorphic rocks, despite the foliation,cannot explain the rapid reduction in size from massive blocks to cobbles and gravel during limited downslope transportation. The macrofabric including multiple jointing and fracturing associated with foliation and faulting, must be responsible for the rapid disintegration of schist blocks.

Refer to photograph N 28286F3

PHOTOGRAPH N28286F3

This photograph demonstrates close spaced joint sets and a small exposure of slickensides. It is the dark facet on the joint block beneath the compass case.



SITE NUMBER : 6
G.R. : 302222 Nelse 1:25 000 NATMAP
ELEVATION : 1881m
ASPECT : near level
GEOMORPHIC SETTING : Portion of summit flat sloping approximately 2° towards north and situated 65m along bearing 344° GB from the summit trig point.
VEGETATION : Kunzea heathland

SURFICIAL STRATIGRAPHY as sampled by auger.

Depth in cm	Fraction Name	Description
0-10	A	Mid brown gravelly organic loam with very few large clasts.
10-20	B	Mid brown organic loam with a few extremely weathered irregular clasts from 2cm to 4cm.
20-30	C	Mid brown gravelly loam with many clasts $\leq$3cm. The clasts are moderate to extremely weathered, platy fragments of schist.
30-40	D	Mid brown gravelly loam with fewer clasts than above.
40-50	E	Orange brown gravelly regolith comprising completely rotted clayey bedrock with a discernible crystal fabric.
50-60	F	Pale buff brown gravelly regolith with some larger competent fragments.
60-70	G	Very pale buff brown gravelly regolith.

The seven fractions sampled at this site were sieved by the following sets of meshes : 12.700mm
3.320mm
2.000mm
0.250mm
0.063mm
and the residuals were weighed. The results are presented on Table 2A4.1

SITE NUMBER : 6 continued

TABLE 2A41 Sieve Analysis of Auger Sample from Site 6, Mt Nelse.

Summary of percentage retained by each sieve size

Sample N 334/65

	FRACTION	Mesh size (mm) 12·7mm	3·32mm	2·0 mm	0·25mm	0·063	<0·063	mm
A	0- 10 cm	0	3·0	9·0	46·6	39·3	0·6	
B	10 - 20 cm	6·1	8·6	11·8	41·9	30·4	1·1	
C	20 - 30 cm	4·1	36·8	8·2	31·0	16·0	2·4	
D	30 - 40 cm	1·0	21·0	11·2	42·9	21·4	1·7	
E	40 - 50 cm	2·9	27·1	16·9	40·9	10·1	1·8	
F	50 - 60 cm	15·4	28·2	7·3	27·9	15·9	4·7	
G	60 - 70 cm	0	8·7	3·8	59·2	25·9	2·1	

SUMMARY

Layer 1 : Depth 0-20cm. This layer, comprising fractions A and B, is a recent, organic gravelly loam soil. The dominant mineral grain is quartz which occurs as irregular stained grains with only minute amounts of biotite grains. The parent rock contains 30% to 40% biotite and about 10% of the rock is coarse biotite. J.C. Dixon (1988), in his paper on chemical weathering, demonstrated the importance of chemical weathering in the alpine environment, and fine biotite in particular can be transformed to a variety of secondary clay minerals and can be altered to hematite by oxidation. The brown coating on fine quartz grains in layer 1 could be clay particles and or hematite derived from the chemical alteration of biotite.

No glassy shards in the very fine sand fraction nor wind pitted grains in the coarse sand fraction were observed under reflected light microscopy for layer 1 which indicates aeolian processes have had little influence in the derivation of this material.

Layer 2 : Depth 20cm - 40cm This layer comprises fraction C and D. The layer is interp reted as frost sorted regolith as there appears to be 40.9% granules > 3.32mm in fraction C whereas fraction D has only 22%. Also, fraction D has a higher percentage of very fine sand than fraction C. A.E. Corte (1966) in his exeriments on particle sorting by repeated freezing and thawing demonstrated that freezing and thawing from the top produces a definite sorting of soil particles by size, the large moving up and the smaller moving down. The differentiation within layer 2 may be due to freeze-thaw, assuming that layer 1

has accumulated during the Holocene since the termination of the last cold phase.

Reflected light microscopy revealed that fraction C, (very fine sand) consisted mostly of irregular stained quartz grains. No broken shards of quartz were noticed, and only minute amounts of biotite were visible.

In fraction D (very fine sand), about 80% of the grains were irregular stained quartz. Other cream/white silicate grains, biotite and minor amounts of magnetite formed the remainder. There appeared to be a few broken shards of quartz suggesting aeolian action has had some influence.

The low proportion of fines in these auger samples suggests that fines have been selectively removed. Aeolian action could be expected to have removed fines from an unvegetated regolith on a windswept summit.

In contrast, fines are being retained in fraction A which has twice the percentage of very fine sand, than fractions C or D. The low percentage of fines (< 0.063mm), may be due in part to adhesion of fines to coarser grains. The samples were oven dried and hand sieved to minimize breakage of natural clasts.

Layer 3 : 40cm : 110cm. This layer includes fraction E, F and G, which represent extremely weathered bedrock. The action of the auger disaggregated this material but portions of the auger sample were observed to retain schistose crystal fabric. The color and texture of auger returns remained consistent between 50cm and 110cm and relic crystalline fabric was clearly evident at 110cm below the surface.

Reflected light microscopy revealed an increasing proportion of pale colored silicate grains in fraction E compared to above fractions, but no signs of any shards of quartz in the very fine sand portions.

The extremely weathered character of the bedrock at site 6 suggests that the moderately weathered clasts in layer 2 have been transported laterally from thier source. Competent slightly weathered bedrock outcrops around the summit, upslope from site 6.

SITE NUMBER : 7
G.R. : 302223 Nelse 1:25 000 NATMAP
ELEVATION : 1880M
ASPECT : near level
GEOMORPHIC SETTING : Portion of the summit flat sloping aproximately 2° towards the north and situated 165m along bearing 344°GB from summit trig point.
VEGETATION : Short open heath.

SURFICIAL STRATIGRAPHY AS SAMPLED BY AUGER

Depth (in cm)	Layer	Comment
000-020	A	Dark brown organic loam containing much fibrous plant matter.
020-040	B	Pale greenish-brown stony loam. Many extremely weathered schist clasts with irregular platy habit.
040-050	C	Pale orange-brown stoney loam.
050-060	D	Pale orange-brown gravelly sand.
060-080	E	Very pale greenish-brown gravelly sand with irregular extremely weathered clasts of schist.
080-100	F	Pale buff-brown extremely weathered stony regolith.
100-110	G	Pale buff-brown extremely weathered stony regolith.
110-120	H	Pale greenish-brown gravelly sand.
120-125	I	Very pale brown gravelly sand
125-156	J	Very pale brown sandy regolith. The 10 fractions sampled at site 7 were each analysed for grain size distribution

SUMMARY

Layer 1 : Depth 0-20cm of dark brown organic loam. The dominant component of the fine grained sand in layer 1 was irregular quartz grains with a yellow brown oxidized coating. No freshly cut shards ofquartz were evident in the very fine sand component.

Layer 2 : 20cm-60cm. This layer consists of fractions B, C and D. The very fine sand component of these fractions consisted of stained irregular grains of quartz, with some minor amounts (5%) of biotite flakes and some (maybe 1%)very fine glassy shards.

Layer 3 : 60cm-150cm. This layer comprised fractions E, F, G, H, I and J. These fractions were much paler in color and the quartz grains revealed under reflected light microscopy of the fine sand component were cleaner and noticeably less coated than in layer 1 and 2. Also there was an increase in the proportion of creamy white silicate grains. Biotite varied in abundance with depth which may be due to bedrock foliation and differentiation.

Layer 3 is interpreted as extremely weathered bedrock. Relic schistose fabric was only recognized in fraction J. The significant depth of weathering at site 7 reinforces the importance of chemical weathering in the alpine environment as well as the lateral transportation of less weathered clasts from upslope.

SITE NUMBER : 7 continued

Table 2A4.2 Summary of percentage of sample retained by each seive mesh size.

	FRACTION	Mesh size (mm.) 12·7	3·32	2·0	0·25	0·063	<0·063	
A	0- 20 cm	0	5·1	9·4	52·5	26·6	5·0	
B	20- 40 cm	29·2	26·7	6·6	23·3	11·8	1·8	
C	40- 50 cm	18·6	27·7	7·8	30·6	12·8	2·1	
D	50- 60 cm	20·5	22·7	6·5	35·7	20·5	2·6	
E	60- 80 cm	0·8	15·4	4·3	49·4	24·9	0·4	
F	80-100 cm	24·8	21·5	5·2	29·6	15·6	3·1	
G	100-110 cm	17·6	27·3	6·0	27·9	19·1	1·8	
H	110-120 cm	19·0	27·3	6·7	30·0	16·0	0·4	
I	120-125 cm	7·1	25·8	20·5	41·4	5·0	0·2	
J	125-150 cm	3·1	33·5	18·4	38·5	4·9	0·9	

Sample N 344/165

SITE NUMBER : 8
G.R. : 301224 Nelse 1:25 000 NATMAP
ELEVATION : 1876m
ASPECT : near horizontal
GEOMORPHIC SETTING : Distal portion of summit flat sloping ,<1° towards the north and distant 285m along 344° GB from trig point.
VEGETATION : Open heathland.
STRATIGRAPHY :

Layer 1 : Depth 0-10cm. Mid brown gravelly organic loam with abundant highly weathered platy pebbles of schist.

Layer 2 : 10cm-30cm. Dominantly gravel and cobbles in silty sand matrix. The small platy gravel clasts up to 20mm are highly weathered but competent and the large angular cobble size clasts and blocks are moderately weathered.

Layer 3 : Below 30cm. Solid rock which may be bedrock or a large floater. Three further probes with a crowbar at this site revealed solid rock at 30cm.

NOTE : Bedrock outcrops close to this site. The difference in degree of weathering of gravel and cobbles compared to the larger angular cobbles and blocks may be explained by suggesting that the larger less weathered clasts have been recently derived from local bedrock which outcrops close by and exists within 30cm of the surface at this site. The more highly weathered platy gravel clasts up to 20mm have been derived from further upslope and have been reduced to their present size due to a long slow process of frost creep.

SITE NUMBER : 9
G.R. : 302225 Nelse 1:25 000 NATMAP
ELEVATION : 1869m
ASPECT : North
GEOMORPHIC SETTING : Distal edge of vegetated sheet of regolith sloping 2° north-north-east.
VEGETATION : Open heathland merging towards tussock grassland/herbfield.
STRATIGRAPHY :

Depth (in cm)	Comments
000-020	Dark brown organic loam. Very few coarse clasts.
020-030	Medium brown gritty loam. Less plant material
030-045	Large platy blocks
045-060	Pale orange brown gravelly loam
060-070	Pale greenish brown sandy loam with friable lumps of extremely weathered bedrock.
070-080	Pale greenish brown sandy loam as above.
080-090	Pale greenish brown stony regolith. Auger broke up extremely weathered insitu bedrock.
090-103	Very pale greenish brown bedrock getting difficult to penetrate.

INTERPRETATION :

Layer 1 : Depth 0-30cm Organic loam

Layer 2 : Depth 30cm-60cm. Frost sorted frost transported regolith with coarsest clasts on top.

Layer 3 :Depth 60cm-103cm. Extremely weathered insitu bedrock with small veneer of local regolith.

SITE NUMBER : 10
G.R. : 302225 Nelse 1:25 000 NATMAP
ELEVATION : 1869m
ASPECT : near horizontal
GEOMORPHIC SETTING : Close to centre of broad gently sloping saddle. Local gradient approximately 1° towards north.
VEGETATION : Poa grassland / Celmisia herbfield
STRATIGRAPHY :

Depth (in cm)	Comment
00-20	Brown organic, loam good crumb structure.
20-40	Brown organic, loam good crumb structure.
40-45	Compact layer of platy cobbles and gravel up to 5cm long.
45-60	Light brown gravelly loam.
60-130	Extremely weathered pale sandy bedrock getting stiffer with depth.

INTERPRETATION :

Layer 1 : 0-40cm. Recent brown organic loam soil.

Layer 2 : 40cm-60cm. Frost sorted, frost transported regolith.

Layer 3 : 60cm-130cm. Extremely weathered bedrock.

NOTE : The size of clasts in the frost sorted layer 2 diminishes rapidly with distance from solid outcrop on gentle slopes. Large blocks are found near the surface near bedrock outcrops but auger samples downslope from such outcrops reveal a rapid comminution of blocky debris, which suggests a long lived slow acting process. The foliation of the bedrock may be responsible for this rapid reduction over distances of 100m, as the gravel sized clasts are usually platy in habit.

MOUNT NELSE SNOW PATCH ZONE

An introduction to Sites Number 11 through 15.

The snow patch zone is a steep arcuate feature on the east side of Nelse which is shwon on the Nelse basemap and vegetation maps. (Figures 2Aq and 2Ar) Its long axis trends north-south and it forms a steep slightly concave depression. It could be described as cirque like except that it does not undercut its floor and instead the slope continues steeply towards the east.

The snow patch zone is recognizable by its vegetation pattern. The upper rim is bordered by dark green Grevillea australis. Below this rim is a pale green discontinuous cover of Celmisia asteliifolia herbfield which forms a compact mat and the lower portions of the snow patch zone have a dense mat of short turf which is dissected in places by drainage lines vegetated by Celmisia sericophylla. This vegetation complex is shown as Unit 8 on the vegetation overlay, (Fig 2Ar)

The Nelse snow patch zone is the site of present and past erosion. Some resistant layers of bedrock still outcrop prominently in the snowpatch zone. Elsewhere bedrock has receded.

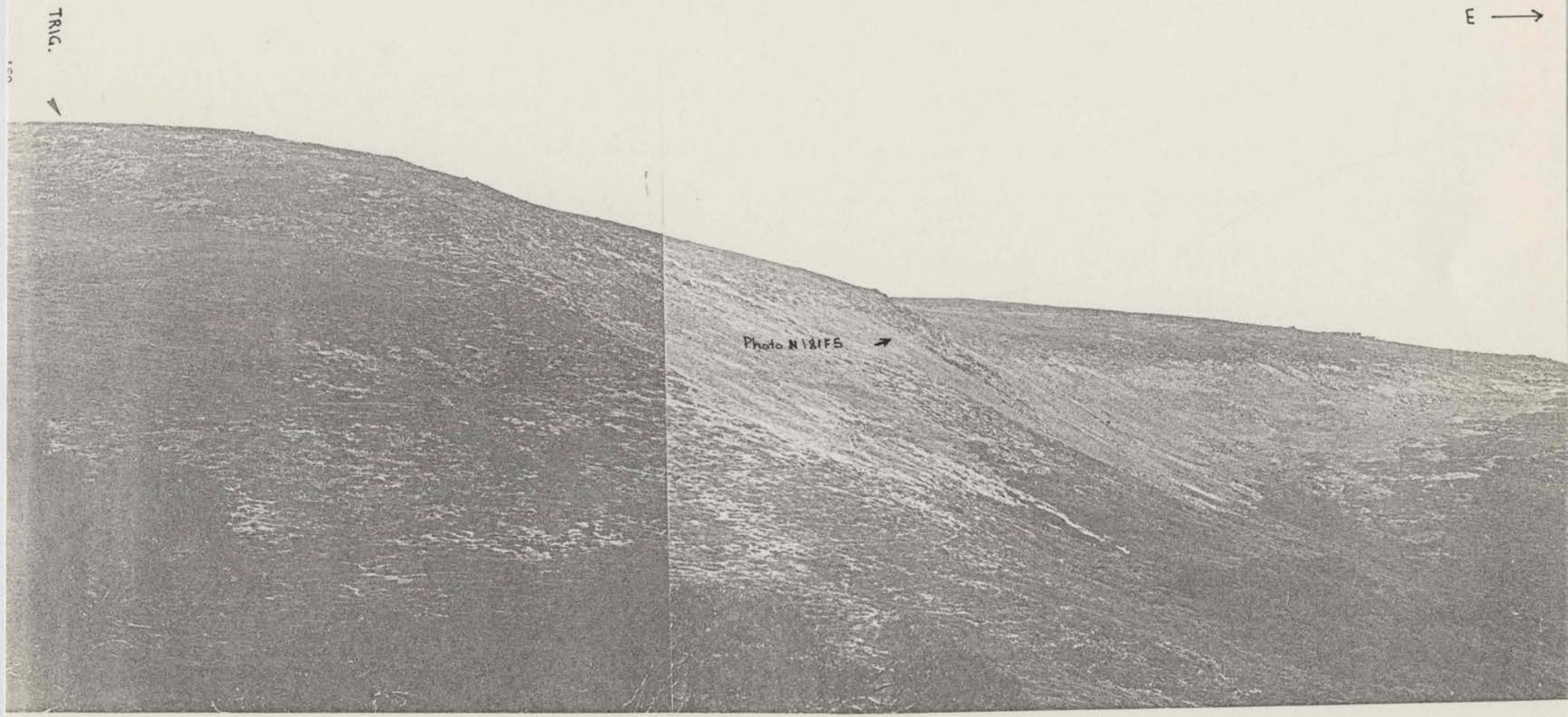
Refer to composite Photograph N 26286F18/19.

This photograph gives an overview of the snow patch zone from the south-west to the north-east, and looking towards the north-west. The snow patch is the pale zone . The summit trig tower is just visible in the upper left corner. Cattle on the distal snow patch give scale.

The snow patch zone is covered by snow usually from June to November with isolated patches lasting until January. As a result there is a considerable proportion of bare blocky ground and with the regular action of needle ice on the bare ground and occasional heavy rainfalls, the snow patch zone is being actively eroded in the present climate. Refer to Photograph N 181F5. The following features within the snow patch zone will be briefly examined at the following sites:

Site 11 - Polished bedrock pavement
Site 12 - Lobe (depositional feature)
Site 13 - Slump
Site 14 - Stony pavements
Site 15 - Terracettes

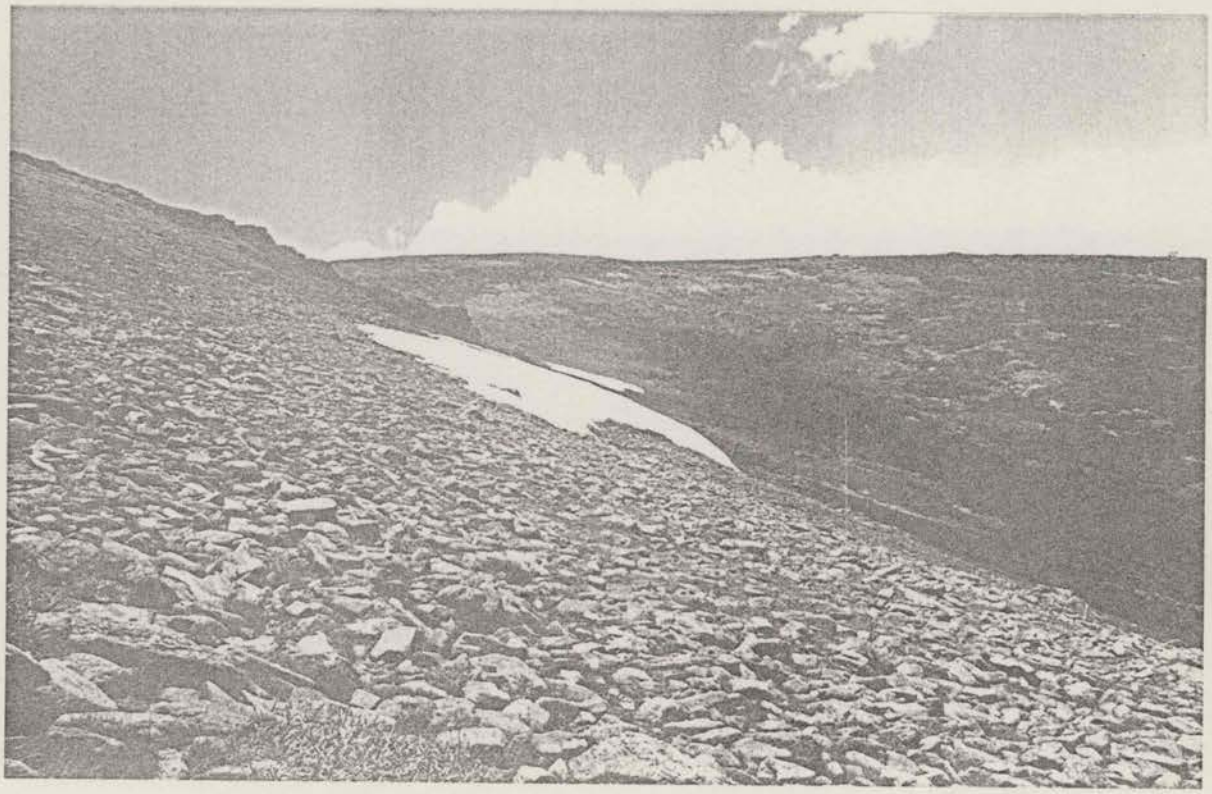
MOUNT NELSE SNOW PATCH ZONE NOTES continued.
PHOTOGRAPH N 26286F18/19



MOUNT NELSE SNOW PATCH ZONES NOTES continued

PHOTOGRAPH N 181F5

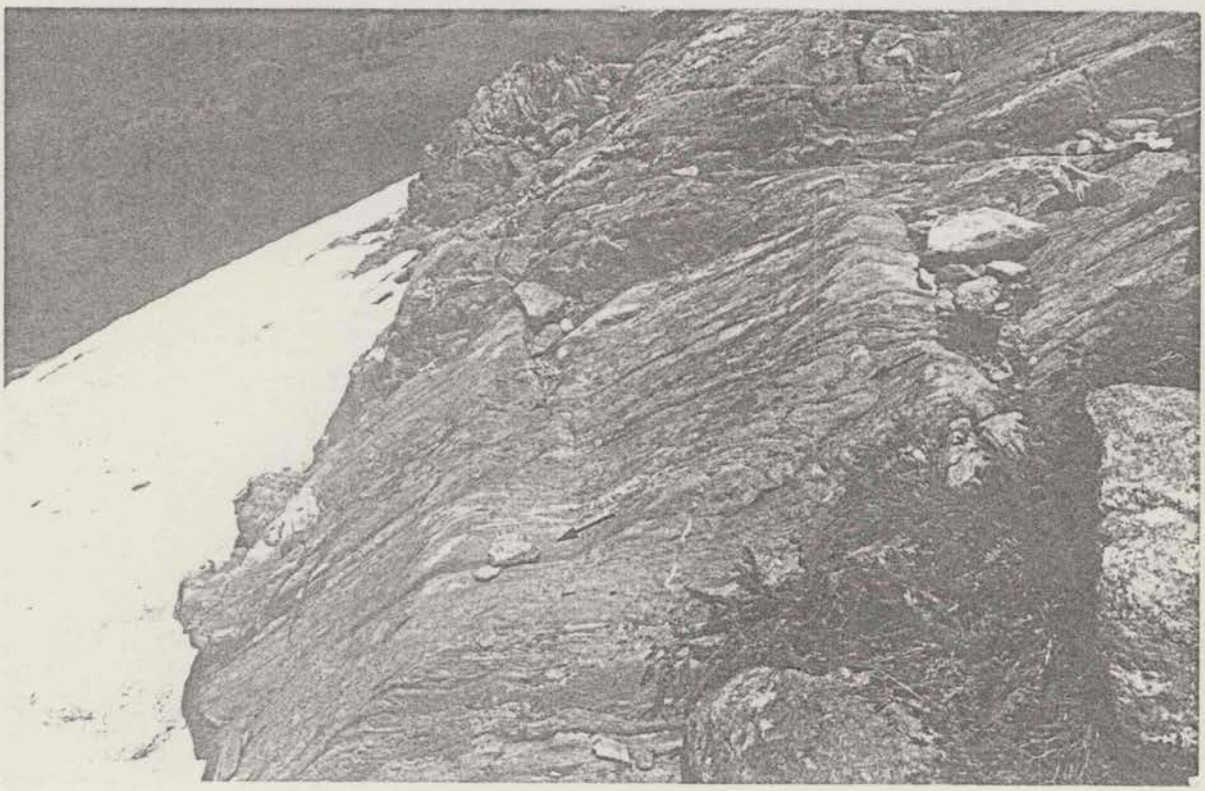
This photograph demonstrates blocky regolith within the snow patch zone. The upper portion of the snow patch zone is vegetated by Celmisia asteliifolia and the central portion is vegetated by short tussocks in the space between blocks. This photograph looks northwards along the lower portion of the Mount Nelse snow patch zone.



SITE NUMBER : 11
G.R. : 305222 Nelse 1:25 000 NATMAP
ELEVATION : 1820m - 1840m
ASPECT : East
GEOMORPHIC SETTING : Steep stepped outcrop of gneissic bedrock sloping at 30° to 40° and polished by localized snow patch movement over steps.
VEGETATION : negligible
STRATIGRAPHY : A thin patchy veneer of angular blocks cobbles and gravel occurs on the steeply sloping bedrock and some material is dragged for up to 1m by snow patch movement each season. Other material falls onto the snow patch during the thaw period and accumulated below or is transported away.

Refer to Photographs N 17285F63, N4486F9, N 181F11, N 381F12, N 381F17, N 381F16 and N 41080F15.

PHOTOGRAPH N181F11



Photograph N 181F11, taken in January 1981 demonstrates the dragging of loose blocks across the stepped bedrock surface. The photograph is close to the same view as photographs N 17285F63 and N 4486F9. Therefore, block transport across this snow patch slope should be an active process. The amounts transported in a single season are small, but blocks should be accumulating further downslope with reduction in grade or increased vegetation cover. The drainage lines within and immediately below the snow patch zone are choked with blocks and cobbles and have transverse

wrinkles suggesting slow downslope movements. These blocky drainage lines are visible on aerial photographs and are vegetated by dense clusters of a daisy Celmisia sericophylla which is endemic to the Bogong High Plains. These stripes of Celmesia are shown on the Nelse vegetation map overlay, Fig 2Ar.

Photographs N 17285F63 and N 4486F9 were taken on 17th January 1985 and 4th April 1986 respectively. They demonstrate that some loose blocks on the solid stepped bedrock may move short distances. The photographs depict approximately the same location, and careful observation of the clusters of small stones and blocks should confirm the above view. The compass case in N 4486F9 is 6.5cm long. These photographs are on the next page.

Photograph N 381F12 is a closeup of the lower portion of the bedrock step illustrated in the previous two photographs (N 17285F63 and N 4486F9). Loose clasts rest on the step adjacent to the camera lens cover (49mm in diameter) but the white marks below the clasts record the passage of other clasts which were dragged downwards by the thawing snowpatch and produced rock flour marks on the bedrock. Similarly photograph N 381F17 demonstrates rock flour marks on another polished rock pavement. These photographs are on the next page but one.

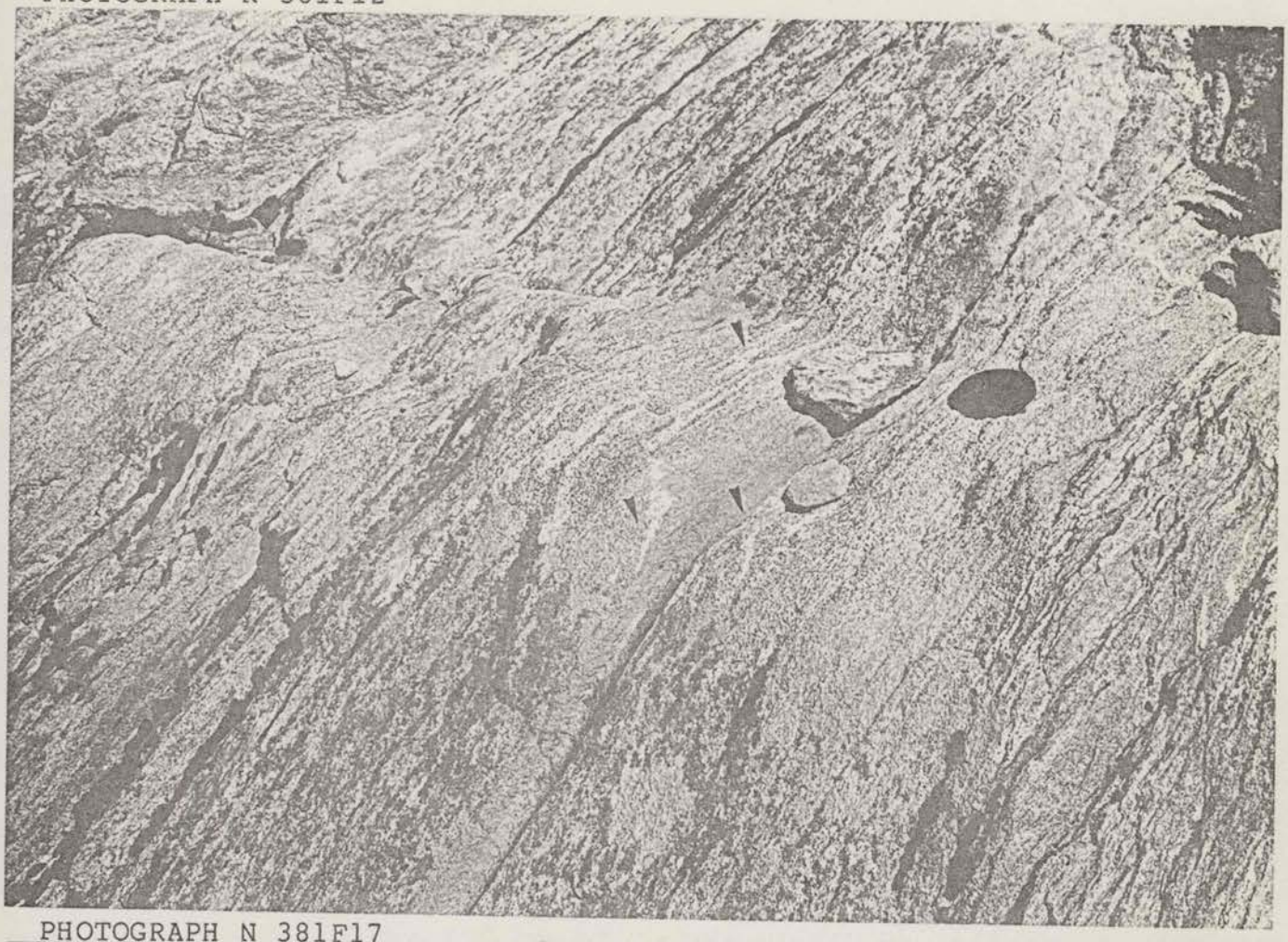
SITE NUMBER : 11 continued
PHOTOGRAPH N 17285F63



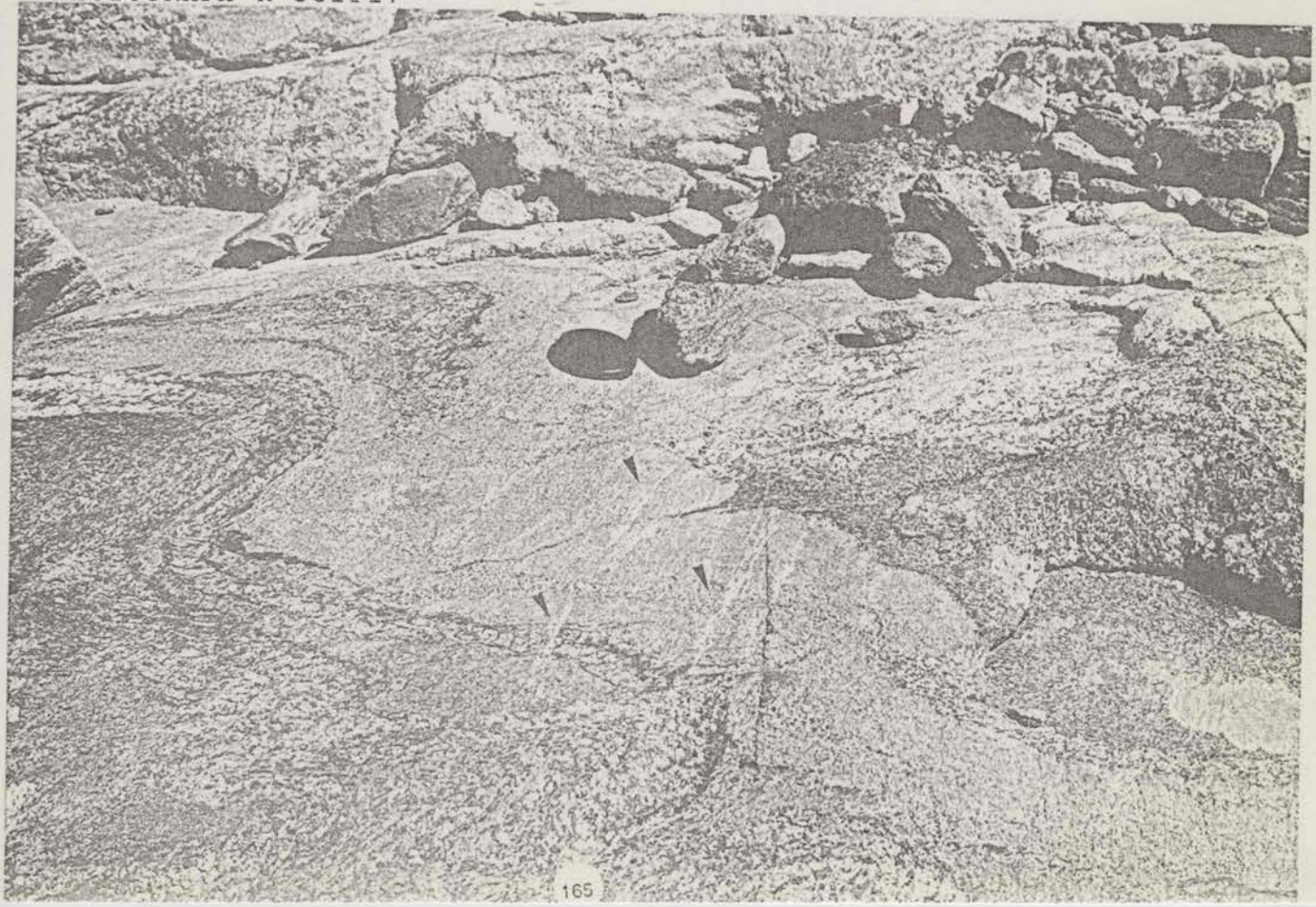
PHOTOGRAPH N 4486F9



SITE NUMBER : 11 continued
PHOTOGRAPH N 381F12

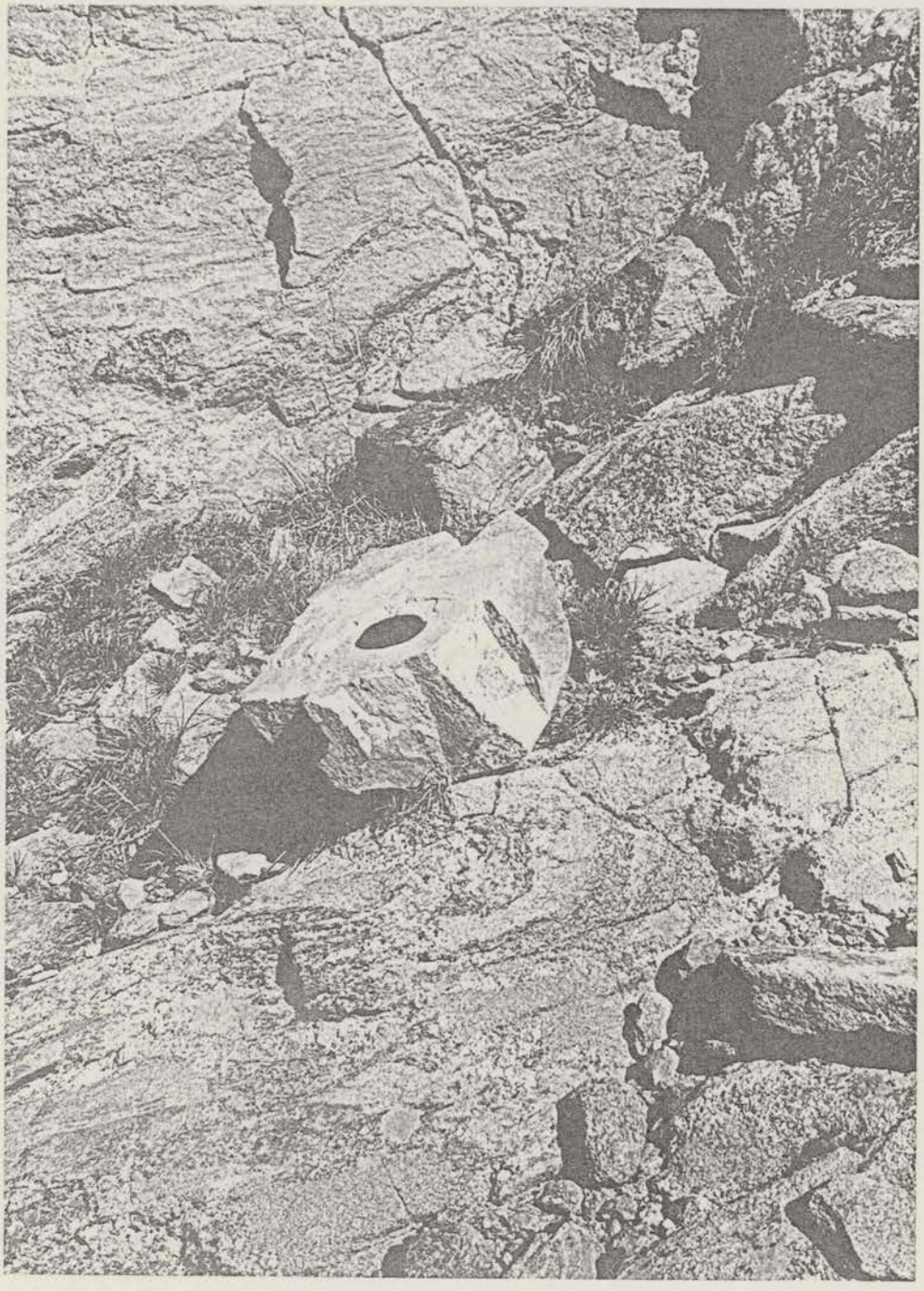


PHOTOGRAPH N 381F17

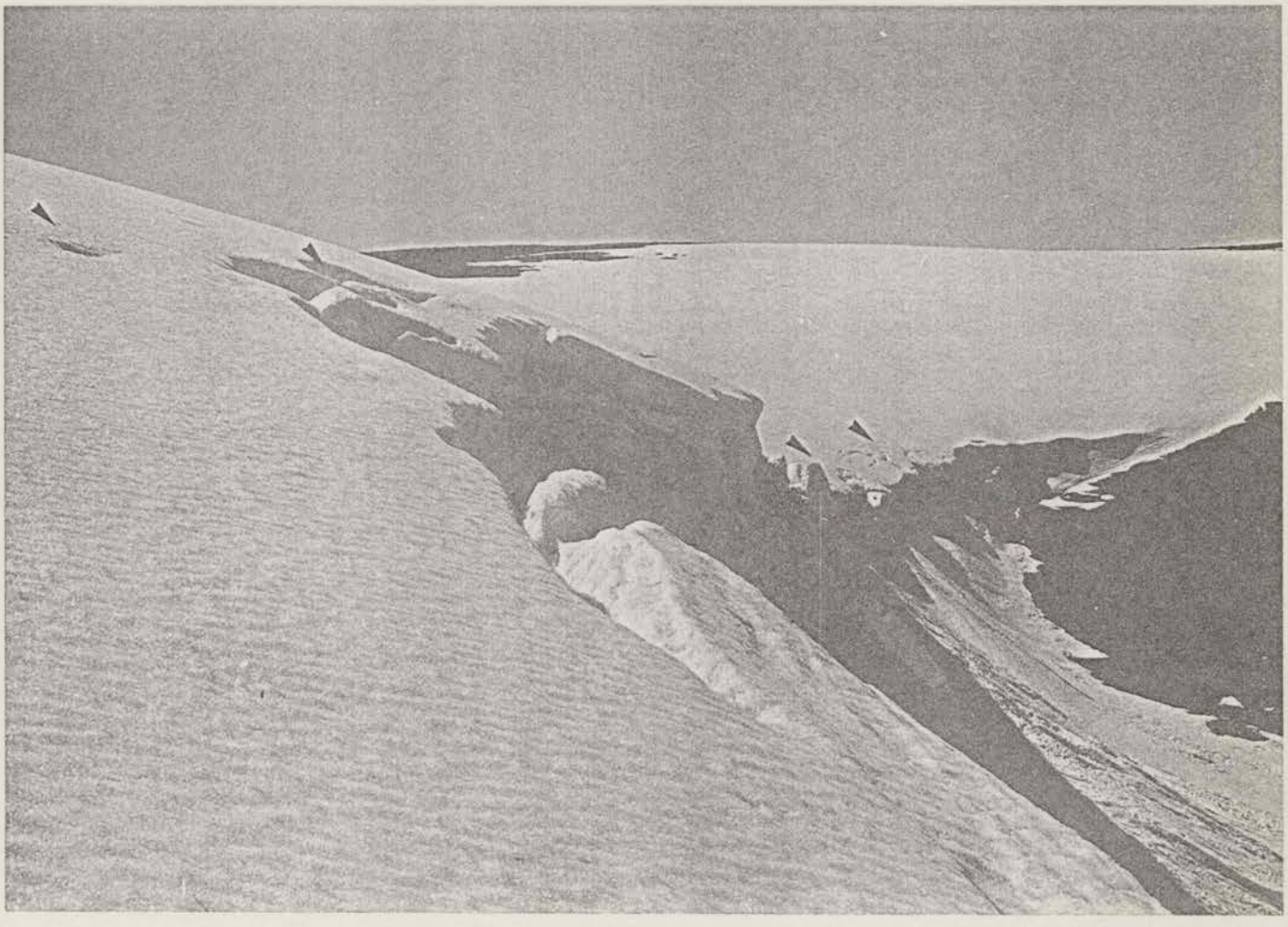


SITE NUMBER : 11 continued
PHOTOGRAPH N 381F16

This photograph illustrates the typical veneer of blocks cobbles and gravel which has accumulated on the polished bedrock pavement zone. As can be seen the volume of loose rock is relatively small and large fresh terminal accumulations of blocks are not evident immediately below the snow patch zone.



SITE NUMBER : 11 continued
PHOTOGRAPH N 41080F15



This photograph above demonstrates the slow downhill creep associated with the decay of the snow patch. Tension fractures form behind the top edge of the snow patch as the whole mass melts from below and creeps slowly down hill for short distances (of the order of 1m) each season.

SITE NUMBER : 12 (Snow patch - upper level lobes)
G.R. : 305222 Nelse 1:25 000 NATMAP
ELEVATION : 1832m
ASPECT : East
GEOMORPHIC SETTING : Snow patch upper level lobes. The lobe comprises large angular blocks and finer regolith and is located adjacent to site 11 on a steep slope at approximately 28°.

Refer to Photographs N 181F10 and N 381F8.

STRATIGRAPHY : The internal composition of the lobe and an adjacent lobe has not been examined but their stability on such a steep slope has been tested in March 1981 and also in 1985 and 1987. Reference pins were hammered into adjacent bedrock and in to five positions within the two lobes. Distances were measured with a plastic coated steel tape to the nearest centimetre. The same tape was used for all measurements.

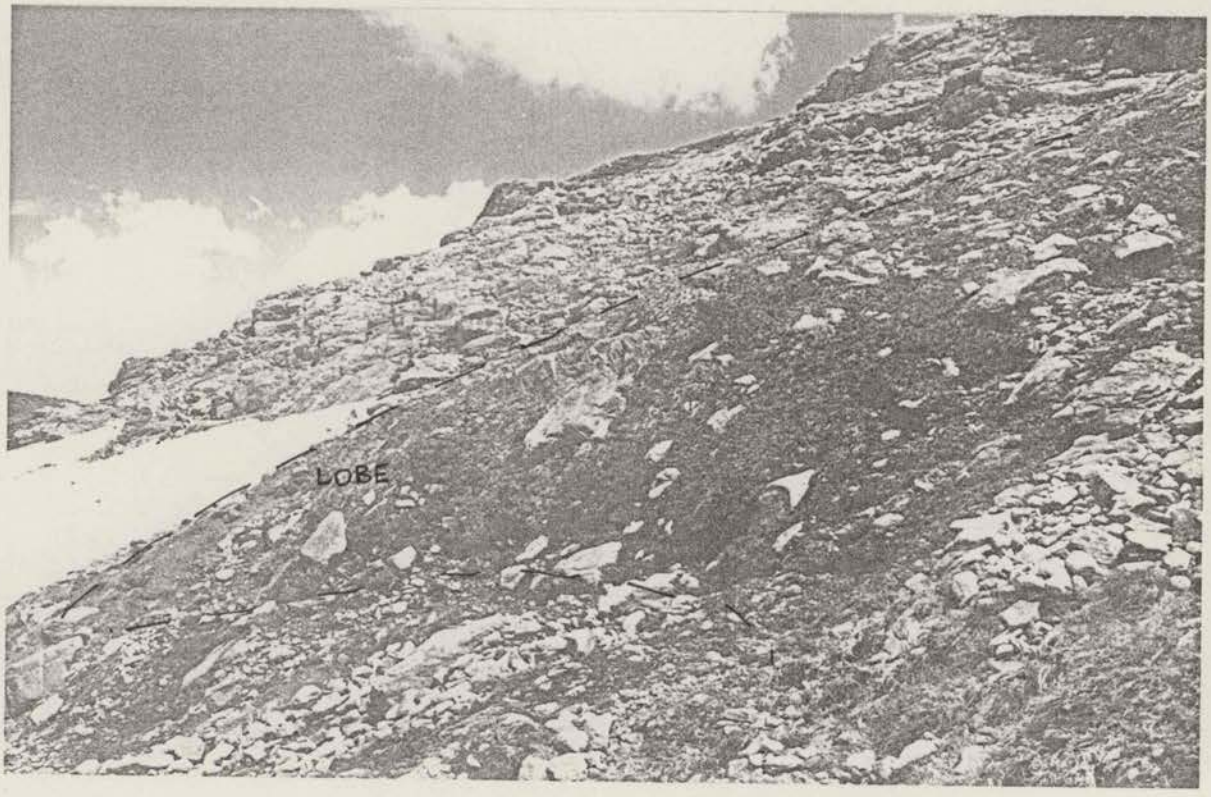
The lobe illustrated in photographs N 181F10 and N 381F8 probably has not moved at all in that time. Although the downhill directional measurements indicated an increase of 4cm between 1981 and 1985, there was an apparent decrease of 2cm between 1985 and 1987. The steel reference pins in the bedrock and in the lobe were driven in as far as they would go. The tops of the 3/8 inch (10mm) pins were bent downslope by the subsequent snow patch movement and this may have caused the slight deviations measured over a distance of 27m.

An adjacent lobe of regolith which appears to be a slump associated with ground water emission, appears to have changed position downslope by 2cm over six years relative to one set of reference pegs and by 8cm over six years with respect to another set of referance pegs. Therefore despite the availability of excess groundwater through material which can be seen to have slumped in the past on a slope of approximately 28°, there is surprisingly little movement. Perhaps these lobes are relic features from which lubricating fines have been elluviated?

Photograph N 181F10 illustrates the blocky character of the lobe and its close association with the polished stepped pavement of site 11 and the snow patch patch zone. Groundwater emanates from the base of this lobe.

Photograph N 381F8 also illustrates the lobe and gives it scale by reference to the people seen in this shot.

SITE NUMBER : 12 continued
PHOTOGRAPH N 181F10



PHOTOGRAPH N 381F8



SITE NUMBER : 13 Snow Patch Slumps
G.R. : 305219 Nelse 1:25 000 NATMAP
ELEVATION : 1787m to 1806m
ASPECT : South-east
GEOMORPHIC SETTING : The lower slope in a snow patch with local gradient of 22°-25°. The slump feature exhibits two slip surfaces and a raised toe characteristic of rotational slip.

Refer to photograph N 181F3 which illustrates the upper portion of the slump.

PHOTOGRAPH N 181F3



STRATIGRAPHY : The snow patch slump demonstrates on going instability and downslope movement of blocky regolith by mass movement. The feature specified at site 13 is also included in the geomorphic profiling (Section 3C) along a traverse 114° GB from the Mt Nelse summit between points 29 and 33 (see Fig 3c). Another slump was picked up on the same traverse between points 40 and 42. The well defined slip surfaces suggest that these features are very recent. The question that is difficult to answer is : are the blocks in this regolith being produced at the same rate that they are being eroded or is mass movement in the snow patch zone transporting relic slope deposits? The relative scarcity of lichen on bedrock outcrop and blocks in the snow patch zone also supports active downslope movement of snow and regolith respectively. By contrast, the relative abundance of lichens on the Mt Nelse summit outcrop and blocks suggests that very little is being contributed from above the snow patch zone in the present climate.

The local reduction in grade within this slump and the sudden change from sparse tussocks to a dense short turf with < 10% of the surface covered by blocks, suggests that fines are

accumulating on this surface which is illustrated in photograph N 181F3. Personal communications from Soil Conservation Officers indicate that summer showers and needle ice are actively removing fines and gravel from the snow patch zone as sediment traps are overfilled after a single downpour. Thus the snow patch zone on Mt Nelse and other snow patch zones at similar altitude with a similar period of snow cover are activly eroding regolith by needle ice, aluviation and mass movement, as well as polishing bedrock outcrop.

SITE NUMBER : 14 Stony Pavements
G.R. : Mostly in the vicinity of 305222 Nelse 1:25 000 NATMAP
ELEVATION : From 1780m to 1840m
ASPECT : East to South-east.
GEOMORPHIC SETTING : Stony pavements occur in drainage lines within and just below the snow patch zone on the eastern flank of Mt Nelse. These drainage lines slope from 11° to 22°. Spring water emanates from the heads of these drainage lines. The stony pavements appear to be inset into blocky regolith and have steps and wrinkles orientated across the slope.
VEGETATION : The fringes of the "stony pavements" set in the drainage lines are covered with Celmisia sericophylla and the stony pavements themselves have a patchy cover of Caltha introloba. Some sections are bare, close packed platy blocks and cobbles devoid of even lichen. Celmisia becomes more dominant in the lower tracts of these stony pavements, often growing in stripes across the slope in association with wrinkles within the stony pavement.

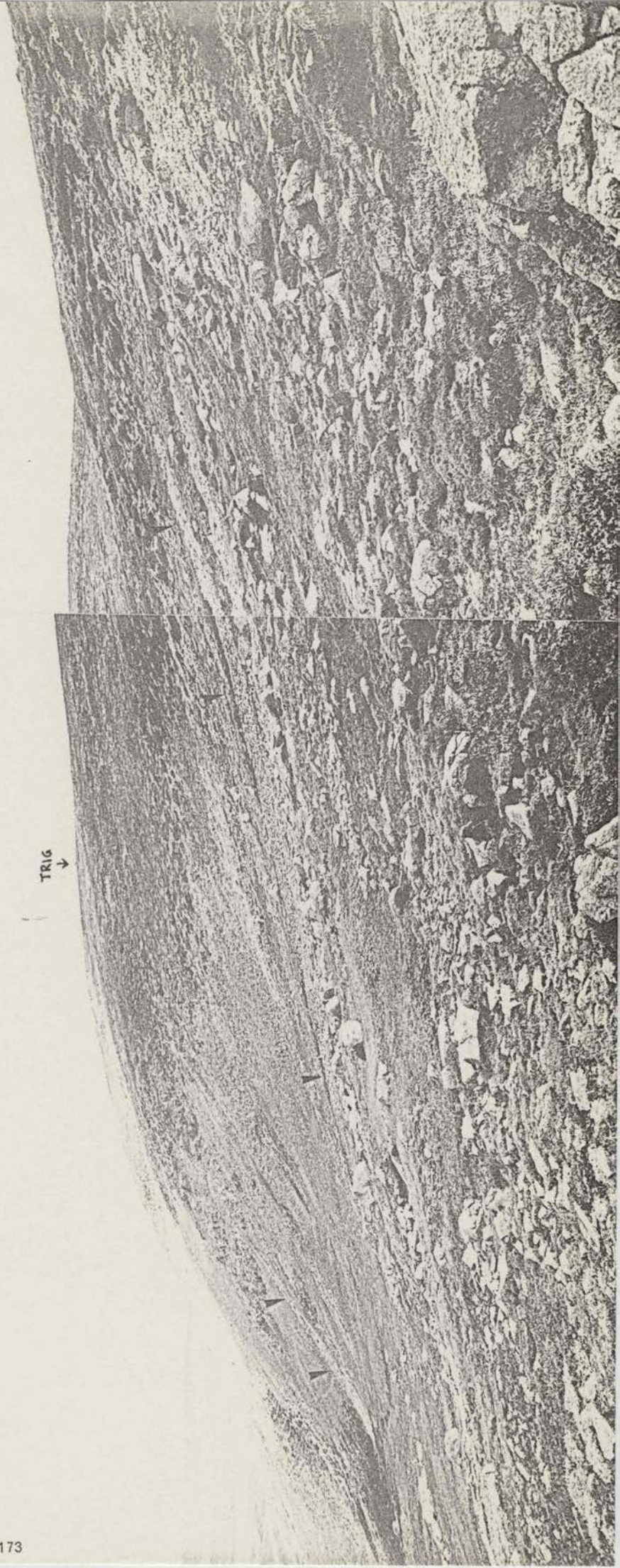
Refer to photographs: composite N 17285F25/27, N 17285 frames 31, 33, 35, 37, 41, and 59, and N 30183F7.

STRATIGRAPHY : The upper tracts of the stony pavements consist of a partially vegetated close packed veneer of platy cobbles and blocks with an imbricate fabric, overlying close packed unstratified irregular cobbles and blocks with a finer grained gravelly silt matrix.

Photograph composite N 17285F25/27 gives a panoramic view from the northern end of the Nelse snow patch zone looking south. The downslope stripes of stony pavement are visible in the midground and at the southern end of the snow patch zone. (See next page.)

SITE NUMBER : 14
continued

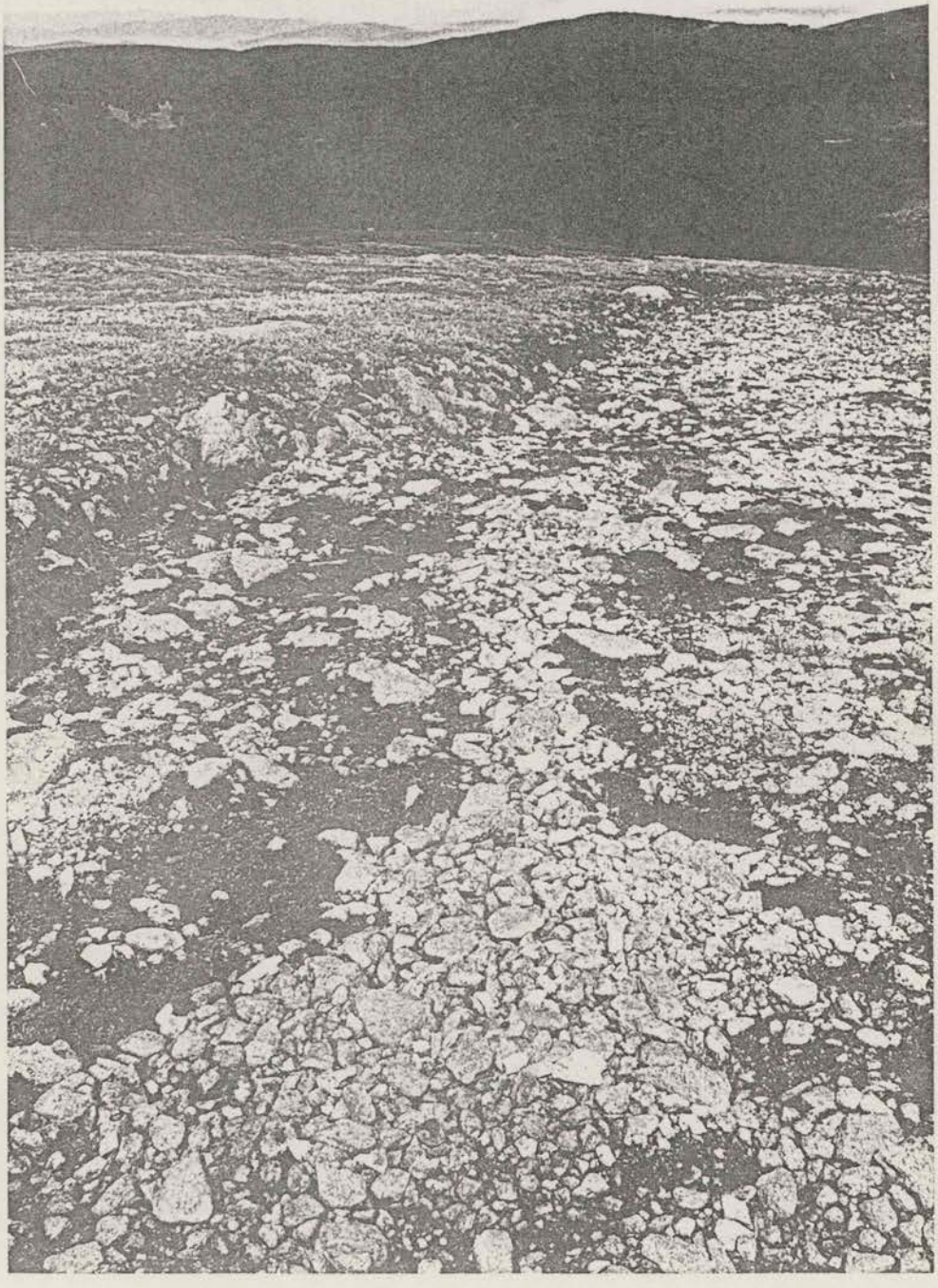
COMPOSITE PHOTOGRAPH
N 17285F25/27



SITE NUMBER : 14 continued

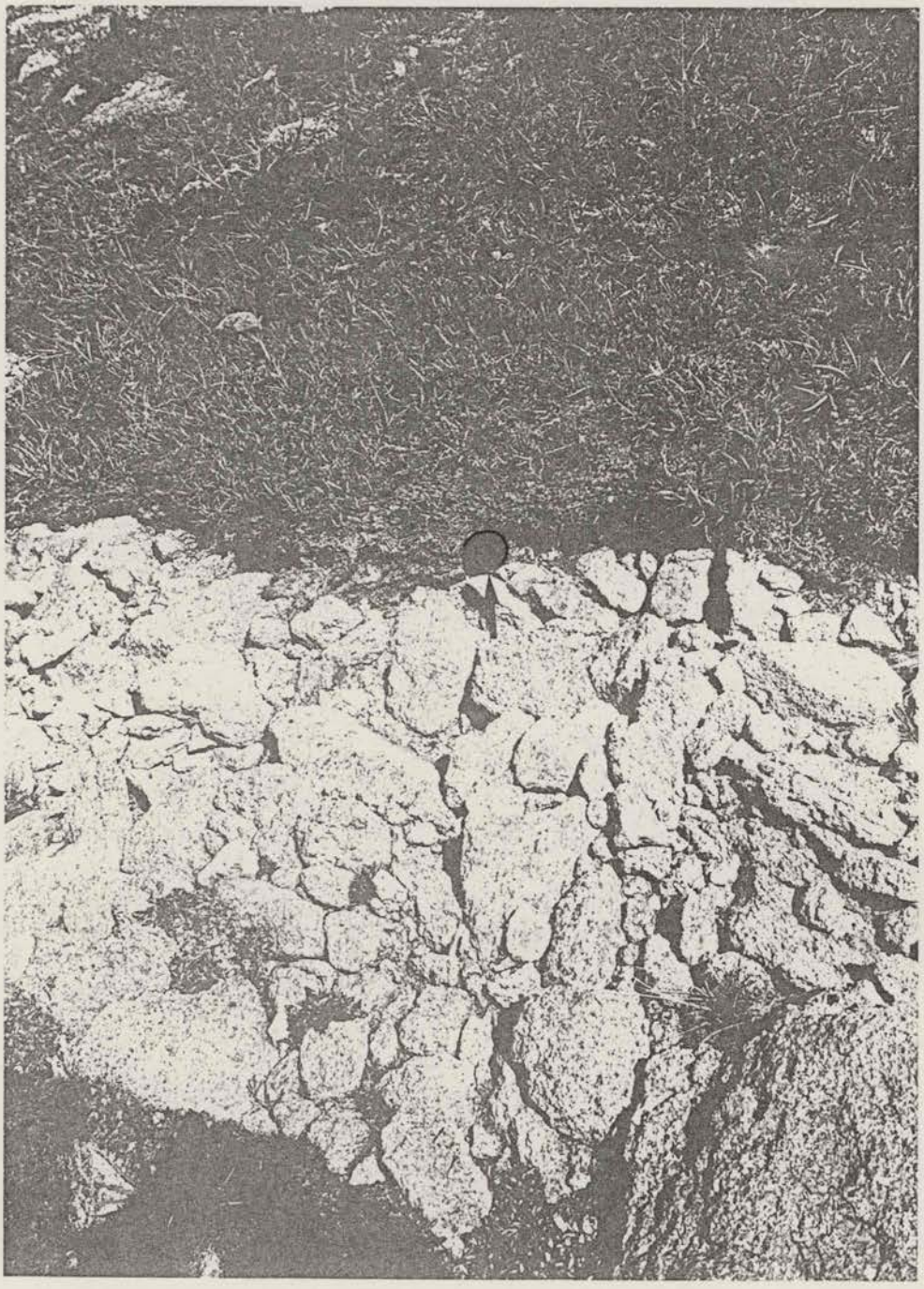
Photograph N 17285F33 is near the head of a stony pavement looking downslope. The stony pavement is clearly inset into the adjacent vegetated blocky regolith.

PHOTOGRAPH N 17285F33



SITE NUMBER : 14 continued

PHOTOGRAPH N 17285F37

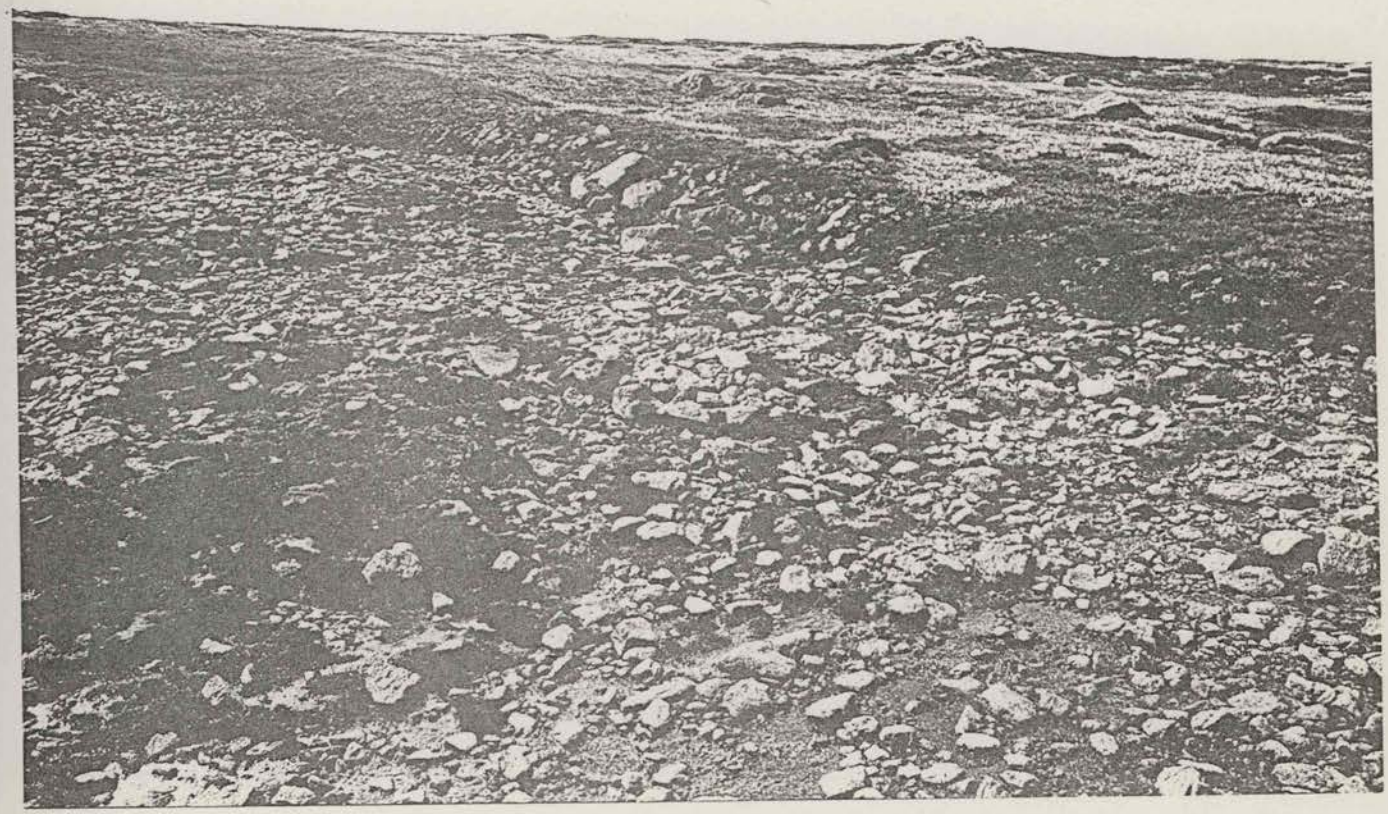


Photograph N 17285F37 is a close-up of the eroded edge of the adjoining blocky regolith. The scale is given by a 49mm lens cover and the eroded section is approximately 50cm deep.

SITE NUMBER : 14 continued

Photograph N 17285F35 looks upstream and further illustrates the stony pavement inset into adjacent blocky regolith.

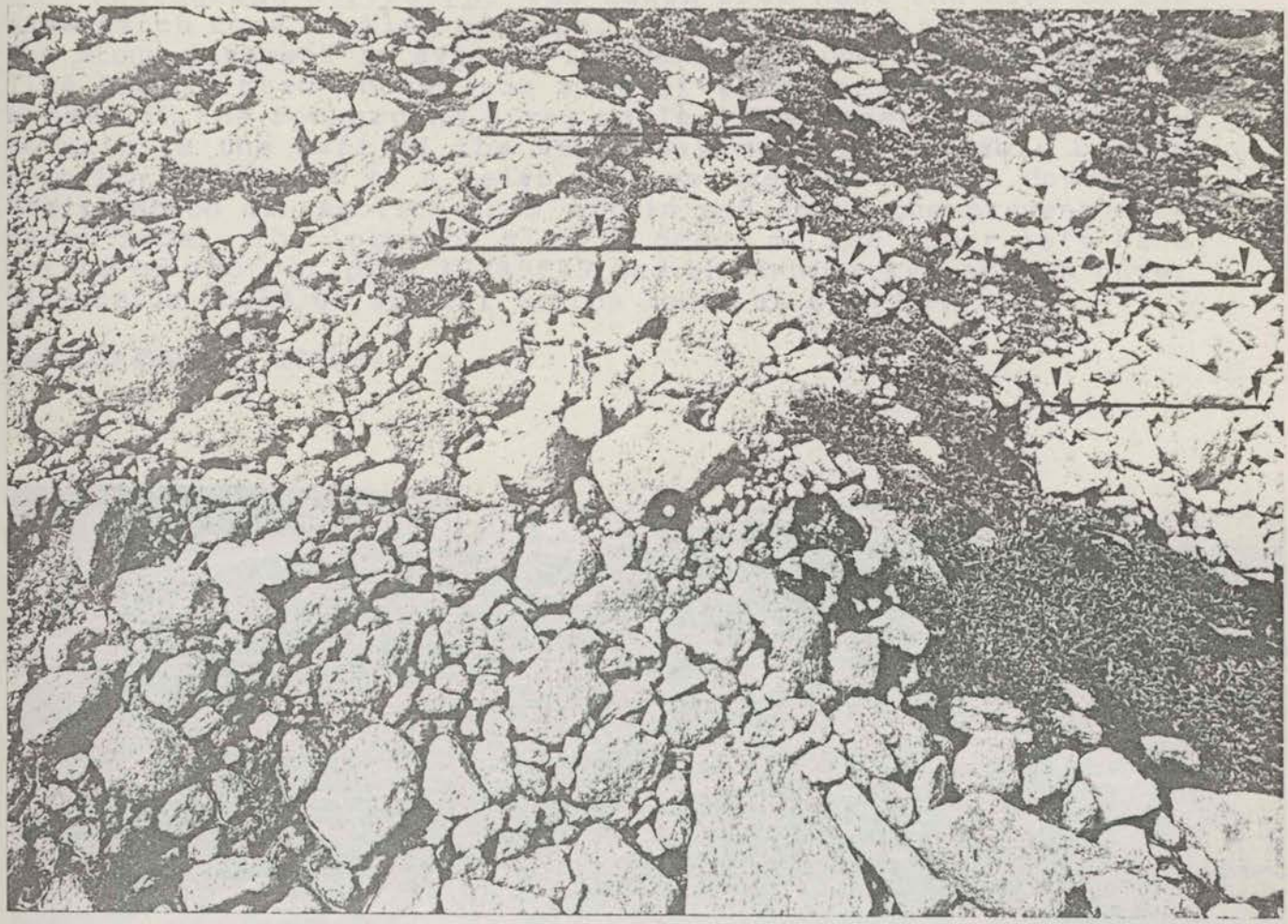
PHOTOGRAPH N 17285F35



Photograph N 17385F31 (next page) demonstrates a small terrace with a vegetated riser. The riser is about 30cm high. The blocks and cobbles form a close packed stony pavement on the terrace tread and an imbricate fabric is evident. This imbricate fabric and the absence of lichens suggests active downslope movement within the stony pavement.

Photograph N 17285F41 (next page) illustrates a larger terrace lower down on the stony pavement, with a riser of about 60cm.

SITE NUMBER : 14 continued
PHOTOGRAPHS N 17285F31 (top) and N 17285F41 (below)

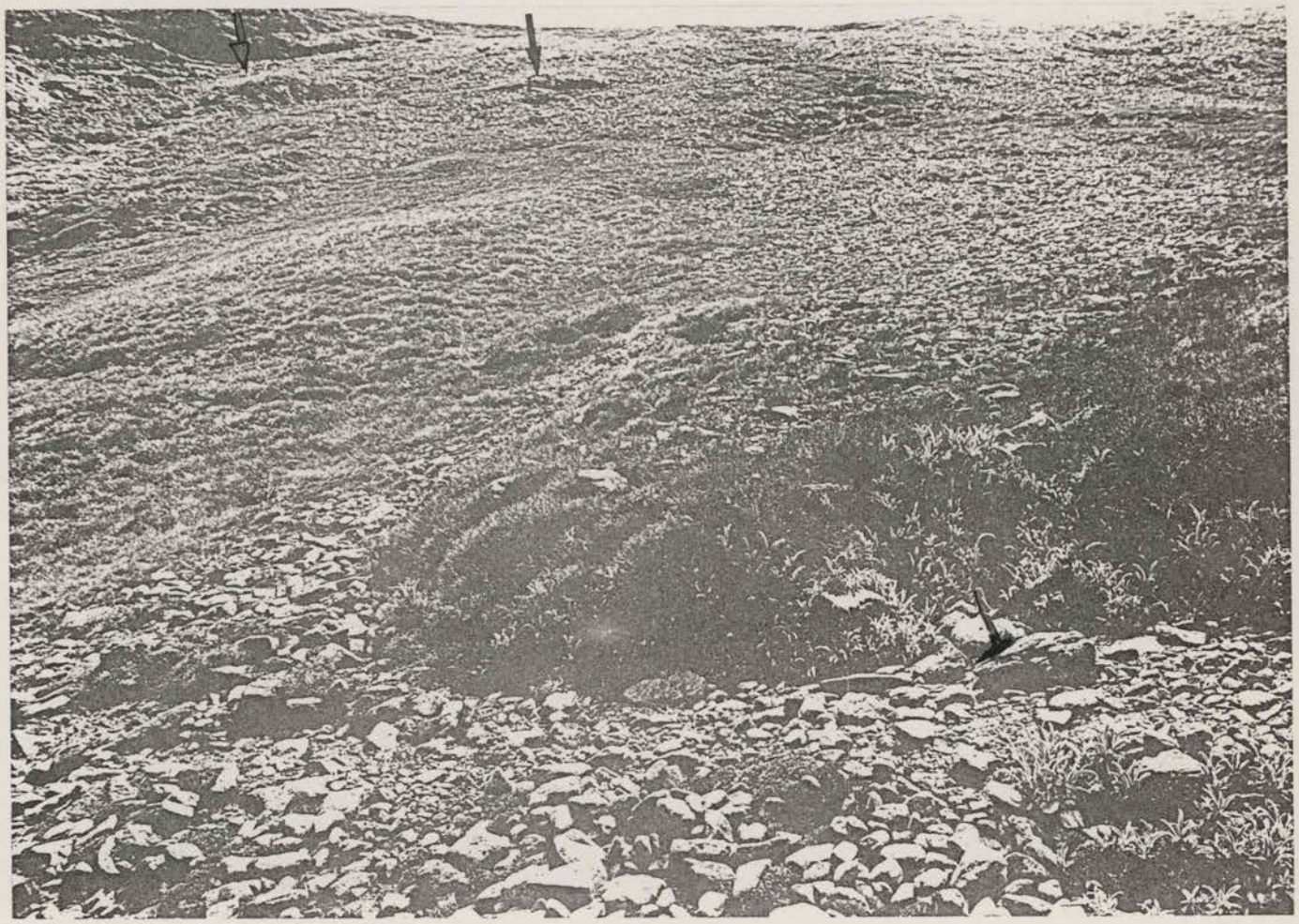




SITE NUMBER : 14 continued

Photograph N 17285F59 was taken from near the base of the snow patch zone looking upslope. The riser of a terrace within the stony pavement is evident in the foreground and the drainage line has skirted around the edge of this terrace. The piton hammer in the foreground gives scale. The vegetated, hummocky terrain to the left of the stony pavement is probably blocky regolith which may be a relic feature associated with downslope mobilization of regolith from within and above the present snow patch zone. The lobes of site 12 occur in the upper left hand corner of photograph N 17285F59 and the hummocky terrain under discussion could be similar to the lobes at site 12.

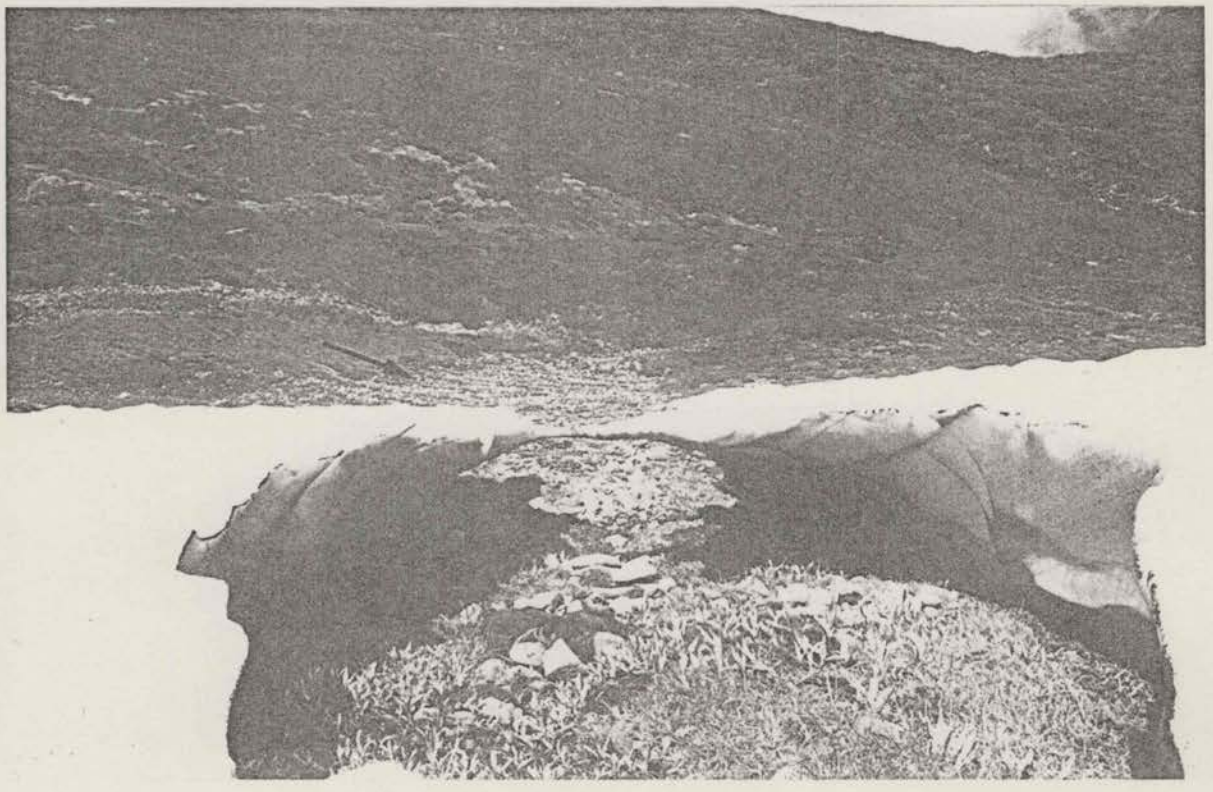
PHOTOGRAPH N 17285F59



SITE NUMBER : 14 continued

Photograph N 181F7 illustrates the wrinkled character of a lower, steeper section of stony pavement near the base of the snow patch zone.

PHOTOGRAPH N 181F7



The stony pavements associated with the drainage lines of the snow patch zones are the avenues of transport of blocky regolith from within the snow patch zone and from the bedrock outcrop within and just above the snow patch zone. The terraces within the stony pavements represent a downslope redistribution of blocky regolith. Probably only the fines escape below the snow patch zone but it is possible that some coarse blocky material is moving slowly downslope. The transverse ripples on the steeper sections of stony pavements also suggest slower mass movement.

The distribution of the stony pavements corresponds to the mapped distribution of Celmisia sericophylla (refered to as "c" in the appendices at the end of this section), with some stony pavements also occuring with groundwater vegetation (refered to unit 9 in the appendices) at the margins of the snow patch zone.

Below the snow patch zone and just above the confluence of the drainage lines from the snow patch zone is an accumulation of

large angular blocks many 2m or more in length. This block accumulation corresponds to a tall wet heathland/bog mapped as unit 9 on Fig 2Ar. The blocks are obviously joint blocks which have been plucked or wedged from solid outcrops upslope. The stepped profile of bedrock in the snowpatch zone suggests these blocks may have been derived from the snow patch zone, but these blocks are now covered with lichens indicating that they are not actively accumulating under present conditions. This zone, (which has a gradient of approximately 14° and exists between 1750m and 1780m) may be accumulating smaller blocks and cobbles which are presently, slowly mass wasting from the snow patch zone.

A small stony pavement located just below the southern margins of the Nelse snow patch zone near G.R. 305215 was sampled in several places. The blocky regolith made penetration difficult. The drainage line in which this stony pavement occurs was profiled and is presented as profile N 096°, in Section 3C. The stony pavement is associated with a minor snow patch between shots 13 and 16, and it forms the floor of this small snow patch zone sloping 5° to 6° with a back wall rising 6m at slopes of 15° to 21°. The backwall is convex but the snow patch zone overall is concave, which is similar but on a smaller scale to the main TNelseNesle snow patch zone.

The snow patch backwall or riser was armoured by a close packed pavement of large platy blocks from 10cm to 50cm with a modal size of about 20cm. The matrix associated with this coarse stony pavement was a loose organic sandy gravel. This upper layer was approximately 15cm thick and overlies a more compact slightly consolidated gravel layer in a brownish matrix of sand and silt. Concretions of limonite occur in this layer. This gravelly layer contained some cobble size clasts which increased in number between 30cm and 40cm below the surface. Below 40cm the matrix changed to blue grey and cobbles were less frequent.

A sample taken from the gently sloping snow patch pavement floor comprised:

Layer 1 : Depth 0-10cm. A veneer of platy clasts from 1cm to 50cm with modal size about 15cm, in a loose organic gravelly matrix. Refer to photograph N 30183F7.

Layer 2 : Depth 10cm-45cm. Orange colored gravel with some larger clasts 10cm-20cm. All clasts except quartz are highly weathered, slightly rounded and coated with limonite. The sand, silt matrix is firm and slightly consolidated. In some holes it changes color from orange to greenish grey. This may be related to change in the oxidation state of iron compounds in the groundwater and to fluctuations in the level of groundwater.

Layer 3 : ??? penetration below 45cm was blocked by a large hard clast or bedrock.

A textural analysis of layer 2 in an adjacent hole at 10cm intervals revealed an increasing proportion of clasts > 2mm with depth, from 22% at the top of layer 2 to 44% in the third interval and 39% in the fourth interval. The percentages of coarse sand, fine sand, silt and clay as a percentage of fine

earths (<2mm) remained fairly constant throughout layer 2. The overall grainsize distribution demonstrated that layer 2 is probably frost susceptible (in comparision to Embleton and King, 1975, Periglacial Geomorphology, Fig 2.5.) The textural analysis is presented below in Table 2A4.

Table 2A4. Textural Analysis of a Soil Sample From Layer 2 of a Small Snow Patch Zone Stony Pavement on Mt Nelse.

Particle size	interval numbers			
	N1	N2	N3	N4
% gravel > 2mm	22	33	44	39
coarse sand as % of fine earth <2mm	41	37	39	37
fine sand	38	44	38	39
silt	10	10	10	9
clay	10	10	10	13

INTERPRETATION

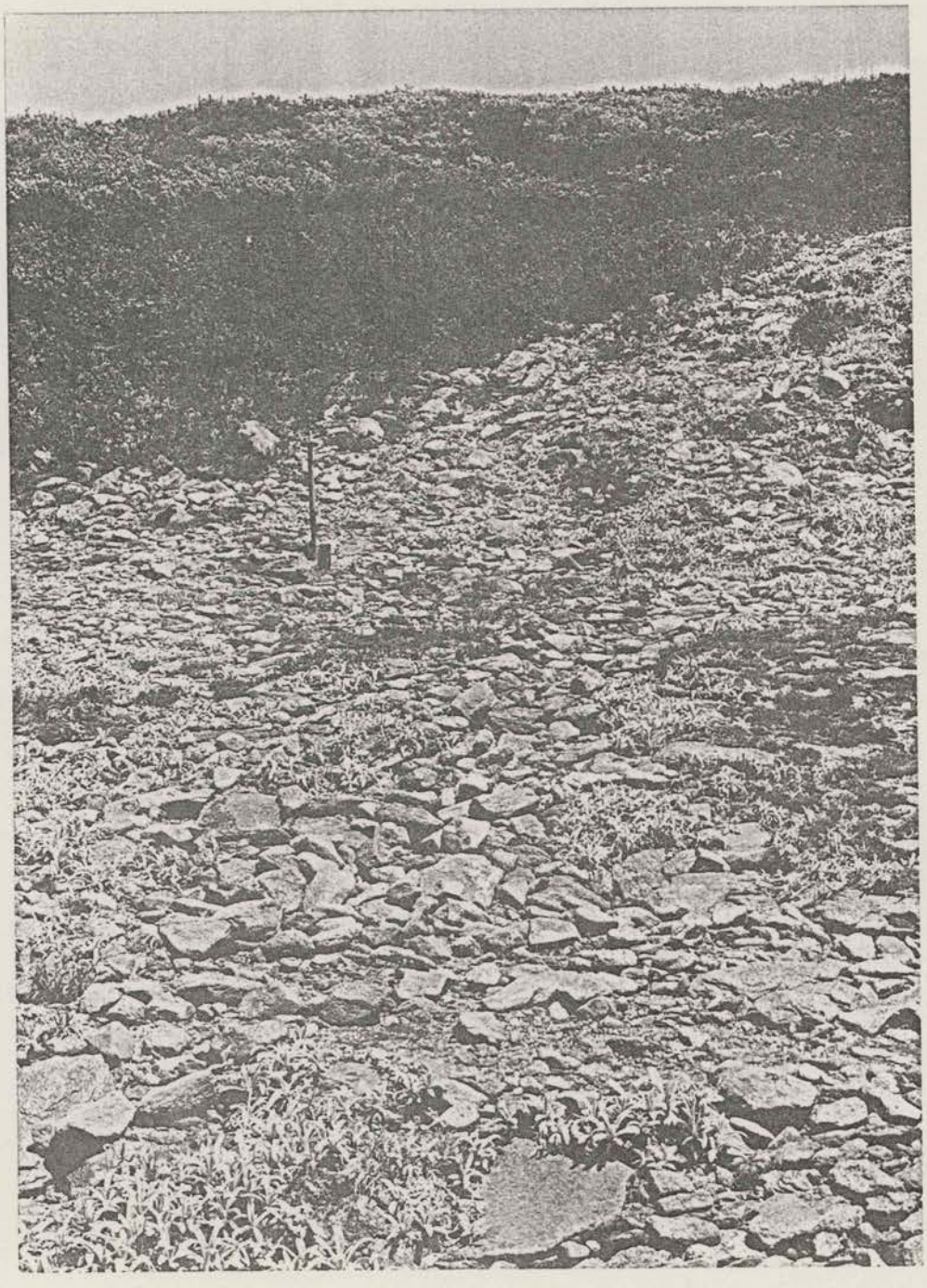
Layer 1 represents a residual layer of coarse clasts recently concentrated as a thin veneer of stony pavement by processes such as needle ice and surface wash in the snow patch zone. The extent that frost heave may have contributed to the aggregation of these clasts at the surface is uncertain. Layer 1 corresponds well with layer 1 described for site 16. and layer 3 at site 17.

Layer 2 represents a relic accumulation of coarse blocky regolith which has undergone significant chemical breakdown since its emplacement in the drainage line. The distribution of gravel within layer 2 may represent the removal of coarse clasts (>2mm) in the upper portion of layer 2 due to frost heave after the emplacement of this material at the foot of a long moderately steep slope on the south-eastern aspect of Mt. Nelse.

The stratigraphy of the other larger stony pavements is probably very similar except that the mobilization of layer 2 regolith may have involved other means of mass movement such as gelifluction.

SITE NUMBER : 14 continued

PHOTOGRAPH N 30183F7



This photograph demonstrates the close packed veneer of platy blocks on the floor of a minor snow patch zone neat Mt Nelse (G.R. 305215). A patchy cover of Celmisia sericophylla again characterises this stratigraphic zone.

SITE NUMBER : 15 Snow patch Terracettes
G.R. : 306224 Nelse 1:25 000 NATMAP
ELEVATION : 1820m to 1840m
ASPECT : South-east
GEOMORPHIC SETTING : The terracettes are located along the upper slopes of the snow patch zone and are best developed close to the head of the main snow patch drainage line on a slope of 20°.
VEGETATION : The dominant vegetation is Celmisia asteliifolia which forms a net-like pattern across the slope. The Celmisia grows mainly on the rises of the terracettes. The treads of the terracettes are mostly bare of vegetation.

Refer to photographs N 28286F13 and N 28286F14

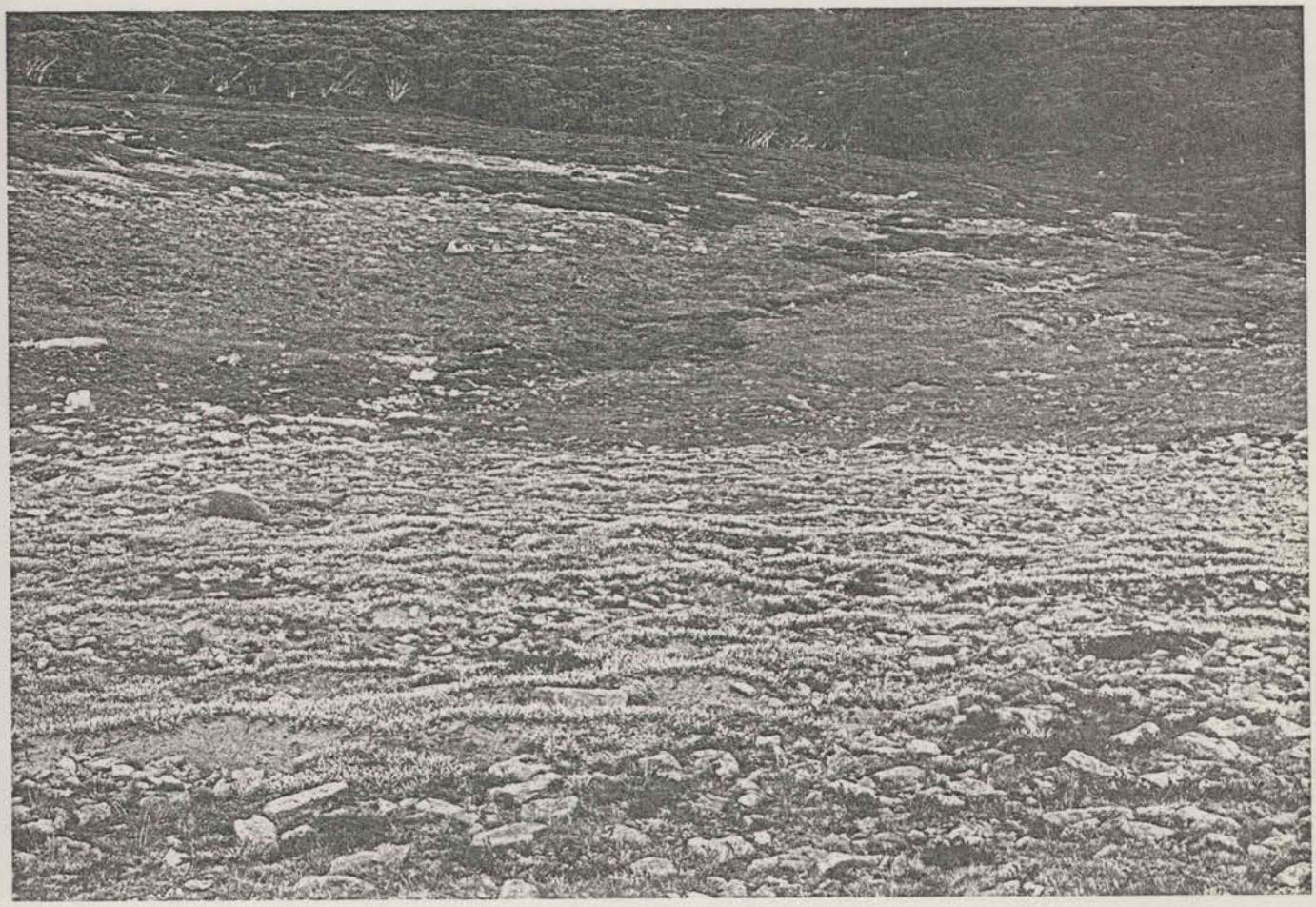
STRATIGRAPHY : The upper slopes of the snow patch are composed of blocky regolith. The thickness is undetermined but probably variable and one small exposure in the upper snow patch zone revealed 70cm of irregular cobbles and gravel in a yellow brown matrix. Blocks seem to congregate near the base of the terracette risers which suggests that they are accumulating fines from behind with the aid of the matted root system of the Celmisia. The terracette treads are near horizontal and crescentic in plan view and mainly consist of fines with a small amount of fine gravel.

Photograph N28286F13 is taken from the head of the main drainage line near the upper margin of the snow patch zone looking downslope towards the southeast. The crescentic terracettes are clearly visible.

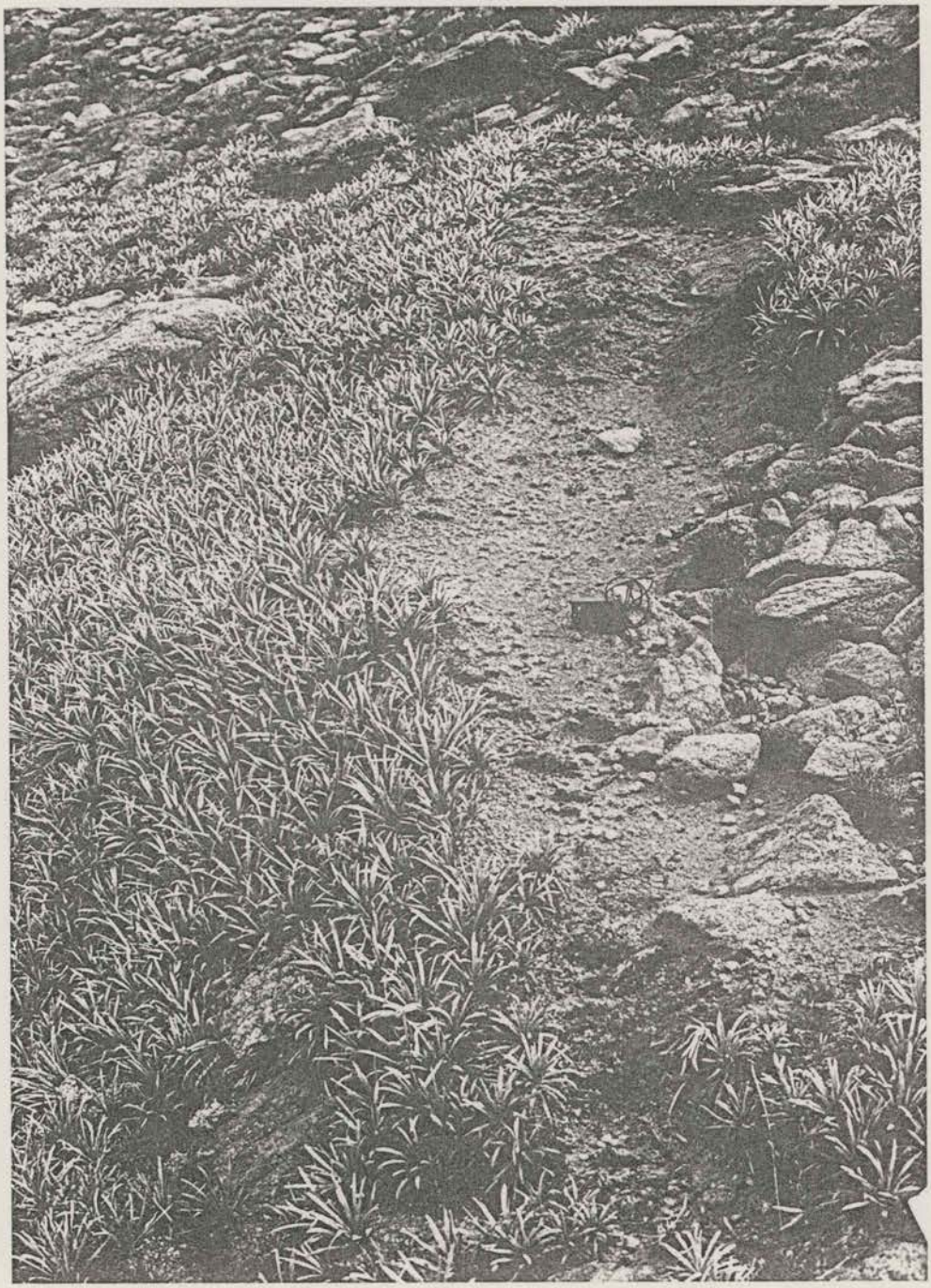
Photograph N 28286F14 is a close view of a single terracette looking crossslope. Irregular blocks are visible along the right hand margin. These belong to the base of the adjacent upslope riser. The Celmisia forms a dense matt which holds the terracette together and traps sediment.

The terracettes again demonstrate that the snow patch zone is a complex feature with a variety of processes currently working on its surface. The thick, blocky regolith is probably a residual layer emplaced prior to the Holocene which is now being locally reworked in the snow patch zone to produce features such as the terracettes and terraced or wrinkled stony pavements, as well as slumps.

SITE NUMBER : 15 continued
PHOTOGRAPH N 28286F13



SITE NUMBER : 15 continued
PHOTOGRAPH N 28286F14



SITE NUMBER : 16 Vegetated Slopewash/Blockfield
G.R. : 303218 Nelse 1:25 000 NATMAP
ELEVATION : 1817m
ASPECT South-south-east
GEOMORPHIC SETTING : This site is located midslope on the south-south-east flank of Mt. Nelse within a relic blockfield covered by a veneer of slope wash on a slope of approximately 11°. The block field is interpreted to be a veneer overlying a bedrock terrace, also sloping at 11° towards 164° GB. Small terracettes occur at the surface and represent recent mass movements of the slopewash layer. Few blocks occur at the surface in this section as slopewash has overrun much of the blockfield.
VEGETATION : Short open heath.

STRATIGRAPHY :

Layer 1 : Depth 0-20cm. Large platy blocks embedded in a brown organic loam matrix. Blocks are large, platy and in a relatively fresh state.

Layer 2 : Depth 20cm-50cm. Tightly packed stratified platy cobbles and blocks with slightly rounded edges in an orange brown matrix.

Layer 3 : Depth uncertain. Blocks prevented penetration below 50cm but the Mt Nelse summit traverse along 164° GB suggests that the bedrock terrace surface is 1m to 1.5m below the surface.

Refer to photograph composite N 26286F16/N 26286F17.

INTERPRETATION : Layer 1 is interpreted as recent slopewash because the clasts are relatively fresh and are associated with and embedded within an organic loam which is recent soil. Vegetation is stabilizing this layer but small terracettes with treads 1.5m to 10m across slope and 0.4m to 0.5m downslope with risers 0.3m high, indicates current, shallow, slow mass movement. The vegetation again marks this terrain.

Orites lancifolia is a sprawling dark green shrub on the tread of these terracettes and contoured strips of dark green Alpine Orites are visible on aerial photographs. An oblique view presented as a panorama from a hill to the south-east of Mt Nelse looking north-west, demonstrates the contoured strips of Alpine Orites on the lower half of Mt Nelse and it also demonstrates the stepped bedrock surface from the summit, visible along the western profile of Mt Nelse. Much of the lower, southern flanks of Mt Nelse is characterized by short open heath vegetation which probably relates to a surficial stratigraphy of shallow slopewash overlying a shallow veneer of relic blockfield over bedrock.

Layer 2 is interpreted as a relic slopewash deposit of coarse platy clasts because of its compact slighlty consolidated character. The absence of obvious vertical sorting within layer 2 suggests that downslope movement by gravitational means was more significant than vertical segregation by frost heaving. This is not surprising given the moderate slope of about 11°. Layer 2 at this site is not disimilar to layer 2 at site 14 (G.R. 305215).

SITE NUMBER : 16 continued
PHOTOGRAPH COMPOSITE
N 26286F16/N 26286F17



SITE NUMBER : 17 Southern Flank of Mt Nelse
G.R. : 304214 Nelse 1:25 000 NATMAP
ALTITUDE : South-south-east
GEOMORPHIC SETTING : Lower slope on the southern flank of Mt. Nelse, 565m from the Nelse summit along 164° GB. Local gradient is approximately 11°.
VEGETATION : Open heath. The dominant shrub is Alpine Orites.

STRATIGRAPHY : from auger sample N 164/565.

Layer 1 : Depth 0-10cm. Medium brown organic loam matted with plant roots.

Layer 2 : Depth 10cm-30cm. Orange brown gravelly sandy silt. No cobbles. Coarse fibrous roots of Celmisia asteliifolia reach deep into the soil.

Layer 3 : Depth 30cm-45cm. Stony layer comprising platy elongate cobbles and blocks from 2cm to 20cm long. Modal size is approximately 5cm. Clasts moderately weathered.

Layer 4 : Depth 45cm-50cm. Blocky layer. Clasts have a platy habit and are 20cm-40cm and are stratified parallel to the surface with a matrix of smaller cobbles. The edges of the large blocks are rounded.

Layer 5 : Depth 50cm->80cm. Layer of platy cobbles from 1cm to 5cm. Clasts are moderately weathered and have rounded edges except for occasional quartz clasts which are irregular and have sharp edges. No blocks encountered.

INTERPRETATION : Layers 1, 2, and 3 are recent soil and colluvium, some of which may have been reworked from relic slope deposits.

