MASTER

A contribution to

THE GEOMORPHOLOGY OF THE EAST CHEVIOT AREA.

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Acknowledgement.

In any research project it is obvious that many individuals are called upon to express opinions, pass judgement, offer advice and, generally speaking, 'help the business along'. This has been my own experience, and I wish immediately to express my appreciation and thanks to all those who have in some way assisted me in this work.

Especially would I mention Prof. A. G. Ogilvie and Prof. A. Holmes, my supervisors, for their patient guidance and sympathetic understanding. Then too, over the Border, Profs. G. H. Daysh, T. S. Westoll and G. Hickling, my former teachers, have always been readily cooperative and interested in my progress. Amongst my colleagues in the Geography Department at Edinburgh, Dr. R. Miller deserves particular mention, and at Newcastle my former tutor, Dr. S. I. Tomkeieff, has helped immensely on matters petrological.

To the Geological Survey I am especially indebted, not only for the material contained in their memoirs and maps, but also for the assistance given by Mr. Anderson (Newcastle), Mr. Eckford (Edinburgh) and Mr. Knox (Edinburgh).

Finally, there are all those who remain anonymous - but not forgotten.

R. Common.

October, 1952.

I wish to acknowledge grants received from the Moray Fund and the Carnegie Trust, which helped to defray the costs of fieldwork, as well as supply ing an Aneroid barometer.

PREFACE.

The research work on the N. Cheviot area was undertaken with three primary aims in view,

1) to provide material which would be of practical use
2) to provide material which would be of academic interest
3) to satisfy the writer's need for experience in his chosen subject.

It is maintained that as the geologist is to the geomorphologist, so must the geomorphologist be to the geographer, by providing in his work material of both practical and academic interest. Like the geologist, the geomorphologist must be prepared to provide detailed descriptions, as well as generalising about the landforms, a need more than ever enhanced following the recent appearance of the Soil Survey who also work close to the ground and in detail. Again, who can estimate what use a thorough study of an area may be in the hands of County Planning Authorities? At the outset the writer makes no apology for the length of the text, for what is included is considered to be appropriate. However, to ease the reader's task, pictorial representation is employed to the full. To cover only part of the area, the Geological Survey run to four memoirs, and, like the Survey, the writer has striven to satisfy needs for the particular as well as the general.

In the academic sphere the writer has noted the deficiency in the knowledge of denudation chronology in Northern England. In time it should be possible to correlate the "surfaces" suggested by the writer, but at present, for the reasons stated in the text, it is considered better to await the results of adjacent areas. Glaciation and its effects bear markedly on the landforms and rivers in the area, and also have been considered. Here, too, unfortunately, the story is an incomplete one, but at least a beginning has been made. The reader, plodding through the essay details will find frequent rhetorical questions, and, whilst these may occasionally be irritating, the writer asserts that progress and experience come from attention to the exceptions.

There is little need to go into the details of the third aim as it represents a bridge which all must cross.

To conclude this general preface, the writer wishes to add several comments about the work itself. Field mapping was carried out using the provisional 1:25,000 sheets (War Edition) chiefly. The new 1:25,000 sheets were used for part of Tweedside, but, since the 6" reductions (with coloured contours) were found to be more satisfactory, the new sheets were abandoned. Again, because of the nature of the ground and the area involved, the most suitable scale for mapping the results of fieldwork was found to be the ½" scale. It cannot be too strongly recommended that vertical air photographs* be used during the later stages of field-

*It is a matter of chance whether or not satisfactory air obliques are available to the worker.

work, and in the period following fieldwork. The air photographs at about 2½" scale were found to be best suited for this type of work. They are excellent for showing space relationships, economical and they give the user adequate detail, besides which, they match the field map scale. It is noted, for example, that in the Bowmont valley the lava strike shows beautifully on 2½" air photos. covering the area and can be appreciated more quickly than in the field. Quickly, too, the worker has to decide whether he will work systematically or attempt to take a broader view of the geomorphology. Personal experience shows that an average of one important geomorphological feature comes along each day. Further, since many geomorphologists are also geographers, it is considered by the writer to be a better thing to write about the landforms and landscape first, than merely to abstract and generalise immediately, leaving the reader to wonder just what the ground really does look like.

THE GEOMORPHOLOGY OF THE E. CHEVIOT AREA.

Lying at the eastern end of the Border hills the Cheviots look down on Teviotdale and Tweedside to the north but, in contrast, are backed by bleak moors and fells about Redesdale to the south. To the east they are separated from the coastal plain by one major and two minor cuestas, developed on sedimentary rocks and disposed roughly en echelon. Whilst the Cheviot (2,676') dominates the surrounding country, its summit is truncated and is now virtually covered by bleak, cheerless, peat hag. Looking westward from this summit the observer is impressed first by the ridges and incised valleys falling away northwards from the principal watershed, then by the still lower summit levels of Lower Teviotdale, above which igneous masses rise in places. Immediately south of and parallel to the Border, in Upper Coquetdale, a trough of relatively lower ground is drained by deeply incised streams, but further afield to the south-west, the tabular outlines of sandstone fells appear. To the south of Cheviot, both Cushat Law and Bloodybush Edge stand as monadnocks upon plateau fragments, and beyond the Cementstone vales of the Aln and mid Coquet the overlying sandstones form an imposing scarp face. In the eastern half of the Cheviots, relics of erosion surfaces give rise to a bold stepped sky line. In the northeast sector these steps are more numerous than in the southeast sector, where breaks of slope are therefore greater. Again, from the same vantage point on Cheviot, the inward facing, occasionally multiple sandstone scarps can be seen sweeping round from near Rothbury, to the east and then northwards. In this traverse, too, the tripartite division of the Cementstone area into basins becomes apparent, with the lowest of them (Milfield basin), forming an appendage to the Merse drumlin area. Beyond the major cuesta, to the east, the inward facing whin crags of the Farne Islands and Budle are just visible, whilst the Longridge to the north can also be seen.

In the core area lies a mass of Lower Old Red Sandstone lavas representing the denuded remnants of a volcano, which originally must have been comparable in size to (the present) Mount Etna. Subaerial in nature, the lavas are now limited in the north and south flanks by boundary faults, and, whilst they pass under Carboniferous sediments to the east, the base of the series and underlying Silurian sediments are exposed on the high ground to the west. Within these lavas and extending to about 22 square miles (of Northumberland) is

(See M.F. p. 2)

the Cheviot granite. Originally interpretated as a laccolith, this granite is now considered to be a replacement and probably it occupies the major vent of this old volcano. Subordinate, but nevertheless responsible for many minor features in the field, are the various types of porphyrite dykes. These form two swarms aligned N.N.W. and N.N.E. respectively and also pierce the granite.

The bulk of the lavas are andesitic although felsite, ash and agglomerate also occur, and, as might be expected, the different igneous rocks vary in their resistance to subaerial denudation. Ashes weather in rough, irregular fashion, weathered agglomerates show knotty surfaces, whilst glassy andesites weather into smooth faced angular blocks with a tendency to exfoliate. Again, whilst the andesites about Cheviot granite form an aureole of tougher rock, gray in colour, north of the River Glen the alternating hard and soft flows correspond to ridges and troughs in the present landscape. The granite, too, is variable, and although its outcrop area is broadly coincident with the highest ground, this is by no means a hard and fast rule.

In this igneous complex two fault and crush systems are recognised, an older N.N.W. and N.E. system together with a younger W. - E. system. Associated with these are two crush breccia types, a quartzose type which is resistant to erosion and tends to form minor upstanding features, also a less resistant calcitic type now generally associated with gullies and depressions. Without doubt the effectiveness of crushes in influencing present topography can best be demonstrated about Scotsman's Knowe (1 mile south of the Cheviot). Here running S.W./N.E. across the massif is the Harthope crush (traceable for 15 miles) whilst the valleys of the upper Davidson burn to the S.W. and the upper Breamish to the S.E. also coincide with crush lines. On a smaller scale, too, the coincidence of stream and crush lines is frequently to be observed in the massif. Finally, one also notes how circumdenudation and differential erosion rates have produced fault line scarps along the north and south boundaries of the igneous area. These features, although eroded, do give the Cheviots a horst-like appearance, particularly when viewed from the east.
(See M.F. p. 3.)

Girdling the igneous complex in crescentic fashion lie sediments of Lower Carboniferous age, whose inner margin extends eastwards from near Kelso then south by Wooler before turning westwards then north-westwards towards Chesters (Roxburghshire). Outwards from the lavas to the N.E., E., S.E., and S. the sediments become progressively younger in age although there is duplication to the east because of faulting
(See M.F. P. 1.)

Igneous material also occurs in the Carboniferous area, and as with the O.R.S. there is much variety in type and distribution, for whilst Lower Carboniferous plug and trap rocks lie in the horns of this crescent, Upper Carboniferous dyke and sill intrusions occur in the E. and S.E. of the area under consideration.

The sediments are mostly arenaceous in composition but shales and limestones, though subordinate, are common, whilst marls and thin workable coals are restricted. The basal Cementstone group (like the Scremerston Coal Measures) shows a facies change when traced southward, and although the Tweed, Till, upper Aln and mid Coquet valleys lie in rocks of this group it also forms bold ridges in the upper Aln valley (the Glanton ridge and Wandystead ridge). The Fell sandstones which overlie the basal group are responsible for the most striking topography in the sediments. Massive sandstone is characteristic with strongly developed vertical and horizontal rock jointing frequently seen e.g. Kyloe Hills, St. Cuthbert's Cave. Whilst the sandstone is finer and less resistant in the north, shales become important enough to divide the group into three in the south, thus forming a triple line of crags along the right bank of the Aln, (at Callaly, Lorbottle and Edlingham) each corresponding to the sandstone. Above the Fell Sandstones come the Scremerston Coal Measures and the Limestone group which both contain thin workable coals, shales and limestones - but all subordinate to sandstones. These latter occasionally are associated with craggy landforms but except in stream courses and coastal sections the limestones rarely produce distinctive natural features.

The present structural arrangement of the area is believed to be predominantly Hercynian in origin, with the faulted and folded Carboniferous sediments adjacent to the Cheviots bounded by the Tweed trough to the north and the Rede trough to the west. (Structural causes have been suggested for both troughs by Gregory and Hickling respectively). Here lie the two large Holburn and Lemmington anticlines, both fault bounded to the west and both asymmetrical with steepest limbs also to the west. The Holburn anticline trends and pitches northwards, being separated from the adjacent Hetton syncline by the Hetton fault. Southward this anticline dies away but is almost immediately replaced by the Lemmington anticline, whose axis is aligned S.S.W. - N.N.E. This anticline is not accompanied by a complementary syncline west of the Bolton fault, instead, the ground has been disturbed by splay faulting. In addition to these large folds minor flexures occur, especially in the S.E., but these do not appear to make significant contributions to the present landscape. (See M.F. p.3, p.4).

The general fault pattern alters when traced from north to south. North of the Holburn anticline, the faults converge on Haggerston in fan-like fashion but southwards the characteristic alignment becomes N.E./S.W. and throws increase considerably (e.g. Chillingham fault 1,000' throw). Further south still, over and east of the Lemmington anticline, fault line alignments vary between E.N.E. and E.S.E., but the splay faults coming off the Bolton fault to the west show southwesterly trends.

Whilst the coincidence of the anticlines and high ground, and the relationships of the Hetton and Coe valleys to the Hetton and Bolton faults are immediately evident, a closer examination of landscape details shows still further the intimate relationship between fault line and topographical feature (e.g. along the cuesta scarp faces, the site of the Aln water gap). Several of these fault lines, too, have determined the spread of the Whin Sill. This sill is a quartz-dolerite of late Carboniferous age, and where present in the landscape it seldom fails to create strong features.

Difficult though it be, at times, to visualize the processes operative in more favoured areas, here in the Cheviots there is a gap in the geological record from Upper Palaeozoic - Quaternary times*. However, by way of compensation, the observer is provided with a more complete record of the later stages of glaciation, in the form of deposits, modifications to pre-existing drainage lines and meltwater channels. Whilst it is recognised that past climates would produce variations in the efficiency of subaerial denudation agents acting in the area, this aspect has so far only received preliminary consideration. Yet might not the landscape be described also as composite - in so much as it has been subjected to more than one climatic regime? With these considerations in mind it will be apparent that for the present only a tentative denudation chronology can be suggested for the area, although the presence of erosion surface fragments† has been demonstrated both in the field and by the use of graphical methods. (See M.F. p. 8, p. 9)

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*Only a solitary dyke of the Tertiary swarm crosses the area and this, the Acklington dyke, is dated as being of late or post-Eocene age.

†In the delimitation of these surfaces attention has been given to the slope factor, depth of overburden and relationships to associated features e.g. valley benches.

At present the landsurface, whose major elements were already fashioned in pre-glacial times, is subjected to subaerial denudation under normal conditions. But even so, from the evidence of wasting peat hags on the higher parts of the massif, there appears to have been climatic amelioration within comparatively recent times. As for the coast, the writer believes that the present sea level is of comparatively recent origin and relatively higher than that of pre-glacial times. The views of Anderson and Woolacott, who independently suggested late or post-glacial sea levels of 200 O.D. and 150' O.D. are now supported, whilst the recorded fragments of submerged "forests" along the Northumbrian coast are cited as further indicators of change in sea level. The coast is interpreted here as being a submerged type which has been subjected to oscillations of sea level. These have led to partial emergence so that the present coast is now in a youthful stage.
(See M.F. p. 29)

Examination of areas of gentle slope in the higher ground show that these are, in fact, remnants of distinct erosion surfaces now mapped for the first time. As the map of erosion surfaces will demonstrate there is a greater number of fragments on the igneous massif than on the cuestas, and it is on the massif alone that the older surfaces are seen. As already mentioned they are best preserved in the northern and eastern parts of the massif where the relief rises in terrace-like fashion into the core with "treads" separated by "risers" of about 200' height. The following three surfaces are easily recognisable:-
(See M.F. p. 12)

1) <u>950'/1,000'-1,200'</u> Though reduced in places to the ridge state, fairly extensive remnants remain elsewhere.
2) <u>750'-550/500'</u> Also reduced to the ridge state on the massif.
3) <u>1,300'-1,500'</u> Remnants of this surface are most striking in the northwest, and it is suggested that southward retreat of the principal watershed was early accomplished.

Between 1,550' and 1,850' there seem to be two surfaces <u>viz</u>:-

4) <u>1,550'/1,600'-1,700'</u> Remnants of this surface occur on or just south of the principal watershed.
6) <u>1,750'-1,850'</u> In the core or the massif there are numbers of accordant summits, a plateau remnant S.S.E. of Cushat Law and a marked topographical break at 1,750'. These however are much less pronounced than the three above mentioned. In addition three further groupings of summit heights may be significant.
7) <u>2,000' and over</u> Few summits occur at this height within the area and therefore there can be no certainty as to the former existence of an erosion surface. The contrast,

however, between the group of summits at 2,000' and those at 2,350' is noteworthy.
8) 900' - 800' Any surface at this level has now largely been removed, but its former existence is suggested by summit accordance on the foothills of the Cheviots.

Monadnocks are commonly encountered, indicative that higher surfaces were formerly of greater extent, and again within the major valleys bench remnants occasionally have been preserved. Dissection of this ground to the ridge state is common north and west of the College stream, but eastwards the degree of stream dissection is less. To the southeast a wedge of relatively low ground is driven westwards into the heart of the massif. From the apex a former high valley line can be traced between Lintlands and Linhope, whilst further east the present Breamish is incised into a plateau-like surface at a lower level, - No. 1) above mentioned, which has its best development here.

Of the surfaces described for the massif the following also extend on to the sediments:-

1) 950'/1,000' - 1,200'
2) 750' - 550'/500'. This surface is plainly seen in the Quarryhouse moor area.
8) 900' - 800'. Like 1) remnants of this surface become more numerous southward on the major cuesta.

In addition to these is the lowest surface of all:-

5) 350' - 550'/600! Clearly seen on Barmoor between 350' - 400' fragmentary evidence from the head of Milfield Plain suggests an upper limit of 550'/600'

The Longridge to the N.E. of the massif probably served as a divide between the lower Whiteadder and Tweed in preglacial times. South of it, now, there is first a limited eastward extension of the Merse drumlin belt and then the ground rises on to the minor and major cuestas. Both cuestas show steep, though irregular, west facing scarp fronts whose northward lowering crest levels (i.e. north of Ros Castle on the major cuesta) have been severely modified by ice erosion. Because of the incomplete bevelling of summits, an observer now viewing the cuestas from the east sees the scarp front crests upon ridge-like or hogback features which rise above the general level of Barmoor and Holburn moss in the north. Southward, on the major cuesta, summit levels increase, with odd residuals in the west rising above a partially eroded 750' - 550'/500' surface. Here the low, undulatory topography of Quarryhouse moor shows peaty deposits in ill-drained sites and duplicates the characteristics of the Barmoor and Holburn moss areas, but pronounced glacial graining diminishes to the southeast. South of the River Aln, because of structure and the state of dissection there is multiplication of inward facing scarp fronts, and summit levels increase still further to the southwest. Along the whole length of the eastern flank of the cuesta, slopes generally are steep although small "treads" occur southwards (e.g. near Adderstone, south of Warenford and, more extensively, near Rock).

The extent of the coastal plain in the north is restricted by the Longridge, the major cuesta and the ice eroded Whinsill crags running eastward to Budle Point. Again, whilst the seaward end of Longridge is being actively eroded, with the production of unstable cliffs and wave cut features, low depositional coastal features are seen to the south. Beyond Budle Point to Howick it is the Whinsill which produces stronger coastal features, although low sea cliffs occur on the arched sediments at Seahouses. Interspersed along this stretch there are numbers of restricted alluvial flats behind blown sand deposits and several extremely interesting geological sections. Inland, a pocket of low-lying ground about Belford lies adjacent to a trough of low ground stretching southwards from Waren Mill, but otherwise the coastal plain is undulating. From Howick to Alnmouth the Whinsill's absence removes character from a low cliffed coastline, whilst inland it is the Whin which forms the inner limit to the coastal plain in the Littlehoughton area. (See M.F. p. 25)

It will be obvious, therefore, that the present landscape, though adjusted to structure, is not wholly due to this alone. Major and minor elements in the present topography are as much due to processes which were interrupted at intervals and which followed the dictates of climatic changes. Thus, whilst the area is in a state of mature dissection it is essential to qualify this statement by noting that remnants of older erosion surfaces to remain on the higher ground of the Cheviots proper.

In Pleistocene times the erosional and depositional processes of ice moving over the area were most important, (especially the latter on the low ground), but conditions favouring severe weathering on the massif during late Pliocene, Pleistocene and early Holocene must not be neglected. It is considered that ice did not override the highest Cheviot summits at maximum glaciation, nor did Cheviot form a centre of ice accumulation and dispersion. Along the east side of the massif the ice level appears to have attained 1,700' - 1,750', and above this height the numbers of shattered tors probably result primarily from multigelation under periglacial conditions (e.g. the Standrop tors, on the Cheviot also). Between 1,700' - 1,000' there are numbers of crags which probably were covered by ice for only a relatively short period. They, too,

are markedly weathered and generally show alignments consistent with ice flow directions. To explain the peculiarities of the glacial deposits in the massif the writer suggests that a period of deep weathering preceeded that of maximum glaciation. The rock waste so produced was removed by ice, and although the bulk of this detritus was carried afield some of it would be deposited in the valleys. This incoming and overriding ice which caused erosion of obstacles and "bottlenecks" in the line of flow must originally have been clean, for "foreign" erratics are absent from the massif proper, appearing only on the margins at lower altitudes. Judged by the minor landforms produced by glacial erosion (especially in the Bowmont and College valleys) and the variability of valley forms within the Cheviots it appears that during maximum glaciation the upper ice layers moved in directions independent to those of the lower layers, whilst some form of glacial protection occurred in the valleys proper. At a later stage a series of well-developed meltwater channels was cut round the east end of the Cheviots from Upper Coquetdale into the Bowmont valley. These, together with the variable and often considerable thicknesses of drift deposits in the Till, Breamish and Aln valleys seem to indicate a halt or retardation in the rate of ice recession. Evidence of proglacial lakes is variable and generally poor, but former levels of about 500' in the Bowmont and 400' in the College valleys are suggested. Much more probable however is a 300' lake level in the Hedgely-Chatton basin (with an associated delta between E. Lilburn - New Bewick) Wooperton) and also at the same height in the M. Aln valley. On the other hand the 200' and 150' "Lake Ewart" levels in Milfield Plain are now considered to be of late or postglacial date and not lacustrine in origin. To seaward, erosion by southward deflected ice has been especially severe on features lying transverse to the direction of ice flow, e.g. the sandstone scarp crests and the Whinsill, but elsewhere with rock strike and/or pre-existing features correctly aligned the ice has merely accentuated the topographic graining, e.g. near Embleton. Overburden thicknesses show considerable range on the coastal plain too, but in contrast to the inland vales the volume of drift deposits is smaller and takes the form of a chain (e.i. the Bradford Kaim and continuations). The form of the drift deposits and the minor set of meltwater channels on the cuesta dip slope presumably date from the time when ice retreating northwards along the coastal plain had become separated from stagnating ice in the Cementstone vales to the west.
(See M.F. P. 26, P. 27, P. 28.)

Small discontinuous benches, possibly due to periglacial conditions, exist in the College and Bowmont valleys together with solifluction products in the upper reaches of most valleys.

As yet no patterned ground due to frost action has been examined and one wedge feature in the Thrunton Tileworks Lake Clays (Mid Aln valley) might be interpreted equally as a "washout" as due to frost action. There are nivation hollows on the higher ground, but the writer does not accept the Bizle or Henhole on the Cheviot to be corries. Instead, they may be relic features subsequently modified by nivation, or entirely due to nivation.

Prior to glaciation the land surface had already reached a state of maturity but by epicycles rather than by one or more uninterrupted cycles. Yet, although the topography is adjusted to structure, interruptions to denudation have allowed fragments of higher erosion surfaces to be preserved on the tougher rocks of the igneous massif. At present it is a matter of opinion whether these higher bevels (i.e. above the 1,000' - 1,200' surface) are considered subaerial or marine in origin, normally developed or pediments produced under more arid conditions. Moreover it is possible that the surface now between 1,750' - 1,850' represents the exhumed base of Permian rocks formerly covering the area.

Despite the importance of quasi-horizontal lines in the distant view of the Cheviots the bulk of the massif is under steeper slope owing to dissection by rivers and modifications by glaciation. The present pattern of the valleys and their form appears to be most satisfactorily explained by the following sequence of events before and after glaciation. On the north side of the massif it is suggested that streams originally flowed from south to north and were parallel. Unequal rates of headward extension and the preservation of higher residual areas (especially about the Cheviot) because of structure and interruptions to process have led to the emergence of a radial pattern at the east end of the massif. Again, whilst the lower courses became increasingly adjusted to structure in the stages following the formation of the 1,000' - 1,200' surface further abstraction and capture probably occurred in preglacial times. More recently the lower stretches of the Kale, Bowmont and Kilham burns have been diverted by ice and by glacial deposits. Indeed, the former appears to have been temporarily diverted eastwards and later permanently westwards. Some may consider these diversions to be excessively hypothetical, but the glacial deposits 2 miles S.E. and S. of Cornhill are of the order of 100' in depth, concealing part of the pre-glacial courses of the Kale and Bowmont. Moreover an examination of the deep cuttings near Wooler will demonstrate convincingly the capacity of meltwater for erosion.
(See M.F. p. 13, p. 14)

South of the River Glen the sequence of events is more difficult to discern because there is little reliable evidence, and some of this is subject to alternative interpretation. One factor primarily decides whether the interpretation offered stands or falls - the acceptance of the supposition that a watershed formerly joined the Ros Castle (1,036') monadnock to the igneous massif. It is considered that during the cutting of the 1,000' - 1,200' surface, the College from flowing northwards shifted its lower course monoclinally. Subsequently, a tributary cutting back eastwards from the College along the lava/Cementstone junction is believed to have captured successive streams, up to and including the Harthope, which were tributaries of a northward flowing, fault guided Hetton burn. Meantime, south of the Ros Castle divide an eastward flowing Breamish stream possibly was joined by two S.E. flowing left bank tributaries, one from the Threestoneburn basin and the second flowing over part of the present Hedgely basin (Rosedean - New Bewick?). At this period the Aln is considered to have been a right bank tributary, a strike subsequent guided in part by the line of the Bolton fault to a confluence point on Longlee Moor (nr. S. Charlton). The lower Breamish probably flowed east through the site of the present Englingham gap to pass north of the site of Rock, (along the line of the Rock fault) until the completion of the 750' - 550' stage. Break through of the Ros Castle divide from the north with capture and realignments of the Breamish and Hetton, was accompanied by diversion of the former Aln to the south, effected by a dip slope tributary of the Coquet which extended its headwaters over the faulted area near Hulne.

The effects of structure and process have already been indicated for the Bowmont, College and Harthope streams and although the original alignment of the Breamish is problematical, its upper valley is now coincident with a "crush" and then with the granite/lava junction. All these streams show deep and well established valleys through the massif, each of which possesses its own distinctive outlines. Furthermore, whilst glacial deposits, odd low terrace fragments and haughland are more pronounced downstream in each valley, variability of form and thickness precludes sweeping generalisations. The glacially overdeepened Milfield, Hedgeley and Chatton basins were later the site of glacial dumping and in the former the Glen and Till streams now skirt the Milfield delta, produced when the basin was flooded to 200' O.D. Linking these basins is the Weetwood water gap, (interpreted as being of meltwater origin) and to the south of it the Till and Breamish skirt another delta, formed beneath a 300' lake level*. The present River Aln shows a lower tract incised into drift deposits infilling part of the former valley, whilst the upper tract now appears misfitted and flowing in a valley enhanced by glacial erosion. Youthful streams on the eastern slopes of the major cuesta and on the coastal plain at present are controlled by depth and form of glacial deposits, form and alignment of glacially eroded features, besides the dip slope itself. On Tweedside and north of the cuestas initial stream development in drumlin topography is seen, with the Tweed below Coldstream and the Till below Etal occupying post-glacial valleys.

Thus the development of the drainage pattern has depended upon the following factors

(a) The struggle between original stream alignments and geological structure.

(b) The interruptions to development because of base level changes with preservation of higher residuals upon an igneous massif undergoing exhumation.

(c) Additional changes induced by lithological variations

(d) Glacial interference.

On a regional basis the area is subdivisible into units which correspond to the igneous massif, the basins between the igneous massif and the major cuesta, the major cuesta and the coastal plain. Closer inspection of these units however suggests further subdivision is possible, into smaller but nevertheless distinctive parts. In the delimitation of all these physical units, whether on a regional, area or locality basis (- map folder p. 30 -) attention has been paid to the factors of altitude and slope, lithology and structural relationships, state of dissection, type and thickness of overburden.

*It is to be further noted that parts at least of the Roddam and Lilburn valleys are of meltwater origin.

CHAPTER 1.

GEOLOGICAL BASIS

It is proposed under this heading to consider briefly and so far as is relevant the salient features of lithology and structure. Whilst the approach in this section is broad, details of locality and site will be included in the main essay to aid landform interpretation. In view of the large area to be covered, the author has been obliged to accept generally the published views of various geologists, confining himself to checking, except in some instances where it was possible to examine new exposures. Two other points which should be noted concern the literature and also the fieldwork. Firstly, there is a dearth of material dealing with the O.R.S. sediments in Roxburghshire and secondly, the degree of masking by superficial deposits in low lying areas makes it difficult to reach a truly satisfactory interpretation.

GENERAL STATEMENT.

Examination of the solid geology map (Map 1) M.F page 1. covering the Cheviot area reveals the following general features

1) In the core area lies the mass of L.O.R.S. andesites, long upstanding and therefore greatly reduced by erosion. Their outcrops are cut off on the North and South flanks by boundary faults, contrasting with a partial fault boundary on the N.E. margin and still more with the western area where the lavas in places are covered by younger rocks or lie close to exposures of the underlying Silurian strata. Within these lavas and covering about 22 square miles lies

lies bhe Cheviot granite, earlier interpreted as being a laccolith formed by a single intrusion in O.R.S. times (Geology of the Cheviot Hills. Geol. Survey 1932). The more recent view however is that this is a replacement granite,(verbal statements by Prof. A. Holmes and Dr. S.I. Tomkeieff) and exposures examined during fieldwork tend to support this view. Geographically the granite outcrops in Northumberland and imparts an asymmetrical aspect to the whole complex.

2) Girdling this core in a broadly crescentic fashion lie rocks of Lower Carboniferous age. Their inner margin runs eastward from near Kelso, swings south through Wooler before finally turning W.N.W.towards Chesters. Outwards from the Andesites to the N.E., E., S.E., and S. the rocks become progressively younger in age, although the succession is duplicated to the East because of faulting. The "horns" of the crescent are distinctive in showing L. Carboniferous igneous rocks and sediments belonging to the basal Carboniferous groups.

3) The L. Palaeozoic sediments do not reveal an immediately apparent ground plan. L.O.R.S. rocks form the greater part of exposures in lower Teviotdale with Silurian rocks showing only in small windows through this cover. It is also suggested that the O.R.S. sediments formerly covered a greater area (B.R. Geology " Southern Uplands" J.Pringle Page 57) and have been stripped back by erosion. Recent work too (Trans. Edin.Geol.Soc. 1948 MacGregor and Eckford

Eckford) in the Jedburgh area has thrown doubts on the validity of the view that some of the local sandstones are "Carboniferous outliers".

The most extensive Silurian outcrop occurs in the present watershed area, showing through the covering of volcanic and sedimentary materials.

4) There is a contrast in the type and distribution of Carboniferous igneous rocks. Early Carboniferous activity occurred in the northern and western areas producing "plug and trap" whilst late Carboniferous activity was associated with dyke and sill intrusions lying in east and south-east areas.

5) Finally, attention is drawn to the Acklington dyke which trends W.N.W across the area. It is one of a swarm of Tertiary age which is dated by reference to the Ardtun plant bed (Tertiary Volcanic Districts J.E.Richey B.R.Geology 1935). The dyke is of late or post Eocene age thus affording a datum for geomorphological considerations.

STRATIGRAPHY

STRATIGRAPHY. The Silurian sediments on the Scottish side of the Border "show a fairly constant dip S.E. though now and again these beds roll over and dip in the opposite direction" (The Silurian Rocks of Britain. Geol.Survey 1899). The succession is one of thinly bedded blue and grey graywackes and shales. It is also noted that approaching the watershed from the N.W. shales become commoner, graywackes finer. Clough ("Cheviot Hills

Hills" (English side) 1888 Geol. Survey) notes in the Makendon-Harden Edge area the occurrence of occasional coarser bands, reversals of dip and apparent uncomformity between the softer and harder shales (compaction or slumping effects?).

To these observations not a great deal more can be added, save for the following generalisations. Despite variations in the strata from a geological standpoint, they are relatively homogeneous in their resistance to erosion. Again, in parts of Teviotdale, although Silurian rocks are not actually exposed, one has the impression that, like the ribs of a thin man, they are not at great depth, and contribute to the topographic graining.

Sediments assigned to the L.O.R.S. period occur almost wholly in the faulted Oxnamrowhill area, contrasting markedly to the great spread of igneous material of comparable age. Cheviot vulcanicity is assessed (believed) to have begun in L.O.R.S. times after orogenic movements and erosion had affected the Silurian sediments. An earlier paroxysmal phase gave way to a quieter and more continuous outpouring of lava. Activity was longcontinued and subaerial in nature, the few isolated sandy and gritty intercalations exposed in the lava area being taken to be the product of surface wash (The Cheviot Hills pp.8-9 Geol. Survey 1932). The base of the volcanic series is exposed on Thirl Moor, and in the basal agglomerate Clough observed Silurian shale fragments and "foreign" felsitic fragments./

fragments. The latter cannot be matched locally, and are inferred to belong to the initial phase.

The accepted succession is here listed, and the points following are of note.

see M.F. page 2.

Augite-Andesite
Oligoclase-Trachyte } covering $\frac{9}{10}$ of the area.
Glassy Andesite
Mica felsite
Basal Agglomerate about 200' max. thickness
Silurian

1. Rocks of the acid phase are restricted in development and in geographical distribution, lying essentially S.W. of Cheviot peak.
2. The Andesites show a variety of colours, dark grey, brown, purple and red, being usually coarse grained, compact and well jointed. Exceptions occur in the form of vesicular and amygdaloidal lavas which weather out to form featureless and rock-strewn slopes.
3. Ashes occur in beds of lenticular habit, being apparently more abundant in the south side of the Cheviots. These ashes weather in rough, irregular fashion, contrasting markedly with the augite andesites which tend to weather into smooth-faced angular blocks.
4. The glassy Andesites weather into massive rounded blocks with a tendency to exfoliate. It has been pointed/

pointed out (Cheviot Hills Geol. Survey 1932) that this type has a broader outcrop S.W. of Cheviot peak and possibly is more resistant to alteration than the crystalline varieties.

5. The trachytes are restricted in development and distribution, being confined to the upper R. Alwin area.

6. Clough has noted that as a rule exposures of these lavas do not show a predominant set of rock joints, an observation which the writer has corroborated during fieldwork. Fieldwork tends to support the view that the dark grey Andesitic lavas form an aureole about the granite (see diagram 1). This aureole might well be an important factor to be considered when explaining present day topography, because of its greater resistance to erosion.

M.F. page 2

7. Finally, the orderliness of the lava types north of the R. Glen call for comment, the alternating hard and soft flows corresponding in the present topography to ridges and troughs.

A diagram has been prepared (Diagram 1) upon which the results of geological investigation in the lava area are portrayed.

M.F page 2

The Cheviot granite outcrop is essentially circular, covering about 20 square miles, together with a possible "finger" some 2 miles long extending northwards from the main mass. It has been remarked and with good reason/

reason (A.G.Jhingran Q.J.Geol. Soc. 1942) that with exposures being so poor there is no direct evidence for linking the Common Burn and Broadhope Hill granite with the main mass. Inspection will at once demonstrate that besides Cheviot itself other upstanding areas are within the granite outcrop, e.g. Comb Fell 2132', Cairn Hill 2545', Hedgehope 2348', Shielcleugh Edge, Standrop Rigg and Dunmoor. (Of these, Hedgehope lies in the approximate focal point.) On general considerations the intrusion was assessed as laccolithic and represented an intrusive phase in O.R.S. times, but, as has already been noted, it is now held to be a replacement granite. Dating is by reference to the Windy Gyle conglomerate which contains granitic boulders (U.O.R.S. by Clough; Basal Carboniferous by the Geol. Survey 1932). The rock itself is variable, divisible into three types -

1. Marginal - dark grey and fine grained,
2. Standrop - light colour, medium to coarse grained,
3. Granophyric - pink colour, medium to coarse grained.

Tomkeieff (Proc Durham Univ. Phil. Soc. 1928) has shown that under the abundant peat cover the granite is bleached and altered leaving a white porous rock of quartz and white mica, there being no kaolinite present. The writer has had the opportunity to verify this statement in the field.

A significant point about the mode of granite emplacement is that if it is a replacement granite then

then change in volume does not necessarily occur. It follows, therefore, that the Cheviot "dome" is open to a different interpretation from that accepted before 1942, as for example Clough & others (See diagram 2. M.F. p.2.)

On the N.W. slopes of the Cheviots, and occupying the lower ground, lie U.O.R.S. sediments. Little has been published recently on these rocks, and the writer has only a limited experience of them in the field. However, the following remarks appear to hold good throughout the area. Horizontality, or near horizontality, of bedding is a characteristic feature, though exceptions occur, e.g. below Edgerston dip 25° N (Trans Roy. Soc. Edinburgh Vol. 15 D. Milne). Sandstones predominate and are usually dull brick red, though paler varieties to near white are recorded and only rarely is their colour yellow. Usually the sandstones tend to be "thin, soft, brittle and easily decomposing" (The New Statistical Account Vol.3) The marked incision of the Jed and tributary valleys may well reflect the comparative ease in downcutting through such rocks. Subordinate to the sandstones are marls and cornstones, and these do not form important elements in the landscape.

Lying at the base of the Carboniferous succession are the Cementstones. It is estimated that these rocks approximate to a thickness of 3000' in Tweedside, thinning out in the Wooler area to a few hundred feet and thickening up again south and south-westwards to some 2000' near Whittingham. (Geol. Survey Memoir "Belford, Holy Island

Island and Farnes" considers diminution of thickness the outcome of overlap) Although the Cementstones are dominantly freshwater and estuarine deposits, when traced southwards marine limestones appear in the series. The rock types displayed include grey, green-grey shales, variegated mudstones, thin cementstone ribs with frequent sandstones. Some insight into former palaeogeographical conditions is afforded by the Roddam Dene conglomerate, accumulated near shore in a pocket eroded into the lavas to form a local base to the series. From a geomorphological standpoint these rocks correspond in large part with the Tweed - Till - Upper Aln and Upper Coquet valleys. However the Cementstones do form the prominent W/E ridge at Glanton, the high scarp front near Wandystead and low parallel ridges in the upper Aln above Whittingham.

Above the Cementstones lies the Fell Sandstone, which is responsible for the most striking topography in the sediments. The Fell Sandstone is found to thicken as it is traced southwards, estimates of thickness vary from 600' in the north, 800' between Wooler and Belford, to 1000' about Rothbury. Whilst massive sandstone is characteristic, changes do occur from place to place. In the northern area the sandstone is finer and less resistant, whilst in the central area the group shows local variations, some outcrops being coarse and thick, others flaggy, in places falsebedded

falsebedded and occasionally containing pebble inclusions. South of Whittingham, (Geol. Survey Memoir Alnwick District) shales which elsewhere are very subordinate divide the group into three parts - the sandstones corresponding to a triple line of crags (Callaly, Lorbottle and Edlingham). Except for the northern area the Fell Sandstone is associated with marked topography. At close quarters in the field, these sandstones show fluted and grooved weathered faces. Usually such faces are a characteristic grey colour, but fresh exposures show yellow-brown, reddish or white colours. Rock joints are frequently seen, often opened far enough to allow eventually cave formation. The falsebedded sandstones, where exposed, are easily enough noticed in the field, since weathering accentuates the bedding planes.

Like the Cementstones the succeeding Scremerston Coal Measures show a facies change when traced N. - S.W., and are found to become thinner as the beds are followed southwards. In the type area they are represented by thick, massive and flaggy sandstones, with shales, fireclay and coals (with thin limestones near the base), reflecting a return to estuarine conditions.(Brit. Reg. Geol. Northern England. Eastwood). From Spittal to Duddo the outcrop corresponds with the watershed of an area of low relief. Southwards from Duddo to Ford Moss a west facing scarp becomes increasingly defined, with these measures forming the cap rock. However, from Ford Moss toward Doddington/

Doddington drift and "moss" largely obscure the outcrop. In this area, and also to the east between Shepherd Kirkhill and Chatton Moor the S.C. Measures are not associated with strong topography. Locally, however, sandstone crags similar to those of the Fell Sandstone do occur. Further south in the Eglingham Moor and Alnwick Moor areas these rocks, though present, do not form striking features on the landscape, whilst in the extreme S.W. this group is almost completely excluded. Comparison of thicknesses suggests that the beds become thinnest in the Alnwick area, and that they thicken again to the southwest.

E.g. Greenwich bores (Scremerston) 1000' thick (10 workable coalseams)

2 miles S. of Lowick — 550' thick

Alnwick ——— 300' thick (3/4 workable coalseams)

Debdon ——— about 500' thick

Whilst the Limestone Group above is of interest to the geologist, to a student of landforms it is far from exciting. The group is composed of essentially arenaceous deposits, but also contains marine limestones, shales and subordinate thin coals. Locally the sandstones form prominent features, but the limestones, except in stream courses, rarely display marked topography. Solution effects in the limestones are lacking in this area - indeed, man-made scars in the form of disused quarries might well be said to to have become their distinguishing characteristic inland. (Coastal sections of this group, however, afford some compensation, and details of these will be included in the coastline survey.) The main limestones number between 15 to 20, range in thickness from 2' or 3' to about 30', and show a marked constancy over the area. A brief summary of the major limestones is added, together with short comments.

Upper - Dryburn. When fresh saccharoidal with pinkish tinge. Sandbanks. Grey earthy colour.

Middle - Acre. Compact, hard, light grey colour.

Eelwell. Hard, grey colour. (Invariably rich brachiopod fauna.)

Oxford. Dark, crinoidal, hard - concretions.

Lower - Woodend. Whitish grey colour.

Dun. Grey when fresh, turning yellow-brown.

At maximum development this group is estimated as being nearly 2300' thick, and geologically it is of interest for two further features. Firstly, within this group is the Doupster oil shale, indicative that conditions at the time of formation were akin to those in the nearby Scottish area where oilshales are well developed. Secondly, there is the occurrence of unconformity below the Red Shin sandstone. Both the shale and unconformity can be seen on the shore, some way south of Spittal.

As one might expect, grits and sandstone beds, with subordinate shales, fireclay and thin coals, make up the Millstone Grit. The area of outcrop here is small, and

and, though largely featureless, some gorge-like tracts in the Coquet valley and low cliffing about Boulmer occur in this group.

U. PALAEOZOIC IGNEOUS ROCKS.

Tomkeieff (Proc. Geol. Assoc. 1931. Geology Nothumberland and Durham) has noted that in the Lower Carboniferous Cottonshope lavas differential erosion has picked out a slaggy zone. (This zone in the area of the Cottonshope Burn and its tributaries corresponds to a terrace-like feature). The lava flows themselves appear in places to be of a pahoehoe type, and elsewhere show rude pillow structures. In contrast the Carter Fell and Lumsdon Law igneous outcrops were intrusive in nature.

On the lower ground of Teviotdale and Tweeddale north of the watershed basaltic lavas were outpoured in Lower Carboniferous times. Initial plateau type basalts were followed by "puys" - the latter today, despite erosion, form upstanding and distinctive topographic features (e.g. Black Law, Lanton Hill, Dunion).

Whilst the Whinsill may be held to be at its best scenically in the vicinity of Hadrian's Wall, its crags never-the-less are impressive in N. Northumberland. The sill is an intrusion of late Carboniferous age. At places of maximum development it attains thicknesses of 80'-120', and shows transgression and fingering out. Typically a quartz dolerite, it weathers dark brown or grey, being blue grey when fresh. Columnar forms are common, spheroidal

spheroidal weathering and/or block disintegration are also characteristic.

Structure.

STRUCTURE. Map 2 (M.F page 3) is in several respects incomplete, but sufficient is shown to justify immediate generalisations on the area's structure. (For Geol. sections see M.F. p4).

An obvious three-fold division is revealed by the map. To the north and south of the Cheviot massif lie the troughs of Tweed and Rede. The latter is interpreted as being structural (Proc. Geol. Assoc. 1931 Hickling), the former also has been claimed to be of a similar nature (Scottish Geog. Mag. 1915. Gregory). To the east stretches an area much faulted, showing two large anticlines together with minor flexures coastwards. In this area one notes further that the northernmost Holburn Anticline is flanked to the west by the Hetton syncline. The third area composed almost entirely of igneous material , is bounded on three sides by the other two areas. Within it crushlines and faults are more abundantly developed on its south side, and the Cheviot granite is exposed at its eastern extremity.

Previous workers have observed that the major fault trends in the volcanics and in the Carboniferous sediments fall into distinctive groupings. It is here noted in addition that the general structural pattern shows a rough symmetry about a line drawn E.N.E. from Scotsman's Knowe

1) from Scotsman's Knowe radii to Kirknewton and Alnham boundary faults were checked and found approx. equal.

equal.

2) The two dyke echelons, High Green and Holy Island, run approximately equidistant from this line.

3) The Holburn and Lemmington anticlines lie on either side of this line.

4) The Whinsill "bulges" in the coastal area about this line fairly symmetrically.

In the Cheviot complex two fault and crush systems are recognized (Geol. Mem. 1932 "The Cheviot Hills"), an older N.N.W. and N.E. system, and a younger E.-W. one. The N.E. system, though possibly following the N.N.W., was stronger, and has been subject to still later movements. Clough (Geol Survey 1888 "Cheviot Hills") early recognised the lines of movement, and commented on difficulties of interpretation in the field. He noted the topographic differences associated with the two main crush breccia types. The more common quartzose type, proving more resistant to erosion, tends to form minor upstanding features in the landscape. In contrast, depressions and gullies form where the calcite breccias weather out more readily. Without doubt, crush features can best be demonstrated on the ground about Scotsman's Knowe. Here, running N.E.-S.W., is the Harthope crush, traceable for 15 miles across the massif, and extending up to 100 yds. width. To the southwest the upper Davidson Burn lies on another crush (calcite breccia), whilst the Upper Breamish valley to the southeast follows

follows another crush line between High and Low Bleakhope. The boundary faults to the lavas appear to continue through the Carboniferous rocks near Ford to the north and Glanton to the south.

The original interpretation of the igneous dykes in this area was made by Clough, who considered them to show a radial pattern. A reinterpretation made by the Geol. Survey more recently groups the dykes into two swarms aligned N.N.W. and N.N.E. respectively (See diagrams 3 and 4). M.F p2. It is not proposed to give further details on the dykes in this section, though some will be given where appropriate in later portions of the essay. (For immediate details reference should be made to Geol. Survey Mem. Cheviot Hills 1932 page 95, whilst Anderson in "The Dynamics of Faulting" considers them along with other Caledonian dykes pp. 168-170).

To the southwest local small-scale faulting (N.N.W.,N.N.E.) on the Scottish side of the Border contrasts with the few long N.E. trending faults south of the watershed. The U.O.R.S. rocks do not appear to have major significant structures (paucity of present information?). The Silurian strata after isoclinal folding, uplift and denudation, were, and still are largely, covered by later deposits.

The general pattern shown by faulting in the Carboniferous rocks north of the Holburn anticline is fan-like convergent on Haggerston. Whilst the coastal series are of minor

minor importance, much heavier faulting occurs inland about Ford, and south of Ford Moss fault throws become southerly. In the latter locality the Geol. Survey observe that lateral movements up to ½ mile are associated with the Slainsfield fault. Southward lies the large Holburn anticline together with the Hetton syncline, but separated by the inferred Hetton fault. Whilst this fault is neither seen nor proven, there is sufficient geological information available to justify the insertion of a faultline. The anticline trends slightly west of north, pitches northwards and is asymmetrical, with the steeper limb on the west flank. No large scale flexures lie to the east, but smaller contrasts of dip are shown. E.g. north of Belford dips are seaward, whilst to the south some undulations occur. In contrast to the northern area faulting is now characteristically N.E./S.W. and throws are considerable, e.g. the Chillingham - Annstead dislocations.

The Holburn anticline when traced southwards dies away, being almost immediately replaced to the east by the S.S.W. trending Lemmington anticline. Like the former, this anticline, too, is fault bounded, by the large Bolton fault lying to the west. This anticline is also asymmetrical, with the western limb showing the steepest dips. West of the Bolton Fault lesser faults splay off S.W., whilst to the east faults generally run in E.N.E.-E.S.E. directions. East of the Lemmington anticline small flexures occur, showing S.-S.E. trends.

trends.

Holmes and Harwood (Min. Mag. 1928), commenting on the Holy Island and High Green Quartz Dolerite dyke echelons, suggest that they formed as the Cheviot area moved bodily to the east (in relation to the ground north and south). Again, the Geol Survey Memoir Alnwick District, referring to faults splaying off the Bolton Fault, add that "such an arrangement seems to reflect the influence of the Cheviot massif acting as a centre of resistance to constant pressure from the east". Anderson (The Dynamics of Faulting pp 38-39, p85, pp52-53) more recently has offered an alternative explanation for the formation of the dyke echelons, Hetton Fault and the Holburn Anticline. In brief, the echelons may be explained by there being different stress directions at different levels in the crust, and the Hetton "fault" may be an Armorican shear zone with the Holburn anticline representing a connected structure.

In conclusion, the following structural elements are listed as being important in considering present landforms.

1. The fault and crush features in the core area are associated with major and minor topographic effects. Allied to these, the dyke swarms are responsible for many small scale, but well marked, features.

2. Whilst the granite is broadly coincident with the highest ground, this is by no means a hard and fast rule.

3. The Holburn and Lemmington Anticlines and the Hetton Syncline are important and will be dealt with in the

the landform section.

4. The faults in the N. Northumberland area which have been described briefly are often associated with large and small scale changes in topography. In addition, several of these faults have conditioned the spread of the Whin Sill. (E.g. N. Kyloe Plantation, where the passage of the Whin from Fell Sandstone to Scremerston Coal Measures is coincident with a faultline.)

5. The Whin Sill forms a strong feature in the present landscape, being occasionally associated with small inversions of relief. Rarely is its characteristic topographical expression wanting (e.g. Alnwick Moor).

MORPHOLOGICAL ANALYSIS.

So far as possible this section attempts to be objective, being undertaken with three ends in view.

1) to afford a visual aid to the reader,

2) to express what has been learned about the topography of the area,

3) to assess the merits of the various techniques used.

The various techniques are considered in turn, and the results tabulated at the end of the section.

1. Hypsographic Curve. (Based on Bartholomew ½" sheet 42 covering the area.)
(See M.F page 5)

Despite the relative crudity of the data it is apparent that marked changes of "area" occur between 400'-600' and again above 1250'. The curve as plotted, suggests critical heights to be at 1750', 1250', 800', 600', 400' and possibly at 200', with the "area" at a minimum above 1750'.

2. Clinographic Curve. (see M.F. p5)

This curve was constructed using the Hanson - Lowe technique, and the areas used for the hypsographic curve. The average slope figures show a threefold division,

a) low average slope values below 600',

b) intermediate values between 600'-1750',

c) highest values above 1750' but progressively diminishing in amount upwards.

The curve itself shows convexity of form at the extremes, in contrast to concavity in the mid portion. Angular

Angular changes of average slope occur at 100', 3/400', 6 /800', 1750', 2250', and 2500'.

In both curves the profound change about 1750' is a significant feature.

ALTIMETRIC CURVE.

3. Altimetric Curves. (see M.F.p5)

These were constructed from 1.25,000 provisional sheets covering the area. The technique is based on that employed by Hollingworth (Q.J. Geol. Soc. 1938), but with slight modification. A 50' interval of summit contour groupings was adopted, and in addition W/E altimetric curve strips were constructed. The aim in construction of strips was to assess the degree of generalisation present in the altimetric curve, and to afford a means of comparison with corresponding superimposed profiles.

At this point the results of Hollingworth's work with maps of the Borders are inserted. He finds a 270' maximum and assigns it to the drumlin topography. A deep 380' minimum occurs, but is not followed by a 400' maximum. Further maxima are noted at 560', 760', and 920', followed by a prominent 1070' peak (the latter rising by way of an intermediate step). Other possible features occur at 1150', 1470' and 1650', with a minor minimum at 1820', together with a 2000' maximum. Finally, he comments on the approximation of Cheviot peak to the Lake District 2630' maximum and the 26/2700' S. Upland summit level./

level.

Examination of the curve plotted shows the following broad trends. There is an increase in numbers of summits to the 200' mark, followed by diminution to about the 400' mark. From this height the numbers increase to a maximum between 5/600' followed again by diminution. The rising trend from about 800' reaches an acme at 1000' mark, and is followed by a general drop to 1800', though a slight inflection about 1400' is of note. Above 1900' the curve is considered unreliable, dealing as it does with scant information.

It appears to be a justifiable criticism that the curve, as constructed, lacks definition at higher altitudes, and maxima and minima are not quite so clear as one would have wished. (See diagram 5 M.F p5 for Hypsographic, Clinographic, and Altimetric Curves.)

Altimetric curve strips are provided, together with a reference map, (see diagram 6) M.F page 6 and the following comments are added.

1) The two southernmost strips show curves which indicate sympathetic variations but with a 100' difference in phase below 1300'. (It is the most southerly strip which shows acmes at the lower altitude.)

2) Strips 20/30 and 30/40 compared show discrepancy at 500' and 600', but between 750' and 1300' the curves are in phase, though amplitudes differ. Above 1300' the curves

curves become out of step again.

3) Strips 30/40 and 40/50. Strikingly in phase to the 6/700' mark, 1100 and 12/1250'.

4) 40/50 and 50/60 compared show strikingly similar curves.

5) 50/60 and 60/70. Similar curves but a 400' maximum absent in the northernmost curve.

6) 10/20 and 40/50, representing the Cheviot flanking strips, are closely similar from 950' upwards.

The main points to emerge from a consideration of these strips is the presence of only one maximum constant for each curve at 200'. In contrast, minima at 350', 450', 950', and 1900' occur in each curve. (See App. 1 for tabular information on these Altimetric strips and also Hypsographic, Clinographic and Altimetric curves.)

In addition to these techniques, use has also been made of superimposed and projected profiles. Nothing new was attempted in constructing the former profiles, but in the latter the writer used a new medium, i.e. balsa sheet, in construction a model, with some success. (It is proposed in the section dealing with projected profiles to give some indication of working method employed in constructing the model.)

SUPERIMPOSED PROFILES

The Superimposed Profiles were constructed from standard 1" O.S. sheets covering the area, and are aligned W- E. They are spaced at 1 mile intervals using a horizontal scale of 1 mile o horizontal scale of 1 mile to the inch and a vertical 1/10" = 100'. The profiles face south, and only the upper parts of the more distant curves are plotted.

Sheet 81. (see M.F. page 7).

