The development of the Bunter Sandstone region of Nottinghamshire

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The Development of the Bunter Sandstone Region of Nottinghamshire.

Part I.

An analysis of the physical factors in the environment of the Bunter Sandstone outcrop of Nottinghamshire

I. Position.

II. Geology.

III. Topography and drainage.

IV. Soils.

V. Climate.

VI. Vegetation.

Maps.

The following maps have been used constantly throughout the survey:-

A. Ordnance Survey.

1. ¼" to 1 mile. Sheet 6A. North Midlands and Lincolnshire.
2. ½" to 1 mile. Sheet 13. Sheffield.
   Sheet 17. Derby, Nottingham and Leicester.
3. 1" to 1 mile. Sheet 38. Doncaster.
   Sheet 46. The Dukeries.
   Sheet 54. Nottingham.

B. Geological Survey.

1. ¼" to 1 mile. Sheet 11.
2. 1" to 1 mile. Sheet 82 N.E. (Old Series): Sheets 112, 113, 125, 126. (New Series)

Figures in margin (in green ink) direct reference to corresponding photographs.

Bibliography.

A. Geology, Topography and Drainage.

Geological Survey Memoirs.

1. Ollerton - Lamplugh, Hill, Gibson, Sherlock and Smith.
2. Nottingham and Newark - Lamplugh, Gibson, Sherlock and Wright.
3. Nottingham - Lamplugh & Gibson.
4. Concealed Coalfield and Yorkshire and Nottinghamshire - Wilson.
5. Permian and Triassic Rocks of the Midlands - Hull.
6. Parts of Nottinghamshire, Yorkshire and Derbyshire - Aveline.
7. Parts of Nottinghamshire and Derbyshire - Aveline.
8. Water supply of Nottinghamshire - Lamplugh, Smith and Mill.

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9. Victoria County History Vol.I. - Geology - Blake.
10. British Regional Geology - The Pennines and Adjacent Areas - Wray.
11. A Scientific Survey of Nottingham and District - prepared for British Association 1937.
    (I) Geology of the district - Swinnerton, Clift and Kent.
    (II) Underground Water of Nottinghamshire - Waters.
12. Nottinghamshire. (Cambridge County Geographies) - Swinnerton. Chs. 1 - 7; 15.
13. The Bunter Sandstone of Nottinghamshire and Its Influence on the Geography of the County - Swinnerton.
14. Physiographic/Sub Divisions of the East Midlands - Swinnerton.

B. Soils.

1. The Soils of Nottinghamshire - Goodwin.
2. Features of Nottinghamshire Agriculture - Robinson (Journal of the R.A. Soc. 1927).
3. A Scientific Survey of Nottingham and District
   (1) Agriculture of Nottinghamshire - Robinson.
4. "The Ecology of the Bunter Sandstone of Nottinghamshire" (Journal of Ecology. Vol XV No.1. Feb 1927)
5. Memoirs of the Geological Survey.
   1. Ollerton pp. 96-97.
   2. Newark and Nottingham. pp. 70 - 72.
   3. Water Supply of Nottinghamshire.
6. Nottinghamshire. pp. 20 - 36. - Swinnerton.
7. Farming Forest Sand - Makings (Dept. of Agricultural Economics. Midland Agricultural College).

C. Climate.

1. Scientific Survey of Nottingham and District.
   1. Climate of Nottinghamshire - Edwards.
   II. Agriculture of Nottinghamshire - Robinson. pp. 82 - 83.
2. Features of Nottinghamshire Agriculture - Robinson. pp. 1 - 3.
3. Nottinghamshire - Swinnerton. pp. 37 - 44.
4. Water Supply of Nottinghamshire - Climate section - Mill.
5. Farming Forest Sand - Makings. pp.12 - 15.

(1) The Bunter Sandstone outcrop in Nottinghamshire lies between the terminal points of Bawtry and Nottingham, extending in an approximate north - south line from the northern boundary of the County to the valley of the River Trent, a distance of about 35 miles. As shown in Map No. 3, the formation maintains a compact and approximately rectangular block shape to a point about 10 miles north of Nottingham, beyond which it narrows considerably, from an average width of about 7 miles to less than 2 miles. There are a few small outlying sections of the outcrop, the chief being near Worksop, Warsop, Mansfield and in the Wollaton - Bramcote district to the west of Nottingham. The total area covered by the sandstone is thus about 240 sq. miles, over a quarter of the area of Nottinghamshire.

The outcrop lies within the drainage area of the Trent, in general occupying an intermediate position and elevation between the Derbyshire hills and the low wide valley of the river (MapNo.5) Closer examination, however, shows the outcrop to be part of a distinct and compact geographical unit, bounded on the west by the Derbyshire hills, on the east by the Lincolnshire Cliff and Belvoir ridge, (a spur of the Leicestershire Wolds), on the South by the ancient mass of Charnwood, and on the north by the Humber flats and the marshy ground of the lower Trent

and its tributary the Idle. The land between these natural boundaries, the shallow saucer of Nottinghamshire, is crossed east centrally by the Trent. There are seven gates and exits into and from this area. The gaps of the Middle Trent and the Soar lie between the Charnwood upland and the Derbyshire Hills on one side and the Leicestershire Wolds on the other. The valley of the Witham, in breaking through the ring of hills twice, provides the Grantham Gap and Lincoln Gap, while between these, leading through the Lincoln Cliff, is the almost dry valley of the Sleaford Gap. In the north are the gateways of Bawtry and the River Rother, between the Derbyshire Hills and the marshes of the Idle, and separated from one another by the higher ridge of the Permian limestone. (Maps No.26, No.27).

(II) Belonging to the Trias beds, the Bunter overlies successively to the west, Permian marls and limestone and and the Coal Measures, while to the east it dips below the Keuper Waterstones and Marls. On the west side of the Trent these formations form blocks similar to the Bunter in direction, narrowing and convergence on the city of Nottingham (Map No. 3).

These successive outcrops dip gently to the east at an angle rarely exceeding 2° (Sections Nos. 8, 9.) The dip of the Bunter is difficult to determine because of prevalent cross bedding, but the indirect method of calculation from relative levels at the outcrops and in borings, gives the average dip over the area to be 105ft. per mile or slightly over 1°. (1).

On the other side of the Pennines, in Lancashire and Cheshire, where the sandstone attains a thickness of about 3000 ft., a tripartite subdivision of the formation into

1. Upper Mottled Sandstone.
2. Bunter Pebble Beds.
3. Lower Mottled Sandstone.

has been made.

In Nottinghamshire however, where the beds are not nearly so thick, only the second and third subdivisions are identified.(2) Of the two, the Lower Mottled sandstone

is the smaller formation, as reference to Map No. 4. shows. It is 20 - 30 ft. thick at Nottingham, 70 ft. thick in the Robin Hood's Hills, 112 ft. thick at Mansfield Colliery. In the northern part of its range it is thin and finally disappears beyond Blyth. In borings at Kelham (situated in the Trent Valley at the same latitude as East Kirkby) it occupies 200 ft. out of a total thickness for the Bunter of 671 ft., and at Bevercotes (near Walesby) 114 ft. out of 682 ft. for the sandstone. In general, the Lower Mottled sandstone constitutes 1/6th of the Bunter formation. It is usually red in colour, though often streaked with lines and patches of yellow and greenish yellow, and consists of sand and soft rock, usually of fine texture and somewhat loamy. Small seams and lenticles of marl, together with lines of pebbles and clay, are present in the lower part of the beds, abundantly so in the south, but more occasionally distributed in the north.(4) The Lower Mottled Sandstone overlies the fine grained red sandstones and chocolate coloured marls of the Permian, and generally the passage between these beds is perfectly continuous.(5)

The Bunter Pebble Beds, which occupy about 5/6ths of the outcrop, are generally yellow in colour, and much coarser than the underlying series, having pebbles scattered throughout the rock. They are prevalently cross-bedded, and the pebbles, which are mainly variously coloured pieces of quartzite, are often concentrated in the bottom portion of

the current channels. The junction of these beds with the Lower Mottled Sandstone is often a marked irregular line, though this is not everywhere so. Indeed, there is more frequently a gradual and indefinite passage between them.(6)

The Bunter formation varies greatly in thickness. It rises to a maximum of more than 600 ft. north of Mansfield. Thence it spreads out fanwise becoming thinner as it passes north south and east. South west of Nottingham it is 200 ft. thick but at Dale it is only 40ft. Along its western edge the base of the Bunter is considerably elevated by the underlying Permian strata. At the head of the Leen Valley the base of the sandstone is 430ft. O.D., at Mansfield it attains its maximum elevation of about 500 ft. O.D., descending to 210 ft. at Warsop, and 180 ft. at Cuckney. (Sections 8 and 9). The form of the rock mass suggests that of a supra terrestrial delta, with its axis pointing to the north west as the direction of origin of the material.(7) The nature of the beds suggests conditions of deposition with high hills to the west and low land to the east, in which there were prevalent desert conditions, an area swept by high winds with consequent sand drifts, and occasional wet seasons, when heavy rain on the mountains brought torrents to the desert plains, carrying much sand and gravel in suspension, and rolling boulders of quartzite and clay along the channels. As the

strength of the currents diminished, the boulders came to a standstill on the river bed, and gravel and sand sank to the bottom in varying degres of coarseness.(8) Considering the fact that the Bunter outcrop was in all probability covered by the Glacial icesheets, the scantiness of Glacial deposits over the sandstone is surprising, the more so when contrasted with the great masses of drift in southern and eastern districts.

There are two distinctive, moraine-like masses on the outcrop, however. The first is at Blidworth, where an irregular mass of boulder clay and gravel, 60 ft. thick, extends for over a mile along a ridge, at a height of over 500 ft. O.D. From its composition and boulder content, it appears to have been brought by ice from the north west. Farther north, between East Retford and Worksop, (¾ mile east of Checkerhouse Station) there is a second deposit of Boulder Clay, loam and sand, occupying a slight hollow on the dip slope, at about 130 ft. O.D. The most probable source of this material appears to have been from the north, its having been brought in along lower ground. Elsewhere the drift occurs in small caps and patches, as at Ollerton, Farnsfield, Annesley Park, and over the Bestwood Park hills.(9) It is an undecided problem as to whether these deposits are actually glacial or late glacial flood gravel. It may be that these deposits are the remnants of glacial gravels, the majority of which have been denuded ffom the

Bunter surface by the post-glacial river system, which was, as shown later in this survey, much more extensive and powerful than is the present drainage system. Suggestions of this denudation are demonstrated in the groups of mounds in the valley of the Meden near Cuckney and Elkesley, and a group of similar mounds near Welbeck Lake in the valley of the Poulter. (These valleys would be major valleys when the drainage was more extensive). (10) The alluvium of the streams of the Bunter outcrop is nearly always a sandy and pebbly wash derived from the sandstone. Naturally the composition of the alluvium varies with the nature of the rocks over which the streams flow, but where a stream crosses from one formation to another it spreads the detritus from the rocks which it has just left, for some distance along its course over the next formation. This happens in the case of the Meden, which, crossing the Permian limestone, deposits detritus of that rock in an alluvial flat at Warsop, and in the case of the Maun and Meden when, reaching the Keuper beyond Ollerton, they spread out Bunter Sandstone detritus. The larger streams which form the Idle all have their sandy alluvial stretches, and in the case of Maun, Meden and Poulter these are augmented by flood gravels forming slight terraces thinly covered with pebbly and sandy wash, denoting a period when the drainage of the streams was greater than now. These gravels occur near the junction of Rainworth Water and

the Maun, and near the junction of the Maun, Meden and Poulter. The artificial lakes at Carburton - known as
34. Carburton Forge Dam and Carburton Dam - have almost submerged the alluvial flats of the Poulter for about three miles.

The lakes at Welbeck and Thoresby are also of artificial construction.

(III) The Bunter Sandstone outcrop geographically consists first of an area of lowland to the north, from Bawtry towards Worksop and East Retford, varying in height between 30 ft. and 100 ft. O.D. This area is continuous with the Humber flats and the low lying and marshy Hatfield Chase. South of the Worksop and East Retford line, the outcrop increases in elevation, rising to a maximum height of over 600 ft. in a line of hills, the Robin Hood's Hills, to the south of Mansfield, in the neighbourhood of East Kirkby. South of this line there is a declination of elevation towards Nottingham, where the outcrop terminates at a height of approximately 150 ft. O.D., in steep bluffs overlooking the Trent valley. Similarly from the western scarp ridge of the outcrop, the varying heights of which can be seen in Map No. 6, there is descent by a broad dip slope towards the east. From the crest of this western ridge, the surface rises and falls irregularly in flowing contours, but with a persistent descent eastward in accord with the dip of the strata, so that, where the Bunter passes beneath the Keuper, the ground is usually 200 ft. lower than at the crest of the escarpment. To the north and south of the region of maximum elevation, the descent to the east is less, but nevertheless marked. (Maps Nos. 5 and 6: Sections Nos. 8 and 9). This sequence of rise and fall is clearly seen in the Bawtry to Nottingham section (section No. 7) and in Map No. 5. To appreciate the Bunter topography, the outcrop must be considered in relation to the

outcrops east and west of it. The Bolsover - Tuxford section (No. 8) and the Alfreton - Edingley section (No. 9) show quite clearly that, in each case, the western edge of the Permian, Bunter and Keuper formations rises in a scarp face, while the east dip slope is long and gradual, each scarp line marking a step in a progressive descent eastwards to the Trent valley. Following the succession from the west each formation produces its own distinctive topography according to its lithological character. Thus the Permian limestone rises in
14.
15. a steep scarp above the Coal measures. The long dip slope to the east is often deeply cut into gorges and sharp valleys,
16. as, for example, at Creswell and Pleasley, and the
17. characteristic feature is interesting undulation. A further feature is the common production of caves and potholes, such as are found at Creswell, Upper Langwith, Whaley and Pleasley Vale. To the east the limestone passes under the Permian marls which vary considerably in width of surface outcrop (Map No.4). These marls produce generally flat land of clayey
18. nature, and consequently are retentive of water. The outcrop is widest and most significant in the neighbourhood of Cuckney and Worksop, but fringes the overlying Bunter outcrop from north to south of its extent.

From this flat land the soft Lower Mottled Sandstone usually rises gently, though occasionally, in more consolidated form, it produces a bold feature.[11.] The Bunter Pebble Beds however, being of superior durability, outcrop usually in a west facing scarp, with a long gradual slope to the eastward. The top

surface of the Bunter is wind eroded, but its most characteristic feature is its ramifying valley systems, clearly the result of erosion by running water at some bygone period, but now all, or nearly all, permanently dry. These dry valleys are particularly outstanding in the neighbourhood of the Robin Hood's Hills, but in gentler form are seen everywhere over the Bunter Country (Map No.12).

The Bunter Pebble Beds dip to the east below the Keuper Waterstones. This subsection of the Keuper is characterised by easy disintegration, and produces, in landscape, long concave slopes. Above these rise the Keuper Marls, as a steep flat-topped escarpment. The cause of the scarp is the inclusion of hard calcarlous sandstone layers - skerry bands - in the regular red bands of stratified clay, the former having considerable erosion resistance. The Keuper outcrop is everywhere beautifully diversified with little "dumbles" and valleys which open on to the valley of the Trent. (12)

This sequence of outcrops determines the nature and form of the drainage of the area under consideration. Before going into detail, however, it is first necessary to examine the distribution of rainfall over the district, as far as it is likely to affect the drainage, and reference is directed to Map No. 19. As can be seen, the region has comparatively light rainfall, with a variation over the Bunter country of 23" to 30". The lightest fall occurs in the northern Bawtry region, increasing southwards to a maximum of 30", as would be expected

in the Robin Hood's Hills neighbourhood, and then decreasing again to about 25" in the Nottingham district of the outcrop. The isohyetal lines run approximately parallel to the scarps. Reference to the drainage map (Map No.10) shows that there are three main sources of streams flowing to the Trent, within the area described.

These are:- (1) The Keuper Marl outcrop - which does not here concern us.

(2) The Permian limestone and coal measures, which rise to over 600 ft. a few miles to the west of Mansfield.

(3) The Bunter Sandstone hills in the neighbourhood of East Kirkby. Here there are two main watersheds,

(a) The main one which runs east to west along the crest of the Central Hills.

(b) The minor one which runs north to south from the main watershed, and separates the valleys of the Leen and Erewash.

The high land of the Permian and Coal measures is the chief source of the streams crossing the Bunter. The streams which rise in this belt are:-

(1) The Erewash and the following which in the main form the Idle (a) The Maun (b) the Meden (c) The Poulter (d) The Ryton and its more northerly tributaries.

The Bunter hills are the source of (a) Rainworth Water (b) The Maun (c) the Leen (d) the eastern tributaries of the Erewash. (13) The Daybrook rises on the Keuper.

Reference to Maps Nos. 10 and 11 show clearly the following points:-

1. The fewness of streams over the Bunter, compared with those on the other formations.
2. The general east - west trend of streams over the outcrop.
3. The northward turn of the Bunter streams when they reach the Waterstones.