Layer 4 is the upper coarse layer of a frost sorted deposit of cobbles and blocks. Layer 5 is the lowest layer comprising only cobble size clasts. Layers 4 and 5 probably represent the distal end of a relic frost sorted colluvium which had come to rest on the lower slopes of Mt Nelse. The vertical segregation interpreted as frost sorting would have occurred after emplacement of the colluvium near its distal margins. The colluvium of layer 4 and 5 is interpreted as a relic cryogenic deposit and is probably laterally equivalent to : the coarse blocky lobes of site 12; layer 2 at site 14; and layer 2 at site 16. These relic cryogenic layers are also probably equivalent to: layer 2 at sites 4, 6, 7, 8, 9 and 10 and to layers 2 and 3 at sites 2 and 3.

CORRELATION OF MT NELSE SURFICIAL STRATIGRAPHY WITH VEGETATION

VEGETATION CODING	VEGETATION TYPE	SURFICIAL STRATIGRAPHY
1	Dwarf Heathland	Dominantly bedrock with patches of close packed platy cobbles and blocks on summit flat.
2	Tall Closed Heathland	Vegetated blockfield. Coarse blocky regolith of variable thickness with open blocks in most drainage lines.
3	Short Open Heathland	Veneer of sandy gravelly loam over frost sorted gravel cobbles and blocks overlying extremely weathered bedrock. Thickness approximately 30cm on upper slopes, becoming thicker on lower slopes.
4	Short Kunzea Heathland	Dominantly bedrock with a patchy veneer of blocks and finer regolith up to 40cm thick.
6	Poa-Celmisia Herbfield-Grassland	Veneer of sandy gravelly loam or relic humified peat overlying gravel and cobbles up to 70cm thick.
7	Celmisia Herbfield	Blocky regolith usually associated with minor snow patch zones. Depth uncertain.
8	Celmisia Short Turf Herbfield	Blocky regolith up to 2m thick. Slumping occurs below springs.
9	Groundwater Vegetation Comprising Wet Heath, Bog and Fen	Generally vegetated blockfield overlain by peat or humified peat.
c	Celmisia sericophylla/ Caltha introloba Stripes	Stony pavements overlying coarse gravelly regolith 1m to 2m deep.
s	Snow Gum Woodland	Generally associated with bedrock near the upper limit of snow gum habitat.

DESCRIPTION OF VEGETATION UNITS SHOWN ON FIG 2Ar NELSE 1:7 000 VEGETATION OVERLAY

Name	Symbol/coding	Description
Dwarf Heathland	1	Very short, prostrate heath plants, 5cm-15cm tall, comprising Epacris microphylla, Ewartia nubigena, Kunzea ericifolia, Grevillea australis and Poa spp. Structure can be described as mostly closed patches. Ewartia nubigena is found scattered within stony pavements.
Tall Closed Heathland	2	Dense stands of tall shrubs often with a sparse understorey, up to 2m tall but commonly about 1m tall on slopes of moderate gradient.
Open Heathland	3	Open structured heath comprising short shrubs (commonly Prostanthera, Orites and Grevillea) with tussock grass and forbs (commonly Poa spp. and Celmisia) occupying the intershrub spaces. Height varies from 30cm at the more elevated exposed range of distribution to 80cm at lower sites.
Short Kunzea	4	Open and closed, prostrate heath of dominantly Kunzea ericifolia and Grevillea australis. This unit is generally less than 30cm high.
Poa-Celmisia Herbfield/ Grassland	6	Celmisia asteliifolia and Poa spp. are the dominant members of this short dense plant community, usually less than 20cm tall, which occupies sites of deep well drained soil such as the saddle north of the Mt Nelse summit, and also the deep humified peats at the head of Edmundson's Hut Creek.
Celmisia Herbfield	7	Short dense herbfield of dominantly Celmisia asteliifolia on concavities and slopes usually occupied by snow banks usually until late November.
Celmisia Short Turf Herbfield	8	Open structured C. asteliifolia with bare stony patches on upper slopes of the large late melting snow patch zone merging with short closed turf along the lower margins.
Groundwater Vegetation incl. Wet Heath, Bog and Fen	9	Generally composed of Sphagnum or sedge with a sparse to dense shrub cover in saturated sites near springs and along creeks.

Name	Symbol/coding	Description
Celmisia sericophylla/Caltha introloba Stripes	c	Open and closed structured communities of C. sericophylla and Caltha introloba associated with drainage lines and springs in and adjacent to snow patch zones. Usually continuously wet.
Snow Gum Woodland	s	Linear patches of snow gums generally associated with well drained terrain with some local relief, especially bedrock.

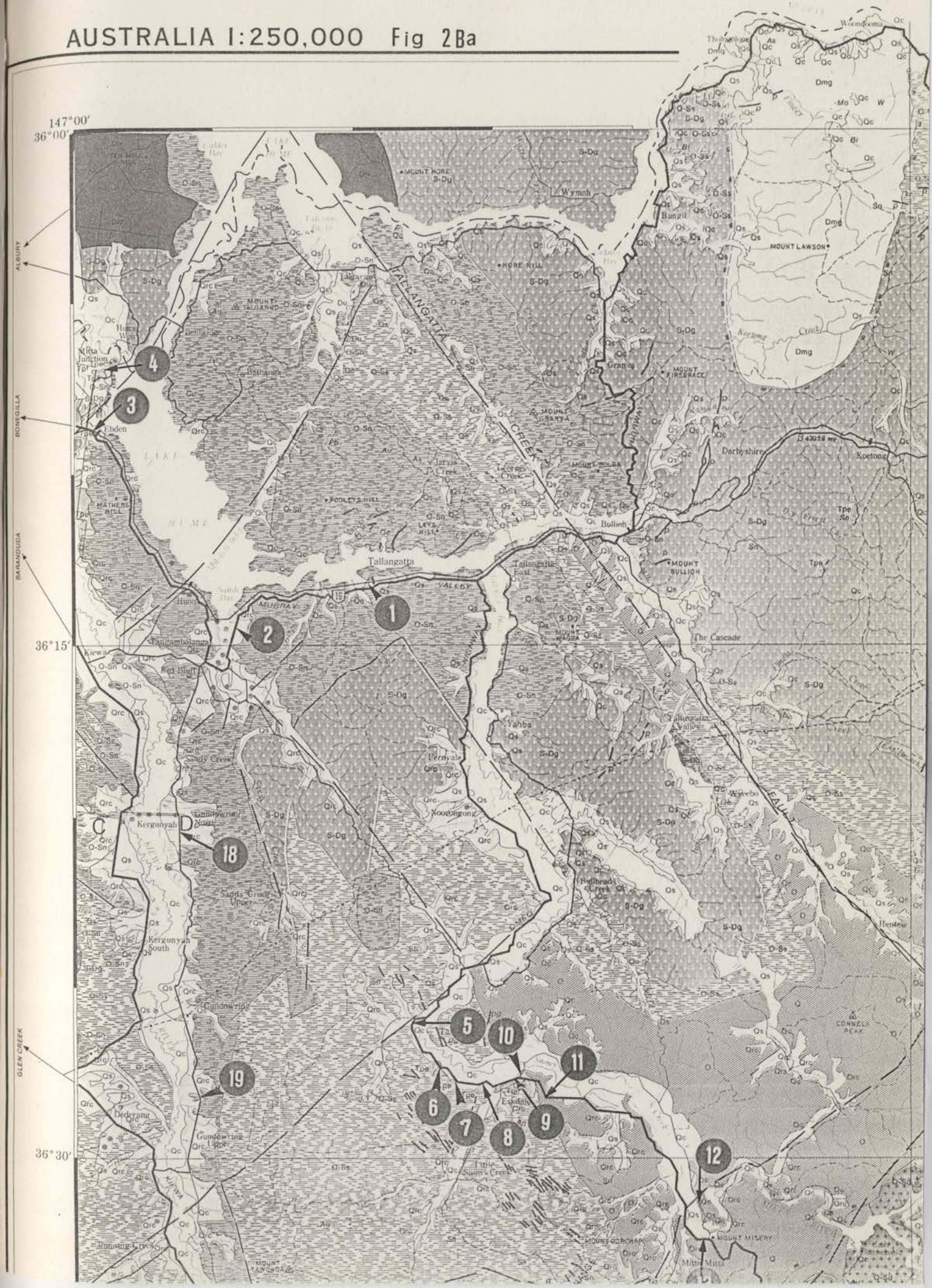
SECTION TWO : STRATIGRAPHY

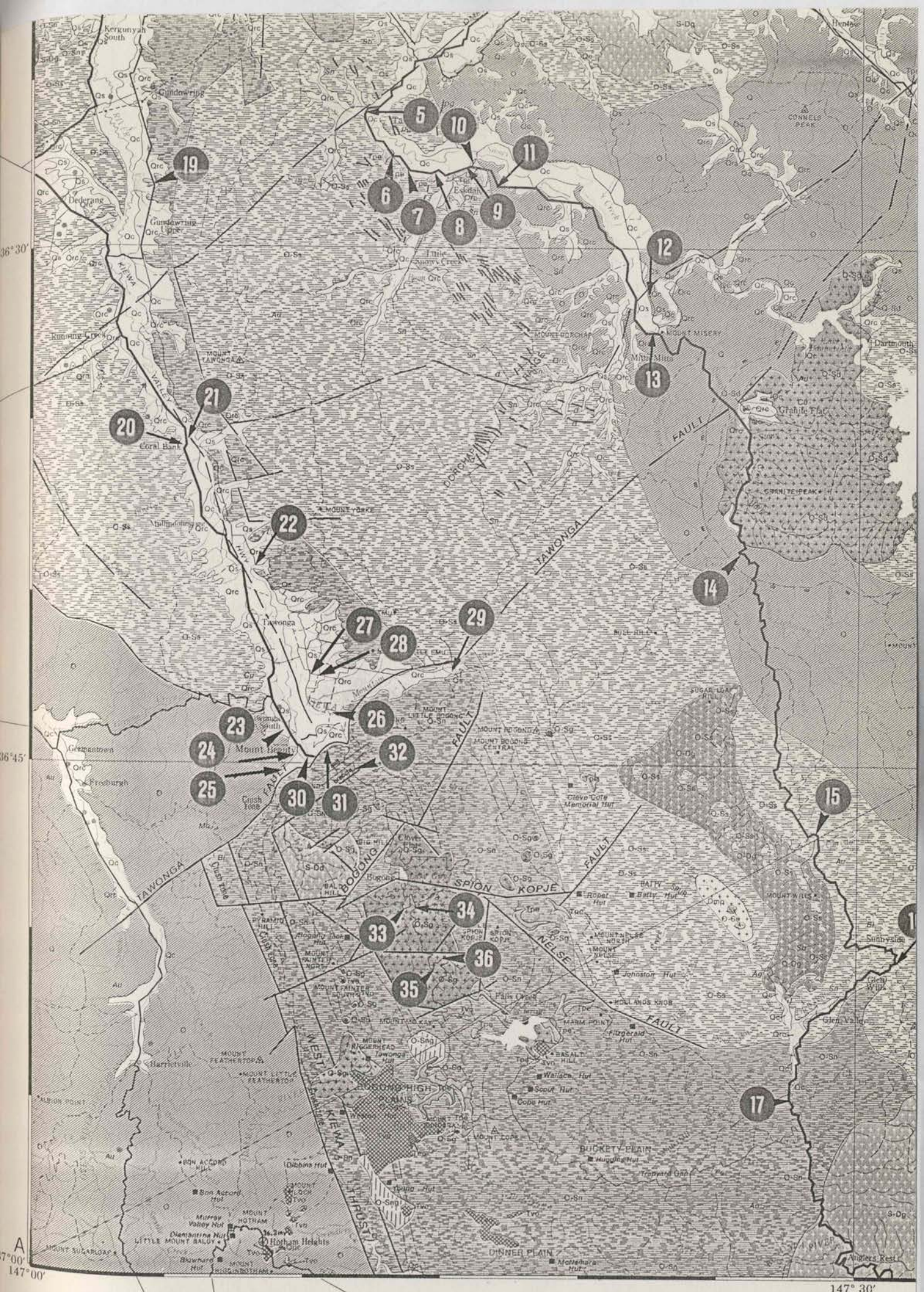
B) DESCRIPTION OF SURFICIAL DEPOSITS IN THE VALLEYS OF THE MITTA MITTA AND KIEWA RIVERS LEADING UP TO THE BOGONG HIGH PLAINS.

The sites are depicted on a photocopy of portion of the Tallangatta 1: 250 000 Geological Sheet (1976), Fig 2Ba. The legend is reproduced below, Fig 2Bb, as well as a stratigraphic section across the Kiewa River at Kergunyah, Fig 2Bc. Note: this stratigraphic section is reinterpreted later in Section 2B.

PART ONE : MITTA MITTA CATCHMENT

AUSTRALIA 1:250,000 Fig 2Ba




Kergunyah South
Gundowring
Dederang
Mount Beauty
Tawonga
Tawonga South
Germantown
Freeburgh
Harrietville
Mount Feathertop
Mount Hotham
Dinner Plain
Coral Bank
Mount Misery
Mount Bogong
Mount Loch
Mount Fainter
Mount Nelse
Mount Jim
Mount Cope
Mount Buckety
Mount Bullanhoo
Mount Granite Flat
Mount Connels Peak
Mount Little Bogong
Mount Bogong Central
Mount Bogong High Plains
Mount Ruggedhead
Mount Little Feathertop
Mount Sugarloaf
Little Mount Baldy
Mount Bullhorn
Mount Blowhard
Mount Bull Hill
Mount Sugar Loaf Hill
Mount Hollands Knob
Mount Basalt Hill
Mount Painter North
Mount Painter South
Mount Ramshead Hill
Mount Big Hill
Mount Bald Hill
Mount Spion Kopje
Mount Nelse North
Mount Hotham
Mount Loch
Mount Cope
Mount Jim
Mount Buckety
Mount Connels Peak
Mount Misery
Mount Granite Peak
Mount Bullanhoo
Mount Bull Hill
Mount Sugar Loaf Hill
Mount Little Bogong
Mount Bogong Central
Mount Bogong High Plains
Mount Ruggedhead
Mount Little Feathertop
Mount Sugarloaf
Little Mount Baldy
Mount Bullhorn
Mount Blowhard
Mount Beauty
Mount Tawonga
Mount Bake

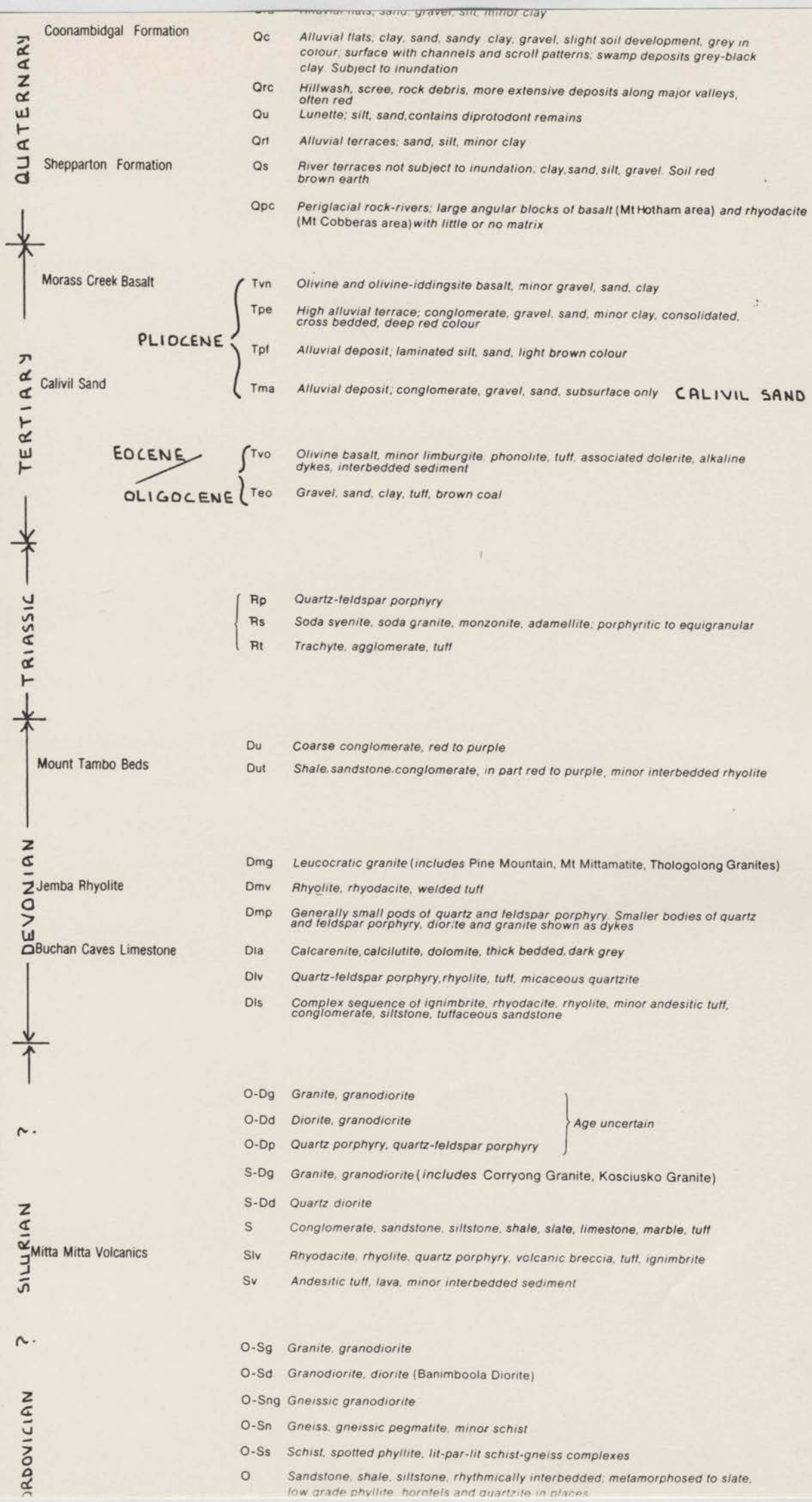
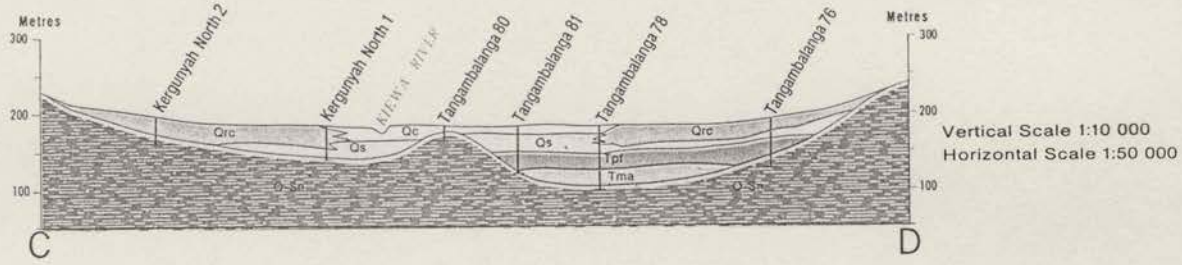


Fig 2Bb : Legend of Tallangatta 1:250 000 Geological Map

VIC. GEOL. SURVEY 1976

Fig 2Bc : Geological Section Across Kiewa River at Kergunyah (from the Tallangatta 1:250 000 Geological Map) Refer to Fig 2Ba for the location of the Section. Legend is reproduced as Fig 2Bb.



SITE NUMBER: 1
G.R.: 153913 Tallangatta 1:100 000 Natmap
LOCATION: Tallangatta Railway Cutting (abandoned)
GEOMORPHIC SETTING: Broad spur sloping <2° towards the north and towards the Hume Weir and Mitta Mitta River. Altitude 215-220m ASL and perched approximately 40m above present level of the adjacent Mitta Mitta river. The rail cutting runs approximately east-west for 100m with a maximum depth of 6m. The section is incomplete due to slumping and vegetation, however the diagram, Fig 2Bd, below gives an overview.

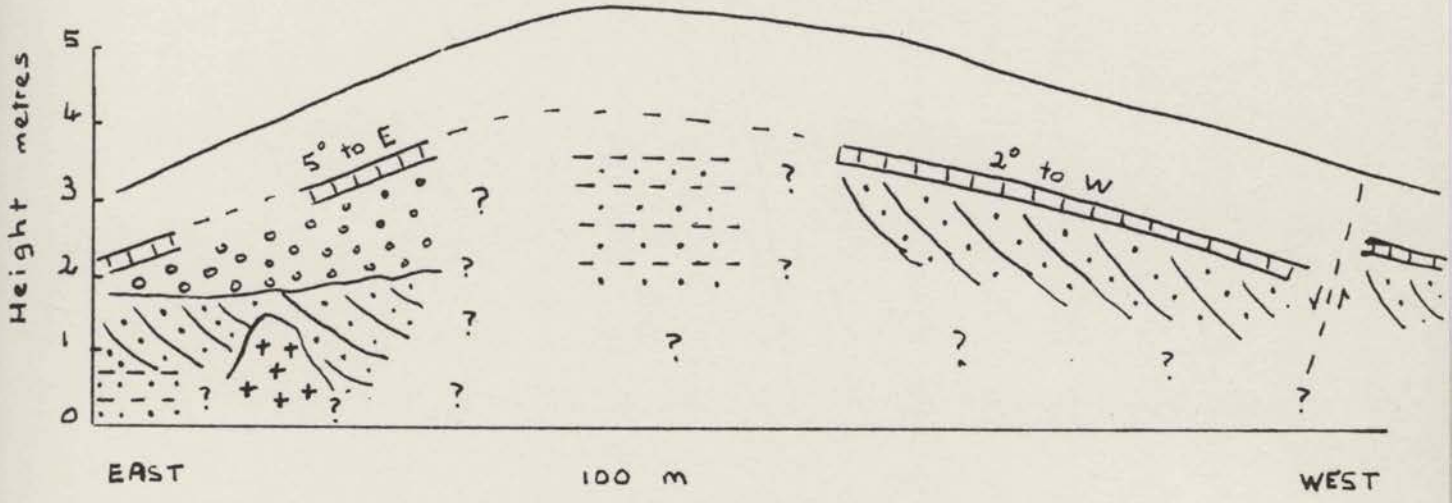


Fig 2Bd (reference TR988601)

LAYER

1 SOIL - 1m thick: grey brown gravelly silt overlying orange brown cobbly clay becoming mottled red/grey at base.

2 DURICRUST: consolidated, resistant layer 50-60cm thick, mostly red.

3 Poorly sorted, extremely weathered, slightly rounded boulders, 30-40cm, in a cemented, grey, sandy, gravelly matrix.

4 Gravelly, cobbly sandstone exhibits good current bedding and rapid lateral variations in clast size. Mostly red and moderately consolidated.

5 Poorly consolidated, sandy, gravelly clay with poorly sorted angular clasts. Near horizontal bedding lines just visible. Some layers preserved by iron precipitation.

Extremely weathered insitu granite bedrock.

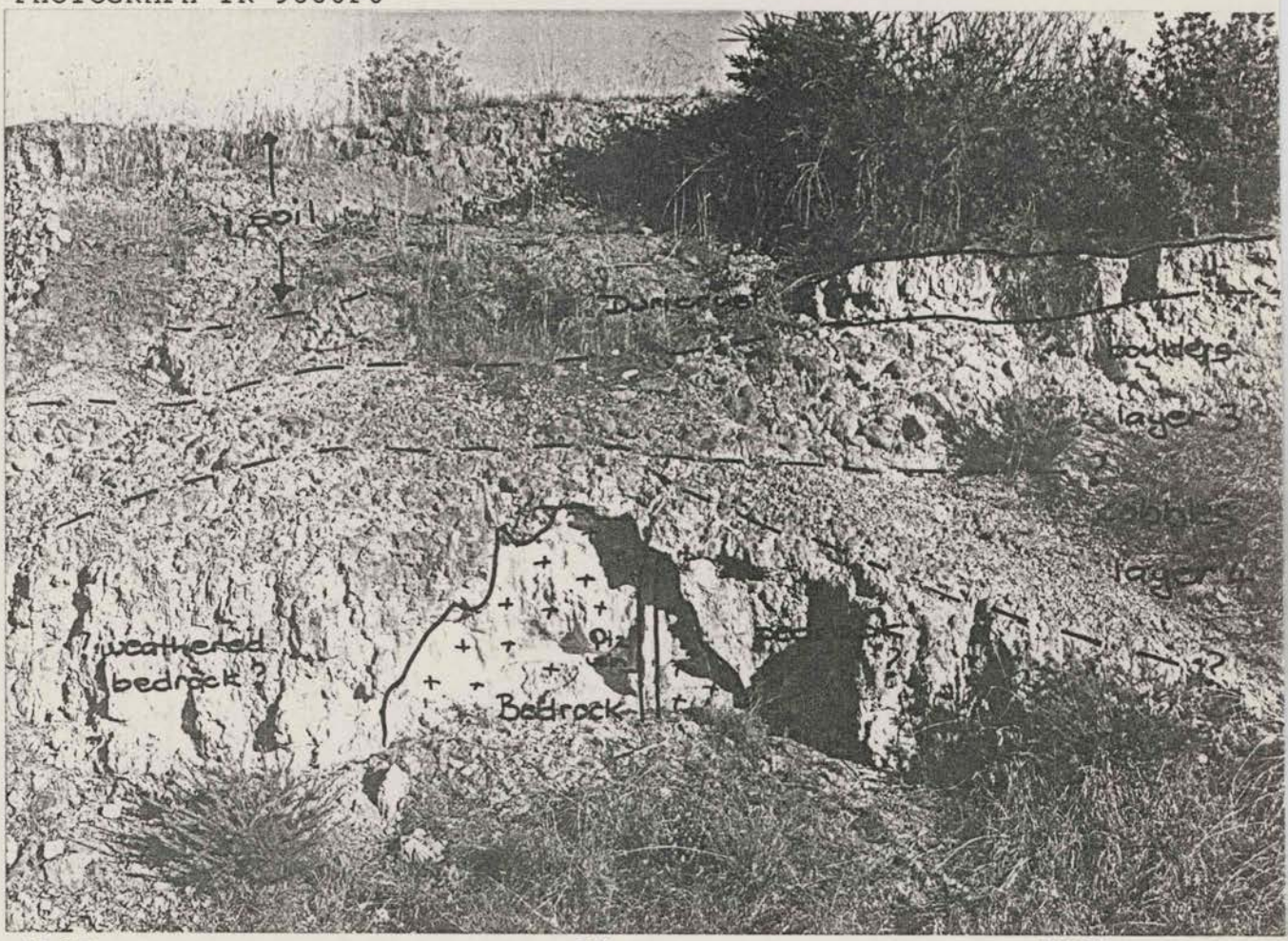
SITE NUMBER : 1 continued

The following photographs and diagrams further demonstrate the character of the sediments in this section. Refer to photographs :

TR 9886F6 -eastern end of section
TR 9886F7 -close up of bouldery layer 3 in TR 9886F6
TR 9886F8 -close up of bouldery layer 3 and duricrust in TR 9886F6
TR 9886F9 -western end of section. Red, consolidated current bedded sandstone.

and diagram:
Fig 2Be -layer 4 sandstone at western end of section.

PHOTOGRAPH TR 9886F6



EAST 7M WEST

Section height is approx. 4m.

The duricrust in the top right corner has a blocky structure and overlies the bouldery layer (3), but is discontinuous to the east. The duricrust is dipping at 5° to the east which is steeper than the present surface. The duricrust appears to be enriched in iron which may account for its consolidation whereas the underlying bedrock is white and the minerals (excepting quartz) are altered to clay. This section suggests lateritisation of the sediments and bedrock. The sandy layer (4) exhibits current bedding with a dip to the west. Weathered bedrock probably extends beyond the clearly defined weathered leucogranite in photograph TR 9886F6 and the precise boundary with layer 4 is difficult to define. The present, adjacent Mitta Mitta River drains to the west.

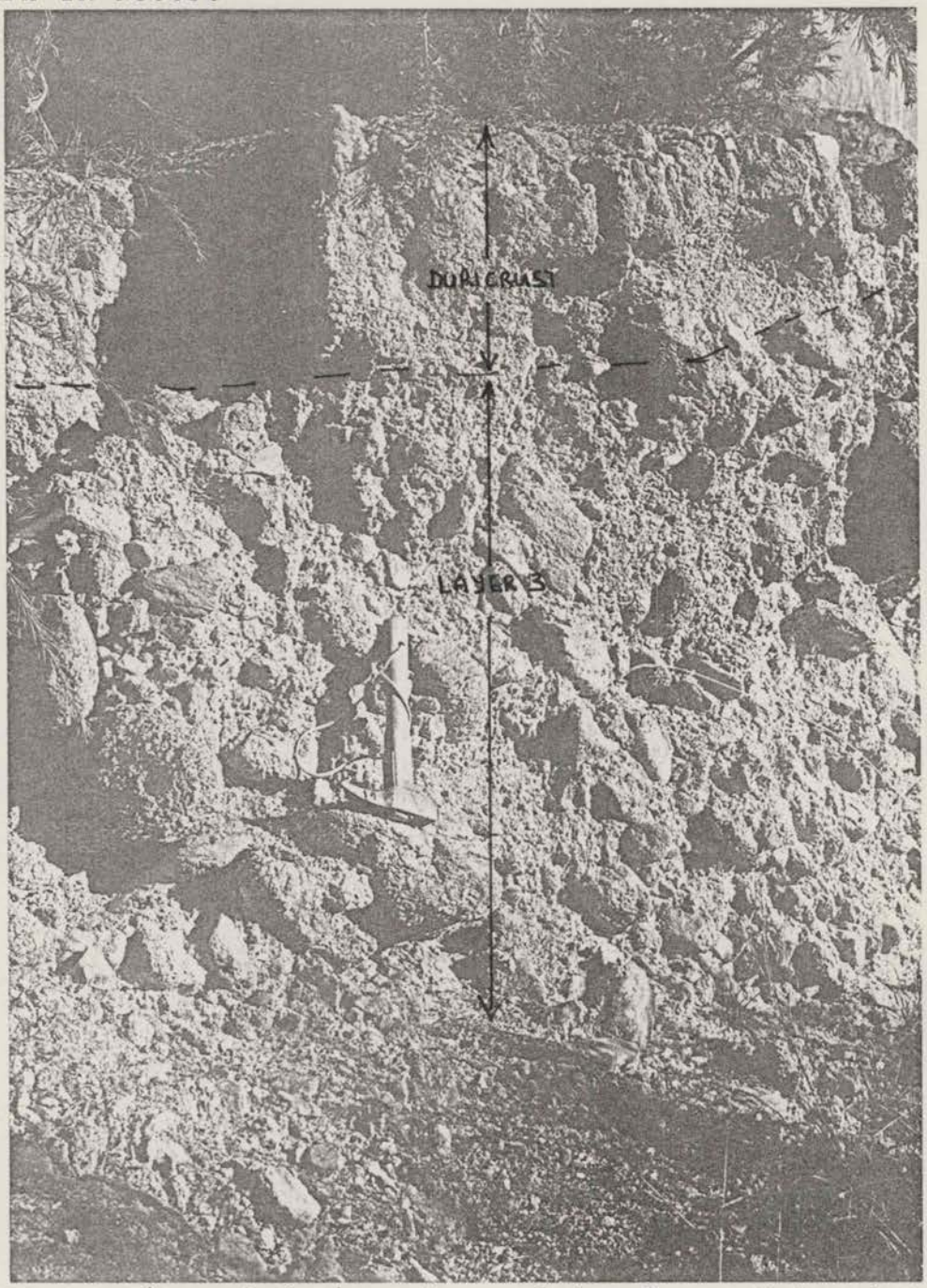
SITE NUMBER : 1 continued
PHOTOGRAPH TR 9886F7



The bouldery clasts of layer 3 comprise schist and pegmatitic granite and quartz. The large clasts of schist and granite are moderately rounded and extremely weathered, but the quartz cobbles are only slightly rounded. These clasts are similar in rock type to the local O-Sn unit, on the 1:250 000 Tallangatta Geological Sheet. There is a distinct, undulose break between the bouldery layer 3 and an underlying layer 4. In addition, layer 3 appears to have a concentration of cobble sized clasts at its base. Layer 3 interfingers with layer 4 further to the east in this section.

SITE NUMBER : 1 continued

PHOTOGRAPH TR 9886F8

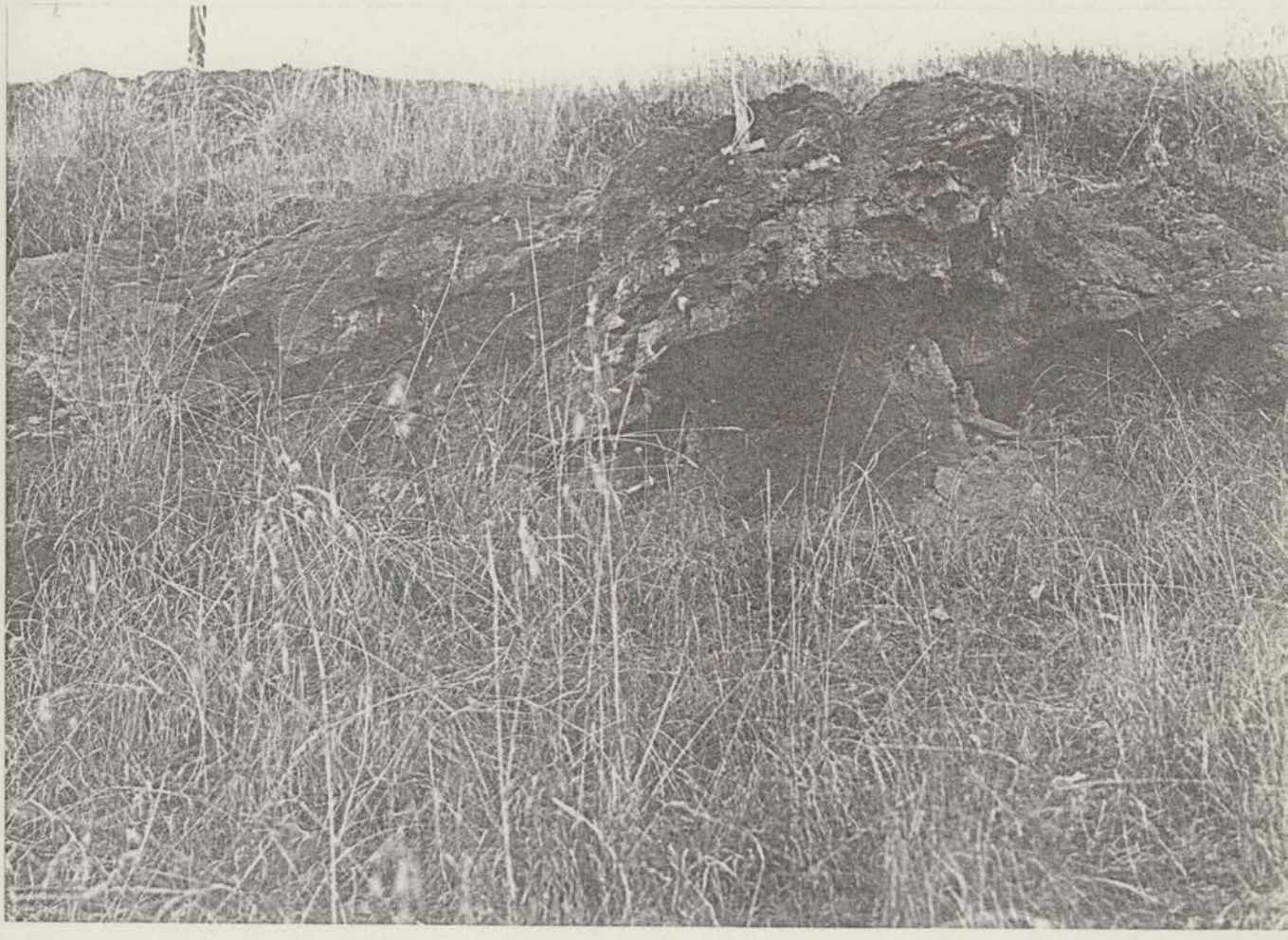


Close up view of duricrust overlying layer 3 in photograph TR 9886F6.

Note the blocky nature of the duricrust and the poor sorting exhibited by layer 3. The duricrust varies in color from deep red to pale grey. The duricrust is well indurated and seems to be permeated by small pores. The well rounded bouldery clasts of layer 3 are local rock; schist, gneiss or pegmatite, which are less competent than the associated angular clasts of quartz.

SITE NUMBER : 1 continued

PHOTOGRAPH TR 9886F9



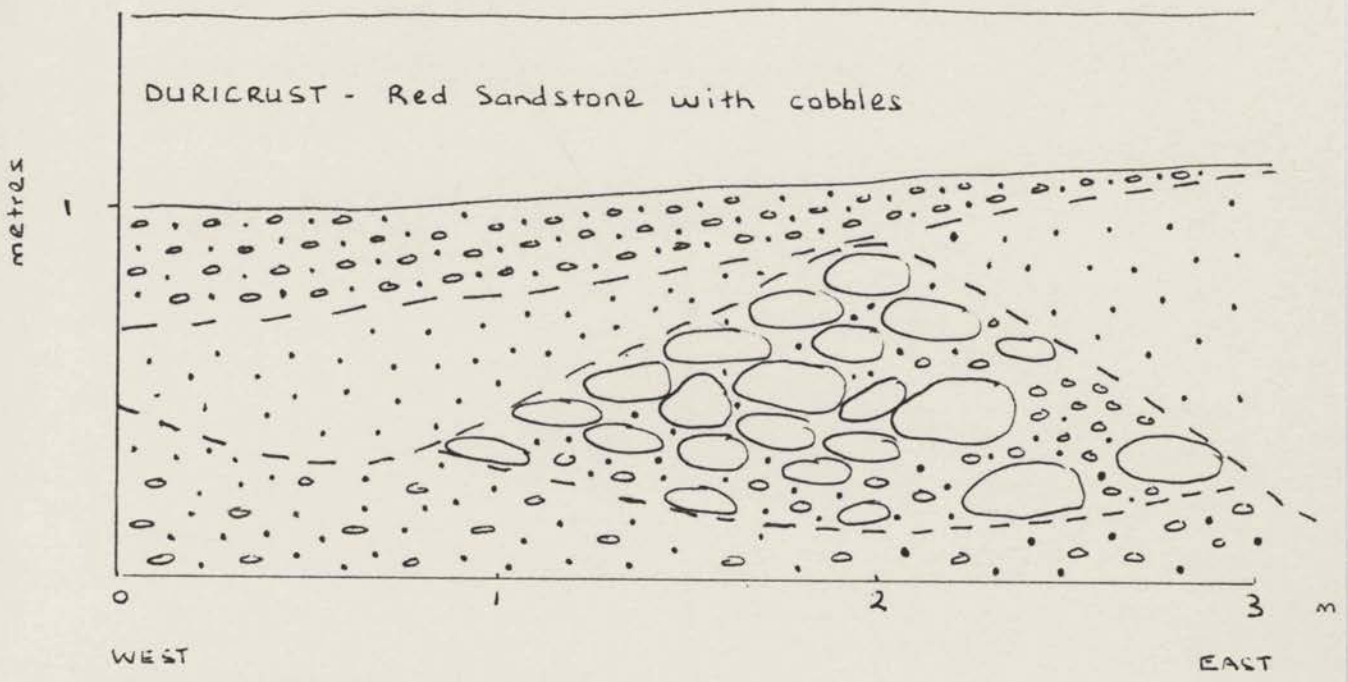
WEST EAST

Red gravelly sandstone of layer 4

The sandstone exhibits current bedding, to the west. True bedding is well demonstrated in the adjacent poorly consolidated sandy gravelly clay which is near horizontal. The sandstone is extremely variable as Fig 2Be illustrates, and interfingers with the lenses of boulders which have been described as layer 3. The upper 60-90cm of this sandstone is well consolidated and forms a duricrust. The sandstone below the duricrust is only weakly to moderately consolidated.

SITE NUMBER : 1 continued

Fig 2Be (Reference TR988602)



Sandstone/duricrust

Gravelly cobbles

Mottled gravelly sandstone

Red cobbles, gravel

Boulders

This portion of the section demonstrates that layers 3 and 4 may well be synchronous since they interfinger and reverse their order. The rapid changes, the poor sorting and slight to moderate rounding of clasts suggest that the environment of deposition was high energy, but transient in nature, and may have been part of a braided river system or alluvial fan. The section site 1 and the adjacent terrace have been mapped as Qs (Shepparton Formation) on the 1:250 000 Tallangatta Geological sheet. This is unlikely to be correct due to the existence of a duricrust, and the obvious antiquity and alteration these sediments and their elevation 30-40m above the adjacent Mitta Mitta River. These sediments are probably pre-Pleistocene and they bear a striking resemblance to those sediments in South East Gippsland, described by J. Jenkins (1968) as the "Haunted Hill Gravels". The Haunted Hill Gravels occur as elevated remnants in a similar situation to these at site 1, but on the opposite side of the highlands. These sediments at Tallangatta site 1 and the Haunted Hill Gravels have structures which are typical of alluvial fan deposits, in particular "stream-flood" deposits. The occasional massive gravelly clay deposit within these otherwise well bedded, sandy gravels may represent "sheet-flood" deposits.

SITE NUMBER : 2
G.R. : 085890 Tallangatta 1:100 000 NATMAP
LOCATION : Road cutting on Murray Valley Highway opposite Sandy Inlet
GEOMORPHIC SETTING: The cutting is towards the distal end of a broad relic fan mesa sloping approx. 3° towards Sandy Inlet. The altitude is 210m ASL.

Layer 1 : 1.5m of red gravelly clay. Coarse clasts are < 10%. Localized, thin lenses of quartz gravel.

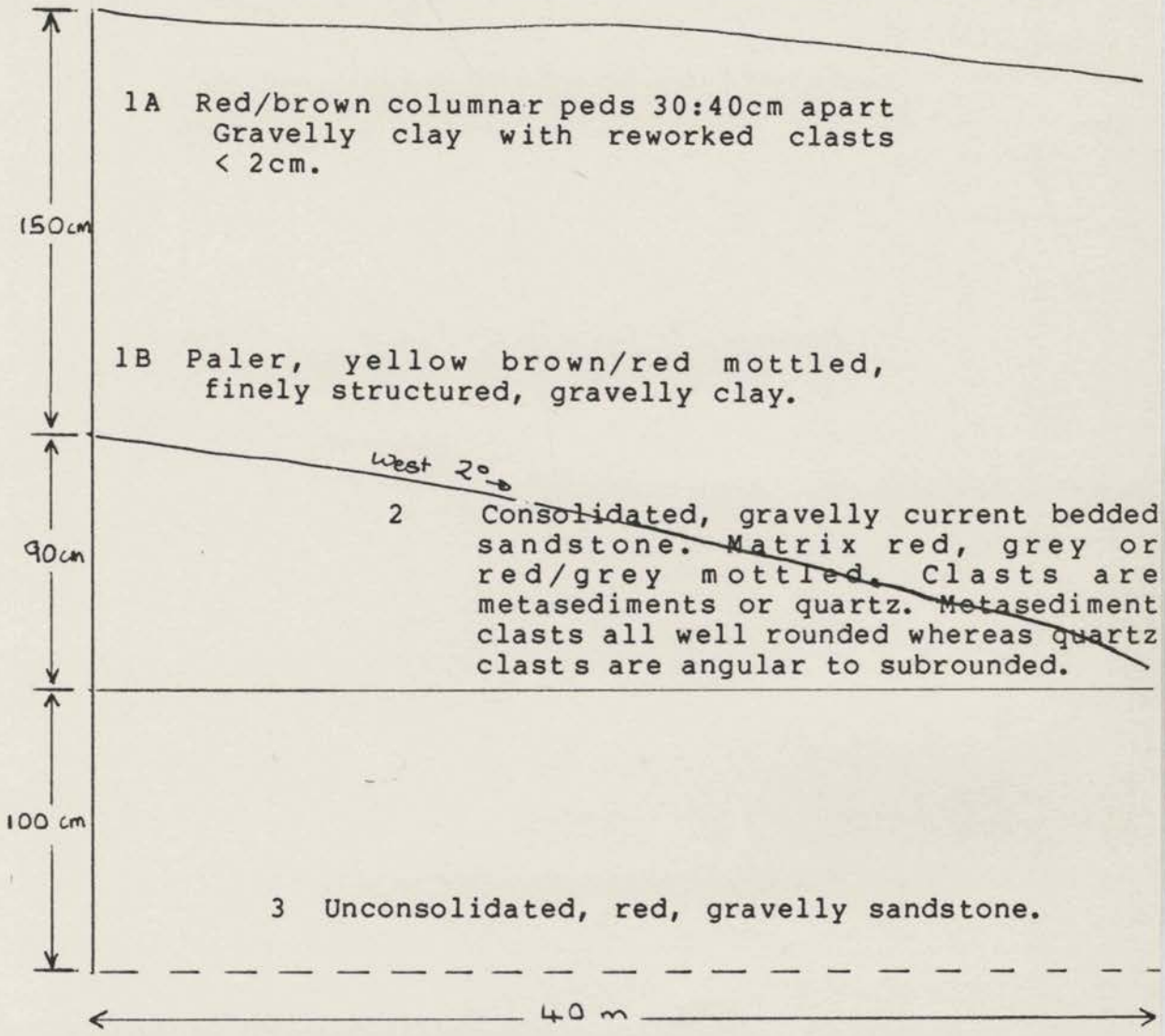
Layer 2 : 30cm-40cm of buff brown, partially consolidated and resistant, jointed, gravelly sandstone. This layer appears to be a duricrust.

Layer 3 : 50cm-90cm of gravelly, blocky alluvium. Some very coarse patches similar to layer 3 at site 1. The blocks are angular, red and extremely weathered.

This site 2 has similiar sediments to site 1. The sediments are also elevated approximately 40m above the adjacent Mitta Mitta River. A water bore just below site 2 intersected 50m of pale sandy silt. It is difficult to differentiate between extremely weathered clasts in a silty matrix and extremely weathered bedrock when the bore is percussion drilled. It is possible that 0-15m of the bore represents coarse clasts in a silty matrix as some pieces of weathered rock showing gneissic crystal fabric survived, whereas from 15m to 50m the material possibly represents extremely weathered bedrock as the drill returns were very uniform, but with relic feldspar crystals surviving as white clay fragments.

SITE NUMBER : 3
G.R. : 008998 Tallangatta 1: 100 000 NATMAP
SITE LOCATION: Rail cutting under Murray Valley Highway near Ebden. (abandoned)
GEOMORPHIC SETTING: Cutting is situated in a nearly level terrace at 200m ASL and approx. 30m above the adjacent Mitta Mitta River.

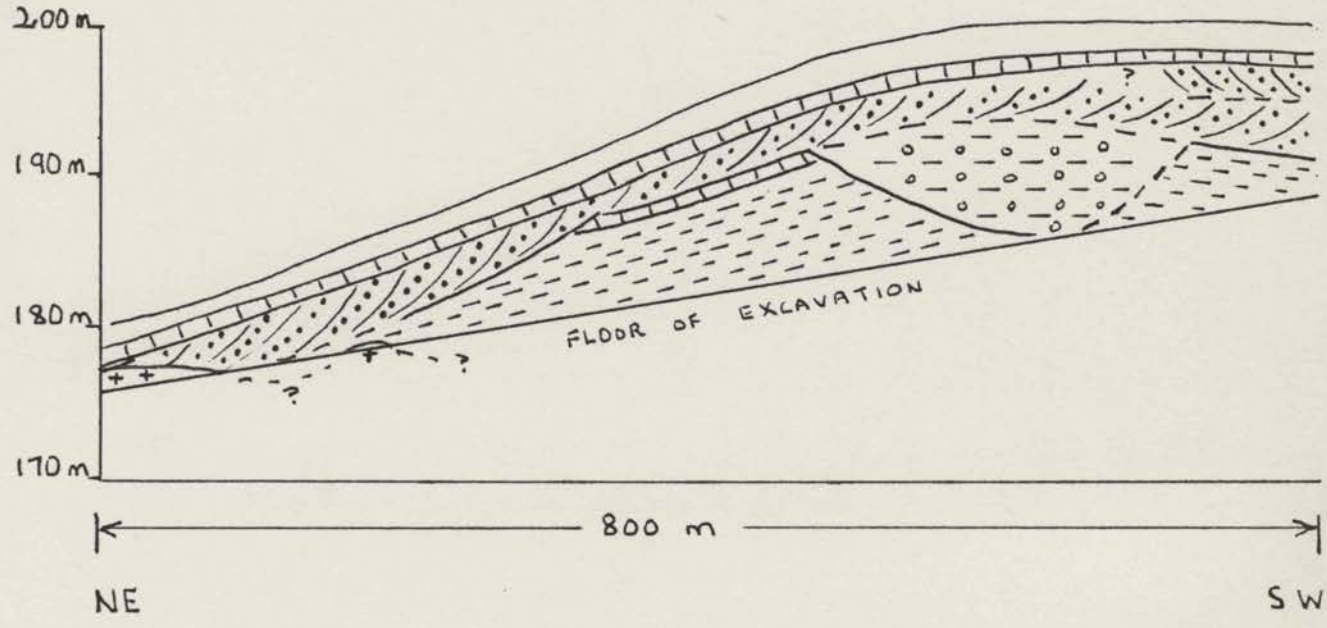
Fig 2Bg Section Through Terrace Adjacent to the Mitta Mitta River



The consolidated sandstone in layer (2) is equivalent to the duricrusted, current bedded sandstone at site (1). Current bedding dips to the north-west indicating a current from the south-east which is the direction of the adjacent Mitta Mitta River. The clasts in layer (2) have a dark brown varnish, not unlike a desert varnish. As with site (1), the sandstone below the duricrust is only weakly consolidated.

SITE NUMBER : 4
G.R.: 015037 Tallangatta 1:100 000 NATMAP
LOCATION : Hume Weir Raceway and Borrow Pits
GEOMORPHIC SETTING : An elevated terrace on gently sloping terrain at 170-200m A.S.L., and 0.5m to 5m above the adjacent junction of the Mitta Mitta and Murray Rivers. The deposit is an isolated relic similar in setting to sites 1,2,3. The following section summarizes the basic relationships.

Fig 2Bh : North-east Section Through Hume Weir Raceway



Layer 1 — Present soil horizon

Layer 2 — Duricrust or laterite

Layer 3 — Red, gravelly, lithic, current bedded sandstone

Layer 4 — Pale, gravelly clay

Layer 5 — Pale silt, very fine sand

Layer 6 — Bedrock- extremely weathered gneiss

SITE NUMBER : 4 continued.

DESCRIPTION OF SEQUENCE AT SITE NO. 4

Layer 1 : Approximately 20cm of grey brown loam overlies orange brown clay which becomes red near the base at 1m to 2m below the surface.

Layer 2 : Duricrust or Laterite. There appear to be at least two layers of duricrust with a possible third sandwiched within the two main sets of current bedded sandstone of layer 3. These separate layers are of different ages and are characterised by oxidation with the development of much limonite as lenticular concretions (also within the silts of layer 5) and or with the induration of the red current bedded sandstone along its upper surface and also the development of pisolitic laterite which is well exhibited in the north-east sector.

Layer 3 : Coarse, red, gravelly, lithic, current bedded sandstone. It is only weakly consolidated and the direction of current bedding implies a current direction from the South East which is in accord with the adjacent Mitta Mitta River. Small lenses of gravel are incorporated within the current bedded sandstone and it also includes an increasing number of small cobbles towards the top.

Most of the clasts are sub-rounded to angular quartz cobbles. A significant proportion of clasts in the sand-gravel range is fine grained metasediment.

There is an apparent reversal in the direction of current bedding in the upper portion of layer 3 exposed in the south-west corner of site 4. There is also a hiatus in the upper portion of layer 3 with the development of a narrow, hard, red, iron-rich zone overlying approximately 40cm of clean white clay.

Layer 4 : This layer consists of large channel fills within layer 5 which postdate layer 5, but appear to predate or coexist with the red gravelly sandstone of layer 3. The sediment in layer 4 comprises pale, angular quartz gravel and massive, grey, micaceous clay.

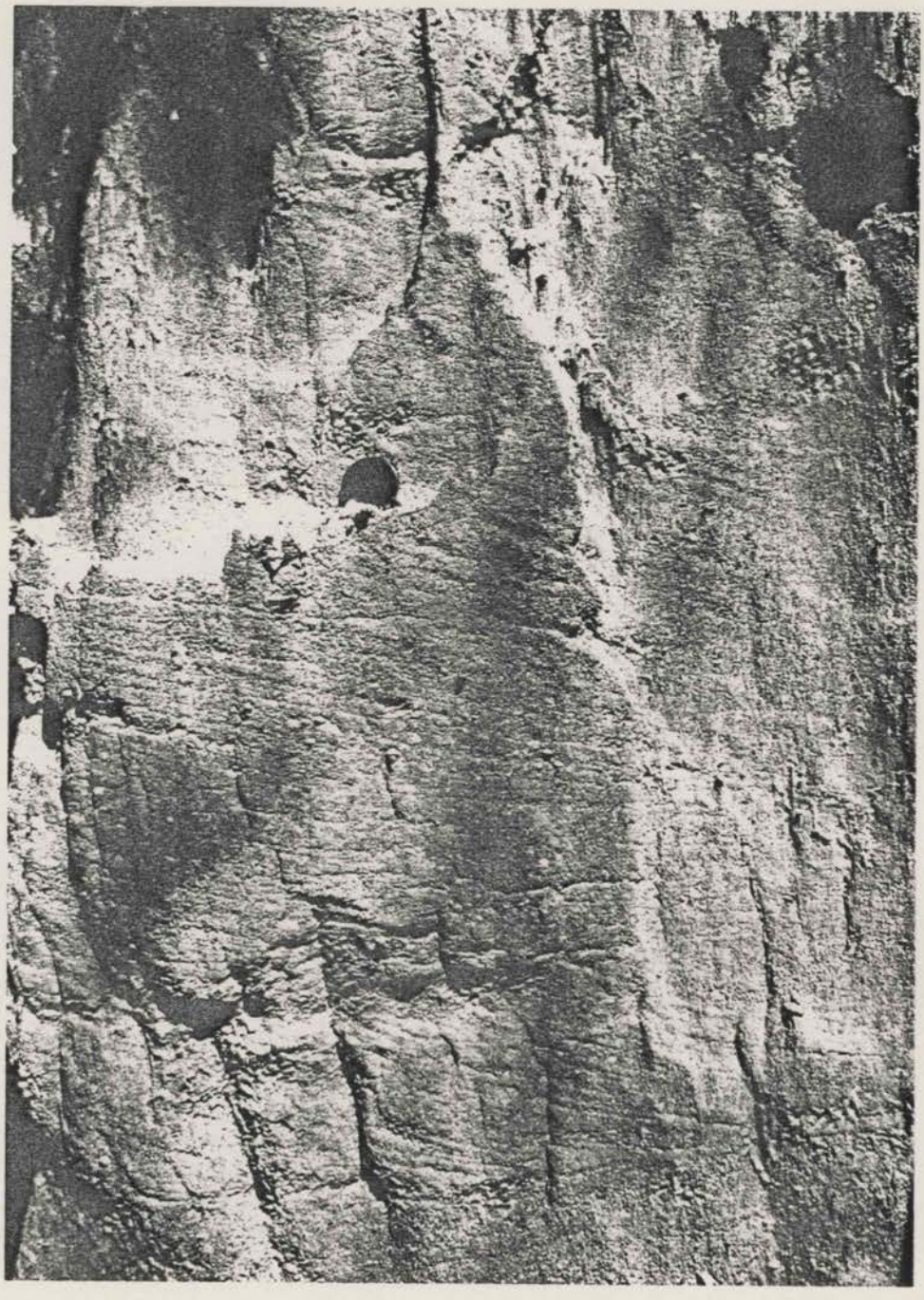
Layer 5 : This is dominantly a pale buff colored finely laminated silt or very fine sand, with its upper surface strongly oxidized with the development of lenticular layers of limonite.

Microscopic examination of a sample from within layer 5 revealed the dominant material to be a well sorted, very fine sand of <0.1mm diameter, with a small amount of coarser muscovite, generally >0.3mm. The sand grains were mostly ragged glass-like shards indicating transport or reworking by wind, rather than transport by water prior to deposition. This may be indicative of an arid climate at the time of deposition.

Layer 6 : Extremely weathered bedrock, probably gneiss of unit O-Sn.

SITE NUMBER : 4 continued

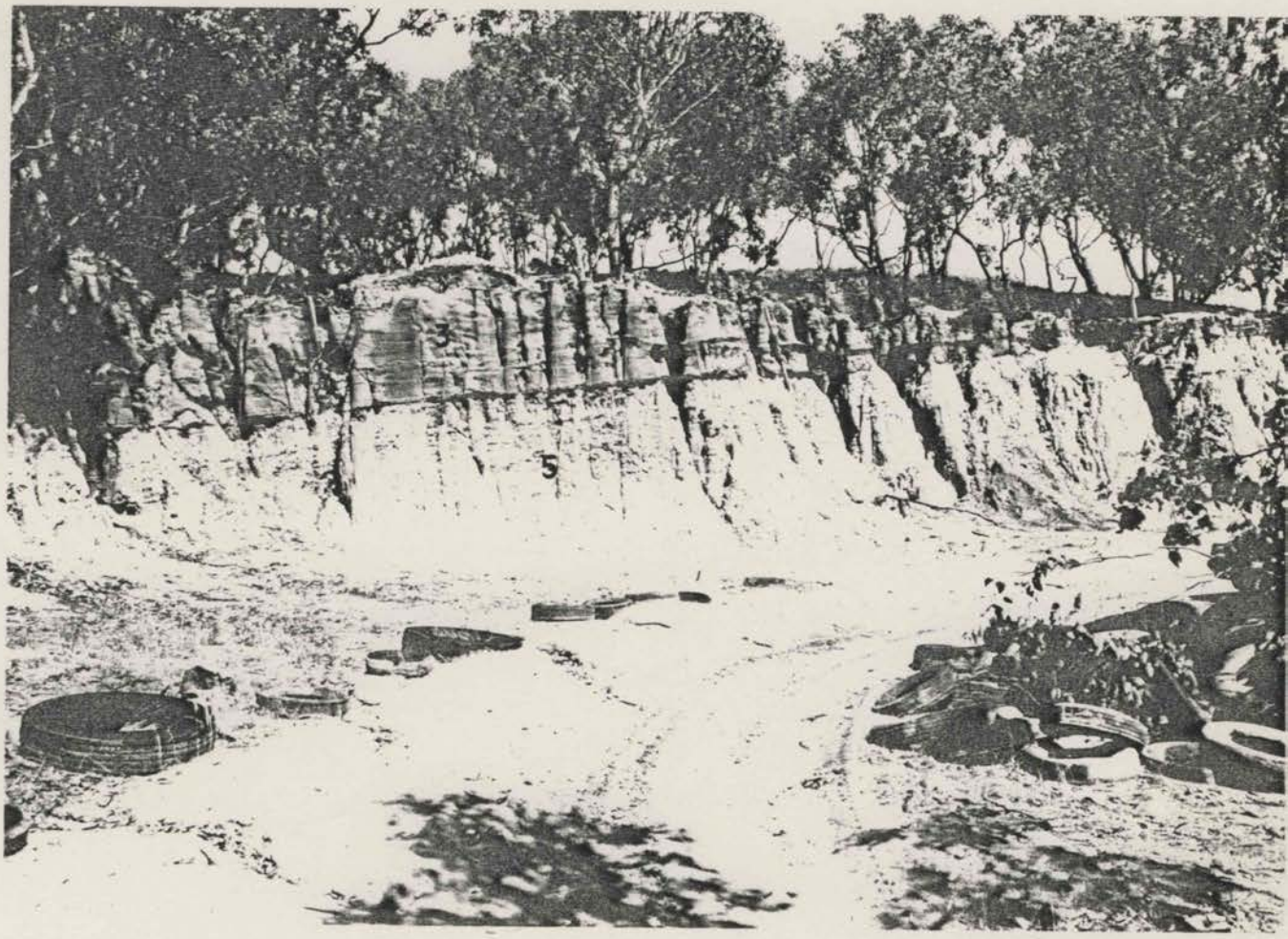
PHOTOGRAPH: HW 6187F4



Close up of coarse, red, gravelly, lithic, current bedded sandstone. Current bedding dips to the North-West.

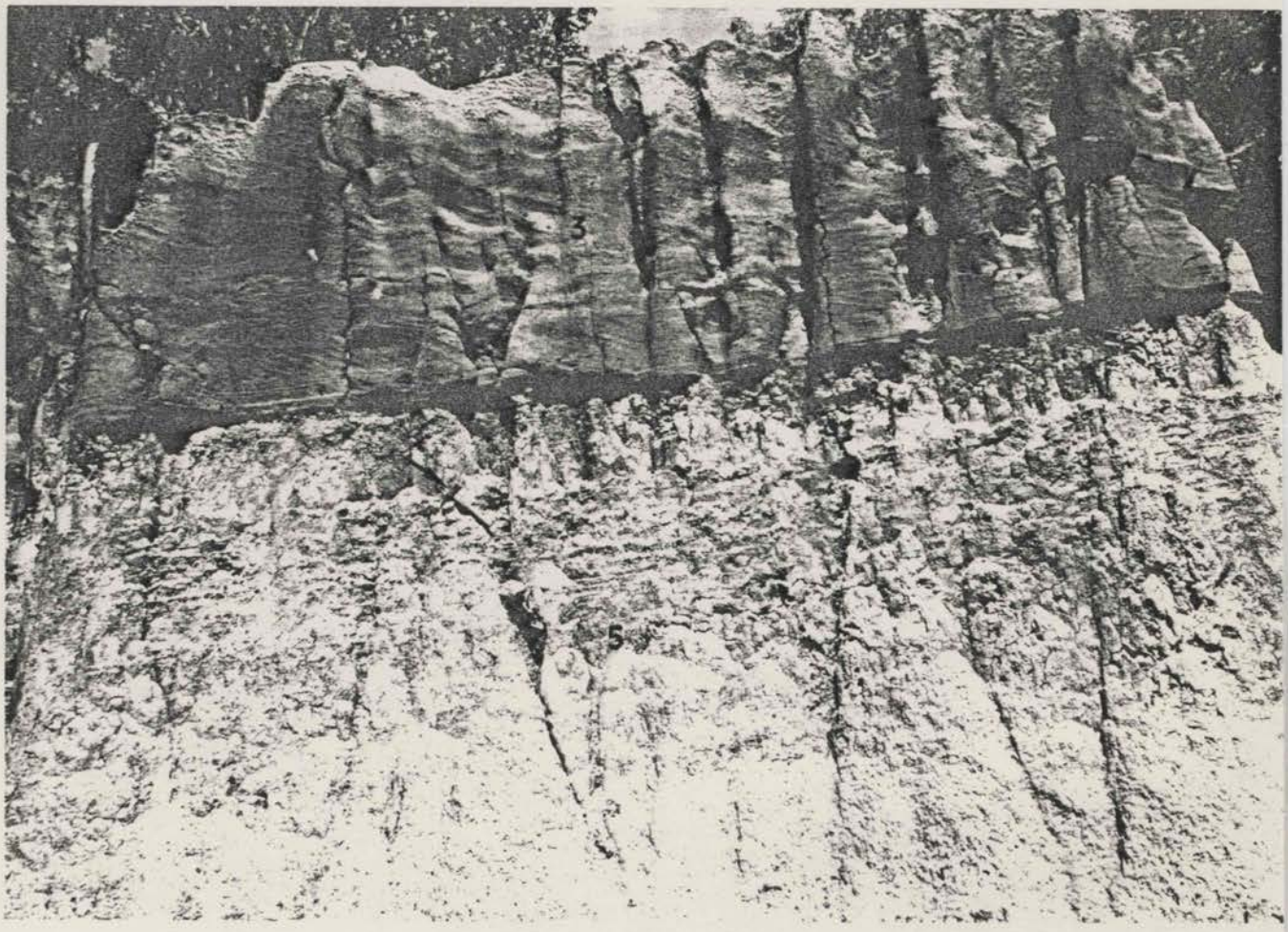
(Lens cap is 50mm diameter)

SITE NUMBER : 4 continued
PHOTOGRAPH: HW 6187F3



Red, current bedded sandstone of layer 3 overlies pale, laminated silt of layer 5. Note the conformity between the bedding and base of the red sandstone and the oxidized zone and bedding of layer 5. This represents a parallel unconformity. Note that the sediments of both layer 3 and layer 5 are dipping towards the South-East at approximately 5°. The section is approximately 4m high.

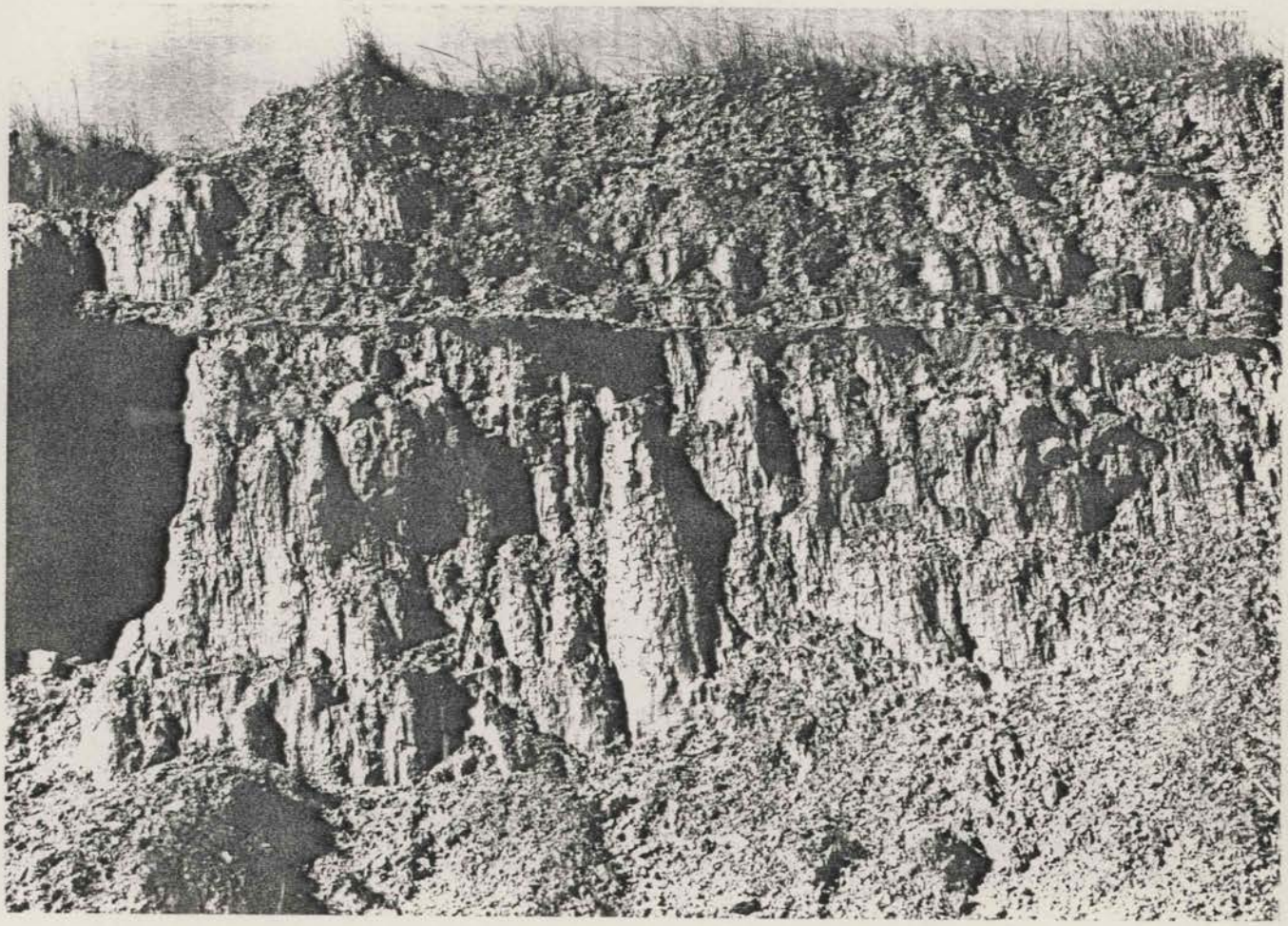
SITE NUMBER : 4 continued
PHOTOGRAPH: HW 6187F1



Close up of portion of photograph HW 6187F3. This also illustrates the parallel unconformity between upper, layer 3, current bedded sandstone and lower, layer 5, silt. The resistant layers in the vicinity of the hammer in the upper portion of layer 5, are bands enriched in limonite.

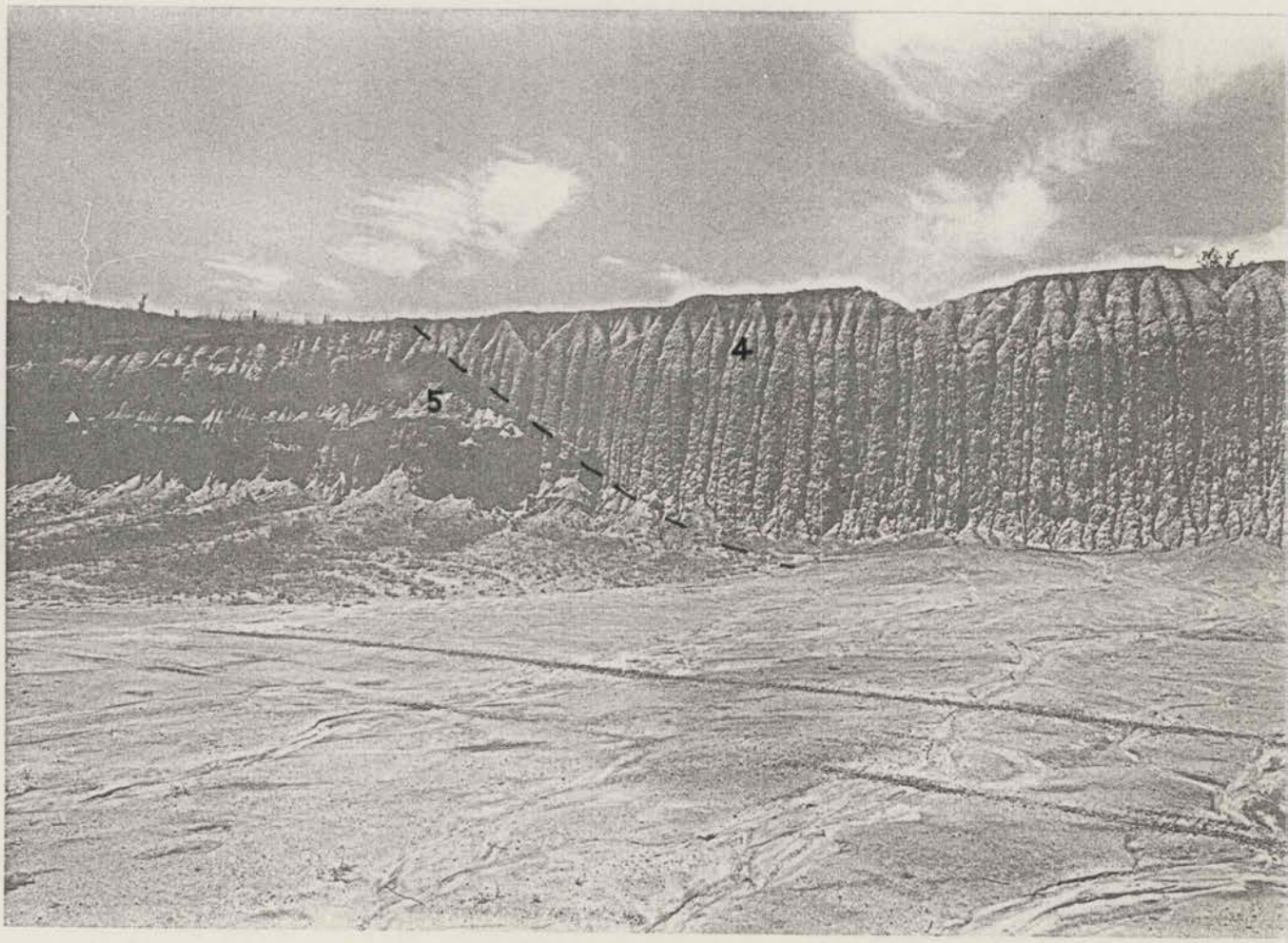
SITE NUMBER : 4 continued

PHOTOGRAPH:HW 10886F3



Portion of layer 5, silt. Note the resistant bands in the upper portion. These are also limonite concretions. Section height is approximately 4m.

SITE NUMBER : 4 continued
PHOTOGRAPH: HW 6187F6



Channel fill sediments of layer 4 have scoured layer 5 sediments, mainly silt, which are exposed on the left hand side. This channel fill is mainly gravelly clay. This extensive, poorly sorted deposit may represent a sheet-flood deposit as described by Blissenbach (1954). The lateral extent of this massive, relatively unstratified deposit is approximately 100m and maximum thickness is not clearly defined, but may be in excess of 6m.

Section height is approximately 5m.

Probable Environment of Deposition for Sediments at Sites 1,2,3,4.

The sediments and sedimentary structures represented at sites 1 to 4 suggest deposition on a river flood plain or at the margins of a flood plain. Sites 1 to 4 are all elevated at least 30m above the present, adjacent, Mitta Mitta River. The poorly sorted, angular, lithic, gravelly character of the sediments at these sites suggests a short duration of transport from local sources with little or no reworking, (except by aeolian means for layer 5 at site 4). The current bedding of the coarse, lithic, gravelly, sand/sandstones at sites 1, 3, 4, suggests a current direction which would be in accord with the present drainage direction of the adjacent Mitta Mitta River, which implies that these deposits are relics of an earlier phase of the Mitta Mitta River or its tributaries. The character of these sediments is typical of alluvial fan sedimentation as described by Blissenbach (1954).

The aridity suggested by alluvial fan deposition is reinforced by the apparent "desert varnish" on clasts at site 3 and by the probable wind blown and shattered grains of very fine sand in layer 5 at site 4.

The red, gravelly, lithic, current bedded sands/sandstone seem typical of " stream-flood" deposits and bear a striking similarity to the Haunted Hill Gravels of South-East Gippsland, described by J. Jenkins (1968).

The laminated silt and very fine sand beneath the red, gravelly sands also show rapid lateral variations with gravelly channel fills. These finer sediments of layer 5 at site 4 closely correspond to the "Coongulmerang Beds" described by Jenkins (1968) in South-East Gippsland, as micaceous silts and fine sands with occasional coarser sandy bars, showing strong surface oxidization, and occurring mainly in sub-surface sections.

The "Coongulmerang Beds" of South-East Gippsland are overlain by the Haunted Hill Gravels which adds further significance to the correlation between these two sets of sediments in South-East Gippsland and North-East Victoria. It is possible that both sets of sediments; the red, gravelly, lithic sandstones of sites 1 to 4 and the Haunted Hill Gravels may be components of the "piedmont downs" (Talent, 1969), which represent a discontinuous fringe of sand/gravel around the margins of the central highlands. Jenkins, (1976), in Geology of Victoria says that : "The main lateritization affecting the piedmont appears to be post early Pliocene to mid Pliocene." Although Jenkins (1968, 1976), favours a younger age than this for the Haunted Hill Gravels, the data available seems not to preclude the Haunted Hill Gravels from being deposited in the early to mid Pliocene.

In addition to similar sediment, sedimentary structure, lateritization and geomorphic location between the Haunted Hill

Gravels and the gravelly sediments described at sites 1 to 4, there is also evidence of post depositional warping and minor faulting, which suggests relative antiquity and possible associated regional uplift. It would appear that since the deposition of red, gravelly sands recorded at sites 1 to 4, that the Mitta Mitta river has migrated northwards and downcut its bed by 100m or more.

The reasoning is that these relic gravels, mapped (on the 1:250 000 Tallangatta Geological Sheet, Fig 2Ba) as Tpe and Tpf at sites 3 and 4, are located at least 30m above the present river, and extrapolating from the Kergunyah section, Fig 2Bc across the nearby Kiewa River, and other mining data, there would appear to be approximately 70m of sediment below the present Mitta Mitta River and its floodplain in the vicinity of sites 3 and 4.

This valley infill has been interpreted in a peculiar manner by King (1976, 1979). Firstly, the Tertiary sediments Tpe, Tpf on the Tallangatta 1:250 000 Geological map have been mapped as elevated surface deposits in the vicinity of Bonegilla, Ebden and to the south between Ebden and Kiewa along the eastern flanks of the Kiewa River. However, at Kergunyah, the section drawn from logged boreholes has depicted Tpf as completely subsurface and overlain by Qs, (Shepparton Formation). An examination of the lithological logs of bores across the Kiewa River at Kergunyah does not provide convincing evidence for the existence of Tpe or Tpf within this section. Instead, the alternating clays and gravels from 0 to 53.95m in bore number 78, are typical of the Shepparton Formation and are similar to the Shepparton Formation in the Ovens-King Valley where they are fairly uniform in thickness between 75 and 100m. (Laing et. al. 1977)

Minor Tertiary gravels occur beneath the Shepparton Formation in the Ovens-King Valley at depths of about 100m but detailed correlation with Murray Basin sediments is problematical according to Laing. These gravels beneath the Shepparton Formation have been mined for gold in many valleys of the North-east of Victoria, where they lie on bedrock (E.J. Dunn, 1909) and conform closely to the description of the Calivil Sands given in Geology of Victoria by Abele et al 1976.

The interpretation of bore logs represented in a section on the 1:250 000 Tallangatta Geological Sheet by the Victorian Geological Survey, 1976, fig 2Bc (p196) is disputed. The interpretation of the logs by this writer is as follows:

Tangambalanga Bore 78

Qc	Coonambigdal Formation	0-10m	clay, silt and coarse waterworn gravel
Qs	Shepparton Formation	10-54m	sandy clays, silty clays gravelly clay, gravelly sand, some wood fragments
Tma	Calivil Sands	54-67.6m	well waterworn quartz sand, gravel and boulders
O-Sn	Weathered bedrock	67.6-68.6m	yellow gravelly clay
O-Sn	Bedrock	68.6-74.7m	bedrock

It is the present writer's view that the strata Tpe and Tpf do not belong beneath the present floodplain and the evidence presented in sites 1 to 4 suggests that these strata are relics and predate the formation of the present valleys and floodplains of the Keiwa and Mitta Mitta Rivers draining north and west from the Highlands, although they are in parallel with and elevated relative to the present river courses.

The preceding argument suggests that Tpe and Tpf were deposited in an ancient floodplain which was located to the south of the present Mitta Mitta River and another to the east of the present Kiewa River, and that subsequent to this deposition there was: 1) rapid down cutting and lateral movement of the ancient river courses away from the Highlands to the South-East.
2) earth movements as evidenced by warped section at Hume Weir Raceway.

This may have been achieved by a relatively rapid uplift of landmass to the South-East of sites 1, 2, 3, and 4, which caused a rapid change in grade of the river draining towards the north, including the Mitta Mitta, Kiewa and Ovens Rivers.

Such a change in grade is suggested by the mining data on deep leads in the upper Ovens Valley. According to J.P.L. Kenny (1925), along the courses of the upper Ovens River and Morses's Creek, there are deep leads down to 60m. The "deep leads" occur at the interface of clay beds, which form false bottoms, and the overlying sands and gravels. The uppermost lead in the upper Ovens is only 4.5m to 9.0m below the surface and the deep leads occur at several levels between the surface and bedrock down to 60m below. These alternating clay beds and sand/gravel beds are mostly the Shepparton Formation and these cyclic variations probably represent a response to climatic variations during the Pleistocene.

According to Kenny (1925) between Wondiligong and Bright, a distance of 6.5km, Morses' Creek has a fall of 9.5m/km (0.54°) and the deep lead has a fall of 14.2m/km (0.81°). Similarly between Harrietville and Bright on the upper Ovens, the river falls 7.6m/km (0.43°) and the deep lead falls 8.9m/km (0.51°).

The data also suggest that there has been uplift in the Highlands to the South-East of sites 1 to 4, probably during the late Pliocene after deposition of units Tpf and Tpe.

The lateritization of units Tpf and Tpe at sites 1 to 4, is further evidence of rapid isolation of these sediments by downcutting of the adjacent rivers. Mc Farlane (1976) summarized the geomorphic environment of laterite genesis as a downward migrating profile, since the overlying soil cannot provide the concentrates if the profile is stable. Therefore residual accumulation during land surface reduction is implied. That reduction would have been made possible by the rapid downcutting of the adjacent Mitta Mitta river in the late Pliocene.

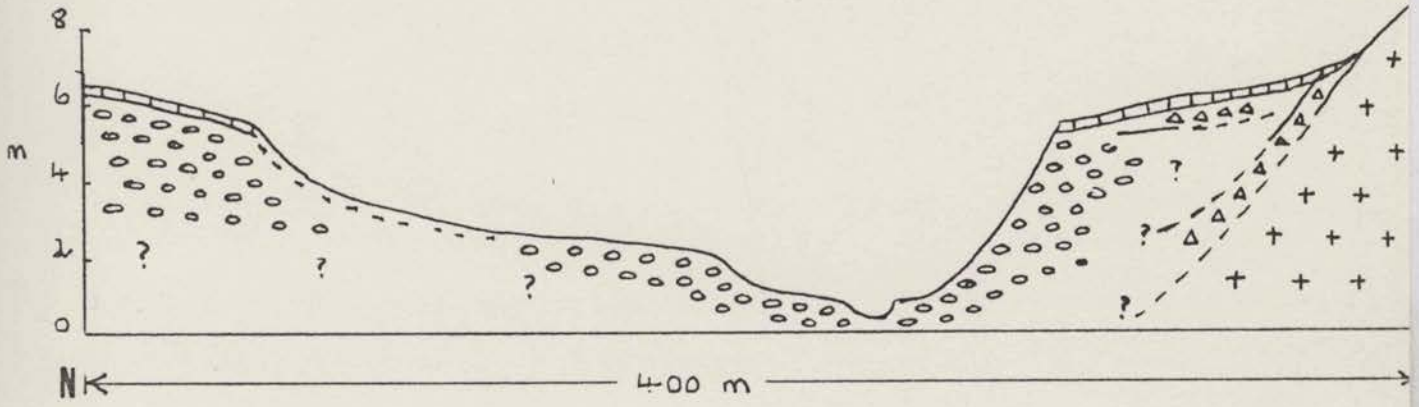
An alternate and or synchronous mechanism to uplift is a change in climate from the arid climate implied by alluvial fan and aeolian sediments of Tpe and Tpf, to a more humid environment

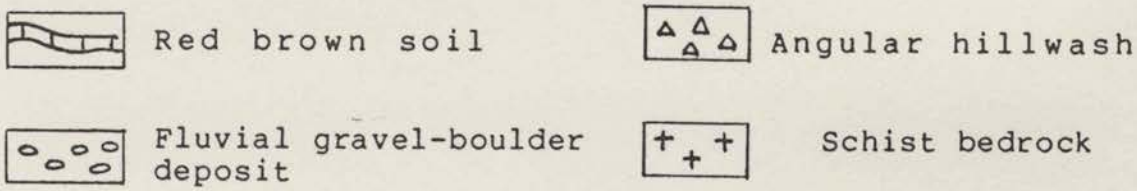
providing streams with a consistent, high energy flow regime which would have assisted in downcutting of the valleys, provided a mechanism for the lateritization of residual sediments such as Tpe and Tpf and left behind a veneer of well rounded coarse, quartz clasts in the floors of the newly excavated valleys.

The sediments of the Shepparton Formation, which overlie the Calivil Sands in the floors of the valleys, represent a rapid infilling of the valley floors by essentially silty gravelly poorly sorted sediments, as the supply of sediment exceeded the capacity of the rivers to transport. The alluvial fan type of sediment accumulation observed for the Shepparton Formation in the Keiwa and Mitta Mitta valleys suggests an arid climatic regime for much of the Pleistocene.

SITE NUMBER : 5
G.R. : 181679 Tallangatta 1:100 000 NATMAP
LOCATION: Little Scrubby Creek, Tallandoon
GEOMORPHIC SETTING: Dissected terrace deposit of waterworn gravel-boulders across the mouth of Little Scrubby Creek, just upstream of its junction with the Mitta river. Little Scrubby Creek drops approximately 900m from its head in 18km to its mouth at site 5.

Fig 2Bi (reference MV 388601)
Cross sectional sketch at site 5





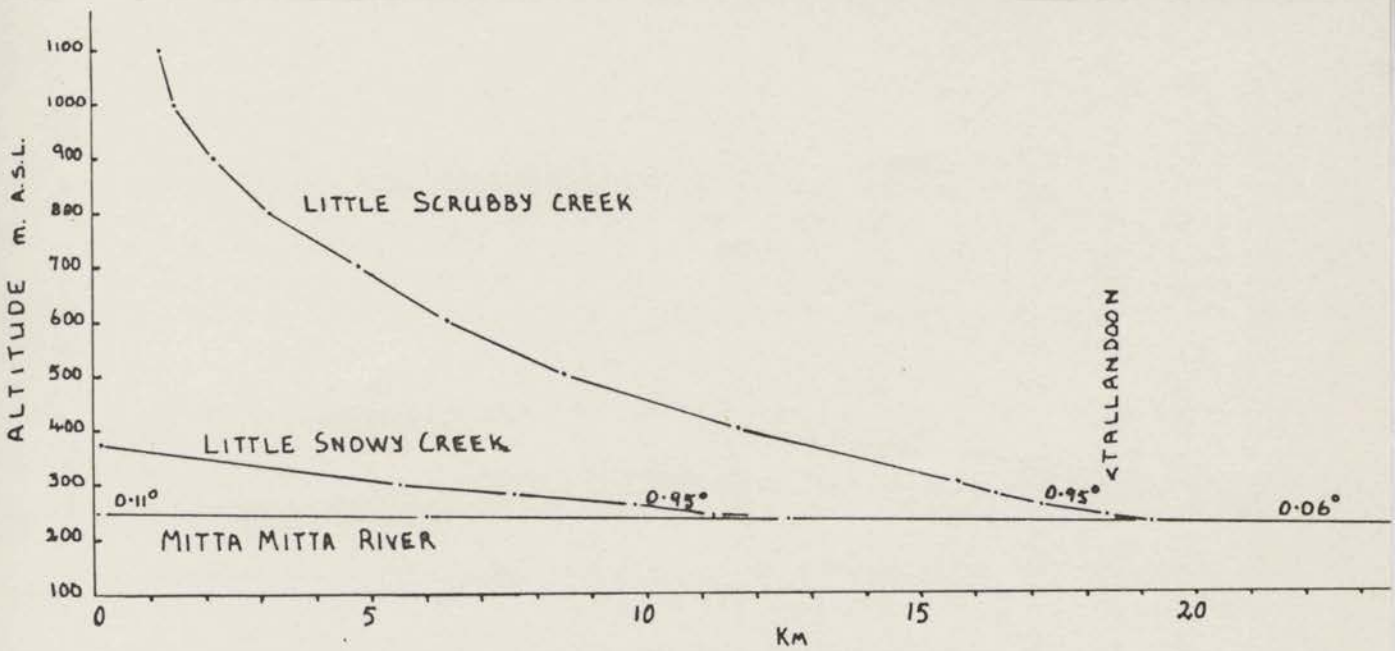


Fig 2Bj : Stream profile of Little Scrubby Creek

SITE NUMBER : 5 continued

Description of Terrace Deposit Adjacent to Bridge at G.R.181679

The deposit consists of tightly packed, platy, rounded, waterworn clasts from gravel to boulder size in an orange sandy matrix. A red brown, sandy, silt, clay soil approximately 50cm thick caps the terrace. The material exposed in the terrace on the south side of the creek comprises well rounded boulders of pegmatite, hornfels and schist up to 70cm, commonly 30-40cm in the lower section. The clasts become smaller and more dispersed in the upper section of the terrace. Laterally the terrace merges with angular hillwash 150m to the south. This hillwash consists of angular, moderate to extremely weathered cobbles in a brownish red, sandy, silt, clay matrix. Clasts comprise >50% of the bulk and have a modal size 0.5cm to 2.0cm, with no fragments > 15cm being visible. This hillwash merges with extremely weathered schist bedrock along a steep, irregular surface. The base of the hillwash near its contact with the bedrock comprises a 1m thick layer of coarse, extremely weathered angular rock fragments with modal size 15cm to 20cm.

The gravel-boulder terrace deposits flank Little Scrubby Creek for several kilometres upstream. The relative relief of the terrace seems to reduce upstream, being approximately 3m above stream level 1km upstream of site 5. Further upstream a road section at the intersection of Abbots Creek with Little Scrubby Creek contains tightly packed, well rounded gravel with coarser clasts up to 10cm and occasional large, angular non-waterworn blocks >1m. The matrix consists of reddish brown silty sands and a 50cm layer of brown sandy silt soil caps the gravel.

The above observation suggests that the source material is from within the catchment of Little Scrubby Creek and that the deposits get more angular towards the edges of the terrace where they interfinger with and are underlain by angular hillwash. These terrace deposits are most rounded close to the axis of the main drainage line, which disguises the probable source of the initially extensive sheets of gravelly boulders prior to dissection.

The stream profile of the present stream of Little Scrubby Creek suggests that more downcutting and dissection is probable, if the stream is competent, as the stream gradient near site 5 is approximately 1.0°, whereas the adjacent Mitta Mitta River has a gradient of 0.06°. This characteristic, together with the steep catenary profile and high relief, is typical of most of the tributary streams of the Mitta Mitta River in this study area. The terrace dissection is represented diagrammatically in Fig 2Bi.

This double inset pattern is typical of many of the tributaries of the Mitta Mitta River and also of the Mitta Mitta Valley floor. The main variations are the scale of terrace dissection and the degree of rounding of clasts in the terrace. These variables may well relate to the scale of the associated catchment. It is probable that the terrace at site 5 was continuous across Little Scrubby Creek prior to dissection and that it merged with the floodplain deposits of the Mitta Mitta River which were 5m to 6m higher that the present floodplain.

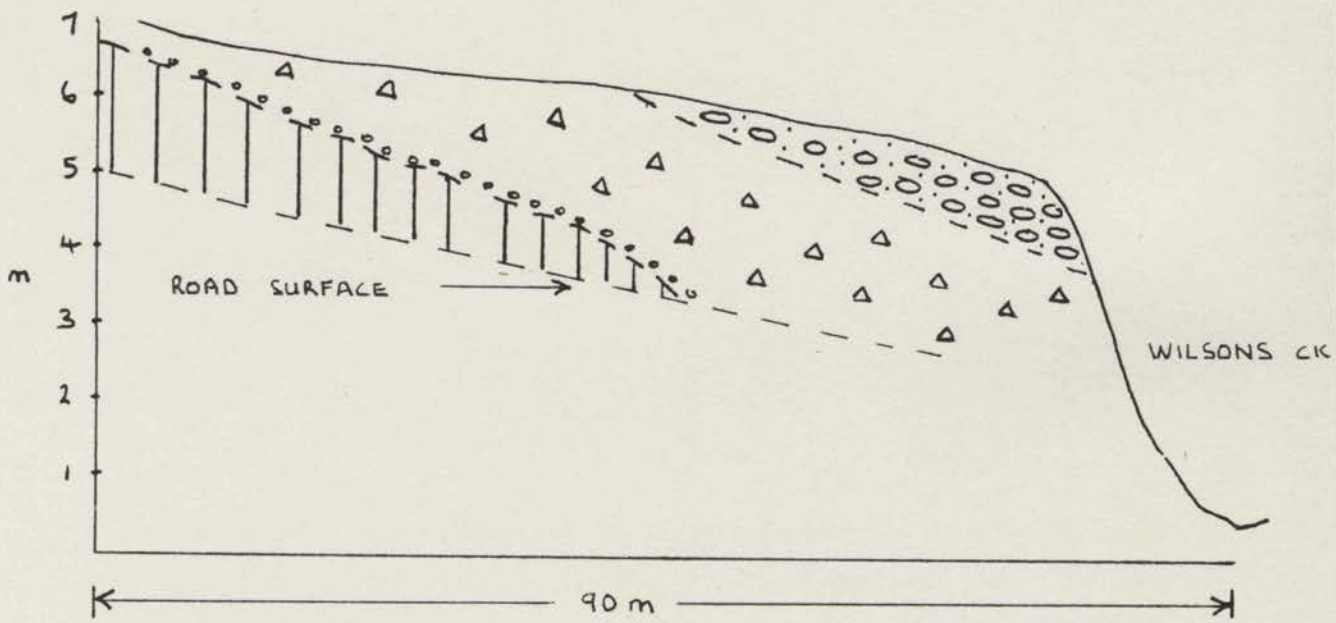
This implies that a large volume of relatively fine grained material had been removed from the valley floor of the Mitta Mitta River due to a relatively sudden change in stream hydraulics and the hydrology of this landscape.

The gravel-boulder deposits at site 5 could well represent accumulations from alluvial fans emanating from the steep tributaries of Little Scrubby Creek which have been reworked along the axis of the trunk stream. The well waterworn clasts are relatively well preserved, as only competent clasts could survive in this environment. However, the extremely weathered, angular, oxidized clasts in the hillwash adjacent to the terrace and the mature soil overlying these angular dispersed clasts, suggests that emplacement of all these materials was in a relatively arid environment prior to the Holocene.

SITE NUMBER : 6
G.R. : 192657 Tallangatta 1:100 000 NATMAP
LOCATION : Wilson's Creek Cutting
GEOMORPHIC SETTING : The road cutting is situated through and elevated creek terrace about 90m wide and tapering from a maximum thickness of 3m near the creek to less than a metre at its outer edge. The terrace surface is approximately 4m to 5m above the adjacent creek. The creek emerges from steep country which rises approximately 600m in 4km. The creek gradient is only 2.5° in the vicinity of the cutting.

The section appears to be a dissected and now relic alluvial fan. There is no evidence of lateritization or duricrust. The section has been mapped on the 1:250 000 Tallangatta Geological sheet Fig 2Ba, as Tpe. The Tpe also includes the adjacent bedrock terrace which extends out onto the flood plain. The incision of this creek terrace is similar to but smaller than, the incision of Qs on the main floodplain of the Mitta Mitta River.

Fig 2Bk (reference MV 1878602) : Section Through Wilson's Creek Cutting



Layer 1 — Boulders and cobbles in a sandy, gravel matrix

Layer 2 — Dispersed, extremely weathered angularclasts (cobbles to boulders) in a red/brown, sandy silt, clay matrix

Layer 3 — Gritty gravel in a reddish brown sandy matrix

Layer 4 — Bedrock- extremely weathered, yellow/brown, fine grained metasediment

SITE NUMBER : 6 continued

Description of Section

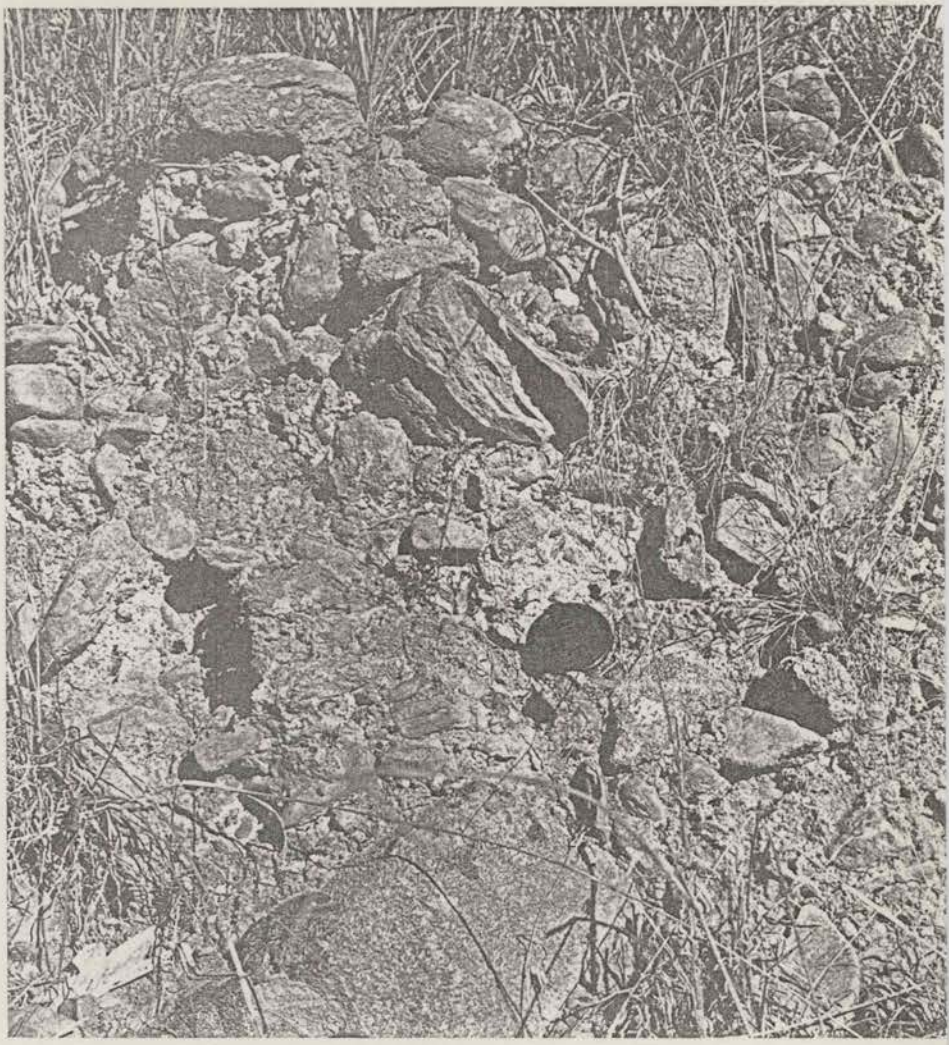
Layer 1 : Comprises boulders and cobbles from 2cm to 50cm with a modal size of approximately 15cm , weakly imbricated but otherwise supported in a weakly consolidated, sandy, gravel matrix. The clasts vary from angular to moderately rounded and include knotted schist, phyllite, pegmatite and hornfels. The schist clasts are moderately weathered, the phyllite and pegmatite clasts are very weathered and the hornfels is only slightly weathered. Quartz clasts are all angular. This layer probably represents a stream flood fanglomerate close to the fan head. This layer is similar to the gravel boulder terrace material at site 5, but smaller in scale.

Layer 2 : tapers to the edge of the terrace and shows a gradation in color from light brown at the base to deep reddish brown at the top. This probably represents insitu weathering since the terrace has been incised by the creek, probably at the beginning of the Holocene. This layer is typical of an alluvial fan debris flow. Debris flows are transient events associated with fairly arid conditions. This layer is similar to the hillwash deposits at the margins of the gravel boulder terrace material of site 5.

Layer 3 : Thin layer of angular quartz gravel over an irregular bedrock boundary.

Layer 4 : Extremely weathered bedrock of unit OSs.

PHOTOGRAPH MV 3886F1



Photograph of Portion of Layer 1 Fanglomerate.
Lens cap is 55mm in diameter.
Section is approximately 90cm high.

There is a variety of clast rock types. The coarse grained clasts are very weathered in comparison with the fine grained clasts which are quite competent and only slightly weathered. The bedding is chaotic but there is a slight indication of imbrication below and left of the lens cap. The current direction was from right to left.

This coarse layer 1 may have preserved this minor terrace since its probable deposition during the Pleistocene. This deposit should therefore represent a portion of an alluvial fan facies of the Shepparton Formation Qs, rather than its nominal tag of Tpe on the Tallangatta Geological sheet.

SITE NUMBER : 7
G.R.: 204644 Tallangatta 1:100 000 NATMAP
LOCATION : Road Cutting Opposite Barney Butlers's Residence on the Omeo Highway.
GEOMORPHIC SETTING : The exposure cuts the upper 1.2m of a small localised alluvial fan deposit sloping approximately 8° towards the adjacent Mitta Mitta River which truncates the deposit and its underlying bedrock. Refer to Photograph MV 3886F4 below.



