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The mineral resources of the Lothians

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The mineral resources of the Lothians

by

A.G. MacGregor

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Parent Body

Natural Environment Research Council, Polaris House, North Star Avenue, Swindon, Wiltshire SN2 1EU

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THE MINERAL RESOURCES OF THE LOTHIANS

(An Economic Summary and Guide to Sources of Information)

by

A.G. MacGregor, M.C., D.Sc.

CONTENTS

I. INTRODUCTION

The problems of long-range planning presented by any region or site require for their solution the conscious or sub-conscious application of geological knowledge. For the most efficient work those responsible for planning should work in close collaboration with technical advisers who have an intimate knowledge of the history and prospects of mining and quarrying, of the nature, sequence and structure of the rocks of the district concerned, and of the resulting general conditions of underground water circulation. At any particular site more precise local knowledge will also be required of the nature and thickness of superficial deposits and of the strata that they conceal. Those who have an intimate knowledge of the geological history of the district may be able to point out the existence of problems which are not apparent to those unfamiliar with the details of the evolution of the local topography (e.g. buried river channels: Ref. 1913, Chapter VI; 1933, p. 99)*.

In Scotland the Geological Survey has been collecting and correlating details regarding superficial deposits, rocks and mining and quarrying operations for almost 80 years. This information has been largely derived from the work of Survey Geologists in field and office, and in the industrial areas much of it has gradually been brought together from the records of mining companies and of mining and water engineers. The data and their interpretation, in so far as they are not confidential, are at the disposal of the public.

Much of the information has been published on geological maps (on scales of 25, 10, 4, 1 and 1/6 miles to the inch), in sheets of graphical sections of strata, in regional and district memoirs of a general nature, and in special economic memoirs and pamphlets, which give details of mining areas or of the distribution of certain minerals throughout Scotland (Ref. 1937a). Among useful data largely unpublished are the records of many thousands of borings, sunk to find minerals or water.

Footnote: * Reference to bibliography at end of pamphlet.

The object of the present summary is to give an outline of the geological history of the Lothians, to indicate the nature and distribution of the rocks and minerals that have been, or still are exploited, and to indicate sources from which more detailed information may be obtained. The introductory sections are written for those unfamiliar with geological methods

and ideas. For up-to-date information regarding the exploitation of the mineral resources of the Lothians, especially in connection with whinstone, sandstone and sand, the Geological Survey is indebted to the Road Surveyors of West, Mid and East Lothian, and to various quarrymasters, contractors and others.

I. 1 GENERAL GEOLOGICAL PRINCIPLES

The formation of the solid rocks and associated minerals in the Lothians has been due to recurring cycles of change in terrestrial conditions (warping, folding, fracturing and erosion of the earth's crust) which, over a period of hundreds of millions of years, have caused great alterations of climate, physiography and sea level, and have often been accompanied by widespread volcanic eruptions. The formation of the superficial deposits, which rest on a very irregular surface of solid rocks, is the result of the most recent major climatic changes, the oncoming of the Great Ice Age, or Glacial Period, and its passing some 50,000 years ago – events which involved considerable alterations of land drainage and sea level. Hence a knowledge of local geological history is needed to understand the distribution of those potential raw materials that are known and to search intelligently for others that may be concealed.

Water may legitimately be considered as one of our mineral resources (Ref. 1940, pp. 52-56). The availability of gravitational water supplies depends on the presence of suitable hills with good run-off conditions and valley sites favourable for the construction of reservoirs. These conditions are controlled by the nature of the rocks forming the hills, and by the distribution of superficial deposits in their valleys. The likelihood of encountering water near the surface in shallow wells and excavations depends largely on the nature and sequence of superficial deposits. The prospects of obtaining water from deep wells and bores (tube and artesian wells) are directly related to the nature of the rocks at the site chosen and the geological structure of the neighbourhood.

In the next section a more detailed outline of local geological history is given for the benefit of those who wish to understand more clearly how our valuable rocks and minerals came to be formed and why it is useless to search for certain raw materials in certain areas.

SEDIMENTARY ROCKS

SUPERFICIAL, OR 'DRIFT', DEPOSITS	Recent and Glacial		Peat; sand and gravel; brick and tile clay. Water from sand and gravel.
CARBONIFEROUS — COAL MEASURES	Barren Red Coal Measures	$d^{5'}$	(Clay for brickmaking). Water
	Productive Coal Measures	d^{5}	Coal, fireclay; blaes for brickmaking; bedded ironstone; building stone. Water
	Millstone Grit	d^{4}	Hearth, moulding and bottle-glass sand; fireclay; bedded ironstone; refractory sandstone; building stone. Water.
CARBONIFEROUS — CARBONIFEROUS LIMESTONE SERIES	Upper Limestone Group	d^{2c}	Building stone; limestone; fireclay; (Refractory sandstone). Water.
	Limestone Coal Group	d^{2b}	Coal, fireclay; bedded ironstone; blaes for brickmaking; hearth, moulding and bottle-glass sand. Water.
	Lower Limestone Group	d^{2a}	Limestone; building stone; bedded ironstone; coal. Water. (Refractory sandstone; hearth and moulding sand).
CARBONIFEROUS — CALCIFEROUS SANDSTONE SERIES	Upper Oil-Shale Group	d^{1c}	Oil-shale; mineral oil and natural gas; building stone; limestone; blaes for brickmaking; grindstone; coal. Water. (Refractory sandstone).
	Lower Oil-Shale Group	d^{1b}	Oil-shale; mineral oil and natural gas; building stone; blaes for brickmaking; grindstone; refractory sandstone. Water.
	Cementstone Group	d^{1a}	Water for brewing etc.
UPPER OLD RED SANDSTONE		c^{3}	Building stone; limestone of Selms, Midlothian. Water for brewing etc.
LOWER OLD RED SANDSTONE		c^{1}	Sites for reservoirs on contemporaneous igneous rocks. Water from springs in contemporaneous igneous rocks.
SILURIAN AND ORDOVICIAN		b^{5-7} b^{2-3}	Roadstone; building stone. Sites for reservoirs. Water from springs.

IGNEOUS ROCKS

CONTEMPORANEOUS LAVA FLOWS AND INTRUSIVE SHEETS AND DYKES IN SEDIMENTARY STRATA		Roadstone; paving-setts and kerbs; oven soles; building stone; stone for concrete aggregate.

Fig. 1. Diagram to show Geological Succession in the Lothians and the origin of the principal Mineral Resources. Items in brackets are possible resources, tested or suggested but not yet utilised. Quantity and quality of underground water supplies are dependent on local geological succession and structure.

The symbols on the tablets of the central column are those used on Geological Survey maps.

Fig. 1 Diagram to show Geological Succession in the Lothians and the origin of the principal Mineral Resources. Items in brackets are possible resources, tested or suggested but not yet utilised. Quantity and quality of underground water supplies are dependent on local geological succession and structure.

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I. 2. OUTLINE OF THE GEOLOGICAL HISTORY OF THE LOTHIANS

The Geological Systems or sub-divisions to which the strata of the Lothians belong are the Ordovician, Silurian, Lower Old Red Sandstone, Upper Old Red Sandstone, Carboniferous, Glacial and Recent (Figs. 1 and 2). Periods of folding and fracturing of the earth's crust, followed by bevelling off of the warped and dislocated strata, occurred at no less than three successive stages:after the deposition of the Silurian, Lower Old Red Sandstone, and Carboniferous Systems.

The folding that affected the sandy and muddy Ordovician and Silurian strata was the most intense, and it resulted in the hardening of these bedded deposits and in the formation of steep closely packed folds (Rocks of the Moorfoot and Lammermuir Hills and of the Pentland Hills near the North Esk Reservoir and Bavelaw Castle).

The Lower Old Red Sandstone, which in the Lothians now appears at the surface only in the Pentland Hills, was laid down on the eroded edges of steeply inclined Silurian beds. Deposition of conglomerates and sandstones under semi-arid conditions was followed by a great outburst of volcanicity, which resulted in the accumulation of superimposed lava flows associated with some volcanic ashes ('tuffs') and the intrusion of masses of granite, microgranite etc. The conglomerates and sandstones are now seen only north of Carlops; the lavas and tuffs, with some associated intrusions, form the Pentland Hills from near Carlops to the southern outskirts of Edinburgh (also Braid Hills and Blackford Hill). Igneous rocks, including granite, were also intruded into the strata of the Moorfoot-Lammermuir area at this period (Broadlaw; Priestlaw).

After the volcanic action had died away the Lower Old Red rocks were in their turn folded, fractured and worn away by erosion. The Upper Old Red Sandstone was laid down partly on the Lower Old Red (Pentland Hills) and partly on the older Silurian and Ordovician rocks (as for instance S. of Dunbar). Semi-arid conditions still prevailed; sandstones and marls were deposited and locally cornstones – nodular limestones of chemical origin – were formed.

Semi-arid conditions persisted, without any intervening earth movements, into early Carboniferous times (Cementstone Group) when widespread volcanic activity again developed, with the formation of superimposed lava flows (Whinny Hill and Calton Hill in

Edinburgh, and Garleton Hills in East Lothian) and numerous subterranean intrusions of igneous rocks (whinstone of Salisbury Craigs, Corstorphine Hill etc.)

There followed a period of alternating lagoonal and estuarine conditions, with intermittent subsidence, over much of the Lothians, giving rise to the deposits of the Oil-Shale Group: sandstone, marl, shale (blaes) and oil-shale. The oil-shales represent fine-grained inorganic debris impregnated with bituminous material derived from plant and animal remains. The special conditions favourable to repeated formation of rich oil-shales were confined to that part of the Lothians west of the longitude of Prestonpans.

At the close of Califerous Sandstone times a widespread submergence carried the whole area under the sea, and the deposition of the Carboniferous Limestone Series began. There was local volcanic activity in the western Lothians during much of this period, of which evidence is now seen in the lava and tuff beds of the Bathgate and Linlithgow Hills. Cycles of downwarping and sedimentation recurred again and again: (1) subsidence of land area below shallow sea; (2) formation of marine limestone; (3) shoaling of sea owing to accumulation of mud, sand etc. (4) formation of a fresh land surface. The climate was warm and moist and at times tropical forests grew on the swampy land surfaces. When subsidence was renewed their remains were buried and later formed beds of coal. Coal seams are especially numerous in the Limestone Coal Group, which represents an epoch during which successive forests flourished, died and were buried by water-borne sediments. The periodic subsidences were rarely sufficiently pronounced to allow the formation of limestone under marine conditions. Ironstone bands and nodules were formed from time to time, by chemical action, in the mudflats and swamps.

At the end of Carboniferous Limestone times there was a general uplift of the whole region accompanied by increased denudation of the adjacent land areas. At this time the coarse-grained false-bedded sandstones of the Millstone Grit (e.g. Roslin Sandstone) were formed in river deltas, where oscillation of land level also gave rise to the formation of some minor coal seams, seat-earths (fireclays), shales etc.

In the succeeding Coal Measures period recurrent conditions of subsidence and sedimentation were similar to those of the period at which the Limestone Coal Group was formed and gave rise to a similar succession of rocks, including many valuable coal seams, with associated

fireclays, ironstones etc. Towards the end of the Coal Measures period the climate became semi-arid, the formation of coal seams ceased and sandstones and clays were the main deposits (Barren Red Coal Measures of Dalkeith and Musselburgh).

At the end of the Coal Measures period we must picture the whole of the Lothians area, at any rate north of the fault that now forms the northern boundary of the Ordovician and Silurian rocks of the Lammermuir and Moorfoot Hills, as deeply buried under more than 8,000 ft. of Carboniferous strata, with the Barren Red Coal Measures everywhere at the surface. Subsequently vertical dykes and more or less horizontal lenticular sheets (sills) of quartz-dolerite were forced in the Carboniferous strata as subterranean intrusions. The dykes are up to 150 ft. in width and the sills up to 300 ft. in thickness; they can be seen in association in the Torphichen district of West Lothian. Earth movements, which later developed broad crustal folds, probably began about the time these subterranean intrusions were formed. The present disposition of the rocks of the Lothians is the result of this warping and fracturing of the crust followed by prolonged erosion which gradually removed the up-warped crests of the folds.

The main structural feature was an upwarp, or broad anticlinal fold, with a crest trending in a north-easterly direction over the present site of the Pentland Hills. In the western limb of this great earth flexure the strata were thrown into gentle undulations over a distance of many miles, but eventually, along a line through Bo'ness and Bathgate, were tilted decidedly downwards towards the west. The eastern limb was fractured along a line through Portobello and Carlops and a comparatively sharp downfold, or syncline, developed immediately to the east of the fracture. As a result the strata plunged down abruptly eastwards, then flattened out and some distance towards the E. and S.E. changed their inclination so as to rise again somewhat less abruptly. As a result of subsequent erosion on a stupendous scale the Carboniferous rocks were completely stripped off the crest of the Pentland fold, where the long-buried Old Red Sandstone and Silurian formations were thus again exposed. To the west undulating strata of the Calciferous Sandstone Series of the Carboniferous were laid bare as far as the Bo'ness-Bathgate area, beyond which Coal Measures were preserved in the great downfolded basin of the Central Coalfield (Lanarkshire, Stirling etc.). To the east of the Pentland arch a smaller isolated basin of Coal Measures was left (Midlothian Coalfield) while in East Lothian Coal Measures and Millstone Grit were removed and the bevelled edges of the strata of the Limestone Coal Group (East Lothian Coalfield), succeeded eastwards by

older Carboniferous rocks, were laid bare. South of the Southern Upland Fault (a major line of crustal fracture that crosses Scotland in a S.W.-N.E. direction from Ballantrae to Dunbar and forms the northern boundary of the Moorfoot-Lammermuir uplands) Carboniferous rocks, of the Calciferous Sandstone Series and Lower Limestone Group, were preserved in the Lothians only in a small downfaulted coastal area S.E. of Dunbar. Elsewhere erosion spared only Ordovician and Silurian sediments, locally covered by relics of unconformable Upper Old Red Sandstone.

The superficial deposits of the Lothians (Glacial and Recent: see Fig. 3) were laid down on a terrain of marked physical relief produced by the profound erosion of late Tertiary times. Just before the oncoming of the Glacial Period, sea level was in fact at least three or four hundred feet lower than at the present day.

The stiff stony 'boulder clay' or 'ground moraine' deposited by the land ice of Glacial times filled up the pre-Glacial valleys and eventually formed a 'mantle' of varying thickness over all the country; only on steep hill slopes, in the more elevated hilly tracts, and in parts of post-Glacial river cuttings are the solid rocks now free of boulder clay.

At the end of the Glacial Period, when the land ice was gradually disappearing, large quantities of 'fluvio-glacial' sand and gravel were deposited by melt-waters, mainly in fairly definite belts. Some of these trend along the major river valleys, while others bear no relation to the present drainage system and may be situated up to some hundreds of feet above sea-level.

Towards the close of Glacial times the land had been depressed, by the weight of the great ice sheet which covered Scotland, until sea level was some 100 ft. higher than now, and in the Forth estuary beds of gravel, sand, and laminated silt and clay (brick-clay) were deposited. When the ice disappeared the land, relieved of its great load of ice, rose again and the sea receded until well below its present level. Subsequently the sea again encroached on the land until it stood for a considerable period about 25 ft. above its present level and formed more beach deposits of sand and gravel. Finally the sea retreated a second time, and after minor oscillations and tilting the existing relative level of sea and land was established. Along the coasts of the Firth of Forth there are thus two main spreads of raised beach deposits: (a) those belonging to the 100-ft. Beach which consist of beds of sand, stoneless clay etc., locally

concealed in part by the later 25 ft. Beach deposits, but further from the sea forming flat ground with a surface 100 ft. (or more) above Ordnance Datum (150 ft. at Stirling); (b) those belonging to the 25-ft. Beach, forming a sandy coastal terrace in most places not higher than about 25 ft. above O.D. but rising gradually westwards to form the 'carse' lands of the Forth valley with their surface now about 50 ft. above the sea. Each old beach often ends inland against an old coastal cliff or line of bluffs.

During and after the period of oscillation of land and sea level the rivers, readjusting themselves to form the modern drainage system, cut down through the fluvio-glacial sands and gravels, locally excavated deep gorges in boulder clay or rock, and in the major valleys formed alluvial terraces at successively lower levels.

Since the final stabilization of land and sea, raised beach deposits have locally become covered by dunes of wind-blown sand (e.g. Musselburgh and Gullane), while many of the numerous lakes left in hollows by the melting ice have disappeared owing to the accumulation of brick-clay, shell-marl or peat, assisted by artificial draining.

II ROCKS AND MINERALS OF ECONOMIC IMPORTANCE

II. 1. COAL

Coal, which as we have seen is found exclusively in the Carboniferous formation, is much the most important mineral asset of the Lothians. The coal seams occur mainly in the Limestone Coal Group of the Carboniferous Limestone Series and in the overlying Productive Coal Measures. These two series of coals, each of which comprises some 20 to 25 seams, are separated by 900 to 1,800 ft. of more or less barren strata (Upper Limestone Group and Millstone Grit). In each of the series of coals about 15 seams are of workable thickness. In Midlothian two coals in the Lower Limestone Group have been wrought locally (e.g. at Gilmerton and Loanhead).

The seams of the Limestone Coal Group are distributed as follows: (1) in West Lothian, in a narrow strip of country running north and south from Bo'ness to the neighbourhood of Blackburn (i.e. along the eastern edge of the great syncline or basin forming the Central Coalfield of Scotland); (2) in Midlothian, along the line Portobello, Gilmerton, Loanhead, Glencorse and Carlops, near Howgate, Temple and Gorebridge, and in a belt of country

between Gorebridge and Prestonpans (i.e. around the edges of the Midlothian syncline or basin of Coal Measures and Millstone Grit. The S.W. end of the Midlothian Basin extends into Peebles-shire, where the Limestone Coal Group forms an irregular U-shaped outcrop from Carlops, through Macbiehill to Leadburn); (3) in East Lothian in the vicinity of Longniddry, Prestonpans, Tranent, Ormiston, Pencaitland and Pathhead. This is the only area where, owing to relatively gentle dips, the outcrop of the Limestone Coal Group is more than ½ to 1 mile across. Here, as a result of the presence of a subsidiary anticline (the 'Roman Camp Ridge' of Cousland and D'Arcy), with a shallow syncline or basin on the north-east, the Group locally attains a width of 6 miles in the neighbourhood of Ormiston (East Lothian Coalfield). On the western margin of the Midlothian basin the coal seams are more or less 'on edge', having been steeply tilted upwards, towards the west, owing to the effect of the great fault along the S.E. side of the Pentland anticline. In consequence the Limestone Coal Group is locally known in Midlothian as the Edge Coal Group.

The Productive Coal Measures of the eastern margin of the Central Coalfield extend across the Lanarkshire county boundary with West Lothian in the vicinity of Armadale and Fauldhouse. The main area of Coal Measures in the Lothians is, however, in the centre of the Midlothian Basin, S.E. of Edinburgh. Here Coal Measures cover an area 1½ to 3 miles wide, which extends for about 9 miles in a S.S.W. direction from Musselburgh through Dalkeith and Bonnyrigg to Rosslynlee and Carrington. In this region the coals of the Limestone Coal Group underlie the seams of the Productive Coal Measures in depth, but, except near the edges of the basin, they have not been much worked below the overlying strata of the Coal Measures, Millstone Grit and Upper Limestone Group.