In the west there is a level suggested at 800' swinging S.E. and falling gently. To the east and broadly coincident with the Andesite outcrop lies a clear cut step to about 975'. This level also trends S.E. and appears to fall slightly in that direction. To the east the level rises to about 1025! A dissected surface from about 1100' to 1275' is suggested by crest alignments above this latter height.

In the central area the most striking feature is the triangular mass upstanding at 2000'+, and beneath, the summit levels occurring at 1800' and 1600'. It is a matter of opinion whether these two heights indicate one or two surfaces.

In the eastern section the most obvious feature suggested is a high level bench falling away S.E. from 1150'-1100'.

Sheet 3.

Of immediate interest is the triangular area of comparatively lower crests opening out southwards. The higher flanking crests show some accordance at 1700', whilst the triangular area may be divided in two parts. Of these, the western portion shows ground falling from 1300' to 1150' in the S.W. and 1100' in the S.S.W. It

It is limited to the west by a 15-1300' ridge. The more easterly portion lies between 1150' and 9/950', being bounded on the east by an upstanding area 1500'-1400'. In this upstanding area a possible valley in valley profile is shown, suggesting the existance of a high level valley bench between 1400' and 1150'. The one profile running west of the Rede line shows that a 1650'-1550' line neatly trims the crest line.

Sheet 2.

The eastern section of these profiles suggests a 600'-450' former surface followed by a sharp descent to the 400' mark. The 600' level is common to both sides of the Fell Sandstone cuesta, and even on the south side also. Is the 600' level then a true flat? The area between the Andesites and Fell Sst. shows a 600' summit level and suggests a southward dipping surface below, with 500' summits in the foreground. The upstanding central portion of Ros Castle is obviously a residual and to be correlated with the high ground to the west. About this monadnock feature an 800' level is suggested.

Sheet 4.

The eastern portion of the curve suggests a 375' level with the next tread coming at 500'-525' rising from S.W.-N.E. Again a well marked 900'-850' surface is of note, and the curve also suggests that 600' is somewhat critical. An alternative suggestion, using summit alignments, is is that there might be two surfaces between 400' and 700'. To the west levels appear again at 1800' and 1300', together with a portion of the low triangular area mentioned on page 24. The last mentioned may be a possible high level bench falling southward from 1100'-950/900'.

The superimposed profile obtained by combining all these profiles is noteworthy in showing accordance of summits at 2000', 1800', 1300', (+1050' centre foreground) in the core area, and 900' on the eastern flank. (see M.F. page 8) diagram 7A.

PROJECTED PROFILES

Projected profiles were constructed using W. D. Johnson's technique (as employed by Fleet) for 1" O.S. sheets covering the area. The profiles are aligned N.E./S.W. (See M.F. p8 diagram 8). and each profile covers a strip of country 2 miles in width. In the construction of each profile height readings were taken at every 1/10 inch, and it was found to be quicker and more accurate to record and then to plot each reading. A horizontal scale of 1"=1 mile and a vertical exaggeration of approximately 10 were used, the author considering that a vertical exaggeration of 20 (advocated by Johnson) to be excessive. The profiles were next placed over 1/8" balsa sheet, clamped and, with the aid of an ordinary pin, the profile points were pricked through onto the wood beneath. The base line (sea level) was also transferred in this fashion. After removal of the paper profile, the profile was redrawn on the wood and the section cut out.

(A cutting knife or razor blade was adequate for the

the cutting). The finished sections were then slotted into prepared battens and finally mounted over a 1" solid geology map of the area.

For sake of comparison with the more tedious method using plywood, the following may be taken as average rates of work. Drawing, transfer of data from paper to wood, 30 minutes per 36" strip. Cutting and trimming 36" section in balsa sheet, about 45/50 minutes.

A brief summary of some features shown from the projected profiles follows. About the monadnocklike Cheviot core one notes the immediate contrast between the eastern flank and the others. As the topographic map clearly shows, the state of landscape dissection is markedly different on the north and west sides of the College R. line. Thirdly, it seems proper to observe here that during Quaternary times the deflection of Tweed ice southwards had a most striking influence on topography and topographic graining, especially in the northern part of this area. These preliminary remarks lead one to expect that what remains of former erosion surfaces should lie south and southwest of Cheviot itself, and that elsewhere, for the most part, only fragmentary evidence can be expected.

The first level of any widespread consequence would appear to be about 1800'. Above it there may be a summit accordance at 2000' but owing to the small area involved

involved and limited distributions, any assertions about this level can be no more than tentative. On the western flank of Cheviot the next critical height is at 1600' (Sections 9, 10 and 11). A marked step down to 1500' hereabouts is followed by a possible surface lying to the west between 15/1300' and sloping southwards. Indeed, Sections 7-11 strongly suggest a valley-in-valley profile cut into this surface with a "valley bench" development. The "bench" drops southwards from 1300'-700' in 6 miles. Another feature of note on this flank is a "high" Breamish valley line coincident with a crush line.

The S.Eastern flank of Cheviot appears to offer little more than fragmentary evidence, and yet that little may be of considerable significance. Firstly, one notes the "tread and riser" form of the topography. Treads roughly correspond to 1750', 1500', 1300' and 1050' at higher altitudes. In the more southerly portions of the Andesites a former surface is suggested beginning at about 950' and falling away to possibly 650'. (650' is a prevalent summit level on the sediments about Cheviot.) Also it may be noted that the height range 750'-650' is a feature in the more southerly areas. Finally, a rather prominent summit height on the sediments occurs at 550'.

On the northern flank of Cheviot one notes again the stepped topography, generally down towards the N.E. The critical height values would appear to be at 1800/1750',/

1800/1750', 1550/1500', 1300', 1150', 900', 750', 550/500'. In addition to the diagram showing the projected profiles, another (Diagram 9) emphasizing and locating the heights mentioned has been prepared - it also embodies the results of field-work and probably speaks sufficiently for itself. A final tentative inference concerning possible groupings of the heights mentioned may be drawn. From the profiles the following height ranges might well be grouped - 18-1600', 1550/1500-1300', 1250-1050', 9-800', 750-600' or 550' (or 950/900-600'). These groupings are merely suggested by the profiles and like the results of other techniques, are not considered to be more than a preliminary interpretation. (For Superimposed Profiles, see Diagram 7, and for Projected Profiles, Diagram 8.)

See M.F. p11.
M.F p7
M.F page 8

It is hardly a matter for surprise that, with the growing volume of material in this section, conflict[illegible] in thought and interpretation should arise. A further set of profiles, somewhat more selective in character, was constructed for the area covered during field-work. The aim was to produce profiles of a more critical nature. The starting point adopted was the watershed, and from this something akin to a projected profile was built up.

Method-

Assume that a light source is held at an infinite distance from the landscape so that the light rays are horizontal and parallel. Next consider that all topography save the watershed in question has been removed, and the

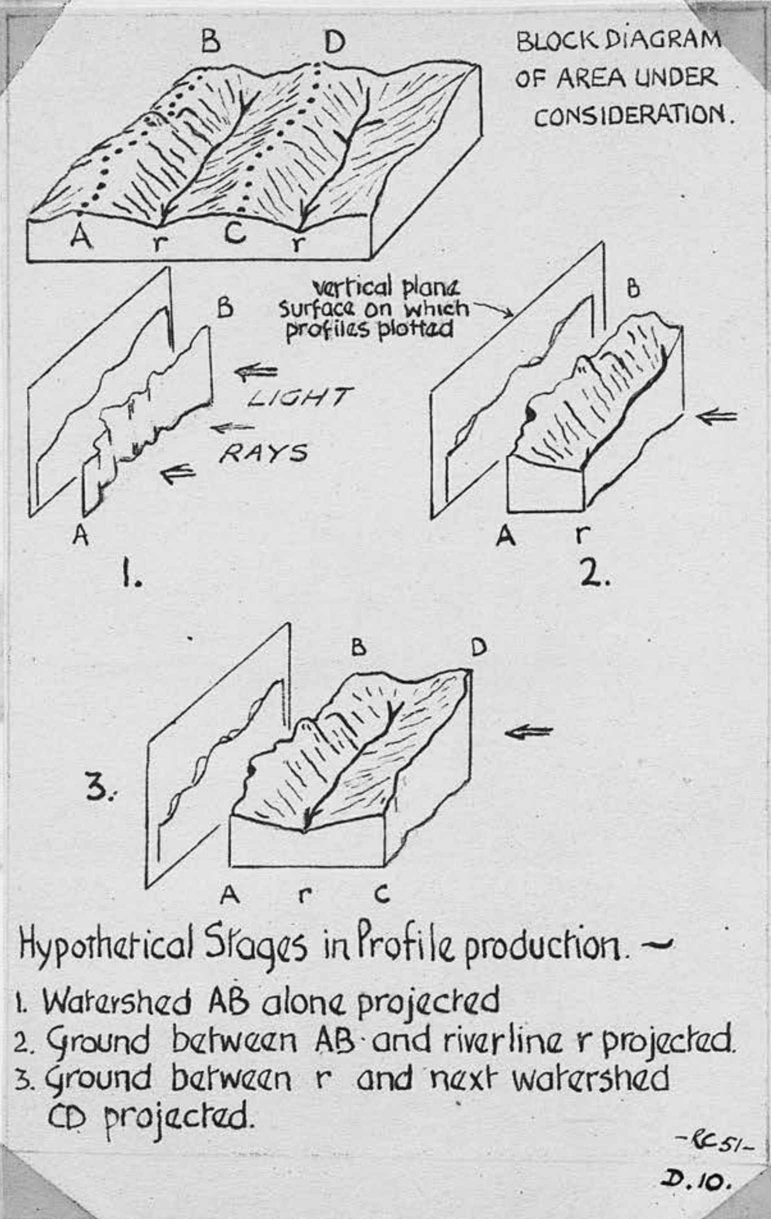
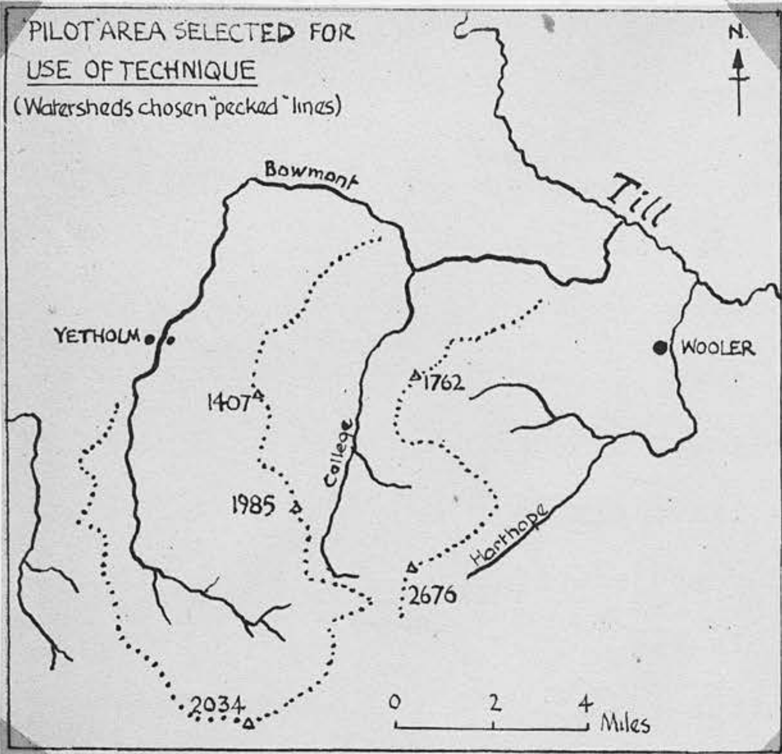

BLOCK DIAGRAM OF AREA UNDER CONSIDERATION.
B
D
A r C r
vertical plane surface on which profiles plotted
LIGHT
RAYS
B
A
1.
B
A r
2.
B D
3.
A r C
Hypothetical Stages in Profile production. ~
1. Watershed AB alone projected
2. Ground between AB and riverline r projected.
3. Ground between r and next watershed CD projected.
-RC 51-
D. 10.

Diagram 10.


PILOT AREA SELECTED FOR
USE OF TECHNIQUE
(Watersheds chosen "pecked" lines)
N.
Bowmont
Till
YETHOLM
WOOLER
1407
1762
College
1985
Harthope
2676
2034
0 2 4 Miles
D.11

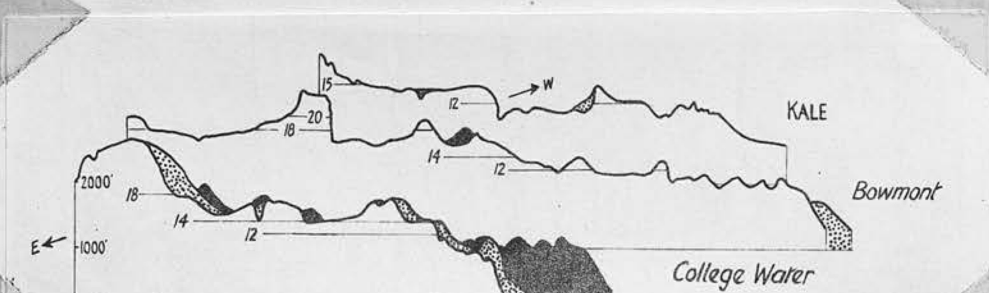

15
12
W
20
18
KALE
14
12
2000'
18
Bowmont
14
12
E
1000'
College Water
S N
H.S. MILES
HARTHOPE
D.11.

Diagram 11.

the resultant shadow cast by the watershed is plotted on a vertical plane surface held at 90° to the light rays. Having plotted this profile, the next stage is to assume that the topography between the watershed and the next stream line (towards the light source) has been replaced. The shadow cast by this terrain is in turn projected as before on to the plane surface. Finally the whole of the topography between the first watershed and the next watershed (towards the light source) is considered to be in place and its shadow projected and plotted as before. (See explanatory diagram 10).

The technique was applied to a pilot area where, for part of their courses, adjacent streams, the Kale, Bowmont, and College, flowed nearly parallel in an approx. N.Easterly direction. Graph paper was mounted on a map east of these streams, and aligned north/south. The light source was assumed to be to the west, and transfer of heights was simply effected by use of a setsquare. Obviously it is a disadvantage to have the watershed turning away westwards or eastwards, but it is hoped that the advantages of the technique are ample compensation. In Diagram 11 the initial profile drawn was the watershed line between Harthope Burn and College Water. The second profile (stippled) represents ground lying between this watershed and the College Burn itself, whilst the third profile (solid) represents the watershed of the College and the Bowmont. The three profiles considered are in the writer's opinion

opinion most promising. An element of solidity is suggested, and there is avoidance of exaggeration in length of profile. Furthermore, the ground in question portrays adequately the stepped nature of the terrain approaching Cheviot from Wooler. It also shows well a dissected ridge watershed between College and Bowmont. Finally, erosional features seen in the field, but apt to be missed by the superimposed and projected profile, are included in this method. From these results a more ambitious series of N-S sections (based on this method) were drawn to cover the E. Cheviot area (Diagram 12). M.F. page 8 The sections differ from the "pilot plots" in that all projected portions between watersheds are undifferentiated and shown in black.

Direct comparison with superimposed profiles (Diagram 7) shows immediately the difference in numbers of profile lines. The critical heights suggested from this N/S set of profiles occur at 2000', 1850/1800', 15-14-1300' lowering southwards, 1200-1100' at north end, 1100-1050' at south end, 700' on sandstone cuesta.

Attempts were made to produce a relative relief map for the area, and also a map of average slopes as outlined by A. Miller (Pres. Address I.B.G.* 1948). In both cases "pilot areas" were deliberately chosen in rather difficult country. (Both occur on sheet 81 1" O.S.S., the former covering ground about Kirk Yetholm, the latter an area athwart Harthope Burn.) The results were disappointing, and both/

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both projects were abandoned. (For further details see

SLOPE ANALYSIS.

Appendix 1(4)) Again, the technique employed by A.G.Ogilvie ("Debatable Land"- A.G.Ogilvie S.G.M.* 1944) was used to produce a map of the area, showing ground with slopes of 1 in 40 and less for heights above 250'. In addition the map portrays, by means of dotted lines, ridges or crestlines with the same limiting slope value. The map itself is best appreciated against a topographic and a drift map. No hard and fast rule can be laid down for the thickness of drift material, save that the drift thins and disappears on the higher upstanding ground. A quick survey of Map 3. shows immediately the contrast in numbers and alignment of these low angle slopes, divisible into the following groupings

M.F. page 9

(a) Teviotdale, (b) Carboniferous cuestas, (c) Cheviot volcanics.

(a) Teviotdale shows several of these areas, especially below 1200', backed by a "riser" to 13/1400' and above. Examined collectively, a general lowering of height to the N.E. is apparent (but note asymmetry of valleys). The greatest frequency of such slopes occurs for height values 7/800' and 850/900'. Moving N.E. to the northern flanks of Cheviot one notes between Kale and Till the ridge alignments which are the result of ice moving down the Tweed Valley and passing over alternating hard and soft lava flows.

(b) To the east, on the Carboniferous sediments, lies the

* SCOTTISH GEOGRAPHICAL MAGAZINE.

the most extensive area with low slopes west and south of Lowick. North of this expanse, glacial graining is again apparent from the map. The Barmoor surface itself appears to be only slightly veneered with glacial deposits (see overburden map), and may be essentially erosional.
MF page 27.
Indeed, examination of this northern Carboniferous area shows the greatest frequency of low slopes to be at heights 450/350' and 300/250'. South of this area, and still north of the R.Aln, occur many low angled slopes, most numerous on the bevelled top of the cuesta and the dip slope east of the N/S watershed. These gentle slopes take the general form of "treads" lowering towards the coast, and they are most abundant at 5/400' and 350/250'. Between the Aln and the Rede the greatest number of gentle slopes occur on the dip slope of the Fell Sandstone cuesta, and rise west (as in the area just considered) to about 800'. From the Aln source to mid Coquet the slope heights rise to the southwest, whilst between Coquet and Rede they rise to the northwest.

(c) In the volcanic country such areas of low slope are largely absent or reduced even to the ridge stage. One can, however, readily trace the higher upstanding watershed ridge trending N.E. along the Border

It is now deemed appropriate to list the findings of the various techniques so that direct comparisons may be made, and also to judge what features are common throughout. Further, to this a brief statement will be added to show

MORPHOLOGICAL ANALYSIS TABULATED SUMMARY.

HEIGHT.	HYPSOGRAPHIC CURVE	CLINOGRAPHIC CURVE	ALTIMETRIC (Hollingworth)	ALTIMETRIC CURVE	ALTIMETRIC CURVE STRIPS	SUPERIMPOSED PROFILES (N)	SUPERIMPOSED PROFILES (S)	PROJECTED PROFILES	MODIFIED PROJECTED.	ALTIMETRIC INDICES	FIELD WORK.
1000'	200 400 600 800	3 - 400 6 - 800	270A 380M 560A 760A 920A	200A 400M c550A 800M 1000A	200A 450M 950M	150? 300 - 400 450/500 - 600 800 975 - 1025	375? 525 850 - 900	550 - 750 or 900?	700 crests	250 - 450 500 - 550 600 - 800 or 650 - 950	350 - 400 possibly from 300 - 550/600' 550 - 750 800 - 900? 950/1000 -
2000'	1250 1750	1750	1070A 1150? 1450? 1650A 1820M 2000A	1400M 1800M	1900M	1100 - 1250? 1600 1800 2000	1300 - 1500 1700	1050 - 1250 or 1150 1300 - 1500 or 1550 1600 - 1750? 2000?	1025 - 1200 1300 - 1500 1800 - 1850 2000?	1450* 1650 - 1700 1750*	1200 1300 - 1500 1550/1600 - 1700 1750 - 1850
		2250? 2500?		? = Uncertainty Á = Acme M = Minimum						* Marked Change in values	2000 - 2100? 2350 +? - RC'52

to show how far field evidence confirms the analysis.

CHAPTER 3.

GENERAL SURVEY AND SUMMARY.

Two maps are prepared (Diagram 9 and 9A) with the first (9A) a graphical representation of

a) the major topographical and significant changes in the present landscape, (see M.F. p11.)

b) the significant crests and summit accordances,

c) the bevelled surface remnants observable in the field.

The second map (9) offers an interpretation made by the M.F. page 12. writer of these features in terms of erosional surfaces. The term 'surface' is here taken to indicate ground bevelled under normal and glacial conditions, being applied to terrain where the overburden is patchy but thin, absent or so far as can be ascertained is of no great depth. (Naturally the slope factor has been considered for the proposed surfaces.) Again, rather than suggest possible correlationships for these surfaces elsewhere the author deliberately refrains from becoming speculative and prefers to await the results of fieldwork in adjacent areas.

This area shows a polycyclic landscape which, despite glacial modification is at present in a state of mature dissection (i.e. topography adjusted to structure). Field study in the area suggests that remnants of the following surfaces occur - these are listed in order of definition in the present landscape.

A. 950/1000' - 1200'. This surface is reduced in places

places to the ridge state but fairly extensive bevelled remnants remain elsewhere.

B. 750 - 550/500'. This, too, in places is reduced to the ridge state, but in the Quarryhouse Moor area it does seem mappable.

C. 1300 -1500'. This surface is best seen in the northwest of the area studied, and suggests that retreat southwards of the main watershed (Border line) was early accomplished.

D. 1550/1600 - 1700. Remnants of this surface occur chiefly on the principal watershed or just south of it.

In addition the following are also suggested, but for the several reasons stated are difficult to delimit precisely.

E. 350 - 400'. It would be a matter for debate to fix rigidly at 400' the upper height limit for this surface. Despite its clarity on Barmoor and possible bench remnants occurring nearby, the writer is not sure

1) that marginal meltwater cutting was responsible for the production of the bench features,

2) that higher equivalents of the Barmoor surface did exist at the southern end of Milfield Plain and in the Holburn Moss area.

F. 1750 - 1850'. This depends largely on the occurrence of a significant topographic break at 1750' and accordance of summits within the height range quoted. However, the

the possibility of a resurrected surface formerly occurring at this level should not be overridden, - Cheviot representing a monadnock on such a surface. (Attempts have been made with mixed results to extrapolate the base of the Permian outcrop from near Ferryhill onto the Pennines to test this possibility there - time, however, has not allowed the matter to be pursued further)

G. 2000' and over. With few summits and remnants available in the area, subdivision tends to be of a tentative nature. However, for what it is worth, summits about 2000' stand in contrast to those at about 2350'.

H. 900 - 800'. Any surface lying between these limits has now been mostly removed, and it is the frequency of summit accordance on the flank of the massif and on the Fell Sandstone southwards which suggest its former presence. On the latter it might be argued that one is dealing with the lower extension of one of the higher surfaces, but examination of these summits in the Kale - Bowmont area tends to offset this possibility.

One further point concerns the actual portrayal of the surface fragments on the map. It will be obvious that the most satisfactory method of depicting outliers or monadnocks of higher surfaces along ridge features is by use of symbols. Furthermore, with dissection to ridge state common, the more conventional mapping of surfaces was hardly applicable.

A description of the major topographical features is is now presented with a general survey being followed by a long systemmatic account of the area. The initial survey considers major topographic changes in the landscape, (1) on the sediments from Spittal southwards towards Alnwick, then southwest towards Rothbury, (2) on the igneous massif from north to south, and (3) in the Till and Upper Aln valley areas. (Reference to 9A and M.F p.11. location map will assist the reader through this section) M.F. p10. The more lengthy treatment which follows is partially descriptive and partially analytical. The method of treatment is to consider the lava country in terms of interstream areas, and the foothill area north of Bowmont is treated after the Upper Aln Basin for comparitive reasons. East of the massif the Carboniferous sediments are examined in a slightly different manner. The smaller western cuesta and its less defined continuation towards Spittal are taken as a unit, and first considered. Following upon this the major cuesta is described, subdivided for topographic reasons as well as convenience into northern, central and southern sections.

(Note: No effort is made to give detailed information on river valleys or glacial effects other than what is sufficient to assist interpretation and understanding of particular features.)

Major topographic changes in the landscape (See map 9A). M.F. p.11.

Whilst the Carboniferous sediments to the east show abrupt scarp slopes facing west, they also show, when

when traced from north to south, bevelling on the cuesta crests, trimming of the dip slopes and a stepping up in summit levels. Inspection shows the trough of low ground between Norham and Goswick to end somewhat abruptly along a line from Berryhill - Lowick - near West Kyloe (a), i.e. broadly coincident with the 350' contour, while some short distance south of this line another 'riser' appears approximating to the 500' contour (b). Although this latter topographic break is well marked at the north end of Kyloe Woods, by Watchlaw it represents the northern end of a former NW/SE trending ridge. Further west however, south of Branxton and at Haddon Rigg and Horse Ridge the 500' contour is again significant topographically. East of Chatton a well defined break of slope (c) running W - E occurs, and south of this the ground rises to 1000' at Ros Castle. Through Chatton Moor itself a trough of relatively lower ground (falling away eastwards) is distinctive. South of the Aln Gap summit heights between 8/900' now become more numerous and widespread, whereas about Ros Castle they are sporadic. Finally, southwest of a line through the Upper Coe and Millstone Burns (d) in the northern Rothbury Forest area, summit heights about 1000' indicate a slightly higher summit level on the cuesta

The eastern slopes of the main cuesta show two major breaks in slope. The first of these is constant at about 500', whilst above it the other break rises southward from 750 - 900'. Although the coastal plain in the north

north displays no major topographic breaks, a trough of low ground between Waren Mill and Newham is to be noted. At the latter place the trough divides, a more restricted line trending southwards towards South Charlton and another branch swinging eastwards via Tughall Grange into Beadnell Bay. Further south the ridge line between Shilbottle and Newton (corresponding to the junction of middle and upper limestone groups) divides the coastal strip from Alnwick Moor, rising by way of a shallow strike vale.

As has already been mentioned, the northern outcrop of the Andesites is associated with a topographic break (b). Southwards at the head of Milfield Plain occurs the most pronounced 'riser' in the area. This break occurs along a line from Kirknewton to Wooler (e) and, like the northern one (b), it reflects the underlying structure. Both changes in topography approximate to lines of faulting and junctions between less resistant Carboniferous sediments and lavas. The Kirknewton - Wooler line most certainly has been made more pronounced by glacial erosion (for at the W. and E. ends 'treads' with crests at 5/600' occur, and streams flowing northwards to Milfield Plain use valleys which hang at about the same height, e.g. Akeld Burn.) To the west between Bowmont and College waters two marked steps occur in the topography.

1) South of a line from Kilham Hill - Coldsmouth - Staerough (Kirk Yetholm) - Grubbit Law summit heights increase. (e)/

(e).

2) Paralleling 1) and closer in towards Cheviot the next step up in summit levels follows a line from Sauchie-side Hill - Craik Moor.

On the N.E. slopes of the Cheviot massif a repetition of this phenomenon occurs. Marked topographic breaks occur along lines

(1) Easter Tor - Great Moor - Coldlaw - Langlee and Long Crags

(2) Newton Tors - Preston Hill - Broadhope - Dunmoor.

In contrast to the concentric 'terracing' of the northern part of the massif, the southern area shows a wedge of relatively lower ground driven west into the S.E. flank (broadly coincident with the Breamish valley). Here on the margin lies a marked break of slope, in part dependent on the Andesite/Sedimentary rock junction and in part due to glacial effects (f). Westward the next marked topographic break follows a line from Kelpie Strand - Reavely intrenchment - near Linhope - Little Dod - Hazeltonrig Hill (g), and above this lying at 1750' comes the next break, V like in plan (with the apex pointing westwards). As with the northern margin of the volcanics, so too the southernmost is marked by a distinct topographic break (h). One final point concerns the residuals at 2000' and over in the watershed area. Windy Gyle, Bloodybush and Cushat Law lie in W-E alignment and are noticeably separated from the Cheviot, Comb Fell and Hedgehope area. Cheviot peak

peak itself lies at approximately the same height as the summits of Hart Fell, White Coomb to the west in the Southern Uplands, whilst the approx. 2000' summits show correspondence to those of Cauldcleuch Head 1996', Greatmoor Hill 1964', and Peel Fell to the southwest. (Note that these latter summits occur on Silurian, Carboniferous volcanic and Carboniferous sedimentary rocks.)

Between the two areas just described a belt of relatively lower ground stretches southwards from the Tweed. It includes Milfield Plain, the smaller cuesta on the west limb of the Hetton syncline, the area of extensive glacial sands and gravels south and east of Wooler and the Upper Aln valley. It is difficult to generalise on this belt of country without becoming involved in detail. There are, in effect, three distinct basins, separated by Weetwood Moor and the Glanton - Beanley ridge into Milfield Plain, the Chatton - Hedgely area and the Aln valley. And despite the two former basins now being linked by the R. Till all three possess their own characteristics. The low lying, flat Milfield Plain is sharply bounded by ground whose summit levels rise southwards. Beyond Wooler in the Chatton - Hedgely area the ground is irregularly veneered with sands and gravels with the east Cheviot slopes (below 9/800') falling by minor breaks in towards the R. Till. Southwards the Glanton - Beanley ridge shows breaching coincident with lines used by glacial meltwaters/

meltwaters with the Aln valley beyond. This valley is bounded by abrupt slopes to north and south, by Hulne is funnelled into a defile eastwards, and lies open to the west in anomalous fashion.

Closer inspection of the ground, however, revealed the existence of facets in the topography which modified (in places) the apparently simple account given above. (See Diagram 9.) In the interpretation of the successive erosional features which follows the writer is only too conscious of its limitations. Some of these, naturally, are unavoidable, e.g. the limited area itself on which successive fragments might be preserved, the variety of effects which glaciation could induce. However, where possible 'valley benches' have been observed they have in some trial cases been plotted over longitudinal stream profiles and then referred to the knickpoints above and the postulated erosional surfaces below. Time has not allowed for more than a minimum of checking in this fashion, and on this ground, therefore, some of the correlationships may be questioned. On the other hand, the author has a working knowledge of the Jedburgh area, and has traversed at periods nearby areas where portions of the proposed surfaces appear to occur. Again, quick reference has been made to student work on nearby areas (student dissertations, Geography Department, Edinburgh) and notes compared with Mr. H. P. White who has worked in parts of the Merse. It follows, therefore, that fieldwork was/

was followed by interpretation which, in turn, gave way to comparison with some nearby areas and only then have the topographic maps covering a wider area been examined.

SYSTEMMATIC ACCOUNT OF THE IGNEOUS AREA.

For the sake of clarity, the volcanic area will be considered first, with successive paragraphs describing interstream areas.

Kale (east side of watershed) - Bowmont. (see M.F. p 18).

Southwards from Crookedshaws along the watershed topography is marked and reduced to a near ridge state. North of Craik Moor summits between 1000-1200' are much in evidence - averaging over 1100', with the upstanding Hownam Law apparently an outlying fragment of the higher ground southwards. South of a marked windgap at the head of Hall Burn, summits between 1400' and 1600' are in evidence (together with more extensive interfluves) rising southwards to the main watershed. The ground between Sourhope Burn and the main watershed to the south is of interest, the bevelled crests there being open to alternative interpretations. Bevelled spurs occur on either side of the Kaim Burn at 1200' on the north side, 1050' on the south. Similarly, Cocklaw Spur suggests bevelling at about 1350' whilst near Pudding Law bevelling seems to have occurred at 1300-1400' and later at 1100-1150'.

Bowmont - College.

In this area there is contrast between the dissected ridge remnants (ie. between affluents) showing marked summit accordance and the

the higher N/S ridgeline upon which isolated upstanding residuals occur. Traced northwards the main watershed shows a lowering of summit height in stepped fashion. This feature is also shown in parts by the topography dropping from the watershed into the major stream lines. The marked accordance of summit heights between

(1) Kilham Hill - Longknowe - Upper Elsdon Burn (c.1100')

(2) Staerough - Windshaw - Wildgoose Hill (1080' average)

is striking. This accordance, together with other similar summits and benchlike features at about this height, stands distinct from comparable features above and below. Below, the affinity in summit height of Harelaw 916' with foothill summits to the S.W., N. and N.E. is to be noted. North of Hethpool, too, White Hill, the Bell and West Hill seem to be related to summit heights lying northwards. Above, there is the close approximation in height between Coldsmouth (1363') White Law (Trowup), 1400', Latchly Hill, 1322' and Loft Hill. These heights suggest a transitionary stage to the still higher ground above. The latter stretches in ridge form from Steer Rig to Auchope Rig, averaging 1600-1650' with the Curr 1849', Black Hag 1801' and the Schil 1985' as residuals upon it.

<u>College - Harthope</u>. (see M.F. p17)

This triangular area falls into three portions, each of which is now considered in turn.

1. The marginal terrain shows lowest summit heights but a relatively high index of relief. It is most extensive

extensive in the east near Wooler, though a minor area exists near Kirknewton. Examination of summits shows a higher set at about 750' (e.g. Earle Hill, Earle Whin, Brownslaw) accompanied by a lower set at 500-550' (e.g. St. Gregory's Hill, Horsdon). Probably associated, too, with the latter is the bench like facet south of Humbleton backing up to the 500' mark.

2. This area is enclosed by a line drawn from Old Yeavering - Humbleton Hill - The Trows - Hartheugh - Harthope Burn - N. Scald Hill - Lambden Burn - E. College valley. Within it summit levels rise from the N.E. westwards and southwest. The summit levels themselves may be grouped initially as follows -

a) Summits between 950-1000'

b) Summits between 1100-1150'

c) Summits about 1400'

d) Summits about 1600'

Relief index tends to be highest on the periphyry, and there is still considerable ground between 950-1200' available for further dissection. Summits over 1600' are in isolation - Newton Tors and Preston Hill being separated by what appears to be a valley stage graded to a possible 1200-950' erosion surface. It is strikingly apparent that the topography of this area contrasts markedly with that west of College Water. Fronting College Water there is a most marked slope from crest to valley floor, a feature also shown in the Harthope Valley/

features akin to high level benches occur near Pinkie shank (Langlee) and Snear Hill in the latter.

3. Moving into the core of Cheviot itself, on the lower slopes Fawcett Shank (1,186') in the College Valley appears to have formerly been a valley bench ice modified, whilst Scald Hill shows a bevelling from 1,800'. On the western upper surface of Cheviot, West Hill and Auchope Cairn (2,350') are at approximately the same height and there is a gradual eastward rise of summit level to the crest at 2,376'. Because of this Cheviot peak appears truncated, the summit area is boggy, featureless and dull topographically.

Harthope - Breamish (see M.F. p 20)

Again a threefold division of topography suggests itself for this area, but unlike that just described delimitation is more difficult. This results from two causes

- firstly, the dumping of superficial material on the lower slopes,
- secondly, the Breamish and Harthope streams whilst now flowing into the Till, might well have belonged to different drainage systems formerly.

1. The lower slopes of the igneous massif near Coldgate Water show a twofold division into summit heights. Higher crests occur at about 700' north of Roddam Burn, whilst a lower set lying at 400' - 450' near Middleton Hall rise southwards being at 550' - 600' near Ilderton and 650' near Roddam. It is obvious therefore that the ground about

Roddam may be assigned to either the upper or lower crests. To add to this - consider how the ground south of Wooler is covered by superficial deposits of varying type and thickness. Here besides till, glacial melt-water cuts, sand and gravel spreads and festoons have all left their mark on the landscape. The bedrock exposed is confined essentially to present stream courses and widely separated localities (mostly between 550' - 600' note). Interpretation of normal erosional features is thus tentative and must also further allow for differential effects of erosion on lavas and sediments. Two characteristic features of this terrain are now mentioned. Firstly, there is a comparatively fine stream density with the present day streams well incised. Secondly, after the distinct rise of ground west of the main road (A,697) the general slope lessens with the ground showing great variability in the form of shape of the sand and gravel deposits.

2. The ground above to the west shows summits and bevelled surfaces lying between 900' - 1,150'/1,200' distinctive from those between 1,350' - 1,550'.

900' - 1,150/1,200' group

In the Harthope Burn area a bevelled spur running N.E. to Brand Hill is striking with the Threestone Burn embayment lying southwards. In the Threestone area it should be noted that granite, andesite and Roddam conglomerate lie in close proximity and have been bevelled indifferently. Heddon Hill to the east shows a hogback form but is now interpreted as having formerly been joined to ground to the west i.e. Dod Hill. (Inference being that Three Stone Burn formerly flowed S.E.). Over the mid Breamish area a 1,000' break of slope is most marked on the south side of Dunmoor, being fronted by bevelled terrain about Hartside and Reavely. In the field the bevelling and also the marked stream incision is striking, and, whilst it may be held that only one surface is present hereabouts, the author prefers two. It is considered that the Hartside ground between 8-900' belongs to a later cycle than that producing a 950'/1,000' - 1,200' surface. Eastwards beyond the Ingram gorge a distinct break of slope occurs at a lower level. Here there is contrast between the smooth flowing surface outlines of the volcanic rocks above and the diverse smaller scale undulations (associated with the effects of glacial retreat) of the ground N.E. of Ingram village.

1,350' - 1,550' group

Northwest up Breamish above Ritto Hill (Linhope) a "finger" of lower ground rises via High Cantle (1,580') to the Lintlands beyond. It is clearly defined topographically and is now interpreted as an erosional remnant (i.e. High Valley line). Northeast of Hedgehope Hill lies the Broad Moss Area apparently representing another erosional remnant, which seen from Scald Hill is smooth, falling away N.E.wards 1,400' - 1,350' but disturbed in places by upstanding Andesitic Xenoliths in the Long Crag - Langlee Crag area.

In the Upper Breamish valley near Bleakhope sharp gradients up to c. 1,750' are shown and along the north side of the Linhope Burn valley bench fragments are suggested between 1,800' - 1,750' by Shielcleugh Edge and Standrop Rig. Shillmoor (1,734') to the south approximates closely to these values and on Dunmoor (south face) the gradient falls off markedly at about 1,750'.

Above and to the north Comb Fell shows a broad domelike summit outline whilst the outlines of Hedgehope (on a smaller scale) are similar to Cheviot. Hedgehope summit is most impressive when viewed from the North and East and is flanked on the west side by an intermediate summit level. In the Upper Harthope valley there is an absence of any clearly marked remnant features although valley transverse sections (as seen in the field) do in places look suggestive.

Breamish - Aln

Contrast is probably the keyword for this area. To the west lies the high, compact Wethercairn - Black Butt area, plateau like with summit heights 1,800' - 1,750' Eastwards, below a pronounced break of slope lies an area where crest accordance and bevelling is a feature (note approximation of topographic break with a N.N.W./S.S.E. crush line), and it is not difficult to suggest that this represents part of a former erosion surface rising westwards from 950'/1,000' - 1,200'. The ground slopes gently now to the North and East whilst to the South a near fault line scarp is observed. The northern portions of this area show numbers of markedly incised stream courses in contrast to the southern flank where but few youthful streams flow into the trough-like shallow valley line used by the present River Aln.

Beyond Fawden Dene dissected ridge features appear i.e. West Hill - East Hill, Castle Knowe - Gibbs Hill - Broomyrook Knowe trending N.N.E. and Chubden stretching Southeastwards. Summit heights of West Hill, Snail-knowe, Gibbs Hill and Chubden (8-900') show approximate accordance and suggest a correlationship with comparable localities in the Breamish valley to the West. On the other hand East Hill and Broomyrook Knowe lying at a lower level are considered to belong to a later denudatbon phase. Probably the summit heights of Hoppers Hill (Glanton) 695', Titlington Pike 765' and Beanley Plantation Camp 699' to the east along the Aln/Breamish watershed depended on this same later cycle. The Fell sandstone country of Beanley and Titlington areas is of interest when examined closely. The splay faults (coming off the large Bolton faults) are often coincident with topographic features. The present Titlington Burn for example flows Northeastward along one of these faults and again the transverse topographic graining in sympathy with the fault lines is to be noted (a probable glacial effect-true, but still broadly coincident with these fault lines).

In the upper Aln valley at about 500' near Alnham the terrain steepens up noticeably, and this height is also associated with slope changes to the east e.g. The Mile, Howmoor. Again along the present Aln/Wreigh watershed summit heights rise when traced from S.E.-N.W. (561' near Lorbottle, 701' Blackchester and 814' near Hazeltonrig). This increase is, in the author's opinion, due to glacial erosion having been more marked near Lorbottle. Part (at least) of the ice coming from the West seems to have been deflected by the Fell Sandstone scarp, with over-steepening as a stoss effect on the scarp front between Lorbottle and Callaly together with increased erosion at the scarpfoot area lying northwards. It is suggested therefore that the Aln/Wreigh watershed lay formerly at c. 700'. A further effect of glacial erosion in this locality has been the topographic graining - in the form of low ridging.

<u>Bowmont - Tweed</u> (volcanic area bounded by Highside - Lintonhill - Carham line to the west).

The topography in a traverse from Kirknewton to Carham impresses one by the alternation of ridge and trough. True there is variation in the amplitude and length of these N.E./S.W. trending features and towards the Tweed outcrop is profoundly masked by drift - nevertheless the alternation is charactersitic. The topography represents an adjustment to underlying structure but in addition has suffered from "glacial graining". In such an area one is forced therefore to depend almost entirely upon summit height accordance in assessing successive erosion stages. Whilst this is reasonably satisfactory along the larger ridges, on the drumlin shaped smaller ones the technique is not quite so sure.

Upon inspection summit heights suggest a twofold division - firstly those lying between 900' - 800' and secondly those between 750' - 650'. The former group with the exception of Monylaws Hill lie close to the main massif and in alignment with pronounced ridges thereon i.e.

1. Linton Hill (926') - Highside (895) aligned with Grubbit Law - Hownam - The Kip ridge.
2. Housedon (877') and Coldside (844') aligned with Kilham Hill - Coldsmouth ridge
3. Venchen Hill (881') and Castle Law (873') aligned with Staerough - the Curr ridge.

The second and lower group tend to lie periphyrally to those described, but in some cases intrude along valley lines into the foothill area.

In the field it is striking how summits N.W. of Highside - Linton Hill - Venchen and Castle Law do lie at a distinctly lower level. Again, about Mindrum a 400' break of slope together with lower ground to the N.E. suggests a former valley stage to have occurred about this height. (Note however the incoming of very deep superficial deposits in this area - see map of overburdens 7.1

MF p27.

SYSTEMMATIC ACCOUNT OF THE CARBONIFEROUS ROCKS.

In considering the topography of the carboniferous sediments east of the Cheviot massif it is proposed to deal with the following localities in turn. (see M.F page 21)

1. The area lying west and northwest of an approximate north - south line through The Low and Hetton Burns, with the Till and Tweed as western and northern boundaries.

2. The major cuesta country from Kyloe southwards subdivided into northern, central and southern portions.

1. In the north of this area strong glacial moulding of the topography has left the low ground in drumlin-like form. It is difficult and hazardous to assess the effects of normal subaerial denudation here and instead a brief description of the topography is given. (However note should be taken of the possibility of this west - east trough having formerly been used by the Tweed. The writer considers the present Tweed outlet to the sea adequate for the Whiteadder but scarcely enough for both Tweed and Whiteadder). Along Tweedside from Velvethall - East Ord (i.e. the Longridge area) the Fell sandstone is associated with a rather marked rise in topography (from 450' -300'). Billylaw 358' marks the culmination of this rise and from it the ground falls away southward in a series of transverse drumlin-like ridges, highest to the west (stoss) and often showing long drawn out tails to the east. Billylaw is matched to the southwest by Mattilees 356'△ and by the topographic break bounding the southside of this relatively lower area. Beyond, the ground rises fairly

sharply to Watchlaw ridge and the terrain hereafter falls into three parts. To the west fronting the Till valley lies a sandstone scarp face, most impressive in the Doddington area and showing a possible bench fragment (400') near Fentonhill. The crestline of this scarp is irregular rising southwards to Dod Law 654'. (There is however coarse matching of crests and bevels with the west side of the Till valley e.g. Dod Law and Lanton Monument Hill area 650' - 684', Branxton Allotment Hill 591' and Doddington north moor 588', Branxton hill 500' and Watchlaw 508'). Viewed from the east this scarp crest appears upon a ridgelike feature rising above a distinct break of slope at 400'. This 400' break is readily traced from Wrangham past Kemping Moss to Bar Moor and delimits a bevelled surface lying to the east. The Bar Moor surface is remarkable even, being only thinly veneered in places by superficial material and it also displays the tendency to have poor or impeded drainage in parts. The irregularity of the scarp face crest is the outcome of glacial erosion, for, in the field, the ridge remnants plainly show how the ice flow direction has altered southwards. South of Dod Law and the short Till defile lies Weetwood Moor where the summit height is lower and bevelling at 550' - 500' is suggested. The third area to the east (approximately along the Hetton Syncline axis) shows smooth and gently sloped ground north of the Coal Burn but southwards small scale ridging appears (N.W. - S.E. alignment). The former terrain suggests a continuation of the Bar Moor surface, whilst the latter probably reflects (1) glacial graining (2) rapid downcutting of streams tributary to the Hetton Burn (3) possible use by glacial meltwaters of some of these small tributary valleys. Southwards too the ground falls sharply into the Chatton Basin where considerable depths of sand and gravel occur.

2. Northern section (Kyloe - Chatton Moor) see M.F. page 25

This in places shows similar topographical features to the area just described - but usually at a different scale and with greater variability. Two factors must immediately be carefully weighed in considering erosional features here. Firstly, there is the Whin Sill, tougher and more resistant to erosion than the sediments, outcropping in parts of the area (with the outcrop crescent-like when seen in plan). Secondly, there is the effect of severe glacial erosion, operative on the west and east flanks of a cuesta buttressed in parts by this intrusive sill. Note, for example, the relationship between the Whin Sill outcrop and upstanding topography (large and small scale) from Kyloe Quarry - Belford - Budle Point. Again, consider how besides producing an irregular scarp crest ice moving southeastwards has gouged out or molded in lens fashion the rock outcrops, impressing a graining on what probably had formerly been a bevelled surface.

The scarp crest to the west is irregular (having been deeply scored by ice) and in places when viewed from the east it seems to surmount a ridge or hogback. Most often, too, it is the case that an ice breach at the scarp front leads to gouged or molded terrain on the leeside. It is as if an enormous rake had gone hard over the ground cutting it to shreds. The furrows cut correspond to present day topographical troughs in which peat or till is often found as a partial infilling, whilst the ridges cut are usually in bedrock showing various forms and dimensions (with those of lesser magnitude lying south-eastwards). This whole area is cut also by a series of N.E. - S.W. fault lines which often produce marked topographic effects at site or locality scale. Colour Heugh for example shows a small scarplike feature abruptly truncated at its southern end along a faulted junction of Fell Sandstone and Scremerston Carboniferous Measures. Again, on a larger scale, compare and note the relationship between this fault pattern and the Fell sandstone outcrop with the present scarp face and the watershed (major). Cocken Heugh 692' represents the culmination in scarp crest heights, but the frequent occurrence and approximation of summits over 650' north and south is noteworthy.

The 'ridge and furrow' area to the east possesses a roughly triangular shape with the apex at Shiellow Crags and a base stretching from Chatton Park Hill to 578'△ Warenton. Within it ridge crests show a general rise southwards and it is fairly clearly delimited to the west and east. Westwards, a break of slope at 500' in the north is replaced further south by a break at 550', but to the east, a clear cut break at 500' in the north is not so continuously shown southwards.

From the higher land in the North the ground falls quickly to 250' where the slope flattens out and leads on to the low semicircular Buckton Moor area (with Detchant Lodge and Fenwick Woods forming its southern and northern limits i.e. adjustment to structure). Beyond Detchant the ground is higher, showing glacially eroded ridge and furrow topography southwards to near Belford. This "spur" of higher ground (corresponding to a broad outcrop of the whinsill) shows a general fall in summit level coastwards and terminates abruptly. It ends along a line from Detchant Lodge - Belford Whin Quarry where the broad whinsill outcrop ceases and the ground drops <u>via</u> a short concave slope (ice produced) on to the coastal plain eastwards. It is plain to see that the Buckton Moor area (northwards) and the Newlands/Moussen ground (to the south) of sedimentary material has succumbed to erosion, (especially glacial) and much more easily than has the whinsill, and, if there formerly was an equivalent hereabouts to the Bar Moor surface, most of it now has been removed. It is considered that only those summits on the whinsill between 400' - 300' are eligible for consideration as possible residual features of such a former surface.

From Belford the ground rises rapidly westwards, but about Adderstone (S.S.E. along A.1. road) a bench like feature interrupts the steady rise in topography from the Lucker trough to the east. Again, Warenton Hill 578'△ serves to divide into two a strip of lower ground[1]. leading off Chatton Moor - one portion continuing eastwards into Cocklaw Dean with the other portion aligned northwards. Interpretation of these features obviously is a matter of opinion, but it is now considered that the latter portion is due to ice erosion.

Central portion (Chatton Moor - Eglingham/Aln gap).

This area contrasts with that to the north in that it is of wider extent, rises to greater heights and possesses more distinctive drainage lines, but like the former it is clearly defined topographically and tapers northwards[2]. Summits on the west facing scarp are particularly impressive above Chillingham and old Bewick, but, as before, the crest area shows ice moulding and gouging - particularly on Hepburn, Sandyford and Amersidelaw Moors. In contrast to the northern portion, the scarpline is here convex (to the west) and is fronted in places by terrace or

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1. Note partial coincidence of this ground to area between Hanghill Burn and Chillingham faults.

2. Inspection of the solid geology map will show that the effect of the Bolton fault and the Lemmington anticline is to repeat the lower part of the carboniferous succession. This suggests, therefore, that the greater width of this area southwards is related to underlying geology and structure and not merely due to erosion.

or benchlike fragments. These occur on Kay Hill 720' north of Kay Hill 550' - 500', Amersidelaw farm 334', Chillingham wood 400' plus and Hepburn c. 400', and whilst they may have been formed under normal conditions, glacial erosion is to be reckoned on together with possible marginal cutting by meltwaters (for the lower set of features). Again the effects of heavy faulting together with the Fell sandstone outcrop appear responsible for details of the scarpline and the landscape scenery e.g. W. Amersidelaw Moor, Cateran Hill.

Inspection of the topographical map shows the up-standing Roscastle summit 1036' to be flanked by a zone of transitional height leading to still lower ground which falls away easily to the N.E. and S.E.. In the field Roscastle certainly looks a monadnock and the transitional zone east and south of it shows summits lying from c.800' - 900' (e.g. Cateran 876' Willie Law 815', Castle Hill 793'). Below, the 750' contour on the west side of Quarryhouse Moor marks the beginning of what appears to have been a 750' - 550'/500' erosion surface. Eohypses can be plotted over the area in question with comparative ease and certainty, and furthermore a traverse from Botany to North Charlton tends readily to support this view. It is maintained that the present moors of Amerside, Windy Law, Quarryhouse, Middle Bewick and Eglingham lie on an erosion surface which has been only partially dissected by streams but later modified by ice erosion and deposition. The

The surface topography is generally low and undulatory, with peaty deposits occurring in ill drained sites; till being fairly widespread and only on the periphyral areas do sands and gravels appear..

Within this area, too, the most obvious effect of structure and lithology on the landscape occurs in the Sandyford -Lucker Moor area. Here the Chillingham and Annstead dislocations meet and the Fell Sandstone is brought against Scremerston and lower Limestone rocks. These geological influences appear to be reflected in the presence of Brownridge (586') and the topographic break from Brownridge Burn (i.e. 500' contour) to Rayheugh Again, it is further to be noted that the "nose" of the Lemmington anticline approximates to lower ground west and north-west of Shipley (i.e. broadly forming the west side of Shipley Burn valley).

South of Warenford the ground rises to a bench-like strip running between Warenford cottage and Brownyside (nr. North Charlton). This strip has been used in parts by glacial meltwaters and has suffered dissection, but sufficient remains to assess its former height range as being from 400' - 350'. Below, to the east, the ground falls steadily into the southward continuation of the Lucker depression, whilst above, to the west, 500' coincides with either a crest level or break in slope. Beyond South Charlton, fragments of the Quarryhouse "moors" surface appear to be represented by the South Charlton - Whitehouse Folly 553' ridge and the Heiferlaw outlier whilst the ground near Rock and Rennington with 350' plus crests may be equivalent to the "bench" near Warenford.

Southern portion (between the Aln and Coquet gaps).

In this area the writer has examined only the line of the River Aln and the ground lying north of the Aln watershed (as far west as Coe Crags), with the rest as yet unexamined closely.

Here again the country shows the Fell sandstone to be associated with scarp and craggy faces and once more bevelling of the cuesta top occurs, but for a change a pronounced cementstone ridge and a double scarp front appear in the landscape to the west. West of the Bolton Fault (approximately the lower Coe valley line, - although the actual faultline N.E./S.W. through Thrunton Tileworks) the Fell sandstone shows strongly marked relief, with the striking crags at Lorbottle, Callaly and Thrunton leading up on to tops lying between 800' - 900'. When seen from the north these crests suggest a transitionary level to the higher summits behind i.e. Coe Crags 1,007', Long Crag 1,047', Shirlaw 1,010'. Between these two adjacent areas lies a narrow west/east valley, coincident for the most part with the Lorbottle - Rough Castle fault, with the second scarp front to the south rising steeply up from the valley line. East of the Bolton fault the Cementstones have been eroded into low valley lines in the north (i.e. Aln and Eglingham) but beyond Butteridge they take the form of a rising asymmetrical ridge. This ridge corresponds to the axis of the Lemmington anticline, with the Coe valley to the west approximating to the Bolton Fault line and the Edlingham valley to the east apparently the outcome of uniclinal shift. Although summits in the Rimside moor and Newtown area lie between 700' - 650', it appears that glacial erosion and deposition are chiefly responsible for this approximation. Near Wandystead the till is extremely thick (see overburden map) and it is now suggested that, during the phase when ice moved southwards over this area, erosion first occurred in the Coe Valley, and that probably the wind gap at Newmoor was produced or enlarged, to be followed at a later stage by plugging in the Wandystead area.