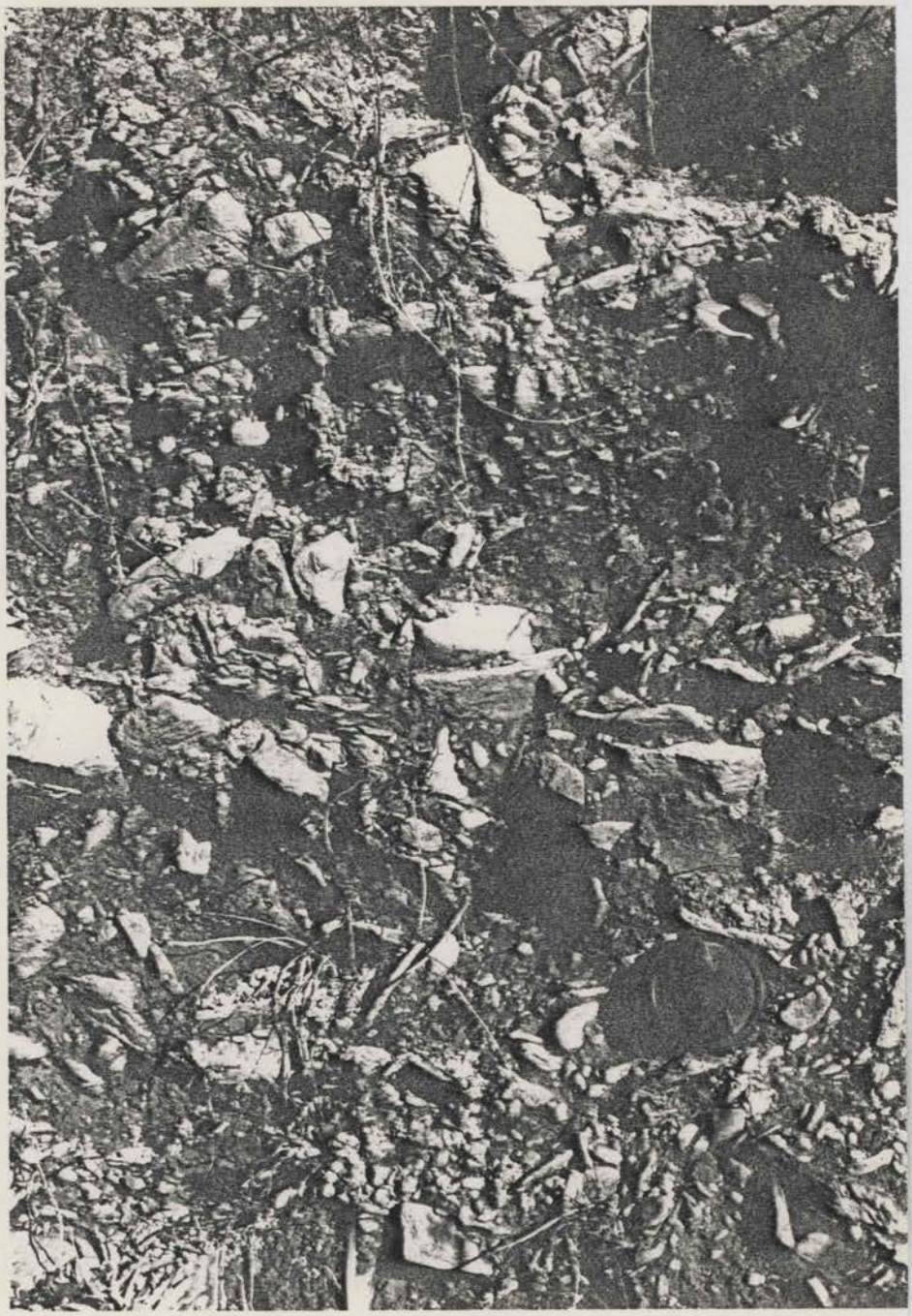
Description of Exposure at Site 7.

Soil development is minimal due to the 8° slope. The section consists of platy and irregular, angular to subrounded clasts of country rock from gravel to boulder size . The clasts are mainly slight to moderately weathered schist. Photograph MV3886F3, below, illustrates the internal structure of the deposit.

The stratification is weak but there is a suggestion of imbrication. The matrix of orange gravelly silty sand appears to support the coarser clasts. This material is typical of a debris flow in an alluvial fanhead situation. It is unconsolidated, but its truncation by the adjacent Mitta Mitta river suggests deposition prior to the Holocene.

SITE NUMBER : 7 continued

PHOTOGRAPH MV 3886F3



The photograph represents about 60cm of the section. The lens cap is 55mm in diameter.

SITE NUMBER : 8
G.R. : 215645 Tallangatta 1: 100 000 NATMAP
LOCATION : Road Cutting 600m West of Eskdale Post Office
GEOMORPHIC SETTING : The cutting exposes portion of a riverine terrace adjacent to the Mitta Mitta river and approximately 5m above the present floodplain.

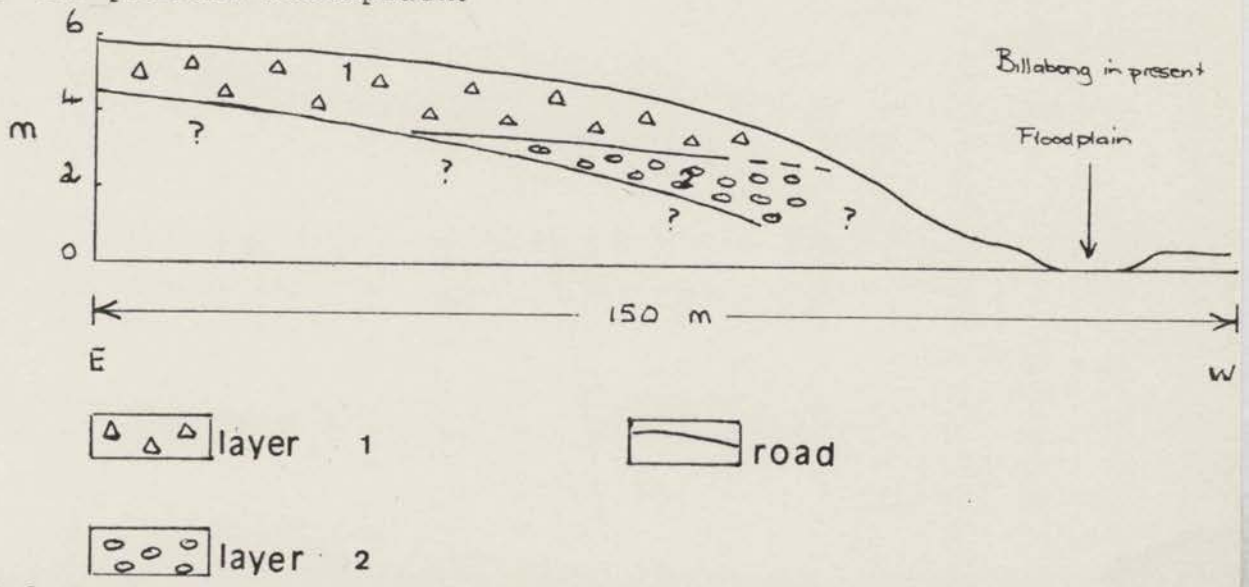


Fig 2B1 (reference MV 388602) : Section Through Terrace Adjacent to Mitta Mitta River at Eskdale.

Description of Section at Site No. 8

Layer 1 : This consists of waterworn pebbles dispersed in a red brown silty clay.

Layer 2 : This consists of a gravel-boulder deposit of water worn moderately weathered clasts of country rock in a matrix of red brown gravelly sandy silt. Photograph MV 3886F6, below, demonstrates the fabric of layer 2.

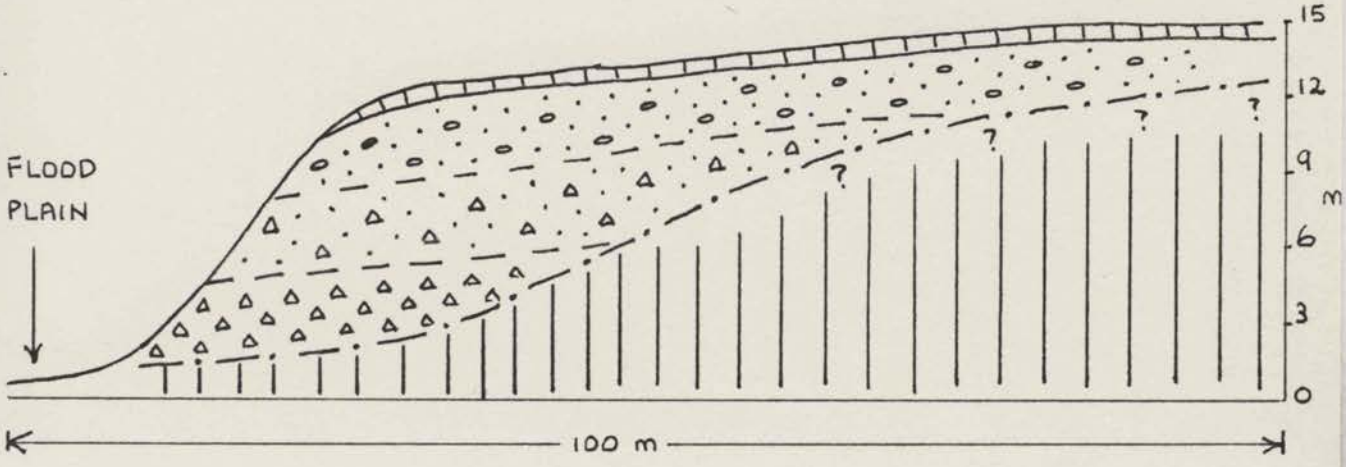
The cobble sized clasts are mostly platy schist. The associated cobble size quartz clasts are noticeably less rounded than the schist clasts and the gravel quartz clasts are irregular. This suggests a limited amount of travel and or exposure to a high energy environment. Layer 2 is equivalent in structure and position to the gravel-boulders terrace material at site 5 and in fact may have originated as outwash from Little Snowy Creek at its junction with the Mitta Mitta River.

Layer 1 appears to be a result of reworking of upper layer 2 and redeposition as hillwash. Layer 1 is probably equivalent to the soil capping above the gravel-boulder deposit at site 5.

The material at sites 6, 7 and 8 appears to have been mapped by King (et. al. 1976) on 1:250 000 Tallangatta Geological Map, Fig 2Ba, as Tpe, but these deposits do not conform in geomorphic setting or stratigraphy to the deposits described as Tpe at Hume Weir, (site 4). Instead, these deposits seem to represent alluvial fan or reworked fan deposits of the Pleistocene which should be regarded as a lateral facies of the Shepparton Formation (Qs).

SITE NUMBER : 9
G.R. : 237648 Tallangatta 1:100 000 NATMAP
LOCATION : Small ravine adjacent to Drummond's Dairy (cuts through a 15m elevated, truncated terrace)
GEOMORPHIC SETTING : Ravine exposes portion of relic alluvial fan associated with valley to the east. This cutting is at the western edge of the fan mouth. The fan surface is approximately 15m above the floodplain at site 9. The drainage line in this valley rises 600m in 4km.

Fig 2Bm (reference MV 588601) : Section Through Relic Alluvial Fan Adjacent to Mitta Mitta River Floodplain near Eskdale.

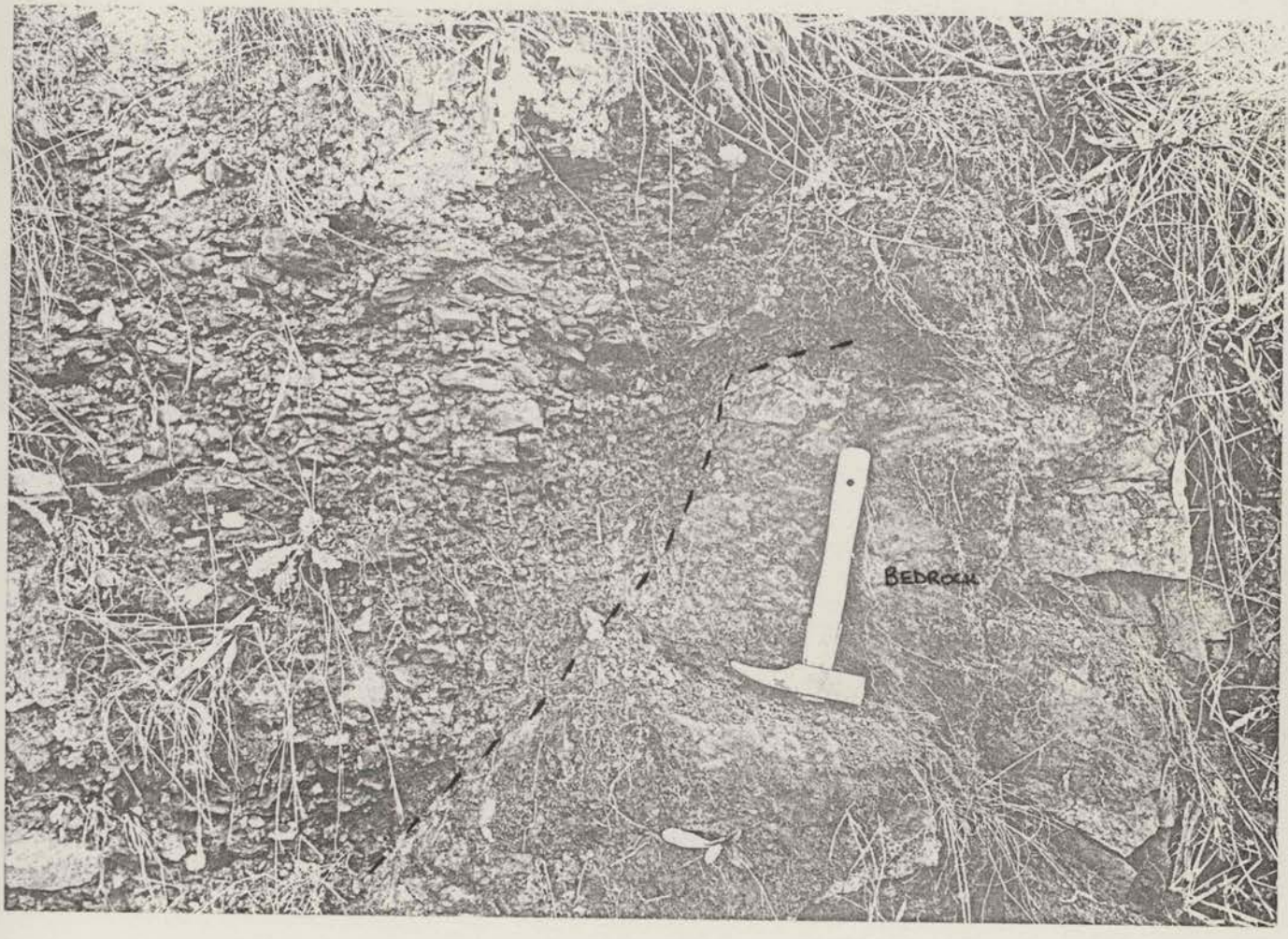


Layer 1		Dispersed clasts in an orange clay
Layer 2		Compact, partially consolidated, angular, gravel and cobbles
Layer 3		Variable : dispersed clasts in clay silt to sand, gravel lenses
Layer 4		Coarse, angular platy cobbles
Layer 5		Bedrock - moderately weathered metasediment
	— · —	Approximate position of bedrock surface

SITE NUMBER : 9 continued

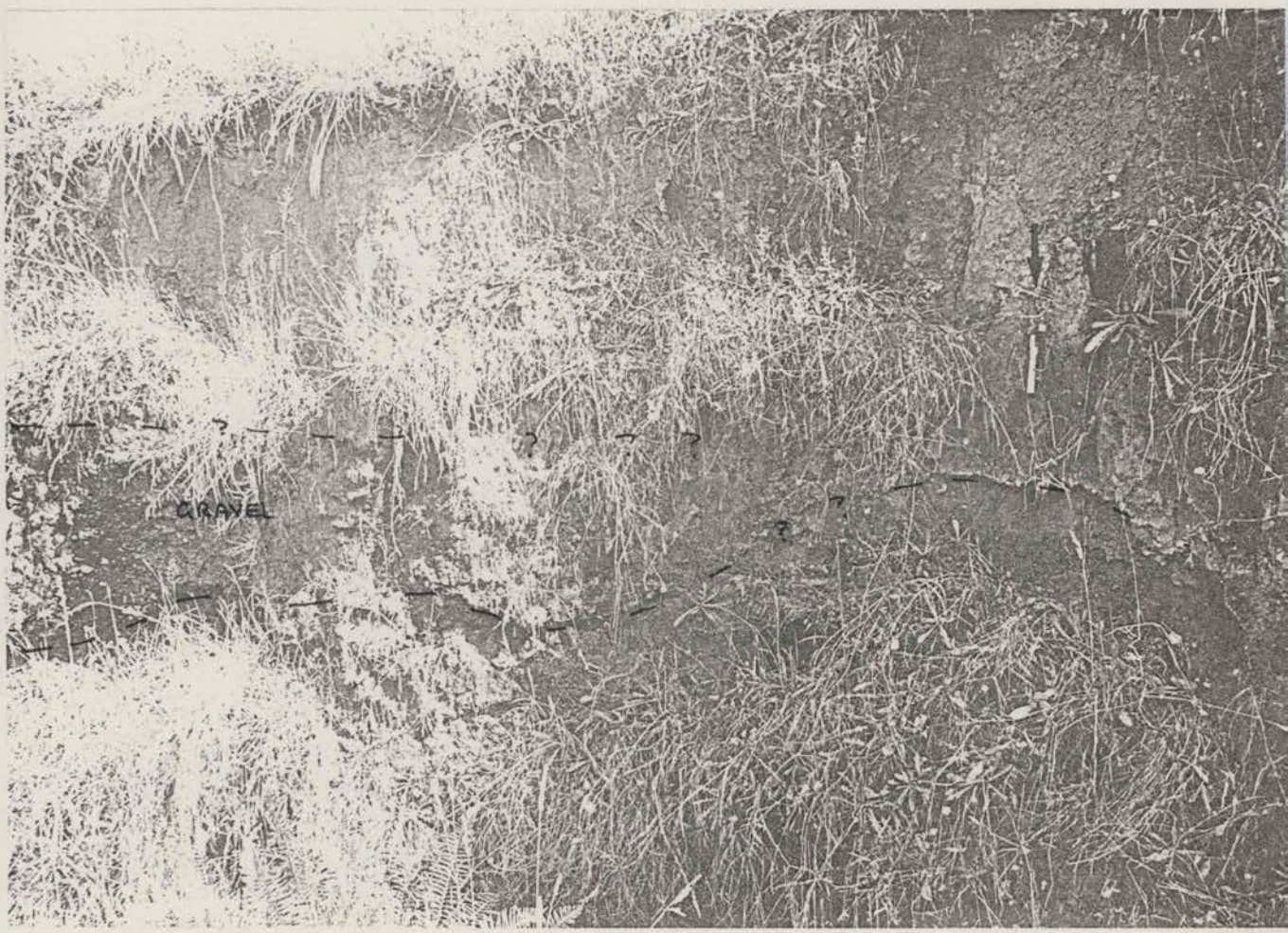
Description of Sediments in Cutting

The available exposures in this cutting demonstrate rapid variation laterally and vertically. Boundaries are irregular. The sediment comprises lenses of close packed angular cobbles dispersed in silt, sand, clay and gravel beds. The uppermost gravel bed is partially consolidated. The clasts are competent throughout the section. Bedrock outcrops in the floor of the ravine and makes a steep irregular contact with the adjacent sediments. Refer to photograph MV 8187F3, below.



The clasts are schist of unit OSs and metasedimentary rock of unit O such as phyllite. The distal edge of the elevated, truncated terrace has been mapped as Tpe by King (et. al.1976) and the remainder of the associated valley floor has been mapped as Qrc which is recent to late Pleistocene hillwash. The absence of lateritization cast doubts on these sediments being Tpe. The uppermost metre of the section comprising dispersed clasts in an orange/red clay matrix may be considered as Qrc which represents a reworking of the upper surface of older alluvial fan sediments of layers 2, 3 and 4. Layers 2, 3 and 4 seem to be related in time and space despite the bedding irregularities, and the partial consolidation of layer 2 may mean that these sediments are not late Pleistocene, but may belong to an earlier phase of the Pleistocene. Refer to photographs MV 8187F1 and MV 8187F4.

SITE NUMBER : 9 continued
PHOTOGRAPH MV 8187F4



A layer of dispersed clasts in a fine grained matrix of orange/red clay overlies a partially consolidated gravel. The gravel is clearly visible in the left of the photograph. The piton hammer is 30cm long.

SITE NUMBER : 9 continued

PHOTOGRAPH MV 8187F1



Photograph of Layer 4 in Lower Portion of Site 9 Cutting

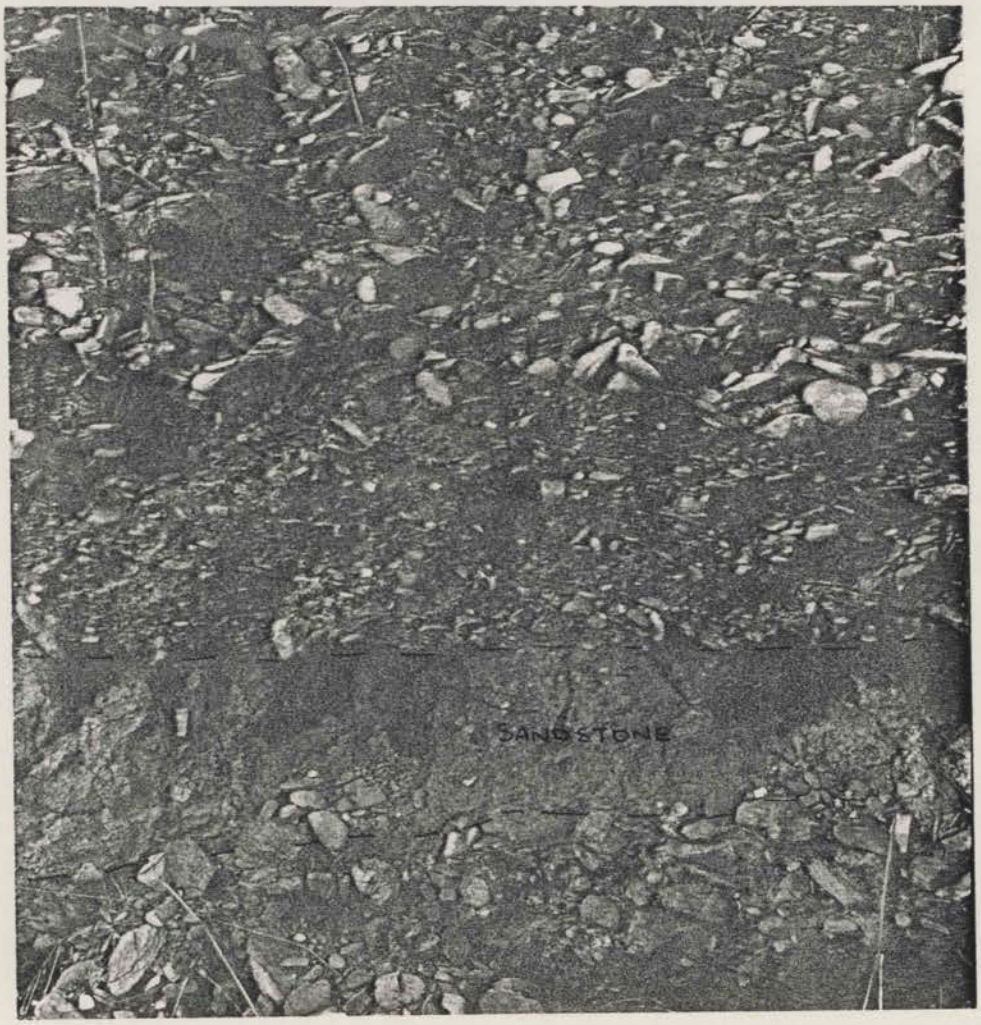
Coarse, clast supported material in lower portion of the photograph is typical of stream flood facies of alluvial fan deposition.

SITE NUMBER : 10
G.R. : 237653 Tallangatta 1:100 000 NATMAP
LOCATION : Road Cutting Adjacent tc Duncan's Homestead and Hayshed.
GEOMORPHIC SETTING : Road cutting intersects the northern portion of the same fan mesa that site 9 is associated with approximately 300m to 400m north of site 9. The fan mesa slopes approximately 4° towards the Mitta Mitta River and it is a deeply dissected remnant of a previously more expansive alluvial fan. The fan mesa surface at site 10 is approximately 15m above the adjacent floodplain. Bedrock outcrops at the base of the fan adjacent to the Mitta Mitta floodplain at G.R. 239655 at its northernmost extremity.

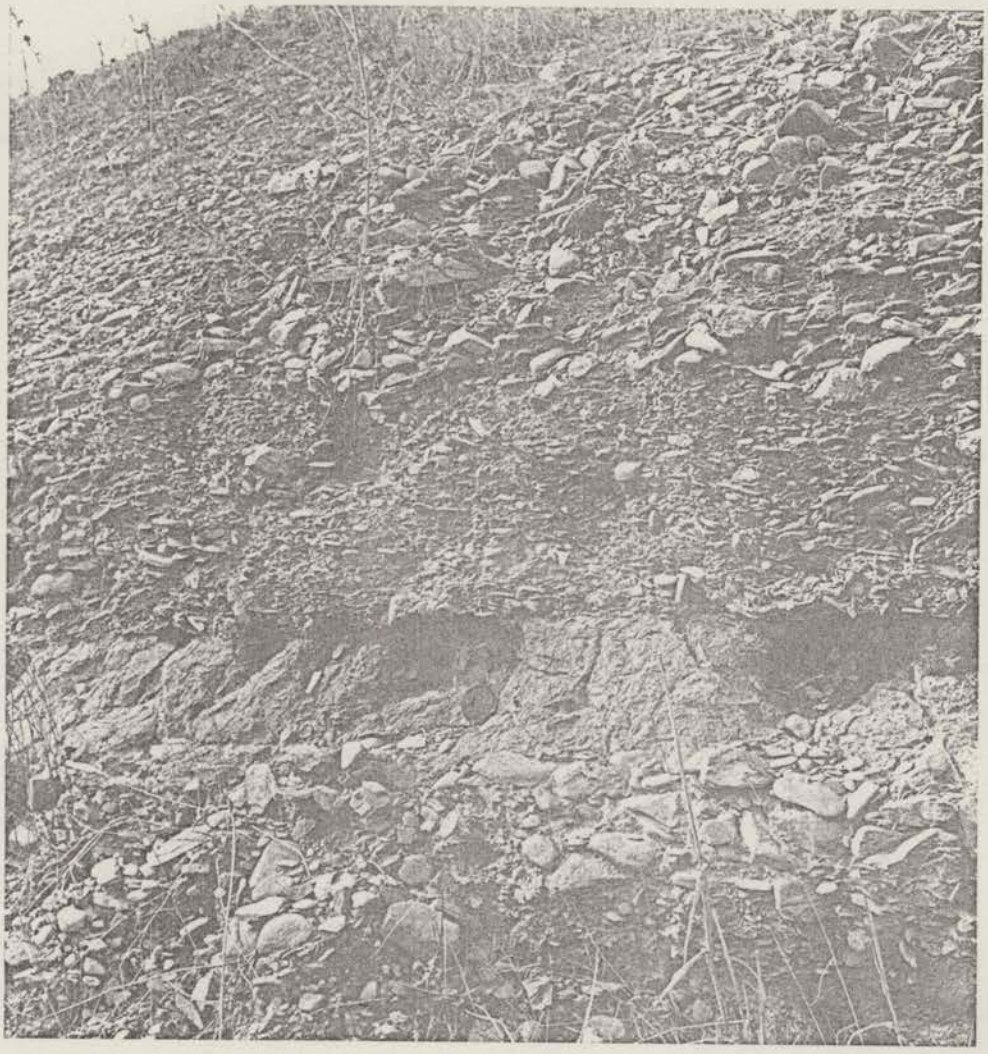
Description of Sediments

Above the extremely weathered, yellow, schist bedrock at the northern end of this section is poorly sorted, bouldery gravel. The soft schist clasts are slightly to moderately rounded whilst quartz clasts are irregular. The clasts are contained in a red/brown, sand/silt matrix.

Further up the section a current bedded, weakly consolidated sandstone lens occurs within the angular bouldery gravel. Refer to photograph MV 5886F8, below. The sediments in this cutting have also been mapped by King (et. al. 1976) as Tpe, but they are probably not Tpe and instead are Pleistocene as discussed in site 9.



SITE NUMBER : 10 continued
PHOTOGRAPH MV 5886F9



Lens cap is 55mm in diameter.

Note the rapid variation from bottom to top: gravel, cobbles, small boulders; sand; cobbles; cobbles and boulders. The imbrication of the platy cobbles indicates a current direction from right to left, which is approximately north. The bedding plane of the partially consolidated sand (sandstone) in the picture is much closer to the horizontal than the present surface which dips 4° to the north. This indicates that the original gradient of the fan was less than 4° and that the fan extended further out onto the floodplain or the floodplain was at a higher level during deposition of the fan, or both. The coarse, clast supported material is typical of "stream flood" facies deposition in an alluvial fan whilst the sand layer may represent "sheet flood" facies (Blissenbach, 1954), due to its broader sheet-like distribution.

SITE NUMBER : 11
G.R. : 258636 Tallangatta 1:100 000 NATMAP
LOCATION : Eastern End of Larsen's Cutting
GEOMORPHIC SETTING : Small fan mesa adjacent to larger fan mesa to the east. Refer to Photograph MV5886F12. Fan mesa at site 11 is approximately 15m above the adjacent floodplain and the surface slopes 8° towards the Mitta Mitta river. The cutting exposes the top 2.5, to 3.5m of the fan mesa. The catchment associated with this fan mesa is small, but rises nearly 400m in 1km.

PHOTOGRAPH MV 5886F12



This photograph demonstrates a fan mesa adjacent to site 11. The water tank sits on the surface of the fan mesa which is approximately 15m above the floodplain in the foreground. The fan mesa has been dissected by a creek on its right hand side. The edge facing the floodplain has been steeply incised by the Mitta Mitta River.

Description of Sediment

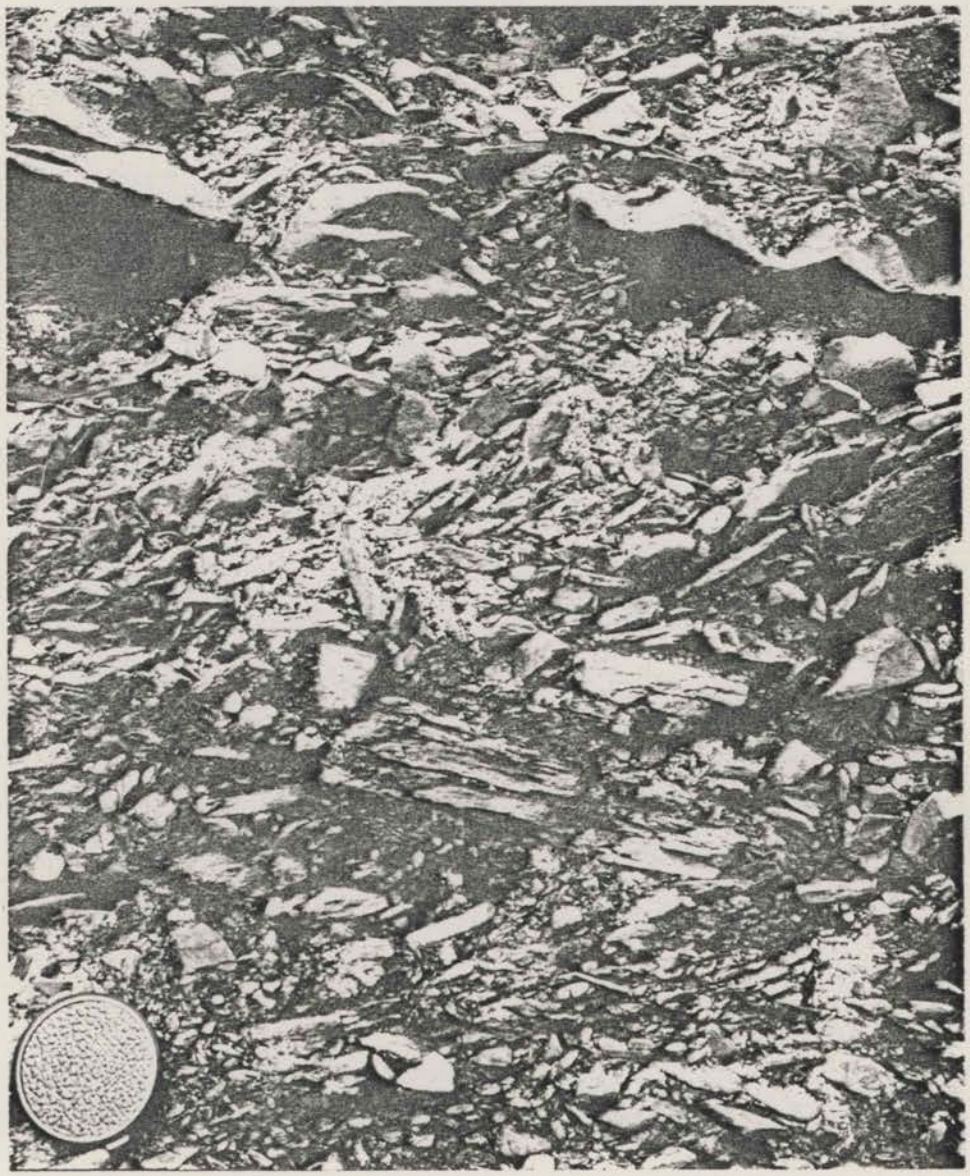
Most clasts are from 2cm to 10cm and are close packed. The clasts are typical of unit O (metasediments) which comprises the hill country in the catchment to the south. The irregular, angular clasts and the huge range in size is typical of a fanglomerate. The material is only weakly consolidated and has a

SITE NUMBER : 11 continued

red, sandy gravelly matrix. Refer to photographs MV 5886F11 and MV 5886F10, below, for an illustration of the sediment fabric.

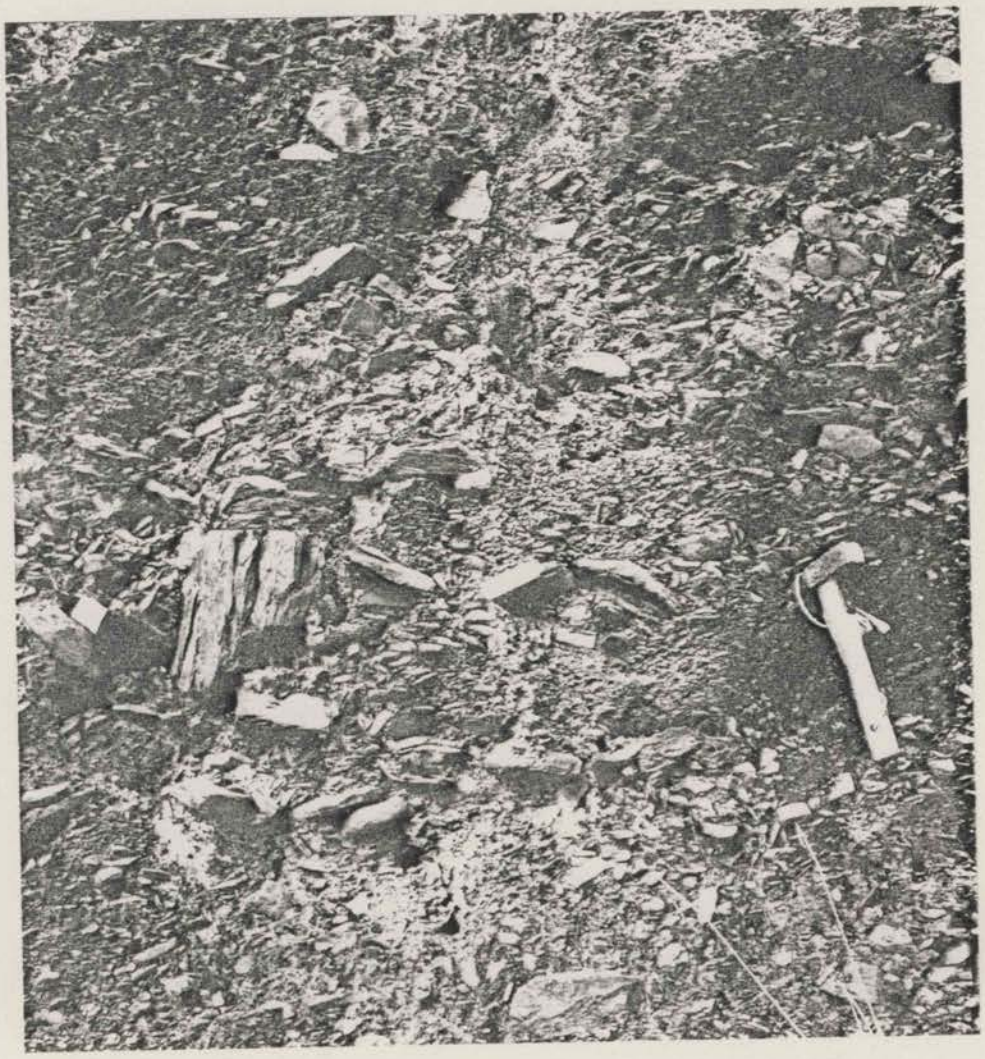
These sediments appear to have a similar depositional environment to sediments described at sites 9 and 10, as well as having a similar geomorphic setting and therefore correlate with them as Pleistocene alluvial fan deposits.

PHOTOGRAPH MV 5886F11



Close up view of 50cm square section of fanglomerate exposed in cutting at site 11. The larger bouldery clasts are almost randomly orientated, but the cobble size clasts appear to be imbricated suggesting a current flow from left to right . Lens cap is 55mm in diameter.

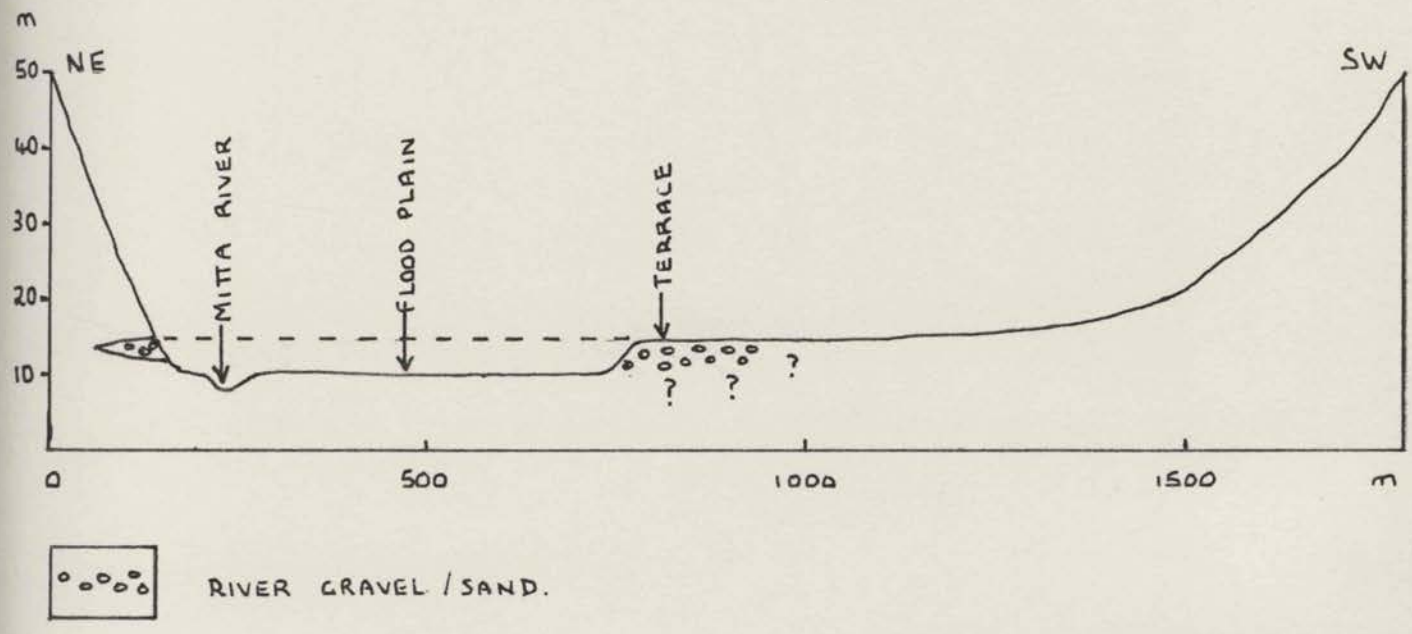
SITE NUMBER : 11 continued
PHOTOGRAPH MV 5886F10



This photograph of a 1.5m square section of the cutting at site 11 demonstrates the lack of sorting and rapid deposition in a series of shallow irregular channels, as well as the short distance these clasts have been transported.

SITE NUMBER : 12
G.R. : 332582 Bogong 1:100 000 NATMAP
LOCATION : Road cutting 50m north-east of bridge and 500m south-west of Magorra Gap.
GEOMORPHIC SETTING : Riverine terrace on bedrock, approximately 4m above the present river. The deposit is approximately 3m thick and has a lateral equivalent across the river to the south-west.

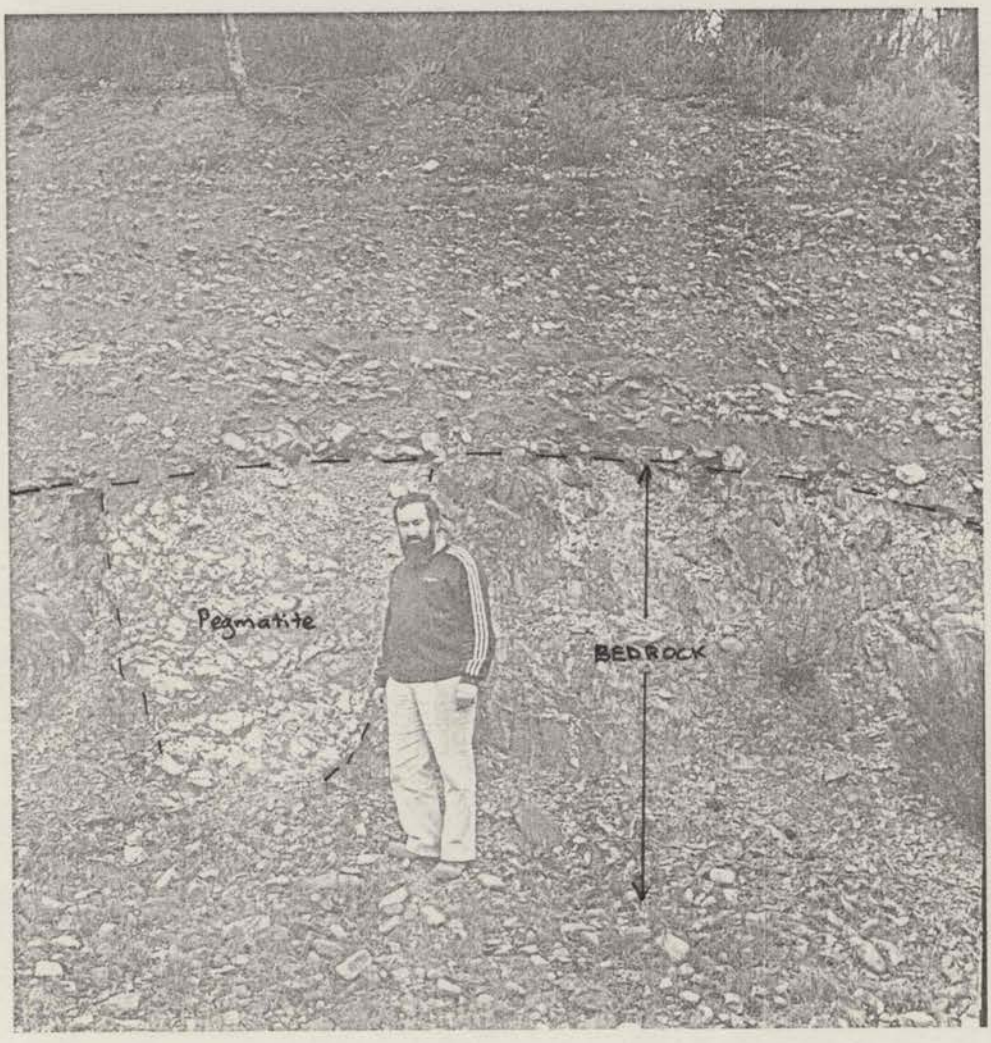
Fig 2Bn (reference MV 588602)



DESCRIPTION OF SEDIMENTS : The exposure comprises 4 laminations of river gravel/cobbles alternating with sand, perched on Ordovician bedrock. Refer to photograph MV 5886F1. The upper surface of this exposure is level with the elevated terrace on the opposite side of the river. The clasts include metasediments, volcanic breccia and quartz. The provenance of this material is local although the volcanic breccia has its source in the Mitta Mitta volcanics 20km to the east. Most clasts are rounded, including the quartz.

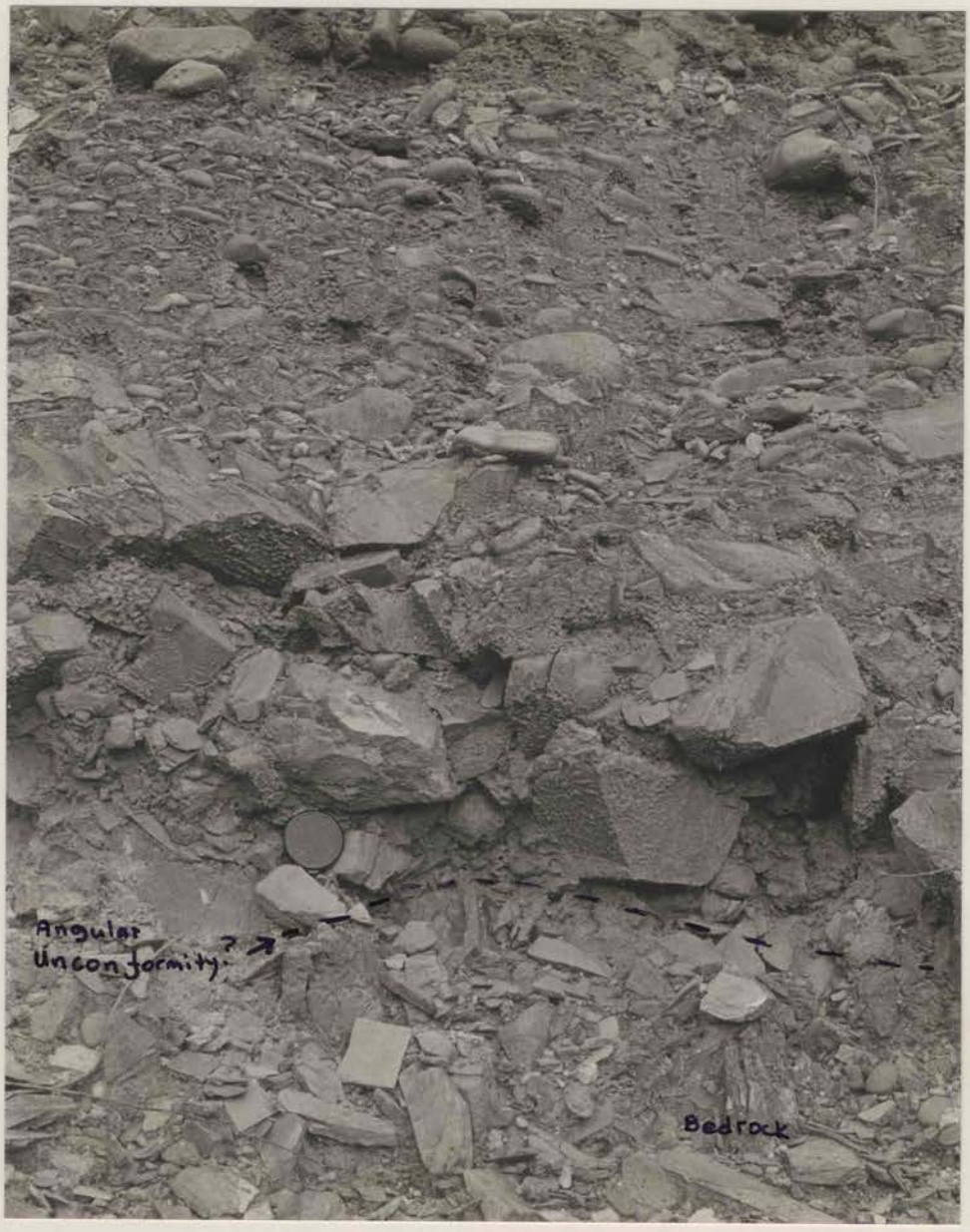
The well stratified, imbricate bedding as well as the clast provenance suggest a riverine environment of deposition rather than an alluvial fan. Refer to photograph MV 5886F2.

SITE NUMBER : 12 continued
PHOTOGRAPH MV 5886F1



Bedrock comprising Ordovician metasediments and a pegmatite vein are smoothly truncated by the sediment which comprises thin sheets and lenses 10cm to 40cm thick of gravel and cobbles alternating with red gravelly sand.

SITE NUMBER : 12 continued
PHOTOGRAPH MV 5886F2



angular

Close up view of exposure at site 12 with the unconformity running across the photograph. The rounded waterworn cobbles are well stratified and competent.

COMMENTS ON RELIC RIVERINE GRAVELS OF SITE 12 : The red sand exposed in this cutting is similar to the red sand and weakly consolidated sandstone of layer 3 at site 4 (Hume Weir Raceway). This is probably due to a similarity in process and provenance, rather than a correlation in time, as the sediments at site 12 show very little consolidation and no evidence of lateritization. The geomorphic setting of these sediments indicates an association with a river flood plain approximately 4m higher than the present.

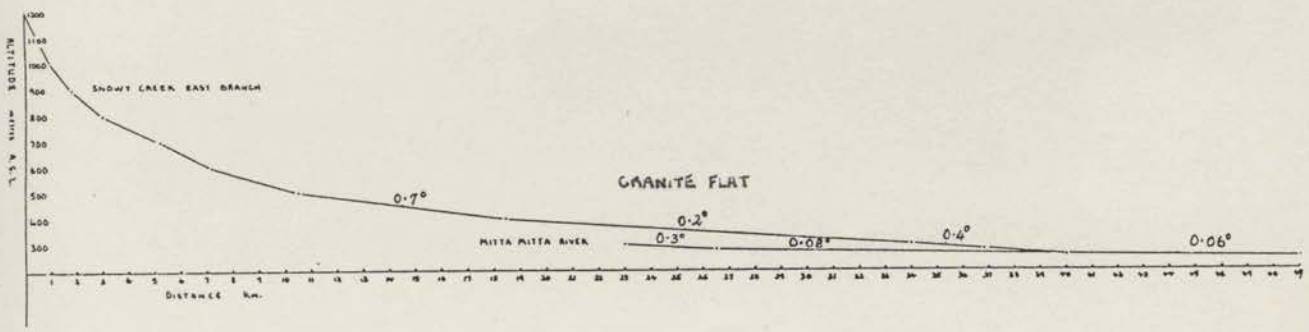
SITE NUMBER : 12 continued

Similarly, the riverine sediments at site 8 are suggestive of a floodplain elevated approximately 5m relative to the present floodplain. The relic terrace at site 8 is probably associated with reworking of outwash of sediments fron the confluence of Little Snowy creek into the Mitta Mitta River. Similarly, the gravels at site 12 are probably associated with reworking of outwash below the junction of Snowy Creek with the Mitta Mitta River. Both of these relic riverine terraces are probably Pleistocene.

SITE NUMBER : 13
G.R. : 329562 to 332562 Bogong 1:100 000 NATMAP
LOCATION : Road cuttings adjacent to the Pioneer Hydraulic Sluicing Coy. workings.
GEOMORPHIC SETTING : The cuttings are along the base of steep slopes adjacent to the Mitta Mitta River which contain elevated terraces of riverine gravel and overlying hillwash. The bedrock base of the lowest terrace is approximately 5m above the present river level.

OVERVIEW OF THE STRATIGRAPHY : The multitude of sections and complexity of this deposit which contains at least 2 sets of terraces on bedrock at different levels and is partially lateritized and partially eroded and overlain by coarse angular hillwash, is best dealt with by a simplified overview. The riverine deposits occur in a piedmont zone which can be realized by reference to the river profile below, Fig 2Bp.

Fig 2Bp : Profile of Mitta Mitta River and Snowy Creek



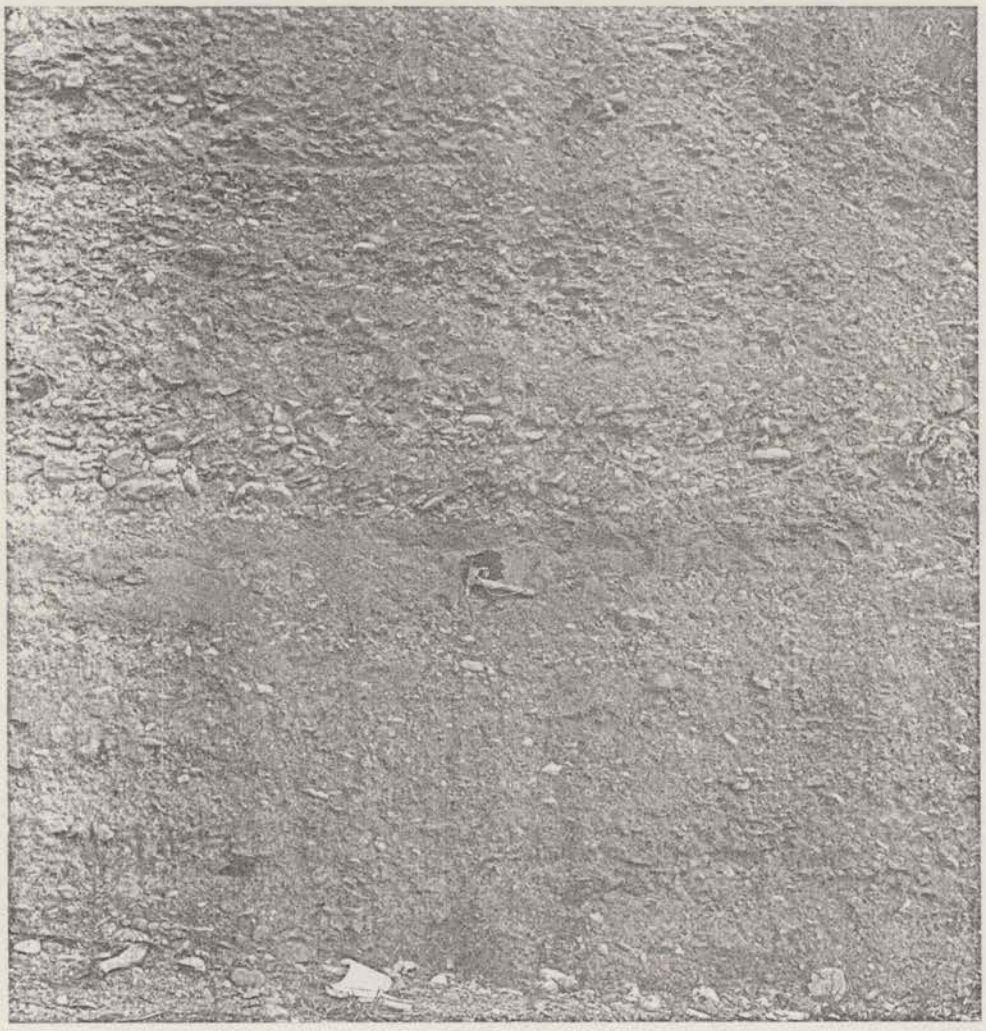
SITE NUMBER : 13 continued

The terrace deposits at the Pioneer can be subdivided into three main layers, starting at the base layer 3.

Layer 3 : This layer comprises coarse gravel and gravelly sand lenses approximately 10m thick in total. the clasts are competent, well rounded and consist mainly of hornfels, quartz, metasediments and some porphyry. The metasediment clasts are extremely weathered, but the remainder are slightly to moderately weathered. The coarse gravels are moderately consolidated in places with a grey, silty clay matrix and iron oxide?precipitate forms thin black layers within the gravel.

Refer to photograph MV 5886F3

PHOTOGRAPH MV 5886F3



SITE NUMBER : 13 continued

Photograph MV 5886F3 demonstrates the fabric of layer 3. This sediment which contains well stratified sands and gravels is similar in fabric and geomorphic setting to the section described at site 12, approximately 2km downstream. Site 12 may represent the distal margin of a massive wedge of gravels and interbedded gravelly sands deposited below the confluence of Snowy Creek with the Mitta Mitta River. The gradient of the Mitta Mitta river averages 0.1° for 13.5km above site 13 and 0.1°for 12km downstream, whereas Snowy Creek averages 0.4° gradient over a section of 6km upstream of site 13.

The provenance of layer 3 was described by Stirling (1888) as belonging to the Mitta Mitta watershed and not the Snowy Creek watershed. The basis for this description was the presence of volcanic breccia and porphyry within the clasts of the lower washes (layer 3) which were assumed to come only from the upper Mitta Mitta Valley (Mitta Mitta Volcanics), according to Stirling.

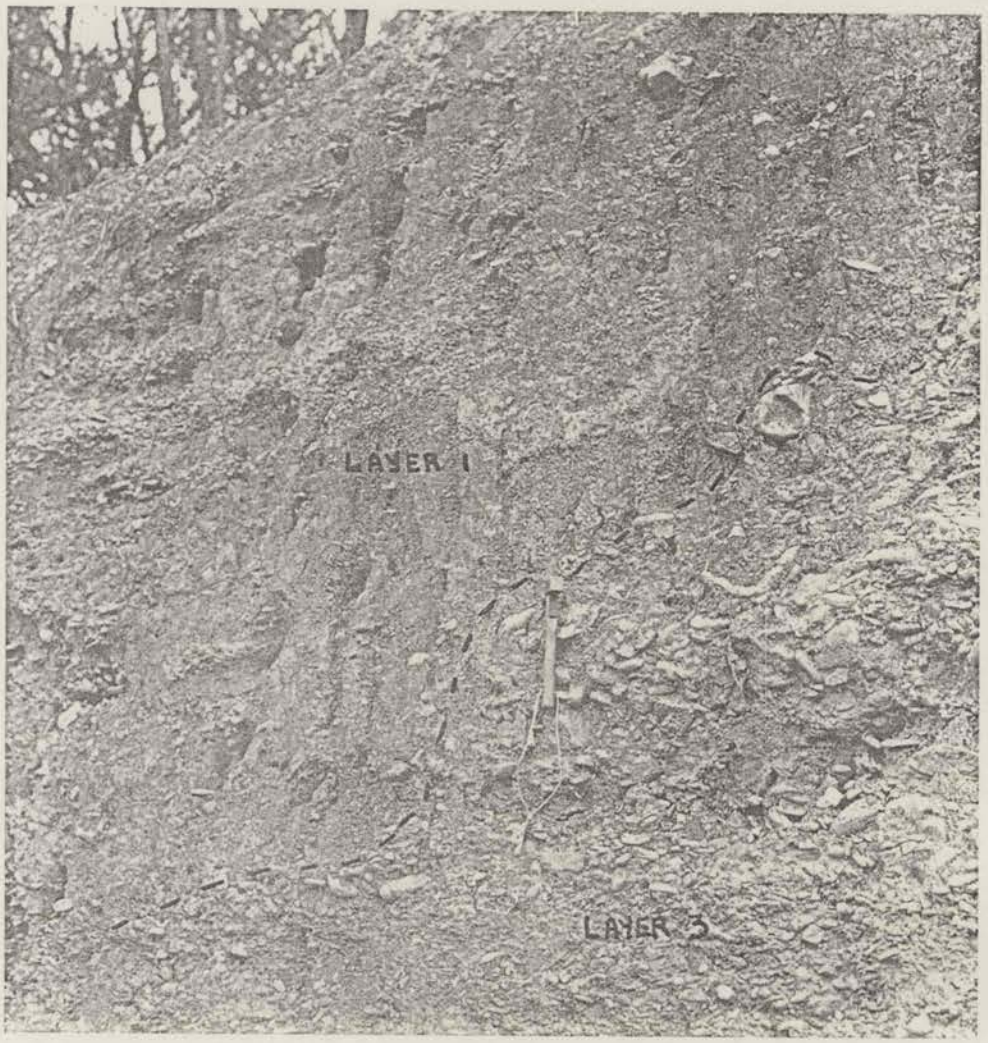
However, the present writer has observed clasts of volcanic porphyry of mafic and silicious composition within point bar deposits of the Snowy Creek , near The Walnuts, about 10km upstream from site 13. This evidence should therefore include the Snowy Creek watershed as a significant provider of clasts to the "lower washes" (layer 3).

Layer 2 : These sediments are accessible by means of an old unsupported, partially collapsed tunnel which intersects the Pioneer Gravels at a steep angle near their south-eastern margin. The sediments comprise partially consolidated silts and well rounded gravels similar to Stirling's (1888) description of the "middle washes", except that there is NOT an absence of fragmented porphyry boulders as indicated by Stirling.

A well rounded weathered cobble of silicious breccia or prophyry was found firmly embedded within layer 2, which extends for a thickness of approximately 25m above layer 3. This clast may have been contributed from either the Mitta Mitta River or Snowy Creek catchment. The gradient of the Snowy Creek suggests that it is or was more competent to transport coarse clasts.

Layer 1 : This layer comprises coarse red angular hillwash with clasts of local bedrock and also clasts derived from the underlying layers 2 and 3. The upper surfaces of layer 2 and 3 have beeen deeply incised and filled with angular hillwash. Refer to photograph MV 5886F5. This material is similar in fabric and geomorphic setting to Layer 2, 3, and 4 at site 9; the gravels and sandstone of site 10 ; the angular gravels of site 11 as well as the gully fills of sites 14, 15, 16, and 17.

SITE NUMBER : 13 continued
PHOTOGRAPH MV 5886F5



Refer to photograph MV 5886F5

This photograph reveals portions of a fresh section of layer 3 which has been steeply incised by layer 1. The boundary lies diagonally between the top right and lower left corners. Note the contrast in bedding fabric and clast roundness.

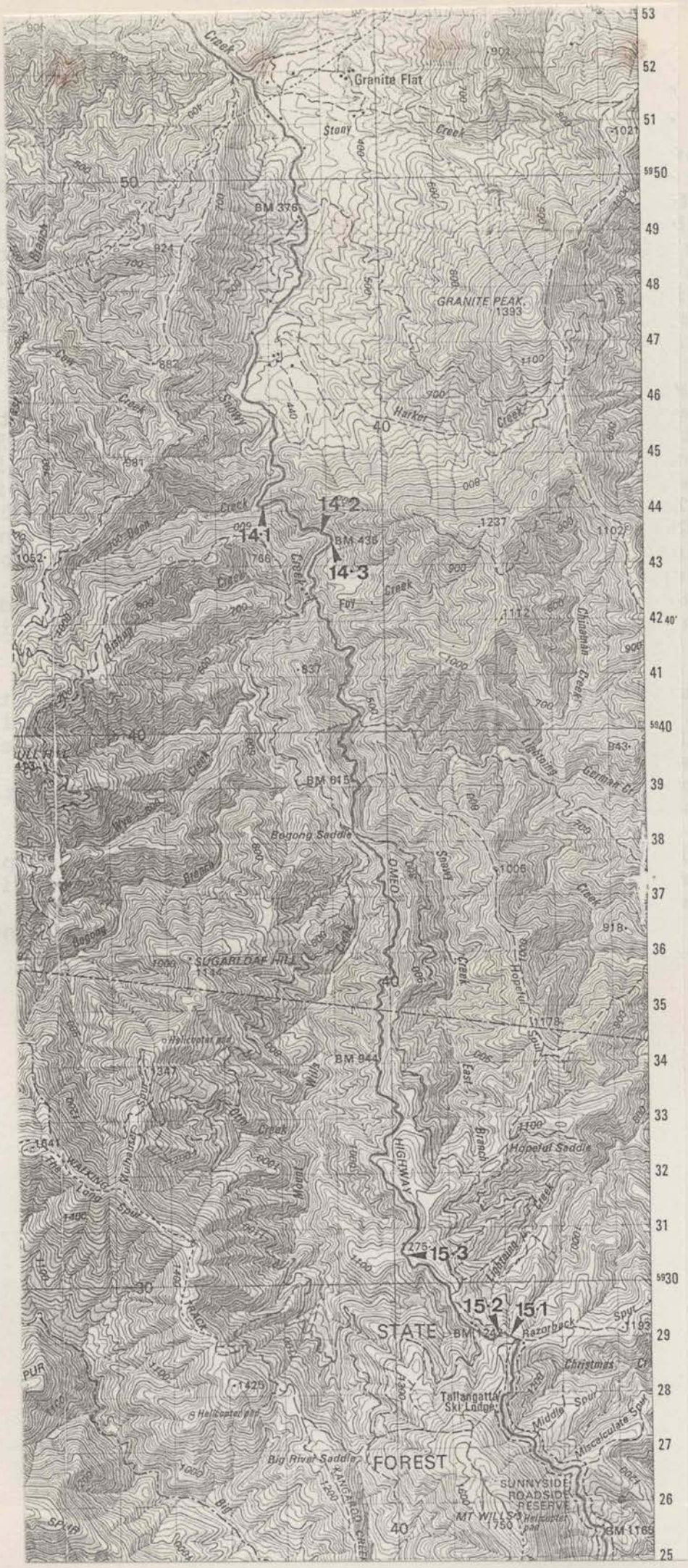
CONCLUSION : The riverine layers of 2 and 3 appear to be the result of a consistent high energy environment although layer 2 contains some fine grained material. These sediments may correlate with the Calivil Sands. According to C.R. lawrence (1975) the Calivil Sands consist of buried paleochannel deposits located in the alluvial filled valleys of the highlands and are

SITE NUMBER : 13 continued
popularly known as deep leads where they have been mined for gold. Despite C.R. Lawrence's comment that there is no surface expression of these leads, the description of layer 2 and 3 at site 13 on the Mitta Mitta River correlates with Lawrence's description : "The Calivil Sand ranges from fine sand to cobble in size, with various admixtures of these. Trends in grainsize are upwards fining from cobble or gravel at the base through sand and sandy clay . " The Calivil Sand is characterized by being grey in color.

The anomalous location of strata, presumed by this writer to be Calivil Sands could be explained by the proximity of the Tawonga Fault which has been demonstrated by F.C. Beavis (1959) to be a low angle thrust, dipping to the south-east, and from its relationship with younger alluvials at Mt Beauty, has been active during the late Cainozoic. The 1:250 000 Tallangatta Geological Sheet, (Fig 2Ba), depicts the Tawonga Fault as extending north-eastwards and intersecting the Snowy Creek near Granite Flat. This may explain the reversal in gradient along the Snowy Creek from 0.7° to 0.2° in the middle reaches, then back to 0.4° for the lower reaches below Granite Flat. (Refer to figure 2Bp)

It is possible that the low angle thrust towards the north-west has banked up and reduced stream gradient in the section near Granite Flat which averages 0.2° and that it has increased the local elevation of the Calivil Sands at Mitta Mitta by enechelon upward sliding of bedrock to the north of the prescribed lineament of the fault.

The overlying red angular gravels of layer 1 which deeply dissect layers 2 and 3 correlate with alluvial fan head deposits which postdate the underlying Pliocene Calivil Sands as demonstrated in the bore section at Kergunyah, (Tangambalanga Bore 78, in discussion of sites 1 to 4).



1:100,000

LOCATION GUIDE

SITES 14 and 15.

SITE NUMBER : 14 part one
G.R. : 376442 Bogong 1:100 000 NATMAP
LOCATION : Omeo Highway adjacent to Snowy Creek, approximately 18km south of Mitta Mitta, in steep, deeply dissected terrain adjacent to the Highlands.
GEOMORPHIC SETTING : Broad spur sloping approximately 40% towards Snowy Creek. The terrain rises steeply from 435m at the exposure to a level ridge at about 1 200m. There is no drainage line directly associated with the gully infill exposed at the surface, and the upper surface of the gully fill is continuous with the broad curving surface of the spur. The relic gully, within the spur is deeply incised into Ordovician metasediments of Unit O. The exposure reveals a V shaped incision into bedrock 7m high and 20m wide at the top, which is filled with sediments. The bedrock walls slope steeply at approximately 40° to 50° on the left hand side and near vertical on the right hand side.

Refer to photographs MV 13387F5 and MV13387F1.

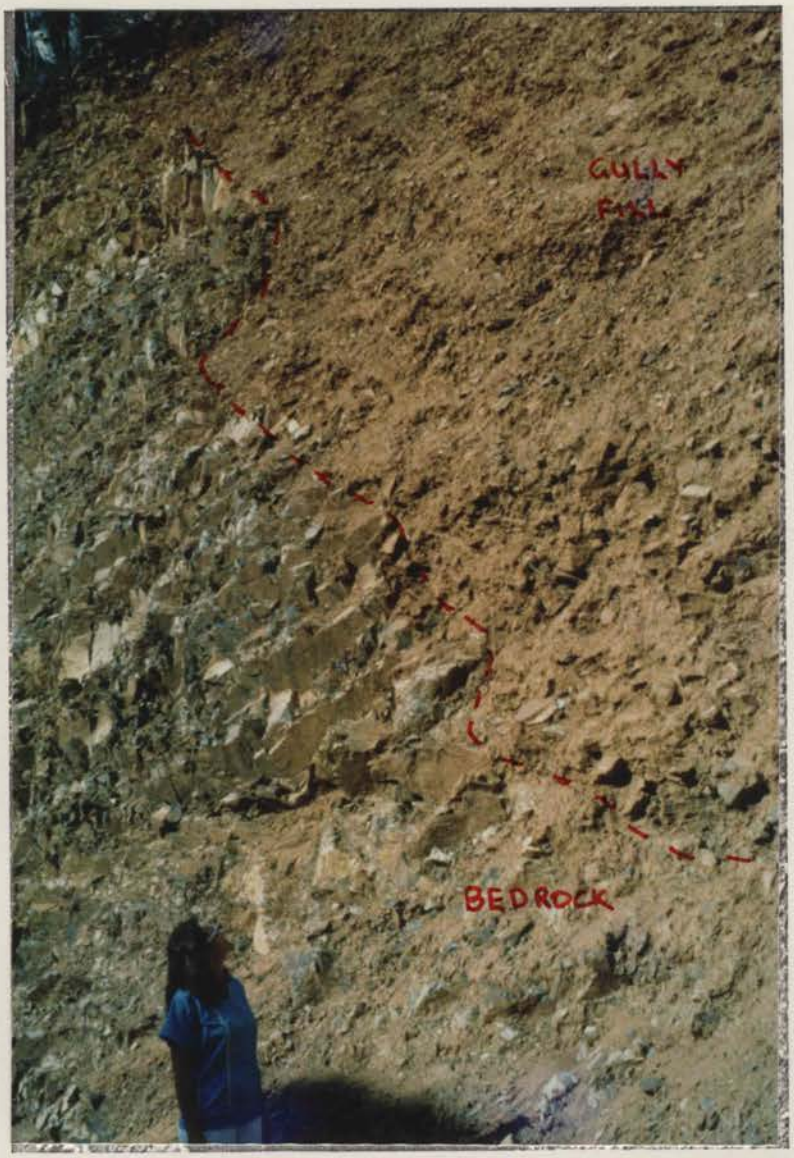
DESCRIPTION OF SEDIMENTS : The sediment consists of angular competent blocks and cobbles of local bedrock in an orange brown gravelly sandy silty matrix. Most of the clasts are randomly dispersed in the matrix but there are some small crescentic channels of stratified clasts of gravel to cobbles within the section which indicate a composite structure. A thin brown mineral soil caps the gully fill and adjacent bedrock.

The limited degree of weathering of the clasts within the gully fill and the apparent lack of oxidation or lateritization and poor consolidation of the sediment suggest that it is not older than late Pleistocene.

PHOTOGRAPH MV 13387F5
Overview of cutting showing its relationship to the spur and steep bedrock walls.



SITE NUMBER : 14.1 continued
PHOTOGRAPH MV 13387F1



The left hand side of the cutting exhibits dispersed clasts with small stratified lenses of cobbles included within the more massive "debris-flow" type sediment.

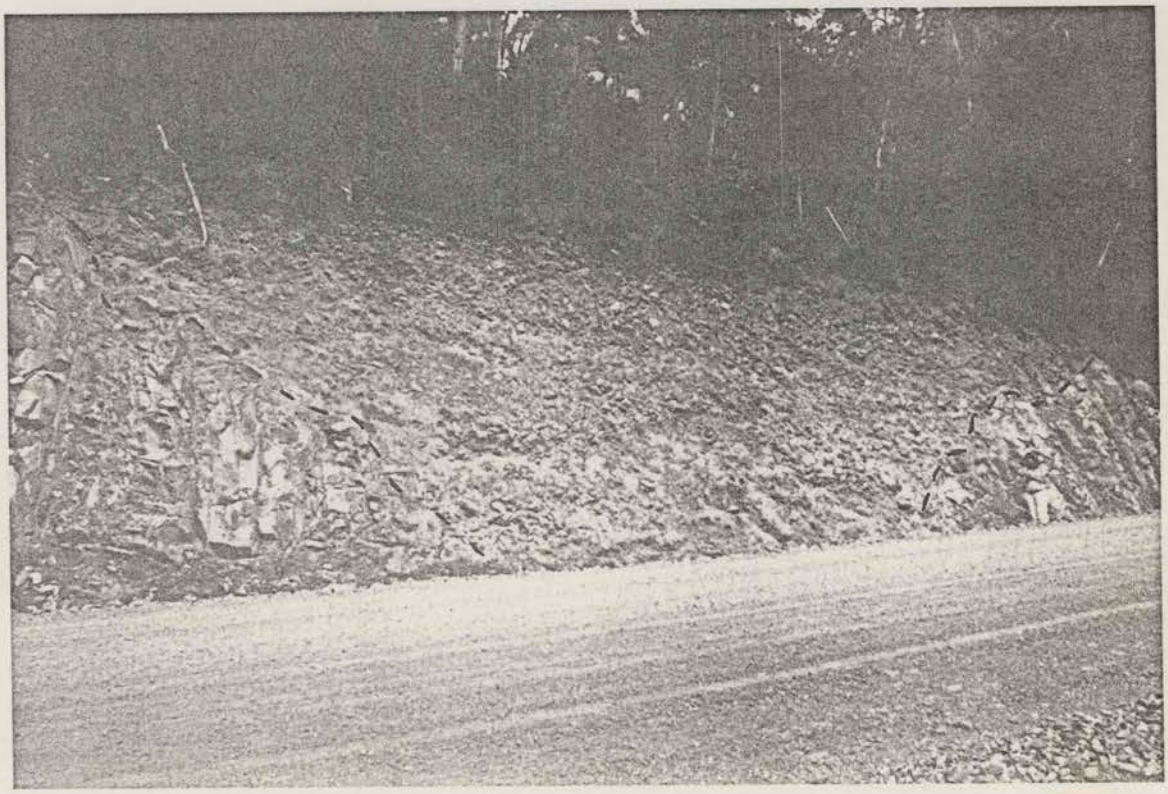
SITE NUMBER : 14 part two
G.R. : 389436 Bogong 1:100 000 NATMAP
LOCATION : Small tributary intersects Omeo Highway just south of site 14.1.
GEOMORPHIC SETTING : Small tributary dissects broad concave slope with moderate sloping toe. The tributary rises from 435m steeply towards a broad, level ridge-top at approximately 1 200m ASL. The gully fill is in bedrock and adjacent to the above tributary. The exposure reveals a V-shaped gully fill with height 4m to 5m. Width at top of cutting 18m and width at base of cutting 6m.

DESCRIPTION OF SEDIMENT : The gully fill comprises competent, angular blocks and slightly rounded cobbles of local country rock in an orange brown sandy silt matrix. The bedding mostly consists of dispersed clasts but there are isolated layers and channels of slightly rounded clasts which suggest stream flow contributed to this deposit in addition to debris flow. A 60cm veneer of gradational brown-red mineral soil overlies this deposit. This deposit is similar to location 14.1 and is typical of many such relic gully fills in the steeply dissected highland terrain of North-eastern Victoria.

Refer to photograph MV 13387F10

This photograph gives an overview of the cutting at site 14.2 showing the steep bedrock walls. The tributary is adjacent and to the right of this cutting.

PHOTOGRAPH MV 13387F10



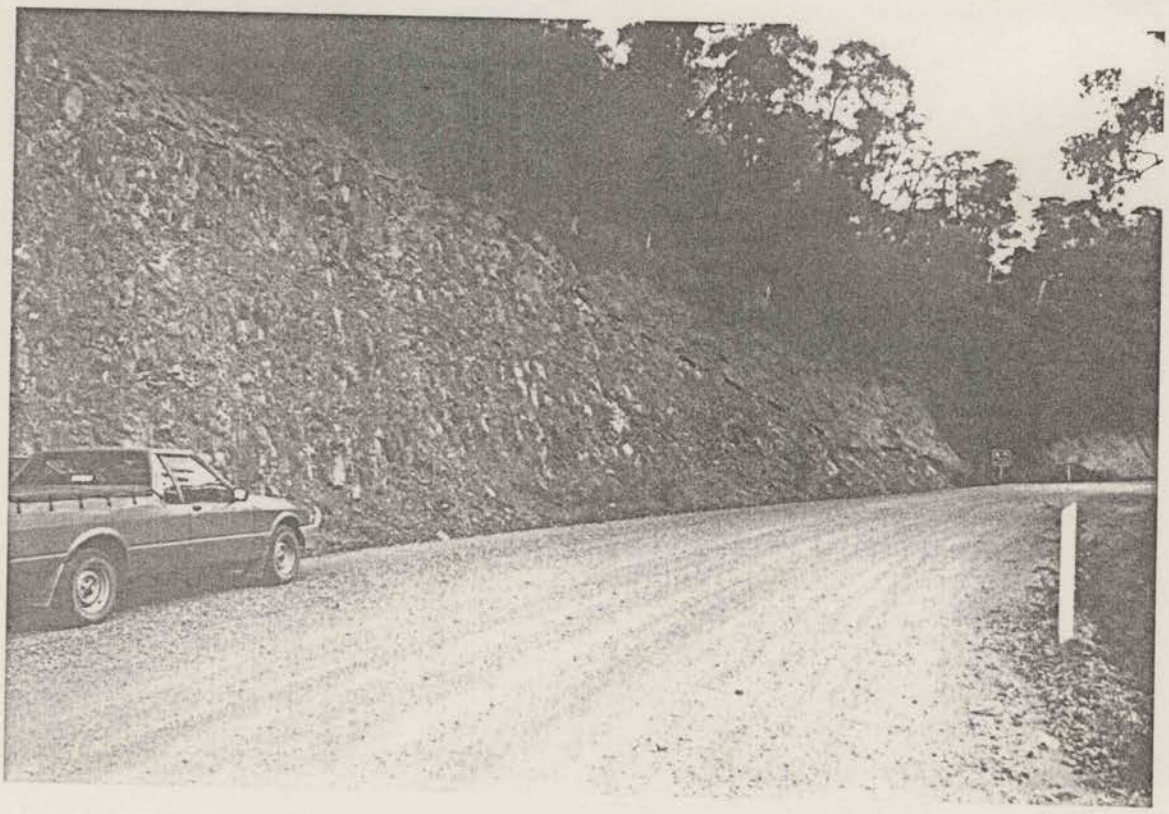
SITE NUMBER : 14 part three
G.R. : 390435 Bogong 1:100 000 NATMAP
LOCATION : Small tributary of Snowy Creek intersects Omeo Highway just south of site 14.2.
GEOMORPHIC SETTING : Cutting situated on moderately sloping toe of a steep slope rising from 435m to 1 200m. The exposure reveals a broad gully fill with a steep southern bedrock contact but with a gentle, low angle bedrock contact on the northern side. The gully fill is approximately 100m wide and maximum exposured height is 6m.

Refer to photograph MV 13387F12

This photograph illustrates the section and demonstrates that the gully fill has been dissected by the tributary creek near its southern end.

DESCRIPTION OF SEDIMENT : Most of the sediment comprises dispersed clasts of competent platy metasediments from gravel to large blocks in an orange brown silty sand matrix. Close packed clasts form isolated alluvial channels in the more massive silty sand.

PHOTOGRAPH MV 13387F12



SITE NUMBER : 14.3 continued
PHOTOGRAPH MV 13387F17

This photograph shows a portion of the cutting at site 14.3, which demonstrates some localized, weakly stratified channels of close packed clasts within the more massive silty sand and dispersed clasts.



COMMENT ON SITE 14 : The gully fills along the slopes of Snowy Creek in this steep highland terrain suggest that the deposition of gully fill sediment has smoothed over a previously more dissected landscape and that these infills caused a lateral migration of overland stream flow as most of these gully fills now occur on spur lines.

The gully fills are not developed on the steeper slopes at higher altitudes. The exposures noted occur near the base of the slopes adjacent to Snowy Creek where there is a local reduction in slope. These sites of deposition have slopes in the range of 10% to 60% gradient.

There appears to be no preferred aspect. The gully fills observed along Snowy Creek and Lightning Creek occur on all aspects with a similar degree of development.

SITE NUMBER : 15 part one
G.R. : 421290 Bogong 1:100 000 NATMAP
LOCATION : Omeo Highway 200m west of Razorback Spur
GEOMORPHIC SETTING : Site 15.1 is located on the northern flanks of the Razorback Spur at approximately 1 240m altitude. The Razorback Spur and another adjacent elevated landmass to the north appear to be relics of a dissected tableland as both features have gentle to moderate sloping terrain close to 1 200m ASL. This section is adjacent to a drainage line.

DESCRIPTION OF SEDIMENTS :

20cm of brown humus soil overlies about 3.5m of orange brown sandy silty matrix with dispersed angular cobbles of schist, together with lenses of close packed angular schist cobbles. Schist clasts are slightly to moderately weathered. Some dispersed charcoal is also present. Below these layers is a pale red sand silt matrix and lenses of close packed angular schist cobbles. Also there exists a brown layer containing humus and charcoal fragments, suggesting a paleosol, about 1m to 1.5m above the base of the section.

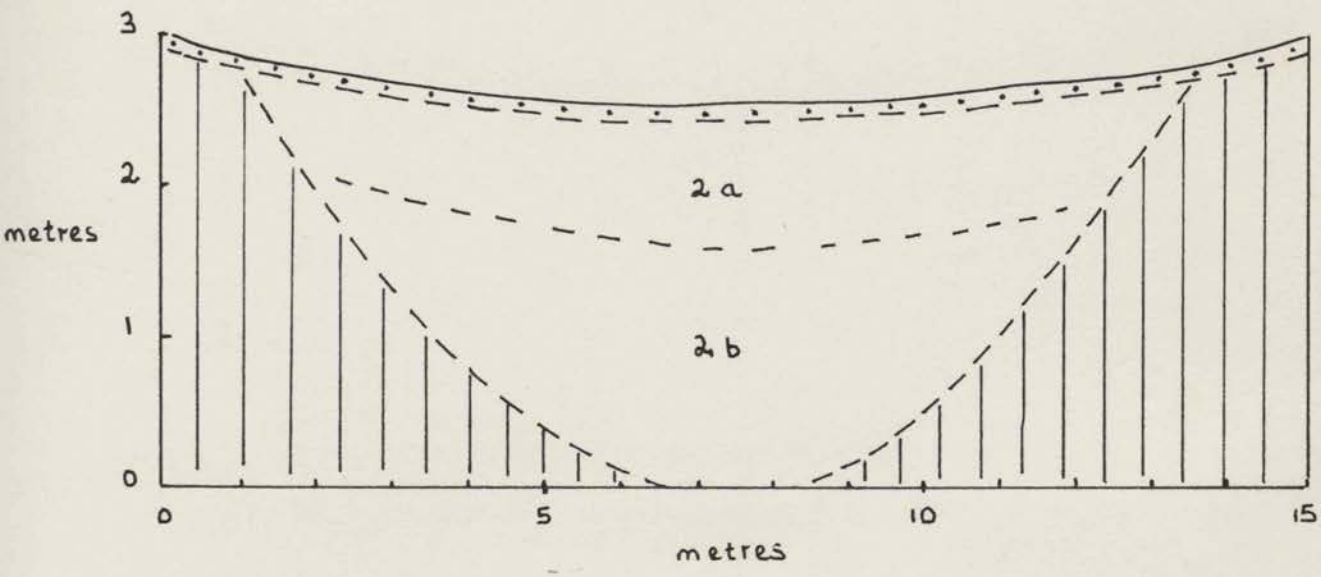
Layer 1 : 20cm of brown humus soil.

Layer 2a : approximately 2m of orange brown sandy silt with dispersed angular cobbles of schist, together with lenses of close packed angular schist cobbles.

Layer 2b : Approximately 1.5m of pale red sandy silt with lenses of close packed angular schist cobbles. There is also a brown layer containing humus and charcoal fragments suggesting a palaeolsol approximately 1m to 1.5m above the base of the section.

SITE NUMBER : 15 part two
G.R. : 418290 Bogong 1:100 000 NATMAP
LOCATION : Omeo Highway approximately 200m east of the Dugout on Mt Wills.
GEOMORPHIC SETTING : Site 15.2 is also situated on the northern flank of the Razorback on elevated gently to moderately sloping terrain at 1 240m ASL near the upper reaches of a small gully. The gradient of the gully is approximately 40%. Mt Wills rises to 1757m, 3.5km to the south.

Fig 2Br (reference MV 2988601): Section Through Relic Gully Fill on Mt Wills.



Layer 1	.....	Thin, brown humic soil layer
Layer 2a		Orange brown matrix of gravel, sand, and silt with dispersed angular platy cobbles of schist and dispersed fragments of charcoal.
Layer 2b		Similar to above, but with pale reddish brown matrix.
Bedrock	||||	Extremely weathered schist of Unit OSs,

DESCRIPTION OF SEDIMENTS : The sediment of layer 2 is situated in a relic gully, cut into bedrock with bounding sides sloping in at approximately 30°. The geomorphic setting and the nature of the sediment is very similar to the gully fills described at site

14, except that they are located at the lowest levels in this steeply dissected terrain and site 15 is located at the upper level on a remnant of elevated, gently to moderately sloping terrain. The steep valley sides which connect the upper and lower level gully fill deposits, with slopes ≥60% possess only a veneer of red blocky meterial less than 30cm above bedrock.

SITE NUMBER : 15 part three
G.R. : 402305 Bogong 1:100 000 NATMAP
LOCATION : 2 km north-east of the dugout on the Omeo Highway.
GEOMORPHIC SETTING : Cutting is located on the western margin of a broad, elevated moderately sloping relic surface at 1 180m ASL.

DESCRIPTION OF SEDIMENTS : A 3m road cutting reveals a layer of angular platy stratified cobbles in an orange gravelly sand matrix, overlying a more massive layer of dispersed cobbles and blocks in a pale brown sandy silt matrix.

Refer to photographs MV 15387F24 and MV 15387F25

This material is similar to the sections at site 14, except that the coloration of the matrix is less red and the scale of the deposit is smaller. This could be due to the reduced relief above this site. The adjacent elevated terrain rises to 100m above this site with a grade of about 20%. The process of debris flow and channel flow appear to have been active up to and including 1 200m during the period that the sediments examined at sites 14 and 15 were deposited. This period is assumed to be late Pleistocene due to the limited degree of weathering and soil development since deposition as well as the probable association of these deposits with an arid or arid/cold environment which would be necessary to provide a surface with minimal vegetation. The inclusion of charcoal fragments in some sections may make C14 dating possible.

PHOTOGRAPH MV 15387F24



SITE NUMBER : 15.3 continued
PHOTOGRAPH MV 15387F25

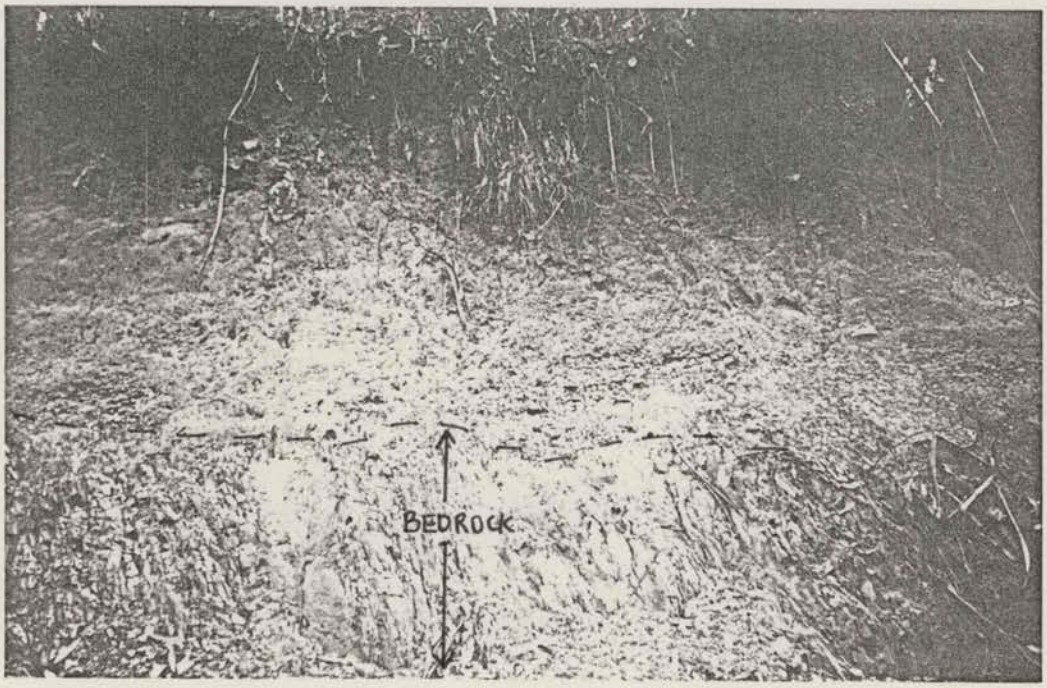


SITE NUMBER : 16
G.R : 464221 Benambra 1:100 000 NATMAP
LOCATION : On the Omeo Highway just below its junction with the Knocker Track.
GEOMORPHIC SETTING : Moderate sloping terrain adjacent to Glen Wills Creek and below steep sloping terrain leading up to a ridge at 1 300m ASL.

Refer to photograph MV 15387F17

The 3m section comprises two parts. The lower third is steeply dipping , extemely weathered bedrock of unit OSs, which makes an undulating boundary with the overlying 2m of blocky sediment. This sediment comprises lenses of close packed, angular stratified cobbles in a more massive orange brown gravelly clay matrix with dispersed cobbles and blocks. The coloration grades from orange brown near the surface to pale grey brown near the bedrock.

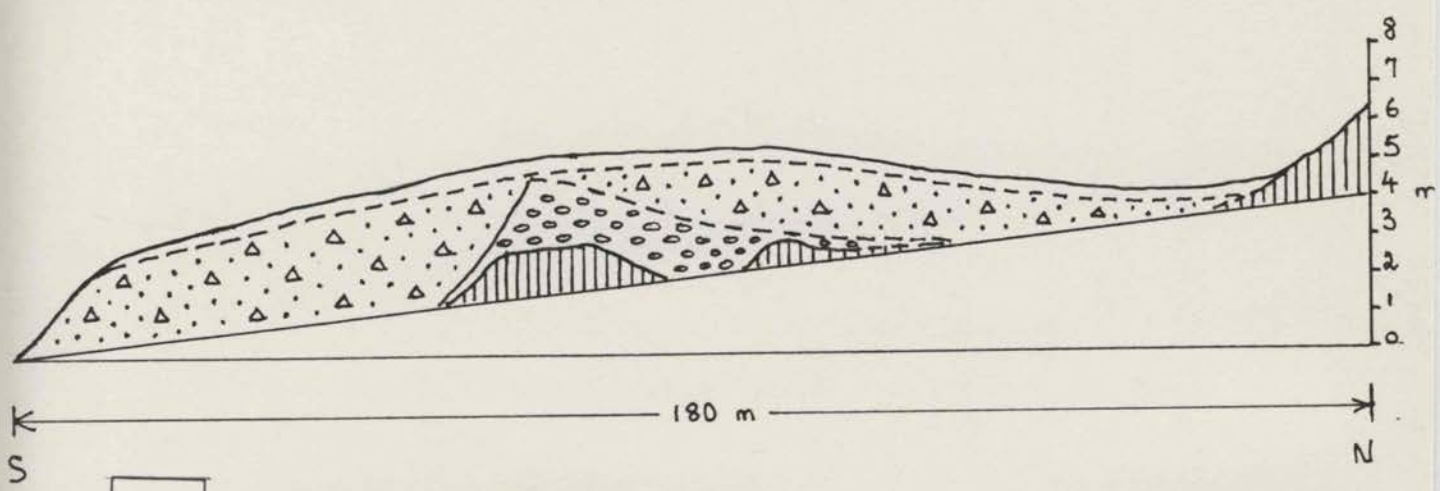
PHOTOGRAPH MV 15387F17



This material is similar to deposits at sites 14 and 15 except for coloration. The deposits at site 15 were deeper and the coloration was a uniform reddish orange brown with a slight tendency to become less reddish at the base of the section. Section 17 has an orange brown coloration near the surface but appears to be leached of coloration below 1m from the surface. The bedrock is similarly affected.

SITE NUMBER : 17
G.R. 409144 Bogong 1 :100 000 NATMAP
LOCATION : Omeo Highway, adjacent to Big River and 0.8km south of the Shannonvale Road.
GEOMORPHIC SETTING : The cutting is located near the upper margin of a terrace adjacent to and sloping towards the river at 20%. The terrace rises from 700m ASL at the river to 900m ASL to the west and to 1 100mASL to the east of the river. The terrain is moderately steep. The terrace adjacent to the river rises 20m in 100m away from the river and its distal edge has been truncated by the river, leaving a 2m to 3m scarp. The road cutting which exposes bedrock, bouldery riverine gravel and overlying hillwash truncates a broad moderately sloping spur.

Fig 2Bs (reference MV 1538701): Road Section at Site 17.



Layer 1 : pale brown loam

Layer 2 : angular competent blocks, cobbles in a pale pinkish brown silty sandy gravelly matrix.

Layer 3 : well rounded, polished moderately to extremely weathered bouldery clasts in a matrix of pale brown silty sand.

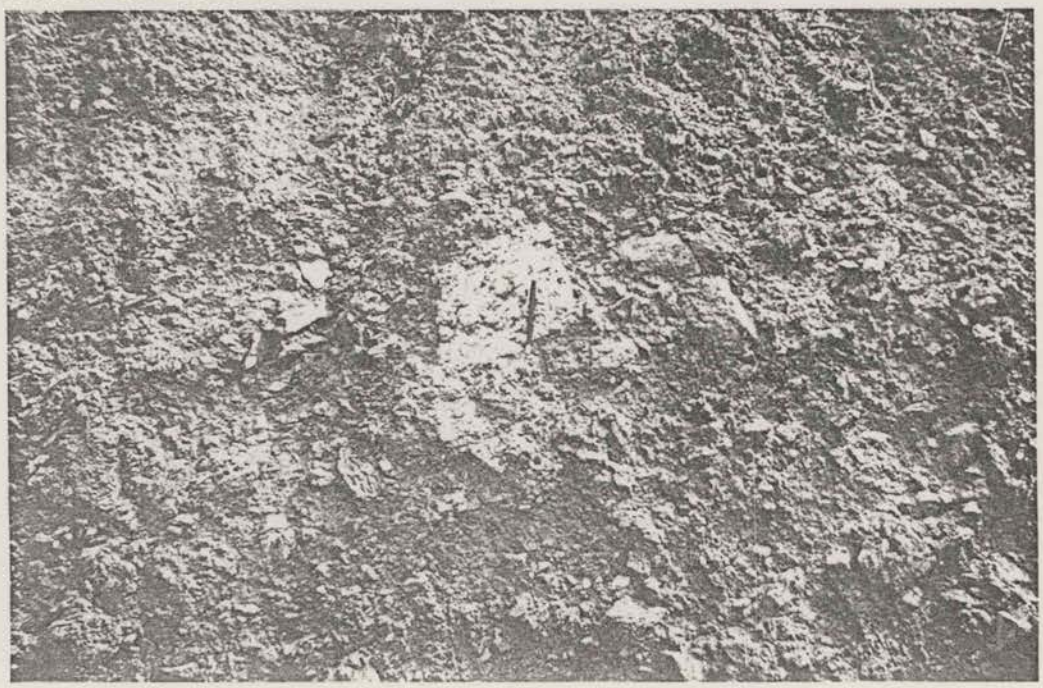
Layer 4 : Bedrock, extremely weathered metasediment.

DESCRIPTION OF SEDIMENTS: Layer 2 is a gully fill which occupies a depression which abuts steeply against the truncated edge of layer 3 on its southern side and less steeply on the northern edge of layer 3. Layer 2 is composed of angular clasts, slightly to moderately weathered, up to 40cm in diameter. The clasts are randomly dispersed in a pinkish brown silty sandy gravelly matrix. The clasts are similar to local bedrock. Layer 2 appears to be a debris flow.

Refer to photographs MV 15387F13, MV 15387F8, MV 15387F10, and MV 15387F6.

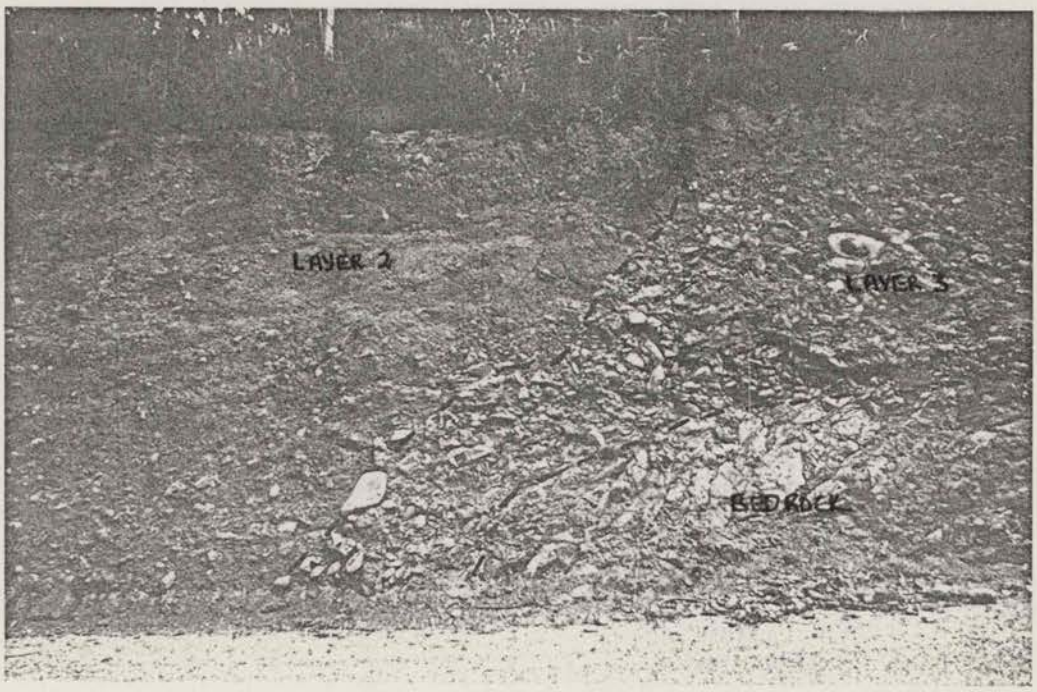
Photograph MV15387F13 gives a close up view of the texture of layer 2.

