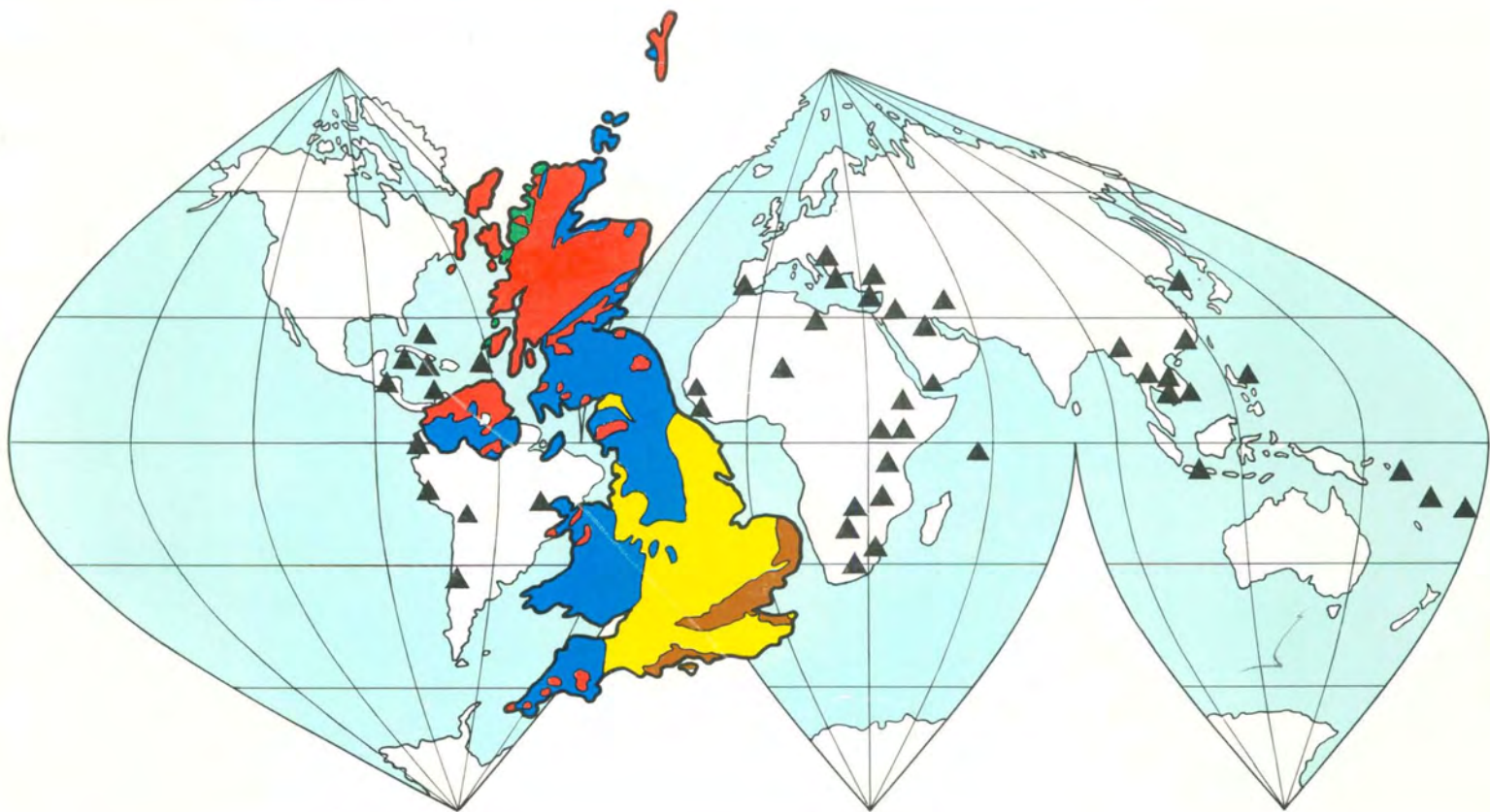


NATURAL ENVIRONMENT RESEARCH COUNCIL

INSTITUTE OF GEOLOGICAL SCIENCES

# Sand and gravel resources of the Grampian region

REPORT No. 77/2



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*It is recommended that reference to this report be made in the following form:*

PEACOCK, J. D. and others. 1977. Sand and gravel resources of the Grampian region.  
*Rep. Inst. Geol. Sci.*, No. 77/2, 24 pp.

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ISBN 0 11 881282 3

## Preface

The following account of the sand and gravel resources of the Grampian Region has been compiled by the Institute of Geological Sciences, 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 It is essentially a summary of the published and unpublished records of the Institute together with other published data mentioned in the list of references at the end of the report.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 the account:

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 notional, being based on experience rather than detailed records of boreholes and sections.
4. Deposits above and below the water table have been considered separately, but are discussed together in the account.
5. Considerations such as possible markets and accessibility have been ignored, or referred to only in passing.
6. Land use, conservation, and amenity considerations have been given only passing mention. There are many 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 in the tables.

Because of the small scale of the accompanying maps it has not been possible to show details of the locations of most of the deposits mentioned in the text. The reader is advised to read the report in conjunction with the relevant Ordnance Survey maps given in the list of references.

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1 September 1976

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# Sand and gravel resources of the Grampian region

J. D. PEACOCK and others

## Introduction

In the Grampian Region the sands and gravels are of several types which reflect to a greater or lesser extent the parent rocks from which they were derived, and their mode of origin. With minor exceptions they were laid down, following the close of the glaciations of the Pleistocene Ice Age, by glacial meltwaters, by marine action when sea level was higher than at present, and by streams, rivers and wind. The exceptions are the gravels of Pliocene age which occur in a belt from Peterhead westwards to the upper reaches of the Deveron and Ythan valleys, and, in certain areas, rock which has been decomposed to sand by the action of weathering and circulating groundwater.

The greater part of the Grampian Region is underlain by crystalline metamorphic rocks of the Dalradian group. These metamorphic rocks represent original sediments, now much altered by heat and pressure. Sandstones are thus represented by quartzite and quartz-feldspar-granulites (psammites), shales by various types of mica-schists and slates (pelites), and rocks intermediate between these two by quartz-mica-schists (semipelites). Limestones in the Dalradian group are now crystalline (marble), and originally impure gritty sandstones have been weakly metamorphosed to become cleaved greywacke and schistose grit. Sandstone and conglomerate of Old Red Sandstone age occur in north to south belts in the Rhynie and Turriff areas, and are widespread south of Stonehaven. In the neighbourhood of Elgin, Old Red Sandstone strata are overlain by Permo-Triassic sandstone. The Dalradian strata are cut by large masses of granite which crop out in a broad zone from Aberdeen westwards. Small granite bodies occur around Peterhead and Strichen. Dark, crystalline basic igneous rocks such as gabbro and hornblende-schist crop out at many places between Portsoy and Huntly, in the Inch district, Belhelvie, and in the east coast area below the thick superficial deposits. It is therefore clear that the pebbles in the gravels can be expected to be formed of a wide variety of rock types.

During the Ice Age, glaciers extended eastwards and northwards from the interior but the coastal areas were crossed by ice flowing down the Moray Firth and by glacier ice derived from the North Sea basin. In the latter areas blocks of Cretaceous limestone picked up from the sea floor are found in some of the deposits together with fragments of marine shells. The glaciers laid down extensive sheets of till (boulder clay), and during their retreat meltwaters deposited sand and gravel in mounds and terraces which may be unrelated in detail to the topography of the underlying rock and till. Where deposits were formed on, or in contact with, ice (ice-contact deposits), they are moundy, and individual beds of sand and gravel are usually found to vary greatly in thickness, grain size and grading within short distances. Beds of silt and clay are common, and layers of till may occur locally, particularly on top of the deposits. Appraisal of this type of resource is

therefore difficult and depends on the availability of reliable borehole data. In the terraced deposits formed by streams issuing from the ice (fluvioglacial deposits) there is less variation in bedding and thickness so that estimating the quantity and quality is somewhat easier, though still requiring borehole evidence. The composition of the sand and gravel at any locality is commonly, although not always, related to the underlying bedrock and to the different strata crossed by the glaciers. The pebbles are usually subrounded or subangular; they have not been greatly abraded because they have travelled only a short distance.

The alluvium shown on the published Institute of Geological Sciences maps is often largely silty in nature, but in the major river valleys such as the Spey, Deveron, Ythan, Don and Dee includes well sorted sand and gravel which in part represent reworked fluvioglacial deposits. The deposits are in places arranged as terraces flanking the rivers, but elsewhere form alluvial flats at present day flood level. Buried channels extending well below present river level, which occur in the lower courses of the Dee and Don valleys, are known to be partly infilled by sand and gravel.