On the (outer) Alnwick Moor the frequency of summit levels between 800' - 900' has already been noted. The relief of the bevelled top as might be expected is subdued in places, although northwards where the amount of this ground becomes reduced, the relief index increases.

The scarp face is at its greatest development below Bigges Pillar and Corby's Crags (together with the abrupt termination at Brizlee), but an intermediate step occurs on the scarp face near Moorlaws (about 400'). It is just possible that this scarp face, in part, coincides with a line of Faulting, for information collected* at Senna Wells

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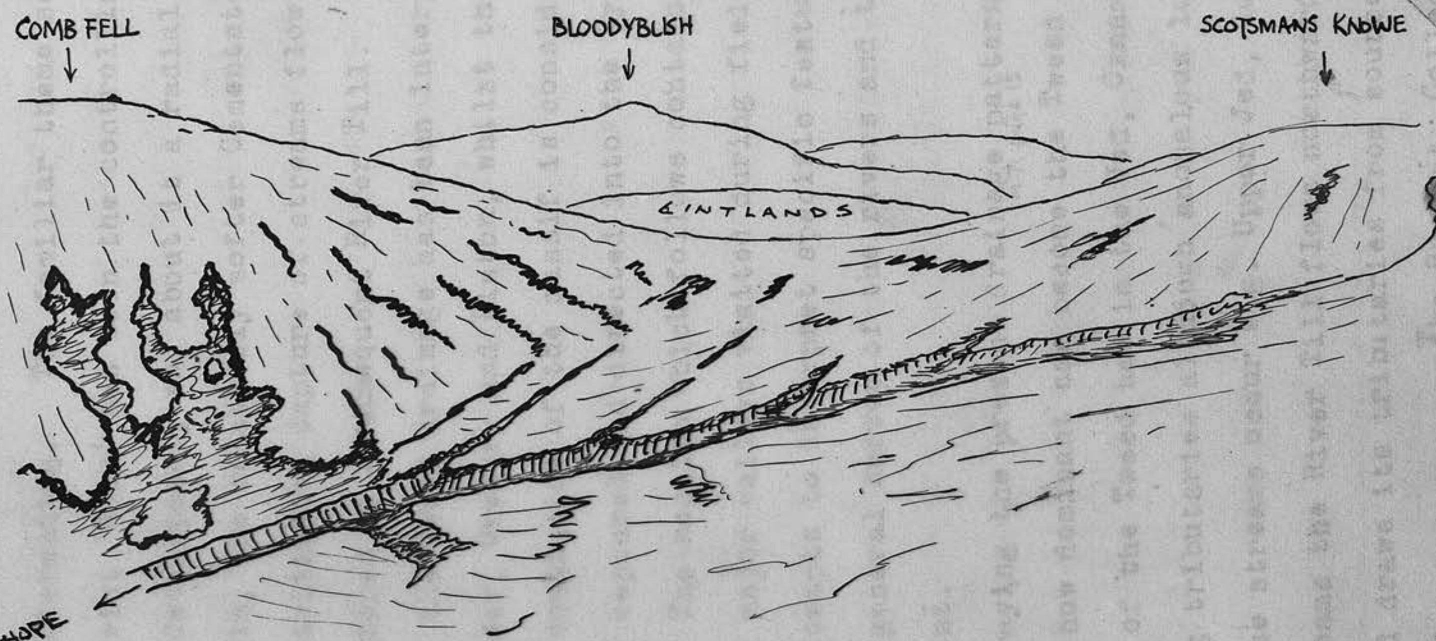
*Borehole records received from workmen on the site (working for Professor Hickling N/cte.)

boreholes strongly suggests a continuation through the borehole site of the N.E./S.W. Overthwarts fault. Inner Alnwick moor seems to be essentially a shallow glaciated trough rising S.W. and separating the higher ground (with hogback looking landform) to the west from the lower Hobberlaw ridge to the east. The latter approximates in height to Shilbottle Beacon Hill 587', Felton Common 616', Longframlington 564' and also a possible bench-like feature running from Rugley towards Glantlees. This bench-like feature, it is to be further noted, is associated with the Whinsill outcrop running S.S.W. past 562' △, St. Margarets, 630' Freeman's Hill and 601' △ north Shiel Dyke. It is probably a justifiable inference to draw, that these summits, with approximate values, arose from a common origin (i.e. an erosion surface).



Field Sketch at head of HARTHOPE. "CRUSH" wall seen along stream course. Extensive peaty area (but wasting). Well marked wide shallow wind gap. Beyond, 1800' B of S and 1600/1650 bevels.

CHAPTER 4.

DRAINAGE OF THE AREA.

GENERAL STATEMENT AND SUMMARY.

It is rather surprising that so littlework has been published on the drainage system ofthis area, as some of the more anomalous features displayed, to say the least, are so obviously interesting. The familiar theme seems to be that the Cheviot 'dome' has been the controlling element in stream development, and about it a radial pattern has evolved. Again, the relatively softer Cementstones are held to have facilitated capture of streams flowing off the east Cheviot slopes by a subsequent River Till. Adjacent, the development of the Tweed drainage has been interpreted variously byMackinder, Gregory and Linton, whilst the River Rede on the south side of the massif is considered to have been early captured and directed into the Tyne drainage system. The section which follows contains a description of the major valleys visited during fieldwork, interspersed by attempts to interpret specific features, but now prefaced by a general survey of the rivers and their possible development.

The map portraying the present drainage pattern (map 4) M.F. page 13 immediately shows how dominant has become the Tweed catchment. The Teviot branch of the Tweed has in the Jed, Oxnam and Kale north flowing tributaries although anomalous looking alignments in these streams occur e.g. Upper Jed, lower Kale. East of these streams the River Till flows northward to join the Tweed and draws its tributaries from sources in the Windy Gyle - Cheviot area. The Bowmont, College, Harthope and Breamish tributaries rise within short distance of one another, and together with the Lilburn and Roddam burns form a loosely radial pattern. Upon closer examination however, it will be noted that the Bowmont and College tend to parallel each other over parts of their courses in response to underlying structure, and both show stream deflection because of glacial effects in their lower courses*. South of these streams, the straightness of the Harthope valley is most striking and reflects structural control, but again glacial effects have been responsible for the present stream's deflection at the margin of the massif. The original alignment of the Breamish is problematical, (see detailed description of the Breamish valley), but, like the other streams mentioned, it shows a deep and well established valley through the igneous rocks. Probably in pre-glacial time the Breamish+ flowed eastwards with the Upper Aln as a strike subsequent, but later partition divested it of the Upper Aln tributary-due to piracy by a dip slope tributary of the R. Coquet (line of present lower R. Aln). In addition, it is considered that the pre-glacial R. Till used the Wooler water gap and diverted the main Breamish waters N.W. into the Tweed catchment. The present River Aln shows a lower tract which is readjusting itself upon glacial deposits

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*although the writer has not examined the Kale in detail, it may well be included in this statement.

+ THE READER IS REFERRED TO TWO DIAGRAMS (A & B) FOLLOWING page d UPON WHICH THE SUGGESTED DRAINAGE DEVELOPMENTS ARE DEPICTED.

and contrasts markedly with the upper valley, which has probably been enhanced by ice erosion. On the eastern slopes ofthe major cuesta and on the coastal plain youthful streams are developed, controlled at present by three factors:- the form and depth of glacial deposits, the form of glacially eroded features and the dip slope ofthe cuesta itself. On Tweedside and in the Shoreswood - Haggerston area, initial stages of stream development in drumlin topography are seen, whilst the Tweed below Coldstream and the Till below Etal are both using post glacial tracts.

So far as it is possible, the characteristics of present streams are indicated upon map 5 - but of necessity supplemented by a written summary to cover deficiencies in representation. It remains only this introductory section, to indicate what possible changes might have occurred in the drainage system under "normal" and "abnormal"* conditions.

M.F page 14.

Along the northern flank of the massif it is suggested that the original stream alignments were parallel, S/N. Because of unequal rates of headwater extension by these streams and the preservation of higher residual areas especially near Cheviot, the upper tracts of some of these streams now show S.E./N.W. sections e.g. obsequent upper Bowmont. Again, the lower courses have become increasingly adjusted to structure in the stages following the formation of the 1,200' - 1,000' surface. With the passing of time, and

* i,e. Because of glaciation.

because of successive cycles running only partial courses, a radial pattern has developed at the east end of the massif near The Cheviot. It seems, therefore, that structure, together with only partial completion of erosion cycles, is responsible for the emergence of this later stream pattern. It is probable, too, that abstraction occurred along the north side of the massif and possibly capture, in pre-glacial times. It would be difficult to prove, or disprove for example, that it was the Halter burn which captured the Bowmont, and flowed out through Mindrum Gap; or again, that the Trowup originally flowed northwards, subsequently to suffer from College tributary piracy. In later times, the lower Kale, lower Bowmont and Kilham burns have been diverted because of glacial effects. Some may consider this to be excessively hypothetical - but an examination of the meltwater channels at Wooler Golf Course and Humbleton Hill will convincingly demonstrate meltwater's capacity for erosion. These features, and the probable occurrence of a halt during ice recession at or near the N.E corner of the massif, prompt the writer to postulate ice diversion.

South of the River Glen, the sequence of events in the drainage history is much more difficult to assess. In the field, erosional and depositional glacial features, together with the presence of only one well marked monadnock (Ros Castle), force the observer to turn first to the geological map and next to the imagination, for possible solutions of

DIAGRAM A.

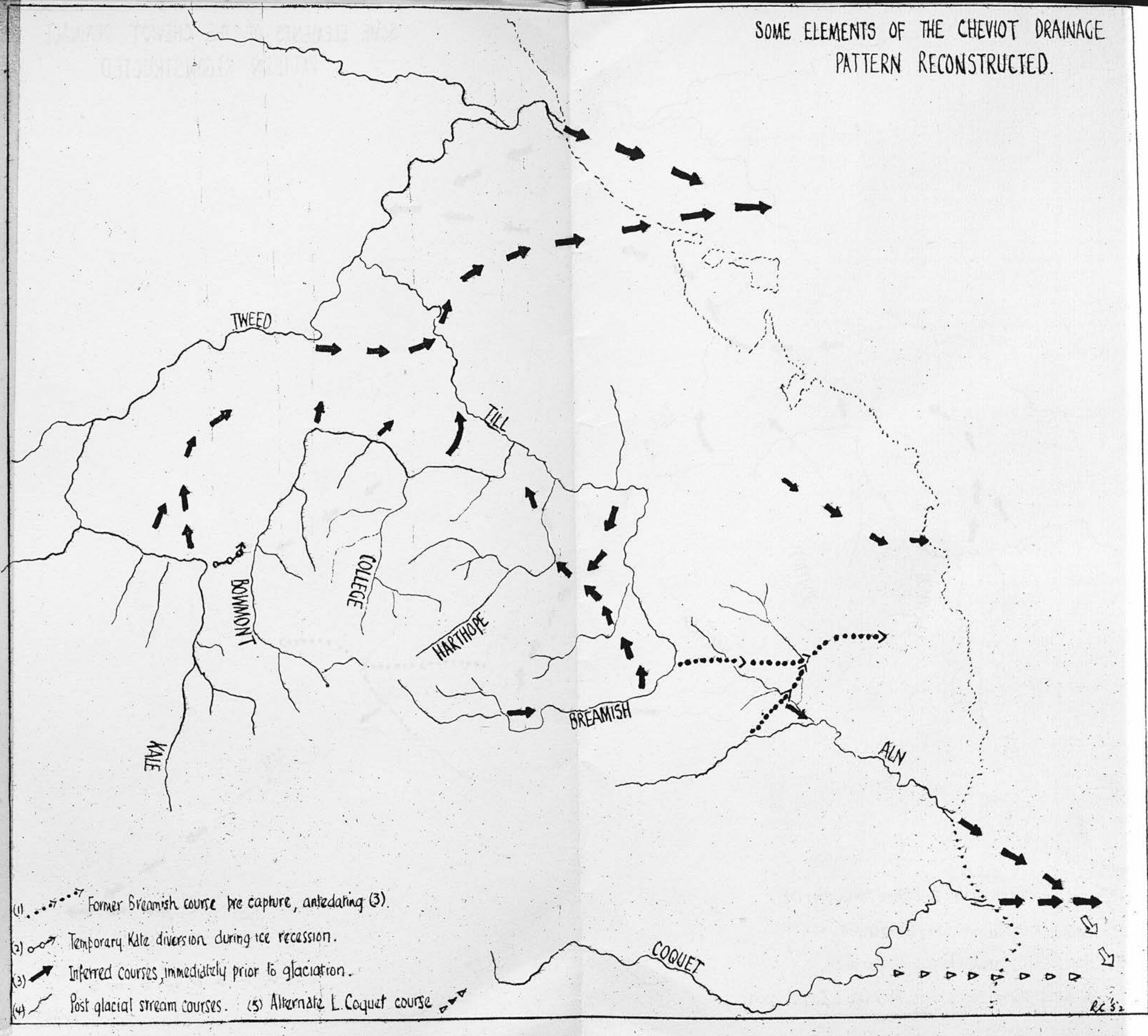
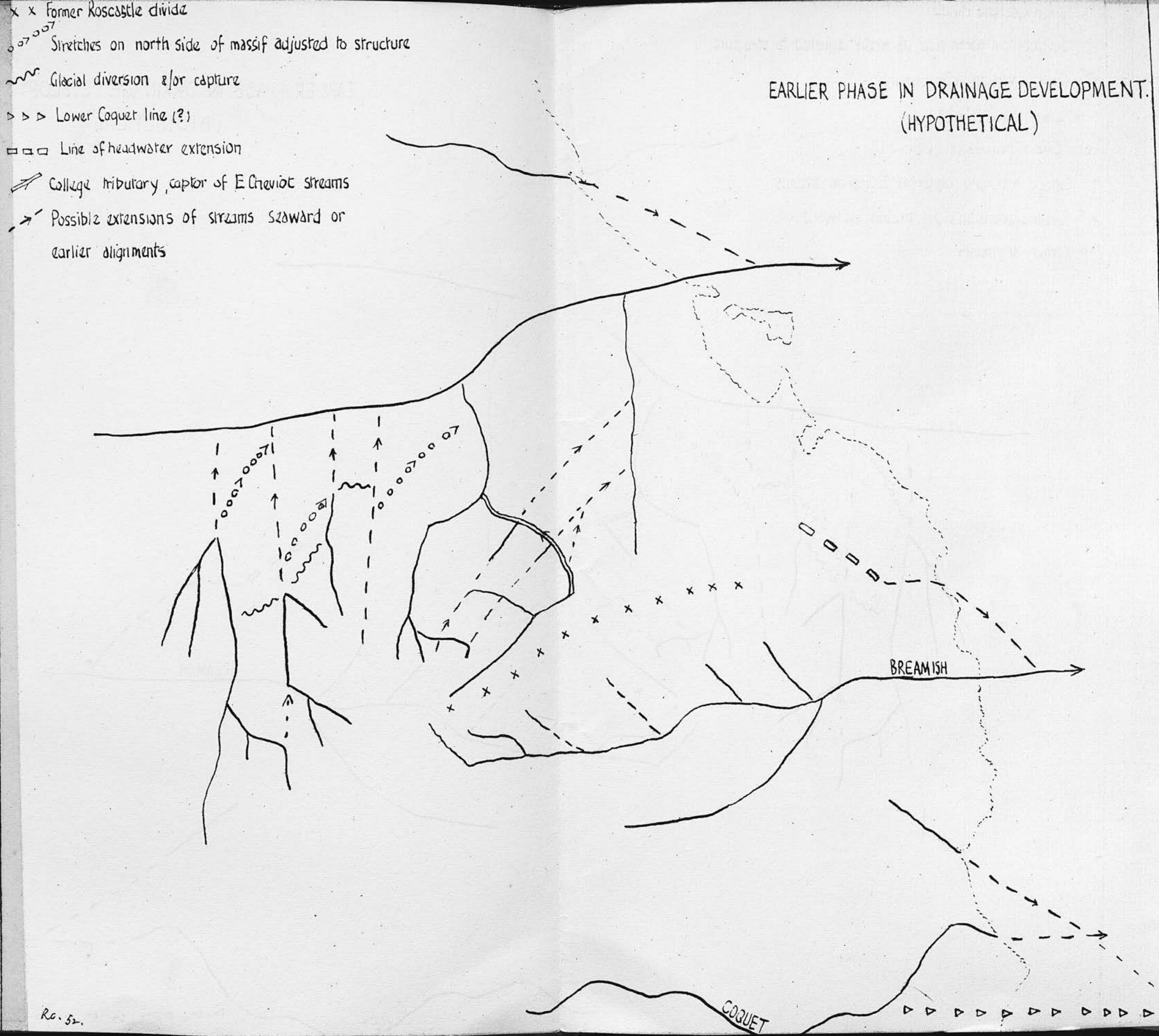

SOME ELEMENTS OF THE CHEVIOT DRAINAGE PATTERN RECONSTRUCTED.
TWEED
TILL
BOWMONT
COLLEGE
HARTHOPE
BREAMISH
KALE
ALN
COQUET
(1) Former Breamish course pre capture, antedating (3).
(2) Temporary Kale diversion during ice recession.
(3) Inferred courses, immediately prior to glaciation.
(4) Post glacial stream courses.
(5) Alternate L. Coquet course
RC '52

DIAGRAM B.

EARLIER PHASE IN DRAINAGE DEVELOPMENT.
(HYPOTHETICAL)



of former drainage lines. Clearly, with few reliable features available, and these occasionally subject to alternative interpretation, the writer's suggestions are tentatively offered.

One factor primarily determines whether the following interpretation stands or falls - it is the former presence of a divide which joined the Ros Castle monadnock to the massif. Using the evidence available, the development story can really begin only with the cutting of the 1,000' - 1,200' surface. On the north side of the massif and east of Westnewton, the writer postulates that the College stream, from flowing northwards, shifted its lower course eastwards uniclinally. On the massif, the present Akeld burn probably continues, in part, the line formerly used by a beheaded N.N.E. flowing stream, which was tributary to a north flowing Hetton burn. (The former Akeld burn line possibly crossed over the present site of Fentonhall), Similarly, the Harthope may formerly have flowed along a line from east of Earle Hill - Wooler - Doddington to join this burn; it is suggested that its line of flow corresponded to the Hetton fault line. Following upon the cutting of the 1,000' - 1,200' surface, it is envisaged that a tributary from the College began back-cutting eastwards (approximating to the lava:Cementstone junction). Capture of the former

Akeld stream would be followed by similar diversion of the Harthope. On the smaller and western cuesta, therefore, one would expect to find first, stream misfitting, and later, reversal of drainage by obsequents. It is imagined that, by the beginning of the 750' - 550' stage, the break of slope on the north side of the former Ros Castle watershed lay along a line from N. Heddon Hill (west of Ilderton) - S. Amerside Moor. On the south side* of this Ros Castle watershed it is proposed that, besides a S.E. flowing Threestone tributary to the Breamish, there was another, also S.E. flowing, along a line from Rosedean - New Bewick. The Aln in this earlier period is considered to have been tributary to the Breamish, a strike subsequent, guided by the line of the Bolton fault to a confluence point on Longlee Moor (nr. S. Charlton). The Breamish is interpreted as formerly flowing through the site of the present Eglingham gap, and continuing eastwards, north of Rock, approximating to the W/E Rock fault, until the completion of the 750' - 550' stage.

The subsequent events probably occurred during the cutting of the Barmoor surface†. Break through in the

*See introductory remarks on R. Breamish concerning original stream alignments

†It would seem that besides the Barmoor surface, higher features in the same stage may have been cut to 550' - 600'

Ros Castle divide from the north* seems to have affected the Breamish and Hetton burn, whilst in the south capture of the Aln tributary was effected by a Coquet dip slope tributary which used the intensely faulted ground about Hulne. In the north, Barmoor seems to have been matched by a similar plain over Milfield, judging by the height of valley "hangs" and the summits about Wooler and Kirknewton. Nearby, the captor stream is held to be responsible for reversed drainage in the now reduced Hetton stream, the Rosedean - New Bewick tributary of the Breamish - and in time embracing the Breamish waters too.

The interpretation as outlined involves the stripping back of the carboniferous cover in the north to produce the Cementstone vale and sandstone cuesta west of the major cuesta. This is in keeping with the general pattern of events for the whole area. Firstly, there is the struggle between original stream alignments and general geological structure and this is followed by further changes induced by lithological factors.

The effects of glaciation have already been mentioned earlier in this section, but the writer wishes to add two

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* It may well be asked, "Why not have the Carey Burn as part of a former south flowing subsequent?" This is a possibility, but the Carey and Common burns most certainly have been used by meltwater, and in the writer's opinion are unreliable.

further comments;

1. The glacially gouged faces along the right bank of the Bowmont differ in form from the valley that "hangs" between Kirknewton and Wooler.

2, The two largest ice gouged and infilled basins of Milfield and Hedgeley are rather similar - both are bounded to the west by igneous rocks and share parts of the Hetton syncline and Holburn anticline (i.e. duplication of the Fell sandstone). They are both partially fault bounded on their southern margins, both show triangular shaped Cementstone outcrops, and both now possess double outlets to the south.

The interpretation is an incomplete one and the writer considers that until the Holystone - Snitter area has been examined the problem of the Aln and Coquet streams cannot be resolved satisfactorily. Similarly, to the west, the Jed and Oxnam streams require detailed study, for it may well be that the "capture" by the Jed of part of the Rule stream has been induced during ice recession. (The observer in the Jedburgh area cannot fail to be impressed by the temporary diversion of the Jed waters into the Oxnam, along a meltwater channel N.E. of Mossburnford, and there may have been a similar occurrence in the upper Rule valley).

Harthope - Coldgate - Wooler Water (see M.F. page 15, 17.)

With headwaters rising in the peaty area of Scotsman's Knowe, the Harthope Burn soon establishes itself to flow N.E. over granite and andesite for 5½ miles joining the Carey Burn near Shining Pool. A map will show the remarkably straight valley line of the Harthope (an understandable feature considering its coincidence in part with one of the major "crushes" in the massif) and also demonstrate how the valley begins west of Cheviot and Hedgehope peaks. In contrast to the Harthope, the Coldgate and Wooler valleys show anomalous looking courses and different forms, with the Wooler Water finally running out over upper Milfield Plain to join the River Till. A longitudinal profile of this stream system plotted from 1:25,000 provisional sheets (diagram MF.p15) shows knicks to occur at 1,750', 1,600', 1,450', 1,200', 750' and 450' with a slight inflection coming about 950'. Again a series of transverse sections down the valley line (diagram MF p17) demonstrates the V-like form of the upper valley with bench like fragments and extensive heughland appearing only in the middle and lower stretches.

For descriptive purposes the stream system may be considered in the following sections -

1. Source to about 1,500'
2. 1,450' to Harthope Linn (1,200')
3. Harthope Linn to Cat Loup (near Langleeford)
4. Langleeford to the Carey Junction
5. Coldgate
6. Wooler Water.

1. Above 1,750' the Harthope is little more than a burn, cutting down through a peat cover which averages 6" thickness. The main valley opens out westwards to a low wide col which overlooks the Breamish and Usway Burn headwaters. Downstream to 1,500' the present stream is busily incising itself, being contained by steep banking and showing slight interlocking of small spurlike features. On the south bank, the convex side of Comb Fell leads down to clifflike or steep 70' - 100' slopes dropping into the present stream course. The containing bank on the north side of the stream rises 50' - 70' steeply, but gives way above to a less severe slope which rises to a break of slope at 1,750'/1,800'. This area of gentlergradient shows a coarsely triangular shape with the apex pointing upstream. In the apex at 1,700' there occurs a hummocky and boulder strewn patch, -interpreted by the Geological Survey as boulder clay, but now suggested to be a solifluction effect. Down valley, this area loses definition, but it may be related to the Scald Hill bevel @ 1,750'/1,800'. There is then an asymmetry to the main valley form here and it would seem that glaciation did <u>not</u> produce any marked topographical effects on this part of the Harthope valley. It is to be noted however that a depression occurring on the south face of Cheviot between 2,500' - 2,150' strongly suggests a nivation effect. Along the stream line outcrop is frequent, veining apparent and the rock often

friable. Whether friability is the result of weathering alone or due to weathering on crushed rock has not been ascertained.

2. The stream emerges from its upper channel at 1,450' where the sheer rock banks rise 30' - 40'. Below to Harthope Linn the present stream seems to be reworking a thin valley fill, for at tributary junctions 20' - 30' of variable fragmentary materials occur (note local origin too). The Harthope is still contained between 30' - 40' steep banks but the floor between has widened out to 50' or so, being veneered by coarse alluvia and boulder beds. In step, the main valley itself opens out markedly and valley slopes diminish. It is equally apparent in the field and from the map that Harthope Linn represents the site of a local base level.

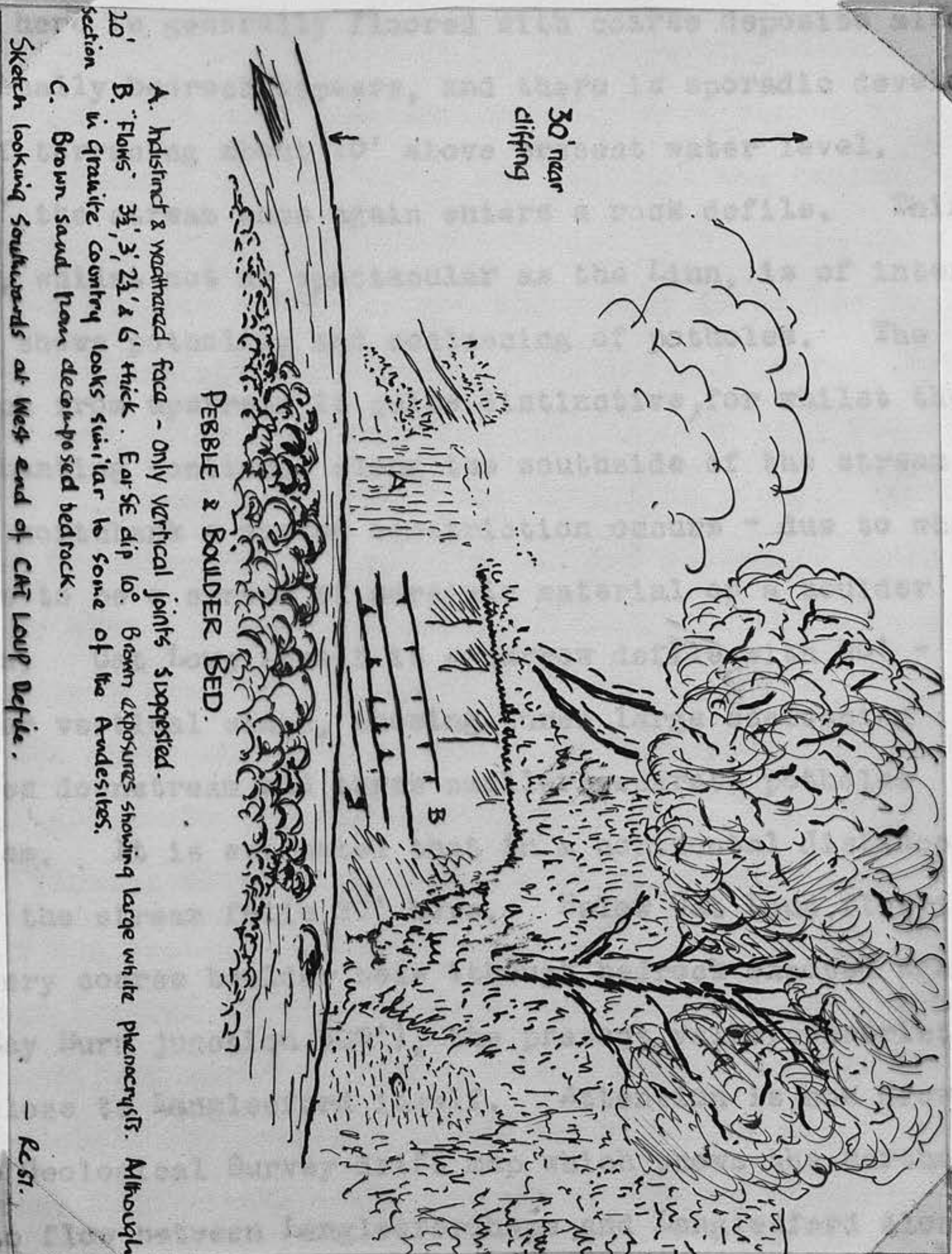
3. Immediately above the Linn the present stream formerly graded out to 1,200', but it is now cutting into a small fan thrust out by south bank tributaries. The Linn itself begins just east of the sheepfold at 1,200' and terminates downstream below 1,150'. Over this tract the burn flows quickly over three small falls separated by rapids and all cut from bedrock. The largest fall lies at the head of the Linn where the water only falls 12' but leads to a 30' defile lying downstream. Leading into the Linn foot there are short-paired terraces, whilst

above these the banking rises sharply some 40'. It has been observed that whilst gullying effects are developed along the north side of the Linn, downvalley, below the Linn foot, it is on the south side that gullying and steep banking are more continuous and common. The stretch of ground between Harthope Linn and Langleefordhope is of interest. Over it the stream now meanders fairly freely and there is a tendency for water-logging to occur near the steading. Again, a slight inflection in the longitudinal profile probably corresponds to a former rock bar lying across the stream course below Langleefordhope. Furthermore, as an examination of the drift map will show, a pocket of alluvium lies within this area with other coarse superficial deposits appearing N.E. of Langleefordhope. In the field 20' of unsorted, coarse angular rock fragments and gritty material are exposed in a tributary burn just east of the steading, whilst upvalley it does look as though a temporary ponding back of water, in late or post glacial times was possible, locally. Taking a wider view here of the main valley, there is contrast to be noted between the convex valleyside to the north and the concave slope of the south side.

Downstream towards Cat Loup the Harthope flows between 30' bankings lying at varying distances up to 100 yards apart. The banking on the south side is more clearly defined and continuous, apparently* formed of granitic

*It is difficult to distinguish clearly, in places, hillwash from material of glacial origin.

material or coarse sand derived from granite. On the north bank however the material tends to be variable, being generally coarse but without any marked claycontent. The stream here is generally floored with coarse deposits also, occas[illegible] appears, and there is sporadic development of [illegible] 10' above present water level. At 900' the stream [illegible] again enters a rock defile. This defile, [illegible] spectacular as the Linn, is of interest for it [illegible] of potholes. The approach [illegible] instinctive, for whilst the steep [illegible] the southside of the stream, on the [illegible] occurs - due to what appears [illegible] material [illegible] terrace [illegible] 30' [illegible] potholes [illegible] upstream. It is [illegible] of 80' the stream [illegible] over very coarse [illegible] near Ray Burn junction [illegible] till close to [illegible] to the Geological Survey [illegible] Burn to flow between [illegible] along the junction line of "drift and solid". Although it is difficult to be definite on this subject, the writer is of the opinion that superficial deposits do appear to have influenced the present stream course at 1,000' and 900' respectively.



material or coarse sand derived from granite. On the north bank however the material tends to be variable, being generallycoarse but without any marked claycontent. The stream here is generally floored with coarse deposits also, occasionally bedrock appears, and there is sporadic development of terracing about 10' above present water level. At 900' the stream once again enters a rock defile. This defile, whilst not so spectacular as the Linn, is of interest for it shows potholing and coalescing of potholes. The approach from upstream is quite distinctive, for whilst the steep banking continues along the southside of the stream, on the northbank a marked constriction occurs - due to what appears to be a spread of morainic material or a boulder terrace. Cat Loup itself is a narrow defile with 20' - 30' near vertical sides, showing three large coalescing potholes downstream and three smaller separate potholes upstream. It is estimated that in a horizontal distance of 80' the stream falls 20' here. Below Cat Loup, flow is over very coarse boulder beds (though bedrock exposed again near Ray Burn junction 820'), the present valleyconstricted till close to Langleeford itself. Attention is now drawn to the Geological Survey drift map which shows the Harthope Burn to flow between Langleefordhope and Langleeford along the junction line of "drift and solid". Although it is difficult to be definite on this subject, the writer is of the opinion that superficial deposits do appear to have influenced the present stream course at 1,000' and 900' respectively.

4. By now the main valley form is changed. Upstream, Cheviot and Hedgehope peaks dominate the upper valley sides and cause the observer to begin thinking in terms of stream misfitting and superimposition. Now, however, possible and recognisable bench features appear, more strongly marked tributary valleys occur and there is the beginning of a flood plain tract north-eastwards. Few would deny that from Langlee - Langleeford the valley is at its best.

At Langleeford the stream is shallow and narrow, lying some 6' down below its banks and passing over well rounded boulders. Immediately below the ford lies a small heugh, flanked by steep banks which are boulder choked. There is still no clay content in the superficial material to remark upon, indeed the whole strip of "boulder clay" along the north side of the valley to Hawsen Burn is coarse grained and looks more like a valley fill. The stream itself flowing north-eastwards now tends to braid, it is shallow and begins to meander a little more freely. At and near Langlee several features are worthy of description. The Shank, just south-west of Langlee, looks anomalous. It appears to be benchlike, but with its inner margin water eroded. The Leech Burn to-day occupies part of the water cut channel, but the upper part is now "dry". Opposite the Shank, the valley side has been oversteepened, with Pinkie Shank a bench remnant which has probably been subjected to meltwater cutting. (see transverse sections). Downstream from Backwood Burn, a strip of superficial deposits is associated with a marginal banking whilst on the south bank Langlee itself is on a terrace remnant 30' above Water Level and possible terrace fragments occur downstream between 7-600' and at 500'.

5. At the confluence with the Carey Burn solid rock outcrops at the fording point but gives way downstream to a flooring of boulders and alluvium (of various grades). The main valley sides hereabouts have been scored by melt-waters, but details on these meltwater features will be given in the chapter on glaciation. Grimping Heugh, too, is liable to flooding - the Coldgate being markedly braided and shallow. (Probably too the occurrence of a water node here tends to aggravate the danger of flooding). The stream channel is severely confined by 150'/200' steep banks in this stretch and it may be legitimately asked if we are not here dealing with a "superimposed tract". A possible solution to this question may be afforded by consideration of the following points

1. There is a convergence of various meltwater cuts on Shining Pool.
2. Between Broom Crook and Old Middleton in the Coldgate Valley there occurs an incised hanging meander - obviously the product of meltwater cutting.
3. At Humbleton Hill the meltwater cutting on the inner margin amounts to approx. 150'

The 'superimposition' may therefore be due to meltwaters - a possibility not to be overlooked. The Coldgate heugh-land narrows downstream where the stream enters a final rock defile above Coldgate Mill (350'). Here the stream course is broken and flows through a 30'-40' deep channel cut through andesite. On the south side the lavas are overlain by sand and gravels and eastwards along this banking it appears that water once flowed <u>via</u> N. Middleton towards Lilburn, with the present stream course developing later. Quitting the rock channel the Coldgate flows a short distance eastwards prior to turning north (where its name is changed to the Wooler Water). In the field (and also on vertical air photos for the area) the effects of lateral stream cutting can be readily seen and heugh development now becomes pronounced and characteristic. Nearness to local base level and approximation to grade, soft unconsolidated superficial deposits and a shallow channel result in the stream braiding and subjecting adjacent heughs to flooding in times of spate. (Wooler suffered sharply in the 1948 floodings and even in 1950 the author witnessed ballasting operations along the river banks, to protect property adjacent to the Wooler Water). Again, it is to be noted that from Bridge End (Wooler) down to the Till junction protective embankments have been erected to offset the risk of flooding. The writer is of the opinion that the Wooler gap represents a glacial breach or an ice enlarged water gap, subsequently partially infilled by superficial material which in turn has been reworked to some degree by the Wooler Water flowing first into Ewart "Lake", and later into the River Till.

Before leaving this stream system a brief comment is added on some of the Harthope tributaries. These, although short, are of great interest for the [illegible] physical features shown.

(A) The New Burn in part coincides with a "crush" line and flows eastwards to join the Harthope below Langleeford. Attention is directed to the headwater area where ice seems to have travelled over the head of the Lambden valley to be followed at a later stage by meltwaters flowing from West to East over the watershed. The result has been to produce at the head of New Burn a meltwater cut sitting in the wider low depression produced by ice moving southward at an earlier stage.

(B) The Hawsen Burn in itself is a classic. Here it is possible to see something of the contact between granite and andesite as one moves upstream. It is by no means a sharp contact but fluctuates between the two rock types, the granite exposures ranging from thin veins to dyke masses protruding from the steep valley sides. Again veining due to "crush" soon appears and some distance upstream one is treated to the sight of a 30' high (6' width x 30' long) exposure of Quartz Felsite (?) running along the valleyline at right angles to the normal flows. This dykelike mass is breached in two places by the stream and is a most striking feature. The burn itself is incised 50' where it emerges into the Harthope valley, and, although for most of its course it flows over bedrock, it does seem to pass through a very coarse fan before leaving its gorgelike valley to flow out into the trunk valley. Finally, upstream, an almost "textbook" knick point occurs at 1,200' where the stream quickly drops c. 30' by small falls from the shallower valley tract above.

(C) Backwood Burn is a youthful stream busily downcutting, but is of interest for several reasons. Firstly, it probably would pay a geologist to examine the central tributary burn which flows down from the eastern end of Cold Law (Field notes suggest W/E slickens in stream floor, 20 yards up from junction with Pinkie Syke). Secondly, Pinkie Syke and Pinkie Shank look anomalous and are possibly related to the later stages of glaciation.

Carey Burn and its tributaries, Common and Broadstruther Burns, will be considered separately.

(A) The Carey burn is formed by the confluence of Common and Broadstruther burns, and flows a short distance as an incised stream to join the Harthope. Four features of note are associated with the Carey,

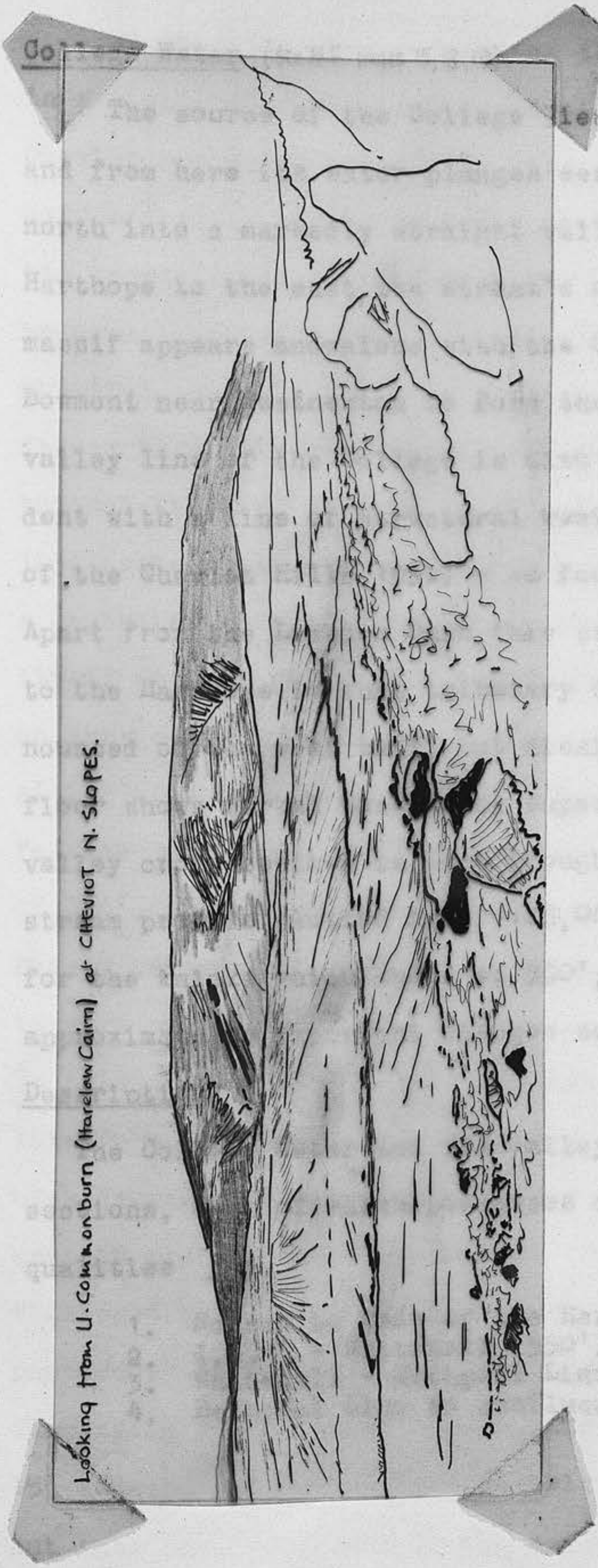
1) On crossing the 600' contour, the stream enters a profound and narrow gorge stretch from which it emerges at 500'.
2) On its right bank opposite Hartheugh a benchlike facet at 900'-950' has been preserved.
3) On the right bank just below the Common/Broadstruther junction the valley side is scarred by by an "in and out" channel, 750-700'.
4) On the valley floor below the Common/Broadstruther confluence there is a short 25' deep slot gorge, presumably because the lavas locally are more resistant due to thermal effects (-a sill like mass of porphyry lies adjacent).

(B) The Common burn rises in a peaty area between Newton Tors and Coldburn Hill to flow northeastwards, but, just when it looks like continuing to form the Akeld or Humbleton stream it turns away southwards to join the Broadstruther. Upvalley from Common burn Steading the present stream line approximates to a fault (or crush?). Sections are frequent, for the burn is now incised 20-40', and shows occasional crude terrace cusps on its floor. Downvalley from Commonburn steading, the stream stretch eastwards shows interesting and variable geological sections. The floor is rough, alternating between bedrock and superficial material. There are indications, too, that this mid and lower part of the valley were used by meltwaters.

(C) The headwaters of the Broadstruther, between Preston Hill and Broadhope, flow along the line formerly used by meltwater. However, at 1000' the upper stretch is replaced by a narrower normal and youthful section Downstream, too, the Broadstruther is joined on the right bank by the Hazely burn - a misfit coming out of an embayment which appears to have been enlarged by southward moving ice. Of special interest are the anomalous depressions at the N. and S. ends of Cold Law, apparently associated with ice recession and grading eastwards. Also on Cold Law, a thin porphyry sill forms a local benchlike feature.

Co[illegible]

The source of the College lies S.W. of Cheviot crest and from here its water plunges westward before turning north into a markedly straight valley line. Like the Harthope to the east the stream's outlet from the igneous massif appears [illegible] the College joining the Bowmont near [illegible] to form the River Glen. The valley line of the College is also considered to be coincident with a line of structural weakness (p. 27 Geology of the Cheviot Hills) [illegible] a fault line being inferred. Apart from the [illegible] the stream is further similar to the Harthope [illegible] tributary development is more pronounced [illegible] dissimilar in that the valley floor shows [illegible] superficial deposits and the valley c[illegible] roughness. The longitudinal stream pro[illegible] 1:25,000 sheets is of interest for the [illegible], 950' and 1,250' closely approxima[illegible] seen in the valley.



Looking from U. Commonburn (Harelaw Cairn) at CHEVIOT N. SLOPES.

Descripti[illegible]

The Co[illegible] valley are considered in four sections, [illegible] one or more distinctive qualities

1. [illegible] (c. 1,250')
2. [illegible]')
3. [illegible]
4. [illegible] with Bowmont

College Water (See M.F. pages 15, 18, 19)

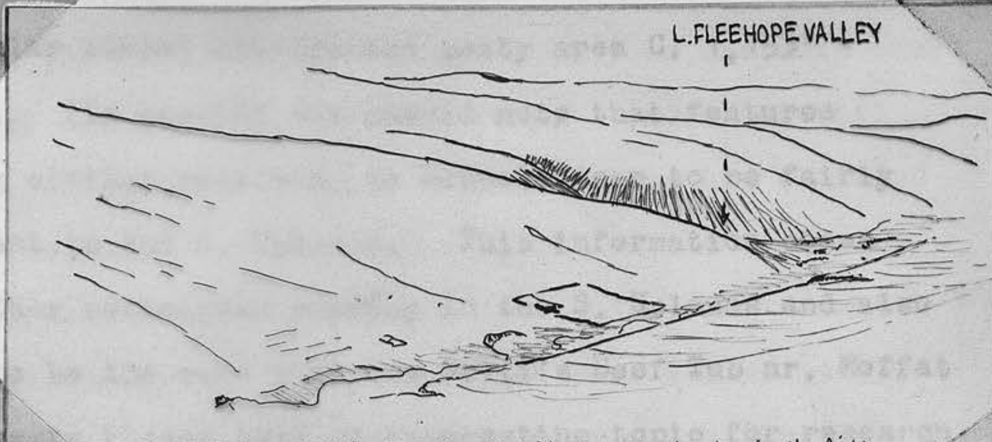
The source of the College lies S.W. of Cheviot crest and from here its water plunges westward before turning north into a markedly straight valley line. Like the Harthope to the east, the stream's outlet from the igneous massif appears anomalous with the College joining the Bowmont near Westnewton to form the River Glen. The valley line of the College is also considered to be coincident with a line of structural weakness (p. 21 Geology of the Cheviot Hills 1932) - a fault line being inferred. Apart from the Lambden Burn, this stream is further similar to the Harthope in that tributary development is most pronounced on the west bank, but dissimilar in that its valley floor shows marked masking by superficial deposits and the valley cross section is more troughlike. The longitudinal stream profile plotted from 1:25,000 sheets is of interest for the knicks which shows at 350', 550' and 1,250' closely approximate to important changes seen in the valley.

Description.

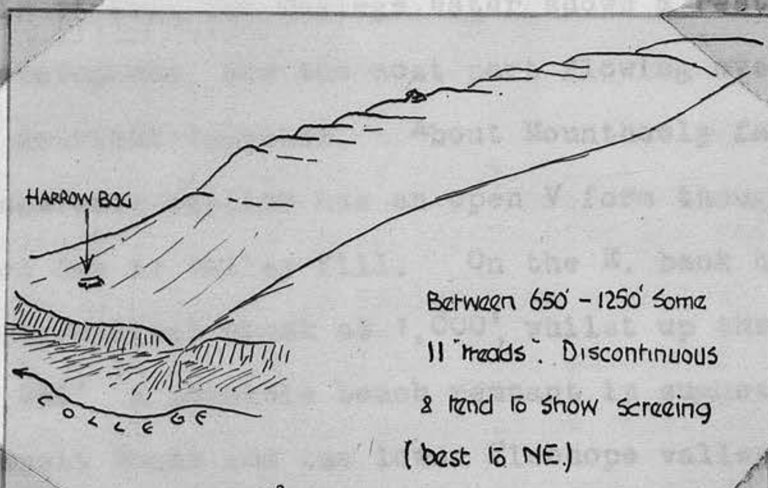
The College Water and its valley are considered in four sections, each of which possesses one or more distinctive qualities i.e.

1. Source to foot of the Henhole (c. 1,250')
2. 1,250' - Whitehall (550')
3. Whitehall - Hethpool Linn
4. Hethpool Linn to confluence with Bowmont

1. The gathering ground for the headwaters lies in a bleak, windswept and featureless tract between Cheviot and Cairn Hill. In this concavity lies a peat hag, broken in places by "washouts" and showing, towards its margin, sands derived from the granite or bleached bedrock. About 2,300' a stream line proper is developed youthful and flowing over boulders. Westwards this stream turns abruptly north, entering a torrent tract through Henhole. Burnett (p. 26 Geology of Cheviot Hills 1932) notes that this S/N stretch may be coincident with a crushline - though note exposures are poor. Henhole itself has been described by Clough and Burnett in writings on the geology of the area, with the latter noting the siting of the lowest waterfall (c. 1500') on a Quartz felsite dyke, east of which rugged crags rise to a height of 500'. He continues "on the north side, the crags are rudely arranged in tiers, but on the south side the rise ismmore precipitous" (p. 26 Geology of Cheviot Hills 1932) To this description it is worth adding that a true corrie like form is absent, and the south side of Henhole shows high jagged outcrops which produce a serrated effect, when seen in plan. Above Henhole, on the north and south sides, shattered tors are a feature, with those tothe north particularly impressive. Here the tors rise 40' -50' displaying coarse talus spreads and shattered blocks 10' - 15' length. Emerging from Henhole the stream soon runs out into the trough end of the main valley, skirting a

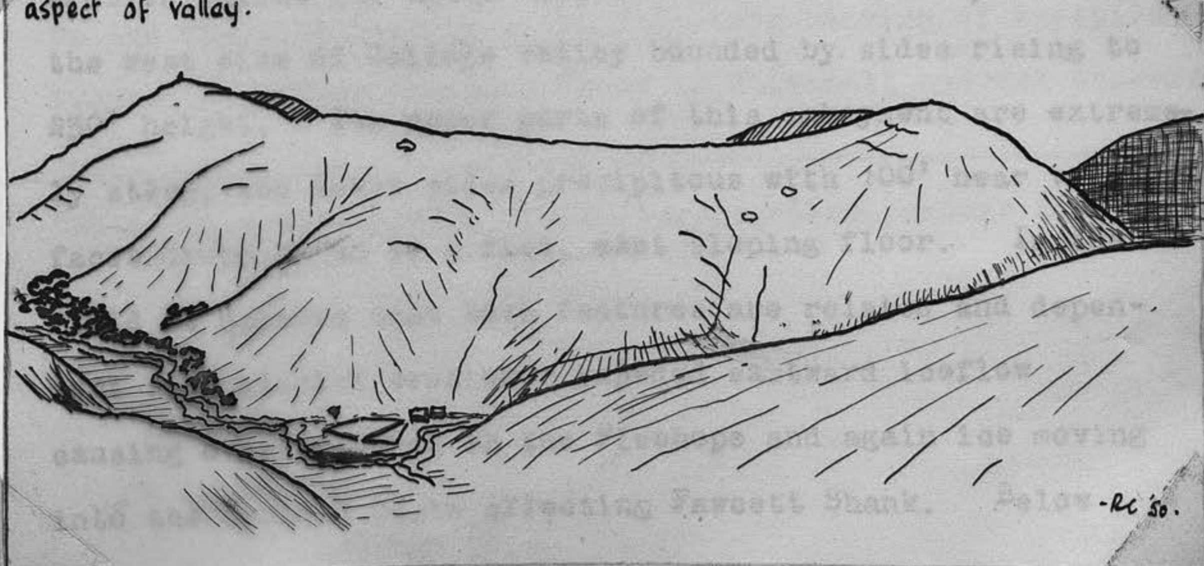


SKETCH OF U.COLLEGE (MOUNTHOOLY) The "biteout" at Fleehope spectacular in the field.



Quaternary or structural?

Field sketch looking down College Water (Southernknowe). Note spur truncation & trough like aspect of valley.



triangular shaped ill-drained peaty area C. 1,153' - 1,350'. (In passing one should note that features showing similar relations to Henhole seem to be fairly prevalent, in the S. Uplands. This information comes from other colleagues working in the S. Uplands and also seems to be the case with the Devil's Beef Tub nr. Moffat It suggests itself that an interesting topic for research lies in the study of these features in S. Scotland)

2. In this stretch the College Water shows a restricted meander development, for the most part flowing over and reworking detrital deposits. About Mounthooly farm the valley transverse section has an open V form though the apex is blunted due to valley fill. On the E. bank here there is a topographical break at 1,000', whilst up the Braydon Burn at 1,256' a possible bench remnant is suggested. Downvalley, Fawcett Shank and the lower Fleehope valley are striking local topographic features. The former appears to have been a bench modified largely by glacial erosion whilst the latter appears as a small embayment on the west side of College valley bounded by sides rising to 250' height. The upper parts of this embayment are extremely steep, the lower sides precipitous with 100' near vertical faces dropping on to a flat, east sloping floor. In the field it appears that both features are related and dependent upon glacial erosion - impeded eastward iceflow causing overdeepening in the Fleehope and again ice moving into the Lambden Basin affecting Fawcett Shank. Below

Fleehope the west bank of College valley is markedly over-steepened and screeing is noteworthy. Indeed glacial erosion in the mid and lower College valley has resulted in spur truncation at and below 1,000' on the west bank with the east bank only showing steepening of gradient below this height. In contrast the same valley stretch shows glacial erosion to have been more effective at 1,250' on the east bank, and clearly several possibilities might be suggested to explain this anomaly -

(a) It may be the outcome of glacial and normal erosion.
(b) It may result from different directions of ice flow at different periods.
(c) It may be that lower ice layers moved along lines distinct from the upper layers over the valley.

The writer tends to support the latter view with the qualification that in the initial and late phases of glaciation the second suggestion ought to be considered.

At Southern Knowe the first signs of true terracing appears*, where the Lambden burn joins the College. It is a local feature, restricted and of small amplitude being matched on the opposite bank by a 40'/50' steep banking of screelike fragments. From Southern Knowe to Whitehall bedrock appears

*Note below Fleehope, a cruder terrace-like feature has been cut also in superficial deposits along the east side of the valley and stream c. 600' and may indicate the possible site of a glacial step. On the other bank the present roadline uses a crude terrace like feature, interpreted by the Geological Survey as a river terrace but here considered of rather doubtful origin.