The key explanation of these features of Bunter drainage lies in the absorptive quality of the sandstone, the rain water percolating rapidly through the surface of the outcrop. Edaphic conditions with 80% - 90% of fine and coarse sand, the latter predominating, together with a general lack of humus and clay, make for excessive drainage, (one-third of the fall is absorbed), quick evaporation (50% - 60%) and slight capilliarity. Water thus sinks rapidly into the Bunter resulting in a water table below the surface. This water table is not an absolute plane parallel to the horizon, but has a gently undulating surface, which reflects in a more subdued form the undulations of the land surface, while maintaining independence of it as a whole. (14) (Map. 13). Thus the water table lies deepest where the formation

rises highest near its bold western scarp, and as the Bunter sinks eastward under the influence of the easterly dip, the plane of saturation rises near to the surface and finally reaches it in many places just before the Bunter disappears beneath the Keuper. (Map 15). In these places the water issues in springs.(15) The same thing happens whenever the water table intersects the land surface, as in a few of the deeper valleys, and all along the western scarp. The table also comes to the surface in many places on the lowlying region which forms the northern part of the outcrop. (Map 14). Map No. 13 shows the contours of the water table in feet. O.D. A comparison with Maps Nos. 5 and 19 shows the fact that in the area of highest land,i.e. round the East Kirkby area, where the base of the sandstone is 400 O.D. (Section 9) and overlying the impervious Permian Marls,and where the rainfall is greatest, water oozes out quietly to become the source of streams which rise on the central hills. (This explains for example the abundance of tributaries on the right side of the River Leen). This supply of water is doled out quietly to the streams, wet or fine, so that very rarely are there torrents, and the widening of the valleys keeps pace with deepening, giving rise to flats with marshes and marsh vegetation along the streams, a distinct contrast to the gorges of the Permian limestone and dumbles of the Keuper Marl. The same quiet doling out of water proceeds in the deeply entrenched transverse river valleys which flow over the Bunter, following the direction of the

water table and surface contours. In these valleys the floor reaches the water table, which provides a constant supply to the streams and again produces wide marshy valleys. On the eastern rim of the Bunter, where the Water stones are encountered, the water table reaches the surface with the result that the comparatively impervious beds form a natural lip which holds the pent up waters. The escarpment of the Keuper marls rises beyond this, and, consequently, the streams which crossed the Bunter in an east to west direction, take a northerly trend to form the River Idle.

The floors of the shallower valleys, which are so characteristic of the Bunter landscape, do not reach the water table and are now consequently permanently dry (Map 12). The most adequate reason for their existence is that they date from a time when the water table in the Bunter was considerably higher than at present. These smaller valleys, which now lead down to the main valleys, have still abundant evidence of water-borne sand and gravel on their floors, and were evidently channels of permanent streams till a comparatively recent period.(16). This is most likely to have been the last glacial period, when the much colder conditions resulted in a frozen condition of the surface and sub-soil, which prevented a downward percolation of thaw water and spring rains into the otherwise permeable rocks. At this period, snow and rain from the hills provided considerable streams, which flowed over the frozen soil,

carrying a vast amount of detritus to the main valleys. When climatic conditions became less rigorous, the water table began to take its present configuration, and eventually the shallower valleys, which no longer cut the underground water surface, became dry, as they are now.

A second factor, which may partially account for their formation, may be the occurrence of periods of exceedingly heavy rainfall, when the surface soil may become very temporarily saturated and torrents of short duration pass over the ground, washing down considerable amounts of the surface soil. Several rain storms of dimensions sufficient to account for considerable erosion have been recorded on the Bunter country. Outstanding examples occurred in 1892, when a great downpour brought soil down from the Robin Hood's Hills to Annesley, necessitating work parties to clear out dwelling houses; on July 30th. 1907, when in 20 minutes, ½" rain was recorded at Nottingham; and on August 7th. 1922, when there was a fall of 3.86" in Nottingham district, ploughed fields were washed down and crops of turnips were carried down hill en masse.(17) Occasional storms of dimensions like these, over a period of several thousand years, might well prove to be the cause of much of the existing dry valley system.

In the northern part of the Bunter outcrop, surface drainage is much more abundant, owing to the fact that the water table is often coincident with the topographical surface, and that

the actual amount of water available is greater here than in the south, owing to the greater thickness of the northern portion of the outcrop. (Maps Nos. 4, 6 and 14). Consideration of drainage on the Bunter inevitably leads to the discussion of the underground water supply which accrues as the result of the porosity of the soils. As regards their water bearing capacity there is not much difference between the two subdivisions of the Bunter, except that percolation takes place more rapidly in the Pebble Beds. The loosely packed sands form an efficaceous filter, and since, as soil analyses show, the Bunter contains little lime or other mineral contents soluble in water, the waters that it stores are of a high standard of natural purity and are moderately soft. In respect to its capacity for water storage the Bunter acts as a single reservoir, its waters percolating freely, though not very rapidly, from one point to another, so that if water is drawn away from any particular spot until the water level there is lowered, there is a gradual inflow from all sides towards the local "cone of depression." To obtain water from the Bunter, wells must, of course, be sunk below the water table. The water level undergoes some seasonable variation and is affected by differences of annual rainfall. The estimates of the available water supply in the Bunter vary considerably. Although the area of the outcrop and the rainfall are known, the proportion that percolates through is variously calculated.

The highest estimates put it at 10" per annum and the lowest is 4½" p.a. The higher estimates of the quantity absorbed over the whole area is 35,040,000,000 gallons per annum, or 96,000,000 gallons daily.(18)

(IV) The following analyses of samples taken from all districts of the outcrop, show the nature of the Bunter sandstone soils and subsoils.

1. Areas from which samples were taken.(19)

Locality.	Remarks.
1. Bestwood.	Very poor pasture field; extremely coarse sand with pebbles.
2. Papplewick.	Arable.
3. Edwinstowe.	Arable.
4. Checkerhouse.	Arable; grows good early potatoes.
5. Blidworth.	Arable; very light sand.
6. Budby.	Very poor pasture; light sand with gravel subsoil.
7. Worksop.	Poor pasture.

2. Mechanical Analyses (Percentages) (19)

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	Surface Soils.							Subsoils.				
	1	2	3	4	5	6	7	1	2	3	4	5
Fine Gravel	3.64	2.04	.47	.99	1.41	1.70	1.30	1.18	2.0	.3	.43	.91
Coarse Sand	73.4	53.79	58.46	59.77	74.98	65.19	64.55	77.23	53.94	61.75	64.04	77.47
Fine Sand	11.23	31.32	29.09	24.71	16.13	21.06	23.51	10.62	33.16	26.21	22.67	15.21
Silt.	4.34	2.44	2.19	1.98	2.09	2.17	2.39	4.66	2.56	1.81	1.55	2.34
Fine Silt.	3.02	2.84	4.98	5.47	.82	4.09	4.35	1.42	1.43	5.02	5.19	.66
Clay	.24	.35	.25	.28	.41	.18	.15	.58	.46	.64	.31	.38
Moisture.	.70	1.26	.68	1.11	.88	1.82	1.07	.64	1.02	.74	1.02	.88
Loss on Solution.	1.43	1.82	1.73	2.33	1.22	2.32	1.23	1.08	2.75	1.46	2.42	1.12
Loss on Ignition.	2.64	5.28	2.86	4.27	2.95	2.68	2.35	1.34	3.30	1.77	3.38	1.92

3. Chemical Analyses. (19)

	Surface Soils.							Sub-soils.				
	1	2	3	4	5	6	7	1	2	3	4	5
%Total Potash K_2O	.012	.02	.0476	.048	.014	.102	.068	.009	.0068	.0476	.008	.010
" Available.	.0034	.001	.0024	.004	.001							
" Total Phosphoric Acid (P_2O_5)	.147	.078	.0936	.111	.106	.1359	.147	.100	.058	.0624	.060	.096
" Available.	.0395	.003	.012	.054	.02							
" Nitrogen.	.132	.103	.106	.140	.101	.114	.125	.08	.07	.091	.079	.076
" Lime as Carbonate.	.37	.0356	.042	.30	.025	.12	.135	.73	.178	.07	.073	.050

From the mechanical analyses the folowing points can be deduced:-

1. The soils are generally dry and sterile because of the large percentage of coarse and fine sand, the former predominating. In all the samples taken the % is between 80% and 90%.
2. There is a general lack of humus and clay. The former is derived from xerophilous plants and is often undecomposed. There is a lack of earthworms and bacteria. (20) The soil is very friable and actually is liable to 'blowing' in many areas.
3. Drainage is excessive, due to the large size and roundness of the grains, and the porosity of the sandstone below. Consequently capilliarity is slight and it has little power of raising water.
4. It is subject to considerable leaching of the available plant foods owing to its coarse nature.
5. It will be liable to burning in a dry season. The chemical analyses reveal the following characteristics.

   1. Though the phosphate reserve is usually satisfactory, the soils are generally deficient in potash, lime and nitrogen, and so inherent fertility is low.

   2. The soil is liable to become sour. This is confirmed by the abundant presence of spurrey and sheep sorrel on cultivated ground. (21).

3. Analyses of the ground water on the Bunter show that the mineral constituents of the soils are generally insoluble and therefore not available greatly for plant food. Analyses of ground water from places on three outcrops afford an interesting comparison in this respect:-

Outcrop.	Locality.	Total Solids on evaporation.
1. Bunter.	Papplewick Water Works.	.018 gms. per 100 c.c.
2. Magensian Limestone.	Annesley Well.	.0668 " " " "
3. Keuper Marl.	Well at Newark.	.188 " " " "

The conclusion reached by these analyses is that soils developing from the Bunter are 'hungry' soils, inimical to agricultural enterprise. There are other factors which tend to reduce fertility still more.

1. The burrowing of rabbits. These bring large quantities of subsoil to the surface of the heaths, arable land, hedgerows and woods.

2. Wind erosion. The Bunter, as already mentioned, produces 'blowing' sand, and Wind erosion is particularly noticeable in March, when small dust storms are often caused on the outcrop.(23) The extensive felling of trees has accentuated this, and there is considerable need for additional pine plantations.

3. Surface denudation by heavy rainstorms. Examples of this have been given in connection with dry valley formation. Rain scars are often noticeable on the higher lands of the outcrop.

A distinction should be made between the soils of two

subdivisions of the Bunter. On the whole the narrower outcrop of the Lower Mottled Sandstone yields a soil which, though very light, is more fertile than the overlying Pebble Beds and particularly so where it is mixed with the underlying Permian Marls. On the other hand, where the Pebble Beds near the Keuper boundary the soils become more loamy and of better quality, apparently due to the residue of clayey Keuper which once covered it, and partly due to its moister condition. The quality of soil of this fringing area has no doubt also been aided artificially in the past by 'marling', as the numerous old marl pits along the neighbouring Keuper show how extensively this process has been practised, though now almost extinct.(24)

Of the neighbouring outcrops to the west of the Bunter, the Coal Measures produce wet poor, stiff, yellow clays. The Permian system soils, on the other hand, are usually light and dry, but vary a good deal over the outcrop. The commonest soil is brown loam, but frequently the limestone decomposes into a stiff clay which almost approaches in tenacity that of the overlying Permian Marls. The unmixed marl forms a very cold tenacious soil, but the thick intercalations of sand with the marl in the county north of Cuckney have produced a deep loamy soil, which is the best agricultural land in the north west of Nottinghamshire. On the eastern edge of the Bunter, the soil produced by the Keuper Waterstones is a red clayey loam, slightly calcareous and generally stiff, but varying in texture according to the local changes in the proportion of

sandstone to marl in the series. The belt of greenish-grey clay at the base of the formation weathers to a stiff yellowish or reddish soil, and has a breadth of outcrop disproportionate to its thickness owing to the low relief of the ground where it occurs. There is a thick downwash of reddish-brown loam on the gentler slopes and in the hollows along the foot of the main Keuper escarpment, which gives rise to soils of great fertility.

The Keuper Marl makes a fertile, stiff, red calcareous clay, which is, however, difficult to till and requires sub-soil drainage. More loamy belts occur, however, where the sandy skerries are close beneath the surface or where there is an admixture of coarse silt in the marl. In the main the Keuper soils are red, fertile, heavy and level though, as shown, they are not of equal fertility.(25) (Summary Map No. 16).

(V). Climate.

Temperatures in Nottinghamshire are affected by the inland situation of the county and by its location east of the Pennines, for both circumstances prevent a full development of western maritime influences. The absence of mountains within this county - 2/5ths of the total area of Notts is under 100 ft. O.D., and only 1/56th is over 600 ft. O.D. - makes for marked uniformity of temperature conditions. On the Bunter Sandstone region this can be seen clearly by a comparison of mean monthly mid-temperatures as recorded at Nottingham castle, at the southern end of the outcrop, and Hodsock Priory at the northern end, between Worksop and Bawtry.

Month.	Nottingham Castle. 192ft. OD. 1901 - 1930.	Hodsock Priory 56ft. OD. 1876 - 1920.
January	38.9° F.	37.6° F.
February.	39.1	38.9
March.	41.8	41.5
April.	45.7	45.8
May.	52.4	51.9
June.	56.7	57.2
July.	60.5	60.3
August.	59.6	59.6
September.	55.6	55.4
October.	49.4	48.4
November.	42.0	42.7
December.	39.6 (26a)	38.6 (26b)

Because of the absence of the moderating influence of the sea, the range of temperature in the region is considerable. The average annual range for Nottingham is 22° F. and for Hodsock 22.9°. It is less, however, than the range for many districts of eastern England, for example, Cambridge, where the range is 24°F. An example of the great variations possible in one day is given in the record for May 20th. 1909, when the daily range for Nottingham was 26° F. In this respect the climate of the region is 'Continental', compared with Coastal districts of the British Isles.

As in all parts of the British Isles the winds over this region are prevalently westerly. Diagrams Nos. 17a and 17 b., showing wind directions at Nottingham for 1929 and 1930, demonstrate that winds with westerly components blow for about half the year. Westerly winds often blow, as elsewhere, in the winter with resultant mild periods. On the other hand long cold spells are not uncommon, caused by the drift of easterly winds over the North Sea resultant from anticyclonic conditions over Europe.

The following table shows the average wind components at Nottingham over 35 years (1891 - 1925).

Main Wind Component	Jan	Feb	Mar	Apl	My	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
North.	6	6	8	9	9	8	7	5	8	8	7	5	86
East.	4	5	4	6	6	5	5	3	5	5	4	3	55
South	5	4	4	4	4	4	4	5	4	5	4	5	52
West.	17	14	15	12	12	13	15	17	14	13	14	16	172

(28

In this series of statistics the decrease of westerly winds in April and May is of importance; in these months North and East winds blow with greater frequency.
Similar observations made at Hodsock,over the period 1876 - 1905,show that west and south west winds together blow there over one third of the year. Here easterly winds are most prevalent in March,when dust storms are raised on the Bunter Country.

The following figures for 1929 and 1930 give an indication of the variation of wind strength at Nottingham. For local agriculture 1929 provided drought conditions,while 1930 was a safe year.

Month	1929 Gale	1929 Strong Wind	1929 Moderate Breezes.	1929 Calm	1930 Gale	1930 Strong Wind	1930 Moderate Breezes.	1930 Calm.
Jan.					0	11	20	0
Feb.	0	8	20	0	0	4	24	0
March.	0	6	25	0	0	9	22	0
April.	0	15	15	0	0	8	22	0
May.	0	10	21	0	0	9	22	0
June.	1	12	17	0	0	8	22	0
July	0	10	21	0	0	20	11	0
Aug.	0	13	18	0	0	14	17	0
Sept.	1	4	25	0	0	10	20	0
Oct.	1	12	18	0	0	12	19	0
Nov.	0	9	21	0	0	8	22	0
Dec.	2	13	16	0	0	4	27	0

In these figures, the most important (as proved by local agricultural experience) are those for April, May and June. Notice should be taken of the relatively strong winds in those months for 1929 as compared with 1930 (Diagram No.18). As Nottinghamshire lies to the east of the Derbyshire Hills, and since there is a prevalence of west and south west winds, the rainfall of the region is comparatively low. As the rainfall map No. 19 shows, the high land of the Bunter Country has the highest fall of

just over 30", while there is a decrease north and south to 23" near Bawtry and about 25" at Nottingham. In the Bunter country, however, the total amount of rainfall per year is of less importance than its actual daily distribution. This fact is pithily stated in the local agricultural saying that farmers on the sand lands "want a shower of rain every day and a shower of muck every night."

The following figures show the monthly average and distribution for each month at Nottingham (Trent Lane) and Hodsock. (NB. The distribution figures cannot be compared because the limit for Nottingham has been taken as .01" and for Hodsock as 1mm).