Coals of various types suitable for gas producing, household, manufacturing and steam-raising purposes are worked at the present day both in the Limestone Coal Group and in the Coal Measures. In the West Lothian area coking coal is mined in the Limestone Coal Group in the vicinity of Bo'ness, Whitburn and Blackburn and anthracite in the Coal Measures near Armadale. This local occurrence of anthracitic coal is due to the alteration of a seam by heat at the time of the intrusion of a large sill or sheet of whinstone (quartz-dolerite).

Detailed information regarding the coal seams of the Lothians and the associated Carboniferous strata has been published in a number of Geological Survey Memoirs (Ref. 1910; 1910a; 1923; 1927; 1933; 1936; 1940) and in eight sheets of Vertical Sections, on the

scale of 40 ft. to the inch, illustrating the stratigraphical succession proved in different districts, also published by the Geological Survey, (Ref. 1937a). The memoirs contain further references, and one of them (Ref. 1933) includes a fairly up to date list of official maps, memoirs and vertical sections dealing with the Scottish Coalfield areas. Dr. Murray Macgregor's monograph 'Scottish Carboniferous Stratigraphy' contains much information on the Lothians (Ref. 1930). In addition some coal data of a technical character have been published by the Fuel Research Board (Ref. 1928c; 1930a; see also 1938, p. 32).

The Scottish Home Department has recently issued a comprehensive report on the present position and prospects of the Scottish Coalfields (Ref. 1944). This Report of the Scottish Coalfields Committee includes up to date general accounts of the geology of the coalfields of the Lothians, accompanied by sketch maps showing geology, leaseholds and location of collieries. The following information is derived from this report.

There are 18 collieries working in West Lothian and west Midlothian, of which 12 work coals in the Limestone Coal Group and 6 work coals in the Productive Coal Measures. In the Report these collieries are groups partly in the 'Central and Douglas Valley Coalfield' and partly in the 'East Stirlingshire Coalfield'. In 1939 the total output of these 18 collieries was 3,290,000 tons. In the 'Lothians Coalfield' (Midlothian Coal Basin and East Lothian Coalfield) 25 collieries are in operation, of which 20 work coals in the Limestone Coal Group, and 5 work coals in the Productive Coal Measures. In 1939 the total output of these 25 collieries was 4,050,000 tons. On a county basis the output of coal in 1939 was as follows: West Lothian 2,417,414 tons; Midlothian 3,509,351 tons; East Lothian 1,066,881 tons.

It is clear from information about collieries given in the last paragraph that in the Lothians the coals of the Limestone Coal Group are of much greater importance than those of the Productive Coal Measures. This may be further illustrated by the 'Lothians Coalfield' output figures for 1939, which were: Limestone Coal Group, 3,300,000 tons; Productive Coal Measures 750,000 tons.

In West Lothian and west Midlothian probable reserves of coal are estimated to be 196,500,000 tons in the Limestone Coal Group and 40,000,000 tons in the Productive Coal Measures. In the 'Lothians Coalfield' (Midlothian Coal Basin and East Lothian Coalfield) probable reserves are estimated to be 1,046,000,000 tons in the Limestone Coal Group and

184,000,000 tons in the Productive Coal Measures. The figure for the Limestone Coal Group does not include large probable reserves in the undersea area outwith existing undersea leaseholds.

The authors of the report state that the 'Lothians Coalfield' is in fact one of the richest in Scotland, and say that it might not unreasonably be asked whether it is being developed to anything like full capacity (Ref. 1944, p. 89).

II 2. OIL-SHALE

In the Lothians the oil industry began in 1851 when the famous Boghead Coal (Torbanehill Mineral or Torbanite) was subjected to destructive distillation. This substance was a unique cannel or gas-coal, unusually rich in volatile constituents, confined to a comparatively small area of Coal Measures near Armadale; it was almost entirely worked out by the early sixties (Ref. 1923, p. 103; 1927, p. 244).

By a curious coincidence other bituminous material suitable for oil-production by distillation had by this time been found near at hand (Broxburn) in much older Carboniferous rocks. This was oil-shale, which gives the name Oil-Shale Group to the upper part of the Calciferous Sandstone Series in which it is found. It is now known that during Calciferous Sandstone times the peculiar physical conditions favourable for the repeated formation of rich oil-shales did not extend eastwards in the Lothians much beyond the longitude of Prestonpans.

The oil-shale field of the Lothians west of Edinburgh is mainly in the Upper Oil-Shale Group, around Kirkliston, Queensferry, Blackness, Ecclesmachan, Broxburn, East Calder, West Calder, Cobbinshaw and Tarbrax. Over this large area 9 mail oil-shale seams have been worked in the Upper Oil-Shale Group. The Lower Oil-Shale Group contains two important seams, the Pumpherston Shale, which has been widely wrought, and the Dalmahoy Shale. The latter, which has not been exploited, is believed to be at a much lower horizon than the former (Ref. 1927, p. 94). It is not possible to indicate a definite horizon in the group below which workable oil-shale will not be found. It is however regarded as most unlikely that workable shale exists in the Burgh of Edinburgh east of the Corstorphine meridian (Ref. 1927, pp. 6-7).

The latest detailed geological information regarding the most productive portion of the oil-shale field west of Edinburgh (around West Calder, Pumpherston, Broxburn and Philpstoun) is contained in Wartime Pamphlet No. 27 of the Geological Survey, of which parts I, II and IV have already appeared (Ref. 1942c; 1942d; 1943c). Part III, dealing with the Broxburn district is in preparation.

On the S.E. side of the Pentland anticline there are only 4 oil-shales in the Upper Oil-Shale Group, of which 3 were formerly worked at Burdiehouse and Straiton (up to 1898). A narrow strip of productive shale measures probably extends all the way down the west side of the Midlothian Basin to Carlops, but the shales dip at high angles and mining would be difficult and costly. Borings in the Carlops-Macbiehill district of Peebles-shire, where the Oil-Shale Group sweeps round the S.W. end of the Midlothian Basin, indicate that at least one workable oil-shale extends over a considerable area (Ref. 1922, p. 49; 1927, pp. 7, 104-5). Borings in the Roman Camp Ridge, E. of Dalkeith, indicate that two thick seams of oil-shale are there present in the Oil-Shale Group, about 600 or 700 feet from the surface (Ref. 1922, pp. 49, 61; 1923a, p. 242; 1927, p. 112; 1938, p. 29).

Recently there have been 10 pits or mines working; these are situated near Dalmeny (1), Uphall (2), Winchburgh (3) and West Calder (4). Output in 1938 was 1,551,346 tons of oil-shale, as compared with 2,857,103 tons in 1924.

Formerly the main substances produced from Scottish oil-shales were lubricating oils, paraffin wax and sulphate of ammonia, but of late years the most important products have been motor spirit, solvent naphthas, diesel oil, burning oil and paraffin wax.

Reserves of oil-shale are very considerable, but effective reserves are not nearly so large as the 500,000,000 tons believed to be available 25 years ago. This is because it no longer pays to work shales of low oil-content for the production of sulphate of ammonia (Ref. 1940, p. 16).

II. 3. MINERAL OIL AND NATURAL GAS

In Midlothian attempts to obtain mineral oil in commercial quantities by boring have been made near West Calder (1919-21), D'Arcy (1919-22 and 1937-40) and Cousland (1937-39). The borings were located on anticlinal structures believed to be favourable to oil-accumulation, the wells near D'Arcy and Cousland being on the 'Roman Camp Ridge' anticline E. of Dalkeith.

The West Calder boring, almost 4,000 ft. deep, produced only slight traces of oil and gas (Ref. 1923a, p. 240; 1927, p. 109). The first D'Arcy boring, at about 724 ft. produced gas (mainly a mixture of methane and ethane) at the rate of 300,000 cubic ft. per day. This was sealed off. At 1,810 ft. some good quality oil was struck; the bore was stopped at 1,820 ft. Over a period of two months trial, the well yielded only about 7 tons of oil (Ref. 1922, p. 61; 1923a, p. 242).

Between 1937 and 1940 over half a dozen wells (bores) were sunk in the D'Arcy-Cousland area. The deepest was over 3,850 ft. As a result at least 15,000,000 cu. ft. of gas and about 1 ton of oil per day were made available as the combined yield of two of the wells. Two of the other wells were also producing some oil in 1940 (Ref. 1938, pp. 19-31; 1940, p. 18; see also Chief Inspector of Mines Reports for 1937 and 1938).

Both at West Calder and at D'Arcy-Cousland, the oil and gas were obtained from rocks of the Calciferous Sandstone Series. Only one bore (D'Arcy) went deep enough to penetrate the Upper Old Red Sandstone. The West Calder bore started in the Upper Oil-Shale Group and the others low down in the Lower Limestone Group.

II. 4. BEDDED IRONSTONE

Layers of ironstone, or of ironstone nodules, in shale (blaes) or associated with coal seams, have been wrought at various times in the Lower Limestone Group in Midlothian, in the Limestone Coal Group in West Lothian, Midlothian and East Lothian, and in the Millstone Grit and Coal Measures in West Lothian.

The bedded ironstones of the Bo'ness district in West Lothian were of great importance in the early days of the Scottish iron industry. Thus clayband ironstones and the Lower and Upper Ironstones in the Limestone Coal Group ('blackbands' or self-calcining ironstones) were extensively wrought from the time of the rise of the industry, about 1760, until 1895, when supplies were exhausted (Ref. 1920, p. 101, 1933, p. 11). An impersistent layer of clayband ironstone associated with the Six Foot Coal of Bridgeness is still worked when met with during coal mining operations (Ref. 1920, p. 102). The Crofthead Slatyband Ironstone at the base of the Coal Measures and two clayband ironstones in the Millstone Grit (Curdly Ironstone and Ginstone) were once worked in the neighbourhood of Fauldhouse (Ref. 1920, pp. 110, 105-7; 1923, pp. 81-83, 69-71). Ironstones met with in working coal seams in the Coal Measures near Fauldhouse, Armadale and West Craigs are still wrought as opportunity offers at the present day.

In Midlothian blackband ironstone in the Lower Limestone Group (Gilmerton Ironstone) was worked at Gilmerton between 1872 and 1875 (Ref. 1920, p. 169). Ironstones occur at a number of horizons in the Limestone Coal Group. Among these worked at various times the most important are the Loanhead No. 1 and No. 2 Blackband Ironstones (Ref. 1920, pp. 174, 181). At Loanhead and Roslin ironstones are still worked as opportunity offers. A Blackband Ironstone in the Limestone Coal Group in East Lothian was also worked at Old Dolphingstone Colliery, and near Penston (Penston Ironstone) in the vicinity of Tranent. The output of the Penston Ironstone at one time reached 100 tons per day, but it was not worked in this district after 1880 (Ref. 1910a, p. 194).

In the future, as at the present day, no ironstone is likely to be mined in the Lothians except as a by-product of the working of coal seams.

II. 5. FIRECLAY, SHALE (BLAES) AND CLAY

II. 5a. Fireclay used for making Refractory Products

Fireclay, for the manufacture of fire-bricks and other refractory products, was formerly worked in the Limestone Coal Group of West Lothian near Bo'ness and Bridgeness, and in the Upper Limestone Group of the same county near Kinneil (Ref. 1933, p. 114). Of recent years fireclay in the Millstone Grit has been mined for refractory purposes near Linlithgow

(at Birkhill or Birchhill, and Manuel; Ref. 1920a, p. 213; 1933, p. 114), Blackburn, Whitburn (at Drum Pits, Torbanehill: Ref. 1920a, p. 220), Bathgate, and Levenseat (Midlothian), while in the Coal Measures fireclay has been worked in collieries near Bathgate and Armadale. The reserves of fireclay in the West Lothian area are believed to be considerable (Ref. 1920a, pp. 220-21).

In Midlothian and East Lothian fireclays in the Limestone Coal Group were wrought prior to 1880 at Preston Links Colliery and at Joppa Quarry for the manufacture of firebricks, pipes and gas retorts at Bankpark Fireclay Works, Tranent (Ref. 1910, p. 348; 1910a, pp. 193-4). Fireclay in the Coal Measures was being used in 1910 at Whitehill Colliery near Roslin to make firebricks and sewage pipes (Ref. 1910, p. 348). Of late years fireclay has been worked at collieries in the Limestone Coal Group at Loanhead, Roslin and Preston Grange and in the Coal Measures at Whitehill. The reserves of fireclay in Mid and East Lothian, of a quality suitable for the manufacture of refractory goods, are not well known, especially in the Millstone Grit.

II. 5b. Shale (Blaes) and Clay (Mudstone) used for Brickmaking

At various collieries in the Lothians shale (blaes) has long been worked for brickmaking. In many instances the blaes is mixed with fireclay etc. before being ground up for use (Ref. 1910, p. 348). Bricks made from blaes mixed with clay are known as ‘composition bricks’ in Scotland. At the present day in West Lothian and west Midlothian blaes of the Calciferous Sandstone Series is worked for brickmaking at Winchburgh (Upper Oil-Shale Group). At Hailes Quarry (Lower Oil-Shale Group; near Edinburgh) blaes and low-grade oil-shale were used for brickmaking from 1908 to 1939 (Ref. 1930b, p. 195). Of recent years it has been found possible to use the spent shale of oil-works bings (of which large quantities are available) as a component of composition bricks, as for instance at Roman Camp Oil Works near Uphall. Blaes for brickmaking has also been wrought of recent years in West Lothian and west Midlothian at collieries in the Limestone Coal Group near Stoneyburn (Foulshields Colliery) and in the Coal Measures near Whitburn, Armadale, Fauldhouse and West Craigs. In the Mid and East Lothian Coalfields blaes in the Limestone Coal Group has of late been worked at Preston Grange (with fireclay), at Woolmet (near Portobello) and Arniston (near Gorebridge), and blaes in the Coal Measures at Newcraighall and Newbattle.

Mottled red, brown and purple clays (mudstones) which occur in the Barren Red Coal Measures near Dalkeith, have been moulded and burnt into miniature bricks said to compare well with Staffordshire blue bricks in appearance and strength (Ref. 1910, p. 348).

II. 5c. Boulder Clay used for Brickmaking

Boulder clay (Glacial ground-moraine) has been worked in the past in West Lothian and the adjacent part of Midlothian for mixing with Carboniferous blaes etc. in the manufacture of composition bricks. The larger stones are removed from the boulder clay before the raw clay mixture is ground up in a pug mill. Bricks made of blaes and boulder clay have been manufactured at Foulshields Colliery, 3 miles S. of Bathgate (Ref. 1910, p. 350; 1923, p. 119), at Braehead and Eastfield Quarries near Fauldhouse, and at Armadale Quarry (Ref. 1923, p. 119). At Winchburgh and Camps, boulder clay and blaes of the Upper Oil-Shale Group were formerly excavated together in about equal proportions for the manufacture of composition bricks (Ref. 1910, p. 350).

II. 5d. Alluvial Clays (Marine and Freshwater) used for Brickmaking etc.

Stoneless laminated marine clays belonging to the 100-ft. Raised Beach, have been worked locally at several places on the southern shores of the Firth of Forth (cf. Ref. 1913, Chapter VII). In West Lothian, Blackness Brick and Tile Works were in operation prior to 1834 and the enterprise is believed to have lasted at least up to 1857. In 1834 the annual output was 150,000 bricks, 200,000 roofing tiles and 200,000 draining tiles (Ref. 1845a, p. 71). This area of brick clay is believed to be of limited extent and to have, or to have had, a maximum thickness of 8 to 12 ft. The clay rests on gravel underlain by boulder clay. In Midlothian, clay of the 100-ft. Raised Beach, said to be locally 100 ft. thick, was dug for many years at Portobello, near Edinburgh, for the manufacture of bricks, tiles, chimney-pots, flower-pots etc. (Ref. 1864, pp. 83-100; 1910, pp. 335, 349; 1934, pp. 61-71). Similar clay was once worked near Smeaton, 2 miles S. of Musselburgh, where raised beach deposits extend inland up the valley of the Esk (Ref. 1910, p. 348). In East Lothian a stiff blue laminated marine clay, underlying deposits of the 25-ft. Raised Beach, was being worked on a fairly extensive

scale about 1850 at Belhaven, near Dunbar, for use in Seafield Brick Works (Ref. 1910a p. 183). There is a site of a small old brick- or tile-works on the W. of the Aberlady-Haddington road about ¾ mile from Aberlady. This is believed to be on a Raised Beach clay although it is in an area where raised beach deposits are not shown on published geological maps. There is a little information about the extent and thickness of this deposit; 27 ft. of clay were proved in a bore about ½ a mile W. of the old tile-works, and clay has been seen in ditches at the edges of the policies of Gosford House, about ½ mile to the S.W. of the works. The railway line to North Berwick runs between the site of the old tile-works and the sites of the bore and of the ditch exposures.

It would appear that, along the coast of the Lothians, accessible marine clays tended to accumulate in the vicinity of what were more or less sheltered inlets in 100-ft Raised Beach times. This inference can be drawn from a study of the distribution of the old brickworks on a map showing the extent of raised beach deposits, and has a bearing on the search for unworked deposits.

Stoneless finely-laminated Glacial clays are also said to have been dug for brickmaking in Midlothian, near Easkbank Railway Station and in the old clay-pits at Newton Grange (Ref. 1910, p. 348). The latter, and perhaps also the former, is thought to be a deposit in a Glacial lake.

Stoneless alluvial clays, on the sites of many of the innumerable small lakes which were a feature of Central Scotland at the close of the Glacial Period have been widely exploited in the past, especially about the middle of the 19th century, for the small-scale manufacture of bricks and tiles etc. At the present day such clays do not appear to be worked in the Lothians, but unusually extensive deposits between 1 and 2½ miles N.W. of Bathgate, in West Lothian, were being exploited as late as 1910. It is believed that there are considerable reserves (Ref. 1923, p. 120; 1910, p. 350).

A deposit of blue clay on the site of a small glacial lake about 900 yds. long by 260 yds. wide was formerly worked ¼ mile E. 10º S. of Gladsmuir, in East Lothian. The old brickfield is just S. of Brickfield Farm, 500 yds. from Gladsmuir along the Haddington Road. The old working face is said to have shown between 12 and 20 ft. of clay. Roofing and draining tiles and probably bricks were produced. It is believed that work ceased about 40 to 50 years ago.

II. 5e. Shale used for making Honestones

A special use for shales of certain kinds is in the manufacture of honestones. Shale in the Lower Oil-Shale Group, hardened and somewhat baked close to the base of a sill of quartz-dolerite, was once quarried for this purpose a short distance somewhat N. of W. of Ratho Hall, Midlothian (Ref. 1928, pp. 122-3). The hones are said to have been of excellent quality, but information about this enterprise is very meagre. It may be recalled that the well known Water of Ayr honestone is also composed of Carboniferous blaes baked by a sill of dolerite. At Hareshaw in the Pentland Hills (in Peebles-shire, just over the Midlothian county boundary) shales of a different type were at one time quarried for hones. These are fine-grained Silurian shales from the fish-bearing zone of the Downtonian Series (Ref. 1899, p. 653; 1940, p. 49).

II 6. LIMESTONE

The limestones of the Lothians are found mainly in the Carboniferous (Calciferous Sandstone Series, and Lower and Upper Limestone Groups). The most important are the Burdiehouse Limestone, at the base of the Upper Oil-Shale Group of the Calciferous Sandstone Series, and the thick limestones of the Lower Limestone Group. The nodular limestones or "cornstones" of the Upper Old Red Sandstone, of considerable local importance elsewhere in the Midland Valley of Scotland, are poorly developed in the Lothians, the only extensive old working being at Selms near Mid Calder, in a small isolated outcrop of this formation (Ref. 1910, p. 46; 1942, p. 8).