3. From approximately 500' downvalley stream braiding over alluvium, pebbles and boulders becomes prominent to Hethpool Linn, with the present stream contained by nearly continuous embankments composed of variable detrital material. These steep embankments rise 20' - 50' above water level leading up about Hethpool on to terrace like upper surfaces. Again, there is usually little difficulty in plotting the upper margin of the 'fill' in the field hereabouts because of its association with an observable (often slight) topographic change of slope. The main valley now shows decided asymmetry in cross section and tributary development before opening out suddenly into a small basin at Hethpool. Writing on this part of the College valley it is noted by the Geological Survey (p. 21 Geology of the Cheviot Hills) that on Newton Tors horizontal step features near the summit suggest the lavas to be almost flat. This is contrasted with slight rock differences and westerly dips across the College Water, and from these a faultline at College valley is inferred. Field observations show that discontinuous step features also to occur lower on the E. side of the valley besides elsewhere in the massif. It seems, therefore, that these

steps (in bedrock) are erosional and associated with glaciation or more likely with periglacial conditions during ice recession. Furthermore, since the present College valley approximates to the junction between the lava aureole and more normal lava types, structural control might still be invoked to help explain the line of the College. It might well be that the more resistant lavas along the E. bank of the College have also inhibited tributary development.

The Hethpool area is of great interest (also to the human geographer) and merits a more lengthy consideration. Viewed from up valley, the wind gap between White Hill and the Bell would appear to be the most likely line to be followed by the College Water. Instead the stream turns away N.E. into a restricted course flowing between the Bell and West Hill before emerging on to flats near Kirknewton. The topography in this area shows that White Hill and the Bell crests approximate, with the lower West Hill and St. Gregory's Hill crests at 703' and 598' respectively.

Why then the anomalous features in this area? There can be little doubt that ice moved eastwards in the Kirknewton area modifying the Glen valley form and also the inner margin of the "tread" between Kirknewton and Easter Tor. Again, it would seem that ice had been forced up on to the higher ground to the S.E, for a rising trough between Easter Tor and Newton Tors is a marked and suggestive feature in the field. It is debatable whether the

College/Elsdon stream formerly flowed E.N.E. from Hethpool to Old Yeavering or whether this depression is due entirely to glacial erosion and meltwater action.

To complete the picture the following additional features and factors should be considered.

1. From the Bell looking north over Bowmont Water, besides the Kilham defile, topographic "furrows" on the opposite bank are noteworthy. The largest of these rises from Crookhouse crossing the watershed between Housedon and Coldside before losing definition. A smaller but similar feature lies S.E. of Coldside Hill, crosses the watershed and leads into Sandy House Dean whilst a third and smallest furrow occurs between Homilton and Housedon Hill.

2. Just west of Kirknewton the boundary fault between sediments and lavas terminates.

3. The nearby Kilham ridge shows breaks in the crestline and shallow indentations on the north facing slopes which may be the result of ice overriding and flowing to the S.E. To the N.E. the Kilham defile is probably the result of glacial diversion of drainage.

4. The Cementstone outcrop is in close proximity and its present form might easily be due in part to the effects offluvial erosion. It seems conceivable to have a former north flowing extension of the College eroding a cementstone cover prior to uncovering the underlying lavas This accomplished uniclinal shifting to the east by this lower College water might have occurred.

5. The presence of the tougher lava aureole to the S.E. may have been a contributory factor influencing the course of College between Hethpool and Kirknewton.

To interpret the immediate features visible north of Hethpool it is suggested that severe local glacial erosion occurred at a nodal point where ice flow directions were conflicting. This was followed in the period of ice recession, by meltwater activity and possible glacial damming to produce a temporary lake standing c. 500'. In contrast to this possibility there was probably a longer established lake at 400'. Field evidence to support these latter views is not entirely satisfactory but is now listed.

A. The terrace-like upper surfaces of the valley "fill" above Hethpool have already been noted together with the change in amount of fill below 500' at Whitehall.

B. It is observed that 500' and 400' north of Hethpool approximate closely to the upper limits of "fill" and alluvia.

C. It may be more than mere coincidence that the cultivation terraces at Hethpool begin about and above the 400' contour.

D. The present Linn at Hethpool at c. 350' could be near the site of a superficial plug behind which water was ponded back before draining off as the plug was removed.

E. The approximation in height between the windgap near the Bell and the topographic depression S.E. of West and St. Gregory's Hill near 500' looks suggestive.

If this be a correct interpretation, Hethpool is on the site of a partially infilled rock basin with the present lake there a shadow ofits former self. (Again it would be inferrable on such an interpretation to date the 400' lake as post-glacial - fringed in part by lake side dwellings?).

4. In this short stretch the stream meanders over a shallow bed below the Linn, working down into detrital material and also showing signs of lateral erosion. It emerges on to flats between West and Kirknewton where the

marked Glen trough begins. Along the south side of this upper Glen stretch a strip of sand and gravels make an observable feature in the field (300' - 250'). This strip may have been part of a more continuous spread, linked previously with the sands and gravels in the lower Bowmont valley but subsequently eroded, or it may represent part of a kame terrace graded eastwards.

The Lambden Burn.

Formed from four streams flowing off Cheviot together with several small burns this west flowing stream joins the College at Southern Knowe. The line of flow, to say the least, looks anomalous and noless strange is the valley form itself.

The upper valley beyond Goldscleugh is asymmetric showing the present stream to be misfit. That ice occupied and enlarged this valley section there can be little doubt, for steepening of the lower Cheviot slopes is apparent, whilst ice has moulded the low col between Broadhope and Scald Hills (moving eastwards). Again, this same col has been used bylater meltwaters as also was the col between Preston and Broadhope Hills. The short valley stretch between Goldscleugh and Dunsdale Ford shows markedly steepened sides with the stream swinging about across a flattish floor. As upstream, asymmetry of transverse valley section is noteworthy and it might well have been that "boiler plating" formerly showing on the north bank has subsequently been obliterated because of weathering, to produce extensive screeing. The lower valley to Southern Knowe is narrower still with the stream now working down through superficial material or bedrock. The stream enters a short defile at 850' flowing for a short distance over lavas before cutting through glacial till. It is noteworthy that the till here does show a perceptible clay content and is interpreted as true morainic material. At 750' near Coldburn the stream enters a restricted rock channel, 25' depth and through dyke rocks, before emerging to continue in a steeply V shaped valley to the College.

Tributary valleys on Cheviot form an interesting topic for investigation - and speculation! One wonders, for example, if their upper stretches considered in turn demonstrate various stages in a similar process i.e. opening out of stream upper valley reaches by nivation. Inspection of a topographic map will show that, eastwards from the largest and deepest ravine at the Bizle, the other enlarged upper valley reaches show diminution in depth and /or development. Field observation (though restricted) suggests that these localities retain snow pockets for considerably longer periods than elsewhere on the massif.

Of the streams tributary to the Lambden, Bizle Burn is probably the most interesting. It behaves in similar fashion to the upper College and rises on Cheviot crest amidst peat hag. By 2,250' the burn is 20' down through peat, sand and rock fragments and flowing over occasional outcrops. Between 2,250' - 2,000' the gradient steepens perceptibly with the water plunging into the Bizle ravine at 2,000' before emerging below at 1,250' to cross a "shoulder" down to Dunsdale. The Bizle proper begins at 1,500' and though not so high overall as Henhole it does show greater lateral extent. "The west side (of the Bizle) is more precipitous than the east and forms a prominent feature for one third of a mile. The scarp face is subdivided into four or five parts by narrow, discontinuous ledges and particularly in the higher beds, cavelike ----. Large tumbled blocks of dark grey Andesite --- strew the foot of the crags" (p. 25 Geology of the Cheviot Hills 1932). The feature can scarcely be claimed to show true corrie form although it does look more suggestive than the Henhole. Whilst it may be argued that the Bizle Burn has helped to destroy the headwall form and that a former lip has been removed, the writer prefers to consider the Bizle as a nivation hollow at its maximum development. Since the floor of the hollow shows a rock debris accumulation and marginal screeing is pronounced, it would appear that accumulation rate is now exceeding that of removal. Obviously if this persists a protective scree cover will develop leading to modification in form of the Bizle itself and lateral growth rates will diminish progressively. Above the Bizle, tors and clitters appear on West Hill and Bellyside Crag whilst a

N/S aligned set of three tors above Bellyside Hill at 2,050' may represent an arete remnant.

One final paragraph is added concerning stream alignments in the Lambden valley. Windgaps between Coldburn Hill and Foulburn Gair, Preston Hill and Broadhope could easily have been used by streams formerly flowing northward off Cheviot. It seems reasonable to suggest that, between them, the College and Harthope could dismember such a drainage pattern with the Lambden capturing the upper stream sections and the Harthope the middle sections. Bizle Burn, however, it is felt, forms one of the earliest branches of College with Lambden Burn an offshoot coming later and encroaching on streams to eastward. Whilst not proven, the very straightness of the Lambden valley suggests structural influence e.g.

1. There may be more than coincidence in the alignment with the Hawsen Burn crush
2. Observed slickens and rock veining about Dunsdale Crags may be associated with a line of disturbance along the Lambden valley (i.e. a complementary set).
3. Eastwards up at the head of Lambden valley a granite/lava contact occurs.

<u>Some other tributary valleys</u>

Of these, that of Elsdon Burn is the largest, flowing eastwards to join the College at Hethpool. Whilst its form suggests that it has been long established, one must remember that ice moving eastwards has also used it (p. 122 Geology of the Cheviot Hills 1932). The present valley is open, with valley sides markedly steep above

c. 750'. Below Elsdon Burn farm the present stream meanders and appears misfitted, whilst approaching Hethpool the topography again suggests a former lake had existed there. The Trowup and Whitehall Burns show steep V-shaped valleys joining the College where they emerge into College valley. The former has cut through 40' of superficial deposits to reach bedrock - a Quartz felsite dyke mass, whilst the latter has excavated 20' depth of rock debris and then cut two low falls (6' height each) in the lavas. The Trowup is noteworthy in that its straight lower course contrasts with a more open upper section. Again, in the field, it suggests itself that over the area north of Black Hag (with Kilham ridge and College water for W. and E. boundaries) the N.N.E. alignments may be indicative of former drainage lines with the W/E stream stretches being of more recent origin and possibly due to College piracy.

River Bowmont. (see M.F. pages 16, 18, 19).

The Bowmont, a tributary of the River Glen rises on the Scottish side of the Border between Cheviot and Windy Gyle. Its waters flow N.W. for a short distance before turning N.N.E. to Mindrum, at which point they turn back into the foothills to join the College near Westnewton. These marked changes in stream alignment are no less anomalous than the following features along its course, now enumerated

1. Downstream from Clifton (1 mile south of Yetholm) the present Bowmont valley appears "one sided" - in so much as the right bank is flanked by higher land.

2. At Yetholm "The Stank" joins the main valley, being the line formerly used by a considerable volume of water and now occupied by a misfit burn.

3. From Yetholm loch to Linton stretches a marked valley showing similar and apparently related features to (2)

4. At Mindrum one would expect the Bowmont to continue its N.N.E. flow. Instead it turns S.E. leaving the low col beyond Mindrum dry and suggesting that the former outlet has been plugged. (Great depths of overburden at Tithehill farm, near Wark and Branxton tend to confirm this view).

5. At Howtel sands and gravel seem also to obstruct the obvious line of the preglacial Kilham Burn northeastwards.

6. Kilham gorge is a marked feature occurring almost at the Bowmont College confluence and appears to result from glaciation followed by stream diversion.

The Bowmont valley may conveniently be considered in the following sections -

(i) Upper Bowmont and headwater tributaries i.e. above Mowhaugh where the stream flows N.W.

(ii) Mowhaugh to Primsidemill

(iii) Primsidemill to Kilham

(iv) Kilham to College junction.

The longitudinal stream profile of the Bowmont plotted from 1:25,000 sheets shows nicks to occur at 450' - 650' (N,B. Primsidemill 444') Similar profiles for Kelsocleugh and Cheviot Burns show nicks at 1,050', 1150' and 1,350' in the former; 900', 1,050', 1,350', 1,650' and 1,950' in the latter (The 900' falls approximate closely to local felsite dykes).

(i) Above Mow Law the trunk stream flows across lava-flows with a general S.E. dip, and Adendritic (near centripetal) headwater drainage plan occurs with Sourhope and Cheviot Burns, Kelsocleugh, Back and Calroust burns as the principal tributaries. Inspection will show that the high ground sweeps round in crescentic fashion from Blackdean Curr and Black Hag - Auchope Rig - King's Seat - Windy Rig with extensions of intermediate height from Windy Rig N.N.W. to Pudding Law and N.W. toward Hownam Law. In the enclosed embayment the streams are well established and incised, with incision most marked in the tributary valleys, Bowmont with an opener valley. In several instances, e.g. King's Seat streams, one notes how the head reaches of the valleys show expanded  or nailhead  plan shapes. These may be the result of ice erosion in some cases, or again they may result from nivation, partial glacial plugging or are due to stream regrading in post glacial times. The King's Seat valley is further distinctive for two other local features. Firstly, Randy's Gap between King's Seat summit and Windy Gyle is partially aligned with a N.N.W/S.S.E crush, and probably the wide col was also used by ice streaming over the watershed eastwards.

Secondly, the old vent on Fundhope Rig is a defined topographic feature with the present King's Seat Stream flowing around it, approximately along its eastern margin. Cheviot Burn flows in a deep V-shaped valley which it is beginning to erode laterally by 1,250.'

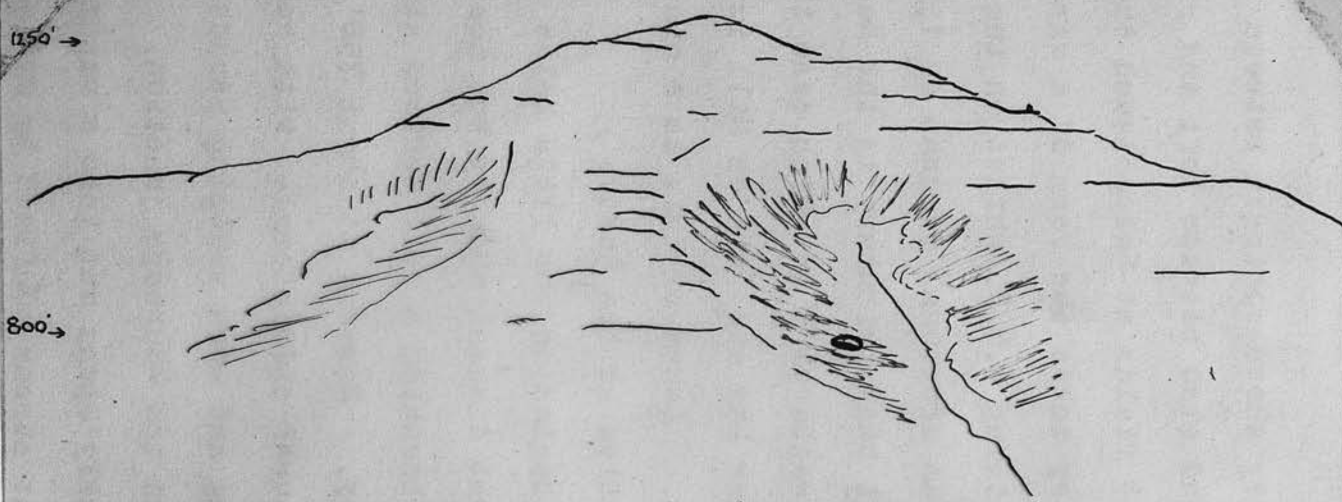
The observer in the field standing upon Auchope Rig cannot fail to be impressed by the contrast of the trough-like College valley to the north and the deep V-shaped Cheviot Burn valley to the south. Sourhope Burn like the Cheviot Burn flows in the lava strike direction (S.W.) and below 1,100' is now re-working assorted superficial material. West and North-west of Auchope Farm the tributary sikes tend to occupy expanded gullies e.g. Gloomy Cleuch and the course of the upper Kaim Burn appears to have suffered from meltwater action. Two other local features in the Sourhope valley are of note

1. The 'tread and riser' terrain along the western part of Fasset Hill results from the denudation of the lava flows,

2. The slight development of solifluction terraces along the foot of Dod Hill being fronted by a small shallow basin probably ice eroded and partially infilled but now damp and ill drained.

The Kelsocleuch valley shows contrast between its lower and upper reaches and also between left and right banks. Above the 'inbye' fields at Kelsocleuch the western limit of the valley takes the form of a marked ridge (Kelsocleuch Rig) rising S.S.W., whilst on the right bank the ground rises to an erosional remnant c. 1,359.' The only well defined left bank tributary is the Back Burn which may have been captured - in which case the "valley line" between Crock Law and Swindon Hill is not the result of ice erosion. (However this is a minor matter and rather speculative at the best).

River alluvium begins on the flats below Cocklawfoot; at first discontinuously but near the Sourhope confluence becoming a well defined strip stretching downvalley. Bowmont at about 750' quickly takes on maturer characters:- with heugh development, braiding and more sweeping meanders characteristic beyond the Sourhope junction. The main valley too, quickly opens out into a mature form with the present stream confined by 20' - 40' steep stream cut bankings. Details of the main valley sides seem to be conditioned by (i) the nature of the lava flows (2) glaciation and

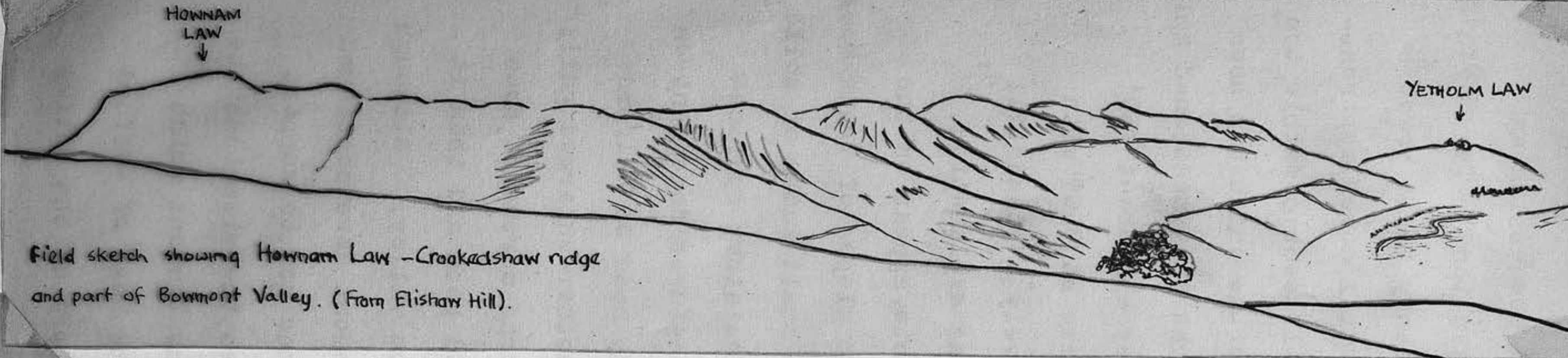


Field sketch of White Law (upper Bowmont) showing discontinuous stepped form. (Vertical scale exaggerated c 2 times).

associated effects e.g. The S.W. face of White Law shows marked facets and odd looking shallow depressions on the hillside (see figure). The facets tend to be of two types - a larger set disposed at 50' intervals and probably corresponding to the lava flows, and a more irregularly spaced and aligned minor series assessed now to be peri-glacial in origin. By contrast the crest and southern slope of Park Law are rough and knobbly though but a short distance away. The south side of the main valley is broken by two small tributaries, the larger of which contains the Calroust Burn. Here again in these side valleys the lava flows produce facetted, steep, west-facing valley sides and these are easily observed in the field. (Whilst the writer is not familiar with the details of the terrain between the Calroust and Kale streams it is strongly suspected that glacial erosion and meltwater features will be manifest there).

Locally, the south bank of the Bowmont and the lower stretches of these tributary valleys display numbers of "cultivation terraces". Whilst prepared to admit that these terraces have been used by man the author does not readily accept them as being wholly artificial features for in some cases they may have originally been solifluctional to be used by man later e.g. In the lower Calroust Burn below 700' and arrayed on the marked slope N.W. of "The Castles" there are a series of terraces with seemingly more natural than artificial alignments and possessing an aspect probably poorly suited to cultivation. The south bank of Bowmont, too, shows a tendency for a break of slope to occur at c. 750', with the till cover apparently thinning out above this height. It seems possible, too, that the col between Mow Law and White Law which has been used by meltwater, the topographic break just mentioned and the disappearance of alluvium up-valley all about 750' are related features. A temporary lake at 750' with overflow east of Mow Law or alternatively a standstill of ice at this level may be proposed as explanation. South of Mow Law further glacial effects appear on the landsurface with the N.W. and N. upper slopes of Craik Moor showing marked mammillations. These small knobs of solid rock 10' - 20' in height impose an undulatory surface upon the hill slopes. Other local features dependent on glaciation include the wind gap at the head of Belford Hope, the Sanghenden Sike lying in another enlarged gully

(ii) At Mowheugh the Bowmont turns northward, soon to enter a short defile cut into solid rock and then it emerges into the middle section of its valley. Although it may be suggested that a former Bowmont here continued westward there is insufficient evidence now to support such a view. Indeed the author takes the view that the Kale possibly captured a branch of the Bowmont which formerly came over the wind gap at the head of Belford Hope. Beyond Mowheugh the present form of the valley



Field sketch showing Hownam Law - Crookedshaw ridge and part of Bowmont Valley. (From Elishaw Hill).

Looking over m. water cut between Cove Hill & Shoulder Hill to Black Hill & the Curr (W→E).
Tread & riser facets reflect lava outcrops.

floor suggests that considerable glacial dumping has occurred, and there are indications of a valley in valley profile e.g. Elisheugh Hill. The present Bowmont seems offset to the east, but has produced a useful strip of heughland downvalley from 525'. The alluvium is clearly defined, with its western limit approximating to the road but diverging at a point 1 mile south of Primsidehill, running through Dean Mill to Primside Mill. On the right bank, the alluvia boundary is a low steep banking between Attonburn and Woodside farms, whilst beyond the latter it follows the 400' contour from Clifton to Hayhope - K. Yetholm.

At Belford the river has removed a considerable amount of glacial till locally so that 20' - 50' high river cliffs back the small haugh. Here, too, the stream continues to be shallow, flowing over coarse gravel and boulders save at 530' where the floor is bedrock. Examination of the till shows it to be gritty, varying in colour from purple/ brown to yellow/ brown and containing assorted rock boulders:- various andesites, silurian (?) shale, a greenstone (often included in lava material) and together with these some dark basaltic (?) fragments. North of Place Hill the west side of the valley is locally oversteepened whilst Mow Law has a northward stretching "tail". This latter feature may be erosional for small "dry" channels lie east and west of it. Beyond Elisheugh Hill the present Bowmont is shallow, braiding, freely meandering and cutting laterally into till deposits - it could be misfitted indeed!. The till seems to have been deposited or eroded into northward trending swells and swales. The condition, if original, probably was dependent on the direction of ice flow, but running water may have enhanced or produced the swales e.g. south of Attonburn farm on the right bank, river cliffing in till is backed by a shallow but defined channel. Again opposite Woodside farm on the left bank a drum-like feature rises southward, being eroded by the Bowmont on the east side to give 20' steep cliffing. North of this feature the road climbs up on to more glacial infilling which has been eroded along the stream frontage into 40'-50' high steep banks.

The major valley form shows contrast, too, between west and east sides down to Primsidemill. To the west Bowmont/Kale watershed is ridgelike but zig-zag in plan, with the cols along the ridge corresponding to "biteouts" to the N.E. on the right bank (e.g. Attonburn, Shareburgh area) which break the symmetry of the N.W. topographic grain there.

On the right bank Wood and Cove Hills present extremely interesting local features. The west face of Cove Hill show in miniature an almost true replica of a corrie form, complete with lip at 650'. Between Cove and Wood Hill a marked depression drops into the main valley and suggests a meltwater feature related to the adjacent Pyatshaw Hole cut between Cove and Shoulder Hill. There is too a "hanging" effect along the west side of these hills, similar to features along the N.W. flank of the Kilham - Longknowe ridge further down valley.

Of the two right bank tributaries, the more southerly Attonburn flows from the Curr westwards in an asymmetrical valley (north side most severe). Between the farms of Attonburn and Blakedean, lateral cutting has begun whilst the upper reaches show stream incision together with the growth of small interlocking spurs. On the north bank between Shoulder Hill - Black Hag the terrain is again facetty because of the lavas. e.g. Shoulder Hill shows 29' "risers" with 30 yard "tread" widths giving way eastwards to north/south aligned rock ribbing. Near the source of the Attonburn the col between Black Hag and the Curr appears anomalous, suggesting that either the headwaters of Curr Sike (tributary to the Curr Burn) have been diverted into the Atton Burn or else the col and bench like feature at 1,150' below Cuddies Tupe ("Fort" on 1" O.S.S. 81) are glacial in origin. The southern side of the Atton valley shows gentler, smoother slopes with only one peculiar stream line present. This occurs N.W. of White Law, begins suddenly and in a marked channel at 1,000'. The present burn is misfitted and tends to be discontinuous. For want of a better explanation the writer considers the feature to be of sub-glacial origin.

The Curr Burn flows N.W. and like the Atton possesses an anomalous col on its north bank near its source. Like the Atton, it possesses facetty valley sides and displays a northward aligned meltwater cut in "The Neuk" between Wildgoose and Matchly Hill. The lower valley of the burn is incised into glacial till, there are restricted meanders and alluvium comes in about 450'. To join the Bowmont the stream uses a well defined gap between Wood and Shareburgh Hill - the observer requiring little imagination to continue the N.W. line of flow into the Yetholm loch area in former times. (The break of slope at 600' on N. Wood Hill and the Crooked shaw ridge may therefore have some significance and not result purely from coincidence*. Below the former Clifton village site the Curr is incised 12' into till (upper clay showing silt content and Clifton farm is perched on a spur of the same material subjected to stream erosion on western and eastern flanks.

On the left bank of the Bowmont the two tributary burns have made a slight impression on the glacial infilling at their lower ends. As for the well defined haughland along the Bowmont, one might tentatively suggest that a proglacial lake formerly stood there at 500'.

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* i.e. former valley floor height?

(The suggestion is tentative, for, because of the time factor and very poor weather conditions whilst working in the area, the author only was able to note that the 500' level was often associated with topographic breaks and that the haughland was flat and ribbon-like).

(iii) Before describing the next section of the Bowmont valley it is deemed appropriate to give attention to the Yetholm loch area. Inspection of the 1" O.S S. 81 will show that the lower Kale valley has an eastward continuation beyond Linton Loch. Further, the north flowing upper Kale turns abruptly west near Morebattle, whilst the apparently obvious outlet for the Kale and Cessford streams lies disused 4 miles N.N.W. of Morebattle (old Softlaws). The present lower Kale valley therefore may be judged anomalous as might also be the valley stretching from Morebattle to Town Yetholm. This latter valley possesses a fine incised meander around the west side of Yetholm Law and though occupied to-day by shrunken loch remnants and by misfit streams, it must formerly have carried a very considerable volume of water, as its size, and marginal sands and gravels about Linton and Morebattle testify. Yetholm Loch itself formerly extended southwards, Linton Loch to the S.W. has probably extended westwards whilst Hoselaw Loch too has been larger (e.g. Din Moss) Field observation shows that in addition a meltwater cut strikes obliquely across Yetholm Law S.W./N.E. seemingly graded two ways to 400'. At Thirlstane, another meltwater cut is now used by the Yetholm/Kelso road, grading N.W./S.E. to 400' at one period. By contrast the ridge crest between Yetholm Law and Crookedshaw seems to have been little affected by transverse meltwater cutting. Possible slight marginal footings along the west side of the ridge at 500' and 400' may occur, but since fieldwork was not extended into the Kale area details have not been followed up. Though limited by lack of knowledge to the west and southwest, the writer feels that it is possible to suggest that the valley line from Kalemouth to Crookedshaw and even beyond to include "the Stank" is the result of glaciation and meltwater action. It would require but a comparatively small thickness of ice to block the Teviot valley between Upper Nisbet and Grahamslaw, the former Kale valley between Mainhouse and Blakelaw Covert, the Bowmont at Mindrum and the Kilham at Howtel to produce a temporary diversion of water around the massif's periphery.

From Primsidemill to Kilham the River Bowmont continues to meander downvalley as a shallow and occasionally braided stream flowing over superficial deposits. Low alluvial terrace fragments occur scattered along this stretch, but never as striking topographic features and contrast with kame terrace remnants at Yetholm, Venchen old Toll, Bowmont Hill farm, Mindrum and Howtel. Furthermore whilst the west bank of the river is flanked by long elongated drum ridges, the east bank rises sharply to a "tread" (whose inner margin is also used by streams) before rising sharply to crest levels of the 11/1200' surface.

Between Primsidemill and Yetholm the 400' contour seems significant locally, corresponding to topographic breaks of slope and also to local base level for nearby meltwater cuts. (Lower lake level?). The left bank, beyond "the Stank" to Mindrum, falls steeply to the valley floor and is unbroken by tributary valleys. This contrasts with the right bank where the first break is made by the Shotton burn joining the Bowmont via a markedly youthful tract. The second break contains Paston Lake, filling part of a meltwater channel, and a third minor feature N.N.W. of Paston Hill is a shallow trough, apparently used temporarily by the Bowmont flowing N.E. towards Paston farm.

The Venchen-Bowmont Hill ridge, besides showing a steep face to the southwest, is also hogbacked with the steep N.W. flank fronted by a well defined trough. Falling away to the N.E. both ridge and furrow end near Mindrum*. The Mindrum embayment is limited to the north by the Horse Rigg - Mindrummill Crag ridge and shows a sand and gravel spread stretching from Bowmonthill farm north-eastwards. About Mindrum the spread begins c. 300' and

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*The writer suggests that a S.W. continuation of the Branxton boundary fault should not be ruled out.

is associated with fairly level and featureless ground whilst to the north-east the deposits lie at generally lower levels and show much greater diversity of form. Kettleholes first appear about $\frac{1}{4}$ mile north of Mindrum station soon to become prevalent and striking features in the lower lying sand and gravel deposits* The line of boundary fault past Moneylaws Hill and Branxton Hill coincides with a major topographic break, but in addition seems in part to correspond with the line of a marginal meltwater channel. This channel begins as a marginal footing (Burntheugh Covert), is in places along the till/drift junction and in places quite a normal two-sided cutting. (The channel falls from 400' to 200' by Mardon lying half-mile east of Branxton). It is of interest, too, to add that the glacial till in the Mindrum and nearby areas on the left bank show characteristic Old Red Sandstone colouring i.e. a "foreign" source.

*Though not mentioned here, the record of overburdens shows great depth of superficial material to the south of Wark, Tithehill farm (right in the Mindrum dry gap) and at Branxton. This suggests either very marked glacial erosion to produce conditions suitable for later infilling or else infilling of a former stream line. Geological Survey suggest the pre-glacial River Till came through this way but since this is opposite to the flow direction of the Tweed I prefer to consider that it was the Teviot that came through between Cornhill and Mindrum. Implication re Bowmont - that it did go out past Mindrum+ to N.E.

+Note: overburden at Cornhill 12'; Wark, Branxton, Tithehill, 100'+

On the right bank below Yetholm the rough facetty appearance of Staerough invited comment, being probably the result of glacial oversteepening followed by severe weathering upon lavas. The Shotton and Halter burns occupy part of a strip of relatively lower ground extending <u>via</u> a wind gap near Thompson's Walls to Kilham and beyond. It may well be that the Halter burn was temporally diverted N.E. into the Kilham burn valley during ice recession prior to a resumption of its pre-glacial course entirely. The resumption of more normal conditions, however, seems to have found the Halter and Shotton as hanging tributaries, subsequently re-adjusting themselves to baselevel and, in so doing, producing youthful lower valleys. (In this exposition, the production or enlargement of the Shotton/Kilham windgap by ice initially is a probable factor to be considered). Although unable to devote much time to the Halter burn valley the following points are of interest

1. Between 700' and 350' the stream is now cutting laterally into valley till, shows a narrow meander belt and occupies a fairly wide, open valley.
2. Offshoots from the main watershed lying on the right bank show topographic breaks at approximate 600' and 800' producing truncated spurs and slight "hangs" in the short west-facing valley heads.

Northwards lie Harelaw and Paston Hill (the latter oversteepened on west and north faces) which contrast very markedly with the high ground to the S.E. There, the former ridge line has been dissected to produce three conical shaped hills, the cols between each having been overridden and enhanced by ice. The stoss side of the ridge seems also to have been furrowed, with the resultant depressions "hanging" and aligned N.N.W./S.S.E.

At Mindrummill the Bowmont, in the face of the valley plug turns eastward flowing as a shallow meandering stream over a 2 mile stretch prior to entering the Kilham gap. At Kilham the valley form changes, and beyond, the river appears to have been engaged in removal of sand and gravel which stretches almost to the College confluence. On the left bank, near Howtel School, sands and gravel deposits occur, they appear to have been originally water bedded and deposited as a plug to the Howtel valley against an ice front which lay to the N.E. Subsequently, with removal of ice, there has been deformation followed by breaching of the deposits by water ponded behind on the N.E. side.

IV. The Kilha m gorge is troughlike, with its narrowest section down to Canno Mill, beyond which it widens out and becomes less severe topographically. Again, whilst the east side of the defile shows the greatest oversteepening, it is the west bank where sands and gravel occur in greatest abundance. Downcutting by the Bowmont seems to have been rapid, for streambanking in drift material is steep and prone to slipping. Solid rock appears at the northend at 250' on the left bank, 350' on the right, whilst downstream it is in evidence again below Crookhouse at 250' and floors the Glen near the Bowmont/College con-

confluence at 200'. To explain this feature involves conflict between three ideas.

1. that pre-glacial river capture had caused the diversion of the Kilham and Bowmont streams.

2. that the College had formerly flowed northwards through the Kilham gap finding outlet either via Howtel or Mindrum.

3. That the defile resulted from glacial breaching or col enlargement followed by almost continual use by meltwaters.

The presence of the "furrows" on the N.W. flank of Kilham - Longknoweridge, the topographic difference in summit levels on either side of the defile and the numbers of cols in the Bowmont catchment which seem to have been glacially enlarged tend to favour the third suggestion. Again the apparent convergency of meltwater cuts in the mid Bowmont valley on this defile suggest it to have been a master meltwater channel similar, for example, to Borthwick in Midlothian.

River Breamish (see M.F. pages 16, 20)

The course of the Breamish, lying on the south side of the massif, tends to be something of a mirror image to the College or Bowmont streams. Rising south of Scotsman's Knowe this stream, following closely as it does a S.S.E. crush for just over 2 miles, appears to be structurally controlled at first. However, instead of continuing between Cushat Law and Shill Moor along the crush as one might expect, it turns to flow about 9 miles in a generally eastward direction. Over this stretch the present valley first follows the granite/lava contact before continuing over lavas, ashes, and finally Carboniferous sediments which are obscured by overburden. Again, the marked valley incision continues almost to Ingram where there is a decided change of valley form. East of Hedgeley the stream turns again, now flowing northward to join the Lilburn stream 4 miles down valley and so form the River Till.

For analysis and descriptive purposes the catchment area will be divided into four sections

(i) source to Linhope

(ii) Linhope to breakwater west of Ingram (i.e. 450')

(iii) Ingram to New Bewick

(iv) New Bewick to E. Lilburn.

The longitudinal profile of the Breamish stream constructed from 1/25,000 provisional sheets shows well marked knicks at 1,450, 1,050', 850' and 700' together with slight inflections at 1,150' and 600'. Below 600' the profile appears to show a graded condition.

Prior to the systemmatic consideration of the Breamish valley, it is proposed to deal briefly with some of the main points of the South Cheviot drainage pattern. As seen from Cairn Hill (and other vantage points) more than one solution to the question of the alignment and location of the Harthope, Usway, Upper Coquet and Upper Breamish is suggested. Firstly, if one accepts the view that the Cheviot granite produced a doming effect during emplacement it is easy to postulate a radial pattern. The details of subsequent geological history need not bother us other than the fact that we note the dome was first hidden beneath later deposits, which in their turn were the first to be stripped off as the underlying dome was resurrected. The resurrection of the dome may obviously have been achieved by circumdenudation or it may have been aided by epigenetic movement,. In either case another radial pattern would result, becoming modified over the sedimentary material into an annular pattern. Secondly, if the Cheviot area re-presents an anticlinal structure pitching N.E. then again the explanation is fairly straight forward i.e. that an initial longitudinal consequent flowed N.E. along the axial crest line whilst on the flanks transverse or oblique consequents arose. By this hypothesis, the upper Coquet and Harthope may now represent remnants of the longitudinal consequent with the intervening portion subsequently captured and subjected to realignment, whilst the flank streams would correspond to the transverse consequents. Such an explanation is attractive, for it would account for the trough running N.E. from Thirl Moor to the wind gap at the head of Harthope. Again, the ground rising northward to the present national boundary would represent one side of this former valley, whilst the divide on the south side between Thirl Moor and Bloodybush might be interpreted as being remnant, because of denudation. The occurrence, too, in this trough of large N.E. crushlines suggests that geological structure would facilitate opening up of the ground by such a former stream, just as some of the other crushes south would assist stream breaching of the Thirlmoor - Bloodybush divide. Turning to the Breamish in particular now, one notes that its upper course may be interpreted in two ways by this hypothesis.

(i) It may be an original transverse consequent flowing S.E. but subsequently captured, making the Spartley Burn a misfit in part of the former Breamish line.

(ii) The lower and middle Breamish may have pushed out a subsequent tributary (present Upper Breamish) to divert part of the Coquet/Harthope stream in post 1,800 surface time, with still later stream piracy divesting Breamish of the captured segment.

There is yet a further possibility to be considered - that the present Breamish is a remnant of a larger east flowing stream, Whose westward extension is now obliterated (formerly continuing beyond Butts Road), and whose lower valley has also been abandoned because of capture or glacial diversion. Glaciation has certainly affected the Breamish Head area too, but to what degree is doubtful. Ice from the west may have been forced over the Harthope windgap or it may instead have been channelled southwards into the Breamish valley. Bearing in mind, then, the part glaciation may have played in modifying the drainage pattern, one is faced with two conflicting sets of stream alignments Firstly, there is the radial or annular pattern centred on the core of the massif and predominating to the east. Secondly, there is the parallel stream pattern, north flowing streams on the north flank and south-east flowing streams on the southern flank. The question to be posed is "Are we dealing with two distinct systems, the one superimposed upon the other, or are the patterns the outcome of similar processes acting on different rocks with different structures?".

(i) The relatively flatter areas of Lintlands, Breamish Head and Lower Scotsman's Knowe are peat covered and provide the tributary burns which go to form the Breamish headwaters. At about 1,500' stream incision begins to become important, becoming more and more pronounced downvalley to reach a maximum in the gorge at Low

Bleakhope. The valley itself is asymmetrical in these upper reaches, highest on the Comb Fell slopes where a topographic break at 1,750' is a fairly constant feature. This break, it is felt, may result from normal erosion processes, but it could be a "high water mark" left by the former ice sheet. On the right bank the valley rises to the surface remnant at Lintlands, south of which the 2,000' monadnocks of Bloodybush Edge and Cushat Law rise above an 1,800' plateau-like level. Within the valley superficial deposits are largely absent, a narrow strip of alluvium from 1,100 - 1,000', (High to low Bleakhope) flanking the stream. and Glacial deposits are almost completely confined to the right bank, whilst on the upper valley slopes peaty deposits appear plentifully and contribute to the smooth flowing outlines of the topography. Tributary development is most pronounced along the right bank where the burns are busily incising themselves, occupying ravines or marked gullies gashed into the valley side. A glance at the geology map of the area (sheet 5) or Geological Survey Memoir "Cheviot Hills" 1932 p. 118-119 suggests that geological structure is an important factor in tributary development for "between Shill Moor and the Ainsey Burn, practically every exposure of lava and ash within half-mile of the granite shows some of disturbance"* Field

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*for geological account, Geological Survey Memoir, 1932 "Cheviot Hills" p. 34-35, 118-119 observation strongly suggests that the Ainsey Burn formerly flowed east to join the upper Linhope Burn; so it may be that the present Ainsey was captured by a tributary pushed out along the crush from a Breamish formerly rising on N. Cushat Law.

The Salters Road continuing south-east from Low Bleakhope, approximating to the Upper Breamish crush, rises to a well marked windgap between Cushat and Shill Moor. Whilst it would be attractive to postulate that the Breamish formerly flowed along this line, it seems more likely that ice erosion was responsible for the gap feature. The plan form of Shill Moor with its steep sides and the asymmetry of the nearby Breamish valley suggest that ice had bifurcated about Shill Moor. (The suggestion seems feasible too when one notes further that ice moving southward over-rode the Hedgehope - Dunmoor col).

Turning at Low Bleakhope, the Breamish enters a gorge tract stretching down to Linhope. This feature, whilst showing maximum development at its western end, is equally impressive to the east where lie the two great watergaps at Linhope itself. The gorge is crossed by numbers of dykes and crushes which are apparently of only local significance topographically* e.g. Broomy and Carswell cleughs

*Author's examination of this stretch not detailed note.

on the left bank are cut wholly or partially along crush-lines. Signs of lateral cutting and stream deposition begin at 950', but only from 800' downstream do alluvial deposits become continuous along the Breamish. Shillmoor forms the southern boundary for any higher valley line, and north of it lies the present valley in valley section. The north face of this hill besides being steep is craggy - one very noticeable crag line rises obliquely from Snuffles Scar (1,000') E.S.E. to 1,450'. Matching this cragline on the north bank opposite is a low wide depression, crossing the Linhope watershed obliquely so that Ritto Hill stands apart as a conical shaped mass.

Just above 700' the Breamish is joined by the Linhope, its principal left bank tributary. Flanked by the highest ground to the north and in granite this tributary valley displays a lower youthful incised section, in contrast to the maturer section above. Linhope Spout marks the upper limit of the lower tract although the Dunmoor burn shows purely youthful characters to c. 1,200'.

The waters coming off Comb Fell and forming the Coldlaw Burn appear to cross two significant breaks at 1,750' and 1,600'. Coldlaw burn lies in a wide shallow valley above 1,350' whilst below the streambed roughens, small rapids occurring as the stream flows between 40' - 50' steep banks or near cliffing. A short respite from the enclosing banks about the Standrop confluence is short lived for c. 1,230' another defile with similar characters to those just described is entered. Quite suddenly at 1,000' the present stream course opens sufficiently to allow development of a narrow meander belt between 12' high banks. This stretch is floored with boulders, sands and gravels and whilst the south bank is [illegible] rock, that opposite is of superficial material. [illegible] Spout, a 50' waterfall abruptly terminates [illegible] and below it the stream crosses two minor fa[illegible] Linhope to emerge from a 300' deep ra[illegible] of channel. The Linhope tributaries [illegible] bank possessing fairly dissimilar characters are [illegible] summarised.

(a) Dunmoor Burn Above [illegible] lies a windgap, probably used by [illegible] ice. The stream rises below [illegible] a feature probably resulting from gl[illegible] and the thickness of peat above. [illegible] burn shows a symmetrical V [illegible] larger asymmetrical valley (steep[illegible]).

(b) Hat Burn Grading [illegible] level than the Dunmoor, the Hat Burn offers a contrast to the former. [illegible] itself in superficial deposits, downcutting by the Hat has not been so savage, so that its valley tends to be shallower and apparently broader.

(c) Standrop Burn Of the tributary burns this the writer would assess to be the oldest. Showing a centrifugal plan the headwater burns literally described is entered. Quite suddenly at 1,000' the present stream course opens sufficiently to allow development of a narrow meander belt between 12' high banks. This stretch is floored with boulders, sands and gravels and, whilst the south bank is of bedrock, that opposite is of superficial material. Linhope Spout, a 50' waterfall abruptly terminates this stretch and below it the stream crosses two minor falls before reaching Linhope to emerge from a 300' deep ravine in a 15' wide slot channel. The Linhope tributaries are left bank possessing fairly dissimilar characters now briefly summarised.

(a) Dunmoor Burn Above its source lies a windgap, probably used by southward moving ice. The stream rises below a "lip" - a feature probably resulting from glacial erosion and the thickness of peat above. Typically the burn shows a symmetrical V incision into a larger asymmetrical valley (steepest on west bank).

(b) Het Burn Grading to a higher local base level than the Dunmoor, the Het Burn offers a contrast to the former. Whilst incising itself in to superficial deposits, downcutting by the Het has not been so savage, so that its valley tends to be shallower and apparently broader.

(c) Standrop Burn Of the tributary burns this the writer would assess to be the oldest. Showing a centrifugal plan the headwater burns literally plunge from 1,750' - 1,500', emerging from their gullies to unite and form the Standrop stream. The valley itself is steepsided and, for the size of the burn, deep, suggesting it to be a long established feature. A point of interest is the possible occurrence of a spread or infilling at the valley head (at 1,450'), where the author noted the stream to be 10' down into coarse sand and gravel of local origin.

Amongst the topographic features of the Linhope valley worthy of description one must first draw attention to the little and great Standrop Tors. Striking in the field, the tors rise 30' and 50' respectively, being much shattered by weathering and showing mural jointing in the granite. (Note they lie above 1,750'). Again, S.E. Comb Fell between the Standrop and Coldlaw burns shows a marked change of slope 1,750'- 1,650', leading down to what probably is a bench remnant at 1,600' (despite the peat cover). The north-east inner margin of this remnant shows a slight depression which is soon sufficiently defined to appear anomalous, and suggests that peat lies as a filling in some form of cutting, or again, that sapping of the peat from below has caused a slight subsidence or sinking. Finally, in the lower Linhope valley and near Greaves Ash three depressions, run up the valley side and over the crest. They appear to be of more recent origin than the finer N.W./S.E. (glacial?) graining in the same area. The two depressions north of Greaves Ash probably were cut by meltwater though subglacially, whilst the third to the south may be either a marginal footing or bench remnant. (See Air Photograph for graining effects).

(ii) The Breamish valley below Linhope *shows an incised stream flowing over a peneplained part of the massif without any obvious relationship to underlying geology. Crests are gentle, and only along the river line and at the peripheries is the relative relief marked. Flanking the shallow Breamish waters below 700' there is a well defined strip of alluvium - coarse material mostly, subjected periodically to inundation and reworking. East of Alnhammoor the river enters what is essentially a rock cut channel, meandering over the veneer covering the flat floor but severely contained by steep valley sides. There is not a great deal of terrace development, only low slip off cusps occurring east of Meggrims Knowe (Right bank) and at the foot of Brough Law (also Right bank) together with some rudely terraced fragments below the Chester Burn confluence. As elsewhere in the massif the observer occasionally sees dyke crossings associated with stream rapids, whilst dyke lines on the hill and valley sides can often by discerned, for, although weathered, they appear more resistant than the adjacent country rock.

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*N.B. Abundant evidence of former cultivation and past settlement (early) in this area e.g. Hartside, Meggrims Knowe, Chesters.

The southern slope of Dunmoor rising abruptly from 1,000' is by no means smooth and in particular the crags running obliquely uphill (S.E.-N.W.) deserve mention. These features are most pronounced near Linhope - their form and location tend to support the view that they result from ice flowing south-eastward. The best example seen in the field is Cat Crag whose west face rises 50', whilst nearby crag heights range from 15'-30'. Above at 1,700' Long Crag shows a 40' east facing crag (ice plucked?) with the effects of ice smoothing showing westward. It may well be that at least one depression along this hillside represents part of a subglacial chute. The feature in question begins at 1,300' with a two sided intake, then becomes onesided (15'-20' height) before petering out just below 1,200'. East of all these lie the Cunyan Crags (1,550') - granitic, shattered and weathered but showing a general -N.W./S.E. alignment.

South of Dunmoor the area of undissected surface north of the Hartside - Greensidehill depression tends to have poor surface drainage. This depression is now interpreted as representing the former line of the Breamish stream and to-day is occupied in part by the Greensidehill burn. From being fairly wide and moderately shallow the depression changes form eastward at 700'. A rapid increase in depth occurs so that by 600' the burn (Greensidehill) is incised 80'-100', has steep bedrock sides (20° slopes est^{d}.) and shows a 50' wide alluvium covered floor. Coming in along the west side of Knock Hill is a tributary doubtfully of "normal" origin because of the meltwater cuts and fluvioglacial deposits there present. The Knock - Reaveley Hill area appears bevelled, shows a slightly higher summit level than the Hartside area and when viewed from the west appears somewhat detached. This impression no doubt is due in part to the erosion which has occurred along its west flank (by meltwater and later the Knock burn). On the south side the area is cut by the Ingram Gorge and to the east there is the marked topographic break as one moves off the volcanic rocks on to the sediments.

Considering next the south side of the Breamish valley, one notes that shortly after leaving Linhope the trunk stream flows across the mouth of the Shank burn valley. This burn seems to be of comparable age to the Linhope, and, like it, probably formed one of the early Breamish tributaries. It results from the union of the Smalehope Burn and the Sting Burn, the former rising in a nivation hollow or enlarged headwater reach on Cushat Law, hanging slightly at 1,500', whilst the latter (in part) follows the line probably used by ice moving from the west. At 1,050' the Upper Breamish crush, which is used by the Dow Cleugh, crosses the Shank burn and corresponds to a waterfall site Again, downvalley from Little Dod the transverse section becomes asymmetrical with west facing slopes most abrupt and the opposite side of the valley (left bank) opening out progressively. The Shank burn itself becomes markedly incised below 1,000', a character shared by the Fore burn tributary. Other features of note in the Shank valley include the windgap west of High Knowe which was probably used by ice and meltwaters, and the wide (Shank/Cobden) interfluve showing three clearly defined meltwater channels between 1,150' and 1,063'

As with the Shank, so too the right banks of the Cobden and Chester Burns are steepest, rising up from youthful streams to what have been bevelled crests. The most interesting features of the Cobden valley are the contrasting marks left on its sides by meltwaters flowing transversely across it. Whilst on the right bank Dry Dean intakes at 950' and "hangs" slightly, the left bank shows a zone of crude terracing and benching from 1,150' - 950'. Small stepped features are discontinuous but give the impression of grading eastward, presumably, therefore, associated with the channels to the west and the Dry Dean cut to the east (i.e. initial stages of marginal footing development?). Dry Dean in its turn appears first to have fed waters into the South Plantation cut at 900' (across the Middle Dean/Chester Burn interfluve lying to the east, north of Cochrane Pike) but later into Chester Burn. Again, the right bank of the Chester Burn is rough and craggy, strikingly different from the rather featureless ground on the left bank. One point of interest, however, in the latter area is the way in which the shallow depression of Drydean burn divides into three about 875', the lower reaches of each branch feeding waters into the Chester Burn. Interesting local details are available along Chester burn, ranging from excellent agglomerate exposures, in parts of the lower stream course, to the fragments of a higher channel preserved alongside the present stream but separated by a glacial plugging.

Through the Ingram gorge the Breamish continues to be shallow, flowing through haughland. The steep, rock valley sides are coated by very pronounced screeing e,g. Ingram glidders, and one notes that whilst the red ash gives a finely fretted surface, weathering leaves the agglomerate surfaces irregular, lumpy and knotty. Unusual, too, is the occurrence of what appear to be scree terraces, showing level upper surfaces and apparently graded like normal terraces. Never of great width, those occurring below the Greensidehill burn confluence rise 20' above present stream level. (The writer was unable to check on their internal structure so that the possibility of their being spreads of coarse material on benches or terraces (normal) cannot be neglected). Another minor feature of note lies on the east side of Hartside Hill, above and along the present valley side. Sufficient is seen, despite the undulatory character of the ground, to suggest that running water had formerly flowed along this strip, either marginally to ice/glacial plugging or, less likely, as part of the Chester burn valley.

(iii.) For convenience this stretch is delimited to the north along a minor watershed running from Reavely Hill - Roddam Rigg - Nova Scotia - Wooperton - New Berwick with the Aln/Breamish watershed as the southern limit. The Breamish itself is now markedly different, for on leaving the Ingram gorge mature and then old age characters are developed and besides river terracing there appear to be fragments of a 300' lake strand line* near Beanley. (The writer on general considerations suggests that the lake might well have stood earlier at 400'). Tributary development is comparatively poor but rather unique for, because of the circumstances prevailing during ice recession, meltwaters flowed over the Aln/Breamish watershed at the head of Middle Dean, Fawdon Dean and Mile Moor, then later recrossed it in the opposite direction (southward), through Shawdon Dean. Also in this phase meltwaters from the north scored the left bank of the valley about Reavely Green Farm and Roddamrigg House. As for the valley form, one notes that relief is strongest on the right bank where the north/south (broadly) topographic grain on the volcanics is replaced on the sediments by a N.E./S.W. wedge of high

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*see Geological Survey Memoir, 1930 Alnwick district p. 93 to 94 for additional information.

ground. On the opposite bank N./S. graining again shows on the lavas but becomes feebler and peters out northwards under the superimposed glacial deposits whilst eastward the ground becomes low and diffuse, sloping gradually in towards the stream line.