	Nottingham (29a)			Hodsock. (29b)		
Month.	Total Rain.		Rainy Days. .01" or more.	Total Rain.		Rainy Days. 1.mm or more.
Jan.	1.74		16	1.77		10
Feb.	1.45		14	1.65	Dry	9
Mar.	1.59	Dry	15	1.80		10
April	1.34		13	1.59		9
May	1.80		13	2.04		10
June	1.85	6.53"	11	1.99		9
July	2.28		12	2.31	6.81"	10
Aug.	2.40		14	2.51		10
Sep.	1.56	Dry	11	1.74	Dry	8
Oct.	2.39		16	2.55		11
Nov.	1.81	6.50	14	1.96	6.87	10
Dec.	2.30		18	2.36		12

The total for Nottingham is 22.51" and 24.30" for Hodsock. Variations from the average are sometimes considerable. For example, at Nottingham in 1872, 36" were recorded, while in 1887, at the other extreme, there was less than 16" of rain. These figures and the graphs of rainfall at Mansfield and Worksop (Nos. 21 and 22) indicate:-

1. That the first few months of the year are generally dry, May bringing more rain than any of the earlier months.
2. That the summer months tend to be wet. At Nottingham, June, July and August account for 29% of the total, a fraction more than for October, November and December. At Hodsock, on the average the three summer months account for 28% of the total, and the three winter months a fraction more. The summer maximum is explained by the occurrence of convection showers, and by rain accompanying thunder storms associated with local secondary depressions. These occur frequently in the afternoon or early evening in summer months.
3. That September usually provides a respite in the rainy sequence of June - December.

The figures for distribution of rainy days show that they are spread out evenly through the year. Apart from October, the months of maximum rainfall are not those with the greatest number of rainy days. The latter are related to the frequency of travelling cyclones, so that December and January,

months of maximum cyclonic activity, have more rainy days than any other consecutive months. (30)

Other climatic factors which deserve consideration, on account of their possible influence on settlement and occupation, are hours of sunshine, thunder, fog and frost. For the first the averages at Hodsock over the period 1876 - 1920 are as follows:- (30)

Month.	Hrs. of Sun.	Month	Hrs. of Sun.	Hrs. Per day.
Jan.	36.2	July	159.0.	
Feb.	57.5	Aug.	144.7	
Mar	99.7	Sept.	119.1	3.4
April	133.7	Oct.	82.4	2.35
May	169.5	Nov.	45.8	1.31
June.	166.6	Dec.	28.4	.81

Total 1242. Av. per day. 3.40.

For Nottingham the following figures are available:-

Total for the year:- 1325 hours. Daily Average:-3.63 hours.

Average for particular months:- Sept:-4.2.hours. per day. Oct:-2.68 hrs. per day

Dec: 0.9 hours per day.

The mean daily amount of sunshine for the Midlands is 3.82 hours. For the Bunter area April to September are very much above the average, with May the sunniest month, but there is rapid falling off in October owing to the development of

autumn and winter fog, a climatic disability to which the region is subject. Cold mists lasting for several days are frequent at the back end and early part of the year, and dense fog often of a widespread nature appears to be due to industrial smoke from the west and the existence of cold still air in the Trent Valley. (Note the greater amount of fog in Nottingham than at Mansfield). As can be seen from Map No. 23 the Bunter Sandstone outcrop lies within the region of maximum thunder activity for the country. The number of thunder storms recorded at Belvoir Castle, on available data, is the greatest for the British Isles. As has already been noted, thunder in this area is associated with small secondary depressions which develop locally in the summer months in afternoons and early evenings.

Finally, on the average at Nottingham 4/5ths of occurrences of ground frost are recorded between November and mid-April. The average dates of incidence for first and last frosts at Nottingham are the 9th October and the 19th April. (32)

This factor does not therefore usually interfere with the cultivation of typical farm crops in the region. (Note the increase in ground frost occurrence in Worksop area compared with Nottingham). The Book of Normals gives the record for snow at Sheffield as 25 days per annum, but further south at Nottingham the average is probably less - 18 to 20 days per annum, and falls occur chiefly in the first three months of the year. On the high land of the Bunter hills it lies

for longer periods than elsewhere in Nottinghamshire.

(Note the greater number of days when snow lies at Mansfield compared with Worksop). The following statistics for the years 1931 - 1937, taken from the weather reports (annual summary), support the statement on snow, thunderstorm frequency, fog and ground frosts:-

Year	Recording Station.	Snow (Days)	Snow lying days.	Thunder storms.	Fog (morning)	Ground Frost.
1931	1.Mansfield	24	24	14	74	-
	2.Notting'm	--	--	--	90	78
	3.Worksop.	26	16	19	--	124
1932	1.Mansfield	17	9	13	57	--
	2.Notting'm	--	--	--	75	80
	3.Worksop.	20	3	15	--	126
1933	1.M	22	27	18	66	--
	2.N	--	--	--	73	95
	3.W	19	26	24	--	133
1934	1.M	11	6	10	53	--
	2.N	--	--	--	62	80
	3.W	10	5	15	--	101
1935	1.M	21Days	20Days	20	41	--
	2.N	--	--	--	76	88
	3.W	26	10	23	--	100
1936	1.M	26	32	20	48	--
	2.N	--	--	--	91	96
	3.W	18	19	19	--	102
1937	1.M	39	27	14	74	--
	2.N	--	--	--	78	82
	3.W	--	--	--	--	--
	Average for period 1931 - 1937.					
	1.Mansfield	22.9	20.9	15.6	59	--
	2.Notting'm	--	--	--	77.9	85.6
	3.Worksop.	19.8	13.1	19.1	--	114.3.

(VI) Finally, a good idea can be gained of the natural vegetation of the Bunter outcrop by referring to photographs Nos. 1 - 5.

No. 1 shows the flat low lying marsh land typical of the north of the outcrop.

Nos. 2 and 3 show the natural forests of the outcrop - chiefly oak and birch.

Nos. 4 and 5 show typical stretches of bracken and heath land, which often break the wooded landscape of the centre and southern parts of the formation.

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(I)The evidences of the earliest stages of human settlement in the geographical region to which the Bunter belongs are scanty, yet they cover the Palaeolithic, Neolithic and Bronze Ages, and afford material to show the control of settlement by the physical factors of the area. Map No. 24 shows the distribution of relics of these periods as far as they have been discovered from the Trent Valley westwards.(33) The map demonstrates:-

1. the absence of remains on the Bunter sandstone, though ancient remains are found up to its boundaries.
2. the concentration of the few Palaeolithic remains on the Permian limestone.
3. the general, though sparse, distribution of finds on Permian, Keuper and in the Trent Valley.

The Palaeolithic remains on the Permian are accountable for by the fact, that of all the outcrops in the region, this was the only one to provide natural shelter for very primitive peoples. In caves in the limestone at Creswell, Upper Langwith and Whaley, on the side of small gorges cut by the River Poulter, evidences of settlement dating back 15,000 to 20,000 years have been discovered. Subsequent settlement of the area the map shows to have been, despite its

comparitive sparsity, dictated by considerations of the nature of the soils. The Permian and Keuper outcrops were chosen and the Bunter avoided. The comparative aridity of the sub-Boreal climatic phase from about 2500 BC - 700 BC must have accentuated the natural difficulties of the Bunter and made it even less inviting.(34) From the earliest stages of history the outcrop has evidently been a barrier between the east and west.

This state of affairs obtained when the Romans invaded the country.

From about 700 BC onwards climatic conditions had passed out of the sub-Boreal phase and had become more oceanic, with wetter and colder conditions over the British Isles. This change had led to the increase of forests on the clay lands and in the river valleys and of marshes in low lying areas. Under these conditions in this region the land between the lower reaches of the Idle and Trent and the Humber was an extensive marsh, large areas of the Keuper and Permian clay soils probably carried heavy forests with dense undergrowth, while the lighter soils of the Bunter and part of the Permian outcrop retained forest growth of a less dense nature over large areas.(34)

At the time of the invasion this area of the East

Midlands was occupied in sparse fashion by the Coritani, a peace-loving British tribe who offered little resistance to the invaders. By 47 AD. the whole of the eastern part of Britain up to the Humber had probably been occupied by the Romans, and afterwards the troops were moved on to begin the subjugation of the hill country to the north and west. The region of which the Bunter is part was therefore in the civilian section, the area of settled life. To the Romans the whole district offered little attraction and consequently their remains are few. The natural features of the region were on a low scale, it was not particularly fertile, rural life was little developed, the land was largely wooded and the soils did not immediately encourage sheep farming and corn growing.(35)

Map No. 25 shows the distribution of towns, roads, villas and small finds which cover the period to the 4th Century AD. The towns shown are small and mainly confined to the far side of the Trent valley, of the villas shown two occur on the edge of the Permian outcrop at Mansfield Woodhouse and Styrrup, while small finds are more profuse on Keuper and Permian than elsewhere. Once again it is evident that no settlement has occurred to change the nature of the Bunter as an east - west barrier.

As in many other regions of England the chief contribution of the Romans to the development of the land lay in their road system.

The most important road in this area was the Fosse Way which entered the region along the Leicesterhsire Wolds and, keeping to the crest of the highest ground south of the Trent, thus maintained a dry foundation between Leicester and Lincoln, between which centres it passed through the smaller towns of Margidundum and Crococolana.

The second road of importance branched off from Ermine St., just north of Lincoln, crossed the Trent at Littleborough (Segelocum), and pursued a north westerly course to Bawtry and thence to Doncaster (Danum). Once again the direction of this road was fixed by geographic considerations, the chief being the desire for a dry route to the north, which meant, in effect the avoidance of forested and marshy lowlands The point on the Bunter where Bawtry now stands offered the first dry crossing to the north, east of the marsh lands of the lower Trent Valley. The road followed the low ridge of sandstone raised above surface drainage, via Clayworth, Wiseton, Everton and Scaftsworth. The Bunter outcrop thus by its aridity opposed settlement, yet offered a dry basis for roads. By Roman times the importance of the position

of Bawtry as the main gateway out of the region to the north had become assured.

Two other roads of doubtful Roman origin are shown on Map No. 25. These are not yet substantiated as Roman roads, though there is evidence to support Roman origin for parts of each.(36)

Recent discoveries on the Permian limestone - further excavation at Mansfield Woodhouse, evidence of a tile-factory at Sookholme and the discovery of a village between Shirebrook and Langwith - at least substantiate the evidence for a western road as shown, even if that road was not Roman in origin (since communication with the outside world would be necessary and likely from such an occupied region). Local evidence suggests that the villa at Mansfield Woodhouse was inhabited by Romanized native Britons of the upper class, and the village near Shirebrook by natives of the lower class.(37

The point, however, of importance for this survey is the probability of a very early road leading from the position of Mansfield in a northerly direction to the position of Bawtry, and throughout its length crossing the Bunter outcrop. The same point applies to the early eastern road, which Roman or British in origin, led from, at least, Ollerton to Blyth and Bawtry, and perhaps south to Farnsfield, Oxton and Arnold, where there are remains of British camps The lighter nature

of the forests on the Bunter and the absence of dense undergrowth did not prevent the beginnings of these north - south roads over the dry surface of the outcrop. Thus, by the time of the close of the Roman occupation the main trend of communications in this region and over the Bunter was becoming established, with the position of Bawtry as the focal point.
At the southern extremity of the out-crop, the avoidance of the site of Nottingham by the Romans is noticeable, but it is probable that the possibilities of its strong natural position would not appeal so irresistibly to them as it did to later invaders. The site was that of a river town rather than a road town and the Roman system of defence and communication ignored rivers as much as possible.(38) Leicester and Lincoln could be linked together without any interference from the Trent, while the road from Lincoln to Doncaster was in every way suitable to Roman engineering - an easy ford over the Trent and then a road for the most part over raised ground. The use of the Trent as a means of transport is suggested by the discovery of a pig of lead from the Derbyshire mining district (Matlock), eight miles east of Mansfield in Hexgrave Park, Farnsfield, which together with other discoveries near the Humber make it possible to conjecture that Derbyshire lead was

shipped by sea from that estuary.(39)

One further activity of the Romans was an attempt to drain the marshes in the lower course of the Idle by the construction of two dykes - the ByCar and Fosse Dykes.

(II). The larger geographical region, of which the Bunter sandstone outcrop occupies a large area, lying between the Lincoln ridge and the Derbyshire hills appears to have been settled by the incoming Angles from two directions.

(I) By the entry of the Humber Estuary.

(II) By the rivers that flow into the Wash, particularly by the Witham and Welland, the former affording access to the central Trent Valley via Lincoln, and the latter with its tributary the Wreak, leading into the valley of the River Soar. Map No. 27 summarises these details(40).

In this new invasion and settlement we can deduce fairly clearly the reactions of the settlers to the various soil divisions deriving from the geological strata within the area. It has been said that the Angle and Saxon pioneers were not archaeologists; still less were they geologists, and if we are to see matters through their eyes it is lithology, not stratigraphy, which must be our guide. To generalise: among the less inviting areas within the area the heavy clay lands and stretches of sandy upland stood prominent. In geological terms this meant the Permian limestone, the Bunter Sandstone and Keuper beds. All these were heavily wooded over large

areas. Within the region two distinct phases of penetration can be distinguished.

1. The entry period. 2. The expansion period. In their entry into the region, the flooded country, covering the lower reaches of the Trent and the Idle, was no bar to the progress upstream of the Humbrensian bands, who, finding at length drier riverside lands and fertile soils deriving from the red Rhaetic marls in South Nottinghamshire and Leicestershire, seem to have laid there the foundations of the Mercian people.(41) A second line of approach to this centre brought new invaders through the Lincoln Gap and down the Fosse Way. Within this area from Newark a line of cremation cemeteries, mostly on the right bank of the Trent stretching away to Burton and beyond, indicates a big incursion which penetrated also up tributary valleys like the Soar, and there met with the settlers who came by the Fen rivers through Rutland and Nottinghamshire. Archaeologically, these settlers of the entry phase are represented by the cremation cemetries on the right bank of the middle Trent and its southern tributaries.(42) It is difficult to use with certainty place names as a guide to original settlement of the region, but assuming that endings - ing and-ingham indicate at least probable primary settlement, the result of such distribution plotted on a geological map of the region is shown in

Map No. 28.

This largely confirms the evidence of cremation cemeteries. Settlement appears to have avoided completely the Permian outcrop and the Bunter sandstone which can be assumed with certainty to have been forested. The richer soils of the Keuper outcrop must have participated in this early settlement. Nottingham at the southern end of the Bunter sandstone was planted by the sixth century, though it had not as yet assumed outstanding importance. The town originated where the Trent valley touches the Buhter Sandstone, significantly enough the only point in the whole course of the river where the valley is not carved from the Keuper beds. Map No. 29 shows the details of the site. Here the southern extremity of the Bunter outcrop terminated in two hills, with a broad hollow between, overlooking the flat river valley. The first settlement was confined to the two hillsides, the one now marked by the castle rising to 250 ft., the other marked by St. Mary's Church being about 150 ft. O.D. Access to Nottingham from the south involved crossing the Trent and the Leen, which followed the sandstone cliff for about 2 miles before turning into the Trent. The site was thus provided with a defined and easily defended margin to the south. Northward, the dry Bunter outcrop offered a basis for northern roads, converging on the river site - an offer soon accepted. Along the Leen a series of water

mills, which in turn developed in village settlement, spaced about half a mile apart marked the origin of Lenton, Radford, Basford and Bulwell and of the northern trend of secondary settlement towards the position of Mansfield.(44)

North of the Trent, cremation, so common south, is conspicuous by its absence, while poorly furnished inhumation and barrow burials suggest a long period before final occupation took place. The chief requirement for this expansion of colonisation in the region, which involved most of the Keuper, Bunter and Permian outcrops, was the felling of forest. That this area was undoubtedly the region of secondary settlement is indicated in Map No. 30, which shows the distribution of all places with names ending in -ley, -leigh, and -field or containing - wood. The assumption has been made that these names show settlement in previously forested regions.(46) The significant features of the map lie in the limitation of these places to the Coal measures, Permian Limestone and Keuper outcrops, and the avoidance of the Bunter. This outcrop, as we should expect because of the scarcity and inaccesibility of water and the hungry nature of its soils, was avoided as long as possible by the Angles and remained largely wooded and uncultivated.(47) Map No. 31 shows the probable extent of the final English settlements.

The first outstanding feature of the map is the continued sparsity of settlement on the Bunter outcrop, which, with the more profuse settlement on the Coal measures, Permian and Keuper outcrops, became more and more pronounced as a barrier between east and west. The second deduction made upon analysis is that the distribution of those settlements which are on the Bunter has been largely determined by geological controls. For this analysis, reference is directed to Maps Nos. 4. 11 and 15. The necessity of water was the determining factor in this settlement. This was actually provided on the outcrop:-

1. By the E - W streams, which would naturally make settlement thin by their fewness.
2. By the presence of impervious boulder clay.
3. By the availability of underground water, where the water table came near to the surface along the eastern edge of the outcrop.
4. By the presence of impervious Permian marls underlying the western edge of the outcrop.

Factors 1 and 3 are supplementary, since the streams largely depend on the doling out of underground water where the valleys cut the water table. These two controls account for the majority of the settlements on the outcrop:- (a) for the string of eastern villages, Arnold, Calverton, Oxton, Farnsfield, Boughton, Walesby,

Elkesley, Babworth, Ordsall, East and West Retford, Mattersey, Sutton, Everton, and Bawtry;(b) for Clipstone Edwinstowe, Ollerton, Blyth , Carburton. The combination of factors 1 and 4 gives the reason for the settlements at Oldcoates , Worksop, Cuckney, Norton, Sookholme, Mansfield Woodhouse, Mansfield and Annesley. Factor 2 accounts for Blidworth and Harworth.