Raised beach deposits are widespread in the Elgin district, but are unimportant elsewhere. They fall into two categories, a late-glacial series extending up to about 30 m OD and a postglacial series found below 10 m OD. The late-glacial beaches are unimportant as a resource, but the postglacial beaches are often formed of gravel and locally cover considerable areas. Such gravel is commonly composed of well rounded pebbles and is accompanied by sharp sand. Since the raised beaches are mainly reworked from other sediments they are compositionally related to the local bedrock only in a very general way. The volume of raised beach deposits may be estimated where there is good exposure in natural and artificial sections, but for the most part boring is required to determine the geometry of the strata and the ratio of gravel to sand.

Sand blown up from the beaches (blown sand) is a significant resource on the coast west of Burghead and south of Fraserburgh, where it occurs both as modern dunes and as older, grassed over mounds. Much of it is fine to medium grained (0.1 to 0.4 mm) with a 'tail' of coarse grained sand and fine gravel, and shell fragments are locally common.

A feature of the geology of the Grampian Region is the extent to which the bedrock is decomposed at the surface. The decomposition affects all rock types but particularly coarse grained igneous rocks such as granite and gabbro. In districts underlain by Old Red Sandstone strata, as for instance the Elgin and Gardenstown areas, the conglomerate of that age may be sufficiently decomposed to resemble modern gravel. Such decomposed rock is frequently mistaken for sand or gravel in boreholes. Postglacial weathering of some gravel deposits has affected the granite, gabbro and schist pebbles to a much greater extent than those of psammite and quartzite, and may render them

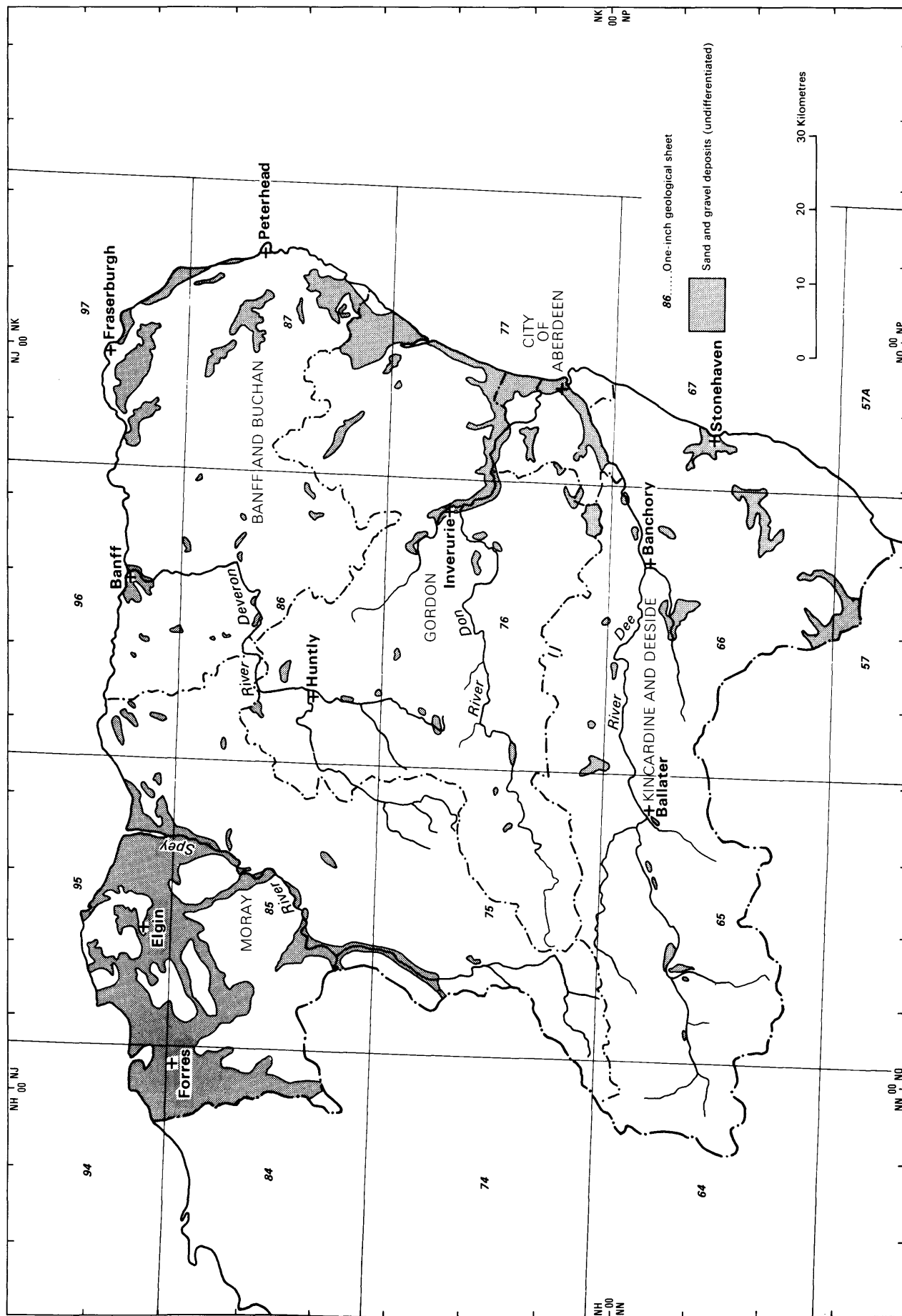


Fig. 1. Index map of Grampian region showing boundaries of one-inch geological sheets.



unsuitable for some purposes.

In the following account a qualitative appraisal is made, where the information allows, of the ratio of sand to gravel in a deposit, and of the lithology, sphericity and roundness of the gravel fraction. Attention is also given to other factors which may affect the quality of the resource, such as the presence of soft stones, silt, hardpan, and staining by ferruginous or organic material. Though the roundness is related in a general way to the processes to which the gravel has been subjected (see above) the sphericity (overall shape) is fundamentally a property of the way in which the bedrock can be split. Thus granite pebbles (derived from rocks with widely separated partings) tend to be ball-shaped or egg-shaped (high sphericity) whereas schist pebbles (derived from rocks with closely spaced partings) are frequently blade-shaped or plate-shaped (low sphericity).

## Banff and Buchan District

The sand and gravel resources in this district are found mainly in the fluvioglacial and alluvial terrace deposits of the major river valleys, in the belt of moundy and gently undulating glacial and fluvioglacial deposits which extends from New Aberdour eastwards along the north flank of Mormond Hill to the Loch of Strathbeg, and in the coastal belt of blown sand between Fraserburgh and Peterhead. Other resources occur in the complex glaciolacustrine and fluvioglacial deposits of the coastal strips south of Peterhead and west of New Aberdour, though in the latter district the resources are generally less extensive than previously thought. Small areas of flint and quartzite gravel accompanied by sand, which occur chiefly in a belt between Fyvie and Peterhead, are thought to be beach deposits of possible Pliocene age. Decomposed granite is locally worked as a sand, but this type of resource is not considered further here. Sandy deposits, which could be either of fluvioglacial or marine origin, occur locally on the coast west of Banff. Finally, there are a number of small, isolated terraces and mounds underlain by sand and gravel which are too small to be shown on the map (Fig. 2), but which could (and in some cases already do) provide material for local purposes.

### DESCRIPTION OF DEPOSITS

#### 1. Sandend Bay

Sand and minor, dominantly quartzite, gravel occur in wind blown dunes and raised beach deposits at Sandend Bay. Up to 15 per cent of shell fragments are present in the dune sands but this falls to about 4 per cent in the raised beach sands where minor peaty bands occur.

#### 2. Newpark

West and south-west of Newpark farm [NJ 544 625]<sup>1</sup> moundy deposits of sand and gravel occur in an area of heathland. The gravel consists of subangular to subrounded small pebbles of quartzite and vein quartz, derived largely from the small Old Red Sandstone conglomerate outlier to the west. The sandy matrix is fine to medium grained with minor silty bands. Observed sand to gravel ratios are 70/30.

<sup>1</sup>Figures in square brackets are National Grid references referring to 100 km square NJ. Index letters are given only once in each subsection, unless a new grid square reference is required.

#### 3. Portsoy-Tillynaught

Around Portsoy, sand and gravel is exposed in an old pit on the southern margin of the town [NJ 587 654]. The boundaries of the deposit are difficult to define and part of it is sterilised by buildings. Basic igneous rocks, quartzite, slate and biotite-gneiss pebbles lie in a hematite-stained silty sand matrix. On the eastern margin of the town sands are interbedded with clays and silts. More extensive tracts of sand and gravel are sited along parts of the burns of Durn and Boyne.

Sand and gravel deposits around Knockdurn farm [583 631] lie below 1 to 4 m of till, and borehole data shows that they are between 4 and 10 m thick. Around Tillynaught Station [601 617] about 3 m of medium to coarse grained sand with minor quartzite and granite pebbles is exposed in stream banks. Till 1 to 2 m thick with basic erratics overlies the sand, and this is overlain by up to 1 m of fine gravel.

#### 4. Troup Head

The only economically significant resource within the complex glaciolacustrine deposits of the Banff coastal belt lies south of Troup Head. Bedded sand with minor gravel is well exposed in a deep gully [NJ 824 665]. The deposit is moundy and thicker to the east. The north coast and its immediate hinterland are designated as sites of special scientific interest.