Ingram on the south bank is situated on a low terrace and lies in the centre of a small amphitheatre of high ground. Two burns, tributaries to the Breamish, break the rim ofthis amphitheatre however, whilst the infalling slopes are at variance; those from Ewe Hill are rather uniform, from Wether Hill broken in two places (650' and 550') and those along the inside of the West - East Hill ridge look decidedly oversteepened by glaciation. From the west the river gorge form is preserved along the north bank of Breamish to Reavely Braes (at 450' opposite Ingram) but it is replaced east of Broughlaw Plantation burn by low till cliffing (20') high at west end) which peters out before Ingram is reached. Rising south of Ingram the Middledean and Fawdon burns both flow N.E., showing melt-water cuts at their sources and lose their youthful incised characters between 500' - 450' (Furthermore they both appear now to possess artificial lower courses). The Middle Dean*

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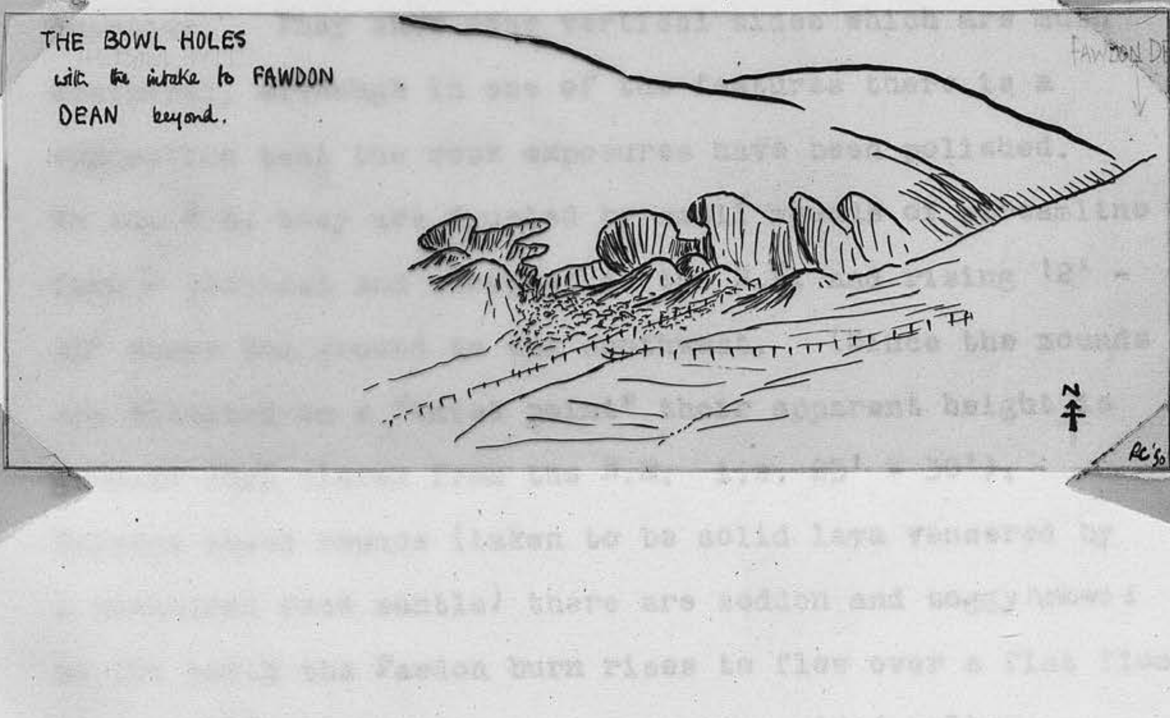
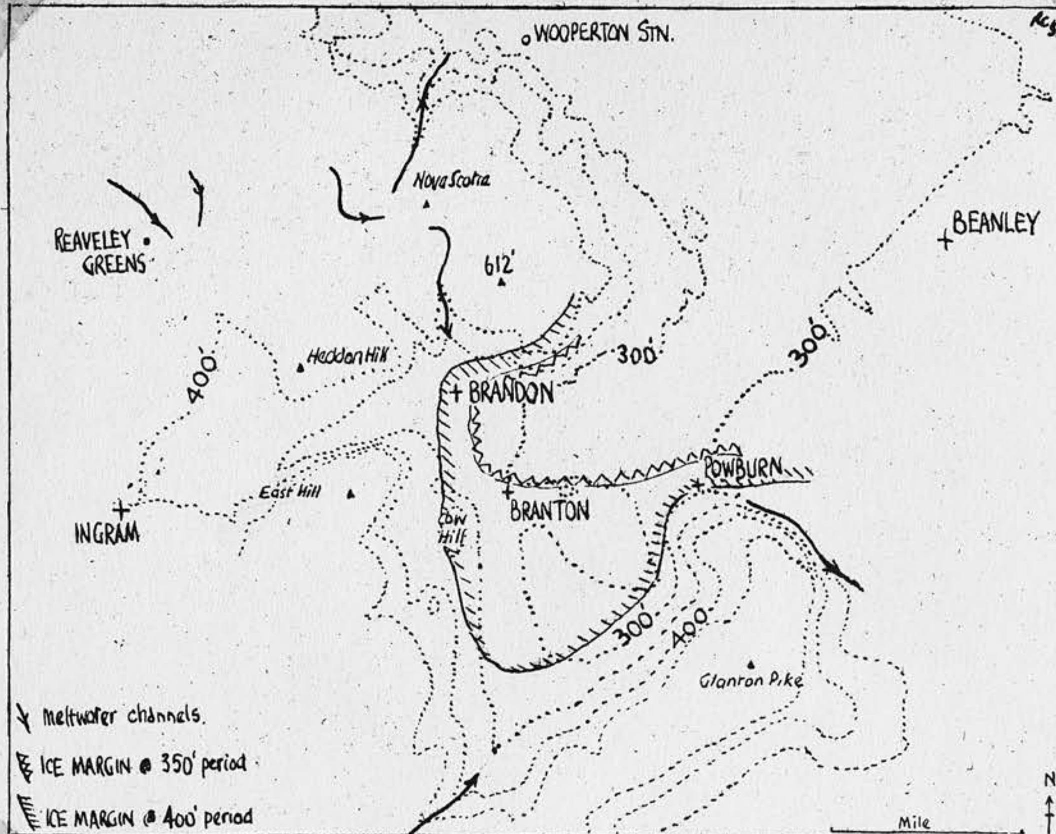
*Excellent cultivation terraces occur here, whilst the whole area about Ingram, Reavely and Fawdon bears marks of past agricultural use.

valley is asymmetrical but besides showing some effects on the right bank a prolongation of the meltwater cutting at the valley head has enhanced the oversteepening between 700' - 800'. Fawdon Dean too has been used by meltwaters, is very deep and broadly follows a fault line. At its head lie the Bowl Holes, unexpected local features of questionable origin and now suggested to be potholes produced by meltwater. Two "potholes" c. 25' deep lie on the eastern slope of Cochrane Pike near the ash/lava [illegible]. They have [illegible] vertical sides which are [illegible] [illegible] although in one of the features there is a [illegible] and the rock exposures have been polished. [illegible] rising 12' - 15' above the ground [illegible]. Hence the mounds [illegible] apparent heights [illegible] from the S.E. [illegible] mounds (taken to be solid lava veneered by a [illegible] mantle) there are sodden and boggy hollows [illegible] the Fawdon burn rises to flow over a flat floor of [illegible] width through a very steep sided valley.



From Ingram downvalley the wide alluvial flat catches the eye, together with the reluctance or inability of the stream to develop wide meander swings until beyond [illegible] whilst south of Branton the very shallow basin drained by [illegible] Burn appears as an appendage to this low ground. On the south bank river cliffing appears as unusual, a normal valley is asymmetrical but besides showing stoss effects on the right bank a prolongation of the meltwater cutting at the valley head has enhanced the oversteepening between 700' - 650'. Fawdon Dean too has been used by meltwaters, is very deep, and broadly follows a fault line. At its head lie the Bowl Holes, unexpected local features of questionable origin and now suggested to be potholes produced by meltwater. Two "potholes" c. 25' deep lie on the eastern slope of Cochrane Pike near the ash/lava junction. They show near vertical sides which are much weathered, although in one of the features there is a suggestion that the rock exposures have been polished. To the S.E. they are fronted by small mounds of streamline form - bluntest and steepest to the N.E. and rising 12' - 15' above the ground to the southwest. (Since the mounds are situated on a "knick point" their apparent height is greater when viewed from the N.E. i.e. 25' - 30'). Between these mounds (taken to be solid lava veneered by a weathered rock mantle) there are sodden and boggy hollows & to the north the Fawdon burn rises to flow over a flat floor of some 20' width through a very steep sided valley.

From Ingram downvalley the wide alluvial flat catches the eye, together with the reluctance or inability of the stream to develop wide meander sweeps until beyond Hedgeley whilst south of Branton the very shallow basin drained by Pow Burn appears as an appendage to this low ground. On the south bank river cliffing appears en echelon, a normal


WOOPERTON STN.
Nova Scotia
612'
REAVELEY
GREENS
BEANLEY
Heddon Hill
400'
300'
300'
BRANDON
POWBURN
BRANTON
East Hill
Cow
Hill
INGRAM
300'
400'
Glanton Pike
meltwater channels.
ICE MARGIN @ 350' period
ICE MARGIN @ 400' period
N
Mile

higher set along the foot of East Hill* (40-50 feet) being replaced by a lower set leading east from Branton and falling into the intake of Shawdon Dean. The Branton basin is bounded to the west by strong topography marking the S.W. corner of the massif where, as one might expect, fragments of marginal metlwater cuts occur, e.g. S.E. slopes of Broomyrook Knowe, (the cols north of Old Fawdon and Gibbs Hill could be interpreted as parts of a temporary overflow from Fawdon Dean). East of Branton the river cliffing rises to a small flat at 357' (water trimmed?) whilst to the west the foot of East Hill shows a break of slope at 400' and terrace edge at 350'. It is suggested that the topography here is in large part due to glaciation - Firstly, erosion by south moving ice roughed out the present form then at a later stage the area lay temporarily under water, forming part of a lake draining off through Shawdon Dean (see sketch opposite)

Immediately north-east of Pow Burn the right bank is steep, rough and much disturbed where sliding and slumping of till under gravity has inhibited river cliff development. Northwards, too, till continues to form the right bank of the stream course but of lessening height and slope, especially once past Beanley Tileworks. The abrupt rise of ground from the stream course to Crawley is not matched to the N.E. Instead, about Beanley, breaks of

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*Note this cliffing rises to a narrow ledging at 400' slope at 300' and 400' occur before the ground reaches the curved scarp front above, whilst S.E. of New Bewick bridge the ground rises to a most anomalous looking divide below 450' (west of Eglingham). It looks almost as though this divide was the remnant of a morainic plug either at a glacial breach or else in a former valley line (writer favours latter view).

Along the north bank of the river it would appear that the meltwaters coming south ceased to use the Reavely burn channel at 500', for the present stream below is insignificant and has not modified the shallow valley of open V-form. Again, east of Heddon Hill the next tributary was used by meltwaters till 350', for a small discordancy north of Brandon can be seen at this height, and at its lower end residual sand and gravels occur (delta remnants?) Rising through the overburden Heddon Hill and 612'△ north of Brandon Hillhead represent the only local outcrops of bedrock (north bank) and are striking, with the former terminating a low ridge which stretches northward for a short distance before being lost under the defined margin of the main mass of sand and gravel deposits. Further east in the Wooperton area it seems more than likely that water was ponded back at 300', for two local meltwater channels mouth at 300'. This contour south to Percy's Cross is associated with a marked slope change whilst eastward crests lie at, near or below 300' over featureless ground. Over this dull ground odd small kettles appear and only the

Randy Burn merits any description. This burn rises south of Wooperton Station in a shallow but widening depression and flows in either a kettle or over ground formerly lacustrine. Furthermore, if the Wooperton Railway cutting was originally natural (and much of it does look so) then water ponded up in the Roddam catchment could escape southwards. (Besides purely topographic evidence, reference is made to Geological Survey Memoir, Alnwick Memoir where lake clay is noted S.W. of Gallow Law, and to Geological Magazine, 1910. Bullerwell "on the superficial deposits at the foot of the Cheviot Hills" - this author noting peat deposits just north of Wooperton)

(iv) Between New Bewick and E. Lilburn the Breamish is partially artificial and part natural, flowing between the sand and gravels to the west and the sandstone scarp to the east. The controlled stretch north of New Bewick reflects the need to check the stream's tendency to meander excessively within an already incised course. It seems therefore that formerly a greater volume of water had been carried by the stream when it graded to 200' at East Lilburn, subsequent regrading having to be undertaken by a reduced Breamish. At East Lilburn itself there is a water node formed by the convergence of the Lilburn and Roddam burns to join the Breamish (giving the River Till), and again, one notes that just here too the stream comes onto the Hetton syncline. The parallel tributary burns coming off the flanks of the massif begin to converge at 300' and show marked changes in the form of their upper, middle and lower reaches. In contrast to these, there is practically no obsequent tributary development, only the cutting past West Harehope produced by a temporary glacial diversion of Harehope burn deserves mention.

The left bank Roddam and Lilburn streams show relatively open upper stretches in till, followed by narrow very incised tracts through the main mass of the superficial deposits (often down into underlying bedrock) and then lower graded portions flowing through the more subdued topography east of 300'. The topographic change in the sand and gravel deposits of the Chatton /Hedgeley basin east of 300' contour is striking, and the streams flowing over this area although incised show floodplain development. The longitudinal profiles constructed for the Lilburn and Roddam burns show knicks at 1,050', 950' and 450' for the former, 800' and 500' in the latter, whilst the Harelaw (tributary to the Roddam) displays a small knick at 800' coincident with the granite margin. Of these knicks, it might well be that those at 450' and 500' reflect stream regrading post 300' lake level? Prior to considering some of the local details of these stream courses, it would be as well to quickly sketch in the topographic form of the sands and gravels along the west side of the basin*

* West of main N/cle-Wooler road A68 between Wooperton - Ilderton Station approx.

As the diagram of meltwater cuts (fig. MF.p 28.) displays there are a series of marginal channels aligned and falling S.S.E. from Brands Hill. Cutting some of these are a set of N.N.E. transverse cuts, broadly parallel to each other and now forming parts of stream courses, whilst eastwards a further set of southward looping cuts provides the third element to the local topography. It follows that the form of the ground is in sympathy with these cuts, the higher marginal cuttings associated with broadly aligned swells and swales, the transverse cuts (interpreted as being subglacial chutes) providing in some cases "water" and in others remaining "dry" gaps, whilst the third set are fronted to the south by topographically higher deposits. The third set are possibly the result of water flowing between the ice front and superficial material, and examples can be seen at near S. Middleton and Roddam. It will be obvious, therefore, that in this seemingly chaotic mass of sand and gravels there is superimposed an orderliness by meltwater action.

The Roddam Burn rises in a meltwater cutting east of Cunyan Crags and flows in a generally north-eastern direction, whilst the Threestone burn, instead of now being a tributary, turns north at Heddon Hill to form part of the Lilburn stream. It requires little imagination to see that the Threestone basin was formerly bounded to the N.E. by a watershed from Langlee Crags - Middleton Crags - Heddon Hill and it is equally easy to suggest that there had been a stream in the basin flowing S.E. to the Breamish* Fieldwork indeed shows that during ice recession the Threestone burn didflow south at Heddon Hill for a short spell and that it also did flow into the Breamish area <u>via</u> Roddam Bog at roughly the same period. Flowing N.E. the present stream only begins to use a bedrock channel north of Calder farm (c. 600'), but returns once more on to superficial deposits at 350'. Along the stream the transverse section changes from normal at 700' to asymmetrical as far as 500' where it becomes steeply incised, but with remnants of a V in V form down to 400'. A normally incised stretch follows to 300' where the dene opens out and the valley peters out (graded to 300' lake?) The lower portion is contrasting, between 250' - 200' it looks unnatural (leaving the obvious course to the east abandoned, low, damp and poorly drained) and below 200' to the confluence point once again incised.

Above the junction of the Roddam and Harelaw streams the ground rises to what have been bench remnants (between c. 1,000' - 1,150') lying round the Threestone basin. Again the rather thick glacial filling from the upper Lilburn extends S.S.W. of Heddon Hill but with diminishing

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*The well marked gap between Reavely and Heddon Hill could hardly be credited to ice erosion for ice here moved south as the beautifully moulded shape of Heddon shows.

thickness though elsewhere in the basin the overburden is assessed to be thin. From the confluence down to Ildertonmoor the stream banks are contrasting. On the left bank the steep ground off Heddon Hill shows a change of slope (lowering N.E. from 750' - 600'), below which the slightly gullied till surface falls in to the stream line. It is interesting to compare this strip of till infilling with comparable ground west of Heddon Hill, for the use of an artificial conduit collecting and draining water to the S.W. has inhibited the gullying, slumping and production of 'catsteps' seen along the left bank of the upper Lilburn Burn. (Paradoxically however, having offset this danger the farmer has allowed the Ildertonmoor ground to run to bracken!) To the northwest of Ildertonmoor the ground rises westward, but shows aligned swells and swales associated with marginal meltwater cutting. By contrast the right bank shows subdued topography rising gently to 650' east of Calder. Here the form and shape of the detached Calder sand and gravel spread suggests them to be a cone due to checking in the rate of meltwater flow (meltwater coming off the higher ground checked by ice front and/or rising ground - or merely a residual form?). W. and S.W. of Calder, too, the stream is decidedly misfitted, wandering aimlessly as little more than a ditch through superficial material. The containing banks rise 40' above present waterlevel and there are in addition two terrace fragments 20' - 25' above streamlevel also. The intake to the Roddam Bog cut is gentle but soon the sand and gravels form a 30' steep bank above the channel. Along the stream course at Calder Dean Ford the Roddam Dene conglomerate is in fact represented by flaggy, ripple marked purple brown sandstone dipping gently west with the stream working along the strike*. Turning eastward the burn flows "through the hill", begins its present gorge tract at 500' and quickly becomes incised to a depth of 100'. In the gorge the following features are of note

1. The conglomerate itself is variable, in some exposures pebblelike whilst elsewhere showing rounded rock fragments, fist to coconut size. One feels sure that, given a different rock type, the stream would have produced a slot gorge. As it is, in one short stretch below a bench remnant the stream comes fairly close to producing such a feature.

2. In two localities remnants of the former stream floor occur. These small benches rise westward, the higher on the south bank rises 30' - 40' above present water level, whilst the lower downstream on the north bank rises to 20' above present water level. (Former at c. 450' where incision 100' the latter c.400' where incision estimated 70').

3. The lower end of the gorge about Dene lodge sees the depth of incision reduced to some 30', alluvium is now present on the valley floor and only a short distance downstream the overburden is exposed in a river cliff. Here on a 25' high face thin sandy layers appear to have formed hardpan whilst the gravels do seem to have their long axes orientated W./E. (As an indication

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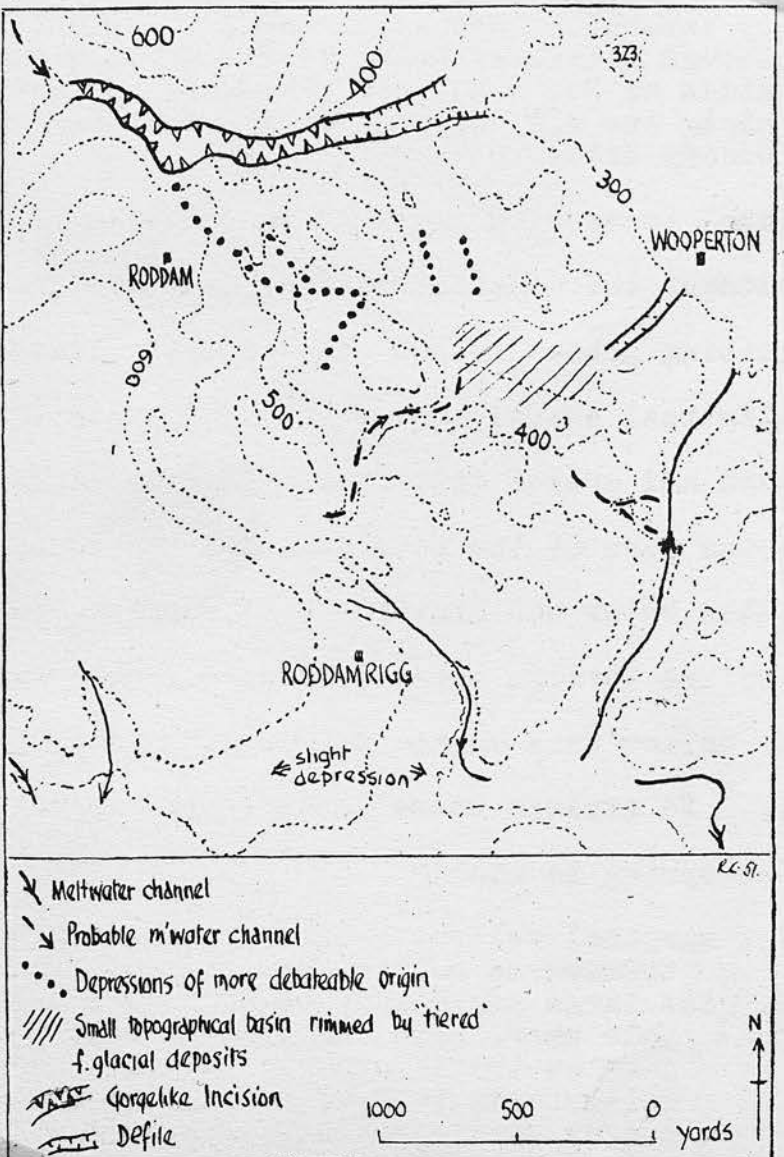
*For details of local geology see <u>Geol. Survey Memoir</u> Alnwick District, 1930, p. 15-17.


600
400
323
300
WOOPERTON
RODDAM
600
500
400
RODDAM RIGG
slight depression
RC 51.
Meltwater channel
Probable m'water channel
Depressions of more debateable origin
Small topographical basin rimmed by "tiered" f. glacial deposits
Gorgelike Incision
Defile
1000
500
0
yards
N

to the degree of cementation present in the "pan", an undercut section 4' depth, 6' height and 8' length occurs at the west end of section)

4. The lack of anomalous looking depressions along the north side of the valley here is matched by several on the south bank. It looks as though intake occurred on the north and south sides of Dob's Law and there are depressions along the S.W. side of Roddam Hall and east of Broomy Hill.

The local topography south of Roddam Dene is without parallel amongst the Chatton/Hedgeley sand and gravels. A narrow cutting graded to 300' at Wooperton leads west into an elliptical shaped area which is flanked by upstanding sand and gravel deposits. By dint of duplication these take the form of two sets of knolls on the south and west side, the outer and higher set being also the most extensive whilst through them, falling and convergent upon the central hollow come marked depressions (absent on east side only). To explain these features two immediate explanations spring to mind:-

either 1. marginal meltwater cutting aided by convergent transverse cutting was responsible

or 2. the large central depression is a large kettle hole where sand and gravels have been let down as the hidden ice melted. (Obviously meltwater action could also be invoked here and/or possible slumping of the overburden).

(See sketch)

Kingston Dean north of Roseden Edge represents another west/east meltwater channel, abandoned but formerly intaking at Ilderton. This channel shows tributary cuts along the left bank, was formerly graded to 300' and to-day is used by an insignificant burn. There are two points of interest about the depressions in this area, firstly, at Ilderton there seems to have been a double intake, and secondly, meltwaters flowing west/east across the line of the present S. Middleton Dean appear to have been responsible for the middle Lilburn burn's alignment. East of Lilburn glebe there is again contrast in the local topography, whilst the lower Ilderton stream flows across a N.N.E./S.S.W. trough then skirts a kettlehole to join the the Roddam burn. One concludes that the triangular spread of deposits between East Lilburn - Wooperton - New Bewick (approx) is deltaic, reminiscent of the Milfield delta (northwards between Milfield - Ewart - Coupland) and like it in showing numbers of distributaries, but dissimilar in that the materials used are sand and gravel. It is unfortunate that there is so little evidence on the east side of the Hedgeley basin to support the view that the lake level at 300' stretched northwards beyond Hedgehope Hall, although water trimming may have produced the terrace like facet (250'-300') at Old Bewick and the 300' feature west of Bewick Folly may also be significant.

The Lilburn burn valley form and (part at least of) its alignment like the Roddam appears to result from late glacial conditions. Reference has already been made to its upper Threestone section, the temporary glacial diversion south at Heddon Hill and the occurrence of gullied till and 'catsteps' south of S. Middleton moor. It is now to be further noted that as the stream flows along the west side of Heddon Hill in an asymmetrical valley its line appears to be moving off the lava on to till. Turning to flow N.E. the stream continues to be very incised, but because of working through unconsolidated material a gorge-like form is absent (- the steep streambankings slipping and sliding under gravity), whilst stream grading has been comparatively easier cp. Roddam burn. Downstream from 400' the haughland broadens out noticeably but it is the south bank which carries river cliffing consistently to the stream's confluence point. On the left bank about S. Middleton moor the steep slopes from c. 1,100' flatten out considerably between 850' - 800', presumably where the depth of overburden thickens. Downvalley to Lilburn Towers the details of topography again are dependent upon the forms displayed by sands and gravels, whilst beyond the geomorphology again alters. On the right bank landforms result from glaciation, ranging from the ice moulded form of Heddon to the sand and gravels - channelled, kettled or marginal to the 300' late glacial lake.

Meltwater intakes occur on either side of Brands Hill a single overflow cut on the west side but a series on the eastern slope are of the marginal type. These latter types have grained the ground between 850'-700' towards S. Middleton moor and it is particularly interesting to note west of Old and S. Middleton one example of terracing produced by meltwater on the flanking sand and gravels. The transverse cuts are well developed, some still in use by burns e.g. at Old Middleton and S. Middleton, and others now dry e.g. 1,200 yards west of S. Middleton. These in turn are replaced on the lower ground east and north by southward looping channels e.g. south of N. Middleton and S.E. of S. Middleton. Of all these channels those at Old Middleton and S. Middleton merit further description. In the former a transverse channel bifurcates, the northern limb joining Coldgate valley having been subjected to back cutting by the present stream, whilst the S.E. limb is now virtually dry. The northern limb has been graded to remnants of an incised meander at 500' which in turn hangs above the present Coldgate valley floor. Just as divergence has occurred here, so too S.E. of S. Middleton the same phenomenon has occurred, but in addition, convergence of two cuttings occurs at the western limit of the hamlet. There can be little doubt that meltwaters crossed what is now S. Middleton Dean in two localities, and probably helped to determine the later Lilburn stream's course. A final brief note is added concerning the sand and gravel deposits stretching from N. Middleton towards Wooler. Some very local small scale kettling had occurred along this well defined strip, where the ground fluctuates between 400' and 350') and which has a terracelike aspect in places (e.g. by N. Earle). In addition, the outlet to the deep

Wooler golf course cut (south Horsdon Hill) at 400' tends to support the view that this strip represents a kame terrace which lowers and peters out east of N. Middleton. Downvalley, on the right bank of the Lilburn stream, two marked kettleholes appear north of Lilburn Southsteads whilst the topographic hiatus of the sands and gravels upstream is replaced by a general surface, undulating and falling eastwards to 300'. On the opposite side of the valley, alluvium fingers out westward and northeastwards from Lilburn Tower, with the ground itself rising northwards towards Westwood Moor and Trickley Crags. Whilst it is comparatively simple (from the local topographic details) to suggest that water flowed for a limited period from the west to deposit the alluvium at Lilburn Tower Farm, the reason for the depression rising up past Lilburn Grange and its alluvial floor is not quite so apparent. When followed northward this depression continues to rise along the front of Trickley scarp but then begins to fall away N.E., past Fowberry Park. Since the present form of Trickley crags appear to result from glacial erosion, it seems more logical to suggest that a former and larger Coldmartin Lough (rock basin but shallow) had for a while found outlet to the S.E. This view seems to be justified when vertical air photos of the area are examined stereoscopically. In addition, the air photos suggest that Coldmartin farm lies in part of a meltwater cutting, and another minor cutting is suggested above Tower Martin. As for the

Lilburn Stream itself, the only small feature of note lies between Newtown Mill and E. Lilburn where a residual ridge of coarse material rises 40' above water level, being fronted on the south side by what appears to have been the former stream course.

River Till (see M.F pages 21, 22)

The Till flows a short distance northwards into the Chatton Basin before escaping westwards via the Weetwood Hill water gap to wander over Milfield Plain, but it is not until beyond Etal that it flows over bedrock, through a post glacial gorge. Tributary development is meagre, on the right bank, apart from the Hetton Burn, only the small Bradford and Finger burns deserve mention, whilst the Wooler Water, Humbleton burn and the River Glen form the chief left bank streams. The present Till course first runs through superficial deposits covering the "nose" of the Hetton Syncline, then turns west to enter Milfield Plain by an obsequent tract. It flows next over the great infilling of Milfield in the general direction of the Cementstone strike, skirts the Cornhill sands and gravels and finally enters a gorge tract, which in parts is also cut along the strike direction. Before considering the catchment in detail, it would be as well briefly to recapitulate some of the already published views on parts of the area. Milfield Plain and part of the Chatton Basin were held to be under a late or post glacial Lake Ewart standing at 200' by G. Butler (Pres. Address Berwick Nat. Club 1907 vol. 19) whilst Milne Home (Trans Royal Soc. Edinburgh vol. 27 pt. 4) earlier had postulated a 185' water level for Milfield. More recently (Geol. Survey Memoir 1932 The Cheviot Hills) the lake level was assigned to 140' in Milfield, with the gently rising ground southward interpreted as deltaic and produced by the Glen, Till and Wooler waters. The Cornhill sands and gravels are interpreted as kettle moraine, superimposed locally upon drumlins and held responsible for the ponding back of this 140' lake. It is striking that both these levels quoted for the lake level should be in accordance with the late glacial sea levels at 140' and 190' proposed by W. Anderson (Geol. Survey) in his recent work e.g. Geol. Mag. 1939, British Association (Newcastle Meeting) 1949. As for the pre-glacial course of the R. Till, Clough and Gunn (G.S. Memoir 1895 Explanation of sheet 110W.) proposed that the lower valley formerly stretched west from Crookham to Cornhill, subsequently being infilled by glacial deposits and marked to-day by only the anomalous Pallinsburn depression. Upon reflection, however, the author suggests that there is more to the Pallinsburn depression than merely the burying of a pre-glacial channel. Examination of the few overburden records available supports the idea of a buried trough of low ground running eastwards for a short distance north of Branxton and then continuing S.S.E. into Milfield Plain. However, when the height of bedrock above sea level is calculated (from these bore records) it would appear reasonable to invoke ice gouging and overdeepening to explain the results. For example, at Ewart the trough floor is at the most 50' above present

S.L., Branxton vicarage field 65' above S.L. At the latter site two boreholes in close proximity show a markedly different thickness of overburden and, when taken in conjunction with the outcrops on Branxton hill, suggest that a fault line scarp is buried locally under glacial deposits. The real problem, however, is how to reconcile the two conflicting directions of ice movement at the N.E. corner of the massif, i.e. ice moving around and ice driving into the Cheviots from the west and north-west, and yet still to explain the occurrence of Milfield Plain.

The present Till valley is subdivisible into three distinct topographic units

1. The Chatton basin
2. Milfield Plain, north to Ford
3. Post-glacial gorge and the Cornhill kettle moraine

each of which will be considered in turn.

1. The characteristics shown by the lower Breamish are maintained by the upper Till as it meanders misfitted through the Chatton Basin. About it the ground rises quickly to the west and northwest, whilst to the east an expanse of ground lying at intermediate height gives way to the pronounced scarp front behind. This well defined topographic basin ends in the north at Holburn, along a line from Coldmartin Lough - Trickley Crags - Chillingham Park - Ros Castle in the south, and may be subdivided further by the Chatton - Broomhouse ridge into a north and south portion.

For a short distance past Newtown the river course is constrained between sand and gravel deposits on the left bank and thinly veneered crude benchlike features on the right. The 200' contour is important, for from above, especially on the left bank, marked slopes falling riverward are checked. On the right bank similar features are observed, though instances occur where the surface of the glacial deposits appears to be graded out to 200'. Approaching Chatton the river first skirts the sand and gravel mass (crossing it later downvalley), and stream meanders show decreased wavelength but increased amplitude between Chatton and the entrance to the watergap at Weetwoodhill. Also beyond Chatton incision into superficial deposits increases and the graded stream leaves the basin through a comparatively short but narrow defile. This gap at its maximum is c. 200' deep with bedrock exposed at 150' A.S.L. at its outlet, but backing the floodplain. Also on the north side of the water gap there are two small benches at 250'/300' and 400'/450' (The latter lies at a slightly greater distance away to N.W. from the gap, whilst Weetwoodhill farm is sited on the former). Within the sand and gravel area by the river exposures are absent, but fortunately a borehole record for Hettonhouse indicates that bedrock there lies at 98½' A.S.L. (anomalous?). Interpretation of the water gap has to contend with the following possibilities -

1. That the gap is of pre-glacial origin and results from headwater extension of an obsequent from the west capturing a strike stream in the Chatton basin.

2. It could be of late glacial origin resulting from meltwater overflow. As such the 250'/300' bench in the defile could be assessed to be of meltwater origin with the cutting beginning after the Shawdon Dean channel fell into disuse (at c300'). Obviously such an overflow would tend to use any pre-existing col or relatively low part of the crestline. As a mass of ice moved southeast over Milfield area, so the guiding influence of topography would increase as the thickness of ice diminished. In time, therefore, ice would tend to stream around the flanks of Weetwoodmoor quitting first the breach or col along the east side, and later withdrawing from the Wooler gap. (A similar bifurcation of the ice stream could be said to have occurred nearby at a slightly earlier date to produce the Chatton Moor gap. In both cases ice would be active but waning)

3. Linton's suggestion (S.G.M. 1933) of an earlier Tweed stream flow W/E across upper Milfield plain - Weet woodhill gap - Chatton Moor gap also merits consideration. Whilst it offers a solution to the siting of the two gaps, in the author's opinion the suggestion rather neglects the geological structure of the Carboniferous sediments, and furthermore the superimposed tract down through Kilham is more likely to have been produced by ice diverted water.

Inspection shows that only in two localities (in the E. area) do major stream courses clash markedly with underlying geological structure, firstly east of Bolton where the Aln crosses the Lemmington Anticline, and secondly here at Weetwoodhill. It would seem, therefore, that the watergap is of comparatively recent origin and preference is given now to to the second possibility.

Eastwards from the Weetwood Moor area the ground falls quickly below 450' but is soon checked at 350'/300' by the incoming of sand and gravel deposits.* The

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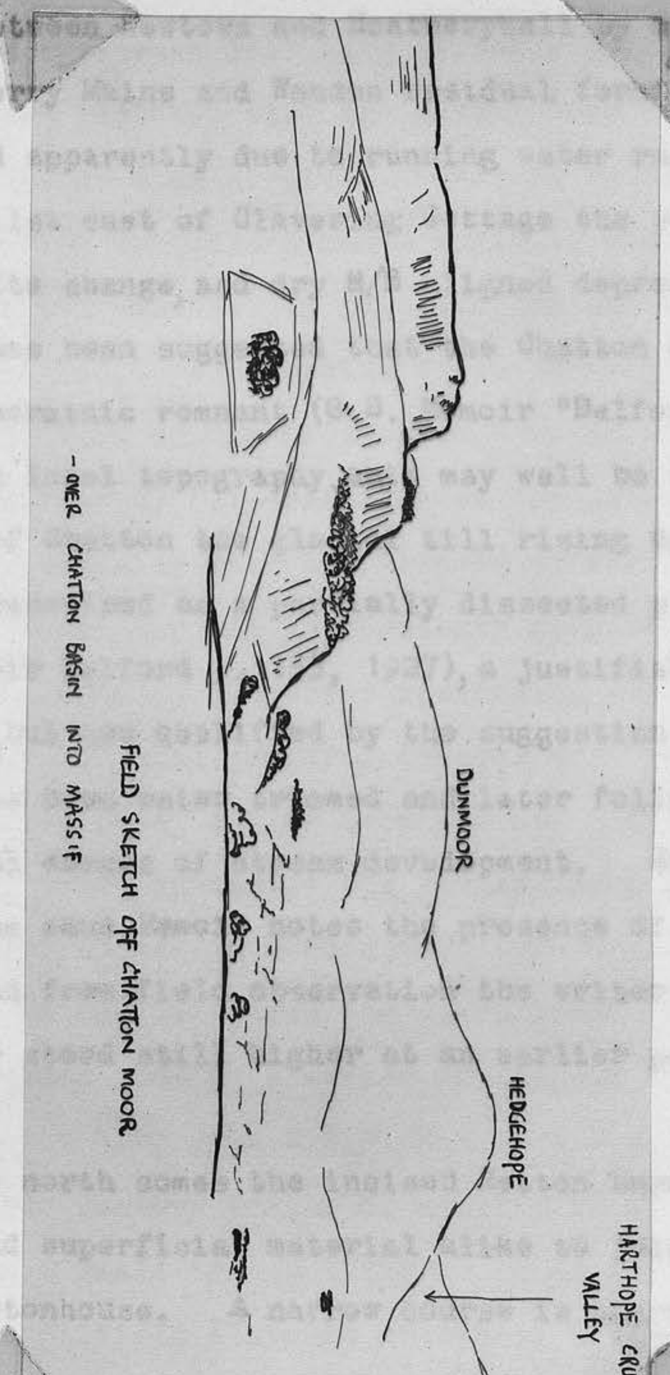
*Whilst the bulk of the glacial sands and gravels lie on the W. side of the Chatton basin, those flanking the Hetton burn rise to 400'/450' and are not so variable as the lower lying southern mass.



HARTHOPE CRUSH VALLEY
HEDGEHOPE
DUNMOOR
FIELD SKETCH OFF CHATTON MOOR
- OVER CHATTON BASIN INTO MASSIF

spreadlike character of these deposits seen about Chatton - Broomhouses is replaced westwards and northwards by residual forms, e.g. between Newtown and Heatheryhall by mounds and knolls, between Fowberry Mains and Wandon residual forms are of greater amplitude and apparently due to running water rather than kettling, whilst east of Clavering Cottage the composition of the deposits change, and dry N/S aligned depressions occur. It has been suggested that the Chatton deposits represent a morainic remnant (G.S. Memoir "Belford"), and, judged by the local topography, this may well be the case.

S.E. of Chatton the glacial till rising up to 300' has been described as a partially dissected plateau (G.S. Memoir Belford p. 153, 1927), a justifiable statement, but now qualified by the suggestion that the surface has been water trimmed and later followed by the initial stages of stream development. East of Chatton the same Memoir notes the presence of lake clays c. 200' and from field observation the writer proposes that water stood still higher at an earlier period at 300'.

From the north comes the incised Hetton burn*, flowing over solid and superficial material alike to join the R. Till near Hettonhouse. A narrow course is characteristic

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* Of the Hetton tributaries deserving mention, one east of Hettonlaw and that using Horse Dean both appear to have formerly carried greater volumes of water.

with small but noteworthy changes of valley form occurring south of Holburn mill and above Hettonhall. At the former, the Coal burn traverses 300' lake strand remnants (?) in a narrow 30' incision with the Hetton Dean opening out below as a shallow open stretch. This is rather short lived, for nearing Hettonhall banks begin to steepen and, although flat and veneered by alluvium, the valley floor becomes restricted. The details of topography on the Hetton's right bank change from north - south and east - west. In the north, ill drained moss and low undulating topography associated with the Barmoor surface gives way westward to higher and increasingly glacially grained ground, culminating in hogbacked upstanding residuals. Southward, too, glacial graining becomes more pronounced reaching an acme along a line from Dod Law - Redsteads, in the lee of which stretches the rather featureless sand and gravel spread on Horton Moor (presumably outwash material). On the left bank the scarp crest is also glacially moulded showing a series of aligned hogbacked rocdrumlins with long axes N.N.W./N.W. - S.S.E./S.E. The only minor feature worthy of mention is of doubtful origin, being a small trough lying north of West Lyham

2. The Milfield Plain is extremely well defined and not until north of Ford is its topographical clarity

impaired*. Over it the River Till and its tributaries meander excessively for gradients are low (and flood risks high), only by Flodden Tileworks is the meander belt width commensurate with valley width. Efforts have been and are continuing to be made to control the Till, Glen and Wooler water, but the scale of operations and the techniques used for conservation could stand improvement. Since the plain is of triangular shape it is proposed to consider it in four parts - corresponding to the sides of the triangle and the plain itself.

(a) Southside

This side stretches westward from Weetwood bridge to Kirknewton and besides including the Glen valley also embraces that of Wooler water. The erosional scarp from Weetwood bridge turning southward peters out near Haugh head and is replaced across the Wooler valley by the foothill zone of the massif. Just as this foothill zone is replaced westward by higher crests, so too the fringing zone of glacial deposits beneath the foothills diminishes when traced westward from Wooler. From Akeld to Old Yeavering the faultline scarp is at its best topographically, for beyond the latter place incoming transitionary summits

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* Excellent accounts of Milfield Plain in
G.S. Memoir 1895 Sheet 110W p. 80
G.S. Memoir 1932 The Cheviot Hills p. 138

of fringing glacial deposits again offset its grandeur. West of Wooler Water, too, numerous meltwater channels appear, especially within an area bounded by Akeld - Wooler - Brand's Hill - Tom Tallon's Crag - Akeld. (See M.F p.17 inset) These features occurring in bedrock and superficial deposits display considerable variation in form and size, but grade either eastward or southeastward. Whilst tributary valleys* along the massif front are not very striking, they tend to "hang" and show parallel alignment N.E./S.W. rather than flow lines tangential to the marginal fault line.

Whilst the Geological Survey map the outer margin of the glacial till along the Weetwood scarp foot as corresponding to a terrace margin, the feature is not especially marked. Rather does the ground slope gradually increase to 250'/300', above which the scarp face rises abruptly (Author suggests that the terrace margin falling from 200' - c. 140' is a residual deltaic feature). As for the scarp front itself, one notes its N.E./S.W. alignment is in sympathy with similar features nearby e.g. N.E. of Doddington and S.E. of Greendikes. These together with ice steepened W. faces of Doddington Law, Fenton Wood and Chattonpark Hill suggest that ice moving S.E. was responsible for the final details of these scarp alignments.

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*It will be obvious that with the conflicting alignments of normal tributaries and meltwater channels it is difficult to assess, for example, to what extent the Upper Humbleton and Carey/Common burns are glacially determined.

40'/50' deep convergent channels join below "The Traws" to form the Humbleton burn whose waters first flow a short distance east before turning north to join the R. Glen. In the upper Humbleton valley one is impressed by the termination of an open upper valley surface at 800' and its replacement by an asymmetrical form below. A short misfitted stream stretch between 750'- 650' is followed by a narrow course resulting from the burn's incising itself through glacial till. Contrasts along the northward stretch are afforded by the steepsided, flat floored section above 450', followed by the incised gash through superficial deposits (chiefly) down to 200' and finally the feeble artificial stretch out over the plain beyond. A traverse along the northern watershed of the burn is distinctive for two reasons, firstly the ground rises and falls by only small amounts e.g. Gains Lay 1,041' Black Law 1,035', Scald Hill 1,066, and secondly for the fact that every col encountered on this traverse shows a meltwater intake upon its southern side. The southern watershed is more robust and between Hart Heugh and Earle Hill there is further evidence of S. flowing meltwater*. North from Coldberry the ground drops quickly to a "tread" c. 500' (where bedrock is replaced by morainic looking debris) before the marked slope begins again between

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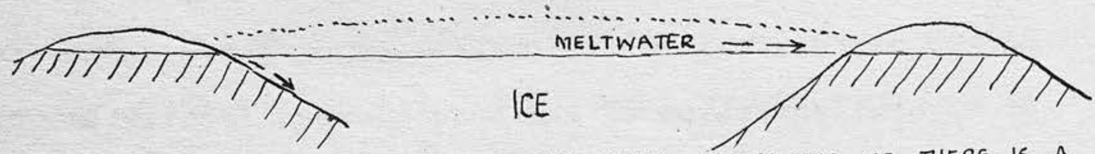
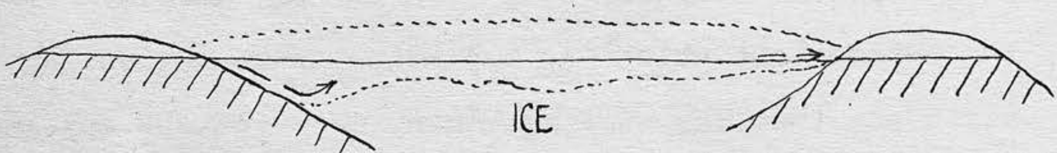
*Just north in the Humbleton valley meltwater fragments occur especially along the slopes of Wooler Moor, all convergent upon Earlehillhead.

Humbleton and Low Humbleton. North-eastwards, however, this tread is not marked, instead there is a gradual slope towards Wooler. The key to the details of local topography hereabouts is meltwater, for stemming from Harehope and Humbleton hills come a series of channels which have produced facets and cuttings in bedrock, knolls, swells and marked depressions in the overburden. There appear to be several varieties of channels present locally, and, while some of them fall east towards Wooler, others bypass the town via Wooler golf course or Earlehillhead. Besides what may be termed the "master" cuts behind Harehope, Humbleton and Horsdon Hills, those rising above "The Trows" probably came away directly from the ice margin. Again, the Horsdon cut which has had both intake and outlet at its north end (besides showing a hanging tributary cutting near its south end), probably was crossed by a subglacial chute which was later used subaerially to produce the anomaly at thenorthern end.

To the west Akeld Burn rises between Tom Tallon's Crag and Scald Hill, and on leaving the high bevelled source area rapidly becomes incised (e.g. by 900' 15 incision). Downvalley, glacial deposits along the valley sides partially offset the severity of the valley transverse section, though by 750' a severe left bank and increased valley depth have asserted themselves. The only stretch where stream gradients ease off occurs between 600'/500' but by [illegible] [illegible] stage (4)



IN THIS CASE, BESIDES THE MAIN FLOW OF WATER ACROSS THE ICE THERE IS A SUB GLACIAL LEAKAGE AT THE OUTLET OF A ROCK CHANNEL ∴ THE VALLEY SIDE IS SCARRED.



HERE IT IS ASSUMED THAT THE FLOOR OF THE MELTWATER CHANNEL, OVER ICE, IS UNGRADED ∴ WATER CAN ERODE & SCAR PART OF THE VALLEY SIDE.

See text Page 146.

Gleadscleugh cottage (472') the burn floor is again rough as the stream works down through coarse deposits obscuring the valley floor. (Upstream from the cottage 20' overburden exposed, shows boulders up to 4' length, clay is absent and instead the matrix is of coarse gravel and grit). Along the crest, above the left bank, between Tom Tallon's crag and Akeld Hill there are a number of meltwater channels, but these, instead of confining themselves to the crests, fall part way into the valley itself. One would have expected these channels to have ended at heights suitably graded to intakes of meltwater cuts upon the opposite crestline.

To explain these oddities either

A. Ice stoodhigher to the west for a longer period than to the east, so that water flowing east ran down into the valley before escaping northward.

or B. Some of the water flowing over ice between the outlet and intake of adjacent channels was also ableto flow down under the ice on the outlet side.

or C. The meltwater channel crossing the ice possessed a floor that was ungraded and deeper (in the ice) against the outlet, allowing running water to remain in contact with bedrock for some way down the valley side.

West from Akeld hill the high ground is dominated locally by Newton Tor, Eastor Tor and Yeavering Bell. The latter, standing apart and possessing a fine conical outline, is fronted by the Glen valley and partially separated from the main mass of high ground by a crescentic shaped depression. The horns of this depression rise southward to a windgap (used by meltwater) and whilst the Bell may have been detached preglacially, glacial agencies most surely have enhanced the effect. (The writer has noted similar, although more distinctly glacially produced, features up Deeside)

West from Low Humbleton the glacial deposits continue to form a zone of transitionary slopes beneath the steep ascending front of the massif as far west as Akeld. Beyond Akeld however the hill face is extremely steep with gradients only beginning to slacken off between 300' and 250'. On the glacial deposits the only minor feature of note occurs west of Humbleton buildings where the 200' contour broadly becomes associated with a break of slope and occasionally surmounts a quick short "riser."

(b) West Side

Along the western margin of the plain*, summit heights lower northeastwards, the relative index of height declines from south to north and slopes tend also to be steeper towards the south. South of the Milfield - Howtel depression the topography shows a greater compactness whilst to the north transverse ridge and furrow topography (i.e. to M. Plain) is characteristic. Present stream development is in its initial stages, although the eye is taken by the windgap above W. Flodden as being a likely outlet formerly used by the Kilham burn.

Above Lanton the R. Glen flows some way on bedrock and the steep N. rising slope above is almost devoid of superficial deposits and topographic features alike,

* For Geology see Cheviot Memoir 1932 p. 58

there being only a slight suggestion of a shoulder above the Bowmont/College confluence @ 300' -350'. Between Lanton and Milfieldhill slopes between 650' - 250' are fairly constant and eastward, whilst at 220' - 230' flattening out occurs about Sandyhouse and north of Milfieldhill. The Sandyhouse Dean is youthful and shows an incised course down to 300'. Like the burns coming off Rape Hill and Kypie plantation nearby (to the north), it continues the line of the shallow depressions observed in the Kilham gorge, and although this is a minor point, one wonders if there is some geological or glacial reason for their occurrence. (Is there any connection between their location and the widening out of the Plain, South of Milfield?). When seen from Brown Ridge to the east, the ground rising from Milfield Plain to West Flodden looks remarkably like a depositional fan, but this illusion is dispelled by closer examination of the ground in question. Beyond W. Flodden the windgap is bounded by breaks of slope at 400' and, whilst the glacial till locally is disposed in undulatory manner, the writer has insufficient information to state definitely whether or not the forms are morainic in origin. (It would, however, be of interest to speculate on the 400' break of slope being an indicator to the pre-glacial height of the Milfield area, taken in conjunction with the 500' "hanging" tributary valleys at the south end and the Fentonhill "bench" @ 400' opposite). Northwards, the east end of

Flodden Hill appears to have been truncated, with the ground there now falling quickly to near flats at 150'. Approaching Crookham the clear cut western margin of Milfield Plain is lost because of lowering summit heights and the incoming of sands and gravel deposits. These latter first appear as periphyral mounds and cause the plain to be bottlenecked east of a line from Encampment farm - Mt. Pleasant - Old Heatherlaws, and they also lap up on to the higher ground at Pace Hill (c. 250') due south of Crookham.

(c) East Side.

This side, like that opposite, shows a general fall in summit level from S-N, but otherwise it is distinctly different*.. The west facing scarp front is most severe at Dod Law, for northwards fringing bench remnants at Whitehill (nr. Fentonhill) and above Ford offset its impressiveness and also reduce the width of plain below. The scarp crest, too, is broken by gaps, diminishing in size northwards and appearing N.E. of Doddington, Rowting Linn and north of Blackchester Hill. (The former pair may have been used preglacially by obsequent tributary streams. All to-day are used by road lines). Present day obsequents are few in number, being youthful in character, and they use these gaps to drain off water lying in the moss areas behind the scarp front crests.

*For Geology see Cheviot Memoir 1932 p. 63-64, 71-76, 84.

Doddington* hamlet is situated upon a small sand and gravel fan or terrace remnant, now dissected by the youthful Doddington burn. Southwards the scarp foot lies at about 200' and is fronted by fringing sands and gravels graded down to 150'. Whilst the Geological Survey consider that these deposits belong to a kettle moraine spread extending up Milfield Plain, the writer sees no reason to ignore the possibility of their having been part of a kame terrace or else trimmed by water first standing c. 200'. To the north the scarp face begins at 300' and below it at Fenton camp there is a local development of a 250' - 200' bench or terrace feature. By Fentonhill, however, the duplication of scarp frontage already mentioned has occurred, and the glacial graining of summits becomes increasingly W/E in alignment beyond.

Although small, the Bradford burn displays several interesting features along its course. It rises on Ford Moss, turns W.S.W. to plunge over a 30' fall in Rowting Linn (c. 340' - 300'). This short linn is about 40' depth at its maximum and is cut in reddish sandstone - thinly bedded and flaggy near the base of the section, but becoming coarse and crossbedded upwards. Only a short distance downstream lies Howdenbank Dean, a steep sided cutting

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*Note Doddington bridge like that at Ilderton Station severely damaged by floods August, 1948.

some 60' deep, and upon emergence from this the burn grades out to 150'. At Kimmerston the waters turn N.N.W. to join the R. Till near Ford bridge - presumably displaying a deferred tributary junction.

East of Fordhill the ground rises with a constant slope up to the crescent shaped dissected ridge at Ford Moss. Like the Bradford, the Cannon burn flows off Ford Moss* and part of its upper course may have carried meltwaters (?). From the R. Till floodplain itself, the present road line through Ford crosses a slight tread between 350' - 400' before climbing up on to Ford Common.

(d) The Plain

The Milfield Plain proper may be considered to stretch from Heather's Law in the north, southwest to Westnewton and S.S.E. to Weetwoodbridge, with small heughland appendages attached to Etal in the north and Haugh Head in the south. It lies almost entirely between 100' - 200' and displays sufficient variation to be considered in sections.