'Wartime Pamphlets' dealing with working and abandoned quarries and mines, and containing index maps, numerous new analyses of the limestones and discussions of the possibilities of future working have recently been published (Ref. 1942; 1943b).

In the past, limestones have been wrought in over 70 quarries or mines of which a considerable proportion are in West Lothian. The following table gives an idea of the extent of quarrying and mining operations during the present century:-

TABLE 1

LIMESTONE OUTPUT IN THE LOTHIANS 1900-1937

County	Tonnage and Number of Working Quarries (Q) and Mines (M)									
	1900		1910		1920		1928		1937	
	Tons	Q&M	Tons	Q&M	Tons	Q&M	Tons	Q&M	Tons	Q&M
West Lothian	1214	1	0	0	0	0	0	0	0	0
Midlothian	177696	12	147219	13	120267	7	69954	4	153492	5
East Lothian	15303	3	20058	3	25289	1	7691	1	24750	1
Total Tonnage Total No. Q&M	194213	6	167277	16	145556	8	77645	5	178242	6

Much of the extensive older exploitation took place in connection with the rapid development of agriculture, iron-smelting and building which characterised the latter part of the 18th and much of the 19th century. Practically all the worked limestones have been wrought opencast to the utmost limit that overburden will permit. Mining by adit or incline was undertaken at many places in the past and is carried on at the present day, and it is believed that future development will be largely controlled by the possibility of mining operations (Ref. 1942, p. 4).

In the Lothians limestone has been wrought of recent years at 7 localities: in Midlothian at Harburn, 2 ½ miles S.E. of West Calder (shaft to Burdiehouse Limestone); at Clippens, Straiton (shaft to Burdiehouse Limestone), at Middleton, S.W. of Borthwick (mines in North Greens Limestone of Lower Limestone Group), near Esperston, S.W. of Middleton (quarries in North Greens and Bilston Burn Limestones) and at Upper Side, S.W. of Temple (quarry in North Greens Limestone of Lower Limestone Group); in East Lothian at Oxwell Mains, 2½ miles S.E. of Dunbar (mine in Long Craig Upper Limestone of Lower Limestone Group).

The limestone is wrought for fluxing purposes in iron-works, for making cement and burnt lime, for stone-dusting in mines (to prevent explosions), for making roadstone chips, and for the production of ground lime for agricultural purposes. A very small amount is used in paper manufacture, but most of the limestones of the Lothians appear to be unsuitable for this purpose, the bulk of the quite considerable needs of the Scottish paper industry being drawn from England. The output goes chiefly to the agricultural and building industries, for use on the land and for the preparation of cement, mortar and plaster (Ref. 1942, p. 4). It has recently been suggested that part of the North Greens Limestone at Cousland, 2½ miles E.N.E. of

Dalkeith, may be suitable for the manufacture of 'rock-wool', a substance used for heat and sound-insulating purposes (Ref. 1942, p. 9).

II. 6a. Details of Limestone Quarries

II. 6a (i) Upper Old Red Sandstone

Apart from the extensive old workings at Selms, already mentioned, the only quarry on record as having worked cornstone in the Upper Old Red Sandstone is in the Pentland Hills, in Midlothian not far W. of Bavelaw Castle.

II. 6a. (ii) Carboniferous: Calciferous Sandstone Series

Limestones of the Calciferous Sandstone Series are of considerable importance. The most extensively worked is the Burdiehouse Limestone, at the base of the Upper Oil-Shale Group. Apart from an important local occurrence at Straiton on the western side of the Midlothian Basin, this limestone is confined to the productive oil-shale area of the western Lothians. In East Lothian there are the Rhodes and Sunnyside Limestones associated with tuffs (volcanic ashes) at the base of the lavas of the Garleton Hills area. N. and E. of Haddington (1910a, pp. 66-7).

In the western Lothians the Burdiehouse Limestone is mined at the present day at Harburn, 2½ miles S.E. of West Calder, for use as a flux and for making cement. Reserves are abundant (Ref. 1942, p. 9).

In the past the Burdiehouse Limestone has been wrought in the western Lothians as follows: in numerous quarries in the Queensferry district, near Hopetoun House (between Newton and Parkhead), and at Dundas Lime Works, Port Edgar (mine); between Dechmont and Livingstone; near East Calder (Raw, Raw Camps and Camps quarries and mines); near Cobbinshaw Reservoir at Kiprig (mine), at Torphin Quarry, and at Harburn and Harburnhead (mines). Most of the limestone from these sources is believed to have been used as a flux for iron-smelting. Another limestone (believed to be the Fells) was also once quarried at West

Torphin; in 1910 it was being mined there, by means of a shaft, for use in the Gartsherrie blast-furnaces (Ref. 1910, p. 355-56; 1923, p. 6; 1927, p. 21 etc.; 1942, pp. 8-9).

In the Midlothian Basin the Burdiehouse Limestone has long been worked near Burdiehouse and Straiton. At Straiton (Clippens Lime Works) the steeply dipping limestone is wrought at the present day from a shaft. The output is used for iron-smelting, cement-making and for agricultural and building purposes. Reserves are believed to be abundant. In 1910 some of the Clippens output was used in connection with gas-purification, a technical process in which limestone is no longer utilised, (Ref. 1910, p. 353; 1942, p. 8).

In East Lothian the limestone of Rhodes Quarry, near North Berwick, was once used both for lime-burning and for the building of walls. The quarry, which has long been abandoned, is notable for the occurrence of the mineral celestite (strontium sulphate) in the limestone. The Sunnyside Limestone has been quarried in the past near Carperstane 2½ miles W. of Whitekirk, at Lawhead (near Tyninghame), at East Linton Quarry, at Sunnyside (N.E. of Traprain Law), and near Luggate, Standingstone, and Whittinghame Mains. There are considerable reserves both of the Rhodes and Sunnyside Limestones (Ref. 1910a, pp. 67, 68, 197; 1942, pp. 11, 19).

II. 6a. (iii) Carboniferous Limestone Series

(1) Lower Limestone Group. The thick Limestones of the Lower Limestone Group are the most important sources of lime in the Lothians, notably on the east side of the Midlothian Basin. In the western Lothians they extend in a belt running southwards from the Forth, near Blackness, to Cobbinshaw Reservoir. East of the Pentland Hills they form a narrow outcrop along the steep western side of the Midlothian Basin from Portobello south-westwards to Carlops. Thence the Lower Limestone Group forms an irregular U-shaped outcrop extending into Peebles-shire round the S.W. end of the basin through Deepsykehead and Bents (Macbiehill) to Leadburn. From here a broad outcrop extends eastwards to the south of Temple and then N.E. between Borthwick and Pathhead to Saltoun Hall and East Saltoun. Here the outcrop bends northwards past Gladsmuir to reach the sea at Aberlady. There are also subsidiary anticlinal outcrops at D'Arcy and Cousland, E. of Dalkeith, and at Lennoxlove, S. of Haddington. An isolated area of

Lower Limestone strata occurs in the extreme E. of the Lothians, forming a coastal belt S.E. of Dunbar and N. of Innerwick.

In the western Lothians none of the limestones is worked at the present day. In the past limestones in the Lower Limestone Group have been extensively wrought in the N. and S. belt referred to above, at Hillhouse (near Linlithgow), Whitebaulks, Wairdlaw, Tartraven, Silvermine, Galabraes, East and West Kirkton, Petershill, (near Bathgate), on the River Almond at Blackburn, near Addiewell and at Baad's Mill (N.W. of Cobbinshaw Reservoir). Between Hillhouse and Petershill outcrops were worked almost continuously for 5 miles and mining as well as quarrying was carried out. (Ref. 1910, p. 355; 1923, pp. 22, 23, 33; 1943b, p. 25).

On the steeply inclined western side of the Midlothian Basin no Lower Limestones are worked at the present day. The Gilmerton Limestone was once wrought near Niddrie House, and farther south there are extensive old quarries and mines in the same limestone at Ferniehill, Hyvots Bank and Moredun, on the subsidiary anticlinal structure N.W. of Gilmerton. There are large reserves available by mining, (Ref. 1910, p. 178; 1942, p. 8). The North Greens Limestone was once quarried near Bilston, and the Bilston Burn Limestone near Gilmerton House. There is another old quarry in one of the Lower Limestones at Gowklie Moss, to the N.E. of Milton Bridge (Ref. 1910, p. 183).

In the important outcrops on the E. and S. of the Midlothian Basin, which are situated in East Lothian, Midlothian and northern Peebles-shire, limestones are wrought at the present day, at Middleton (S.W. of Borthwick; mines) and at Upper Side (S.W. of Temple; quarry), both in Midlothian. Reserves are extensive. The Middleton lime is used for agricultural and building purposes. A quarry at Esperston (about 1 mile S.W. of Middleton), recently abandoned owing to difficulties due to overburden (Ref. 1942, pp. 9, 10), is now active again, and a new quarry has been opened not far away.

Along the main outcrop of the Lower Limestone Group from the sea at Aberlady to Carlops in Peebles-shire, there are at least 30 old limestone quarries or mines, as for example: at Aberlady Mains; Gosford House; Harelaw (Longniddry); Landridge (N. of Gladsmuir); Samuelston and Jerusalem (N.E. of Pencaitland); Spilmersford; Saltoun; Blance Bridge; Law; Glenkinchie Distillery (S. of Pencaitland); Lampland; Peaston, Dodridge Law, Magazine

(S.E. of Pathhead: mine); Currie Lee (quarries and mines); Crichton; Catcune (quarry and mine); Middleton (working mines); Common Hill; Esperston (E.S.E. of Temple); Upper Side (S.W. of Temple; working quarry); Mount Lothian; Hillhead; Fullarton; Whim; Macbiehill; Bents; Bankhead; Whitfield; Carlops. The last six localities are in Peebles-shire (Ref. 1910a, pp. 138-45, 198; 1910, pp. 184-90; 1942, pp. 9-12).

In addition limestone was formerlly quarried or mined at Cousland. Chalkiside, D'Arcy, Mayfield, Hillhead and Blinkbonny, on the Roman Camp Ridge E. of Dalkeith, and at Lennoxlove, S. of Haddington. At Cousland reserves are abundant (for mining). (Ref. 1910, pp. 191-94;1910a, pp. 146; 1942, pp. 9, 11).

In East Lothian in the coastal area of the Lower Limestone Group S.E. of Dunbar, the Long Craig Upper Limestone is mined at the present day at Oxwell Mains Lime Works. The output is mainly used for cement-making and for stone-dusting in coal mines. Limestone (believed to be Skateraw Middle Limestone) formerly quarried at Oxwell Mains (in 1910) was partly used for smelting in the W. of Scotland and partly for burning for agricultural lime. Limestone was also formerly quarried at Skateraw and Catcraig. A small limestone quarry at Chapel Point at one time produced roadmetal (Ref. 1910a, pp. 134-38, 197-98; 1942, pp. 11, 19).

(2) Upper Limestone Group. Limestones of the Upper Limestone Group are found in the same districts as those of the Lower Limestone Group (except at Dunbar) but they are as a rule thinner than those of the latter Group, and are not exploited at the present day.

The only important old quarries are in the western Lothians. The Calmy Limestone was once mined somewhat extensively in the Bo'ness district, at Dykeneuk and near Kinneil, and there are old workings S.W. of Linlithgow, in Carriber Glen. The Castlecary or Levenseat Limestone, at the top of the Group, was wrought at Craigenbuck (near Inveravon) and on the River Avon near Avonbank, where there was extensive mining. The limestone from Craigenbuck was chiefly used for mortar, and much of that obtained at Avonbank was utilised for smelting purposes in the old Kinneil Ironworks. Further south the Castlecary Limestone was also worked in a line of old quarries and mines extending from Carribber Glen to Bowdenhill (Ref. 1933, pp. 112-13; 1943b, p. 25). The same limestone was also long wrought on an extensive scale, latterly by mining, at Levenseat Quarries, near Fauldhouse,

where work was still in progress in 1910, but had ceased by 1923. This quarry was said in 1868 to have been in operation for a century and a half, and before the days of good roads lime for building and agricultural purposes was carried away in baskets or bags slung on horses' backs. At all these localities it is unlikely that there are any reserves except in depth (Ref. 1910, p. 354; 1923, p. 43; 1943b. p. 25).

II. 6b. Ochre Beds

Ochre, formed by the decay of limestone, has been worked in the past (before 1910) in the Lower Limestone Group of Midlothian, in the Bilston Burn 3 miles S. of Gilmerton. Here, immediately W. of Pathhead, there is a series of coarse Ochre beds, the thickest of which (21½ ft.) represents the Gilmerton Limestone (Ref. 1910, p. 180). The date and scope of this enterprise are not known. In the same burn the North Greens Limeston has a 3 ft. bed of ochre at its top (Ref. 1910, p. 183). In the Nine Mile Burn, 7½ miles to the S.W., the Gilmerton Limestone is represented by an ochre bed of which 20 ft. have been seen (Ref. 1910, p. 180).

II. 7. SANDSTONE

II. 7a. Sandstone used as Building Stone

Almost all the Lothians' sandstones that have been used for building purposes are of Carboniferous age, and most of the quarries that have become widely known because of the excellence of their product are in the lowest of the series of beds into which the Carboniferous strata have been subdivided. They are either in the Granton Sandstone sub-group of the Lower Oil-Shale Group, or in the Upper Oil-Shale Group, both of which are subdivisions of the Calciferous Sandstone Series.

The geological distribution of the more important quarries, past and present, is as follows: Upper Old Red Sandstone 8; Carboniferous 94. Of the latter, 30 are in the Calciferous Sandstone Series, 10 in the Lower Limestone Group; 28 in the Limestone Coal Group, 13 in the Upper Limestone Group, 3 in the Millstone Grit and 10 in the Coal Measures.

Data regarding some of the physical and chemical properties of a number of the quarried rocks have been published from time to time (Ref. 1893, p. 272 etc.; 1910 p.358; 1911, pp273-4 etc., 1902b, p157,1920c, p.24; 1928a; compare also 1925a, pp. 258-66).

Stones from a few of the well-known old quarries (Binny, Dalmeny, Hermand, Hailes) engraved with the name of the parent quarry, can be seen in the pillars erected at the west end of the Meadows (Melville Drive) Edinburgh in 1888 (Ref. 1942b, p. 315). Many Scottish sandstones are represented in the large collection of dressed samples of building stone in the Geological Survey and Museum, London.

During the latter part of the 18th century, throughout the 19th century and for the first 10 years of the 20th the quarrying of sandstone for building purposes constituted an industry of considerable importance in the Lothians. The following table gives some idea of the extent to which work has diminished since the present century began:-

TABLE II
SANDSTONE OUTPUT IN THE LOTHIANS 1900-1937

County	Tonnage and Number of Working Quarries (Q)									
	1900		1910		1920		1928		1937	
	Tons	Q	Tons	Q	Tons	Q	Tons	Q	Tons	Q
West Lothian	77045	9	20852	6	3129	2	5654	2	5525	1
Midlothian	132761	10	41015	5	12000	2	23287	5	33350	3
East Lothian	6576	8	3891	6	60	2	0	0	20	1
Total Tonnage Total No. of Quarries	216382	27	65758	17	15189	6	28941	7	38895	5

The decline in the quarrying of Scottish building stone is due in part to the present day popularity of small cheaply built dwellinghouses of a detached or semi-detached type, in which very little stone may be used, as compared with the massive blocks of dwelling houses and flats and the substantial all-stone villas which characterised the 19th and the beginning of the 20th centuries. Another adverse factor is probably the hardness of the stones formerly so much in use, for at the present day, even in the case of comparatively soft rocks, the rate of

production of dressed stones by masons is said to be very much lower than it was fifty years ago, and masons are not so numerous.

It has also been argued that the decline in quarrying is in some measure due to difficulties that arise in finding large supplies of stone of uniform quality. According to Dr. M. MacGregor "The Scottish Carboniferous sandstones do not often yield material that can be readily dressed into large blocks; they are too often split up irregularly by partings or bands of flaky or shaly material, and even when good freestone posts occur they appear to be impersistent. They are often much broken up by joints, and many of them, especially those from the Lower Carboniferous, show traces of oil, giving rise to black patches on the surface of the stone when exposed to weathering" (Ref. 1930, p. 508, see also 1928a, pp. 90-104 in connection with oil in sandstones). In view of the extent of quarrying in the past and the size of blocks taken from some of the Lothians' quarries (Ref. 1893, p. 256, 260) the above seems a rather pessimistic estimate as far as the better-known Lothians' sandstones are concerned.

At the present day the only quarries on the active or potentially active list are: Hopetoun Quarry, in the Dunnet Sandstone of the Upper Oil-Shale Group, 700 yards E. 30º S. of Hopetoun House in West Lothian; Hawkhill Wood Quarry, Craigmillar, Edinburgh, in Upper Old Red Sandstone; Craigleith Quarry, Edinburgh, in the Granton Sandstone Sub-Group; Garvald (Garvauld) Quarry, in Upper Old Red Sandstone, a little S.W. of Garvald, East Lothian; Wester Broomhouse Quarry in Upper Old Red Sandstone near Dunbar, East Lothian.

Hopetoun stone is used only for local estate purposes. Before the war Hawkhill Wood had a considerable output, mainly for rubble work (e.g. Reid Memorial Church, Edinburgh). It has also been used for monumental work, for rough or hand-dresssed corner-stones, and latterly for making concrete aggregate. Craigleith Quarry was worked on a small scale from 1922 up to 1939. Latterly the output was rough building stone and crushed or ground rock for making concrete aggregate, for bottoming roads paved with setts, and for making artificial stone. Garvald Quarry stone is soft and easily hewn but is said to stand the weather well. It was used between 1934 and 1937 for pitching the bank and for parts of buildings at Hopes' Reservoir, 4 miles S. of Gifford, and has long been used for local building purposes. No details have been obtained of the recent use of Wester Brookhouse stone, but quarrying has gone on there for at least 100 years. Before the war Braehead Quarry near Fauldhouse, Midlothian was

active, in sandstone of Coal Measures age. The stone was widely used in central Scotland for rubble work, lintels, wall-copings etc. References are as follows: Craigleith (Ref. 1893, pp. 255, 272; 1910, p. 357; 1911, pp. 122, 273; 1920b, p. 157; 1920c, p. 24); Garvald (Ref. 1910a, p. 196); Wester Broomhouse (Ref. 1910a, pp. 195-6; 1911, pp. 113, 266); Braehead (Ref. 1911, pp. 131, 281; 1923, p. 114).

II. 7b. Details of Sandstone Quarries

II. 7b. (i) Upper Old Red Sandstone

In Midlothian large quarries in the Upper Old Red Sandstone are confined to the vicinity of Craigmillar Castle (Craigmillar and Hawkhill Wood Quarries). Craigmillar Quarry, W. of the Castle, has had a long history, for its pale pinkish sandstone was used in the building of Heriot's 'Hospital' (School), Edinburgh in the middle of the 17th century. This rock was employed in the construction of Leith Docks in 1876, and was used for building various churches and many of the villas on the south side of Edinburgh as well as for George Square, Regent Bridge, and the Barracks at Jock's Lodge (Ref. 1845, p. 21; 1893, p. 257; 1910, p. 357-58). The quarry was last in operation from 1906 to 1931, but latterly it did not produce much stone. Hawkhill Wood Quarry, N.E. of Craigmillar Castle, has been in operation since about 1922, and was active up till the outbreak of war. The stone has been mainly used for rubble work. Examples may be seen in Edinburgh in the Reid Memorial Church, near Blackford Station, and in villa groups in Mayfield Road, Esslemont Road and Ross Road. For face work Doddington stone from the N. of England was used in the Reid Memorial Church and Braehead stone from Fauldhouse (II. 7b. v) in the villa groups. Hawkhill Wood rock has been used in additions to George Heriot's School, Edinburgh, and for a church at Niddrie Mains, Midlothian. The colour of the rock varies from pale pink to yellowish or almost white.