PHOTOGRAPH MV 15387F13

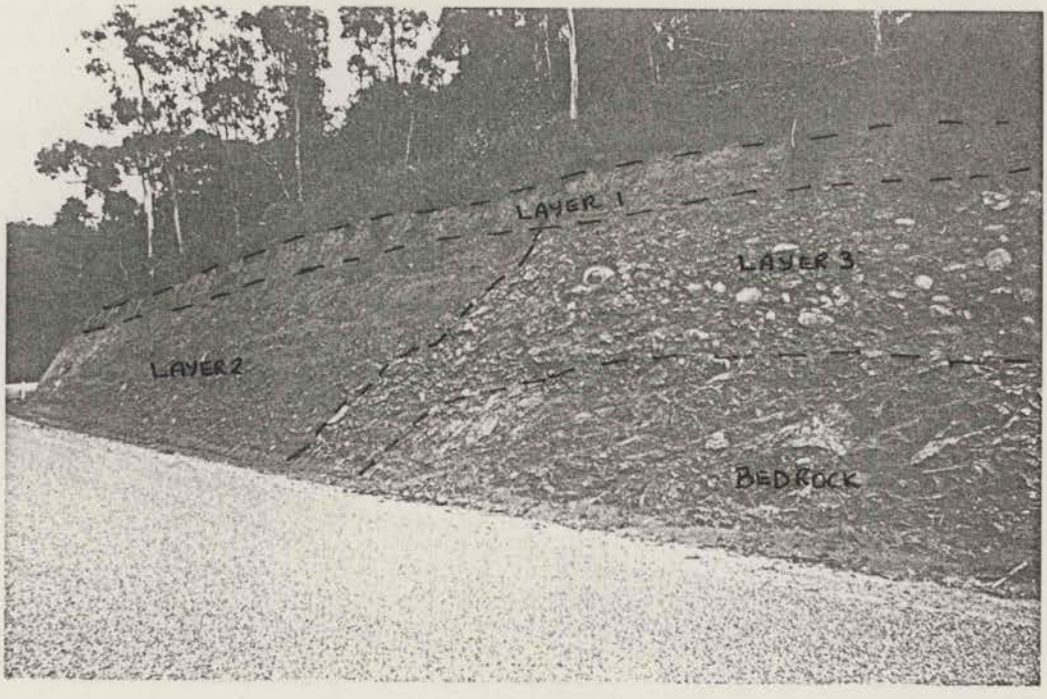


PHOTOGRAPH MV 15387F8

This photograph illustrates the steeply sloping southern boundary between layer 2 (gully fill) and layer 3 (boulder deposit).

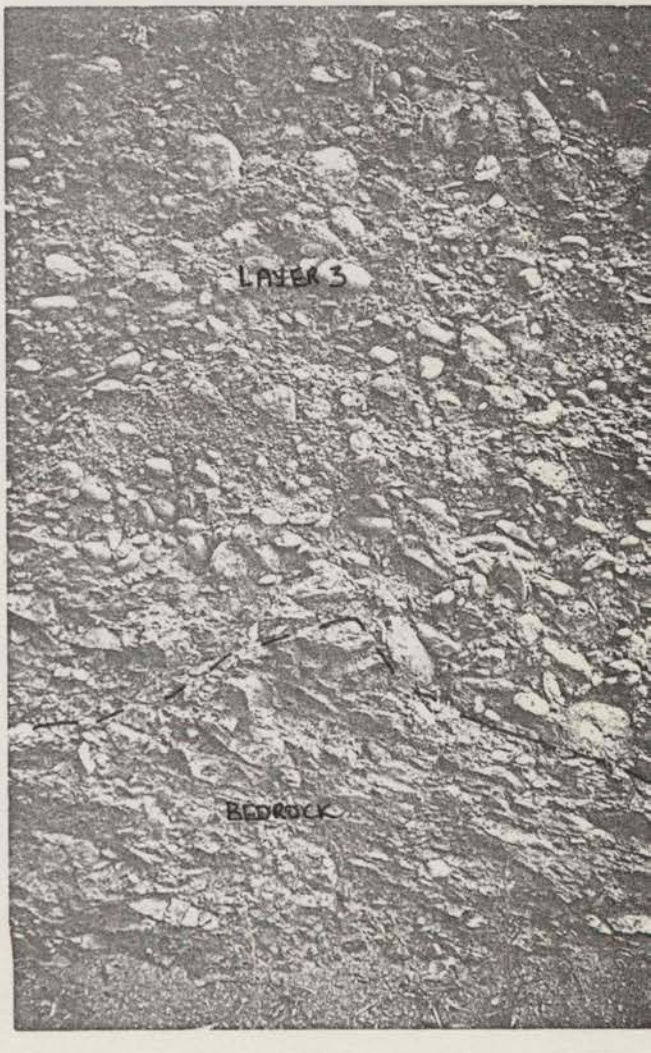


SITE NUMBER : 17 continued
PHOTOGRAPH MV 15387F10



This photograph (MV 15387F10) further demonstrates the steeply sloping boundary of layer 2 against layer 3 and the character of layer 3 boulder deposit which outcrops above the bedrock.

Photograph MV 15387F6 (right) demonstrates the variability within layer 3 as well as the irregular to undulose boundary between layer 3 and bedrock. Lenses of gravel and cobbles occur within the more bouldery material. Layer 3 includes clasts up to 100cm, but clasts are commonly 40cm to 50cm diameter, well rounded, polished and moderately to extremely weathered. Some isolated angular clasts within this layer may have been ripped off local bedrock. The matrix is pale brown silty sand.



Both layer 2 and 3 are relatively unconsolidated. The layer 2 gully fill has been dissected by a drainage line at the southern edge of the exposure, although the main body of the gully fill now forms a broad spur line.

SECTION TWO : STRATIGRAPHY

B) DESCRIPTION OF SURFICIAL DEPOSITS IN THE VALLEYS OF THE MITTA MITTA AND KIEWA RIVERS LEADING UP TO THE BOGONG HIGH PLAINS.

PART TWO : KIEWA CATCHMENT

Decription of surficial deposits in the Kiewa River Valley adjacent to the Bogong High Plains.

Sites 18 to 36 comprise the Kiewa River Valley investigation and the location of these sites is shown on Fig 2Ba, and in some cases on portions of larger scale topographic maps.

SITE NUMBER : 18
G.R. : 053777 Tallangatta 1 :100 000 NATMAP
ELEVATION : 200m
ASPECT : West
GEOMORPHIC SETTING : Distal end of a broad, weakly dissected surface running 2km from a north trending ridge of 500m altitude. The upper section of the slope has a gradient of 6° and the lower, distal portion has a gradient of 2°. The drainage pattern is incised $\leq$ 5m into this surface and is of a subparallel pattern.
STRATIGRAPHY :

Layer 1 : 10cm-20cm thick. Brown gritty loam

Layer 2 : 50cm thick. Quartz grit and dispersed black nodules in red/brown sandy clay matrix.

Layer 3 : Approximately 10cm thick. Concentration of black friable nodules of goethite.

Layer 4 : Approximately 1m thick. Angular quartz granules and gravel in a yellow/brown sandy clay matrix.

INTERPRETATION :

Layer 1 appears to be a recent (Holocene) soil.

Layer 2 appears to be a pre-Holocene accession on an alluvial fan, which has reworked part of an older lateritised surface (Layer 3).

Layer 3 is a lateritized layer, possibly pre-late Pleistocene.

Layer 4 is a matrix supported mudflow associated with an alluvial fan.

SITE NUMBER : 19
G.R. : 064641 Tallangatta 1:100 000 NATMAP
ELEVATION : 280m
ASPECT : West
GEOMORPHIC SETTING : Broad, gently sloping fan mesa with a gradient of 4° towards the west. The adjacent stream is 20m lower than the fan mesa.
STRATIGRAPHY : A 3m section through the top of a fan mesa.

Refer to Photographs K 24587F14, K 24587F13, K 24587F16 and Fig 2B(i) and Fig 2Ba.

Layer 1 : Approximately 20cm thick. Brown gritty loam

Layer 2 : 50cm - 100cm thick. Small, dispersed clasts in a matrix of red clay.

Layer 3 : Remainder of the section. The bedding is complex, but comprises close packed extremely weathered boulders of schist and granite in a red silty sand matrix. The schist and granite clasts are sightly rounded to angular and attain dimensions up to 1.2m. Quartz clasts are all angular. The boulders become matrix supported in places. Also, there exists irregular trough bedded lenses of gravelly sand. Stratification of clasts is limited to localized, weak imbrication. Otherwise clast arrangement is chaotic. Clasts and matrix show alteration and red mottling indicates weak lateritization.

INTERPRETATION :

Layer 1 is a recent (Holocene) soil.

Layer 2 is a late Pleistocene accretion, probably derived from the reworking an older, underlying fanglomerate.

Layer 3 is a slightly consolidated fanglomerate consisting of bouldery debris flow with some stream flood deposits and probably represents a fan head deposit prior to the last cold phase of the Pleistocene.

SITE NUMBER : 19 (continued)
PHOTOGRAPH K 24587F14



This photograph demonstrates layers 1, 2 and portion of layer 3 at site 19. Two large irregular clasts over 1m long are evident. Despite the close packed nature of the clasts, they appear to be supported by the red sandy matrix. The pen in the centre of the photograph is 14cm long.

Photograph K 24587F13 (overleaf, top) is a close up of portion of the close packed fanglomerate of layer 3. The red sandy matrix is evident below and to the left of the pen. (14cm long)

Photograph K 24587F16 (overleaf, below) shows the close packed fanglomerate of layer 3 which overlies a silty lens, also part of layer 3. The dispersed character of layer 2 is evident in the upper portion of the picture above the fanglomerate. The pen is 14cm long.

SITE NUMBER : 19 (continued)
PHOTOGRAPH K 24587F13



PHOTOGRAPH K 24587F16



SITE NUMBER : 19 (continued)
FIGURE 2B(i) : Portion of the Dederang 1:25 000 NATMAP.



The position of site 19 on a flattened spur (fan mesa) implies an inversion in the landscape since the bouldery debris flow was emplaced. The catchment behind the site rises to 1 000m. Road cuttings just to the south of site 19 indicate that the fanglomerate was laterally extensive and that it was at least 30m thick.

SITE NUMBER : 20
G.R. : 080501 Bogong 1:100 000 NATMAP
ASPECT : East
GEOMORPHIC SETTING : A flattened spur adjacent to a deeply incised creek. Deep Creek dissects this fan mesa by 20m. The fan mesa terminates as a steep truncated slope against the Kiewa River at Redbank. The upper section of the fan mesa slopes at 8° and the lower section slopes at 4.5°. The geomorphic setting is similar to site 19.
STRATIGRAPHY : A 3m section on the Keiwa Valley Highway, north of Deep Creek.

Refer to Photographs K 271086F10, K 271086F11 and Fig 2B(ii).

Layer 1 : 20cm-30cm of grey loam.

Layer 2 : 2m of red clay with dispersed clasts and lenses of clast supported and matrix supported conglomerate. Clasts are rounded, moderately to slightly weathered cobbles, mostly 20cm ± 10cm.

Layer 3 : 50-60cm of well structured brown clay with blocky peds.

Layer 4 : A mottled red, brown, grey, sandy clay with dispersed, moderately to extremely weathered clasts. All clasts are of local provenance being metasediment, gneiss or quartz.

INTERPRETATION :

Layer 1 is recent (Holocene) soil.

Layer 2 is a late Pleistocene accretion of debris flow and streamflood channel deposits on an older more extensive fan mesa surface.

Layer 3 probably represents a relic soil horizon from an earlier phase of the now relic alluvial fan.

Layer 4 appears to be earlier (Pleistocene) debris flow.

Photograph K 271086F10 (overleaf, top) depicts the cobble channel fill of layer 2 which rests on the well structured brown clay horizon of layer 3. The hammer is located on layer 3 which is approximately 50cm to 60cm thick. Below this is a mottled red, brown, grey sandy clay with the dispersed clasts of layer 4.

Photograph K 271086F11 shows a 4m section in which a late Pleistocene, V- shaped channel fill of layer 2 dissects layer 3 and a portion of layer 4.

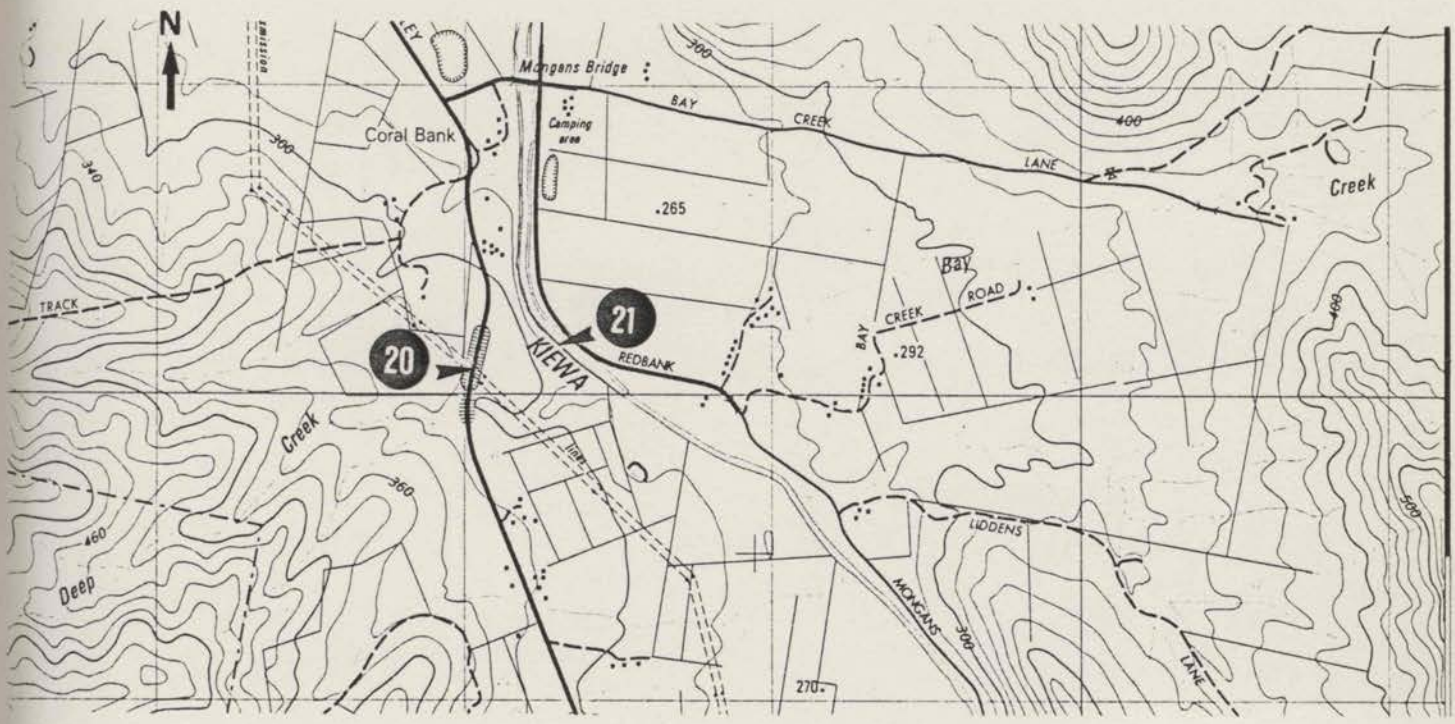
SITE NUMBER : 20
PHOTOGRAPH K 271086F10



PHOTOGRAPH K 271086F11



SITE NUMBER : 20 (continued)
Fig 2B(ii) : Portion of the Running Creek 1:25 000 NATMAP



This figure illustrates the context of the cutting at 080501. The catchment of Deep Creek rises to 1 000m in approximately 3 km above site 20. This figure also illustrates the position of site 21 on the truncated fan mesa adjacent to the Kiewa River.

SITE NUMBER : 21
G.R. : 083502 Bogong 1:100 000 NATMAP
ELEVATION : 280m - 295m
ASPECT : East
GEOMORPHIC SETTING : Fifteen metre exposure of the truncated distal end of the fan mesa described at site 20.
STRATIGRAPHY :

Refer to Fig 2b(ii).

Layer 1 : 30cm thick. Grey loam.

Layer 2 : 70cm thick. Red clay with dispersed rounded clasts, above 2m $\pm$ 1m of bouldery conglomerate and channel lenses comprising rounded clasts c.f. layer 2 at site 20.

Erosional boundary : irregular boundary - cut and fill.

Layer 3 : 1,m thick. Fine grained red/grey mottled material with columnar structure c.f. layer 3 at site 20. This layer contains some dispersed clasts.

Layer 4 : 3m thick. Irregular lenses of rounded cobbles and boulders in a chocolate brown matrix.

Erosional boundary : sharp and laterally continuous

Layer 5 : 3m of boulders in a pale grey/yellow brown matrix.

Material below this layer was obscured.

INTERPRETATION :

Layer 1 is recent (Holocene) soil.

Layer 2 is debris flow and stream flood channels of the late Pleistocene, slightly reworked in the top 70cm. The lower stream flood channels have erased portion of the underlying relic soil horizon.

Erosional boundary.

Layer 3 is a relic soil weakly lateritized during a warm, wet climatic interval.

Layer 4 is from an earlier phase of Pleistocene fan accretion comprising channels of stream flood facies within a 3m section of debris flow.

The sharp undulose erosional boundary was formed as the above phase of fan accretion scoured the underlying material.

Layer 5 is from an older phase of Pleistocene accretion comprising bouldery debris flows.

SITE NUMBER : 22
G.R. : 120437 Bogong 1:100 000 NATMAP
ELEVATION : 300m - 320m
ASPECT : The spur slopes towards the south-west. The cutting faces south.
GEOMORPHIC SETTING : The section passes through a truncated fan mesa revealing 10m -20m of fan accretion, adjacent to the Kiewa River. Refer to Fig 2B(iii). The catchment above site 22 rises to 1 100m in 5km and covers approximately 10 sq. km.
STRATIGRAPHY :

Refer to Photographs K 21186F14, K21186F15, K 7187F13 and Fig 2B(iii).

Layer 1 : 20cm of brown loam

Layer 2 : 3m-4m thick. Relatively fresh bouldery clasts and gravel in a brown sandy matrix.

Layer 3 : approximately 10m thick in combination with layer 4. Extremely weathered cobbles in a compact red, gritty matrix.

Layer 4 :Red, weakly consolidated arkose.

INTERPRETATION :

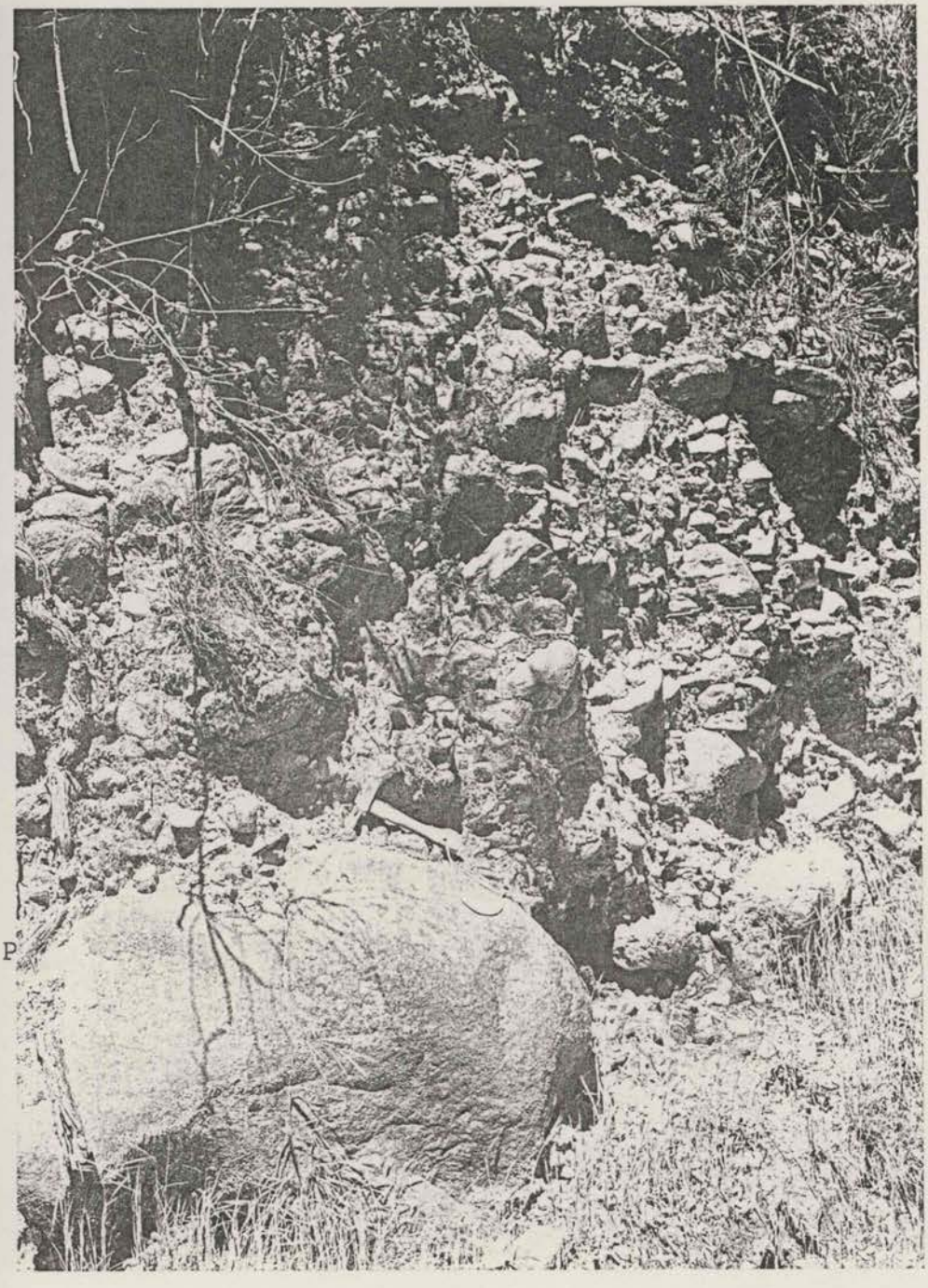
Layer 1 is recent (Holocene) soil.

Layer 2 is a late Pleistocene accretion of bouldery debris flow on alluvial fan surface, which extended further westwards, prior to the Holocene.

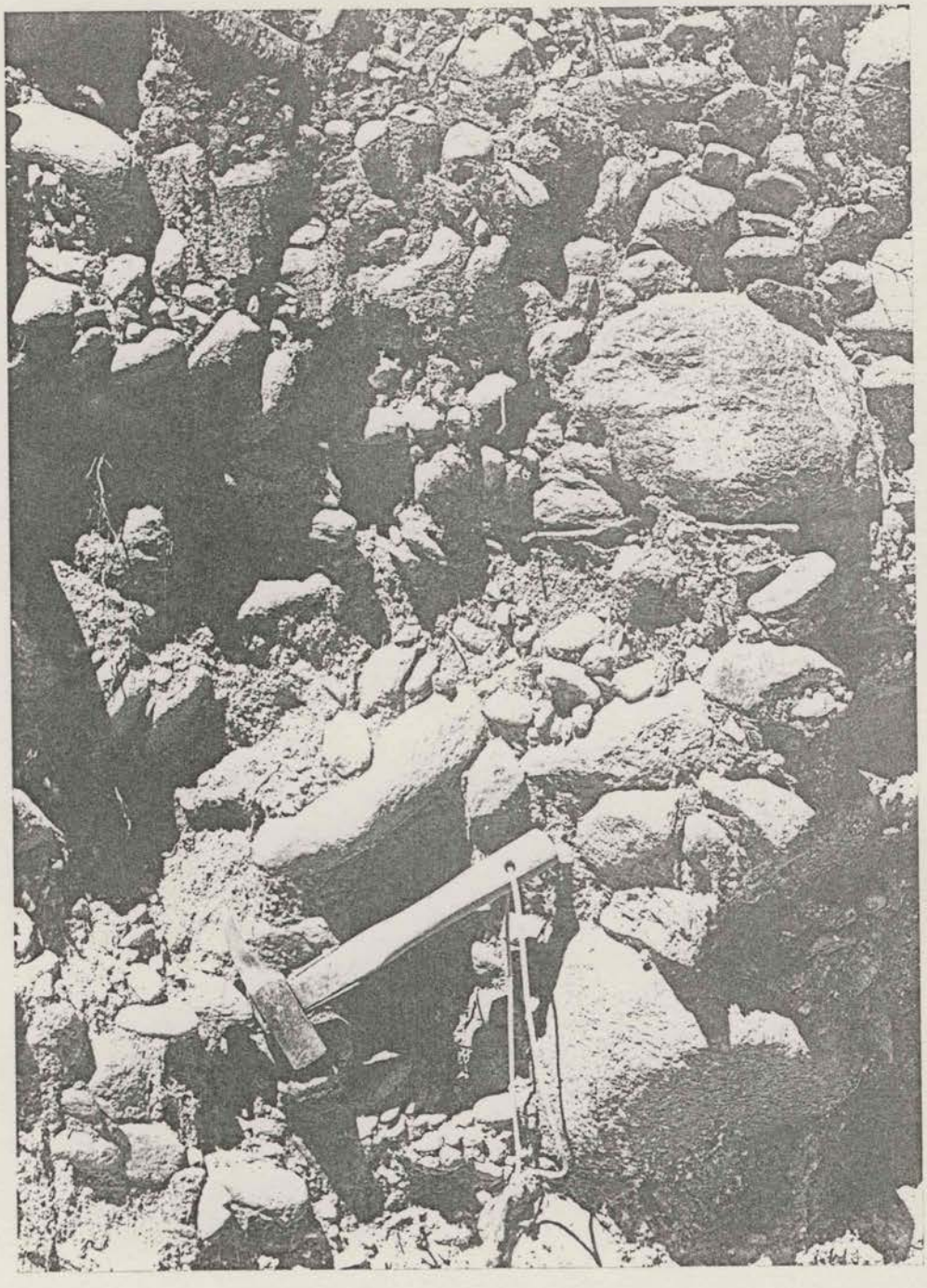
Layers 3 and 4 are older, partially lateritized alluvial fan accreations of debris flow and streamflood facies.

Photograph K 21186F14 (overleaf) demonstrates the upper portion of the road cutting at the distal edge of the truncated fan mesa. The pick gives scale and the clasts range in size from sand to boulders 1.5m across. The clasts are relatively fresh and the matrix is also relatively unaltered compared with the material below it.

SITE NUMBER : 22 (continued)
PHOTOGRAPH K 21186F14

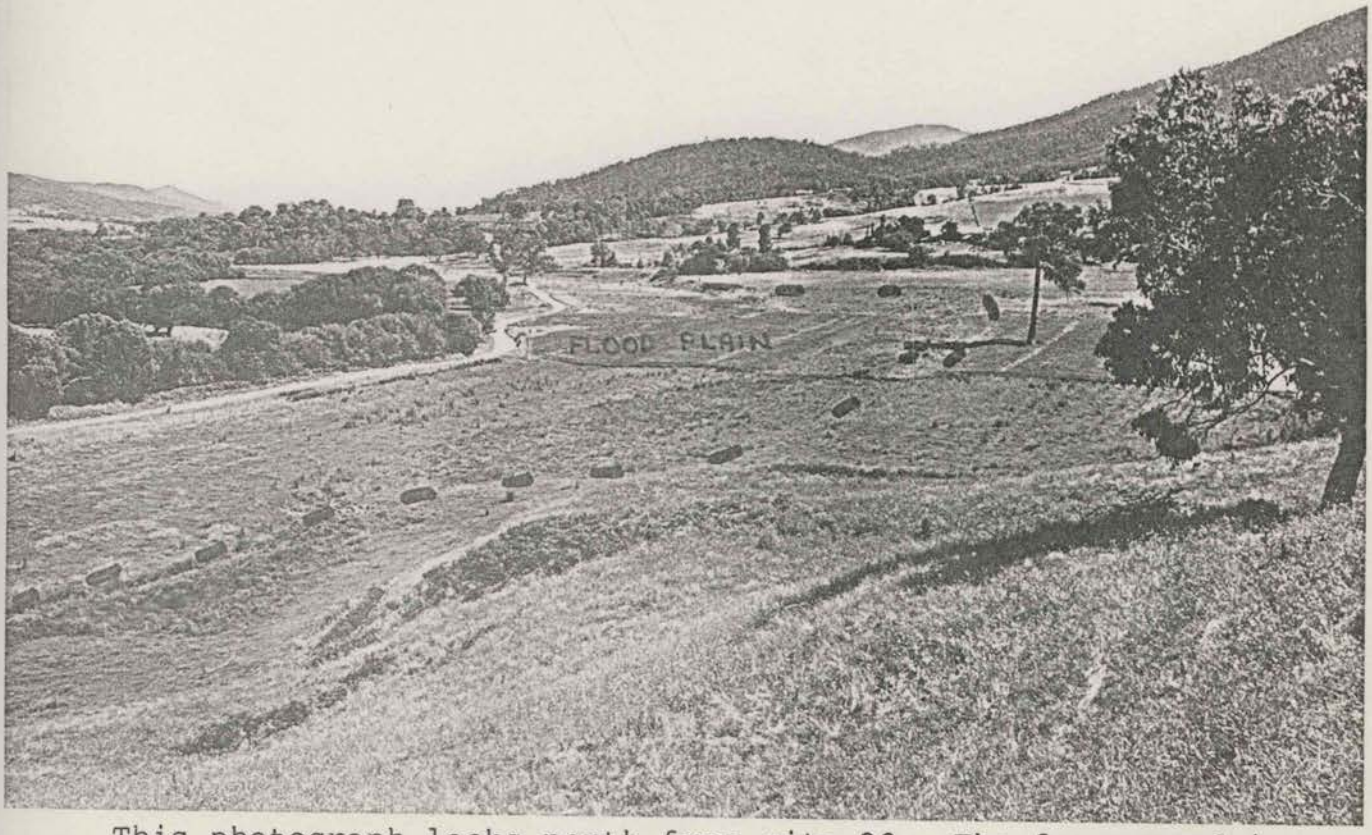


SITE NUMBER : 22 (continued)
PHOTOGRAPH K21186F15



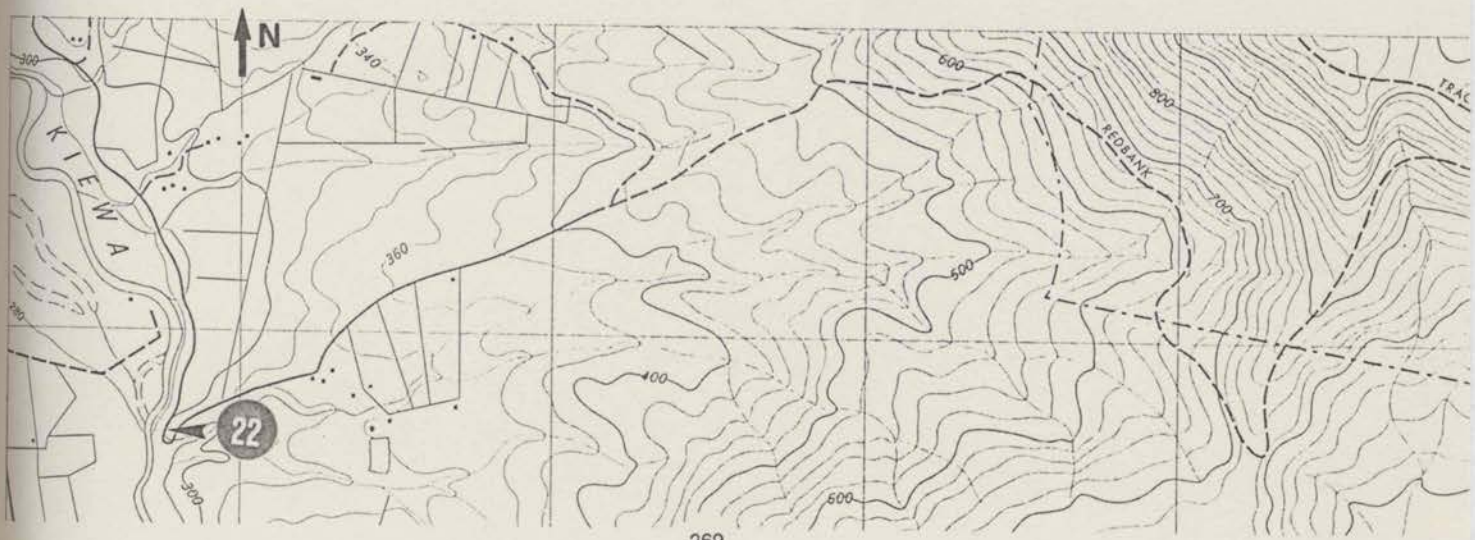
Photograph K 21186F15 demonstrates the close packed, slightly rounded, competent bouldery clasts similar to layer 2 at site 20. The sandy matrix is clearly visible in the photograph.

SITE NUMBER : 22 (continued)
PHOTOGRAPH K 7187F13



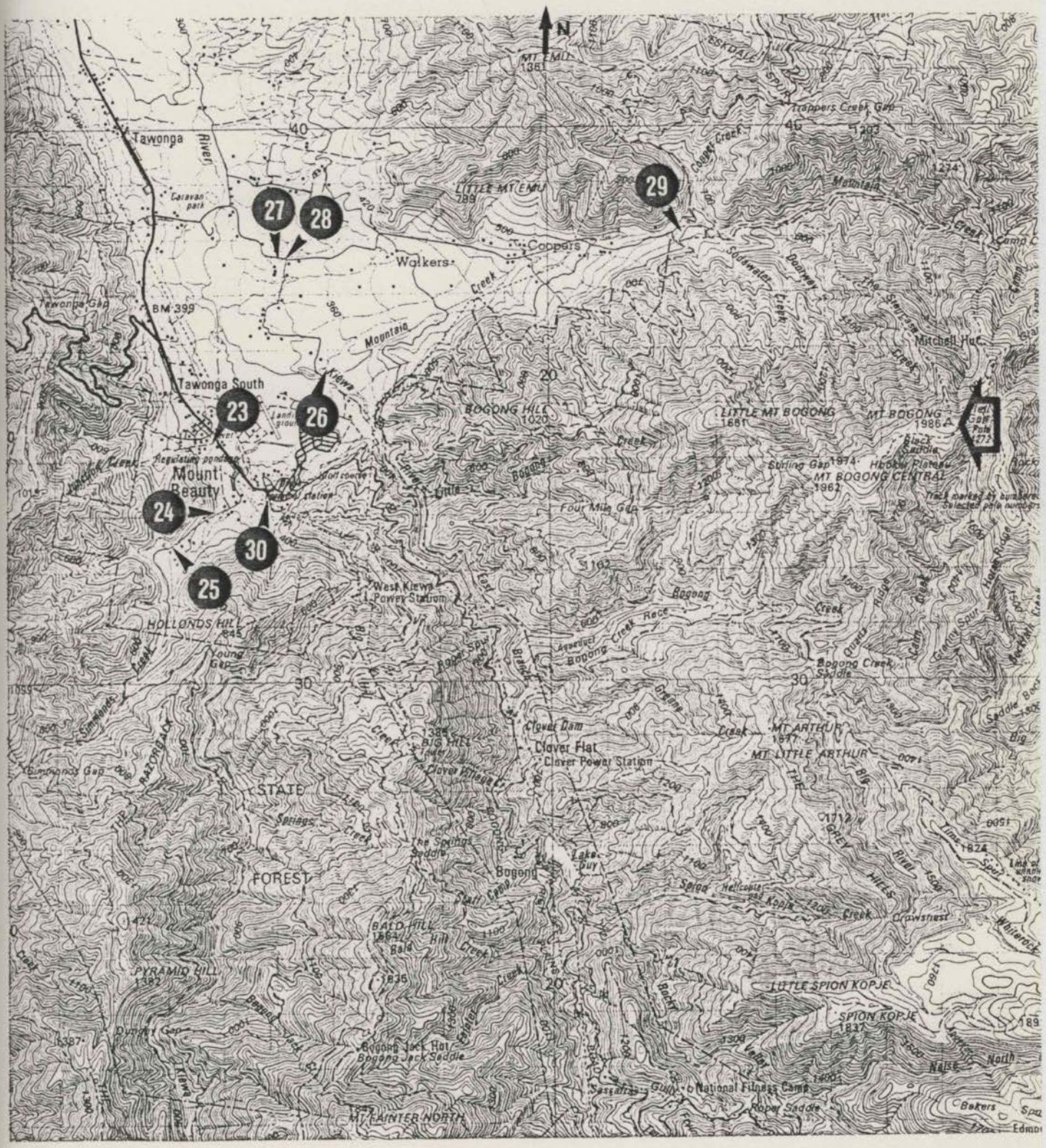
This photograph looks north from site 22. The foreground is the distal end of the truncated fan mesa. The road in the midground lies on the flood plain adjacent to the Kiewa River. The floodplain is incised 1.5m into a relic floodplain, the escarpment of which is clearly visible near the centre of the picture and to the right of the distant section of the road. To the right of this at the foot of the forested slopes lie several other fan mesas, which have been dissected by lateral tributaries of the Kiewa River.

Fig 2B(iii) : Portion of Mt. Beauty 1:25 000 NATMAP



SITES 23 to 30 REFER TO THE FOLLOWING FIGURE.

Fig 2B(iv) : Portion of the Bogong 1:100 000 NATMAP



SITE NUMBER : 23
G.R. : 139343 Bogong 1: 100 000 NATMAP
ELEVATION : 350m
ASPECT : East
GEOMORPHIC SETTING : Site 23 is located at the distal end of a fan mesa truncated by the Kiewa River. The fan mesa slopes at about 4° at its proximal end and 2° towards its distal end. It is dissected by Junction Creek to a depth $\leq$10m. Junction Creek is a portion of a small catchment rising to 1 000m in about 3km to the west of site 23. Refer to Fig 2B(iv), on previous page.
STRATIGRAPHY :

Refer to Photographs K 251086F2 and K 251086F3

Layer 1 : 30cm thick. Grey/brown loam

Layer 2 : 1m -1.2m thick. Coarse gravel and cobbles.

Layer 3 : 1.2m to 1.3m thick. Red brown sandy silty clay with dispersed clasts of up to 15cm.

Layer 4 : 40cm - 50cm thick. Mottled grey, red, brown gravelly sandy silt with dispersed gravel clasts.

Layer 5 : 60cm to 100cm thick. Platy, slightly rounded clasts of metasediment and irregular clasts of quartz.

Layer 6 : mottled, yellow brown gravelly sandy silt.

INTERPRETATION :

Layer 1 is recent (Holocene) soil.

Layer 2 is stream flood gravel facies of alluvial fan sedimentation.

Layer 3 is debris flow facies.

Layer 4 is weakly lateritized debris flow or relic soil horizon.

Layer 5 is streamflood gravel desposit.

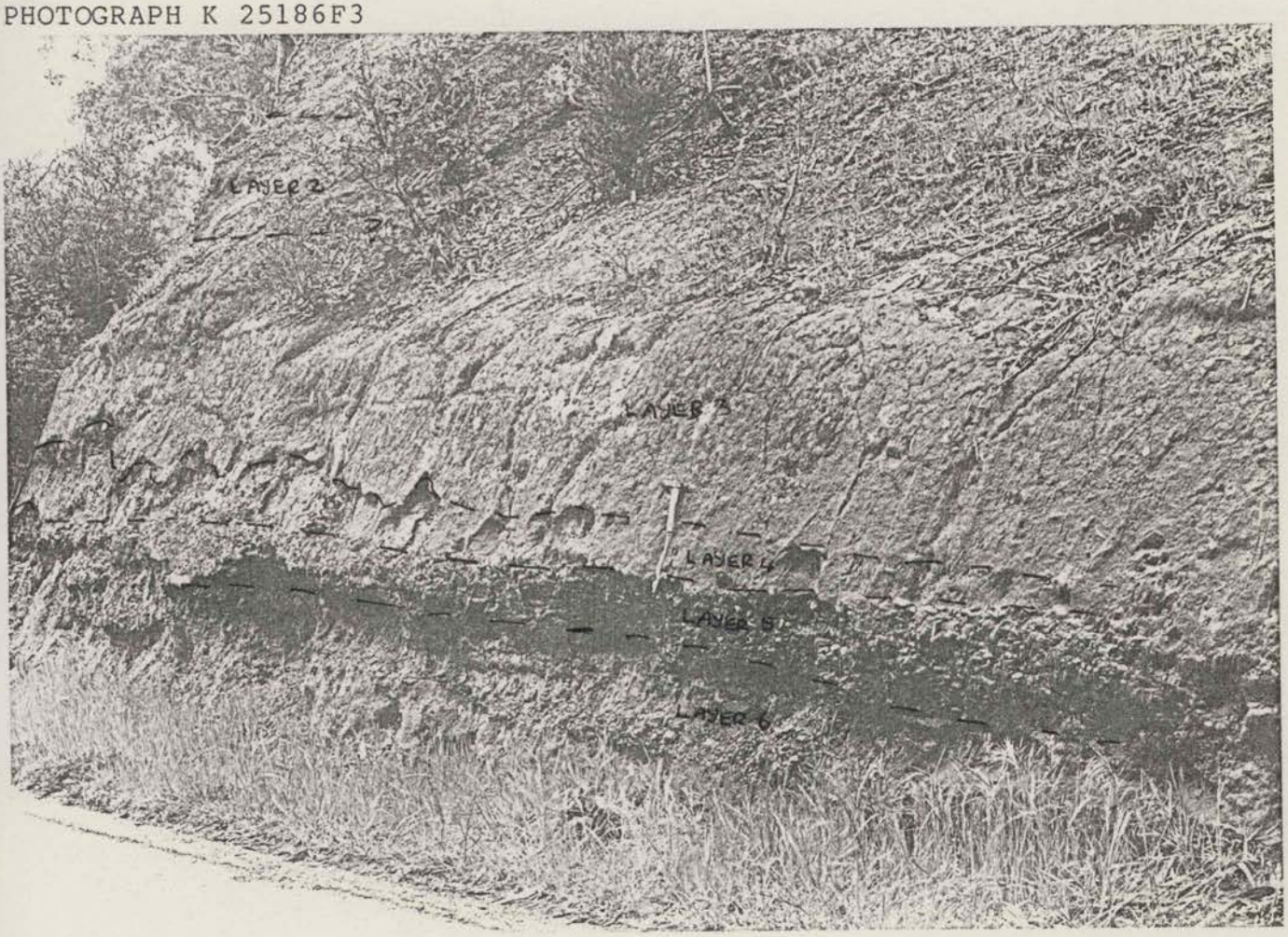
Layer 6 is a weakly lateritized debris flow.

Photograph K 251086F3 (overleaf, top) gives an overview of portion of the cutting near G.R. 139343. The hammer is located near the boundary of layers 3 and 4. Below this is the coarse gravel of layer 5.

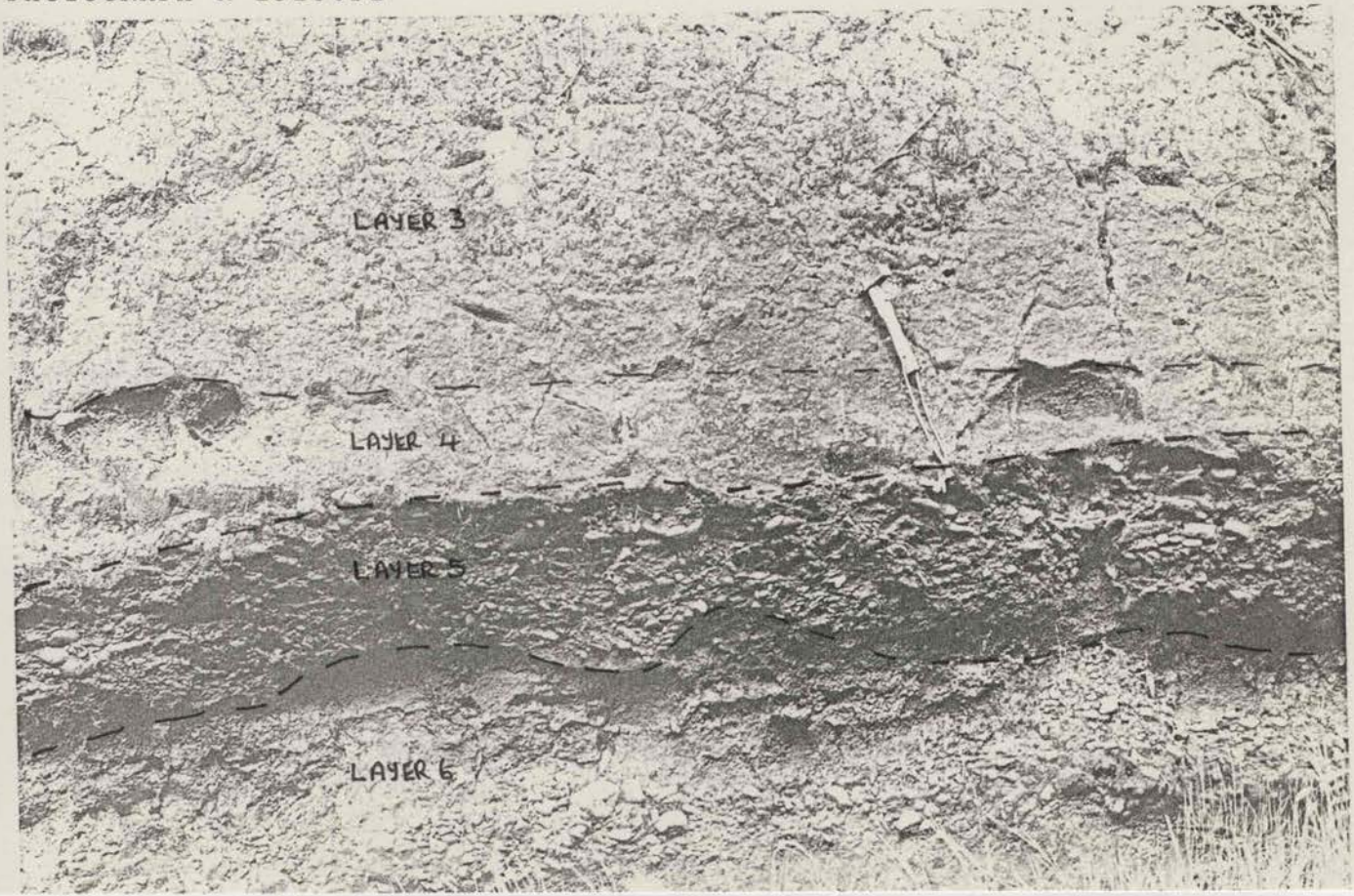
Photograph K 25186F2 (overleaf, below) shows a closeup of the cutting at site 23. The hammer is in the same position as in photograph K 25186F3. This shows the dark well stratified layer 5 comprising close packed, slightly to well rounded clasts. The boundaries of layer 5 are undulose. Most of the coarse clasts in layer 6 have fallen from above.

SITE NUMBER : 23 (continued)

PHOTOGRAPH K 25186F3



PHOTOGRAPH K 25186F2



SITE NUMBER : 24
G.R. : 139331
ELEVATION : 380m
ASPECT : Simmonds Creek drains north-east.
GEOMORPHIC SETTING : Top edge of the truncated margin at the distal end of a relic fan mesa. The fan mesa is dissected to about 15m by Simmonds Creek and is truncated by the Kiewa River. The fan mesa slopes about 4° towards the north-east.
STRATIGRAPHY :

Refer to Photograph K 251086F6, Fig 2B(iv) (local topography) and Fig 2B(v) (Stream profiles)

Site 24 is a 2m section, and is illustrated in photograph K 251086F6.

Layer 1 : 20cm thick. Brown loam.

Layer 2 : 30 cm thick. Red clayey sand.

Layer 3 : 15cm (variable) thick. Cobbles in a clay sand matrix.

Layer 4 : 40cm-50cm thick. Clayey sand

Layer 5 : 10cm thick. Weakly stratified cobbles

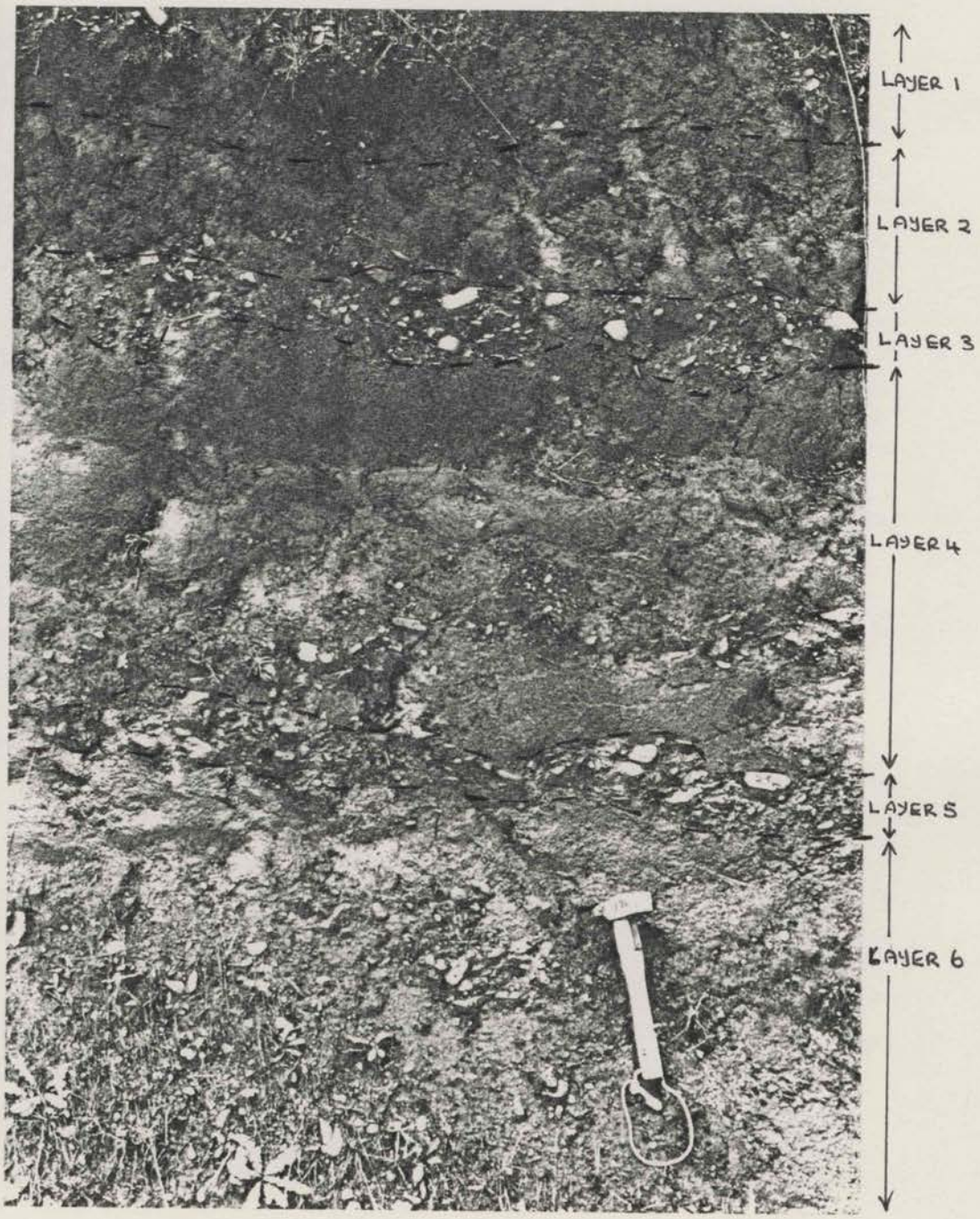
Layer 6 : 40cm - 50cm thick. Clayey sand.

Most of the other exposures in the upper section of the lower fan mesas against the Kiewa River, are mostly composed of dispersed clasts in a red clayey matrix.

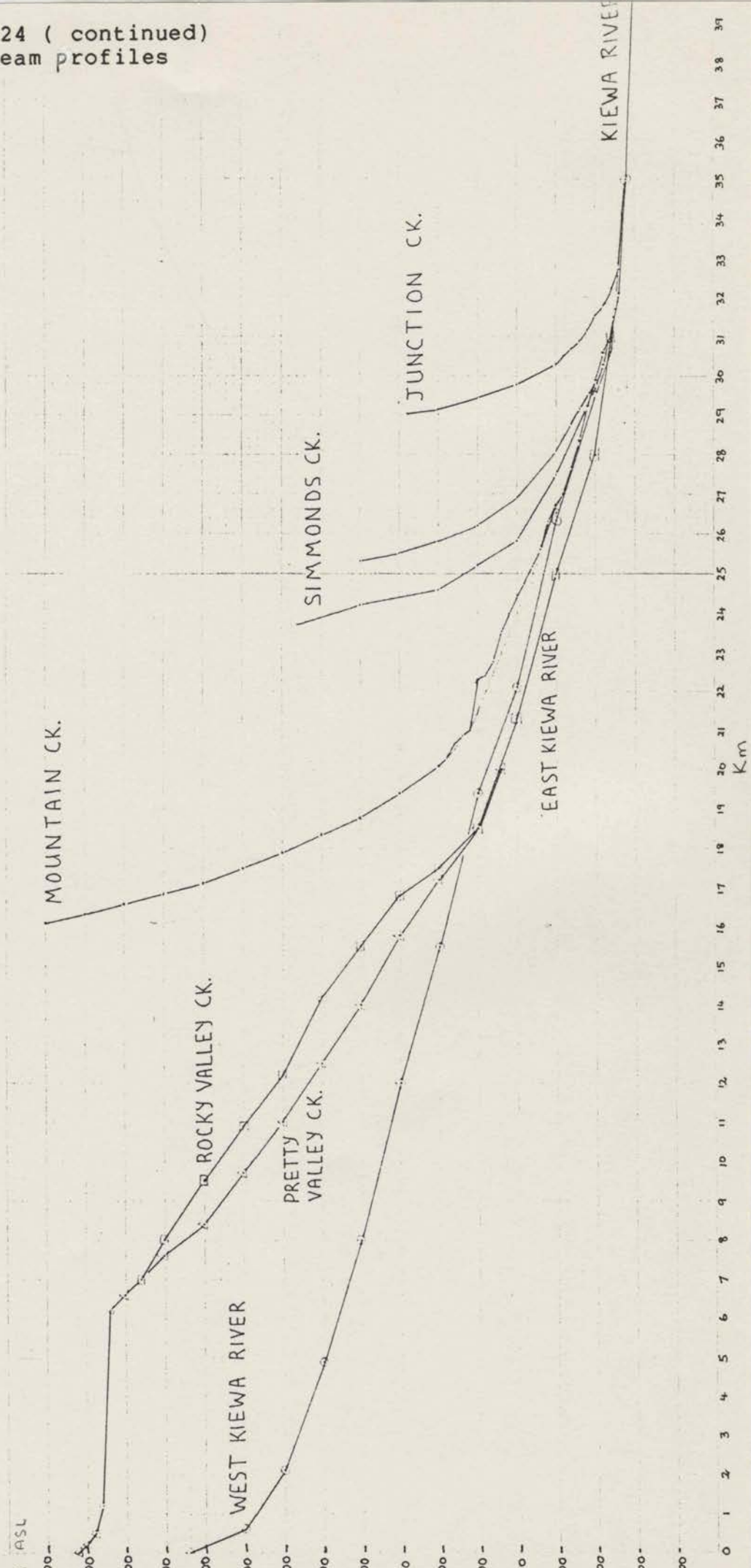
The alternating cobble layer/clayey sand layer at site 24 is similar in style to the exposure at site 23; and probably represents accretions derived from alternate sheetflood facies and debris flow facies. The clasts are moderately weathered to extremely weathered : knotted cordierite schist, biotite schist, hornfels, phyllite and spotted hornfels.

Most of the material in this distal section of the fan mesa is probably pre-late Pleistocene due to its degree of weathering, deep dissection and depth of reworking along the upper surface.

SITE NUMBER : 24 (continued)
PHOTOGRAPH K 251086F6



SITE NUMBER : 24 (continued)
Fig 2B(v) Stream profiles



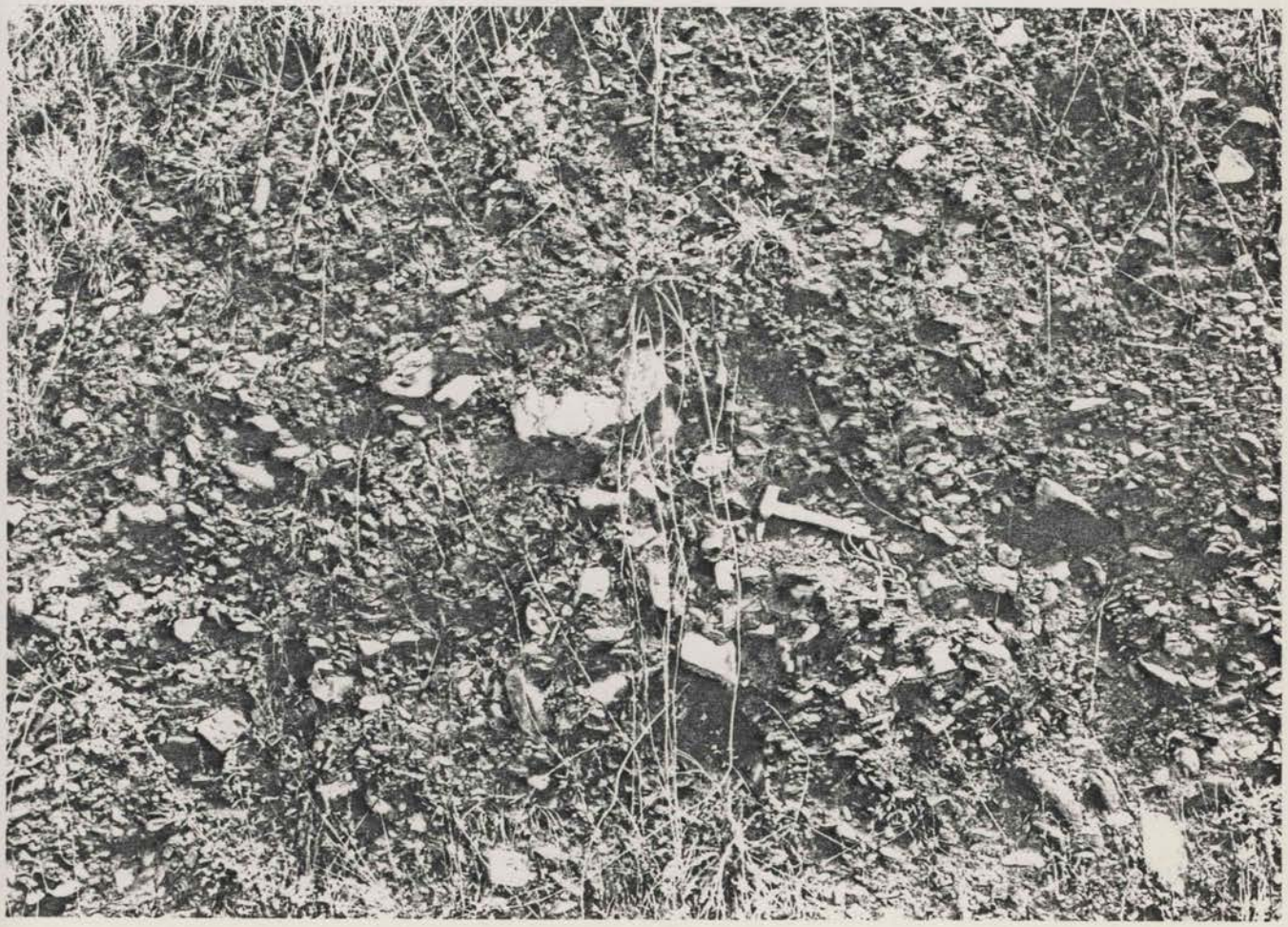
SITE NUMBER : 25
G.R. : 130325 Bogong 1:100 000 NATMAP
ELEVATION : 420m
ASPECT : Tributary Creek drains east.
GEOMORPHIC SETTING : Mid fan section near the intersection of a tributary with the main trunk of Simmonds Creek. The tributary rises to 1 100m in 4km.
STRATIGRAPHY : Site 24 is a 2.5m section at G.R. 130325.

Refer to Photographs K 251086F4, K251086F5, Fig 2B(iv) and Fig 2B(v).

Layer 1 : 30cm thick. brown loam.

Layer 2 : Moderately rounded to angular, competent clasts of phyllite and spotted grey cordierite hornfels in a gravelly clay matrix. The relatively unweathered clasts are mostly between 2cm and 40cm and stratification is mostly non-existent except for localized lenses of cross-bedded gravel.

PHOTOGRAPH K 251086F5
This photograph gives an overview of much of the section at site 25. The bedding is complex and includes channel fills and debris flow.



SITE NUMBER : 25 (continued)
PHOTOGRAPH K 251086F4



This photograph is a closer view showing the cross-bedded gravels within the coarser debris flow. The lack of alteration of this material and its minor dissection by streams suggest that it is relatively young, perhaps late Pleistocene, as it is overlain by a brown loam soil which is assumed to be Holocene.

SITE NUMBER : 26
G.R. : 160356 Bogong 1:100 000 NATMAP
ELEVATION : 350m
ASPECT : South-west
GEOMORPHIC SETTING : An elevated river terrace of bouldery riverine gravel situated 4m above the adjacent East Kiewa River floodplain, near its junction with Mountain Creek. These elevated gravels are at the distal margins of the Mountain Creek alluvial fan complex which has been mapped as Qrc. The gravels at this site have been mapped as Qc on the Tallangatta Geological Map (Fig 2Ba), which is supposed to represent riverine sediments in the present floodplain.
STRATIGRAPHY : The 4m section is inside the quarry at site 26.

Refer to Fig 2B(iv) (topographic plan), Fig 2B(vi) (cross-sectional sketch) and Photographs K 21186F17 and K 21186F19.

Layer 1 : 60cm thick . 20cm of dark grey loam overlies 40cm of red/brown loam.

Layer 2 : 1m-1.5m thick. Bouldery gravel comprising slightly weathered to highly weathered, rounded clasts in a red/brown micaceous sand matrix. Most clasts are competent.

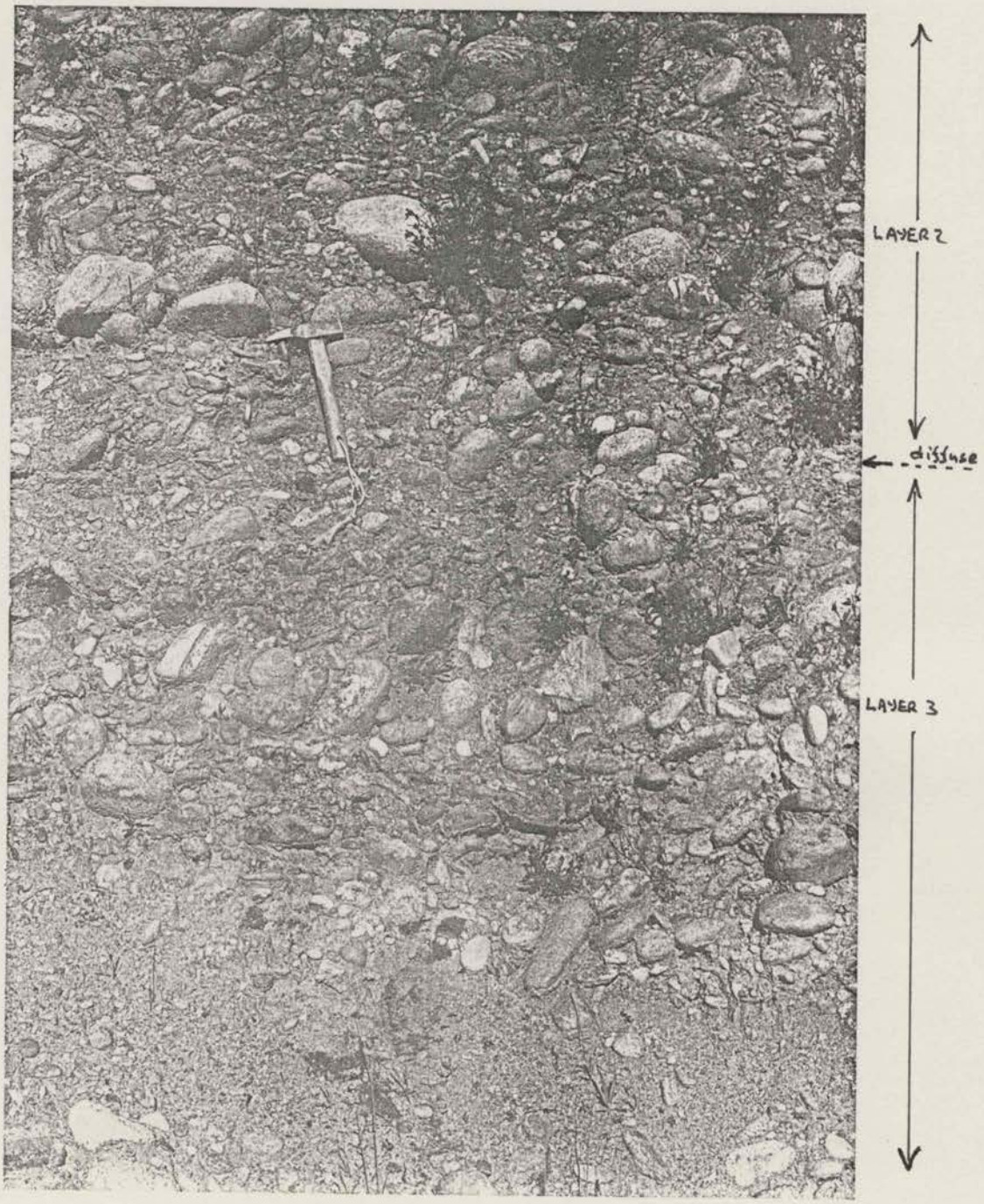
Layer 3 : Remaining 2m. Bouldery gravel in a grey micaceous sand matrix with interbedded sand/gravel lenses. Iron staining is evident within the sandy matrix in places.

Approximately 600m upstream, the elevated terrace continues to expose gravel material but clasts are poorly sorted and rounded to sub-rounded in a red sandy matrix. Most clasts are still competent, being slightly to moderately weathered.

The clast provenance at site 26 appears to be local and comprises gneiss, porphyry and knotted schist. Clast size decreased towards the top of the section at this site. The modal size of the clasts is 4cm-5cm.

Photograph K 21186F17 (overleaf) demonstrates a 3m section of the exposure at site 26. Texture appears to be mostly chaotic imbricate in places.

SITE NUMBER : 26 (continued)
PHOTOGRAPH K 21186F17



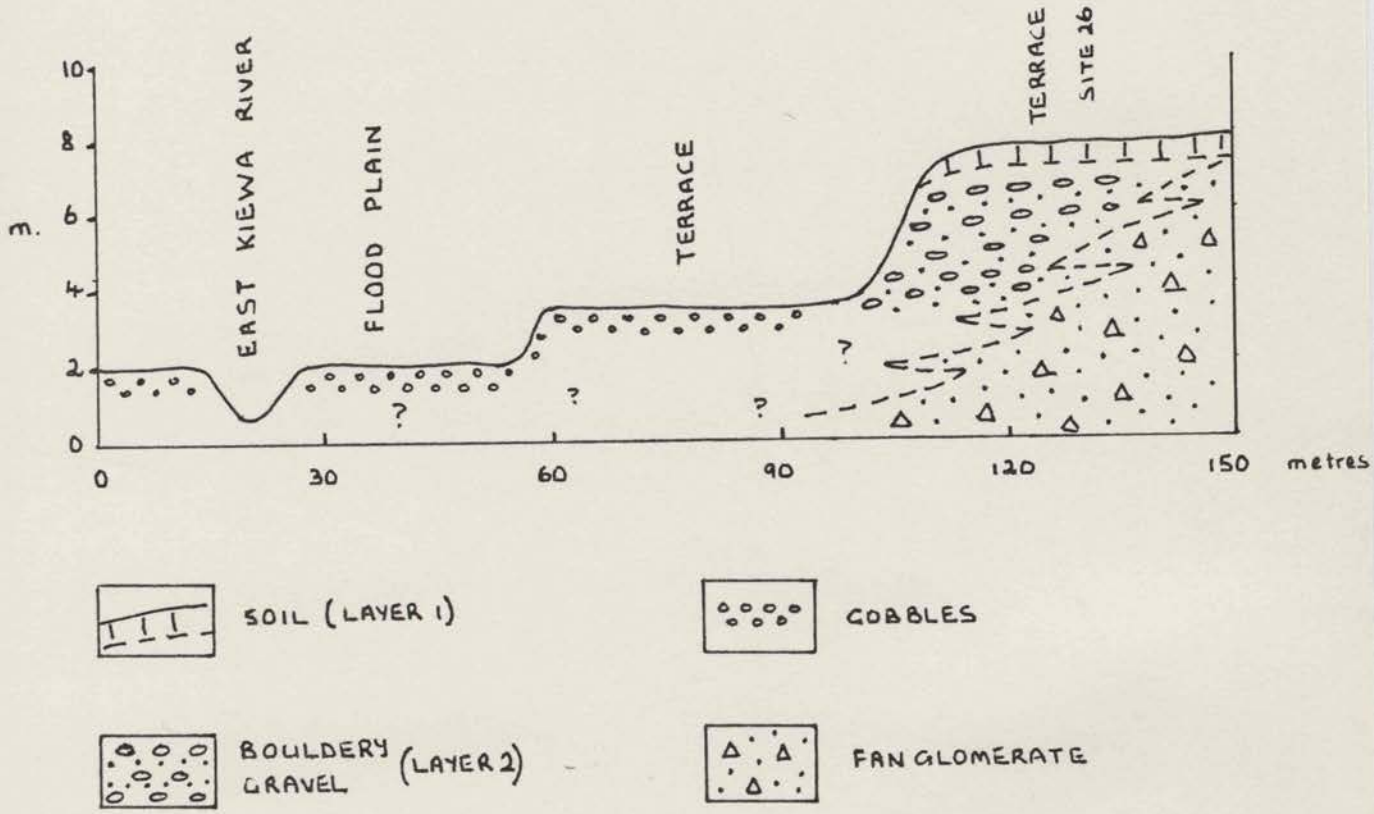
SITE NUMBER : 26 (continued)

PHOTOGRAPH K 21186F19



Photograph K 21186F19 reveals a 2m section of the exposure at site 26, which demonstrates the composite stratification within the section of lenses and channels. Some of the larger clasts are only slightly rounded which suggests that material has not been transported far or subjected to a high energy environment for long periods.

SITE NUMBER : 26 (continued)
Fig 2B(vi) : Cross-Sectional Sketch Across the Kiewa River at Site 26.



This figure summarizes the relationships of the river to the elevated terrace and demonstrates that the elevated terrace at site 26 cannot be Qc Coonambidgal Formation because its elevation and associated soil development indicate that it is pre-Holocene. The lower terrace and floodplain are Coonambidgal Formation which comprises a lag deposit of cobbles after a high energy phase of water flow down the Kiewa River earlier in the Holocene. The bouldery gravels of layer 2 at site 26 probably represent reworked fanglomerate at the distal margin of the Mountain Creek alluvial fan complex which approximates to the distribution of Qrc and Qs along Mountain Creek. Refer to Fig 2Ba. Layer 2, the bouldery gravel, could be late Pleistocene but it also could be older.

SITE NUMBER : 27
G.R. : 151377 Bogong 1:100 000 NATMAP
ELEVATION : 340m
ASPECT : West
GEOMORPHIC SETTING : Small telescopic fan where the creek exits from a reentrant into a large truncated fan complex. The creek has cut a section through the small teloscopic fan which projects onto the adjacent Kiewa River floodplain. The adjacent truncated alluvial fan terrace rises 10m to 15m against the floodplain.
STRATIGRAPHY : Site 27 is a 1.7m section in the creek cutting.

Layer 1 : 30cm thick. Dark, organic loam.

Layer 2 : 70cm thick. Grey gravelly sand, silty clay.

Layer 3 : mottled orange/grey clay with dispersed clasts becoming sandy at the base of the section.

INTERPRETATION:

The small telescopic fan could have formed earlier in the Holocene in response to a change in drainage from fan-like to dendritic which would have accelerated erosion at the distal margins of the Mountain Creek fan complex. It may have been contemporaneous with the lateral corrasion of the Mountain Creek fan complex against the actively downcutting floodplain of the Kiewa River earlier in the Holocene.

Refer to Fig 2B(iv) for local topographic detail.

SITE NUMBER : 28
G.R. : 153377 Bogong 1:100 000 NATMAP
ELEVATION : 355m
ASPECT : Surface of fan complex slopes towards the west.
GEOMORPHIC SETTING : This site is located at the upper surface of the Mountain Creek fan complex adjacent to its escarpment with the Kiewa River floodplain.
STRATIGRAPHY : Site 28 is a 1.8m section of the fan complex.

Refer to Photographs K 251086F9, K 251086F7 and Fig 2Ba and Fig 2B(iv).

Layer 1 : 30cm thick. Brown loam.

Layer 2 : Approximately 1m thick. Dispersed blocks and cobbles in a red clay matrix.

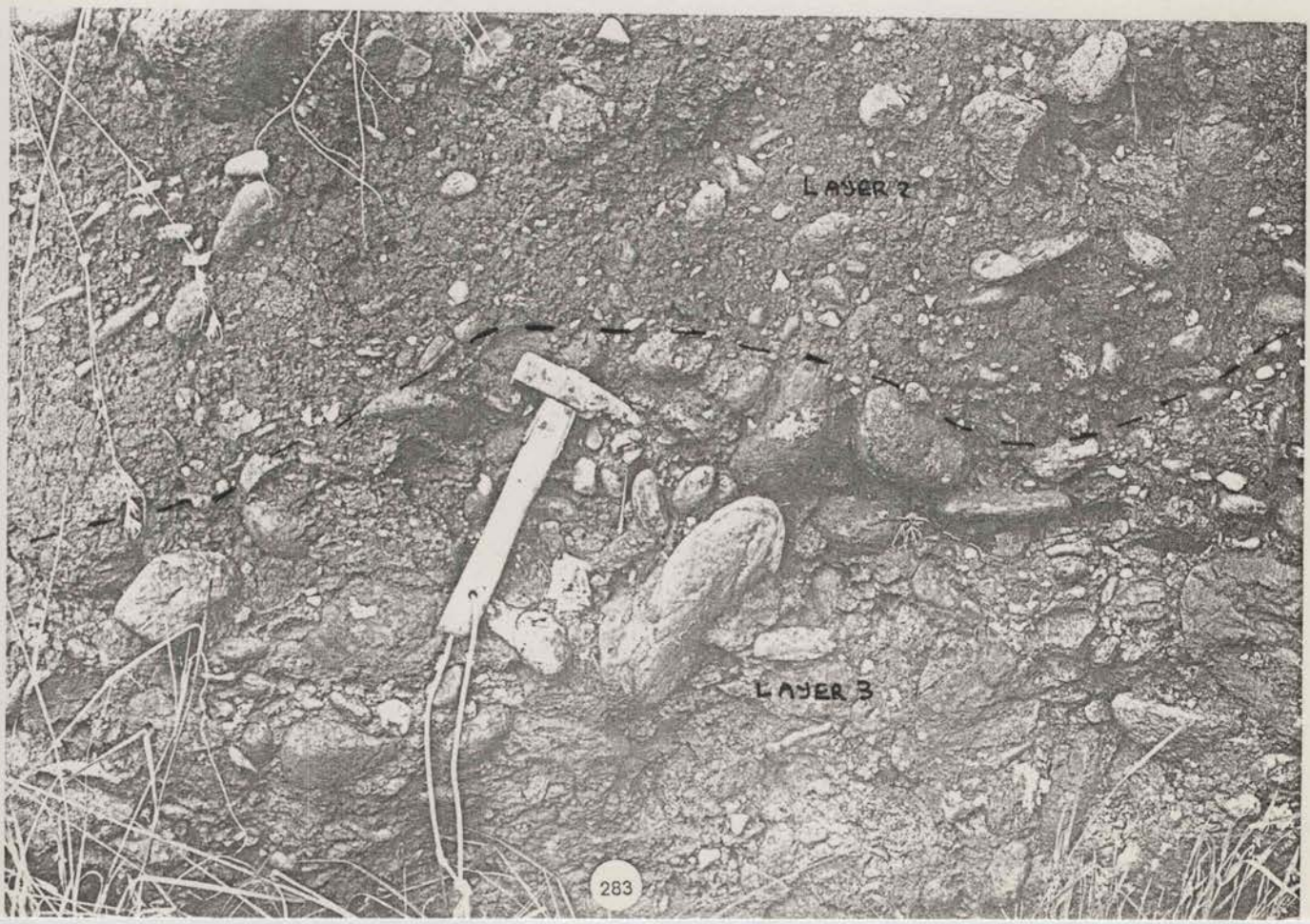
Sharply defined, undulose erosional boundary.

Layer 3 : close packed cobbles and blocks in a yellow sand-clay matrix.

Large clasts of extremely weathered granite and moderate to extremely weathered metasediments which are moderately rounded. Quartz clasts remain irregular with minimal rounding or smoothing, suggesting that this material has not been exposed to a high energy environment for any significant length of time.

PHOTOGRAPH K 251086F9

This photograph demonstrates the undulose boundary between layers 2 and 3. Layer 2 conains a lot more clay and a lot fewer clasts than layer 3. The head of the hammer is located just below the boundary of layers 2 and 3.



SITE NUMBER : 28 (continued)
PHOTOGRAPH K 251086F7



This photograph demonstrates a similar section to the previous photograph. The bedding in layer 3 below the pick point is poorly sorted and chaotic, and similar to material described as layer 3 of site 19. The imbricated, dispered clasts above the pickpoint suggest reworking of layer 3 and this layer 2 is similar to layer 2 at site 19.

The higher clay content of layer 2 may be explained by decomposition and dispersion of extremely weathered clasts during the reworking phase.

INTERPRETATION :

Layer 3 exposed at site 28 is probably pre-late Pleistocene given its location within a deeply dissected fan mesa. The material exposed is consistent with a debris flow characteristic of alluvial fans in semi-arid environments where occasional (rare) heavy downpours can mobilise a large amount of loose weathered surface material in a slurry capable of considerable downslope movement. The overlying layer 2 probably represents late Pleistocene reworking of layer 2 and the soil layer 1 is probably Holocene.

This site has been mapped as Qs on the Tallangatta Geological Map, but it is not riverine in character.

SITE NUMBER : 28 (continued)

Other sections in the road cutting below site 26 which comprise layers below layer 3 within the Mountain Creek alluvial fan, consist of extremely weathered, moderately rounded metasediment clasts and slightly rounded quartz dispersed in a matrix of red brown sandy clay. This also is consistent with a debris flow process of deposition. The material in the distal portions of the Mountain Creek fan complex has been isolated by downcutting due to rejuvenation of the tributary streams of Mountain Creek. This isolation of the distal fan components of the Mountain Creek alluvial fan complex may predate the late Pleistocene.

SITE NUMBER : 29
G.R. : 223381 Bogong 1:100 000 NATMAP
ELEVATION : 600 m
ASPECT : N.A.
GEOMORPHIC SETTING : A cross section of the upper reaches of Mountain Creek near the head of the Mountain Creek alluvial fan complex. The small inset floodplain of Mountain Creek is flanked by a riverine terrace 1m to 1.5m high composed of large rounded boulders, which in turn is flanked to the south by a 15m escarpment of a fan mesa composed of fanglomerate.
STRATIGRAPHY : Stratigraphy is best represented by a cross-sectional sketch (Fig 2B(vii)) and the accompanying notes as well as Fig 2Ba, Fig 2B(iv) and Fig 2B(v).

The fanglomerate comprises bouldery clasts dispersed in a red sandy clay matrix. Clasts range from rounded to angular and slightly weathered to very weathered. Clasts become closer packed towards the top of the fanglomerate exposure. The fanglomerate terrace extends out from the flanks of Mt Bogong for several hundred metres, sloping 4°-6° towards the north-west.

The brown sandy clay matrix is unconsolidated, friable and contains no mottling. Some boulder clasts are up to 1.2m across, irregular and extremely weathered. The fanglomerate appears to extend upstream along the northern flanks of Mt Bogong. The cleared, sloping farmland downstream, due west of site 29, reveals dispersed angular blocks in a red matrix, similar to the material exposed in the fan mesa escarpment at site 29.

The boulders in the terrace perched about 3m above Mountain Creek at site 29 are waterworn competent and range in size from 0.5m to 1m. These boulders probably represent a lag deposit from the corrasion of the distal edge of the adjacent fanglomerate terrace which must have been extended further northwards in the past judging by its steeply truncated form.

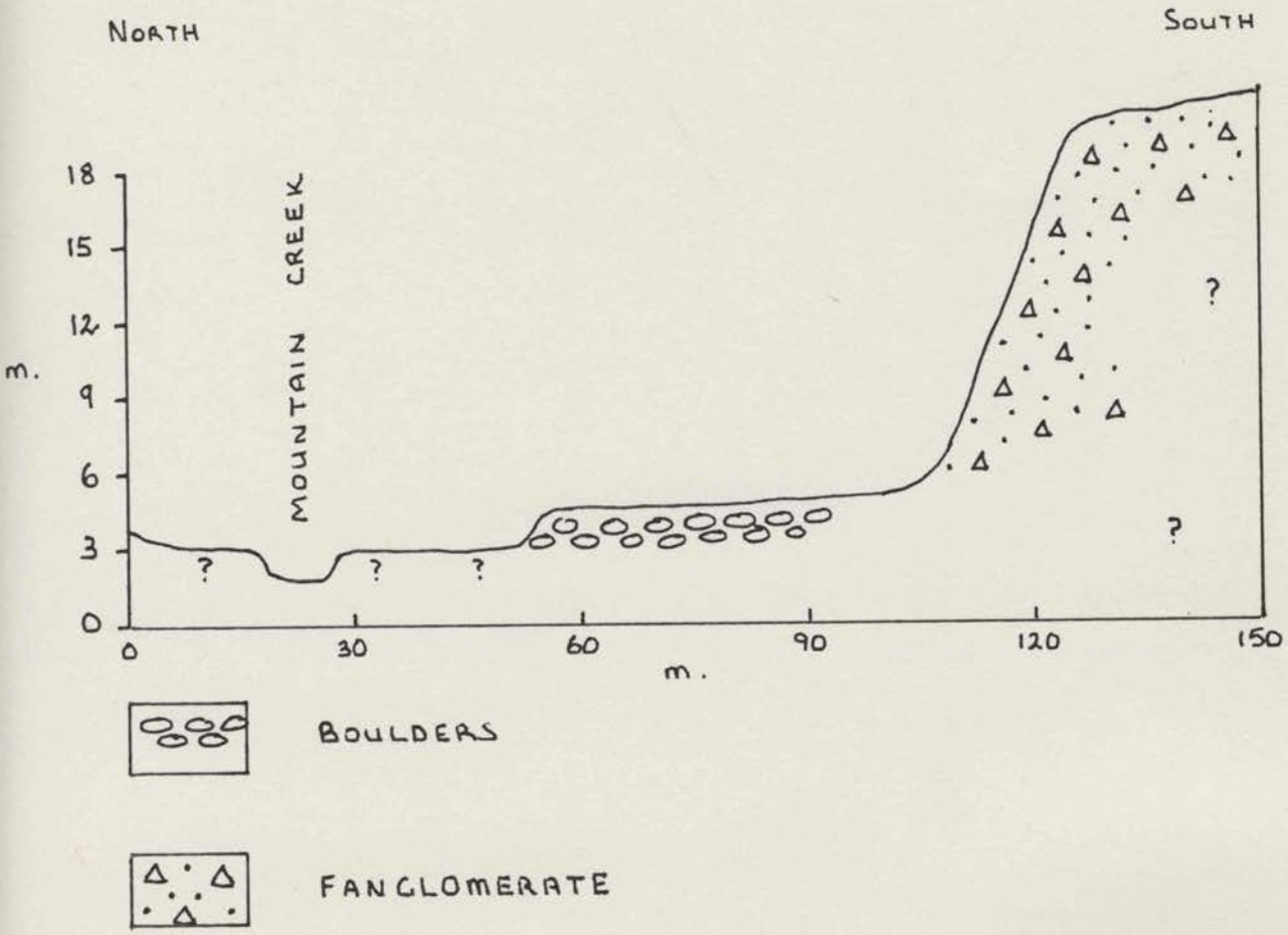
This boulder deposit in the floodplain has probably caused the creek to migrate slightly northwards over less resistant terrain. A perusal of Fig 2B(v) reveals a step in the profile at 730m.ASL. This step probably represents the start of similar lag deposits further upstream and the profile seems to run above its expected catenary curve for as far downstream as 480m. ASL.

All this material may be indicative of alluvial fan activity on this section of the Mountain Creek fan complex during the late Pleistocene as no examples of lateritization or relic soil horizons have been observed in this upper section of the Mountain Creek fan complex.

The Tallangatta Geological map (Fig 2Ba) depicts site 29 and a similar site upstream, as Qs (Shepparton Formation). This material is not riverine in character and since similar material has been mapped as Qrc elsewhere on the Tallangatta Geological Map, it seems inconsistent to map the fanglomerate as Qs.

SITE NUMBER : 29 (continued)
Fig 2B(vii) : Cross sectional Sketch Across Mountain Creek at G.R. 223382 BOGONG 1:100 000 NATMAP.

The creek has been displaced to the north.



SITE NUMBER : 30
G.R. : 148335 Bogong 1:100 000 NATMAP
ELEVATION : 355m
ASPECT : N.A.
GEOMORPHIC SETTING : This site is a profile from the Tail Race Channel at Mt Beauty across the floodplain of the West Kiewa River near its exit and across the lineation of the Tawonga Fault. The Profile is drawn as Fig 2B(viii), and is just downstream of and perpendicular to the Portal of No. 4 Tail Race Tunnel. Another figure, taken from Beavis (1959) is a longitudinal section through the No. 4 Tail Race Tunnel and is reproduced here as Fig 2B(ix).

STRATIGRAPHY: The riverine boulder and cobble deposit in Fig 2B(viii) is exposed along the length of the Tail Race Channel below its exit from the mountain. This deposit comprises tightly packed, weakly imbricated cobbles in a sandy matrix in the upper portion of the section with cobbles and waterworn boulders (40cm-50cm) in the lower portion of the section. (Similar to layer 2 site 26.)

over the riverine boulder and cobble deposit

The 60cm capping of red/brown loam suggests that this material may have been contemporaneous with layer 2 bouldery gravel at site 26, despite the differences of scale. The clasts in this deposit are nearly all very competent which suggests that it is not very old. The soil capping suggests pre-Holocene which means that this material could be late Pleistocene. This riverine boulder and cobble deposit was intersected during the excavation of No. 4 Tail race Tunnel.

According to Beavis (1959) " The No. 4 Tail race Tunnel portalled in the boulder conglomerate and was driven into this material for a length of 425 feet at which point, brecciated gneiss appeared in the back of the tunnel, overlying the alluvium....."

Beavis noted that the plane of the Tawonga Fault had a strike of N 048° E with a dip of 16° south east. This is illustrated in Fig 2B(ix). Beavis (1959) noted the presence of Tertiary basalt clasts in the alluvium, the rounded nature of boulders and virtual absence of clay particles from the matrix. This then suggests that the Tawonga Fault has been active up until the late Pleistocene.

The Tallangatta Geological Map (Fig 2Ba) represents the floodplain material at the foot of the Tawonga Fault in the vicinity of site 30 as Qrc (hillwash) when it is quite evident that it is riverine gravel. The elevated terrace of riverine boulders and cobbles at site 30 could probably be mapped as Qs (Shepparton Formation) and the adjacent, lower riverine cobble/sand deposit could be mapped as Qc (Coonambidgal Formation) which represents a reworking and incision of the older Pleistocene deposits. Hillwash however, is evident on the moderately steep terrain behind (south) of Mt Beauty township, which had been mapped as O-Sn (Ordovician metasediments) on the Tallangatta Geological Map.

SITE NUMBER : 30 (continued)
Fig 2B(viii) : Profile Sketch Across the West Kiewa River at Mt. Beauty.

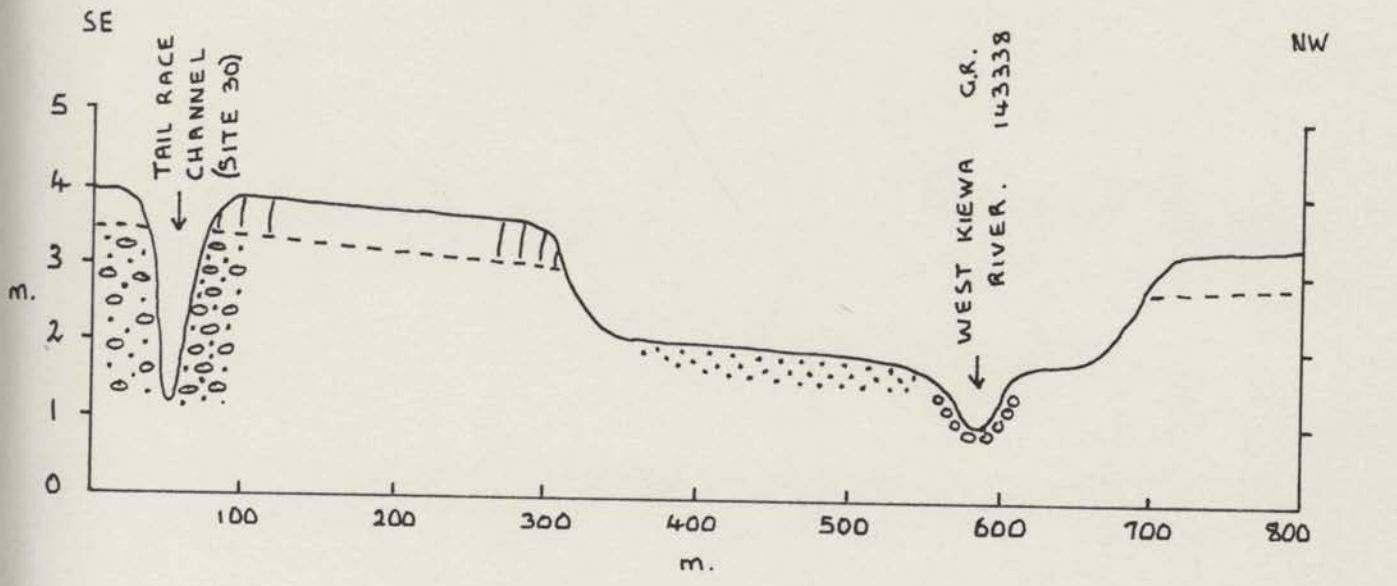
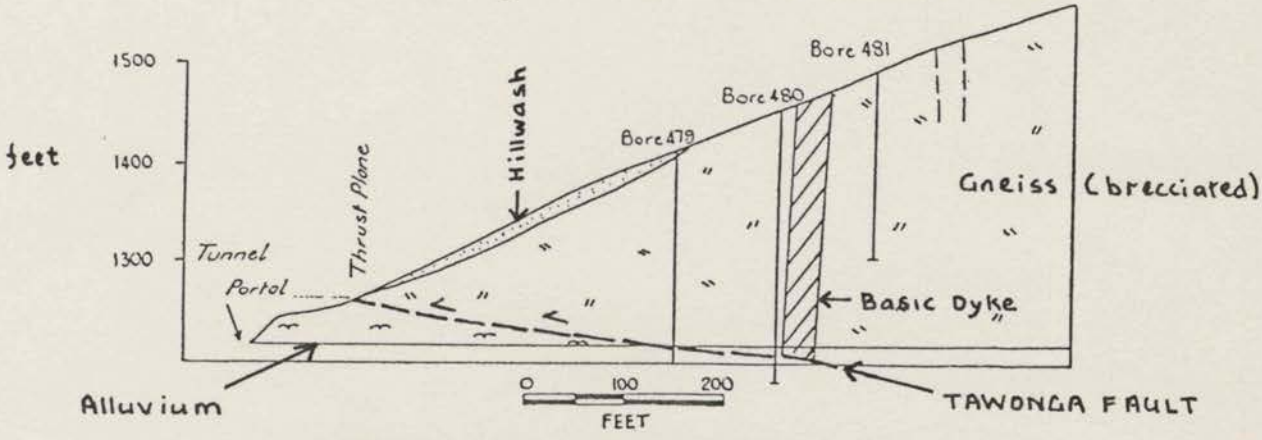


Fig 2 B(ix) (BEAVIS 1959)



—Map of Part of Crush Zone of Tawonga Fault, Mt. Beauty Township, with section along the No. 4 Tail Race Tunnel.

SITE NUMBER : 31
G.R. : 156336 Bogong 1:100 000 NATMAP
ELEVATION : 390m
ASPECT : North-west
GEOMORPHIC SETTING : Mid slope section sloping to the north-west at 10°, becoming concave towards the toe.
STRATIGRAPHY : Site 31 is a 2m road section.

Layer 1 : 40cm thickness of grey brown sandy loam.

Layer 2 : Large angular clasts (20cm-40cm) in a reddish brown gravelly clayey sand. Clasts comprise about 10% of the bulk.

SITE NUMBER : 32
G.R. : 188310 Bogong 1:100 000 NATMAP
ASPECT : North
GEOMORPHIC SETTING : Mid slope section with gradient of 50% or 26°.
STRATIGRAPHY : This broad relatively even slope represents a composite gully fill which is illustrated in the section below.

Refer to Fig 2B (x) and Photograph K 487F21.

The east and west contacts of the gully fill with the bedrock are very steep but diffuse, due to the extremely weathered gneiss. Thicknesses of the layers are represented on Fig 2b(x)

Layer 1 : approximately 50 cm of grey brown gravelly loam with dispersed clasts formed by reworking and humification of the underlying fanglomerate.

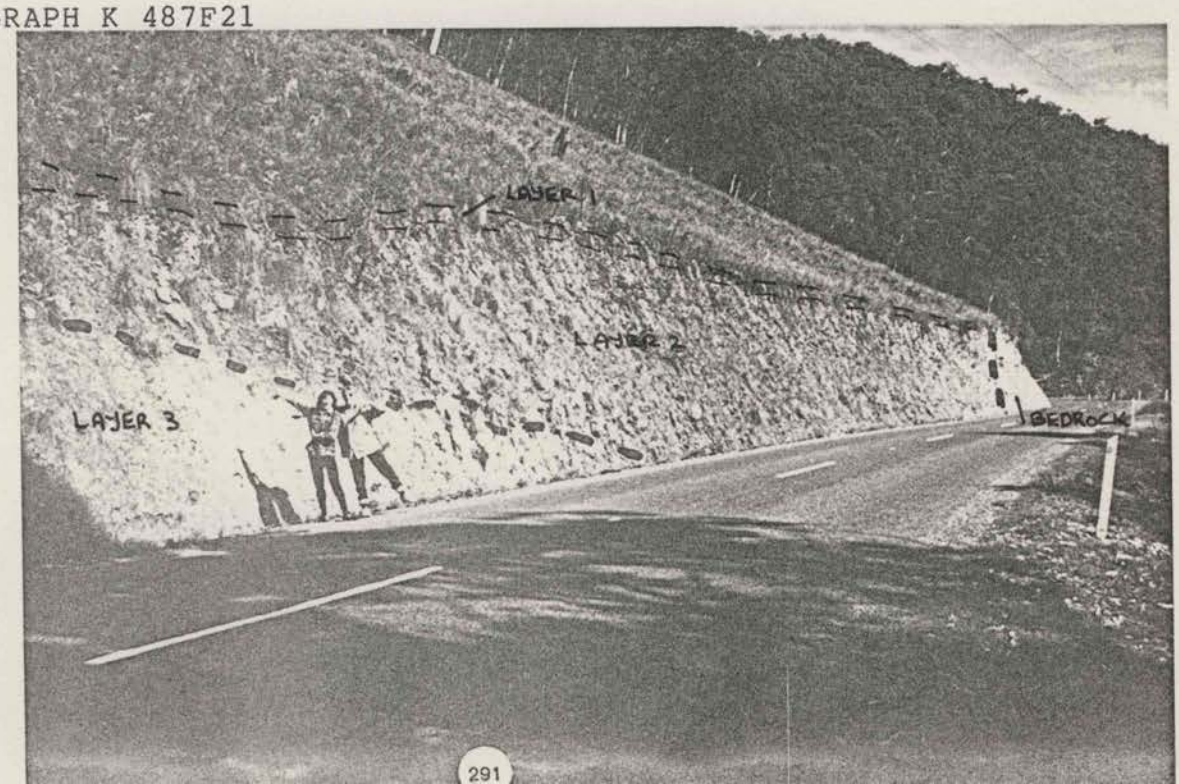
Layer 2 : Fanglomerate, comprising angular blocks dispersed in an orange brown gravel and clay matrix. Clasts are moderately to extremely weathered, local rock with maximum dimensions of about 60cm. Clasts comprise up to 70% of the bulk. Fragments of charcoal and plant remains were observed in the matrix.

Layer 2 appears to be inset into an earlier gully fill (layer 3). Photograph K 487F21 illustrates the contact between layer 2 and layer 3.

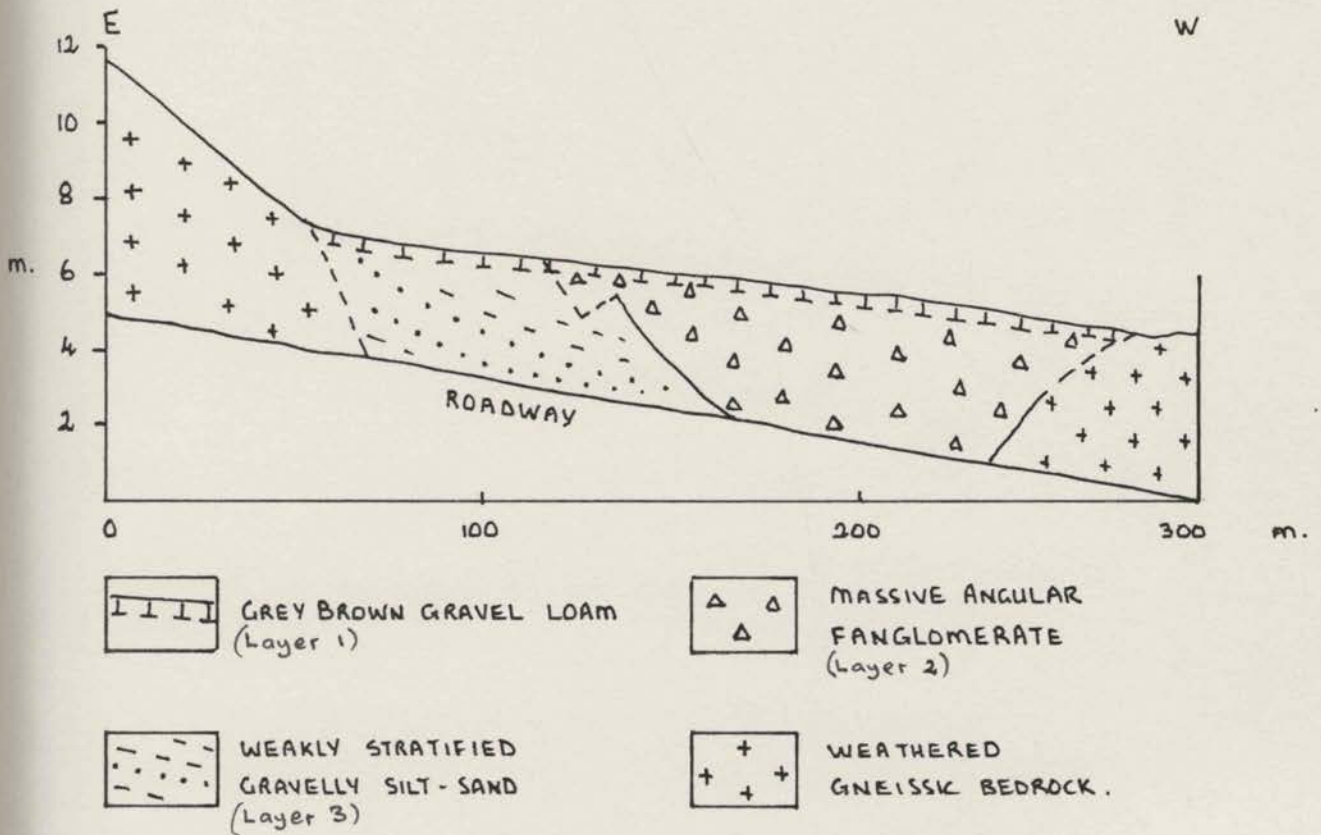
Layer 3 : Consists of a weakly bedded pale reddish brown gravelly silt-sand with dispersed angular clasts. The deposit has some stone lines shown as dots on Fig 2B(x), which curve up towards the contact with bedrock.