#### 5. Banff-Boyndie

The sands and gravels of the Banff-Boyndie area are a significantly large resource in the Banff and Buchan District. They form a series of hills stretching south-west from Banff to Ladysbridge [NJ 651 636]. Gravels are more abundant near the margins of the deposit and persistent thin silty bands are commonly present in these areas. The majority of the sand is 'soft'. Pebble types in the Hills of Boyndie, for example, Gowden Knowes [667 638] include quartzite, red feldspathic sandstone, granite and basic igneous rocks. To the south greywacke, grit, biotite-gneiss, quartzite and minor andalusite slate are more common as pebbles, for example, at Paddocklaw farm [662 617]. The Deveron floodplain near Banff (5b) is underlain by 2 to 3 m of silt which overlies 7 to 15 m of deposits including sand and gravel (Table 2).

#### 6. Blackhills

Around Blackhills farm [NJ 619 576] sand and minor gravel underlie a wide area but are poorly exposed. The best exposures are found in the southern part of the area [617 572] where fine to medium grained, clean sand crops out in stream banks. Locally up to 1 m of till may overlie the sands, particularly in the eastern half of the district.

#### 7. Alvah-Rosyburn

In the Alvah-Rosyburn area remnants of prominent gravel eskers and small kames are common. There is no overburden on most of these deposits and because of their relief they are easy to quarry. The resources are small (Table 1). Sand to gravel ratios vary from 50/50 to 20/80 in the observed pits and generally the matrix contains a proportion of silt and clay. Sand grains and pebbles are angular to subrounded. Pebbles of slate and greywacke predominate, but subsidiary quartzite pebbles are to be seen in several pits.

#### 8. Lower Deveron Valley

There are several terraces along the banks of the River

Deveron between Turriff and Bridge of Alvah [NJ 680 611]. The higher terraces are chiefly underlain by till with pockets and lenses of sand and gravel. The lower terraces are formed of fluvial sands and silts. No quantitative estimate of sand and gravel has been made for this area.

#### 9. *King Edward*

Along the course of the Burn of King Edward there is a high terrace underlain by considerable quantities of gravel. The burn follows a 30 m deep meltwater channel. At some localities the gravel overlies an undulating eroded bedrock surface, and up to 10 m of gravel occurs in hollows. The gravels become finer grained to the east and thin rapidly to the west, where they also become more sandy. A large pit, which was recently worked adjacent to Bridgend farm [NJ 729 567], shows 6 m of coarse and fine gravel with minor cross-bedded sand in its lower part. The pebbles are composed of greywacke, grit, and sandstone. The sand to gravel ratio is roughly 10/90.

#### 10. *Tippercowan*

A prominent sand and gravel terrace occurs around Tippercowan farm [NJ 815 551]. Cross-bedded, medium grained sands are overlain by gravel, which becomes more abundant in the north-west part of the deposit. A 10 m face is exposed in an old pit [817 549] adjacent to the B 9027 road, where sand to gravel ratios are 80/20. The pebbles comprise quartzite, granite, greywacke, red sandstone, feldspar-porphyrity and minor slate.

#### 11. *Glenbarry*

Small eskers and hummocks of sand and gravel are well exposed west of the Glenbarry Hotel [NJ 553 547]. Part of the deposit lies within the Moray District but records show that sand and gravel, of unknown type and thickness, also occurs immediately north of Glenbarry in the Banff and Buchan District.

#### 12. *Auchintoul*

Along the Auchintoul valley between Kinnairdy Mill [NJ 611 501] and Lootcherbrae [606 540], are several deposits of sand with subsidiary gravel, particularly on the west side of the valley. At their base they may be locally interbedded with till. Minor sand and gravel terraces near Janefield farm [612 511] are related to the present valley.

#### 13. *Upper Deveron Valley*

Along the Deveron valley between Marnoch [NJ 598 500] and Laithers House [670 487] there are three large terraced fluvio-glacial sand and gravel deposits with smaller fluvial sand terraces at lower levels. At Cobblehouse north of Inverkeithny [630 470] some 3 to 4 million tonnes of deposit underlie the upper fluvio-glacial terraces with observed sand to gravel ratios of about 60/40. Gravel is more abundant in the upper parts of this terrace complex and consists of subrounded pebbles (average diameter 2 cm) of quartz, quartzite, sandstone, feldspar-porphyrity and slate with a few decomposed basic igneous rocks. The other two terraced fluvio-glacial deposits have higher sand to gravel ratios but the pebble contents are broadly similar. Pebbles of basic igneous rocks and greywacke are more common to the west, whereas pebbles of quartzite, quartz and quartzose sandstone become dominant in the terraces to the east.

#### 14. *Turriff Area*

Around the market town of Turriff sand and gravel terraces are extensively developed on both sides of the Deveron valley and on the east side of the Idoch Water valley. A particularly thick and extensive terrace underlain by sand extends south-east from Turriff itself. The terraces are fluvio-glacial in origin and lie at about 50 m OD although there is a succession of small terraces up to 100 m OD above Upper Smiddyseat farm [NJ 744 497]. Two large sand pits have been worked until recently on the south-east margin of Turriff and near Lower Smiddyseat farm [736 491]. The estimated resources in the Turriff area are about 10 million tonnes, the remainder (Table 1) being sterilised by the presence of houses, factories, farms and golf courses.

At Lower Smiddyseat Pit [737 489] 2 m of well bedded sand and gravel overlies 15 m of cross-bedded, clean quartz sand with very minor gravel. Pebbles consist of quartz, greywacke, grit, slate, sandstone, granite, pegmatite and feldspar-porphyrity. The sand and gravel is overlain by 1 to 2 m of sandy till.

Sand to gravel ratios in the exposed pits vary from 60/40 to 90/10 with sand generally predominating. Pebble types are fairly consistent but some striped limestone was noted in a disused pit [715 496] west of Turriff.

At Silverstripe farm [680 514] a prominent ridge of sand underlain by thin silty gravel occurs at a height of 100 m OD. The ridge is probably an esker.

#### 15. *Balquhindachy*

Along the valley of the Idoch Water around Balquhindachy farm [NJ 763 487] and on the western margin of Cuminestown, glacial sand and gravel occurs in hummocks up to 5 m high. A small pit [760 485] with a 4 m high face shows well bedded, medium grained sand and poorly sorted subrounded gravel in a ratio 60/40. Pebbles average 2 cm in diameter and consist chiefly of indurated sandstone, granite, intermediate igneous rocks, quartz and quartzite with smaller amounts of friable red sandstone and feldspar-porphyrity. Small fluvial gravel and sand terraces 1 to 2 m thick occur locally along other parts of the Idoch Water valley.

#### 16. *Fyvie-Woodend*

The Turriff-Fyvie valley, which acted as a very large southerly flowing overflow channel into the Ythan valley, contains sand and gravel terraces between Woodend and Fyvie. Around Woodend farm [NJ 752 449] and the lower parts of the Burn of Balquholly, bedded sand and gravel form terraces up to 7 m high. At a large pit [752 450] near Woodend, poorly sorted, subrounded gravel is composed of pebbles of granite, sandstone, quartzite, chert, slate and greywacke. Finer grained slate-rich gravel occurs near the base of the pit. The sand to gravel ratio is about 50/50.

To the south, the Old Red Sandstone conglomerate has locally weathered to give a dirty, hematitic and bouldery gravel. A small pit [755 419] shows completely decomposed boulders of granite and basic igneous rocks.

The Fyvie gravels are largely derived from erosion of conglomerate of Old Red Sandstone age and hence the constituent pebbles are commonly rounded quartzite and sandstone. The matrix is generally silty sand. The bulk of the Fyvie gravels lies within the private estate of Fyvie Castle.

### 17. 'Pliocene' Gravels

These distinctive gravels consist dominantly of very well rounded, pure white quartzite and subsidiary white to fawn flint pebbles in a white sandy matrix. Clay is commonly present in minor quantities, particularly in the lower parts of the deposits. The gravels invariably occur at 120 to 130 m OD and form areas of heathland or woodland. Only remnants of this formerly more extensive marine terrace are now found (Read, 1923, p. 183).

#### a. Windyhills

Many small pits have been developed in this large deposit from time to time. A good exposure occurs at present at a small pit [NJ 801 399] where a face of 3.5 m shows quartzite gravel with scattered flints in a matrix of medium grained sand. Over 1 m of white sand with clay and muscovite underlies the gravel.

#### b. Delgaty

Brown sandstone pebbles are found here [744 508] in addition to the predominant well rounded quartzite clasts. Exposure is generally poor and the high water table would restrict the workable thickness.

#### c. Hospital Wood

There is a small pit [735 460] showing 3 m of typical quartzite gravel and white sand at the edge of Hospital Wood [735 458]. Poor exposures also occur in the wood itself.

