FIELD GUIDE TO THE QUATERNARY GLACIAL,
PERIGLACIAL AND COLLUVIAL FEATURES
OF THE
EAST CAPE DRAKENSBERG

Colin A. Lewis
Rhodes University
Grahamstown

Field Guide Number One

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**Note:** Most of the sites described in this publication are located on privately-owned farmland. Permission to visit sites should be obtained from the relevant landowner.

This Field Guide was produced for a Field Meeting of the Southern African Society for Quaternary Research, held in May 1994 and based at Rhodes, led by Colin A. Lewis, (Rhodes University), Evan S.J. Dollar (University of Transkei), Trevor Hill (Rhodes University).

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Field Guide to the Quaternary Glacial, Periglacial and Colluvial features of the East Cape Drakensberg.


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‘Southern Africa differs fundamentally from continents of the Northern Hemisphere in the absence from its landscapes of the effects of Pleistocene glaciations ... ’ (Moon and Partridge, 1993).

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PREFACE

This, the first Field Guide published by the Southern African Society for Quaternary Research, was produced for a Field Meeting held in the East Cape Drakensberg and based on Rhodes in May 1994. Some of the material included in the Guide has not previously been published in the scientific literature and is in the process of preparation for journal publication.

Field Guides have been published by other Quaternary Societies, in various parts of the world, for many years. They have been of value, not only to participants in the original Field Meetings, but to generations of students and more advanced scientists who have subsequently visited the sites at their leisure. The present Guide is published in the hope that it will serve the same purpose and stimulate interest especially in the Quaternary geomorphology of the East Cape Drakensberg.
INTRODUCTION

Active periglacial features in the Drakensberg have been reported on numerous occasions in the last three decades, while fossil features figure in the literature for over four decades. Lewis (1988a) has reviewed this literature and suggested (1988b) that subperiglacial conditions exist at present at high altitudes in the Drakensberg. In 1993 Lewis produced Tables and maps showing the known location of periglacial features, active and fossil, in southern Africa (Table 1, Figure 1, Table 2, Figure 2).

TABLE ONE

<table>
<thead>
<tr>
<th>Active periglacial features recorded in southern Africa in and before 1993.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head/solifluction</td>
</tr>
<tr>
<td>Solifluction terraces</td>
</tr>
</tbody>
</table>

TABLE TWO

Fossil periglacial features recorded in southern Africa in and before 1993.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Altitude (m)</th>
<th>Mean Annual Air Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rock glacier</td>
<td>2800-3000</td>
<td>+5°C or less</td>
</tr>
<tr>
<td>Frost ripples</td>
<td>2550-3053</td>
<td>+1°C to -4°C</td>
</tr>
<tr>
<td>Blockstream</td>
<td>2000 or 2800</td>
<td>+1°C or less</td>
</tr>
<tr>
<td>Blockfield</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Debris cone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rock glacier</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

FIGURE 3 Modern climatic conditions in the Natal, Lesotho and East Cape Drakensberg as evidenced by active periglacial features. Source: Lewis, 1993.

During the Bottleneck Stadial the permafrost zone extended down to at least 1 840 m, as evidenced by rock glacier deposits in Bottleneck (Lewis and Hanvey, 1993) and suggested by protalus ramps in Kilmore (Lewis, 1994), which is a tributary valley to Bokspruit (Figure 4). The lower limit of the permafrost zone, and of the zone of systematic freeze-thaw that was effective enough to engender periglacial features, is as yet, unknown. Lewis has recently discovered glacial features of Quaternary age in the East Cape Drakensberg. Striations on a rock surface at Eliasdale, in the Bokspruit valley downstream of the confluence of Bokspruit and Rifle Spruit, indicate ice flow down that valley. The ice presumably fed-off an ice cap on the high plateau at the head of Bokspruit and Rifle Spruit, considerable areas of which lie above 2 500 m. From the crest of the Drakensberg escarpment, which forms the eastern margin of the high plateau drained by the Rifle Spruit, to Eliasdale, is 21 km. The terminus of the glacier has not yet been ascertained, but it must have lain downvalley of Eliasdale. The distance from the eastern edge of the ice cap to the terminus of the Bokspruit glacier must, therefore, have been considerably more than 20 km.

From the above information it is apparent that periglacial features are widespread in the East Cape Drakensberg.

Lewis (1993) has also reviewed the evidence that indicates that, in the East Cape Drakensberg, periglacial conditions existed at and above 1900 m in the time between 24 300 and 13 000 BP. Lewis and Hanvey (1993) have named this the Bottleneck Stadial: rock glaciers that existed c 21 000 BP in Bottleneck witness the nature of at least part of this Stadial.
Within the Rifle Spruit valley, at Stillorgan, organic-rich deposits dating to 27 000 ± 510 BP (Pta-5260) are overlain by slope or possibly by glaciogenic deposits associated with a valley-side glacier (Lewis and Hanvey, 1993), but not by a valley glacier. Since the glacial striations at Eliaisdale lie 8 km downvalley of Stillorgan, it is evident that the glacier that caused the striations at Eliaisdale pre-dates 27 000 BP.

In addition to striae, erosional features that may be p-forms also exist at Eliaisdale. Striae curve out of at least one such feature, suggesting that it was formed by erosion associated with the movement of water-soaked ground moraine that moved in laminar fashion due to differences in ice pressure (Gjeising, 1965). This indicates that the Bokspruit/Rifle Spruit glacier at Eliaisdale was of a temperate character (Souchez and Lorrain, 1991) with water present at its bed. The small patch of gravelly debris overlying bedrock at Eliaisdale, from which striae can be seen to issue, may thus result from bedload deposition in a lee-side cavity (McCabe, 1993).

The settlement of Rhodes, which lies at an altitude of c 1800 m, is partly built on a gravel deposit that extends upvalley for c 1.5 km. The gravels are almost entirely of basalt, although deposited on Clarens Sandstone. They form a feature that is essentially flat topped, but that has a steep face opposite the confluence of Carlisle's Hoek with the Bell River. The steep face resembles an ice-contact slope and the limited bedding exposed in road and farm sections suggest that the deposit is a kame moraine. Upvalley of the moraine lie lacustrine deposits with occasional included dropstones, suggestive of the former presence of a pro-glacial lake. A Middle Stone Age implement was discovered in the kame moraine upvalley of the Bell River - Carlisle's Hoek confluence, suggesting that the deposit dates to the Last Glacial Stage. Rock glacier deposits exist within the limits of the pro-glacial lake, on the north side of the valley.

Downvalley of Rhodes there are debris lobe deposits on the northern side of the valley (Lewis and Hanvey, 1988) which resemble lobate rock glaciers. On the opposite side of the valley road cuttings beside the Rhodes-Barkly East road, expose bedded sand and gravels that may have originated as an outwash train from the Rhodes moraine or that may be remnants of a kame terrace. Assuming that the debris lobe deposits originated as lobate rock glaciers, that they are of the same age as those of Bottelnek and that during their formation they removed whatever bedded sand and gravel deposits that might have previously existed on the northern side of the valley, the sand and gravel deposits exposed beside the road must predate the Bottelnek stadial. A similar argument holds for the rock glacier and glacio-lacustrine deposits upvalley of the kame moraine.
The evidence from the Bell River valley, in conjunction with information from Stillorgan in the Rife Spruit valley, indicates that a glacial advance dating to before 27 000 BP but occurring within the Last Glacial State (witnessed by the Middle Stone Age artefact mentioned above) preceded the Bottleneck Stadial in which rock glaciers existed (Figure 5). At Birnam, in Bokspruit, lacustrine and associated sediments have been dated to 35 000 ± 1 500 BP to 27 700 ± 1 000 BP (Hanvey and Lewis, 1990). Angular and apparently frost shattered deposits intrude into the lake sediments and overlie organic material that dates to 24 300 ± 510 BP (Lewis and Hanvey, 1993). At Dynesvorg Park in the valley in which Bottleneck is tributary, insect remains dating to 31 600 ± 950 BP (Lewis and Hanvey, 1993) occur beneath periglacial (head) deposits (Lewis and Dardis, 1985). A palaeosol within rock glacier debris in Bottleneck dates to 21 000 ± 400 BP indicating that the rock glacier was existent before and subsequent to that date (Lewis and Hanvey, 1993). The Stillorgan, Birnam, Bottleneck and Dynesvorg Park evidence therefore suggests that interstadial conditions existed in the region from before at least 27 000 BP and possibly before 35 000 BP but terminated after 24 300 BP and before 21 000 BP. The glacier advances in the region witnessed by the striae at Eliesdale and the deposits around Rhodes presumably predated at least 27 700 BP. The sequence of events during the Last Glacial Stage in the region, as already discussed, is outlined on Table 3. The Stage is herewith named Rhodian, after the supposedly glacial deposits in the vicinity of the settlement of Rhodes.

