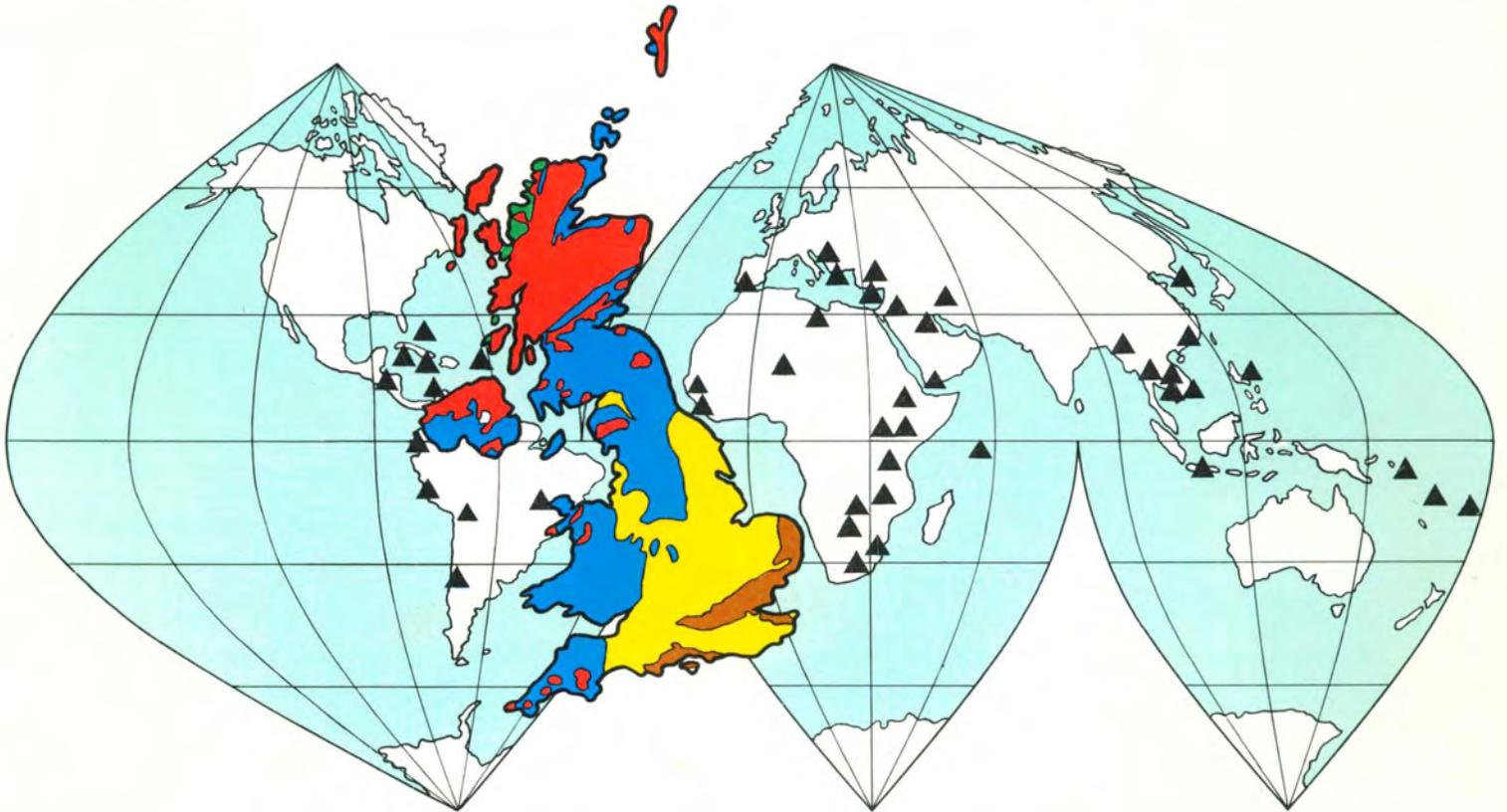


NATURAL ENVIRONMENT RESEARCH COUNCIL

INSTITUTE OF GEOLOGICAL SCIENCES

# Sand and gravel resources of the Fife Region

REPORT No. 77/5



HMSO

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M. A. E. Browne

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## Preface

The following account of the sand and gravel resources of the Fife Region has been compiled by the Institute of Geological Sciences, Edinburgh, at the request of the Scottish Development Department. It is essentially a summary of the published and unpublished records of the Institute together with other published data mentioned in the list of references at the end of the report. The information has been augmented by visits to selected areas where time has permitted. The coverage is not comprehensive, but further detailed information is available for many localities and can be consulted at the Institute's Edinburgh office, Murchison House, West Mains Road, Edinburgh EH9 3LA.

The following constraints have been adopted in compiling this report:

1. The ratio of sand and gravel to overburden is 1:1 or more.
2. The thickness of deposit is 2 m or more.
3. The deposits are classified as resources rather than reserves and may include silt, clay, till and other unsuitable materials. Tonnages, where given, are at best inferred, being based on experience rather than detailed records of boreholes and sections. The conversion factor of one cubic metre equals two tonnes has been used throughout.
4. Deposits above and below the water-table have been considered separately.
5. Such considerations as possible markets and accessibility have been ignored.
6. Land use, conservation, and amenity considerations have been given only passing mention. There are National Nature Reserves and Sites of Special Scientific Interest in the Region: information on these can be obtained from the Nature Conservancy Council, Hope Terrace, Edinburgh.
7. Resources underlying built-up areas are included. Estimated quantities of sand and gravel are given in Appendix 3. A list of working sand and gravel quarries and their localities is given in Appendix 1.

A. W. Woodland  
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1 November 1976

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# Sand and gravel resources of the Fife Region

M. A. E. BROWNE

## Introduction

### *OUTLINE OF SOLID GEOLOGY*

The oldest rocks in the Fife Region (Fig. 1) are exposed in the Ochil Hills; they consist mainly of andesite lavas and associated lava-conglomerates of Lower Old Red Sandstone age and reach a maximum thickness of 2700 m in places. The lavas are overlain by some 300 m of fluviatile sandstones in the area north-east of Cupar. In the Howe of Fife the Lower Old Red Sandstone rocks are overlain unconformably by sandstones and siltstones of Upper Old Red Sandstone age. Conglomeratic beds occur near the base of this formation and concretionary limestones are interbedded in the uppermost part of it. These predominantly fluviatile sediments total between 600 and 1200 m in thickness and are overlain with apparent conformity by at least 2700 m of Carboniferous sediments. These measures consist of sandstones, siltstones and shales which are interbedded with subordinate organic limestones, ironstones and coals. They are of mixed origin being partly fluviatile, deltaic or marine and form the bedrock over two-thirds of the Region. Contemporaneous extrusive basaltic tuffs and lavas are present in many areas (particularly in the neighbourhood of Burntisland). Intrusive basalts and dolerites occur commonly as dykes, sills and plugs. Intrusive basaltic tuffs and agglomerates also occur as infillings of volcanic pipes and necks.

### *NATURE OF THE DEPOSITS*

#### *Fluvioglacial sand and gravel*

Stratified fluvioglacial deposits constitute the major part of the sand and gravel resources of the Fife Region. These water-laid materials were deposited by meltwater streams flowing in tunnels and caves within the ice and also by streams issuing from the margins of the ice-sheet or glacier. They are commonly rather poorly-sorted when compared with more recent alluvial and beach deposits. Two types of fluvioglacial sand and gravel deposits are distinguished in this report, largely on the basis of present-day landforms. The first type is characterised by an irregular topography and commonly contains steep-sided mounds and ridges (eskers) which may be separated by low-lying, often marshy, areas. Such steep-sided landforms usually indicate deposition in close proximity to ice (ice-contact slopes), the deposits marking the sites of tunnels and caves in the ice and also river channels and lakes which formerly existed on the margins of the ice (kame-terraces). Closed depressions, often filled with peat or fine-grained lake sediments, are known as kettle-holes; these features commonly mark the sites of former ice-masses which have subsequently melted away.

The second type of deposit consists of flat-topped outwash spreads of sand and gravel, often of great

lateral extent and in some cases pitted by kettle-holes. They were probably laid down by streams which issued from the ice-margin. Behind the ice-margin they may pass into mounded sand and gravel. Farther downstream, they may pass into river terrace or deltaic deposits (in places lacustrine or marine). A common feature of these deposits is the development of a series of terraces due to the removal by erosion and subsequent redistribution of the older deposits downstream either in response to changes of relative mean sea-level or by shifting glacial streams. Mounded sand and gravel can commonly be distinguished from outwash deposits by the considerable variations in grain-size both laterally and vertically within the former and by the lower degree of sorting of the fragments as compared with the latter type.

#### *Alluvial deposits*

Alluvial deposits are commonly represented by the floodplain (overbank) and channel sediments of rivers but some of them may also be of lacustrine origin. They are commonly flat-topped or terraced outwash fluvioglacial deposits and may conceal older mounded or outwash fluvioglacial gravels in the sites of buried channels. Alluvial deposits are generally well-sorted but vary in grain-size from coarse gravel to clay. The top surface of these deposits commonly is as little as 2 m above the level of the river and as a consequence most of the resource lies below the water-table.

#### *Raised-beach deposits*

Thin deposits of well-sorted, raised-beach sands and gravels of Late-Glacial and Post-Glacial age occur extensively around the Fife coast. Typically, the raised-beach deposits are associated with a prominent former shore-line feature which marks the edge of a marine wave-cut platform. It does not follow, however, that beach sand and gravel has been deposited everywhere upon the platform and in the past the distribution of the actual deposits has not always been accurately ascertained. Thus the areas mapped as raised beach may also include deposits of marine silty clays or pre-existing materials such as boulder clay. It is also possible that some beach deposits of sand and gravel have not been distinguished because they were not associated with distinct coastline features and occur only as drapes. Locally, where beach or associated deltaic deposits accumulated in association with remnant masses of stagnant ice, kettle-holes may be present. The deltaic sediments may be terraced and commonly consist of sands and gravels which rest upon marine silty clays. On exposed coastlines the younger, Post-Glacial, raised beaches consist largely of well-sorted sand and gravel with much shelly material but in more sheltered places they are composed mainly of silts and clays.