INTERPRETATION : This deposit is probably late Pleistocene and is typical of an upper fan head deposit. A C14 date of charcoal fragments might prove useful.

PHOTOGRAPH K 487F21



SITE NUMBER : 32 (continued)
Fig 2B(x)



SITE NUMBER : 33
G.R. : 202252
ELEVATION : 750m
ASPECT : North-east
GEOMORPHIC SETTING : Lower portion of a steep concave slope with local gradient of 34°.
STRATIGRAPHY :

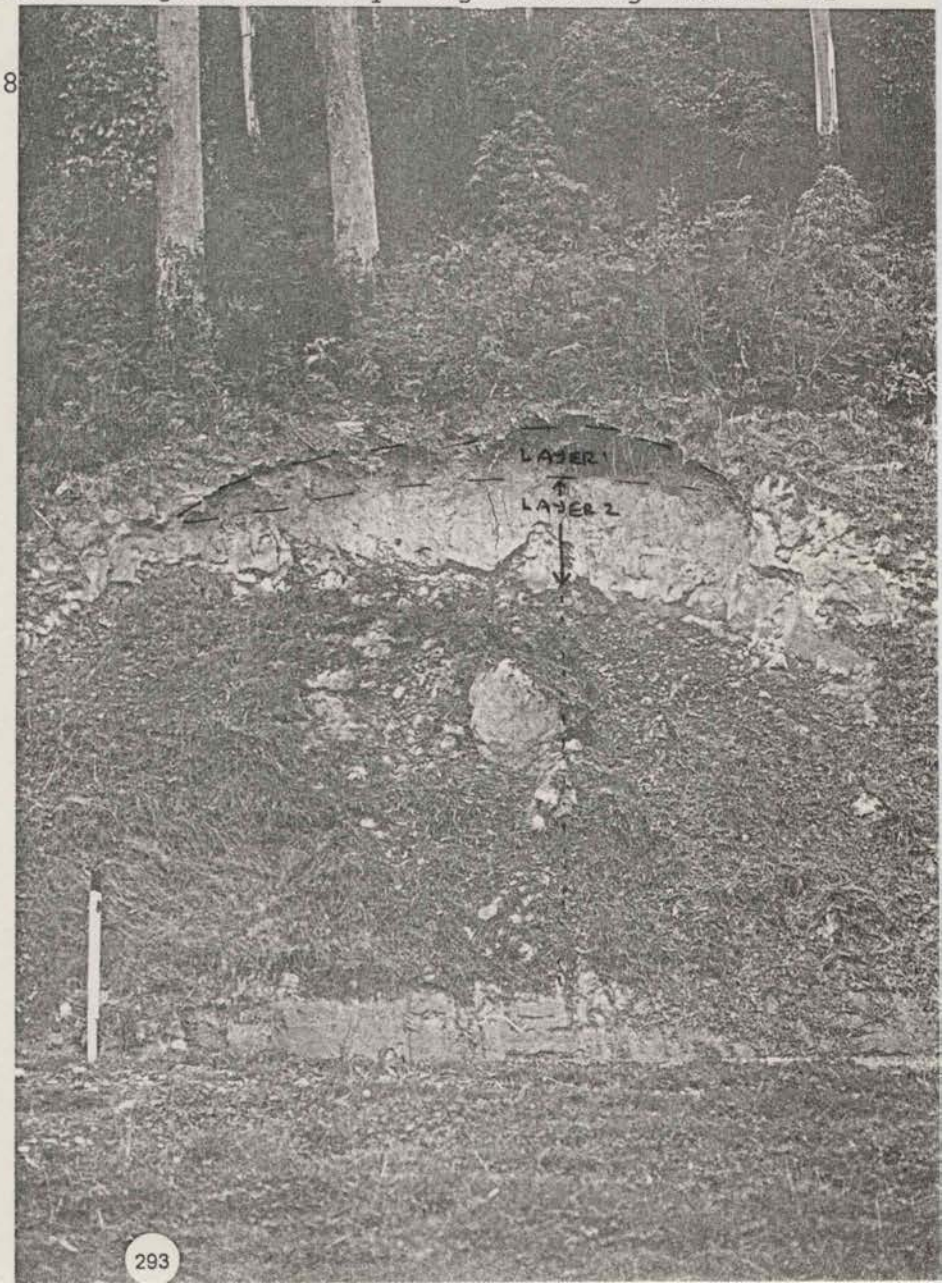
Layer 1 : Approximately 50cm thick. Gravelly blocky loam.

Layer 2 : insitu extremely weathered granodiorite with loose, very weathered corestones.

INTERPRETATION: A recent road cutting in the extremely weathered insitu granodiorite (0-Sg, Fig 2Ba) has induced a circular slip in bedrock. Refer to Photograph FCMB 3686F18.

This photograph, below, demonstrates the instability of the local bedrock due to its deep weathering. It also suggests that the local bedrock has little cohesive strength in its commonly extremely weathered state and that it would provide a substrate capable of rapid erosion in the event of climatic change or damage to the protective vegetation by engineering works as illustrated here.

PHOTOGRAPH FCMB 3686F18



SITE NUMBER : 34
G.R. : 204251 Bogong 1:100 000 NATMAP
ELEVATION : 850m
ASPECT : North
GEOMORPHIC SETTING : Lower portion of steep concave slope. Local gradient is about 50%.
STRATIGRAPHY : Site 34 is a 4m-6m road section.

Layer 1 : 3m-4m thickness. Reddish brown clayey, gravelly sand with some angular stones dispersed throughout. Clasts were moderately to extremely weathered. Fragments of charcoal were also dispersed throughout.

Layer 2 : Yellow brown extremely weathered insitu gneiss or granodiorite

INTERPRETATION : Layer 2 represents a relic (now vegetated) slope deposit of possible late Pleistocene age, A C14 date would be useful.

SITE NUMBER : 35
G.R. : 216218 Bogong 1:100 000 NATMAP
ELEVATION : 1 140m
ASPECT : South-west
GEOMORPHIC SETTING : Mid slope section with gradient approximately 30% or 16°.
STRATIGRAPHY : Site 35 is a 3m road section which lenses out 50m further up the road.

Layer 1 : thin veneer of organic loam.

Layer 2 : weakly developed stone line, 30cm-40cm below the surface.

Layer 3 : 3m thick. Pale orange brown silty sandy gravel with randomly dispersed blocks comprising <10% of the bulk. There is also a charcoal layer about 1.8m below the surface.

INTERPRETATION : This exposure represents a gully fill similar to site 15 and 16. Layer 3 appears to be a composite layer, and could be late Pleistocene.

SITE NUMBER : 36
G.R. : 218223 Bogong 1:100 000 NATMAP
ELEVATION : 1 200m
ASPECT : North
GEOMORPHIC SETTING : Mid slope section on the side of a spur with a gradient of 40% or 22°.
STRATIGRAPHY : Site 36 is a 3m exposure.

Three metres of red, clayey, silty sandy gravel with irregular angular clasts of moderate to extremely weathered granodiorite and fine grained mafic igneous rock comprising 30% to 40% of the bulk. Particles of charcoal occur within the section and were observed 2m below the surface. Stratification is localized and chaotic similar to gully fill at site 14.

The degree of alteration suggests pre-Holocene for this material. Charcoal occurs in road sections above this point on the road to Falls Creek, up to an altitude of 1 300m, but was not observed above 1 300m along this road section to Falls Creek. If this material was late Pleistocene, then it might indicate the level of the tree line during the last cold phase of the Pleistocene in this area.

The sections examined above site 36 on the Mt. Beauty - Falls Creek Road are presented in Section 2A.1 "Falls Creek to Howmans Gap."

SECTION TWO : STRATIGRAPHY

C). CORRELATION OF 2A AND 2B WITH AN INTERPRETATION OF THE TRANSITION OF DEPOSITS AND PROCESSES BETWEEN 2A AND 2B.

Interpretation of stratigraphy at specific sites is mostly discussed within Section 2A and 2B as a conclusion to the individual site investigations or to a group of sites.

What is attempted in the table that follows is a correlation of layers and associated processes within a problematical time frame.

The discussion which follows the tabulation of stratigraphy is an overall interpretation of the relationship of the stratigraphy of the lower valleys to the stratigraphy of the elevated, alpine terrain and the complementary climatic inferences contained therein.

TABLE 2C (i) : Correlation of surficial stratigraphy at Basalt Hill, Pretty Valley and Mt. Nelse from Section 2A.

Note that S1 L2 refers to Site 1 layer 2.

HOLOCENE

Basalt Hill	Pretty Valley	Mt. Nelse
S1 L1 (humus only)	S1 L1, L2	S1 L1
S5 L1 (humus only)	S2 L1	S2 L1
S17 L1	S3 L1	S3 L1
S18 L1	S6 L1	S4 L1
S22 (humus only)	S7 L1	S6 L1
S23 frost sorted regolith	S8 L1	S7 L1
S24 L1	S9 L1, L2, L3	S8 L1
S25 L1, L2?	S10 L1, L2	S9 L1
S26 L1	S11 L1, L2	S10 L1
S27 L1, L2?	S12 L1, L2, L3	S14 L1
S28 L1	S13 L1, L2, L3	S15 terracettes
S29 L1	S14 L1, L2, L3	S16 L1
S30 L1	S15 L1, L2, L3	S17 L1, L2, L3
S31 L1	S16 L1, L2	
	S17 L1	
	S18 L1, L2	
	S20 L1	

PLEISTOCENE

NOTE : B.A. means block accumulation

Basalt Hill	Pretty Valley	Mt. Nelse
S1 L1, L2	S1 L3?	S1 L2
S2 L1	S2 L2, L3	S2 L2, L3
S3 L1	S3 L2, L3	S3 L2, L3
S4 L1, L2	S4 blockstream	S4 L2
S5 L1, L2	S5 L1, L2	S5 stony pavement
S6 L1	S6 L2, L3	S6 L2
S8 L1	S7 L2	S7 L2
S10 L1 B.A.	S8 L2	S8 L2
S11 L1 B.A.	S12 L4	S9 L2
S13 LI B.A.	S14 L3	S10 L2
S14 L1 B.A.	S15 L4	S12 (lobe)
S15 LI B.A.	S16 L3	S14 L2
S16 L2	S17 L2	S16 L2
S19 L1 B.A.	S19 L1, L2	S17 L4, L5
S20 vegetated B.A.		
S21 vegetated B.A.		
S22 L1, L2		
S24 L2		
S25 L3		
S26 L2. L3		
S27 L3		
S28 L2		
S29 L2. L3, L4		
S30 L2		
S31 L2		
S32 L1, L2		

TABLE 2C (ii) : Correlation of surficial stratigraphy at sites 1 to 36 in Section 2B.

Note that S1 L2 refers to Site 1 layer 2. For some sites layers are not numbered, these are referred to by descriptions. Also for some layers an upper or lower portion of a layer is referred to.

<=> means similar or approximately equivalent to the site and layer that follows.

HOLOCENE

S1 L1 (upper)	S2 L1 (upper)	S3 L1 A	S4 L1 (upper)
S5 L1	S9 L1 (upper)	S15 L1	S17 L1
S18 L1	S19 L1	S20 L1	S21 L1
S22 L1	S23 L1	S24 L1	S25 L1
S26 L1(upper 20cm)		S27 L1, L2	S28 L1
S29boulder terrace		S30 red brown loam; riverine cobble sand deposit; boulder, cobble lag deposit.	
S31 L1	S32 grey brown gravel loam		S33 L1
S34 L1	S35 L1, possibly L2		

PLEISTOCENE : Late Pleistocene (last cold phase).

S1 L1 (lower)	S2 L1 (lower)	S3 L1 B	S4 L1 (lower)
S5 L2	S6 L1, L2, L3,	S7 L1 fanglomerate	
S8 L1, L2	S9 L1 (lower)	S11 fanglomerate	
S12 riverine gravels? <=> S30 L2, S26 L2.			S13 L1
S14 gully fill<=> S32, S17 L2			
S15 L2 gully fill <=> S32 fanglomerate, S36 (below)			
S16 stratified cobbles <=> S15 L2 gully fill			
S17 L2	S18 L2	S19 L2	S20 L2
S21 L2	S22 L2	S23 L2, L3	S24 L2
S25 L2	S26 L1(lower 40cm)		S27 L3
S28 L2	S29 fanglomerate		S31 L2
S30 riverine boulders and cobbles in a sandy matrix			
S32 fanglomerate		S34 L1	S35 L2, L3
S36 red clayey, silty sandy gravel			

PLEISTOCENE : Early Pleistocene (prior to the last cold phase)

S5 L3?	S9 L2, L3, L4, L5		S18 L3, L4
S19 L2	S20 L3	S21 L3, L4	S22 L3, L4
S23 L4, L5, L6	S24 L3, L4, L5, L6		
S26 L2 (see note below)		S28 L3	S34 L1?
S32? (weakly stratified gravelly silt sand)			S35 L3? <=>S15 L2

Note: Refer to S26 L2. Site 26 is similar to sites 12 and 36. It is possible that site 12 riverine gravels, and site 30 riverine boulders and cobbles in a sandy matrix, are also pre-late Pleistocene. All these layers have similar sediment derived from similar processes and they have a similar geomorphic setting.

PLIOCENE : (Late) Calivil Sands or equivalents

S13 L2, L3 S17 L3?

PLIOCENE : (Early) Piedmont Downs Surface, equivalents to Haunted Hill Gravels and underlying Coongulmerang Beds of Gippsland.

S1 L2, L3, L4, L5 S2 L2, L3 ?
S3 L2, L3 S4 L2, L3, L4, L5

DISCUSSION OF HOLOCENE STRATIGRAPHY

The Holocene is represented by a thin accretion of gravelly loam at the sides of the Kiewa and Mitta Mitta Valleys, ranging from 20cm to 50cm in depth and including dark, grey-brown, red-brown and brown colorations. This material represents an insitu humification of pre-Holocene material. The loam probably developed after the surface became revegetated in the post-Pleistocene.

The Holocene has been a period of change. The truncated terraces evident along the sides of the valleys and the series of inset floodplains suggest that water flow in the valleys has changed from intermittent with an oversupply of sediment, resulting in poorly sorted deposits in the valley floors to a more consistent high energy flow which has eroded material in the valley floors leaving behind coarse, well rounded, competent gravels which are interpreted as the Coonambidgal Formation. There is a minimal development of soil over the surfaces of the current floodplain and its adjacent 1.5m high terrace. The Coonambidgal deposits are essentially lag deposts as demonstrated for sites 26, 29 and 30, of Section 2B. They are probably underlain by massive, fine grained, poorly sorted sediments, as indicated in the geological section Fig 2Bc, across the Kiewa River at Kergunyah.

The large truncated terraces of fanglomerate which exist mainly as fan mesas, may have been truncated during an earlier interglacial period within the Pleistocene, as most of the upper surfaces of these fan mesas appear to have been relatively inactive during the late Pleistocene, due to incisions by tributaries of the the major rivers.

As one ascends the margins of the Bogong High Plains, and passes southwards over the Tawonga Fault, the Holocene is represented by 40 cm- 50cm of grey brown, gravelly loam at the lower altitudes which diminishes to about 20cm of dark, organic loam at 1 000 m. The organic matter is not decomposed as rapidly by soil organisms at higher elevations.

Above 1 000m the development of the uppermost layer is dependent on slope gradient and exposure (wind chill) which affects the potential to accumulate and the availability of organic matter on exposed elevated surfaces. The uppermost layer often comprises a thin brown gravelly loam of about 10cm thickness, whereas on broad valley floors such as Pretty Valley, up to 1.5m of peat and silty sand may have accumulated in the early Holocene with a further 30cm of organic loam in the late Holocene. For sites intermediate between exposed summits and broad valley floors on the Bogong High Plains, the Holocene is usually represented by 20cm-30cm of dark, gravelly organic loam.

It would appear that the inclusion of Holocene sediments on Geological Maps has not been consistent or accurate. A particular example is the mapping of the floor of Pretty Valley on the Bogong High Plains as Tertiary (Tpe), when in fact a

significant deposit of gravel, sand and peat of recent age is deposited there. A mapping system should incorporate surficial deposits in a 2 bit code, such as $\frac{Xm2}{OSn}$ where Xm2 describes the character and thickness of surficial deposits and OSn describes the bedrock beneath.

DISCUSSION OF LATE PLEISTOCENE STRATIGRAPHY

The late Pleistocene accretions show similar trends as one moves upstream along both the Kiewa and Mitta Mitta Valleys towards the Bogong High Plains.

Sites 1 to 9 in the Mitta Mitta Valley which range from 60km to 30km north of Mt. Bogong have been interpreted as veneers of 0.5m up to 2m of red/orange-brown gravelly clays derived by reworking of the older deposits directly beneath.

Sites 18, 19 20 and 21 in the Kiewa Valley have also been interpreted as possessing thin accretions of dispersed clasts in red clay with thicknesses of 0.5m to 1.0m, during the late Pleistocene. These reworked deposits are thin because the surfaces at sites examined were old and relic. Many of the sites were fan mesas which are isolated relics with gently sloping surfaces which are not subject to significant high energy erosive forces since the major drainage lines which created them by dissection of the original fans have left them high and dry.

In closer proximity to the Tawonga Fault there is a marked increase in probable late Pleistocene deposition with the existence of thick, relatively unaltered red, angular gravels notably at site 13 (layer 1) in the Mitta Mitta Valley and at sites 25 and 29 in the Kiewa Valley.

The absence of organic matter and the dominant, red, oxidised color of the "alluvial fan" sediments could be explained by relative aridity during the late Pleistocene. Alluvial fans containing debris flow material as the dominant facies are indicative of dry alluvial fan deposition (Mack and Rasmussen, 1984).

The climatic implications for alluvial fan aggradation were described by Blissenbach (1954), who described recent alluvial fan deposits in the South-western U.S.A.. Blissenbach noted that practically all fan accessions are due to brief, infrequent periods of downpour, characteristic of areas with arid and semi-arid climate. The alluvial fans studied by Blissenbach in Arizona, received an annual precipitation of 250mm to 500mm.

The catchments of the Mitta Mitta and Kiews Valleys which possess relic alluvial fans have a precipitation of 1 000mm to 1 500mm per annum. It would require at least a 50% reduction in precipitation in the above study area before conditions approached those necessary for fan aggradation.

Catchment size is also an important factor with respect to the level of activity in the late Pleistocene. The latest fan

aggradation at Mountain Creek has been most active at the proximal end above the 420m contour, with massive deposits near the junction with Sodawater Creek and Doorway Creek. This is reflected in the irregularities of the stream profile for Mountain creek (Fig 2B (v)).

A distributary drainage network is still evident in the upper portions of the Mountain Creek alluvial fan which is in contrast to the dendritic network characteristic of most of the inactive fans which have been fragmented into fan mesas as a result of changes in hydrological conditions.

South of the Tawonga Fault at the margins of the Bogong High Plains in steep terrain up to 1 300m, the late Pleistocene deposits comprise massive gully fills. Some such as site 14 are weakly stratified while others such as sites 32, 34, and 36 are chaotic and contain dispersed charcoal fragments and lenses of humus suggesting colluvial rather than alluvial origins.

These gully fills are related to the alluvial fan activity and this gully fill activity would have contributed material downslope to produce fan head deposits in some cases.

The charcoal fragments were not observed in surficial deposits above 1 300m. Another trend with increasing altitude was a change in color and thickness of these piedmont deposits.

Above 1 300m, the surficial deposits become less massive, less red and generally exhibited a weak stratification of platy clasts in comparison to the dispersed, irregular clasts which dominated below 1 300m.

It would appear that 1 300m marks a change or transition from massive colluvial and alluvial gully fill deposits of the lower slopes to thinner, more stratified, carbon free, frost actuated deposits of the upper slopes, as demonstrated in sections between Howman's Gap and Falls Creek. (Section 2A :1). Coarse bouldery gravel deposits accumulate in drainage lines in the terrain above 1 300m but these become differentiated from colluvial gully fill deposits of the lower slopes by characteristics such as vertical sorting, imbrication, open block accumulations and accumulation on gently sloping surfaces where alluvial or colluvial processes active on the lower slopes could not operate without modification by cryogenic processes.

The stratification and vertical differentiation which sets the elevated surficial deposits apart from the lower, deposits of dispersed blocks in a silty, sandy gravel is demonstrated by Basalt Hill sites: S25, S27 and S20; Pretty Valley sites: S1 L3, S2 L2/L3, S3 L2/3, S6 L2/3 and S8 L2; and Mt Nelse sites: S2 L2/3, S6 L2, and S9 L2. These layers probably represent frost transported and frost sorted regoliths.

The accumulation of angular blocks on a relatively gentle slope such as described at site 10 (Basalt Hill) is markedly different from anything observed or described at lower elevations. Simple alluvial or colluvial models cannot account for these deposits without the assistance of cryogenic processes.

The "blockstreams" or coarse accumulations in drainage lines extend as far down as 1 300m as demonstrated for site 15 Basalt Hill. This further demonstrates that 1 300m ASL represents a transition from cryogenic surface processes above to simple alluvial/colluvial processes below, and it may correspond to the treeline in the late Pleistocene which represents a 400m to 500m recession.

Discussion of Early Pleistocene Stratigraphy

The sites interpreted as pre-late Pleistocene to early Pleistocene are characterised by extremely weathered clasts, (except quartz), are located within deeply dissected, isolated relics of an older surface, with weak to moderate consolidation, and display varying degrees of lateritization in one or more layers. It would appear that there may have been an inversion of relief in some localities. The blocky fanglomerate of site 19 is preserved on a gentle spur line which dips about 4° towards the Kiewa River. This broad spur line is interpreted as a relic fan mesa which has been deeply dissected and isolated from active erosion in the current landscape near site 19. This fanglomerate probably represents a fan head deposit derived from flash floods off the steep elevated terrain to the east of site 19. No such accretion of bouldery debris can occur at this site under present cirumstances, since it is elevated about 20m above the adjacent creek.

Potential early Pleistocene exposures diminish in frequency as one approaches the Tawonga Fault from the north. This is probably due to the increasing size and elevation of watersheds in this direction, which would have improved the potential for significant late Pleistocene accretions in the upper reaches of the Kiewa and Mitta Mitta Valleys.

The character of the probable early Pleistocene deposits noted in Table 2C(ii) is similar to the fanglomerates of the late Pleistocene and comprises bouldery debris flows with some clast supported stream flood deposits.

The apparent diminished activity and accession of late Pleistocene piedmont deposits downstream of Gundowring in the Kiewa Valley, suggests that the late Pleistocene was not as cold or dry as earlier phases of the Pleistocene. This may have contributed to slope stability by increased vegetation over the lower reaches during the late Pleistocene. It is assumed that maximum development of alluvial fan accessions is dependent on occasional, even infrequent, heavy downpours over relatively bare, unprotected surfaces in order to mobilise a large quantity of loose material over a short distance.

Discussion of the Pliocene Stratigraphy

Pliocene deposits are rare as surficial deposits in the study area and the examples described are mainly at the extreme north of the study area and include Section 2B sites: S1, S2, S3 and S4 with possible Pliocene river gravels at S14 and S17. These sites have already been discussed in Section 2B in relation to the palaeogeography of the Kiewa Valley and the adjacent Shepparton Formation.

It is worth noting that Tpe deposits in valleys on the Bogong High Plains appear to be Holocene/late Pleistocene rather than Pliocene. This is discussed in detail in Section 2A (Pretty Valley).

SECTION THREE : GEOMORPHIC ANALYSIS OF THE BOGONG HIGH PLAINS

A) OVERVIEW OF GROSS GEOMORPHOLOGY

B) SUMMARY OF CRYOGENIC FEATURES ON THE BOGONG HIGH PLAINS

- i. Overview and Nomenclature
- ii. Definition of Cryoplanation/Blockfield Terrain and Striped Terrain
- iii. Description of Cryoplanation/Blockfield Terrain
- iv. Description of Striped Terrain
- v. Description of Open Block Accumulations

C) DETAILED DESCRIPTION AND INTERPRETATION OF TARGET AREAS:

1. Basalt Hill
2. Pretty Valley
3. Mt. Nelse

D) PALAEOCLIMATIC INFERENCES AND MODELS

SECTION THREE : GEOMORPHIC ANALYSIS

A) OVERVIEW OF GROSS GEOMORPHOLOGY

The Bogong High Plains surface is an old surface with modest local relief, which has been elevated relative to the adjoining terrain by about 600m during recent geological time. This is illustrated in Fig 1Bg which is a cross section from Mt. Emu to Mt. Wills via Mt Bogong. The slope between Mountain Creek and Mt. Emu is about 19° towards the south-east. The slope of the Tawonga Fault at Mt. Beauty as measured by Beavis in 1959 is about 16° towards the south east. It is possible that the Bogong High Plains has been pushed up and onto the terrain to the north, which includes Mt. Emu on the Eskdale Spur. The Eskdale Spur is an elevated strip of land with remnants of a low relief surface, which may have been continuous with the Bogong High Plains surface prior to the Tawonga thrust faulting.

The Bogong High Plains surface appears not to have been warped since the extrusion of basalt about 36 million years ago. This is apparent in Fig 1Bd which demonstrates isolated basalt cappings between Mt. Loch and the Bundara River. These cappings are exactly coplanar.

The activity associated with the Tawonga Fault appears to be the result of near horizontal stress from the south-east. Denham et. al. (1981) after an investigation of earthquake evidence in Southeastern Australia concluded that a regional compressive stress in the crust with an azimuth of 120° is consistent with most of the earthquake focal mechanisms and the insitu stress measurements throughout Southeastern Australia.

The attitude of the Tawonga Fault and the thrusting of Ordovician schist over Pleistocene, possibly late Pleistocene riverine gravels at Mt. Beauty, is consistent with regional compressive stress in the crust of Southeastern Australia today. This suggests that the Tawonga Fault may still be capable of more movement.

The section between Mt. Emu and Mt. Wills Fig 1Bg, also demonstrates the possible enechelon structure of the Tawonga Fault. It appears that Mt. Wills has been thrust up and over adjacent terrain to the north-west. This enechelon sliding could quite possibly be associated with basal jointing. Basal jointing appears to be a dominant factor in the development of stepped surfaces on the Bogong High Plains, during the Pleistocene.

B) SUMMARY OF CRYOGENIC FEATURES ON THE BOGONG HIGH PLAINS

3Bi):
Overview and Nomenclature

The Bogong High Plains surface has been presented in two ways. Firstly, Fig 1Bc: Bogong High Plains Regional Setting presents the High Plains as steeply dissected, elevated remnants above 1 700m. The relationship of these elevated remnants to local drainage lines and associated structural weaknesses is quite evident. The relationship of these surfaces to the Tawonga Fault is also evident.

The second presentation is Fig 3Ba which defines surfaces as either >20% surface gradient or < 20% surface gradient and shows the distribution of block accumulations on the Bogong High Plains.

Most of the elevated terrain (> 1 700m) corresponds to the surface gradients < 20% slope as illustrated on Fig 3Ba. The 20% slope line was drawn in order to define the differences in surface texture evident from aerial photographs over the Bogong High Plains. Before discussing the surfaces of the Bogong High Plains any further it is necessary to define some of the specialized nomenclature used in the remainder of this thesis and to indicate the origins of the nomenclature.

COMMENTS ON NOMENCLATURE

BLOCK : A coarse detrital fragment of more than 10cm size whose form has not been significantly altered by processes of transport. (Caine, 1968)

BLOCKFIELD : Broad slope usually level or of gentle gradient (<10°) covered with moderate sized or large angular BLOCKS of rock. In practice more than 50% of such a surface should be covered with blocks to qualify. (Washburn, 1979)

BLOCK GLACIS : A BLOCKFIELD which is most extensive in a cross slope direction. (Caine, 1968) Occasionally occurs at the base of basalt cliffs with southern and southeastern aspects along the margins of the Bogong High Plains. GLACII is used as the plural of GLACIS.

BLOCK SLOPE : Similar to a BLOCKFIELD but occurs on a steeper slope. (Washburn, 1979) These block accumulations are generally on slopes greater than 20% (11°) and may merge with or include TALUS.

BLOCKSTREAM : Extensive accumulations (of BLOCKS) confined to valleys or forming narrow linear deposits extending down the steepest available slope. Usually none of these deposits has a large bedrock cliff or free face at their head, as occurs with TALUS. (Washburn 1979) The relic blockstreams of the Bogong High Plains generally have a gradient with 5%-27% (3°-15°) range. This means that blockstreams can cross the nominal 20% slopeline boundary between Cryoplanation/BLOCKFIELD terrain and BLOCKSLOPE terrain, and in doing so occasionally merge with TALUS. This perhaps explains hybrid blockstream/talus deposits at places.

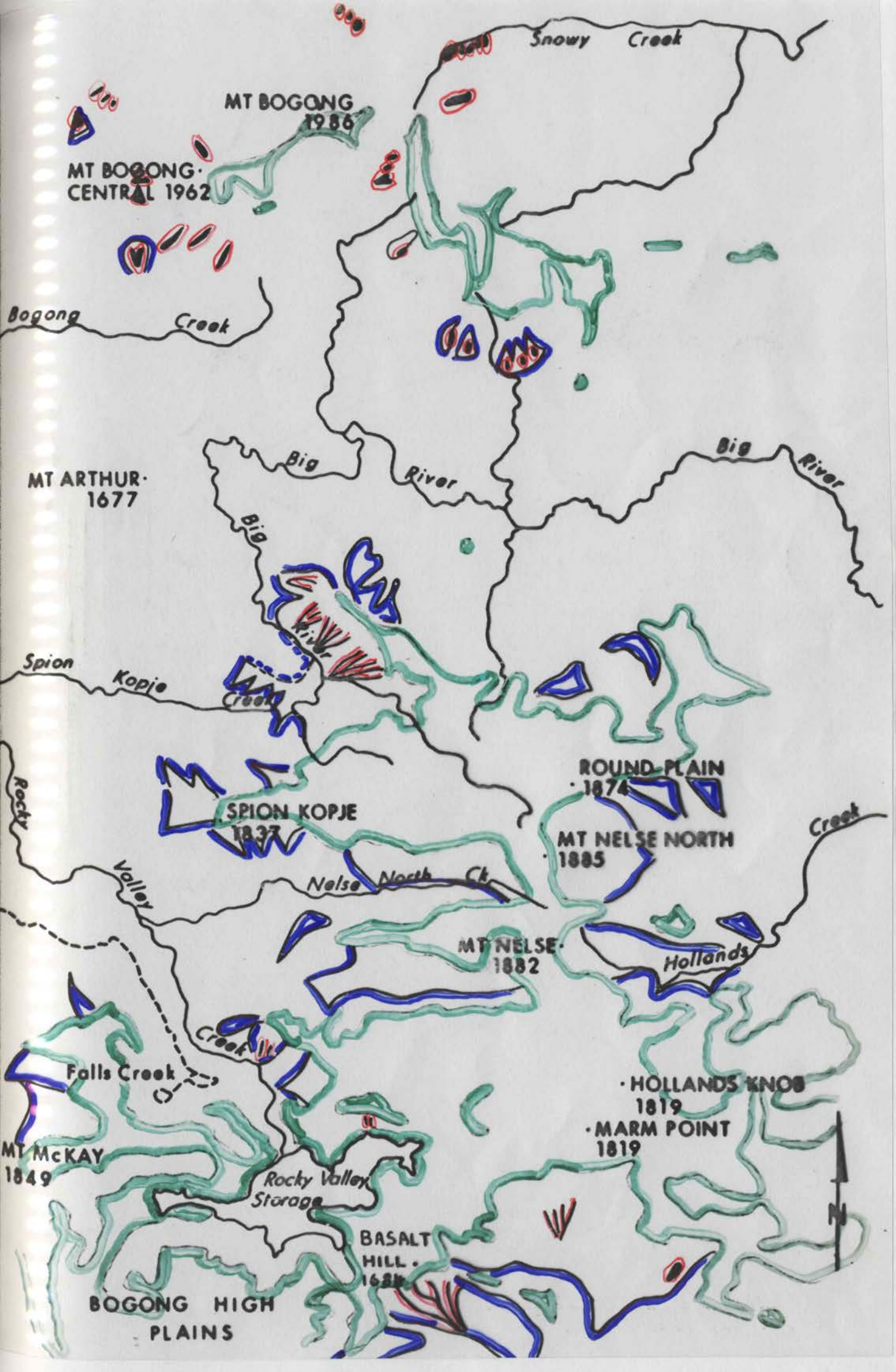
TALUS : Apron-like accumulations of angular slide rock due to the breaking way of rock from a cliff face. Slopes may range from 14° to 38.5°. (Washburn , 1979)

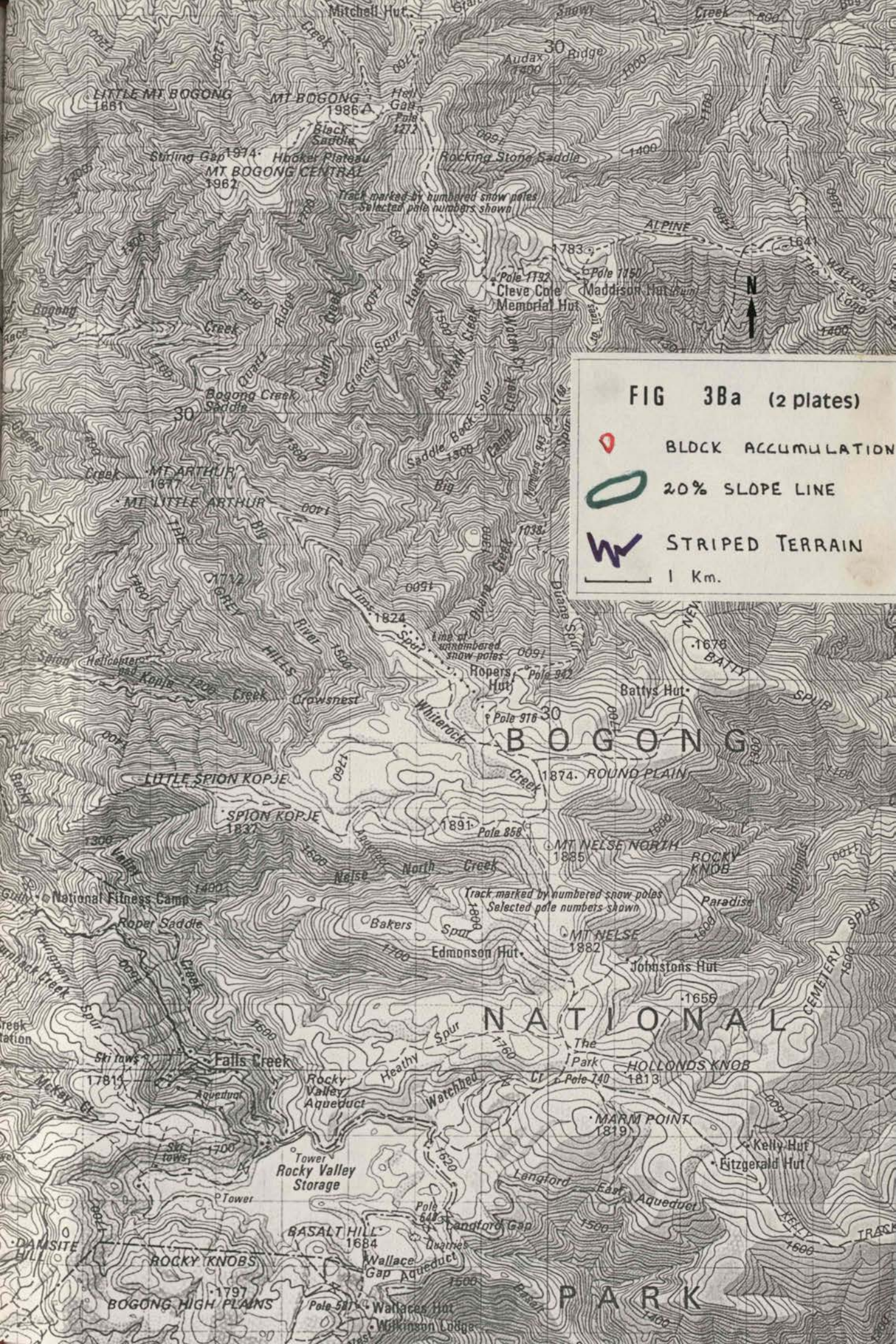
3bii):
Definition of Cryoplanation/Blockfield Terrain and Striped Terrain.

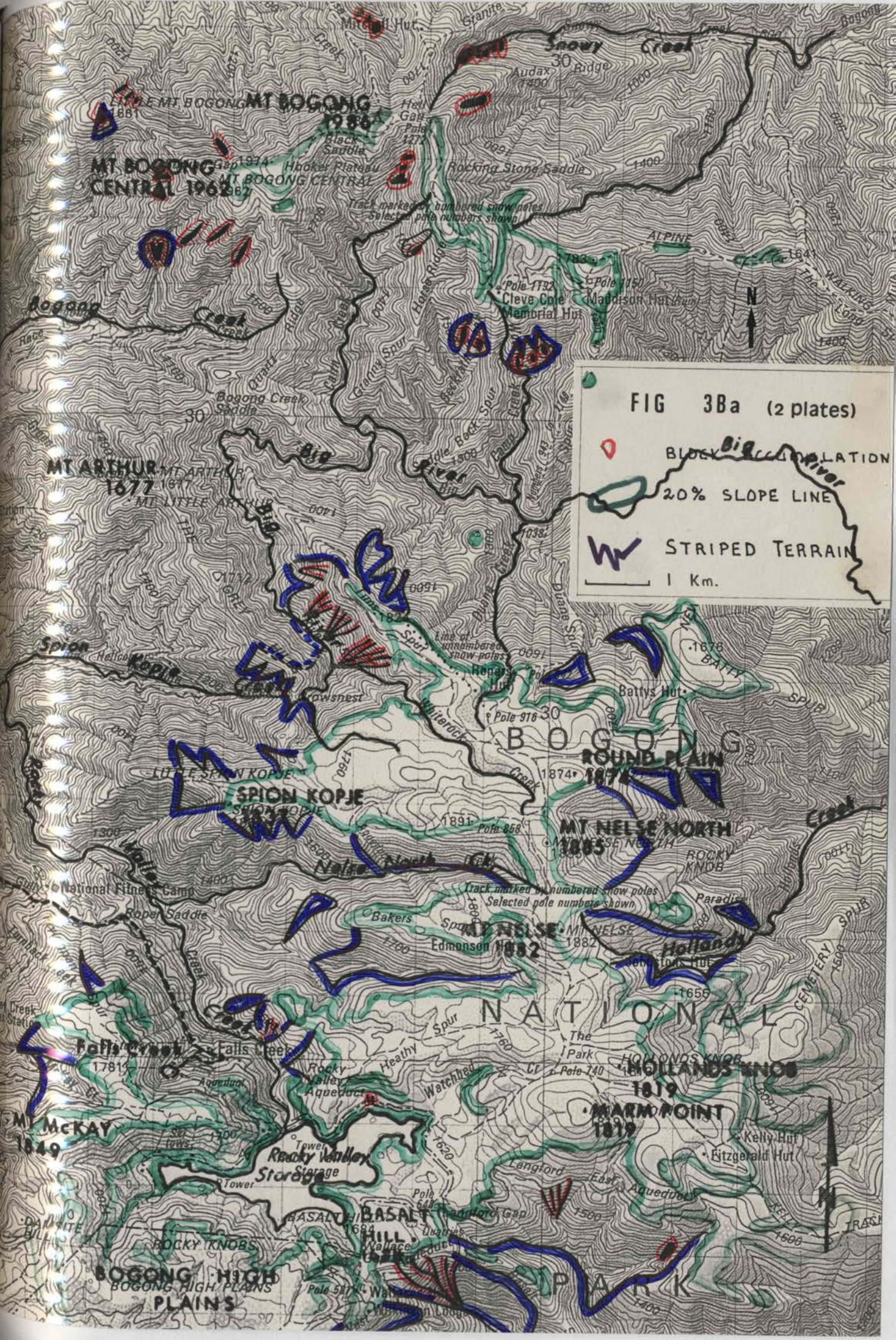
The 20% slope line differentiates the elevated, gently sloping stepped bedrock surfaces of the Bogong High Plains, here after referred to as "cryoplanation/blockfield terrain", from the steeply sloping surfaces at the margins of the elevated terrain which commonly bear a distinct downslope texture visible on large and small scale aerial photography and hereafter referred to as "striped terrain".

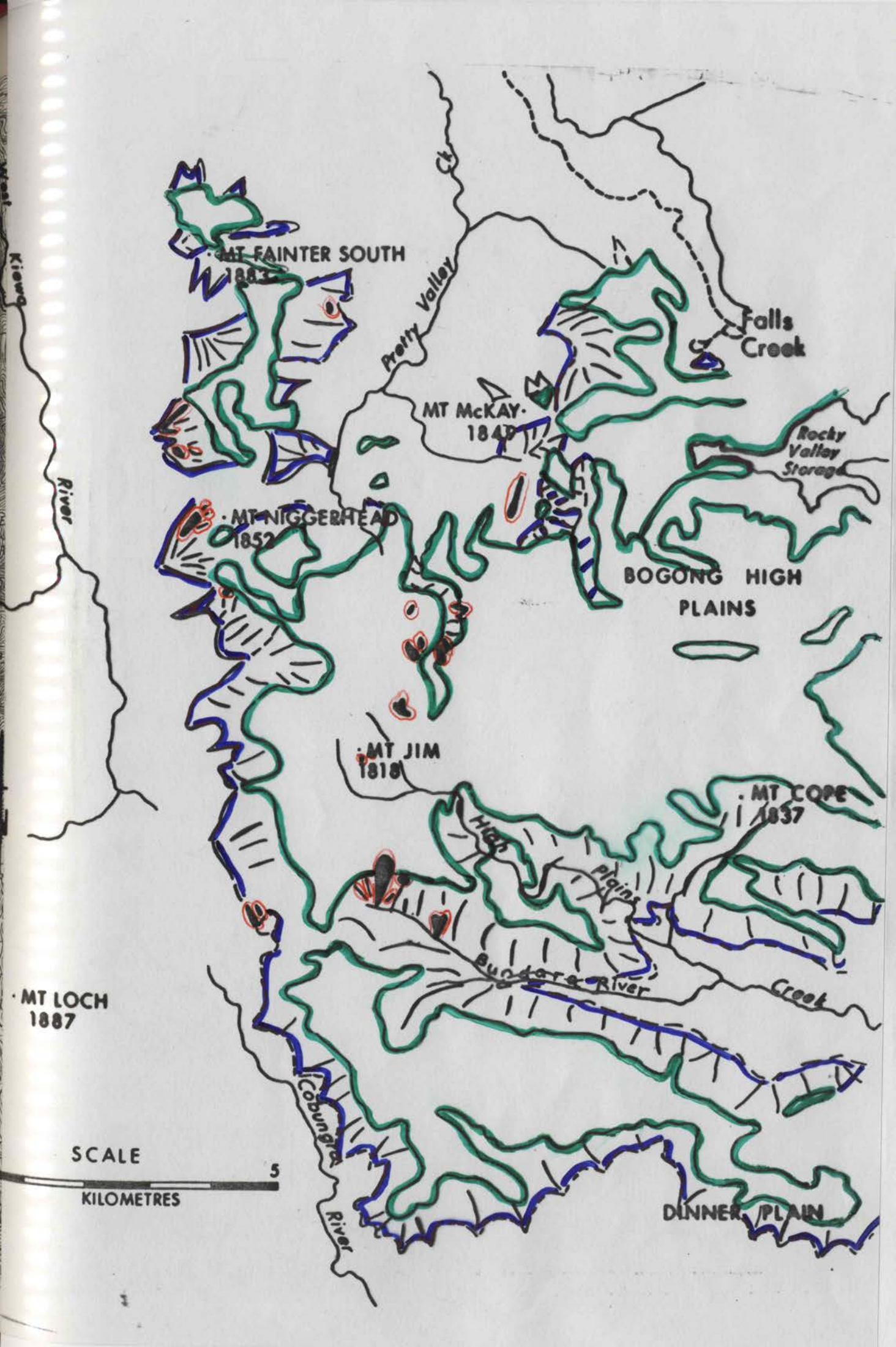
The character of the two terrains separated by the 20% slope line is demonstrated on aerial photograph 3477-141 taken by the then Department of Crown Lands, Victoria, on the 16/2/1980, and presented as Fig 3Bb. The pale colored surface is treeless, exposed basalt plateau south of Mt. Jim and just north of the headwaters of the Bundara River and immediately east of the headwaters of the West Kiewa. Refer to Fig 1Bc and Fig 3Ba for location and definition.

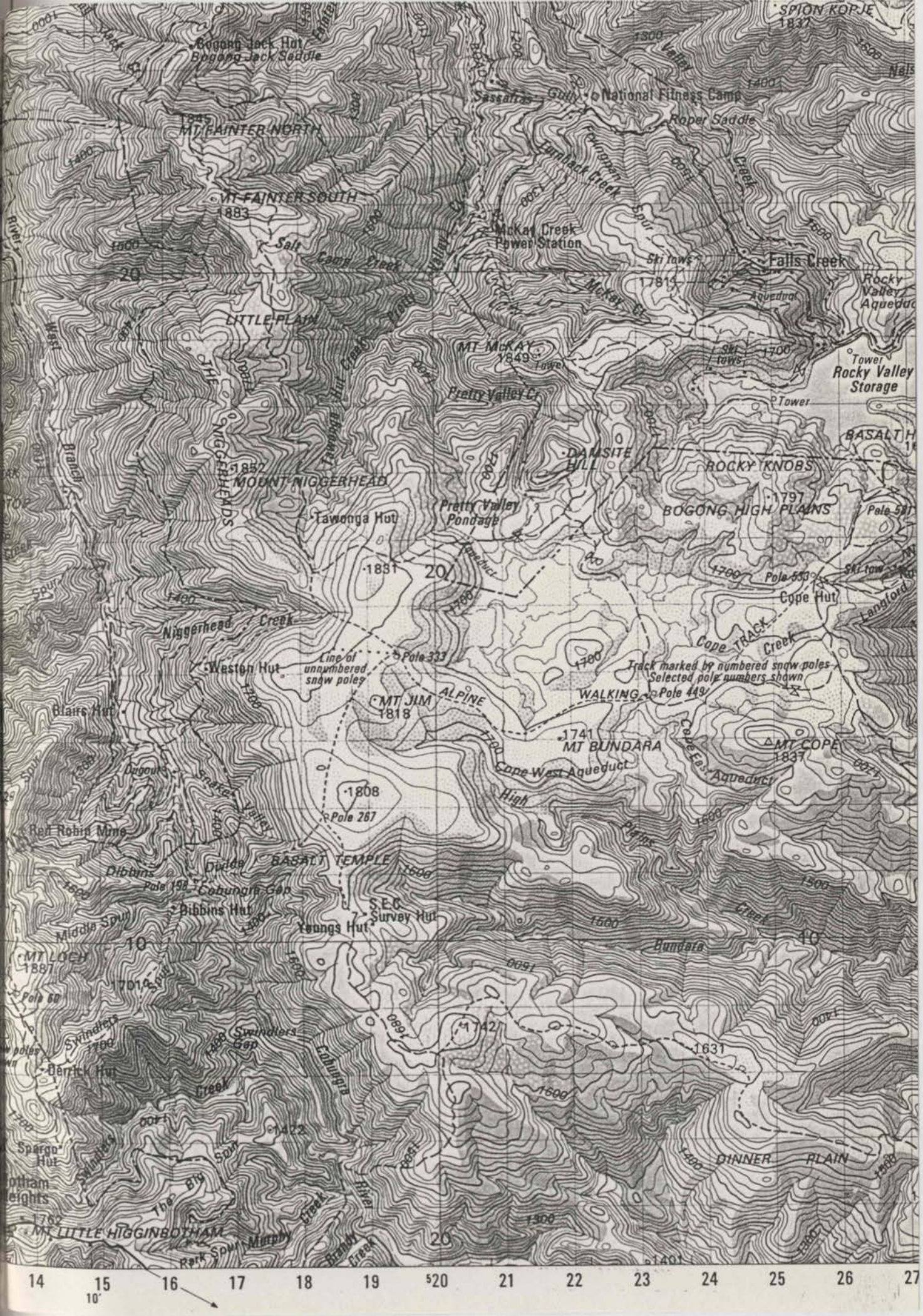
This treeless, exposed basaltic plateau is a gently sloping, stepped bedrock surface with a 2° dip towards the south-east. It represents typical cryoplanation/blockfield terrain. The terrain changes rapidly at the margins of the basalt plateau and the 20% slope line is indicated on the overlay to Fig 3Bb. The terrain below the 20% slope line is not only steeper but is marked by a rapid change in vegetation and a striped texture running downslope in sympathy with local drainage.


Snowy Creek
MT BOGONG 1986
MT BOGONG CENTRAL 1962
Bogong Creek
Big River
MT ARTHUR 1677
Big River
Big River
Spion Kopje Creek
ROUND PLAIN 1874
SPION KOPJE 1837
MT NELSE NORTH 1885
Rocky Valley Creek
Nelse North Ck
MT NELSE 1882
Hollands Creek
Falls Creek
HOLLANDS KNOB 1819
MARM POINT 1819
MT McKAY 1849
Rocky Valley Storage
BASALT HILL 1628
BOGONG HIGH PLAINS
N


FIG 3Ba (2 plates)
BLOCK ACCUMULATION
20% SLOPE LINE
STRIPED TERRAIN
1 Km.
N
Mitchell Hut
LITTLE MT BOGONG
1661
MT BOGONG
1986
Hell Gap
Pole 1272
Black Saddle
Stirling Gap
Hooker Plateau
MT BOGONG CENTRAL
1962
Rocking Stone Saddle
Track marked by numbered snow poles
Selected pole numbers shown
Audax
1400
Snowy
Creek
Ridge
30
ALPINE
WALKING TRACK
Pole 1192
Cleve Cole Memorial Hut
Pole 1150
Maddison Hut (burnt)
Bogong Creek
Saddle
MT ARTHUR
1677
MT LITTLE ARTHUR
Big
Quartz
Granny Spur
Saddle Back Spur
Line of unnumbered snow poles
Ropers Hut
Pole 942
Pole 916
Battys Hut
1676
BATTY SPUR
Whiterock
BOGONG
1874
ROUND PLAIN
LITTLE SPION KOPJE
SPION KOPJE
1837
1891
Pole 858
MT NELSE NORTH
1885
ROCKY KNOB
Nelse
North Creek
Paradise
National Fitness Camp
Roper Saddle
Bakers Spur
Edmonson Hut
MT NELSE
1882
Johnstons Hut
1655
CEMETERY SPUR
NATIONAL
PARK
Falls Creek
Ski tows
1781
Heathy Spur
The Park
HOLLONDS KNOB
1813
Pole 740
Rocky Valley Aqueduct
Watchbed Cr
MARM POINT
1819
Kelly Hut
Fitzgerald Hut
Tower
Rocky Valley Storage
Langford East Aqueduct
Pole 648
Langford Gap
BASALT HILL
1684
Quarries
DAMSITE HILL
ROCKY KNOBS
1797
Wallace Gap
Aqueduct
BOGONG HIGH PLAINS
Pole 581
Wallaces Hut
Wilkinson Lodge


FIG 3Ba (2 plates)
20% SLOPE LINE
STRIPED TERRAIN
1 Km.
MT BOGONG 1986
MT BOGONG CENTRAL 1962
MT ARTHUR 1677
SPION KOPJE
MT NELSE 1882
MT NELSE NORTH 1885
ROUND PLAIN 1874
HOLLANDS KNOB 1819
MARM POINT 1819
MT McKAY 1849
BOGONG HIGH PLAINS
NATIONAL PARK
Cleve Cole Memorial Hut
Maddison Hut
Battys Hut
Rocky Valley Storage
Falls Creek
Rocking Stone Saddle
Hooker Plateau
Bogong Creek Saddle
Roper Saddle
Edmonson Hut
Kelly Hut
Fitzgerald Hut
Langford
Wallace
Whiterock Creek
Big River
Snowy Creek
Bogong Creek
Rocky Valley Aqueduct
Watchhed
Heathy Spur
Horse Ridge
Quartz Ridge
Granny Spur
Middle Back Spur
Duane Spur
Nelse Spur
Bakers Spur
Cemetery Spur
Rocky Knobs
Basalt Hill
Basalt Quarries
Track marked by numbered snow poles
Selected pole numbers shown
Line of unnumbered snow poles
Pole 1132
Pole 1150
Pole 916
Pole 858
Pole 740
Pole 644
Pole 517
Rogers Hill
Rocky Knob
Paradise
Audax Ridge
Granite Hill
Mt Hill Hut
Hell Gap
Black Saddle
Tower
Aqueduct
Lookout
Track
Creek
Ridge
Spur
Saddle
Hut
Lodge
Quarries
Aqueducts
Tunnel
Gap
Park
Plains
Knob
Hill
Kopje
Peak
Plateau
Valley
Storage
Camp
Fitness
Cemetery
Walking
Alpine
Granite
Snowy
Bogong
Audax
Hell
Black
Hooker
Rocking
Horse
Quartz
Granny
Middle
Back
Duane
Nelse
Bakers
Roper
Whiterock
Big
Rocky
Valley
Aqueduct
Watchhed
Heathy
Langford
Wallace
Basalt
Quarries
Rogers
Rocky
Knob
Paradise
Cemetery
Walking
Alpine
Granite
Snowy
Bogong
Audax
Hell
Black
Hooker
Rocking
Horse
Quartz
Granny
Middle
Back
Duane
Nelse
Bakers
Roper
Whiterock
Big
Rocky
Valley
Aqueduct
Watchhed
Heathy
Langford
Wallace
Basalt
Quarries
Rogers
Rocky
Knob
Paradise
Cemetery
Walking
Alpine


MT FAINTER SOUTH
1883
Pretty Valley
Falls Creek
MT McKAY
1841
Rocky Valley Storage
MT NIGGERHEAD
1852
BOGONG HIGH PLAINS
MT JIM
1818
MT COPE
1837
High Plains
Bundara River
Creek
MT LOCH
1887
Cobungra River
DINNER PLAIN
SCALE
5
KILOMETRES


Bogong Jack Hut
Bogong Jack Saddle
MT FAINTER NORTH
1845
MT FAINTER SOUTH
1883
Salt Camp Creek
LITTLE PLAIN
THE NIGGERHEADS
MOUNT NIGGERHEAD
1852
Tawonga Hut
Tawonga Hut Creek
Niggerhead Creek
Weston Hut
Blairs Hut
Red Robin Mine
Dibbins Hut
Pole 198
Cobungra Gap
Youngs Hut
S.E.C. Survey Hut
Middle Spur
MT LOCH
1887
Pole 60
Swindlers Gap
Derrick Hut
Spargo Hut
MT LITTLE HIGGINBOTHAM
1762
Murphy Creek
Brandy Creek
Cobungra River
Sassafras Gully
National Fitness Camp
Roper Saddle
Turnback Creek
McKay Creek Power Station
McKay Cl
Falls Creek
Ski tows
1781
Aqueduct
Rocky Valley Aqueduct
MT McKAY
1849
Tower
Rocky Valley Storage
Pretty Valley Cr
DAMSITE HILL
ROCKY KNOBS
1797
BASALT H
BOGONG HIGH PLAINS
Pretty Valley Pondage
Pole 581
Pole 553
Cope Hut
Langford
Cope TRACK
Creek
Pole 333
Line of unnumbered snow poles
Track marked by numbered snow poles
Selected pole numbers shown
Pole 449
WALKING
ALPINE
MT JIM
1818
1741
MT BUNDARA
MT COPE
1837
Cope West Aqueduct
Cope East Aqueduct
High Plains
Pole 267
BASALT TEMPLE
Bundara
DINNER PLAIN
1742
1631
1422
1401
SPION KOPJE
1837
Valley
Creek
Spur
Ridge
Track
Range
Divide
Gap
Hut
Mine
Tower
Aqueduct
Pole
Ski tows
Langford
Bundara
Cope
Creek
Valley

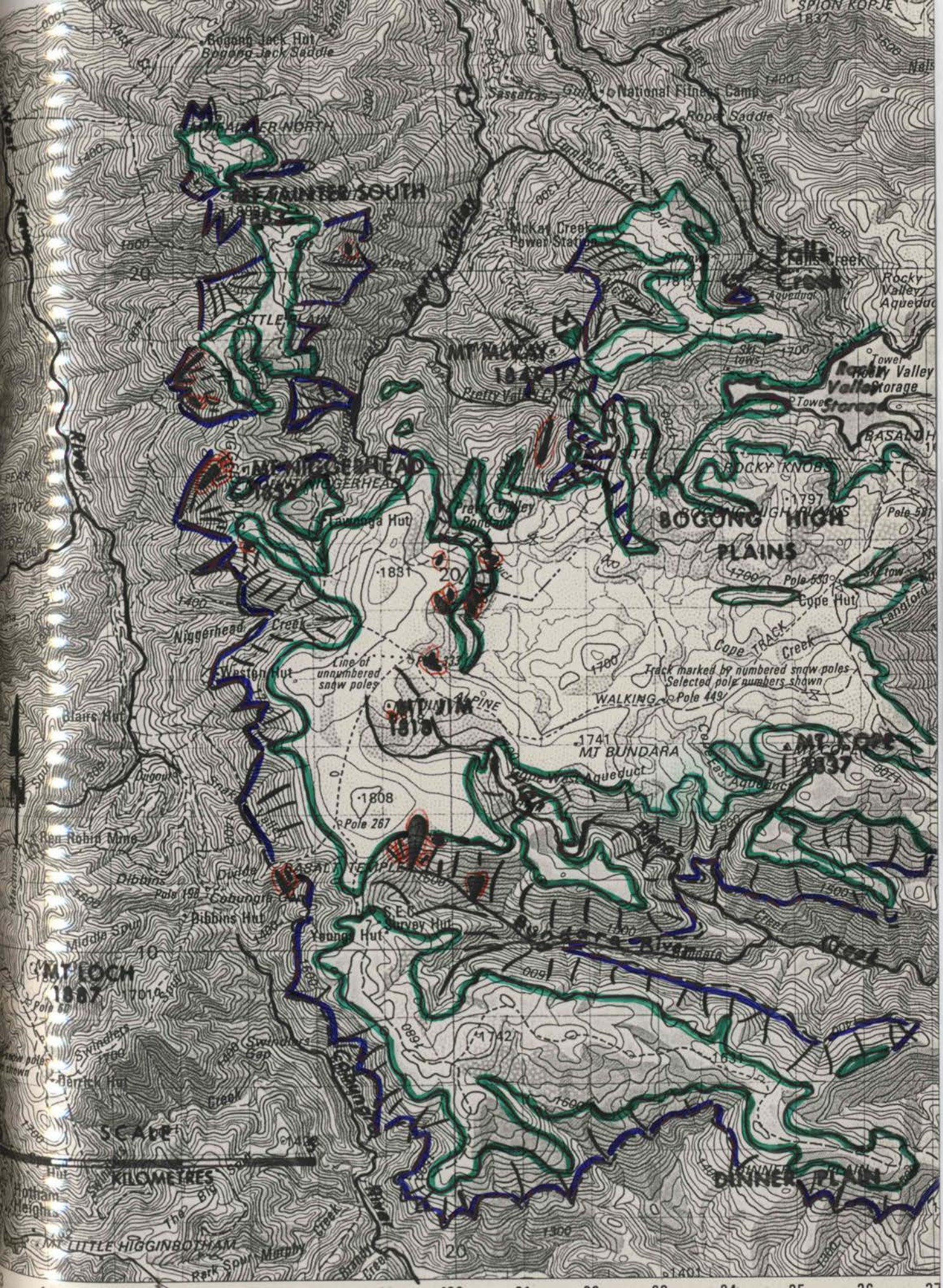
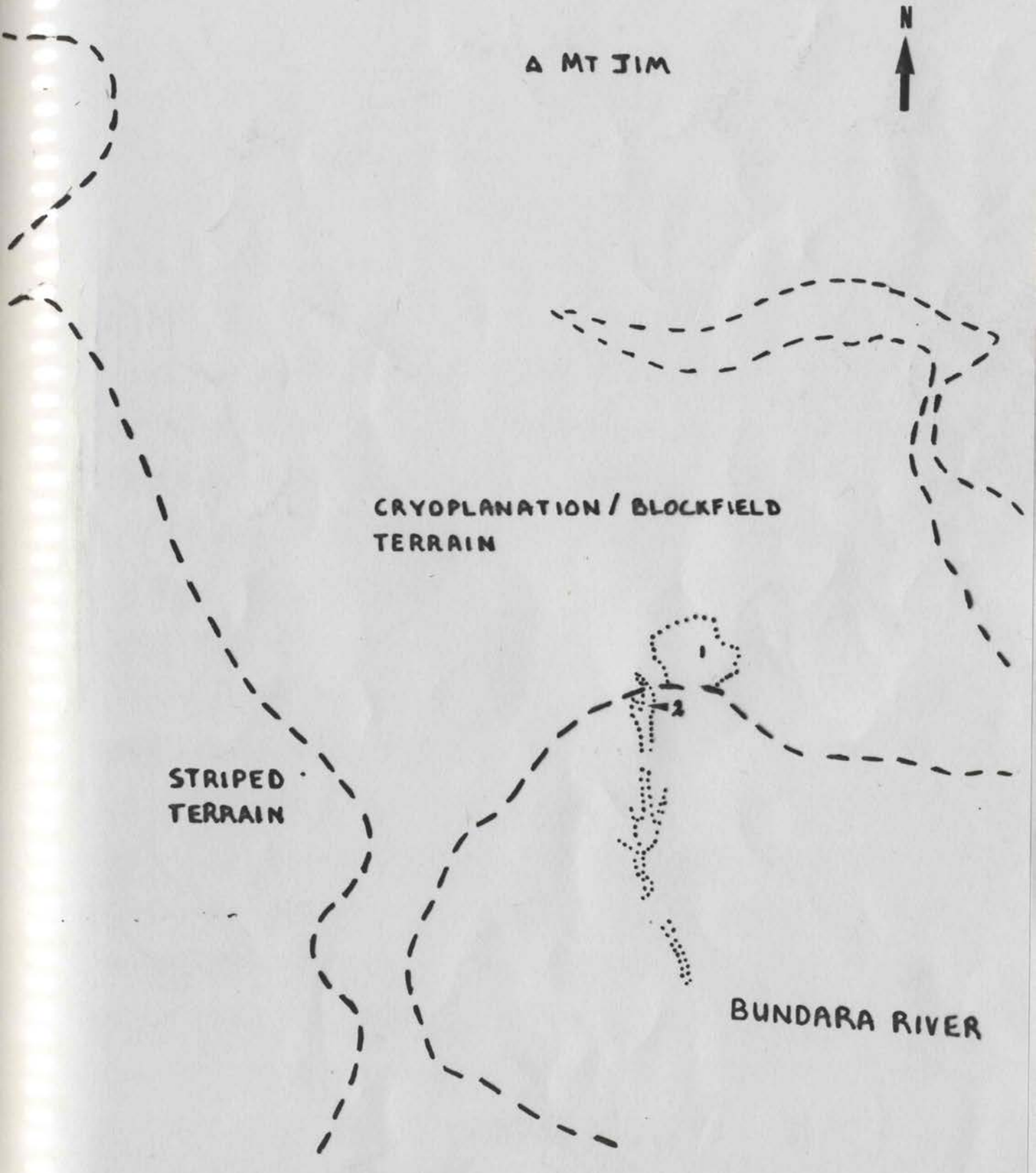

Bogong Jack Hut
Bogong Jack Saddle
National Fitness Camp
Rope Saddle
Mt Beauty North
Mt Beauty South
Falls Creek
Rocky Valley Aqueduct
Mt Mackay
Rocky Valley Storage
Rocky Knob
Bogong High Plains
Cope Hut
Cope Track
Mt Niggerhead
Niggerhead Creek
Line of unnumbered snow poles
Track marked by numbered snow poles
Selected pole numbers shown
Mt Loch
Mt Bundara
Mt Cope
Dibbins Hut
Young Hut
S.E.C. Survey Hut
Swindlers Gap
Mt Little Higginbotham
Dinner Plain
SCALE
KILOMETRES

FIG 3B(b)


N
MT JIM
CRYOPLANATION / BLOCKFIELD TERRAIN
1
2
STRIPED TERRAIN
BUNDARA RIVER

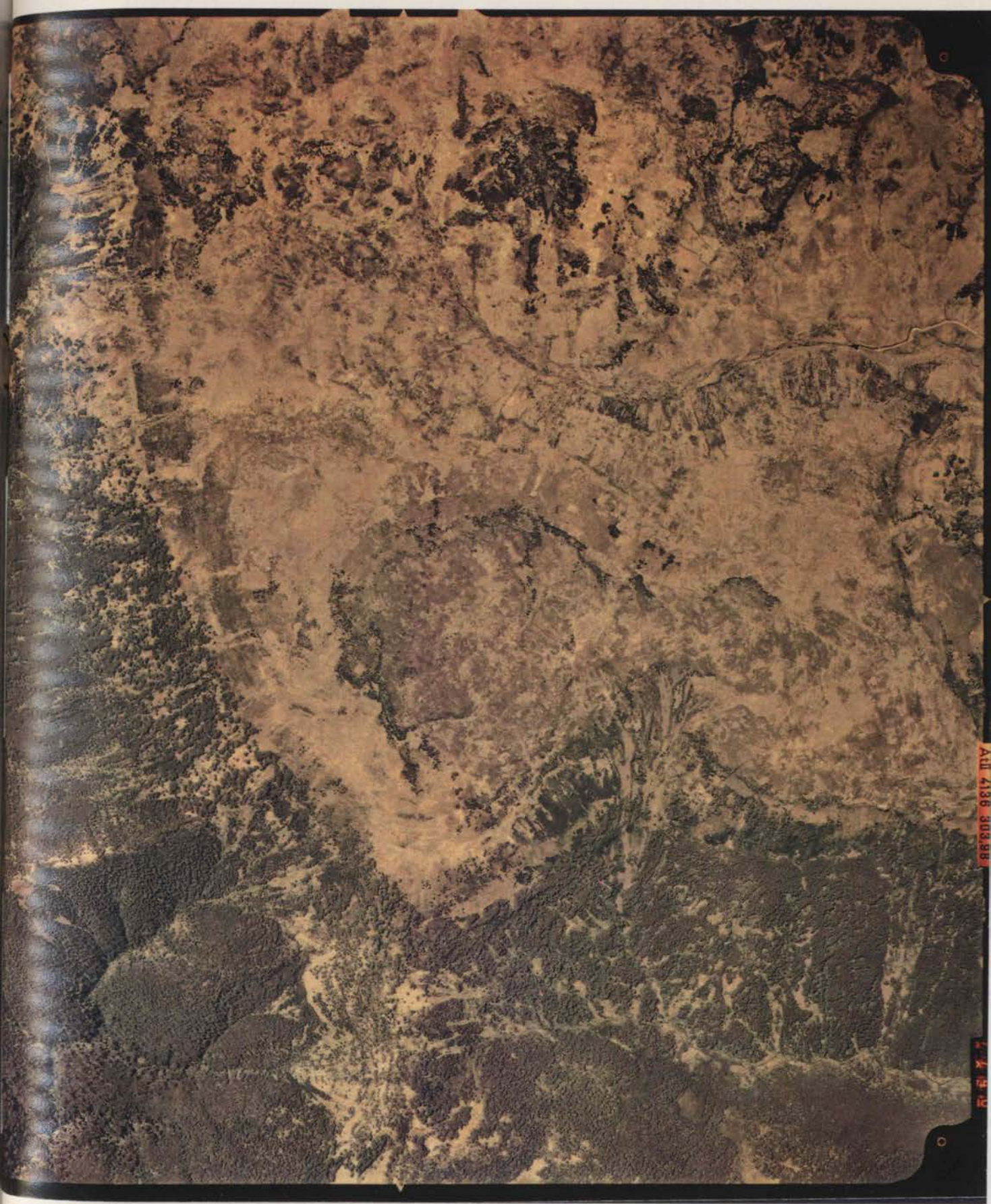
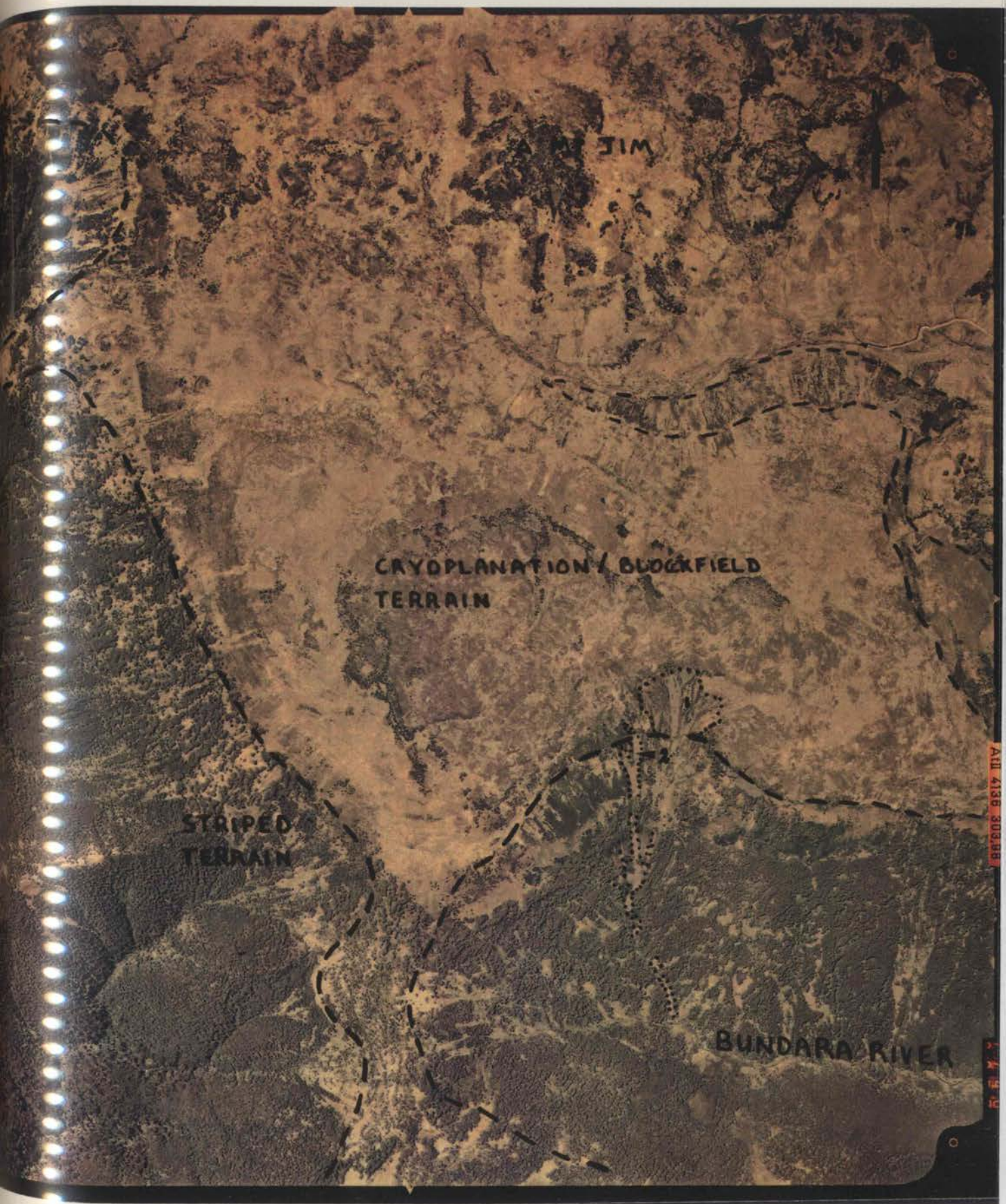

AGU 4136 30398

FIG 3B(b)


JIM
CRYOPLANATION / BLOCKFIELD TERRAIN
STRIPED TERRAIN
BUNDARA RIVER

3Biii) :
Cryoplanation/Blockfield Terrain

These regions generally occupy the gently sloping, stepped bedrock surfaces and shallow surficial deposits of the Bogong High Plains on slopes averaging less than 20%. Detailed profiles of this terrain are provided for Mt. Nelse and also the Basalt Hill traverse from the Summit Cairn to the Lake along Bearing 279° GB and portion of the Pretty Valley traverse. Massmovement of material, including cobbles and blocks is evident across slopes as low as 1.2° (Mt. Nelse traverse from summit along 344° GB) The accumulation of stony layers of competent cobbles and blocks above the extremely weathered bedrock and below recent organic loam, on such gentle slopes, suggests mass movement by frost action prior to the Holocene.

Based on personal observations

frost action is not currently active deeper than approximately 20cm below the present surface. Most of the stony layers of cobbles/blocks in the cryoplanation/blockfield terrain occur below the present organic loam soil which is usually 30cm deep on gentle slopes. The stony layers themselves, revealed in road cuttings and auger samples, vary in thickness from a few centimetres to 50cm and often overlie a relic brown mineral soil or extremely weathered bedrock.

The nature of the blocky, surficial material is dependent on rock type, rock structure, and access to moisture. Schist bedrock produces sand, gravels, small platy cobbles, and a lesser quantity of platy blocks whereas basalt produces gravel, platy cobbles and columnar blocks.

Vertical sorting is often evident within the stony layer with a preference for coarser fragments towards the top of the stony layer as reported in Section 2A. This is suggestive of frost sorting as described by Corte (1966) in his paper "Particle sorting by repeated freezing and thawing.".

The widespread development of a stony layer of cobbles and blocks close to the surface in the gently sloping, elevated, cryoplanation/blockfield terrain of the Bogong High Plains has acted as a natural rip-rap and protected the surface from widespread incision by a dentritic drainage network. Instead, much of the elevated surface appears smoothly sculpted.

Overland waterflow had caused localized removal of Holocene soil material on long slopes such as the southern flanks Mt. Nelse and the western flank of Basalt Hill. The erosion is limited by underlying blockfield sheets, which are exposed in the small drainage lines on these slopes.

Tall heath plants prefer the blocky substrate along these drainage lines whereas Poa grassland and short open heath prefer at least 30cm of mineral soil. This differentiation of vegetation on the cryoplanation/blockfield slopes also produces a striped effect, observable on aerial photographs, but it is not as dramatic as the lower, steep "striped-terrain".

Most of the patterning observable on cryoplanation/block-field terrain is associated with vegetation response to bedrock terraces, which are often concentric about summit flats, and usually where bedrock is at or close to the surface. Refer to the Nelse Maps and Sections presented in Section 3C.

Fig 3Bb also demonstrates terracing of basalt bedrock in the cryoplanation/blockfield terrain, whereas Mt Nelse bedrock is foliated schist and gneiss. Also at Mt. Mt. Nelse, there is a recent terracing of surficial material visible on the lower slopes. This terracing is made visible by preferential colonization by Orites heath producing a cross slope patterning on the lower slopes. This has been reported in Section 2A, Mt. Nelse, Site 16.

A variation on the patterning mentioned above was noted on the gentle rolling terrain between Mt. Cope and Basalt Hill. Here small rounded hills of gneiss (OSn) are vegetated by open snow gum woodland patterned into subparallel stripes. Each stripe is one or two trees wide and runs for 100m to 200m along a bearing of 030° GB . The stripes are separated by grassland or open heath land. The snowgum stripes seem to be following joints as the strike of the snowgum stripes is parallel to one of the two main directions in the rectilinear drainage pattern, but it is not clear why there is a colonization along one direction and not the other. Again this patterning is only associated with bedrock and should not be confused with the downslope patterning of the "striped terrain" which involves downslope movements of blocky regolith over surfaces with >20% gradient.

3Biv) :

Description of Striped Terrain

Striped terrain represents surfaces with visible downslope texture as observed from aerial photography at large and small scales. The texture comprises discontinuous linear stripes of contrasting vegetation, best revealed in heathland along the margins of the basalt cappings of the Bogong High Plains where slope changes rapidly and is generally greater than 20%. The transition from cryoplanation/ blockfield terrain appears to occur near the 20% slope line, as estimated from contoured maps and also corresponds to a sudden change in slope, with slope generally becoming steeper below the 20% slope line. This striped terrain is generally contained within small drainage basins at the margins of the Bogong High Plains with preference for a southerly aspect and also generally occurs within the altitude range of 1 400m to 1 700m ASL. This striped terrain corresponds to a cryogenic feature described as blockslopes, defined earlier in Section 3.

The optimal development of striped terrain within southerly catchments below basalt cappings is probably related to the relatively abundant production of basalt blocks in these locations and their downslope movement in the past. Basalt blockstreams/blockfields/blockslopes commonly occupy the drainage lines within striped terrain, and contribute to the visible striping. Since the block accumulations seem to be an integral part of the striped terrain, and since the block accumulations are relic features on the present landscape and within the present climate, it is assumed that most of the mass movement that has produced the lineations is also relic.

Measurements of vegetated, blocky lobes on the eastern flank of Mt. Nelse over 5 years have revealed negligible movement. These lobes occur within the snow patch zone of Mt. Nelse on steep gradients and lend support to the concept that the massive deposits of blocks and blocky material are relic features. This it not to say that active mass movement is absent from the High Plains landscape. Current examples of mass movement are evident as minor, low angle slips in alpine humus soil and also as slope failure associated with less permeable Tertiary sediments interbedded with the basalts of the High Plains.

TABLE 3B(1)

LOCATION (Bogong 1:100 000)	ASPECT	ALTITUDE RANGE (m)	SLOPE	DESCRIPTION
288349 Audax Ridge	S.E.	1560-1700	57%	TALUS :narrow accumulation of blocks in drainage line OSs (Schist) bedrock outcrops at head.
285355 " "	N	1300-1700	50-80%	TALUS :thin, vegetated OSs.
272361 Staircase Spur	N.E.	1350-1600	72%	TALUS: OSs
235348 Mt.Lt. Bogong	N.E.	1350-1550	72%	TALUS: OSn (Gneiss)
227342 " " "	S.S.E.	1450-1500	40%	BLOCKSLOPE :striped terrain on southerly aspect. OSn bedrock
248340 Stirling Gap	N.W.	1650-1820	66%	TALUS? : thin accumulation on valley floor. OSn bedrock.
239335 W.of West Peak	W.S.W.	1400-1600	50%	TALUS: lenticular. vegetated, OSn bedrock.
238325 SW of West Peak	S	1050-1380	50%	BLOCKSLOPE: no cliffs at head.
249323 W. of Qtz. Ridge	S.E.	1250-1450	80%	BLOCKSLOPE (minor), no bedrock cliffs at head
245320 SW of Qtz. Knob	S	1100-1300	50%	BLOCKSLOPE: vegetated, in striped terrain.
276338 to 277336 Cairn Creek	W. to S.W	1560-1780	50%	TALUS: relic accumulations on eastern flank of Cairn Creek in OSs. Plan view: dendritic accumulations in drainage basin. Good outcrop, crags at heads!. S.W. facing talus is relatively large - " 400-500m long, 200-300m wide at head, well vegetated at margins.
276342 to 275339 Cairn Creek	S.E.	1600-1750	60%	TALUS CONES: set of 5 small, coarse blocks forming in sub parallel gullies below large bedrock slope and terminating in Cairn Creek.
278325 Cairn Ck tributary	S.W.	1500-1700	66%	TALUS:relic, dendritic accumulation in minor elevated drainage basin
285312 & 288310 W. of T Spur	S.S.W.	1350-1600	44%	TALUS: minor accumulations in drainage lines, may be vegetated.
298312 " " "	S.E.	1400-1750	50%	TALUS: relic, well developed striped terrain on steep south facing slopes down to 1400m, possible block accumulations in drainage lines. may be relic talus sheet. Vegetated by snow gum and tall heath.
285312 Beckrath Ck tributary	S.S.W.	1450-1600	45%	TALUS: minor, elongated non-vegetated. Steep headwall is a possible nivation hollow

LOCATION (Bogong 1:100 000)	ASPECT	ALTITUDE RANGE (m)	SLOPE	DESCRIPTION
264356 W. of Staircase Spur	N.N.W.	1660-1800	58%	TALUS: relic, vegetated, striped terrain, dendritic accumulation of blocks, portion unvegetated in steep upper section of drainage basin.
265276 to 274260 S.W. slope of Timms Spur	W./S.W	1400-1700	40%	TALUS: relic, striped terrain across S.W. facing slope below Timms Spur, extending 1km across slope and 500m down slope. Block accumulation cuts out quickly towards 20% slope at upper edge. Vegetated Podocarpus and snowgum. Small outcrop cliffs near top edge. OSn (gneiss)
164169 Mt. Niggerhead	S.W.	1550-1750	44%	TALUS: relic, large granodiorite blocks below cliffs.
Mt. Niggerhead	S.W.	1750-1800	28%	BLOCKSTREAMS/BLOCKFIELD
163185 Nth Niggerhead	S.E.	1500-1750	57%	TALUS SHEET: relic linear block accumulations are portions of a larger, vegetated talus sheet. Greatest depth of accumulation is in drainage lines. Strong downslope lineations
165180 " " "	W.	1540-1650	57%	TALUS: relic, a granodiorite bedrock headwall is evident.
164170 " " "	S.W	1560-1640	43%	BLOCKSLOPE :bedrock OSg (granodiorite)
175111 Basalt Temple	S.E.	1500-1660	56%*	TALUS/BLOCKSLOPE COMPOSITE :basalt block accumulation, stepped bedrock head. Blocks concentrated in drainage line. Upper slope near headwall is 40%. Lower slope is 67% , suggesting talus.

LOCATION (Bogong 1:100 000)		ASPECT	ALTITUDE RANGE (m)	SLOPE	DESCRIPTION
191136	Mt. Jim	S.	1780-1800	28%	BLOCKFIELD (AUTOCHTHONOUS): basalt columns 1m-1.5m diameter and vegetated at the margins by Podocarpus.
192137	" "	E.	1770-1800	20%	BLOCK GLACIS: Vegetated by Podocarpus, large jointed basalt blocks.
198142	Pretty Valley Creek	S.E.	1720-1750	12%	BLOCKSTREAM: basalt and granodiorite
199151	" " "	S.E.	1710-1750	20%	BLOCKSTREAM: basalt
202150	" " "	S.	1690-1720	12%	BLOCKSTREAM: basalt
203158	" " "	E.	1680-1730	17%	BLOCKSTREAM: basalt
199159	" " "	N.E.	1740-1760	16%	BLOCKSTREAM: minor, basalt
186165	Tawonga Huts	N.N.W.	1660-1680	26%	BLOCKSTREAM: minor, basalt
195118	Bundara	S	1700-1760	4-21%	BLOCKFIELD/BLOCKSTREAMS : below shallow basalt scarp.
194118	Bundara	S	1530-1700	20-33%	BLOCKSTREAM : in striped terrain with dicontinuities over bedrock steps.
204110	Bundara River	S.	1500-1660	30%	BLOCKSLOPE/STRIPED TERRAIN
201109	" "	S.S.E.	1520-1600	27%	BLOCKSTREAM: with abrupt toe in striped terrain
197116	" "	S.	1730-1750		BLOCK GLACIS: localised, large basalt blocks up to 2m. Short concave slope.
285165	Basalt Hill	S.E.	1300-1640	21-55%	BLOCKSLOPE/BLOCKSTREAMS: both vegetated and open. Dominantly basalt with some granodiorite.
287165	Basalt Hill	S	1300-1600	57-70%	BLOCKSLOPE/TALUS :dominantly granodiorite.
312131	Buckety Plain	N.N.W.	1200-1400	67%	TALUS: minor "apparent" block accumulations, in sub-parallel drainage lines below cliffs.
319171	Langford East Aqueduct	S.	1400-1500	53%	BLOCKSLOPE: no free bedrock face. Thin bands of blocks visible in drainage lines. OSn gneissic bedrock.
304178	" " "	S.	1460-1600	43%	BLOCKSLOPE/BLOCKSTREAMS in STRIPED TERRAIN: no free bedrock face at head. Some block accumulations apparent as narrow bands in drainage lines. Probably OSn bedrock.

NB. Rock type is indicated where it is known.
Some block accumulations have been described only from aerial photographs and topographic maps.

3Bv):

Description of Open Block accumulations on the Bogong High Plains

An examination of aerial photographs and comparison with 1:25 000 topographic maps and 1:15 000 vegetation maps has produced a description of open, block accumulations over the Bogong High Plains with respect to precise location, aspect, altitude range, slope and classification. These data are presented as Table 3B(i). The large, more visible block accumulations have been included on Fig 1Bc and a more complete distribution is represented on Fig 3Ba.

As can be observed from these figures most of the block accumulations occur at the margins of the Bogong High Plains in close association with "striped terrain".

There is a preference for block accumulations and striped terrain to occur within drainage basins with a south to south-easterly aspect, in an altitude range of 1 400m to 1 700m on slopes of 30% to 80%. Most of these block accumulations have been described as blockslope or talus deposits because the slope angle exceeds 15° or 26% which is the maximum angle recognised in the definition of BLOCKSTREAMS.

Blockstreams have been differentiated from talus and blockslop es because their morphology and setting are very different, which implies that the processes which produced them were different to talus and blockslopes. However, there are examples where blockstreams, may have acted as feeders to blockslopes and possibly talus. Two such examples are : near the Bundara River- G.R. 193117 (Bogong 1:100 000 NATMAP) also refer to Fig 3Bb, and on the western flanks of Mt. Niggerhead- G.R. 164169 (Bogong 1 :100 000 NATMAP).

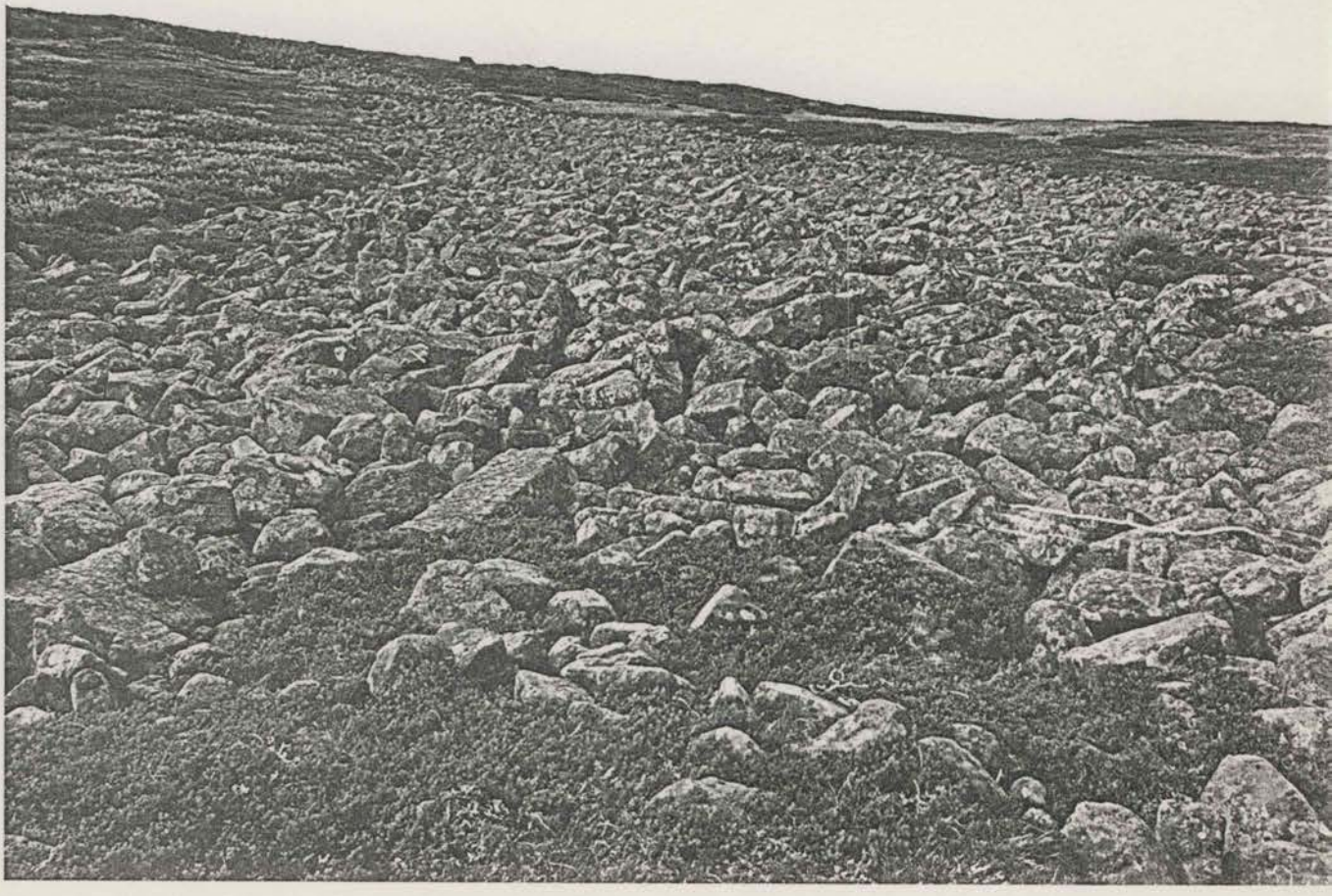
In Fig 3Bb, there is a partially vegetated blockfield which gives the impression of a dendritic set of blockstreams. This is outlined by dots on the overlay and marked (1). This blockfield has its proximal margins at 1 760m, ASL at the edge of a basalt plateau which slopes less than 2° to the south-east. The slope at the head of this blockfield is fairly uniform at about 3° or 5% and increases downslope.

There is a short discontinuous basalt scarp encircling the head of this blockfield and other concentric basalt scarps occur further downslope. The next lower basalt scarp corresponds closely to the cryoplanation boundary line on the overlay and represents a basalt strata step. Further bedrock steps occur lower down in the drainage basin. The depth of block accumulation on blockfield (1) appears to be fairly consistent at about 60cm. This depth correponds to an impervious base below the loose block accumulation.

The drainage lines within this blockfield act as a locus for collection and some of these linear accumulations have edges raised 0.5m to 1m in relief to the adjoining vegetated blockfield. In addition, the centre line of these linear accumulations is depressed with respect to the edges, suggesting a collapse due to the removal of interstitial material. The

blockfield narrows downslope as slope increases to 5° and terminates on a slope of 12° or 21%, close to the cryoplanation boundary line, Fig 3Bb and just above another bedrock step. The blockstream accumulations within this blockfield terminate with abrupt toes at about 1 720m and their surfaces are pitted in a similar manner to basalt block accumulations described at Basalt Hill site 10, suggesting thermokarst.

PHOTOGRAPH PV 21382F13

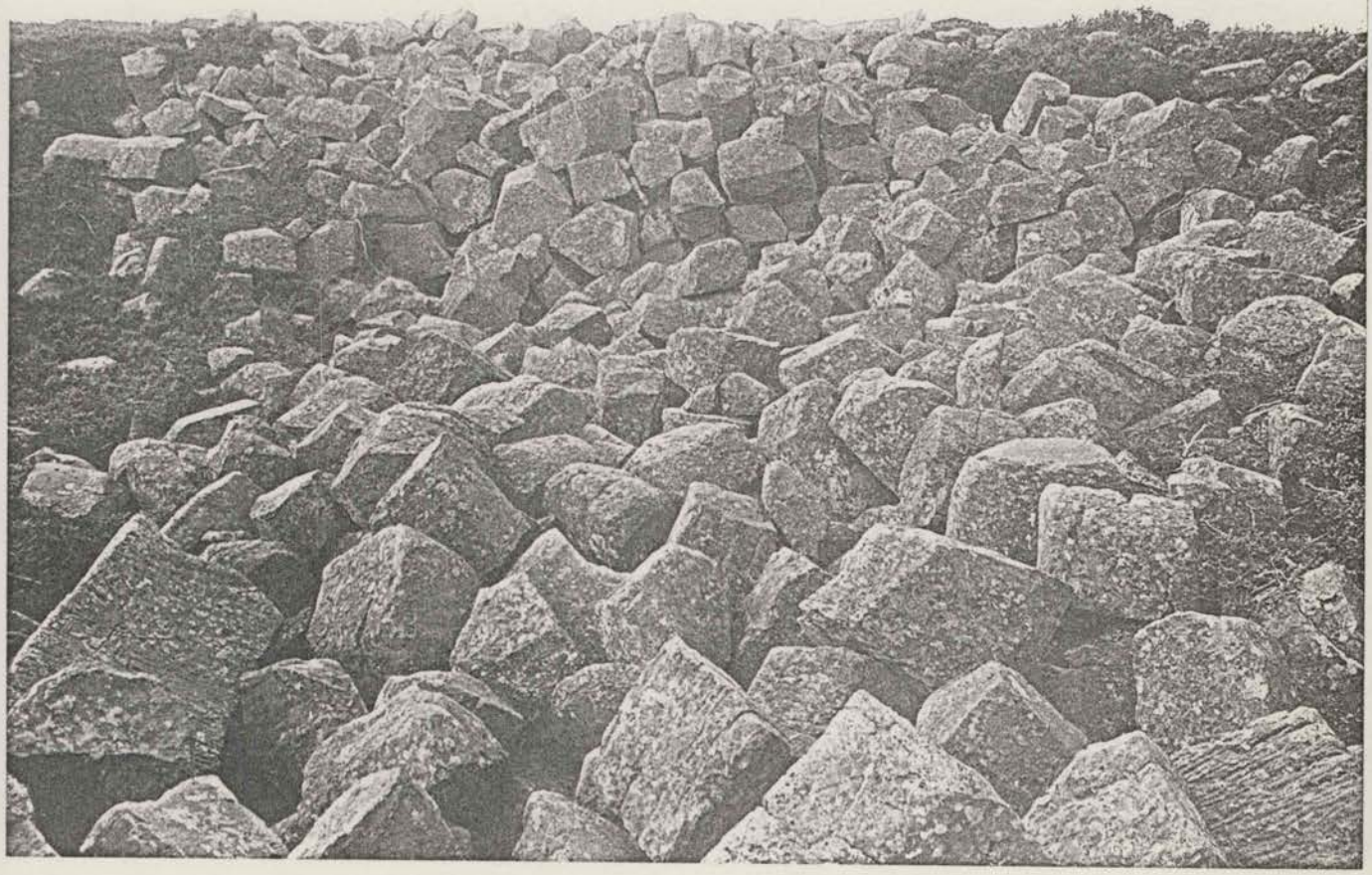


The photograph above is a view of the blockfield at Bundara, G.R. 195118 (Bogong 1:100 000 NATMAP) looking upslope towards a shallow bedrock scarp at the top edge.

Photograph PV 21382F14, overleaf top, is a view of blocks in portion of the basalt bedrock scarp at Bundara, G.R. 194119 (Bogong 1:100 000 NATMAP).

Photograph PV 21382F12, overleaf bottom, shows the Bundara blockfield below G.R. 195119 (Bogong 1:100 000 NATMAP).

PHOTOGRAPH PV 21382F14



PHOTOGRAPH PV 21382F12



Below the bedrock step close to 1 700m ASL and the cryoplanation/striped terrain boundary line, the drainage line slopes at 22% and increases to 28% before flattening out above the next bedrock step at about 1 680m.

There is an open, non-vegetated block accumulation (identified as (2) on the overlay of Fig 3Bb), in the adjacent drainage line to the west, which has its head at the foot of a bedrock scarp close to the cryoplanation/striped terrain boundary. The head of this block accumulation appears to be a relic, arcuate nivation hollow etched into the bedrock scarp. Some block material may also be derived from the blockfield above.

This block accumulation is located along this drainage line from 1 700m down to the Bundara River at about 1 530m. The patterning in the striped terrain on the adjacent slopes which have gradients of 20% to 40%, suggests that much material has been transported down these slopes and accumulated in the drainage line. These slopes correspond to the definition of blockslopes and probably combined processes of rolling, sliding and frost creep. On slopes of 3° to 12° blocks probably moved by frost creep with gelifluction in the drainage lines. The partially vegetated slopes in the striped terrain to the east of block accumulation (2) Fig 3Bb are also blockslopes, with gradients around 30%. The blocks extend from the cryoplanation boundary down to about 1 500m close to the Bundara River.

Fig 3Bc and Fig 3Bd follow.