An additional incentive to settlement on the edges of the Bunter lay in the presence of loamy soils which developed as the result of the mixture of Lower Mottled Sandstone and Permian marls on the west side, and of the Keuper Clay and Pebble Beds on the eastern boundary. (48) The greater part of the outcrop then remained unoccupied and must have still been covered, particularly in the southern half, with birch and oak wood, and open glades of bracken and heath, while the northern part was less wooded and more marshy owing to the proximity of the water table to the surface. Despite this, the formation had become the site of the most important road to the North, a fact which it owed to its aridity, This route - the North Road - connecting Nottingham, Ollerton, Blyth and Bawtry, remained important until after the Norman Conquest.

This must have been the state of affairs up to the time of the Danish invasion in the ninth century. The new invaders penetrated southwards from the Humber and those

that made headway up the Trent in their ships found that at Nottingham the river passage converged upon the overland route, already mentioned, from York by the Rufford Road taken by their brethren. Nottingham from this time assumed a new importance. The smaller Saxon settlement which was founded in the sixth century now became one of the five main boroughs of the Midland Danelaw. Nottingham now became established as the head of navigation on the Trent. The contact of land and water routes was consolidated in the year 924 by the building of the first bridge across the river.(49)

An attempt has been made in Map No. 32 to show the extent of Danish settlement in the region, using place names ending in -by, -thorpe and recognised Scandinavian personal names, recognising that this method only produces probability and not certainty.(50)

The chief feature of this map from the point of view of the Bunter Sandstone is the comparatively extensive Danish settlement between Bawtry and the River Maun, over the northern part of the outcrop. The place names plotted on this section of the map are Bilby, Ranby, Barnby Moor, Scrooby, Serlby, Lound, Ranskill, Carlton-in-Lindrick, Scaftsworth with Budby, Thoresby, Perlethorpe, Walesby, Kirton and Bilsthorpe on or near the Maun. On the western edge of the sandstone farther south are Kirkby and Skegby, Linby, and possibly Papplewick. The type

of the place names over the northern area suggests that the settlement was of a late period of the Danish occupation.(51) Two essential factors in control of the distribution of these Danish villages were;-(1) the adequacy of the water supply over the northern part of the Bunter outcrop as the water table is very near or at the surface. Reference to Map No. 15 shows this clearly. The 1" OS. map (the Doncaster district) shows that many of these settlements are placed above the level of the surface water - many of them on the edge of the 50' contour line. For examples, see Ranskill, Torworth, Barnby Moor, and Lound.

(2) the distribution of the Roman and main roads. During the Danish invasion the earliest settlements would be made by the army in the central parts of this region, e.g. at Lincoln, from which the Roman roads ran out in all directions. Considerations of a military nature would then play an important part in colonisation. It would be desirable that the army could be collected quickly and moved from one place to another. Since the Roman roads were the chief means - (though not the sole means) - of communication, then there is obviously a close connection between the distribution of Danish settlements and these roads.(52) This applies to the Danish settlements on the northern part of the Bunter Sandstone. One notices the obvious Danish control over

the roads which converge on Bawtry. On the western side of the Bunter the Danish settlements completed the line of villages between Nottingham and Mansfield. Linby, Papplewick, East Kirkby and Kirkby in Ashfield would appear to be the result of Danish penetration up the valley of the Leen, perhaps beyond the English settlements. At this stage there was probably a western route on the Bunter from Nottingham to Mansfield, to join the older road already mentioned.

It is reasonable to suppose that one of the peculiar features of Bunter Sandstone agriculture became established with the Danish colonisation of the northern section. In 1798 Lowe in his survey of the agriculture of Nottinghamshire, referring to the Bunter sandstone area, wrote "There was always about each forest village a small quantity of inclosed land in tillage or pasture, the rest lay open, common to the sheep and cattle of the inhabitants. It has been besides an immemorial custom for the inhabitants of the township to take up breaks or temporary enclosures of more or less extent, perhaps from 40 - 250 acres, and keep them in tillage for five or six years." The word break or breck is of Scandinavian derivation, (ON. brekka = a hillside; slope; brink; edge), which suggests that the practice of taking in brecks, - "an immemorial custom", dates back to

the Danish settlement. This peculiar deviation from the Midland system of agriculture was made necessary by the nature of the soils, and rendered possible by the tremendous amount of virgin waste land at the disposal of the inhabitants of the villages. The early agriculture of the Bunter outcrop, indeed until the beginning of the 19th century, was, under the conditions of hungry soils and uncertain climate (yet to be demonstrated), mere subsistence farming. Map No. 37 shows the 'breck' system of agriculture in use in the village of Carburton in 1615AD.

By the time of the Norman conquest the settlement of this region had been fixed. The Bunter outcrop, as has been shown, was sparsely and reluctantly settled, later than all the other outcrops of the region. (Map No.33). As a result, there existed a barrier between eastern and western regions of denser population. Though thinly populated, the outcrop, because of its aridity, carried the main north-south road, and already another route of growing importance ran over its surface, to connect Nottingham with the line of western villages and Bawtry. Finally the barrier aspect of the outcrop meant that the lines of settlement on the eastern and western edges faced outwards in their agricultural activities, to the more fertile Keuper and Permian lands. Meanwhile the few villages on the lines of the streams practised their

subsistence farming, augmented by the 'Breck' system, while the greater part of the outcrop remained birch and oak forest, land with large heaths and stretches of undulating bracken-covered waste.

(III). With the Norman Conqest the forest law and the forest courts of Normandy were introduced into England. The word "forest" is a legal term and means land outside the Common law and subject to a special law, whose object was the preservation of the King's hunting. Of the Conqueror, the chronicler wrote under the year 1087, "He made large forests for deer and enacted laws therewith.. The rich complained and the poor murmured but he was so sturdy that he recked nought of them." (53) The natural conditions of the Bunter sandstone outcrop rendered its passage into the hands of the Crown a comparatively simple process. The Doomsday map of Nottinghamshire shows that many villages which were afterwards within the Sherwood Forest limits, were members of the King's Great Manor of Mansfield. (Map No. 34). Hence it became an easy matter for the early Norman Kings to extend this large amount of Royal desmesne into a great forest. The Great Pipe Roll of 2 Henry II (1156) shows that over half of Derbyshire and Nottinghamshire was waste - part of it due to deliberate devastation, and part of it naturally so. (54) The first precise historic notice of the Sherwood Forest occurs in 1154, when William Peveril the Younger had it under his control and held its profits under the Crown. On the forfeiture of the Peveril estates in the early days of Henry II, Sherwood Forest lapsed to the King. (55) The extension of arable land in the area, already discouraged

by natural soil conditions,was now further denied by fines levied in the special forest courts. Through the reigns of Henry II and John,a considerable part of the Clay division of the N.E. of Nottinghamshire and the northern part of Hatfield above Worksop was declared forest. The Great Charter of John (signed under pressure of the Barons),and the Forest Charter of Henry III,restored these parts to the common lord of the land. The earliest extant perambulation of the Crown Forest of Sherwood of 1232 AD, with the still more precise perambulation of 1300 AD.,show it to have been approximately 20 miles in length by 8 miles in breadth. At the southern extremity was Nottingham, while, as Map No. 35. shows,the River Meden was the northern limit, with Mansfield inside the northern edge and Worksop just beyond it. As can be seen from the map, the forest extended on to the Keuper and the Permian, but the major part of its 100,000 acres occupied the Bunter outcrop,within the limits already mentioned. These bounds were still maintained according to a perambulation of 30 Henry VIII (1539) (56)

Thus the natural obstacles provided by the Bunter sandstone outcrop drew the greater part of the region into the control of the Crown. The same natural conditions made the second controlling factor in the life of the region from the 12th century to the 16th century, the Church. This isolated and secluded area provided the ideal conditions for monastic settlements. From the early part of the Norman Conquest,

on the sandstone and its borders were founded religious houses of nearly every variety of monasticism. In order of establishment on the outcrop the foundations were:-

1. Blyth Priory founded 1088 by Roger de Builli and occupied by Benedictines.
2. Worksop Priory " 1103 by William de Lovetot and occupied by Black Canons
3. Rufford Abbey " towards end of reign of Stephen by Gilbert de Gaunt Earl of Lincoln. and occupied by Cistercians.
4. Welbeck Abbey " 1153 by Richard and Thomas de Flemmaugh and occupied by Black Canons.
5. Newstead Priory " C.1170 by Henry II and occupied by Premonstratensians.
6. Mattersey Priory " C.1185 by Roger de Mattersey and occupied by Gilbertines.

while on the borders of the sandstone were

1. Wallingwells founded in the time of Stephen by Ralph de Chevrelcout and occupied by Benedictine nuns.
2. Lenton Abbey founded in the time of William I by William Peveril and occupied by Cluniacs.
3. Felley Priory " 1156 by Ralph Britto of Annesley and occupied by Black Canons.
4. Beauvale Priory founded 1343 by Nicholas de Cauntlow and occupied by Carthusians.

(Map No. 36)

Further evidence of the activity of the Church in the district lies in the foundation of hospitals or almshouses - five in

Nottingham itself, two at Blyth and one at Bawtry.(57) These religious houses had a dominating influence on the life of the region for several centuries, bringing the region into the trade life of England and laying foundations for later agricultural development. Many of the Bunter parishes were directly part of the endowment of these religious houses, which thus dominated the life of the villages, and of the county town itself (in the case of Lenton Abbey). Blyth Priory's control extended north to Bawtry, Rossington and Thorne, south to Shireoaks, Bothamsall, Ordsall and West Retford, and included Scrooby, Mattersey, Blyth, Barnby and Sutton.(58) Welbeck Abbey, which later in 1512 was made the supreme house of all foundations of the White Canons in England and Wales, controlled Cuckney and Norton, had an interest in mills at Retford and possessed land between Warsop and Worksop.(59). Newstead Priory controlled the neighbouring village of Papplewick, and had land in Linby.(60) An outstanding example of the extent of this monastic control is the case of Blyth Priory, which had the right to hold a fair, market rights in Blyth, and took toll over the road between the Rivers Ryton and Thorne. There is a record of 1276 giving an account of a complaint from the jury of Retford against the Prior of Blyth, because he took the exorbitant toll of 4d per sack of wool passing over his

territory. At the same time, toll was taken on all carted timber and all merchandise passing over the Priory lands.(61) Though Blyth appears to have been outstanding in this respect, standing at the junction of two very important N - S roads and having on that account to provide frequent hospitality, the other religious houses exerted a similar control, e.g. Welbeck owned the mills in Cuckney, and Newstead those in Papplewick.

The monastic settlements were responsible for the introduction of sheep rearing on a large scale to the Bunter Sandstone outcrop. There was a natural stimulus to this, in that the dry lands of the Bunter were less liable to cause animal disease of the foot and liver, and provided suitable short grass in many open parts. That Nottinghamshire became important in this sheep rearing occupation is indicated by the fact that, in 1340 the tax levied on all wool in England was fixed by the price that the commodity commanded in the Nottingham market.(62) The most important local record is that which records a grant made to Thomas de Cuckney to make sheep walk and pasture for seven hundred sheep.(63) The wool produced by the monastic settlements was exported to Flanders and Italy, and in this respect the houses on the Bunter were fortunately placed with easy access to

the ports of Kingston on Hull and Boston. For the outcrop, the inland wool collecting centres were Blyth and Nottingham. From Nottingham the wool was shipped down the Trent, while from Blyth it was carted to Bawtry and then shipped down the Idle. In both cases Hull was the primary collecting centre.(64)
In the lists kept by the Flemish and Italian merchants, of the monastic houses of England that could be relied upon for wool, Rufford, Welbeck, Mattersey, Blyth, Worksop and Newstead are all named.(65)
The second direction in which the monasteries laid bases for more than subsistence agriculture was in the business of enclosure of erstwhile unused land and in the clearing of the forest, in which activity they were not the only participants. Both enclosure and forest clearing were done lawfully, i.e. with the Crown permission, and unlawfully, as the following items from monastic histories show.

1. In the case of Newstead, in 1251 Henry III granted the Priory 10 acres of land in Linby with licence to enclose: this was followed in 1304 with a similar permission for 180 acres in Linby. Henry VI., in 1437, granted the Prior 8 acres in Sherwood in front of the Priory to enclose and cultivate, and another royal grant from Edward IV. in 1461 brought 48 acres to the north, east and south of

the Priory for further enclosure and cultivation.(66

2. In the case of Welbeck, in 1307 permission was given to break and enclose 60 acres in Roomwood (between Warsop and Worksop)(67). There is also a record of illegal enclosure by this religious house, which will serve as an example of what must have been more than an isolated instance, in which the Abbot had enclosed 24 acres of arable land outside the monastery gate, in spite of the protests of the King's tenants of Carburton who claimed rights of Common on it.(68)

This enclosure of land from the vast wastes of forest and the Bunter outcrop must have gone on steadily during the Middle Ages, only the permitted enclosure being recorded, while a great deal more was done without Crown permission, and much taken in in the form of brecks or temporary enclosure. Leland states that in his time much of the land between Worksop and Retford was already enclosed, while the survey of 1609 totals enclosures as 44,839 acres, a figure which undoubtedly contains a very large area of temporary enclosure taken in by forest villages.(69)

The same record of lawful and unlawful felling of timber over the monastic period, indicates that the Crown Forest was also dwindling in size, and becoming more open. The records of the monastic houses show

how generously in this respect they were treated by successive English Kings. The grants to Lenton include one by Henry III for 25 tie beams out of Mansfield wood, and 2 oaks from Linby Hay, while in 1232 there is recorded a grant for 30 oaks from Sherwood.(70). There are similar records of grants to Rufford over a long period, and one case in which the Abbot was charged at the Forest Eyre of 1267 of having felled 483 oaks for building purposes, and of his appealing successfully to a charter of Henry II to justify his action. Again in 1359, the Abbot of Rufford was charged with having laid waste the wood of Beskhall, cutting down and selling oaks over 20 acres and 3 roods of land. He was, however, able to plead that charters given by earlier Kings justified his action, and was then allowed to continue the felling to the extent of 40 acres of woodland.(71)

Between 1231 and 1234 Royal gifts of timber from the forest included 5 oaks to Gilbert Spigurnel to make a mill: five oaks and thirty tie beams to the Chaplain of Hugh de Burgh: twenty oaks to Brian de Insula: five lime trees to the Franciscan Friars of Nottingham to make their stalls: thirty oaks to the Dean of St. Martin's, London, for timber for his chancel at Elm: forty rafters to Brother Robert de Dyva: ten oaks to Robert Lupus: fifteen oaks to William de Albini for

making rafters. Besides gifts to the monasteries and to private individuals, the wood of Sherwood was thinned by other uses. When in 1316 the Parliament was held at Lincoln, Edward II ordered the forest keeper of the great wood at Blidworth to deliver to the sheriff fifty leafless oaks from that wood, to be used for making charcoal, and for boards for trestle tables. Thirty oaks were likewise to be sent to Nottingham, for firewood in the King's hall against the ensuing Parliament, and thirty more for the King's chambers. The timber was also occasionally used for military purposes, as when towards the end of the year 1323, the Sheriff of Nottingham and his carpenters were instructed to obtain as many oaks and other suitable trees out of the forest as were necessary to make nine springalds, (military catapults), and a thousand quarels, (heavy arrows for discharge from springalds), for use in a military expedition in the Duchy of Aquitaine.(72)

Undoubtedly, too, the destruction of timber by villagers and private individuals proceeded regularly, since at the Forest Eyre of 1334 there were over seven hundred and fifty fines imposed for vert trespass. By the time of Henry VII the complaints as to the gradual destruction of oaks in Sherwood became very numerous.(72) This process of destruction,

as will be shown, accelerated quickly after the dissolution of the monasteries, an event which, as can be readily seen, produced great changes in the life of the Bunter sandstone region, indeed of the whole of Nottinghamshire. Not only did the monasteries lay the foundation of later agriculture on the Bunter outcrop, but to a large extent they must have stimulated local industries in the forest villages, to augment the subsistence forming carried on there. The monks introduced plants into the region connected with the wool industry. Meadow saffron, which was grown at Nottingham, was imported from Europe (it is a native of the Pyrenees) by monastic immigrants.(73) Country weld or dyer's weed was grown at Scrooby, Ranskill and Torworth, and probably connected with the sheep industry of the region.(74) Details are given later of a local iron industry with forges in the forest villages, but mention should be made of bellfounding at Bawtry and Nottingham, as a probable monastic craft in origin.(75) Other local crafts connected with the forest, and possibly stimulated by the monastic houses, were wood carving at Edwinstowe and its development in chair making at Worksop.(76) Basket work is mentioned as early as 1303, while the making of besoms in the forest villages was a winter industry. An agricultural activity, obviously connected with the

sport of the Crown Forest, was the breeding of hunters at Edwinstowe.(77)