### 18. Auchterless

One kilometre south-west of Kirktown of Auchterless about 3 m of gravel with a silty sand matrix are poorly exposed in terraces on the east side of the River Ythan [NJ 710 409]. The pebbles are poorly sorted and are composed predominantly of greywacke and sandstone. Further west at Thorneybank farm [686 401] there is an exposure showing 2 m of bedded fine grained sand.

### 19. Easterton

One kilometre south-south-west of Easterton farm there is a small pit [NJ 764 302] showing coarse grained, angular feldspathic sand and gravel of probable ice contact origin. Weathered basic igneous rocks with minor slate, quartzite and granite occur as pebbles.

### 20. New Aberdour to Boyndlie

Glacial meltwater sand and gravel is disposed in mounds across this area, resting on an irregular floor of bedrock and till which is exposed locally, particularly in the valleys. Faces up to and over 10 m high could be opened up in places, but the overall thickness is much less than this. Sand probably predominates. A large quarry at Blackhills [NJ 924 612] shows the following section.

Gravel: up to 10 m moderately graded, with sandy and bouldery beds. Pebbles are dominantly of Dalradian grit with subsidiary quantities of granitic rocks, mica-schist, sandstone, quartz and basic igneous rocks. Iron pan occurs in the top metre.

Sand: up to 7 m fine to coarse grained. It contains a few fragments of marine shells.

### 21. Rosehearty to Rathen

Sand and gravel in the area forms ridges, mounds and flat terraces which extend from near Rosehearty to Rathen. This area is subdivided into three units for convenience of description.

a. A gently undulating terrace formed of glacial outwash deposits extends east-south-east from Mid Ardlaw [NJ 943 639] to Cairnmuir [982 620]. At the

latter locality a working quarry exposes between 2 and 4 m of moderately graded gravel overlying sand. The gravel is varied regarding sphericity, roundness and pebble lithology, being composed predominantly of psammites (metamorphosed sandstone), with subsidiary granite, gabbro, schist and limestone. It is slightly to moderately weathered, and reddened or blackened in places by ferruginous hardpan. Only the gravel bed is being currently worked, and extraction is constrained either by the underlying sand or by the water table, which is at no great depth. The general conditions seen at this quarry probably apply to the remaining parts of the terrace, which is expected to be predominantly formed of gravel.

b. The mounds and ridges which can be followed from 2 km south of Rosehearty to the Sinclair Hills and Ford O'Fowrie [993 618] have been worked on a small scale in the past for sand and gravel. At the latter locality a small pit (now entirely covered up) formerly showed about 5 m of sand and gravel with a little silt. The pebbles and cobbles included not only metamorphic and igneous rocks of the type noted in 21a but soft porous limestone of Cretaceous age. These limestone pebbles may be quite widespread throughout this area. The largest deposit here probably occurs in the Sinclair Hills which reach a height of nearly 20 m above their surroundings and cover an area of a little less than a square kilometre. Though there are few exposures it is likely that sand predominates over gravel.

c. The sand and gravel hills extending north-east of Rathen village are known to have been formed by meltwater in contact with glacier ice and are not sand dunes as reported by Anderson (1943, p. 25). A 4 m quarry face [NK 011 624] exposes sand passing upwards into fine to coarse grained gravel consisting of subangular to subrounded fragments of schistose grits, psammites, mica-schists, quartz and sandstone. The gravel, which is up to 3 m thick, includes a 50 cm thick layer of hardpan near the top in which some of the pebbles are weathered. Elsewhere in the area about Rathen Station, faces between 5 and 10 m high could be opened up, and the estimate of the volume of the resource in this area (some  $8 \times 10^6 \text{ m}^3$ ) may be greatly exceeded.

### 22. St Combs-Peterhead

The coast here is backed by dunes which extend inland about half a kilometre. These are composed of medium grained sand with shell fragments which are abundant in places. Gravel is known, from borehole evidence, to underlie the blown sand at one locality between St Fergus and Rattray Head [NK 110 580], and may occur beneath the dunes elsewhere. No tonnage can be given for this deposit.

### 23. Satyrhills

This deposit [NK 000 575], mentioned by Anderson (1943), has yet to be exploited. It consists of ridges and mounds in which faces up to 6 m high could be opened up. Another ridge, which is a continuation of those at the Satyrhills, extends north-north-west for 1.5 km from Strathstodley [030 563]. The composition of these mounds is not known.

### 24. North Ugie Water

Terraced deposits of alluvial and possibly fluvioglacial sand and gravel flank the river from Strichen downstream to the Longside area (see area 26 below).

Near Strichen the terrace deposits are mainly gravel, but downstream at Denhead [NJ 998 522] sand and silt predominate. The deposits in the latter area occur as an alluvial fan or delta at the exit of a glacial drainage channel which carried meltwater from ice standing to the north. Strichen itself is built on a gravel terrace possibly 3 to 4 m thick. Similar deposits were extensively worked until recently south of Hillhead at a locality [960 535] where the deposits (mainly sandy gravel) averaged about 3.5 m thick.

In the Denhead area a recently worked pit [990 528] exposed 3 to 4 m of gravel, on fine grained sand 2 m+; another pit [993 522] 3 to 4 m of sand and fine to medium grained gravel, and an intermittently worked pit [997 521] sand and fine grained sand 4 m with only a little gravel. The nature of the material below pit level is not known. Sand, particularly fine grained sand, predominates over gravel. The terrace south of the river in this neighbourhood could also be a further source of sand and gravel, though the sand to gravel ratio is not known.

A small area of deposit [NK 001 550] near New Leeds exposes some 3 m of sandy gravel with cobbles.

In area 24 as a whole the pebble assemblage of the gravel is very varied with grits (greywacke), psammite, schist, slate, felsite, quartz and quartzite. Dark basic igneous rocks and sandstones also occur. The schists and basic igneous rocks tend to be slightly weathered, but hardpan does not seem to be extensive.

#### 25. Rora

Terrace deposits of sand and gravel flank a tributary of the River Ugie between the northern edge of Rora Moss [NK 050 527] and the Burnthillock area [072 505]. In a pit at Burnthillock about 3 m of sandy gravel and gravelly sand lie on sticky red till. The pebbles in the gravel include psammite, greywacke, hornfels, basic igneous rock, granite, biotite-schist, pelite, quartz and limestone. There are few stones greater than 50 cm long. Some schist and granite pebbles are weathered. Hardpan and iron weathering are irregularly distributed on a small scale. About 2 km up valley there are sand and gravel deposits in the valley bottom about which little is known. They probably extend below the water table.

#### 26. Longside

Flat or gently undulating sand and gravel of fluvial and fluvioglacial origin which covers an area of 10 km<sup>2</sup>, is currently being worked in five quarries, all of which are adjacent to the North Ugie Water:

Most of the gravels are moderately well graded with subangular to subrounded pebbles. The sphericity depends to some extent on composition, being lowest for schists pebbles (somewhat platy) and highest for granite. The pebble content varies with grain size. In fine grained gravels, schistose grits and fine grained schists predominate, with some psammite (well rounded), vein quartz, andalusite-schist, granite and basic igneous rocks. The coarser bouldery gravels are composed of about 50 per cent granite pebbles.

Hardpan is significant locally and in places occurs both immediately below the peaty soil and at the base of the deposit, near the water table. A few pebbles of granite and schist are weathered.

There is little or no overburden over most of the deposit, but at a recently abandoned quarry at Faichfield [NK 063 467], gravel is capped by up to 1.5 m of reddish-brown laminated silt and clay. This type of overburden together with peat is to be expected at other localities near the valley bottom.

#### 27. South Ugie Water

a. Terraced deposits of sand and gravel underlie and extend northwards from Stuartfield [NJ 973 457], and are therefore partly sterilised by buildings. No information is available on the grading and lithology of the strata.

b. Sand and gravel mounds were formerly worked at two pits near Fridayhill [NJ 922 523] and Grassiehill [912 520], being excavated to a depth of about 4 m at the latter locality. Sand probably predominates over gravel. The pebbles are chiefly of semipelite and psammite with a few of vein quartz and granite. It is probable that further workable sand and gravel occurs hereabouts, but no estimate can be given of area and thickness.