Modern beach deposits and offshore deposits are essentially similar in nature to the Post-Glacial

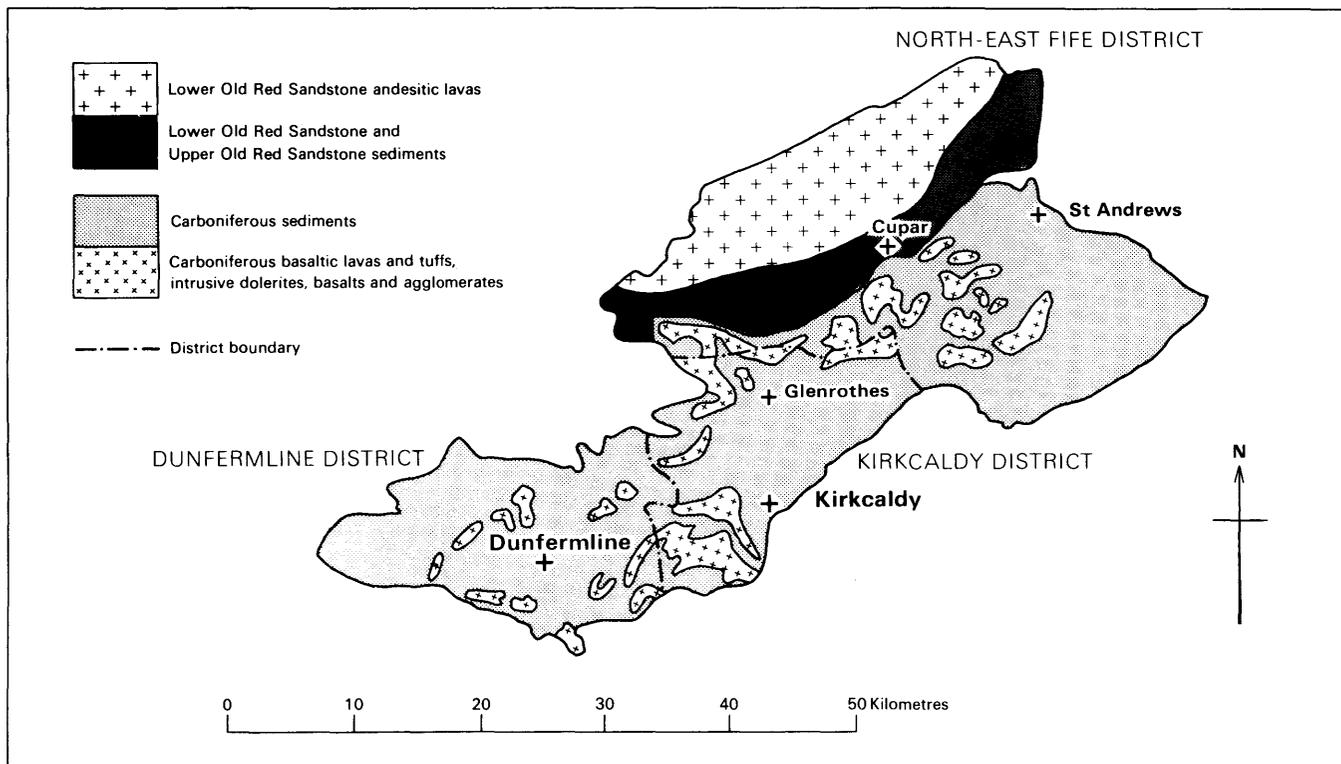


Fig. 1. The simplified solid geology of the Fife Region.

sediments but are not considered further in this account although it is possible that offshore dredging might yield significant quantities of sand and gravel.

#### *Blown sand*

Blown sand forms elongate dune-ridges on some parts of the Fife coast. These deposits generally consist of clean, fine to coarse-grained sand, commonly with some shell debris. They cover considerable areas around Lundin Links, Earlsferry and Tentsmuir.

#### *Lithology of the deposits*

The bedrock geology of the Region closely controls the composition of the sands and gravels of Fife, which, excluding the aeolian coastal dunes, are all water-sorted; as a result some of the component pebbles may have been transported for many miles from their sources: others have been locally derived from the disaggregation of conglomerates where these are the bedrock. In general the deposits of the Fife Region contain a small percentage of such Highland-derived rocks as quartzites, impure quartzites, Dalradian grits, vein-quartz and minor amounts of epidiorite and amphibolite, but locally-derived material normally constitutes the greater part. Thus in areas where Old Red Sandstone lavas form the bedrock, they may constitute more than 50 per cent of the pebble content of the gravel. Where the lavas are overlain by strata of Upper Old Red Sandstone age these sediments are generally well represented in the pebble content. In areas where Carboniferous sediments form the bedrock, the pebble content of the gravels consists chiefly (sometimes entirely) of white and brown-coloured sandstones with siltstones, ironstones and varying quantities of coal and black mudstone. Beds of sand with a high proportion of coal and mudstone pebbles

are common and, in places where the local bedrock consists of extrusive or intrusive basaltic lavas and tuffs, the drift deposits may consist almost entirely of igneous pebbles and fragments.

In general, the quality of the gravels of the Fife Region with regard to shrinkage, frost susceptibility, etc., is highest where the proportion of Highland-derived rocks is greatest (i.e. in eastern North-East Fife). The occurrence of coal and mudstone in any quantity is deleterious to the quality, and the presence of limestone or calcareous shell debris which may occur, for example, in the aeolian dune sands of the Fife coast may alter the properties of the resource. Granular rocks, such as the widely-occurring sandstones and siltstones of Fife, do not constitute high-quality materials. The presence of a large quantity of basaltic or andesitic material in the sands and gravels may cause shrinkage and frost susceptibility problems in finished concrete and it is notable that, even in the natural state, a significant percentage of the andesite lava pebbles found in the drifts of the Stratheden area are so decomposed that they crumble and disaggregate immediately after quarrying.

#### *DISTRIBUTION OF THE SANDS AND GRAVELS*

The sand and gravel resources of the Fife Region are described in three areas which correspond to the main administrative divisions (Districts) of the Region. A sketch-map showing the distribution of all the significant deposits and their nature within the three Districts is presented (Fig. 2). The three most important occurrences in two of the Districts (Kirkcaldy and North-East Fife) have also been illustrated with sketch-maps on a scale of 1 inch to 1 mile (Figs. 3, 4, 5). In the text the deposits have been treated systematically by District subdivided conveniently for ease of reference.

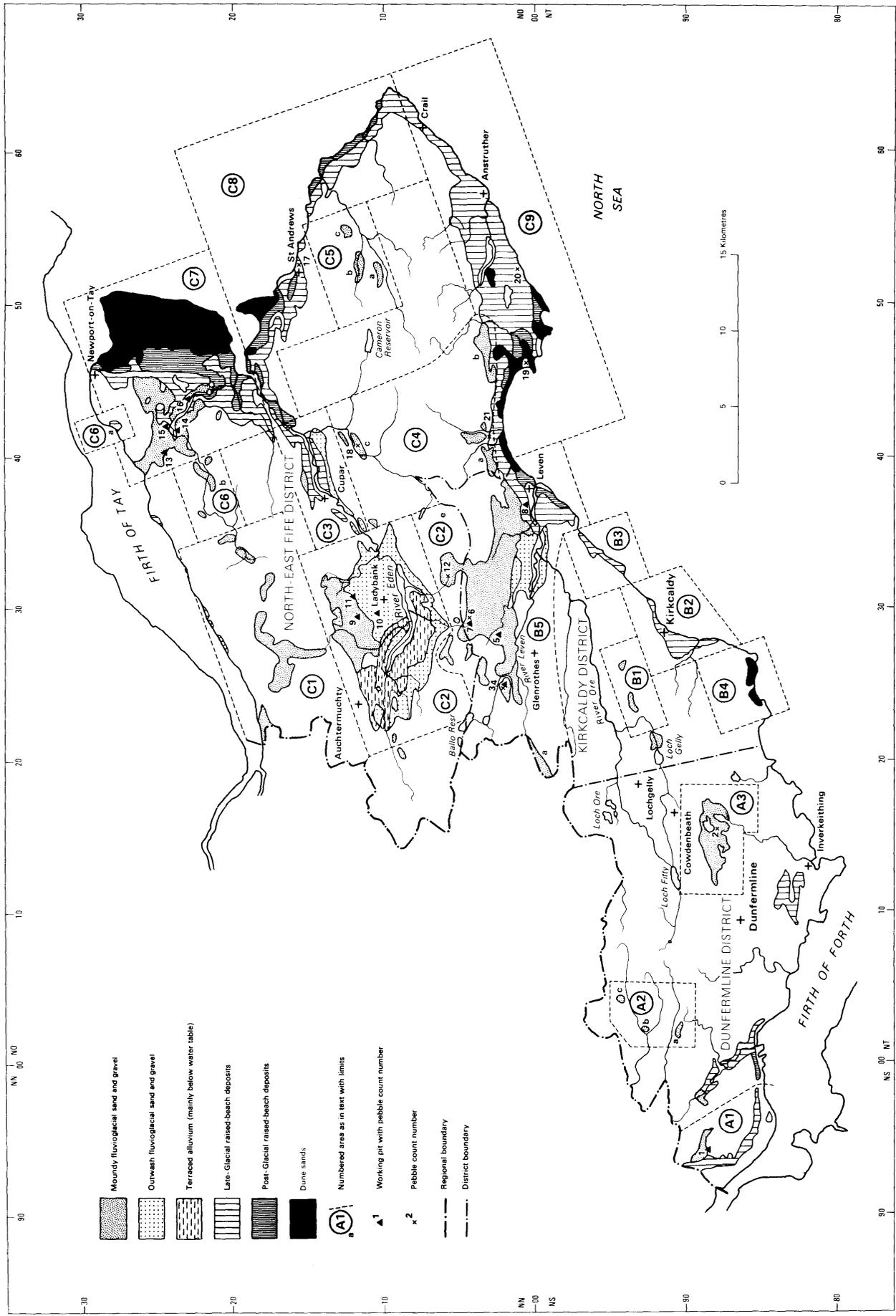


Fig. 2. Sand and gravel resources of the Fife Region

In the Dunfermline District there are no major occurrences of sands and gravels although there is one quarry at Tulliallan. The Kirkcaldy District contains one major spread of sand and gravel in the valley of the River Leven which extends from Loch Leven in the west through Leslie, Glenrothes and Markinch to Leven on the coast. These deposits are varied both in nature and lithology. In the North-East Fife District there are major occurrences of sands and gravels in the Auchtermuchty–Ladybank and the Wormit–Leuchars areas, which are of very varied natures and lithologies. Smaller areas of consequence are to be found in the Newburgh–Lindores area and along the East Fife coast where thin but extensive raised-beach deposits and dune sands are to be found.