Meanwhile at the south of the Bunter outcrop Nottingham was growing in importance, both as a strategic point in time of war and as a centre of commerce. In his advance on the north, William I took an early opportunity of securing the town and erecting a castle, to the west of the older Anglo-Danish settlement and overlooking it. On the other hand the town was the centre of routes from north and south, and was connected with the east coast ports by the Trent, and with the west and north west by the Derwent and Trent. Local industries developed. By 1155 it was a centre for dyeing cloth, and by 1348 there was a local coal trade as the result of surface mining of coal on the Coal measures of the Nottinghamshire - Derbyshire border to the west of the town. Together with these industries it became famous for alabaster, (derived from the Keuper Marls), while the proximity of iron ore in the Erewash Valley, Derbyshire, and of oak bark from the forests to the north, saw the beginning of iron working and a leather industry, (with a further development in a shoe making trade). Connected with the supply of oaks in the Forest, wood carving and a furniture trade grew up. As has already been stressed, Nottingham occupied a most important position in

the medieval wool trade with Flanders and Italy, while Lenton Fair became a great mart for cloth, and the town itself was made a staple town in 1355. The Nottingham Gild of Weavers was one of the few gilds acknowledged by Henry II. In these medieval trades are the forerunners of the chief industries of modern Nottingham.(78) The medieval period saw further developments in the system of main roads. By the 13th century, the North road running from Nottingham to Bawtry, over the Bunter outcrop, via Ollerton and Blyth, had ceased to be of great note as a route. The western road, running parallel to it, from Notting'm via Basford, Bulwell, Linby, Papplewick, and passing through Mansfield, with its royal manor, Warsop and Worksop, with its great priory, had superceded it. (Map No. 35). Another trunk road, the Great North Road, crossed the Fosseway at Newark, and passing through Tuxford on the Keuper and East Retford on the River Idle, also ran to Bawtry. Thus four ancient roads converged on Bawtry at the northof the Bunter outcrop. Map No. 26 shows how this focussing on the northern exit from the region was dictated by geographical factors. These ancient roads enter the area by the Soar Gap, the Grantham Gap and the Lincoln Gap. Where they enter the region they are wide apart, but the corridor nature of the area.between its

parallel east-west hills, and the marshes of the Humber in the north, cause them to converge on the most easterly point where the marshes could be passed, i.e. on Bawtry.(79)

(IV) The dissolution of the religious houses of the outcrop, which began in 1536, saw the complete redistribution of territory and brought the area under the control of a new external factor in the form of local gentry, a vigorous mercantile class, some belonging to the old nobility and many more to the nouveau riche stratum of society of the period. The following summary indicates the nature of this change:-

1. Blyth Priory lands in 1538 were obtained by Sir Gervase Clyfton.
2. Wallingwells Priory was obtained by Richard Pype, Leather seller, and Francis Bowyer, Grocer, both London merchants.
3. Welbeck Abbey site and surrounding property was first sold to Richard Whalley of Screveton, who later resold a large part of it to Edward Osborn, "citizen and cloath worker" of London, who sold it again, after which it passed to the Charles Cavendish and so to the Duke of Newcastle.
4. Rufford Abbey estates were granted, along with their large endowments, to the Earl of Shrewsbury.
5. Worksop Priory was granted by Henry VIII to Francis, Fifth Earl of Shrewsbury.
6. Newstead Priory and property was made over to Sir John Byron of Colwick.
7. Mattersey Priory went to Anthony Nevill, Esq.

On a larger survey it may be stated that few, if any, of the gentry of Nottinghamshire failed to take advantage of the times, and the land that was slipping from the hands of monk and peasant was shared, not unequally, among the descendants of the old baronial houses and the new men from the towns.
The results of this vast change were in many ways bad. The new owners often proved to be absentee landlords, speculation on the part of the new rural capitalist often led to rapid sales, (eg. in the case of Welbeck Abbey), tremendous increases in rent, and, sometimes, eviction of tenants. On the other hand, this political and social change led to the exploitation, enclosure and serious cultivation of the comparatively uncultivated outcrop of the Bunter sandstone. There was ample space for enterprise and the new gentry, once in possession, took their opportunity to increase their fortunes. Agrarian enterprise in the Forest and Bunter districts had only been in its infancy at the closing of the monasteries, and when, in the seventeenth century, Church power had largely disappeared and the Crown could no longer sustain its ancient rights, the local lords began to extend their claims, real and imaginary, to the soil of the Forest and its environs, where once in actual possession, they cleared, enclosed, ploughed and planted it in wholesale fashion. This

enclosure movement, as can be seen from the foregoing, was no new thing. It belonged to a process which had been accelerating from medieval times, continued into the seventeenth century and reached its culmination at the close of the eighteenth century.(80) The causes of this energetic enterprise on the part of the rural capitalist are not far to seek. Sheep rearing, as a business proposition, was losing its place with the decline of the price of wool from the beginning of the 17th century, while there was on the other hand, a tremendous increase in the price of wheat in the 16th and 17th centuries. In 1320 the average price in England was 6.5d per quarter. In the following century a local price is given at 3/4d - 4/- per quarter. At the beginning of the 16th century the price began to increase, ranging about 10/- per quarter, but had risen to about 20/- per quarter at its close. Prices at Worksop for 1583 give wheat as 21/4d per quarter: for 1584 as from 16/- to 21/4d: while in the wet seasons of 1595 and 1596 it commanded as much as £2. 2. 8 per quarter, though, of course, it resumed the normal price of about 20/- in the closing years of the century.(81) Between 1603 - 1612 the commodity was at an average price of 35/3½ per quarter, and had jumped towards the close of the century, between 1693 - 1702, to 43/2¾ per quarter. Corn growing was also indirectly encouraged

by legislation. Under the Commonwealth an Act was passed permitting the export of Corn. When the price of wheat had reached 40/- per quarter export was allowed. The statute was re enacted in 1660; and in 1663 the liberty given was extended, by allowing wheat to be exported when the price at home was not more than 48/- per quarter. In 1672 a bounty of 5/- per quarter further stimulated corn production for three years, and this provision was revived in 1689. Thus, by the end of the century, England had become an important corn exporting country. Other causes, too, stimulated arable farming. The landed gentry, finding land profitable and forming a majority in both Houses of Parliament, endeavoured to promote agriculture by legislation. As the result of the development of industries. towns were increasing in population, with the consequent factor of a new home market for food crops.(82) It was under these national conditions that the Bunter outcrop, with its still vast virgin acres, proved to be an ideal region for the new business of corn production.

The first and most obvious result of this, was the clearance and practical disappearance of the old Crown Forest. The Survey of the Royal Forests, Parks and Chases of 1608 gives the following figures for Sherwood:-

Timber trees 23,370: Decaying trees 34.900, and further details attaching to the Survey give the following acreages.

Woods 9486 acres: Enclosures.44839 acres. (Most obviously largely temporary enclosures as brecks)

Clipstone Park 1583 acres.

Bestwood Park 3,672 acres. Unenclosed 35080 acres.

Bulwell Park 326 acres.

Nottingham Park 129 acres.(83)

Felling and clearing, however, were making havoc of this supply of timber. A MS. letter of 1641 (Nottingham Reference Library) describes the change overtaking Sherwood so:-

"I have myself seen in that Lordly Lindhurst and other parts of this forest, numberless numbers of goodly oak without Bush or Twig, saving the Top Bush, such for tall and streight as a man would conceive the cedars of Lebanon ..... to be, where now there is ..... not so much as a Bush for a Nightingale to rest in. Yet there are some reliques of the Ancient Beautie of this Forest in the parts of Belhaigh and Birkland, though these be shrewdly gelded and pruned, which woods..... consist only of fair and stately oaks."(84) It can be said that, in 1686, there were 12,500 oak trees less in Birkland and Bilhaugh than in 1609.(84a)

An outstanding example of this early forest enclosure is that of Bestwood Park, described by Leland as "a mighty Great Park" (see 1609 acreage above), but by Thoroton in 1677 as "parcelled up into little closes on one side and much of it ploughed, so that there is scarce wood or venison, which is also likely to be the fate of the whole Forest of Sherwood". A tremendous amount of timber was destroyed during the Civil War, in which respect the chief local landowner affected was the Duke of Newcastle. His lands were deforested to the following extent:-

> Clipstone Park and woods cut down to the value of £20,000.
>
> Kirkby woods, for which my Lord was formally proffered £10,000.
>
> Red Lodge Wood, Rome Wood and others near Welbeck £4,000.

Welbeck Park was the only one of the Duke of Newcastle's eight parks that was not destroyed.(85) This deforestation gathered speed towards the end of the century. The extent of the business may be gathered from the tremendous and extravagant grants of timber made by the Commonwealth Government. For example, a certain Mr. Clarke was given the right of felling 28,000 trees (fantastic figure') from Sherwood, for his own use, by the Committee for the sale of Traitors' Estates.

But the really systematic destruction opened with the Restoration.(86) There were two prime causes for this devastation, apart from the desire to obtain land for corn growing:-

1. The growth of English maritime power and commerce, with the increasing demands for timber for the navy in the shape of stout mature oaks of about 100 years old, and the much larger requirements of merchant shipping for timber for the hulls and planking of ships.
2. The manufacture of charcoal for the smelting of ores - in this particular instance, iron ore.

The woodland of the Bunter outcrop was used for both of these purposes. For the former purpose the wharf at Bawtry was clogged with timber: in 1670 it was said that the forest still contained 4,500 loads of serviceable timber, sufficient for the frames of four third-rate ships and large quantities were sent from East Stockwith to Deptford, but in the same year it was reported that "not any more timber is left in the woods." The result of this rapid clearance of timber was seen in the many complaints of the destructiveness of the deer, which now were deprived of shelter. They roamed in the cornfields, woods and meadows, miles from the forest, some were killed by angry tenants, and the verderers complained

that they would be exterminated unless something was done. As they multiplied at their usual rate, they were unable to get food in hard weather and wandered into barns and fields while watchmen had to be employed to defend the standing corn.(87) Finally they were confined as private herds in enclosed parks and by the end of the 18th century the wild deer were exterminated. In this rapid deforestation, though the best trees were taken for the needs of shipbuilding, a second factor of importance was the need for wood and charcoal for the local iron industry, the forges of which were located in some of the forest villages on the sandstone outcrop, and on its western edge, on the Permian limestone and coal measures. This industry reached its peak period in the seventeenth century, adding considerably to the fortunes of the local squires and repairing the breaches made by the fines of the Civil war, in which Nottinghamshire was a centre of conflict. The list of names of local Royalist lords and squires, who must have been financially affected and impoverished at the close of the war includes William, Earl of Newcastle (Welbeck), Gilbert, John and Philip Byron (Newstead), Sir Willoughby Hickman (Mattersey), John Mazine (Carburton), Sir John Digby and Sir Thomas Blackwell (Mansfield Woodhouse), Thomas Markham (Ollerton) and many others.(88)

Details of this industry can be gleaned from a letter book of 1662 - 1666, belonging to George Sitwell of Renishaw,(about eight miles due west of Worksop), one of the squires concerned in the business. In this picture of the industry the following forges are named:- Renishaw, Staveley, North Winfield, (4 miles SSE. of Chesterfield), Upper and Nether forges of Pleasley, (2 miles N.W. of Mansfield), Stanley, Stone, Cuckney, Carburton and Clipstone, the last three being in Bunter sandstone villages, and the remainder close to its western boundary. In this industry, it was a frequent practice for two or more employers to become partners in some big bargain for the purchase of wood or the delivery of iron. In such cases, they hired or built a furnace or forge, and divided the tools when the business was finished. Sometimes one partner would contract to supply another with iron or with wood. The main supply of ironstone came from the Staveley, Sheffield and Erewash districts, and wood charcoal was always the fuel at the forges and furnaces. Actually much iron was imported, via Hull and Bawtry, from Sweden and Spain, a trade which began as early as the 14th century, for the manufacture of steel at Sheffield, since the local ore, with its phosphoric impurity, was of little use for making steel knives. The charcoal was made in the Forest villages concerned, the timber being bought, felled and turned into charcoal on the spot, and thence carried in baskets and 'charcole waines' to its destination. The cost of carriage was the greatest item in expenditure.

The timber that was made into charcoal was of the inferior kind, the cordwood offal wood, lopps and toppes being made use of, while the giants of Sherwood were reserved for shipbuilding requirements. There is, for example, in this record an account of how that in 1664 it was intended to cut down about 3000 trees from Clipstone woods to make planks, of which the remnants would be worth about £500, and of the rivalry of the local squires for this bargain. From the records given it is evident that a tremendous amount of wood was used for the iron industry, and both purposes must have provided a great incentive to the felling of timber on estates belonging to impoverished squires and lords. Among the many articles of manufacture recorded in the industry, there are named sow iron, chimney plates, sugar cane rollers, sugar stoves, guns, hammers, smoothing irons, pots, mortars and pans, at the furnaces, and bar iron, slitt iron, flat iron, iron plates, brewers squares, saws and nails, at the forges.
Work at the furnaces and forges was only done in the winter and the early part of the year, so that the goods might go to the water in summer, because it was very difficult to carry them in winter, even at a double charge, because of the very poor roads, particularly on the clay soils. The goods were first transported overland to Bawtry, and thence sent down the Idle, unloaded at Stockwith and transferred to larger boats, taken to Hull, and thence despatched to London.(89)

While the business of deforestation proceeded rapidly,

the enclosures on the Bunter wastes were making rapid headway under the stimulus of the material causes already given. The following facts show the enclosure movement accelerating towards its 18th century peak, under the energetic drive of the new land owners. In 1636 -37, for example, Sir William Savile obtained permission to plough up and sow as much of his soil in Sherwood Forest as he liked, in order to destroy coneys and their burrows. In 1601, Sir John Byron tried to extend his claims over Bulwell Moor for a similar purpose, but was prevented by the Copyholders and tenants of the Manor, who petitioned the Privy Council and were upheld in their rights. In 1663 John Trveman, Verderer of Sherwood, petitioned for a commission to enquire into contracts for the enclosure and ploughing up "of thousands of acres" in the Forest, by agents of the local proprietors, and there is evidence in a letter of the Duchess of Newcastle in 1711 that enclosure was taking place, along with deforestation, on a considerable scale on the Newcastle estates.(90)
Meanwhile this mercantile activity was influencing considerably the growth of population in the region in the 17th century. In the absence of accurate statistics, it will be best to consider the condition of some of the growing towns that lay on the east and western edges of the Bunter outcrop - Nottingham, Mansfield, Worksop, Bawtry and East Retford, - and to attempt a rather speculative survey of the distribution of

population over the county . It is evident that in the general distribution of population many parts of the Bunter sandstone country were very thinly inhabited, and great stretches were still entirely unoccupied, and that though the outcrop provided a basis for the important north - south roads already named, it continued to be the broad barrier between the now comparatively industrial west, and the agricultural east of the Trent Valley and Keuper outcrop. From Nottingham to Mansfield the road still ran through wide tracts of virgin woodland where the red deer still roamed wild. Farther south,owing to the encroachment of cornfields, the activity of the woodman's axe, and the enclosures of the local lords, the forest was disappearing. The district was intersected by numerous lesser roads and tracks, but apart from the great estates like Welbeck and the small villages in the clearings, it offered only a hard earned livelihood to the inhabitants. Despite this apparent sparsity of settlement, evidence does not suggest that this north western part of Nottinghamshire was, at this period, far behind the south east, across which ran the fertile Trent valley, in population or wealth. For example,in the subsidy of 1641 in Nottinghamshire, 1211 persons were assessed in 206 parishes, and paid a total sum of £1059.12.0. To these figures, the two hundreds of Broxtowe and Bassetlaw, comprising the N.Western section of the county , contributed

527 persons, 93 parishes and £476.10.8. Nottingham itself contributed 71 persons and £55. 8. 8, so that it appears that the two north western hundreds were nearly equal in taxable capacity, - reflecting population and wealth, - to the remaining four hundreds of the country. These two hundreds, however, contain parishes west of the Bunter on the outcrops which were in the early stages of new industrial development, such parishes as Selston, Eastwood and Sutton in Ashfield, besides some of the prosperous Keuper parishes, as, for example, Tuxford and East Markham. These mask the continued sparsity of population on the Bunter outcrop . Stray facts, recording the size of the forest villages at the time, bear the marks of exaggeration. During the Civil War, Carburton Chapel was stated to have 600 communicants, while at Blyth, in 1650, the vicar was stated to be "too weake a man for soe great a congregation". The Carburton parish registers, on the other hand, record 40 burials for the decade 1627 - 36, which suggests a total population of about 120 (allowing a death rate of 1 in 30). Edwinstowe for 1634 - 43 had 154 burials and a probable total population of about 450.(91) Similar figures for Ollerton parish record 57 burials between 1630 and 1639, giving a probable population of about 170-180. The numbers of people of age to take the sacrament in local towns gives an indication of their comparative sizes:- (1) Nottingham - 2912. (11) Mansfield 994. (III) Worksop. 1200. (IV) Retford 400 - though there is no indication from how wide an area round

the towns, these people came to the Churches.(92) Nottingham probably contained a population of about 5000 people,(burials recorded at the three parish churches for 1650 - 1659 total 1740), and was occupied with many branches of growing commerce, in the manufacture of iron and steel, in the local coal industry of South West Nottinghamshire, malting and brewing, (for which the gypsiferous waters of the river were particularly suitable), hosiery and silk and industries connected with cattle, such as tanning and shoe making, while it was the market centre for the agricultural produce of the neighbouring country side. Besides, the town did a considerable river trade down the Trent which connected it in commerce with Hull and London, and inland with the west Midlands.(93). Mansfield was 'a great market town,' possessing a hall where the manorial courts, and the Swanimote and attachment courts of the forest of Sherwood were held, besides participating in the growing hosiery and silk trade of the county town. The statement, however, that the manor of Mansfield at the close of Elizabeth's reign had 8000 inhabitants, is obviously an exaggeration, though its prosperity is reflected in the foundation of a Grammar School in Elizabethan times. In the Civil War period Mansfield Parish is stated to have had 1000 communicants. Farther north, Worksop, though it also was a market town for its area, consisted of two streets only. On the opposite side of the sandstone outcrop, East Retford on the Idle had

an active commercial life, with a river trade in Derbyshire lead, (which was brought overland from Matlock district via Chesterfield) , the timber of Sherwood, and corn from the Keuper clay lands. Politically it alone of all the towns of the country, shared with Nottingham representation in the House of Commons.(94) It was in the 17th and 18th centuries that the geographical position of Bawtry, at the northern end of the Bunter outcrop, made it an inland port of great importance and activity. Defoe's description of it runs so, ".....Bautry, a town blessed with two conveniences which assists to its support, and makes it a very well frequented place.