Extensive colluvial deposits exist on slopes in the Rhodes region. A 10 m deep section at Eliesdale exhibits a series of palaeosols separated by a variety of silt and gravel deposits. This section may well provide a record of events from the retreat of ice from the site in the Eliesdale Stadial, to the present. Samples have been submitted for radiocarbon dating, but dates are not yet available. A deep donga on Parkgate farm, upvalley of the glacio-lacustrine sediments east of Rhodes, reveals numerous palaeosols and colluvial deposits, the lowest of which may predate the Eliesdale deposits. Downvalley of Rhodes, on the north side of the valley opposite Monard farm house, there are extensive colluvial, fluvial, periglacial and possibly even glacial deposits. Palaeosols occur within these deposits, none of which have yet been dated.

The Bell and other rivers in the region are still adjusting their channels following major deposition, particularly in the Bottleneck Stadial. The Bokspruit is still directed to the south side of its valley by the rock glacier/ niche glacier deposits adjacent to the boundaries of the farms of Bodwell and Birnam. Active erosion of similar deposits is underway at Birchstone, opposite the farm of Knockwarren. Historically recent channel change is particularly obvious on the gravelly deposits immediately upvalley of the access road to Knockwarren farm.

Dollar (1992) has studied channel changes in the Bell River during the twentieth century. His work shows a frightening increase in donga erosion as well as appreciable channel changes in the main river, apparently due to management techniques and climatic variations in the catchment. From his description of the Bell River it is apparent that the river is still adjusting to the phases of heavy sedimentation during the Rhodian Stage.

### TABLE THREE

<table>
<thead>
<tr>
<th>Radiocarbon Dates</th>
<th>Stage Name</th>
<th>Event</th>
<th>Identified Features</th>
<th>Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 200</td>
<td>Ravenscraigian</td>
<td>Post Glacial</td>
<td>Fluvial and Archaeological deposits</td>
<td>Ravenscraigian³</td>
</tr>
<tr>
<td>21 000</td>
<td>R</td>
<td>Stadial</td>
<td>human artifacts rock glacier deposits</td>
<td>Bottleneck</td>
</tr>
<tr>
<td></td>
<td>H</td>
<td>Stadial</td>
<td>protalus ramparts slope and aeolian deposits</td>
<td>Stadial¹</td>
</tr>
<tr>
<td>24 300</td>
<td>O</td>
<td>Interstadial</td>
<td>organic remains</td>
<td>Birnum</td>
</tr>
<tr>
<td>27 000</td>
<td>D</td>
<td>Interstadial</td>
<td>? lacustrine deposits?</td>
<td>Interstadial²</td>
</tr>
<tr>
<td>27 700</td>
<td>I</td>
<td>Interstadial</td>
<td>? insect remains?</td>
<td></td>
</tr>
<tr>
<td>31 600</td>
<td>A</td>
<td>Stadial</td>
<td>? lacustrine deposits?</td>
<td>Eliesdale</td>
</tr>
<tr>
<td>31 600</td>
<td>N</td>
<td>Stadial</td>
<td>? insect remains?</td>
<td>Stadial¹</td>
</tr>
<tr>
<td>pre 35 000</td>
<td></td>
<td></td>
<td>glacial striae and moraine deposits witnessing advance of ice down-valley from high plateau</td>
<td></td>
</tr>
</tbody>
</table>

Sources

¹ This publication. ² Hanvey and Lewis, 1990. ³ Lewis and Hanvey, 1993. 

Note: The Rhodian Stage, Eliesdale Stadial, Birnum Interstadial and Ravenscraigian Stage are herewith named for the first time.
Unfortunately our knowledge of events in the Rhodian is still extremely sketchy and much research remains to be done in the East Cape Drakensberg. The limits of the glacial advances need to be established, as do the number and age of the advances: it is by no means certain, for example, that the glacial evidence at Eliasdale is of the same age as that at Rhodes. An inventory of rock glaciers in the region is desirable. Valley terraces need to be mapped and theirthalwegs plotted. An inventory of proglacial ramparts awaits initiation. Palynological investigation of the sediments at Birnam, Stillorgan and elsewhere is critical to our understanding of the Rhodian Stage. Archaeological investigations have provided extremely valuable information about climatic change in the region, but it is especially important that further Middle Stone Age sites be discovered and excavated. Even present periglacial features in the region need investigation. In fact, the list of desiderata is virtually endless! Nevertheless the broad outlines of the Last Glacial Stage in the East Cape Drakensberg are now apparent and the myth that southern Africa escaped glaciation in the Quaternary has finally been laid to rest.

ITINERARY

DAY ONE

1. Eliasdale. 30° 53'S 27° 52'E

The site lies beside a stream that flows north from Berriedale into the Bokspruit. The stream is crossed by a concrete drift on the Rhodes to Barkly Pass road little more than 100 m west of Eliasdale. On Sheet 3027 DD (1:50 000) the site lies on the east side of the stream that flows between Eliasdale and Barrydale. The site is at an altitude of c 1 760 m.

a) Glacial striations, p-forms and (?) ground moraine.

Immediately north of the road is a stream-site cutting that exposes over 10 m of colluvium with palaeosols. Follow the stream bed downstream of the colluvium and around a bend to the east, the stream then turns north. A rock face on the east side of the stream, downvalley of the bend, is scarred with numerous striations. The rock face is of Clarens sandstone and striae trending parallel or sub-parallel to the axis of the main Bokspruit valley exist where the rock has not been exfoliated.

The striations are best seen in early morning light and some of them are just deep enough to hold a pencil in place: most are shallow scratchings. The striae evidence ice-flow down this portion of the Bokspruit, presumably from the Rifle Spruit (which is essentially in line with and the headwaters of this portion of the Bokspruit) and the upper Bokspruit. The glacier that moved down the Rifle Spruit/Bokspruit must have been at least 22 km long above Eliasdale. The downvalley terminus of the ice is not yet known.

Semi-circular hollows exist on the rock face, and striae occur within and arc out of at least one such hollow. These hollows are probably p-forms (Dahl, 1965) and developed when the basal layers of the glacier contained water-soaked ground moraine, moving under pressure at the sole of the glacier. Gjesting (1965) has argued that pressure differences under the ice, as might be expected to occur in this lee-side cavity situation, would cause directional differences in the flow of water-soaked ground moraine, leading to the formation of striations, not all of which are parallel to each other.

Downstream of the first bend the stream flows over bedrock and the bedrock beside the water on the east of the valley is partly undercut beside the stream. In this area faint striations can be seen trending parallel or subparallel to the stream valley. The valley obviously predates glaciation and has been little altered subsequently at this point. Subglacial water-soaked ground moraine apparently moved westward parallel to the axis of Bokspruit, but in the base of the lee-side cavity there was also movement down the minor valley, probably at right angles to the direction of glacier flow, as the slurry at the glacier sole made use of the pre-existing drainage line.
A small patch of pebble/gravel debris, mixed with fines and matrix supported, that is perched on top of bedrock on the east side of the valley, from which striations issue, may be the remnants of a more extensive cover of ground moraine. McCabe (1993) has reported pebble as well as gravel, matrix supported material, in what appear to have been lee-side cavities in drumlins. The deposit at Eliasdale occupies a comparable lee-side cavity situation. Tests are presently been undertaken to determine whether or not this is a glacial deposit.

b) Colluvial and palaeosol deposits.

Immediately downstream of the road at least six palaeosols may be seen in what appears to be a colluvial deposit. Some 50 - 100 m further downstream only four palaeosols are apparent: Figure 6 depicts the stratigraphy of this portion of the section.

![Colluvial deposits and palaeosols at Eliasdale. Source: Measurements by Dollar, Hill and Lewis.](image)

As Figure 6 indicates, the colluvial deposits are formed of a variety of silts and gravels, with included palaeosols. The bedding appears to dip downvalley, and it may be that these are alluvial rather than colluvial deposits, formed by fluvial deposition rather than by valley-side, slope, processes.

Samples from the palaeosols have been submitted for radio-carbon analysis, but dates are not yet available. A clast that resembles a Middle Stone Age artefact was collected from the upper layers of the deposits, but its precise position was not recorded. If it really is a Middle Stone Age implement, its existence in the deposit would suggest that the deposits are not older than the Last Glacial Stage, or possibly the previous Interglacial. It is, however, inconceivable that those soft sediments could have survived the glacial advance that was responsible for the adjacent striations. Evidence has already been presented (in the Introduction) that suggests that the ice occupied the site in the Last Glacial Stage, prior to c 27 000 BP. The sediments shown on Figure 6 are therefore believed to have accumulated in the Interstadial that succeeded that ice advance and in the remainder of the Last Glacial Stage and possibly in the Holocene. The palaeosols witness phases of stability in which sedimentation was replaced by soil formation. The gravels that overlie some of the palaeosols evidence phases of relatively high fluvial energy, presumably with erosion upstream and deposition at this point, where the valley profile becomes less steep.

Under present circumstances erosion appears to be the predominant process: the stream has eroded to bedrock but is still not sufficiently competent to remove all the soft sediments in the valley. No evidence of such vigorous erosion exists in the exposed section and it may be that the present phase of erosion is the most vigorous since the retreat of the Bokspuit Glacier.