## Dunfermline District

In the Dunfermline District there are some deposits of sand and gravel with occurrences of mounded fluvio-glacial sand and gravel in two areas (A1, A3 on Fig. 2) and with smaller fluvio-glacial mounded deposits in the central part of the District (A2 on Fig. 2).

### *AREA A1: TULLIALLAN*

An area of mounded fluvio-glacial sand and gravel occurs north-east of Kincardine-on-Forth. It has been worked by Tillicoultry Quarries Limited at Tulliallan [NS 945 895]. Sections in the pit show up to 3 m of fine to very coarse, subangular to subrounded gravel overlying at least 7.5 m of very fine to coarse-grained sand with thin pebbly sand and fine gravel beds. This uppermost gravel varies in grain-size from less than 2.5 cm up to 30 cm or more but averages around 7.5 cm and the matrix may be clayey rather than sandy in places. Thin beds (up to 45 cm) of medium gravel and coarse to medium-grained sand occur. The 7.5 m of sand beneath the upper gravel coarsens in grain-size upwards and near the top may include thick but variable beds of gravel (2.5–5.0 cm in grain-size) and cross-bedded, coarse-grained sand beds up to 30 cm thick. Cross-bedded lenticles rich in coal and shale also occur. Generally the sands are either flat-laminated or ripple-laminated. This area of mounded fluvio-glacial sand and gravel is almost worked out to the west of Peppermill Dam but further reserves may be available eastwards on the north side of the reservoir [NS 945 896]. On the basis of the exposures at Tulliallan most of the remaining resource may consist of dominantly sand-grade materials amounting to about one million tonnes. The pebble content of the gravels will be mixed, consisting chiefly of sandstones, some basaltic lavas and impure Highland quartzites (Appendix 2, No. 1).

### *AREA A2: SALINE*

Small patches of mounded fluvio-glacial sand and gravel occur in the Saline area at Blairsgreen (A2 on Fig. 2), West Balgonar (A2a on Fig. 2) and Bonnington (A2b on Fig. 2). All three areas have been exploited on a small scale in the past. At Bonnington [NT 040 948], gravel appears to dominate but at Blairsgreen [NT 020 913] and West Balgonar [NT 020 933] sand dominates. At West Balgonar up to 7.5 m of medium to fine-grained sand with some silty laminae and coal-rich lenticles were worked and at Blairsgreen some 3 m of similar sand with some gravel were proved.

### *AREA A3: CROSSGATES*

A relatively extensive area of mounded fluvio-glacial sand and gravel occurs around Crossgates [NT 145 890]. The deposits are poorly exposed and a boulder clay drumlin rises through the undulating top surface of the deposit at Cuttlehill. Extensive deposits of peat occur on the lower ground and some of the resource has already been destroyed by opencast coal-mining near Donibristle Farm [NT 164 885]. Previous accounts record the presence of old sandpits west of Crossgates and a road section was cut in a mound 3 to 6 m high east of the village. None of these exposures are now visible but at the latter locality [NT 154 888] the deposit consists of subangular to subrounded coarse gravel from 5 cm up to 15 cm in grain-size, mainly of sandstone pebbles with subordinate amounts of impure Highland quartzites and basalt lavas (Appendix 2, No. 2). Traces of shale and coal were also noted. At Cadgerford Bridge, about 1 km farther south, a poorly exposed disused pit formerly showed up to 6 m of cross-bedded fine to coarse sand with coarse gravel. The pebble content appears to resemble that at Crossgates. Borehole information in this area, whilst plentiful in quantity, is of a very poor quality and few records even refer specifically to sand and gravel. From these records, however, it seems possible the deposit may reach up to 8 m in thickness but clearly it is much thinner in places. It is also possible that some of the mounds may consist of boulder clay rather than sand and gravel. Taking these features into account, some 16 million tonnes of sand and gravel may be present in the Crossgates area.

## Kirkcaldy District

Most of the important deposits of sand and gravel in the Kirkcaldy District are situated in the valley of the River Leven and in the associated Kirkforthar [NO 290 045] area (Fig. 2). Most are mounded or outwash fluvio-glacial, deltaic or raised-beach deposits. Outwith this area some small patches of mounded fluvio-glacial, raised-beach and blown sand deposits also occur. Although there are still extensive areas of accessible resources remaining in this district, there are distinct possibilities that some of the deposits will be sterilised or destroyed by urban growth and development, particularly around Glenrothes [NO 290 020]. Most of the deposits occur above the level of the local water-table except where otherwise stated.

### *AREAS B1 TO B4: KIRKCALDY DISTRICT EXCLUDING THE RIVER LEVEN AND ITS TRIBUTARIES*

Small patches of mounded fluvio-glacial gravel occur in the neighbourhood of Tullylumb Plantation [NT 235 940], Tough Row [NT 260 947] and Kinglassie [NT 230 981], but these are of little importance (Area B1 on Fig. 2). Deposits of marine silty clay, sand and gravel of the Late-Glacial raised beaches occur within the burgh of Kirkcaldy (Area B2 on Fig. 2) and may reach a thickness of up to 10 m. Boreholes show however that the basal 3 m is commonly composed of silty clay. The gravel content of these deposits is generally coarse but is not exposed at present and the whole area is currently sterilised by urban development and associated amenity land.

Several thin, narrow strips of Late-Glacial raised-beach sand and gravel occur along the coast (Area B3 on

Fig. 2) from Pathhead [NT 290 925] to north of East Wemyss [NT 348 975] but do not form a very important resource. Blown sand occupies quite extensive areas on the coast (Area B4 on Fig. 2) between Burntisland [NT 235 860] and Pettycur [NT 266 866] where the deposits have been worked on a small scale in the past. At the east end of Burntisland [NT 245 865] 4.5 m of bedded sand and gravel, partly of raised-beach and wind-blown origin, was worked. Blown sand has been worked north of here from time to time as far as Pettycur and was used for glass-making.

#### *AREA B5: RIVER LEVEN AREA*

Very extensive deposits of mounded and outwash fluvioglacial, raised-beach and deltaic sand and gravel occur in this area of the Kirkcaldy District (Figs. 2, 3). There is also some evidence that sand and gravel deposits occur beneath deposits of boulder clay in the NCB Westfield Opencast Site [NT 205 990] and borehole records have proved deep buried channels below the present-day rivers Leven and Ore.

A small part of the fluvioglacial sand and gravel deposit of the Loch Leven basin falls within this District, east of New Gullet Bridge (Area B5a on Fig. 2). Farther west, outside the Region, temporary sections and records of old sand pits showed over 3 m of medium to coarse-grained, bedded sand with some thin bands of fine gravel. Layers of peat were also noted, indicating that these materials are probably of lacustrine origin. Difficulties in working this small deposit are likely to include the fact that the water-table is likely to be met within 1.5 m of surface and that there is a Nature Reserve at Loch Leven [NO 150 010].

Farther east, at Leslie (B5b on Fig. 3) an extensive area of mounded sand and gravel occurs. Leslie is situated on an isolated patch of glacial deposits which have been worked on a small scale at the west end of the burgh. To the north of Leslie, at Balsillie Laws [NO 247 026] sand has been extensively worked but the area is now being restored to agriculture. A small exposure in the pit [NO 247 026] showed mainly bedded, very fine and fine-grained sand which was used in the manufacture of asphalt. It is clear that the ground to the south of the Balsillie farm road could have made a natural extension of this pit and the ground to the north shows predominantly sand in the surface soil. At Roaring Hill [NO 254 024] Rothes Plant Limited of Leslie have a working pit in which some 9 to 12 m of mixed sand and gravel is exposed. Exposures in the lower face show about 6 to 9 m of thickly bedded, sandy, medium to coarse gravel. The gravel, which is subrounded in shape, varies in grain-size from 0.05 m up to 0.37 m averaging around 0.075 m. Above this, in the higher face, about 3 m of thinly bedded fine to coarse-grained sand with some very thin fine gravel bands can be seen. Lamination in this deposit is generally flat but in the coarser beds cross-bedding is developed. Extensive patches of the deposit are strongly cemented by calcite and this material has had to be crushed since it would not disaggregate by washing. In places, wedges of, and channels filled by, fine to coarse gravel up to 0.7 m in thickness also occur in these sands. The pebble content of the gravel is rather varied and consists mainly of local Carboniferous rocks (including coal and mudstone), Upper Old Red Sandstone sediments, lavas, minor quantities of dolerite, and mixed Highland rocks (Appendix 2, Nos. 3 and 4). In the south-east corner of the pit laminated silts and fine

sands occur which closely resemble the materials from the Balsillie Pit to the west. Production at this pit appears to be of approximately equal quantities of sand and gravel. Further development here is limited as these workings are in an isolated high mound but some four million tonnes are probably available in the neighbourhood. Further small areas (B5c on Fig. 3) of mounded glacial deposits occur near Balgeddie [NO 260 030], Collydean [NO 270 032] and on Rhind Hill [NO 260 040] amounting to perhaps two million tonnes.