As a locus for new quarries in the Upper Old Red Sandstone of the Edinburgh district attention has been directed to the N.W. slopes of the Pentland Hills S. of Balerno where there is a large area of sandstone partly free from serious overburden (Ref. 1942b, p. 260).

In East Lothian bright red is the prevalent colour of the Upper Old Red Sandstone, which has been much wrought for local building purposes between Dunbar and Garvald. The most notable quarries are Wester Brookhouse and Bourhouse near Dunbar, quarries near Beil N.E.

of Stenton, Black Bank Quarries (Old and New) and Garvald Quarry respectively E. and S.W. of Garvald (Ref. 1910a, pp. 195-6; 1911, pp. 113, 266). Some of these quarries are over 100 years old (Broomhouse and Garvald) and apparently none is actually being worked at the present day. Wester Broomhouse and Garvald were wrought to some extent during the first quarter of the present century. Garvald stone was used at Hopes' Reservoir between 1934 and 1937. The colour is dark to light red, spotted, or locally white. The rock has a heavy overburden and a large proportion of the quarried stone goes to spoil.

II. 7b. (ii) Carboniferous: Calciferous Sandstone Series

(1) Lower Oil-Shale Group. Quarries in this group are confined to Midlothian, where there are 6 on the western outskirts of Edinburgh. From N. to S. they are Granton, Barnton Park, Craigleith, Ravelston, Hailes and Redhall, all in the Granton Sandstone sub-Group.

There are 3 old quarries near Granton, the oldest of which probably dates back to about 1550. All are now disused and flooded. The most extensive quarry at Granton Point, was worked from 1835 to 1855 when it became flooded by the sea. Between 1835 and 1838 it provided a hard creamy white stone for the pier and breakwater at Granton (Ref. 1893, p. 258).

Barnton Park Quarry was opened before 1880 (when it provided a drab-grey stone used in building the Imperial Institute, London) and was worked until 1914. The quarry also yielded a dark blue-grey stone ("blue liver rock") used for glass-cutting (II. 7c) as well as for building and a fawn-coloured rock with dark markings ("common rock") used for second-class structural work (Ref. 1911, pp. 123, 273; 1920b, p. 157; 1928a, p. 98).

One of the oldest and most famous Edinburgh quarries is that at Craigleith, which is known to have been working early in the 17th century. Craigleith stone, which has been described as "well-nigh imperishable" was for long the principal building stone in Edinburgh; it was also used in London and on the Continent of Europe. Between 1770 and 1875, for example, this close-textured grey siliceous sandstone was used in Edinburgh to build the Register House (in part), the Old University, the Dean Bridge, Charlotte Square, and St. Andrews Church in George St., while in London it was utilised for the Bank of England, the British Museum and part of Buckingham Palace. The stone has also been used for docks, piers, column foundations and engine seats. A layer in the quarry known as the 'Lower Rock' provided

material for monumental work and grindstones (stone wheels for glass-cutting: II. 7c). After lying idle for 15 years the quarry was worked on a small scale from 1922 to 1939. (Ref. 1893, pp. 255, 272; 1910, p. 357; 1911, pp. 122, 273; 1920b, p. 157; 1920c, p. 24).

The Ravelston Quarries ('Ravelston' and Ravelston Black': Ref. 1893, pp. 257-8; 1910, p. 358; 1928a, pp. 98-104) have been worked from a very early period, and were active up to 1936. They provided greyish white, pale brownish buff and dark grey stone used for building and monumental work, for the production of non-slip paving stones and for grindstones (II. 7c).

Hailes Quarry is believed to have been opened up before 1800. It has provided white, greyish or blue, and pink stone. Grey rock was used for the following Edinburgh Schools: Dalry (1876), Lochend Road (1886) and Sciennes (1891). "Blue Hailes" was used for the Free Church Assembly Hall (1846) and "Pink Hailes" for the Royal Infirmary building of 1875, for "Red House", Cluny Gardens (1880) and for other villas in Morningside. Hailes stone has been much used for stone steps and stairs and for "platts" (slabs for stone landings) in tenements, for foundations and for rubble work. Little stone has been used for building since 1918; reserves are still available (Ref. 1845, p. 124; 1893, p. 260; 1910, p. 358; 1911, p. 123, 273). In the quarries the "Blue Hailes" underlies the "Pink Hailes", which is succeeded by about 145 ft. of blaes (shale) alternating with ribs of sandstone. Between 1908 and 1939 this blaes was utilised for the manufacture of bricks (II. 5b).

Redhall Quarry, now in a built up area, was working from the beginning of the 19th century until 1880 or somewhat later. It provided both white and reddish stone, softer than that of Craigleith, and was used in Edinburgh for Churches (e.g. St Paul's, York Place and St. John's, Princes St., between 1816 and 1818) for schools, and for the Synod Hall built in 1871 (Ref. 1845, p. 124; 1893, pp. 259, 273; 1910, p. 358).

(2) Upper Oil-Shale Group. In West Lothian and Midlothian the Dunnet and Binny Sandstones have been quarried, as well as sandstone at higher horizons, between the Binny Sandstone and the Houston Coal.

The Dunnet Sandstone, which has a grey to brownish colour, has long been wrought in West Lothian at Hopetoun Quarry (700 yards E. 30º S. of Hopetoun House). Hopetoun House was

built of this stone and quarrying dates back to 1697. The quarry provided stone for many other buildings on the Hopetoun estate and is still worked. Reserves are said to be considerable. In Midlothian the Dunnet Sandstone has been quarried in the vicinity of Limefield House, near West Calder (Ref. 1927, p. 30).

The Binny Sandstone was worked during the 19th century, at nine localities in West Lothian, which, from N. to S. are as follows: Dalmeny Quarry (Ref. 1893, p. 262; 1910, p. 358; 1927, pp. 10, 90); Hopetoun White Quarry, at Whitequarries near Philipstoun (Ref. 1927, pp. 71-2); N. of Duntarvie Castle near Philipstoun (Ref. 1927, p. 64); Craigton and Cockmuir Quarries near Philipstoun (Ref. 1893, p. 264; 1927, p. 72); Craigend, Humbie and Glendevon Quarries near Winchburgh (Ref. 1927, pp. 64, 90; 1925, p. 45; 1928a, p. 93); and Binny Quarry, N. of Uphall (Ref. 1893, pp. 259, 272; 1910, pp. 357-8; 1925, pp. 44-5; 1927, p. 10; 1928a, pp. 93-5). In Midlothian the only important quarry W. of the Pentland Hills was at Hermand, near West Calder (Ref. 1893, pp. 263, 273; 1910, pp. 357-8; 1920b, p. 158; 1920c, p. 24; 1925, p. 45; 1927, pp. 9, 30) while E. of the Pentlands the Binny Sandstone was once worked at Straiton Quarry (Ref. 1910, p. 356; 1928a, pp. 91, 94).

So far as is known only Hopetoun White Quarry (1905-22) has been active during the 20th century.

The Binny Sandstone is usually grey in general colour, with local rusty tints, but at Craigton and Whitequarries it is described as white. At Binny, Humbie, and Straiton Quarries the sandstone contains traces of oil (Ref. 1928a, pp. 93-95). Staining due to the presence of this crude oil at Straiton was found in time to mar the surfaces of the dressed stone, and led to the abandonment of the quarry (Ref. 1910, p. 356).

The Dalmeny stone was used in Edinburgh and Leith between 1874 and 1888, for instance in the construction of the Union Bank, George St., the Palace and Windsor Hotels, the east side of Palmerston Place and much of the Drumsheugh and Magdala Crescent area. The Hopetoun White Quarry stone was used only for estate purposes, and its working was discontinued because of poor quality. The Craigton rock can be seen in the 1890 additions to the Surgeon's Hall, Edinburgh. The Humbie stone was used to construct the railway viaduct across the Almond Valley W. of Ratho (Ref. 1925, p. 45). The following are Edinburgh examples of the use of sandstone from Binny Quarries: the first Bank of Scotland (1806); the Scott Monument

(1840-46); the Assembly Hall and spire (1842-4); Donaldson's Hospital (1842-51); the National Gallery (1850-59); the General Post Office (1866) and parts of the Register House. The Binny stone was also used for monumental work, e.g. the Queens' Statue at the Royal Institute (1836), and for making wheels for glass-cutting (II. 7c). The Hermand stone was used in Edinburgh between 1883 and 1889 for the Bank of Scotland branch, 103 George St., for St. Mary's Cathedral School, for the west wing of the Royal Scottish Museum, and for Free St. Andrew's Church, Drumsheugh Gardens.

Sandstones between the Binny Sandstone and the Houston Coal have been wrought at Kingscavil Quarry, 2 miles E. of Linlithgow and at Pardovan Quarry near Philipstoun (Ref. 1910, p. 356; 1933, p. 111). The rock of Kingscavil Quarry was used for the old walls of Linlithgow Palace, and was worked in 1843. Pardovan Quarry was not abandoned until 1910, although it does not appear to have yielded a very durable stone. (Ref. 1925, p. 92).

In Midlothian grey to brownish or yellowish sandstone near the top of the local equivalent of the Oil-Shale Group was once worked at Currie Glen, Borthwick (Ref. 1893, pp. 266, 273; 1910, p. 358; 1920b, p. 157).

In East Lothian sandstones in the Oil-Shale Group or its probable local equivalent have been wrought for local use in the past in quarries W. of Gullane (e.g. Red Quarry, Gullane, 1906-14), at Rentonhall, S.E. of Haddington, at Thornton and Branxton near Innerwick and in Dunglass Dean near Cockburnspath (Ref. 1910a, p. 196). The Gullane sandstone is somewhat calcareous. The Thornton and Branxton sandstones are red in colour, while that in Dunglass Dean (Bilsdean Sandstone) is white to pale yellow.

II. 7b. (iii) Carboniferous Limestone Series

(1) Lower Limestone Group. Sandstones in this Group were quarried before 1900 in West Lothian at Burnfoot near Carriden, at Porterside, 1 mile E. of Linlithgow (Ref. 1933, p. 111) and at Cauldhame (Hillhouse Sandstone Quarry), 1 mile S.E. of Linlithgow. The Cauldhame rock contains pyrites and does not weather well, but owing to its softness it has been much used for local building purposes (Ref. 1910, p. 357; 1933, p. 111).

In Midlothian two quarries in sandstone of the Lower Limestone Group were in operation near Gilmerton in the opening years of the 20th century (Ref. 1910, p. 356). The sandstone is described as soft and yellow to whitish in colour, with carbonaceous patches. West Edge Quarry, Gilmerton, apparently the last to be worked, was abandoned in 1907. Three unnamed quarries in sandstone associated with shale and coal were worked, prior to 1906, E. 25º S. of Lawfield about 2 miles E.N.E. of Newton Grange.
In East Lothian, neat Woodside about ¾ mile E. by S. of Gladsmuir there are two old quarries in sandstone of the Lower Limestone Group. In one reddish yellow friable sandstone is crumbling to sand. In the other 20 ft. of massive false-bedded yellow sandstone are still to be seen.

(2) Limestone Coal Group. Sandstones in this Group have been wrought in West Lothian, Midlothian and East Lothian.

In West Lothian small quarries were opened from time to time (before 1900) to the E. of Bo'ness in a sandstone which forms the roof of the Red Coal (Ref. 1910, p. 356; 1933, p. 112). The rock has been described as a hard, white fine-grained sandstone and as a "somewhat inferior freestone".

In Midlothian, sandstones in the Limestone Coal Group have been worked at the following localities: (a) Edgehead Quarry, 500 yards S.S.W. of Gilmerton (white sandstone); (b) Melville Quarry, 1 mile S. 10º W. of Gilmerton (white sandstone); (c) Four unnamed quarries in yellow sandstones dipping at 45º - 65º (three about ¼ mile E.S.E. of Gilmerton and one near Drumbank 1100 yards E. 40º N. of Gilmerton); (d) Shaw's Quarry, near Easthouses, 1 mile S.E. of Dalkeith. This rock is yellowish and slightly speckled. It is believed that there are large reserves (Ref. 1910, p. 356; 1942b, p. 278); (e) Three quarries up to a ¼ mile N. 40º E. of Lawfield, near Easthouses (massive sandstone); (f) Masterton Quarry, almost 1 mile E. 40º S. of Newton Grange (massive coarse sandstone with small quartz pebbles); (g) Whitehouse Quarry, almost 1 mile N. of Gorebridge (fine and coarse sandstone); (h) Millstone Brow Quarry, 2/3 mile E. of Gorebridge (coarse brown to yellowish sandstone, last worked 1908); (i) Quarry 500 yards S. of Millstone Brow Quarry (yellow sandstone); (j) Marfield Quarry, 3 miles S.W. of Penicuik, where a yellowish freestone of good quality was obtained for local building purposes (Ref. 1910, p. 356); (k) Lillyburn Quarry 2 miles S.E. of Penicuik. The rock here is a yellowish-brown rust-spotted medium-grained sandstone which

has of late years been worked on a small scale as a source of material for facing artificial stone. Before use the sandstone is crushed and roasted so as to give the iron oxide a red tint (Ref. 1940, pp. 29-30). With the exception of Lillyburn and Millstone Brow none of these quarries is known to have been active since before 1900.

In East Lothian, sandstone in the Limestone Coal Group was wrought up to 1911, in several quarries near Tranent (e.g. Upper Birsley, Kailpark, Bankton, Sandee, Paragon). 'Tranent Stone', of a light cream, almost white colour, said to have been very popular with architects for decorative work, possibly came from Bankton Quarry. In one of the quarries the sandstone is described as coarse and gritty, and in another as brown in colour and containing plant remains (Ref. 1910a, p. 196; 1911, p. 124, 274). There are other quarries in sandstones of the Limestone Coal Group of East Lothian, at Elphingstone Tower (2 miles S.S.W. of Tranent) in massive false-bedded yellow sandstone and near Winton Castle, Pencaitland (e.g. Tyneholm and Dean Quarries). The sandstone here is said to vary in grain from medium to very coarse; only the finer-grained rock was used as a building stone. In at least one quarry the stone was so soft that it was used as building sand (Ref. 1910a, pp. 196-7).

(3) Upper Limestone Group. Sandstone in this Group has been worked in West Lothian and Midlothian.

In West Lothian the quarries are in the neighbourhood of Bo'ness (Kinneil, Deanfield, Maiden Park, Brand's, East Kerse Mains, and between the latter locality and Dykeneuk). The last in operation were Kinneil, Deanfield and Maiden Park which were closed down in 1911, 1912 and 1913 respectively (Ref. 1910, p. 356; 1933, p. 112).

In Midlothian, in the neighbourhood of Woodmuir, near Fauldhouse, there are a few long abandoned quarries in the Upper Limestone Group (Ref. 1923, p. 112). The Joppa Sandstone, of a yellow colour, was worked at Joppa Quarry, Edinburgh and near Cowdenfoot (3 quarries) 1½ miles E.N.E. of Dalkeith. The Joppa Quarry is now in a built-up area, and some of the quarries have been used as refuse dumps, but there are believed to be considerable reserves at Cowdenfoot, under boulder clay (Ref. 1910, p. 356; 1942b, p. 278).

II. 7b. (iv) Carboniferous: Millstone Grit

The sandstones of the Millstone Grit are usually soft and medium to coarse in grain, with gritty or pebbly bands. They do not as a rule yield a durable stone and have only been quarried for building purposes to a small extent, for example in West Lothian near Torbanehill Mains, Whitburn (a yellowish sandstone: Ref. 1923, p. 113) and in Midlothian at Pinkie Quarry, Levenhall, near Edinburgh. In this quarry, (closed down in 1906) the sandstone has the reddish colour characteristic of the 'Roslin Sandstone' of the Edinburgh District. There are two large abandoned quarries in the Millstone Grit on the east side of the Midlothian Coalfield, where massive sandstone was once wrought: (an unnamed quarry 800 yards E. 40° S. of Smeaton, 2 miles N.E. of Dalkeith, and Roans Quarry 800 yards N.N.E. of Newton Grange).

II. 7b. (v) Carboniferous: Coal Measures

Sandstones in the Productive Measures have been quarried on a large scale only in West Lothian, near Fauldhouse, and in Midlothian S. of Inveresk and at Bonnyrigg.
At Fauldhouse there is a number of old quarries in sandstones at different horizons (Ref. 1923, p.114.) The oldest appear to be those at Crofthead. Other quarries, at Eastfield and Falahill, were working until 1908, while Braehead Quarries were in operation until 1939. At Braehead there are abundant reserves. The Falahill stone was similar to that produced at Braehead (which although fairly soft is said to stand well, but the Eastfield rock was not of such good quality. Most of the Braehead stone has a pale yellowish brown to brownish grey colour, and is medium to coarse in grain with some local pebbles and carbonised tree remains (Ref. 1911, pp.131, 281). In recent years, before the outbreak of war, the Braehead stone was widely used in central Scotland for rubble work, lintels, wall copings etc. The stone was used, for example for Fauldhouse School, for a bridge at Buchlyvie, and in Edinburgh for villas at the western end of Comiston Drive, for Alma Lodge in Midmar Drive, and for villas in Grange Loan built in the grounds of Grange House.
In Midlothian there are two long abandoned quarries, separated by a fault, at White Craigs, Cowpits 5/8 mile S. Of Inveresk. The sandstone is white in one quarry and pink in the other. Yellowish sandstone in the Productive Coal Measures has also been worked at Bonnyrigg (e.g. Viewbank and Polton Quarries). Viewbank Quarry was closed down in 1907 but Polton Quarry was in operation until 1928. The quarries are now largely filled in and partly surrounded by houses (Ref. 1910, p. 356); 1942b, p. 279).

II. 7c. Siliceous Sandstone used to make Stone Wheels for Glass-cutting etc.

Siliceous sandstone from Barnton Park, Craigleith and Ravelston Quarries near Edinburgh (Lower Oil Shale Group) and from Binny Quarry near Uphall (Upper Oil Shale Group) has long been used in Edinburgh for the manufacture of stone wheels for glass-cutting etc. (Ref. 1893, p. 257; 1911, p. 123; 1920b, p. 157; 1928a, p. 101; 1940, p. 30). The stone used has been described as 'Liver rock', a trade term applied to a hard, compact homogeneous sandstone which can be wrought with equal facility in any direction. Such rock is also much used for monumental purposes.

The wheels made are of two different colours – cream and dark grey ("black" or "blue"). The bulk of the dark grey stone has come from Barnton Park Quarry. Wheels of different hardness are used for cutting different kinds of glass or for making different kinds of cuts. These made of Craigleith stone (cream coloured) are the hardest, and these fashioned from Binny stone and from the 'black' stone of Ravelston are softer. Wheels of a great variety of sizes are manufactured, and have been widely exported. They are used for making 'cut-glass' ware, for bevelling and polishing plate-glass, for grinding optical glass, and for grinding purposes in the ceramic industry.

II. 7d. Sandstone used as Slabs for Furnace Hearths and Oven Soles

A yellow, rather coarse-grained, sandstone in the Upper Limestone Group was being much used about 1845 for hearths and ovens. The source of the stone was probably a quarry by the roadside near North Hainings in West Lothian, between Bo'ness and Polmont (Ref. 1933, p. 112).