2. Killmore protalus ramps. 30° 57'S 27° 56'E

![Protalus ramps at Killmore. Source: Lewis, 1994.](image)
The site is located on the western side of the Killmore valley at an altitude of c. 2000 m. The Killmore is a south bank tributary of the Bokspuit and joins that valley beside the farmhouse of Killmore. The site lies on the bench indicated by the 2100 m contour on Sheet 3027 DD (1:50 000) approximately below spotheights 2187 and 2324 on the farm of Killmore (Spotheight 2324 is on Glen Hay farm, but the bench does not extend so far south).

A boulder clutter on the northern end of the bench extends southwards and forms a pronounced ridge, or rampart. This clitter/rampart is c. 1.5 km long (Figure 7). Profiles of the rampart (Figure 8) show it to be as much as 17 m high above the base of the adjacent depression and up to 83 m wide. The distance from the foot of the talus, below the basaltic cliffs, to the crest of the rampart is up to 69 m.

**FIGURE 8** Profiles of the proatalus rampart at Killmore. Source: Lewis, 1994.

The rampart is composed of arcuate, but joined, segments. Slope angles on the proximal side of the rampart vary from 13° to 27°, and on the distal side from 15° to 25° (Table 4).

**TABLE FOUR**
Dimensions of the Killmore Rampart

<table>
<thead>
<tr>
<th>Profile</th>
<th>Type</th>
<th>L</th>
<th>W</th>
<th>H</th>
<th>Z</th>
<th>D</th>
<th>B Max</th>
<th>C Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Arcuate</td>
<td>187</td>
<td>80</td>
<td>17</td>
<td>16</td>
<td>27</td>
<td>27</td>
<td>25</td>
</tr>
<tr>
<td>B</td>
<td>Arcuate</td>
<td>130</td>
<td>60</td>
<td>8.5</td>
<td>9.5</td>
<td>53</td>
<td>13</td>
<td>15</td>
</tr>
<tr>
<td>C</td>
<td>Arcuate</td>
<td>298</td>
<td>83</td>
<td>14</td>
<td>13.5</td>
<td>49</td>
<td>18</td>
<td>21</td>
</tr>
<tr>
<td>D</td>
<td>Arcuate</td>
<td>52</td>
<td>9</td>
<td>8</td>
<td>69</td>
<td>23</td>
<td>24</td>
<td></td>
</tr>
</tbody>
</table>

* The symbols are fully explained in Lewis (1994).

**FIGURE 9** Relationship between rampart dimensions at Killmore and in Britain. Source: Lewis, 1994.
Figure 9 shows that there is a strong relationship between the width and thickness of the rampart: a similar relationship occurs for protalus ramparts in Britain. Figure 9 also shows that in other respects differences occur between relationships at Killmore and at British protalus ramparts.

The morphology of the Killmore rampart resembles that of fossil protalus ramparts elsewhere (vide Lewis, 1994). Furthermore, the sedimentology of the rampart resembles that of protalus ramparts in Norway (Ballantyne, 1987). The morphology of quartz grains from the rampart resembles that of quartz grains from an active protalus rampart in Norway (Harris, 1996). The accumulated evidence therefore suggests that the Killmore deposit is a fossil protalus rampart. Shakesby (1992), in a series of simple diagrams (Figure 10) has indicated the differences between the mechanisms leading to the formation of glacial moraines, protalus ramparts and rock glaciers.

**FIGURE 10** The formation of: A: glacial moraines; B: protalus ramparts; C: rock glacier. Source: Shakesby, 1992.

Ballantyne (1987) has defined a protalus rampart as 'a ridge or ramp of predominantly coarse detritus, usually located at or near the foot of talus, that formed through the accumulation of debris along the downslope margins of a perennial snow-bank'. He showed that debris on the ramparts exhibits size-sorting dependent upon its resting place on the ramparts. Figure 11 shows equivalent size-sorting of clasts at Killmore.

Ballantyne (1987) has also shown that bimodality exists in the fine matrix of deposits on the distal side of active protalus ramparts. Figure 12 (Sample A) exhibits the same characteristic. Sample B (Figure 12) was collected between the base of the vegetation cover on the rampart and the uppermost unexposed clast. The sample material probably post-dates the formation of the main body of the rampart and may be of wind-blown, loessic origin: its high silt content (69.8%) is comparable to that of Belorussian loesses (70-80% silt; Saigašk, 1991).

Harris (1986) has studied the morphology of quartz sands collected from an active protalus rampart in Norway and has shown that they predominantly exhibit fresh clean surface and 'mechanical features'. Similar features are exhibited by quartz grains from the Killmore rampart (Lewis, 1994).

**FIGURE 11** Clast size distributions from the Killmore ramparts. Source: Lewis, 1994.

The Killmore protalus rampart probably dates to the Bottleneck Stadial (after 24 300 BP and before 13 000 BP; Lewis and Hanvey, 1993). The presence of the protalus rampart proves that, while it was being formed:

1. perennial snowbeds (the toes of which correlate with the altitude of the local equilibrium line) existed in the East-Cape Drakensberg at 2 000 m and above.
2. at least discontinuous permafrost occurred in these mountains at 2 000 m and above' (Lewis, 1994).
have been because local climatic conditions were only marginally suitable for snowbed survival, so that the snowbed was restricted to the area that was shaded from the direct rays of the afternoon sun by the cliffs from which the protalus sediment was derived. The snowbed may also have been nourished by (strong) westerly winds drifting snow off the adjacent uplands to windward.

3. Birnam: lacustrine, overbank and other deposits. 30° 55'S, 27° 57'E.

This site was described, briefly, in 1990 by Hanvey and Lewis. The site is located at an altitude of 1 850 m beside the Bokspruit. Access is via the farmyard of Birnam. Vehicles should be left in the yard and people should walk to the river, crossing it on the low bridge/pipe drift. Follow the wire fence on the left of the pathway to the first gate. Enter gate and turn left, walk to the bend of the river where it undercuts the field that is immediately upstream of Birnam farm buildings. The section lies along the eastern edge of this field and is exposed by stream erosion.

![FIGURE 13 Quaternary stratigraphy at Birnam. Source: Hanvey and Lewis, 1990.](image)

According to Hanvey and Lewis (1990) five distinct sedimentary units are exposed (Figure 13), although not all of them are seen throughout the section. The lowest unit comprises rounded pebble gravels which are replaced in the eastern part of the section by Unit 2: 'shattered, sharply angular rock fragments ... devoid of a matrix'. Unit 3, 'an overlying disorganized boulder gravel unit'. This, in turn, is overlaid by colluvium (Unit 5) that is up to 4 m thick. The whole exposure is up to 16 m deep and is seen over a distance of 60 m.

Unit 3, the silty mud, contains at least eight organic-rich layers (Figure 14). Lewis and Hanvey (1993) report that the lowest organic-rich layer dates to 35 000 ± 1 500 BP (Pxa-5263), while the uppermost layer dates to 27 700 ± 1 000 BP (Pxa-5246). Organic material underneath the angular, shattered rock fragments, dates to 24 300 ± 370 BP (Pxa-5088).

The above conclusions are based on the findings of Ballantyne (1987): that protalus ramparts form at the toe of perennial snowbeds; and Haebeler (1985): that permafrost exists under these snowbeds. If the permafrost extends under the rampart, then the rampart begins to creep downslope and a rock glacier forms (Haebeler, 1985). There is no evidence of such permafrost creep at Killmore, although rock glaciers occur in the region.

Lewis (1994) writes that: 'The relationship at Killmore between rampart thickness/rampart width and crest-talus distance suggests considerable stability from year to year in the size of the snowbed responsible for protalus formation. This may
Hanvey and Lewis (1990) interpreted the deposit as: Unit 1: fluviatile; Unit 2: a remobilized layer; Unit 3: lacustrine; they did not designate the origin of Units 4 and 5 except to write that Unit 4 is a 'disorganized gravel unit', and Unit 5 is a 'colluvium deposit'. In 1990 Hanvey suggested that Unit 4 may be 'a form of glacial outwash', or 'be related to the disintegration of snow patches along the south-facing valley flank'. Unit 5 she 'believed to result from slope wash processes and may well be a recent Holocene accumulation'.

Further study of the site by Zhuikova (personal communication, 1992) indicated that rhythms exist near the top of Unit 3 and that Unit 4 exhibits channels, in some of which there is organic material. Unfortunately Zhuikova abandoned her work later in 1992 before she had analyzed the paleonlogy of the deposits.

Close examination of Unit 3 shows that it possesses characteristics of overbank as well as lacustrine deposits. Hanvey and Lewis (1990) suggested that the lake evidenced by Unit 3 may have been caused by 'localized glaciation (and the associated blockage of the main valley by ice)', or by river blockage by a 'large debris cone'.