From the east end of Leslie [NT 260 020] to Markinch [NO 300 020] there is an extensive area (B5d on Fig. 3) of mounded fluvioglacial deposits with some prominent mounds of which one has been worked by J. C. Balfour at the Icehouse Pit [NO 284 025]. This particular pit recently stopped working as the mineral rights were transferred from the operators to the Glenrothes Development Corporation. Borehole records show that these deposits vary in thickness from as little as 2 m to over 30 m. The Icehouse Pit shows fine to coarse subrounded to rounded gravel from 2.5 cm up to 25 cm in grain-size and averaging around 7.5 to 13 cm. The gravels may be well-bedded with occasional bands of fine to coarse-grained and occasionally pebbly sand which may be as much as 66 cm thick. Cross-bedding was noted in the coarser materials and flat lamination in the finer. The outer surface of the mound shows iron-panning and these slopes appear also to be draped by siltier sediments. Calcite cementation was noted and extends over patches up to 2 m across and 15 cm thick. It is probable that the original surface level of this mound has been lowered by at least 8 m and possibly 12 m. The pebble content at this locality (Appendix 2, No. 5) is very varied but closely resembles that at Roaring Hill with coal and shale debris quite common as minor constituents. The mounds of sand and gravel to the east of Markinch [NO 310 024] in the Dalginch area and to the north at Coul [NO 282 027] and Newton Farms [NO 295 030] form an integral part of this spread. Much of this area is to be developed by the Glenrothes Development Corporation but due to the number of old mine shafts in the area is likely to be used mainly for parkland. However, it is expected that part of this important resource, which amounts to about 10 million tonnes, will be sterilised by building for the foreseeable future.

An area of subdued low ground links the Markinch spread with the development around Kirkforthar Feus (B5e on Fig. 3) where these deposits are being worked by J. C. Balfour. At the eastern end of this pit extensive sections show up to 6 m of fine to medium-grained sand which is either flat-bedded or cross-bedded in places. Individual beds of sand may reach 15 cm in thickness but are generally much thinner. Towards the northern end of this face from 2 to 2.5 m of interbedded fine gravel (less than 2 cm) and coarse sand is found at the top of the sequence. Large boulders (over 30 cm) form a pavement in this general sequence. At the north-eastern extremity [NO 294 048] up to 3 m of conspicuously cross-bedded fine gravel, gritty sand and coarse to medium-grained sands in beds from 15 to 30 cm thick occur. Pebbly sands are quite common here and include much coal and shale debris in blackish-coloured lentils. At this locality the gravel is subangular to subrounded and up to a maximum of about 4 cm in grain-size. The lithology of these pebbles is varied but is dominated by Carboniferous sediments, Upper Old

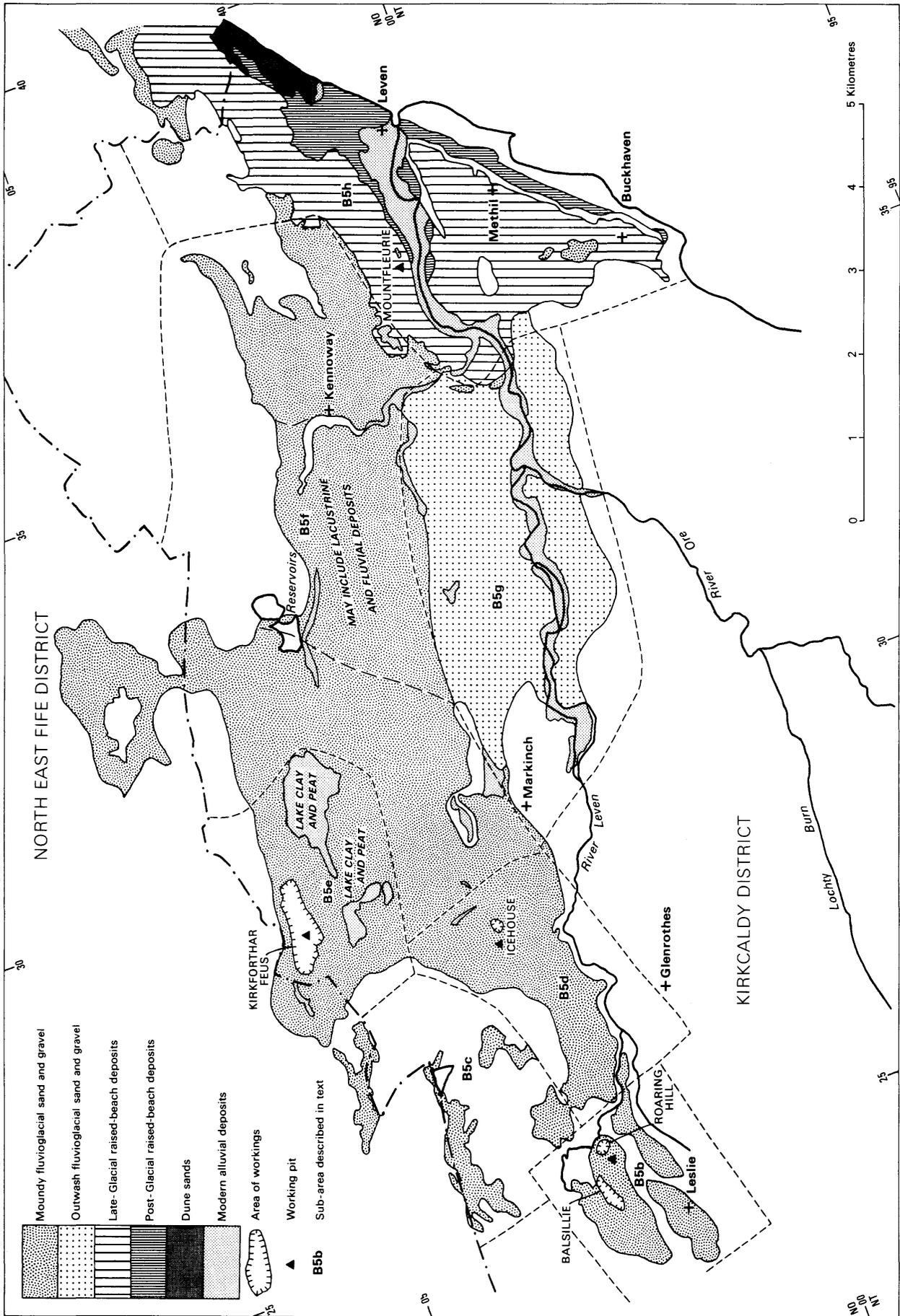


Fig. 3. Sand and gravel deposits of the River Leven area

Red Sandstone sediments and lavas (Appendix 2, No. 6). On the northern side of these workings [NO 290 050] a remnant of a high mound has been left unworked. The deposits here consist of fine to medium, subangular to subrounded gravel (Appendix 2, No. 7) and coarse to medium-grained sand underlying about 3 m of laminated silts and fine sands containing reddish-brown clay bands. Large boulders up to 66 cm in diameter (usually about 30 cm) are common in these finer materials. In new faces on the southern side of the pit up to 3 m of bedded, generally flat-laminated, fine to medium-grained sand is well exposed. Thicknesses in excess of 15 m have been proved by drilling for these materials but an average thickness appears to be about 5 m and some 20 million tonnes may be available in this area. Little gravel is produced at this quarry as most of the coarse material is worked at the Icehouse Pit and brought from there to be washed and graded at Kirkforthar. The water-table throughout this quarry is low and seems to lie about 7 m below the original ground level.

Future extension of the Kirkforthar Pit in an easterly and south-easterly direction may be possible since this deposit is present as far east as Kennoway (B5f, Fig. 3). Little information is available as to the thickness of the deposit present in the ground between Kirkforthar and Kennoway but shallow temporary sections around Star showed rock very near to the surface in places and also the presence commonly of interbedded or overlying silts of possible lacustrine origin. High mounds in this ground are present at Pyeston [NO 317 045], and Carriston [NO 324 045] and form a series from Maiden Castle [NO 351 015] to Windygates [NO 346 003]. At Windygates there is a railway cutting at the southern end of Duniface Hill [NO 352 007] which shows up to 6 m of fine to coarse-grained bedded sand with fine to coarse gravel. Much of the sand and gravel outwith the area of the mounds is in fact sterilised by buildings. Some 24 million tonnes of thinly spread sand and gravel may be available in this area.

South of a line drawn through Markinch and Kennoway (B5g, Fig. 3), there is an extensive spread of outwash fluvioglacial sands and gravels on both banks of the River Leven which total about 16 million tonnes. Information from borehole records suggests that these deposits, which are seen to overlie boulder clay in the banks of the river, may exceed 6 m in thickness (maximum 12 m).

These fluvioglacial deposits pass eastwards into the Late-Glacial raised-beach deposits which in the Leven area appear to be of deltaic origin (B5h, Fig. 3). In the Leven area at Mountfleurie [NO 365 008], A. Cook (Readymix) and Company Limited are working these deltaic deposits for local use. Thickly-bedded, coarse to medium-grained subangular to subrounded gravels around 5 cm up to a maximum of 15 cm in grain-size are being worked. Bands and lenses of medium to coarse-grained sand are common in places. Only 2 m of this deposit is exposed in any one section but the deposit may exceed 12 m in thickness according to records of nearby boreholes. The Late-Glacial raised-beach deposits elsewhere in Leven, however, have been worked in pits showing faces 4.5 m high. Much of this deposit is currently sterilised by buildings. The pebble content is varied, consisting predominantly of lavas, Carboniferous and Upper Old Red Sandstone sediments and some Highland rocks (Appendix 2, No. 8). Shale and coal debris is present in places. Much of the continuation of the Leven deposit in the

Methilhill, Methil and Buckhaven area appears from borehole records to be generally less than 9 m thick. Deposits of Post-Glacial raised-beach gravel and sand also occur, the most extensive patch underlying Leven. Deposits of blown sand up to 9 m in thickness occur on the golf course north of Leven and except for being somewhat shelly may form a valuable resource of sand. In all some 16 million tonnes may be available in this area.