The sandstone known as the "Quarry Rock", in the Limestone Coal Group near Wilsontown, was once used for furnance hearths as well as for building purposes (Ref. 1923, p. 52). The locality is in Lanarkshire, a little S. of the Midlothian county boundary.

II. 7e. Ganister-like Sandstone and Silica Rock suitable for use in the manufacture of Silica Bricks, etc.

The nature of ganister, ganister-like sandstone and silica rock, and the uses made of such materials are fully described elsewhere (Ref. 1918a, 1920b, 1920c). Ganister is a variety of siliceous sandstone, but its precise definition presents difficulties and the subject is too technical to be considered here. It is probable that no 'true ganisters' occur in Scotland (1920c, p. 34).

At one locality in the Lothians, at Drum Pits, Torbanehill, near Whitburn, West Lothian, 'ganister' (siliceous sandstone) was mined about the year 1916 for the experimental manufacture of silica bricks (Ref. 1920b, p. 146). A high-class silica brick was produced from this Millstone Grit sandstone, but manufacture was soon discontinued and has never been resumed, although reserves are available for mining.

Ganister-like sandstones which have been suggested as potential sources of raw material for refractories (e.g. silica bricks) are found in the Lower Limestone Group of the Carboniferous Limestone Series as follows: in Midlothian at Westhouses 1½ miles E. of Newton Grange, at Vogrie House 2 miles N.E. of Gorebridge, near Middleton and Esperston 2½ miles S. of Gorebridge (Ref. 1920b, pp. 153-4; 1920c, pp. 24, 25, 30, 34) and in East Lothian at Chapel Point 4 miles S.E. of Dunbar (Ref. 1910a, p. 137; 1920b, 154). In north Peebles-shire, close

to the Midlothian border and at the S.W. end of the Midlothian Coalfield, ganister-like sandstones which are probably on the same geological horizon as these just mentioned occur in the Cairn Burn near Macbiehill and at Deepsykehead Quarry. Tests of their refractory qualities were made about the year 1916, but the deposits have not been exploited (Ref. 1920b, pp. 151-4; 1920c, pp. 25, 29, 30).

A ganister-like sandstone at the top of the Upper Limestone Group near Auchendinny, in the Midlothian Coalfield, has been analysed (Ref. 1910, p. 349; 1920c, pp. 24-25).

Siliceous sandstones in the Oil-Shale Group of the Calciferous Sandstone Series have been suggested as potential sources of raw material for refractory products; they include the sandstones of Craigleith, Ravelston and Barnton Park Quarries near Edinburgh (Ref. 1920b, p. 158; 1920c, pp. 14, 24, 25), and of Currie Glen, Borthwick (Ref. 1920b, p. 157). The 'black' variety of sandstone from Ravelston Quarries is said to have been used in the manufacture of silica bricks (Ref. 1928a, p. 101).

II. 7f. Sandstone used as a source of Sand for Furnace Hearths for Moulding Purposes, for Glass Manufacture and for Soil-dressing

Soft sandstones which, when crushed washed and graded, provide siliceous hearth, moulding and glass sands, are known in the Lower Limestone Group and in the Limestone Coal Group of the Midlothian Coalfield, and in the Millstone Grit of west Midlothian. The Millstone Grit sandstone has been exploited for more than 30 years, but sandstone of the Limestone Coal Group was not worked until 1937.

The properties of sands suitable for the purposes under consideration have been fully described in a number of publications (Ref. 1918; 1918a; 1920b; 1920c).

A sandstone in the Lower Limestone Group at Chapel Point, 4 miles S.E. of Dunbar, East Lothian, has been suggested as a source of moulding sand, (Ref. 1920b, p. 155). No tests appear to have been carried out on this rock.

A sandstone in the Limestone Coal Group at Kittleyknowe Quarry, Carlops (in northern Peebles-shire) close to the Midlothian border and at the S.W. end of the Midlothian Coalfield) was wrought as a source of silica sand from 1937 to 1943, when work was temporarily suspended. After processing, the sand produced was used for pig-iron moulding, for steel-moulding, for acid open hearth furnaces and for the manufacture of bottle-glass. There are large reserves available.

It has been suggested that throughout the Midlothian Coalfield the soft sandstones in the lower part of the Limestone Coal Group would almost certainly be of considerable value for moulding purposes if a local industry were to develop (Ref.1940, p.25).

At one locality in the Lothians, at Breich or Levenseat Sandstone Quarries near the abandoned Levenseat Lime Works in Midlothian not far S.E. of Fauldhouse, soft sandstone in the lower part of the Millstone Grit has been worked since about 1912 as a source of silica sand for …… open hearth furnaces, for making synthetic moulding sand (i.e. moulding sand naturally bonded) and for glass-making (Ref. 1918, p. 88; 1918a, pp. 50, 80, 108, 116, 201, 214, 220; 1920b, p. 195-6; 1920c, p. 74).

Before the war of 1914-18 the sand produced here was mainly used for pig-iron moulds, while some was utilised in the manufacture of bottle-glass. During the 1914-18 war and for some years afterwards the sand was used for the hearths of steel furnaces and for steel-moulding as well as for pig-iron moulding and for bottle-glass manufacture. New quarries were opened up in 1936 and 1942-43 and a new processing plant was installed. At present the monthly output is about 7000 tons of which approximately 48% is used for synthetic steel-moulding sand, 43% for acid open hearth furnaces and 9% for ‘amber glass’ manufacture. Large reserves of sandstone are available. A high-grade fireclay (high in alumina and of a light colour) is worked below the sandstone and is used to mix with the sand to form a ‘bond’ for moulding purposes.

The coarse residue of the silica sand produced from the Kittleyknowe and Levenseat Quarries has been utilised by the Forestry Commission for soil-dressing in connection with fir plantations.

II. 8. WHINSTONE: IGNEOUS ROCK AND GREYWACKE

II. 8a. Whinstone used in Roadmaking

The Lothians are well supplied with rocks suitable for employment as roadstones. The best material is provided by igneous rocks, in the form of intrusions or lava flows, of Lower Old Red Sandstone, Carboniferous and Permo-Carboniferous ages (Ref. 1936, pp. 23, 49, 62, 70).

In the Lothians igneous rocks of Lower Old Red Sandstone age are mainly found in Midlothian, in the Pentland Hills anticline (Ref. 1936, Map, Plate II; 1942b, p. 259), where basalt and andesite lavas are well developed. The main outcrops of Carboniferous lavas are in the Bathgate Hills area of West Lothian (between Bathgate and Bo'ness: Ref. 1923, p. 117) and in the Garleton Hills area of East Lothian (near Haddington, East Lothian, Whitekirk and North Berwick: Ref. 1910a, pp. 118, 127, 199; 1936, pp. 53-4 and Map Fig. 12). In West Lothian the lavas are basalts, while in East Lothian they include dark porphyritic basalts and paler coloured mugearites, porphyritic trachyandesites ("quartz-banakites") and trachytes. The Carboniferous intrusions of West Lothian and Midlothian are mainly sills of teschenite (olivine-analcite-dolerite), while in East Lothian there are in addition intrusions of fine-grained black monchiquitic rock (analcite-basalt or basanite) and of paler trachyte and phonolite (Ref. 1910, pp. 276-82; 1910a, Chapt. X and pp. 198-201). The Permo-Carboniferous intrusions consist of thick sills and broad E. – W. trending dykes of quartz-dolerite and tholeiite. Quartz-dolerite dykes are found throughout the Lothians, although of little importance except in West Lothian, but the sills of quartz-dolerite are confined to West Lothian and western Midlothian. The chief occurrence of tholeiite is in the form of a sill at Dalmahoy, near Balerno in Midlothian (Ref. 1936, pp. 70-74 and Map, Plate VI; 1942b, p. 297; compare also 1937, pp. 102-5, 142-3).

For general descriptions of the various types of igneous rock two publications are of particular value (Ref. 1929, pp. 41-45; 1936, pp. 53, 54, 63, 70). The characteristics of many of the rocks as rockstones are referred to in "Attrition Tests of British Roadstones" and elsewhere (Ref. 1929, pp. 20, 24, 30, 41-49; also 1906; 1910, p. 360; 1910a, p. 198; 1935, pp. 62-118; 1940, p. 44).

In the “Annual Reports of H.M. Chief Inspector of Mines” from which are taken the tonnage statistics of Table III, and in the “Lists of Quarries” published by the Mines Department, the term “igneous rock” is often wrongly used to include the output of quarries working greywacke. In the present account, where greywackes are distinguished from igneous rocks, the general term ‘whinstone’ is used to cover both. Greywackes are indurated impure sandstones and grits, generally of a greenish-grey colour, which are found in the highly folded Ordovician and Silurian sedimentary strata which occur in Midlothian and East Lothian to the S.E. of the Southern Upland Fault. Greywacke was not, as a rule, so good as sound igneous rock on water-bound roads, but it may be quite satisfactory for use as tar macadam. Up till about 12 years ago about 9 quarries in greywacke were being worked for roadmetal in the Lothians. At the present day there is only one active (Ref. 1910a, p. 198; 1929, p. 55; 1940, p. 44).

In West and East Lothian the number of working roadmetal quarries has greatly decreased since the beginning of the century, as is indicated in Table III. It will be seen, however, that the total annual tonnage of whinstone quarried in each county has greatly increased. This is a result of the improvement of main and secondary roads and of the increasing availability and efficiency of motor transport, which have enabled County authorities and quarrymasters to concentrate on the most suitable material obtainable in bulk and distribute it over a wide area.

TABLE III

WHINSTONE OUTPUT IN THE LOTHIANS 1900-1937

County	Tonnage and Number of Working Quarries in Igneous Rock (Ign.) and Greywacke (Grw.)														
	1900			1910			1920			1928			1937		
	Tons	Quarries		Tons	Quarries		Tons	Quarries		Tons	Quarries		Tons	Quarries	
		Ign.	Grw.		Ign.	Grw.		Ign.	Grw.		Ign.	Grw.		Ign.	Grw.
West Lothian	21962	16	0	39791	17	0	48952	13	0	88152	10	0	71493	6	0
Midlothian	99349	14	5	150094	13	5	138704	12	4	274091	13	6	343915	12	1
East Lothian	20952	17	4	23490	16	4	17010	13	4	32365	11	4	46341	3	0
Total Tons	142262			213375			204666			394608			461749		
Total Ign. Qys.		47			46			38			34			21	
Total Grw. Qys.			9			9			8			10			1

We have seen that the distribution of various types of igneous rocks and of greywacke is far from uniform throughout the Lothians. In consequence the choice of rock for quarrying on a large scale is different in each county. It will therefore be convenient to consider each county in turn and given an account of its characteristic roadstones and their uses.

(1) West Lothian. In West Lothian, where quartz-dolerite sills and dykes are well represented, quarrying at the present day is largely concentrated on these rocks. They provide setts and kerbs, as well as roadmetal which is generally of much better quality than that made from the local olivine-basalt lavas or from the teschenite sills.

For sett-making three mutually perpendicular directions of easy splitting (called 'reed', 'hem', and 'head' or 'hardway') must be present in the rock. A discussion of such planes of weakness in quartz-dolerite sills and dykes has recently been published (Ref. 1937, pp. 104-5). An adverse opinion on the wearing quality of Scottish quartz-dolerites expressed by Dr. B.H. Knight (Ref. 1935, p. 114) does not seem to be readily reconcilable with the number of important quarries working in these rocks at the present day, not only in the Lothians, but in Stirlingshire and Fife.

In West Lothian the making of setts and kerbs is confined to the sills of quartz-dolerite, but elsewhere in Scotland dykes have also been used for this purpose. The best quality of quartz-dolerite in West Lothian is said to be got from the Avonbridge sill, 4 miles W. of Bathgate (Ref. 1923, pp. 107, 117), and from the Blackridge sill 6 miles W.S.W. of Bathgate (Ref. 1923, pp.107,117; 1929, p.30).

Of recent years 3 quarries have been worked in quartz-dolerite sills, 2 at Gowanbank in the Avonbridge sill 3½ miles W.S.W. of Torphichen, and 1 at Craigton Hill 1½ miles N.W. of Winchburgh, while one has been active in a dyke at Kildimmery 1¼ miles E. 30º S. of Linlithgow Station (Ref. 1933, p. 114). Craigton Hill Quarry has been in operation over 45 years (Ref. 1019, pp. 283, 360). Kettlestoun (Kettleston) Quarry, in the Kettlestoun Hills sill ¾ mile S.S.E. of Linlithgow, is being reopened; it was of considerable importance at the beginning of the century (Ref. 1910, pp. 284-5, 359; 1933, pp. 91-2). Just south of the county boundary, in Lanarkshire, there are two important working quarries in the Blackridge Sill: Westcraigs (Ref. 1923, p. 117) and Blairhill. The former is ½ mile S.E. and the latter 2/3 mile S.S.W. of Blackridge.

Teschenite is at present worked for roadstone and setts at Craigie Hill Quarry, near Dalmeny (Ref. 1942b, p. 298)

The olivine-basalt lavas of the Bathgate and Linlithgow Hills do not yield a stone durable enough for use on main roads where traffic is heavy. Four quarries worked during the first quarter of this century are now seldom or never in use. (Ref. 1923, p. 117; 1929, pp. 24, 30; 1933, p. 115).

(2) Midlothian. In Midlothian quartz-dolerites (Ratho sill 2 miles S. of Kirkliston and Cramond Bridge sill just W. of Cramond Bridge) and olivine-tholeiite (Dalmahoy sill W. of Balerno) are of importance at the present day as sources of setts and kerbs as well as roadmetal. Well known working quarries in the Ratho sill, all active since before 1900, are: Hillwood 1 mile N.W. of Ratho (Ref. 1910, p. 360); Norton ⅝ mile N. 25º W. of Ratho; and Craigpark ¾ mile W. of Ratho. Ratho quarry itself, ¾ mile W. 10º N. of Ratho, was closed down about 1918 (Ref. 1910, pp. 283, 360; 1942b, p. 298). In the Cramond Bridge sill there are 2 active quarries; Braehead, 1 mile S. 15º W. of Cramond Bridge, in operation since 1934 (Ref. 1942b, p. 299) and Lenny (Lennie), 1 mile S. 35º W. of Cramond Bridge, worked since before 1900 (Ref. 1910, p. 360; 1942, p. 299).

Quartz-dolerite dykes are not at present quarried in Midlothian.

In the Dalmahoy olivine-tholeiite sill, Kaimes Quarry, 2¼ miles W. of Balerno, is still in operation (Ref. 1910, p. 360; 1927a; 1929, p. 20; 1935, p. 115; 1936, p. 72; 1942, p. 298). The Dalmahoy rock varies in grain and character in different layers and is in part tholeiite, in part dolerite and in part basalt. It contains chlorophaeite, a soft pale green mineral which turns black on exposure to the air (Ref. 1927a, p. 489) and is said to make the rock unsuitable for concrete work (Ref. 1935, p. 115).

In Midlothian lavas of Lower Old Red Sandstone age are also worked on a large scale on the southern outskirts of Edinburgh, where Blackford Quarry (andesite) and Torphin Quarry (basalt) have been producing roadmetal since before 1900. The Torphin stone is the softer of the two (Ref. 1910, p. 360; 1929, p. 20; 1935, pp. 64, 118; 1942, p. 259). Mortonhall Quarry (andesite), between Blackford and Torphin, has also been active until fairly recently. Here the

andesite lava is associated with a coarse volcanic breccia or agglomerate which has been used quite extensively for garden rockeries (Ref. 1942b, p. 259).

A small granodiorite intrusion of Lower Old Red Sandstone age has been worked a little of recent years for roadmetal at Broadlaw Quarry, near the Innerleithen road 8½ miles S. of Dalkeith. It is believed that at one time (prior to 1900) paving setts were made here, and that the quarry provided the first setts used in Princes St., Edinburgh, (Ref. 1929, p. 20; cf. also 1925b, p. 361; 1928b, pp. 156, 159).

Teschenite is wrought, chiefly for roadmetal, at Barnton Quarry, in the Corstorphine Hill sill on the western outskirts of Edinburgh, ½ mile S. of Davidsons Mains. Although petrologically the rock is far from 'fresh' the quarry has been working for more than 45 years (Ref. 1910, p. 360; 1929, p. 20; 1942b, p. 299).

Greywacke is still worked at Hazelbank Quarry, Fountainhall, Stow, on the Edinburgh – Galashiels road south of Heriot.

(3) East Lothian. In East Lothian the only recent working in quartz-dolerite is at Grange Quarry in an E. – W. dyke on the coast 2 miles E.N.E. of Musselburgh, where roadmetal is produced (Ref. 1942b, p. 298).

The most important modern quarry in the county is in a dome-shaped intrusion of phonolite (a variety of trachyte) forming Traprain Law. This fresh rock has been continuously quarried for over 45 years (Ref. 1910a, pp. 199-201).

From before 1900 until about 1925-30, five of the local Carboniferous intrusions of basanite (analcite-basalt) provided good quality black fine-grained roadstone suitable for use on tarred roads, but they were abandoned in favour of Traprain Law, where centralised quarrying on a large scale is possible (Ref. 1910a, pp. 198-201).

The Carboniferous basalt and mugearite lavas, which are widely developed, have not been used as a source of roadmetal for very many years. Trachyte lava, however, quarries at Craigs Quarry, just W. of Dirleton, mainly for building purposes, is also used for road-bottoming (Ref. 1910a, p. 200) and trachyandesite ("quartz-banakite") lavas are quarried for roadstone at Bangly Quarry, 2 miles W.N.W. of Haddington, and at Skidd Hill Quarry, 1½ miles

N.N.W. of Haddington (Ref. 1910a, pp. 199-200). The intrusive trachyte of Pencraik (Pencraig) Quarry 1 mile W. 10° S. of East Linton, is also worked for bottoming purposes at the present day. Unlike the lavas of Bangly and Skid Hill, it is a fresh rock (Ref. 1910a, pp. 200-1). Bangly, Skid Hill and Pencraik quarries have been in use since before 1900, and prior to the development of Traprain Law Quarry, Bangly was the most important source of roadstone in the country.

No stone setts or kerbs are produced in East Lothian.

(4) Concrete Aggregate. Practically all types of stone quarried as roadmetal at the present day in the Lothians are believed to be suitable for making concrete aggregate. For instance concrete kerbs, channels or paving flags etc. are made from andesite (Blackford Quarry, Edinburgh), from basalt (Torphin Quarry, Edinburgh) and from greywacke (Hazelbank Quarry, Midlothian). The Traprain Law phonolite is used for concrete work, and other trachytic rocks in East Lothian have of late years been used for concrete runways on aerodromes. If, as is alleged, rocks containing a good deal of chlorophaeite are unsuitable for concrete work (Ref. 1935, p. 115) not only the Dalmahoy sill, but the neighbouring small sills at Selms, Kirknewton and Auchinoon Hill would be ruled out for this purpose (Ref. 1927a, pp. 490-94 and Map, Fig. 1).

II. 8b. Details of Roadstone Quarries

II. 8b. (i) Ordovician and Silurian Greywackes

Greywackes (Ref. 1910a, p. 199; 1936, Map, Plate III; 1942b, p. 259) were wrought for road metal at 4 or 5 quarries in Midlothian and at 4 quarries in East Lothian up to about 12 years ago. Of recent years only one quarry has been in operation (Hazelbank Quarry, Fountainhall, Midlothian). Greywacke was not, as a rule, so good as sound igneous rock on water-bound roads, but it is quite satisfactory for use as tar macadam.