#### 28. Boddam

This contains scattered localities for sand and gravel, including flint gravels possibly of Pliocene age of which details are given by Anderson (1943). Occurrences are described from west to east.

a. A hillside quarry [NK 024 440] near Oldmill exposes about 12 m of coarse grained sand with pebble beds, overlain by 0 to 3 m of brown till. The pebbles, locally of cobble size, are well rounded and of moderate to high sphericity and consist of fresh pink granite, schists, diorite (some weathered), basalt and flint. There is little information available on which to estimate the tonnage remaining at this locality.

b. There is no new information concerning the Pliocene gravels which underlie the Corse of Balloch

Grid ref. NK	Worked thickness (m)	Substratum/ working limit	Comment
022 505 Mill of Hythie	3 to 5	Not reached	Gravel with much sand
029 500 Dumpston	2.5 to 5	Silt and dark laminated clay	Dominantly bouldery gravel
036 494 Knaps of Auchlee	4 to 6	Water table: till?	Mainly sand
038 491 Woodside	4 to 5	Not known	Mainly sand
046 486 Auchlee	2 to 5	Water table: soft sand and red silt	Gravel with sand below

[050 410], Hill of Longhaven [085 420] and Boddam Den [114 415]. According to Anderson (1943, p. 19) about 80 to 90 per cent of the pebbles in these gravels are flint, and the remainder quartzite. The matrix is silt and clay. It is unlikely that the average thickness of the deposits exceeds 2 or 3 m, though at Boddam Den the gravels are found on the sides of a channel some 20 m deep. Near Savock an exposure [066 426] in a 3 m high bank near the bottom of another channel is of sandy gravel full of very well rounded flints together with a few pebbles of quartzite, granite and schist. The deposit is probably of negligible extent.

c. There is a small area of fluvio-glacial outwash gravel near North Collielaw [093 430]. A quarry exposure 3.5 m high shows sand with subsidiary gravel and silt locally overlain by a till-like deposit. The pebbles are of reworked, well rounded flint with subsidiary granite, and much of the sand seems to be derived from decomposed granite. There are many patches of ferruginous staining and black hardpan.

### 29. Cruden Bay

The deposits here lie at the northern end of a belt of interbedded sand, silt, gravel and till which extends northwards from the River Ythan. These sediments reach a great thickness in places (perhaps 40 m at Aad Braes [NK 063 365]) but seem to consist mainly of fine grained reddish micaceous sand of doubtful economic value, and only a small proportion of gravel. Inland, however, potentially workable deposits (probably mainly sand) are present in the Hatton area, and at the village a quarry [054 371] exposes about 1.5 m of fine to coarse grained sandy gravel overlying 6 m of fine to coarse grained sand with very subsidiary beds of red silt. The section is locally covered by thin till. Shell fragments occur in the sand. Psammite and mica-schist pebbles predominate in the gravel, accompanied by significant quantities of granite, greywacke, and limestone, and by sparse flints. Another temporary section nearby [055 370] recently exposed 2 m of interbedded gravel and sand, together with red silt, clay and till.

Inland, sand and gravel forms the isolated Hill of Auchleuchries [NK 005 367] where a small quarry 5 m deep exposes sandy gravel with pebbles mainly of psammite, granite, and basic igneous rocks.

## City of Aberdeen District

The sand and gravel resources of the City of Aberdeen comprise fluvio-glacial and fluvial terrace deposits in the valleys of the River Dee and Don together with spreads laid down in contact with glacier ice at the close of the last glaciation. The latter are particularly important near the coast north of the River Don where they form a series of north-north-east trending ridges and mounds. Thick sand and gravel deposits are also present beneath Aberdeen itself where many of the more accessible localities have already been worked out or are covered by buildings. Resources are likely to greatly exceed the figures given in Table 1, but boring will be needed to confirm known deposits and to substantiate other possible sources of sand and gravel.

### DESCRIPTION OF DEPOSITS

#### 1. Dyce

The south side of the Don valley at this locality is underlain by undulating fluvio-glacial sand and gravel

which has been extensively worked for a number of years at the Mill of Dyce (St Fergus) sand and gravel quarry [NJ 875 150]. The present quarry face, 8 to 14 m high, exposes a threefold succession with coarse, well graded, cobbly and bouldery gravel 2 to 7 m thick sandwiched between two sand units composed predominantly of sharp sand with horizons of pebble-size stones. These beds vary in thickness across the quarry, the upper sand thickening from zero to several metres in the hollows. The lower, deltaic, sand is not bottomed in the quarry. Granite and gneiss pebbles predominate in the gravel, with subsidiary psammite, quartzite and mica-schist. Clayey and peaty lenses at the contact of the gravel and the upper sand unit are accompanied by hardpan, but otherwise ferruginous staining is slight.

The rock floor of the Don valley extends well below river level in this area. A borehole at Boat of Hatton bridge passed through over 20 m of deposit including sand and gravel, without reaching rockhead. Resources of sand and gravel below the water table are therefore likely to be several times those given in Table 1.

#### 2. Stonewood

Mounds of gravel mixed with stony till cover the valley bottom for 3 km west of the village. No quantitative information is available but it is unlikely that individual mounds would provide working faces of more than a few metres. The ratio of gravel to till is also not known.

#### 3. Bridge of Don to Corby Loch

The sand and gravel in this area is disposed in mounds (some of which have been destroyed by quarrying), in undulating sheets lying on till, and as beds within sequences of silt, till and fine grained sand. There are also coastal sand dunes (blown sand) which probably constitute a resource of several million tonnes. Rockhead is not exposed near the coast north of the Bridge of Don and superficial deposits are known to extend well below Ordnance Datum in places. Such deposits may include resources of sand and gravel on a scale similar to those known to lie beneath Aberdeen itself, but this possibility requires to be investigated by boring. Further resources may occur in a postulated buried channel of the River Don between Dyce and the coast to the east (Chester and others, 1974).

At present there are only two working pits in the area. North of Corby Loch a trial excavation 4 m high in Kaim Hill [NJ 924 149], which is part of an area of mounds, exposes bouldery gravel with sandy cross-beds capped by 0.5 m of silt and till. Gravel predominates over sand, the pebbles and cobbles being mainly granite, with psammite, semipelitic schist, mica-schist and gabbro. Some of the granite and gabbro pebbles are weathered. Another opening just outside the District near Newtonhill [930 155] shows about 3 m of moderately to well graded gravel lying on greyish brown stony till. At Annfield [927 140] an opening in undulating country between mounds exposes about 2 m of sand and gravel on till, there being considerable hardpan development in places. These pits probably give a good idea of the lithology and thickness of deposits in mounds and in inter-mound areas (though exaggerating the proportion of gravel). From these indications it could be inferred that the mounds north-east of Corby Loch contain about 1.5 million tonnes of deposit. This figure could probably be augmented by extracting the thin resources of the inter-mound areas.

A flat topped mound [930 135] at Leuchlands apparently constitutes a readily workable resource of sand and gravel with the usual wide size range of gravel (Table 1).

#### 4. *Nigg and Cove*

Small amounts of sand and gravel mixed with silt are present at Nigg and in the area west of Cove Bay (Fig. 2). A buried channel of the River Dee extending eastwards to the Bay of Nigg could also contain several million tonnes of deposit, chiefly below the water table. Deposits including sand and gravel are known from borehole evidence to reach at least 15 m below river level at Bridge of Dee [NJ 928 036].

#### 5. *Deeside*

Terraces on the north bank of the River Dee are a potential resource of sand and gravel. The proportion of sand to gravel and the lithology of the gravel pebbles are not known, but the latter is likely to be similar to that noted for areas north of Aberdeen. It is unlikely that these deposits could be exploited because they are largely built over. Other resources may be found in the Westfield area [NJ 856 035].

#### 6. *Anguston*

Sand and gravel underlying an area centred on Easter Anguston [NJ 823 016] rests on till and rock at no great depth, and the deposit may possibly be adversely affected by hardpan. Nothing is known about the pebble composition.

#### 7. *Brimmondside*

Sand and gravel occurring as mounds and terraces extends from Wynford [NJ 843 089] south-west to near Kingsford [852 064]. This material is worked at a pit [850 080] 15 m deep where the deposit consists of roughly equal quantities of sand and gravel with a small amount of silt, but sand predominates at the south side of the excavation. As in most ice-contact sands and gravels there is a rapid lateral and vertical variation in grain size. Pebbles of granite predominate, closely followed by psammite and mica-schist, and much of the matrix is sharp sand derived from granite. Some of the granite pebbles are decomposed. Though no figure can be put on the volume of the resource at this neighbourhood it is to be expected that other working faces could be opened up.

#### 8. *Leuchar Moss*

Fluvioglacial outwash gravels underlie part of the Moss. A small pit [NJ 790 043] exposes about 3 m of medium to coarse grained pebbly sand with a few cobbles. The clasts are mainly granite. Extraction here and below the rest of the Moss would probably be limited to a depth of 2 or 3 m by the water table, and the deposit is probably overlain by 1 to 2 m of peat in places.

## Gordon District

The sand and gravel resources of the Gordon District are to be found mainly in the river terraces flanking the Deveron, Don and Ythan valleys together with mounded, ice-contact deposits laid down at the close of the last glaciation. The latter occur in a broad west to east band, north of and parallel to the lower course of the River Don, and also in the coastal hinterland from

Aberdeen northwards. Dune sands occur immediately inland from the coast at many localities. For the most part the resources are of good quality, but in places they are adversely affected by weathering, the presence of silt beds and staining by iron and manganese oxides and hydroxides. Overburden is thin or absent throughout most of the district, but may become a problem near the coast following the exhaustion of accessible and easily worked deposits.

In the following account attention is given almost entirely to resources which can be worked above the water table. As noted in appropriate sections below, however, a great thickness of deposits including sand and gravel occurs below river level in the Don valley south of Inverurie, the resources possibly amounting to several tens of million tonnes. Other sand and gravel deposits occurring below the water table are listed in Table 2.