## North-East Fife

The North-East Fife District contains extensive deposits of sands and gravels, particularly in the Howe of Fife and in the Wormit-Leuchars area. Moundy and outwash fluvioglacial, and raised-beach sands and gravels and blown sand, all occur. This District is richer in sand and gravel resources than either of the other two Districts of Fife, and, although the deposits are currently being exploited at six active quarries, there still remain extensive unexploited areas. Most of the deposits occur above the water-table except for some terraced alluvial materials in the Howe of Fife (C2f, Fig. 4).

### *AREA C1: NEWBURGH AND LINDORES*

West of Newburgh [NO 220 183], on the Mugdrum Estate, coarse gravels with a lava-rich pebble-content have been recorded from the nature of the soil and from a possible old gravel pit. A borehole sunk by the Institute of Geological Sciences on the waterfront at Newburgh [NO 232 185] proved some 30 m of sand and gravel but it is likely that the deposit is generally rather thinner than this elsewhere. Temporary sections in the continuation of this deposit on the lands of Easter Clunie (outside the Region) showed in excess of 2.5 m of fine to coarse gravel in a sandy matrix. South of Newburgh [NO 247 173] mounds in excess of 9 m of reddish-brown sand and coarse gravel are developed as far south as Lindores Village [NO 273 164]. These deposits are exposed in a railway cutting [NO 255 170] where they are seen to consist of fine to coarse subrounded gravel in a sandy matrix. An esker-ridge up to 9 m in height extends along the east bank of Lindores Loch and small exposures show coarse and very coarse (2.5 to 33 cm) subrounded gravel and boulders in a sandy matrix. East of this ridge subdued undulating ground, showing mainly fine to coarse gravel in the soil, extends as far as Dunbog village [NO 285 183] and in discontinuous narrow strips also along the Motray Water valley to Luthrie [NO 335 195]. The thickness of these deposits is not known but in a railway cutting at Dunbog it is as little as 1 m thick and rests on lavas. About 18 million tonnes may be present in the whole of this area.

### *AREA C2: HOWE OF FIFE*

An extensive area of moundy and outwash fluvioglacial and alluvial sands and gravels occupies the Howe of Fife (Fig. 4). The moundy deposits (C2a, Fig. 4) occupy an extensive area on the north side of the Howe at Collessie and isolated mounds occur sporadically near Dunshelt [NO 240 093], Falkland [NO 258 082] and Pitlessie [NO 350 097]. These deposits have been extensively worked at Collessie [NO 295 123] by the Fife Sand and Gravel Company Limited. In this pit from 3 to 9 m of gravel with some sand is seen in several exposures. These deposits are seen to rest on reddish-

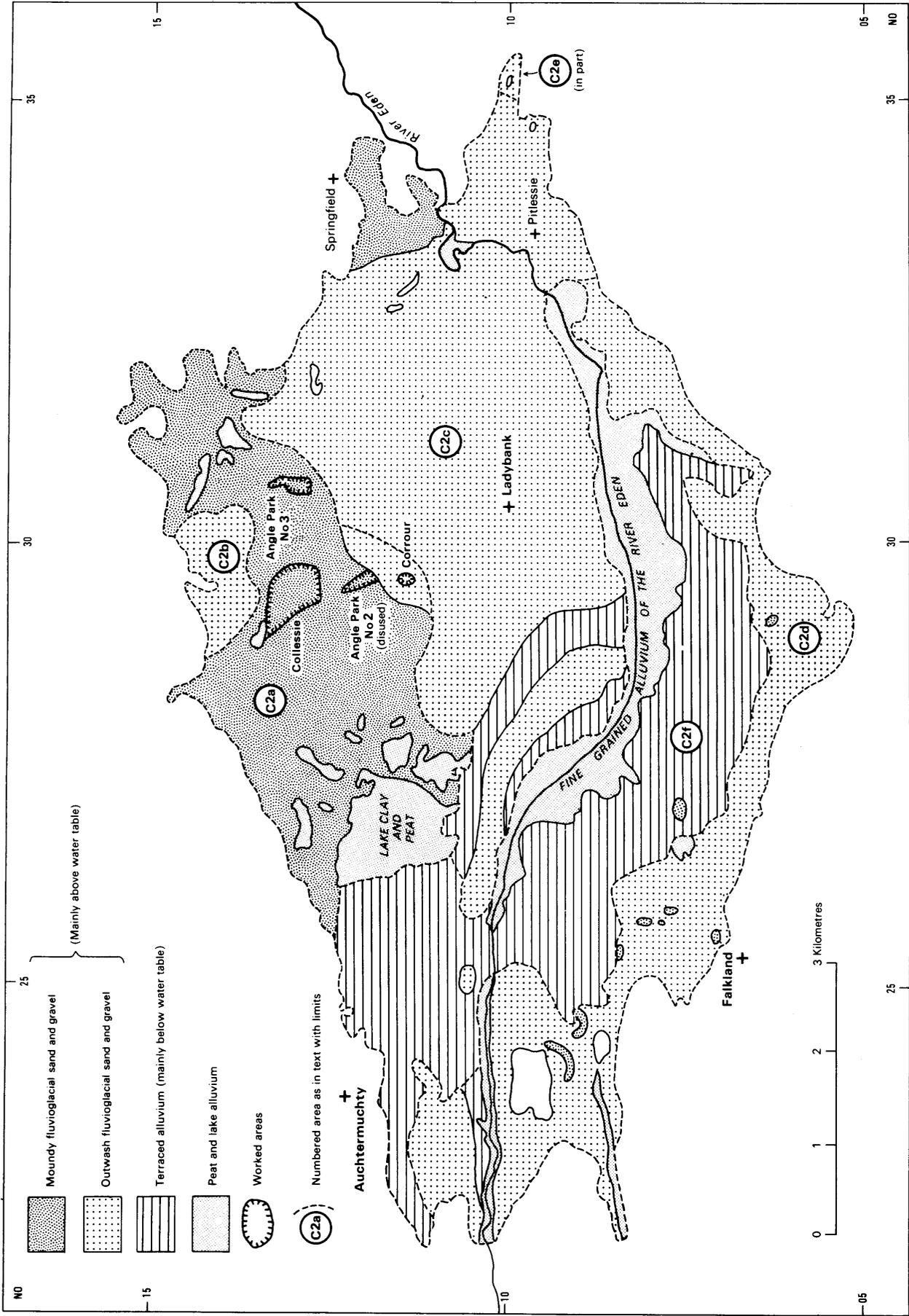


Fig. 4. Sand and gravel deposits of the Collesie area

brown boulder clay in places and have been worked to a minimum thickness of 1.5 m. Coarse and very coarse subrounded gravel predominates, with grain-sizes most commonly varying from 5 to 25 cm, although some boulders exceed 66 cm. The gravel is coarsely bedded and may show imbrication and beds up to 33 cm thick of medium gravel also occur. Lenses up to 33 cm and lenticles of coarse to medium-grained, cross-bedded, reddish-brown sand, which are pebbly in places, are present. The pebble content (Appendix 2, No. 9) is dominated by andesitic lavas with subordinate quantities of Upper Old Red Sandstone and some Carboniferous sediments, metamorphic Highland rocks, dolerite and diorite or granite. The water-table is low (at least 9 m below surface in places) and all water produced in the workings is used in washing processes. At the present time about 75 per cent of the material produced consists of gravel grades. There are two further pits in this neighbourhood situated approximately where the mounded deposits pass laterally into the outwash deposits without kettle-holes, at Corroul [NO 296 111] (formerly Angle Park 1) and Angle Park 2 [NO 295 116]. Corroul is operated by the Forestry Commission on an intermittent basis without permanent plant and Angle Park 2 is abandoned and, as it is used as the local refuse tip, is now very poorly exposed. At Corroul 2.5 to 4.0 m of coarse gravel is exposed (Appendix 2, No. 10). The gravel, which is subrounded in shape, varies in size from 5 to 15 cm and there are conspicuously more abundant beds of reddish-brown sand than in the Collessie sections. These beds and lenticles of medium to coarse-grained sand up to 33 cm thick are usually cross-bedded and may be pebbly in places. The sands are well-compacted but do not contain a clayey matrix or a cement. The pebble content consists of somewhat less lava than at Collessie but this still predominates. Farther east at Melville Lodge Gates [NO 305 123] another working pit (Angle Park 3) is owned by Angle Park Sand and Gravel Company Limited. In this pit, fine to coarse, subangular to subrounded gravel, generally varying in grain-size from 5 cm up to 33 cm (average 5 to 10 cm) is present (Appendix 2, No. 11). Lenses and bands of coarse to medium-grained, reddish-brown sand up to 40 cm in thickness occur and beds of pebbly sand and fine to medium gravel showing cross-bedding are also present. The maximum thickness of deposit seen is of the order of 7.5 m and in the south face reddish-brown boulder clay is exposed beneath. The water-table is low and the workings are dry. The pebble content is rather similar to that of the Corroul and Collessie pits and gravel appears to represent 60 per cent of the total production. Apart from these working pits there are other pits, now abandoned, in the area, the farthest east of which occurs at Ballantagar [NO 311 138]. Evidence from temporary sections indicates that the materials become finer and incorporate more sand eastwards from Collessie. About 48 million tonnes of sand and gravel are available in this area.

The small area of outwash deposits (C2b, Fig. 4) at Melville Home Farm [NO 297 135] consists of coarsely bedded medium to coarse subrounded gravel from 5 to 40 cm in size in a sandy matrix. Six million tonnes of sand and gravel are probably available in this small patch.

The more extensive area of outwash fluvioglacial deposits around Ladybank (C2c, Fig. 4) and associated narrow strips at Bowhouse [NO 270 100] and Shiells

Farm [NO 283 090] were found in temporary sections to consist of well-bedded fine to coarse-grained sand and fine to medium subrounded gravel with many sandy lenses and bands. South of the Rossie Drain at Shiells [NO 283 090] cross-bedded lenticular beds of fine gravel and medium to coarse-grained sand were noted. There are some abandoned pits in these deposits at Dunshelt [NO 245 103], where medium to coarse-grained cross-bedded sands are seen, and in the Ladybank area, where over 4.5 m of sand has been recorded. North and east of Ladybank the gravel content of these deposits increases and at Peterhead [NO 330 113] and Rankeilour records of exposures in old pits show up to 4 m of bedded sand and gravel. Some 40 million tonnes of resources are probably available in this area.