Most of the quarries are in greywackes of Ordovician age (Llandeilo – Caradoc). Those in Midlothian are mainly on the Edinburgh–Galashiels road between Heriot and Galashiels; the following quarries may be mentioned:- Garvauld, Hangingshaw (Ref. 1929, p. 20), Cortleferry (Ref. 1929, p. 20), Hazelbank, Craigbank, Bow, Craig Gala. Another Midlothian working was on the Dalkeith – Lauder road (Soutra Quarry: Ref. 1910a, p. 198). Quarries formerly worked in East Lothian Ordovician rocks were Blegbie, 5½ miles S. 35° W. of Gifford (Ref. 1910a, p. 198), Lammerlaw, about 3 miles S. 15° W. of Gifford, and Hornshill, 3 miles E. 10° S. of Gifford (Ref. 1910a, p. 198).

Greywacke of Silurian age (Llandovery–Tarannon) has been wrought at only one or two quarries in the Lothians, e.g. in East Lothian at Pathhead Quarry, 4 miles E. 17° N. of Garvald and at Clints Quarry 2 miles S.E. of Garvald (Ref. 1910a, p. 198).

II. 8b. (ii) Lavas of Lower Old Red Sandstone Age

In the Lothians these rocks are confined to the Pentland Hills Anticline (Ref. 1936, Map Plate II; 1942b, p.259). In addition to the quarries already mentioned Silverburn Quarry, in basic andesite 2 miles W. of Penicuik, was active for more than 20 years, but has not been worked since 1920 (Ref. 1910, p.359.

II. 8b. (iii) Intrusions of Lower Old Red Sandstone Age.

The only intrusive rock of Lower Old Red Sandstone age that has been exploited in the Lothians is a small granodiorite mass already mentioned as being quarried intermittently at Broadlaw. The rock is fine-grained for a granodiorite and pinkish to very pale greyish in colour (cf. Ref. 1925b, p.361; 1928b, pp.156, 159).

A much larger composite mass of granodiorite, pink to greyish in colour, is situated in East Lothian, at Priestlaw, on the Whiteadder Water 8 miles S.E. of Garvald. So far as is known the rock has not been quarried, although it is traversed by the road connecting Garvald and Gifford with Duns (Ref. 1925b, p.360; 1928b, pp.155, 158, 161).
There is a large mass of pink intrusive felsite forming Black Hill in the Pentland Hills, (2½ miles S.E. of Balerno, Midlothian) which has never been quarries presumably because of the difficulty of access, for felsites are much used in Scotland as roadstones (Ref. 1910, p.26; 1936, Map, Plate II).

II. 8b. (iv) Lavas of Carboniferous Age

In West Lothian olivine-basalt lavas (cf. Ref. 1929, pp. 24, 30) have been worked during the present century at Earngath (Irongath) Hill Quarry, 1½ miles S. of Bo'ness from 1908 to 1928 (Ref. 1933, p. 115) and at the adjacent Whinny Hill Quarry from before 1900 to about 1922. The only other olivine-basalt quarry which has been much worked is Kinglass, about 1 mile S. 30º E of Bo'ness, in operation from 1912 till about 1928. There is an unimportant quarry (Little Craig) in a small isolated outcrop of basalt lava 2 miles E.N.E. of Bathgate.

The principal East Lothian quarries have already been mentioned. A few that may have been worked for roadstone at one time are referred to later (II. 8c.)

II. 8b. (v) Intrusions of Carboniferous Age

The numerous intrusions of Carboniferous age that occur in the Lothians are of three main types: trachytic, teschenitic (olivine-analcite-dolerite) and monchiquitic (analcite-basalt or basanite). All types of rock have been used as roadmetal, but the teschenites alone have been found locally suitable for making paving setts (e.g. Craigie Hill). The trachytic rocks are fine-

grained and pale greenish in colour when fresh but pale yellowish brown to dark red-brown when decomposed. The teschenites are dark grey rocks usually of rather coarse grain. The monchiquitic intrusions are black in colour and very fine-grained. The teschenites are found throughout the Lothians, but the trachytic and monchiquitic rocks are confined to East Lothian. The distribution of the teschenitic and monchiquitic intrusions of the Midland Valley of Scotland has been shown on a special map (Ref. 1936, Plate VI). A map of part of East Lothian shows trachytic intrusions, as well as teschenitic and monchiquitic rocks (Ref. 1936, Fig. 12).

(1) Trachytic Types. The trachyte intrusion worked for more than 40 years at Pencraik (Pencraig) Quarry, 1 mile W. 10º S. of East Linton is a pale coloured, altered, rather soft rock, but is regarded as a good stone for bottoming purposes.

The intrusion of phonolite (a variety of trachyte) forming the prominent hill of Traprain Law is pink or reddish to grey in colour and comparatively fine-grained, though coarser in the interior of the mass than near the margins. The large quarry in Traprain Law, as has already been mentioned, is the most important source of roadmetal in East Lothian at the present day.

(2) Teschenitic Types. The teschenites that have been worked during the present century are mainly in West Lothian. Near Dalmeny there are several quarries in the Craigie Sill (e.g. Dickson's Craig, Dolphington and Craigie Hill) and one in the Dundas Castle Sill (Carmel Hill). Boghall Quarry, in a small outcrop of teschenite 1¼ miles E. 15º S. of Bathgate was in operation from before 1900 until about 1931. This stone was not very durable, and was not worked on a large scale. At the present day only Craigie Hill and Dolphinton Quarries are in operation, the former being the more important.

In Midlothian the only important working in teschenitic rock is at Barnton Quarry. Just to the south is the old Barnton Mount Quarry. At Auchinoon Quarry 3½ miles S.S.E. of Mid Calder an olivine-dolerite rich in chlorophaeite was worked intermittently between 1912 and 1920 (Ref. 1910, p. 360).

In East Lothian, Gosford Quarry, in the Gosford Bay teschenite sill on the foreshaore close to the road, produced a good quality roadstone from before 1900 until 1918 (Ref. 1910a, pp.198-201), while Galalaw (Gallow Law) Quarry, in the more easterly of the two Gullane

teschenite sills (by the roadside 1 mile S. 30º W. of Gullane), furnished a rather soft stone which was worked intermittently up til 1916 (Ref. 1910a, p.200).

(3) Monchiquitic Types. During the present century fine-grained intrusions of analcite-basalt (or basanite) have been worked in East Lothian as follows: at Kidlaw Quarry from about 1900-1931, in a small intrusive mass 3 miles S. of 35º W. of Gifford (Ref. 1910a, pp. 199-201); at Baro Quarry, from before 1900 to about 1928, in the large sill 1½ miles E.N.E. of Gifford (Ref. 1910a, pp. 198-201); at Chesters Quarry, from before 1900 to about 1928, in the large sill 3 miles N.E. of Gifford (Ref. 1910a, pp.198-201); at West Fenton Quarry, from before 1900 to about 1925, in a small intrusion 1½ miles S. 35º E. of Gullane (Ref. 1910a, pp. 199-200); and at Seacliff Quarry, from about 1922 to 1931, in a small intrusion on the coast 3 miles E. by S. of North Berwick. The Baro Quarry sill was also quarried long ago at Sheriffside, 1¼ miles E. 10º S. of Gifford.

II. 8b. (vi) Permo-Carboniferous Intrusions

The Permo-Carboniferous intrusions consist of thick sills and broad E. – W. trending dykes of quartz-dolerite and tholeiite. The general characters of these intrusions and their distribution in the Midland Valley of Scotland have been dealt with elsewhere (Ref. 1936, pp. 70-74 and Map, Plate VI; 1942b, p. 297). A useful account of quartz-dolerite sills in relation to their use as a source of roadstone, setts and kerbs has been given in connection with the sills of the Kilsyth district of Stirlingshire and Dumbartonshire (Ref. 1937, pp. 102-5, 142-3). Quartz-dolerite dykes are found throughout the Lothians, but sills of quartz-dolerite and tholeiite are confined to West Lothian and western Midlothian. An unusual type of olivine-bearing tholeiite forms the Dalmahoy Sill, just W. of Balerno, Midlothian.

The quality of the rocks has been referred to in a number of publications (Ref. 1910, p. 360; 1910a, p. 200; 1929, pp. 20, 24, 30, 47; 1935, p. 114; 1940, p. 44; 1942b, p. 297).

(1) West Lothian. In this county sills have been widely quarried for roadmetal, setts or kerbs and dykes have been worked for road metal only (Ref. 1929, p. 24).

The quartz-dolerite sills of West Lothian comprises: the Blackridge sill, 6 miles W.S.W. of Bathgate (Ref. 1923, pp. 107, 117; 1929, p. 30); the Avonbridge sill 4 miles W. of Bathgate

(Ref. 1923, pp. 107, 117); the Torphichen sill 3 miles N. 10º W. of Bathgate (Ref. 1933, p. 92); the Carribber sill 1½ miles S.W. of Linlithgow (Ref. 1910, p. 359; 1933, p. 91-2); the Kettlestoun Hill-Cockleroy (Cocklerue) sill 1 mile S.W. of Linlithgow (Ref. 1910, pp. 284, 359; 1933, pp. 91-2) the Witch Craig-Raven Craig-Whitelaw sill 1¼ miles E. of Torphichen (Ref. 1910, p. 285); the West Bangour sill 1½ miles W. of Uphall (Ref. 1910, p. 283); the Dechmont sills 2 miles W.S.W. of Uphall (Ref. 1910, p. 283); the Craigton sill 1 mile E. by S. of Philpstoun (Ref. 1910, p. 283); and the Hound Point sill at Dalmeny (Ref. 1923b, p. 368). A sill of exceptionally fine grain forms Binny Craig, 1¼ miles N.W. of Uphall (Ref. 1928d, p. 74).

Most of the Blackridge sill is in Lanarkshire, but in the past it has been wrought in West Lothian at West Craigs No. 1 Quarry, a few hundred yards E. of Blackridge and just N. of the Barbauchlaw Burn (Ref. 1923, p. 117), and at Redburn Quarry ¼ mile W.S.W. of Blackridge.

The Avonbridge sill has been intensively quarried, especially at the north end where, from W. – E., there are the following disused quarries: Craigend (Ref. 1923, p. 116); Craigbank; Linnhouse, Blackcraig, Muckraw and Craigengall. Craigend and Craigbank quarries are in Stirlingshire, just over the county boundary. Gowanbank Quarries, about 1¼ miles S.S.E. of Avonbridge, are believed to be still active. Further south other disused quarries are Newhouse and Drumbowie (Ref. 1923, p. 116), respectively 1½ miles N.W. and 2 miles W.N.W. of Armadale. There are one or two small quarries (e.g. Ogleface) at the south end of the sill, N.E. of Blackridge.

In the Torphichen sill there are disused quarries at Broompark ½ mile W. 10º S. of Torphichen; near Slackend just S. of Torphichen; on Craigend Hill ¾ mile N. of Torphichen; and about ½ mile E. of Carribber. None of these appears to have been worked on a large scale.

In the Carriber sill there are three disused quarries N.E. of Easter Carribber wrought mainly at the end of the 19th and the beginning of the 20th centuries (e.g. Blawshenny and Bellside).

In the Kettlestoun Hill-Cockleroy sill there are three old quarries at the N. end near the Union Canal. From W. – E. they are Avontoun, Kettlestoun and Braehead. Kettlestoun Quarry is at present being re-opened.

In the Witch Craig-Raven Craig-Whitelaw sill there are a few small old quarries of which the names and history are unknown.

The West Bangour sill has been worked in a small way at the south end, in Bangour Quarry and West Bangour Quarry, respectively NE. and S.W. of West Bangour.

The Dechmont sills have also been worked on a small scale at the north end (Dechmont or Rockview Quarry in the larger sill) and near the south end (both sills).

At the W. side of the Craigton sill there is the important Craigton Hill Quarry, $^{7}/_{8}$ mile E. 5º S. of Philpstoun, which is over 45 years old and still in operation.

The Binny Craig stone seems to have been little quarried; it is fresh and fine-grained (largely of basaltic texture) is characterised by a strong development of irregular minor joints and emits a bituminous odour when freshly broken (Ref. 1928d, p. 75).

In West Lothian quartz-dolerite dykes have been worked at Westfield and Langcraig Quarries, respectively 1½ miles W.S.W. and ½ mile E.S.E. of Torphichen, and at Parkly Craigs Quarry, Kildimmery Quarry, Nancy Hill Quarry, and Ochiltree Mill Quarry which are respectively ¾ mile S. 30º E., 1¼ miles E. 30º S., 1½ miles E. 25º S. and 2½ miles S. 40º E. of Linlithgow Station (Ref. 1923, p. 117; 1933, pp. 89, 93). Kildimmery Quarry has been active from 1925 to the present day. Parkly Craigs Quarry has not been worked during the present century. Langcraig, Nancy Hill and Ochiltree Mill Quarries were in operation at the close of last century and during the first 25 or 30 years of the 20th century. Westfield Quarry was active intermittently from 1910 till about 1925.

(2) Midlothian. In this county there are two large quartz-dolerite sills, the Ratho sill 2 miles S. of Kirkliston (Ref. 1910, p. 360) and the Cramond Bridge sill just W. of Cramond Bridge, both of which have been intensively quarried for roadmetal, setts and kerbs. The workings in the Ratho sill are in its northern half, while the main quarries in the Cramond Bridge are in its southern portion. The working quarries have already been mentioned.

In the Cramond Bridge Sill West Craigs Quarry, 1½ miles S. of Cramond Bridge, was active from 1928 to 1934.

Quartz-dolerite dykes are not at present quarried in Midlothian. There are, in fact, very few in the county. One dyke has been worked in a small way in the past in 2 quarries respectively 1 mile N.N.W. and 1¼ miles E. 15° N. of Mid Calder. Recently attention has been drawn to another dyke, 2 miles W.N.W. of Balerno, which has so far been quarried only on a small scale. It is close to road and rail communications and is exposed for some distance in small crags free of overburden (Ref. 1942b, p. 298).

In Midlothian there are three sills of olivine-tholeiite in the district around Kirknewton. These are the large Dalmahoy sill W. of Balerno, the smaller Selms sill, 1 mile S.E. of Mid Calder, and the still smaller Kirknewton sill, just W. of Kirknewton. The Dalmahoy sill has long been an important source of roadmetal, setts and kerbs, (Ref. 1910, pp. 359-60; 1927a; 1929, p. 20; 1935, pp. 115-16; 1936, p. 72; 1942b, p. 298). Kaimes Quarry, at present still active, has already been mentioned. Work on a large scale was formerly carried on in this sill at Ravelrig Quarry (Ref. 1910, p. 360; 1929, p. 20; 1935, pp. 115-16), Ravelrig New Quarry (1 mile N.W. of Balerno) and Hannahfield Quarry (¾ mile W. 10º N. of Balerno) at various dates during the present century and earlier. Shales (Sheds) Quarry,1¼ miles W. 20º N. of Balerno (Ref. 1927a, p. 490) was in operation in the 19th century. Sometime before 1900 the Selms sill was worked on a large scale at Gowanbrae Quarry, at the north end of the outcrop, while in the Kirknewton sill the central prominence was once wrought at Hallcraigs Quarry (Ref. 1927a, p. 494).

(3) East Lothian. In this county quartz-dolerite is represented only by one or two dykes. In one of these Grange Quarry, on the coast 2 miles E.N.E. of Musselburgh, is at present producing roadmetal (Ref. 1942b, p. 298). This dyke can be traced inland for 5 miles in a direction E. 10º - 15º N. and in the past it has been worked in a quarry near Seton West Mains (Ref. 1910a, p. 200) and in two quarries respectively ½ mile S. and ¾ mile E.S.E. of Longniddry. A parallel quartz-dolerite dyke a mile to the north has been quarried at Spittal, 2 miles from the coast. At one time roadstone, said to be of excellent quality for surface and wearing properties, was obtained from Millstone Neuk Quarry, in a dyke 2 miles E. 15º S. of Dunbar. Quarrying was only possible, however, at low-water spring tides (Ref. 1910a, p. 200).

II. 8c. Whinstone used as Building Stone

In the past whinstone, including both greywacke and igneous rock, has been used for building purposes in the Lothians.

No precise data have been obtained regarding the use of greywacke in the very sparsely inhabited parts of Mid and East Lothian where Ordovician and Silurian rocks occur. Throughout the Southern Uplands generally, however, this stone has been widely used for building purposes where sandstone is not available (Ref. 1899, p. 652).

In West Lothian quartz-dolerite has been used to a small extent for house-building near important roadstone quarries (e.g. at Blackridge).

In Midlothian the quarrying of igneous rocks for building purposes is practically unknown, unless we include the modern use of concrete to make 'bricks' and blocks (unfaced or faced with artificial stone), paving-slabs, fencing posts etc. (Ref. 1940, p. 28). Greywacke from Hazelbank roadmetal quarry, andesite from Blackford Hill roadmetal quarry and basalt from Torphin roadmetal quarry are all used for concrete work at the present day. Sand for facing the artificial stone has been got from sandstone quarries at Levenseat near Fauldhouse, Craigmillar in Edinburgh, Lillyburn 2 miles S.E. of Penicuik (Ref. 1940, pp. 29-30) etc. Some fluvio-glacial sands are also used for this purpose.

In East Lothian igneous rocks have, in the past, been used to a considerable extent for local building purposes. Thus the trachyte lavas of Craigs Quarry, just W. of Dirleton (Ref. 1910a, pp. 197, 200) and of Rattlebags Quarry, 1¼ miles S.S.E. of Dirleton provide good building stone. The Craigs rock has numerous large pale coloured feldspars set in a pinkish grey groundmass. The older part of Haddington is largely built of porphyritic trachyte from Peppercraig Quarry, ½ mile N.W. of the town (Ref. 1910a, p. 197). The rock varies in colour from purplish to brownish grey and the numerous large porphyritic feldspars may be either white or pale to dark green. The hard yellowish brown trachytic 'tuff' of the old Abbey Quarries, on the north of the Haddington – East Linton road about 1 mile from Haddington, were once used extensively for local walls and buildings. The phonolite of Law Quarry, on

the S.W. side of North Berwick Law, has long been quarried as a building stone. Much of North Berwick was built of this rock, which has a rich reddish-brown colour (Ref. 1910a, p. 197). Trachybasalt lavas (mugearites) have been quarried at Lawhead (1½ miles S. of Whitekirk), at Waughton (2 miles W.S.W. of Whitekirk), at West Fortune (1 mile E. 10º S. of Drem), at Brownrigg (3 miles E. 15º N. of Drem) and at Smiley Knowes (on the western outskirts of North Berwick). The rocks of Lawhead and Waughton were mainly used for building purposes. The other quarries may possibly have been opened for roadmetal long ago. Porphyritic olivine-basalt lavas have been used for building purposes in East Linton and Dunbar (Markle and Bog Quarries near East Linton). There are other old quarries in porphyritic basalt lava at Kippielaw (1 mile S.S.W. of East Linton), White Park (near Whitekirk and Kingston) (2 miles E. 30º S. of Dirleton). It is known that the White Park rock was mainly wrought for building purposes.

II. 8d. Igneous Rock used as slabs for Oven Soles

An interesting and unusual local industry has long been carried on at Rusha Quarry, in the Blackburn picrite-teschenite sill 3 miles S. 20º E. of Blackburn in West Lothian (Ref. 1910, p. 359). Here for over 100 years, up to about 1937, 'lakestone' or 'leckstone' (picrite) was quarried for making the soles of bakers' ovens. The quarry is now flooded, and not likely to reopen.