1. That it stands upon the great highway from London to Scotland and this makes it to be full of very good inns and houses of entertainment.
2. That the little but pleasant River Idle runs through, or rather just by the side of it, which, contrary to the import of its name, is a full and quick, though not rapid and unsafe stream, with a deep channel which carries hoys, lighters, barges or flat bottomed boats, out of its channel into the Trent, which comes within seven miles of it, to a place called Stockwith, and from thence to Burton, and from thence, in fair weather, quite to Hull, but if not, 'tis sufficient to go to Stockwith, where vessels of 200 ton burthen may come up to the town

loaden as well as empty. By this navigation, this town of Bautry becomes the center of all the exportation of this part of the country, especially for heavy goods, which they bring down hither from all the adjacent countries, such as lead, from the lead mines and smelting houses in Derbyshire, wrought iron and edge tools .... from the forges at Sheffield..... Also millstones and grindstones, in very great quantities, are brought down and shipped off here, and so carried by sea to Hull, and to London, and even to Holland also. This makes Bautry Wharf be famous all over the south part of the West Riding of Yorkshire, for it is the place whither all their heavy goods are carried, to be embarked and shipped off".(95) It is evident that the increased importance of Bawtry was due to the developing activity on the Bunter outcrop and the growth of a manufacturing region to the west of it. In the absence of good roads, water carriage was necessary to make available for export lead, timber, corn and iron and steel goods, where previously the main source of trade had been wool.
In 1637 there had been a project for making the Derbyshire Derwent, described by Defoe as "a fury of a river" -, navigable to Derby, in order to bring the ore of the mines at Wirksworth more easily to the Trent, and to reduce the costs and difficulties of road transport, via Chesterfield to East Retford and Bawtry. This was opposed by Nottingham,

Bawtry, East Retford, the land carriers of Loughborough, Blyth Mansfield, and those desirous of maintaining a high price for corn. The Act was not passed till 1720, so that Bawtry's trade in lead remained into the 18th century. Prior to the drainage of Hatfield Chase by Vermuyden, the Idle had three outlets to the sea - by a navigable cut, the By Carrs Dyke to Stockwith, by Mare Dyke, and by a natural channel to Adlingfleet. After the drainage scheme, the By Carrs Dyke became the chief and navigable branch of the Idle, throughout open as far as Bawtry.(96) At the same time, besides the iron and steel industry of the Sheffield and Hallamshire district, coal mining was increasing its output on the exposed coal field to the west of Nottingham and Mansfield - at Wollaton, Strelley, Bramcote, Bilborough, Trowell and in the Newstead - Kimberley district - for local purposes, industrial use, and for export out of the county, in exchange for corn and other commodities. An estimate of the annual output of the coal pits of the Trent valley for the beginning and close of the 17th century, shows an expansion from between 30,000 - 50,000 tons, to between 100,000 - 150,000 tons.(97) Connected with coal pits, other heavy industries had been developed in the area, particularly glass at Wollaton and Awsworth, and iron and brass goods in and around Nottingham. In Nottingham and the villages to the north - some on the edge of the Bunter, as e.g., Calverton and Woodborough - the hosiery trade was in its infancy, and there were said to be a hundred stocking frames at work in the county town by 1669, a figure which had

increased to 400 by the beginning of the 18th C. These were worked on the worsted, spun locally from the wool produced on the southern part of the Bunter outcrop.(98) Finally, the beginning of a further change in the Bunter environment should be recorded. This was the attempt to drain the drowned lands to the north of the outcrop, known as Hatfield Chase. For this work Sir Charles Vermuyden, the famous Dutch engineer already mentioned, was commissioned by Charles I in 1630. How much was reclaimed it is impossible to say. Much of the area remained very boggy and impossible to plough by horse.(99)

This agricultural and industrial endeavour increased in strength in the 18th century, which from the point of view of the Bunter sandstone, is the century of enclosure. Map No. 38, which should be compared with Map No. 39, shows the increased scale on which this was done. This enclosure proceeded by four methods:-

1. By Parliamentary Act, by which at least 4000 acres were enclosed in 18th century, and 900-10000 acres in the 19th Century.
2. By private agreement of the proprietors, and private enclosure.
3. By unrecorded absorption by the Forest villages, in the form of brecks.
4. By the squatters and cottagers living on the outskirts of the centres of population, - particularly around Mansfield (Maps.Nos. 38 and 39).

The greatest progress was made by private enclosure, of which Lowe in his "Agricultural Survey of Nottinghamshire" 1798. gives the fullest account. The following examples will serve to indicate the progress being made by permanent enclosure.

1. Clumber Park, with its mansion (built in 1770). lake and river, and circumference of 10 - 11 miles, had been created within the previous thirty years from a 'black heath of rabbits, with a narrow river running through' and contained besides expensive plantations, "above 2000 acres --- in regular and excellent course of tillage, maintaining at the same time 3000 to 4000 sheep."
2. Newstead Park, cultivated with three farms.
3. Bestwood Park, with an area of 3700 acres, and previously cultivated only in breaks, was divided into eight farms.

In a list of private enclosures, Lowe shows that 10,366 acres had been enclosed by eight individuals, in twelve different parts of the forest and its borders, in the latter half of the 18th century. (100)

Much of the land taken in by the villages of the outcrop was brought into temporary cultivation, allowed to lapse to pasture for sheep, and brought back into cultivation, when it had recovered. Gervase Markham, a famous Nottinghamshire agricultural improver, writing in 1629 advocated a sequence of crops occupying 10 - 11 years, of which three to four

years were spent "lying at rest for grass". His books had a big public, and this system may well have had a vogue on the Bunter sandstone, as it was very suitable for light soils, in which case it formed a transition stage between the three field system and four course rotation.(101)

Another feature of the agricultural development of the outcrop in the eighteenth century, was the halting of the policy of devastation of forest after the Restoration period, and the beginning of enclosure for plantation on the part of private land owners. In his visit to the old Forest region in the early part of the century, Defoe records ".... there are some fine parks and noble houses in it, as Welbeck..... and Thoresby..... But..... the woods which formerly made it so famous for thieves are wasted; and if there was such a man as Robin Hood, a famous outlaw ..... , that so many years harboured here, he would hardly find shelter for one week."(102) The widespread movement for plantation however is thus summed up by Defoe's editor in 1778: "the spirit of plantation has nowhere exerted itself with more vigour and effort than in this county The Dukes of Norfolk, Kingston, Newcastle and Portland, have made prodigious plantations. Lord Byron, Sir Charles Sedley, and many others have given a new shade to their respective estates, but Sir George Saville has planted a whole country: So the Sherwood Forest may once again be clothed in all the dignity of wood." Some of the parks admired so by Defoe were made quite early. For instance, in 1661 Sir Patrick Chaworth was given the right to enclose

1200 acres in the Manor of Annesley, for purpose of sport. In 1709 the Duke of Newcastle made a very good bargain with the Crown, for enclosing and planting 4000 acres of Clumber Park. Though this part of the Forest had been almost stripped of timber, by 1778 it had been replanted by the Duke in a manner "that reflects honour upon his taste, and will in time restore it to more than its pristine beauty." The plantations increased as the century wore on. In 1798, Lowe gives a list of twenty three parks on the Bunter sandstone and its borders, totalling 7,197 acres in area. The increase in value and beauty of the area was bought at the expense of its inhabitants and the Crown. At the end of the century, after dubious methods had been used to wrest the old Forest area from the possession of the Crown, the latter possessed no more than the Hays of Birkland and Bilhagh, near Edwinstowe, and even here the soil was claimed by the Duke of Portland as part of the Manor of Edwinstowe.(103) In the Survey of 1783 the Old Forest contained only 1368 trees of over 30ft. and 8,749 defective trees of all sizes. The external factor in this extreme activity for enclosure and for cultivation, was undoubtedly the continued increase in the price of corn. For this the Bunter sandstone had offered an extensive field for new enclosure of previously waste land, and a share of the spoils to the owners. Before leaving the 18th century, some consideration should be made of two further changes during its procedure, that had overtaken the region. These two were, the improvement of the roads by

turnpiking, and the cutting of canals. In both cases they were a means of stimulating commerce and of making possible the export of the products of the region. The improvement of roads was especially necessary, since only over the Bunter country were there satisfactory routes. East and West the roads passed over clay soils, which often rendered travel impossible and held up commerce. There is a record, for instance, of the hold up of 6000 tons of coal at Belper in March 1764, because the road was impassible between that town and Nottingham, pending better weather conditions. Defoe's comments on the state of the local roads show how necessary improvement was. He says, talking of the Great North Road "From thence you enter upon the clays, which beginning at the famous Arrington Lanes, and going on to..... Grantham, Newark, Tuxford (call'd for its deepness, Tuxford in the Clays), holds on 'till we come almost to Bautree,..... and there the country is hard and sound, being part of Sherwood Forest." And again "Suppose you take the other northern road..... On this road..... you enter the deep clays which are so surprisingly soft, that it is perfectly frightful to travellers..... At Nottingham you are passed them, and the Forest of Sherwood yields a hard and pleasant road for 30 miles together." The turnpikes improved this state of affairs for the region, and during the century, from 1725, new foundations were given to the old routes. Not that it should be imagined that the turnpike roads were first class. Indeed, faulty construction, though not neglect, made

this very unlikely. Nevertheless they were a great improvement on the old roads.

From the point of view of the development of the Bunter outcrop the concentration of improved roads on the towns on its edges, connected Worksop to Chesterfield and Sheffield; East Retford to Rotherham, Chesterfield, Gainsborough and to Newark; Mansfield to Newark, Chesterfield, Alfreton, Derby; Nottingham to Grantham, Newark, Loughborough, Leicester, Mansfield and Worksop, and the towns of the Western Coalfield. The result was the easier transport and shipment of coal out of the area via the Trent and Humber, and the drawing of the towns of Mansfield, Worksop and East Retford into the scheme of industrial development of the region.(104)

The construction of canals augmented this process. The three which concern the region, are the Erewash, the Nottingham and the Chesterfield - East Stockwith Canals. The two former were used for the transport of coal from the Erewash valley to the Trent, for shipment to the Humber estuary. The last named, cut in 1775, killed the trade of Bawtry, but enhanced the prospects of development of Worksop and East Retford, since it connected them with Staveley and Chesterfield.(105)

(V). At the time of Lowe's Survey the external economic factor was at great strength. The nation was in the middle of the Napoleonic wars which, forcing the point that in serious national clashes agriculture comes next in importance to direct fighting, raised corn prices still further and hastened enclosure. Coupling national crisis with a series of bad harvests, the price of wheat soared from 46/- to 84/- per quarter,(the highest price of wheat in England is that of Dec. 1800, when it reached £6. 13. 4. per quarter.) Rapid and extensive enclosure for wheat growing by the 'Capitalist' farmers followed, and even the naturally difficult sand lands of the Bunter shared in the agricultural 'boom' (106) It is against this background, that Lowe's survey must be considered. Twenty years before Lowe's "General View of the Agriculture of Notts.", Sir George Saville had succintly described the resources of Nottinghamshire as "four Dukes, two Lords and three rabbit warrens", (his estimate was prejudiced by his contact with the Bunter outcrop.), whereas Lowe states enthusiastically that - "Little waste land is now left in this county, much the greater part of the forest being inclosed", but later modifies this with - "what remains is mostly poor barren land: a good deal of it is in rabbit warren, and it is to be doubted whether it would answer so well in any other shape. Some part has formerly been taken into

cultivation and thrown up again." Rabbit warrens had been destroyed at Farnsfield, Clumber Park, Bestwood Park, Sansom wood and Haywood Oaks, but still existed at Clipstone, Oxton, Blidworth, Calverton and Newstead. Nevertheless, though Lowe's enthusiasm probably tinged his account with exaggeration, he had much reason to be excited over the agricultural development that he saw. His report chronicles the emergence of Bunter sandstone agriculture from a poor form of subsistence farming into a business, as has already been stressed, under the stimulus of an external economic and political factor.(107)

The main improvements which Lowe saw might be summarised as follows:-

1. The development of sound rotations with the introduction ofturnips . Prior to the introduction of root crops the system in the brecks was,

1st yr. oats or pease)
2nd yr. barley.) ,and then the land was
3rd yr. rye.) left to recover by rest.
4th.yr. oats.)
5th yr. skegs. (thin oats)

After the introduction of root crops, the sequence in the brecks, producing better and more valuable crops, became

1st. yr. turnips.
2nd, yr. Barley.
3rd. yr. Rye.
4th. yr. oats with seeds (for hay)

after which the break was thrown open.

On the permanent enclosures experimental rotations were being tried out, varying with location and owner.

At Clumber, for instance, on the best land the sequence was as follows:- 1st yr. Turnips, 2nd yr. Barley, 3rd yr. Clover, 4th yr. wheat, 5th yr. Turnips, 6th yr. Barley, 7th year and following 5 or 6 yrs. - seeds; on poor land 1st yr. turnips, 2nd yr. - oats, 3rd yr. and following, - seeds.A common sequence elsewhere was:- 1. turnips, 2.barley, 3. clover, 4. wheat, and sometimes:- 1. oats, 2. wheat, 3. turnips, 4. barley, 5. seeds for three years. It was, finally, as a result of this kind of individual experimenting that the best rotation for the Bunter sandstone soils was evolved.

2. The introduction of new manures and fertilisers. He names lime, bone dust, oil cake, green manures, malt combs, scrapings of oiled leather, bog earth and farmyard manure.

3. Irrigation schemes at Clumber, Thoresby, and Carlton near Worksop, excite his approval. These projects resulted in big schemes being put forward in the early part of the 19th century. For instance, from 1816 - 1837 the Duke of Portland spent over £39,000 on the construction of water meadows (The flood dyke system between Mansfield and Ollerton.)(108)

4. The introduction of machinery. He particularly notes the drag harrow (cultivator or scuffler).

5. The improvement of livestock, particularly of the old breed of forest sheep, - small polled with grey faces and legs -, by crossing with Leicestershires. Lincolns were also gaining favour. As an example of this improvement, he

states that 4 year old Forest Wethers were sold by a Mr. Jones of Arnold at 14/- each, whereas shearlings of the new breed brought 34/- each. Interest was also growing in the improvement of cattle. Of local crops, Lowe notes weld or dyer's weed grown at Scrooby, Ranskill and Torworth, liquorice at Worksop and hops at Rufford (80 acres), Ollerton (30 acres) and Elkesley (30 - 40 acres).

During the following century the agricultural history of the Bunter outcrop was particularly controlled by external national economics and politics, which caused frequent fluctuations of prosperity and depression. This is what would be expected, since it is evident from the soil analyses that the region would largely be unable to stand on its own legs agriculturally in times of depression, when along with poor land elsewhere, big areas would go out of cultivation. The boom of the Napoleonic war period was succeeded by serious agricultural depression marked by a vast decrease in the price of corn to an average of 53/- per quarter. In spite of the legislation of the Corn Laws to maintain high prices, farming suffered severely, and, in consequence, much of the poorer sand land must have gone out of cultivation.(109)

Other factors dissolved this depression however. The one particularly at hand was the growth of industrial and urban population, to the west of and on the edges of the Bunter outcrop. To the west lay the exposed coalfield of Nottinghamshire and Derbyshire, now in the heyday of

exploitation, with the growing industrial district between Sheffield and Derby, while on the edges of the Bunter Mansfield, Worksop and East Retford were increasing rapidly in population, and to the south Nottingham , Arnold and Calverton with adjacent villages were becoming the centre of the hosiery industry, while their populations almost doubled between 1801 - 1841. The following figures give an indication of the expansion of local population over the first half of the century:-

Town.	1801.	1851.
Nottingham.	28,861.	58. 419.
Basford.	1948	2943
Arnold.	2768	4704
Calverton.	636	1427
Kirkby.	1002	2363
Sutton in Ashfield.	2801	6542
Mansfield.	5988	10667
Worksop.	3263	7215.
East Retford.	1948	2943.