FIG 3Bc


N
1 KM.
OPEN BLOCK ACCUMULATION
BLOCKSLOPE FABRIC
GRANODIORITE SCARPS
DRAINAGE DIVIDE



FIG 3Bc



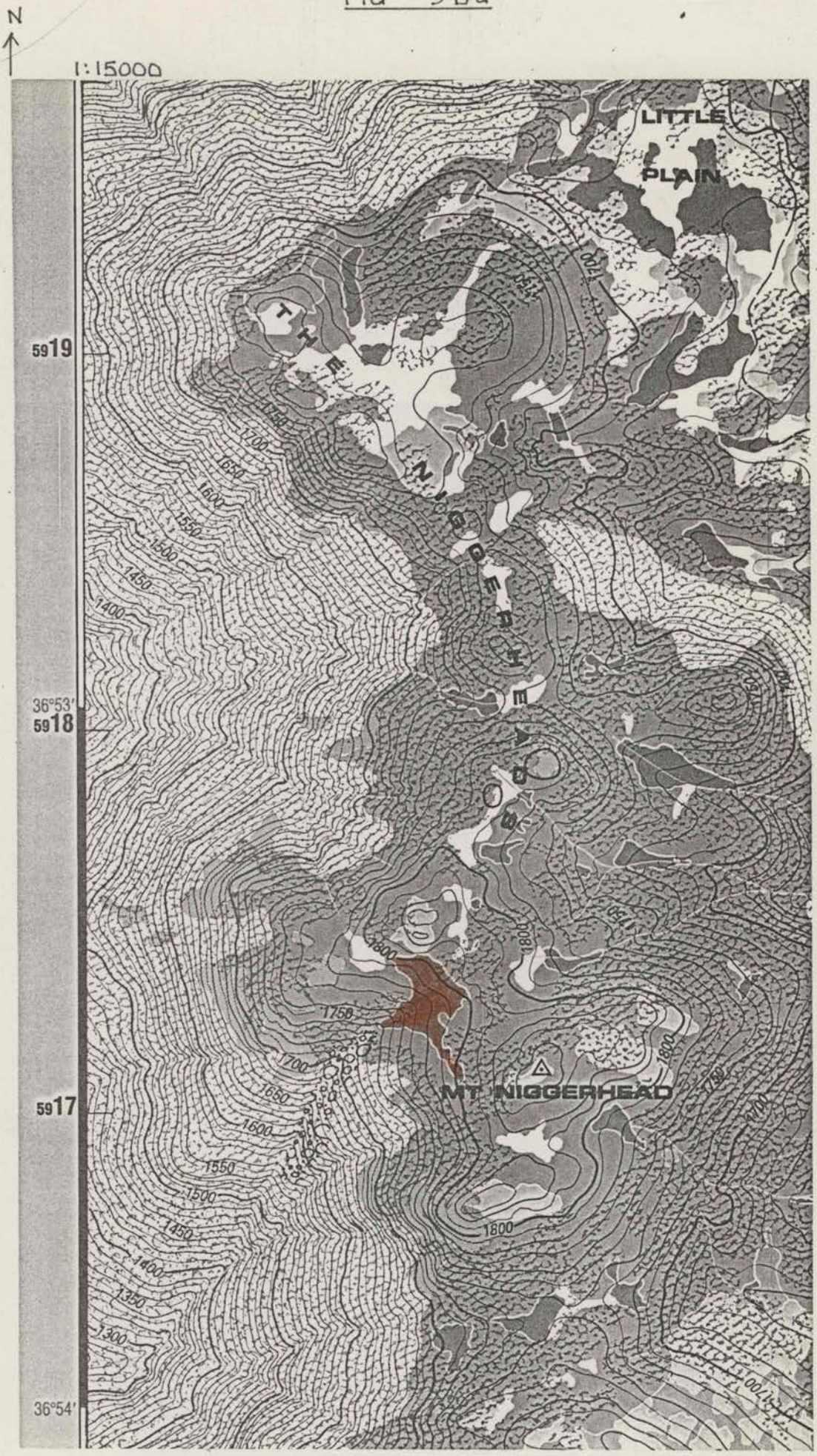
OPEN BLOCK ACCUMULATION

BLOCKSLOPE FABRIC

GRANODIORITE SCARPS

DRAINAGE DIVIDE

FIG 3Bd



SPAGNUM BOG

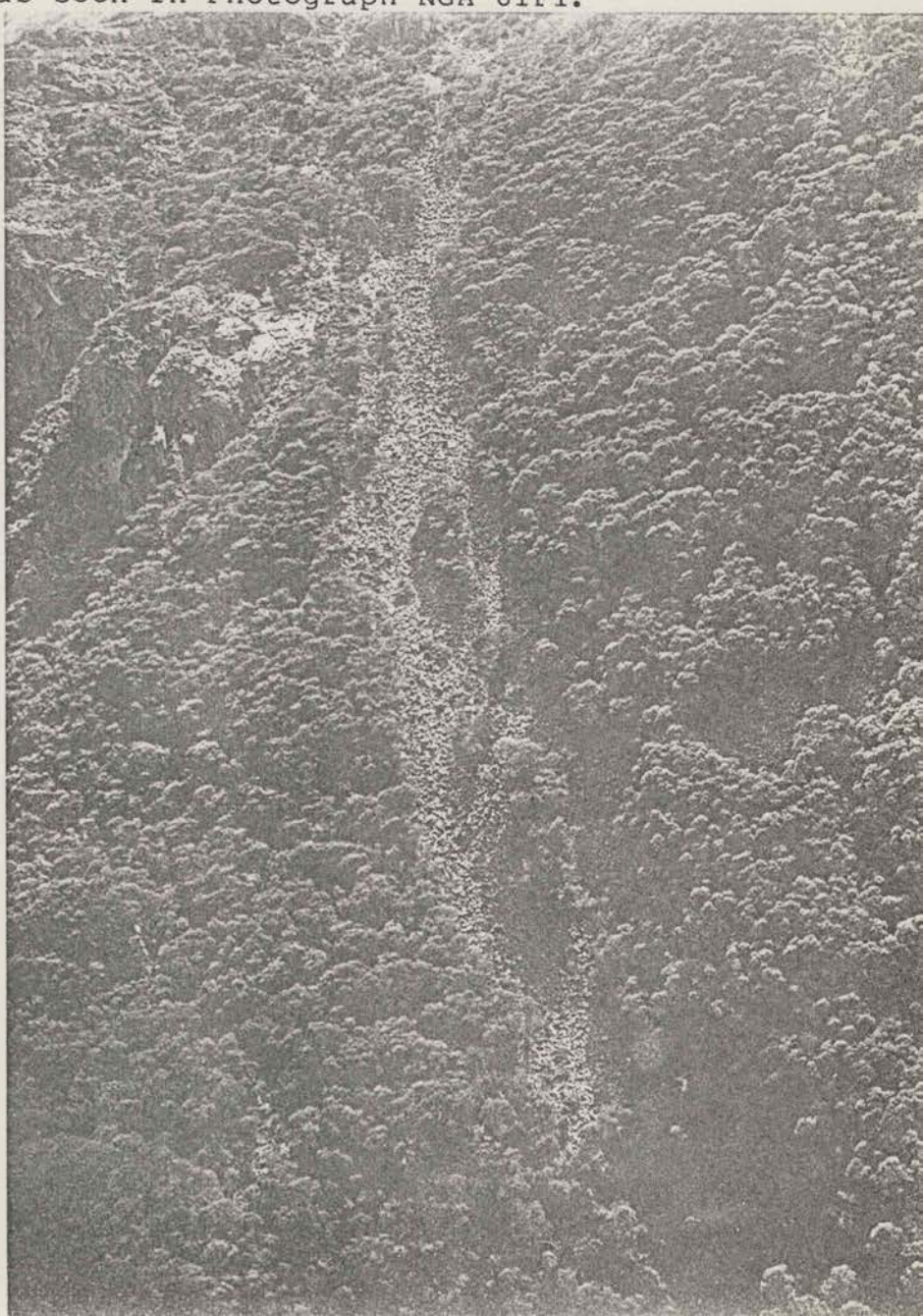
BLOCK ACCUMULATION

The Mt. Niggerhead example is illustrated in Fig 3Bc and Fig 3Bd on the previous pages. The head of the open block accumulation in the drainage line, west of Mt. Niggerhead is located at G.R. 166172 (Bogong 1:100 000 NATMAP) and at about 1 740m ASL. The block accumulation in the drainage line continues from G.R. 166172 down a slope of 28% at the proximal end increasing to 50% near the distal end at G.R. 163168 and at about 1 550m. This lower section is probably a talus which has accumulated below the steep granodiorite, bedrock cliffs to the north. The aspect of the intervening, vegetated slope is south which is in accordance with other well developed blockslopes and talus.

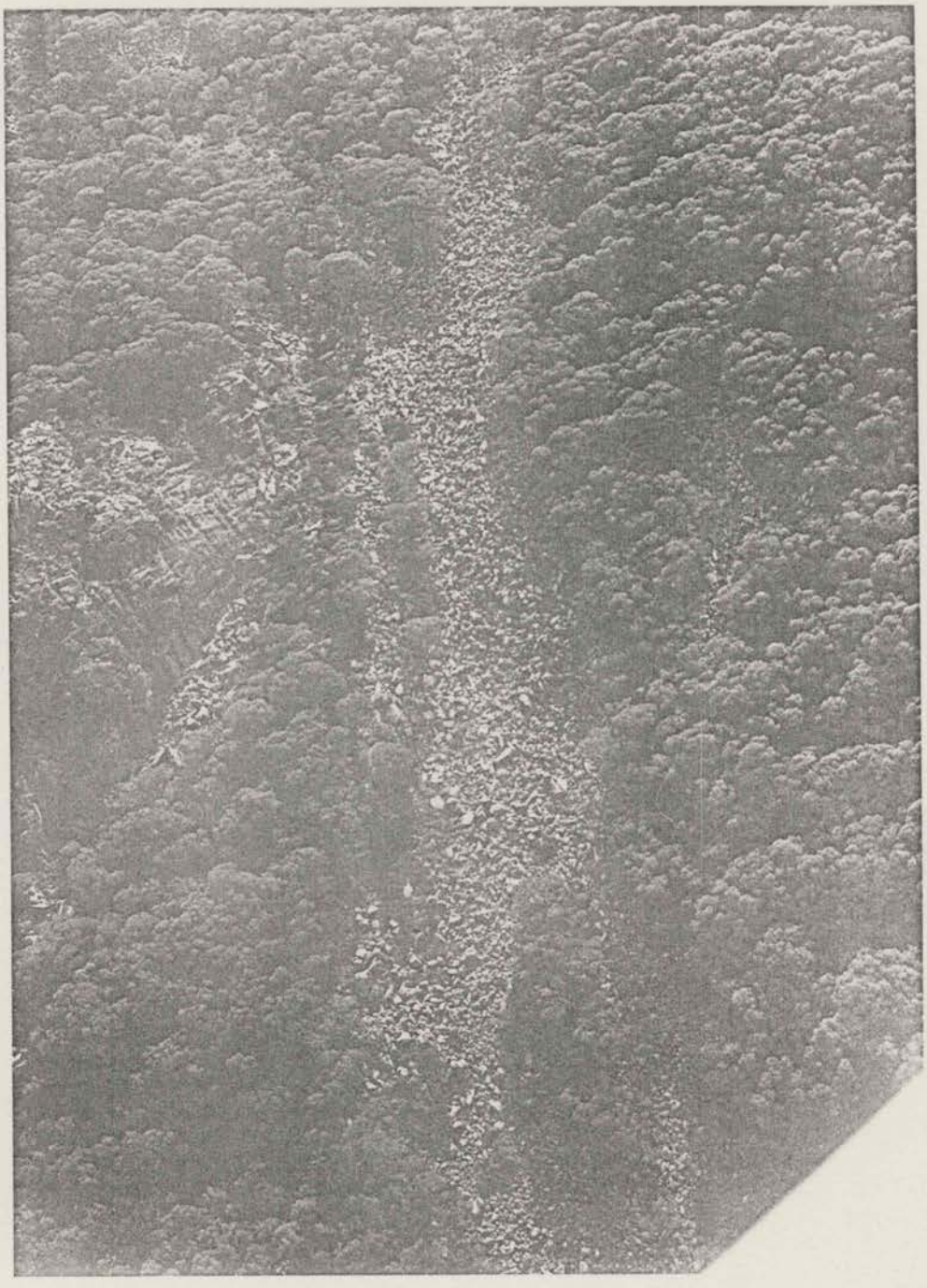
The visible open block accumulation in the drainage line is further illustrated in Photographs NGA 81F1, NGA 81F2, NGA 81F3, NG 82F27 and NG 82F35.

The alpine bog community which is depicted in the shallow drainage basin above this open block accumulation in the 1:15 000 vegetation map (Fig 3Bd) occupies slopes of 16% to 25% and appears to be a vegetated blockfield which may have contributed material downslope. The slope to the south-east of the block accumulation, which has a north-west aspect, appears to be a vegetated blockslope. Blocks are visible on this slope through gaps in the snowgums as seen in Photograph NGA 81F1.

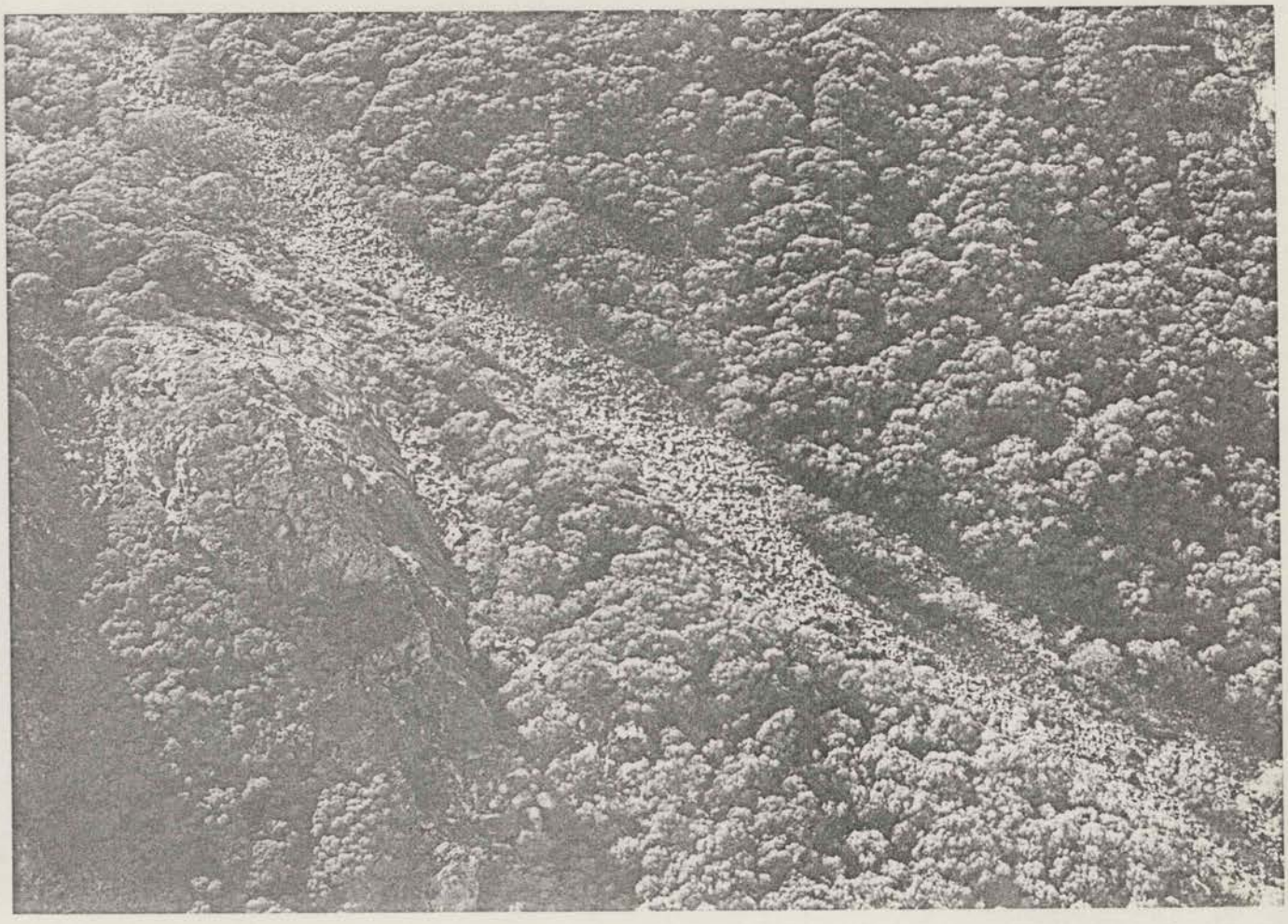
PHOTOGRAPH NGA 81F1



PHOTOGRAPH NGA 81F2



PHOTOGRAPH NGA 81F3

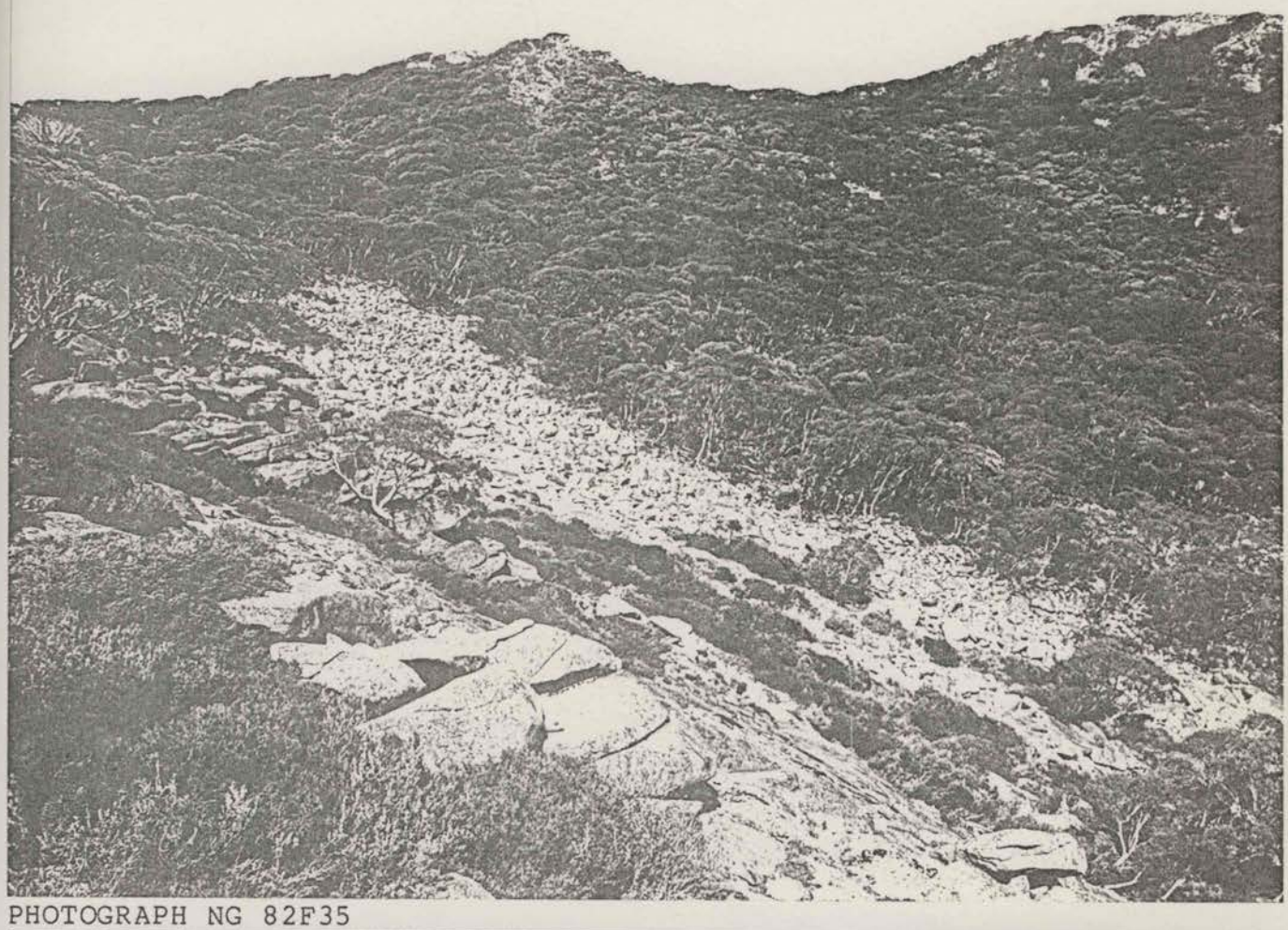


There is some suggestion of movement of the large tabular granodiorite blocks in the Mt. Niggerhead block accumulation. Firstly, Photographs NG 82F35 and NG 82F27, following page, demonstrate an imbricate fabric for the granodiorite blocks indicating downslope movement. Secondly, the patterning visible from the low altitude oblique aerial photographs NGA 81F1 and NGA 82F2, previous page, and even from the high altitude photographs, consists of narrow downslope strips of snow gums. There are insufficient data to account for these stripes due to difficulties of access into this locality, but they suggest downslope movement or perhaps transverse ripples relative to the adjoining slope to the north which appears to have contributed much scree.

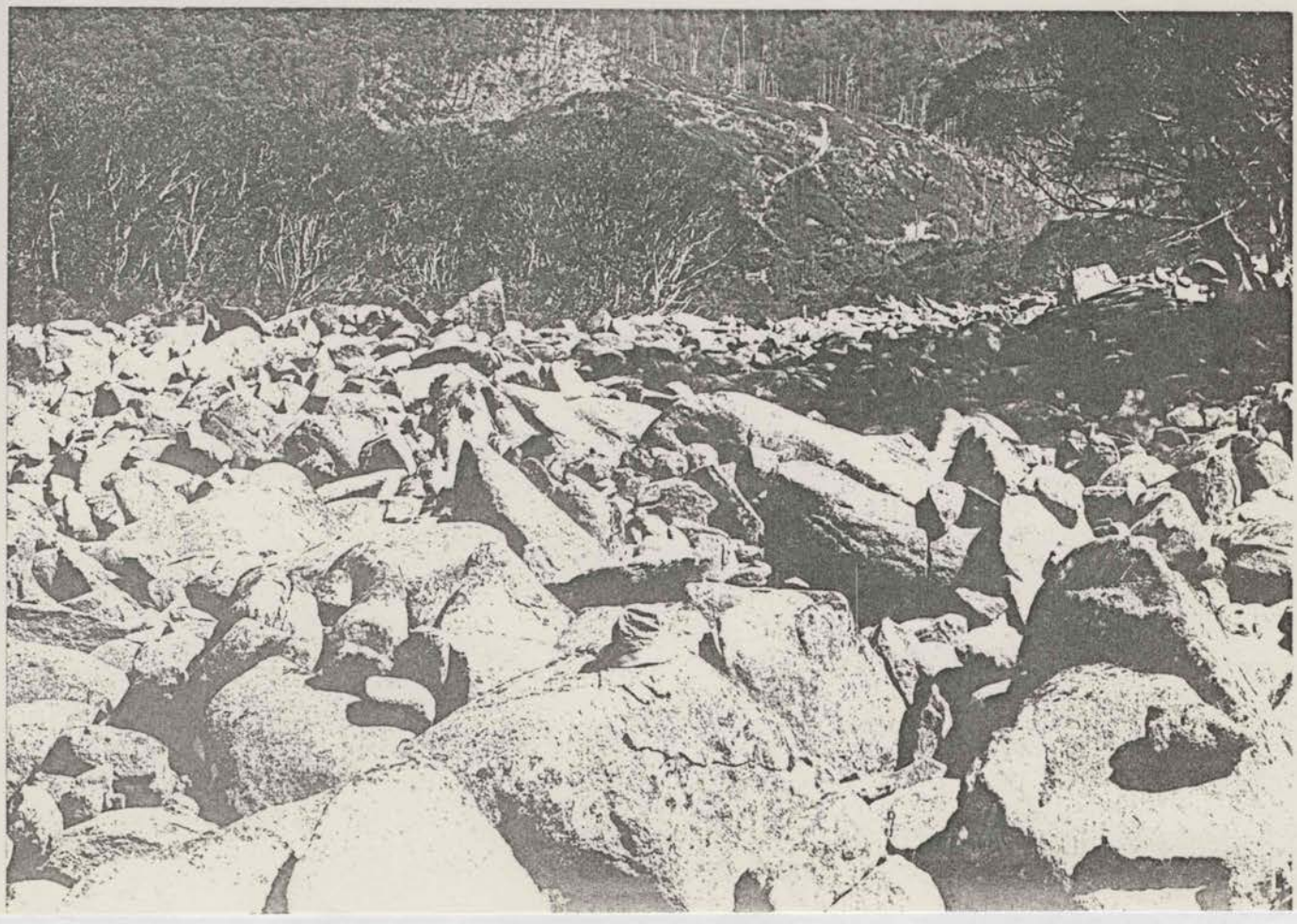
Photograph NG 82F27, overleaf top, looks south from rock scarp near the head of Mt. Niggerhead block accumulation.

Photograph NG 82F35, overleaf bottom, looks downslope from near the proximal end of the Mt. Niggerhead block accumulation.

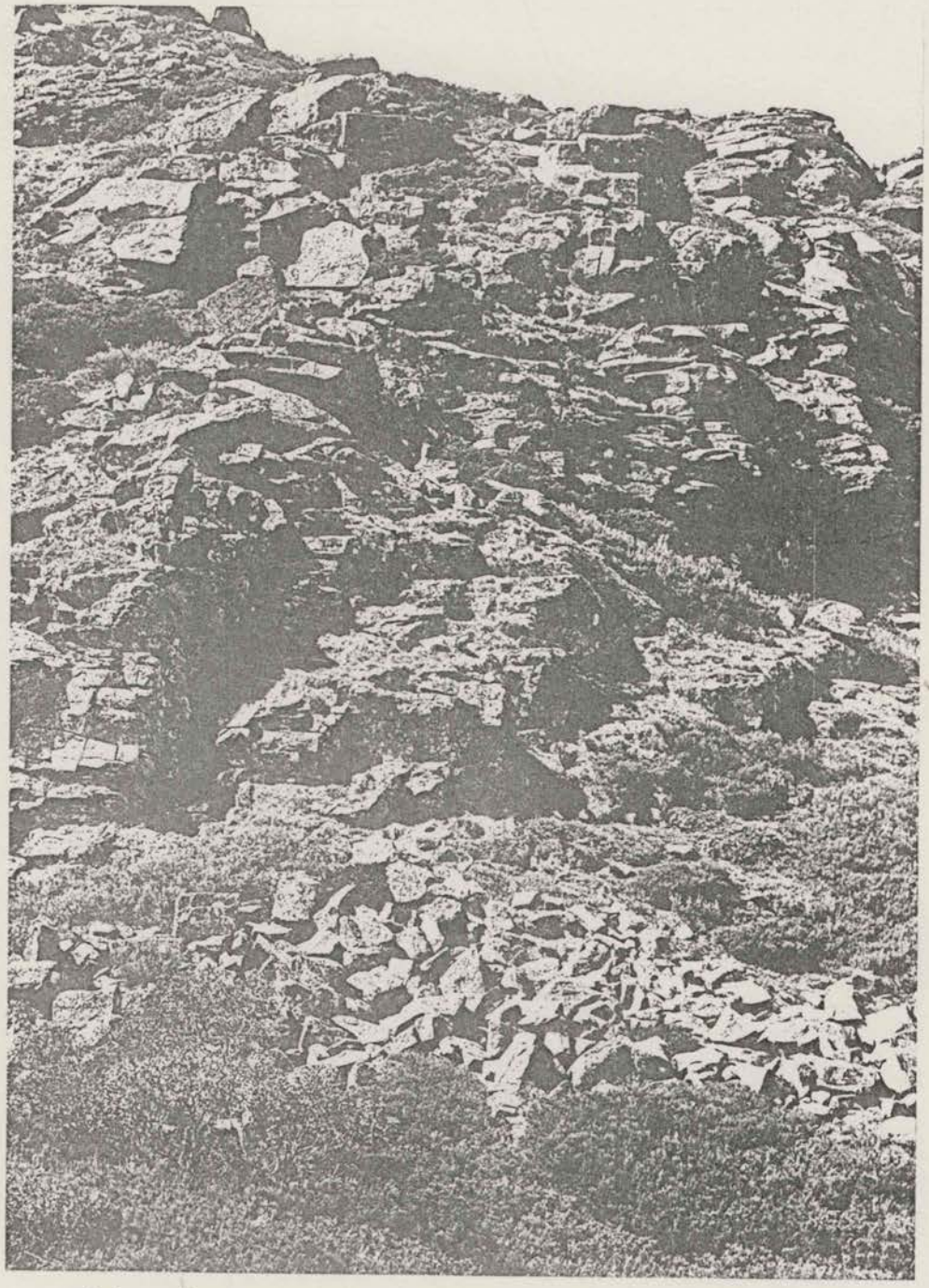
PHOTOGRAPH NG 82F27



PHOTOGRAPH NG 82F35



PHOTOGRAPH NG 82F17



This photograph, taken from just above the head of the Mt. Niggerhead talus/blockslope, demonstrates a small talus at the foot of a well jointed angular granodiorite bedrock scarp.

Most deposits marked TALUS in Table 3B(i) have well defined cliffs or steep bedrock slopes at 44% to 80%. The BLOCKSLOPE accumulations of open blocks appear to be combinations of scree and blocks moving downslope by frost creep and sliding,as they occur on slopes of 30% to 56% and bedock cliffs are usually absent at their heads.

The deposits described as blockstreams generally occur within the cryoplanation/blockfield terrain in drainage lines sloping at5 % to 27%. They are best developed below well jointed bedrock outcrops which are located near the heads of southerly to easterly draining basins where deep snow banks accumulate from the north-westerly winds and thereby contribute a reliable supply of moisture in the spring and early summer. Most blockstreams are basalt but there are some granodiorite blockstreams despite the large tabular blocks produced by granodiorite bedrock.

Most blockstreams appear to terminate on gently sloping terrain with a marked toe which is usually peppered with conical pits interpreted as thermokarst. The blockstreams often occur in dendritic swarms over broad slopes but their individual width is generally less than 10m, their length less than 1 000m (often only 100m-200m) and their thickness from 50cm to 200cm. Many of the small blockstreams have been buried by a veneer of Holocene hillwash and vegetated. The larger blockstreams survive because they form accumulations with steep edges with up to 1m local relief relative to the surrounding terrain, without inhibiting waterflow in the drainage lines. This inversion of relief in the axis of the drainage line has preserved the form of the block accumulation. A good example of this preservation is recorded at Basalt Hill site 10, Section 2A.

In many instances where apparent blockstreams occur as discontinuous accumulations of blocks along the course of the same drainage line, a detailed examination (refer to Section 3C Basalt Hill traverse along 164° and Pretty Valley traverse A1) reveals that the discontinuities may relate to the original nature of block distribution. In the above cases, small accumulations of basalt blocks emanate at the base of small bedrock steps and continue for short distances, usually <100m where they terminate in well defined, steep sided arcuate toes and the surface of the distal ends of these block accumulations is generally peppered with thermokarst. This style of accumulation is repeated at successive steps in the terrain with no sign of continuity of block movement down the axis of the drainage basin. Instead, the blocks which accumulate at lower, successive steps seem to have been mobilized from the sides of the valleys, perhaps by frost creep and the morphology of the blocks appears to change as the distance from the bedrock outcrop at the head of the drainage basin increases. In general basalt blocks get smaller, with platy or irregular habit at greater distances from source areas whereas blocks are mainly larger prismatic columns close to source areas.

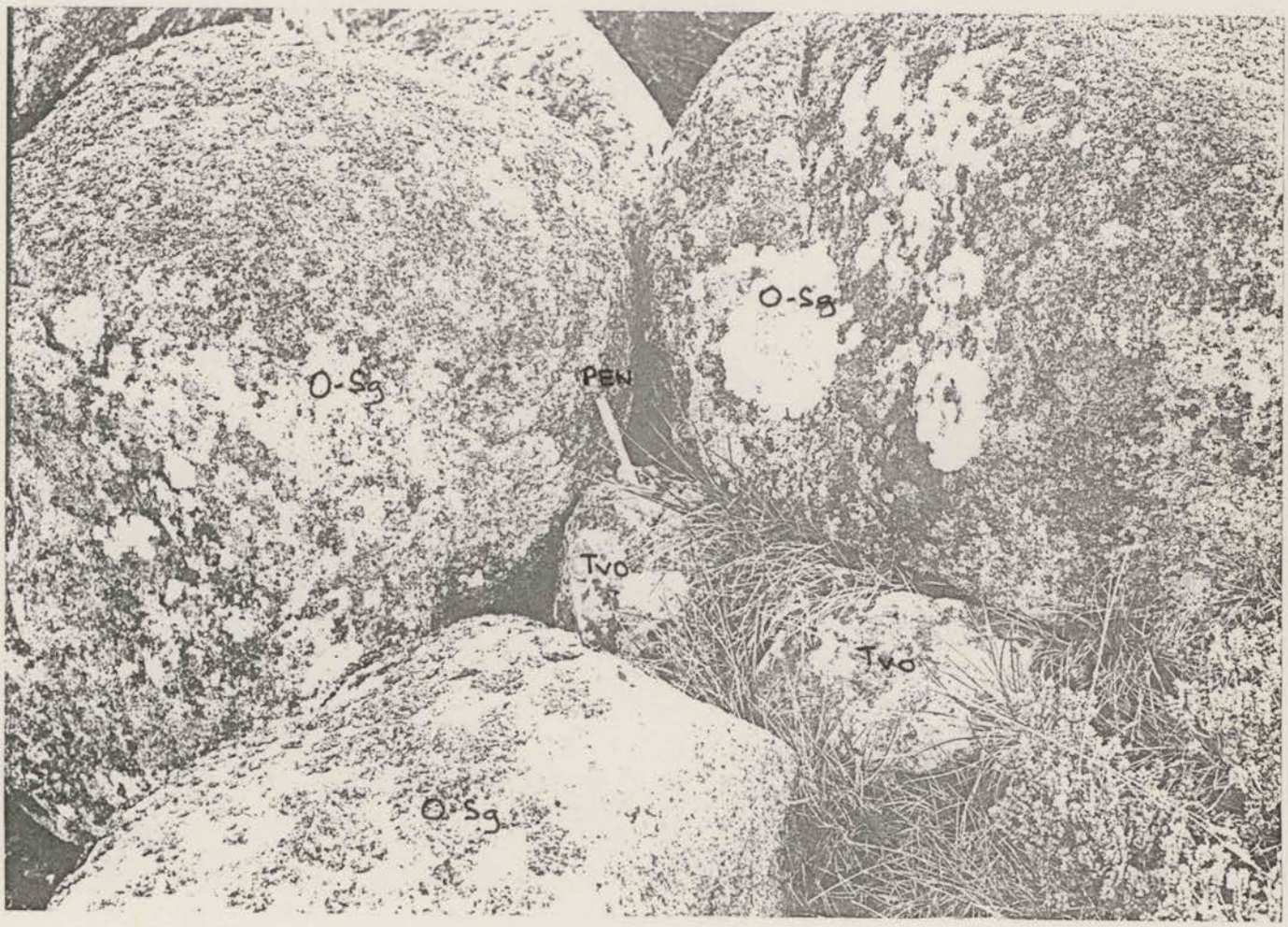
In many instances apparent blockstreams maybe a string of block glacii threaded along the drainage line, forming in response to changes in slope down the stepped terrain. This is illustrated in Fig 2Ag for a small portion of the Pretty Valley

area where geomorphology was mapped from aerial photographs. The same situation was observed for blockstreams at the head of the Bundara River, illustrated in Fig 3Bb, and also on the eastern flanks of Basalt Hill, reported in traverse 164° in Section 3C.

Some block accumulations, including small discontinuous ones have migrated short distances down the drainage line. This is evident from steep walled, lobate toes at their distal ends and also from obvious imbrication of platy blocks with a downstream flow direction. Refer to Photographs PV 15484F6, PV1584F7, PV15484F4, PV 15484F5, PVDB86F1.

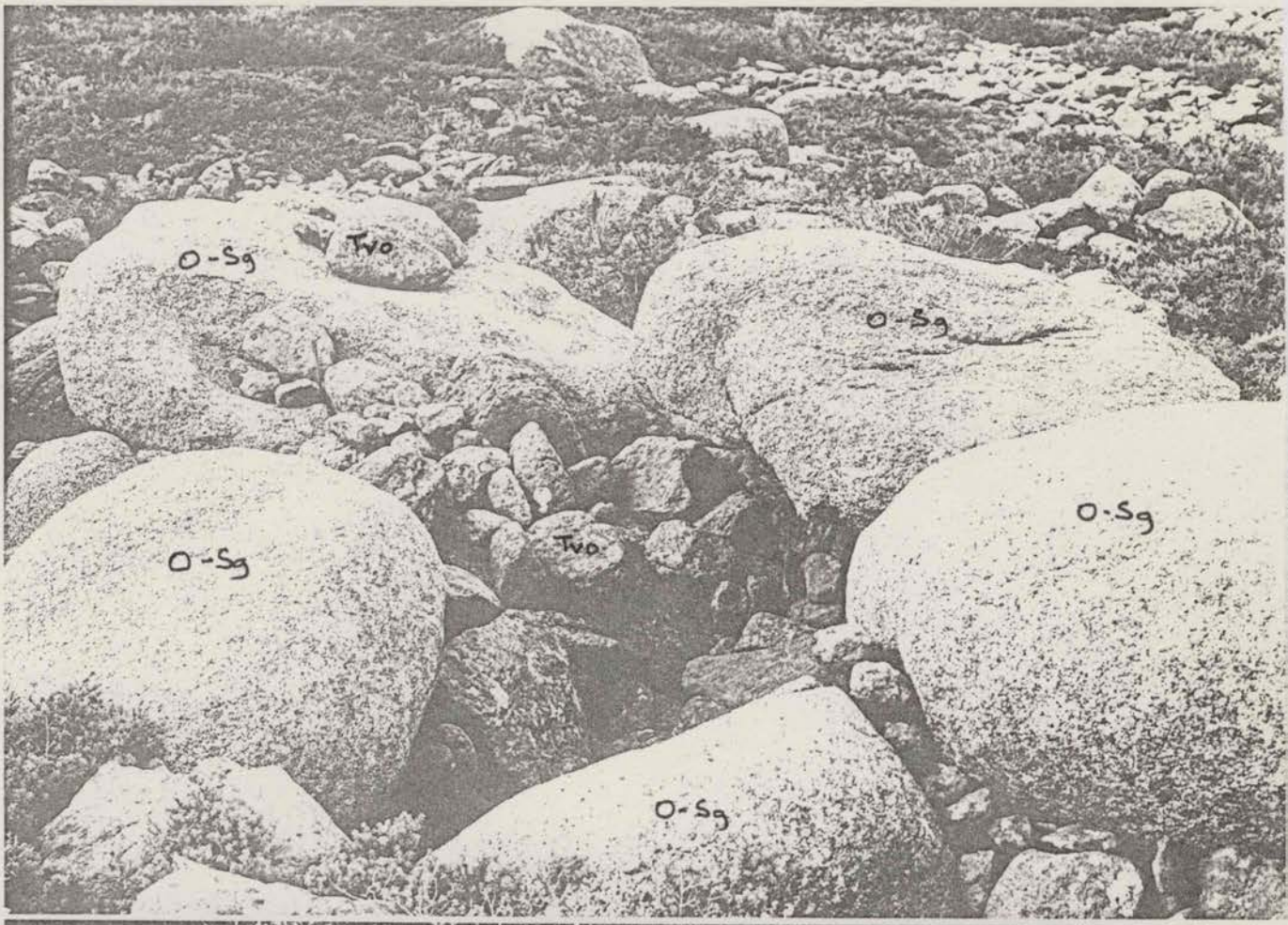
PHOTOGRAPH PV 15484F4

This photograph demonstrates a basalt block within granodiorite blocks on a granodiorite bedrock slope away from the drainage line. This demonstrates that much interstitial material has been dispersed. This interstitial material may have been the source of the Holocene sediments in Pretty Valley.

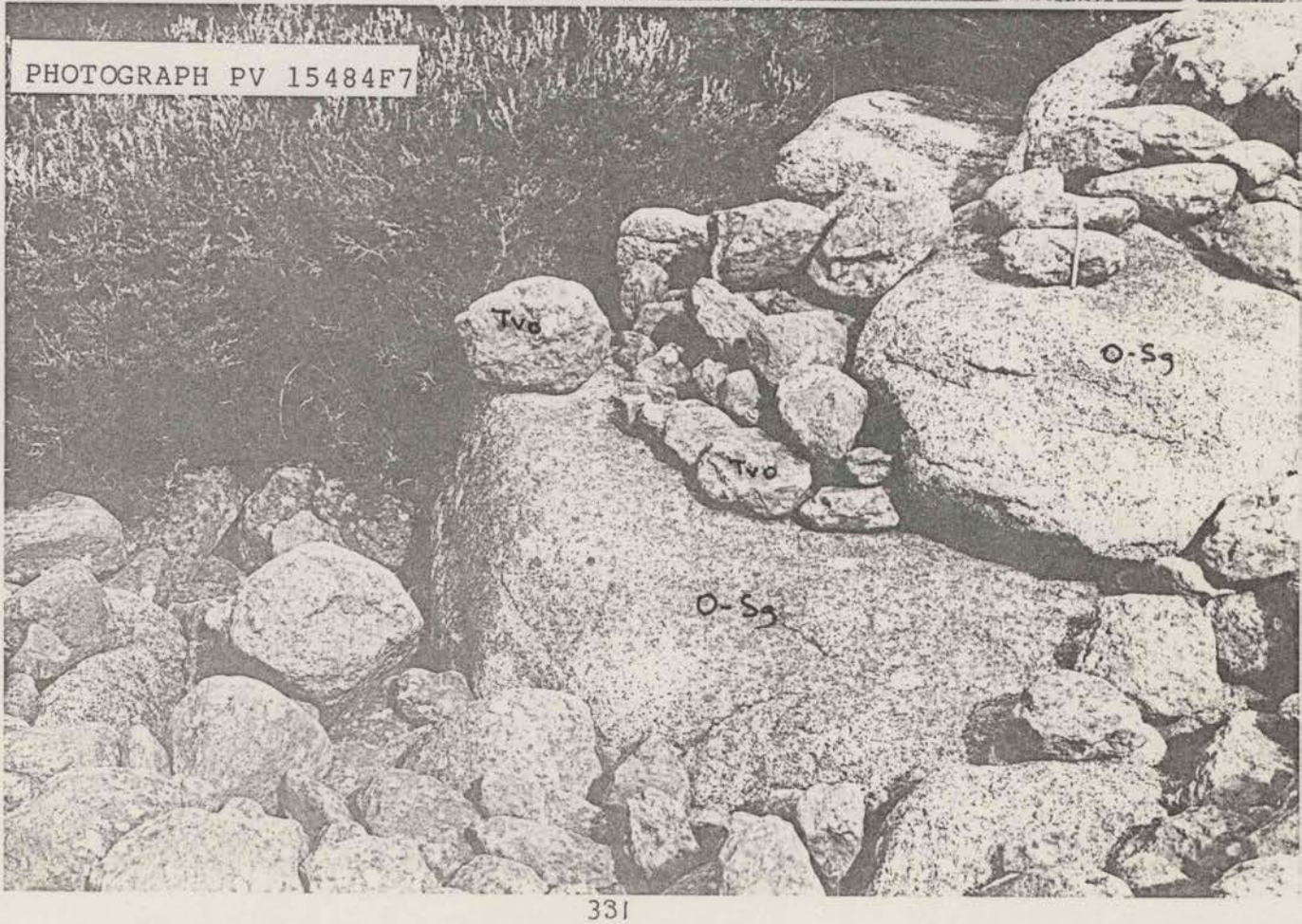


Photographs PV 15484F6 and PV 15484F7, overleaf, demonstrate intermixing of granodiorite and basalt blocks in the drainage line.

PHOTOGRAPH PV 15484F6

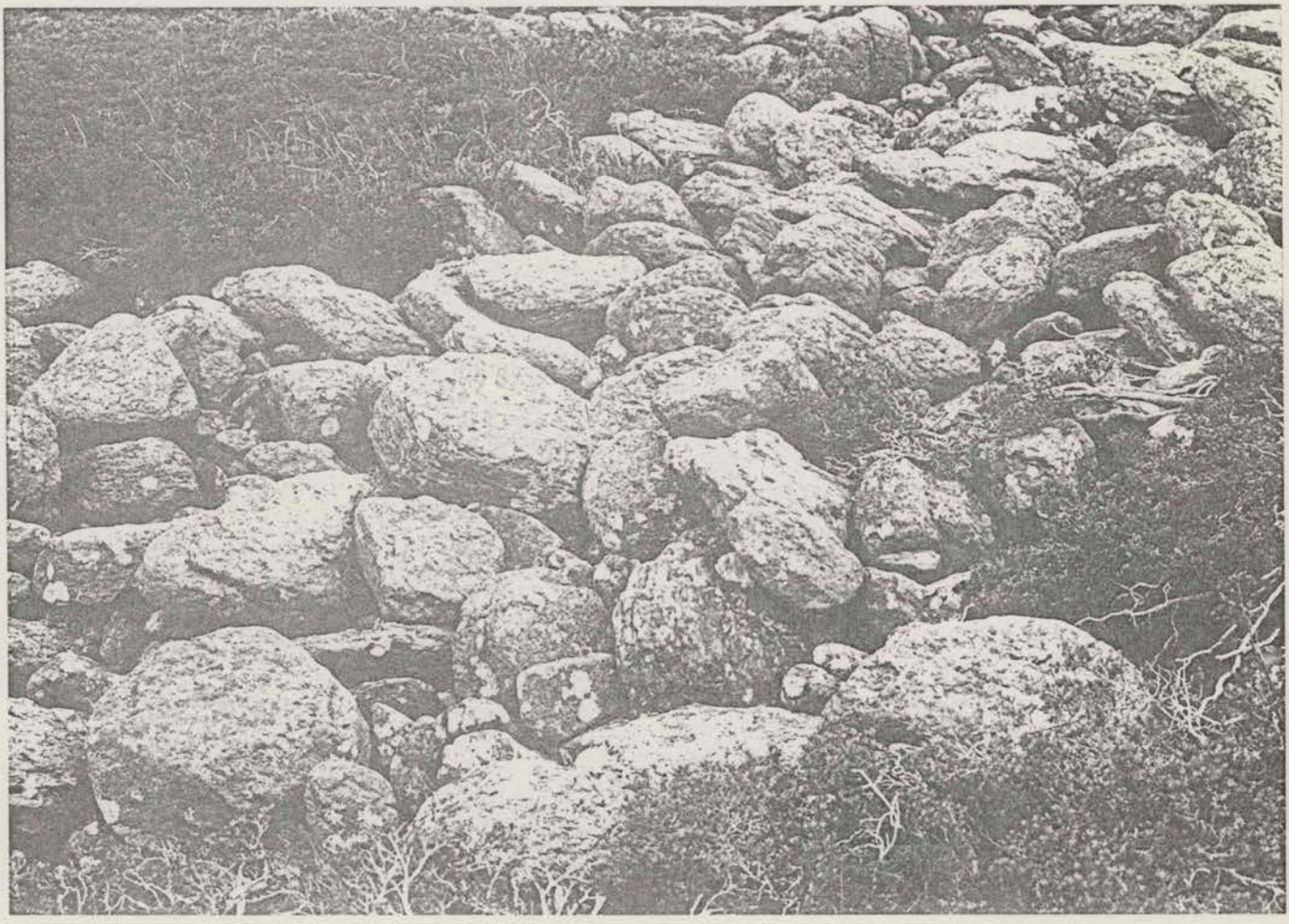


PHOTOGRAPH PV 15484F7



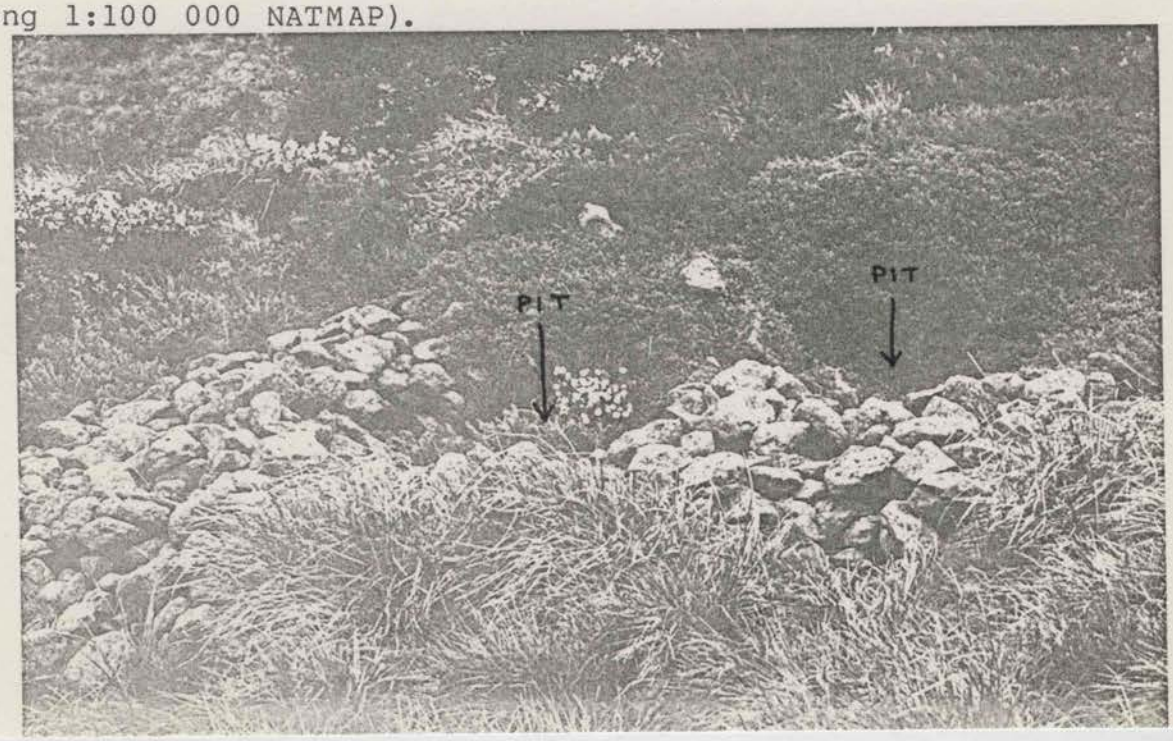
PHOTOGRAPH PV 15484F5

This photograph demonstrates imbricate blocks in a drainage line at G.R. 198142 (Bogong 1:100 000 NATMAP). These basalt blocks have migrated about 200m downslope over granodiorite bedrock.



PHOTOGRAPH PVDB 86F1

This photograph demonstrates the relative relief and pitting at the distal end of a block accumulation, located at G.R. 201249 (Bogong 1:100 000 NATMAP).



Most of the isolated block glacii occur at the margins of bedrock steps or scarps which are not associated with a drainage line. These small localized accumulations of blocks occuring as near level bands at the foot of basalt scarps are still the sites of significant snow bank accumulation and this is presumed to be the only source of moisture which would have serviced the frost shattering process and local mobilization of these blocks.

Frost shattering is relatively dormant at present as demonstrated by lichen growths, weathering pits and rinds on the surfaces of insitu bedrock at these sites. In fact, the insitu bedrock exposed at these scarps exhibits a similar degree of alteration to the individual blocks in the block glacis treads below. The level apron like accumulation of blocks in many of these isolated block glacis accumulations (e.g Basalt Hill site 11, Section 2A) is in contrast to talus accumulation and suggests the blocks slowly flowed outwards and established an equipotential surface before coming to rest a short distance from the scarp. This is in contrast to what might be expected from a large permanent snow bank which might have produced an arcuate mound of protalus debris. In fact, the blocks adjacent to some south facing basalt scarps appear to have been fluidised, and instead of producing a flat apron have a bulging toe, probably due to rotational slip.

Their location adjacent to these scarps where snow accumulation is slow to melt even in today's climate, suggests that the interstitial material which fluidised these block accumulations was ice. The peppering of conical pits over the surface of these features suggests thermokarst and further supports ice as the interstitial material. The above argument suggests that these sites of relic block glacii were once sites of small, permanent snow patches and that the climate was cold enough for ice to remain within the block mass for a considerable period of time, in order to allow the slow downwards and outward flow necessary to attain their present (relic) distribution.

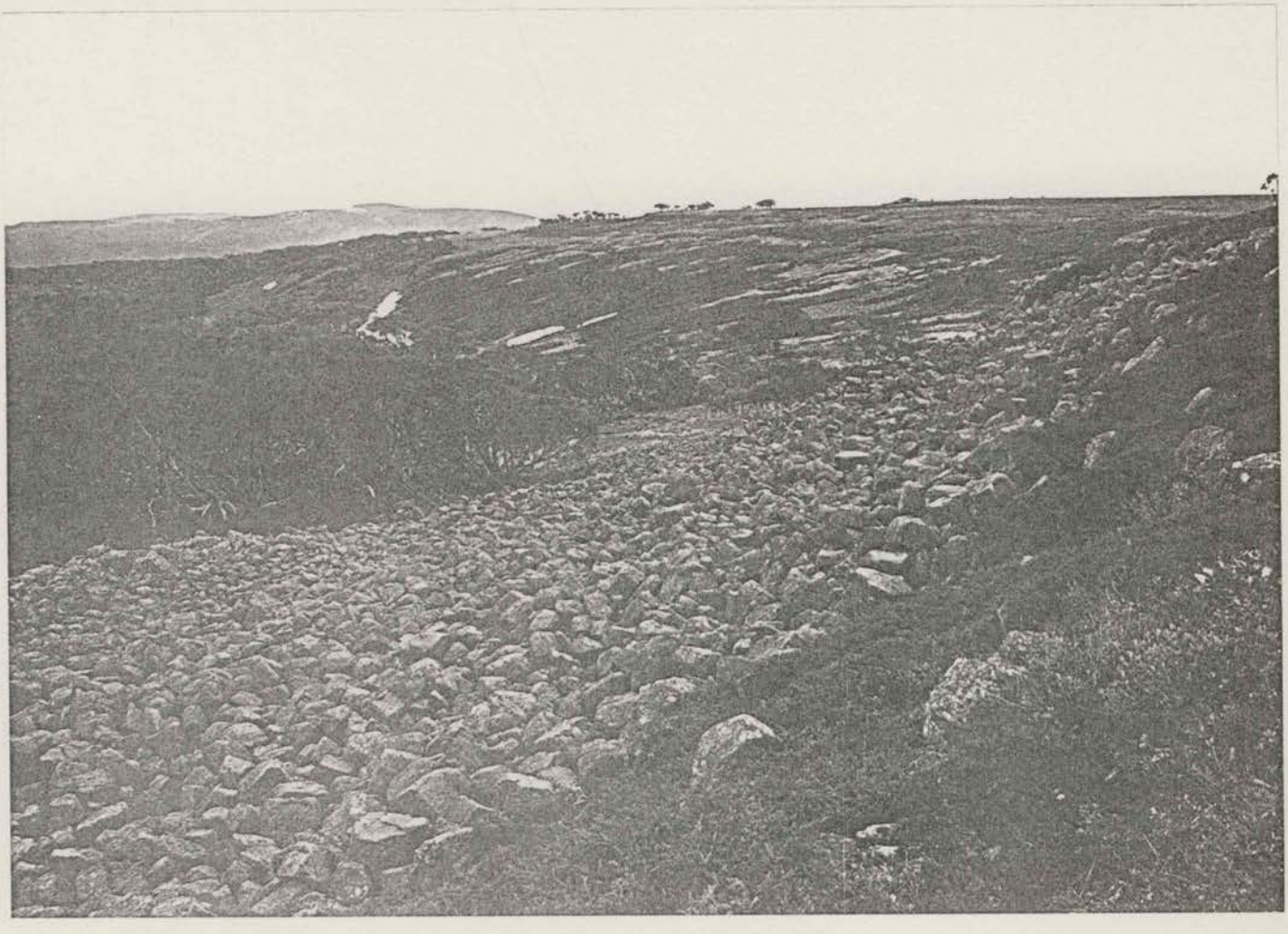
Refer to Photographs BH 1083F10, BH1083F11 in Basalt Hill site 11, Section 2B.2, for examples of a near level block glacis with thermokarst.

Refer to the following Photographs : PV 84F28, PV 21382F7, PV 21382F10, HPA 81F22, HPA 81F24, PV 21382F17, PV 20282F2, PV 1182F15 and PV 20282F5,for examples of block glacii which may have developed as protalus ramparts below bedrock scarps, some of which demonstrate localised slumping.

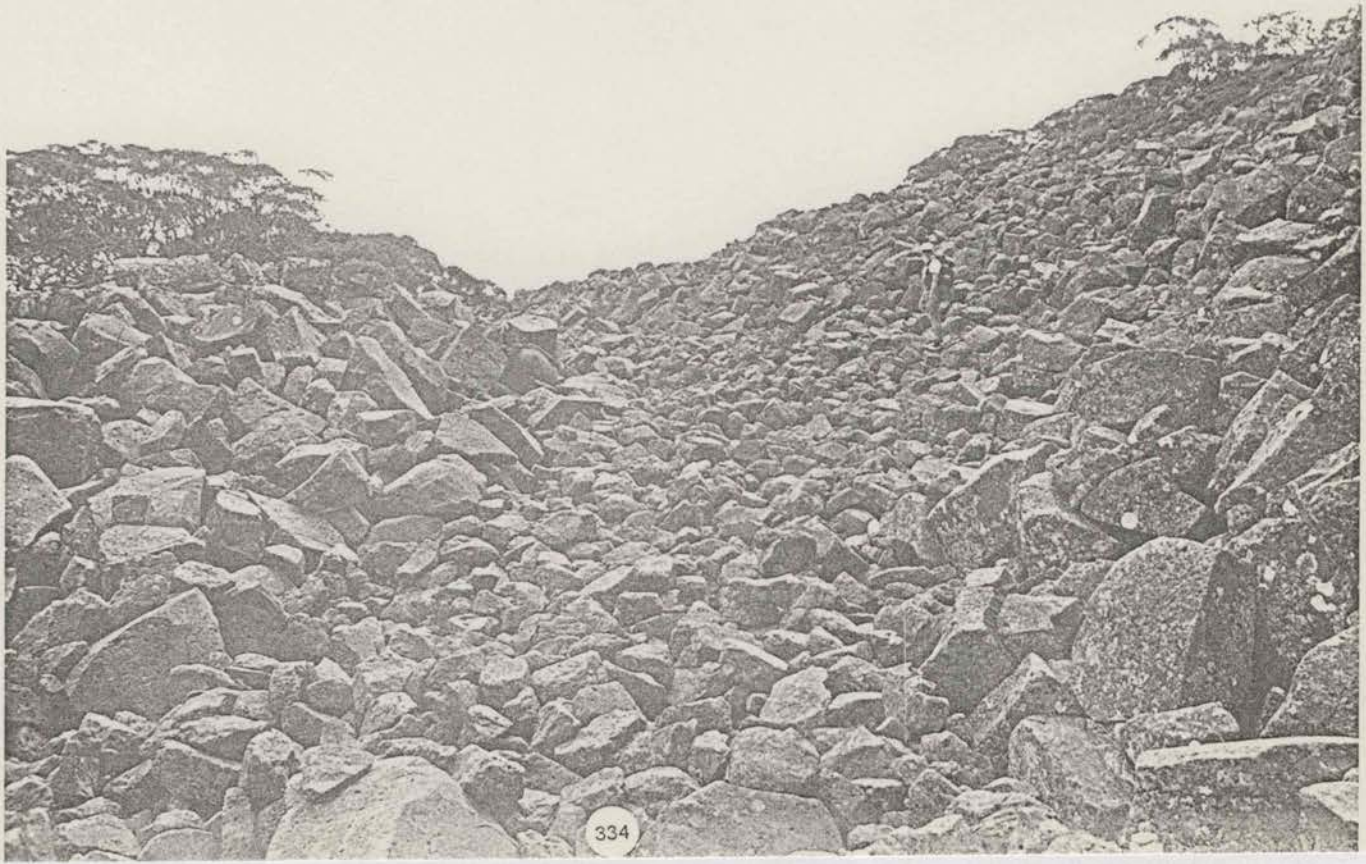
Photograph PV 84F28, overleaf top, location G.R. 197116 (Bogong 1:100 000 NATMAP) looking westwards towards the basalt plateau with a block glacis below the basalt scarp in the foreground.

Photograph PV 21382F7, overleaf bottom, shows a protalus rampart or rotational slip in a block glacis?, located at the southern margin of the basalt plateau near G.R. 197116 (Bogong 1:100 000 NATMAP).

PHOTOGRAPH PV 84F28

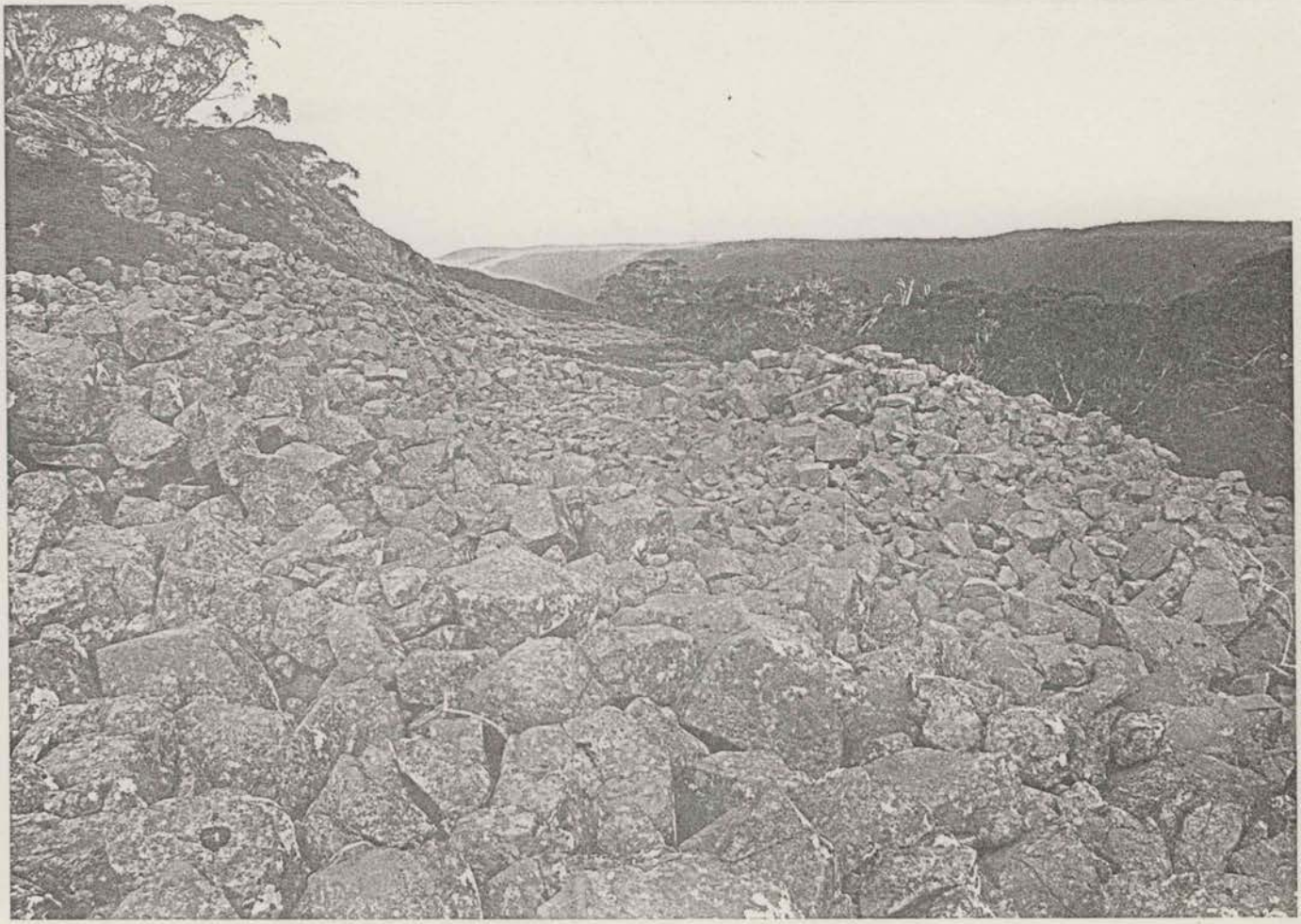


PHOTOGRAPH PV 21382F7



PHOTOGRAPH PV 21382F10

Photograph PV 21382F10 below, shows the same feature as PV 21382F7, but looking from the opposite direction. The blocks are angular and relatively unaltered indicating they have moved little from their source.



Photograph HPA 81F22, overleaf top, is a low altitude, oblique, aerial photograph of Mt. Jim from the south, showing a small autochthonous block slope on its southern margins and a block glacis on its eastern flank.

Photograph HPA 81F24, overleaf bottom, is a closer view of Mt. Jim showing features mentioned for the previous photograph.

PHOTOGRAPH HPA 81F22

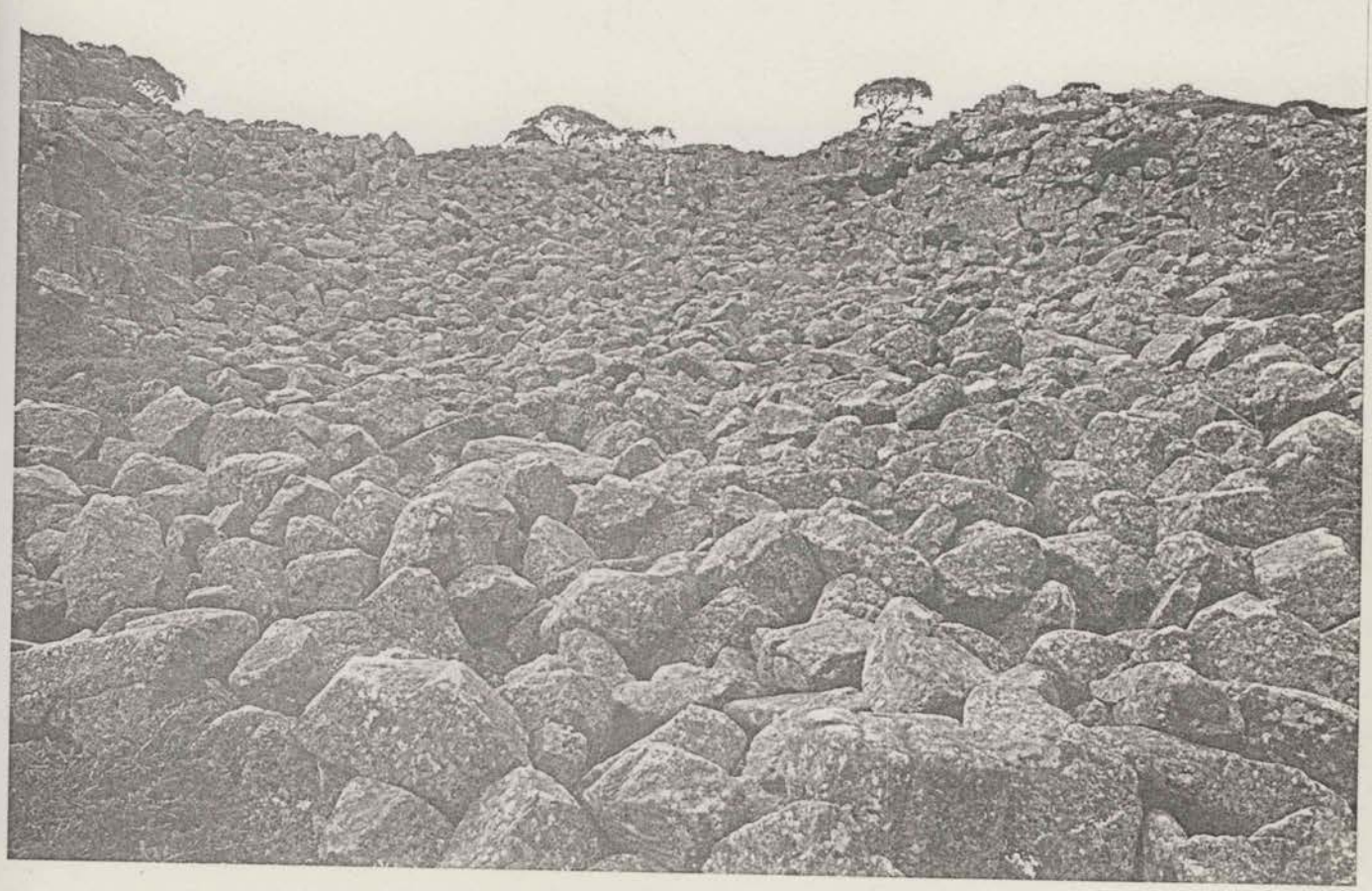


PHOTOGRAPH HPA 81F24



PHOTOGRAPH PV 21382F17

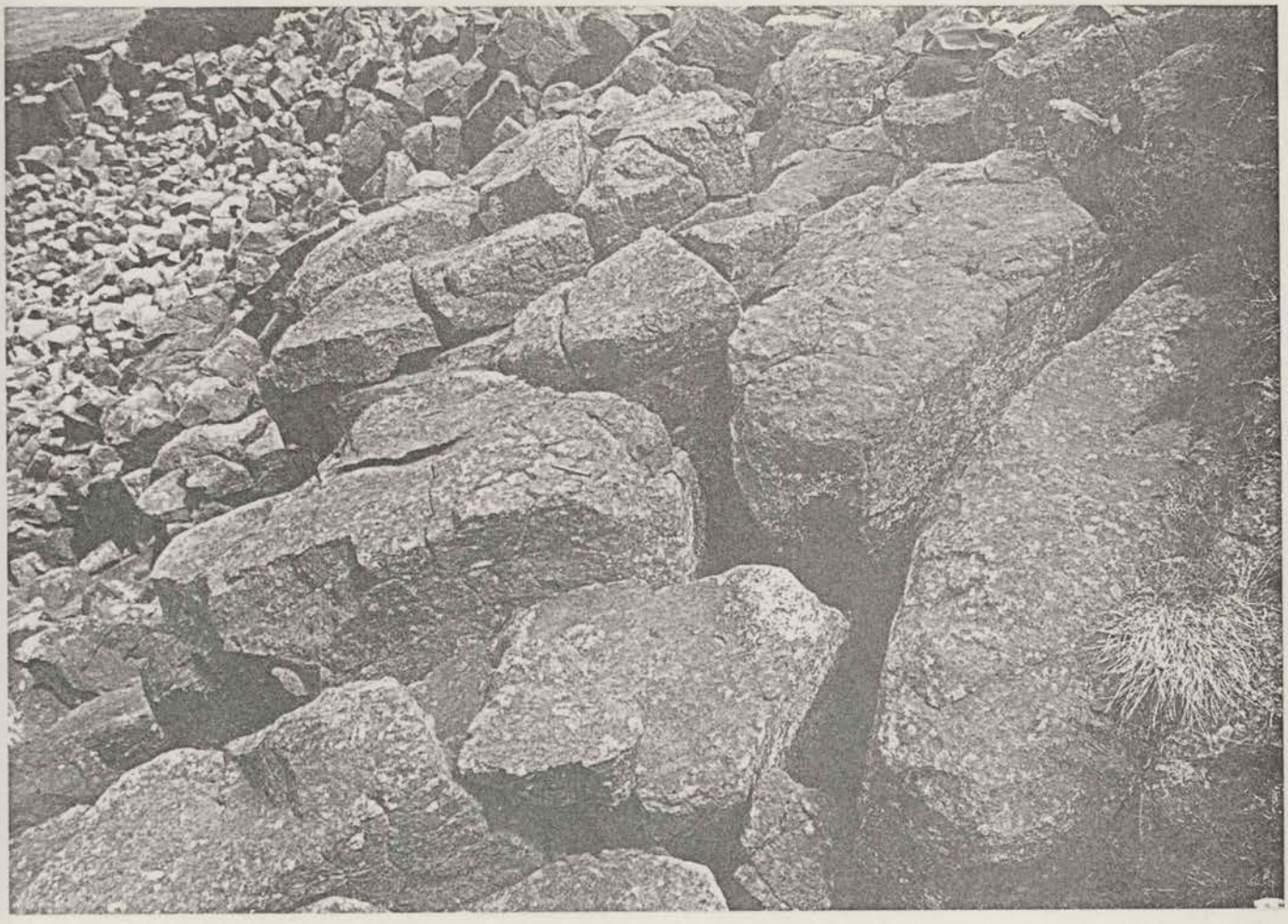
This photograph represents a view from the distal end looking upwards at the autochthonous blockslope on the southern margin of Mt. Jim.



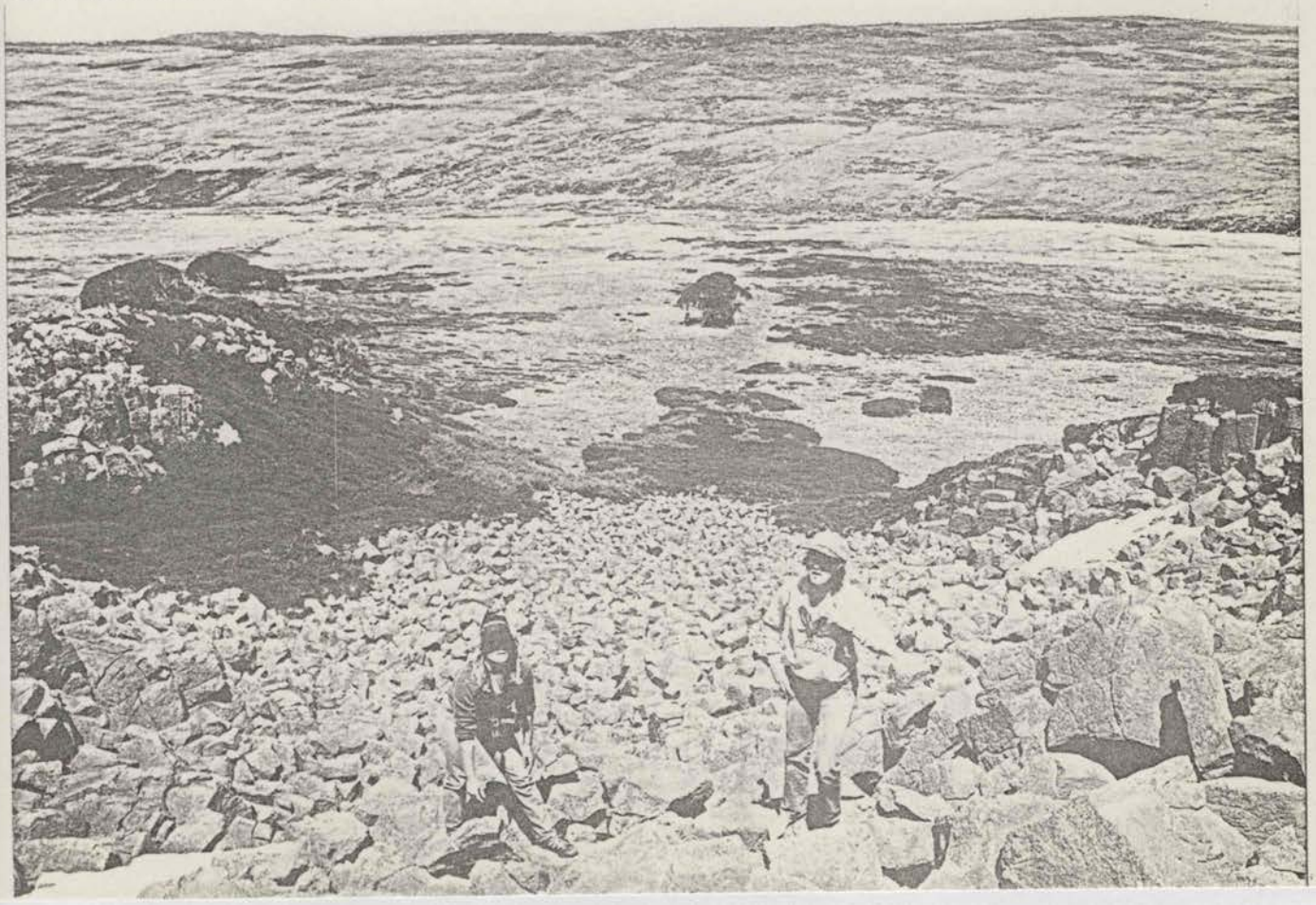
Photograph PV 20282F2, overleaf top, is of the basalt bedrock at the proximal edge of the autochthonous blockslope, Mt. Jim. Note the slight rotation of the large basalt columns.

Photograph PV 1182F15, overleaf bottom, is a panorama from the proximal edge of Mt. Jim autochthonous blockslope looking south.

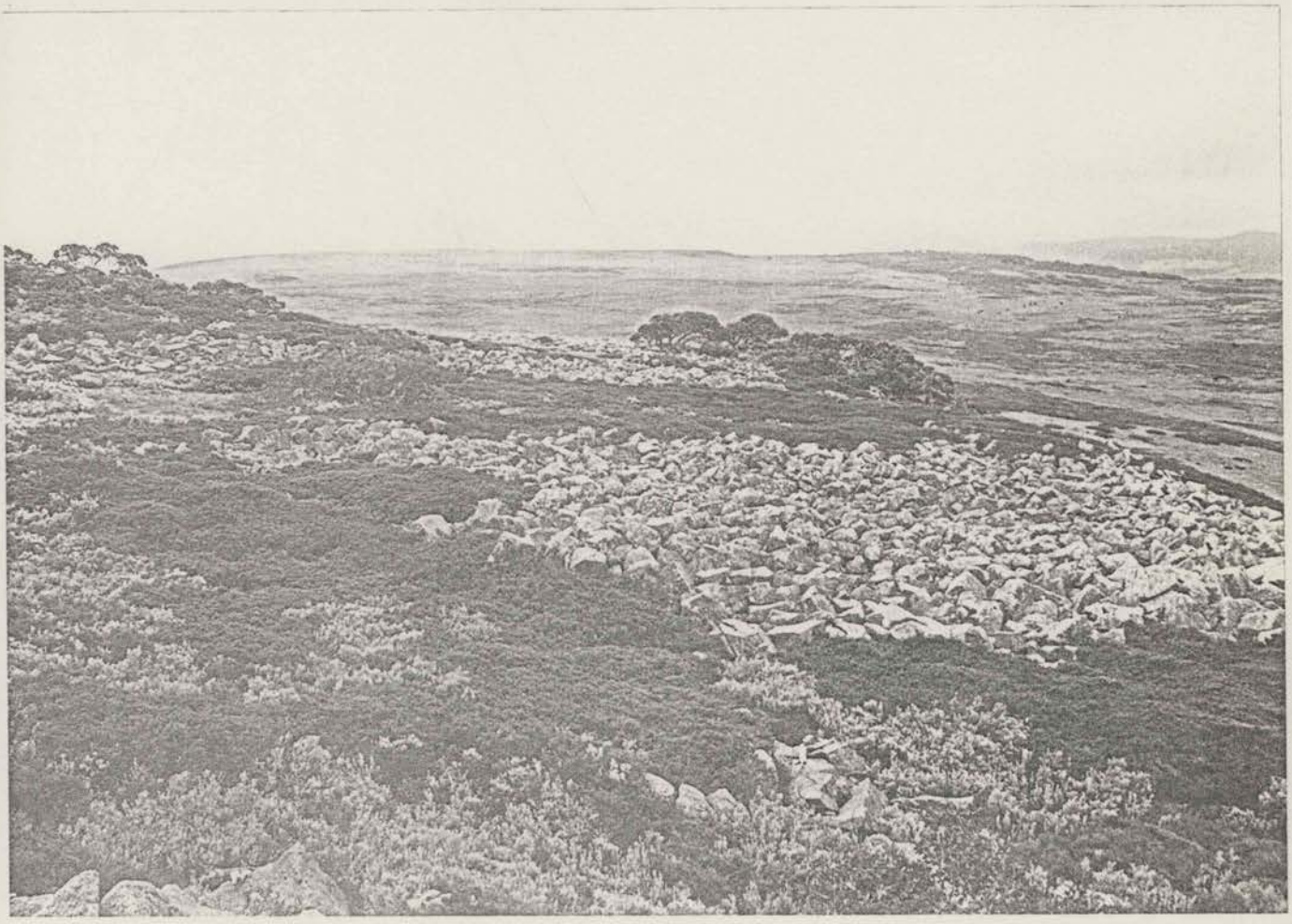
PHOTOGRAPH PV 20282F2



PHOTOGRAPH PV 1182F15



PHOTOGRAPH PV 20282F5



The above photograph shows the block glacis on the eastern flank of Mt. Jim.

Mt Bogong presents a few anomolies with respect to the distribution of blocks. Most of the block accumulations appear to be talus with some examples of blockslopes and virtually no clear examples of blockstreams. The location of talus is similar to block accumulations on the remainder of the Bogong High Plains with a preference for steep southerly slopes in an altitude range of 1 300m-1 800m ASL. Striped terrain is not apparent on the northern slopes of Mt. Bogong and appears to be restricted to a few, localised , southfacing catchments in close association with relic talus. In one catchment, located near G.R. 238324 (Bogong 1:100 000 NATMAP) striped terrain was apparent down to 1 050m in association with a blockslope.

The dominant rocktype on Mt. Bogong is schist (unit OSs), with OSn gneiss on the western margins, which is probably not as susceptible to producing blocks as basalt, hence reducing the incidence of striped terrain. The topography of Mt. Bogong demonstrates more relief at the margins with slopes of 30° or more, possessing large bedrock scarps at their heads. Most of the talus deposits also have snow patch hollows near their proximal ends, developed at the base of the bedrock scarps. This suggests that moisture availability may also have been a limiting factor on Mt. Bogong, when compared to the Bogong High Plains, as these talus deposits were mostly on southerly aspects where snow patches could survive whereas the windward, sunny, northern flanks of Mt. Bogong appear almost devoid of relic block accumulations, except for minor scree.

Photograph BG 382F32 demonstrates a vegetated apron of talus in the upper reaches of Cairn Creek on Mt. Bogong. The head of the creek above the talus apron is a late lying snow patch zone.

PHOTOGRAPH BG 382F32



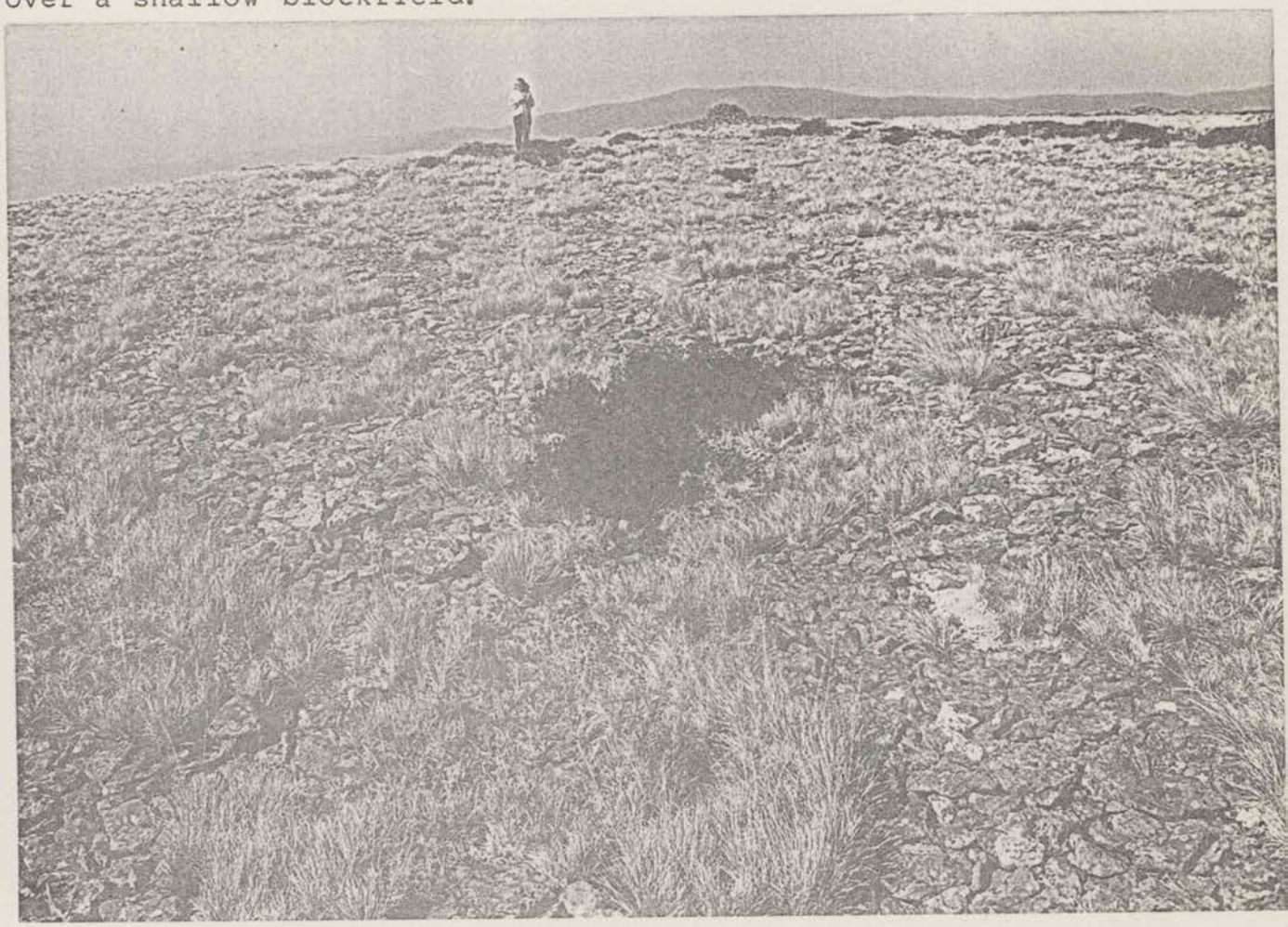
SECTION THREE : GEOMORPHIC ANALYSIS

C): DETAILED DESCRIPTION AND INTERPRETATION OF TARGET AREAS.

The detailed traverses and associated photographs are presented together with an index diagram or with a reference to a locational diagram. A discussion and interpretation of geomorphic data follows the presentation of each set of traverses.

PART ONE : BASALT HILL

PHOTOGRAPH BH 5487F1 : Point 1, Summit Cairn Basalt Hill, looking east. This photograph shows scattered tussocks (Rocky Grassland) over a shallow blockfield.



Photograph BH 5487F4 : Point 13, overleaf (top), shows hummocky grassland with small pools, suggesting recent frost heave.

Photograph BH 5487F6 : Point 22, overleaf (bottom), looks eastwards from point 22 towards point 21. Shallow bedrock scarps just visible in the background, have produced small block glacii which are now mostly vegetated.

Photographs BH 5487F7 and BH 5487F8 are on the pages following BH 5487F4 and BH 5487F6.

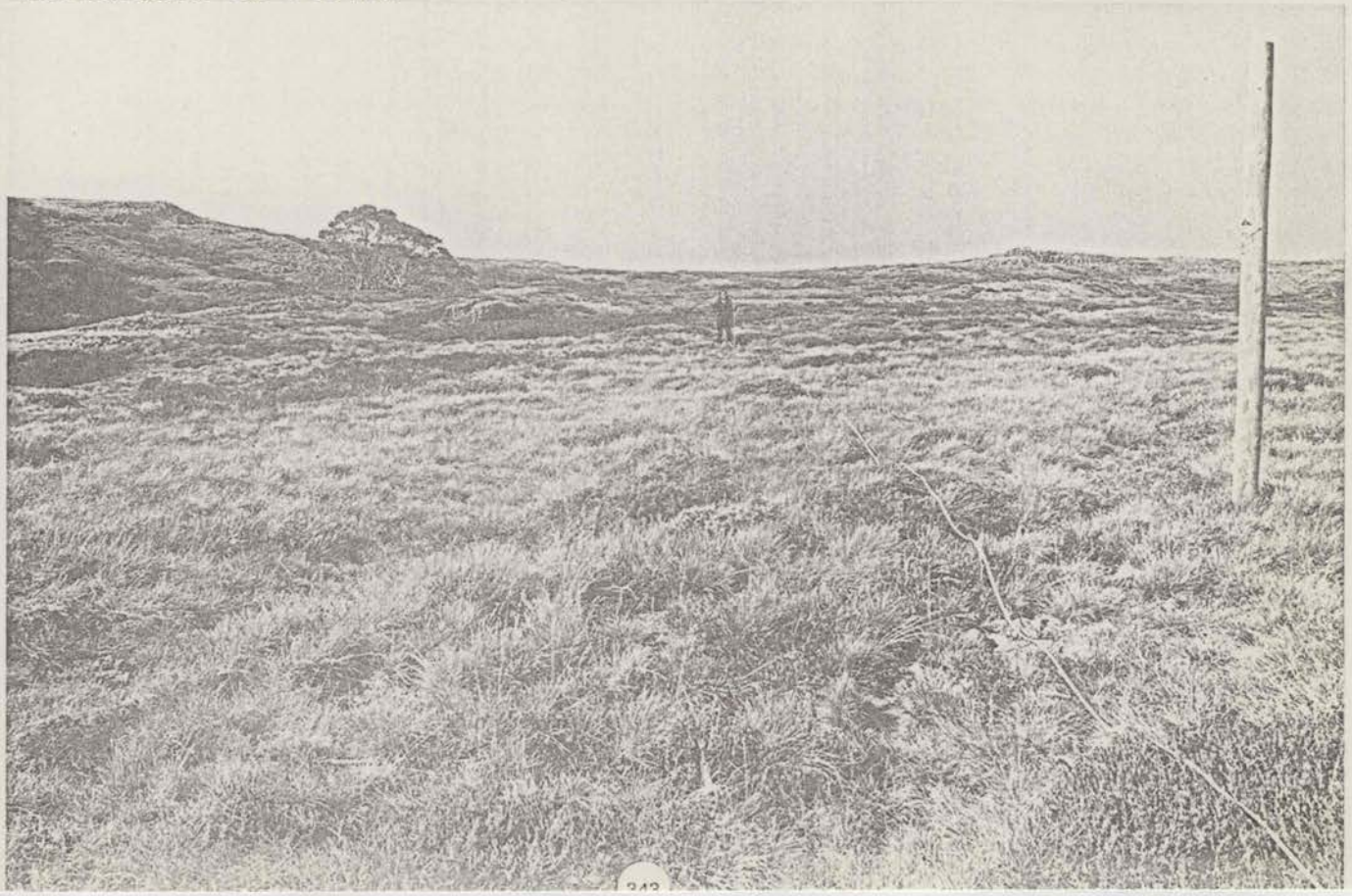
Photograph BH 5487F7 : Point 26, shows blocks exposed on a 4° slope at the edge of a lobe or blockfield sheet.

Photograph BH 5487F8 : Point 29, basalt blocks override granodiorite bedrock.

BASALT HILL TRAVERSE 279° (continued)
PHOTOGRAPH BH5487F4



PHOTOGRAPH BH 5487F6



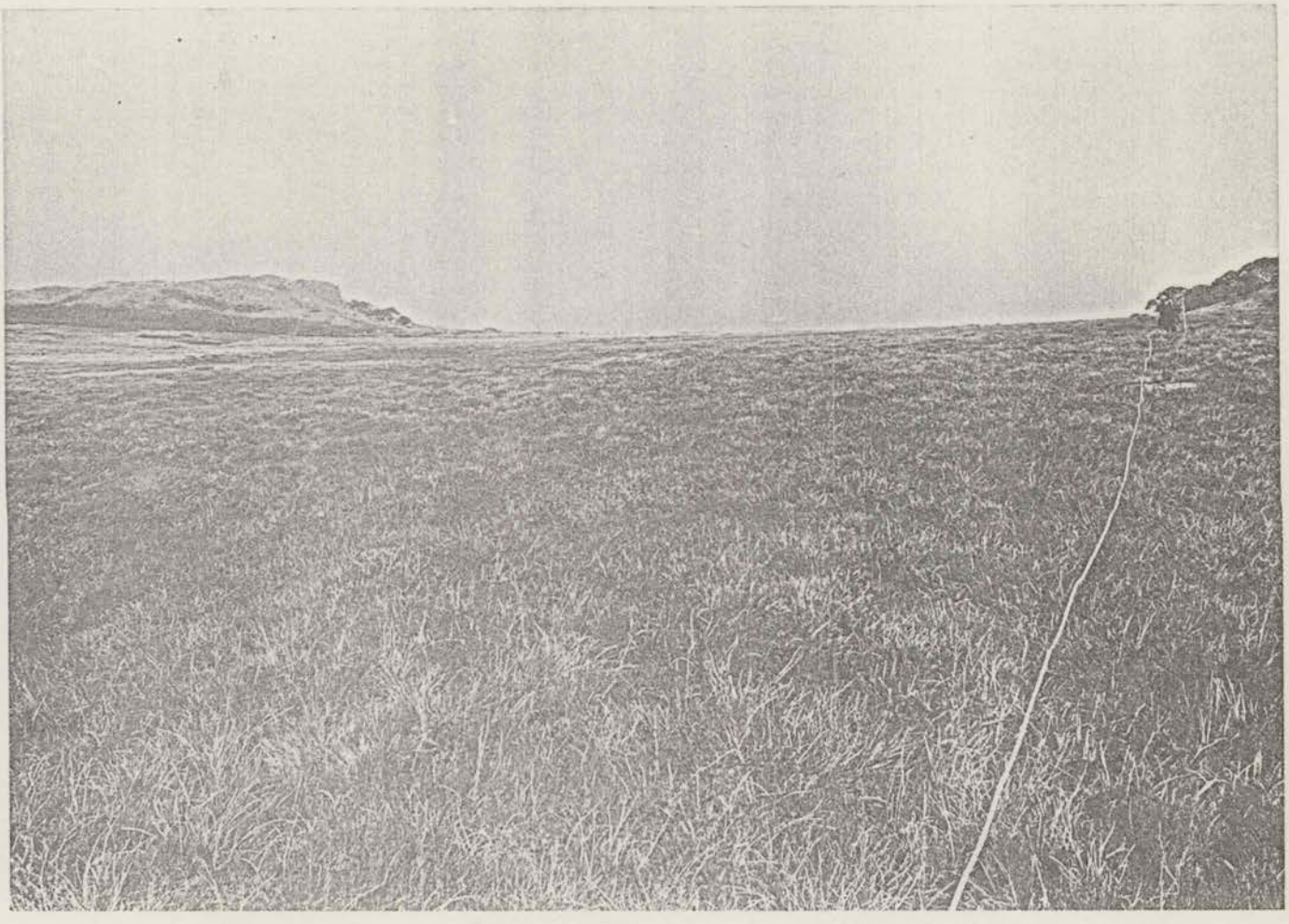
BASALT HILL TRAVERSE 279° (continued)
PHOTOGRAPH BH 5487F7



PHOTOGRAPH BH 5487F8



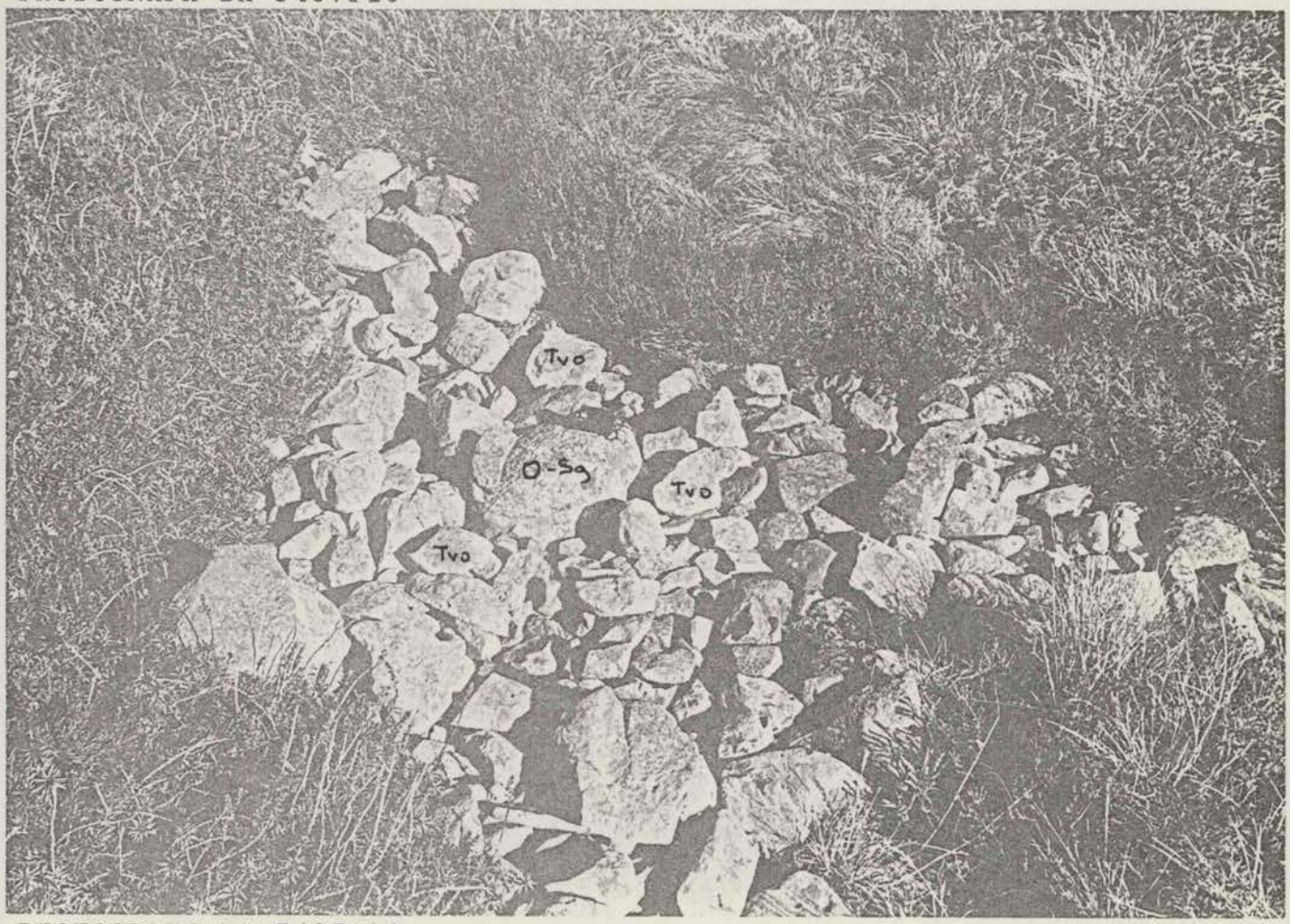
PHOTOGRAPH BH 5487F9 : Point 35, a panorama looking upslope from point 35 with a fen community in the foreground.



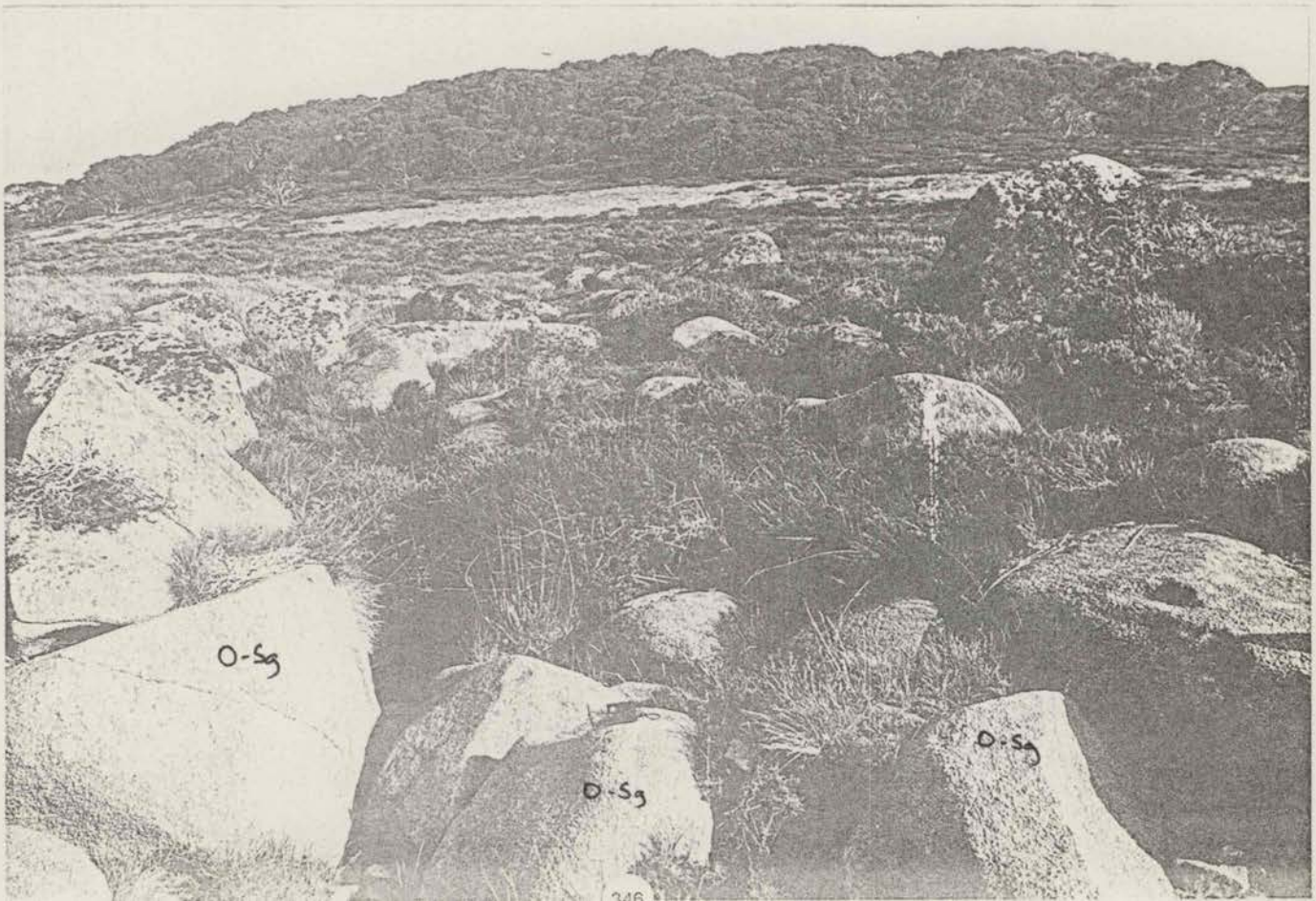
Photograph BH 5487F10 : Point 36, overleaf (top), reveals a hybrid block accumulation nearby.

Photograph BH 5487F13 : Point 36, overleaf (bottom), shows a granodiorite blockfield just south of point 36.

BASALT HILL TRAVERSE 279° (continued)
PHOTOGRAPH BH 5487F10



PHOTOGRAPH BH 5487F13



Discussion of Basalt Hill Traverses

Refer to Fig 2Ab, on page 43, for the location of the traverses on Basalt Hill and also note the location of bedrock boundaries. Fig 3Ca contains a detailed record of surficial geology from Basalt Hill Summit Cairn westwards across the gently sloping basalt surface towards the shoreline of Rocky Valley Storage.

The surface of Basalt Hill is essentially a bedrock surface with a veneer of blocky regolith. The aerial Photograph 3477-85 suggests that lobate sheets of regolith have emanated from the drainage lines exiting from Basalt Hill. Ground investigations, reported in Section 2A support this view.