Picrite is a dark 'basic' igneous rock formed by the concentration of ferromagnesium minerals. Its suitability for oven soles lies in its unusually low conductive power for heat. At Rusha Quarry a layer of teschenite overlies the picrite (Ref. 1910, pp. 28-81, 299-301). This picrite is very liable to crumble when exposed to the weather. After quarrying the stone has therefore to be buried with ashes and covered with wet sacks.

About 30 stones, 8 inches thick, go to make up an oven sole of 80 to 100 sq. ft., which, with care, is said to last for about 100 years. About the beginning of the present century the usual annual output from Rusha was 20 to 30 soles. The use of 'lakestone' for soles fell off after the introduction of the drawplate oven, but there is still a small demand. The Rusha 'lakestone' has provided soles for bakers' ovens in all districts of Scotland and also in parts of England and Ireland.

Blackburn Mains Quarry, in the same sill about ½ mile S.S.E. of Blackburn, also produced oven soles from before 1899 up till about 1913. The 'lakestone' of this quarry was a much harder stone than that of Rusha.

For the above technical details the author is indebted to Mr. T. Brash of West Calder.

Picrite underlies teschenite in Barnton Quarry in the Corstorphine Hill sill but is there left unworked (1910, p. 279; 1936, pp. 65, 66; 1942b, p. 299).

II. 9. Sand and Gravel

Deposits of sand and gravel are found throughout the Lothians (Fig. 2) but they are mostly restricted to a coastal belt, largely of marine origin (Raised Beaches), and to several inland belts (fluvioglacial deposits).

Coastal sands and gravels of marine origin, locally associated with brick-clays, form the raised beach deposits that fringe the shores of the Firth of Forth from Bo'ness in West Lothian to the neighbourhood of Aberlady, in East Lothian, and less continuously to Dunbar (Ref. 1910, pp. 335-6; 1910a, pp. 181-4; 1913, pp. 112-9, 1933, pp. 103-7). Raised beach deposits extend inland for 1 to 1½ miles between Leith and Musselburgh and up the valley of the Esk to Dalkeith, some 3½ miles from the sea. The light soil of the raised beach sands forms valuable agricultural land, used, for example, for market gardening at Prestonpans, in Midlothian. A coastal spread of fluvio-glacial sands and gravels, from ½ mile to 2 miles in width, extends from the neighbourhood of Dunbar, in East Lothian, south-eastwards to near Oldhamstocks and Cockburnspath; here also the agricultural value of the soil is fully exploited (Ref. 1910a, p. 176, and Map, Plate VII; 1943a, p. 16).

Wind-blow sand overlies coastal raised beach deposits locally in East Lothian as at Musselburgh, Gosford Bay (between Longniddry and Aberlady) and Gullane, and E. of Whitekirk. Many of these tracts have determined the sites of well-known golf-courses, and thus have a very specialised kind of economic value. Local drifting of sand has been in progress quite recently and has led to the overwhelming of a small stretch of pine wood N.W. of Dirleton.

Inland belts of fluvio-glacial origin form the main source of sand and gravel used in industry. In West Lothian the most extensive belt lies between Linlithgow and the neighbourhood of Blackness, and forms the eastern end of the Falkirk-Polmont-Linlithgow belt, (Ref. 1933, pp. 102-3; 1943a, p. 13). There are less extensive deposits immediately W. and S. of Bathgate and 2½ miles N.W. of that town (Ref. 1923, p. 119; 1943a, p. 14). In Midlothian, W. of the Pentland Hills, there are only a few small scattered deposits, e.g. at Livingstone (Ref. 1943a, p. 14); at localities 2½ miles W. and S.W. of Balerno; and at Gogar, 1½ miles W.S.W. of Corstorphine. The main belt, which lies E. of the Pentland Hills, stretches from the neighbourhood of Penicuik in a N.E. direction to Dalkeith, with an easterly off-shoot extending from Auchendinny to Carrington. The north-easterly belt is the source of by far the largest proportion of the sand and gravel produced in the Lothians (Table IV). Further south and east there are extensive deposits, south of Temple and around Borthwick (Ref. 1910, pp. 331-2; 1942b, pp. 312-13, and map, fig. 1; 1943a, pp. 14-16 and map Fig. 1). In East Lothian a somewhat discontinuous belt forms an extension of the Borthwick deposits for 17 miles in a direction about E. 30º N., past Humbie, south of Gifford and on to Garvald and Stenton (Ref. 1910a, pp. 174-5 and map, Plate VII; 1943a, p. 16). /There are also other deposits: one area near the valley of the Tyne Water between Pathhead and Ormiston, and another extending across-country from Aberlady eastwards to the mouth of the Tyne Water and East Linton.

The bulk of the Lothians' sand and gravel deposits consists of sand, the gravel occurring as intercalated lenticular layers. The sand of the fluvioglacial deposits is seldom quite free from coaly fragments, often concentrated in certain layers, but details of local characteristics are at present known only in the case of pits (quarries) now working or recently active (Ref. 1943a, pp. 13-16). There is available, however, in the Geological Survey Office in Edinburgh a large suite of samples of sand and gravels from all over Scotland.

The Lothians' deposits will be described in detail in forthcoming 'Parts' of 'Wartime Pamphlet No. 30: The Sands and Gravels of Scotland', to be issued shortly by the Geological Survey. Those of West Lothian will be dealt with mainly in the Part concerned with Quarter-inch-to-mile Sheet 14 of the Geological Map of Scotland, while those of Mid and East Lothian will be described in the Part with Quarter-inch Sheet 15.

A general account of Scottish sands and gravels, indicating their origin, form, characteristics and distribution has recently been published for the Institute of Quarrying (1943a). This small book, written by Dr. J. G. C. Anderson of H.M. Geological Survey, brings together a series of articles which has appeared previously (1940a) and contains up-to-date information about sandpits now working in the Lothians.

TABLE IV
SAND AND GRAVEL OUTPUT IN THE LOTHIANS 1900-1937

County	Tonnage and Number of Working Sand-pits (SP)									
	1900		1910		1920		1928		1937	
	Tons	SP	Tons	SP	Tons	SP	Tons	SP	Tons	SP
West Lothian	10287	1	7727	1	11453	1	5576	2	14658	2
Midlothian	8130	2	23229	4	45876	3	41119	8	156091	13
East Lothian	0	0	0	0	0	0	0	0	1015	1
Total Tonnage Total No. of Sand Pits	18417	3	30956	8	57329	4	46695	10	171764	16

The statistics given in Table IV indicate clearly the enormous increase in the demand for Midlothian sand and gravel since the beginning of the century. The demand at various dates has been controlled almost entirely by the needs of the building trade. Thus the high figures for 1920 and 1928 correspond closely to the peaks of housing booms. Between these dates there was a somewhat fluctuating output with a minimum of 18,301 tons in 1923 and a maximum of 60,836 tons in 1924. After falling to 34,491 tons in 1929 the output shows a continuous annual increase of some thousands of tons.

In West Lothian, with more restricted resources and a much smaller potential local demand, output in 1921 (14,323 tons) was almost as high as in 1937. From 1921 to 1935 it fluctuated between 5,000 tons and 11,500 tons. From 1935 to 1937 there was an annual increase of one or two thousand tons per year.

The practically negligible output in East Lothian, so far as can be judged before the deposits are examined in detail, is most probably due not to lack of suitable resources, but to comparative difficulty of access and distance from large centres of demand.

In the Lothians, in recent years, there have been about 23 pits (quarries) working sand or gravel. Of these 4 are in West Lothian, 15 in Midlothian and 4 in East Lothian. The workings in fluvio-glacial deposits, 22 in number, are situated as follows: in West Lothian at Linlithgow Bridge (Ref. 1943a, p. 13), at Baron's Hill Pit ½ mile E.N.E. of Linlithgow Palace, at Balbardie Pit, Bathgate, S. of the railway about ½ mile E. of the town (Ref. 1943a, p. 14), and at Coustoun Pit about 2½ miles N.W. of Bathgate; in Midlothian in the Penicuik-Dalkeith belt, at John St. and Kirkhill Rd. Pits, Penicuik (Ref. 1943a, p. 16), at Oatslie, Roslin No. 2 and Bilston Pits near Roslin (Ref. 1943a, pp. 15-16) at Burghlee Pit Loanhead (Ref. 1943a, p. 14), at Clippens Pit near Straiton, at Melville No. 2, Melville No. 3, Wester Melville and Eskbank Pits near Lasswade (Ref. 1943a, p. 14); just E. of the Penicuik-Dalkeith belt at Hawthornden and Parkneuk Pits near Rosewell (Ref. 1943a, p. 14); and further east at Borthwick Bank Pit in the Borthwick deposits S.E. of Gorebridge (Ref. 1943a, p. 16); in East Lothian in the Borthwick-Stenton belt at Humbie, Keith Marischal and Windy Mains Pits about 4 miles S.E. of Orimiston (Ref. 1943a, p. 16), and at Lammerlaw Pit, Blinkbonny Wood, S. of Gifford. The only places where sand of marine origin is at present worked is in the 100-ft. Raised Beach, at New Hailes Pit, near Musselburgh.

The sand and gravel are used almost entirely in the building trade (building-sand, plaster-sand, and sand or gravel for concrete work). Sand is the main product, comparatively few pits providing gravel in any considerable quantity. 'Sand-bricks' were at one time made from fluvio-glacial sand at Bathgate and possibly elsewhere but it is believed that their manufacture is discontinued (Ref. 1910, p. 350). Loam sand from New Hailes Pit, Musselburgh is used for moulding purposes.

Reserves of fluvio-glacial sand and gravel in the Lothians are very large.

II. 10. Mineral Veins

At the present day the few mineral veins known in the Lothians are believed to have no economic value. In the past, two veins, containing ores of silver and iron respectively, have been productive.

Hilderstone Silver Mine, in West Lothian 3½ miles S. of Linlithgow, was worked in the time of James VI, at the beginning of the 17th century. The primary ores in the vein were galena

and niccolite, the secondary ores annabergite, erithrine fit from the mine was estimated at £500 sterling per month. In 1608 the mine was taken over by the state. The workings were reopened and explored in 1870-73, when it was found that practically all available ore had been removed. The vein is said to have consisted locally of 6 ft. of barytes. In 1915 good quality white to pink barytes was seen on the old dumps (Ref. 1921, pp. 61-2; 1925, Chapter XXX).

Garleton Haematite Mine, in East Lothian about 1½ miles N.N.W. of Haddington, was last worked from 1873-1876. In 1874 10,283 tons of brown haematite were produced. The vein, which has been traced for about 300 yds., was found to be irregular in thickness (about 3 ft., swelling to 5 or 6 ft. locally) and to pinch out northwards. At 280 ft. from the surface the ore was nowhere of workable thickness. At the south end, when working stopped, no ore was found in the upper levels and, at 200 to 260 ft., from the surface, only 20 inches of haematite (Ref. 1920, p. 212).

In West Lothian galena has been recorded in a vein in the old Burdiehouse Limestone Mine at Port Edgar (Ref. 1925, p. 359).

In Midlothian copper ore was mined at Currie, 5 miles S.W. of Edinburgh, about the year 1683, but the site of the mine is unknown (Ref. 1921, p. 131). The site of a reputed lead mine near Malleny Hill, Balerno, is also unknown (Ref. 1921, p. 64). Veins of barytes somewhere in the Pentland Hills lavas (of Lower Old Red Sandstone age) in the Parish of Glencorse were at one time wrought in the expectation of finding copper or silver (Ref. 1845, p. 312).

In East Lothian, near the Faseny Water, W. of Priestlaw (8 miles S.E. of Garvald) trials for copper ore were made about the beginning of the 19th century on veins said to contain barytes and green carbonate of copper (Ref. 1898, p. 53; 1989a, p. 60).

Scattered crystals of galena have been recorded in a vein in the limestone quarry at Catcraig, at the E. end of White Sands 2 miles E.S.E. of Dunbar, and in little strings in the quartz-dolerite dyke formerly quarried for roadstone at Millstone Neuk Quarry on the foreshore just N.W. of White Sands. Neither occurrence is regarded as of economic value (Ref. 1910a, p. 195).

III. PEAT AND ASSOCIATED DEPOSITS

III. 1. Peat

A general account of Scottish peat deposits, written by Dr. D.K. Fraser of the Macaulay Institute for Soil Research, has recently been published by the Geological Survey, as Part I of Wartime Pamphlet No. 36 (Ref. 1943d). Forthcoming Parts of this Pamphlet are to deal with local details of the peat mosses of various Scottish districts.

Dr. Fraser's monograph deals very fully with the origin, characteristics, classification and physical and physio-chemical properties of peat, and with its working, processing and utilisation.

Thick peat covers considerable areas in West Lothian near Fauldhouse; in Midlothian near Cobbinshaw Reservoir and Leadburn, and at Blackhope Scar and Ladyside Height in the Moorfoot Hills; and in East Lothian near Willies' Law and Meikle Says Law in the Lammermuir Hills.

Peat has been worked on a commercial scale only in West Lothian, near Fauldhouse and Crofthead (Ref. 1923, pp. 120-21) and in two comparatively small peat mosses respectively 2 miles S. and S.E. of Bathgate. The deposits exploited consist of 'basin type' peat in the raised moss stage of development. Only the upper Sphagnum layer is cut, the lower fuel peat being left. The cutting requires skilled hand labour, but after drying out the peats are shredded by machinery.

In the commercial exploitation of peat good means of access, railway facilities and proximity to markets are important controlling factors. At the present day the only workings are at Fauldhouse and Crofthead, and at Easter Inch Moss 2 miles S.E. of Bathgate.

One of the main uses of Lothians peat is as moss litter for stables, byres, etc. The absorbing powers of peat are so much higher than those of straw that the nutrient value of moss litter manure is much higher than that of straw manure. Peat, as opposed to moss litter manure, is also of value as an organic ameliorant for hot-house and horticultural soils and is finding increasing use for such purposes. Other uses of peat are as a source of peat mull employed as a filler for molasses in castle feed, as raw material for the manufacture of millboard etc., as a

filtering medium, and (in conjunction with bog iron ore) as a scrubber in the purification of heating and illuminating gas (cf. Ref. 1943d, pp. 30-44). In addition large quantities of Sphagnum peat are now used in the manufacture of magnesium (Ref. 1943d, p. 43; 1943e, p. 692).

Hill peat has not so far found a use in the Lothians, except of course locally as domestic fuel in isolated dwellings. Midlothian hill peat has however recently been sampled and tested as a source of ester waxes for use as a substitute for the harder Montan wax extracted from lignites in Saxony and Thuringia (cf. Ref. 1943d, pp. 44, 48).

III. 2. Associated Deposits: Shell Marl and Diatomite

Peat is often associated on old lake sites with beds of sand, silt, clay and shell marl. Less often it covered a deposit of diatomite (Ref. 1943d, Fig. 2c, p. 53). The total thickness of such deposits may be as much as 40 or 50 ft. even in the case of quite small lakes. Knowledge of the nature and thickness of deposits that are to be expected below flat ground occupying hollows in glaciated country is obviously of importance to those contemplating the erection of buildings on such sites.

Lake clays have already been dealt with under Section II, 5d, where their use for brick- and tile-manufacture has been mentioned. Lake deposits may also provide a convenient local source of ‘puddle-clay’ for use in the construction of reservoir dams.

Shell Marl. Shell marl, in some places up to 20 ft. in thickness, is known to be present in several of the vanished lakes of Edinburgh, for example Corstorphine Loch, The Burgh Loch (now ‘The Meadows’) and Holyrood Loch (Ref. 1864, pp. 124-136; 1910, pp. 332-3; 1913, Chapter VIII and Map; 1934a, p. 110).

In areas where limestone is not readily available shell marl of similar origin is a valuable source of lime for agricultural purposes.

Diatomite. A deposit of diatomite of small extent and of a maximum thickness of about 14 inches was discovered in 1925 at the edge of a peat-covered marshy flat just S. of Dalmahoy

Hill, W. of Balerno, Midlothian. Although the deposit is of great purity it was regarded by its discoverer as too small to be of economic value (Ref. 1928e, p. 1975; 1940b, p. 10).

Diatomite is an extremely fine-grained white deposit consisting essentially of the siliceous skeletons of microscopic algae (plants) known as diatoms. It is used as a filtering agent, as an absorbent, as a heat- and sound-insulator, as a mild abrasive in metal polishes, and for other purposes. Diatomite deposits have been worked in Skye and Aberdeenshire (Ref. 1940b).

IV. WATER SUPPLY

Water, like oil and natural gas, is one of the mobile mineral resources of the Lothians. This account of its distribution is concerned almost entirely with the possibilities of obtaining supplies of underground water by sinking wells or boreholes. Surface water in rivers, lakes and reservoirs is mentioned only incidentally.

IV. 1. General Principles

A rock is said to be pervious or permeable if it contains pore-spaces and/or fissures large enough to permit the passage of water under normal hydrostatic pressures. A substance such as clay may be porous, and so able to absorb water, but it is not pervious because its pore-spaces are so minute that capillary forces prevent the passage of water through it.

Rain water which sinks into the ground penetrates downwards in the rocks of the earth's crust until it reaches a stratum impervious because of its nature (e.g. a bed of clay) or in the simpler and more generalised case of homogeneous pervious rocks, until it reaches a zone rendered impervious by the closing of its pores and fissures owing to increased pressure. Above the watertight zone water accumulates in rock pores and fissures. Owing to leakage caused by the outflow of springs and by evaporation, the upper limit of the saturated zone which, with sufficient accuracy for our present purpose, may be regarded as the 'water table' does not normally reach the surface of the ground. The 'water table', in spite of its name, is an undulating water surface liable to seasonal oscillation. It is often at or near ground level in the bottom of valleys, is farthest from ground level below the crests of intervening ridges, and falls or rises in response to drought or heavy rainfall. In order to obtain a permanent supply of

water, a well or bore-hole must therefore penetrate some way below the local level of the 'water table' in times of drought.

In a series of alternating pervious and impervious beds, such as is exemplified by the Carboniferous rocks of the Lothians, water held up above impervious beds is often encountered at successive levels in bores. Water accumulating from a lateral source below an impervious stratum may eventually be trapped under hydrostatic pressure. Such confined water, when tapped by a bore, may give rise to a true artesian well, that is to say a well from which water under hydrostatic pressure flows out naturally at ground level. Several true artesian wells are known in the Lothians.

Examples of impervious rocks are:-

(1) Unfissured compact igneous rocks, strongly cemented sandstones, and limestones (non-porous, and impervious because of absence of fissures).
(2) Clay, soft marl, mudstone, blaes and shale (porous, but impervious because of the minuteness of their pores).

Examples of pervious rocks are:-

(1) Fissured compact igneous rocks, strongly cemented sandstone, limestone and hard sandy marl (non-porous, but pervious in varying degree because of fissuring).
(2) Unconsolidated sands and gravels, and incompletely cemented sandstones (porous, and pervious because their pore-spaces are not too minute).

In the Lothians the best water-yielding rocks are thus unconsolidated sands and gravels (particularly those of fluvio-glacial origin) and incompletely cemented sandstones of the Upper Old Red Sandstone formation and of parts of the Carboniferous succession (e.g. Coal Measures, Millstone Grit, and Upper Limestone Group). The sandstones yield water from fissures as well as from the pore-spaces between constituent grains and provide far greater quantities of water than the sands and gravels. This is because the fluvio-glacial sands and gravels have a much more limited storage capacity and are rapidly drained by springs which flow out over the surface of the impervious boulder clay on which they usually rest. It is almost entirely by controlling such springs that the water stored in the sands and gravels is

made available for use. The fissures referred to in the sandstones may be due to the presence of bedding planes, joints or fault-zones.