Sand land farming again became a profitable business. There is no agricultural literature for the depression period 1815 - 40, but Corringham, writing in the Journal of the R. A. Soc. 1844, is enthusiastic over the further progress. He states "where in former times only the rabbit browsed large flocks of sheep are now fed, nutritious pasturage in summer and fine crops of turnips in winter furnishing to them an abundance of foods, whilst these crops are succeeded every alternate year by cereal ones of the best quality." Once again it is probable that Corringham's account, like Lowe's, was coloured by enthusiasm. After all, the darkest period in British agriculture had just passed away . He attributed the improvement to the introduction of the swede turnip, with a consequent increase in the number of sheep reared. Particularly it was the coming of drills for sowing, and slicing machines, with the lavish use of the then cheap bone manures, that made such improvement possible. The following rotation of crops is praised by him, as excellent for the sand land:- 1. Turnips 2. Barley. 3. Grass seeds or Red Clover. 4 the same. 5. Wheat To Corringham the big advances made are confirmed by the comparison of the sheep keeping capacity of his time and of Lowe's. In Lowe's time he states many of the farms of 300 acres on the outcrop had "... not more than 50 ewes upon them, and these of an inferior kind, and that much difficulty was experienced in supporting them through the winter. These same farms in the present day.....

support from 500 to 700 sheep throughout the winter, the greater part of which are sent fat to market, at weights of from 80 lbs to 120 lbs each". Corringham finally emphasises the improvement in livestock.

1. Sheep. The old Forest breed were nearly extinct, having been superceded by pure Leicster or Leicster - Lincolnshire crosses.
2. Cattle. The important breed was the Durham or "Improved Shorthorn", which was kept primarily for the production of yard manure, an absolute necessity for the maintenance of fertility and production of future crops.
3. Pigs. These had been improved immensely and are called by Corringham "The Improved Nottinghamshire Pig".(109)

The effect of this improvement in agriculture is reflected in the population maps (Nos. 41 and 42) and a comparison should be made of those for 1801 and 1851. The 1851 Map marks the peak of prosperous conditions for Bunter sandstone agriculture, two generations after enclosures had become general. The increase in population over the outcrop during fifty years is general, keeping step with improved agriculture. The population graph No. 45 shows the same increase in another form.

This period of agricultural prosperity continued from Corringham's time till 1876. Indeed the period from 1853 - 1876 was the most prosperous era for British

agriculture.

Over this period, wars occurred in the U.S.A. and Europe at comparatively short intervals, maintaining high food prices, the home market was still expanding, and Colonial competition was scarcely in its infancy. Together with these factors, as far as the Bunter outcrop was concerned, a new development was taking place in the vicinity in the sinking of mines through the neighbouring Permian limestone outcrop, to the seams of the concealed coalfield (see map No. 51), with a vast increase in local population.

There are two recorders of the state of Bunter sandstone agriculture during this period of prosperity - Parkinson in 1860 and Jenkins in 1869, both writing in the Journal of the Royal Agricultural Society. Once again in Parkinson's account there is the note of enthusiasm. He confirms all that Corringham said, and describes the increase in the numbers of livestock, and the outlay of owners of farms spent in rebuilding and increasing the size of farm houses and cottages. Further, much unproductive land had been taken in as water meadows, roads had been made, fences had been planted, and the then - modern agricultural equipment was being used generally.

Jenkins' report, however, is less fulsome and more critical. He notes how little the farmers can depend on the land because of the poverty of the soil, and how high expenditure has to be on artificial manures to maintain crops, (he

describes the case of a farm where the cost for manures was about £1200 per annum). The rotation of crops in Jenkins' time was the same as in Corringham's - fixed as a result of experience in these poor soils. He notes the scarcity of grassland on the farms.(110)

This report of 1869 brings us close to a long continued period of decline. During the century from 1770 to 1870, there took place the enclosure of most of the waste of the Bunter sandstone outcrop, the development of agriculture on previously uncultivated soils, and, under the stimulus of suitable economic and political conditions of the same period, a sound and successful basis was given to farming on this sand land. This in turn had had its effect upon the population of the villages and parishes on the outcrop, which generally up to 1850 - 70 reached their peak, under agricultural conditions of social life.

The back end of the '70's saw the end of prosperity however, and the period 1879 - 1894 brought a succession of bad harvests, the rise of colonial competition, a consequent fall in prices and in the amount of land under cultivation. In 1883, wheat was 41/7d per quarter, but in 1884 it had fallen to 35.8d, in 1886 to 31.0 and in 1894 to 22.10d. Since then it has been usually below 30.0. per quarter.(111) Under these conditions, naturally, the poorest land went out of cultivation first, and the Bunter sandstone outcrop was severely affected. Indeed artificial economic stimulus

had overweighted farms with great areas of marginal land. The comparatively artificial structure of agriculture in the area began to crumble, and, in spite of periods of modest improvement, including the 'boom' period of the Great War, present day conditions on the Bunter farms are very depressing. The natural conditions have been too strong in their enmity of agriculture to allow success when external economic circumstances are unfavourable. This is confirmed by all recent surveys and statistics for the area (by Robinson 1927; by Dowling 1929; Makings 1936; and Robinson 1937).

The experience of pre-depression days proved the value of the following features, for the continuation of agriculture on the outcrop:-

1. The necessity for liberal manuring, not only in the form of artificial manure, but as farm yard manure to give 'body' to the light soils. Naturally therefore this was linked with
2. the necessity of keeping cattle and sheep.
3. the need for a regular supply of lime for the land.
4. the value of irrigation.
5. the value of the proved 4 course rotation.
6. the place of barley, rather than wheat, as the best crop for this type of land.

Since the beginning of the depression period, most of these factors for successful farming have been allowed to go out of usage. At the present time the recent surveys of

agriculture show that large areas of land are deficient in lime, owing to high costs, that there has been a growing tendency to allow the 4 course rotation to go out of use, and for crops to be grown in accordance with convenience and economic circumstances, rather than in the proved rotation. Further, the barley acreage has decreased in favour of wheat (which brings a better price), and sugar beet has been introduced as a cash crop. The Bunter farms in general are under staffed, under cultivated and under stocked; many of the water meadows, so expensively constructed nearly a century ago, are falling into disrepair and disuse, and farm buildings and roads often show the results of about twenty - five years neglect. Large tracts of land, once successfully farmed, are now going back into the natural state. With the decrease in the numbers of livestock, milk production and poultry farming have been resorted to, in order to try to strike a money making system in depression days.(112) To some extent, however, the slide from prosperity into the slough of agricultural depression has been slowed down by two factors, both connected with coal:-

1. The mushroom growth of colliery villages on the Permian outcrop and now on the Bunter itself has created local markets for market garden produce, eggs, potatoes, and milk, which have helped many farmers to overlook natural difficulties.

2. The profits from coal, since many of the large estates on the Bunter share in the royalties, have been used by estate owners in the past towards the improvement of agricultural estates. In recent years, however, many of the big estates have been sold in whole or in part, owing to the impossibility of their being maintained in continuing depression.

Population figures for the solely agricultural villages and parishes on the outcrop record the decline. The general features of nearly all graphs for agricultural villages:- (1) an increase of population from 1801 to, at the latest, 1871, and (II) since that census general decrease.

Three examples will serve to show this, taken from the northern central and southern district of the outcrop. (the figures are for each census from 1801 - 1931).

1. Blyth : 589: 670 : 801: 811: 758: 765: 698: 621: 618: 529: 540: 638: 600: 540:
2. Cuckney:- 397: 427: 633: 625: 620: 540: 663: 555: 506: 489: 487: 416: 349:
3. Oxton. . 697: 778: 798: 841: 850: 738: 636: 516: 439: 440: 405: 392: 460:*

(+ 1931 increase due to fashion as residential area for Nottingham business people).

Apart from market conditions, the two controls on agriculture are (1) soil conditions (2) climate. The nature and

deficiencies of these Bunter soils have been emphasised throughout this survey, but comparatively little has been said about the climatic factor. There is one aspect of this which is of vital importance to agriculture on the outcrop, viz. the rainfall figure during the growth period of crops, and particularly for the months of April and May. An analysis of the sixty year rainfall record for April and May at Hodsock Priory, in the vicinity of Worksop, and a comparison with the actual record of successful and failure seasons for agriculture over the region, leads to these conclusions:-

1. When the rainfall during these two months is 2" or less, drought conditions ensue, which are likely to lead to crop failure.
2. (a) If rainfall, for the same months, is between 2" and 4"' crops are in danger, and

   (b) if this amount of rain is accompanied by cold, drying winds, then drought is again probable. On the other hand,

   (c) if this 2" - 4" is accompanied by mild conditions, then crops are not so likely to be adversely affected.
3. Over 4" of rain for the period usually ensures successful seasons.

The sixty year record for Hodsock shows on analysis:-

1. 7 years - drought conditions.
2. 31 " - danger of failure.
3. 22 " - sufficient rain to eliminate danger.

Between 1920 and 1935 there have been:-

1. 2 drought years. 1929 and 1935.
2. 7 danger years. 1921, 1924, 1926, 1927, 1928,1933, 1934.
3. 6 safe years.

Occasionally June rain may compensate for low falls in April and May, and so divert drought. Allowing, over three months, 3½" as the drought limit, and 3½" - 6" as the danger - of - drought limit, the analysis of the Hodsock figures still shows (1) 7 drought years (11) 29 danger years (111) 24 safe years. Between 1920 and 1935 there have been:- (1) 2 drought years. 1921, 1929. (11) 9 danger years (111) 4 safe years. 1926. 1930. 1931. 1932.
In fact it may be said that, though good results may come when the rainfall is satisfactory, the expectation of a good season on the average is about one year in three. It is interesting to note that the occurrence of safe years has been noticeably less since 1900, than it was during the previous quarter century.

1. From 1875 - 1900 there were 15 safe years i.e. 3 out of 5.
2. From 1901 - 1935 " " 9 " " i.4. 2 out of 7 (113)

The same depressing analysis results from an examination of the rainfall graphs for Worksop, Mansfield and Nottingham, in areas where the rainfall is higher than at Hodsock. Reference should be made to graphs Nos. 20, 21 and 22, which on analysis give the following results.

1. Worksop:- 1926 (D): 1927 (S-D): 1928 (D): 1929 (Dro)
1930 (S): 1931 (S): 1932 (S): 1933 (D):
1934 (D): 1935 (D-Dro) 1936 (S-D).

2. Mansfield:- 1926 (D): 1927 (S): 1928 (D): 1929 (Dro)
1930 (S): 1931 (S): 1932 (S): 1933 (D):
1934 (D): 1935 (D): 1936 (S):

3. Nottingham:-1926 (D): 1927 (S): 1928 (D): 1929 (Dro):
1930 (S): 1931 (S): 1932 (S): 1934 (D):
1935 (D): 1936 (D):

Dro= drought.
S = Safe.
D = Danger.

Allowing for the fact that, as Map No. 19 shows, the rainfall to the east of Mansfield, north - east of Nottingham and north - east of Worksop, is less than at the recording towns, the figures show the anti-agricultural nature of the climate over the Bunter outcrop. Another factor which should be coupled with these vital rainfall figures is the strength and direction of winds for the April-May - June period. A comparison of the diagrams (NO.18) for the April - June period for wind strength in 1929 and 1930, a drought year and a safe year respectively, shows

that the decidedly stronger winds for 1929 were a potent factor in bringing drought conditions. Again in 1935, cold strong drying winds in April and May retarded growth so much, that even 3½" of June rain was not sufficient to compensate, and drought conditions followed. (114)

The conclusion to which the soil analyses, the continuing adverse climatic factors, and conditions of depression in home agriculture force us, is that much of the Bunter sandstone outcrop is unprofitable land for agriculture. Under the present circumstances the poorest land should be allowed to go out of cultivation. As history shows it came into cultivation largely as the result of a great external economic stimulus, which is no longer acting. When the two variable factors, national economics and the climate, improve, this part of the land may once again be used for agriculture. This very poor land is that which has 75% - 80% of coarse sand on analysis. There is, however, better land on the outcrop capable of cultivation. (The best soils are those with 25% - 30% of fine sand and not more than 60% of coarse sand). At the present time some of this is physically exhausted and needs, according to agricultural experts, considerable liming and a return to the rearing of livestock and particularly of sheep as the mainstay of farming, to effect the return of humus to the soil.

Big areas of the outcrop might be successfully devoted to pine plantations in a Government Forestry policy. There are at

the present time three Forestry Commission areas on the sandstone at:-

1. Bawtry.	132	acres with	264,000 trees.
2. Clipstone	602	" "	1,961,000 trees.
3. Sherwood	463	" "	815,000 trees.

The major part of each of these areas is planted with pines. For the present the continued decline of the agricultural population of the area is to be expected.

Summary of Agricultural Statistics.

The following figures contrast agricultural conditions on the Bunter outcrop in 1875 (in the prosperous period), and in 1937 (depression period). In all cases, they are totals of Parish Returns for 48 parishes on the outcrop, from Finningley to Arnold (Map No. 2).

	1875	1937		1875	1937
1. Total acreage under crops and grass.	12,8080	109,699	Dairy Cattle.	4418	6067
Wheat (acres)	19,610	12,668	Other Cattle	11,116	9965
Barley (acres)	16,149	3,587	Sheep	110,378	44,321
Potatoes (acres)	1833	3543	Pigs	6484	14305
Turnips and Swedes. (acres)	18,665	7,858	Poultry	(No Figs given.)	83,464
Mangolds.	725	1030	Total Workers.	"	2260
Sugar Beet.	No. figs. given. (very little if any.)	1494.			

The figures show:-

1. Great decrease in amount of land cultivated - about 30 sq. miles.
2. Big decline in wheat, barley, turnips and swedes, cattle and sheep.
3. Increases in potatoes, sugar beet, dairy cattle, pigs and poultry. The dairy cattle increase is connected with the milk trade for the expanding population: the other items are deviations from the old system, in quest of a money-making scheme in the depression.
4. The fewness of workers engaged in agriculture on the outcrop. For the same parishes the total population for 1931 was over 170,000 so that less than 1.5% of the total population is engaged in agriculture on the outcrop. This figure of course would be higher, as a percentage of workers only.

(Refer to Maps 56.ff.)

(Vb) While agricultural prosperity was at its peak on the Bunter outcrop, and before the natural obstacles to continued success in that activity began to show themselves fully again, another natural factor in the environment of the sandstone began to come into operation.

The visible coalfield of South Yorkshire, Derbyshire and Nottinghamshire, had been worked for more than 700 years, but, up to the middle of the 19th century, working had been restricted to the area west of the Permian limestone outcrop. The consequences of this lay in the line of industrial centres extending southwards from Sheffield and Rotherham, through the north Derbyshire towns of Chesterfield and Staveley, to the valley of the Erewash in south Derbyshire, culminating in the growing centres of Derby and Nottingham. The northern group of towns centring on Sheffield, by the middle of the nineteenth century had become associated with the manufacture of steel with allied industries. (Chesterfield had iron, steel and engineering and was a lead market: Rotherham had iron, iron goods e.g. fire grates, steel and glass: Doncaster had wire, brass and glass) (115) The southern group of towns had become the centres of a textile industry (hosiery and lace), but once again this dominating trade overshadowed a large number of lesser ones. Nottingham, for instance, had metal working (from the ores of the Erewash valley and Derbyshire lead mines), machine knitting, brewing, lace manufacture, cotton, tanning and

leather industries. Though less favoured than the Sheffield region, the Erewash valley had its centres of iron smelting near Alfreton and Ilkeston.

These growing industrial centres needed better facilities for the export of their products, though Nottingham and district had always had the advantage of the Trent, These came in the form of canals and railways. In 1819 a canal from Sheffield to Tinsley was opened, bringing access to the Trent, via the Rother and Don. Doncaster had had its canal to the Trent for 80 years before this: 1832 saw railway connection with Rotherham and the north - south line; 1845 brought connection with Manchester and Lincoln (now the L.N.E.R.)[116] Mention has already been made of the Chesterfield - Stockwith, the Nottingham and Erewash Canals, all of which were additional routes from the western industrial area to the Trent. In the south, in 1839, the first railway from Nottingham was built to the south of the River Leen. With the railway era, a great expansion took place in the coal industry of the region, which in turn led to the further development of the steel and textile industries and their offspring.

Already the small towns on the edges of the Bunter outcrop were beginning to feel the pressure of the industrial developments to the west. Though Bawtry had lost its commercial importance, Worksop and Retford were in connection with Chesterfield, Staveley and district, and Sheffield, by

Canal and rail respectively, and from this time onwards their industrial development became wrapped up with that of the N. Derbyshire and S. Yorkshire region. Mansfield, Kirkby, the villages of the Leen valley on the edge of the Bunter, and many of the villages on its southern outcrop were participating in the textile industries. Map No. 54 shows this connection in 1845. In 1819 Mansfield was connected to Pinxton on the coalfield at the head of the Erewash valley, by means of a railroad or tramway, along which horses drew iron wagons as far as the highest point at Kirkby, whence the wagons descended down the slope to Mansfield under their own weight. On their return journey they were drawn to the summit, and allowed to descend to Pinxton again. By 1847, however, the Erewash valley Railway line was brought into the town.(117.)