(1) The area contained between Milfield -Ewart - Lanton represents a low deltaic spread pushed out by waters coming down the upper Glen valley. Two former distributaries can still be traced to-day across this delta, the first stretches northward past Marley Knowe to Milfield, and the second runs north-eastward from near Coupland -

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*The peaty overburden present at its greatest depth is 32'

Galewood. Although the less distinctive topographically, the former can be clearly seen near Milfield, for where it grades out on to a terrace surface there is a topographic break. The latter, although showing poor definition in its upper reaches, becomes a sizeable feature where it crosses the trunk road* and in its lower parts appears to have undergone partial regrading. Slopes over the delta surface are gentle ½° - 1° (Abney) and tend to be symmetrically disposed on either side of a Coupland - Galewood line, whilst the height of the delta surface falls from c. 190' near Lanton to 140' at N. Chapel field (Ewart). The delta's shape also deserves a comment for its outer margin is uncannily straight with slope changes frequently coincident with this line (c. 150'). The present southern limit is clear cut, the margin standing 15' above the Glen flood plain at Lanton, 30' beyond Coupland and 25' near Akeld steads. Above and behind the delta, stretching from Sandyhouse almost to Lanton, lie sand and gravel deposits disposed in terrace form. The upper surface of this terrace grades eastward from c. 225' - 200' and its outer margin is separated by a difference of 20' - 25'. Whilst its present form is residual, these deposits may have formed part of a kame terrace, or they mayhave been joined to similar deposits in the Glen Valley as a more extensive spread, but now largely reworked by water.

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* Although only 12' - 15' deep here the depression is extremely wide and flat floored.

West from Akeld the surface of the superficial deposits rises westward to Old Yeavering and also back up to the hillfoot southward at 200'. Like the opposite bank there is a break between the margin of these deposits and the present floodplain, a 'riser' which increases in height from 12' west of Akeld station to 30' - 40' between Yeavering and Old Yeavering. Although terrace like in general appearance the inner margin of these deposits show odd depressions with generally northward alignments. Some ofthese features, it is true, are associated with burns coming off the hillside, but their general disposition looks anomalous, and, in the writer's opinion, is not the product of kettling. Further, it is observed that incised burns coming off the hill at Old Yeavering and south of Yeavering appear to have been primarily incised to 300', and again two nearby exposures of sand and gravel (near the same two places mentioned above) show differing internal composition and form. That near Old Yeavering (c. 215' A.S.L.) appears to show foreset bedding dipping S.S.W. whilst that at Yeavering contains a greater amount of silt and fine material, is horizontally bedded and appears to result from more normal fluvial conditions.

(2) The south-eastern portion of the plain lies roughly within a quadrangle bounded by Milfield - Kimmerston - Doddington - Wooler - Milfield, covering an area of lower ground mostly below 150' and gently sloping

in toward the R. Till line. However, at Wooler one is confronted by a series of cuttings which have been graded out to 200' at Lowburnhouse, Cottage Hotel and the Peth which passes the remains of Wooler Pele Tower. Of these, the Humbleton stream at Lowburn appears first to have been graded to 200' then 150' and now in the present cycle is reincising itself. Behind the Cottage Hotel a dry channel grades out to 200' and is fronted by remnants of a small, delta. This delta in its turn has been partially eroded by lateral cutting of the Wooler water, a 12' - 15' scar behind Wooler Auction Mart bearing testimony to this erosion. Southwards from Wooler railway station a marked river cliff rises quickly to c. 40', but beyond the township reaches an acme in a 150' high bank (cut in superficial material). Whilst the characters of the superficial deposits about Doddington have already been noted, observations about Fenton and Kimmerston remain to be added. Between these two places a very clear topographic break occurs just below the 15 0' contour, and west of Kimmerston the flat bog @ 135' constitutes a truly negative area topographically.

(3) The northerly portion of the plain is featureless until the periphyral Cornhill sands and gravels are encountered. Slopes are gentle, falling riverward, but backing up to a topographic break just below 150'. Near Ford bridge terrace edges stand some 15' above present water level, and the stream itself is contained between 8' bankings. (The hardpan described in the Geological Survey

Memoir occurring north of Flodden Tileworks was proved and sampled by the author in the course of field work in this area).

(e) The lower Till valley rapidly increases its incision beyond Ford Bridge, soon to flow in a gorge reaching 100' depth below Twizel bridge. Along this stretch the stream flows over bedrock, the gorge sides only become sheer in the lower reaches and fragments of river terraces appear at St. Cuthbert's chapel field (confluence point), east of Tillmouth Park and also at Etal, on the right bank. The sandstone scarp front turns away N.N.E. from Etal, losing definition as it goes but bearing scars of heavy ice erosion. Drumlin like features first appear west of Duddo* and become the dominant element on the ground northwards. East of Duddo hamlet a very fine overflow intakes at 218' and terminates E.N.E. at Ancroft (c. 80'). This channel (Haydon Dean) was considered by Butler to form the overflow of Lake Ewart, but, since there is a slight anomaly between the 200' lake level and the 218' intake, his conclusion may be questioned. On the left bank, the river skirts the Cornhill fluvioglacial deposits before traversing drumlin topography to reach the River Tweed. The sands and gravels cover 8 square miles and are roughly contained in a triangular

*Grindon Rigg farm borehole records 40' overburden.

area bounded by Cornhill - Crookham - Mindrum railway station. "The margins are ragged and irregular, with small outliers from the main mass. It is a region of abrupt hillocks, tumultously arranged, and with deep hollows between, as such, it offers a remarkable contrast to the drumlin country on either side, on which the gravel has been superimposed"* Kettling is widespread with great variation in size and shape of kettlehole, so that it is difficult at first for the observer to see any ground plan to the topography. Closer inspection, however, shows that the crests fall into the Tweed valley near West Learmonth, with Pressen Hill, Broomy Knowe and Blakelaw drumlin like mounds appearing above the general surface. The Wark Kaim shows a residual form, for the Tweed flowing at a higher level went south of the Kaim and on to the terrace eastwards. This terrace is backed by an abrupt, bowshaped river cut bank between Wark and Cornhill, with the crests to southward suggesting water trimming to c. 150' and 200'. Of the two burns flowing over this area, the Willow looks more normal than that at E. Learmonth which appears to occupy a channel cut by a greater volume of water formerly. Eastwards towards Till the spread becomes more constricted with the Bog, used by Pallin's Burn, resulting either from infilling of adjacent kettleholes and /or a line used by meltwater. Along the left bank of Till, west of the Tillmouth/Crookham road the local topography is more vigorous, and, like the higher ground on the right bank,

p. 126 G.S. Memoir "The Cheviot Hills" A full description given p. 126-132 shows a change in the alignment of glacial graining.

The Haydon Dean channel is considered to have been used by meltwater from Milfield Plain and also from the area of dead ice at and near Branxton, and not from Butler's Lake Ewart. At a later stage the lower Till tract came into use and the Haydon channel fell into disuse. The reader will have noted that the Geological Survey Memoir refers to lateral moraine and dead piedmont ice lying from Cornhill up the Till valley and, whilst supporting these views, the writer considers that on topographic evidence fragments of a lateral? moraine remain at Shidlaw, Wark (?Kaim), from Cornhill to Pallin's Burn, Faddon Hill and Grindon Rigg. If this be so, the Tweed defile east of Goldstream may have been determined by these morainic deposits. Again, the 140' lake in Milfield and also a higher level c. 200' may be also post glacial in origin, dating from a period when the lower Tweed was flooded and temporarily estuarine* . (Note the 200' "lake" level in the Teviot valley near Crailing, also the very marked break of slope about 200' between Carham and Sprouston).

(The author during fieldwork covered the South bank of the Tweed from Sprouston - Tweedmouth but observations were made ONLY on this side. Since the notes made correspond

* Note, the cold water fauna recorded by Gunn in the lower Tweed, on the N. bank 90' above S.L.
See p. 34 G.S. Memoir "Berwick on Tweed" 1926

closely with part of those made earlier by Milne Home, the writer considers it sufficient (at this stage) to reproduce a summary of Milne Home's observations and his diagram).

see M.F. page 23.

River Aln (see M.F. pages 16, 24).

The comparatively short R. Aln flows in a generally eastward direction and has its upper reaches separated from the lower by a gorge tract. Between Alnham and Bassington the stream flows along part of the axis of a well defined topographic trough, and, whilst the Aln's source comes unexpectedly in the two meltwater channels above Alnham, the larger valley continues beyond. The left bank tributaries of the upper Aln are youthful, being either of recent origin and/or using meltwater lines, and they contrast with the longer established right bank tributaries over the same stretch. River terraces and alluvium are not important features, occurring for the most part between Whittingham and Hulne Abbey, together with restricted heughland development east of Alnwick. From Hulne Abbey to Alnmouth the higher and scenically finer ground occurs along the right bank, and over this same stretch, f/glacial sands and gravels flanking the stream form various local topographic features. Finally, one notes that within historic time the Aln abandoned its former mouth and now turns east to join the sea past Alnmouth instead of continuing to the S.S.E. (The old abandoned channel south of the present mouth can readily be seen in the field)

1. Upper valley

The Aln is formed by the confluence, nr. Alnham house, of streams flowing in convergent meltwater channels. The northernmost channel is 40' - 50' deep, stretches from Hazelton Rig and has been subjected to partial reworking by the present stream, together with dissection by very youthful burns flowing off Northfield hill. The other channel extending from Scrain Wood, is some 30' deep but of greater width than that from Hazelton Rig. Whilst the Aln itself is rather insignificant downvalley until beyond Eslington Hall, the two sides of the valley are contrasting. On the left bank, slopes quickly steepen up as the margin of the massif is approached, but even so, a suggestion of a bench facet occurs at Northfieldhead 700' - 750'; and at Prendwick, faulting together with Cementstone overlap appear to have aided the formation of an indentation to this margin. Here at Prendwick there is an incipient centrifugal drainage pattern, with two of the youthful streams fault guided. At Great Ryle a coarse superficial veneer occurs on micaeous flaggy sandstone where the present stream emerges from a valley apparently of meltwater origin. However, there is a slight anomaly in this valley, for whilst the meltwater intake occurred just below 700' and the outlet is at 600', the oversteepened S.E. slope of Chubden Hill (adjacent) bears traces of meltwater cutting at c. 700', 670' and 600'. If the Great Ryle channel was graded to those on Chubden then the ice must have been thicker westwards, or alternatively the lower part of Great Ryle valley may have been cut subglacially or pre-existing. Beyond Great Ryle the outcrop of the igneous rocks turns away northward at Mile Moor, and the present divide is formed of sandstones belonging to the cementstone group. The ground continues at first to fall into the river line quickly, although slopes do ease off eastwards and gradient changes occur east of Eslington Hall between 300'/250'.

Along the south bank, rocks of the Cementstone group protrude through the glacial till and these sandstones form "the parallel escarpments which run between Whittingham and Alnham" (p.11 G.S. Memoir Alnwick 1930), transitional to the high scarped front of the Fell sandstone above and to the southeast. There is little of note along this stretch, the general ground slope is eastward to the scarp foot, and bears a superimposed E.N.E. graining. A few small youthful burns appear in the troughs, and only the Callaly burn appears to use an anomalous channel, now assessed to be of meltwater origin with intake at 500' near Lorbottle Hall.

At Ryle Mill the Aln is contained by 7' - 8' bankings (a height of bank roughly maintained for some distance downstream), and one further observes that from East Lodge (at 300') virtually to the Eglingham burn confluence the present stream seems misfitted and displays small scale, though closely packed, meanders. At East Lodge, too, low residual mounds of sand and gravel appear, especially along the north bank, and are fairly continuous features to the

Bridge of Aln. Similar deposits occur beyond at the lower ends of the Coe and Edlingham valleys, whilst more extensive spreads flank the Shawdon dean north of Bridgend. All these deposits occur below 300' and, apart from those patches in the upper Shawdon Dean and at the end of Eslington highhill ridge (i.e. at the confluence of Aln/Callaly streams), the bulk are below 230'. Since meltwater ceased to flow south through the Shawdon cut just above 300' and undoubted lake clays occur at Thrunton tileworks (c. 320'/330'), there would appear to be a case for inferring the presence of a late glacial lake standing for a time in the upper Aln valley. The period, however, would need to be long enough for lake clays to be deposited at Thrunton, a delta to be pushed out from the Shawdon channel to Bolton, whilst sands and gravels were deposited at the lake head. Examination of the Eglingham valley tends to support the notion of a late glacial lake - for what better agency could have produced the beautiful smooth surface gently rising along the west side of this valley from Bassington past Kimmer lough almost to the present village site, together with the clear cut break of slope at 300' beyond Hunterheugh crags?

Along the left bank beyond Glanton the Fell sandstone is eroded into two upstanding hill masses separated by a fault line valley N.E. of Titlington. The mass to the north shows a scarp front to the Breamish and an over-steepened face to Titlington, whilst the gently south slop-

sloping summit shows the E.N.E. graining about Beanley Moss replaced by S.S.E. glacial graining on Beanley Moor. In contrast, the southerly mass is more akin to an enlarged roche moutonnée aligned E.N.E./W.S.W. Beyond these, the Eglingham burn flows S.E. to join the Shipley burn and though small and apparently offset, it occupies a very marked trench below Shipley moor*. At the effective valley head (i.e. just west of Eglingham) the ground rises suddenly to an area of confused undulatory and hummocky ground west and north of Broomhouse but, towards Beanley Moor (S.W.) the surface appears to be sandier and is more disposed to form northward falling ridges. Above Eglingham the drift plugging in the lower Harehope valley is still responsible for offsetting the two tributary burns, one of which flows into the Breamish and the other becoming the Eglingham burn. Burnett, writing in the Proceedings of the Berwickshire Nat. Club 1934 on the Longlee Moor glacial deposits and development of the lower Shipley burn, notes that the Eglingham gap was used to drain off some of the Hedgeley Basin meltwater before the Shawdon cut came into use. He adds "There is, however, no well marked drainage channel to indicate a definite river

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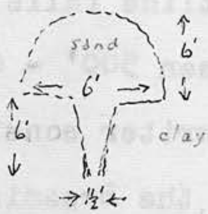
*where the road from Shipley Law - East Bolton crosses the burn, slight incision is shown into the flat floor of a wide and 30' deep trench.

bed", inferring that no single course was used across the gap for any length of time, or else that water may have escaped through or over the ice here. Whilst this may have been the case, it might equally be true that water in the Aln valley flowed marginally through the Hunterheugh crags, bringing Cheviot gravels into the Eglingham valley that way, as well as, or instead of, over from the Hedgeley Basin at Eglingham. The detailed description of the Longlee deposits provided in the article, together with those in the G.S. Memoir "Alnwick and district" p. 94 - 97, are more than adequate for the reader. The Shipley burn itself flows through a valley of contrasting parts. The upper valley tends to be shallow, with the stream incision becoming noteworthy below 350'. On the right bank the crestline falls by a series of treads, and lower summit levels between 500' - 650' are associated with damp moorland. The writer considers that, prior to diversion by the River Till, the Breamish formerly flowed eastwards from Eglingham to S. Charlton, being joined by the upper Aln and Titlington as fault guided tributaries on its south bank, with the Harehope and Red burns as left bank streams. Later capture by a dip slope tributary of the Coquet, occupying the present lower Aln course, diverted the Aln to its present course, and the present lower Shipley burn is probably therefore of later (late glacial?) origin.

Along the south bank the Aln is joined by the Swine, the Coe and Edlingham burns, and is bounded by higher

Thrunton Tileworks



and stronger topography. The Swine burn is short and its left bank shows again the capacity for the Cementstones to form a ridge feature, whilst on the right bank the scarp face begins at the base of the Fell sandstones. The Coe valley approximates to faultlines flanking the Lemmington Anticline, and seems to have been glacially deepened upstream. Indeed, at or near the head of all these three burns, ice driving southward appears to have enlarged and deepened the upper valley reaches e.g. Howmoor plantation, Rough Castles and Rimside Moor*. In the Coe valley, the most interesting features are associated with the Thrunton Tileworks area. The working face in the claypit showed 20' of blue brown clay overlain by 6' of rather gravelly clays. Rock fragments included in the clay appeared to be comparatively fresh, varying from limestone and sandstone to andesite, granite? and whinsill?. The writer must acknowledge the enthusiastic assistance given by the foreman who demonstrated other depositional phases present in the works. These included more gravelly exposures, varying and wedge shaped inclusions. One such wedge examined, showed silty sand surrounded by clay, being sufficiently distinct to be photographed. According to the foreman, the area of ground south of Learchild moor house, where the main road

*Note the borehole record for Wandystead Farm on Rimside shows 138' of overburden.

crosses the Coe burn, is constantly sinking and subjected to constant attention by the road authorities. He claimed the reason for this behaviour was due to there being a great depth of running sand in the vicinity. The Edlingham valley at present shows youthful characteristics, flowing N.E. and then north to join the Aln. Where it turns northwards, below Edlingham Station, the scarp front to Moorlaw is fronted by ground which could formerly have been graded north-eastwards by the preglacial stream. Therefore the present north flowing section might be of more recent origin. North-northeast from Milrig bridge the scarp face becomes severe, and off it, numbers of obsequent 'letches' flow to the Edlingham burn in narrow ungraded gullies. Nor is the scarp front always a clean, clear cut feature, for, in places, e.g. Corby's crags, a series of crags and rocky knolls clutter the rising front to produce extremely rough terrain. At the valley head, the Wandy burn flows more continuously over bedrock. The surface gradient steepening up to New Moor also suggests that the glacial deposits on Rimside, whilst locally thick, thin out rapidly to the north and east. The G.S. memoir for Alnwick district describing Rimside Moor (p. 99 - 100) refers to small esker-like mounds upon the peaty flat east of Wandy Marsh, and suggests kettling of dead ice at a morainic margin to explain the nature of the local glacial deposits. South-east of New Moor house the windgap has been used by ice and later by meltwaters flowing south. It seems feasible to suggest that, at a slightly later date, this meltwater flowed marginally N.E. around Brizlee Hill then southwards again through Freeman's Gap and the Hawdon Grange gap (Alnwick Moor). If this be the case, then the mossyfloored feature N.N.W of Townslaw Cairn at 550' may be associated with the later phase.

2. Lower valley

On the south bank below the Aln/Shipley confluence the high cuesta of Alnwick Moor is being dissected along the line of strike by the Stocking Burn, whilst beyond the Alnwick hogback a well marked strike vale (S.W. - N.E.) is bounded by the Shilbottle-Lesbury ridge to the east. The sharp corner of the cuesta displays only a slight "tread" at and west of Brizlee Tower (e.g. △ 556'), but slopes become easier eastward, falling into the line of the Stocking burn. Besides the two meltwater channels already mentioned on Alnwick Moor, another also occurs 1 mile east of the Hawden grange cut at Swansfield House (@400', at the head of Clayport bank, Alnwick). At Alnwick the ground slope is checked just below 200' in Bailiffgate, Narrow gate and Bondgate within (△ 188' lies just west of theLouvre Cafe) grading out to a terracelike stretch fronting the river. Near the British Railway station residual hillocks of sand and gravel occur, being replaced in turn to the S.E. by a spread whose eastern margin is "dissected" (- all approximating to 200'). The writer is uncertain whether the virtually dry depressions occurring at the margin result from running water or are depositional in origin, but similar features also appear along the margin of similar deposits along the north bank to riverward. Beyond Alnwick the south bank shows first the strike vale used by the Cawledge burn, then the Shilbottle ridge, and finally the coastal plain.

The stream course is restricted downvalley with a short stretch of heugh and terraced ground at E. Brizlee being followed by a narrow, incised tract. From Hulne to the Lion Bridge at Alnwick, the Aln shows gorgelike characteristics where the stream flows over or against sandstone rocks, but usually its course is immediately confined by 6 - 10' bankings, upon which narrow ribbons of river alluvium are found. Beyond the Lion Bridge the stream's flow is disturbed by numbers of artificial weirs as far as Lesbury, together with short stretches of rapids near Denwick Mill (where the Oxford limestone crosses the river) and Bilton Mill (where flaggy sandstones form the river bed). Downstream too, heughland accompanying an incised meander belt appears, the river alluvium being flanked by banks of glacial till and overlying sand and gravel deposits*.

*It will be observed that the upper margin of the fluvio-glacial deposits in the lower Aln falls consistently from c. 250' at Hulne along the N. bank, whilst on the S. bank it rises to c. 350' in the Deer Park before falling eastwards. Again, whilst clearly plugging the lower pre-glacial Aln valley, the origin of the glacial deposits east of Hulne is a matter of conjecture (see G.S. Memoir Alnwick p. 98-99)

The lower Aln has few tributaries, only the Denwick burn on the north bank together with the Stocking, Rugley and Cawledge burns on the south. The Denwick burn appears to have been deflected by the sand and gravel deposits and flows eastwards past Denwick quarry over bedrock in a 30' deep, narrow incision. It is also suggested that it formerly graded out to c. 150' and, whilst its present lower tract to the Aln is south-westerly, it may formerly have flowed S.S.E. <u>via</u> Hawkhill. (A dry depression rises to the N.N.W. away from the river valley towards the Denwick burn and looks rather anomalous). The characteristics of the Stocking burn are fairly simply stated, for it shows a youthful, incised and ungraded lower stretch in Alnwick Parks with a young, though opener, valley form upstream. The Cawledge and Rugley burns unite and join the Aln south of Old Hawkhill. Of these, the latter shows two clearly defined sections, separated by a 30' - 50' incised tract at Rugley woods. Upstream in a shallow basin (rather poorly drained ground) between Rugley House and Hawden Grange, the headwater streams are gathered together, whilst beyond the incised tract a youthful stream is firmly incised into gently sloping ground lying between 300' and 200'.

Whilst not showing such clearly defined topographic units, the north bank possesses a wedge of higher ground between S. Charlton - Heckley House & Shipley, which is separated from the Pepper Moor area by a shallow ill-defined depression north of Denwick. The Whinsill crags at Ratcheugh, too, form a local bold feature and, like the Shilbottle ridge, serve to delimit the coastal plain to the east. The valley side between Hulne and Alnwick rises quicklynorthwards, with the line of a low S.S.E. aligned trough from Abbeylands appearing somewhat incongruous. Eastwards, too, the margin of the fluvioglacial deposits becomes increasingly defined, the whole appearing as a flat topped ridge (when viewed from the south) and graded out to 200' just east of Denwick. The whinsill crags of Ratcheugh have suffered from ice erosion with the "tail" at Shell Laws ridgelike (but with graded crestline to c. 150'?). West of the Little Houghton - Lesbury road a virtually dry, but marked, north/south trough hangs above the present river valley and is of doubtful origin. Again, the marked dip slope from Ratcheugh eases off first c. 200' and again c. 150', whilst the smooth gently E. sloping ground to Boulmer is strongly suggestive of water trimming (Anderson's late glacial sea levels?).

It would seem, therefore, that the lower Aln has only in recent times ceased its incision into glacial deposits lying in the line of the pre-glacial valley. Again, the higher sand and gravel deposits on the south bank may be associated with an earlier depositional phase. Melt-water on Alnwick Moor drained southwards at 500' and 400', whilst the later Trobes Dene overflow at Shilbottle (intake 200') probably was followed by removal of an ice (?) barrier

in the lower Aln valley to allow the resumption of eastward drainage. Although the writer has not examined the ground in great detail it may be tentatively suggested (on general grounds) that a temporary ponding back of water occurred in the lower Rugley and Cawledge valleys while the Trobes Dene cutting was operative, and at this time some transfer of sands and gravels from the upper Aln basin occurred. (The upper and lower Aln basins may have both shared a common lake level for a time). The removal of the barrier in the lower valley would in its turn lead to further reworking of the sands and gravels and hence explain the train of Cheviot material in the gravel deposits referred to by J.A. Smythe 1912 Trans. Nat. Hist. Soc. Nld. & Durham.
In this brief hypothesis on events in the lower Aln, the author feelsbound to include a reference to W. Anderson's late glacial 190' and 140' sea levels and Woolacott's 150' post glacial raised beach (Geol. Mag. 1921). There seems to be sufficient evidence in the lower Aln valley to suggest a late or post-glacial ria phase down from Alnwick, with water standing c. 200' and 150'.

COASTAL PLAIN. (in M.F. page 26)

In this section the area is sub-divided into portions, each of which possesses some individuality and characteristics of its own.

1) In the North, the seaward end of Longridge is being actively eroded, but cliffing is soon replaced between Goswick and Cheswick Point by a low lying depositional area (marine and fluvial deposition) [illegible] the lower ground in the North which [illegible]

Westward [illegible]

Southward [illegible]

A.—SYNCLINE IN MIDDLE LIMESTONE GROUP, GREEN'S HAVEN, BERWICK-ON-TWEED.

[illegible] which [illegible]

2) South [illegible] low

is associ[illegible]

sea-clif[illegible] houses.

Inland, t[illegible] nched

cut by L[illegible] has

already [illegible]

3) From [illegible]

characte[illegible] the

which [illegible] l little

Lowbury ridge form the steep limits to the plain.

1. The coastline South from Spittal is extremely interesting and shows a variety of features, some of which unfortunately [illegible] will cause abandonment of some existing lines of communication, unless firmly checked IMMEDIATELY. Spittal is built on a low raised beach fragment between the steep [illegible] slopes of Longridge and the present shore, but from the South end of the town to Saltpan rocks the coast shows 50 - 60' cliffing

COASTAL PLAIN. (see M.F. page 25).

In this section the area is sub-divided into portions, each of which possesses some individuality and characteristics of its own.

1) In the North, the seaward end of Longridge is being actively eroded, but cliffing is soon replaced between Goswick and Budle Point by a low lying depositional area (marine and fluvial deposition). Again, the lower ground in the North which merges Westward into the lower Tweed valley becomes more restricted Southwards with the appearance of the major cuesta.

2) South from Budle Point to Howick it is the Whinsill which is associated with stronger coastal features, although low sea-cliffing occurs on arched sedimentary rocks at Seahouses. Inland, the pocket of low lying ground at Belford is pinched out by Lucker, and the Waren Mill - Chathill depression has already been referred to in an earlier chapter. (p.39)

3) From Howick to Alnmouth the Whinsill's absence removes character from a low cliffed coastline. To the West, the Whinsill outcrop in the Littlehoughton area and the Shilbottle-Lesbury ridge form the inner limits to the plain.

NORTHERN PORTION

1. The coastline South from Spittal is extremely interesting and shows a variety of features, some of which unfortunately in time will cause abandonment of some existing lines of communication, unless firmly checked IMMEDIATELY. Spittal is built on a low raised beach fragment between the steep seaward slope of Longridge and the present shore, but from the South end of the town to Saltpan rocks the coast shows 60 - 80' cliffing.

These cliffs do not form a continuous feature, but are interspersed between broken rock piles and slumped faces, the whole standing above a wave cut platform which continues alongshore to Scremerston Limeworks. The cliffs are unstable, for high seaward rock dips (30-35°) and rhythmic bedding in the sediments are conducive to sliding (undergravity) of sandstones upon waterlogged shales. Besides wave action at the cliff base, rock jointing, local small faults and numbers of springs probably speed up the process of cliff recession. The wave cut platform is best seen near the Doupster oil shale outcrop and here, too, differential erosion on shales, ssts. and lst. has occurred. On the more massive sandstone Southward the shore is rougher with a tendency to have potholing, and again the limestone rocks usually form carrs.* Cliff recession has already closed a secondary road above Saltpan rocks, and must already threaten the Edinburgh-Newcastle railway to the North.

From the cliffs South of Spittal looking Northward the ground between Berwick and present shore seems to have been water trimmed at 50', and Southwards, too, in the Scremerston limeworks area a similar process seems to have occurred. Amongst the limestone workings, variable amounts of reddish clay and blown sand upon bedrock are fronted by small skerrs and beach (the greatest thickness of till seen by the writer being 9'). North from Goswick, first low multiple sand dunes then 40-50'

* It was presumably an offshore extension of one such limestone carr which S/S Rask struck near Scremerston Limeworks.

hillocks back the beach, whilst the damp NNW/SSE swales inshore of these features indicate that the underlying clay lies close to the surface. Beyond Goswick Railway station the reddish till is replaced by Khaki coloured alluvium lying as an extensive flat to Haggerston and Beal. Drab topographically, and drained by artificial, occasionally interlaced, water channels (i.e. Lows), this area is separated from the tidal Holy Island sand flats by a narrow sliver of blown sand only 10 - 20' high.

To the West, the rising crest level in a trough of relatively lower ground (Cheswick-Beal-Felkington-Norham) is accompanied by increasing definition of drumlin features. On the seaward side the subdued topographic graining leads the observer to suggest that depositional drumlins or drumlin "tails" had subsequently been modified by erosion. The rocdrumlin fronts look down onto the lower Tweed valley and about their bases ill-drained, boggy patches of ground occur. The Southern side of Longridge shows a slight topographic break at 100' between Cheswick and Nobhill, and towards Billy Law and Richardson Steads there may have been slight bevelling at 250' and 200'. The Allerdean stream certainly appears to have carried away water that formerly was penned in the Thornton, Longridge and Murton bog areas and probably was connected at some period with the Murton Dean* overflow channel.

* Murton Dean channel shows a two way talweg, leading out onto a bog at its SE end, 150-125' and a terrace to the NE at 175-150'.

A further possibility to be entertained, is that meltwater temporarily flowed from the foot of Grindon Rigg (upper Finger burn) via Grievestead Moor and Shoreswood bog into the Thornton area (insufficient time however has prevented the writer checking this latter suggestion). The Shoreswood ridge crest on the South bank of the Allerdean burn averages 260/270' and rises sporadically to 300'. Since bedrock is sufficiently in evidence along the ridge crest and also on gently sloping ground to the South, it may be suggested that an easterly sloped surface between 300-250' formerly occurred locally. Between Shoreswood and Duddo the drumlin topography continues, but South of Duddo it is the scarp front which has been ice eroded. At Duddo there are two small roches moutonnées, whilst South of the Haydon Dean intake the watershed from Jack's Law Δ 324' rises quite suddenly at Berryhill. Whilst the rapid fall in surface level North of Woodside Moor and the gentle fall in summit level along the right bank of Haydon Dean may be glacial effects, they may initially have depended upon a preglacial stream flowing over the area. This stream would have the Till as a tributary, and may have been the lower line of Tweed/Bowmont (or Teviot if the preglacial Tweed ran eastward along the south side of Longridge?). It is noted that the larger of the present streams are decidedly incised at or just below 100' (depth c30'). Again, the Low seems to have been graded to 150' formerly, whilst the narrow incised middle tract of the Berrington burn ceases suddenly at North

Berrington just under 150'. Several of the present burns can readily be seen to follow the rock strike e.g. Drydean burn, Lickar burn, and all are convergent on the Haggerston flats. East of Bowsden the numbers of crests c200' are to be mentioned, e.g. North and South of Sandyford bridge, Lickar farm, and presumably reflect water trimming. The North end of the major cuesta is breached, and SE of Kentstone farm meltwater has used the gap to flow seawards. The lower end of this channel (now used by the Dean burn) hangs slightly above what may have been a later channel, cut along the SW side of Fenhamhill. Beal and Fenhamhill are both small, conical ice moulded hills, but both show anomalous, alluvium floored depressions along their western flanks. Although speculative, the writer tentatively suggests that water, from either or both the Haydon and Allerdean channels, first flowed through the Kentstone channel; and later flowed obliquely across the Haggerston area, along the West side of Fenhamhill and then later between Beal hill and Fenhamhill.

South from Beal Point a shingly shore* is backed by a clayey banking of variable height (e.g. Whitelee letch 20' brown clay bank shows 25-30° seaward slope) and the Holy Island sand flats change their character beyond the South Low, to become mudflats. Approaching Ross links, the clay is last seen at Cockly Knowes as it passes under blown sand, in a section showing 10' blown sand overlying 2' grey clay, and to seaward sand flats reappear. The characteristics shown in the Goswick area are repeated by the

* Note however the small exposure of sst. on the shore. N. of Elwick farm (dip SE 3°)

blown sand deposits on Ross Links - though on a larger scale. Ridges and hillocks stand highest to the North (i.e. between Jack's Waste - lookout hut 34), parallel to the shore, losing height and definition southwards. Landwards to the South-West, swales and swells appear, with the NW/SE waterlogged Long Bog especially noteworthy. (This feature is almost one mile in length). The inner margin of Ross Links is fairly well defined by two alluvial flats which flank a low continuation of Royalways swell ending at Kirkley Hill, Ross. A hooked spit forms the northern margin of Budle Bay and the sandy flats about it are replaced by mud of the Chesterhill Slake, across the Ross Low. The shoreline NW of Waren Mill is unusual, for the inner margin of the mudflats shows pits of variable shape - several yards in length, 2-3' width and averaging 1' depth. Examination of several such pits produced sections with c5" black organic, rather sandy mud underlain by c7" brown clay. As for the low banking above H.W. mark, the best section occurs where Ross Low enters the slake showing

1' soil,
3' brown silt,
1' brown clay with three thin dark rust-coloured pan layers,
2' gray clay.

Along the south shore of the bay a narrow shingle band from Waren Mill to Kiln Point lies between the mudflat and a bedrock face which is capped by superficial deposits. At Kiln Point considerable numbers of boulders appear to have been buried beneath the blown sand, and this may be indicative of an old storm beach. From Kiln Point to Heathery cottages abrupt cliffing of superficial deposits rises above shingle, whilst beyond Heathery cottages sandstones replace limestones in the shore section. Approaching Black Rock from the West numerous springs issue from the base of the sand cliffs, whilst on Black Rock the upper rock surface shows a pattern of eroded joints contrasting with marginal sandblasted serrated edges and flutings.*

Inland, the 100' contour sweeping SE from Fenwick Stead separates Buckton Moor and the higher ground of the Whin Sill from an area of gentle slopes and minor topographic features. Faulting and erosion have resulted in the Whin showing a triple echelon of crags aligned eastwards and whilst crags are south facing east of Belford, to the West they generally face South of West.** The three echelons are of variable width, the first occurs between Detchant - Middleton, the second from Middleton - Belford is pinched out at Chesterhill, and the third begins near Belford B.R. station to run out to sea at Budle Point. The shallow depression of Buckton Moor is bounded to the West and South by strong features, although a small terracelike feature at Detchant (198'-190' falling W - E) and the small area of flattish ground behind Buckton farm (185-180') are to be noted.

* For a fuller description of raised beaches locally see Belford Memoir p. 157-159.

** The exceptions between Detchant lodge - Belford Northbank, and at Longhills (Belford E.) where a near crag and tail occurs, are due to severe ice erosion and form of outcrop.

These features, together with the local topography, suggest the former presence in the Buckton Moor area of gently E sloping facet between 200-180'. South of Detchant Lodge the Whin locally shows a 30' eastfacing cliff, but nearing Belford (about Chesters) it is the breaks of slope at 300' and below 150' which take the eye. [1] Between Easington and Chesterhill the checking of Northward slopes at 100' is apparent whilst the Whin outcrops above have been heavily scored and plucked by southward moving ice. The crest line here is much more ragged than to the East of Waren burn where Whin summits are higher and more accordant (between 250-200'). West of Waren burn steep seaward slopes ease off eastwards and the only minor topographic features lie East of Warenhouse. Here the fault line and rock strike (under the Whin) are associated with a small depression and crude benchlike features, also South of Budle farm a short dry depression lies on the inner margin of a former terracelike feature (150'-132').

There is little of note in the stream development over this area. The Elwick burn is incised 20' where it crosses A.1. road, flows over bedrock for a short way past Easingtongrange Mill and then as the Ross Low flows over superficial material between 6'-10' banks. Its tributary, the Middleton burn, shows an anomalous stretch past Swinhoe farm, and at Middleton bridge the 12' narrow incision into bedrock upstream is replaced by a short stretch of rapids downstream.

(1. Whilst it may be considered artificial to consider only the N. facing Whin slopes between Easington and Budle Point, in the least it is convenient.)

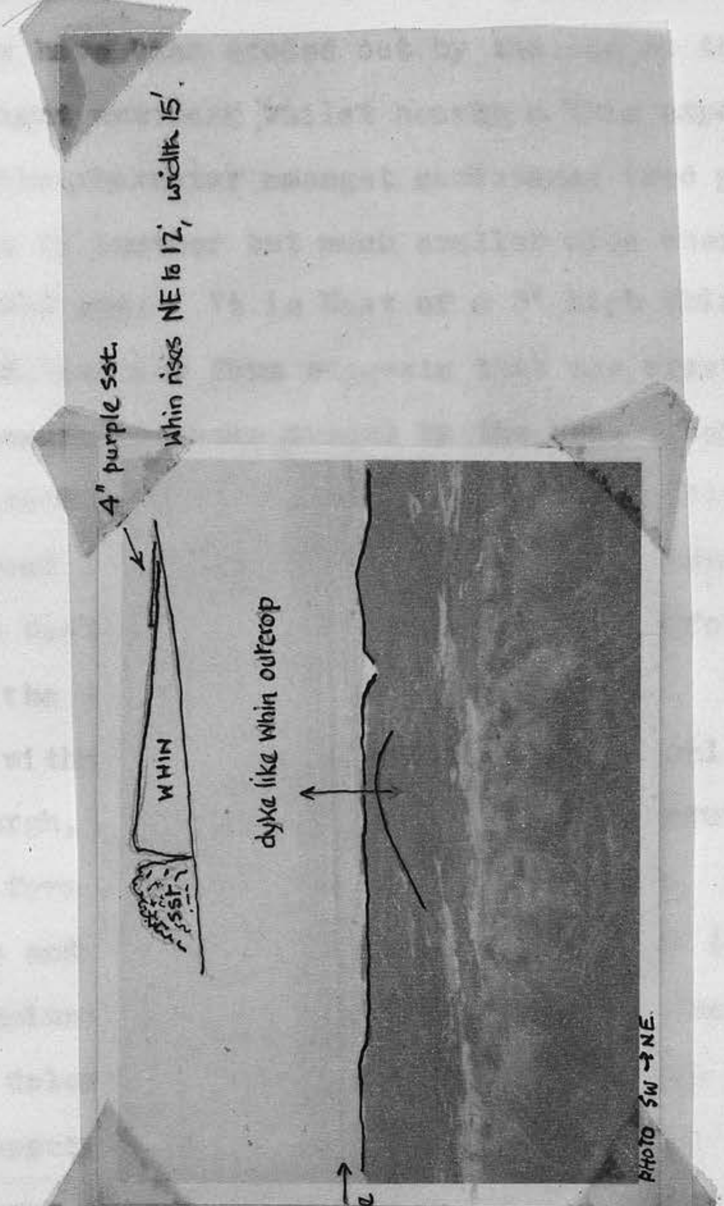
COASTAL PLAIN continued.

SOUTHERN PORTION.

2. Near Black Rock the seaward end of the Whin outcrop corresponds to coastal cliffing and carrs, but southwards the coastline becomes more subdued with only local features occurring at Bamburgh Castle rock and the truncated low ridges from Burton - Greenhill and North Sunderland - Seahouses. Between Black and Harkess Rocks the Whinsill appears to have been trimmed at 50', then veneered by blown sand, and from this narrow bench a steep (c40°) banking of sandy and scree material lets down onto skerrs and beach below. The Harkess Rocks, for their part, are geologically quite fantastic with complex sections-"the details of many of them of a so minute character that no plan or section, unless on a very large scale, can give a faithful representation of the remarkable instances of intrusion here to be observed, some of which have been mistaken for dykes" (p.114 G.S. Memoir Belford district).* In the present essay it is sufficient to note that East of Black rocks Lighthouse a South facing Whin exposure overlies shale, limestone (or cal. mudstone) and sandstone. Furthermore, the sea has eroded out a roughly horseshoe shaped area South of this Whin reef to expose sediments included in, or lying under, a locally thinner portion of the sill. To the North, the comparatively smoother surface of the Whinsill slopes to the sea North and East, whilst southward the Whinsill surface is gently undulating.

* For full description see same volume p.115-116.

In the enclosed case the details are varied but produce
a rough [illegible] of rocks e.g. At [illegible] rock the underlying
sediments [illegible] scoured out by [illegible] that the sill
has a slight [illegible], whilst nearby a [illegible] displays
a dyke-like [illegible] amongst sediments (see photos). Nearby,
the [illegible] but much smaller [illegible] where bedrock has
been [illegible]. It is that of a 3' high whinsill bench
(on [illegible] form a [illegible] of a small
local [illegible] Harkess
a [illegible] sand, first
in a [illegible] Castle rock.
Bamburgh [illegible] formed of whinsill
capping the [illegible]. The ridge is
aligned with [illegible] golf course NW
of Bamburgh, [illegible] direction; so its
present [illegible]. However, at its
northern [illegible] 150' length) which
upon [illegible].



1) The [illegible] from top to base.
In the [illegible] is shown, but
the columnar [illegible] passes
through a [illegible] where
columnar structure is [illegible] weathered rock.
2) In the lower portion [illegible] fragment of purple
sandstone [illegible] thick, 8' length, dipping 45° seaward, is to be
observed.
These facts together with the narrow width of the Whin
exposure raise doubts on the Whin here being a sill; instead,

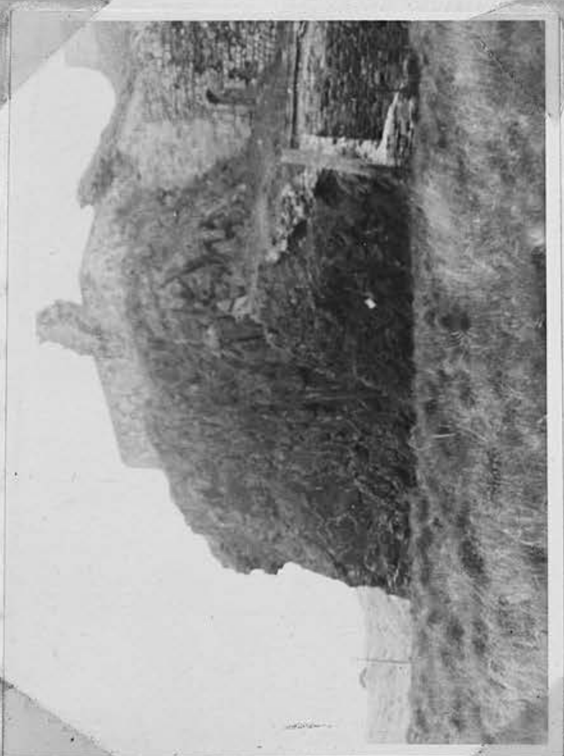
SAND BLAST ACTION on rocks at BUDLE POINT.
(3d piece standing on end for scale)

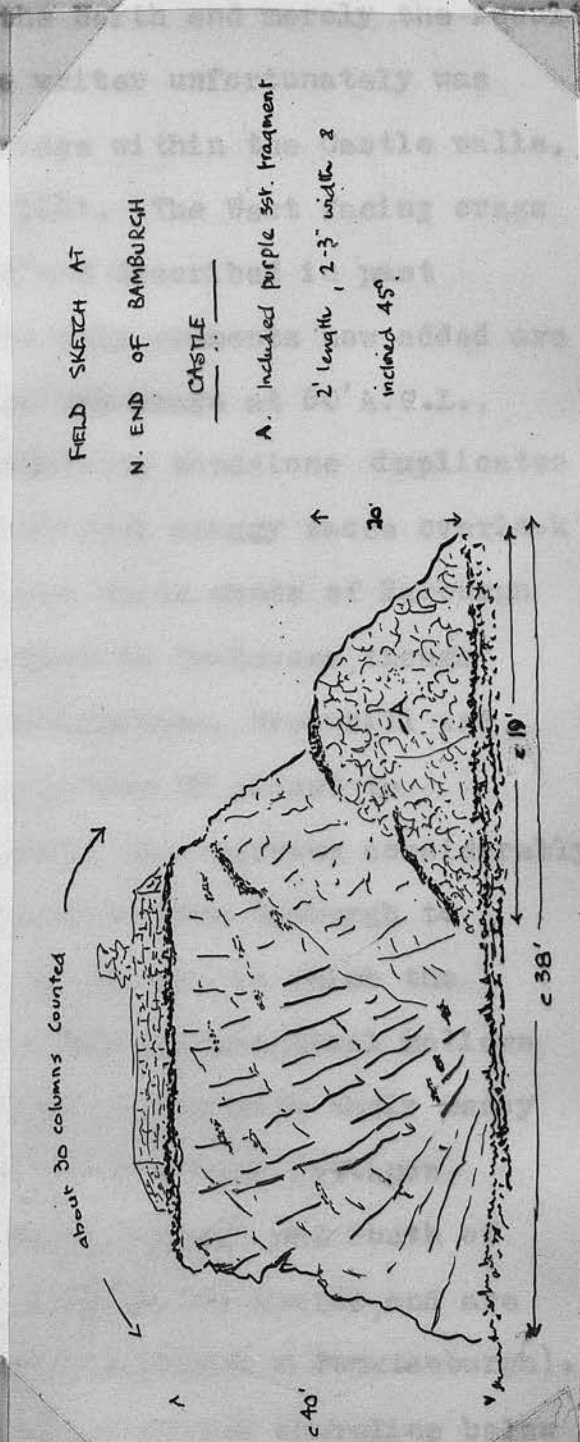
In the enclosed area the details are varied but produce a rough jumble of rocks e.g. At Stag rock the underlying sediments have been eroded out by the sea so that the sill has a slight overhang, whilst nearby, a Whin exposure displays a dyke-like character amongst sandstones (see photos). Nearby, too, there is another but much smaller area where bedrock has been eroded out. It is East of a 3' high Whinsill bench (on H.W.M.) and its form suggests that the crest of a small local flexure has been eroded by the sea. Beyond Harkess a fine beach appears and this is fringed by blown sand, first in a spread form, but as sandhills about Bamburgh Castle rock. Bamburgh Castle is built upon a NW/SE ridge formed of Whinsill capping the underlying sandstone and shale. The ridge is aligned with ice striations found on the local golf course NW of Bamburgh, looks wedgelike in plan and elevation, so its present form is probably due to ice erosion. However, at its northern end the ridge terminates in a cliff (40' height) which upon examination shows several interesting features.

1) The dolerite appears to show a transition from top to base. In the uppermost part of the section columnar form is shown, but the columns appear to radiate. This upper portion passes through a transitionary zone to the lowest section where columnar structure is replaced by spheroidally weathered rock.

2) In the lowest portion of the section a fragment of purple sandstone 2-3" thick, 2' length, dipping 45° seaward, is to be observed.

These facts together with the narrow width of the Whin exposure raise doubts on the Whin here being a sill; instead, it seems to be transgressing as a dyke and only just beginning to become sill like along the eastern margin of the outcrop. Again, are the three zones seen at the North end merely the result of erosion upon a single flow? The writer unfortunately was unable to examine legitimately the ledge within the Castle walls, but it does appear to be [illegible]. The West facing crags of Castle rock have been [illegible] and described in past literature on numerous [illegible] have added are [illegible]





patches and altered [illegible] (25' and mapped as [illegible] Monk's House. (These [illegible] characteristic of the [illegible]). At Seahouses, the [illegible] a low cliffing [illegible] the cliffs are more pronounced, higher [illegible] The instability of cliffing behind [illegible] fairly rapid it seems to be transgressing as a dyke and only just beginning to become sill like along the eastern margin of the outcrop. Again, are the three zones seen at the North end merely the result of erosion upon a single flow? The writer unfortunately was unable to examine legitimately the ridge within the Castle walls, but it does appear to be crested at 100'. The West facing crags of Castle rock have been illustrated and described in past literature on numerous occasions, the only comments now added are that there is a marked termination of the crags at 50'A.S.L., and, towards the South, a wedge of underlying sandstone duplicates the frontage. On the East side, occasional craggy faces overlook the adjacent sandhills. The fine, near white sands of Bamburgh beach continue SE along the coast almost to Seahouses, though alternating with skerrs and carrs at Islestone, Greenhill and Shoreston. The large sandhills, too, extend SE almost to Seahouses, but the width of the sandhill zone narrows considerably southwards from Greenhill. In a traverse from Bamburgh to Seahouses the observer is impressed by the way in which the sandhills lie athwart of, and seal, shallow topographical hollows or basins. Examples of these shallow hollows with their mossy patches and alluvium are to be found at Armstrong Cottages (25' and mapped as Raised Beach by Geol. Survey) and South of Monk's House. (These features appear again southwards, and are characteristic of the coastline between Bamburgh - Dunstanburgh). At Seahouses, the Tumbler rocks stretch along the shoreline below a low cliffing (c20'height) but beyond the harbour the cliffs are more pronounced, higher (c40') and unstable. The instability of cliffing behind Broadcarr rocks results from fairly rapid undercutting of low dipping rocks. Whilst the shore is platform like, the gently dipping rocks are not perfectly planed but gently serrated instead, because of lithological variation and differential erosion. There may formerly have been a low promontory locally, for at the South end of the harbour breakwater a stack remnant is suggested. Again, marine erosion seems to have been somewhat selective, for the present harbourage is fault bounded to the South, and the Braidstone Hole is in a breached and eroded low anticline or dome. On the golf course South of the village the ground slopes gently SE from △56' to △46', whilst to the West, between N. Sunderland and Southfield farm, a small dry depression grades out to 45'. Between Snook and Beadnell Points the coast first shows the sequence of alluvial flats, sandhills and beach again, but these become progressively excluded Southwards as the amount of rocky shore increases. The alluvium terminates at Annstead farm, the blown sand at Beadnell Square (although the sandhills end at Linkhouse), whilst the beach fringe South of Beadnell Haven is replaced by bedrock, boulders and shingle to Beadnell Harbour. The Annstead flats, like those in Beadnell Bay, are more extensive than comparable features North of Seahouses or South of Newton Point. The Annstead alluvium lies in a shallow depression, and, as its surface lowers NEward, it may be deltaic. Such an interpretation makes the facile assumption that the sandhills are homogeneous, but the author prefers to assess these features as being of doubtful origin. On the shore North of Beadnell, the rock outcrops are tangential to the coast with limestones forming low carrs. Wave trimming has not resulted in perfect planation, nor has the sea entirely removed rock debris. The excellent shore section at Beadnell was examined in detail, and particular attention paid to the Great limestone which showed small scale features illustrating the effects of marine erosion and solution. The 15 - 20' cliff which bounds the South side of Beadnell Haven continues to Beadnell Point with but small variations in its height. Approaching the fault which lies on the South side of Dell Point the cliff exposures show slight corrugations, whilst on the shore SE and S aligned fissures, vesicles and veins appear. The South side of Dell Point shows pronounced veining associated with the fault (plus localised brecciation), and the shoreline looks akin to "crazy paving" with blocks 1-4' width, 4-6' length producing a slightly knobbled surface. Nacker Hole is eroded out of sandstone and shales, with the former more prominent North of the W/E Whinstone dyke which cuts across the area. The wall-like dyke is 18' width, rises to 10' height, and now forms a natural breakwater for a small anchorage inshore. The dyke has produced thermal effects upon adjacent sediments and the breach in it most probably is man made. Separated from Nacker Hole to the North by a limestone (Sandbanks) reef, Lady's Hole is bounded to the South by a 20' cliffing founded upon the Great limestone, and therefore appears to have resulted from the easier erosion of the intervening sandstone and shales. East of Beadnell harbour, boulders and coarse sand are soon replaced, first by blocks, and then by a gently SE dipping outcrop of the Great to Beadnell Point. Near H.W.M. the outcrop has been ripped up into blocks, whilst at L.W.M. a slight nip is suggested, but more important still, the observer can distinguish surface zones, parallel to the strike, which change down dip. The characteristics shown by each zone are now summarized, and it will be apparent that quick variation in mechanical and solution effects are reflected by surface changes on the limestone. (See photos. in Map Folder)

Zone 1. Width variable. Just on and above H.W.M. the limestone surface is smooth, but shows large Southward trending fissures.

Zone 2. Width 17'. Blocks with sides measuring 1 - 2' length occur. N/S and E/W rock jointing picked out, and in places small pits ½" deep occur giving rugosity.

Zone 3. Width 5½'. Here fissures 1' depth and 3 - 4" width. Again, small potholes developed, being 1 - 2' diameter and averaging 1' depth.

Zone 4. Zone 3 merges into this zone, estimated to be 5½' wide. Fissures now 6" - 1' width and the potholes are replaced by pits 2 - 3" diameter. Surface is now coarsely scarred.

Zone 5. In some places a transition from Zone 4, but elsewhere a clear cut change. Width 9'. A surface of small nobbles. The larger upstanding lst. margins have now been reduced almost to the level of the fissure floors and pits 2 - 4" width, 3" deep, become finer seawards.

Zone 6. Width 24' and corresponds to the seaweed line. Surface is now almost smooth, there being only small crenulations. Here fissures are few in number, widely spaced and, where present, vary in depth from 6" to a mere trace.

Zone 7. Width 24'. Virtually on L.W.M., the surface completely smooth.

Whilst it may be of no significance, it is to be noted that Zones 1 and 2 are grey in colour, tinged with brown and black, Zone 3 is dark grey / to near black and zones 4 - 7 Khaki brown in colour.