The series of terraces and shallow steps on the basalt bedrock surface of Basalt Hill are well demonstrated in Traverse 279°. This stepped bedrock terrain is interpreted as a cryoplanation surface with a veneer of blocks, and is assumed to be a relic of the last cold phase of the Pleistocene and or earlier cold phases. In form, these features on Basalt Hill correlate well with descriptions by Washburn (1979). Washburn states:

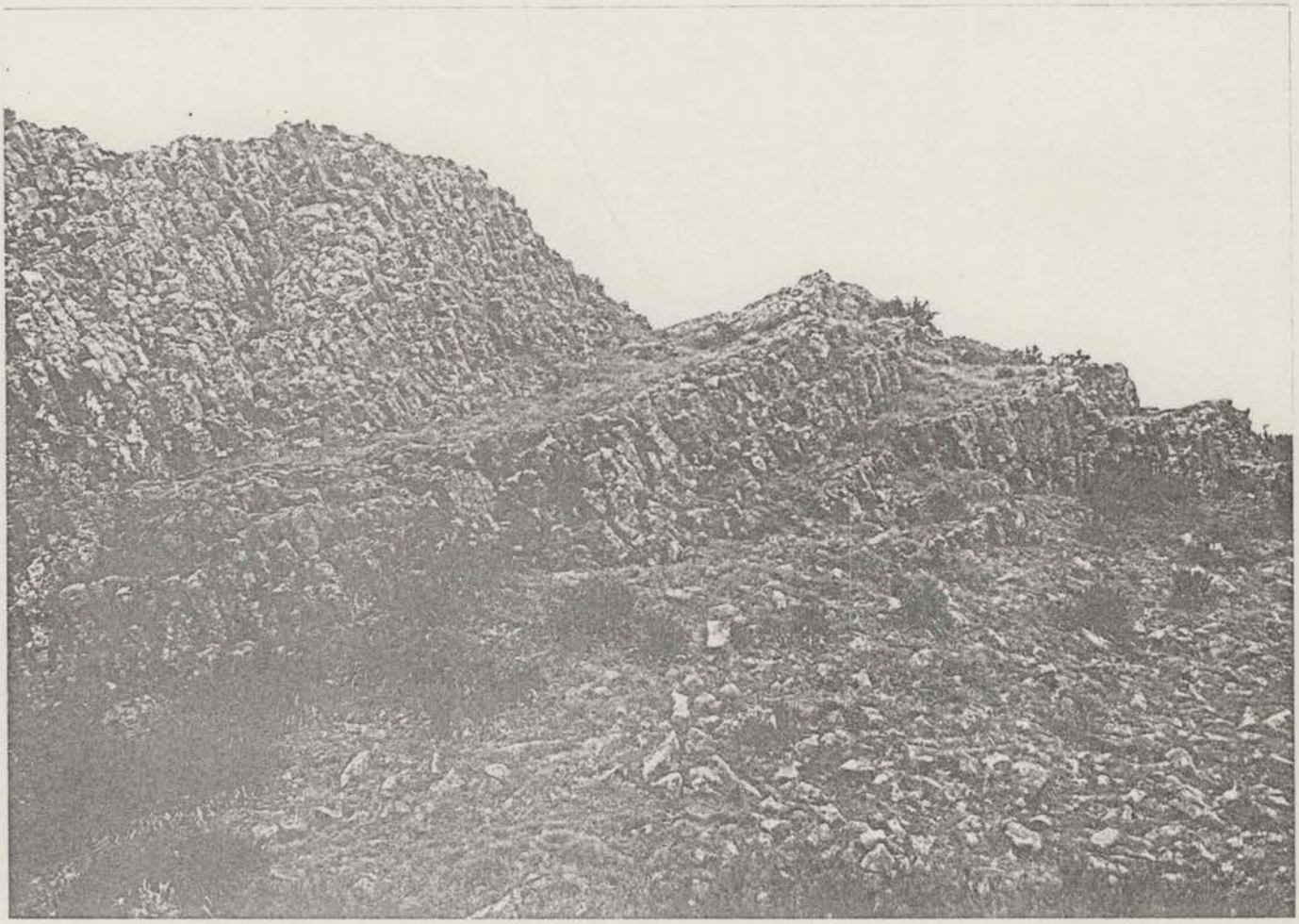
"Cryoplanation terraces have a veneer of solifluction debris which may be imprinted with patterned ground. Lithology and structure such as jointing may help influence location and degree of developement of some terraces. Cryoplanation terraces range in size from 10m across to widths of 2km-3km and lengths exceeding 10km. The gradient of the terrace tread is 1°-10° and the terrace riser has a height ranging from 3m to 76m and a gradient of 9° to 32° where debris covered, but nearly vertical where bedrock appears. The thickness of debris on a terrace ranges from <1m to 3m."

The basalt rock mass is ideally structured for rapid frost shattering into blocks. This is demonstrated in Photograph BH 20486F2 overleaf. This photograph demonstrates the basalt scarp at the southern end of Basalt Hill. Columnar and basal jointing are evident. The small terraces formed in this outcrop could also be called cryoplanation terraces. Their edges are almost normal to the treads and are sharply defined. Such edge sharpness is not usually developed in a humid climate where rounding of corners and edges is achieved by chemical weathering.

That this gently sloping terraced terrain is a relic cryoplanation surfaced is supported by the transport of angular blocks of basalt across slopes of 2° to 3° for distances of 450m beyond the basalt/granodiorite bedrock boundary. Sheets of basalt blocks are evident at the end of Traverse 279° on a slope of 4° near the edge of the lake and are illustrated in Photograph BH 5487F11 on page 105.

Accumulation of basalt blocks is best exhibited in snow patch zones although there is no activity apparent under present conditions. The lack of activity is evidenced by lichen growth on all upper surfaces of blocks and on bedrock scarps as well.

PHOTOGRAPH BH 20486F2



Snow patch zones occur along the southeastern margin of Basalt Hill and the associated relic block glacii have been described in Section 2A Part 2, Basalt Hill sites 10 and 11. The snow patch zones probably represent relic nivation hollows.

The vegetation and soil development over the surfaces surveyed in Traverse 279° also demonstrate the absence of active frost wedging and frost creep. Most of the blocks lie below $\leq$30cm of organic loam.

Basalt Hill Traverse 164° (Fig 3Cb) profiles the elevated basalt surface and the steep terrain to the east and south-east. On the near horizonatal basalt pavement is a veneer of blocks, partially vegetated by tussock grass. Moving eastwards over the basalt scarp is a series of treads and minor scarps with a veneer of blocky regolith. Most of the surface is vegetated. Block accumulations appear and disappear. The localisation of blocks within the drainage line is illustrated by a block glacis just north of point 20 and recorded in Photograph BH 487F15 and BH 487F16 overleaf.

PHOTOGRAPH BH 487F15



This photograph demonstrates a block glacis in a relic nivation hollow on the eastern flank of Basalt Hill near point 20 Traverse 164°. The blocks form a platform at the foot of the arcuate, concave depression.

PHOTOGRAPH BH 487F16

This photograph demonstrates a closer view of the block glacis near point 20 on Traverse 164°. The distal edge forms a sharply defined, steep rampart at the left of the photograph, while the surface of the glacis has a lesser gradient.



Another example of a localised accumulation of blocks within the drainage line occurs between points 31 and 39 on Traverse 164°

Fig 3Cc shows the distribution of open basalt block accumulations on the southeastern flanks of Basalt Hill. The numbers on this figure correspond to position numbers on Traverse 164°. The above mentioned block accumulation has its proximal end in the drainage line on a slope of 20° to 31° and it appears to terminate on a large bedrock step with a slope of 12°. The concave slope from points 33 to 37 appears to be a large relic nivation hollow with the floor at about 1570m ASL. The block accumulation has terminated within about 35m of the floor of this relic nivation hollow.

The basalt blocks at the surface are merely a veneer and are located 300m beyond the basalt outcrop and are overlying granodiorite bedrock. The etching of this large step in granodiorite bedrock possibly precedes the last cold phase. It is possible that due to the slow downslope movement of blocks by frost creep, granodiorite blocks could have been frost heaved and transported down the slope from this nivation hollow at the same time that basalt blocks were frost heaved and transported from the basalt outcrop further upslope.

The presence of a permanent snow patch in this nivation hollow may have assisted the concentration of blocks into this drainage line from upslope. Further nivation hollows are suggested between the 1540m contour and the aqueduct. This zone has a concave slope and it lies immediately above a set of block accumulations of basalt and granodiorite, illustrated in Fig 3Cc.

The lower set of block accumulations including the basalt block stream between points 46 and 69 on Traverse 164° and the granodiorite accumulations at similar levels to the north-east are located below large concave slopes or bedrock steps. Much material has been mobilized downslope as illustrated in Photographs BH 487F24 and BH 487F25. The location of the photographs is shown on Fig 3Cc.

PHOTOGRAPH BH 487F24



Photograph BH 487F24, above, looks upslope from the distal end of a massive granodiorite blockslope with a gradient of 35°. There is NO cliff or free bedrock face immediately upslope of this blockslope.

PHOTOGRAPH BH 487F25



Photograph BH 487F25, previous page, is a view across the foot of the granodiorite blockslope. The concavity to the right of the centre of this photograph suggests slumping from within the blockslope. Isolated basalt blocks are included within this granodiorite block accumulation despite the absence of basalt bedrock at the head of this drainage line. This suggests that material has moved cross-slope, in this case from the north-west. Refer to Fig 3Cc.

Such a mechanism precludes simple rolling or sliding as the sole means of transport, as the basalt blocks would have to have moved across slopes of about 10% or 6° before they reached the head of this drainage line.

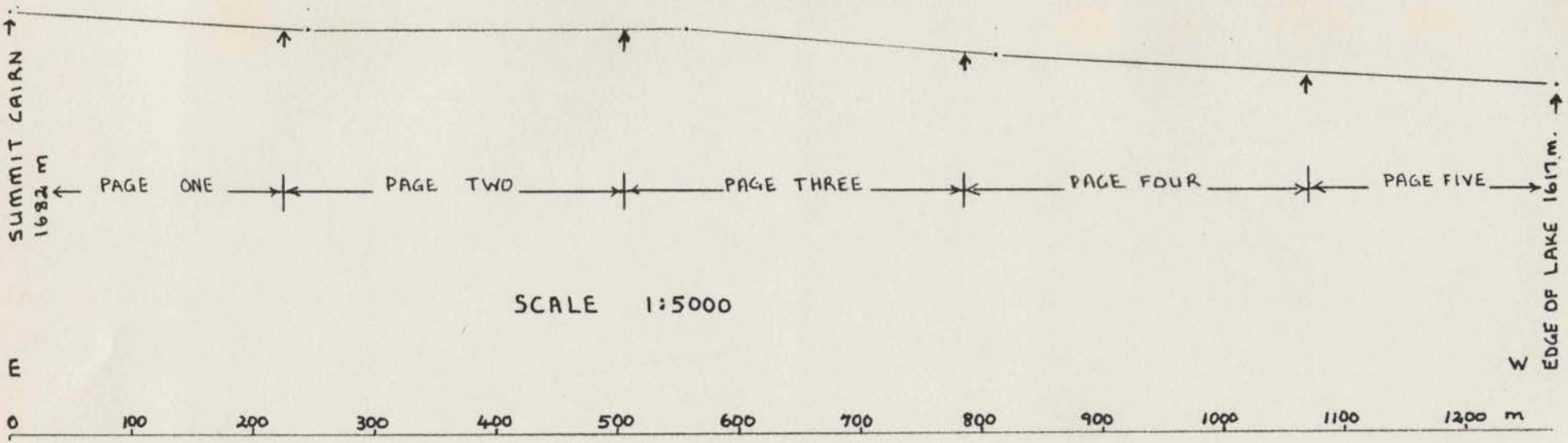
The abrupt termination of the basalt blockstream with the formation of a rampart sloping at about 30° and 2m to 3m thick suggests that this block accumulation's internal cohesion has increased due to the removal of interstitial material such as ice, which may have lubricated the aggregate of blocks. The prevelence of conical pits between points 58 and 61 on Traverse 164° suggests thermokarst due to interstitial ice and if so the basalt rampart may have been just below the 0° isotherm for this southeastern slope, towards the end of the last cold phase. The rampart is located at 1435m ASL.

As explained in Section 2A, the granodiorite blockstream which is continuous below point 61 on Traverse 164°, could have been contemporaneous with the basalt blockstream. Both block accumulations may have started simultaneously but because of different starting points, with the basalt outcrop further upslope, the basalt slowly overran the granodiorite blockslope below. The use of the word "blockstream" has not been strictly correct in the above discussion, because of the gradient, but was used to describe an apparent stream of blocks. Slopes of 33° in the basalt blockslope and 35° in the granodiorite blockslope are suggestive of talus except that there is no bedrock cliffs at the heads of these streams of blocks and the block accumulations themselves are discontinuous.

Frost creep seems a logical mechanism for downslope movement of blocks and it is strongly supported by other circumstantial evidence including the presence of block glacii in relic southeastern nivation hollows and the transport of basalt blocks over slopes of 2° to3° in the case of Traverse 279°.

BASALT HILL TRAVERSE FIG 3Ca

BEARING 279° FROM SUMMIT



SCALE 1:5000

SUMMIT CAIRN ALTITUDE 1682 m GRID REFERENCE 281171 (COPE 1:25,000 SHEET)
HORIZONTAL AND VERTICAL SCALES ARE 1:1000

BASALT BEDROCK WITH A THIN VENEER OF FROST SORTED COBBLES AND A PATCHY COVER OF TUSSOCK GRASS. REFER TO PHOTOS BH050487/F1 → BH050487/F3

SMALL SCARP AT EDGE OF BASALT OUTCROP, VEGETATED WITH SHORT OPEN HEATH

SHALLOW SECONDARY SCARP AT EDGE OF (LEVEL 1) BASALT

BASALT BEDROCK WITH A THIN VENEER (<1m) OF BLOCKS AND SOIL COVERED BY CLOSED SHORT HEATH.

TO EDGE OF BASALT OUTCROP (LEVEL 2) COVERED WITH SHORT CLOSED HEATH DISPERSED BASALT BLOCKS UNDERFOOT.

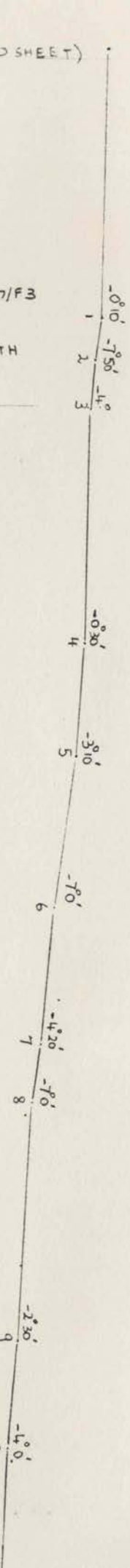
GENTLE SCARP AT EDGE OF LEVEL 2 BASALT LAYER. VEGETATED BY OPEN HEATH

CLOSED GRASSLAND OVER LEVEL 3 BASALT LAYER

GENTLE, MINOR SCARP DEFINES EDGE OF LEVEL 3 BASALT. BED ROCK EXPOSED

BASALT BEDROCK COVERED BY A VENEER OF BLOCKS AND SOIL
VEGETATION IS OPEN HEATH WITH 10% OF SURFACE COVERED IN LOOSE BLOCKS

MINOR STEP COVERED IN OPEN HEATH. CONTINUATION OF LEVEL 4 BASALT



FLAT GRASSLAND ADJACENT TO MAIN DRAINAGE LINE. INTERSECTED SMALL LOBE < 30CM HIGH. WET HEATH IN DRAINAGE LINE. -1°40' 11

EVEN SLOPING GRASSLAND APPROACHING MAIN DRAINAGE LINE -0°20' 12

CLOSED GRASSLAND WITH HUMMOCKY SURFACE. LOCAL DEPRESSIONS SATURATED. BASALT BLOCKS VISIBLE WITHIN DEPRESSIONS. REFER TO PHOTO BH050487F4 +1°0' 13

GRASSLAND AND SHORT HEATH. ISOLATED PITS 30-40 cm BELOW SURFACE BLOCKS VISIBLE IN FLOOR OF PITS. +1°0' 14

SHORT OPEN HEATH WITH MANY SMALL PITS AND HUMMOCKS BARE BLOCKY GROUND COVERS ~ 40 % OF SURFACE. +0°20' 15

BASALT BEDROCK (LEVEL 4 ?) WITH VENEER OF VEGETATED BASALT BLOCKFIELD. VEGETATION SHORT OPEN HEATH -0°30' 16

BASALT BEDROCK WITH A VENEER OF VEGETATED BASALT BLOCKFIELD -0

~10% SURFACE IS BLOCKY PATCHES. BEDROCK IS EXPOSED IN MINOR ADJACENT SCARP

17 50'

CONTINUATION OF ANOTHER BEDROCK STEP IN LEVEL 4 BASALT. POSITION OF PROFILE IS OFFSET BUT PARALLEL TO DRAINAGE LINE INTO WALLACES GAP.

18 -0°56'

VEGETATED BLOCKFIELD COVERED BY GRASSLAND. BLOCKS ARE EXPOSED AT LESS THAN 10% OF THE SURFACE, WHICH PASSES OVER SEVERAL SMALL BEDROCK STEPS

19 -2°36'

TRAVERSE IS CLOSE TO MAIN DRAINAGE LINE. SURFACE IS HUMMOCKY AND COVERED BY TUSSOCK VEGETATED BLOCKFIELD. PEAT IS EXPOSED IN DRAINAGE LINE

20 -5°10'

DRAINAGE LINE. GROUNDWATER VEGETATION (SEDGE) AND PEAT OVERLAY BLOCKS, WHICH ARE ONLY LOCALLY EXPOSED. SMALL BLOCK GLACIS OCCURS BELOW SCARP - REFER PHOTO BH0504 87 F 6

21 -5°10'

GRASSLAND. DRAINAGE GOES UNDERGROUND ⇒ UNDERLYING BLOCKFIELD

22 -6°30'

CONVEX BEDROCK SLOPE (SCARP) OPEN HEATH VEGETATION

23 -8°10'

VEGETATED BLOCKFIELD. TRAVERSE PASSES THROUGH GAP IN ADJACENT BEDROCK SCARPS.

24 -6°10'

VEGETATED BLOCKFIELD SLOPE IN DRAINAGE LINE TERMINATES AGAINST GENTLE CONVEX RISER
TRAVERSE HAS MOVED BEYOND INSITU BASALT BEDROCK.
BEDROCK FOR REMAINDER OF TRAVERSE IS GRANODIORITE

25 -5°0'

MOSTLY VEGETATED BLOCKFIELD IN GRASSLAND WITH HUMMOCKY SURFACE. REFER PHOTO BH050487F7

-4°20'
26

30 CM HIGH LOBE OR SHEET VEGETATED BY GRASSLAND. CLOSE PACKED BASALT BLOCKS AT SURFACE BELOW DISTAL EDGE OF SHEET. ISOLATED GRANODIORITE TORS EXIST NEARBY

-3°10'
27

SHEETLIKE FEATURE ENDING IN A DISTINCT 40-50 CM RISER WITH CONVEX SLOPE. SHEET SURFACE IS HUMMOCKY AND BASALT BLOCKS SEEM TO FORM A LAYER CLOSE TO THE SURFACE

-2°10'
28

BASALT BLOCKS OVERRIDE GRANODIORITE BEDROCK
REFER TO PHOTO BH050487F8

-2°40'
29

SECTION CONTINUES DOWN DRAINAGE LINE IN GROUNDWATER VEGETATION OF HEATH AND SPHAGNUM. BASALT BLOCKS VISIBLE BUT DIFFICULT TO ASSESS

-2°40'
30

SPHAGNUM BOG. BASALT BLOCKS EXPOSED IN STREAMLET.

-2°30'
31

SPHAGNUM BOG CONTINUES. BASALT BLOCKS VISIBLE IN STREAMLET 50 cm BELOW WATER LEVEL

-3°0'
32

SPHAGNUM BOG/SEDGE CONTINUES. BASALT BLOCKS VISIBLE IN POOLS.

-4°10'
33

WET HEATHLAND. BASALT BLOCKS AND QUARTZ COBBLES IN POOLS. LARGE GRANODIORITE BLOCKS SCATTERED.

-3°0'
34

WET HEATHLAND. LARGE ISOLATED GRANODIORITE BLOCKS VISIBLE. PANORAMA OF LOWER SECTION OF TRAVERSE : PHOTOS BH050487 F9, F10.

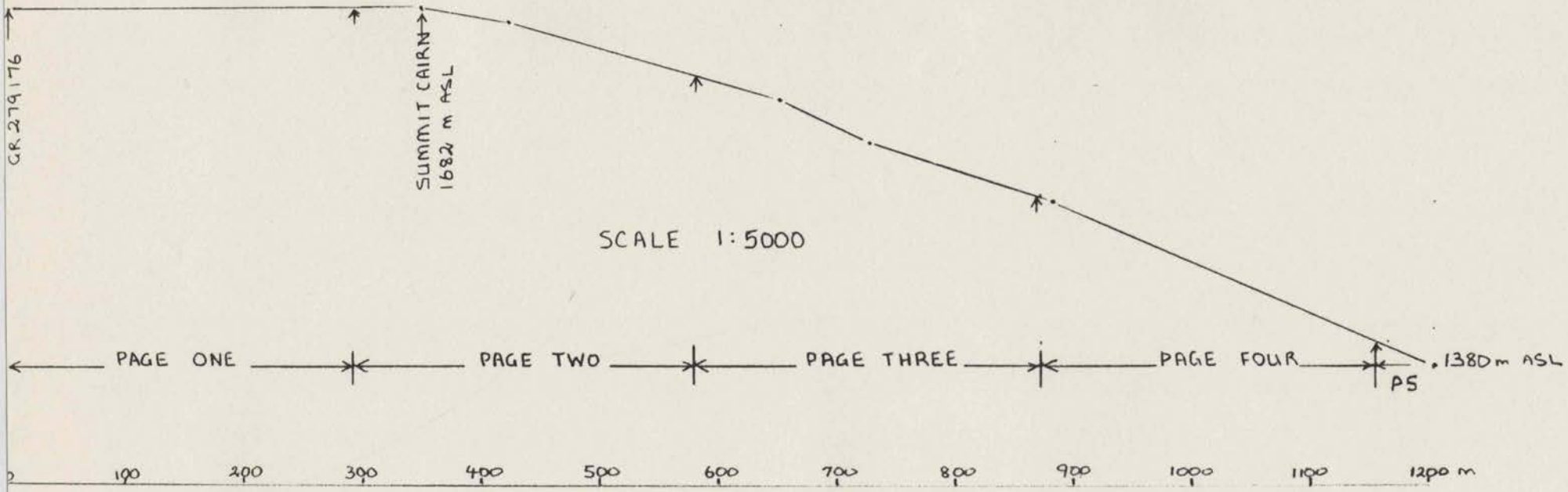
-3°40'
35

TRAVERSE ENDS IN CREEK AT EDGE OF LAKE. OPEN HYBRID BLOCKFIELD OF GRANODIORITE AND BASALT BLOCKS OCCURS IN PATCHES FOR >50 m ACROSS DRAINAGE LINE. WATER TABLE = 30cm BELOW BLOCKS. REFER PHOTOS: BH050487 F11, 12 THIS BLOCKFIELD APPEARS TO BE THE DISTAL END OF A SHEET OF BLOCKY MATERIAL EMANATING FROM A DRAINAGE LINE THROUGH SADDLE AT COPE GR 274172. GRANODIORITE BLOCKS ARE LOCALISED JUST SOUTH OF THIS POINT. REFER TO PHOTO BH050487F13. THE ERODED SECTION AT EDGE OF LAKE REVEALS GRANODIORITE BLOCK OVERRIDING BASALT BLOCK LAYER 10-20cm THICK, WHICH OVERLIES COMPACT GRAVELLY LAYER REFER TO PHOTOS BH050487 F14, F15

-4°20'
36

BASALT HILL TRAVERSE FIG 3C6

BEARING 164° FROM G.R. 279176



EDGE OF QUARRY ALTITUDE 1680 m GR 279176 (COPE 1:25000 SHEET)
HORIZONTAL AND VERTICAL SCALES ARE 1:1000

ROCKY GRASSLAND ON A BENCH OF INSITU BASALT — 1 — -4°10'

ROCKY GRASSLAND ON INSITU BASALT OUTCROP — 2 — +0°30'

DWARF HEATHLAND (KUNZEA, EPACRIS) — 3 — +2°40'

DWARF HEATHLAND WITH 10% BARE GROUND/ ISOLATED BLOCKS IN BARE PATCHES — 4 — +0°45'

MIXED TUSSOCK/DWARF HEATH, BARE PATCHES ETCHED OUT AND COVERED IN SMALL BLOCKS — 5 — +0°20'

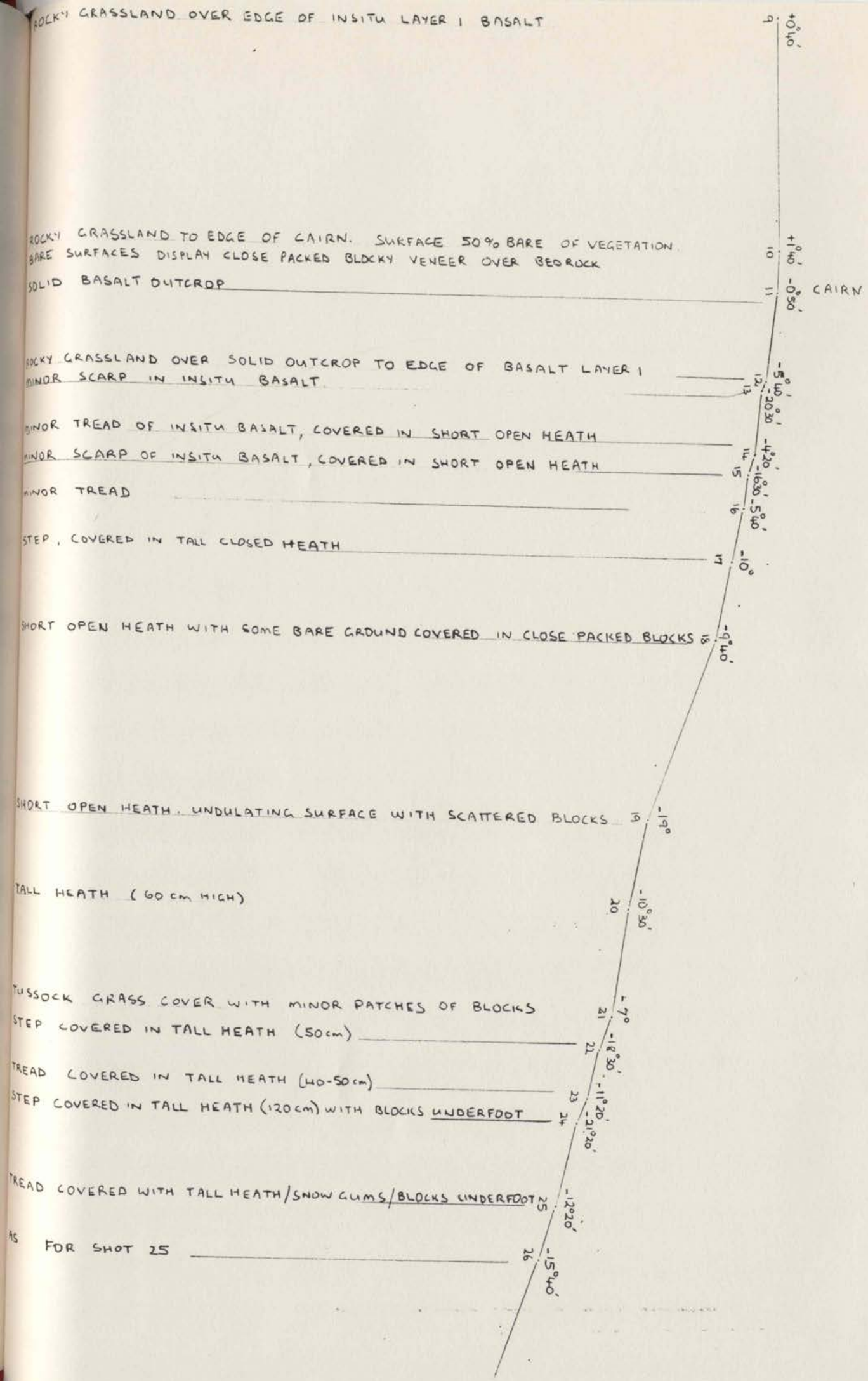
MIXED DWARF HEATH/TUSSOCK GRASS. SHOT TERMINATES AGAINST SOLID BASALT OUTCROP. — 6 — +0°20'

ROCKY GRASSLAND OVER INSITU BASALT PAVEMENT — 7 — +1°30'

ROCKY GRASSLAND WITH BARE GROUND > 40%. CLOSE PACKED BLOCKS OVERLY SOLID BASALT PAVEMENT — 8 — +1°40'

BASALT HILL TRAVERSE 164°

BASALT HILL TRAVERSE 164°



27 -19° EVEN SLOPE TERMINATING IN A SNOW PATCH ZONE. TALL HEATH IN UPPER SECTION

28 -13°40' SHORT TURF, SNOW PATCH ZONE

29 -12° TALL HEATH AND GRANODIORITE OUTCROP ?

30 -15° TALL HEATH AND GRANODIORITE OUTCROP/FLOATER JUST ABOVE AQUEDUCT

31 -20°40' NARROW BLOCKSTREAM (BASALT)

32 -21°20' NARROW BLOCKSTREAM WITH MINOR UNDULATIONS AND HOLES IN SURFACE

33 -24°20' BLOCKSTREAM. LARGE RANGE IN SIZE OF BASALT BLOCKS FROM 10CM TO 60 CM. SHAPES INCLUDE PRISMATIC, PLATY, AND IRREGULAR

34 -26°40' BASALT BLOCKSTREAM (STEEPER SECTIONS HAVE SMALLER BLOCKS AT THE SURFACE)

35 -31° NARROW, UNVEGETATED BASALT BLOCKSTREAM ~ 6m WIDE

36 -20°40' BASALT BLOCKSTREAM WITH TRANSVERSE WRINKLES AND SOME BROAD PITS ~ 3m WIDE, 0.5m DEEP.

37 -20°30' BASALT BLOCKSTREAM WITH MINOR UNDULATIONS IN SURFACE SUGGESTIVE OF SLUMPING

38 -12°20' CONVEX SLOPE IN BLOCKSTREAM WITH DISTINCT PITS IN SURFACE AND SHARP LATERAL BOUNDARY. PROFILE PARALLEL TO CONTOUR IS ALSO CONVEX. BLOCKSTREAM APPEARS TO HAVE STAGNATED.

39 -19°20' TWO DISTINCT STEPS AND BLOCKSTREAM TERMINATES. TERRAIN BELOW IS VEGETATED. GRANODIORITE OUTCROP/FLOATER ? VISIBLE

40 -23°20' ACCUMULATION OF LARGE GRANODIORITE BLOCKS IS COVERED BY VEGETATION (TALL HEATH/ SNOW GUMS)

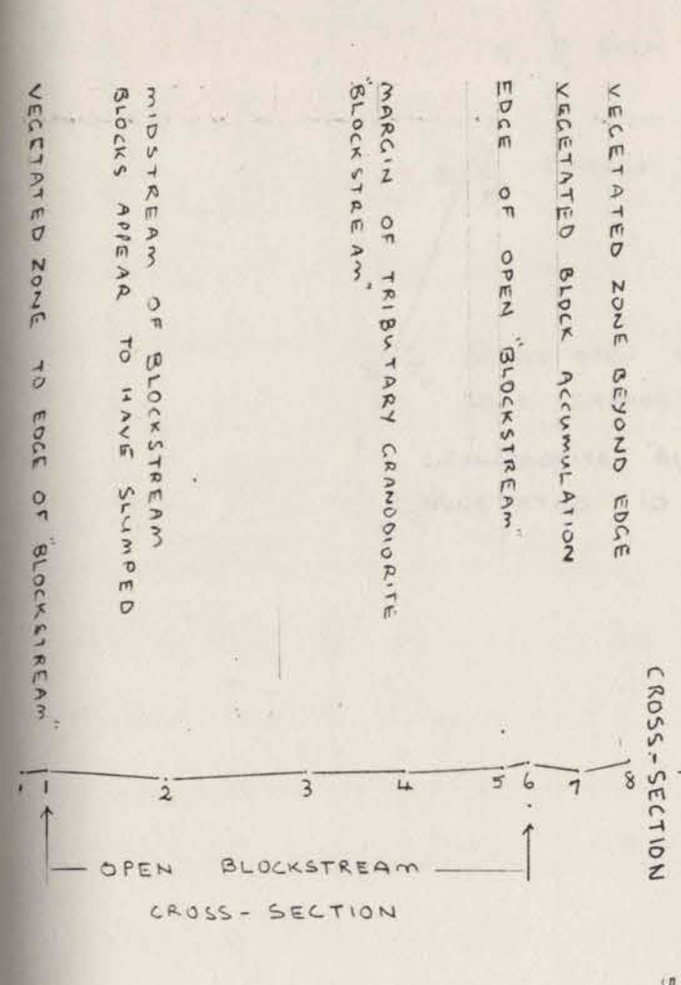
41 -11° VEGETATED BLOCKFIELD COVERED IN PODOCARPUS.

42 -8°20' VEGETATED BLOCK ACCUMULATION (BLOCKSTREAM) COVERED IN GRASS TUSSOCKS

43 -9°40' VEGETATED TRIBUTARY BLOCKSTREAM

44 -11°20' VEGETATED BLOCKSTREM. ISOLATED GRANODIORITE BOULDERS.

45 -26° VEGETATED BLOCKSTREAM



CROSS-SECTION

49 -11°20' VEGETATED BLOCK ACCUMULATION. SOME LARGE GRANODIORITE BLOCKS POKE UP.

47 -33° STEEP STEP. UNVEGETATED BLOCKSTREAM WITH LARGE (≤3m diam) GRANODIORITE BLOCKS INCORPORATED ON AND WITHIN THE BASALT BLOCKS, WHICH ARE MOSTLY COARSE AND TABULAR (30-60) CM LONG.

48 -15°10' HYBRID BLOCKSTREAM WITH DISTINCT PITS IN SURFACE. GRANODIORITE BLOCKS HAVE BEEN WELL ROUNDED DUE TO INSITU SPHERICAL WEATHERING

46 -18°40' DISTINCT PITS 2-3m ACROSS AND 50 CM DEEP IN BLOCKSTREAM (THERMOKARST)

50 -23°30' EVEN SLOPING BLOCK ACCUMULATION. MAINLY BASALT BLOCKS BUT WITH GRANODIORITE BOULDERS ENCROACHING FROM THE SIDES AND INTERMIXING WITH BASALT BLOCKS
REFER PHOTOGRAPH BH 3384F6 ON PAGE 74

51 -30°40' BROAD EVEN BLOCK ACCUMULATION. SMALL BASALT BLOCKS DOMINATE. NOTE CROSS-SECTION.

52 -21°30' TREAD OF LARGE, TRANSVERSE RIPPLE IN BLOCK ACCUMULATION

53 -33°20' RISER BELOW TREAD OF TRANSVERSE RIPPLE

54 -19°20' TREAD OF RIPPLE. PITS VISIBLE IN SURFACE OF BLOCK ACCUMULATION (BLOCKSTREAM)

55 -24° RISER IN BLOCK ACCUMULATION SURFACE

56 -12°10' TREAD WITH BROAD PITS 3-4 M. ACROSS AND 0.5m DEEP IN BLOCK ACCUMULATION

57 -18°20' PITS CONTINUE BUT BECOME NARROWER

58 -29° STEEP EVEN SLOPE, CONCAVE IN UPPER THIRD.

59 -11°50' SURFACE PITTING IN BASALT BLOCK ACCUMULATION WITH GRANODIORITE BOULDERS CONCENTRATING ALONG SOUTHERN MARGIN.

60 -19°30' SHARP CONICAL PITS 2m WIDE AND 1 M DEEP IN BASALT BLOCK ACCUMULATION

61 -29°40' TOE OF BASALT BLOCK ACCUMULATION FORMS AN ABRUPT RAMPART. ALTITUDE ~ 1430 m. REFER PHOTO BH 3384 F8 ON PAGE 76

62 -21°20' NARROW GRANODIORITE "BLOCKSTREAM" (<10m WIDE) CONTINUES BELOW THE TERMINATION OF BASALT BLOCK ACCUMULATIONS

63 -16°20' NARROW PARTLY VEGETATED GRANODIORITE "BLOCKSTREAM"

GRANODIORITE BLOCKSTREAM CONTINUES WITH AN IRREGULAR SURFACE.
PROFILE PARALLEL TO THE CONTOUR IS CONVEX

64 -18°20'

65 -18°30' RISER IN GRANODIORITE "BLOCKSTREM SUGGESTS A THICKENING IN BLOCK ACCUMULATION BETWEEN SECTION 62 AND 65

66 -27°



67 -20° EVEN SLOPE ON GRANODIORITE "BLOCKSTREAM"

68 -28°30' CONVEX TOE IN GRANODIORITE BLOCKSTREAM

69 -21° BROAD OPEN SLOPE IN GRANODIORITE "BLOCKSTREAM"
SOME GRANODIORITE BLOCKS ARE >4m ACROSS

GRANODIORITE "BLOCKSTREAM" BECOMES THICKLY VEGETATED 10 m BELOW SECTION 69

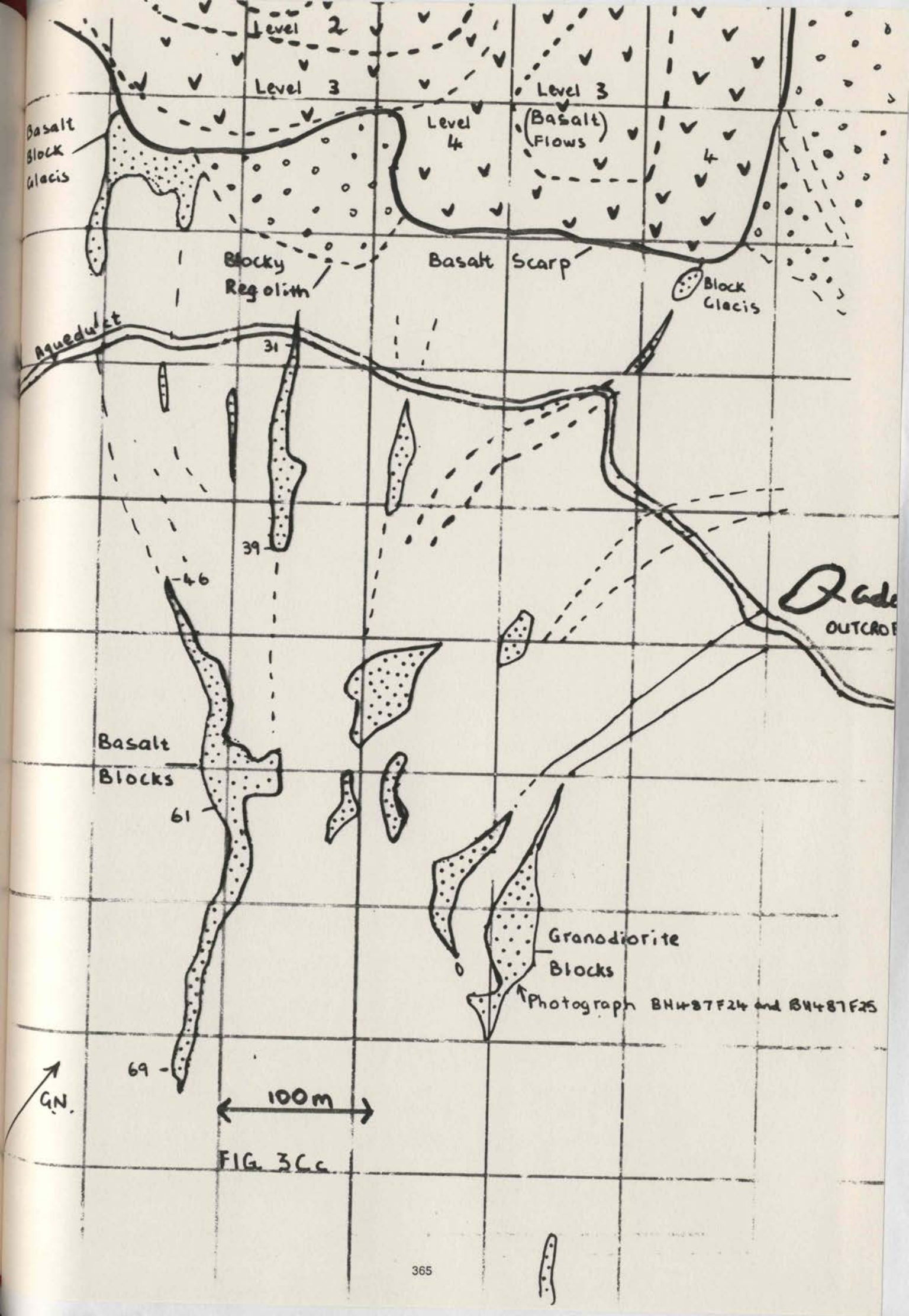

Level 2
Level 3
Level 3
Basalt Block Glacis
Level 4
(Basalt) Flows
4
Blocky Regolith
Basalt Scarp
Block Glacis
Aqueduct
31
39
46
OUTCRO
Basalt Blocks
61
Granodiorite Blocks
Photograph BH487F24 and BH487F25
69
GN.
100m

FIG. 3Cc

SECTION THREE : GEOMORPHIC ANALYSIS

C) : DETAILED DESCRIPTION AND INTERPRETATION OF TARGET AREAS

PART TWO : PRETTY VALLEY

Discussion of Pretty Valley Traverses.

The surveyed sections at Pretty Valley are presented as Fig 3Cd (index sheet), Fig 3Ce (Traverse A1) and Fig 3Cf (Traverse A2). The locations of these traverses is represented on Fig 2Aj, page 128, and on Fig 2Ae, page 109.

Traverse A1, points 1 to 25 represents a set of terraces and risers. The terraces have slopes of 6° to 9° and the risers have slopes of 10° to 13°. The bedrock is basalt but is not exposed as outcrop between points 1 and 25. There is a suggestion of bedrock control in the profile of Traverse A1 which is indicated on Fig 3Cd. The shaded sections within this profile indicate a resistant layer of basalt with an apparent dip of 1° to the south. The actual dip measured near Mt. Jim is about 2° to the south-east. This apparent layering could represent stratification within the Tvo Unit or it could represent basal jointing. The effect of the tilt is to produce an asymmetric profile with steeper risers on the northern aspect than the southern aspect.

Traverse A1, points 25 to 27 represents a summit flat which is dominantly bedrock. Fig 2Ag (page 128) demonstrates in plan view the stepping associated with this terrain. Most of the steps, which are arcuate in plan view, have a block accumulation with a south to south-eastern aspect. This arcuate plan and preference for a south or south-eastern aspect is similar to the nivation hollows described on Mt. Nelse. The steps or risers on the northern aspect of Traverse A1, as seen on Fig 2Ag, are less arcuate in plan view. This arcuate disposition of steps or risers with a south or south-eastern aspect is shared by present day snow patch zones which are displayed on the 1:15 000 vegetation Map, Fig 2Ae (page 109), because of their associated vegetation. These sites probably represent relic nivation hollows in association with the terraces and steps which are interpreted as relic cryoplanation terraces and risers.

The distribution of "blockstreams" on these cryoplanation surfaces may not be as continuous, linear accumulations of blocks, but rather as discrete accumulations on individual terraces sharing a common drainage line. The reason for suggesting that these linear block accumulations are discontinuous is illustrated for Traverse A1 in plan (Fig 2Ag) and section (Fig 3Ce) and for traverse A2 (Fig 3Cf). Point 10 on Traverse A1 records the apparent termination of a blockstream with raised outer margins and conical pits at its distal end. These are illustrated by Photographs PV 10487F1 and PV10587F3.

This blockstream has its proximal end near the base of the 11° slope between points 11 and 12, and it forms a continuous accum ulation of basalt blocks about 60cm deep and up to 12m wide for about 60m. The cross-section of this blockstream is concave with raised margins as if the body of the blockstream had deflated. These characteristics are typical of many small blockstreams, and are repeated for another block accumulation in the same drainage line, but on a higher terrace with similar slope between points 18 and 20. The depressed cross-section and

occurrence of pits behind a raised distal margin all suggest that interstitial material has been removed. If it were material derived from regolith then some gravel material should remain after the fines were dispersed.

This does not seem to be the case as the block accumulation appears to comprise blocks devoid of gravel to a depth of about 60cm where the water table occurs. The nature of material below the water table was not tested here, but observations nearby indicate cobbles and gravel in an orange clayey silty sand matrix. It would appear that basalt blocks have moved down slope over a 5°-6° terrace and selectively accumulated within a drainage line on the terrace tread.

The distal margins of the block accumulation present the most relief to the surrounding terrain suggesting resistance to further downslope movement. The inclusion of ice within the blockmass is logical as water would be occasionally available in the drainage line and the high thermal conductivity of basalt blocks would present a cold environment for the possible formation of ice blisters similar to "naled", at the water table, within and beneath the block aggregate. The presence of ice within and beneath the block accumulation would have prevented the accumulation of fines within the blockstream. This model suggests that blockstreams, and probably blockfields and blockslopes, were discontinuous patches of permafrost.

The remainder of the cryoplanation terrace probably comprised blocks, cobbles, gravels and fines with frost action favouring the coarser fragments at the surface and providing a mechanism (frost creep) for their transport across the terrace, with the drainage line providing a trap and sorting mechanism for the blocks, which present themselves today as discontinuous blockstreams. Subsequent erosion in the early Holocene probably removed some of the fine grained material on these terraces which caused a slight lowering of the terrace tread relative to its drainage lines and thereby enhanced the relative relief of the the block accumulations which has assisted their preservation to the present day.

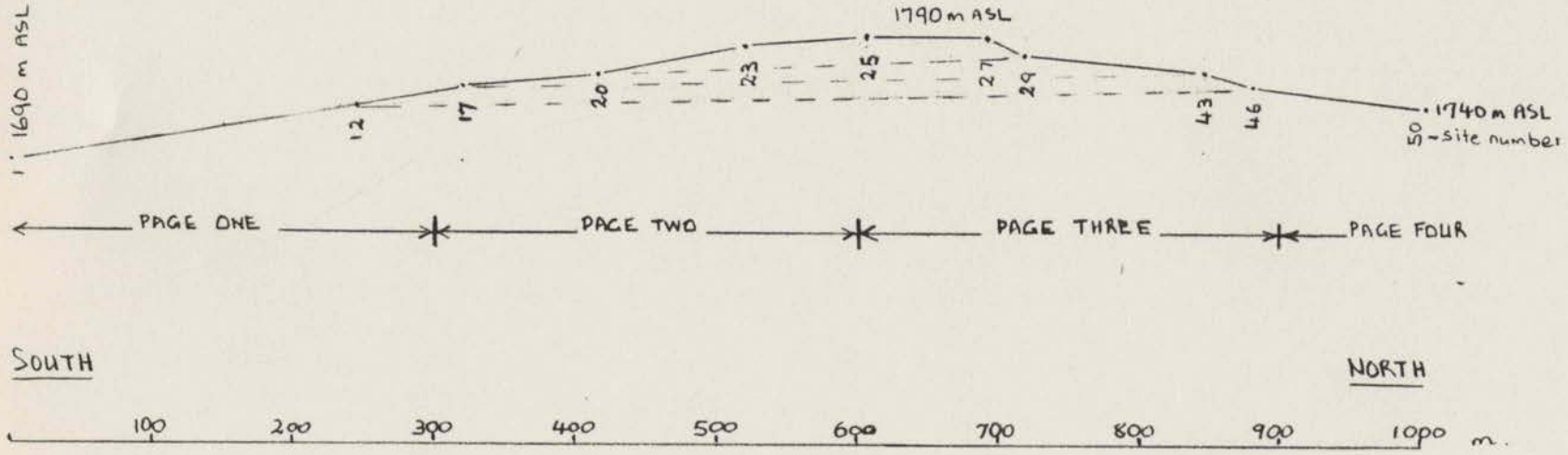
The fines which are supposed to have been removed from the terrace tread in the model presented can be accounted for as layer 2, (Holocene sediment) in the floor of Pretty Valley. This Holocenesed comprises silt sand and gravel in a 0.5m to 1.0m high alluvial terrace adjacent to Pretty Valley Creek, over the floor of Pretty Valley and roughly mapped from aerial photographs onto the overlay on Fig 2Ae.

PRETTY VALLEY SURVEYED SECTION A1

FIG. 3C d

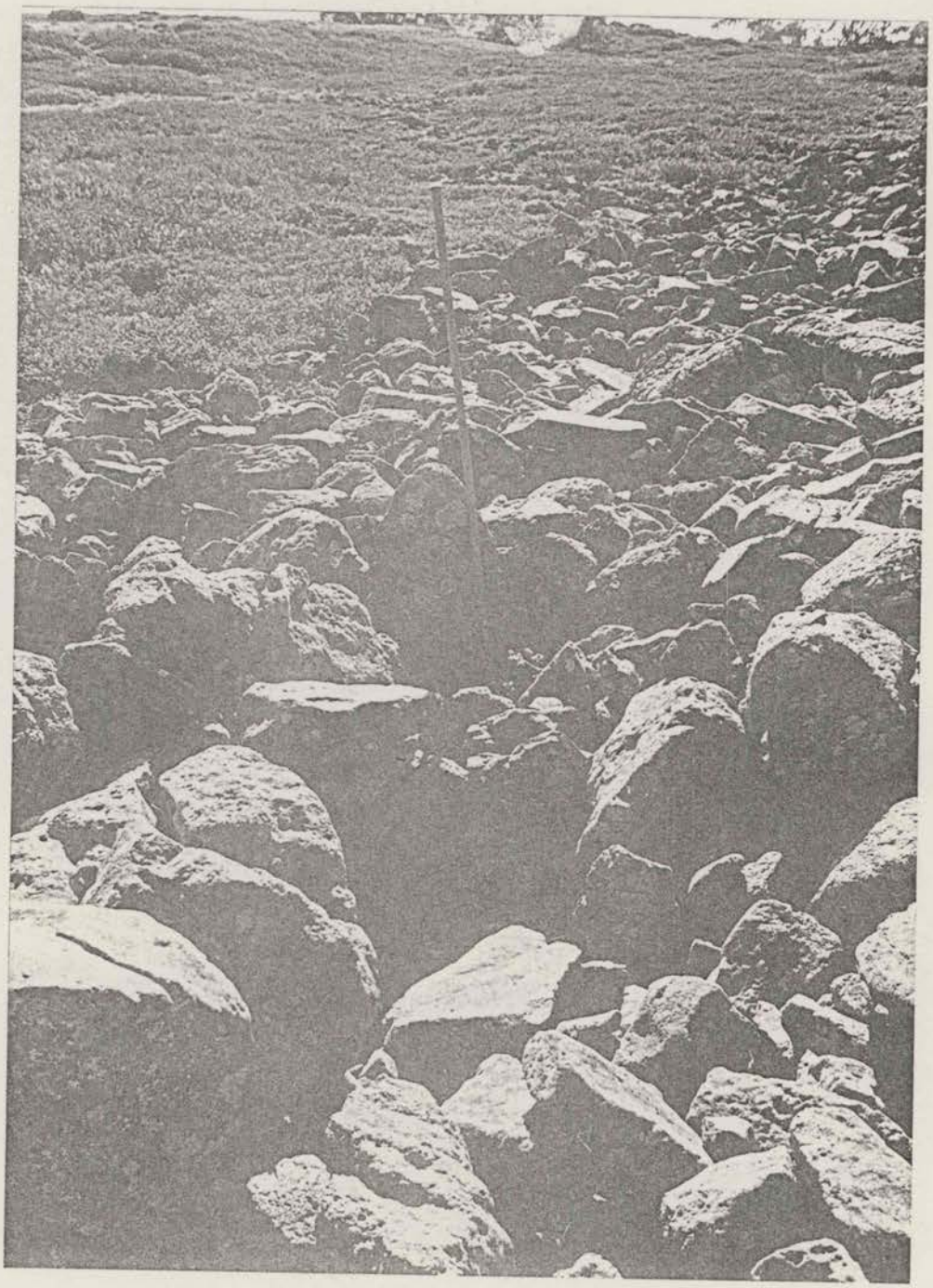
REFER TO FIG 2Aj ON PAGE 128 FOR LOCATION PLAN

SCALE 1:5000



PRETTY VALLEY SURVEYED SECTION (TRAVERSE) A1 (continued)

PHOTOGRAPH PV 10587F1 : Point 10, block accumulation. The conical pits probably represent thermokarst.



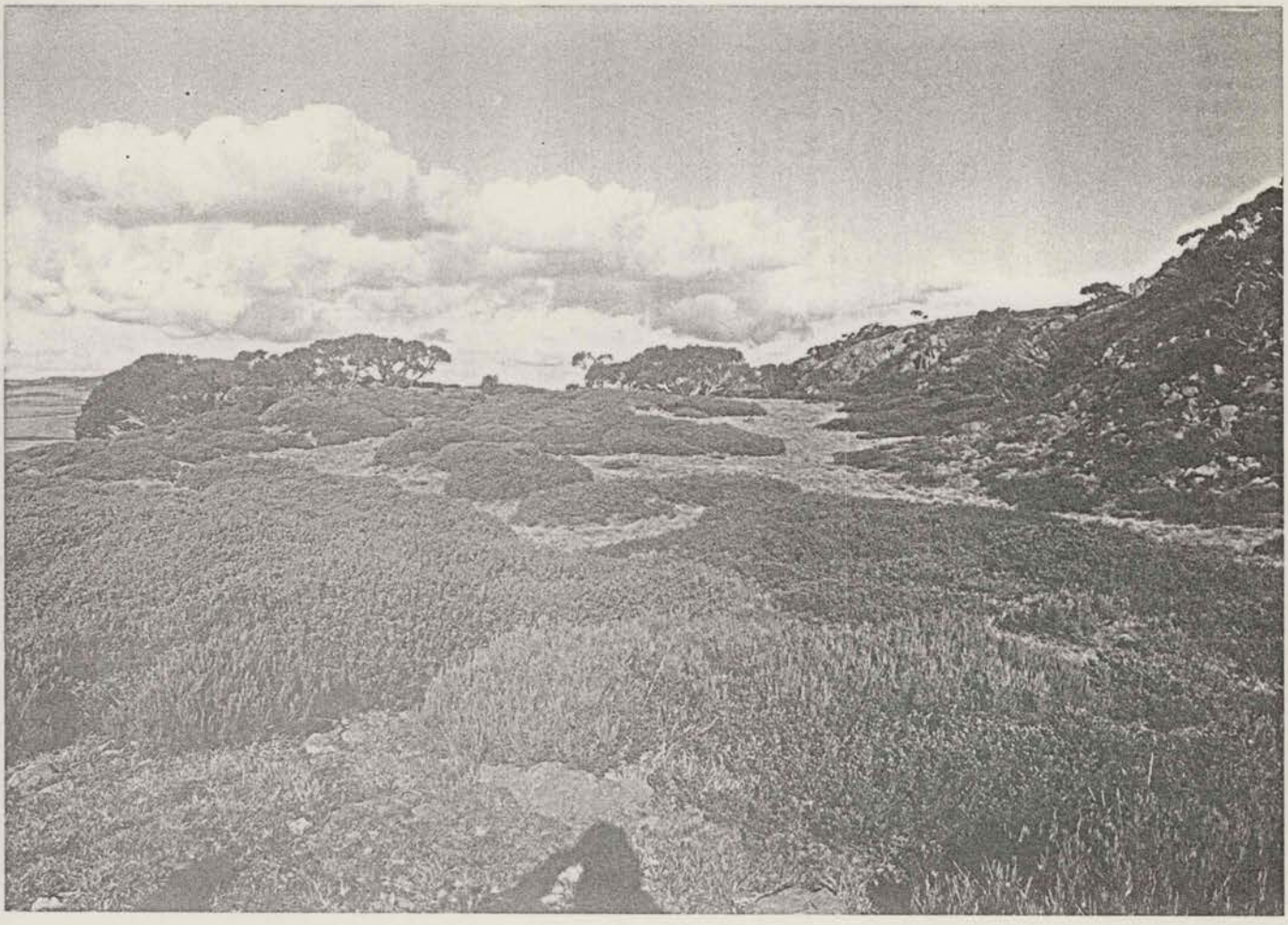
PRETTY VALLEY TRAVERSE A1 (continued)
PHOTOGRAPH PV 10587F3: Point 10, block accumulation, looking upslope. Note the raised distal edges of this block accumulation.



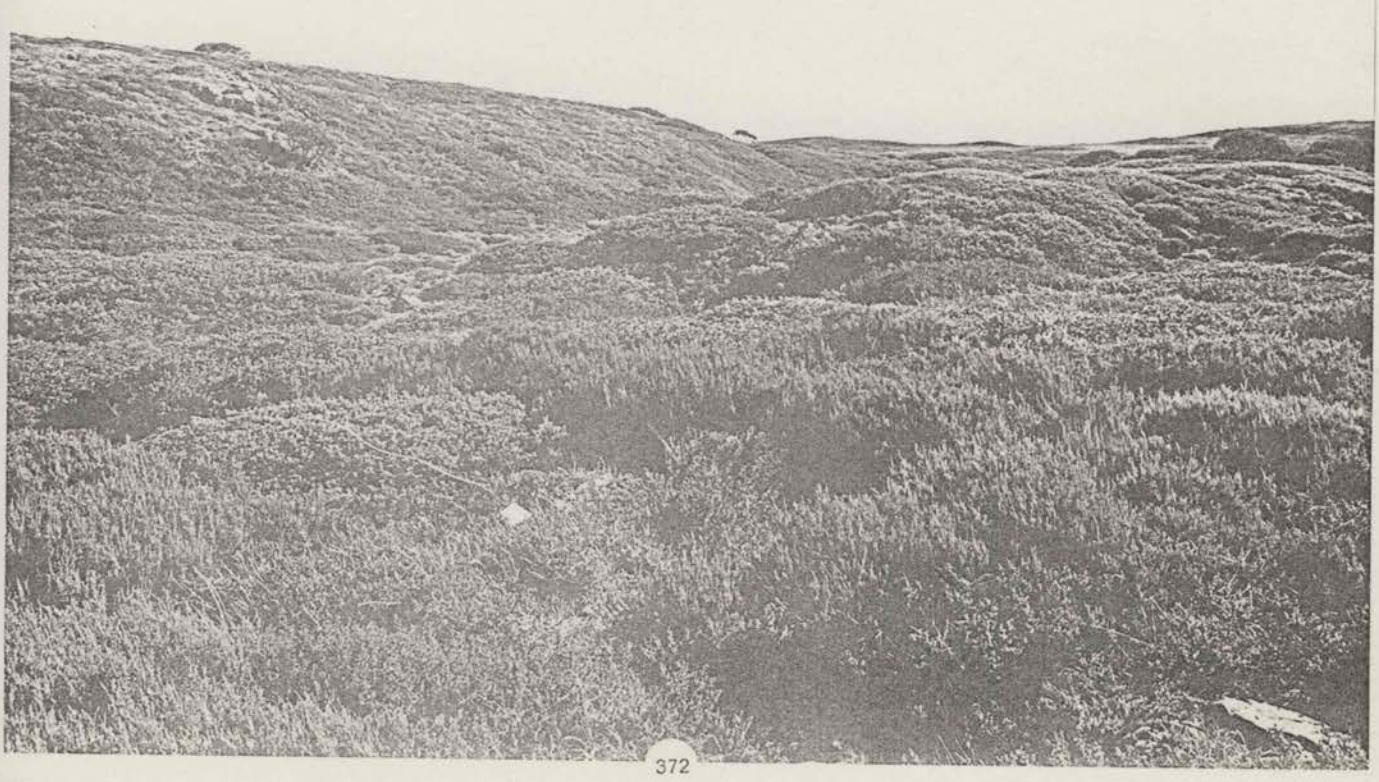
Photograph PV 10587F6 : Between points 28 and 30, overleaf (top), looking south-east. A view of the basalt scarp and the adjoining terrace.

Photograph PV 10587F4 : Point 32, overleaf (bottom). A view of the basalt scarp and adjoining terrace with a raised, linear mound in the foreground. This linear rise is parallel to the scarp in the background and appears to be a slump feature. Bedrock is exposed on the scarp.

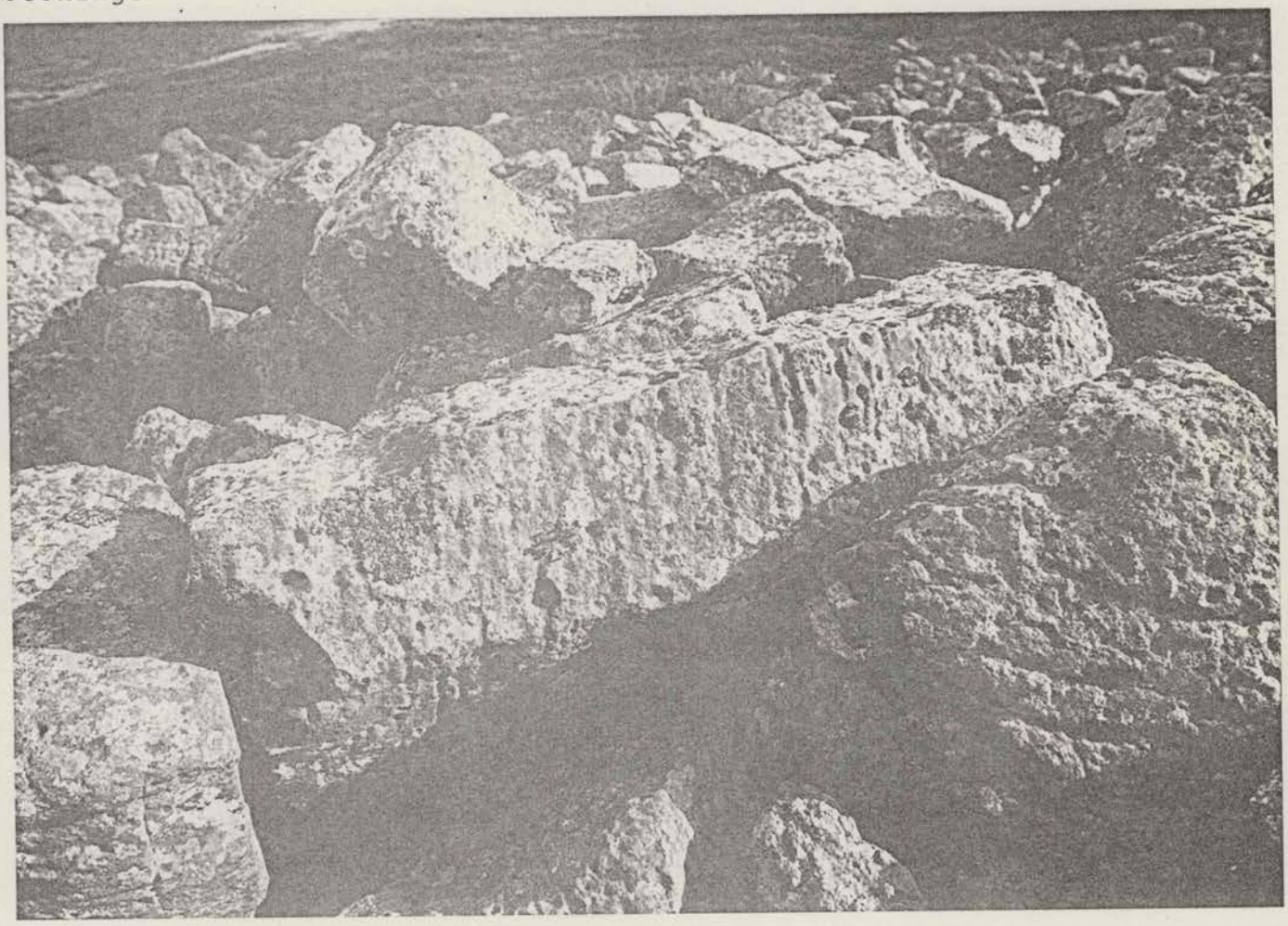
PRETTY VALLEY TRAVERSE A2 (continued)
PHOTOGRAPH PV 10587F6



PHOTOGRAPH PV 10587F4



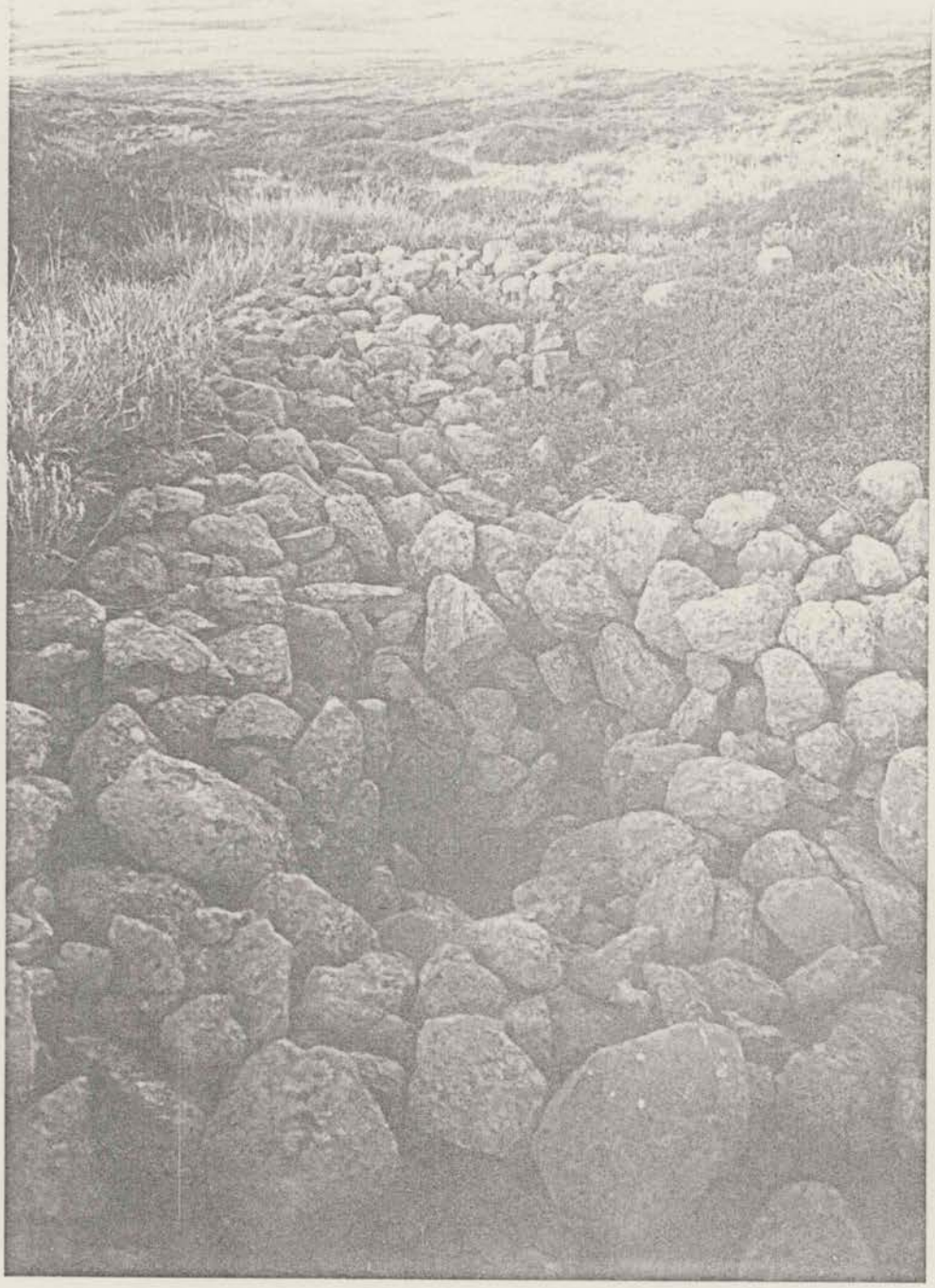
PRETTY VALLEY SURVEYED SECTION (TRAVERSE) A2 (continued)
PHOTOGRAPH PV 481F6. This photograph is a close up view of basalt blocks in the proximal section of blockstream surveyed in Traverse A2. Note the 1.2m prismatic column with lateral etching.



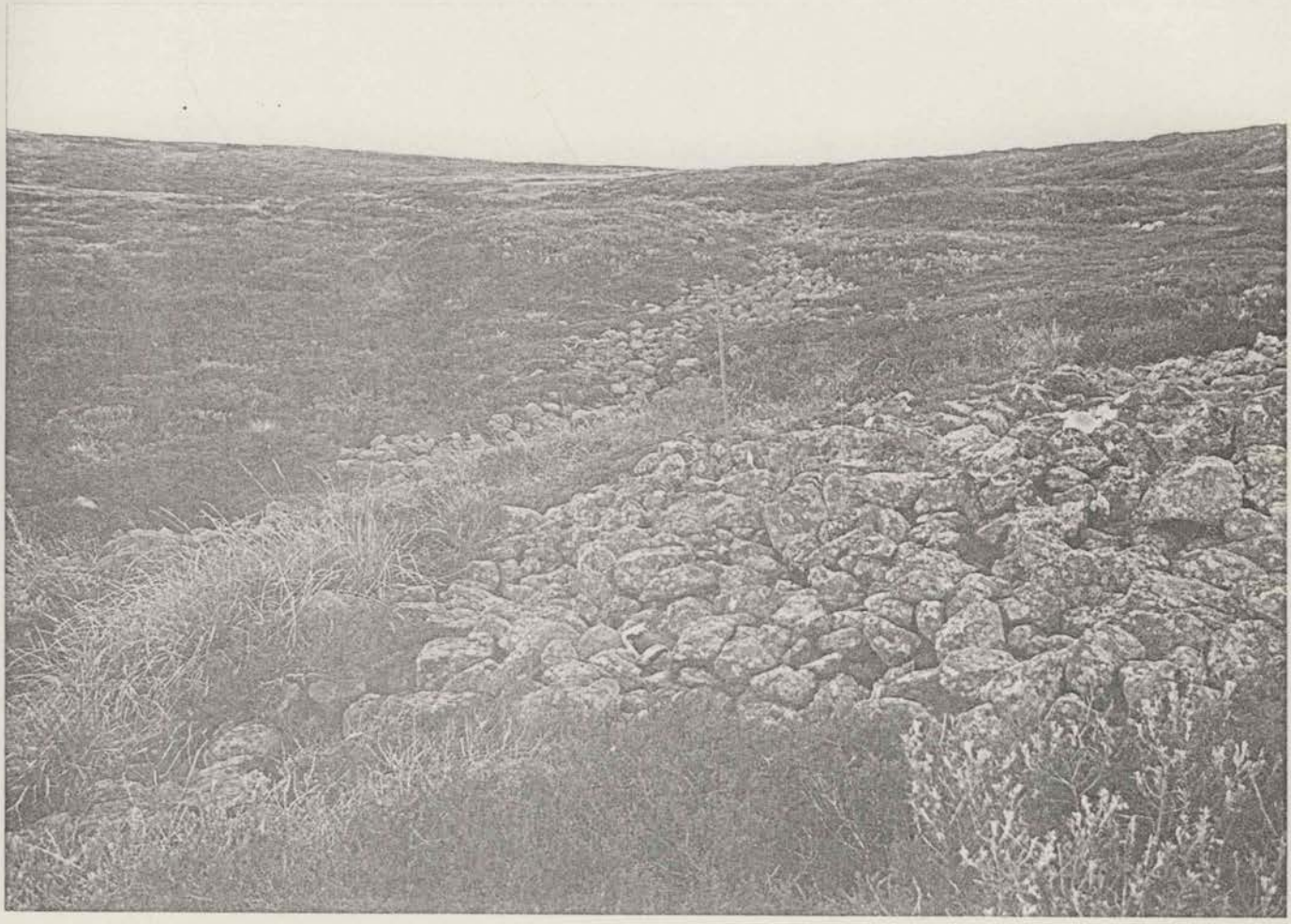
Photograph PV 491F22 : Point 11, overleaf (top). This block accumulation is located near point 11 at the distal end of the blockstream. Note the conical pit about 60cm deep and 1m across. This is interpreted as thermokarst. Also note the difference in habit of the basalt blocks compared to those in the Photograph PV 481F6 (above).

Photograph PV 10587F7 : Point 12, overleaf (bottom). A view taken from the northern side of the distal end of the block accumulation. Note the elevation of the block accumulation (1m) and the sharply defined edge.

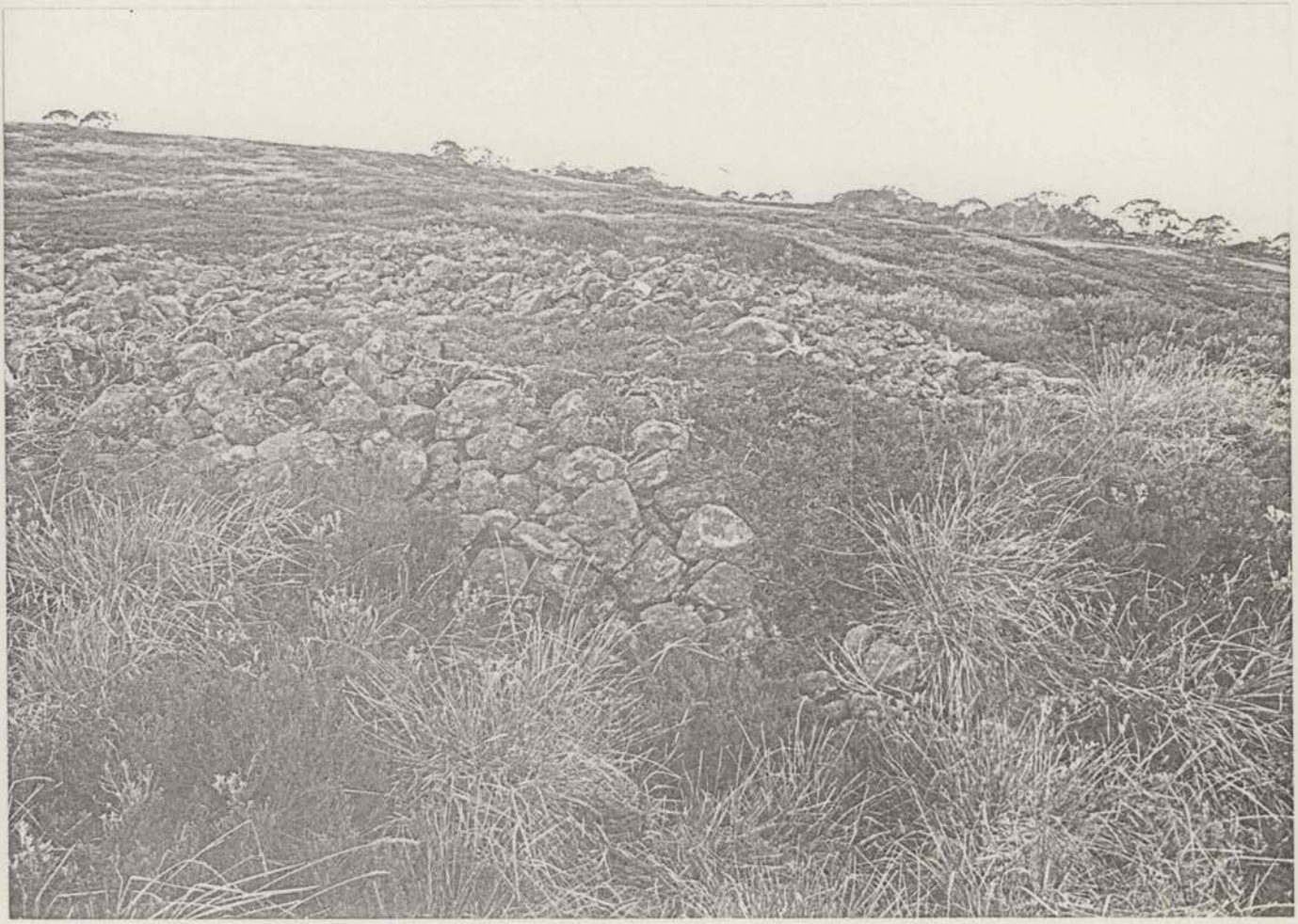
PRETTY VALLEY TRAVERSE A2 (continued)
PHOTOGRAPH PV 481F22



PHOTOGRAPH PV 10587F7



PRETTY VALLEY TRAVERSE A2 (continued)
PHOTOGRAPH PV 10587F9 : Point 12, from the southern side. Views the distal end of the block accumulation. The basalt blocks are 10cm-40cm in size and have irregular or platy habit.



CREEK INTERSECTION. GR 202149 FEATHERTOP MAP SHEET S324-3-2

SCALE 1:1000

PAGE ONE PRETTY VALLEY SURVEYED SECTION A1

FIG 3Ce

13° OPEN HEATH

8.5° TUSSOCK GRASSLAND

2 3 16° Step

9° TUSSOCK GRASSLAND

7 11° BASALT BLOCKS IN SOIL

5

7° TUSSOCK GRASSLAND COVERING BASALT BLOCKS

9 11° STEP. SURFACE SATURATED

7 8 7.5° TUSSOCK GRASSLAND COVERING BASALT BLOCKS / SURFACE SATURATED

13° TUSSOCK GRASSLAND COVERING BASALT BLOCKS/ SURFACE SATURATED

9

6° BLOCKSTREAM WITH THERMOKARST PITS AT DISTAL END WHICH IS ELEVATED ~ 50 cm AT ITS OUTER MARGINS, FORMING A LIP. REFER TO PHOTOGRAPHS PV10587 F1 and F3.

6 9° BASALT BLOCKSTREAM, 12m WIDE, RAISED EDGES, CONCAVE CROSS-SECTION

BLOCK SIZE DECREASES WITH DEPTH AND GROUNDWATER IS 60 cm BELOW SURFACE OF BLOCKS.

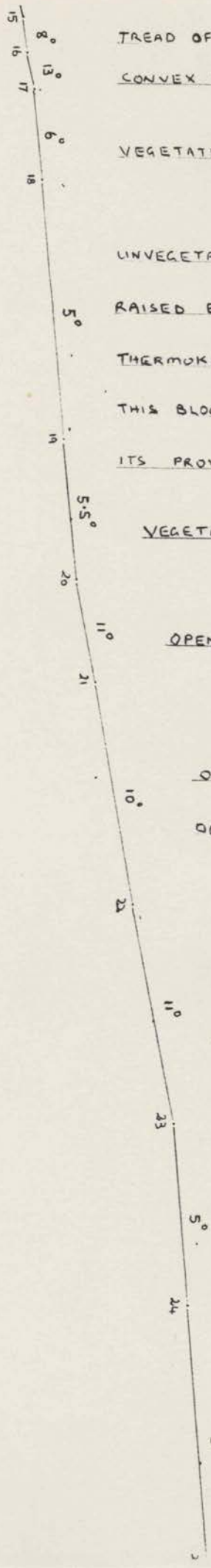
= 11° BASALT BLOCKSTREAM / BLOCK COVER THINS OUT ABOVE CHANGE IN SLOPE

SLOPE GETS PROGRESSIVELY MORE VEGETATED / SURFACE SATURATED

3 10° PARTIALLY VEGETATED BLOCKSTREAM / BLOCKS CONCENTRATED AT TOP OF SECTION

3 ω° GENTLY CONCAVE GRASSY SLOPE

4 ω° SMALL STEP - 1m HIGH



TREAD OF SMALL VEGETATED TERRACE

CONVEX SLOPE (TOE TO ABOVE TERRACE)

VEGETATED TERRACE LEADING TO RAISED LIP OF BLOCKSTREAM

UNVEGETATED BLOCKSTREAM 50-60cm DEEP. WITH RAISED EDGES, CONCAVE CROSS SECTION AND THERMOKARST PITS AT DISTAL END

THIS BLOCKSTREAM IS OVERRUN BY GRASSLAND AT ITS PROXIMAL END

VEGETATED BLOCKSTREAM

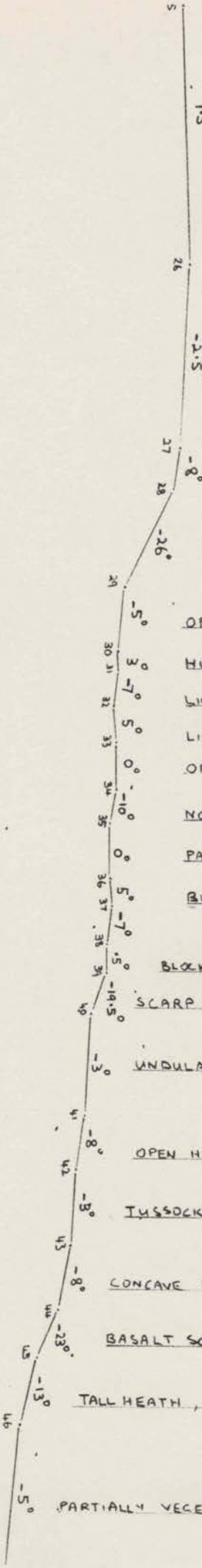
OPEN HEATHLAND / NO BLOCKS VISIBLE

OPEN HEATHLAND/ BASALT BLOCK GLACIS OCCURS BELOW BEDROCK SCARP 50 m EAST.

OPEN HEATH/ CONVEX SLOPE/ BASALT BEDROCK OUTCROPS 40 m EAST

GRASSLAND/ ISOLATED BASALT BLOCKS ON SURFACE TERMINATING AGAINST A 1 m STEP.

PRETTY VALLEY SURVEYED SECTION A1



OPEN HEATHLAND

OPEN HEATHLAND / BASALT BLOCKS EXPOSED AT SURFACE - COVERING ~20%

SLOPE DROPS TO EDGE OF BASALT OUTCROP

BASALT SCARP / TALL CLOSED HEATHLAND

OPEN HEATHLAND REFER PHOTOGRAPH PV10587 F6 and PV10587 F4

HUMP / COVERED BY ORITES HEATH

LINEAR DEPRESSION, PARALLEL TO CONTOUR (PV10587 F1)

LINEAR RISE, PARALLEL TO CONTOUR

OPEN HEATH

NORTHERN SLOPE OF LINEAR RISE

PAN WITH BLOCKS ON FLOOR

BLOCKY MOUND / BEDROCK NEARBY

BLOCKS AT SURFACE / MOSTLY VEGETATED WITH OPEN HEATH

SCARP WITH INSITH BASALT

UNDULATING SURFACE WITH OPEN HEATH

OPEN HEATHLAND

TUSSOCK GRASSLAND

CONCAVE UPPER EDGE OF BASALT SCARP

BASALT SCARP / BLOCKS AT SURFACE

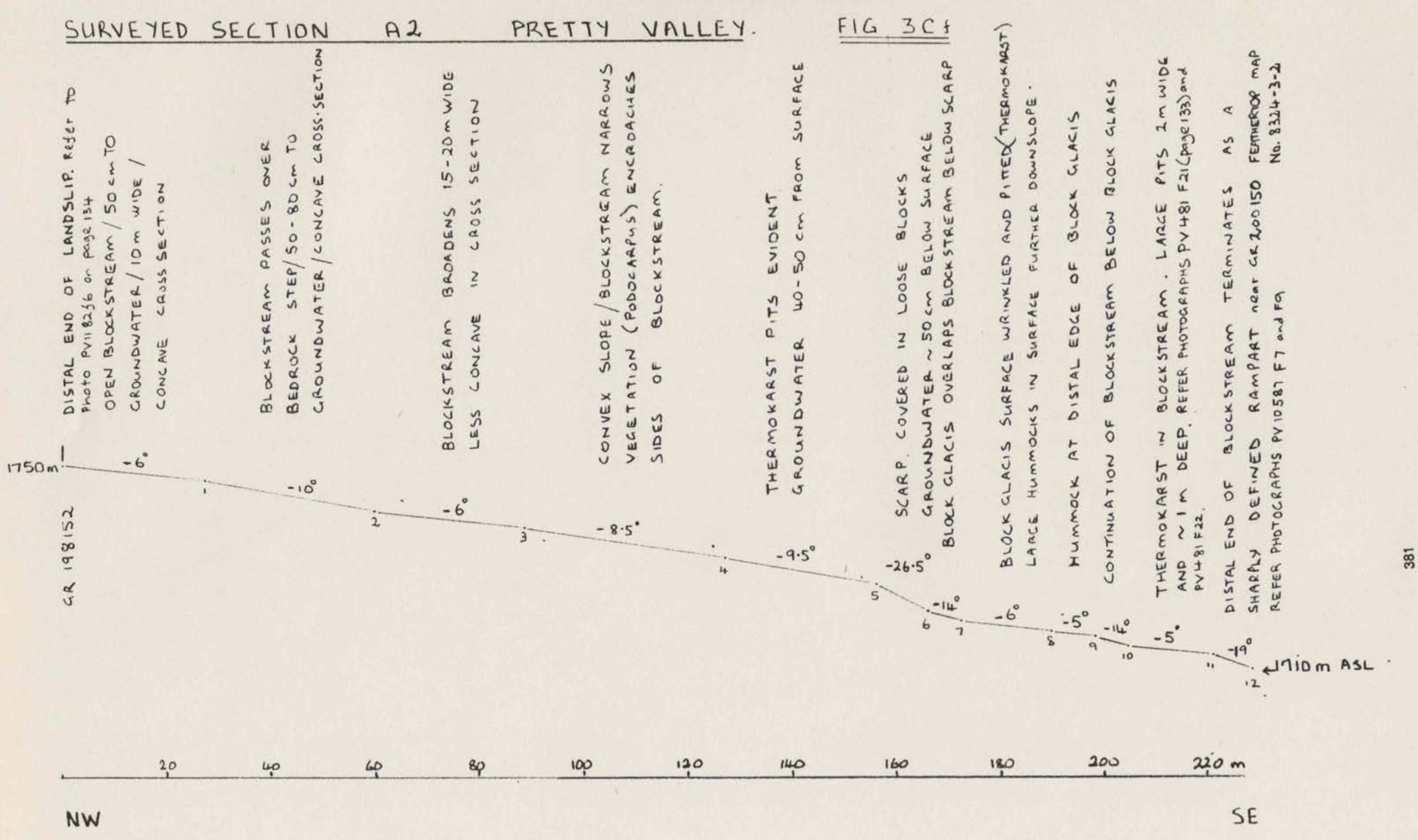
TALL HEATH, BLOCKS UNDERFOOT

PARTIALLY VEGETATED BLOCKFIELD / BLOCK GLACIS

PRETTY VALLEY SURVEYED SECTION A1

SURVEYED SECTION A2 PRETTY VALLEY.

FIG 3C



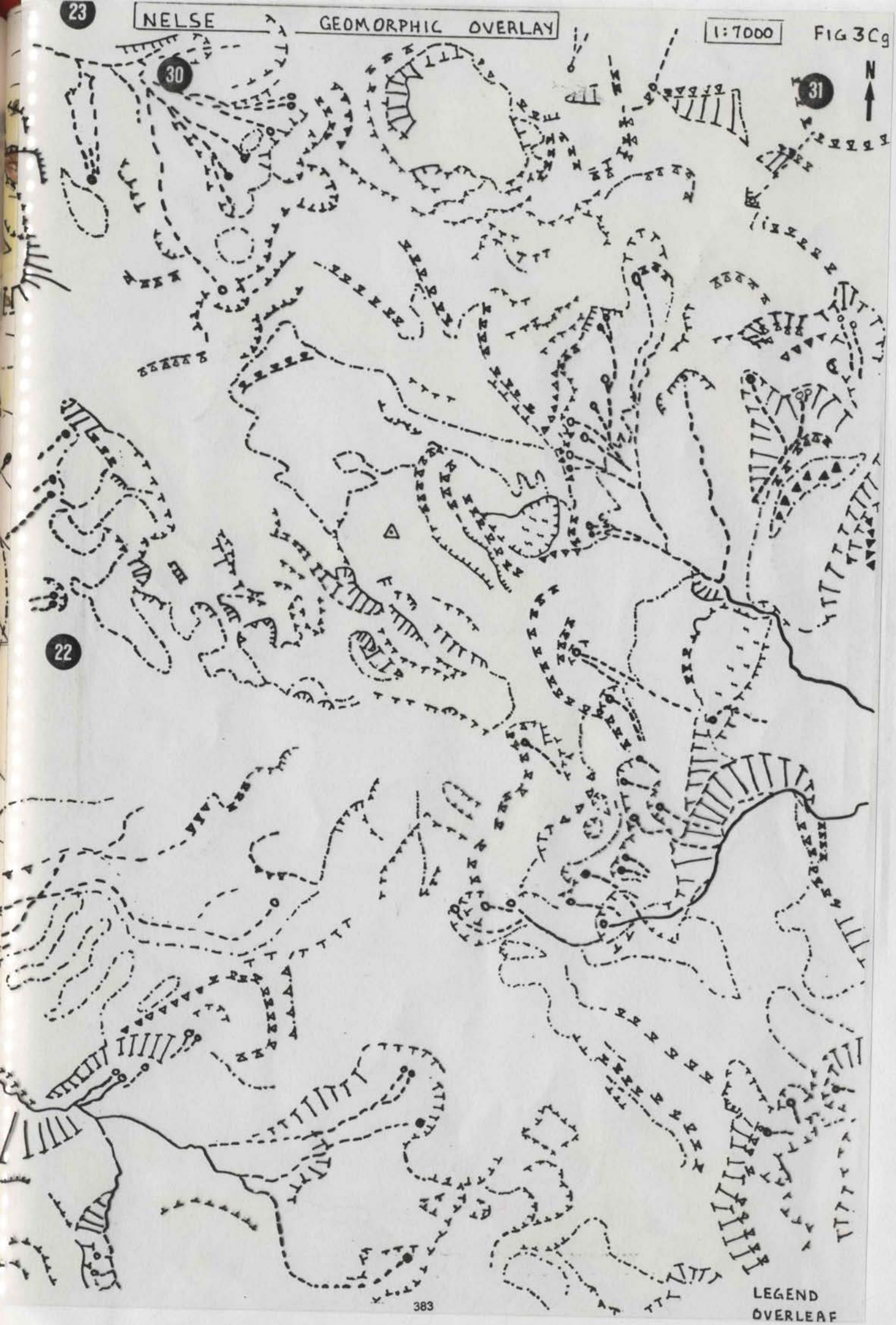
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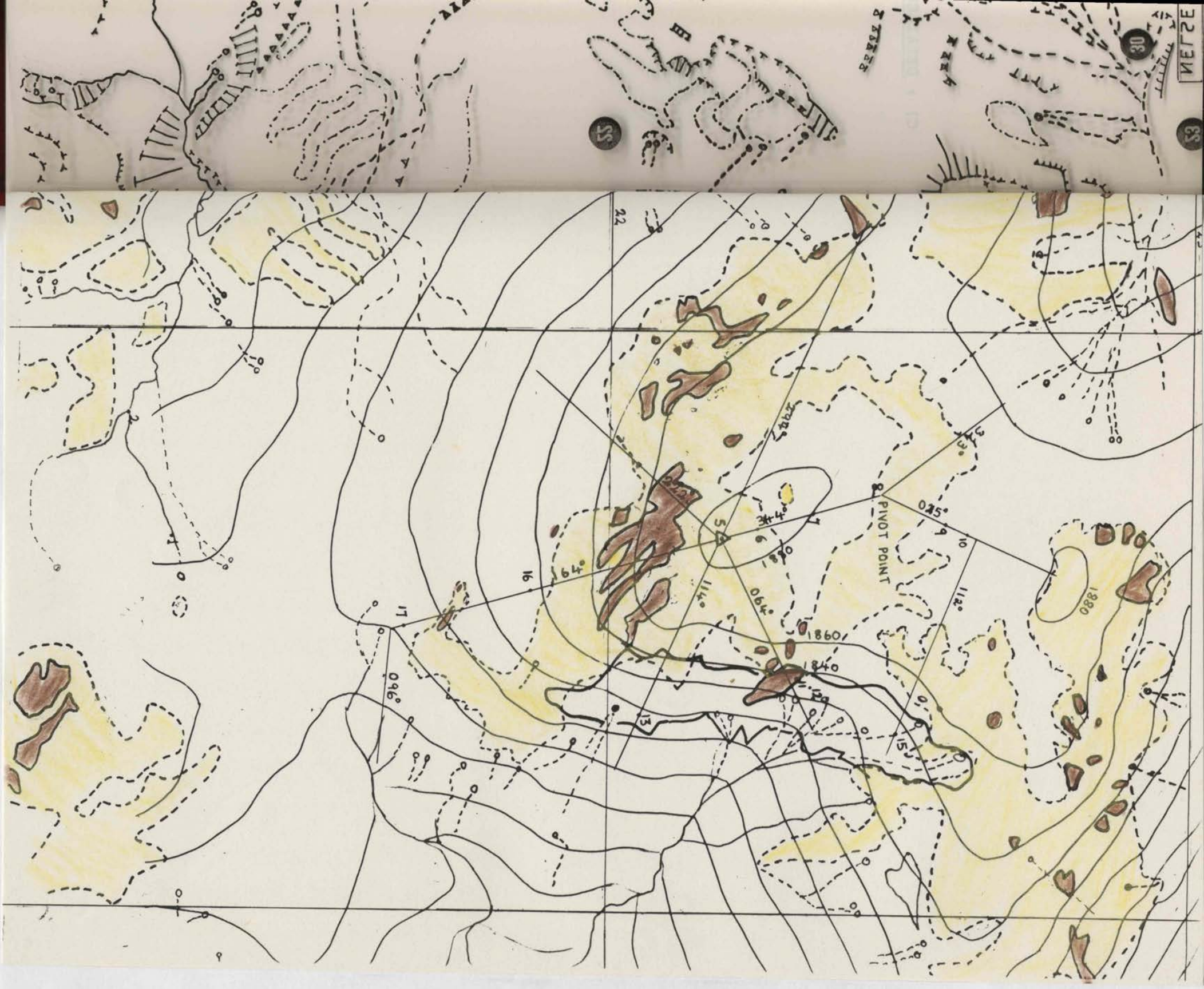
REFER TO FIG 2Aj (P128) FOR LOCATION PLAN

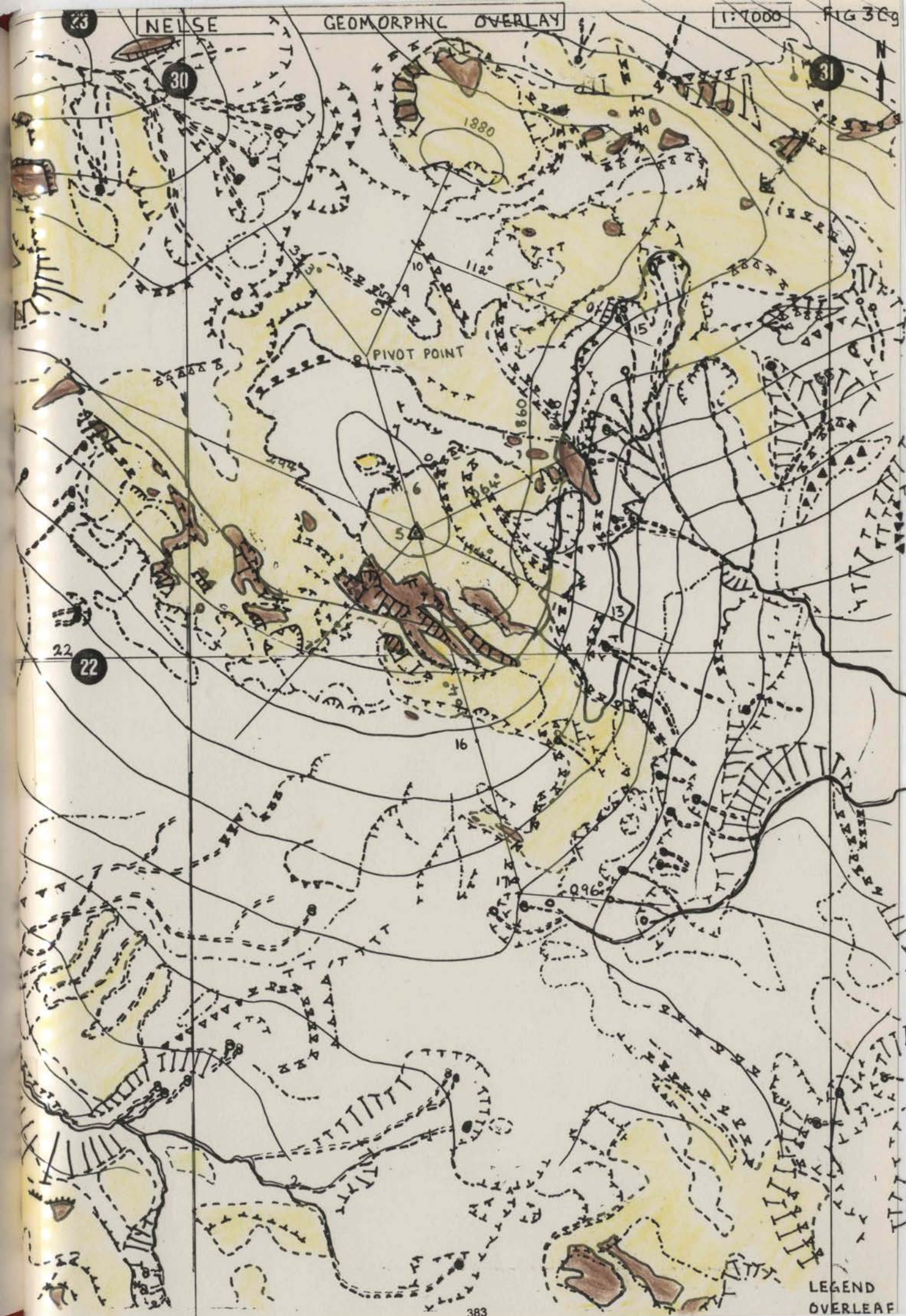
SECTION THREE : GEOMORPHIC ANALYSIS

C) : DETAILED DESCRIPTION AND INTERPRETATION OF TARGET AREAS

PART THREE : MT. NELSE


NELSE
GEOMORPHIC OVERLAY
1:7000
FIG 3Cg
N
23
30
31
22
LEGEND
OVERLEAF

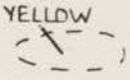

PIVOT POINT
025°
064°
096°
164°
1860
1880
1840
22
16
17
13
15
10
11
12
30
53
55


NELSE GEOMORPHIC OVERLAY
1:7000
FIG 3Cg
N
PIVOT POINT
1880
1860
1840
1820
1800
112°
096°
LEGEND
OVERLEAF

LEGEND FIG 3Cg



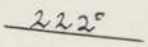
Bedrock outcrop



Bedrock close to surface (<30cm) as inferred from aerial photography

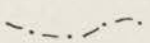


Spring and drainage line



Traverse with bearing

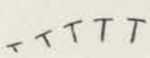
Stratigraphic sites, as described in Section 2A (Nelse)



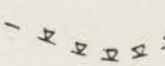
Form line. Gentle change in slope inferred from aerial photographs



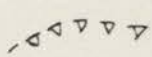
Scarp. Relatively sharply defined



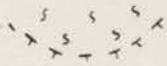
Scarp with diffuse change in slope



Concave slope



Convex slope



Head deposit



Open block accumulation

Discussion of Mt. Nelse Traverses.

Fig 3Cg presents a plan of bedrock outcrop, inferred bedrock close to the surface, drainage lines, stratigraphic sample points and location of traverses with a geomorphic overlay depicting changes in slope, scarps and concavities.

The largest concavity is the snow patch zone 300m east of the summit, the current disposition of which is shown on the bedrock map. The upper edge of the present snow patch zone is marked by a sharp break in slope with a concave surface immediately downslope. The lower edge was not as well defined by slope changes observed from aerial photographs, possibly due to tall heathland and snow gums.

The summit area is characterized by being essentially a bedrock surface with significant outcrops of schist with foliation and outcrop trending north-west/south-east. Scarps are present on all bedrock outcrops. The distribution of scarps is strongest in the direction of foliation (north-west/south-east) but minor scarps, steps and flex ures in the surface slope occur right around the summit and are closely associated with inferred bedrock distribution. The yellow, bedrock zones have been mapped from 1:5 000 color stereo aerial photographs and checked in the field by traverses.

Fig 3Cg the location of the traverses and Fig 3Ch, Fig 3Ci and Fig 3Cl are index diagrams which give an overview of the traverses at 1:5 000 scale.

A bedrock summit flat bounded by a shallow bedrock scarp, is indicated for: Traverse 344° (points 1-14), Traverse 164° (points 1-4), Traverse 323° (points 1-8), Traverse 294° (points 1-30), Traverse 114° (points 1-5), Traverse 222° (points 1-4) and Traverse 064° (points 1-2).