## DESCRIPTION OF DEPOSITS

### 1. *Ruthven-South Rothiemay*

The most important deposits in the Strathbogie area are the fluvioglacial sand and gravel terraces around Ruthven. These are quarried in a large pit [NJ 512 469] in which a 6 to 10 m working face shows poorly sorted subangular gravel with medium to coarse grained sand. The sand to gravel ratio is 40/60 and the gravel consists of slate, basic rocks, striped limestone, quartzite, feldspar-porphyry, greywacke and minor decomposed mica-schist. Sand and gravel is also well exposed in a 12 m deep stream valley near the ruin of Dough farm [507 477] where small sand lenses lie in a similar lithology. Boreholes in the vicinity of Littlemill farm [518 475] suggest that gravels, possibly fluvial in origin, lie beneath the water table to a depth of about 10 m. Small sand and gravel deposits also occur around Tillytarmont farm [530 465] and on the south bank of the River Deveron at Rothiemay.

### 2. *Kinnoir*

In the vicinity of Longmoor Wood [NJ 564 438] and Carse of Kinnoir [550 435] up to 3 m of clean, medium to fine grained quartz sand with minor mica and hornblende is found in scattered, disused pits. The bulk of the sand resource is below the water table, which lies within 1 m of the ground surface in most areas. The absence of borehole data and lack of relief precludes any estimate of tonnage for this deposit. The sand is associated with silt and clays which probably underlie the area.

### 3. *Kirkstile*

Around Kirkstile, some 5 km south of Huntly, two prominent north-north-east trending eskers, the Riggan and Little Riggan, are composed of sand and gravel. In a pit [NJ 526 351] up to 10 m of subangular gravel and coarse grained clean sand is exposed. The sand to gravel ratio is about 65/35. Resources in the area may be about 900 000 tonnes. The gravel consists of subangular pebbles which are mainly of slate, porphyry, indurated sandstone and quartzite.

Fluvial sand and gravel of local importance occurs further north, about 1 km south of Greenhough farm [520 375], where disused and overgrown pits are found in 3 m high terraces.

### 4. *Gartly-Cults*

Sand and gravel underlies terraces 750 m east of Mains of Kirkney farm [NJ 519 335] and adjacent to Gartly

Station [523 323]. At the former locality much of the deposit has already been quarried. Although these deposits are chiefly fluvio-glacial, some local reworking by streams may have occurred subsequently.

Near Cults farm [534 310] a thick deposit formed chiefly of sand is well seen in two small pits. Gravel is more abundant in the north-east part of the deposit and near the top of the sequence. Pebble lithologies are dominantly indurated sandstone, quartzite and porphyry.

#### 5. *Blairindinny*

Discontinuous fluvial gravel terraces are found on the east bank of the Water of Bogie near Blairindinny [NJ 518 289] and Haremire [525 300] farms. Rounded to subrounded pebbles and cobbles lie in a sandy silt matrix. The pebbles are dominantly sandstone and arkose with minor granite, weathered basic igneous rocks, vein quartz and porphyry. The water table restricts the depth of quarrying to 2 or 3 m.

#### 6. *The Shevock*

West of Kennethmont at the Shevock [NJ 583 293], ridges and mounds of fluvio-glacial sand and fine gravel are found adjacent to the A979 road. Exposure is generally poor and resources are probably small.

#### 7. *Lumsden*

Near Lumsden [NJ 478 228] there is a deposit of fluvio-glacial sands, gravels and silts with an average thickness of around 5 m (though with mounds up to 15 m in height), covering an area of approximately 100 hectares. The resource here is thought to amount to about 9 million tonnes. At Govals [478 228] 1 m gravel is seen in a small pit overlying 2 m sand with fine gravel lenses. Pebbles in the gravel are up to 10 cm in diameter, a few being decomposed. Fragments are of quartzite and vein quartz, with some mica-schist, gneiss and granite pebbles. There are also a few pebbles of limestone and sandstone. Another small pit nearby [476 228] shows poorly sorted sand and gravel. The gravel here is much coarser, with clasts up to 20 cm in diameter common.

The above deposits occur within a larger area of ridges, mounds and channels extending from Kildrummy [470 177] to approximately 1.5 km south of Rhynie, an area approximately 8 km in length by 2 km wide. Within this area deposits are highly variable in type and extent. The mounds and ridges are seldom more than 2 m high. Those to the south of Lumsden, where exposed, are generally composed of coarse gravel with boulders up to 25 cm in diameter (as at South Deskie [474 207]). Other small exposures show fine grained sand, for instance at Birkenbrowl [464 209]. Further north, at an exposure near Quarry Hill [493 255], 2 m of bedded sands and gravels are seen. Pebbles are dominantly of quartzite and indurated feldspathic sandstone with some diorite and gabbro. A few of the pebbles are highly weathered or completely decomposed.

#### 8. *Cock Bridge*

Several small terrace deposits of fluvio-glacial sand and gravel occur in this area. They are not extensive and possibly of low economic potential due to their distance from likely markets. The terraces are in general around 2 m in height.

#### 9. *Water of Nocht*

The resources here are composed of fluvio-glacial deposits in the form of kames and ridges. Near Ledmacay [NJ 342 142] 10 m of sands and gravels are exposed at the riverside. In general, these are composed predominantly of sand, but with a few beds of gravel over 1 m thick. The clasts in the gravel are 5 to 10 cm in diameter.

#### 10. *Water of Buchat*

Fluvio-glacial gravels occur along the Water of Buchat from Kirkton of Glenbuchat to the River Don. These are in general thin, and not very extensive. They have been worked in several places on a very small scale, for example, at Dockington [NJ 385 157] and Blackhillock [396 157]. Similar deposits are to be seen in some of the other tributary valleys in this area, for example, near Birkford [352 095] where there is a series of low mounds around 2 m in height covering an area of approximately 25 hectares. There are no exposures to be seen, but the deposits are likely to consist of mixed fluvio-glacial sands and gravels. A 2 m high terrace of poorly sorted fluvio-glacial sand and gravel, possibly modified by more recent river action, occurs on the north side of the River Don near Towie [455 133]. Surface area is between 2 and 5 hectares.

#### 11. *Blairdaff*

This is an area of mounded fluvio-glacial deposits. As there are few exposures estimates of workable resources are very tentative. The average thickness of the deposits is probably in the region of 4 to 5 m, covering an area of approximately 140 hectares. At a locality [NJ 713 183] 1 m of unsorted sand and gravel is seen with pebbles up to 5 cm in diameter. The pebbles are mainly of granite with some of gneiss.