Layers of clay which may be encountered in sinking wells or bores in alluvial deposits of marine or freshwater origin, and beds of marl etc. in the Upper Old Red Sandstone and Carboniferous formations, either do not yield water at all or yield it only very slowly indeed. Parts of the Carboniferous succession which locally contain a high proportion of fireclay, mudstone, soft marl, marly blaes, or blaes, therefore yield comparatively little water to bores (e.g. Cementstone Group), and may prevent much water from reaching underlying pervious beds.

The yield of all other types of rock found in the Lothians is almost entirely dependent on the number and size of their fissures. The yield is usually found to be too small for practical purposes. Water should therefore not be sought for by boring in compact igneous rocks or in the strongly cemented Ordovician and Silurian greywackes of the Southern Uplands, with their intercalated shales and mudstones, unless in some local zone known to be very highly fissured.

Certain types of igneous rock may be somewhat even when unfissured. Thus the slaggy decomposed upper surfaces of successive lava flows may give rise to a series of layers in a volcanic sequence which are more or less pervious owing to their porosity. Again more or less pervious layers in a volcanic sequence may be produced by the presence of intercalated poorly cemented tuffs (volcanic ashes) which are classed by geologists as ‘pyroclastic igneous rocks’. At Calton Hill, Edinburgh, water is obtained from a Carboniferous volcanic sequence embodying more or less pervious layers of these kinds.

The prospects of obtaining water by boring are also influenced profoundly by the local geological structure (e.g. by the inclination of the strata, by the presence or absence of faults and igneous dykes which may hold up circulating water, and by the presence or absence of superficial boulder clay.) These complications cannot be considered here (see 1944a, Chapter VI).

In assessing the prospects of a bore at a particular site it is very helpful to have data regarding the depth and yield of existing wells and bores in the neighbourhood, of the seasonal

variation of standing water level, the draw-down to pumping water level, etc. Data of this kind, combined with geological information and referring to the greater part of the Lothians, are to be found in Wartime Pamphlet No. 28, Parts II and III, issued by the Geological Survey for limited circulation but not for sale (1942a; 1943).

The depth of water bores in the Lothians has rarely exceeded 600 ft. Bores in Carboniferous rocks that penetrate to depths greater than 1500 ft. have tapped saline water, even though situated far from the sea. It is therefore inadvisable to sink a water bore in the Lothians to a depth greater than about 1200 ft.

IV. 2. Notes on the Hydrology of the Rocks of the Lothians

Hill Peat. The hill peat that covers considerable areas of the high ground formed by the Pentland and Moorfoot-Lammermuir Hills absorbs a considerable proportion of the local rainfall and gives it up again very slowly. Hydrologically it is of importance only as a factor in preventing too rapid a run-off of the rainfall.

Sand and Gravel. Fluvio-glacial sands and gravels are mainly of importance as sources of spring water, for example in West Lothian at Linlithgow, in Midlothian at Comiston (Edinburgh), Lasswade, Bonnyrig and Dalkeith, and in East Lothian at West Barns near Dunbar. The yield of such springs, single or combined, ranges up to 6,000 to 90,000 gallons per day. Water from such superficial sources is naturally very liable to contamination and may have to be treated before use for drinking purposes (See also Ref. 1910, pp. 363-66; 1910a, p. 203).

In the Lothians there is little or no definite information about water from wells or bores in Raised Beach sands and gravels, but considerable quantities of water are locally obtained from these elsewhere in Scotland.

Boulder Clay. Boulder clay, even if the matrix contains more sandy than clayey material, as is often the case where it is derived from comparatively soft sandstones, yields only a small quantity of water. Except in the Upper Old Red Sandstone areas of East Lothian (between Fala and Dunbar and from Dunbar southwards to the county boundary E. of Priestlaw) and of

Midlothian (in parts of the Pentland Hills) the boulder clay of the Lothians is very tough and impervious.

Barren Red Coal Measures. These rocks are preserved in the Lothians only in two small areas of the Midlothian Coal Basin, at the west end of Musselburgh and just north of Dalkeith. The strata consist of rather coarse-grained reddish sandstones with intercalated beds of red and mottled clay and mudstone. A well and bore in these beds are known to produce a combined yield of hard water pumped at the rate of 4,000 gallons per hour.

Productive Coal Measures. In the Midlothian Basin these beds are composed largely of sandstones with numerous intercalated seams of coal and beds of fireclay and blaes. Water is abundant, especially in the higher beds. A bore in a particularly favourable situation has given the highest yield recorded in Scotland, 60,000 gallons per hour. The water is very hard.

The Productive Coal Measures are drained by pits and mines which require to pump at rates varying from 200 to 1,100 gallons per minute. This pit water is very hard.

Millstone Grit. This group is made up of gritty sandstones with subordinate beds of fireclay and blaes and occasional coal seams. It is a good water-yielding formation. Yields obtained in the Lothians have ranged from 3,600 to 6,420 gallons per hour of good quality water suitable for domestic purposes (see also Ref. 1910, p. 364; 1910a, p. 203).

Upper Limestone Group. This group contains a large proportion of sandstone associated with flakes, blaes, and some thin limestones. Although a good water-yielder the group is not on record as having been tapped by boring in the Lothians.

Some of the sandstones, however, are known to yield large quantities of hard water to the shafts of collieries. For example the Joppa Sandstone, at the base of the group, contributed 200 gallons per minute to the shaft of Lady Victoria Pit, Newbattle (Ref. 1910, p. 365).

Limestone Coal Group. The Limestone Coal Group contains less sandstone than the Upper Limestone Group and is not to be recommended as a source of underground water. No records are known of water bores sunk in this group in the Lothians, but numerous collieries working coals in this series of beds pump at rates varying from 100 to 700 gallons per

minute. The water produced is very hard and sometimes somewhat acidic. Elsewhere in Scotland the yields from water bores in these strata are comparatively small, and in some instances natural gas comes up through the water (cf. Ref. 1910, p. 364; 1910a, p. 203).

Lower Limestone Group. The Lower Limestone Group comprises thick beds of sandstone and marine limestone, along with blaes. In the Bathgate and Linlithgow Hills intercalated volcanic rocks are developed. A bore in Linlithgow about 500 ft. in depth, although it penetrated only about 30 ft. of intercalated igneous rock, gave only a small yield of irony water. In Midlothian, bores of less than 250 ft. have obtained water under artesian pressure on the west limb of the Cousland and D'Arcy anticline east of Dalkeith. On the eastern limb of this anticline a 250 ft. bore of small diameter yields 180 gallons per hour.

Calciferous Sandstone Series. Water is to be obtained in this series throughout the Lothians, but the quantity and quality vary according to group and district. (cf. Ref. 1910a, pp. 203-4).

The most successful bore on record in the series was sunk in East Lothian in 1905 to a depth of 425 ft. It started in the Lower Limestone Group on the edge of the foreshore at Catcraig Quarry, 2 miles E.S.E. of Dunbar, and when completed gave an artesian flow of 10,000 gallons per hour of good potable water. In 1907 the natural flow was about 6,000 gallons per hour; by 1931 it has fallen to 2,100 gallons per hour. The water comes from a sandstone zone about 365 ft. thick at the top of the Calciferous Sandstone Series and immediately below the Long Craig Lower Limestone and calcareous shale, which must act as an impervious confining stratum.

All data regarding yield from the Upper Oil Shale Group refer to mines or pits working oil-shale. Their rate of pumping ranges from 80 to 1,100 gallons per minute and the water is very hard. The group, as a rule, contains a high proportion of sandstone.

St. Catherine's Balm Well, a spring situated close to the Pentland Fault 1½ miles W. of Gilmerton, Midlothian, is in the Upper Oil-Shale Group. It yields a little crude oil which can be seen floating on the top of the water in the well (Ref. 1910, p. 365).

In the Lower Oil-Shale Group there are a number of bores in the Edinburgh district, where the group contains some thick sandstones. Yields range from 3,000 to almost 8,000 gallons

per hour. The water is hard and not as a rule suitable for drinking purposes. It is locally somewhat contaminated with oil (cf. Ref, 1914, p. 108).

St. Bernard's Mineral Spring, in Edinburgh, comes from the Lower Oil-Shale Group. It contains a good deal of magnesium sulphate and is reputed to yield a little crude oil occasionally (Ref. 1910, p. 365).

The rocks of the Cementstone Group of the Edinburgh district yield a hard water suitable for brewing and mainly used for this purpose. Owing to the high proportion of marly beds and the highly cemented nature of many of the intercalated ribs and bands of sandstone, yields are not high. In order to obtain yields of say, 4,000 to 7,000 gallons per hour it is, as a rule, necessary to have collecting tunnels run out from well shafts. The water probably comes mainly from fissures (cf. Ref. 1914, p. 108).

In Edinburgh some water for brewing is also derived from the lavas and tuffs of the Calton Hill Carboniferous sequence which immediately overlies the Cementstone Group (cf. Ref. 1914, p. 108).

Upper Old Red Sandstone. This formation contains a very high proportion of sandstone and is one of the best water-yielders of the Lothians. It gives water of a type very suitable for brewing and is responsible for the concentration of breweries at Craigmillar. Yields from bores, or from bores and wells combined, range from 1,800 to 13,000 gallons per hour (cf. Ref. 1910, p. 363; 1910a, pp. 203-4; 1914, pp. 107-8).

Lower Old Red Sandstone. The chief hydrological importance of this formation lies in the fact that the Pentland Hills, formed mainly of impervious lavas of Lower Old Red Sandstone age, have provided good elevated reservoir sites (Loganlee, Glencorse, Bonaly, Torduff). A small part of the water supply of Edinburgh is, however, derived directly from springs issuing from Pentland lavas (e.g. near Swanston).

Ordovician and Silurian. Boring for water in these highly folded rocks is too speculative to be a practical proposition. The terrain is in fact impervious except where fissures occur and so its valleys, like those of the Pentland Hills, provide good sites for reservoirs.

Spring water from fissures may, however, be of local importance. For instance a series of small springs along the Southern Upland fault-scarp near Broadlaw, 8½ miles, S. of Dalkeith, have in recent years been collected to provide a local water supply.

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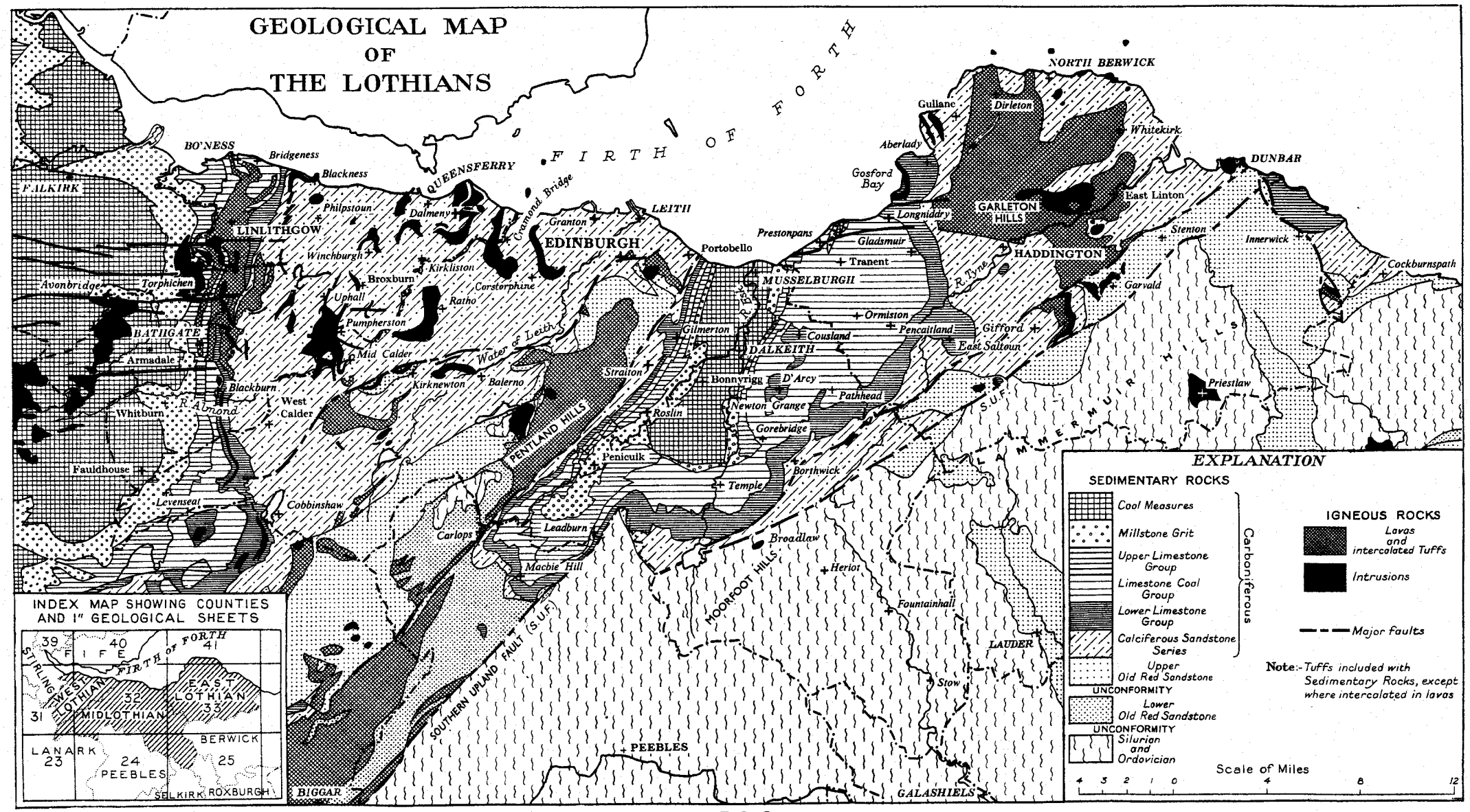
GEOLOGICAL MAP
OF
THE LOTHIANS
F I R T H O F F O R T H
NORTH BERWICK
Gullane
Dirleton
Whitekirk
Aberlady
DUNBAR
Gosford Bay
East Linton
GARLETON HILLS
Longniddry
Prestonpans
Gladsmuir
Tranent
HADDINGTON
Stenton
Innerwick
Cockburnspath
R. Tyne
Garvald
MUSSELBURGH
Ormiston
Pencaitland
Gifford
East Saltoun
Cousland
DALKEITH
Gilmerton
Priestlaw
Straiton
Bonnyrigg
D'Arcy
Pathhead
Newton
Grange
Roslin
Gorebridge
Penicuik
Borthwick
Temple
Leadburn
Carlops
Macbie Hill
Broadlaw
Heriot
Fountainhall
LAUDER
Stow
MOORFOOT HILLS
SOUTHERN UPLAND FAULT (S.U.F.)
PEEBLES
BIGGAR
GALASHIELS
PENTLAND HILLS
Portobello
LEITH
EDINBURGH
QUEENSFERRY
Cramond Bridge
Granton
Dalmeny
Philpstoun
Blackness
Bridgeness
BO'NESS
FALKIRK
LINLITHGOW
Winchburgh
Kirkliston
Broxburn
Uphall
Ratho
Corstorphine
Pumpherston
Mid Calder
Water of Leith
Kirknewton
Balerno
Avonbridge
Torphichen
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Blackburn
West Calder
Whitburn
R. Almond
Fauldhouse
Levenseat
Cobbinshaw
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Limestone Coal Group
Lower Limestone Group
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Carboniferous
Upper Old Red Sandstone
UNCONFORMITY
Lower Old Red Sandstone
UNCONFORMITY
Silurian and Ordovician
IGNEOUS ROCKS
Lavas and intercalated Tuffs
Intrusions
Major faults
Note:- Tuffs included with Sedimentary Rocks, except where intercalated in lavas
Scale of Miles
4 3 2 1 0 4 8 12

FIG. 2

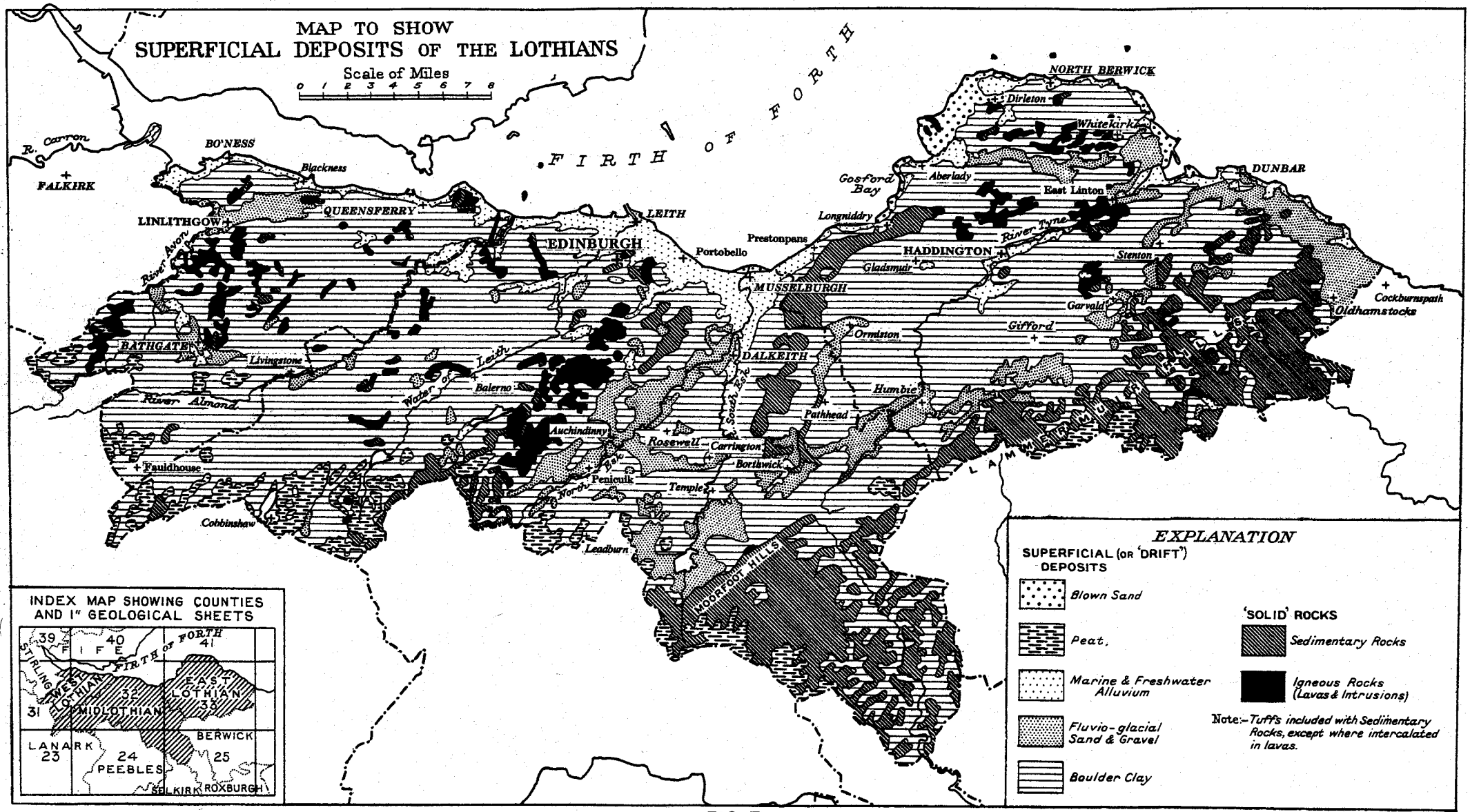

FIG. 3