Below the summit bedrock flat is a set of terraces and risers roughly concentric about the summit, cut into bedrock with step-like profiles down to about 1830m-1840m. This is well developed on the southern and eastern sides. Below about 1830m, especially on the southern side, the slope is particularly uniform at 12°-14° over about 400m. This may represent several terraces with shallow risers which have been overun with blocky detritus from above, which has tended to smooth out the slope. The stratigraphic data from auger samples confirms this view. This slope could be described as a relic blockslope.

The above mentioned set of terraces and risers between 1830m and the summit flat at about 1880m conforms very closely to Washburn's description of cryoplanation terraces in plan, in section and in their close association with bedrock. The downslope evacuation of competent angular cobbles and blocks over gradients of 1.0° to 1.7° (Traverse 344°) on a broad, even surface, with underlying bedrock extremely weathered in places, suggests that frost creep rather than fluvial or colluvial

processes, has been the dominant agent of transport. The vertical sorting of cobbles towards the surface of layer 2 as described in Section 2A, could also be explained by frost sorting as described by Corte (1966).

Although the steps associated with the cryoplanation terraces are best defined where they run nearly parallel with the foliation and jointing, the terraces and steps occur on all aspects about the summit.

The development of blockfield terrain is less apparent on Mt. Nelse than on Basalt Hill. It would appear that the foliated highly fractured quartz biotite schist of Mt. Nelse produces fines and platy cobbles in greater profusion than blocks when compared to the columnar basalt of Basalt Hill or Pretty Valley. The only block accumulations visible at the surface in the Mt. Nelse area are associated with isolated, dolerite and granodiorite rather then schist.

On Fig 3Cg, a block glacis of granodiorite and dolerite occurs in association with a relic nivation hollow near G.R. 310223, and another comprising dolerite and gneiss blocks occurs near G.R.298215. These sites demonstrate that well jointed rocks such as granodiorite, dolerite and even gneiss are more readily broken into blocks compared to schist.

The extent of blocky (layer 2) material also appears to be less on Nelse than on Basalt Hill. Between the Mt. Nelse summit and the hill to the north of the summit via bearings 344° and 025°, the gravel and cobbles of layer 2 appear to thin rapidly at about 400m from the summit, whereas on Basalt Hill, basalt blocks form a partially vegetated blockfield 1 200m from the summit and at least 400m beyond the basalt outcrops. This suggests that blocks have been more readily mobilised across this surface than fines or gravel and supports frost creep as a mode of erosion. This is the reverse of what could be expected from an alluvial process of transport.

The Mt. Nelse snow patch zone, represented on Fig 3Cg is marked by a rapid change of slope near its upper margin and a transition from bedrock cryoplanation terraces above to blocky detritus within the snow patch zone. The blocky detritus, in some instances in the form of lobes (Section 2A4, Mt. Nelse, site 12), appears to be a relic feature which is now being eroded by needle ice due to the suppression of vegetation in the snow patch zone. Diurnal frost action is producing very little new material and active mass movement of blocky detritus is also evident in the snow patch zone. If the blocky detritus was emplaced during the last cold phase of the Pleistocene, it suggests that very little snow was present in this present snow patch zone during the late Pleistocene. There is a set of smaller snow patch zones/relic nivation hollows downslope and east of the main snow patch zone.

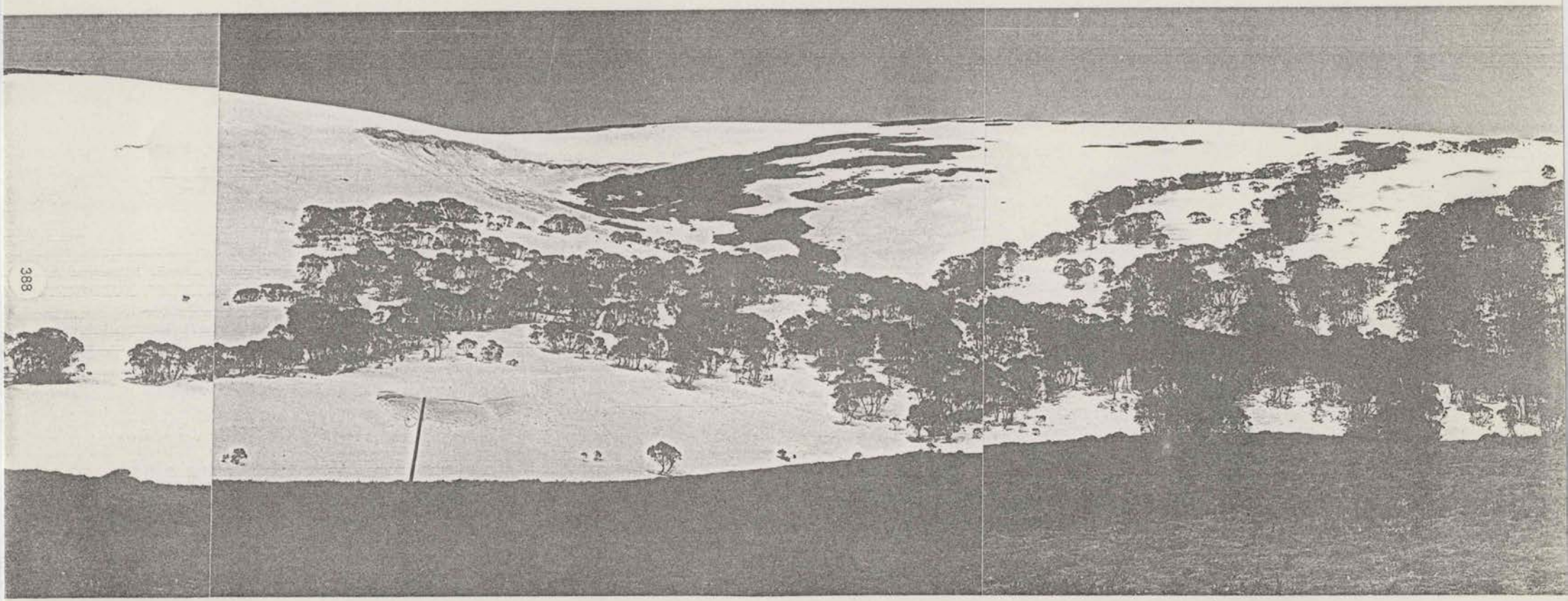
Some of these are marked on the geomorphic overlay of Fig 3Cg as arcuate concavities with a southeasterly aspect. The scarp marked at G.R. 309218 locates one example on Fig 3Cg. Another such feature has a block glacis developed in its floor at G.R. 310223.

These features are marked by late lying snow and a vegetation cover of short turf and Celmisia or wet heath and sphagnum in the lower terrain.

Composite Photograph N 41080F5/F6/F7 illustrates a set of snow patches separated by linear patches of snow gums east of Mt. Nelse. The snow gums occupy locally elevated bedrock which provides good drainage as snow gums cannot tolerate saturated soil conditions.

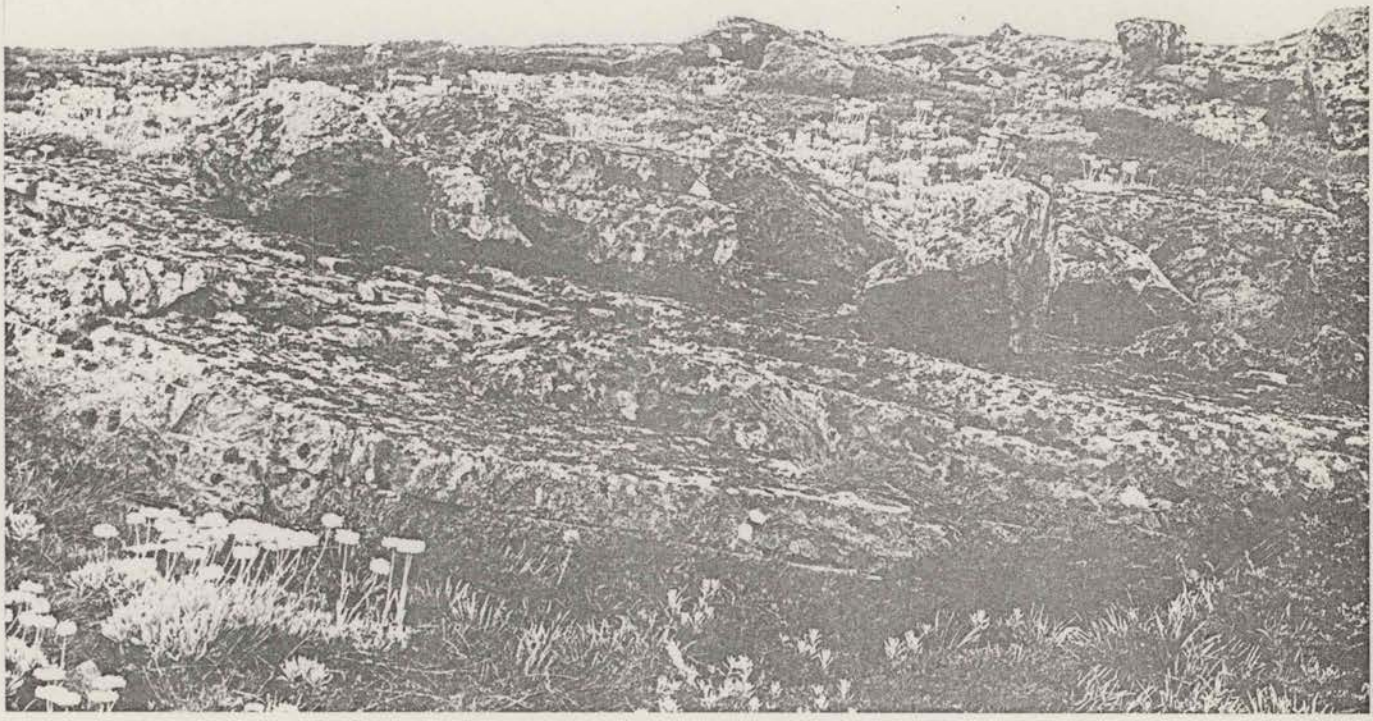
These nivation hollows extend eastwards beyond the area mapped on Fig 3Cg and appear as low down as 1 600m in association with granodiorite bedrock and associated autochthonous blockfields near G.R. 317218.

The photographs that make up Composite Photograph N 41080F5/F6/F7 were taken in spring from a point near G.R. 308213, looking northwards at the eastern flanks of Mt. Nelse.

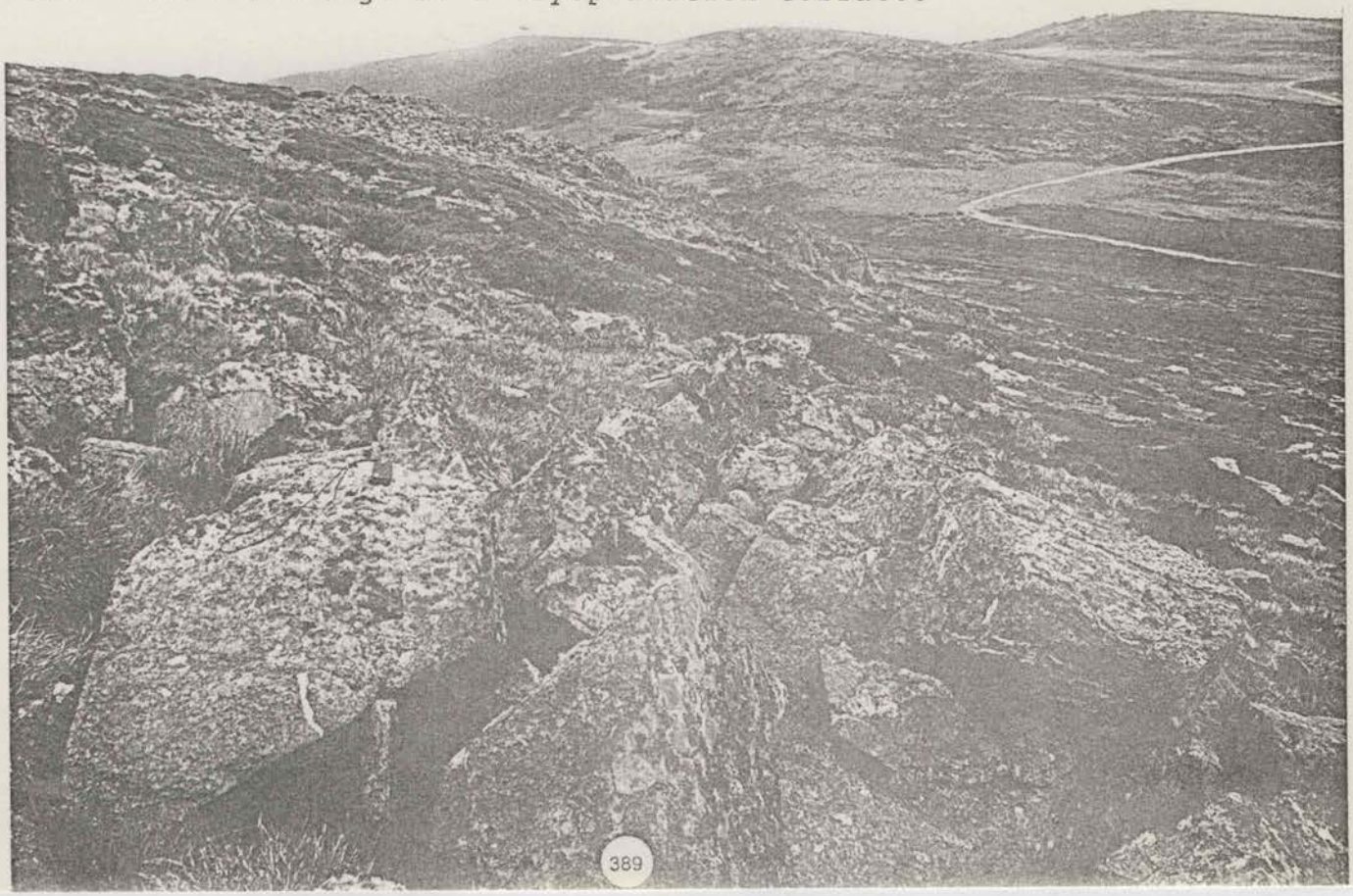


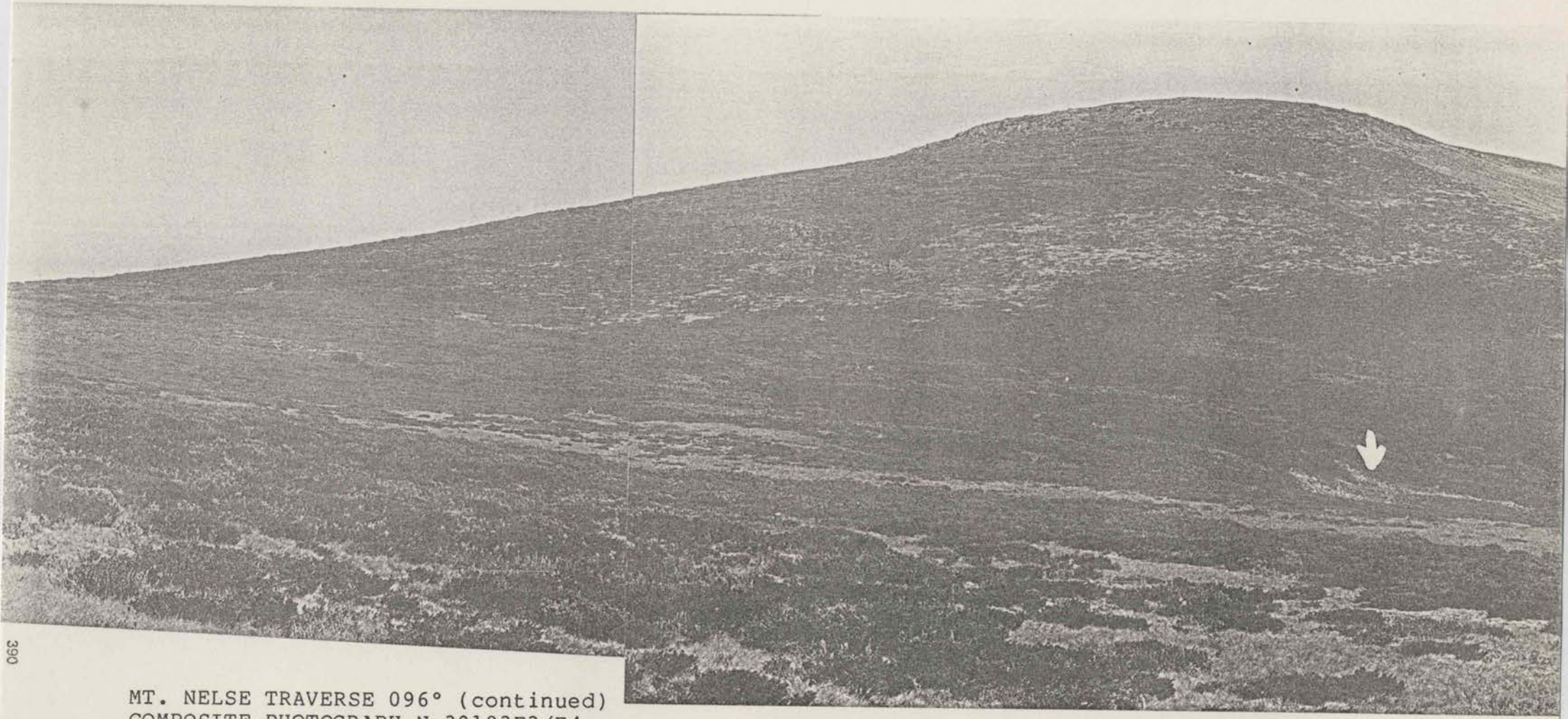
COMPOSITE PHOTOGRAPH N 41080F5/F6/F7

MT. NELSE TRAVERSE 164° (continued)
PHOTOGRAPH N 28286F4 : Point 3. Illustration of a lag deposit of large blocks on a bedrock surface sloping gently to the south-east.



PHOTOGRAPH N 28286F6 : Point 5. Demonstrates a veneer of coarse blocks near the edge of a cryoplanation terrace.

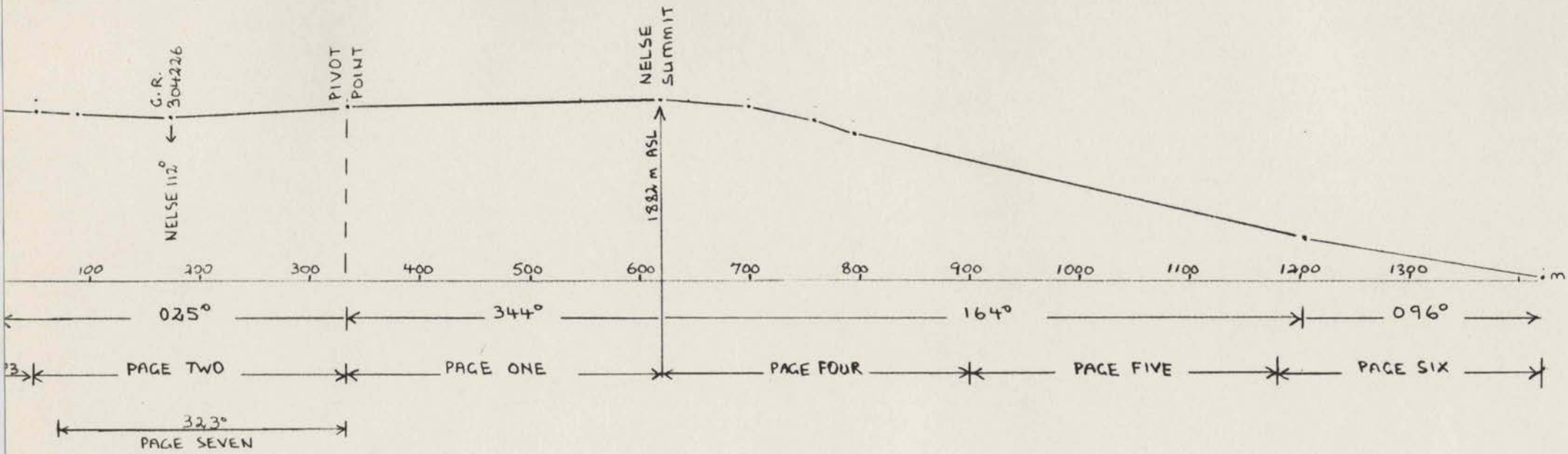




MT. NELSE TRAVERSE 096° (continued)
COMPOSITE PHOTOGRAPH N 30183F3/F4
This photograph views the southern slopes of Mt. Nelse with a terraced drainage line in the midground. The bare (pale) ground in this drainage line is a stony pavement associated with a small snow patch zone, at the foot of a terrace.

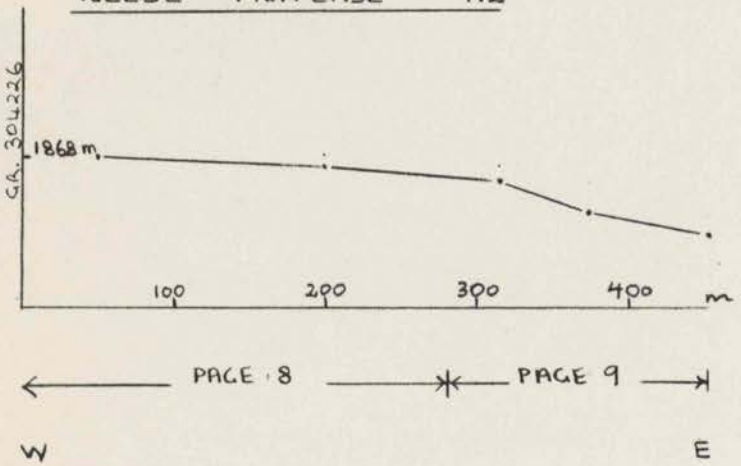
NELSE TRAVERSES 025° / 344° / 164° / 096° / 323° / 112° FIG. 3Ch

REFER FIG 3Cg (NELSE 1:5000 PLAN) FOR POSITION OF TRAVERSES



SCALE 1:5000

NELSE TRAVERSE 112°



SCALE 1:5000

NELSE SUMMIT ALTITUDE 1882 m TRAVERSE BEARING 344° GB
HORIZONTAL AND VERTICAL SCALE IS 1:1000

344°

DWARF HEATHLAND. COARSE ANGULAR BLOCKS OCCUPY 40% SURFACE.
AUGER SUGGESTS BEDROCK AT 30 cm BELOW SURFACE

SHORT KUNZEA HEATHLAND BARE GROUND < 10%

SHORT KUNZEA HEATHLAND ≤ 30cm TALL. SMALL PATCHES OF OPEN GROUND. AUGER SAMPLE N344/65: EXT. WEATHERED BEDROCK AT ~ 40 cm BELOW SURFACE OVERLAIN BY 30cm STONY GRAVELLY LOAM OVERLAIN BY 10 cm ORGANIC LOAM

SMALL HUMMOCKS ON VEGETATED SURFACE IN NET-LIKE PATTERN WITH APPROX 15 cm VERTICAL RELIEF AND 90 cm BETWEEN CENTRES. NO BLOCKS VISIBLE AT SURFACE

NET-LIKE PATTERNED GROUND STRONGLY DEVELOPED WITH HOLLOWS 5–30cm DEEP
AUGER STRUCK CLOSE PACKED ANGULAR COBBLES FROM 25cm TO 40 cm AND WAS UNABLE TO PENETRATE FURTHER. ABOVE THE STONE LAYER IS 25 cm ORGANIC LOAM
A FEW ANGULAR BLOCKS WERE ASSOCIATED WITH THE COBBLES

PATTERNED GROUND LESS EVIDENT. SHORT OPEN HEATHLAND

VEGETATION IS SHORT OPEN HEATHLAND AUGER SAMPLE N344/165
REVEALS EXTREMELY WEATHERED BEDROCK FROM 60 TO 150 cm BELOW SURFACE, OVERLAIN BY 40cm STONY LAYER OF PLATY, WEATHERED, SCHIST COBBLES IN A BROWN SANDY SILT MATRIX OVERLAIN BY 20 cm OF ORGANIC LOAM

GROUND SURFACE SMOOTH AND VEGETATED BY POA GRASSLAND

POA GRASSLAND. NO BARE SURFACE

AUGER TEST AT 225 m: WEATHERED BEDROCK BELOW 80cm, OVERLAIN BY TIGHTLY PACKED LAYER OF WEATHERED GRAVEL/COBBLES FROM 30cm – 80cm DEPTH, OVERLAIN BY STONY ORGANIC LOAM

POA GRASSLAND

VEGETATION TRANSITIONAL TO SHORT OPEN HEATHLAND

SHORT OPEN HEATHLAND. SOME BARE PATCHES WITH STONES EXPOSED

NELSE TRAVERSE 344°

1	-0·3°
2	-1·2°
3	-1·3°
4	-1·3°
5	-1·0°
6	-1·7°
7	-1·5°
8	-1·6°
9	-1·2°
10	-1·2°
11	-0·8°
12	-1·2°
13	-1·0°
	-0·6°

FIG 3C i (9 PAGES)

NELSE TRAVERSE 025°

SCALE 1:1000

SHORT OPEN HEATHLAND. ISOLATED SOLID OUTCROP NEARBY
THIS SHOT IS THE PIVOT POINT FOR TRAVERSES ALONG 025° GB AND 323° GB
AUGER SAMPLE N344/285 : SOLID BEDROCK AT APPROX 30 CM OVERLAIN BY COBBLES AND BLOCKS IN A GRAVELLY LOAM.

SHORT OPEN HEATH. LARGE BLOCKS AT SURFACE. BEDROCK OUTCROPS NEARBY
SOME BARE (UNVEGETATED) PATCHES IN SURFACE

SIMILAR TO SHOT 1

SIMILAR TO SHOT 1

VEGETATION TRANSITIONAL FROM SHORT OPEN HEATHLAND TO GRASSLAND
SOME COARSE BLOCKS AT SURFACE.

SIMILAR TO ABOVE. AUGER TEST : FROM 70 CM TO 35 CM, COBBLES IN A GRAVELLY SILTY SAND MATRIX OVERLAIN BY 5 CM GRAVELLY SANDY SILT OVERLAIN BY 10 CM PLATY COBBLES IN BROWN SANDY SILT MATRIX OVERLAIN BY 25 CM ORGANIC LOAM

VEGETATION ESSENTIALLY POA GRASSLAND. OUTER EDGE OF DISTINCT SHEET (GELIFLUCTION LAYER) AUGER SAMPLE N025/120 : AT ≥70 CM BELOW SURFACE IS PALE EXTREMELY WEATHERED BEDROCK. OVERLYING THIS AT 45-70 CM IS DARK BROWN GRAVELLY LOAM, OVERLAIN BY 15 CM OF COBBLES AND BLOCKS, OVERLAIN BY 30 CM BROWN ORGANIC LOAM.

POA GRASSLAND. AUGER TEST : EXT. WEATHERED BEDROCK BELOW 40 CM, FROM 30-40 CM GRAVEL, SMALL COBBLES IN LIGHT BROWN SANDY SILTY MATRIX, OVERLAIN BY 5 CM COARSE PLATY COBBLE LAYER, OVERLAIN BY 25 CM DARK ORGANIC LOAM

POA GRASSLAND. EVEN GROUND SURFACE. NO SIGN OF SURFACE PATTERNING, BLOCKS OR BARE PATCHES. AUGER SAMPLE N025/160 : EXT. WEATHERED BEDROCK BELOW ~60 CM; OVERLAIN BY 15 CM LIGHT BROWN GRAVELLY LOAM, OVERLAIN BY 5 CM LAYER OF COBBLES, OVERLAIN BY 40 CM BROWN ORGANIC LOAM.

CENTRE LINE OF VALLEY. POA GRASSLAND. LARGE CIRCULAR DEPRESSIONS 1→3 M ACROSS AND 0.5 M DEEP PIT THE SURFACE ALONG CENTRE LINE OF VALLEY (STRIKING 118° GB)

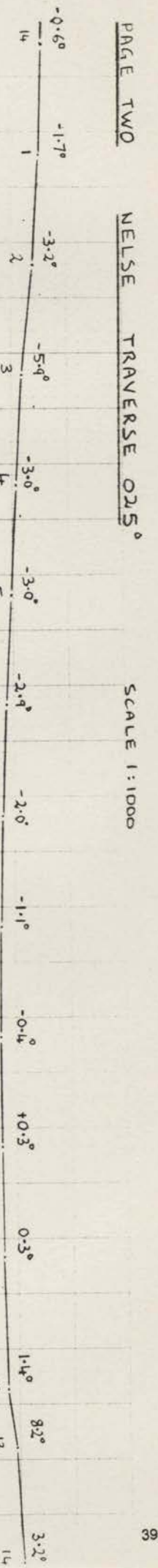
POA GRASSLAND. SOME BARE PATCHES ~5% OF SURFACE. NO COARSE BLOCKS EVIDENT.

POA GRASSLAND. SOME HUMMOCKS 2-3 M ACROSS AND 0.3 M HIGH. COARSE BLOCKS SCATTERED ON SURFACE

VEGETATION CHANGES TO OPEN HEATH

BEDROCK RAMP? (STEP) NO OUTCROP VISIBLE
THIS RAMP LIKE FEATURE COULD ALSO BE A SHEET OF SEDIMENT

SELMIGIA HERBFIELD (MINOR SNOW PATCH ZONE) NO BARE GROUND.

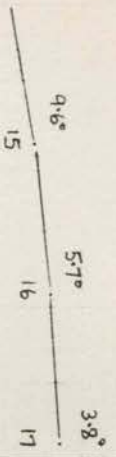


NO BLOCKS, NO OUTCROP VISIBLE

OPEN HEATHLAND, BARE GROUND ~10%, COARSE BLOCKS VISIBLE
SOLID OUTCROP NEARBY

SIMILAR TO SHOT 15. CONVEX SLOPE

SHORT OPEN HEATH. BARE GROUND 20-30% EXPOSES COARSE ANGULAR BLOCKS. BEDROCK OUTCROPS SPORADICALLY ALONG THIS RIDGE AND IS CLOSELY ASSOCIATED WITH SHORT CLOSED HEATH IN PATCHES



TRAVERSE FROM NELSE SUMMIT AT GR.304222 (NELSE 1:25000) ALTITUDE 1882m
ALONG BEARING 164° GB. SURVEYED ON 22/2/86 SCALE 1:1000

BLOCKFIELD AND SPARSE, DWARF (EPACRIS) HEATHLAND. 5–15cm TALL. PLATY GNEISSIC COBBLES AND BLOCKS FORM CLOSE PACKED PAVEMENTS WITH IMBRICATE TEXTURE. BEDROCK OUTCROPS DISPLAY STRONG BASAL JOINTING DIPPING ~5° TO S.E. VERTICAL JOINTS ⊥ TO FOLIATION AND STRIKING 146° GB. REFER TO PHOTOS: 280286 F7 → F10 pages 146 to 147 Section 2A

BARE PATCHES RANGE FROM 0.2 m² TO 15 m², ARE COVERED IN BLOCKS AND COMPRISE 10–20% OF SURFACE COVER. DWARF HEATHLAND

ESSENTIALLY BEDROCK SUMMIT FLAT. BEDROCK OUTCROPS NEARBY. STRONG BASAL JOINTING DIPS ~5° TO S.E., WITH 20cm SPACING. VERTICAL JOINTS STRIKE 010° AND 120° WITH ~30cm SPACING REFER PHOTOS N280286/F4, F5.. (F5 IS ON PAGE 145)

BARE PATCHES ~1m² COMPRISE ~10% SURFACE. OTHERWISE SIMILAR TO ABOVE

BEDROCK RISER AT LOWER EDGE OF SUMMIT FLAT. LARGE PLATY BLOCKS REST DIRECTLY ON BEDROCK. REFER PHOTO N280286/F6

BEDROCK TERRACE

BEDROCK RISER

BARE BLOCKFIELD ~ 10% SURFACE. REMAINDER, DWARF HEATH MUCH BEDROCK EXPOSED.

TRANSITION IN VEGETATION FROM DWARF HEATHLAND → DOMINATED BY HELIPTERUM ALBICANS TO SHORT OPEN HEATHLAND DOMINATED BY CELMISIA ASTELIIFOLIA.

BEDROCK TERRACE

BEDROCK RISER BEDROCK OUTCROP WITH LARGE BLOCKS PERCHED ABOVE AND DEMONSTRATING ROTATION AND IMBRICATION.

BEDROCK TERRACE VEGETATED BY SHORT TURF INDICATING A SNOW PATCH ZONE

BEDROCK RISER BEDROCK WITH A VENEER OF IMBRICATE BLOCKS MINOR SNOW PATCH ZONE

VEGETATED BLOCKFIELD. 70% SURFACE IS SHORT OPEN HEATHLAND. SURFACE IS CONVEX. BASAL JOINTING DIPS 12° TO S.E.

BEDROCK TERRACE

VEGETATED BLOCKFIELD ON BEDROCK. SHORT OPEN HEATH COVERS 95% OF SURFACE

BEDROCK RISER BLOCKS ON EXPOSED BEDROCK. SHORT OPEN HEATH HAS 60% SURFACE COVER.

VEGETATED BLOCKFIELD ON BEDROCK. SURFACE COVER 20% BLOCKS, 80% SHORT OPEN HEATH

VEGETATED BLOCKFIELD. SURFACE COVER 30% BLOCKS, 70% CLOSED HEATH. BLOCKS CONCENTRATED (EXPOSED) IN DRAINAGE LINE

BEDROCK TERRACE

VEGETATED BLOCKFIELD, WITH SHORT OPEN HEATH.

SIMILAR TO SHOT 19

1 -1.3°
2 -3.6°
3 -5.4°
4 -6.7°
5 -14.9°
6 -10.2°
7 -16.4°
8 -9.9°
9 -10.8°
10 -13.2°
11 -29.6°
12 -14.9°
13 -25.9°
14 -16.5°
15 -10.9°
16 -17.5°
17 -11.4°
18 -9.2°
19 -9.3°
20 -11.9°

NELSE TRAVERSE 164°

VEGETATED BLOCKFIELD, BUT BLOCKS DISAPPEAR FROM SURFACE BELOW THIS POINT (21)

21 -11·2

FEW BLOCKS VISIBLE AT SURFACE
VEGETATION - SHORT OPEN HEATH

22 -11°

FEW BLOCKS VISIBLE AT SURFACE

23 -10·6°

ISOLATED BLOCKS ON SURFACE
VEGETATION SHORT OPEN HEATH

24 -10·7°

SIMILAR TO SECTION 24

25 -13·5°

TERRACETTES WITH ~30cm RELIEF, VEGETATED BY ORITES HEATH VISIBLE AS DARK GREEN BANDS PARALLEL TO CONTOUR

26 -14·7°

TERRACETTES CONTINUE IN ASSOCIATION WITH SMALL BARE PATCHES

27 -13·3°

AS ABOVE. ISOLATED BLOCKS VISIBLE

28 -12·3°

AS ABOVE (26-28)

29 -13·4°

END OF BEDROCK TERRACE

30 -11·3

BEDROCK RISER

BEDROCK OUTCROPS

31 -18·2°

ISOLATED BLOCKS ON SURFACE

32 -11·8°

TERRACETTES RUN ALONG CONTOUR FOR ≤ 10 m
VEGETATION IS OPEN HEATH FOR SECTIONS 33 TO 39
REFER TO PHOTOS: N 26028 6 F16, 17 ON PAGE 187

33 -12·1°

34 -13·1°

BEDROCK TERRACE

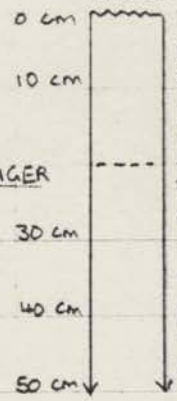
35 -13·3°

36 -12·9°

37 -13·1°

38 -11°

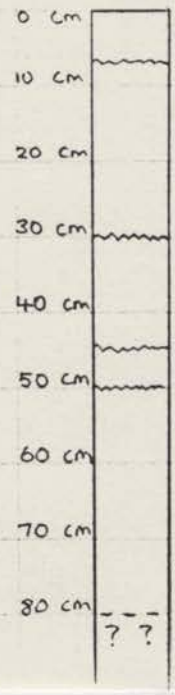
AUGER PROFILE



AUGER

LARGE PLATY BLOCKS EMBEDEDDED IN A BROWN ORGANIC LOAM MATRIX
BLOCKS ONLY S. W.*
TIGHTLY PACKED COBBLES AND BLOCKS (2→40cm) WITH MATRIX BECOMING ORANGE BROWN AT 45 cm
BLOCKS ARE HARD AND ANGULAR.
UNABLE TO PENETRATE FURTHER THROUGH BLOCKS

AUGER PROFILE N 164/565



MATTED PLANT ROOTS AND ORGANIC MATTER

ORANGE BROWN GRAVELLY SANDY SILT
NO COBBLES

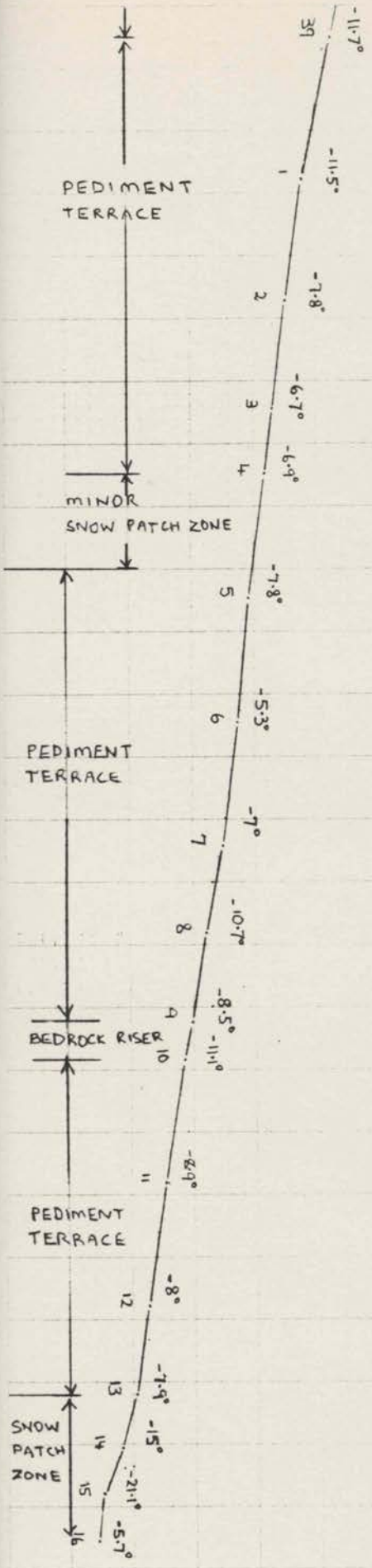
STONY LAYER: CLOSE PACKED PLATY COBBLES IN A LIGHT BROWN SILTY SANDY GRAVEL MATRIX

LAYER OF PLATY BLOCKS 20-40 cm LONG
SMALLER COBBLES FORM A MATRIX

DISPERSED COBBLES IN A SILTY SANDY GRAVEL MATRIX - NO BLOCKS PRESENT

MOST CLASTS IN PROFILE WERE MODERATELY WEATHERED BUT RELATIVELY HARD AND COMPETENT

LIMIT OF PROFILE



← AUGER SAMPLE N164/565

PROFILE CONTINUES DOWN DRAINAGE LINE ALONG 096° GB

OPEN ORITES HEATH

CLOSED KUNZEA/BAECKEA HEATH. LARGE BLOCKS EXPOSED IN BARE PATCHES

DRAINAGE LINE HAS ENTRENCHED ITSELF INTO BLOCKFIELD. 20 cm OF PEAT OVERLIES BLOCKFIELD, AND IS VEGETATED BY BAECKEA HEATH

OUTER EDGE OF VEGETATED BLOCKFIELD TERRACE REFER TO PHOTO N181080/F5 (PAGE 144)

SMALL, LINEAR NIVATION HOLLOW. SPRINGWATER ISSUES FROM BASE OF NIVATION HOLLOW

OPEN BAECKEA HEATH. BLOCKS AT SURFACE

CLOSED BAECKEA HEATH. BLOCKS EXPOSED IN OCCASIONAL BARE PATCHES

AS ABOVE

BEDROCK OUTCROPS NEARBY. OUTER EDGE OF TERRACE

TERRACE RISER

HUMMOCKY TERRAIN, VEGETATED BY BOG COMMUNITY: RICHEA, SEDGE, SPHAGNUM

COARSE BLOCKS EXPOSED IN DRAINAGE LINE THROUGH BOG COMMUNITY

SHORT WET HEATHLAND: EPACRIS, KUNZEA, RICHEA, WITH BLOCKS AT SURFACE

CONVEX TERRACE RISER COVERED IN RICHEA, SPHAGNAM BOG COMMUNITY

STONY PAVEMENT BELOW TERRACE RISER. THIS CONCAVITY IS ALSO A SNOW PATCH ZONE.
REFER PHOTOS N30183/F7 (P182) AND F3→F5 (PANORAMA)

PIVOT POINT — START OF TRAVERSE ALONG 323 GB

NELSE TRAVERSE 323° FROM PIVOT POINT AT END OF TRAVERSE 344°

SHORT OPEN HEATH. ISOLATED SOLID OUTCROP. SURFACE IS 10-20% BARE GROUND WITH SOME LARGE AND SMALL BLOCKS ON SURFACE

GENTLE CONVEX SLOPE. SMALL SOLID OUTCROP AT END OF SECTION

OPEN HEATH. BARE GROUND NEGLIGIBLE

OPEN HEATH. NO BARE SPOTS. NO BLOCKS VISIBLE

MORE CELMISIA GROUNDCOVER. OTHERWISE AS ABOVE

AS ABOVE

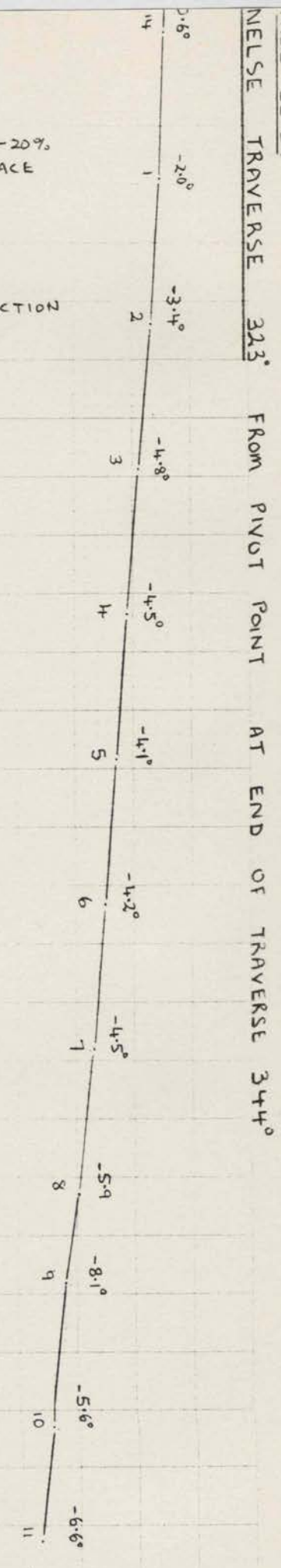
POA - CELMISIA SP. DOMINANT GROUND COVER. NO BARE PATCHES NO BLOCKS VISIBLE

TALL OPEN HEATH. NO BARE GROUND. NO BLOCKS VISIBLE

DECLINE (POSSIBLY MARKS DISTAL EDGE OF CRYOPLANATION TERRACE) THIS CONCAVE SLOPE EXPOSES BLOCK MATERIAL AT ITS BASE.

SHORT OPEN HEATHLAND. NEGLIGIBLE BARE GROUND.

EDGE OF ROAD. NEGLIGIBLE BARE GROUND. 30CM BLOCKY MATERIAL EXPOSED IN SMALL ROAD CUTTING



TRAVERSE FROM SADDLE AT NELSE GR 304226 ALTITUDE 1868 m ALONG 112° GB

POA GRASSLAND REFER TO PHOTO N280286 F13 (PAGE 4)

POA GRASSLAND. CIRCULAR DEPRESSIONS 1–2 m ACROSS 0·5 m DEEP

SMALL UNDULATIONS IN SURFACE

SHORT OPEN HEATH. NO BARE GROUND, NO OUTCROP, NO FLOATERS OR BLOCKS

SIMILAR TO 4

SIMILAR TO 4

SIMILAR TO 4

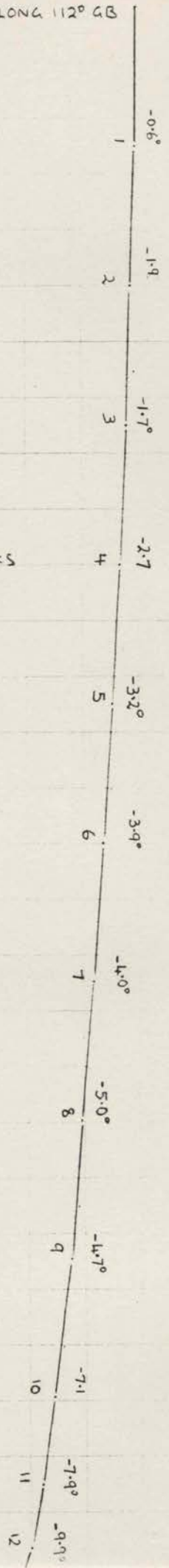
SOLID OUTCROP NEARBY

SHORT KUNZEA HEATH. MANY SMALL OVAL HOLES APROX 1 m ACROSS AND 20–30 cm DEEP

SHORT KUNZEA HEATH. SCATTERED BLOCKS 40-50 cm LONG SOME LARGE BARE PATCHES

BLOCKS ON SURFACE

BLOCKS UP TO 50 cm STREWN OVER SURFACE. BARE PATCHES 0·5 m² TO 1 m² HAVE REDUCED LOCAL SLOPE WITH GRAVEL ON LOWER EDGE AND BLOCKS ALONG UPPER MARGIN



SNOW ON GROUND. ACTIVE SNOW PATCH ZONE WITH MUCH BARE GROUND AND TERRACETTES PARALLEL TO CONTOUR
REFER TO PHOTOS: N 280286 F13 AND F14 (PAGES 184, 185)

NEAR TOE OF SNOW COVERED SNOW PATCH ZONE
SURVEY CARRIED OUT 25/4/84. STAFF PENETRATED TO GROUND LEVEL

HUMMOCKY TERRAIN BELOW TOE OF SNOW PATCH COVERED WITH BLOCKS AND SHORT TURF

HUMMOCKY TERRAIN

TO DRAINAGE LINE ACROSS HUMMOCKY TERRAIN

TO LARGE SOLID OUTCROP ACROSS CONTINUATION OF HUMMOCKY TERRAIN

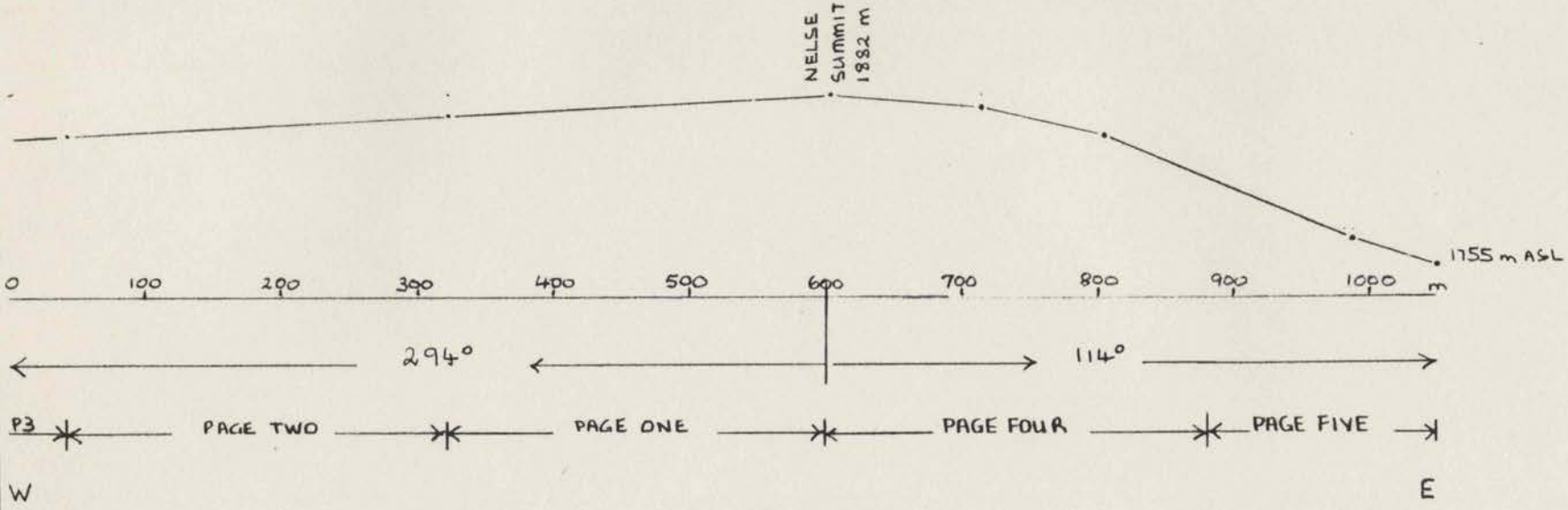
FROM OUTCROP TO DRAINAGE LINE.

TO EDGE OF GRASSLAND ACROSS ANOTHER DRAINAGE LINE. DRAINAGE LINES FROM SNOW PATCH ZONE RUN SUB PARALLEL TO LOWER EDGE OF SNOW PATCH ZONE.
THERE WAS MUCH BLOCKY MATERIAL AT SURFACE AND IT WAS CLOSE PACKED INTO A PAVEMENT IN PLACES MANY LARGE BOULDERS 1 - 2 m ACROSS WERE EXPOSED IN CREEK. THIS HUMMOCKY TERRAIN COMPRISING MUCH BLOCK MATERIAL AND ONLY SPARSELY VEGETATED PROBABLY REPRESENTS PROTALUS RAMPART DEPOSITS.



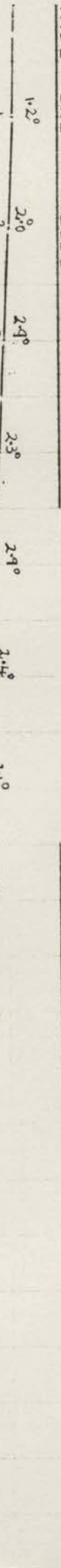
NELSE TRAVERSE 294/114

FIG 3Cj



SCALE 1:5000

NELSE SUMMIT ALTITUDE 1882 m TRAVERSE BEARING 294° GB
HORIZONTAL AND VERTICAL SCALE IS 1:1000



DWARF HEATHLAND COVERS ~70% SURFACE. OPEN BLOCKFIELD COVERS ~30%

GROUND SURFACE IS LUMPY BUT OTHERWISE SIMILAR TO SHOT 1

DWARF HEATH GETTING TALLER (APPROACHING 30 cm)

ALMOST COMPLETE COVER OF DWARF HEATHLAND. BLOCK COVER VISIBLE < 10%

DWARF HEATH BECOMES OPEN STRUCTURED. VISIBLE BLOCKS < 10% SURFACE

SHORT OPEN HEATHLAND

SHORT OPEN HEATHLAND NO VISIBLE BLOCKS

AS ABOVE

AS ABOVE.

AS ABOVE. ISOLATED BEDROCK OUTCROP.

SHORT OPEN HEATHLAND. NO VISIBLE BLOCKS.

SHORT OPEN HEATHLAND. NO VISIBLE BLOCKS. BEDROCK IS EXPOSED NEARBY

ISOLATED BLOCKS VISIBLE AT SURFACE (CLOSE TO BEDROCK)

ISOLATED BLOCKS AND LARGE OUTCROP OF BEDROCK NEARBY (20 m SOUTH)

FIG. 3CK (5 PAGES)

AS ABOVE

AS ABOVE

AS ABOVE

AS ABOVE

AS ABOVE

ISOLATED BLOCKS AND SMALL INSITU OUTCROP AT SURFACE

AS ABOVE

AS ABOVE

AS ABOVE

SHORT OPEN HEATHLAND PROVIDES 95% COVER. INSITU OUTCROP NEARBY

AS ABOVE

SMALL PATCHES OF OPEN BLOCKS EXPOSED AT SURFACE

°

15 4·4°

16 4·4°

17 4·4°

18 3·4°

19 3·4°

20 3·3°

21 2·7°

22 2·3°

23 1·7°

24 1·8°

25 2·5°

26 2·6°

27 2·6°

28 2·5°

SOLID 'INSITU OUTCROP EXPOSED. LOCATION CLOSE TO DRAINAGE LINE	29	2.2°	
PARTLY VEGETATED BLOCKFIELD - 20% SURFACE IS OPEN BLOCKS	30	0.4°	

TRAVERSE FROM NELSE SUMMIT AT GR 304222 (NELSE 1:25000) ALTITUDE 1882 m
ALONG BEARING 114° GB. SURVEYED ON 8/2/86. SCALE 1:1000

SPARSE DWARF HEATH 60%. BLOCKS COVER REMAINING 40% OF SURFACE
ESSENTIALY A BEDROCK TERRACE OR BEDROCK SUMMIT FLAT

SIMILAR TO SHOT 1

ROCK OUTCROPS AT POINT 3

ROCK OUTCROPS

LARGE LOOSE BLOCKS ON SOLID OUTCROP

OUTER EDGE OF BEDROCK TERRACE OR SUMMIT FLAT
TERRACE RISER

ESSENTIALY BEDROCK TERRACE WITH SHALLOW BLOCKFIELD VENEER

BEDROCK TERRACE CONTINUED. BASAL ROCK JOINTS ALMOST PARALLEL TO SURFACE. JOINTING IS ORTHOGONAL AND CLOSE SPACED (10-40 cm)

SIMILAR TO SHOTS 8, 9

SIMILAR TO SHOTS 8, 9

PARTIALLY VEGETATED BLOCKFIELD ON BEDROCK TERRACE

PASSED OVER SMALL STEP. SURFACE BLOCKS COVER 20-30% OF SURFACE
MANY ISOLATED OUTCROPS OF SOLID ROCK

BASAL JOINTS DOMINATE AND RUN PARALLEL TO SURFACE.
BEDROCK TERRACE WITH BLOCKFIELD VENEER CONTINUES

MAJOR JOINT SURFACE NOW ALMOST HORIZONTAL. TERRACE ENDS

BEDROCK TERRACE RISER

BEDROCK OUTCROPS IN PARALLEL BANDS STRIKING 120°

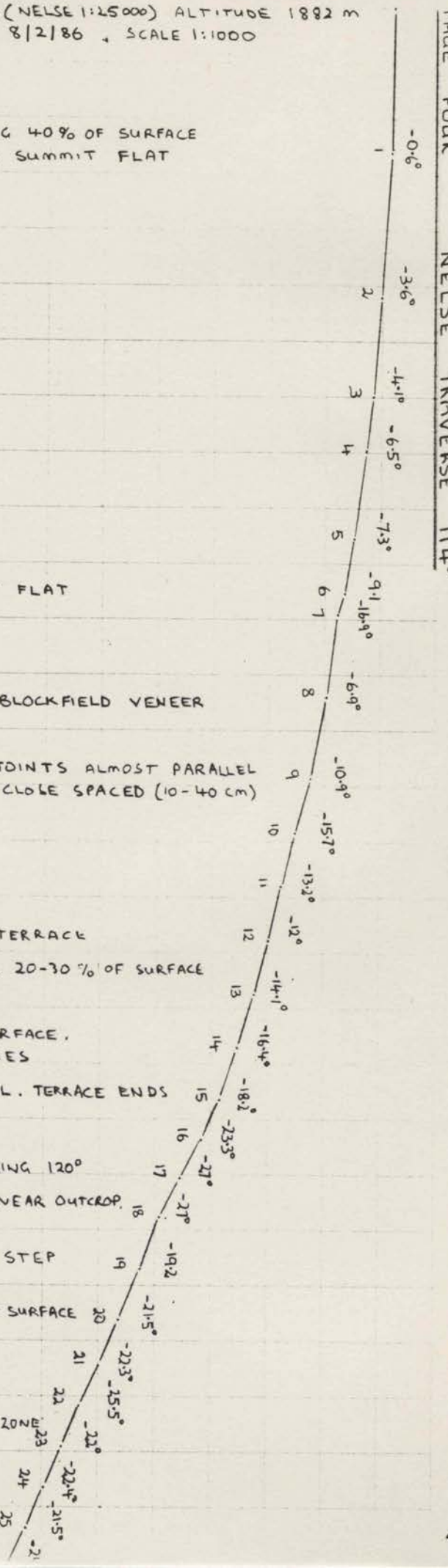
SMALL GULLIES OR SHUTES OCCUR BETWEEN LINEAR OUTCROP

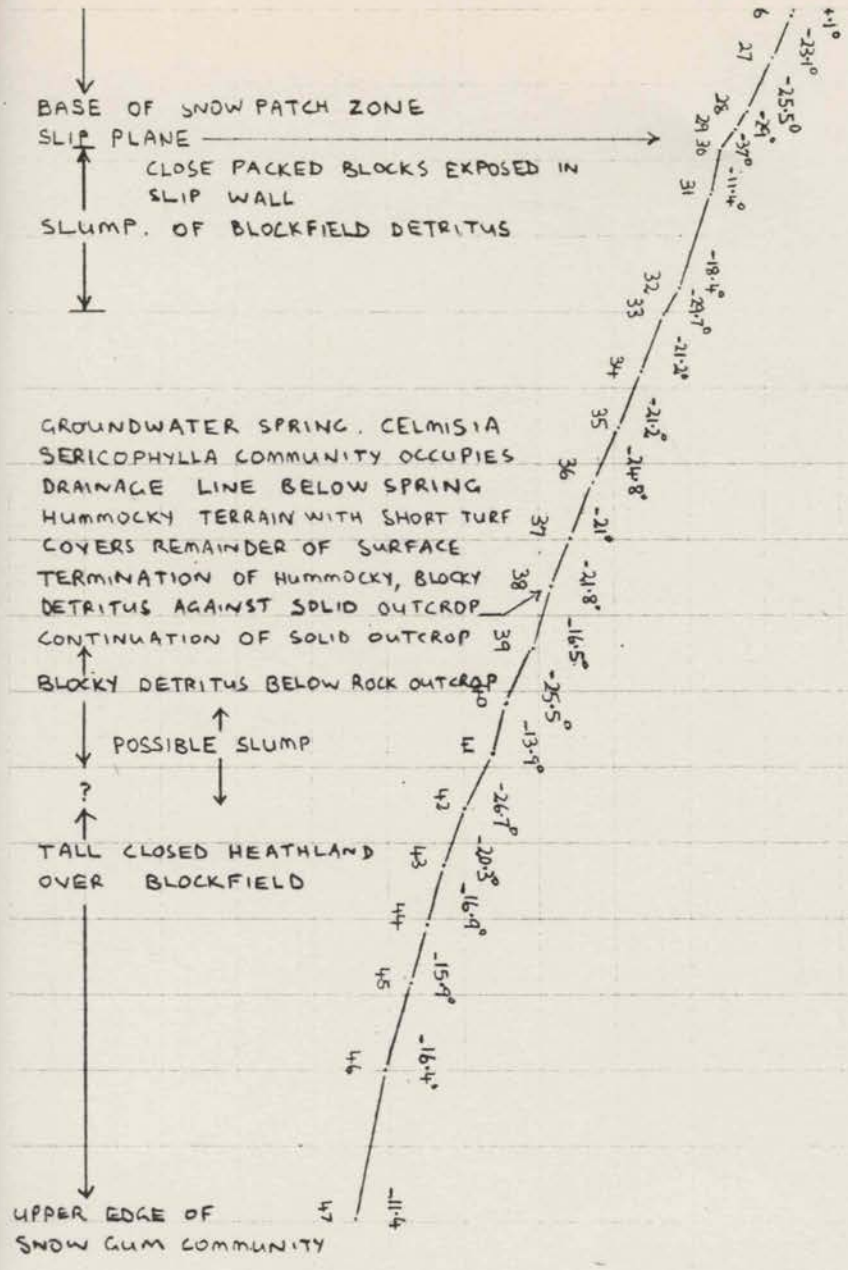
HUMMOCKY TERRAIN. DETRITUS ACCUMULATED ON STEP

TOP EDGE OF SNOW PATCH ZONE. BLOCKFIELD AT SURFACE

BLOCKFIELD 20% OF SURFACE, SHORT HEATH COVERS ~ 80%

BLOCKFIELD 70% OF SURFACE, CELMISIA HERBFIELD 30%
NEGLIGABLE SOLID OUTCROP OBSERVED IN SNOW PATCH ZONE

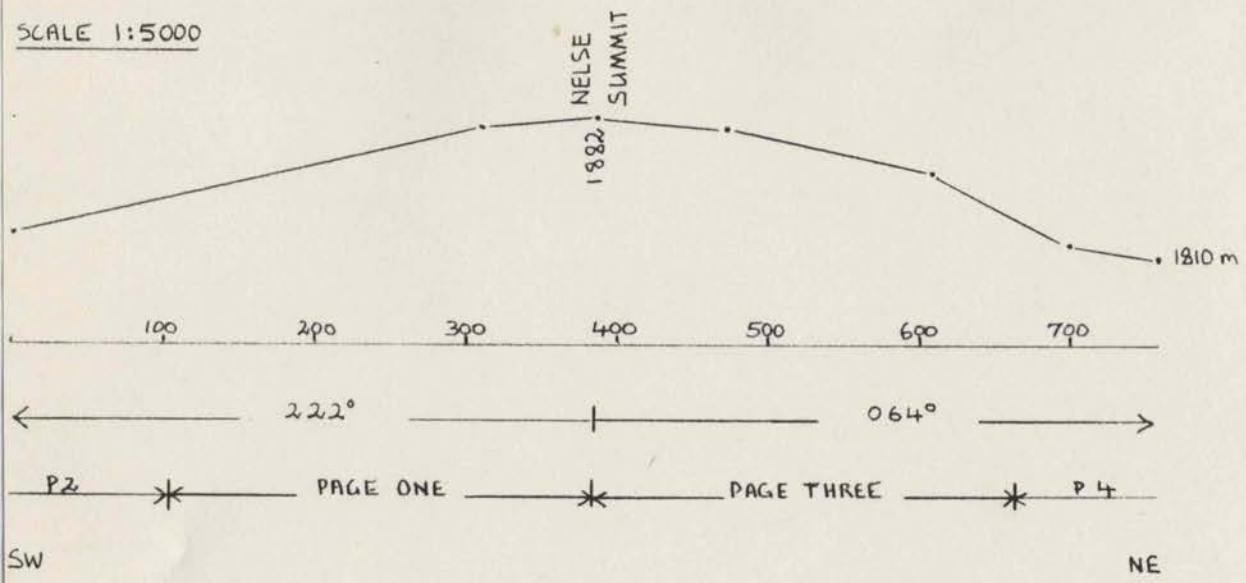



BASE OF SNOW PATCH ZONE
SLIP PLANE
CLOSE PACKED BLOCKS EXPOSED IN SLIP WALL
SLUMP. OF BLOCKFIELD DETRITUS
GROUNDWATER SPRING. CELMISIA SERICOPHYLLA COMMUNITY OCCUPIES DRAINAGE LINE BELOW SPRING
HUMMOCKY TERRAIN WITH SHORT TURF COVERS REMAINDER OF SURFACE
TERMINATION OF HUMMOCKY, BLOCKY DETRITUS AGAINST SOLID OUTCROP
CONTINUATION OF SOLID OUTCROP
BLOCKY DETRITUS BELOW ROCK OUTCROP
POSSIBLE SLUMP
?
TALL CLOSED HEATHLAND OVER BLOCKFIELD
UPPER EDGE OF SNOW GUM COMMUNITY
+1°
-23·1°
-25·5°
-24°
-27°
-11·4°
-18·4°
-29·7°
-21·2°
-21·2°
-24·8°
-21°
-21·8°
-16·5°
-25·5°
-13·9°
-26·7°
-20·3°
-16·9°
-15·9°
-16·4°
-11·4
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NELSE TRAVERSE 222/064

FIG 3C.2

SCALE 1:5000



NELSE SUMMIT ALTITUDE 1882 M TRAVERSE BEARING 222° GB
HORIZONTAL AND VERTICAL SCALE IS 1:1000

PAGE ONE NELSE TRAVERSE 222°

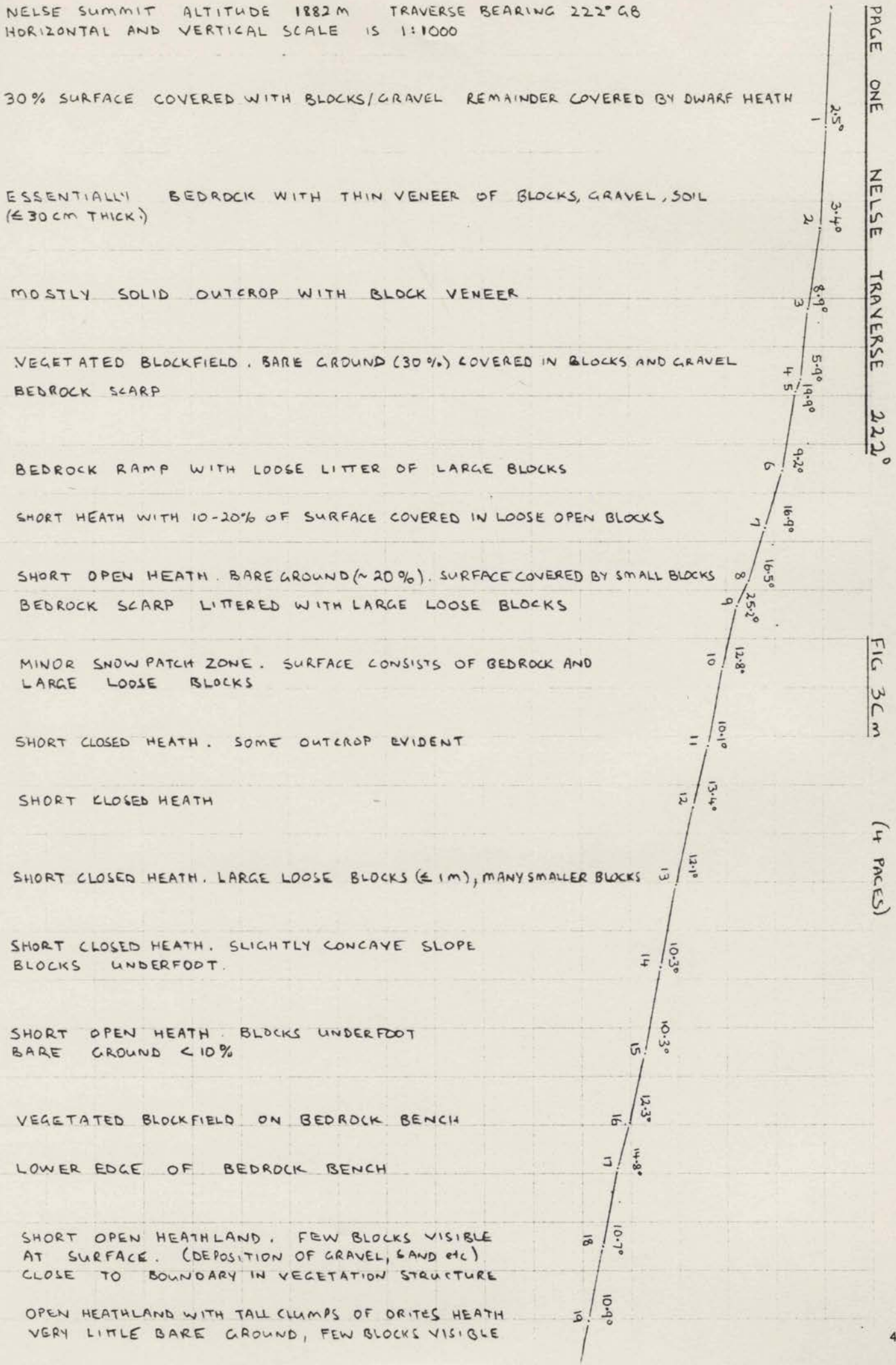


FIG 3Cm (4 PAGES)

AS FOR SECTION 19

AS FOR SECTION 19

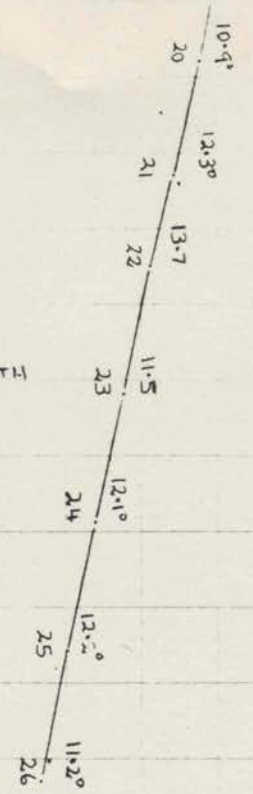
AS FOR SECTION 19

VEGETATION BOUNDARY. TALL ORITES HEATH CUTS OUT. SHORT OPEN HEATH BELOW

SHORT OPEN HEATHLAND
NO BLOCKS VISIBLE AT SURFACE

AS FOR SECTION 24

AS FOR SECTION 24



TRAVERSE FROM NELSE SUMMIT AT GR304222 (NELSE 1:25000) ALTITUDE 1882 M
ALONG BEARING 064° GB. SURVEYED 25/4/84 AFTER EARLY SNOWFALL

BEDROCK TERRACE WITH A THIN VENEER OF BLOCKY DETRITUS

BEDROCK RISER

DWARF HEATH - MOSTLY < 10CM HIGH . CLOSE PACKED PLATY BLOCKS ON 30% SURFACE. ISOLATED LARGE BLOCKS SCATTERED.

BEDROCK TERRACE WITH THIN VENEER OF BLOCKY DETRITUS

LARGE ISOLATED BLOCKS ~ 1M ACROSS. UNVEGETATED SURFACE (30 %) COVERED IN A VENEER OF PLATY BLOCKS, COBBLES

SHORT KUNZEA HEATHLAND. 30-40 % OF SURFACE IS UNVEGETATED AND PAVED WITH PLATY BLOCKS. SOLID OUTCROP NEARBY. ISOLATED BARE HOLLOWS WITH SORTED SURFACES. REFER TO PHOTOS N 280286/F16, (PAGE 149)

BEDROCK RISER

BEDROCK TERRACE WITH THIN VENEER OF BLOCKY DETRITUS FROM POINT 8 TO POINT 14

STUNTED OPEN HEATH (KUNZEA) BLOCKS ON BARE PATCHES PATTERNED GROUND - NETLIKE CIRCULAR DEPRESSIONS WITH LOCAL RELIEF OF 20 - 30 cm

SHORT OPEN HEATH WITH PATCHES OF CLOSE PACKED BLOCKS

SHORT OPEN HEATH

UPPER EDGE OF RECENT SNOW BANK. STAFF PENETRATED TO BASE OF SNOW DRIFT. SURFACE VEGETATED BY CELMISIA ASTELIIFOLIA AND LITTERED WITH BLOCKS

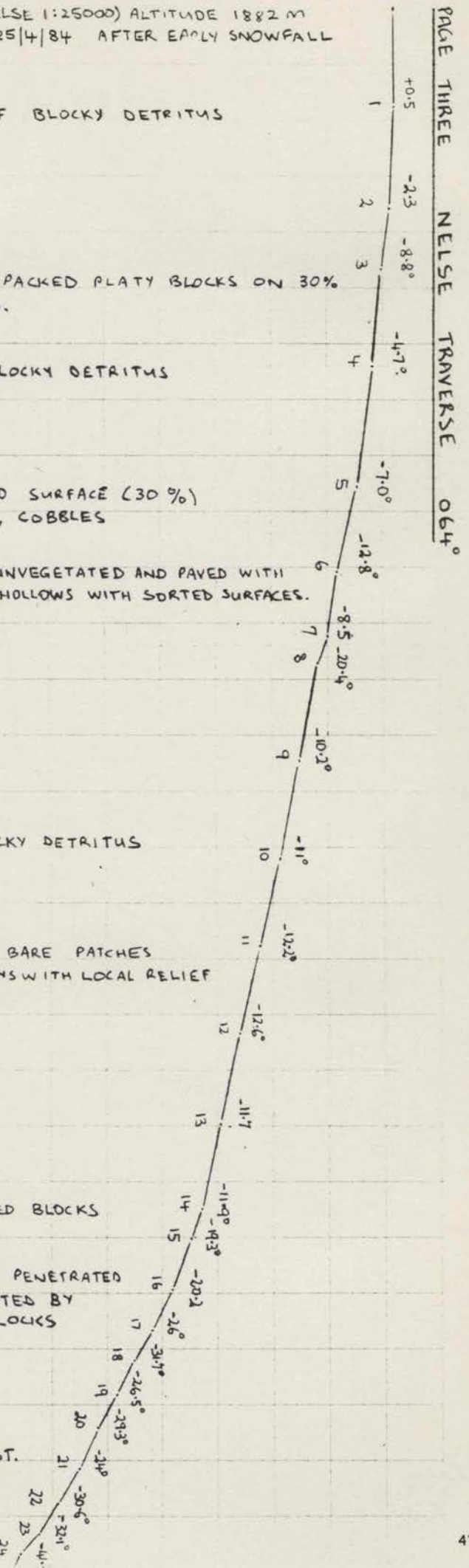
SNOW BANK 1·2 M DEEP.

DISTAL EDGE OF RECENT SNOW BANK

BLOCKS AT SURFACE, VEGETATED BY CELMISIA AST.
SOLID OUTCROP

SOLID OUTCROP

BASE OF LARGE ROCK OUTCROP



PAVEMENT OF PLATY BLOCKS, COBBLES

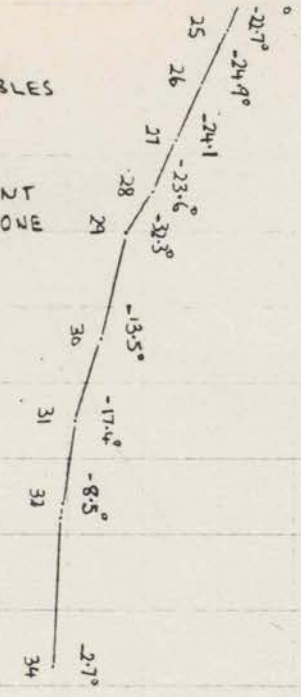
ROCK OUTCROP WITHIN STONY PAVEMENT
DRAINAGE ZONE BELOW SNOW PATCH ZONE

TOP OF LOBE

FOOT OF LOBE

STONY PAVEMENT

WET HEATHLAND



SECTION THREE : GEOMORPHIC ANALYSIS

D) : PALAEOCLIMATIC INFERENCES AND MODELS

PALAEOCLIMATIC INFERENCES AND MODELS

The relic cryogenic features mapped and described on the Bogong High Plains include cryoplanation terraces, nivation hollows, blockfields, blockstreams, blockslopes and talus. Of these, the most useful in terms of inferring palaeoclimatic data for the late Pleistocene are the blockstreams, cryoplanation terraces and nivation hollows. The interstitial and or basal ice, which is postulated in this thesis to have been associated with blockstream formation, would require a mean annual air temperature close to or below 0°C.

Most other writers including White (1976) and Caine (1968) postulate that blockfields and blockstreams represent an active layer of frost sorted angular blocks which have moved by gelifluction. Stromquist (1983) also implies that the active layer moved over a permafrost table. The interstitial fines of this active layer have now mysteriously disappeared according to White and Caine . The removal of this fine material and later emplacement of black humic mud at the base of such block accumulations dated at 3 000 BP by Caine for Tasmanian blockfields, is neither necessary, feasible nor sufficient.

Interstitial ice within the Tasmanian blockfields would have inhibited penetration of fines during the development of such blockfields and provided moisture for ongoing saturation and seasonal gelifluction of the older, weathered, regolith below. It is the regolith which existed prior to the last cold phase which probably provided the active layer for the conveyance of blocks from adjacent cliffs and valley sides of the Mt. Barrow blockfield/blockstreams.

The upper layer of open blocks which presents itself so intriguingly in these relic blockstream/blockfield deposits of Southeastern Australia, probably never had any fine grained interstitial material, other than ice. This is apparent when one compares the alteration and surface weathering of basalt blocks in three situations:

i) basalt bedrock scarps
ii) open basalt block accumulations
iii) basalt blocks in soil.

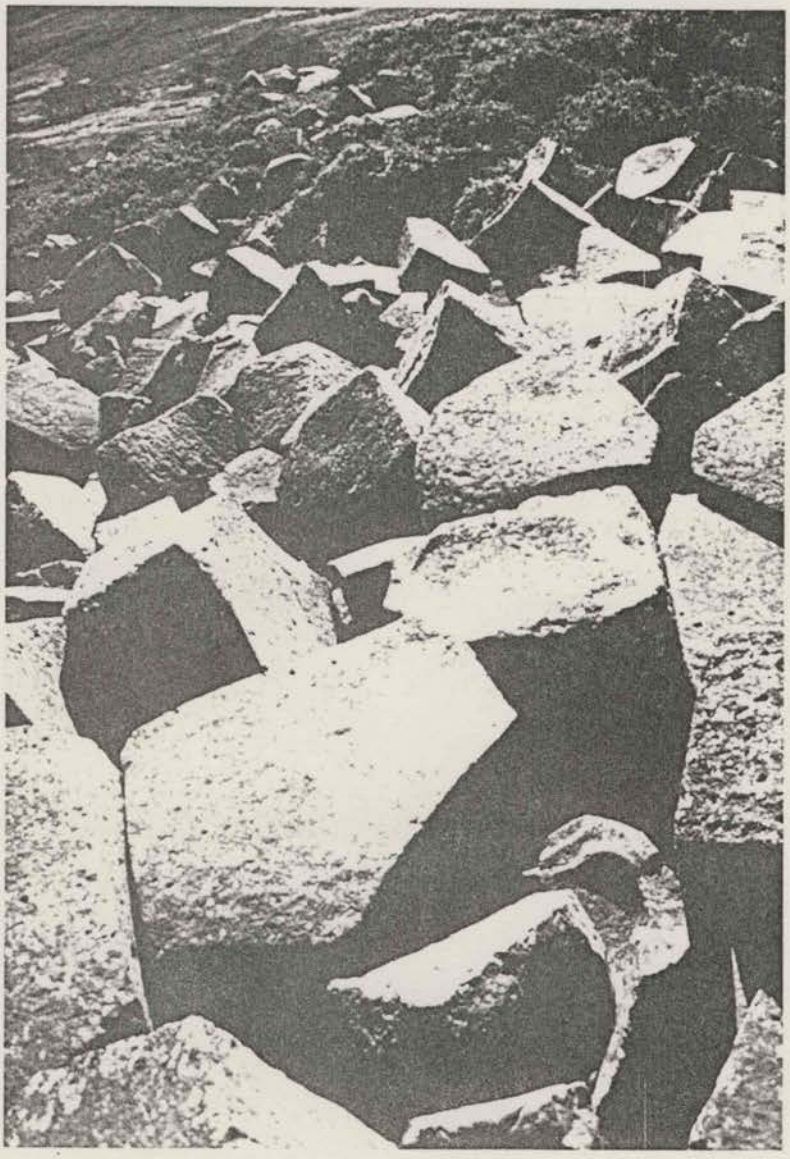
In the first two cases basalt blocks develop a thin weathering rind, about 0.5mm thick, are pitted where phenocrysts such as olivine or augite occur at the surface but otherwise are little altered and retain their original joint faces with little or low curvature at the edges. The blocks are extremely competent and the glassy groundmass of the mineral fabric together with their location above the water table has protected them from significant chemical weathering for thousands of years.

In contrast, basalt blocks which have moved across slopes in a fine grained sand/silt matrix, and remained in that fine grained matrix show radical alteration, with almost complete breakdown of the mineral fabric in some cases

The contrasts in alteration are apparent in the following Photographs : PVDB 185F1, BHDB 185F16, PVDB 185F13.

PHOTOGRAPH PVDB 185F1

This is a view of the top edge of an autochthonous blockslope at the southern margin of the basalt plateau above the Bundara River. The angular basalt columns have been slightly rotated out of insitu positions by deep seasonal freezing and demonstrate minimal alteration.



PHOTOGRAPH BHDB 185F16

This is a close up of a fragment of columnar basalt located on a blockslope surface below Basalt Hill at about 1 450m ASL. This block has been transported downslope about 500m (horizontal distance). The original joint faces are clearly defined and the only obvious alteration has been cleaving along basal jointing planes, since its emplacement, thousands of years ago.



PHOTOGRAPH PVDB 185F13

This is a view of blocks on an essentially bedrock surface on the exposed basalt plateau south of Mt. Jim. Note the deep pitting and rilling caused by chemical alteration of the surface of these blocks due to their inclusion within fine grained material.



The main mechanism of movement of surficial material on the Bogong High Plains during the late Pleistocene is thought to have been frost creep due to the prevalence of coarse detritus (blocks) at the top of layer 2. (Layer 1 is recent, Holocene organic loam in most cases.) This is not to say that gelifluction could not or did not occur. Deep seasonal freezing is sufficient for gelifluction as well as frost creep, but it is probable that gelifluction was constrained by availability of moisture and restricted to nivation hollows and some drainage lines. Permafrost is not necessary for either process. Gelifluction, however, would not be expected to produce vertical sorting of surficial material, but rather produce a more massive fabric of clasts randomly dispersed in a silty sandy matrix with little stratification. Examples of such possible gelifluction flows are evident at site 1, Pretty Valley, layer 3 (page 110) and site 1, Basalt Hill, layer 2 (page 45).

A speculative model for the development of block accumulations in well jointed bedrock on gentle slopes is presented below.

Model for Accumulation of Blocks in Blockstream, Blockfields and Block Glacii.

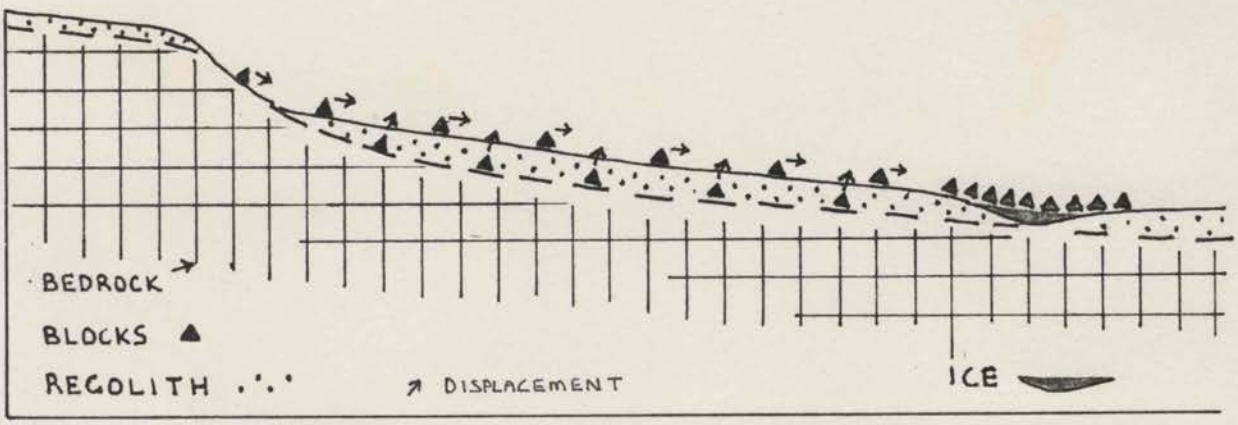


Fig 3Da : Oblique Section Through Cryoplanation Terrace Showing Riser, Terrace and Drainage Line.

Proposed sequential development of block accumulations during the last cold phase.

i) Location below nivation hollow or cryoplanation riser within a shallow drainage basin which makes moisture available to the regolith downslope.

ii) Deep seasonal freezing caused frost heave and upwards movement of blocks from the bedrock.

iii) Seasonal and diurnal freezing caused downslope creep of blocks.

iv) Blocks collect in the drainage line or preexisitng depression or move beyond the zone of available moisture and so stagnate. The drainage line seems the most popular venue for collection of blocks moving downslope.

v) Lenses or blisters of ice (naleds) form beneath the veneer of blocks in the drainage line due to the rapid loss of heat from blocks (especially basalt), cold air drainage and the availability of moisture in the drainage line. This may have elevated blocks and inhibited accumulaton of fines within the block accumulation.

vi) Accretion of blocks against the initial accumulaton in the drainage line to form a blockfield on the adjacent, gentle slope. The consistent 60cm thickness of many basalt blockfields on gentle slopes may reflect a limit to seasonal chilling and subsequent frost heave amplitude. A block glacis may be formed by the termination of block material a short distance beyond the foot of the associated scarp due to limitations in the supply of moisture, which would inhibit seasonal frost heave. Thermokarst associated with block glacii could be explained by meltwater from the snow drift against the scarp refreezing beneath the blocks in a localised zone of permafrost.

vii) Subsequent deflation of the blockstream after thawing of basal and/or interstitial ice resulting in a concave cross-section with raised edges.

A blockslope occurs on steeper slopes with gradients greater than 10° and up to 35°. Blockslopes generally do not have a scarp or large bedrock outcrop at their head. The blockslopes on the eastern flanks of Basalt Hill comprising basalt and granodiorite blocks occur on steep slopes with south to south-easterly aspects and appear to have nivation hollows at their heads. The mechanism proposed for blockslope development is outlined below.

Proposed mechanism for the development of blockslopes.

i) Location of blockslope head in the floor of a nivation hollow in a well jointed bedrock which is excavated by seasonal deep freezing and frost wedgeing and transported downslope by frost creep, rolling, sliding and gelifluction.

ii) Development of icing (or naled) beneath the block accumulation. Mass movement of the blocks over an active substrate by seasonal gelifluction (could have induced terracing). The icing would inhibit the collection of fines within the block aggregate.

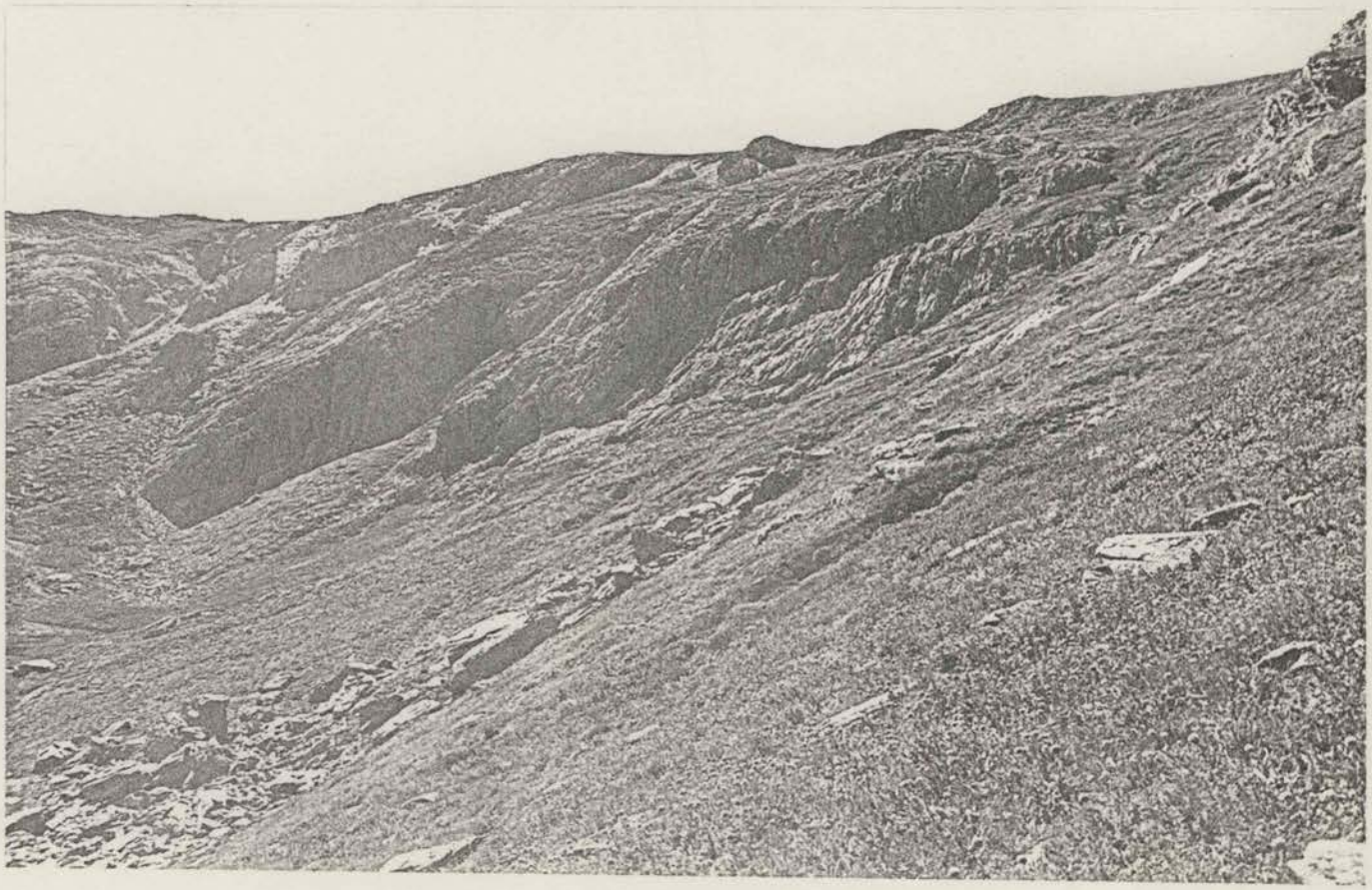
iii) Stagnation of the distal end of the blockslope where it outgrows available moisture or extends below the zone of effective frost heave, or extends beyond the active layer.

The development of massive blockslopes as described near Basalt Hill is probably transi tional to rock glaciers which

exist elsewhere in similar situations, but perhaps slightly colder conditions. There are no deposits on the Bogong High Plains which are clearly recognisable as relic rock glaciers but these features do occur 100 km to the north-east on the Kosciusko Main Range. Three apparent relic rock glaciers occur with their heads in large concavities with a south-easterly aspect at altitudes of 1 950m to 2 100m. These relic features occur at locations known as Blue Lake, Club Lake, and Lake Cootapatamba. Mt. Clark and Muellers Peak also appear to be associated with relic rock glaciers, which have a north-easterly aspect instead of a south-easterly aspect. The lateral extent of the associated moraine is about 200m for Lake Cootapatamba, and about 1km for Club Lake moraine.

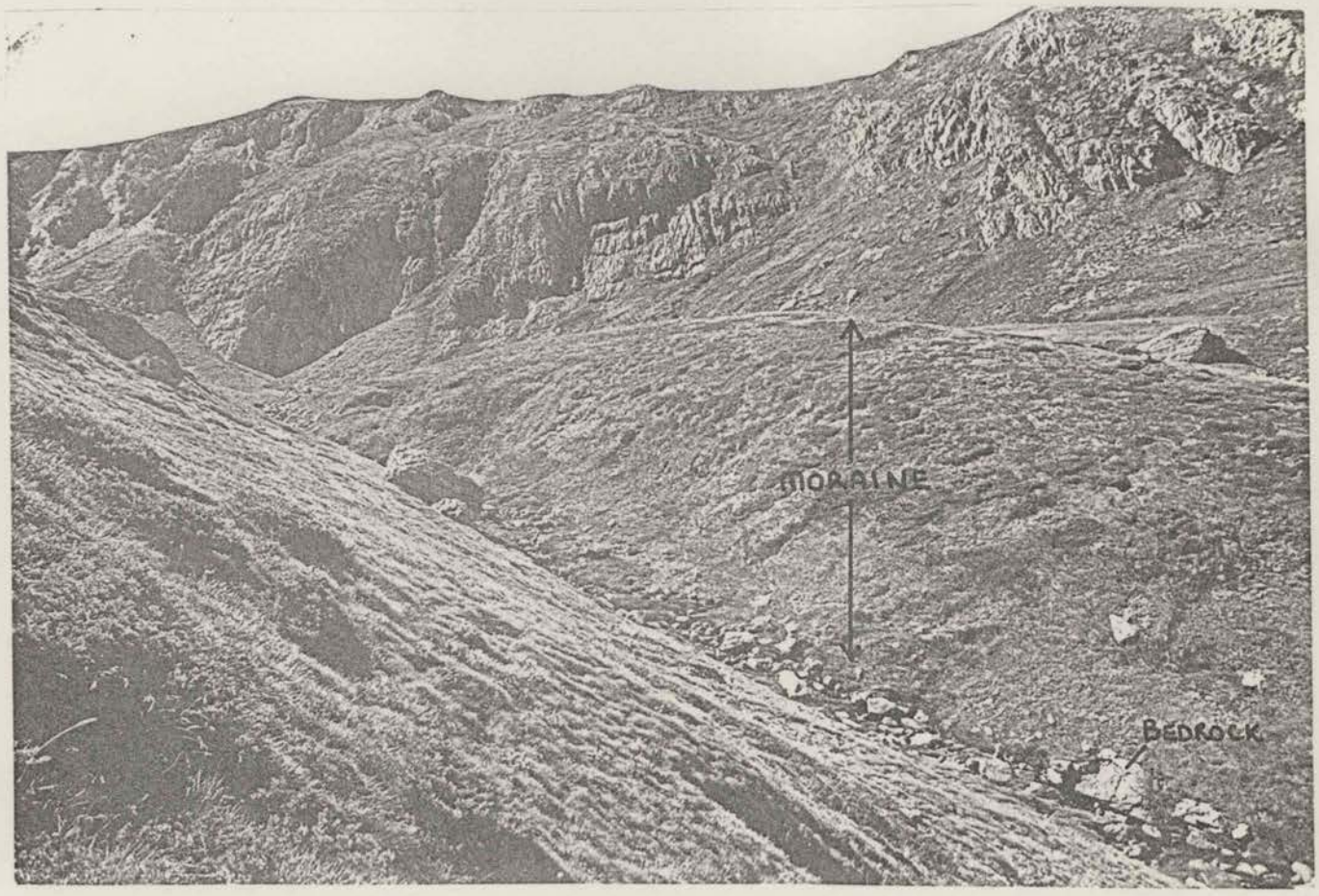
The angular, joint controlled, bedrock scarps associated with the cirque-like amphitheatre at the head of Club Lake suggests that these scarps were exposed to frost action. Photograph Ko 15386F17 illustrates this.

PHOTOGRAPH Ko 15386F17



The photograph, above, gives a view of well jointed phyllitic metasediment in a cirque-like feature at the head of Club Lake.

Bedrock outcrops in the drainage line about 200m below the lake margin and beneath the tongue of moraine up to 15m thick emanating from the lip of the lake. This moraine probably represents the proximal end of the deflated rock glacier and is illustrated in Photographs Ko 15386F18, below, and Composite Photograph Ko 15386F13/F14/F15, overleaf.



PHOTOGRAPH Ko 15386F18

A view of the moraine and drainage line 200m from the Club Lake shoreline, looking north towards Mt. Caruthers.

The glacier has not produced a typical U-shaped valley section below the lake and small patches of polish and striations are preserved on angular rock ledges in the small, steep V-shaped gully between the proximal and distal ends. These are illustrated in Photograph Ko 15386F21 on page 23.



COMPOSITE PHOTOGRAPH Ko 15386F13/F14/F15

Barsch (1978) described active rock glaciers as moving bodies of frozen talus cemented by interstitial ice. Such bodies, according to Barsch, are indicators for permafrost in their neighborhood, and the lower limit of active rock glaciers is approximately the lower limit of discontinuous alpine permafrost. Furthermore, Barsch has reported that active permafrost can survive beneath an unfrozen layer of rubble below the snowline under present climatic conditions in the Swiss Alps. If sporadic alpine permafrost can be found below the lower limit of active rock glaciers, with mean annual air temperature above 0°C to -1°C in the Swiss Alps, then it is possible that patches of permafrost existed beneath the now relic blockstream, blockslope and blockfield deposits of the Bogong High Plains in the late Pleistocene. This may explain the preference these deposits have for a south to south-easterly aspect.

The nivation hollows found in association with the cryoplantion terraces of the Bogong High Plains are apparent down to 1 600m near Mt. Nelse and 1 540m near Basalt Hill. This may represent the palaeosnowline in the late Pleistocene cold phase which implies an average annual temperature of about 0°C. By comparison to todays temperatures, this implies at least a 5°C drop in average annual air temperature. Wilkinson's Lodge at 1 630m on the Bogong High Plains has an average annual temperature of 5.3°C.

The absence of charcoal fragments in layer 2 or layer 3 within the road sections above 1 300m reported in Section 2A, suggests that the tree line has been located at about 1 300m. This requires a recession of 500m vertically and implies a temperature decrease of about 5°C, probably representing the late Pleistocene cold phase.

Reger and Pewe (1976) assert that cryoplanation terraces require low snowfall and cold summer temperatures with shallow permafrost necessary to provide a base for mass movement . This requires mean annual temperatures in the vicinity of -12°C or colder according to Reger and Pewe.

It is possible that some of the cryoplanation observed in the Bogong High Plains may be a relic of earlier cold phases in the Pleistocene but this is speculative and there is little means available to demonstate such a concept. The well developed terracing observed on Mt. Nelse between 1 880m and 1 830m would require a drop of 15°C relative to present estimated mean annual air temperature of about 3°C, if Reger and Pewe's assertions are correct.

In addition to a mean annual temperature of 0°C or less, rock glaciers are generally associated with low precipitation levels according to Barsch (1971). Lliboutry (1956) reports precipitation of 1 000mm for rock glaciers in the Chilean Andes and Potter (1972) reports 1 200mm annual precipitation for Galena Creek, Wyoming.

It has been proposed by Potter (1984) that there should be a continuum from clean glaciers at one extreme to rock glaciers composed of considerable debris cemented by interstitial ice at the other extreme. The present writer feels that this continuum could be extended beyond rock glaciers to link up with blockslopes which are thinner accumulations of blocky detritus, characteristic of cold, dry conditions and well jointed bedrock. The following Table 3D(i) summarizes a relationship between glaciers, blockslopes and blockfields.

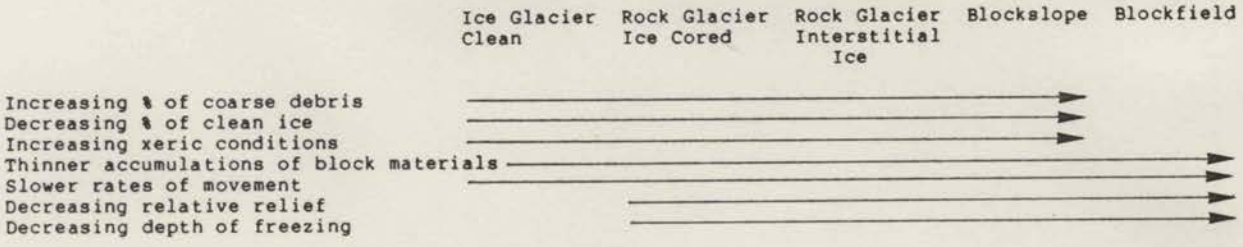


TABLE 3D(i) : Relationships Between Glaciers, Blockslopes and Blockfields.

The precipitation levels for the Bogong High Plains are indicated by the alluvial fan deposits on the lower piedmont slopes at the margins of the Bogong High Plains. The presence of debris flows which result from the generation of slope wash on steep slopes with loose debris and low vegetation cover are most common in arid and semi-arid climates.

Blissenbach (1954) indicates that mudflow (debris flows) deposits cannot be expected in alluvial fan strata where annual precipitation exceeds 500mm-650mm. As discussed earlier, this represents a 50% to 60% reduction in precipitation over piedmont catchments.

If that precipitation decrease is extrapolated to the High Plains, which currently receive up to 2 500mm of precipitation annually, then the late Pleistocene precipitation on the Bogong High Plains may have been less than 1 500mm per annum.

From the above it seems reasonable that temperatures in the study area were depressed by at least 5°C and precipitation by at least 50% to 60%.

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