Two palaeosols exposed in the side of a donga that is eroded into colluvial deposits in the Birnam valley (i.e. the valley that runs through Birnam farm and is a right bank tributary of the Bokspruit) c 400 m upstream of the farm house, indicate a minimum age for Unit 5. The lower palaeosol, located 2 m below the ground surface, dates to 3 620 ± 60 BP (Pta-5485). The upper palaeosol, at a depth of 1.2 m, dates to 2 200 ± 70 BP (Pta-5497). The main bulk of Unit 5 must, therefore, predate 3 620 BP.

Detailed investigation of the Birnam deposits is urgently required since they appear to provide a record of at least the last 35 000 years. Major questions are posed by the deposits:

i) Is Unit 3 an interstadial or a stadial deposit? If it accumulated in a proglacial or debris cone/rock glacier-dammed lake, then it must be stadial and cold conditions must have existed between c 35 000 and 27 700. Opposing such an interpretation is the date derived from insect remains which may be interstadial in origin that underlie head at Dynevor Park: 31 600 ± 950 BP (Pta-5657; Lewis and Hanvey, 1993). Nevertheless the insect remains have not been identified, so it is possible that they are of stadial origin. At Stillorgan in the Rifle Spruit valley, organic-rich material underlying slope or valley-side (nich) glacier deposits dates to 27 000 ± 510 BP (Pta-5260; Lewis and Hanvey, 1993): it is unlikely that such organic deposits accumulated under stadial conditions, although they may have developed soon after the termination of stadial conditions. Hill is presently researching the paleonlogy of the Stillorgan organics and his findings are eagerly awaited.

ii) Are the rhythms discovered by Zhuikova near the top of Unit 3 actually varves? If they are, then they strengthen the interpretation of the sediments as having been deposited in a proglacial lake.

iii) What is the origin of the sediments comprising Unit 4? There appear to be stacked channels in the Unit, suggestive of a braided stream origin. If that was their origin, were they deposited as glacial outwash? Rose (1993) writing of
lowland Britain has suggested that in the Loch Lomond Stadial (11 000 - 10 000 BP) braided river sedimentation was dominant because of a `high sediment yield driven by gelification under conditions of minimal vegetation' and that these sediments `are at a valley bottom location and are buried by fine-grained Holocene overbank deposits'.

iv) How did the `colluvium' accumulate? Is it really a slope deposit, or series of deposits, or main valley fluvial (including overbank) deposits similar to those described by Rose (1993) as `fine-grained Holocene overbank deposits'?

No matter what the answers to the above questions may be, the presence of the Birnam deposits shows that the Bokspuit valley underwent a major stage of infilling subsequent to 35 000 BP. Erosion later occurred and at least 16 m of sediment has been removed from part of the valley floor since deposition of the main mass of the deposits ceased (i.e. since the end of major colluvial deposition). Did this occur during the Bottelnck Stadial, the Ravenscraig (Holocene), or when? If Hanvey (1990a) is correct, and Unit 5 is of Holocene age, that would imply (in view of the subsequent palaeosol already mentioned that dates to 3 620 BP) that most of the colluvium deposition and erosion took place between c 10 000 and 3 620 BP. Hanvey's postulation is not likely, and it is more probable that the colluvium was deposited mainly during the Bottelnck Stadial with most erosion being of more recent age but predating 3 620 BP.

4. Before leaving Bokspuit the general morphology of the valley should be noted. The contrast between the northern and southern sides of the valley is marked. Major accumulations of slope deposits exist at Bothwell/Birnam, and at Buckstone. The Bokspuit has been pushed to the southern side of its valley by the Bothwell/Birnam deposits, which may be the remains of a nape (Groom, 1959) or rock glacier. The toe of the sediments is exposed by fluvial erosion. The Buckstone niche/rock glacier (?) deposits are well exposed by the road leading to Knockwarren farm. Similar features are not seen on the southern side of the valley.

South west of Louissiana farm buildings, on Knockwarren, there is a debris accumulation nested in a hollow under the upper valley side that appears to be a cirque moraine. Initial mapping has been undertaken, but further study is necessary before the feature is described further in the scientific literature.

5. The route now entails retreating from the recesses of Bokspuit to the junction with the Rifle Spruit road. Turn east and follow the Rifle Spruit road to the site at Stillorgan (Site 6). Notice, en route, the trough-like nature of the Rifle Spruit valley upstream of the Tullyveolan gorge: spurs appear to have been truncated and the valley floor appears to be infilled with unconsolidated deposits. Notice the contrast between either side of the valley: large debris accumulations occur at the foot of south facing slopes and are well exposed by fluvial erosion, but similar deposits are largely absent on north facing slopes. The micro-relief of the gorge section is also worth noting: the Clarends sandstone bedrock exhibits a variety of what appear to be water-sculpted features.

6. Stillorgan: Organics, slope/glacigenic deposits 30°52'S 27°57'E

The site is located at an altitude of c 1 820 m on the northern bank of the Rifle Spruit beside the first bend of the river downstream from Stillorgan farm buildings. Vehicles should be parked beside the Rifle Spruit road in the wooded area immediately down-valley of the farm house of Bremerside. Access is on foot along the edge of the field bordered by the river immediately north west of Bremerside. The site occurs on the opposite side of the stream and takes the form of a 7 m high exposure. Care should be taken when wading the stream beside the section: deep holes occur on the stream bed adjacent to and towards the west of the section.

The main interest at Stillorgan (Figure 15) is the blue-grey bouldery and organic-rich diamicton that has a silty matrix and that is located on the eastern end of the section. Many of the clasts in this unit are faceted and bullet-nosed. This is a characteristic of clasts that have been deposited as lodgement till (Boulton, 1978). The unit has been dated to 27 000 ± 510 BP (Pta-5260; Lewis and Hanvey, 1993). The clasts in the unit are mainly basalt, although bedrock in the vicinity is of Clarends sandstone. The organics in the deposit probably post-date the diamicton since they contain root and stem remnants that appear to be in growth position: it is unlikely that they would retain such position if over-ridden by ice.


Above the blue-grey diamicton is a boulder layer on top of which are muds that display wavy lamination. Pebble gravels extend west of this sequence and underlie a massive brown diamicton. A cylindrical bouldery unit, fining towards its centre, is located within the brown diamicton about midway along the exposure.

Hanvey (1990b) wrote that the 'massive compact diamictons, bevelled clasts and a preponderance of basalt which is not the local substrate rock in the immediate vicinity but derived from higher levels, are suggestive of a possible glacigenic origin. Therefore these sediments may represent basal melting beneath a small localized glacier which existed within the upper reaches of this valley'. She argued that 'The interbedded fines and gravel layers found within the sequence are not contrary to such an origin since similar inclusions are known to occur in glacigenic deposits elsewhere.
(Dremanis, 1988) where they are attributed to subglacial meltwater production and evacuation, and localised squeezing and flowage of saturated 'till'.

Clast orientation and other analyses have yet to be undertaken on the diamictons, but initial visual inspection suggests that the brown diamicton is a slope deposit. As such, it is unlikely to have been deposited by even 'a small localised glacier' that occupied and moved down 'the upper reaches of this valley'. The possibility remains, however, that the diamicton formed in association with a valley-side (or niche, Groom, 1959) glacier that clung to the northern side of the main valley and occupied the 'Stillorgan tributary valleys', or was associated with a rock glacier. Compared with clasts in the blue grey diamicton, few of those in the brown diamicton appear bevelled, which reduces the possibility that they are of glacial origin.

The blue grey diamicton, with its associated fines, and its bevelled clasts, appears more likely to be a glaciogenic deposit than the brown diamicton. The organic remains in the blue grey diamicton, which as already argued, apparently post-date deposition of the diamicton, thus provide an upper limiting age for the glacial advance down the Rifle Spruit valley that was probably responsible for the diamicton: \( 27\,000 \pm 510 \) BP.

7. Mount Mourne.

**Water deposited gravel, sand, silt and clay. 30°52'S 27°5'E**

This site is located beside the Rifle Spruit road immediately upvalley of the gate leading to Mount Mourne Farm, north east of spotheight 1941. Upvalley of the gate is a bench on Clarens Sandstone overlaid by unconsolidated deposits exposed in a road cutting on the south side of the road. Beyond the bench the road descends to the valley floor.

The unconsolidated deposits are composed essentially of basalt and other material derived from the upper reaches of the valley, rather than from the underlying Clarens sandstone bedrock. Many of the clasts are deeply weathered. Although the section has not been recorded in detail it is evident that a pond, or essentially still-water deposit, is located towards the left hand extremity of the section (left and right assume that the observer stands with back to the road). Various sand and gravel deposits comprise much of the remainder of the deposit. Colluvial deposits cap the underlying layers.