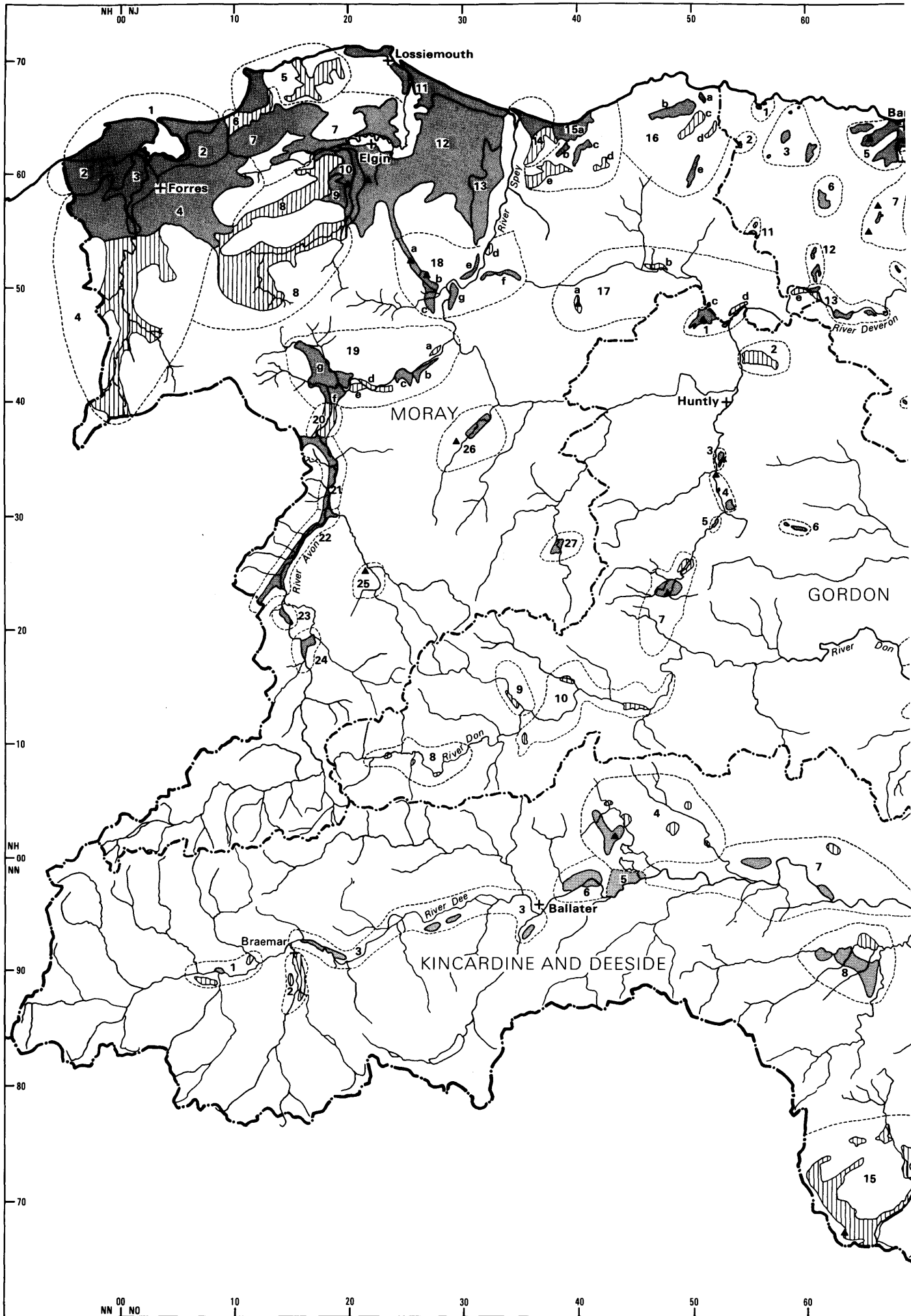
#### 12. *Kemnay*

The deposits of sand and gravel in the Kemnay area occur in a terrace north and north-west of Kemnay, and in a kame which extends from near the golf course [NJ 726 153] to Dalriach, with a possible extension to the south-south-west (see below).

The terrace deposit to the north of Kemnay [733 168] is being worked on a small scale at present for local use. In general the exposures show coarse granitic sand (perhaps 90 per cent of the deposit), with gravel lenses containing pebbles up to 5 cm in diameter. The present working is removing the top 3 to 3.5 m of the terrace feature. The base of the deposit is unknown, but river level is at about 8 m below the base of the present working. The surface area of the workable deposits is estimated at around 30 hectares with a maximum thickness of 8 m. Adjoining this deposit is a small kame composed of coarse gravel with some thin bands of sand. The boulders in the gravel commonly reach 30 cm in diameter and consist mainly of granite with some schist. Approximately 50 per cent of the pebbles in the top 1 m of this exposure are decomposed.

#### 13. *Dalriach*

The kame feature running south-west from the golf course has an average height of 6 m and an average width of 15 m. It has been breached in several places and its surface area may be in the region of 20 hectares. An exposure at the roadside [NJ 725 151] shows 6 m of coarse unsorted gravel with clasts of 5 to 25 cm in diameter, composed mainly of granite. A few of the pebbles are decomposed.





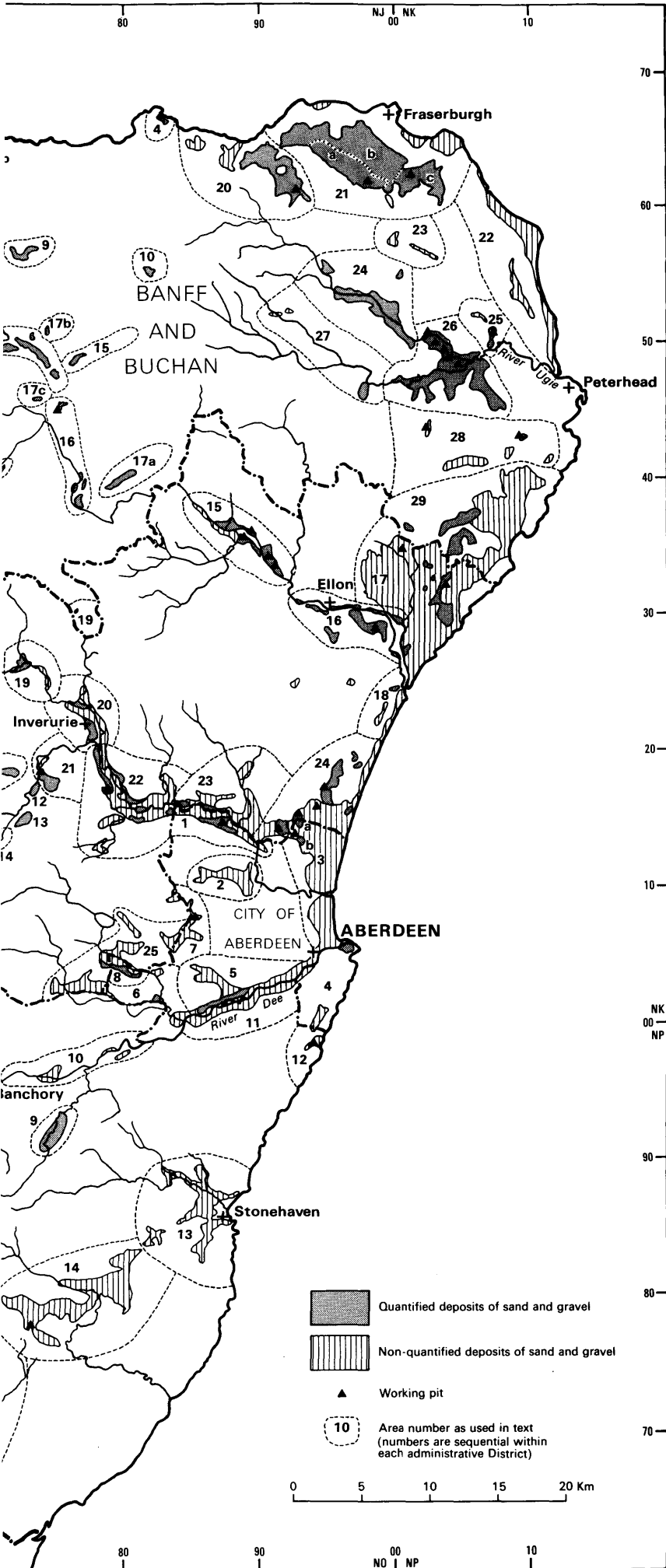


Fig. 2. Resources of sand and gravel above the water table.

#### 14. *Ton Burn and Cunningar Wood*

This is a poorly exposed mounded area, probably underlain by sands and gravels. At the Ton Burn [NJ 695 134] there is a ridge, approximately 8 m in height and several hundred metres long, in which there are traces of sand and gravel. At Cunningar Wood [694 130] meltwater deposits cover an area of approximately 4 hectares.

The mounds have an average height of around 2 m and where exposed show a bedded coarse sand and a fine gravel with pebbles up to 1 cm in diameter. The clasts appear to be entirely of granite.

#### 15. *Haddo and Michael Muir*

The River Ythan below Methlick is flanked on both sides by fluvial and fluvio-glacial terraces formed chiefly of gravel. The deposits are currently being exploited in four pits:

Grid ref.	Worked thickness (m)	Substratum/working limit	Comment
NJ 883 358	7 to 12	Water table	Gravel, some sand
NJ 893 358	9	Brown stony till	Gravel, some sand
NJ 906 340	3.5	Laminated silt	Gravel
NJ 908 336	4 to 7	Brown clay	Gravel and sand

There is a tendency for the sandier beds to occur towards the base of the deposits. At all four localities the gravel is well graded, with the medium grained gravel less angular than the coarser fractions. Boulders up to 1 m across occur locally, and those about 30 cm across are numerous. The stones are mainly hard psammite, quartzite and semipelite, with subsidiary mica-schist, granite and gabbro. Some of the granite and gabbro pebbles are decomposed, and at one locality [NJ 893 358] the sand fraction may be derived from decomposed basic rocks and schists. Hardpan formation is slight in most places. Unexploited deposits occur at Bellmuir [875 365] where faces up to 20 m high could be worked in bouldery gravel.

#### 16. *Ellon district*

The resources here are to be found in terraces of the River Ythan and in ice-contact sand and gravel on the higher ground south of Ellon. At Deepheather [NJ 977 292] a recently worked quarry exposes between 2 and 4 m of fine to coarse grained gravel above the water table. The deposit as a whole is finer grained than the terrace gravels in area 1, though still predominantly gravel. The pebbles are chiefly of psammite with smaller proportions of granite, schist and gabbro. Some soft stones occur, and there is considerable iron staining locally. Similar deposits are to be found on the north side of the River Ythan at Waulkmill [NK 002 295] in a disused quarry, and also in natural exposures in the right bank of the river west of the bridge [002 268] north of Newburgh, where up to 3 m of gravel and sand are seen. The ice-contact sand and gravel south of Ellon is exposed in an old pit [NJ 953 282] near Cross Stone, where a section 8 m high in the side of a mound shows sand with subsidiary fine to medium grained gravel, and another section near the farm [953 278] exposes 1.5 m of gravel with subsidiary sand.