An interesting development, too, lay in cotton manufacture. This was done in Nottingham and also on the Leen at Papplewick, but ceased in 1840, in consequence of the growth of the Lancashire industry. (This accounts for the marked decrease in population at Papplewick in the early part of the century). The attempt to start cotton spinning at Worksop at the close of the 18th century ended in failure. Even at Cuckney, 7 miles north of Mansfield, a mill was erected as early as 1788, to spin wool for worsted, but was eventually turned into a corn mill. Similar ventures at Retford, Arnold and the Leen valley ended in failure. In this respect it may be said that the future of the southern

half of the Bunter outcrop lay with that of Nottingham.(118) For many years it had been thought that, either the coal seams worked on the open coalfield did not continue under the Permian limestone, or that the general easterly dip of the strata would carry them to a depth too great for profitable exploitation. In 1854 sinking was begun at Shireoaks on the Permian outcrop, two miles to the north west of Worksop, and in 1859 the valuable Top Hard or Barnsley coal was cut at a depth of 1530 ft., where the seam was 3'6" thick.(119) Since that date, the extension of the coalfield under the newer formations of the Permian, Bunter and Keuper has been proved by extensive borings and shafts to cover about 1200 square miles. It is bounded on the north by the River Ouse, on the south by a line from Grantham to Ruddington, (about 4 miles directly south of Nottingham) while a recent boring at Harby, six miles west of Lincoln, points to the possibility of available reserves of coal in Lincolnshire, beyond the Trent.(120)

These borings have shown the visible area of the coalfield to be the western part of a basin, the remainder of which is concealed by an unconformable cover of newer rocks to the east. As regards the accessibility of coal, the boring at Kelham (in the Trent valley 2 miles N.W. of Newark) indicates that the lower seams of the Middle Coal measures are well within the 4000' limit of working in Nottinghamshire; the Thorne boring in South Yorkshire (12 miles north of Bawtry) leads to the same conclusion, while the Top Hard Coal in

Nottinghamshire and the Barnsley Seam in Yorkshire should seldom exceed 3000 ft. in depth.(121). The conjectural structure of the field is shown in Map No. 50, which in view of recent borings would probably be slightly modified. A section (No. 49) shows the underground structure from Chesterfield to the eastern boundary of the Bunter beyond Ollerton. Since the sinking of Shireoaks Colliery, further colliery development took place rapidly to the south on the Permian outcrop. Map No. 51 shows the extent of this to the end of the century. The effect of this upon the population of the previously modest agricultural area of the Permian is shown in Map No. 47. Indeed, the result was an influx into the older towns and farming villages, and in some cases the creation of new colliery villages, near the newly opened collieries. This existence side by side of old agricultural villages and so - called model villages (in name only), is the chief social feature of the Permian outcrop at the present time. Worksop and Mansfield began to increase rapidly in size, - a growth which shows no signs of abating, as the following census figures show:-

1801 A.D.	1901 A.D.	1931.A.D.
Mansfield 5988.	21445.	46077
Worksop. 3265	16112	26285.

There was a great expansion of population down the Leen valley, and,with the sinking of collieries within the city boundary of Nottingham (Clifton, Radford and Cinderhill),

and near it, (Gedling and Bestwood) local industries there were given a big impetus to further development.
In following the Top Hard Coal to the east, it was discovered that its eastward dip gradually diminished, and there seemed to be every prospect of discovering the seam at workable depths beneath the Bunter outcrop. Successful operations were concluded in the opening of Gedling Colliery, near Nottingham, and this was followed by further sinking at Manton, east of Worksop, and in the South Yorkshire area near Doncaster. Since the beginning of the Great War, further collieries have been opened to the east and south east of Mansfield; Welbeck and Rufford 1914, Clipstone 1922 Ollerton 1925, Blidworth in 1926, Bilsthorpe and Thoresby 1928, while sinking is now proceeding at Calverton.
The results of this for the Bunter sandstone outcrop become evident from an examination of the population graphs (No.45), and Maps Nos. 41 - 44. The graphs show generally;-(I) an increase in population for Bunter villages from 1801 - 1850 or 1860, the peak of the agricultural period, (II) a decline from 1860 to the early part of the 20th C, (III) a phenomenal increase, due to the opening of a colliery. The same is evident in another form by a comparison of the population maps for 1801, 1851, 1901, and 1931. While, to an extent, these maps are inaccurate in that population is not evenly distributed over the parishes, nevertheless a true picture is given of the change that has overtaken the outcrop. The population map of East Derbyshire and

Nottinghamshire (No. 47) shows that the outcrops of Permian Limestone and Bunter Sandstone are the most densely populated parts of Nottinghamshire.

Since, generally speaking, the farther east a mine is situated the deeper the shaft, and since the sinking of a shaft is a difficult and expensive business, fewer collieries are to be expected on the Bunter Sandstone than on the more westerly outcrops. On the other hand,these collieries and Colliery villages are at the beginning greater in size and population and a greater area is worked underground from the one shaft.(122) The following figures for 1933 give an indication of the large staffs employed in the latest collieries:-

Colliery.	Men below.	Men above.	Total.
1. Harworth.	1614	349	1963
2. Manton.	1319	383	1702
3. Welbeck	1226	405	1631
4. Ollerton	1206	344	1550
5. Bilsthorpe.	1307	288	1595
6. Gedling.	1208	450	1658
7. Thoresby.	1200	385	1585.

There are great difficulties, from an engineering point of view, in the sinking of shafts through the water bearing sandstones. The application of a cementation process during sinking has been successful in recent enterprises.

The new colliery villages, which have come as the result of this expansion of the coalfield, are in many ways an advance upon the villages on the Permian outcrop. Like all older colliery villages, the latter bear the marks of, at least, lack of planning. Often the colliery tips are overwhelmingly near the colliery village, as, for example, at Langwith and Warsop Main. On the other hand, whatever their faults, the new villages on the Bunter, particularly the later ones, have been planned to a much greater degree, for example Blidworth, Forest Town, New Ollerton. In many cases entirely new villages have been laid down, as in Welbeck Colliery Village and Forest Town, while elsewhere the new colliery villages have been more or less joined to the agricultural villages, as at Ollerton, Edinstowe, Blidworth, (Map No. 4) Because in most cases a completely new community of several thousand people has been planted in these villages, the colliery companies have become almost entirely responsible for the social life of the people. In all these villages social life centres round the Colliery Welfare, with their sports clubs and brigades. Often the Company owns, besides the houses, shops and cinemas and gives annual grants to the chapels and churches in the village. The coal from this inland field has from the first been mainly produced for the home market, and though, from the end of the Great War, there has been increased competition with other fields which re-entered the home market on the decline of the export trade, new collieries

capable of an output far beyond demands of present consumption, have been opened, as Map No. 53 shows, even during the industrial depression period. The following figures give an indication of the comparative prosperity of this region in the coal mining world:-

Year.	Yorks CF.	Derby-Notts-Leic.	Durham.	Monmouth & S.Wales.
1873.	15,311.778	10,701,020	23,278,556.	16,180,728
1900.	28,250,679	25,977,987	34,800,719	39,328,209
1913.	43,680,016	33,702,521	41,532,890	56,830,317
1921.	28,482,202	20,929,300	21,768,459	30,572,013
1937.	45,115,121	33,915,985	33,485,652	37,773,013

The figures show that Yorkshire and the Derbyshire, Nottinghamshire and Leicestershire fields are now producing more than the pre-war figures. This is undoubtedly due to the activity and development in the South Yorkshire and Nottinghamshire areas of those fields. Durham and South Wales are now, in comparison, considerably below the pre-war output. The total tonnage of coal produced in 1937 in Nottinghamshire was 16,400,000 tons, and in South Yorkshire 32,406,498, tons, out of a total for England and Wales of 208,167,227 tons i.e. the 'concealed' coalfield produced more than 23% of the total output.

The following figures show in another fashion the same comparative prosperity. Out of all the coal mining areas in Britain, with the exception of Kent where activity is very small, South Yorkshire and Nottinghamshire are the

only fields that can show a greater employment of men at the present time, over pre-war years:-

	1913	1936	
Lancs & Cheshire.	107.656	59.985	(123)
S.Wales & Monmouth.	232.800	135.901	
Leicester.	10.327	9052	
S.Derby.	4.843	3189	
N.Derby.	55.412	41.816	
W.Yorks.	63.826	43.500	
Durham.	165.246	115.971	
North-umberland.	60,627	45,715	
S.Yorks.	96,572	99,733	
Notts.	40,473	45.579	

There is a further aspect of the industrial development of this region in which the Bunter Sandstone outcrop has taken, and is now taking, a vitally important part. This is in the matter of a water supply for the growing population of the area. That this should be so would have amazed the English invaders, who avoided the outcrop because of its aridity. Nevertheless, the complement of that surface aridity is a vast underground supply of water, accessible to deep wells sunk beneath the water - table. In no part of England is the underground water supply of such great economic importance as in industrial Nottinghamshire, since the greater part of its water is drawn from this source. It is not that the region is devoid of streams and springs, but, that with the growth of the industrial and manufacturing areas in the Trent basin and on the coalfield west of the Bunter outcrop, and in the absence of planning of the use of the streams during the second half of the 19th C, they have become hopelessly polluted. This matter is the more serious for Nottinghamshire, since all its main streams rise beyond its boundaries, and are already unfit for human use before they reach the county. Under these conditions the Trent has been called, with justification, 'a common sewer', and the Erewash, Leen, Maun, Meden, Poulter, Ryton and Idle have all been similarly contaminated. In these circumstances, the great subterranean reservoir of the Bunter sandstone is a particularly fortunate and convenient source of supply for the growing industrial regions. Since about 1870, this supply has been drawn upon increasingly by the towns on the

eastern and western boundaries of the outcrop, and by the villages on the Bunter and the neighbouring strata. Map No. 48 shows the towns and villages using the supply. Besides many private wells, the following organised public supplies rely on this source of water:-

1. Nottingham. 2. Mansfield. 3. Worksop, 4. E. Retford. 5. Kirkby in Ashfield. 6 Sutton in Ashfield. 7. Hucknall Torkard 8. Warsop. 9. Blidworth. 10. Edwinstowe. 11. Stapleford. 12. Lincoln. 13. Southwell and Newark.

Reference to the map No. 45 shows that many other large villages, particularly on the Permian outcrop benefit from these main supplies. There are also semi-public supplies at Blyth, Carburton, Thoresby, Clumber and Calverton.

The estimated reserves of this great subterranean supply have already been given in Part I. The amount withdrawn daily has been calculated as about 14,000,000 gallons by the organised public supplies, and 7,000,000 - 8,000,000 gallons by private wells. The supply is not inexhaustible, but, though it may be necessary eventually to augment it from other sources, with the increasing demands of the growing population, it will always be a most valuable source of water for the area. Nottingham has added to its supply by participating in the use of the Derwent Resevoir in the Peak district.(124)

Another industrial connection of the sandstone lies in its use as a moulding sand (particularly the Lower Mottled Sandstone) in iron manufacture. There are many sand pits and quarries on

the outcrop, the chief being in the Leen Valley, at Lenton and Bestwood, and at Mansfield. Some of the sand is used locally at iron works at Stanton, Bestwood and Butterley, much is transported by road and rail to other parts of the Midlands, and some is exported for foreign use.(125).

The development of the concealed coalfield of Yorkshire and Nottinghamshire means that the future of the Bunter Sandstone region is wrapped up with that of a great mining area. In the extension of this coalfield there are probably larger potential reserves than in any other coal bearing district in the country. The area over which the most important coal, the Top Hard Seam, has been proved to be workable in the easterly portion of the coalfield is more than 600 sq. miles, and it is estimated that there are over 2,000 million tons of this seam available for working, at a depth not greater than can be mined under present day conditions. The northern part of the Bunter outcrop now belongs economically to the South Yorkshire coalfield, centring on Doncaster, and conveniently placed for the growing iron and steel industires of North Lincolnshire, at Scunthorpe and Frodingham. The southern half of the Bunter lies within the sphere of influence of Nottingham, and at the present time the two sections of the outcrop are becoming coal supply regions for these industrial centres. The future should see the continued expansion of Worksop, East Retford and Mansfield, as centres of industry within these two regions. Up-to-date, the new collieries on the Bunter have been sunk chiefly where the Top Hard Seam is at a minimum depth below the surface, i.e. in the Mansfield area, and near the few railway lines which cross the outcrop. The colliery lines from Blidworth, Rainworth, Clipstone, Forest Town and Bilsthorpe are connected to the Mansfield-Southwell line: Ollerton, Welbeck and Thoresby to the Chesterfield - Lincoln

line; Harworth and Langold to the section between East Retford and Doncaster. (Map No.55).

How much farther the outcrop will be occupied is a matter for speculation. That there will be more collieries sunk and villages planted is certain. The next developments should be expected where the Top Hard Coal is at a minimum depth and where the water bearing sandstone is at moderate thickness. If this is so, Map No. 50 would suggest that the central and southern districts will continue to outstrip the north. Up to the present the number of collieries opened in the northern section is only one quarter of the total on the sandstone. With the more modern technique of sinking, however, the north should continue to be exploited. Recent years have seen the amalgamation into larger groups of many of the smaller colliery companies. The co-operative action of these larger concerns with interests on the outcrop, might well avoid the disorders which are so evident on the more westerly outcrops and in the older coalfields, as the result of the rampant individualistic exploitation of the past century. Since new colliery villages are likely to be more widely spaced on the Bunter, there is no reason why the distinctive beauty of the remaining portions of the old woodlands and the open commons should be destroyed, though there is grave danger of this with the break up of the large estates and the advance of mining. Reasonable planning might result in the preservation of large areas of woodland and heath for the use of the community, in the devotion of a large part of the outcrop to more plantations, to the continuation of agriculture on the best

sand land, and to planned colliery villages with greater facilities for the social life of their inhabitants, - for the future use of the area presents a considerable social problem, as well as those connected with the scientific aspects of agriculture and mining.

At least, the present comparative undevelopment of the outcrop still offers this opportunity for planning.

In review, the social and economic development of this large sandstone area of Nottinghamshire is seen to have been conditioned, at all stages, by the physical factors, which in summation make its environment.

These factors, on analysis, resolve themselves into three groups:-

I. Those inherent in the sandstone itself:

1. Moderate elevation.
2. Porosity of soil giving rise to (a) Absence of surface water and fewness of streams. (b) Underground water table.
3. Hungry soils.
4. General absence of boulder clay and suitable alluvium on the outcrop.
5. Climatic factors (a) Comparatively extreme climate
   (b) Distinctive rainfall distribution, and wind direction and strength variations.
   (c) prevalence of fog and thunder.
6. Natural vegetation; the oak - birch - heath association.

II. Factors in the larger geographic unit to which the Bunter belongs:-

1. Nature of underlying and covering strata (a) Permian marls at the base of the sandstone.
   (b) Better soil conditions east and west of the outcrop.

2. The nature of the Trent: possibilities of the Idle: proximity of the Humber estuary to the north.
3. The natural entries into, and exits from, this larger geographic area.
4. The structure and potentialities of the coalfield to the west.
5. The occurrence of mineral ores in this geographical unit.

III. External economic and historical factors, national and international, which are themselves, on analysis, the product of a series of geographical facts.

Presented with Groups I and II, it is possible to evolve a theoretical history of development of the Bunter sandstone outcrop. This would include the following deductions:-

1. The likelihood of a very tardy human occupation of the region, because of the absence of water, poor soils and more attractive areas to east and west.
2. The probability of the area retaining its natural vegetation for a long period.
3. The certainty of a very sparse occupation because of the fewness of places on the outcrop where water would be available.
4. Peculiar agricultural difficulties and technique when the outcrop was occupied.
5. The general positions of the main roads of the

region, and the extreme probability of the early importance of the northern and southern points of the Bunter outcrop.

6. The probable importance of the Idle as an outlet for trade to the Humber estuary.
7. The likelihood of the eventual use of the coal seams beneath the outcrop. In all probability this would be a late exploitation because of the difficulties of discerning the structure of the coalfield and of sinking deep mines.
8. The probable eventual use of the underground water when men had worked out the technique of making deep wells.

The third group of controlling factors accounts for the entry of 'sport' elements into this deduced history. Long continued isolation of the region eventually brought it into the hands of the Crown, which further retarded its being exploited: the same isolation made it attractive to monastic settlement, which saw the real beginning of its economic development: the dissolution of the religious houses (the result of religious and economic factors) saw its passage into the hands of a mercantile class, who viewed it in the light of potential exploitation: the rise of food prices (again the result of an external series of geographic facts) made this exploitation possible, and saw the development of a real agricultural system. Finally, the needs of an encroaching industrial community brought the exploitation of the water and coal reserves of the outcrop, and drew it into the

sphere of industrial development.

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