Although the origin of the water-laid deposits is not yet clear they may represent deposition adjacent to an ice body. Flow tills have not been clearly identified, but slurry like deposits have been noted. Scientists who have worked in Ireland, where evidence of Midlandian (Last Glaciation) glaciation is abundant, have observed that, if this section was located in the Irish Midlands it would be interpreted as of glacial/fluvio-glacial origin and possibly as a kame remnant. Further investigation is urgently required to establish the origin of these deposits: they may be associated with the valley glacier that, on the evidence of striations seen at Eliasdale, is known to have formerly occupied the Rifle Spruit valley, and that may be responsible for the blue-grey diamicton at Stillorgan. The base of the section is c 18 m above the present river level.

8. ± 100 m downvalley of Site 7.

Bedded, angular, slope deposits are exposed in a road side cutting. They are formed of a series of fining upwards deposits, composed of detritus from the bedrock that lies immediately upslope, and appear to be of periglacial origin. The age of these sediments may vary considerably from those exposed at the previous site. In 1990 Hill (personal communication) stated that, in his opinion, these are the only deposits of an indisputable periglacial origin that he has seen in the East Cape Drakensberg.
DAY TWO

Depart from Rhodes at 9.00 a.m. and follow the Barkly East road to that town, then turn south along the main road towards Elliot.

1. **Hendria. Terraces and unconsolidated sediments. 31°04'S 27°39'E**

   The main road runs along the crest of a well defined terrace: lower terraces are also evident in this area. Road cuttings on either side of the main road at c 1 780 m adjacent to Hendria farm buildings show a variety of bedded sand and gravel deposits. The foreset-like bed that contains clasts in a finer matrix should be noted. Although much work remains to be completed in this area, the possibility that the deposits accumulated near an ice-front should not be ruled out. The sediments were deposited essentially by northward flowing water and the foreset-like bed may indicate that ice was in close proximity to the site when deposition took place. Syage (1973) has argued that similar deposits (‘flat-bedded gravel terraces’) in Ireland at Ballinaclash evidence a ‘clear stage of local glaciation’ in a comparable valley situation leading away from a mountain range. River terraces should be traceable upstream, but fluviolacustrine terraces begin at an ice-front while kame terraces occur beside a glacier and the valley side. (Kame moraines and perforation kames occur in different positions).

2. **Ravenfell/Chesney Wold. Water laid deposits on bedrock. 31°07'S 27°43'E**

   Road cuttings on either side of the main Barkly East to Elliot road near the junction with the gravel road to Bottelnek at c 1 820 m expose water laid deposits that, in some cases, rest on bedrock of Clarens sandstone. Much of the unconsolidated material is of basaltic origin and is therefore unlikely to have been emplaced by the Langkloof Spruit. This stream drains north westward from the vicinity of the Barkly Pass and flows mostly over Clarens sandstones, although basalt does outcrop on the upper sides of the valley. The possibility that the water laid deposits were associated with the melting of a glacier that flowed down Bottelnek should not be discounted. The terraces on the valley floor in the vicinity of Arnold Hechter Bridge and the spectacular Kromdraai gorge may be related to the melting of a Bottelnek glacier. Mapping of terraces in the Langkloof and its tributary valley and recording of sections is a necessity if the Quaternary history of this beautiful area is to be properly understood.
Lewis and Hanvey (1993) have described debris accumulations on the northern side of this valley (Figure 16), some of which they interpret as the remains of rock glaciers. Bottleneck is aligned east-west. 'The valley is asymmetric, with steep basaltic cliffs on its northern flank and more gentle slopes, predominantly developed on Clarens sandstone, but normally culminating in minor cliffs cut in basalt, on the southern flank'. The valley floor, at altitudes between c 1 820 and 2 000 m, is eroded about 400 m below the adjacent summit plateau. Terraced alluvium exists on parts of the valley floor. The southern side of the valley is of exposed Clarens sandstone.

**FIGURE 16** Debris accumulations, some of which resemble rock glaciers, on the northern flank of Bottleneck. Source: Lewis and Hanvey, 1993.

or of sandstone with a thin veneer of superficial sediments, giving way to basalt and associated debris at higher levels.

The rock glaciers descend to the river, or almost to the river, from Chesney Wold to Rosehill. As one drives east up the gravel road towards the pass of Bottleneck the debris accumulations on the northern side of the valley should be noted. The first stop is beside the trees immediately west of Rose Hill Farm. A large debris mass on the northern side of the valley is exposed by fluvial erosion and may be clearly seen from the road. Figure 17 shows that four major stratigraphic units exist in this deposit.

Unit One, resting on Clarens sandstone bedrock, is a matrix supported diamicton essentially of sandstone debris. Unit Two comprises basaltic cobbles and gravels. Unit Three is of angular clasts (medium length 24 cms), in a sandy/silty matrix. The uppermost Unit, within which is a channel deposit, is a matrix supported diamicton with basaltic clasts up to 2 m in length. Table 5 indicates the particle size characteristics of the fine fractions of each Unit.

**TABLE 5**

<table>
<thead>
<tr>
<th>Unit</th>
<th>Sand (%)</th>
<th>Silt (%)</th>
<th>Clay (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>74.3</td>
<td>20.2</td>
<td>5.6</td>
</tr>
<tr>
<td>3</td>
<td>59.3</td>
<td>31.6</td>
<td>9.2</td>
</tr>
<tr>
<td>2</td>
<td>68.0</td>
<td>24.4</td>
<td>9.4</td>
</tr>
<tr>
<td>1</td>
<td>71.7</td>
<td>21.8</td>
<td>6.5</td>
</tr>
</tbody>
</table>

The surface features of quartz grains collected from each of the stratigraphic units were examined under the scanning electron microscope. 80% of the grains examined exhibited conchoidal fractures, 60% linear/sub-linear fractures, 45% parallel and sub-parallel steps.

Clast size within the sediments and on the surface of the debris accumulation were recorded (Figure 18) and showed that Unit 3 has markedly smaller clasts than Unit 4.

The morphology of the Rose Hill debris accumulation (Figure 19) is best seen by looking up the front of the deposit and onto the surface. On either side of the accumulation there is a stream in an entrenched valley. In cross section, therefore, the accumulation is separated from the valley sides and forms a raised platform between adjacent and parallel gullies. In detail, according to morphological mapping by Hanvey, ridges and valleys run essentially up and down the debris accumulation, with some exhibiting curvature. Bedrock is exposed on either side of the valley within which the debris mass is located.

**FIGURE 18** Clast size and sorting: Rose Hill rock glacier. Source: Lewis and Hanvey, 1993.

The Rose Hill feature was interpreted by Lewis and Hanvey (1993) as the remains of a rock glacier on the basis of its morphology, stratigraphy, particle size, clast characteristics and morphology of quartz grains. They were particularly impressed by the coarse debris overlying finer debris in Units 4 and 3, since this is a well-known feature of rock glaciers. According to Haebelri (1985) coarse material occurs in the upper layer, which is the active layer above the permafrost table, and finer material occurs below the permafrost table. The same characteristics have been reported by many scientists who have studied rock glaciers (vide Giardino, Shroder and Vieck, 1987).
FIGURE 19 Morphology of the Rose Hill rock glacier.
Source: Lewis and Hanvey, 1993.

FIGURE 20 The stratigraphy of sediments in the Chesney Wold rock glacier.
Source: Lewis and Hanvey, 1993
The second stop in Bottelnek involves returning down valley to Redbrook. Vehicles should be parked near the gateway on the northern side of the road that is a short distance upvalley of Redbrook farm: willows fringe the road at this point. Enter the gate and proceed on foot diagonally across the field in an upvalley direction until one meets the boundary fence beside Bottelneke spruit. An exposure in unconsolidated sediments lies on the opposite side of the stream. A laterally persistent palaeosol, about 2 cm thick, may be seen in the lower third of the section. This palaeosol dates to 21 000 ± 400 BP (Pta-5654) and indicates that the rock glacier in which it occurs was existent before and subsequent to that date.

The third stop is further downvalley, at a gate on the north side of the road immediately west of which is a prominent outcrop of Clarens sandstone, a few hundred metres upvalley of Chesney Wold farm buildings. Leave the vehicles, enter the gate and walk directly to the Bottelneke spruit. The debris accumulation of Chesney Wold (Lewis and Hanvey 1993) lies on the opposite side of the stream (Figure 20), and exhibits comparable stratigraphy to that of Rose Hill and has been interpreted as a fossil rock glacier.

An outcrop of Clarens sandstone a few hundred metres upstream of the above exposure exhibits a variety of channel and pot-hole features that may have developed under, or adjacent to, a glacier.

4. Sonskyn. Slope deposits, some of which indicate periglacial conditions.

31°07'S 27°46'E


This site is located between the farm buildings of Rosehill and Sonskyn in the upper reaches of Bottelnek. After ascending east of Rosehill the road runs through a cutting that exposes the unconsolidated sediments that form this site at an altitude of c. 2,000 m.

The site has been described by Hanvey and Lewis (1991) who published a diagram showing the stratigraphy of the deposits (Figure 21), which are exposed over a distance of 120 m and to a depth of 6 m.