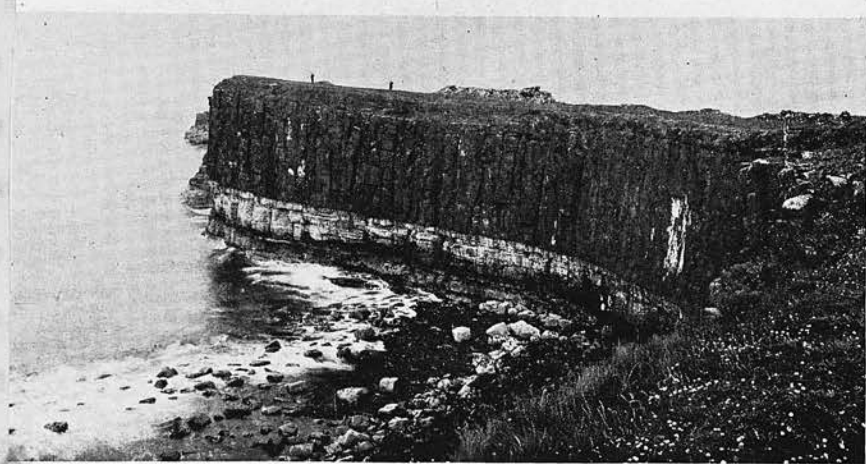
Crescentic Beadnell Bay has a fine beach, backed almost continuously by sandhills and, more sporadically, alluvial deposits - South of Beadnell Green and North of Newton Links House. Just East of Beadnell Harbour a few water-trimmed skerrs are soon replaced by fine sand, whilst in the bay itself wavecut rocks emerge and are visible at low water. The sandhills continue to rise to heights between 50-60' (a limiting value?)[1] but, as at Annstead, they are stream breached. The Newton Links flats are extensive, and may formerly have been continuous with the patch northwards. The lowest ground is liable to flooding, the Long Nanny and Brunton burns form small tidal creeks in their lower courses, whilst the whole suggests that silting up of shallows behind a bar has occurred. Other points of interest concern the streams flowing into the area, for they appear formerly to have graded to 25' ASL. Also the Long Nanny at one period may have flowed eastwards to the sea at Millers Nick, for North of Tughallmill a low shallow swale falling seaward is discernible. At the South end of the bay Football Hole[2]

1. Note, however, the one exception on Dunstanburgh Links, where the sandhills reach 86' ASL, but probably rising off drift.

2. For Geol. description see G.S. Memoir "Belford etc." page 83.

lies between adjacent Whin/Great limestone outcrops striking NE and in echelon about ½ mile apart. The Hole appears to result from selective erosion by the sea of the weaker sediments in a locally faulted area.

Southwards from Newton the Whinsill makes its presence felt in the topography of the coastal area, and since the rock strike matches the general direction of ice movement in places hereabouts, the landscape shows a NNW/SSE graining. Between Newton Point and Dunstanburgh, beach and skerrs alternate on the shore, fringing sandhills appear together with small alluvial patches behind. By contrast, the coast South of Dunstanburgh to Cullernose is dominated by the Whinsill, and then to Howick by sedimentary rocks, with the virtual exclusion of sand. Southwest of Newton Point gently dipping limestone rocks on the shore show only jointing and staining, perhaps the absence of other features comparable to Beadnell is due to the Great here grading down to limy sandstone. Above O.T.H.W.M. small planated skerrs are replaced by a transitionary slope (12' width) to the base of a 12' high banking, and above this the ground quickly rises Northwards. The geological relationships in Newton Haven practically duplicate those shown at Football Hole, and it seems likely that the Haven was formerly a horseshoe shaped embayment, but because of erosion it is now gradually coalescing with Embleton links. A depressed marshy area 12-20' A.S.L., South of Newton Seahouses, is separated from a similar alluvium patch near Embleton Golf Club House by ice grained Whinsill. About 250 yds. SW. from the Club House, too, the lower Embleton burn is now



B.—WHIN SILL ON SANDSTONE, CASTLE POINT, EMBLETON, NORTHUMBERLAND.

incised c30', but by the Club House it may formerly have graded out to 25'. SE of Embleton the beach is replaced first by a coarse boulder storm beach (Whin), and then by disturbed limestone at Gray Mare Rock. The limestone forms a low, narrow carr, but is rucked up to form a small knee-shaped flexure - probably an effect associated with the adjacent fault. At Dunstanburgh[1] the Whinsill overlies sandstones and shales, and is distinctive from the main mass to the South because of the Cushat Stiel fault and erosion. The Castle stands at c100' on the summit of this mass which shows crags to the West and cliffing to the sea Northwards. Writing on Dunstanburgh Castle in "The English Gate" (p.155) Wills comments on the noise created by the sea as it thunders in a deep cove "Rumbling Churn" to the North of the Castle, and continues to describe a blowhole in the Northern cliff. "It is as though a whole octagonal column of rock had been worn out of the basalt and left a deep hole with an opening at the bottom. At times an advancing wave strikes the foot of the cliff and sends a white column of water like a jet of mighty foam soaring high into the air. During the day, that is spectacular; but at night it is terrifying, weird and fantastic." Southwards the West facing Whin crags and the seaward dip slope are most impressive. The crestline to Craster[2], whilst at a constant height, is discontinuous, for several breaks (shairds) occur along the scarp front and these in some cases match "holes" e.g. Oxberrylaw, Liverpool holes eroded

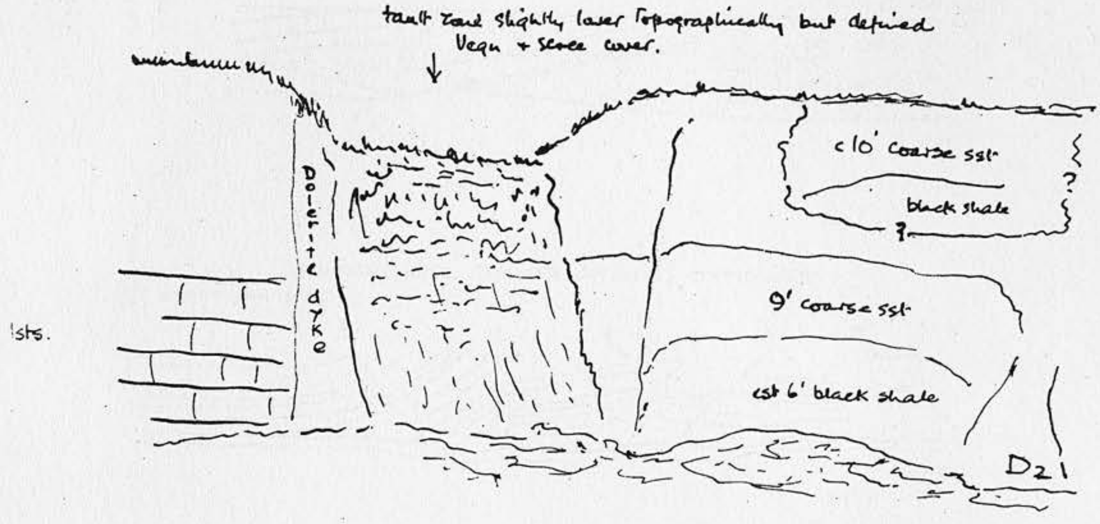
1. For geological description see Alnwick G.S. Memoir p.75-78.
2. "The strata in this district (i.e. Dunstan and Craster) are arranged in a "Horst"" p.48 Ibid.

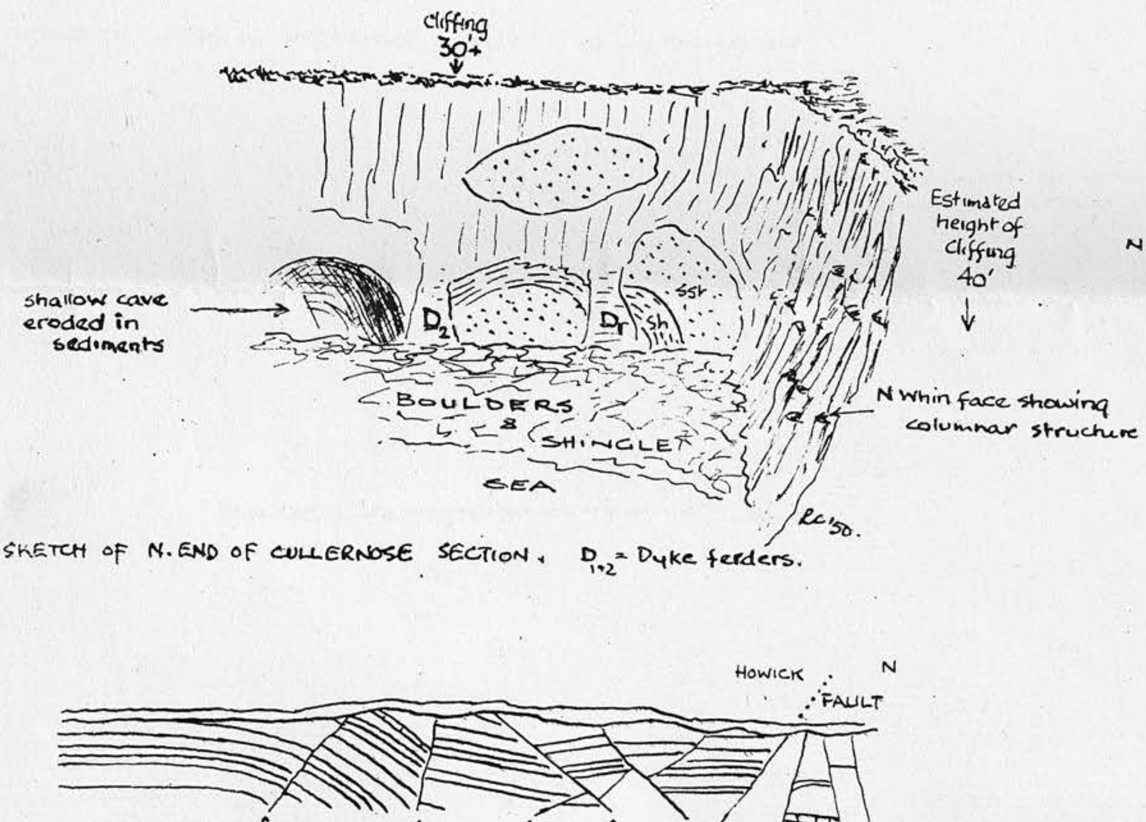
by the sea along the foreshore. Some of these breaks are fault guided e.g. Cushat Stiel, Craster Harbour, but it is doubtful whether they all result from faulting, crushes or jointing - could they not have been produced in the earliest phase of glaciation when the ice moved eastwards, or again might they not result from meltwater action in the later stages of glaciation? At the Northern end of the Whin crags between the Due and Castle rock lies a small patch of alluvium, infilling glacially over deepened ground, whilst to the West, low swells and ridges converge upon Howick to the South. The foreshore does not reveal any clear cut jointing, instead the rock surface looks like "crazy paving," and above a slight nip, a low banking leads up onto the dip slope. Seen from the South, the Castle rock shows two small topographic breaks on the dip slope, and it is suggested that similar features occur on the dip slope of the Whin North of Craster. (The writer did not have time to check whether these features were due to marine or glacial erosion, ∴ their origin and extent uncertain). South of Craster the dip slope of the Whin still dominates the coast to Cullernose, and at this latter spot a classical geological section is exposed. Before turning to Cullernose Point, the writer wishes to refer the reader back to Craster. Here a faultline is associated with the harbour on one side of the village and a narrow cutting through the Whinsill on the other. If the depression running SSE from Embleton Glebe carried meltwater at one time Southwards, then the Craster gap in the Whin may be an associated feature.

The description and diagram of Dr. J.A. Smythe of Cullernose

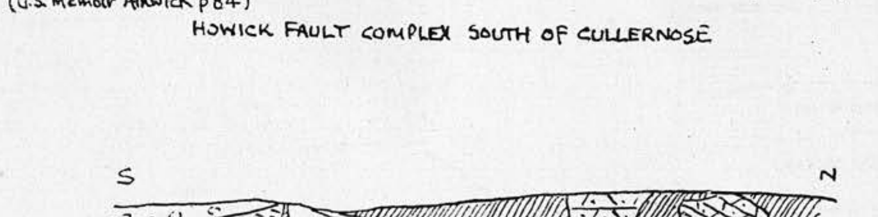
DIAGRAMS OF COASTAL SECTIONS
AT
CULLERNOSE AND HOWICK.

DIAGRAM DRAWN IN FIELD AT S. END OF CULLERNOSE. (Vert. Scale much exaggerated).

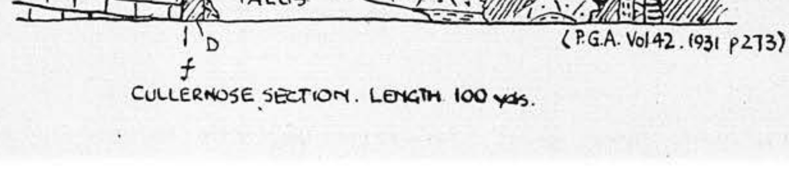




FIELD SKETCH OF N. END OF CULLERNOSE SECTION. D_{1+2} = Dyke feeders.



HOWICK FAULT COMPLEX SOUTH OF CULLERNOSE



CULLERNOSE SECTION. LENGTH 100 yds.

CULLERNOSE POINT from the South.

Philipson Ltd.

are included, together with the writer's own notes and semi-diagrammatic sketches of the locality. It will be observed that the only divergence concerns the two Whin exposures on the North side of Cullernose fault - the writer considering them to be dyke feeders whilst Smythe appears to interpret them as part of the Sill proper.

P.G.A. Vol. 42 (1931) page 273.

"The limestone at the South end (of the Cullernose section) is the Four Fathom or Eight Yard, over which lies boulder clay charged with large Whin boulders. The limestone and associated shales are faulted down to the South against the thick garnetiferous Dunstanburgh sandstone across which the Whin is breaking. A dyke, D, flanked by breccia, occupies the fault. Large fragments of the sandstone have become detached and have floated away in the magma, some maintaining their original orientation, others being tilted on end, or possibly reversed in position. These fragments are penetrated in places by thin strings of the igneous rock (shown in black). The horizon of the Whinsill is a little below that of the Great limestone and its base can be seen, a short distance from the position in the section, resting on sandstone."

The east dipping Whinsill emerges from the sea at Cullernose Point and shows about 40' of quartz dolerite in a South facing cliff. The cliffing is steep, showing a columnar structure, and if the columns are any indicators of dip, then the latter seems to increase seawards. The shore immediately beneath the cliffs is boulder strewn and rises to the foot of an East facing Whin cliff which contains sandstone and shale Xenoliths. The continuity of this of this cliff is broken by a 10' wide bank of lower height (approximating to the faultline), South of which lies a narrow dyke, then limestone and shale. On the shore, too, Southward there is a change from the bouldery shingle to gently undulating limestone rocks. The remaining section of coast between the Cullernose section and Howick burn continues to be cliffed, fronted by a shingle and rocky shore where the rock strike broadly parallels the coast. A section extracted from the Alnwick Memoir is included to show the faulting locally, and mention is also made of the recordings of buried forest remnants between tide marks off Howick[1] (p.105 Alnwick Memoir).

Turning next to the coastal plain inland, the ground there will be described systemmatically, in so far as this is possible. From Lucker northwards a wedge of low ground between Lucker - Belford - Waren is bounded by the Whinsill to the North, plain at a higher level to the East, and the major cuesta to the West. NW of Belford the Whinsill crests lie between 4-300' and, because of heavy ice erosion, now show a series of West facing crags NW/SE aligned. In contrast, the Whin outcrops from Easington to Chesterhill are not so high, having been even more roughly handled by the ice, whilst the Longhills show a "tail" stretching SE towards Bradford. On the leeside of the Whin, the ground slopes gently South from Belford Hall into a shallow basin where several low mounds rise 10-15' above the alluvium floor to crests between 141-145'. Whilst this basin is bounded to the West by a change of slope at 200', to the South the ground begins to rise from 150' to reach a benchlike facet South of New Moussen.

1. For fuller information on the geology of Howick area and the coast section see Alnwick G. Memoir p.49-50. 56. Appx. I (23) p.126-127

East of Belford Station[2], a partial bench (Part-solid/part-till) lies between Easington Farm and A139' B.R. station, whilst the "tail" of Longhills is a low swell forming a minor watershed. The line of the Whinsill most likely coincided with a watershed in pre-glacial times, but of the three ice breaches at Belford, Waren and Inner Sound the first two are now used by the railway track and Waren burn respectively. (The Belford gap presumably had ice in it long enough to prevent the establishment of a stream line through it Northwards, for it is now virtually dry). If this be the case, then the present Waren burn affords an example of drainage reversal because of glaciation, and its lowest portion was probably used sub-glacially. The present Waren burn crosses the Whinsill in a stretch of rapids 10' at Waren Mill, whilst upvalley to Bradford a fierce stream incision into ground lying between 130-100' A.S.L. is noteworthy[3]. It is joined by two small anomalous tributary valleys, the first of which - Chesterhill Dean - appears to have been used formerly by a larger stream arising SSW of Outchester, whilst the second joins the main valley South of Spindlestone crags. The second results from the union of a meltwater channel which runs around the northern side of South Hill and a depression of more doubtful origin which continues the line of long Barracks ridge. Above Bradford the Waren burn is joined by the Newland and Winlaw burns which flow in exactly opposed directions (the Newland flows SE whilst the Winlaw flows NW). Both tributaries are small and

2. Note overburdens Belford Rly. Stn. 45½'. Bradford 65'. Hoppen 40'.
3. 50' incision at Spindlestone Mill with sides sloping at c25°, 30' incision at Bradford where burn 20' into bedrock.

and serve simply as links between alluvium and peaty tracts South of Belford, West of Bradford in one case, Embleton's Bog and Lough Bog in the other.

The next area to be considered lies East of the Waren burn and is bounded to the South by the Long Nanny stream. It is well enough defined with Whin crags to the North, upstanding glacial deposits to the West and represents a gently undulating plain falling southwards and Eastwards. Above Budle Bay the crest of the Whin outcrop lowers Eastwards, and although South Hill and Brada Hill both possess SSE aligned "tails" the other outcrops show variation in the forms produced by ice erosion, but all possess South facing crags. On the leeside of Spindlestone Crags, in addition to the meltwater cut there is the "Spindlestone" itself. Stack-like in appearance, the stone is approximately 20' in height, with sides 4' and 6-8' respectively. It is difficult to suggest how it could have been formed and preserved during glaciation, and probably it results from post glacial weathering. To the East in the Bamburgh Golf course area, the Whin crags appear to have been nipped or slightly trimmed at 200' in places, and all share marked changes of slope at 150' (the scarp foot). Furthermore, it is noted that the marked, though short, depression which isolates Kittling Hill is at about the correct height and in alignment with the two small drift spreads South of the crags and West of Bamburgh. From Spindlestone crags South to Hoppen the right bank of the Waren burn is grained NNW/SSE by outcrop (occasionally), till and drift features, culminating in the esker like Long Barracks → Pigdon Hill discontinuous ridge and drumlin-like forms of Lidderton Hill, Bradford Golden Hill and Cockle Hill. Upon these latter features, which lie to the East of the esker ridge, there are variable amounts of sand and gravel. It is a matter of opinion whether the "drumlins" be considered as such, or as morainic residuals, nor is it proposed at this stage to consider the details of the Bradford Kaim, since these are provided elsewhere. Sufficient at present to note the occurrence of this double ridge between South Hill and Hoppen, in some parts distinct and separate, in others almost coalescing. Topographically the features are at their best E and SE of Bradford farm, petering out at the North end near South Hill and merging into a till ridge East of Hoppen. South of Hoppen the drift deposits soon reappear, first as a spread, but nearing Newham disposed in NW-SE troughs and ridges. Apart from small drift patches near the intake of South Hill channel and excluding the lower esker-like portion, the glacial deposits associated with the Bradford Kaim South to Newham crest below 200'. If the nearby drift patches of Burton Golden Hill and Elford be included, the crest heights are found to range between 170-195'. Behind the Kaim and to the east, Burton GoldenHill[1] ridge introduces a local transverse element into the landscape. (Similar occurrences are found at Elford and Swinhoe to the South, but considering the geology of the area one would have anticipated the W|E element to be more frequent in the landscape). At Burton farm a dry depression from the West peters out at c100' contour and probably saw slight use by meltwater. South of the farm, where the overburden is being stripped for limestone extraction, the rock head is slightly torn in places, but as the rock surface is undulating the ice probably

1. See G.S. Memoir Belford for description of local superficial deposits p.148.

moved SSE over this locality. Whilst the ground NE of Glororum slopes away gently NE to the sea, the "tail" features from the Whin are replaced to the SW by the low lying alluvial ground of Wet Reins. Wet Reins is probably associated with the adjacent Kaim to the West and the Burton cut to the East. Southwards, the Elford mound forms an upstanding local feature East of the main drift area, and about 700 yds. South of the steading the Crackerpool burn may be considered excessively incised (to be normal) where it crosses the 100' contour. The Southern continuation of the Bradford Kaim to Newham is a distinctive feature, being bounded by peaty flats to the West and a low swale from Newham Hall - Newham Mill (92') on the East. Whereas the the base of the drift is fairly constant on the West flank at c140', on the east it is more variable, and the underlying till at its southern end (Newham Five Acres locality) appears to have been eroded. The crest line lowers Southward and from the drift at Newham an esker-like, though discontinuous, and sinuous ridge emerges to continue Southwards towards the next drift spread area at Doxford. Along the railway track through Newham there is continuity between the Lough Bog and more Southerly Crutch Bog, but this is probably artificially produced. More natural looking, and suggesting water trimming, are the crests between Newham and Chat Hill which display two distinctive levels i.e. on Chat Hill, Horse Hill and S. Newham, whilst amongst the artificial terracing on the West side of Chat Hill at least one appears to have been naturally formed, presumably when water was ponded back up the Long Nanny valley to the South.

East of Chat Hill the ground is locally near flat at 90-100'

A.S.L. and then begins to slope gently eastwards towards Beadnell Bay, but separated from the Annstead shallow basin by the low Swinhoe watershed. The only other minor feature refers to the Shoreston - North Sunderland area, where the twin depressions flanking N. Sunderland are likely to have resulted from temporary meltwater action, the water flowing Southwards and its course traceable Northwards to near Shoreston Hill.

East of the main railway and South of Tughall the surface rises up onto higher ground associated with the Whinsill outcrop between Embleton and Newton Point, whilst West of Embleton the gentle featureless expanse of Embleton Moor rising South is replaced by the triple ridge outcrops of the Eelwell, Acre and Sandbanks limestones. At Embleton itself the Whinsill forms a ridge whose crest reaches 150' A.S.L., and to the West of it a shallow depression, alluvium floored, rises Northwards and probably is a meltwater feature. To the South, the line of Stamford Cast and Stamford Bog separates glacially grained topography to the East from the W/E Prickly Rigg[1] and the locally undulating ground South of it. West of the railway track the esker-like continuation of the Kaim loses definition where it bifurcates at Preston, although the narrow flats which lie to the West become more and more anomalous looking upvalley. As in the North, a drumlin-like feature lies East of the esker near Preston, but because of other local peculiarities the writer is discouraged from subscribing to a drumlin interpretation. Between Doxford

(1. Note the rather similar disposition of this feature to the Kaim cp. Burton Golden Hill)

and Charlton Hall the spread is dissected in places by the present streams, and probably was also by ice meltwater. In the southernmost extension the drift between Charlton hall and West Linkhall suggests Kettling, similarly on part of Longlee Moor Kettling is also seen. Between these two localities there is the meltwater cut at S. Charlton, to the east of which the drift forms small topographic features.

At Preston two low hillocks lying between Preston Mains and South Broomford terminate the comparatively featureless ground South from Chathill. South of these two hillocks an alluvial area is flanked by a sharp bluff along the east side of Preston "drumlin", and, as the line taken by the present road past the hamlet could have been water formed, it looks as though these features about Preston result from marginal phenomena. From Broomhouses (on the Charlton burn) the ground rises Southwards to what appears to be a surface at 300' + behind Rock Moor House. The rise is not continuous, for South of a small area of comparatively level ground at West Fallodon there is a slope into the Kittycarter burn prior to the ascent to Shellrig. Southwards along this traverse W/E topographic graining insinuates itself, and one also observes the line of a depression (of doubtful origin) NW of Shellrig bridge.

SW of Rock the ground rises up to the wedge of higher crested terrain referred to in the Aln valley description, whilst to the SE, alluvial patches in the sweep of low ground toward Howick Hall are a feature. These, together with occasional drift patches dotted on the sides of the Stamford burn valley suggest that glacial influence has dictated the line of the Stamford burn and the origin of the Stamford Bog. Of similar origin are the S. Charlton bog and Rock Middlemoor areas, for both have had impounded water which first escaped Southwards through Hinding Dean.

The streams in this Southern area do not merit lengthy description. The Long Nanny is normal upstream to Crutch bog, but Southwards towards Doxford it is markedly misfitted. As might be expected, portions of the Charlton and Shipperton burns above Doxford are severely incised as they flow through the drift deposits, or along drift/till margins. The Embleton stream, for its part, is incised to the Prickly bridge area, whilst to the South the Stamford burn flows first over a wide shallow area SE of Rock, but its valley is bottlenecked beyond Littlemill and incised (Proximity to base level and nearness of Whin outcrop). Finally, it is of interest to note (p.55 G.S. Memoir Alnwick) that in dry weather the Great limestone causes stream disappearance for a short distance near Redstead (Howick).

Above the coastal plain, South of Lucker, the ground coming off the cuesta is crudely and discontinuously stepped. One notes, for example, the chain of hillocks stretching South from Bankshill with summits between 330-370'. The inner margins of these features in some cases, have been used by meltwater, and South of Warenford they appear to belong to a former bench which looks down onto a lower tread between 250-215'. Meltwater features along this zone marginal to the plain grade Southwards and apparently form series. In the North, meltwater probably just flowed SE from near Swinhoe farm past the Banks(Bankshill), then later, on passing the West side of Newlands, turned eastwards along the North side of New Moussen (see Belford G.S. Memoir p.150). The next series to the South are higher and come in West of Warenford cottage to grade SEward and end near A.1. road N. Charlton. (Meltwater features in the S. Charlton area have already been mentioned).

(3) There seems to be little point in repeating the description given for the N. bank of the lower Aln valley under the guise of "coastal plain", and for further information on the coastline itself the reader is referred to the G.S. Memoir Alnwick p. 56 and Appendix I (22) p. 124-126.

THE MAJOR CUESTA.

To complete the landscape description, it is proposed briefly to consider some of the features shown on the cuesta between Kyloe and Shipley. M.F page 25 A traverse over the northern part of this area shows clearly how the ice flow direction changes from ESE to SSE. The abundance of hogbacks, low discontinuous scarps and Westward facing crags as single, or closely spaced multiple, features, often separated by mossy depressions, is astonishing. Besides ice breaches and icegouged depressions there are probably meltwater channels in the area, but these are difficult features to interpret satisfactorily. Again, the Holburn Moss with its continuation towards Middleton Moor is distinctive enough to suggest that water had been temporarily ponded in this stretch. Particular features noted are now listed in summary form.

1. There is striking duplication of sandstone and Whinsill crags in the Kyloe Hills area and West of Greymare Farm.

2. Weathered rock joints in the sandstone are often of considerable proportions e.g. in the Fell sandstone NE of Shepherds Kirk Hill, near Due Heugh, a joint 130' length, 15-20'

depth, 1-3' width is easily followed northwards; on the West side of Greensheen Hill a burn rises from a joint 3-9' width, 100 yds length, 30-40' depth. Besides vertical features they occasionally give caves[1] e.g. St. Cuthbert's Cave, where the lower part of a 40' exposure shows a cave 15' depth, 12'-4' height.

3. The ability of the Fell sandstone to form "pan" and impede or check runoff, referred to by W. Anderson p.25 "A Physical Land Classification of Northumberland & Durham", seems applicable to some of the other sandstone rocks in this area.

4. At Colour Heugh Crags there is a clear demonstration of the NE/SW faulting, which, together with ice erosion, gives the scarp front so much of its character. Here the crags rise Southward to 50' and suddenly are truncated at the line of faulting. (Slickens and some brecciation can still be seen at this truncated end).

5. Clear cut meltwater features lie in the north and south of this area, two channels just South of West Kyloe grading Eastwards, and two channels South of Warenton grading South then East. Between these, there may be others falling NW in the scarp front area and grading SE along the eastern margin, but, since they are coincident with the strong glacial graining, it is a matter of opinion to decide whether the depressions result from ice or water erosion.

The highest ground to the South tends to become rather monotonous topographically once East of the scarp front. Whilst the scarp front between Hepburn and Sandyford Moors shows glacial

1. Longheugh crags, of Scremerston sandstones, shows similar tendencies under weathering, but here there is the extreme example of a perched block produced by weathering along jointing.

graining NNW/SSE, there is not the same rapid alternation of features as to the North, and the graining itself becomes less pronounced and southerly near Shipley. Small basins of moss and shallow damp depressions are a feature of Bewick Moor, Quarryhouse Moor and Middle Moor, giving a bleak character to this exposed area. Once again, it is difficult to interpret features as being truly meltwater in origin, e.g. NE/SW depressions on Amerside Moor, southward trending depressions on Middlemoor, whilst the origin of Rosebrough Moor is doubtful - preglacial capture of the Sandyford burn or ice erosion on Sandyford Moor diverting Sandyford burn?

Glaciation. (See M.F. pages 26, 27, 28).

The writer presents, in general terms, the results of previous workers over the area, together with findings of his own field work. A good general account of glacial events on a regional basis is given by A. Raistrick p. 281 P.G.A. 1931, and more detailed statements are to be had in the G.S. Memoirs covering the area. In this section, too, the writer has deliberately refrained from excessive repetition of features already described in previous parts of this work.

GENERAL STATEMENT.

Quaternary deposits and effects in the area studied have already been described, firstly by workers like Clough, Gunn and Tate, and later by men like Garwood, Smythe, Gregory, Burnett and Carruthers - to mention a few of the many. Naturally as time has passed the volume of literature has grown, and yet in some respect it shows defficiencies.

e.g.

1. Kendall and Muff earlier recognized the meltwater channels around the margin of the massif, and the later extension of their work by Smythe and Geological Survey officers is only partially completed.
2. Little has been written on the possible changes that may have occurred to the drainage pattern because of glacial effects.
3. The occurrence of features resulting from weathering under periglacial or colder climatic conditions merits closer attention.

Writing in B.R. Geology "Northern England", Eastwood briefly and simply states the opposing opinions on the subject of glacial advance and retreat over N.E. England. There are those who maintain that there was one period of glaciation with changes of ice flow direction occurring during this coverage. Others consider that the following events occurred:-

1. The Scandinavian icesheet advanced and impinged on the Durham coast first, to be followed by a period in which loess like deposits were formed.
2. Two advances of Cheviot, Tweed and E. Scotland ice occurred into the S. Northumberland and Durham coastal areas, but were separated by an intervening period when ice from S.W. Scotland, the Lake District and local centres flowed east to the coast.

All seem agreed that it was the Scandinavian ice sheet lying off the coast to the east which induced eastward moving ice to turn south. Turning to the more particular now, we find that there is general agreement on the main directions of ice flow around the Cheviot area at maximum glaciation. Carruthers notes how ice coming from the west was split into two streams by the Cheviot massif "the branches creeping around the flanks of the hills to meet once again on the southeast" (p. 121 "The Cheviot Hills" G.S. Memoir 1932). Centres of ice dispersal affecting the Cheviot country include the Ettrick - Yarrow - Tweed headwater area, S.W. Scotland* and the Lake District. Whilst the latter stream did not actually impinge on the massif, it seems to have caused southward moving ice in the N. Tyne and Rede areas to be deflected eastwards (p. 285 P.G.A. 1931 Raistrick). As for the Cheviot itself forming a local

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* H. Miller records Crifell granite at the W. end of the Simonsides (Rothbury). Cheviot Memoir 1888 edition.

centre of dispersion, we find the ranks of opinion divided. Clough held that whilst the higher parts ofthe Cheviot were never overridden by foreign ice it acted as an independent centre. West of Cheviot, Hugh Miller noted that the hills on the south side of the Rede (north of Blakehope) show no evidence of foreign ice from the west having crossed them, and he considered that there was a local ice cap on Carter Fell. More recently the concept of ice accumulation and dispersal from a Cheviot centre has been challenged (p. 125 G.S. Memoir "The Cheviot Hills). Field observations tend to support the view that Cheviot did NOT, indeed could NOT, supply the amount of névé to form a local ice centre. Furthermore, the "corries" of the Henhole and Bizle can scarcely be said to display typical features, and the writer considers them to be deep nivation hollows. Consider, too, their height above sealevel - are they not too low to be corries, considering, too, their longitude? Then again, there are numbers of shattered tors on the higher parts of the massif which form noteworthy features in the field and appear to result from intensive frost action, above the general ice level.

If the Cheviot behaved as a nunatak, then to what height did the icesheet rise flowing around it? Clough records granite boulders near the Shivering Stone* on Bloody-

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* The writer as yet has not checked this record in the field

bush Edge (1,900') and this is the greatest height recorded for erratic material in the area. Elsewhere, however, the writer considers that at its maximum ice covered up to 1,750' and probably stood at this height for only a relatively short period, if the number of shattered crags below this height and above 1,100' are any indication. The ice level does seem to have remained at 1,100' - 1,000' for a considerable period of time, judging by the great meltwater channels along the margin of the massif, and also the "carry in", from the north, of carboniferous material on to the eastern flank of the massif. When H. Miller wrote "The dispersal of Cheviot porphyrite may point to the joint action of ice in the valleys and ice on the Fells, the valley ice bearing the boulders outfrom the hills and the upland ice distributing them eastwards" (p. 105 Cheviot Memoir 1888) he probably gave a correct interpretation, provided "valley ice" is read as ice coming from an external source picking up rock fragments as it was driven through and/or over the Cheviots*

The distribution of glacial deposits is indicated on the map (MFp26) provided whilst another (MF. page 27) records overburden depths and glacial striae. More than adequate descriptions of the glacial deposits are available in the current G.S. Memoirs, and there can be little doubt that much

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*Smythe notes towards the end of Cheviot glaciation, ice flow was from the north-west.

of what R. Carruthers saw in the N.E. counties has been embodied in his recent papers on the part played by bottom melting in glaciers, during ice recession (e.g. <u>Q.J. Geol. Soc.</u> 1939: Proc. Yorks G. Soc. 1947) In brief, we find two boulder clay types over the low ground, the upper is generally of a reddish colour and shows far carried small rock fragments whilst the lower clay contains local, angular rock fragments and generally has a colour in keeping with the local rock types. In the igneous area glacial deposits are decidedly deficient in clay, usually being composed of angular or subangular blocks set in an arenaceous matrix - but nevertheless, quite closely packed. Colour in these deposits is variable, dependent upon the local lava types. The drift deposits have already been described in varying detail in the previous chapters and their distribution is now tabulated.

1. Cornhill - Mindrum - Crookham.
2. Marginal strips about Milfield Plain and in the lower Bowmont valley.
3. West bank of the Wooler water merging southwards into the Hedgeley deposits.
4. Chatton area and the Hetton burn valley.
5. Occasional dumps in the Beanley - Eglingham area.
6. In the Aln valley, near Whittingham and downstream from Hulne.
7. The Bradford Kaim and associated deposits, between Spindlestone - Longlee Moor (Shipley burn valley)

CONCLUSIONS

As the result of fieldwork over the E. Cheviot country the writer concludes

1. that the ice has been selective in its erosion, both in time and place,
2. that the ice for a considerable period of time formed a protective cover in adjacent valleys.

If the observer* begins on Tweedside and visits each valley

*To avoid repetition, details recorded in the valley descriptions are not restated.

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1. Cornhill - Mindrum - Crookham.
2. Marginal strips about Milfield Plain and in the lower Bowmont valley.
3. West bank of the Wooler water merging southwards into the Hedgeley deposits.
4. Chatton area and the Hetton burn valley.
5. Occasional dumps in the Beanley - Eglingham area.
6. In the Aln valley, near Whittingham and downstream from Hulne.
7. The Bradford Kaim and associated deposits, between Spindlestone - Longlee Moor (Shipley burn valley)

CONCLUSIONS

As the result of fieldwork over the E. Cheviot country the writer concludes

1. that the ice has been selective in its erosion, both in time and place,
2. that the ice for a considerable period of time formed a protective cover in adjacent valleys.

If the observer* begins on Tweedside and visits each valley

*To avoid repetition, details recorded in the valley descriptions are not restated.

In turn south to the Aln we cannot fail to note the different form displayed by each one. In the north, the valley of the Bowmont shows troughlike sections in parts, whilst that of College is more troughlike throughout. However, the Harthope and Breamish are contrasting, with the Aln valley ringing further changes in valley form. The writer suggests that

some ... occurred in these valleys as the ice went
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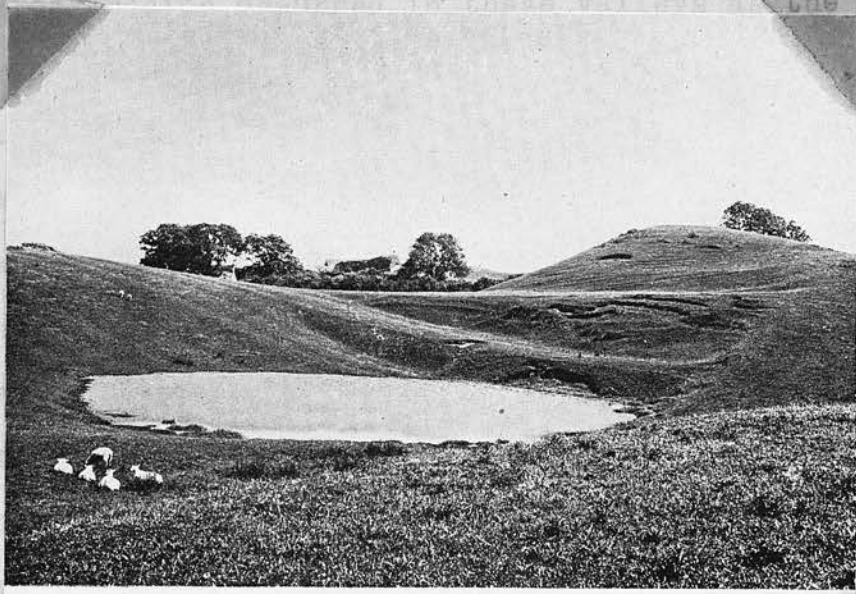
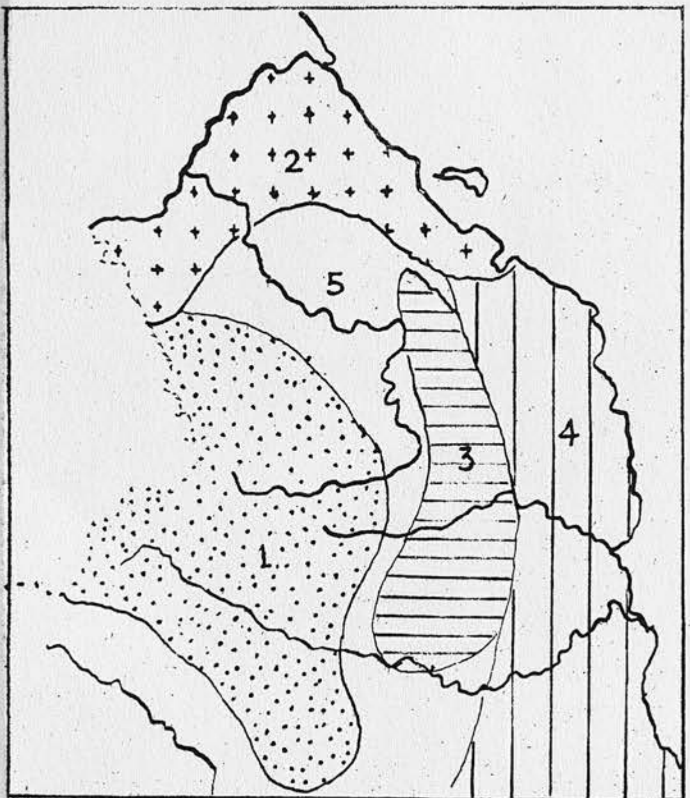


B.—KETTLE-HOLE IN GLACIAL GRAVELS, NEAR CORNHILL, NORTHUMBERLAND.

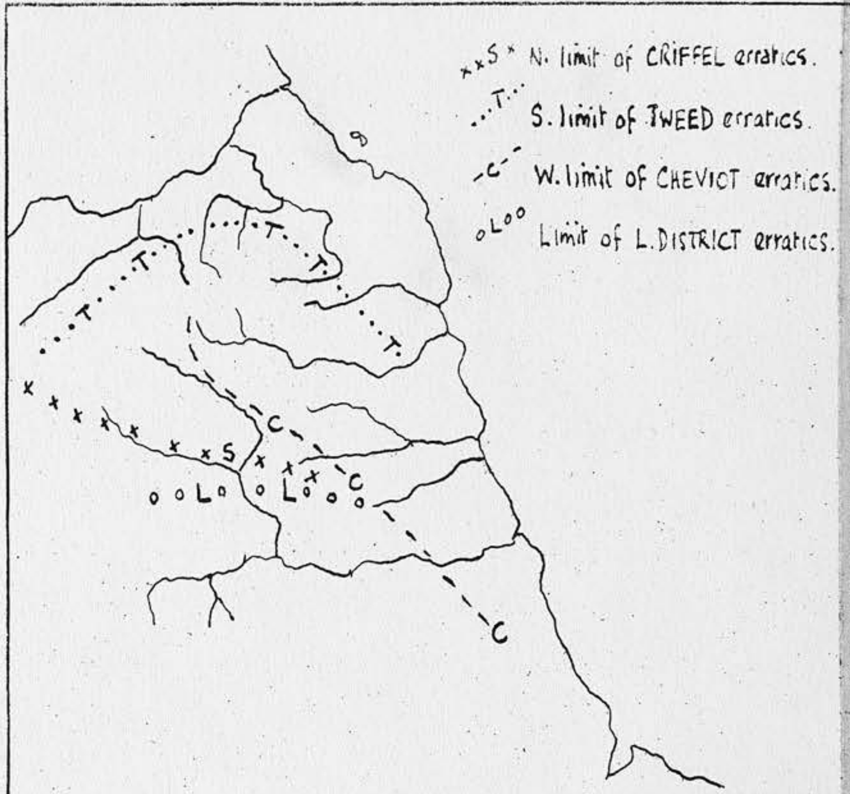
Tweedside behaved rather differently, for ... lay in the lines of the main ice stream) The writer considers that similar features to those described by R.P. Sharp (J. Journal Glaciology Oct. 1948) on extrusion flow etc. might be invoked to explain glacial flow during this post maximum glaciation phase within the massif, e.g. Fleehope and Fawcett Shank. Again, at the period of maximum glaciation the ice streaming around the Cheviotsunatak must have been comparatively clean for "foreign" erratics are absent. "Foreign" erratics occur only along the massifs margin, and data from in turn south to the Aln he cannot fail to note the different form displayed by each one. In the north, the valley of the Bowmont shows troughlike sections in parts, whilst that of College is more troughlike throughout. However, the Harthope and Breamish are contrasting, with the Aln valley ringing further changes in valley form. The writer suggests that some ice erosion occurred in these valleys as the ice went into them, but once installed, the valley ice formed a cushion over which ice flowed during maximum glaciation. There may have been some extrusion flow by the lower layers of ice in the cushion, or it may have been non-effective, and furthermore, the active upper icelayers would flow along lines different from those beneath them. Once past the maximum phase of glaciation, the ability of ice to override the higher ground of the massif would be reduced, and there probably was some movement of ice again in the Bowmont and College valleys (The ice in the Aln valley, like that in Tweedside, behaved rather differently, forboth lay in the lines ofthe main ice stream) The writer considers that similar features to those described by R.F. Sharp (B. Journal Glaciology Oct. 1948) on extrusion flow etc. might be invoked to explain glacial flow duringthis post maximum glaciation phase within the massif, e.g. Fleehope and Fawcett Shank. Again, at the period of maximum glaciation the ice streaming around the Cheviotnunatak must have been comparatively clean for "foreign" erratics are absent. "Foreign" erratics occur only along the massif's margin, and date from



P29. Physical Land Classfn. of N'ld. & Durham. N.E.D.A.

PARENT MATERIAL OF SOILS.

1. Igneous
2. Old Red Sandstone.
3. Fell Sandstone
4. O.R.S. & Lower Carboniferous
5. Mainly Carboniferous till but some admixture.



From PGA 1931 page 283.

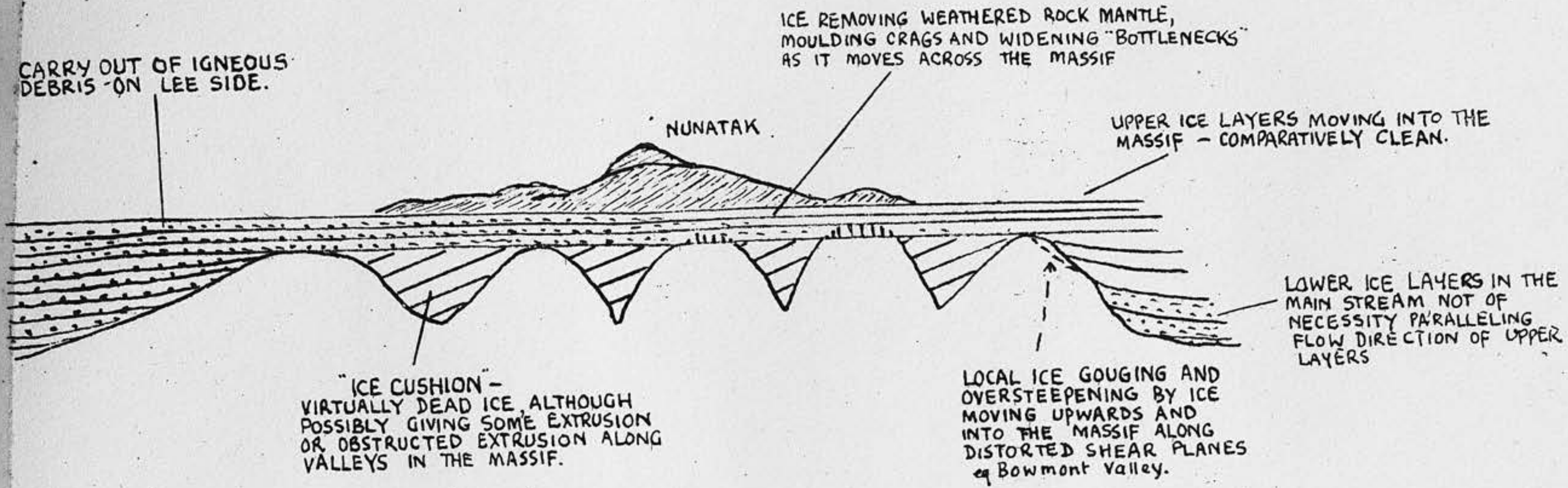


DIAGRAM RECONSTRUCTING PROCESSES OVER CHEVIOT MASSIF (EAST END)
DURING MAXIMUM GLACIATION

-Rc 52-

a later period when the ice thickness had been reduced. The work of the ice as it moved over the higher ground seems to have been the uplifting of weathered igneous rock fragments, local erosion to produce glacially aligned crags, and the widening of "bottlenecks" along the line of ice flow. A more general effect wasprobablythe subduing of hill outlines over the "tread and riser" terrain between Cheviot and Wooler. The writer suggests that Chamberlin's diagram of ice moving over a projection in the bed of a glaciermight, with modification, serve to illustrate what occurred on the E. Cheviots during maximum glaciation (see fig. opposite).

Whether one considers the area has been glaciated but once or several times, it will be agreed that ice flow direction has been subject to large and small scale fluctuation. In the former case it probably was the Scandinavian icesheet which called the tune, whilst in the latter, ice thickness and topography exerted additional controls. (The lavas, because of their mode of weathering, do not hold glacial striations, so that the writer has been forced to rely more exclusively upon topographic features, in assessing iceflow directions in the igneous area). The notion of the lower layers of ice moving in one direction and the upper layers of the same sheet moving in another is not new, and seems to be applicable to this area. Again, a comparison of observations made concerning the ice "high water mark" suggests that the upper surface of an ice sheet passing through hill ground is more tolerant to height differences than water, (i,e. ice does not seem to strive to maintain its own level as water would). One concludes that ice first streamed down Tweedside and along the Aln valley prior to deflection southwards. At this early period ice may have flowed north-eastwards along the valley lines north of the present College /Glen line. The next phase saw the main Tweed valley ice being deflected southwards over the low ground, whilst in the hills the direction of ice flow became first oblique, and later probably tangential to what it had been along the north side of the massif. In this phase the right bank of the present Bowmont became heavily scored by ice moving into and over the Bowmont/College watershed. Iceflow in the lowerlayers of valley ice either ceased or was reduced to small-scale extrusion flow whilst the higher parts of the massif became nunataks. In this phase, too, the flow of ice down the Aln valley was probably first checked and then deflected southwards. At a later period, however, the Aln ice may have partially re-asserted itself, for during the earlier phases of ice recession the behaviour of meltwater channels along the upper Aln - Breamish divide suggests that the Aln ice was thicker temporarily than ice coming from the north. We have the coincidence here, along the Aln-Breamish divide, of a watershed which also was an ice divide.

Whilst later stages of glaciation have left a comparative abundance of evidence around the periphyry of the massif (see meltwater diagram M.F. p28) in the form of fluvio -

glacial deposits and meltwater channels, along the coastal plain the evidence is not so readily apparent (see overburden map however). M.F. p.27 The volume of superficial material laid in the Milfield, Chatton and Hedgeley basins must be considerable and points to infilling of glacially overdeepened areas, with the Eglingham and Aln gravel trains presumably the outcome, amongst other things, of ice lying to the north of Hedgeley and Alnwick. The presence of dead ice, during the recessional stages, south of Cornhill proposed by Geological Survey officers is readily acceptable - but unfortunately the story is incomplete. There is a lack of recent work in the Merse and whilst the writer has done some work in the Jedburgh* area, little is forthcoming on the Hownam area. In his recent article on the "Retreat stages ofthe last ice sheet in the British Isles"(Irish Geography 1952) Synge provides a map (p.169) which is incomplete between Stage 1 and Stage 3 along the east coast. The writer suggests that the counterpart to Synge's second stage in Cumberland lies around the eastern margin of the Cheviots from Cornhill - Hedgeley basin and north side of the Aln valley. Furthermore, Synge's suggested mode of drumlin formation (or is it mode of drumlin preservation?) deserves consideration - for what better way is there of explaining the course of the Tweed below Leaderfoot than

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*Meltwater features certainly occur south and south-east of Jedburgh but it is as yet uncertain whether they are linked to the series north-east of Yetholm.

to postulate diversion by "dead ice"?

On the coastal plain the sand and gravel deposits associated with the Bradford Kaim are judged by the author to result from several factors. Firstly, esker-like remnants have been preserved near Spindlestone (Long Barracks) between Newham and Preston, and a small fragment occurs on Longlee Moor (S. Charlton). The presence of the Waren gap and S. Charlton gap recall similar features seen near Burn of Vat, Deeside associated with eskers* . Amidst terminal ice deposits an esker is seen rising eastwards towards a minor watershed. The esker peters out but is replaced immediately by a meltwater channel which continues the esker alignment. By analogy then, the Waren gap was probably used by subglacial meltwater, as, too, was the S. Charlton gap. The writer does not imply that water borne deposits were laid contemporaneously alongthe line from Spindlestone - Longlee Moor, for the composition of the long Barracks esker suggests it formed late and was formed from material carried but a short distance from its source. However, the very alignment and form of these sands and gravels suggest they were formed after the coastal section of the icesheet had separated from that inland, and the following interpretation is offered to explain them.

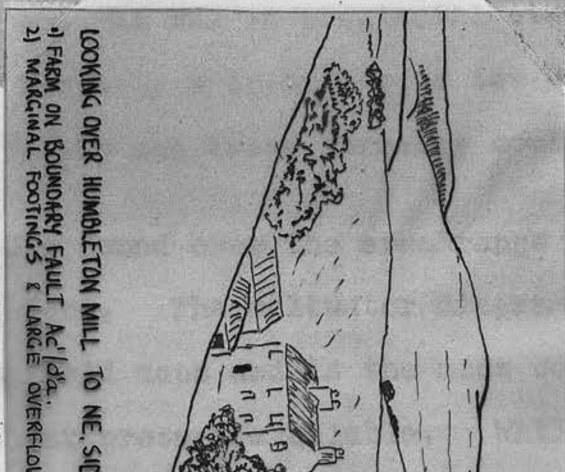
The coastal ice terminated along the north side of the

* The writer wishes to thank Dr. K. Walton, Aberdeen University for drawing his attention to this relationship.

Aln, and being in the piedmont phase showed an expanded foot. The retreat of ice to the northeast would be accompanied by attempts of meltwater along the western margin to repeat the phenomenon seen in the Hedgeley basin. However, with small catchment areas to draw upon and smaller water volumes, the meltwaters coming away off the cuesta would not be able to deposit such extensive areas of drift, and probably they reworked parts of the esker and esker cones as they emerged at the ice margin. By this means the drift deposits would show esker-like stretches interrupted by spreads, whilst any meltwater channels preserved would be convergent on the drift deposits - which is a fair description of the present day distribution of thesefeatures. One would expect, further, to find the drift deposits variable - in placesshowing clear bedding, in others, where the drift is of glacieluvial origin, the bedding not so apparent. North of Newham (see photo) very clear bedding is seen in a sand exposure, whilst S.W. of Newhouses, in a silage pit, the deposits are coarser, gravelly and show cruder bedding.

In the still later stages of ice recession or in post glacial times a temporary transgression may have occurred, with water standing first at 200' A.S.L. and later 150' A.SL Sufficient has been seen over the area studied to support the views of W. Anderson (British Assoc. Newcastle. 1949), D. Woolacott (Geol. Mag. 1921 The Interglacial Problem) and Mr. Knox (Geol. Survey, Edinburgh) who find signs of transgression at this height elsewhere in the North country.