In the Falkland area (C2d, Fig. 4), rare temporary sections in the outwash deposits have shown sand and fine to coarse gravel, but hummocks of mounded sand and gravel rise 3 to 7 m above the general level of the terrace. At least two drumlins of boulder clay are also known to emerge through the surface and the thickness of this deposit appears to be rather variable up to a maximum of about 6 m. A total of 24 million tonnes of material may be present.

Small isolated patches (C2e, Fig. 4) of mounded sand and gravel of unknown thickness occur at Balreavie [NO 270 066], East Conland [NO 268 048] and New Inn [NO 280 050] (which forms an integral part of the Kirkforthar spread in the Kirkcaldy District) but are not likely to be of much importance. A rather more extensive spread of mounded sand and gravel and alluvium occurs in the Rameldry area [NO 325 028]. There are no exposures but a temporary section in the alluvium showed up to 2 m of bedded fine to medium-grained sand with some silty laminae and small rounded pebbles and angular blocks mainly of Carboniferous sandstones and lavas (Appendix 2, No. 12).

#### *Deposits below the water-table*

There are extensive areas of terraced and modern alluvium in the Howe of Fife (C2f, Fig. 4). The lithology of the raised alluvium is known from temporary sections where it was seen to consist of laterally variable, fine to coarse-grained, flat and cross-bedded sands with beds of clay and thin peats in places. Bands of fine to coarse gravel and pebbly sand were also present. The thickness of the deposit varied from as little as 66 cm up to a maximum of 4.5 m. These deposits, of which there are about 32 million tonnes, may overlie fluvioglacial gravel, boulder clay or laminated brown silty clay.

#### *AREA C3: CUPAR*

In the vicinity of Cupar, fluvioglacial deposits of sand and gravel form a narrow strip mainly on the south bank of the River Eden as far west as Springfield [NO 350 115] and as far east as Kemback [NO 415 147]. Temporary sections and information from augering suggest that the deposits consist chiefly of orange-coloured bedded sands and silts seen locally to a thickness of 5 m but more commonly 2 m. They have been worked in the past and may provide a source of sand for local needs.

#### *AREA C4: BLACKETYSIDE, HATTONLAW, COLINSBURGH AND CERES*

East and north of Leven there are several areas of mounded and some outwash fluvioglacial sands and

gravels. Apart from the Ceres area these deposits are unexposed and their existence is inferred from the nature of the soil or from borehole records.

In the Blacketside and Hattonlaw areas (C4a, Fig. 2) thicknesses between 6 and 12 m have been recorded in boreholes and the materials were described as a mixture of sand and boulders. At Colinsburgh (C4b, Fig. 2) sand or sand and fine gravel has been recorded in the soil but no borehole evidence is available to indicate the thickness of the deposit.

At Ceres, mounded and outwash fluvioglacial deposits of sand and gravel occur and extend along the Ceres Burn to Pitscottie. Exposures in an elongate esker-like ridge show up to 2 m of fine to coarse subrounded gravel in a sandy matrix. The pebble content (Appendix 2, No. 18) is dominated by Carboniferous sediments and lavas with some Highland rocks. The thickness of these deposits is uncertain but may exceed 6 m in places.

**AREA C5: LATHOCKAR, KINALDY, STRAVITHIE, BONNYTOWN AND BOARHILLS**  
Mounded and outwash fluvioglacial sand and gravel deposits are to be found in these areas. Little is known of them apart from information derived from local soil conditions.

At Lathockar Mill [NO 500 097] mounds of sand and gravel occur which cover a rather restricted area. No details are available. Beside the Kinaldy Burn (C5a, Fig. 2) an extensive spread of mounded and outwash fluvioglacial deposits occurs. These deposits are recorded as sand and fine gravel and a maximum known thickness of 2 m was seen at the eastern end of the area. West of Stravithie Mill Bridge (C5b, Fig. 2) an extensive area of mainly outwash fluvioglacial sand and gravel occurs. A borehole at the western end of the deposit showed about 2 m of sand and clay, and exposures beside the burn about 600 m west of the Mill Bridge show only 1 m of sand on rock or grey boulder clay. At Bonnytown (C5c, Fig. 2) low mounds of sand with some gravel occur but the deposit appears to be rather thin. Three separate mounds of sand and gravel occur near Boarhills, with surface indications here that the materials consist of sand. These deposits may be up to 5 m in thickness.

**AREA C6: NEWPORT ON TAY, BALMERINO, MOTRAY WATER AND LUTHRIE**

Two small areas of mounded fluvioglacial sand occur near Newport on Tay (C6a, Fig. 2). The mounds rise some 6 m above the surrounding ground and indicate thicknesses in excess of this in places. Little gravel is present and the sand is orange or reddish-brown in colour. Small patches of fluvioglacial gravel (C6b, Fig. 2) beside the Motray Water at Kilmany [NO 389 220] are of unknown thickness. Another small patch of mounded sand and gravel occurs at Balmerino [NO 362 247] where low mounds mainly of sand and fine gravel occur. These deposits may reach 3 m in thickness in places.

**AREA C7: THE WORMIT GAP AND TENTSMUIR**

This part of the North-East Fife District contains extensive resources of sand and gravel of various types (Fig. 5). Large quantities of mounded fluvioglacial, raised-beach and deltaic sand and gravel and blown sand occur. They have been exploited in the past on a small scale and currently are being worked at four pits.

The mounded deposits near Wormit (C7a, Fig. 5) take

the form of hummocks up to 30 m high, elongate ridges (eskers) and flat-topped kame-terraces. They are very varied in composition, consisting of most grades from very coarse gravel to laminated silts or clays. They occupy a deep channel in which, from borehole evidence, about 40 m of sand and gravel have been deposited during the last Ice Age. In and around Wormit the sands and gravels of the Wormit Gap have been worked on a small scale in the past but are not being exploited at the present time. At Newton Hill, St Fort (Appendix 2, No. 13) a large pit is being operated by Scottish Aggregates Limited [NO 406 207]. The materials in this pit consist of bedded medium, coarse and very coarse, subrounded to rounded gravel in a reddish-brown, variably coarse, sand matrix. Beds of medium to coarse-grained sand up to 30 cm thick commonly show cross-bedding and flat-bedding. The pebble content is varied and consists chiefly of Highland rocks with plentiful amounts of Lower Old Red Sandstone lavas and sediments (as well as some sediments of Upper Old Red Sandstone age). The maximum known thickness is about 40 m which was recorded in a borehole sunk on the site to provide water; the working faces show about 24 m of sediments. The production of gravel exceeds that of sand in general and the grain-size of the gravel in the pit varies from 2.5 cm up to 1 m or more, averaging between 5 and 20 cm. The water-table is low and may be more than 15 to 20 m below the surface.

Farther south at North Straiton (Appendix 2, No. 14) and East Links Wood (Appendix 2, No. 15) Fife Sand and Gravel Company Limited have two working pits. The East Links Wood Pit [NO 420 245] works a high elongate ridge (esker). In this pit some 20 to 30 m of fine to very coarse, subrounded gravel are interbedded with silty fine to coarse-grained, occasionally pebbly, laminated sand. Cross-bedding, ripple-lamination and flat-bedding are all common in the finer materials and small channels cut into the finer beds are present filled with coarse gravel. The beds of gravel are usually between 15 and 45 cm thick and the grain-size varies from 2.5 cm up to a maximum of 75 cm, averaging between 5 and 15 cm. The ratio of sand to gravel varies in the pit from east to west. The eastern faces show mainly fine and medium-grained sand, but the western faces show a gravel-rich sequence probably adjacent to the position of the original meltwater channel in the ice. The pebble content (Appendix 2, No. 15) generally resembles that at Newton Hill, St Fort.

The North Straiton Pit [NO 418 238] is being quarried into a kame-terrace which has steep-sided margins leading down to the level of the alluvium of the Motray Water. The pit sections show some 20 m or more of fine to coarse-grained, reddish-brown or orange sand interbedded in places with fine to coarse gravel, the uppermost 3 m of which contains many lenticular beds of coarse gravel. Most of the deposit is either cross-bedded, ripple-laminated or flat-bedded. The gravel varies in size from 2.5 cm up to boulders of about 33 cm but this pit produces mainly sand (more than 65 per cent). The pebble content of the gravel is similar to that at St Fort with Highland rocks and Lower Old Red Sandstone and Upper Old Red Sandstone sediments together forming 65 per cent and with about 20 per cent of Lower Old Red Sandstone lavas. Extensive resources still exist in this general area.