Rounded and subrounded basalt clasts predominate in the western part of the section, with angular sandstone clasts dominant in the east. The following sedimentary units were identified by Hanvey and Lewis:

i) a number of isolated pockets of fine colluvium at the base of the section, succeeded in the eastern part of the section by:

ii) Angular and weakly stratified clast-dominant sediments, into which:

iii) channelized units comprising rounded basalt boulders' have been cut.

The western end of the section exhibits 'chaotically bedded, rounded basalt-dominant sediments, interspersed with small isolated minor units of angular sandstone material and colluvial lenses'.

Middle Stone Age artifacts occur in the angular stratified deposits and 'at the base of an adjacent channelized unit'.

Hanvey and Lewis (1991) concluded that:

a) the colluvium was deposited 'in a cold environment largely devoid of vegetation, and thus is indicative of relatively severe cold-climatic conditions'.

b) the angular stratified sediments reflect 'a transition to sheet solifluction processes'. Frost action was probably 'the primary agent' responsible for the shattered nature of the clasts.

c) the channelized bouldery deposits represent 'cylindrical solifluction' or 'lobe or tongue-like solifluction'.

They believed that the stratified sediments formed partly as a result of moisture supplied from snow patches further up slope. Furthermore, the channelized features, they thought, were caused 'by augmented moisture levels induced by the final melting of a snow patch' (Figure 22).

The Middle Stone Age artifacts suggest that the angular and channelized deposits are not more than 140,000 years old, and are probably less than 20,000 years old: Middle Stone Age people are known to have occupied parts of the East Cape Drakensberg until about 22,000 BP (Opperman, 1992). The artifacts have obviously been modified since produced, and transported and deposited with the angular and channelized deposits.
5. Rhodes/Kinnel. Glacial deposits. 30°46′S 27°58′E

Ben Macdhui (3 001 m), the highest peak in the East Cape Drakensberg, rises above an extensive plateau at altitudes of between 2 500 and 2 700 m. The plateau extends for 15 km from east to west and is 5 to 7 km wide. To the east the plateau is drained by the Bell River and its headwater tributaries, to the west by the Voor and Funny Stone Stream, and to the south by Carlisle’s Hock.

Carlisle’s Hock is entrenched up to 600 m below the adjacent plateau and, in its lower reaches, is trough like. The valley is V-shaped and precipitous in its upper reaches. Occasional patches of gravel in a finer matrix occur on the valley sides adjacent to the road, particularly down valley of Elbank farm buildings. Basalt-rich gravels rest on Clarens sandstone bedrock where the road crosses the Bell River at the mouth of the valley. The gravels are overlain by locally derived slope sediments. The bedrock that underlies the gravels exhibits a variety of bedforms, some of which appear to have been made by water flowing down Carlisle’s Hock: they may be p-forms.

The portion of Rhodes uphill of the church is built on a gravelly feature that may be traced upvalley to where the main Naude Nek road rises and heads south, just east of the Kinnel farm buildings that are nearest to Rhodes. (Two Kinnel’s are shown on 1:50 000 topographic sheet 3027 DD). The gravel feature is essentially flat-topped, as may be seen behind Rhodes police station. Upvalley of the Police Station the Naude Nek road skirts the inner edge of the gravel feature, which has a steep northern face. Shallow exposures towards the eastern edge of the field adjacent to the Police Station show sands and gravels in the face of the flat topped feature.

South of where the word Furrow is printed on Sheet 3027 DD the gravelly feature bends, in a flatly dished manner, away from the road. Upvalley of the western

Kinnel it swings north and is crossed by the main road, which ascends the face of the feature and passes through its upper surface in a cutting that is about 2 m deep. Surface exposure in the adjacent field indicate that there is at least 8 m of unconsolidated material below the level of that exposed in the road cutting.

The road cutting exhibits forest sand and gravel dipping down upvalley (i.e. into the upper Bell valley), underlain by gravel in a finer matrix on top of silts. Towards the western edge of the exposure, which is some 15 m long, are sediments that may be rhythms.

Exposures behind the labourers’ huts west of Kinnel farmhouse, and beside a water trough, indicate that sands and gravels occur widely, if not throughout, the ‘feature’. Visual inspection, as yet unsupported by quantitative analyses, suggests that 90% or more of the debris in the feature is of basalt origin, although bedrock below the feature, as well as on the floor of the Bell River immediately upstream of the feature, is of Clarens sandstone. A Middle Stone Age artefact was discovered in the gravels below the forested beds in the cutting on the north side of the main road.

FIGURE 32 Depositional model for sediment accumulation at Sonskyn.

35

FIGURE 23 Preliminary map of moraine and proglacial lake deposits near Rhodes.

The gravelly feature is interpreted as a kame moraine that formed at the terminus of a glacier that flowed down Carlisle’s Hock, draining from an ice cap on the 2 500 - 2 700 m plateau below Ben Macdhui. The steep face fronting Carlisle’s Hock from south of the Furrow to Kinnel may have been an ice contact slope, similar to slopes
described by Synge (1950) from the Galtrim kame moraine in Ireland. Figure 23 indicates the extent of the moraine and of associated features, but is based on preliminary rather than on detailed mapping.

Upvalley of the road cutting, between it and the point where the main road descends near the eastern Kimmel farm, road cuttings expose water laid sediments. Some of these are silty-clays, and occasional dropstones occur in these deposits. Close examination shows that the bedding of the soft sediments has been disturbed by dropstone deposits. The first donga beside the road, upstream of the cutting in the kame moraine, exposes still or low energy water-laid sediments and two pronounced gravel layers. These sediments are interpreted as lacustrine, evidencing the former existence of a pro-glacial lake upvalley of the kame moraine. The gravel layers probably evidence phases of glacier advance into the lake, or of more than usually pronounced glacier melting.

On the north side of the Bell River valley, opposite and at a lower level than the sediments described in the previous paragraph, lie slope deposits that may be the remains of a lobate rock glacier. Assuming that was their origin, and that the rock glacier was of the same age as those in Bottleneck, the proglacial lake, the kame moraine, and the Carlisle's Hoek glacier that was responsible for the kame moraine and the lake, must predate the Bottleneck Stadal.

The gravel deposits, predominantly of basaltic origin, adjacent to where the Carlisle's Hoek road crosses the Bell River, plus various valley side gravel exposures beside that road higher up Carlisle's Hoek, are interpreted as deposits associated with the former Carlisle's Hoek glacier.

6. Parkgate. Donga in colluvial sediments. 30°46'S 28°01'E

This site is a donga on the south side of the Rhodes to Naudes Nek road on Parkgate farm. Vehicles should be parked near the gate that is opposite but not far from a corrugated iron farm building that is on the north side of the road west of the turning to Kloppers Hoek. Enter the gate and walk to the donga that is visible diagonally to the right. Follow the donga upslope, where it deepens to expose layered sediments.

Initial examination of the sediments indicate that they are derived from decomposition of bedrock that lies upslope of them and have been transported to their present position by colluvial processes. At least two palaesols are exposed in the donga. Dollar and Rowntree discovered bone material in the side of the donga, but did not record its position, stratigraphic location, identity, or collect samples. The sediments are now the focus of examination by Dollar.

7. Rhodes to Monard. Water laid deposits. 30°48'S 27°56'E

Between Rhodes and Monard farm entrance the Rhodes to Barkly East road cuts through and exposes water laid deposits of gravel, sand and fine sediments, much of which is derived from the basaltic rocks that overlie the Clarenst sandstones. Bedrock, where exposed under the unconsolidated deposits, is of Clarenst sandstones. The water-laid sediments have been removed by erosion where tributary valleys cut across them. The sediments exhibit bedding and other structures indicative of deposition associated with water flowing essentially down the Bell River valley.

Equivalent deposits have not been identified on the northern side of the Bell River valley. Instead there exist debris lobes (Lewis and Hanvey, 1988) that may be the remains of rock glaciers, and extensive colluvial and possibly periglacial and glacial deposits associated with snow/ice masses that formerly existed on that side of the valley. The absence of equivalent water laid deposits on the northern side of the valley is presumably because they either never existed or (more likely) because they have been removed by erosion. Assuming that the debris lobes are the remains of rock glaciers and that they date to the Bottleneck Stadal, it is likely that the water laid sediments pre-date that stadal.

Lewis found occasional stone artifacts in the water laid deposits in the early 1980s, but unfortunately did not record their exact location or determine their age. The deposits lie more than 5 m above the alluvial floor of the Bell River valley and may be an outwash train associated with the Rhodes-Kimmel kame moraine or a kame terrace formed between the glacier and the valley side. Detailed mapping and sedimentological investigation is needed to establish their origin.
1. **Tushielaw. Debris lobe deposits. 30°48'S 27°57'E.**

This site is on the north bank of the Bell River less than one kilometre west of Rhodes. Vehicles should be parked beside the Rhodes to Barkly East road near the entrance to Earlstown farm (on the south side of the road). Almost opposite the farm entrance there is a gate into a field on the north side of the road. Proceed on foot through this gate, across the field, and through a 'concertina' barbed wire gate in the boundary fence beside the Bell River. The site lies opposite the fence at an altitude of 1 800 m.