Following upon this [illegible] there was a relative lowering of sea level again to [illegible] level, followed in turn by another rise [illegible] present [illegible] - recorded by the submerged [illegible] along the Northumbrian coast. But [illegible] present day S.L. is relatively [illegible] for surely the [illegible] just as the [illegible] of Berwick.



Meltwater [illegible] in their definition [illegible] (M.P. p.28) was constructed from [illegible] comprehensive map of these features [illegible] reference has already been made [illegible] (M.P. 69, 70, 72, 73, [illegible] 122, 125, 127, 129, [illegible] 189, 192, 198, 200) [illegible] to differentiate the differing [illegible]

1. "Master" channels [illegible] rates of [illegible]

2. In and out channels appear on valley sides in several localities e.g. [illegible] valley and [illegible] valley. In many cases, these, too [illegible] but in bedrock.

3. Marginal footings appear on some of the peripheral slopes e.g. Humbleton Hill, and [illegible] may be present.

* THE READER IS ALSO REFERRED TO THE AIR PHOTO & [illegible] DIAGRAM [illegible]

Following upon this transgression there was a relative lowering of sea level again to below present day level, followed in turn by another rise of the sea to its present mark - recorded by the submerged "forests" (e.g. Howick) along the Northumbrian coast. But even so, the writer maintains that present day S.L. is relatively above what it was in preglacial times, for surely the Aln was formerly a tributary to the Coquet just as the Whiteadder joined the Tweed formerly south-east of Berwick.

Meltwater channels found over the area range widely in their definition and form. The meltwater diagram (M.F. p.28) was constructed from field maps and is the most comprehensive map of these features at present available. Whilst reference has already been made to some of the channels in passing (e.g. P. 69, 70, 72, 73, 81, 92, 96, 97, 98, 103, 112, 116, 118, 120, 122, 125, 127, 129, 131, 143, 146, 160, 163, 166, 170, 174, 176, 189, 192, 198, 200) it is now considered appropriate to differentiate the different types.*

1. "Master" channels. These lie along the massif's margin in particular between Kirknewton and Earle. They are extremely deep (100'+), cut through bedrock and besides carrying a substantial volume of water must have been long used. In some cases, e.g. Wooler golf course, they show multiple intakes, two way talwegs and hanging tributary meltwater cuts. Several of these "master" channels are associated with convergent series of lesser channels which suggest unequal rates of ice margin retreat e.g. Kilham, Kingston Dean.

2. "In and out" channels appear on valley sides in several localities e.g. Coldgate valley and Carey valley. In many cases, these, too show two way talwegs, cut in bedrock.

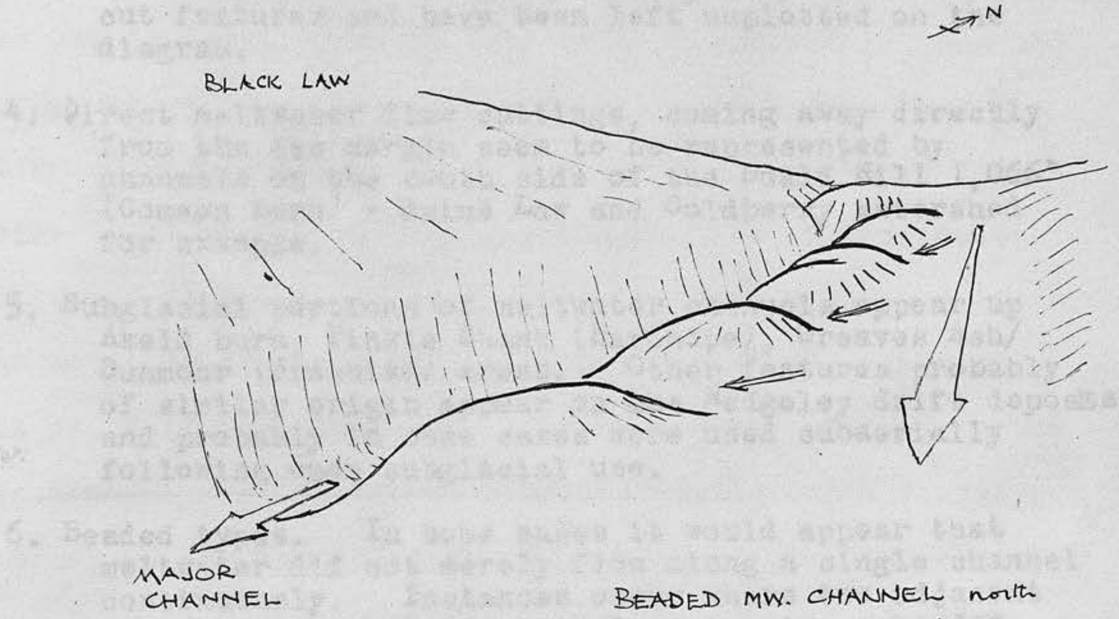
3. Marginal footings appear on some of the periphyral slopes e.g. Humbleton Hill, and whilst some may be present

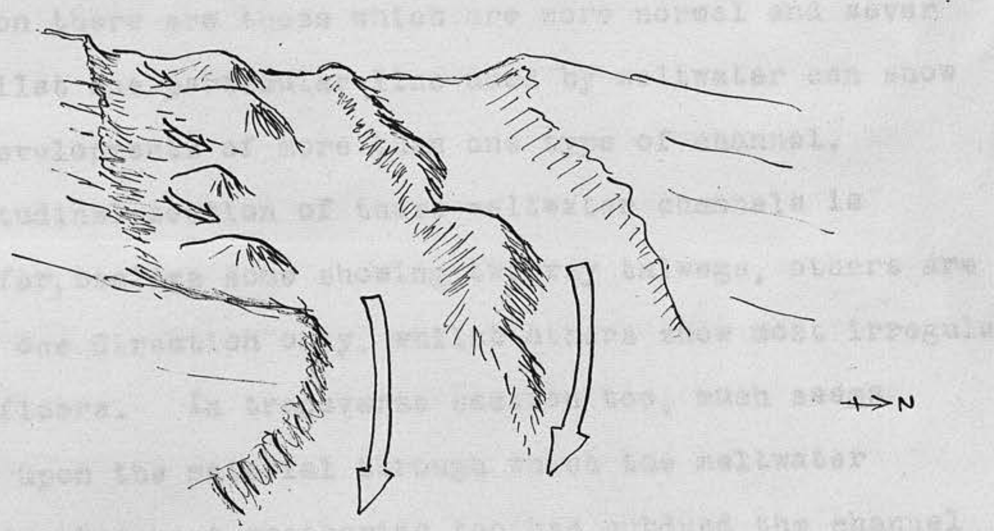
* THE READER IS ALSO REFERRED TO THE AIR PHOTOS & INSET DIAGRAM p.17. M.F. (Also Air Photo 5009)

Semi diagrammatic field sketch at SHINING POOL showing trunk stream prone to braiding & flooding in gorgelike stretch. Also the relationship of some of the m. water cuts convergent on this point.

N

-RC 51.





SEMI-DIAGRAM FIELD SKETCHES.

-RC. 1951.52.-

on the major cuesta scarp crest, they are not clear cut features and have been left unplotted on the diagram.

4. Direct meltwater flow cuttings, coming away directly from the ice margin seem to be represented by channels on the south side of the Scald Hill 1,066' (Common burn) - Gains Law and Coldberry watershed for example.

5. Subglacial portions of meltwater channels appear up Akeld burn, Pinkie Shank (Harthope), Greaves Ash/ Dunmoor (Breamish) areas. Other features probably of similar origin appear on the Hedgeley drift deposits and probably in some cases were used subaerially following upon subglacial use.

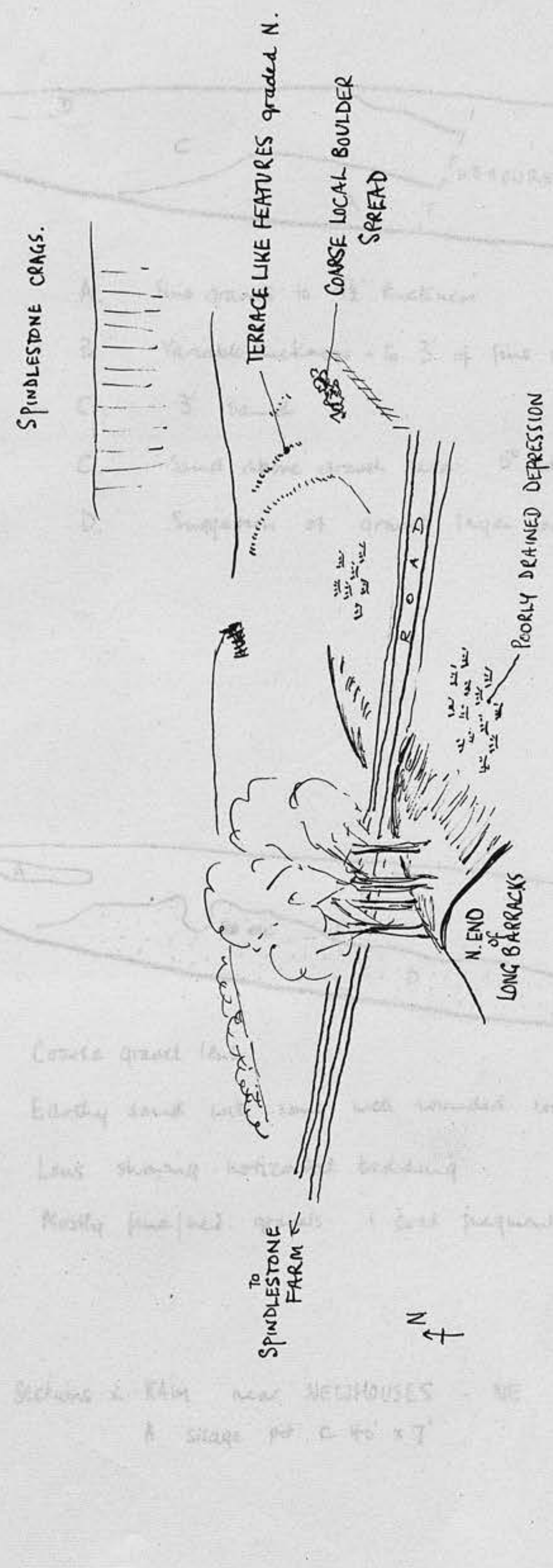
6. Beaded types. In some cases, it would appear that meltwater did not merely flow along a single channel continuously. Instances occur where two adjacent channels occasionally interlace to give a beaded effect e.g. near the Trows, south side of Mid Breamish valley. In most cases, however, one of the channels appears to have become dominant and hence is deeper or more clearly defined than the other.

In addition there are those which are more normal and sever spurs, whilst one particular line used by meltwater can show partial developments of more than one type of channel. The longitudinal section of these meltwater channels is variable, for, besides some showing two way talwegs, others are graded in one direction only, whilst others show most irregular ungraded floors. In transverse section too, much seems to depend upon the material through which the meltwater passed, and subsequent weathering too has subdued the channel sides, in many cases, by the production of screeing.

In many instances to-day one finds that the upper section of a tributary burn lies in one of these meltwater channels, and, without doubt, sections of the major streams would be swollen by meltwaters during ice recession. Mention has already been made of the Kale and Bowmont diversions, the use by the present R. Till of the Weetwoodhill gap and the plugging of an overdeepened valley line from Wark towards Pallinsburn. It is further suggested that the lower Tweed has suffered diversion because of glaciation, but since the present Tweed course between Kelso and Leaderfoot has not been examined in detail the extent of diversion is not yet fully ascertained. The reader is referred to the map showing present stream characteristics for a visual summary of the main effects of glaciation upon the streams.

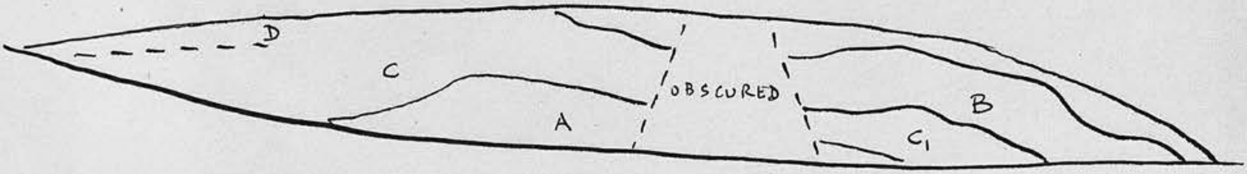
Turning next to weathering features produced under colder climatic conditions, the writer has formed the opinion that most of the features suggested might be periglacial in origin. Without experience and field knowledge of true periglacial features the writer has relied upon descriptions and illustrations in published papers and is conscious of these shortcomings. Already the number of shattered tors and markedly weathered crags have been noted in the massif. One wonders, too, to what extent man has aped nature and improved her soliflucional terracing and modified her stone polygons to give hut circles? Certainly some of the cultivation terraces up Bowmont have difficult sites and incorrect exposures to be originally man made. Again, the numbers of discontinuous facets along some of the valley sides in the massif may be altiplanation features. Good solifluction terraces are seen along the S.E. side of Preston Hill and N.W. side of Broadhope hill. Finally

The BRADFORD KAIM



F. SKETCH AT N end of BRADFORD KAIM.

WEST SIDE.



A. Fine gravels to 4½' thickness

B. Variable thickness - to 3' of fine gravels.

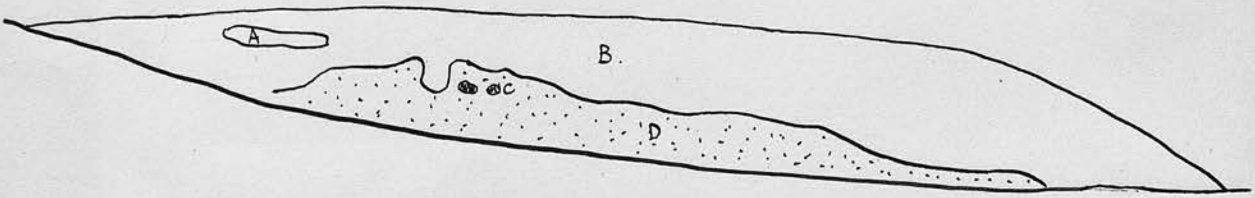
C_1. 3' Sand

C. Sand above gravel base 5° south dip where bedding seen

D. Suggestion of gravel layer (or material coarser. 2' thick.

→N

EAST SIDE.



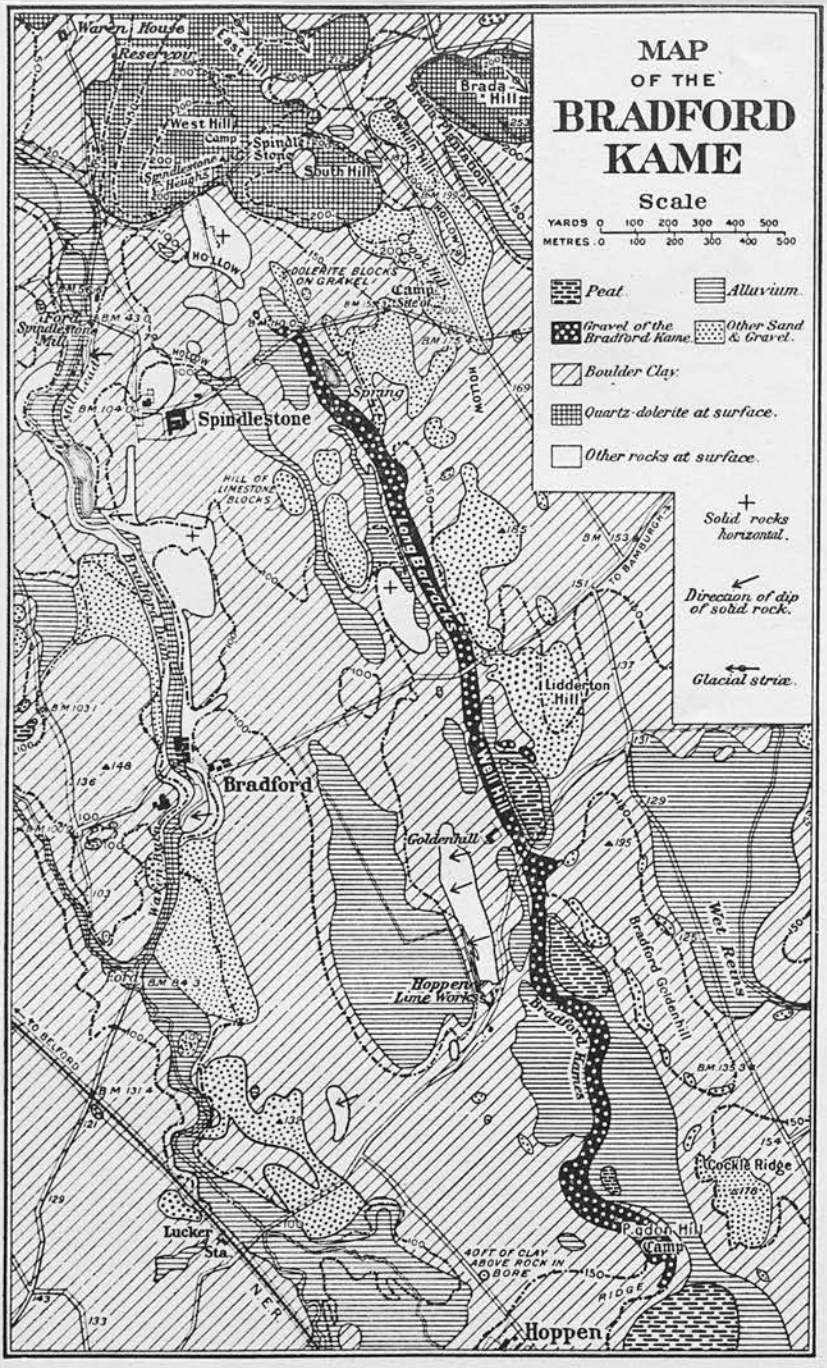
A. Coarse gravel lens.

B. Earthy sand with some well rounded rock fragments present

C. Lens showing horizontal bedding

D. Mostly fine/med. gravels + coal fragments.

Sections in KAIM near NEWHOUSES - NE. ELLHILL
A silage pit c 40' x 7'



Map of the Bradford Kame and its surroundings.

p. 136 G.S. Memoir "Belford ..."

there are evidences of nivation hollows in various stages of development around Cheviot and the high ground south of it.

THE BRADFORD KAIM

It only remains to provide a more detailed account of the form shown by the drift deposits lying between Spindlestone and Longlee Moor.

Near to, and east of, Spindlestone farm, the Long Barracks ridge virtually terminates on the south side of the roadline. Between the road and Spindlestone crags are low terrace features 10-20 yrds. width, 6-9' height, which lie along the western foot of South Hill. Above the terraces, a short train of large Whin boulders is to be seen, and these are obviously not far removed from their source. Below, near the road, there is a small waterlogged depression, backed by a low mound, which probably forms the northern end of the Long Barracks. Above all these features on the N. side of the road, the ground is first hummocky, but becoming smoother as one moves onto the sand and gravels between South Hill - Crookhill.

Long Barracks looks very esker like, at its northern end about 6' height, but quickly rising to 30-40', before lowering again southwards to about 20' height. In places the ridge is symmetrical, but elsewhere is hogbacked, with the longest slope to the west, and the steepest slope to the east. The ridge contents seem to be variable, for in one locality 1"-2" rock fragments in a ¼"-⅛" gravelly matrix contrast with another section seen at the Bradford road cutting. In this cutting erratics to head size occur, although most rock fragments tend to be fist size and partially rounded. Included were Whinsill, Chesterhill Dean Lst., sandstone, Dun(?) lst. and gray limestone materials. The width of the Long Barracks ridge is variable, probably 30-40 yards atits greatest, and about 70' at the roadcutting mentioned. To the west of the ridge lies a hillock of limestone blocks, flat crested, paralleling the ridge alignment and separated from it by a NNW/SSE aligned depression. South of this feature and closer into the Long Barracks lies another, though less defined, feature. It is a low ridge, (ice eroded outcrop), which first parallels the esker ridge, then turns into it southwards, and as it converges so it loses definition.

Well Hill, lying east of Goldenhill farm, continues the Long Barracks ridge, also being steepest on the E. flank, and showing the longest slope to the west. On the east side of Well Hill another depression, like that at the north end of Long Barracks, appears, but is of greater dimension here. A kettlehole is suggested, and two former strands show above the present pond level. West of Well Hill, there is the tendency to have repetition of the ridgelike features seen south of Spindlestone, and west of the Kaim.

East of Hoppen Hiln, sinuous ridge remnants wind southwards to Pigdon Hill, where the sands and gravels merge into a till ridge from Hoppen. Between these features and

Bradford Goldenhill to the east, lie flats with small remnants of former water levels present. Again, the content of the ridge features still seems variable, for pure sand in quantity was observed in one locality, whilst elsewhere on the north side of Pigdon Hill bedding was seen, with indications of grading having occurred.

The writer does agree with the Belford Memoir that, in the north, the Long Barracks ridge was late formed, and not by strongly running water. Southwards, however, the presence of sand and some bedding suggest that running water was relatively more important. For fuller details, the reader is referred to the Belford Memoir p134-p152.

As already mentioned, the observer may judge the upstanding till deposits on the east side of the northenn part of the Bradford Kaim as drumlin or possibly moraine (lateral?).

South from Hoppen to Newham, the sand and gravel deposits appear now to be in residual form, but are assessed to have been formerly a spread. Variability in character still seems to be typical, for two sections separated by about 1500 y ards are contrasting (see photos.). The section SW of Newhouses shows occasionally bedded lenses in gravelly deposits (see sections opposite), whilst near Newham 6' of sandy dark brown laminated clays overlie 3' (exposed) fine grained light sands, also bedded. (Note: Included coal fragments helpful in showing bedding.)

Emerging from the sand and gravel mass at Newham, another esker like stretch continues southwards. Chat Hill is sinuous in form, flat crested and terraced on the western flank. The lowest terrace, however, at c. 125' appears to be natural, and possibly dates from a period when water stood in the Long Nanny valley southwards. An exposure on the SE side of the hill showed gravel particles, pea to egg sized, rounded but without any signs of sorting or grading visible. Topographic definition is maintained southwards to near Preston but, beyond, the sands and gravel deposits reappear in force near Doxford.* In this area, Dunstan Hill camp is located on a flat topped mound of coarse sandy gravel. Fragments of the Chesterhill Dean 1st., Whinsill and sandstone are noted in the deposits, whilst meltwater probably was responsible for cuttings on W. and E. flanks of the hillock. Between Doxford and Charlton Hall, the Shipperton burn is deeply incised between the drift and till junction, with 30' high bluffs present along the drift margin. West of Doxford, too, a topographic depression west of Combe plantation links the Charlton and Shipperton burn lines, and suggests meltwater activity. In the North Charlton area and near West and East Linkhall the drift deposits have been used in earlier times for settlement sites.

* See G.S. Memoir Alnwick District p95-p97 for further details.

As a result, many of the features displayed now are of artificial origin, but natural kettleholes still appear. The kettling displayed on the drift deposits near North and South Charlton is clear but on a much smaller scale than that displayed in the Till catchment (i.e. Hedgeley and Cornhill).

Whilst in agreement with Burnett* on the details of the sand and gravel deposits lying near S. Charlton on Longlee Moor, and their connection with the Bradford Kaim, the writer prefers a slightly different interpretation for the production of the whole Kaim (already described).

* See Proc. Berwick Nat. Club, 1934.

A SHORT GEOGRAPHICAL APPRECIATION.

The Cheviot Hills, at their eastern end, rise above the lower ground of the Till/Breamish and Aln valleys in horst like fashion, being partially encompassed to seaward by a cuesta of essentially arenaceous sediments. They form a barrier to lines of communication and, in large part, are inaccessible except by foot or on horseback. The cuestas, major and minor, form less formidable barriers , but channel present roads and railways into topographically more favoured routes. To the north, lies Tweedside and Teviotdale, where the ground is lower and more open, but subject to social and administrative anomalies because of the national boundary line.

In the past, the inaccessibility of the Cheviots has been used to advantage by earlier people who established themselves in the Bowmont, College and Breamish valleys.* In later times, the pele towers and castles erected to protect the "English

*The exception is afforded by the earliest settlement near Wooler. Here settlement was on and about Humbleton Hill, but it is of interest to note that, as time passed, people came off the Hill to the footslopes at Humbleton, and later moved down to the present site at the neck of the Wooler Water Gap and above the heughland. One wonders to what extent these earliest people indulged in seasonal migration with their livestock, and the writer queries many of the "forts" shown on the topographical maps of the area as being such. Instead, it is suggested that many of these forts" could have been used for the protection of animals grazing on the hill. Finally, there is the need for the "cup and ring" markings, commonly found over the sandstone country, to be systemmatically checked and considered as rock maps (as suggested by F. A. Wills in "The English Gate").

Gate" show a marked appreciation of topography in their siting.

The E. Cheviots rise into the upstanding core by "tread and riser" topography, but, whilst the northern flank has been dissected by streams to the ridge state, to the south of the R. Glen a dissected plateau like aspect remains. Along the southern flank, too, there is a dissected plateau like character, but to the west in Upper Coquetdale the sedimentary cover has not been stripped back so far as elsewhere. As a result, the ground here also looks plateaulike but dissected into scarplike features. Who, travelling southwards, by road, over the Carter Bar, has failed to be impressed by the change in the landscape south of the Border upon coming off the O.R.S. rocks onto the Carboniferous? Flowing out from the Cheviots come the Bowmont, College, Harthope and Breamish streams, in deep valleys possessing distinctive characteristics. The Bowmont and College valleys are floored by glacial deposits to a greater extent than the others, whilst in the Harthope and Breamish it is those sections nesrest the massif's margin which have the most glacial deposits present. These deposits are deficient in clay content and the stream alluvium is often coarse. In the Bowmont valley there is a considerable amount of heughland available for agriculture, but in the College, Harthope and Breamish coarseness of superficial deposits and/or bad management (i.e. reduction of carrying capacity due to establishment of bracken) are to be noted. The future of the hill area depends upon several factors. Inaccessibility and exposure are most important considerations, whilst the "flashy" tendencies of the streams add complications. Even if, by public demand, the area is set aside for recreational purposes, there is still the need to have nearby trunk roads improved. However, since the lower hill slopes and stretches of the valleys have been planted, it seems reasonable to suggest that the area under timber could be increased.With nearby rural districts without really satisfactory and reliable water supplies, it seems logical to look to stretches of these valleys as likely sites to be impounded for water supply.

In the low lying areas periphyral to the igneous massif there is the need for more positive methods of flood prevention than those shown at present. Here, as one might expect, the limits of agriculture,(at the upper margin) have fluctuated with the fortunes of this industry. The writer mentions areas of ground up the Humbleton burn valley (Wooler Moor), up the Breamish near Chesters, Hartside and Linhope which have been improved formerly, but now appear to be reverting. (Abandonments occur at Humbleton, Old Middleton, and Wooler Moor)

On the sandstone cuestas, minor and major, the twin curses of impeded drainage and wrong exposure must be faced if the land is to be improved. On these areas it is the cold NE and E winds which are most unfavourable, whilst below the surface "pan" layers probably require destroying. The uses of shelter belts in the Barmoor area would probably do much to offset its present bleakness, whilst on the major cuesta the Kyloe and Detchant timber stands show what could be done elsewhere on this largely negative area. On both these cuestas, coal was formerly extracted by bellpitting and there may be a good topic for research here. Certainly, some of the older local inhabitants can recall some of these pits working in their youth.

To the east on the coastal plain, conditions generally are more favourable, but here, too, the cold Nor'Easter and haars introduce harsher elements into the climate. Windbreaks near the coast, immediate conservation of the cliffs south of Spittal and at Seahouses, and the introduction of long term reclaimation projects for the Holy Island area and Budle Bay, should be considered. It would seem that Highland cattle are being tried in some of the more exposed coastal tracts, whilst, on the hill, cattle seem to be more numerous on the Scottish side of the Border than on the English side.

Two maps are provided to accompany this short section, and in both cases the limiting factors of clarity in representation and ease of interpretation have been considered. (see M.F pages 29, 30.)

B I B L I O G R A P H Y

Milne Home, D. 1876 Notices of High Water Marks on the Banks of the River Tweed, and Some of its Tributaries.
Trans. Roy. Soc. Edin. Vol. 27, [illegible] pp. 513 - [illegible]

Tate, G. 1868 The Cheviots.
Proc. Berw. Nat. Club. Vol. 5 pp. [illegible] - [illegible]

Tate, G. 1866 Records of Glaciated Rocks in the E. Borders
Proc. Berw. Nat. Club, vol. 5, pp. [illegible] - [illegible]

Smythe, J.A. 1914 The Glacial Geology of Northumberland
Trans. Nat. Hist. Soc. Northumberland Vol. 4 pt. 1; pp. [illegible]

Smythe, J.A. 1923 A Seceded Burn.
The Vasculum Vol. [illegible], pt. 1; p. [illegible]

Geol. Survey Memoir 1936 The Geology of the Country around Rothbury, Amble and Ashington.
H.M.S.O.

Geol. Survey Memoir 1927 The Geology of Belford, Holy Island and the Farne Islands
H.M.S.O.

Geol. Survey Memoir 1932 The Geology of the Cheviot Hills
H.M.S.O.

B I B L I O G R A P H Y

Milne Home, D.	1876	Notices of High Water Marks on the Banks of the River Tweed, and Some of its Tributaries.
		<u>Trans. Roy. Soc. Edin</u>. Vol. 27, pt. 4 pp. 513 -
Tate, G.	1866	The Cheviots.
		<u>Proc. Berw. Nat. Club</u>. Vol. 5 pp. 359 - 370
Tate, G.	1866	Records of Glaciated Rocks in the E. Borders
		<u>Proc. Berw. Nat. Club</u>, vol. 5; pp. 236 - 240
Smythe, J.A.	1914	TheGlacial Geology of Northumberland
		<u>Trans. Nat. Hist. Soc. Northumberland</u> Vol. 4 pt. 1; pp. 86-116
Smythe, J.A.	1929	A Beheaded Burn.
		The Vasculum Vol. 15, pt. 1; p. 12.
Geol. Survey Memoir	1936	The Geology of the Country around Rothbury, Amble and Ashington.
		H.M.S.O.
Geol. Survey Memoir	1927	The Geology of Belford, Holy Island and the Farne Islands
		H.M.S.O.
Geol. Survey Memoir	1932	The Geology of the Cheviot Hills
		H.M.S.O.

Geol. Survey Memoir	1930	The Geology of the Alnwick District H.M.S.O.
Geol. Survey Memoir	1926	The Geology of Berwick on Tweed, Norham and Scremerston. H.M.S.O.
Geol. Survey Memoir	1888	The Geology of the Cheviot Hills (English Side) H.M.S.O.
Geol. Survey Memoir	1887	The Geology of the Country around Otterburn and Elsdon. H.M.S.O.
Geol. Survey Memoir	1895	The Geology of Part of Northumberland (Wooler/Coldstream) H.M.S.O.
Geol. Survey	1946	British Regional Geology "Northern England" H.M.S.O.
Geol. Survey	1948	British Regional Geology "The South of Scotland" H.M.S.O.
Geol. Survey	1948	British Regional Geology "The Tertiary Volcanic Districts, Scotland" H.M.S.O.
Various,	1931	Contributions to the Geology of Northumberland and Durham. <u>Proc. Geol. Assoc.</u> Vol. 42; pp. 217 - 296.

Eckford, R. 1928 On Certain Terrace Formations in the South of Scotland and the English Side of the Border.

Trans. Soc. Antiq. Scot. Vol. 2, Series 6; pp. 107 - 120.

Hollingworth, S.E. 1938 The Recognition and Correlation of High Level Erosion Surfaces in Britain.

Q.J. Geol. Soc. Vol. 94, pp. 55 - 78

Jones, O.T. 1938 Anniversary Address on the Evolution of a geosyncline.

Q.J. Geol. Soc. Vol. 94, pp. 60 - 106

Carruthers, R.G. 1939 On the Northern Glacial Drifts: Some Peculiarities and their Significance.

Q.J. Geol. Soc. Vol. 95 pp. 299 - 328

Jhingran, A.G. 1942 The Cheviot Granite

Q.J. Geol. Soc., Vol. 98, pp. 241 - 253

Paterson, T.T. 1940 The Effects of Frost Action and Solifluction around Baffin Bay and in the Cambridge District.

Q.J. Geol. Soc. Vol. 96, pp. 99 - 126

Woolacott, D. 1905 The Superficial Deposits and Preglacial Valleys of the Northumberland and Durham Coalfield.

Q.J. Geol. Soc., Vol. 61, pp. 64 - 95

Woolacott, D. 1921 The Interglacial Problem and the Glacial and Post-glacial Sequence in Northumberland and Durham.
Geol. Mag., Vol. 58, pp. 21 - 32
68 - 69

Trotter, F.M. 1929 The Tertiary Uplift and Resultant Drainage of the Alston Block.

Proc. Yorks. Geol. Soc. Vol. 21; pp. 161 - 180

Baulig, H. 1935 The Changing Sea Level

Trans. Institute of British Geographers. No. 3 (G. Philip, London)

Cholley, A. 1950. Morphologie Structurale et Morphologie Climatique

Annales de Geographie, No. 317; pp. 321 - 335.

Cailleux, A. and Tricart, J. 1950 Un Type de Solifluction; les Coulées boueuses.

Revue de Geomorphologie Dynamique No. 1; pp. 4 - 46

Williams, J.E. 1949 Chemical Weathering at Low Temperatures

Geog. Review Vol. 39 (1); pp. 129 - 135.

Ogilvie, A.G. 1951 S.E. Scotland: The Region and its parts.

Scientific Survey of S.E. Scotland; Brit. Assoc. pp. 11 - 35

House, J.W. 1949 Physiography of N.E. England

Scientific Survey of N.E. England: Brit. Assoc. pp. 3 - 9

Hills, E. Sherbon 1943 Outlines of Structural Geology, 2nd Edition.

Methuen, London.

Kendal, P.F. and Muff, H.	1905	On the Evidence for Glacier Dammed Lakes in the Cheviot Hills. Trans. Edin. Geol. Soc., Vol. 8, pp. 226 - 230
Linton, D.L.	1951	Problems of Scottish Scenery Scot. Geog. Mag., Vol. 67 (2), pp. 65 - 83
Linton, D.L.	1933	The Origin of the Tweed Drainage System. Scot. Geog. Mag., Vol. 49 (3); pp. 162 - 175
Linton, D.L.	1934	On The Former Connection between the Clyde and the Tweed. Scot. Geog. Mag. Vol. 50 (3); pp. 82 - 92
Bailey, E.B.	1934	The Interpretation of Scottish Scenery Scot. Geog. Mag., Vol. 50 (5); pp. 308 - 330.
Ogilvie, A.G.	1944	Debatable Land in Scotland. Scot. Geog. Mag., Vol. 60 (2) pp. 42 - 45
Gregory, J.W.	1915	The Tweed Valley and its Relations to the Clyde and Solway. Scot. Geog. Mag. Vol. 31 (9); pp. 478 - 485
Fleet, H.	1938	Erosion Surfaces in the Grampian Highlands of Scotland. Rapp. de la Comm. pour la Cartographie des Surfaces d'Appl. Tertiares, Union Geogr. Internat., Paris. pp. 91 - 94.

Gregory, J.W. 1922 The English "Eskers" - their structure and distribution.

Geol. Mag. Vol. 59, pp. 25 - 29

Anderson, W. 1939 Possible Late Glacial Sea Levels at 190' and 140' O.D. in the British Isles.

Geol. Mag., Vol. 76, pp. 317

Bullerwell, R.G. 1910 On the Superficial Deposits at the Foot of the Cheviot Hills between Wooler and Glanton.

Geol. Mag. Vol. 7 pp. 452 - 458

Goodchild, J.G. 1904 The Geology of Lower Tweedside

Proc. Geol. Assoc. Vol. 18, p. 105

Macgregor, A.G. and Eckford, R. 1948 The Upper Old Red and Carboniferous Sediments of Teviotdale and lower Tweedside, and the Stones of the Abbeys of the Scottish Borderland.

Trans. Edin. Geol. Soc. Vol. 14, pt. 2 pp.

Tomkeieff, S.I. 1928 On the Weathering of Cheviot Granite under the Peat.

Proc. Univ. Durham. Phil. Soc. Vol. 7, pt. 4, pp. 233 - 243.

Butler, G. 1907 Anniversary Address on Lake Ewart.

Proc. Berw. Nat. Club, Vol. 19 pp. 97 - 107

Wooldridge, S.W.	1950	"The Upland Plains of Britain" Presidential Address to Section E., British Association, Birmingham.
Geikie, J.	1893	Fragments of Earth Lore. P. 62. J. Bartholomew
Milne, D.	1844	Geological Account of Roxburghshire. Trans. Roy Soc. Edin. Vol. 54. p. 443
Sharp, R.P.	1948	The Constitution of Valley Glaciers Journal of Glaciology Vol. 1 (4) P.182
Carruthers, R.G.	1946	The Secret of the Glacial Drifts I Proc. Yorks Geol. Soc. Vol. 27, P. 43
Carruthers, R.G.	1948	The Secret of the Glacial Drifts II Proc. Yorks. Geol. Soc. Vol. 27, P.129
Various	1949	Geografiska Annaler Arg. 31, Hafte 1-4
Miller, A.A.	1948	Presidential Address Trans. Inst. Brit. Geographers
Synge, F.E.	1952	Retreat Stages of the Last Ice Sheet in the British Isles Irish Geography P. 168
North East Development Association	1950	A Physical Land Classification of Northumberland and Durham A. Reid, Newcastle.
Flint, R.F.	1947	Glacial Geology and the Pleistocene Epoch John Wiley & Sons Inc., New York.

APPENDIX I

(a) Data for Hypsographic Curve

Total area considered 939.08 sq. miles

Contour	Area in sq. miles	Percent. Total
100'	840.52	89.5
200	712.28	75.8
300	584.64	62.2
400	494.32	52.6
600	81.82	8.7
800	52.77	5.6
1,000	33.48	3.4
1,250	18.90	2.0
1,5000	7.57	0.8
1,750	1.08	0.11
2,000	0.78	0.08
2,250	0.52	0.05
2,500	0.15	0.01

Cheviot summit 2,676'

(Coradi planimeter employed for measurements)

(b) Construction of the Clinographic curve

Average slope angles calculated as follows

$$\tan\theta = \frac{h}{R - r}$$

Where θ is the average angle of slope between two adjacent contours.

h is the contour interval in feet

R-r is the difference in feet of the radii of circles for adjacent contours drawn at equivalent areas to the true area

Average slopes

0 - 100'	1°21'	10 - 1,250'	3°10'
1 - 200	00°50'	1,250 - 1,500'	3°
2 - 300'	00°46'	1,500 - 1,750	2°45'
3 - 400	1°	1,750 - 2,000	28°19'
4 - 600	00°18'	2,000 - 2,250	27°21'
6 - 800	2°9'	2,250 - 2,500	14°7'
8 - 1,000'	2°42'	2,500 - 2,676'	8°42'

For the convenience of plotting 3 is taken to be the constant factor i.e. multiply these angles by 3.

Data used in assessing average slope values

R - r values (x5,280 to make unit constant)			Corresponding h. values.
	R	17.29	
	r	16.36	
0.93	r'	15.06	
1.3	r''	13.64	100'
1.42	r'''	12.54	
1.10	r^{iv}	5.104	
7.436	r^{v}	4.099	200'
1.005	r^{vi}	3.302	
0.797	r^{vii}	2.453	
0.849	r^{viii}	1.552	
0.901	r^{ix}	0.5862	250'
0.9658	r^{x}	0.4983	
0.1883	r^{xi}	0.4068	
	r^{xii}	0.2185	

e.g. consider angle between 800' and 1,000'

$$\tan\theta = \frac{200}{.797 \times 5280} \qquad r^{v} - r^{vi} = 4.099 - 3.302 = .797$$

$$\therefore \theta = 2^{\circ}42'$$

3. Altimetric curve

(i) Strips

Ht.	10/20	20/30	30/40	40/50	50/60	60/70
100						
200		← max.	Rising to a	← max.	← max.	← marked
300		250 & 350 mins *	500' max.	← max	250 – 450 min *	350 – 450 min *
400				← max		
500	Minimum *		←	450 min *	← 500 max	
600	← max.	min @ 650 *	600 min *			←5/600 max
700	Falls away to 950'			Equidimensional max. at 5, 6 & 700'.	Falling away to	Falls away to
800			Curve rises to a			
900	*		well marked		950 min *	900 min *
1,000			←1000' max.	← 1000' max		
1,100	← max c1150'	1100 min *	Descends to	falls away to	← 1100 -1150' max	
1,200	min. at 1250 *	← 1250 max	1200' min *			
1,300			← 1250 max	1250 min *		
1,400	min. at 1400 *	?	Indeterminate spread	← Slight max @ 1400		
1,500						
1,600				Indeterminate		
1,700	min. *	← 1750 max				
1,800	← slight max		min 1850 *	min 1850 *		
1,900	min *	min *				
2,000			← slight			
2,100						
2,200						
2,300				2350 ?		
2,400			?			
2,500						
2,600				?		

Summary.

Figures for Altimetric curve

(ii) 1. Based on prov. 1/25,000 sheets
2. 50' closed contours used for grouping

Height	Totals	Height	Total	Height	Total	Height	Total
50	42	750	41	1,450	20	2,150	0
100	58	800	48	1,500	19	2,200	0
150	45	850	28	1,550	18	2,250	0
200	149	900	52	1,600	18	2,300	1
250	70	950	24	1 650	14	2,350	2
300	93	1,000	58	1,700	9	2,400	2
350	26	1,050	36	1,750	12	2,450	0
400	68	1,100	28	1,800	14	2,500	0
450	27	1,150	40	1,850	2	2,550	0
500	79	1,200	15	1,900	0	2,600	2
550	40	1,250	36	1,950	3	2,650	0
600	81	1,300	17	2,000	3	2,700	0
650	48	1,350	19	2,050	0		
700	65	1,400	23	2,100	1		

(iii)* In an effort to compensate for the failure of the altimetric curve at higher altitudes, the writer has attempted to employ an index number. This number is obtained by dividing the number of summits at a given altitude by the area of ground at the same height above S.L. (Reference made to the hypsographic curve for the height areas).

It is suggested that a small index number will reflect, either a small scale of dissection, or, be the outcome of only a small area being available, on the ground. Again, constancy of index number over a height range may reflect a similarity in stage of dissection. Furthermore, a surface initially graded, then uplifted and subjected to subaerial erosion, might well show a decrease in index value with height prematurity. Post maturity, the reverse case might be anticipated. With these possibilities in mind the indices

* It is of interest to compare this technique with that proposed by O.T. Jones Q.J.Geol. Soc MAY 1952 —RC Oct 1952

were calculated and are duly tabulated. The results show the following features.

(a) From 250′ - 450′ a low number, progressively decreasing and followed by 500′ and 550′ values strikingly similar, but of increased amount.

(b) From 650′ - 950′ alternate values markedly similar, and at the upper end of this scale the incoming of new and higher values about 10.

(c) Finally at 1,450′ and 1,750′ marked changes in index values again occur.

Height	Index	Height	Index	Height	Index
ft.		ft.		ft.	
100	0.64	650	6.4	1 200	6.6
150	0.54	700	9.6	1 250	18
200	1.96	750	6.8	1 300	9 7
250	1 03	800	8.7	1 350	12.6
300	1.48	850	6 .2	1 400	18
350	1.6	900	12.2	1 450	10.2
400	1.2	950	6.4	1 500	24
450	0.9	1 000	17	1 550	24
500	2.63	1 050	12	1 600	36
550	2.2	1 100	10.2	1 650	56
600	9.3	1 150	16	1 700	53
				1 750	109

4. Sheet 81. Relative relief.

The pilot area was bounded by Thirlstane Hill (jus (just west of Hownam) and Cairn Hill (Cheviot S. side) on the south, with Hethpool and Coldsmouth Hill on the north. The eastern boundary was straight (between Hethpool and Cairn Hill) but the western ran from Coldsmouth to the source of the Curr Burn, then west to Morebattle Hill to turn south to Thirlstane. The assessment of relative relief was carried out on 1:25,000 sheet 41/64 S.E. using rectangles with 1,000 yard sides. Even an adjustment to rectangle sides of 2,000 yards still produced disappointing results.

										650	550	600	300	500
										650	450	600	700	1200
										450	450	550	800	900
										600	650	750	700	500
300	580	470	600	550	410	350	430	900	900	500	600	700	500	730
250	410	450	900	750	270	450	700	800	950	1100	785	500	700	700
300	450	530	720	750	590	550	600	640	600	900	900	900	1003	1078
250	550	350	450	400	400	530	650	500	410	650	637	1050	800	316
478	470	400	400	350	680	470	450	300	250	609	631	889	682	306

25 30 35 40

Ref. Sheet 41/6 4S.E.

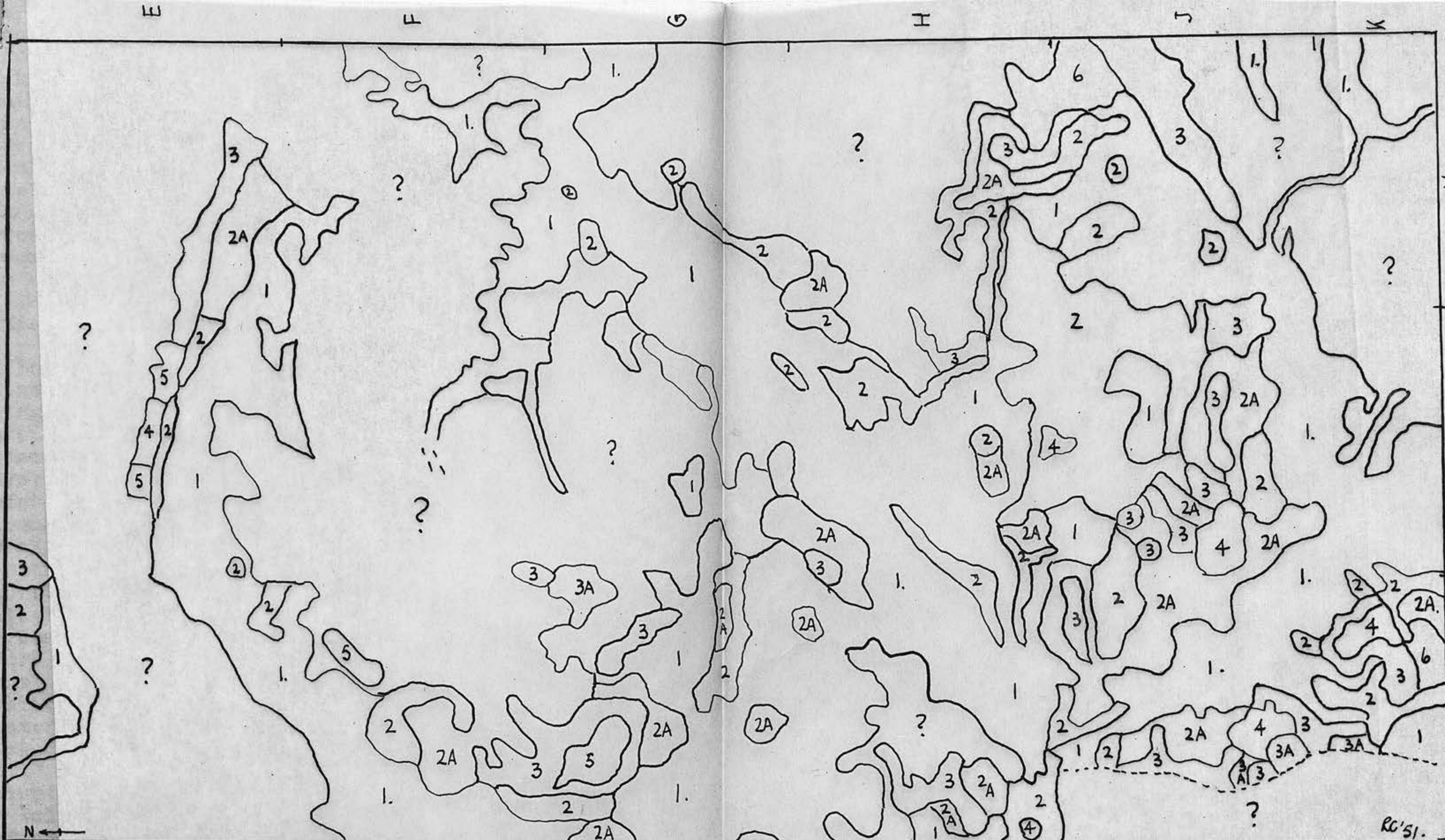
The assessment of slope values was based on the technique outlined by Wentworth. The conclusion reached from the "pilot area" was that in the area of the Cheviot volcanics it only afforded some index to relative relief and state of dissection.

The extreme S.E. corner of sheet 81 (1" O.S.S.) was gridded to produce rectangles with 1" sides. The results are tabulated below but in addition the actual directions of slope are included. It is this last factor more than anything else which discouraged further work in this area though the writer is prepared to admit that with relatively simple landforms largely untouched by subaerial erosion the technique probably does give satisfactory results e.g. scarp and dip slopes on a cuesta.

		N11		N11		N11			
21° 7'	1° 42'	15	13° 24'	10 57	10° 57'	4° 15'	4° 15'	0° 51'	E
5 57	6 48	9° 18'	2 35	10° 57'	5 6	7 38	13 24	3 24	F
10 7	4 15	10 7	6 48	11 46	18 7	8 28	8 28	2 33	
3 24	7 33	5 6	15	12 35	15 47	12 35	8 28	8 28	G
10 57	10 57	13 24	12 35	15	8 28	5 57	6 48	5 6	
10 7	8 28	16 34	6 48	9 18	4 15	7 38	7 38	4 15	H
17 21	13 24	19 39	5 6	7 38	10 57	5 6	3 57	5 57	
12 35	6 48	11 46	3 24	6 48	15 47	11 46	6 48	5 57	J
10 7	5 57	16 34	12 35	15 47	7 38	7 38	7 38	10 7	
12 35	12 35	18 54	9 18	7 38	10 57	10 7	6 48	10 7	K
	8 28								

13 14

Sheet references given 1" O.S. popular edition number 81



SLOPE CATEGORY MAP. SE CORNER 1" O.S. SHEET 81 Popular

Sheet grid references provided

Project abandoned ∵ time factor.

- SLOPES -	- REF. NUMBER -
Steeper than 1 in 5	1.
1 in 5	2.
Between 1 in 5 - 1 in 10	2A
1 in 10	3.
Between 1 in 10 - 1 in 15	3A.
1 in 15	4
Between 1 in 15 - 1 in 20	4A
1 in 20	5
Between 1 in 20 - 1 in 25	5A
1 in 25	6.
Area not considered	?

<u>Overburdens:</u> (Sources - Geol. Survey, N.England Institute Mining Engineers.)

Barmoor Red House 7'
Belford Rwy. Stn. 45½'
Hetton House 51½'
Bradford Farm 65'
Lowick (west of:) 5½'
Cornhill Agric. Hostel 12'
Felkington Farm 2'
Grindonrigg 48'
Gallowlawhill Wooler 35'
Milfield Hill Birn 34'
Brackenside Farm. Ford 10'
Bowsden Moor Farm 7'
Grindon Farm. Norham 6'
Tithe Hill Farm. Cornhill 110'
Ford Moss 22'
Branxton 1. 57' and hit boundary fault
2. 135'
West Bowsden Farm 6½'
Alnwick Dispensary St. 51'-61'?
Titlington Hall 13½'
Brunton 14½'
Boulmer 14'
Wandystead Farm. Edlingham 138'
Stamford Farm. Dunstanburgh 22'
Gallowmoor Stamford Farm 8'
Alnwick Clayport 27'
Netherton Pike (SW of Yetlington) 6½'
Powburn(1m. south) 10'
Acklington Town 44'
Allerdean Estate Ancroft 14'
Belford nr. Sionside 19½'
Brownridge Lowick 12'
Brownridge Moor Etal 1.-4. 5'-8'
Christon Bank 5½'
Elwick 32'
Eshott 44' (Estate)
Felkington Colliery 1'
Holy Island 13'
Longframlington (Adl. Mitford's Royalty) 6'
Newton on the Moor 36'
Twizell Estate 4'
Scremerston Jack Tar Pit 4'
Engine Pit 19'
Shilbottle Farm House Sh. Colliery 27'
Tile Sheds 1.-17. 16-28'
Alnwick Moor 1. 7'
2. 4'

Overburdens (cont.)

Alnwick Moor 8'
Stable Yard 55½'
Howick St. Brewery 43'
Ancroft Moor 1. 7'
2. 4'
Bamburgh (coal pit) 10'
Brunton 1. 9' } uncertain of
2. 111' } location
Eshott 21'
Felkington Old Pit 9'
Ford 1.-4. 4'-12'
Gatherick 9'
Alnwick Greensfield 24'
Greenlawwalls 7'
Holburn 71'
Longframlington John Pit 127'
Fanny Pit 71'
Howey Pit 84'
N. Sunderland nr. Snook Pt. 6'
nr. Old Engine Pit 13'
Rennington Estate 1.-3. 5'-21'