The almost exhausted St Michael's Pit near Strathburn [NO 440 227] is operated by L. H. Spence and Son. This pit is working mounded sand and gravel

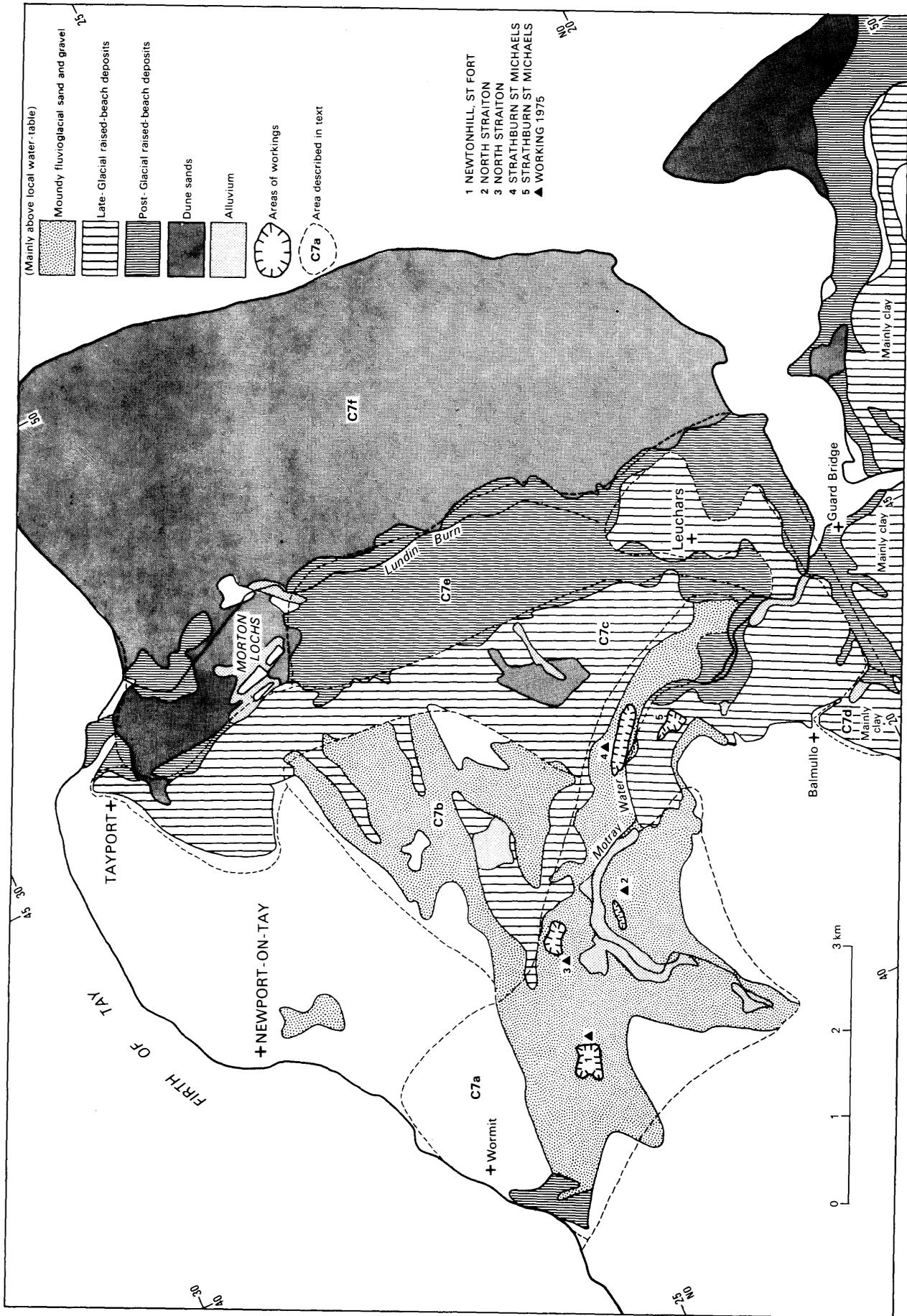


Fig. 5. Sand and gravel deposits of the Wormit area

and an abandoned face at the north end of the pit shows a cross-section through an esker-ridge consisting of very coarse gravel. The exposures in the working part of the pit show 6 m of well-bedded, fine to coarse and very coarse subrounded gravel and boulders from 2.5 cm up to 40 cm in grain-size with many thin beds of fine to coarse-grained sand. Beds of pebbly sand are quite common. The pebble content (Appendix 2, No. 16) is essentially similar to Newton Hill. Cross-bedding and, less commonly, ripple and flat-bedding were noted in the sand. About 4.5 m of thinly-bedded, reddish-brown or orange, silty, fine to coarse-grained sands with clayey laminae overlie the gravels. These deposits become interbedded eastwards with gravel and are in part overlain in the face by bedded coarse and medium gravel. Although the lithology of the finer materials resembles that of the Late-Glacial raised-beach deposits of this area no traces were found of the animal burrows noted in the latter. In all, a minimum of 60 million tonnes of sand and gravel are probably available in the whole of this area (C7a, Fig. 5).

Over the rest of the area of moundy sand and gravel in the Wormit Gap (C7b, Fig. 5) there is no borehole information to indicate variations in thickness of the deposit from place to place. However, it seems reasonable to assume an average thickness of at least 2 m and it is clear from the soil composition that the materials will closely resemble those described from the various working pits. About 12 million tonnes of sand and gravel may be available here.

The Late-Glacial raised-beach and deltaic deposits of this area occupy rather less surface area than the glacial gravel but are of no less importance, although they are not being worked at the present time (C7c, Fig. 5). These deposits form a fringe to the glacial deposits but also extend northwards to Tayport and southwards into the River Eden and Moonzie Burn valleys. The deposits were formerly worked at St Michael's [NO 437 225] and Brackmont [NO 437 224]. The exposures seen in the latter pit show up to 12 m of thinly-bedded reddish-brown or orange-coloured, fine to coarse-grained sand. They are usually flat or ripple-laminated but cross-bedding was noted in places. Pebbly sands are present, particularly where the deposits show cross-bedding. Clay bands are present from time to time and a notable feature was the innumerable burrows 1 to 2 mm thick of a small estuarine animal (*Corophium*). Between St Michael's and Tayport the soil and small exposures demonstrate the presence generally of fine to medium-grained gravelly sand with reddish-brown clay bands. This area is estimated to contain some 32 million tonnes of sand.

South of a line drawn through Pusk Farm and Balmullo (C7d, Fig. 5) the reddish-brown clayey soil indicates the presence of brick clays and this line should be regarded as the approximate southern limit of significant sand resources.

The Post-Glacial raised-beach deposits (C7e, Fig. 5) occupy a strip of ground up to 2 km wide near Rhynd [NO 465 238] but also occupy valleys cut into higher and older deposits and are overlain by blown sand, particularly in the Tayport area. The sediments which make up these deposits vary in grain-size from silty clay to gravel and the deposits may be underlain and overlain by peat in places. In sheltered areas such as at Dron [NO 433 174] and Moonzie Mill [NO 433 200] the raised-beach sequences comprise mainly silt and silty clay with some fine sand. In the more exposed Tentsmuir area [NO 050 250] the sequence may consist

entirely of sand resting on bedrock or older drift deposits or consist partly of silt and clay and partly of sand. These sands cut into the underlying clays and may reach over 12 m in thickness near the present shoreline but they thin westwards and comprise both sand and clay. Exposures beside the River Eden [NO 459 199] show about 2 m of sand overlain by thin silts resting on Carse Clays. Further investigations would be required to assess the full potential of this area's sand resources but some 16 million tonnes of materials may be available. However, the presence of Leuchars Airfield sterilises much of the deposit south of Leuchars.

Blown sand deposits occupy much of the area of Tentsmuir (C7d, Fig. 5) and some ground around Tayport (Fig. 5). These deposits commonly show a dune-ridge morphology. They may reach 9 m in thickness as in a borehole at Kinshaldy, although part of this sequence consists of raised-beach sediments. Both the height and direction of the dune-ridges varies in different parts of Tentsmuir. In the north they trend west-south-westwards as far south as Fetterdale Farm [NO 471 255]. South of Fetterdale the dunes trend north to south and are commonly separated from each other by low-lying marshy alluvial deposits. East of Leuchars Airfield and in a coastal fringe 1 km wide which extends from the airfield north to Kinshaldy and onwards to the north coast, the dunes trend west-south-westwards again. This latter trend is much more subdued than the north to south lineation. These extensive sand deposits are heavily afforested at the present time and the water-table may be high between the ridges. In the borehole at the Tayport Golf Course between 15 and 30 m of soft wet sand was proved (no accurate record of this hole is available) and yields in excess of 4550 l/h have been obtained from wells in the surface deposits of the Tentsmuir area. An estimated 40 million tonnes of sand may be available in this general area.

#### AREA C8: ST ANDREWS TO FIFE NESS

South of the River Eden from Guardbridge to St Andrews there are extensive areas of raised-beach deposits and wind-blown dune-sands in the Pilmour Links area. Except in St Andrews, the Late-Glacial raised-beach deposits consist largely of brown silty brick clays. Patchy deposits of raised-beach sand and gravel occur within St Andrews, with a maximum known thickness of 4.5 m proved in a temporary section at Kinburn House [NO 503 166]. At Kinkell Brae [NO 522 157], 2 m of raised-beach sand and gravel rests on rock in the cliff face. The gravel is fine to coarse in grain-size, subangular to subrounded in shape and composed mainly of local rocks including sandstones and fine-grained basalts (Appendix 2, No. 17). At Boarhills [NO 570 146] and Kingsbarns [NO 595 120], the soil indicates the presence of sand and fine to coarse gravel in places but, in general, sections in cliffs and valleys show less than 4 m of deposit resting on boulder clay or rock. Post-Glacial raised-beach deposits consist mainly of clays and silts in the Eden Valley but on the open coast they are generally gravelly in lithology and up to 6 m thick but are restricted in areal extent. Blown sand deposits are present on the Pilmour Links [NO 495 185] north of St Andrews in ridges up to 8 m high. These deposits are now sterilised by the famous local golf courses.

#### AREA C9: FIFE NESS TO LUNDIN LINKS

Sands and gravels of raised-beach origin and blown

sand deposits are present in this area. Only on the St Ford Links, near Earlsferry, are there substantial deposits of Post-Glacial raised-beach deposits.

Between Fife Ness and Crail evidence from boreholes indicates that up to 4 m of shelly Late-Glacial raised-beach sand and gravel is present in places. Similar, probably thin, sandy deposits occur south of Crail [NO 610 070] to Kilrenny [NO 580 050] and overlie brown silty brick clays. At Kilrenny and westwards, the raised-beach deposits occupy an extensive area but there is little evidence as to the thickness or nature of the sediments which constitute them. However, most of the local streams expose solid rock and it appears unlikely that these deposits are very thick. Although sand and fine gravel is recorded in the soil in many places, most of the sections in drift north of Anstruther [NO 565 035] and St Monance [NO 525 020] show brown silty brick clays, suggesting that the sandy deposits are thin or absent here. Between Pittenweem and St Monance borehole records show at least 2 m of sand and gravel overlying 4 m of silty clay. At Grangemuir House [NO 550 044], the maximum recorded thickness of sand and gravel is 6 m. From Elie [NO 501 001] westwards to Kilconquhar [NO 480 020] and southwards to Lundin Links there are extensive Late-Glacial raised-beach deposits but the nature and thickness of these is poorly known except at Lundin Links, where borehole records show up to 7.5 m of material.