Lewis and Hanvey (1988) recognized five lithostratigraphic units at this site (Table 6) when they examined two sections exposed by fluvial erosion in the debris lobe (Figure 24).

![](image)

**FIGURE 24** Sections in debris lobe deposits near Rhodes. Source: Lewis and Hanvey, 1988.

Lewis and Hanvey (1988) argued that the basal muds accumulated due to suspended sedimentation in a small pond. Unit 2, which 'shows internal crude stratification', they interpret as debris flows with component clasts that have experienced frost shattering. Unit 3 they believed to be 'similar to ... rhythmically stratified slope deposits' resulting from 'intense frost action together with periglacial slopewash'.

---

### TABLE 6

**General Stratigraphy of the Rhodes debris lobe**

<table>
<thead>
<tr>
<th>Lithostratigraphic Unit</th>
<th>Description</th>
<th>Facies Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Coarse grade alternating bed facies</td>
<td>Dcm</td>
</tr>
<tr>
<td>4</td>
<td>Massive silts with pebble lags</td>
<td>Fmd</td>
</tr>
<tr>
<td>3</td>
<td>Fine grade alternating bed facies</td>
<td>Dcm</td>
</tr>
<tr>
<td>2</td>
<td>Diamicton (Dm(s))</td>
<td>Fmd, Dmm</td>
</tr>
<tr>
<td>1</td>
<td>Basal muds</td>
<td>Fm, Fmd, PGmm, Dmm</td>
</tr>
</tbody>
</table>

Unit 4 they considered to be either aeolian or water-lain in ponded conditions. Unit 5, they argued, 'reflects some form of freeze-thaw activity ... more catastrophic than that responsible for Unit 3'. They thought that:

- **Unit 1:** formed under 'Interstadial/periglacial' conditions.
- **Unit 2:** formed under Periglacial conditions.
- **Unit 3:** was also of Periglacial origin.
- **Unit 4:** was of Interstadial origin.
- **Unit 5:** was of Periglacial origin.

They produced a model to illustrate the sequence of events that, based on the sedimentary evidence, they thought had taken place at the site (Figure 25).

When Lewis and Hanvey wrote their 1988 paper they did not take into account the possibility that the debris lobe might be the remains of a rock glacier. They ascribed a climatically induced origin to each sedimentary unit, ignoring the possibility that all (or most) of the units could have accumulated in one geomorphic landform, namely a rock glacier. They also failed to consider whether some, or all, of the deposits may have had a glacial origin. Clark and Lewis (1951) have shown that active glaciers in Norway, such as Skauthoebreen, extend over a vertical distance of only some 100 m, and, horizontally, over no more than 220 m: both dimensions are exceeded by the dimensions of the Tushielaw hollow. Finally, although they argued that Unit 2 was composed of debris flows, they did not discuss the possibility that this Unit might be formed of flow tills, which are, in essence, a form of debris flow.
be able to ford the river and ascend the opposite slope along the farm track. Occupants of other vehicles should park then wade the river, then follow the track up the northern side of the valley until a donga is seen beside the track: thenceforth follow the donga.

The sediments exposed in the walls of the donga are the subject of study by Mr. E. Dollar. Near the eastern head of the donga there are sediments that appear to be glaciogenic.

3. **Kilchurn. Gelisfluction deposits. 31°08'S 27°55'E.**

Access to this site, which is at an altitude of 1,920 m, is off the Rhodes to Barkly Pass road, turning east beside Nkonkwezi stock pens. A small church, that is also used as a school, is located near the stock pens and is clearly visible from the main road. Follow the gravel road that leads to Glen Orchy farm: this road is difficult to negotiate when wet. Pass Kilchurn farm house and proceed through the gate. The road turns eastward and runs along the margins of an alluvial terrace. A large fan of superficial material is visible on the northern side of the Glen, with obvious exposures due to fluvial erosion. Park, and proceed on foot across the alluvial terrace to the sections located on either side of a small stream that is tributary to the Sterkspruit.

**FIGURE 26** Slope and river terrace deposits at Kilchurn. Source: Lewis and Hanvey, 1991.

Lewis and Hanvey (1991) showed that the upper fan (12 m Fan) is composed of different sediments from those of the lower (7 m) fan (Figure 26). They believed that slope deposits (the alternating bed facies) rest on top of gravel and silt in the upper fan (Figure 27). Samples taken from locations G - K (Figure 27) were examined in relation to their liquid limits and plasticity and results indicated that the alternating bed facies was deposited as a result of gelisfluction (Figure 28).
The 7 m fan, according to Lewis and Hanvey (1991) is of colluvial origin. Two palaeosols within the sediments (Figure 29) were radiocarbon dated to $2470 \pm 45$ BP (Pu-5089) and $2440 \pm 60$ BP (Pu-5211). Whether the interpretation of sediments shown as colluvium on Figure 29 is correct is debatable: in numerous aspects they resemble alluvial overbank deposits.

The importance of this site is that it indicates, as strongly as comparative studies are ever likely to do, that the alternating bed facies in the upper fan is of gelifluction origin, thereby proving that periglacial conditions formerly existed at the site. Similar fans, or lobes, of debris exist both up and down valley. A number of questions arise at this site, especially:

a) is the sediment in the lower fan colluvium or alluvium?

b) is the upper fan the remnant of a form of rock glacier, or is the alternating bed facies merely low angle gelifluction deposits?

4. Dynevor Park. Head and other deposits. 31°09'S 27°46'E

This site is beside the main road from Elliot to Barkly East about 26 km from the latter town. A road cutting exposes unconsolidated sediments on the western side of the road, at an altitude of c 1980 m.

Lewis and Dardis (1985) recognised six sedimentary facies types at the site, as shown on Table 7.

---

**FIGURE 27** Stratigraphy within the 12 m fan at Kilchurn.

**FIGURE 28** Plasticity chart, that includes deposits from Kilchurn, of fossil presumed gelifluction deposits in England and Wales; clay 'soils' in England and Wales with periglacial shears; modern gelifluction deposits in Norway and Greenland; deposits from the alternating bed facies at Kilchurn. Source: Lewis and Hanvey, 1991.

**FIGURE 29** Stratigraphy within the 7 m fan at Kilchurn.
**TABLE 7**

<table>
<thead>
<tr>
<th>Code</th>
<th>Facies Type</th>
<th>Internal Organisation</th>
<th>Bedding Type</th>
<th>Interpretation of Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dcm</td>
<td>Diamicton</td>
<td>Predominantly clast-supported; massive unstratified or poorly stratified; poor to well-developed imbrication; Boulder-mud admixture; clast dominant</td>
<td>A/B</td>
<td>Periglacial slope deposit</td>
</tr>
<tr>
<td>Dmm</td>
<td>Diamicton</td>
<td>Predominantly matrix-supported; massive; unstratified; pebble-mud admixture; matrix-dominant</td>
<td>A</td>
<td>Periglacial slope deposit</td>
</tr>
<tr>
<td>Gcm</td>
<td>Horizontally bedded</td>
<td>Clast-to-matrix supported-stratified; well-developed imbrication; normal or inverse grading; gravel-sand admixture</td>
<td>B</td>
<td>Fluvial deposit</td>
</tr>
<tr>
<td></td>
<td>gravels</td>
<td></td>
<td></td>
<td>(Microdelta)</td>
</tr>
<tr>
<td>Gt</td>
<td>Trough cross</td>
<td>Clast-to-matrix supported; stratified; cross-bedded;</td>
<td>B</td>
<td>Fluvial</td>
</tr>
<tr>
<td></td>
<td>stratified</td>
<td>normal or inverse grading; gravel-sand admixture</td>
<td></td>
<td>(Microdelta)</td>
</tr>
<tr>
<td>Sp</td>
<td>Planar</td>
<td>Matrix-supported; coarse sand; cosets vertically stacked;</td>
<td>B</td>
<td>Fluvial</td>
</tr>
<tr>
<td></td>
<td></td>
<td>normal or inverse grading; bedding horizontal or subhorizontal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fl</td>
<td>Laminated</td>
<td>Fine-sand, clay</td>
<td>B</td>
<td>Fluvial-overbank deposit</td>
</tr>
</tbody>
</table>

* A - lenticular; B - horizontally continuous.

They published a section (Figure 30) showing that the deposits are exposed over rather more than 180 m from north to south. Much of the northern extend of the ... section consists of alternating beds of ... diamictic head deposits (occurring) as long, relatively continuous layers, inclined at angles varying from 30 to 5 degrees. 'Type A diamictic head deposits ... are generally thinly bedded (0.1 - 0.5 m) and grade northward ... into boulder lags (i.e. stone lines). They consist of angular, frost-broken rock fragments and are clast-dominant. Type B diamictic head deposits occur as thicker beds (0.5 - 2.5 m) and, internally, are poorly sorted and unstratified. They consist of angular, frost broken fragments set in a muddy sand-dominant matrix. Individual clasts are generally oriented downslope'.

**FIGURE 30** Stratigraphy of the Dynevor Park section.

Source: Lewis and Dardis, 1985

Six lithostratigraphic units were noted in the unconsolidated deposits by Lewis and Dardis (1985), as shown on Table 8.

**TABLE 8**

<table>
<thead>
<tr>
<th>Lithostratigraphic Unit</th>
<th>Description</th>
<th>Facies Composition</th>
<th>Inferred climatic Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Upper Head</td>
<td>Dcm</td>
<td>Periglacial</td>
</tr>
<tr>
<td>2</td>
<td>Alternating</td>
<td>Dcm/Dmm</td>
<td>Single or multiple periglacial phases</td>
</tr>
<tr>
<td>3</td>
<td>Bed Facies</td>
<td></td>
<td>Interstadial</td>
</tr>
<tr>
<td>4</td>
<td>Upper Gravels</td>
<td>Gt</td>
<td>Interstadial</td>
</tr>
<tr>
<td>5</td>
<td>Sand</td>
<td>Sp/Fl</td>
<td>Interstadial</td>
</tr>
<tr>
<td>6</td>
<td>Lower Head</td>
<td>Dcm</td>
<td>Periglacial</td>
</tr>
<tr>
<td>7</td>
<td>Lower Gravels*</td>
<td>Gem</td>
<td>Interstadial</td>
</tr>
</tbody>
</table>

* Containing ice-wedge casts

The lowest and oldest Unit, is the Lower Gravels. Lewis and Dardis (1985) noted that the grain size and sedimentary structure of the gravels resembles that found on longitudinal bars, 'which are a common feature of braided stream environments'. They also noted that 'current flow was from S to N at the time of deposition'.

Unit 5 is believed to be a head deposit, 'composed mainly of angular ... fragments of
local bedrock materials ... typically unstratified and poorly sorted'.

Unit 4 is of sand with planar stratification, 'typical of low-energy fluviatile deposits'. Trough cross bedded gravels (Unit 3) overly Unit 4 for c 25 m and appear to have been deposited in a braided stream. Units 2 and 1 are the diamicton head deposits already discussed.

When Lewis first saw the section in 1984, three wedge shaped features existed in the Lower Gravels. The orientation of clasts in these wedges was vertical and subvertical. The wedges were photographed and details of two of the wedges were published in the 1985 paper. Road maintenance, which has involved widening the drainage ditch beside the road, appears to have removed all evidence of the wedges, but part of one of them is clearly depicted in the 1985 publication: they were not, therefore, fragments of a fevered scientific imagination! Lewis and Dardis interpreted the wedges as the casts of ice-wedges, which form under permafrost conditions.

Pévé (1966) argues that mean annual air temperature has to be at least - 6°C for ice wedges to develop, while Romanovskij (1976) has shown that, in gravels similar to the Lower Gravels at Dynevor Park, mean annual ground temperatures have to be at least - 5°C to - 7°C for ice wedge formation. Lewis and Dardis (1985) therefore concluded, having ascertained the mean annual air temperature of various third order meteorological status in the Drakensberg, that the ice wedges formed when mean annual air temperatures were c 15°C less than those of the present.

Lewis and Dardis (1985) also argued that the sand and gravel that forms Units 4 and 3 were 'fluviatile braided stream deposits' laid down under interstadial conditions. The lower and upper head Units (5 and 1) they interpreted as 'periglacial head deposits, which reflect the former operation of gelification and frost creep processes'. Williams (1961) has shown that such deposits form where warm summers do not occur and where the mean annual air temperature is less than 1°C. Karte (1983 states that the Freezing Index (°C days/year) lies between 800 - 7 000 during the deposition of this type of sediment. Lewis and Dardis (1985) concluded that Units 5 and 1 were deposited under less harsh conditions than those evidenced by the ice wedge casts, when mean annual air temperatures were probably only c 14°C less that at present. Finally, they argued that two cold phases are evidenced in the Dynevor Park section, separated from each other by warmer, interstadial conditions.

In 1990 Lewis discovered insect bearing sediments exposed beneath the heads 85 m from the northern end of the section (Figure 30). These deposits had been exposed by roadside maintenance when the roadside ditch was widened and deepened. Although entomologists at Rhodes University examined the remains they were unable to identify them, except as being 'insect'. The remains date to 31 600 ± 950 BP (Pta 5637). Although the stratigraphic situation of the insect bearing sediments is unclear, since the sediments that presumably underlay them have not been exposed, it is possible that they accumulated in interstadial conditions. They may, therefore, witness the presumed interstadial between the cold phases in which the ice wedges formed in the Lower Gravel and in which the alternating bed facies and upper head accumulated.

The evidence from Dynevor Park supports that which has been presented from many other sites during this Field Meeting: that two stadials, separated by an interstadial, are evidenced by Quaternary sediments in this region. Furthermore, the earlier

(Eliasdale) stadial appears to have been colder than the more recent (Bottelnek) stadial.

A number of questions are posed by the sediments at Dynevor Park:

i) were the Lower Gravels deposited in a braided stream environment due to the melting of ice in the region, i.e. are they sandur (outwash) deposits?

ii) are the wedge shaped features in the Lower Gravels really the casts of ice wedges?

iii) what is the relationship of the insect bearing deposits to other sediments at the site?

iv) were Lewis and Dardis (1985) correct in interpreting the alternating bed facies and the Lower and Upper Heads as gelification deposits?

Some of the questions can only be solved by further research. Examination is needed to establish the relationship of the insect-bearing to other sediments. Entomological studies are necessary to identify the insect remains and ascertain the climatic and other conditions under which those insects lived. Thin section and other laboratory analyses are necessary to establish whether the 'gelification' deposits really were of geliffuctional origin.

5. Dinorben. Bushman paintings. 31°10'S 27°45'E.

The site is accessible via a gravel road that joins the Barkly East to Elliot road c 28 km from Barkly East. Vehicles should be parked beside the farm buildings at Dinorben farm. Proceed on foot into the garden behind the farm house, having first informed the staff of one's presence. The site is a cliff face at the bottom of the garden, approached via a rickety foot bridge.

The area in which this Field Meeting has been held was occupied by Middle Stone Age people from an unknown date until c 22 000 BP (Opperman, 1992). By 10 200 ± 100 BP (Pta-3451) people again inhabited the region, as evidenced by archaeological investigations at Ravenscraig (31°0'S 27°47'E) where there is a rock shelter at an altitude of 1 850 m on the western slopes of the Sterkspruit valley (Opperman, 1987). The Sterkspruit is the valley in which Kilchurn (Site 3 of Day 3 of this Field Meeting) is located. No evidence has been reported for occupation between c 22 000 and 10 200 BP which is not surprising in view of conditions at and above 1 800 m at that time, as demonstrated during this Field Meeting (e.g. active rock glaciers, snowbeds associated with the development of protalus ramparts, gelification).

During the Ravenscraig (i.e. Holocene) there is evidence that, until the nineteenth century AD, the area was occupied at least seasonally by Late Stone Age hunter-gatherers (Opperman, 1987). In the early nineteenth century three groups of San hunter-gatherers lived in the region of the East Cape, East Griqualand, adjacent
Lesotho Drakensberg. Of these the Nqabayo occupied the area that included the Barkly Pass.

The Nqabayo, c. 1850, consisted of 'approximately 43 men' with their families. They were occasionally joined by Xhosas, on a temporary basis. The men hunted eland, buffalo, hartebeest, wildebeest and other game, using poisoned arrows and other weapons. They also engaged in stock theft. The women gathered plant food, cooked, and looked after the rock shelters in which they lived. The Nqabayo, like other hunter-gatherer groups, followed seasonal migratory patterns, following the game on which they depended for survival (Opperman, 1987).

According to oral tradition a group of San (Bushmen) who had stolen cattle were tracked by a farmers' commando to Dinorben in 1870. The stolen cattle, plus Bushmen, were located in the depression between the cliffs where the modern sheep pens and sheds are located. Members of the commando surrounded the site on top of the cliffs, opened fire, and exterminated all but one of the hunter-gatherers. The sole survivor, according to oral record, was last seen fleeing eastward up the adjacent valley side. Thus, if tradition is correct, all or many of the Nqabayo were exterminated at Dinorben.

The rock paintings clearly depict eland, buffalo, and various smaller antelope, as well as baboons and people with animal features (therianthropes). Shamans and people in trance are also depicted, as are hunting scenes, possibly procreative and natal scenes, and snakes. Power lines, the lines leading from the nostrils of people and animals, are also depicted and may represent semi-religious ideas, as suggested by Lewis-Williams (1990).

The hunter-gatherers were the last of a line of Stone Age people who, presumably, experienced the climatic changes responsible for the sediments and geomorphic features that have been the subject of this Field Meeting: as a consequence it is appropriate that Dinorben, with its beautiful paintings, should be the last stop on this SASQUA Field Meeting in the East Cape Drakensberg.

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