The Post-Glacial raised-beach deposits form fairly extensive spreads of sand and gravel from Elie to Leven and are overlain by wind-blown dune sand at Elie [NO 501 001], Earlsferry [NO 481 001], St Ford Links [NO 465 005] and Lundin Links [NO 400 020]. In the Cocklemill Burn [NO 461 009] some 6 m of flat-bedded sand with gravelly and shelly bands is exposed (Appendix 2, No. 19). The deposits at this locality form part of the St Ford Links spread and a considerable quantity of resource may be available here.

In general the raised-beach gravels are subangular to subrounded in shape and consist of Carboniferous sandstones, lavas, tuffs and ironstones with minor quantities of shale, coal and limestone (Appendix 2, Nos. 20, 21). Shell debris is also present in places.

Blown sand deposits occur quite extensively between Elie and Lundin Links and in patches as far north as Kilrenny [NO 590 050] and Abercrombie [NO 517 017]. The deposits consist largely of sand with a little shell debris and have been worked in the past near Balchrystie [NO 460 030], on St Ford Links and on the Elie East Links; the workings showed between 2 and 6 m of bedded sand. These deposits overlie Late-Glacial and Post-Glacial raised-beach deposits.

## Selected bibliography

ANDERSON, J. G. C. 1946. Sands and gravels of Scotland: Stonehaven-Perth-Dundee. *Wartime Pam. Geol. Surv. G.B.*, No. 30, Pt. 2, 30 pp.

— 1946. Sands and gravels of Scotland: Glasgow and west central Scotland. *Wartime Pam. Geol. Surv. G.B.*, No. 30, Pt. 3, 51 pp.

HALDANE, D. 1946. Sands and gravels of Scotland: Fife-The Lothians-Berwickshire. *Wartime Pam. Geol. Surv. G.B.*, No. 30, Pt. 4, 32 pp.

### Maps:

One-inch (1:63 360) Geological Sheets:

- No. 32 Edinburgh (Drift)
- No. 40 Kinross (Drift)

No. 41 North Berwick (Drift)

No. 48 Perth (*out of print, new edition at 1:50 000 is in preparation*)

1:50 000 Geological Sheets:

No. 32W Livingston (Drift) (*in preparation*)

No. 39E Alloa (Drift)

No. 49W and E Arbroath (Drift) (*in preparation*)

## Appendix 1: List of working pits and operators

ANGLE PARK NO. 3 PIT [NO 305 123]

Geological Sheet 40; Six-inch Sheet NO 31 SW

Owner: Angle Park Sand and Gravel Co. Ltd, Melville Lodge Gates, near Ladybank (Telephone Ladybank 303).

COLLESSIE PIT [NO 295 123]

Geological Sheet 40; Six-inch Sheet NO 21 SE

Owner: Fife Sand and Gravel Co. Ltd (Telephone Ladybank 636).

CORROUR PIT [NO 296 111]

Geological Sheet 40; Six-inch Sheet NO 21 SE

Owner: Forestry Commission, East Scotland Conservancy, 6 Queen's Gate, Aberdeen AB1 6YL (Telephone Aberdeen 33362).

ICEHOUSE PIT [NO 284 025]

Geological Sheet 40; Six-inch Sheet NO 20 SE

Owner: J. C. Balfour, c/o Bell-Ingram, Durn Isla Road, Perth PH2 7H (Telephone Perth 23231).

KIRKFORHTAR FEUS PIT [NO 290 050]

Geological Sheet 40; Six-inch Sheet NO 20 SE

Owner: J. C. Balfour, c/o Bell-Ingram, Durn Isla Road, Perth PH2 7H (Telephone Perth 23231).

MOUNTFLEURIE PIT [NO 365 008]

Geological Sheet 40; Six-inch Sheet NO 30 SE

Owner: A. Cook (Readymix) Ltd, Scoonie Park, Leven KY8 4TD (Telephone Leven 2841).

NEWTON HILL PIT, ST FORT [NO 406 247]

Geological Sheet 49; Six-inch Sheet NO 42 SW

Owner: Scottish Aggregates Ltd, Newton, Wormit.

NORTH STRAITON PIT, WEST [NO 418 238]

NORTH STRAITON PIT, EAST [NO 420 245]

Geological Sheet 49; Six-inch Sheet NO 42 SW

Owner: Fife Sand and Gravel Co. Ltd (Subsidiary of Alexander Russel & Co. Ltd), St Fort, Wormit (Telephone Wormit 841).

ROARING HILL PIT [NO 254 024]

Geological Sheet 40; Six-inch Sheet NO 20 NW

Owner: Rothes Plant Hire Ltd, Regal Cinema, Murray Place, Leslie.

STRATHBURN ST MICHAEL'S PIT [NO 440 227]

Geological Sheet 49; Six-inch Sheet NO 42 SW

Owner: L. H. Spence and Son, Brackmont Hill, Leuchars (Telephone Balmullo 205).

TULLIALLAN PIT [NS 945 895]

Geological Sheet 39; Six-inch Sheet NS 98 NW

Owner: Tillicoultry Quarries Ltd, Tulliallan, Kincardine-on-Forth (Telephone Kincardine 481).

## Appendix 2: Pebble counts

No.	Location	Grid Ref.	Quartzite and vein quartzite		Impure quartzite and grits		Schists		Sandstone and conglomerate		Lavas	Mudstone	Acid igneous	Epidiorites	Dolerite	Coal	Shells	Roundness
<b>DUNFERMLINE</b>																		
1	Tulliallan	NS 945 895	7.5	25.4				43.3	15.7	7.5			0.7					SA-SR
2	Crossgates	NT 154 888	2.2	12.5				65.4	14.7	4.4		0.7						SA-SR
<b>KIRKCALDY</b>																		
3	Roaring Hill	NO 254 024	2.8	7.0				52.1	32.4	*		5.6		*	*			SR
4	Roaring Hill	NO 254 024	1.8	5.4				75.0	14.3	1.8		1.8		*	*			SR
5	Icehouse	NO 284 025	13.3	11.1				37.7	35.5	1.0								SR-R
6	Kirkforthar	NO 294 048	11.3	12.9				33.9	37.1	1.6		1.6				1.6		SA-SR
7	Kirkforthar	NO 290 050	11.1	9.3				24.1	40.7	5.6		7.4	1.9					SA-SR
8	Mountfleurie	NO 365 008	7.2	12.2				25.2	47.5	2.9		5.0						SA-SR
<b>NORTH-EAST FIFE</b>																		
9	Collessie	NO 295 123	6.4	20.0	0.8			21.6	43.2			5.6	2.4					SR
10	Corrour	NO 296 111	11.8	17.6				31.1	33.6			4.2	1.7					SR
11	Angle Park 3	NO 305 123	4.8	25.4				21.4	35.7			10.3	2.4					SA-SR
12	Rameldry	NO 325 058	7.2	9.6	2.4			42.4	25.3	6.0		3.6	2.4					A-SA
13	Newton Hill, St Fort	NO 406 247	7.8	47.8				14.6	27.3			2.0	0.5					SR-R
14	North Straiton	NO 418 238	9.7	38.3				26.5	19.4			6.1						SR-R
15	North Straiton	NO 420 245	11.5	33.2				21.2	24.9			9.2						SR
16	Strathburn, St Michael's	NO 440 227	11.8	41.9	1.6			16.1	21.5			7.0						SR
17	Kinkell Brae	NO 522 157	2.0	5.5				60.5	21.5	7.5		3.0						A-SR
18	Ceres	NO 409 120	3.2	18.1				30.9	35.6	10.6		1.6						SR
19	Cocklemill	NO 461 009	4.8	8.1				20.1	54.5	0.5		1.0		0.5			10.5	SA-SR
20	St Monance	NO 520 014		6.4				37.6	24.3	29.5							2.3	SA-SR
21	Lundin Links	NO 412 032	3.1	15.5				50.3	26.1	5.0								SA-SR

\* Also present

A = angular

SA = subangular

SR = subrounded

R = rounded

## Appendix 3: Estimated resources

	Area ha	Thickness Av. Max. recorded		Quantity Million tonnes	Remarks
		m	m		
<b>DUNFERMLINE</b>					
Tulliallan	25	2	10.5	1	Restricted prospect.
Crossgates	400	2	8	16	Poorly-known area, perhaps of restricted importance.
<b>KIRKCALDY</b>					
Leslie B5b	100	2	12	4	Restricted prospect.
Balgeddie B5c	50	2	9	2	Restricted prospect.
Markinch B5d	250	2	30	10	Being built over.
Kirkforthar B5e	200	5	15	20	Currently the most important active area in this District.
Kennoway Star B5f	800	1.5	6	24	Poorly-known area, deposit rather thinly spread.
River Leven B5g	400	2	6	16	Little-known area.
Leven Coast B5h	400	2	12	16	Mainly built over.
<b>NORTH-EAST FIFE</b>					
Newburgh C1	300	3	30	18	Prospects good.
Collessie C2a	600	4	9	48	Intensive activity in this area, good reserves.
Melville Home Farm C2b	75	4	8	6	Possible extension of Collessie.
Ladybank C2c	1000	2	5	40	Prospects good.
Falkland C2d	600	2	5	24	Prospects good.
River Eden C2f	800	2	4.5	32	Only Fife deposits with essentially high water table problems.
Wormit Gap C7a	600	5	40	60	Most important resource in the region.
Comerton C7b	300	2	?	12	Possible important extension of Wormit area.
Leuchars C7c	800	2	12	32	Extensive deposits of sand.
Rhynd C7e	400	2	12	16	Reasonable prospect for sand.
Tentsmuir C7f	2000	1	9	40	Occurs in ridges (estimated thickness is an average), large resource of sand.

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