#### 17. *Collieston*

The resources in this district occur in ridges and mounds, particularly in the neighbourhood of Meikle Loch, in interstratified sand, silt, till and gravel, and as blown sand. The last named is more or less confined to the Forvie Nature Reserve and is not considered further here. At present only the resources in the ridges and mounds adjacent to Meikle Loch are quantifiable for the purposes of this account, since it is not possible to assess the interstratified deposits even in the very general terms of this report because of their variability.

Exposures in the mounded deposits are few. At Whitefields [NK 032 320] an intermittently worked pit excavated into a flat-topped mound exposes up to 10 m of sand with subsidiary beds of gravel and silt, the whole capped by till up to 1 m thick. Here, as well as the usual varied collection of metamorphic rocks (psammite, semipelite, mica-schist, gneiss and granite) the pebbles include up to 20 per cent of Cretaceous limestone, and both the gravel and sand contain shell fragments. This deposit is probably fairly typical of those to be expected in the ridges further south. However, a second exposure by the River Ythan near Waterside [005 266] is devoid of limestone, the pebbles being chiefly granite and psammite. At this locality sand and gravel occur in roughly equal proportions.

At Tillybrex Quarry [001 348] the deposit lacks surface expression. Here about 7 m of deltaic gravel is underlain by silty to medium grained sand and capped by till about a metre thick. The gravel shows a predominance of moderately well rounded pebbles and fewer angular fragments than is usual for ice-contact deposits. Hardpan and ferruginous staining are widespread, and much of the gravel is slightly weathered.

#### 18. *Newburgh*

In this area the resources comprise coastal sand dunes, and ridges and mounds of sand and gravel. Just south of Newburgh itself a prominent mound (Gallows Hill [NJ 998 247]), is apparently composed of sand and gravel, but the exposures are too few to give any indication of proportions. Sand and gravel underlying till is also known to occur at a new housing estate [996 251]. Farther south, the more accessible mounds and ridges have been worked out near Drums [986 226], but some resources remain.

#### 19. *Whiteford*

Alluvial sand and gravel occupying a triangular area where a side stream enters the River Urie was formerly worked to a depth of nearly 5 m in a small pit at Bridgend [NJ 724 264]. There is no record either of the proportion of sand to gravel or of the composition of the pebbles. Other resources may occur in the valley of the River Urie east of Whiteford.

#### 20. *Balhalgardy and Inverurie*

The resources include fluvio-glacial and alluvial terraces adjacent to the River Urie. Of these the largest is sterilised by Inverurie itself, but about a third (2 to 3 million tonnes) occurs near Balhalgardy [NJ 762 237]. Another terrace on the east side of the river opposite Inverurie may also contain workable deposits of sand and gravel, but is possibly underlain by till at some localities. Rockhead may be at a considerable depth in the Urie valley near Inverurie and resources totalling several million tonnes may occur below river level (estimate not included in Tables).

### 21. *Mill Farm and Glenhead*

In this district sand and gravel occurs chiefly in the form of a complex of low mounds (2 to 3 m), higher ridges (up to 20 m), and terraces. A pit at Mill farm [NJ 738 177] exposes about a metre of cobbly gravel overlying 4 m of medium to coarse grained sand with a 10 cm bed of silt. The pebbles in the gravel are dominantly of granite and psammite with a few of basic igneous rocks, and vary from platy to almost spherical in shape. Hardpan is only weakly developed.

### 22. *Kintore*

There are widespread deposits of sand and gravel in the Kintore district, chiefly in the form of fluvioglacial and river terrace deposits. Subsurface deposits in the River Don valley may also prove to be very large (perhaps several tens of million tonnes), as boreholes at Hatton Bridge [NJ 837 158] and near Broomend [782 195] penetrated up to and over 20 m of sediments including sand and gravel.

The largest and most important deposit above the water table extends northwards from Tavelty [790 172] to Port Elphinstone [780 200]. This resource is currently being worked at a locality [787 172] near Tavelty where a 5 m section is exposed in sand, with gravel and cobbles forming perhaps 20 per cent of the deposit. This section is almost on the site of a ballast pit (Anderson, 1943, p. 10) in which nearly 10 m of sand with about 10 per cent of gravel was recorded. The pebbles are of granite and psammite with subsidiary schist. Intermittently worked sections at Cairnhall [785 178] show up to 7 m of coarse grained sand with subsidiary fine to medium grained gravel, the sand fraction consisting in part of washed, disintegrated granite. Similar sections have been reported at Fullerton [782 184] and Broomend [778 193] (Chester and others, 1974). Iron and manganese hardpan and staining are present in some sections, but are of little importance in the Tavelty quarry. A few of the granite and schist pebbles are decomposed.

On the opposite side of the River Don a gravel terrace extends southwards from near Ardmurdo House [792 188] to Wester Fintray [810 164]. At its northern end the gravel rests on till, but elsewhere may lie on the decomposed granite which is seen higher on the valley side. No information is available regarding the gravel to sand ratio and pebble lithology, but the material is expected to resemble that in the Tavelty-Elphinstone deposit. Other small deposits of sand and gravel occur at Dalwearie [808 152] and Kinaldie [833 153] on the south side of the Don.

### 23. *Hatton and New Machar*

The resources in this area comprise terrace deposits on the north bank of the River Don between Hatton of Fintray and Cothall [NJ 874 158] together with sand and gravel mounds extending northwards to New Machar. There is little exposure of these deposits at the present day, but the terrace near Hatton of Fintray was formerly quarried near Boat of Hatton [840 160] where Anderson (1943, p. 12) recorded almost 10 m of sharp, rather dirty sand with considerable gravel, the pebbles being mainly granite. About 5 per cent of the pebbles are noted as being decomposed (Chester and others, 1974). Sand and gravel also underlies a narrow belt between Cairnie [858 170] and Hawkshill [880 167] and the mounded ground south of New Machar. Other mounds in the neighbourhood of Monykebock [875 182] are known to consist of bedrock. Subsurface deposits in the River Don valley could be an important

resource of sand and gravel (see area 1 of the City of Aberdeen District).

### 24. *Potterton*

Sand and gravel in this area occurs as mounds and more featureless deposits together with sand dunes on the coast (see also area 3 of the City of Aberdeen District). The mounded deposits are at present worked in four pits, but other potential resources have not been exploited.

In the north of the area a large resource (perhaps of the order of 10 million tonnes) is to be found in the mounds which extend from Milton of Potterton [NJ 947 162] to South Orrok [962 191]. A roadside exposure at the south end of the deposit [947 163] shows 4.5 m of interbedded fine and coarse grained sand with beds of red silt and medium grained gravel. Farther north, sections in Cairntack quarry [948 175] show up to 6 m of well graded gravel with the material ranging from silt grade to boulders over 1 m across. This material is capped by red till, silt and gravel. The pebbles are a mixture of local psammites and mica-schists with many basic igneous rocks of the type to be seen at Balmedie Quarry nearby. Some of the gravel is weathered, and there is considerable iron staining with layers of hardpan.

West of Milton of Potterton, mounded deposits have been worked in two small pits [944 162 and 947 162]. The west pit exposes fine to coarse grained sand and red silt 3 to 4 m thick, with pockets of cobbly gravel, and the east pit a similar succession about 6 m thick overlain by up to 2 m of poorly sorted cobbly gravel. The pebbles in the gravel are composed chiefly of granite, schists and gneisses with a few of quartz and basic igneous rocks.

An area of mounds south of Newtonhill [930 154], which extends into the City of Aberdeen District (Fig. 2), has been worked at two localities. At Newtonhill sections in a quarry [930 155] show up to 3 m of well graded gravel on about 1 m of sharp pebbly sand. Till is exposed at the base of the excavation. There is considerable hardpan in places.

An important area of mounded sand and gravel occurs between Corby Loch and Bishops' Loch [912 142]. In this neighbourhood sand and gravel appear to extend some 10 m below the base of the mounds, occupying a hollow in the rock floor, and the resource has been assessed at between 4 and 6 million tonnes (Chester and others, 1974). Faces up to 6 m high are currently being worked at Loch Hills quarry [910 144] in a varied assemblage of silty sand, sharp sand, and fine grained to bouldery gravel, but thicknesses are up to 25 m in the central part of the excavation. Sand predominates over gravel. The larger boulders (up to 1 m) are chiefly granite, but mica-schist, psammite and semipelite are more significant in the gravel grades. The deposit is overlain by an overburden of interbedded till, sand, silt and gravel up to 2 m thick. Iron staining is slight where the overburden has been removed.

### 25. *Garlogie and Leuchar Moss*

Most of the appraised part of the resource here lies within the boundary of the City of Aberdeen District. The resources in the Gordon District comprise (a) a narrow, 2 km long belt of sand and gravel extending north-west and south-east of Kirkton of Skene [NJ 802 077], (b) sand and gravel mounds extending eastwards for 3 km from Roadside of Garlogie [782 054], (c) outwash sand and gravel underlying Leuchar Moss [785 045], and (d) mounds and ridges of sand and gravel in the valley of the Gormack Burn [770 023]. Little is

known about the resources in (a). In (b) a pipeline trench between localities [801 055] and [803 061] showed sand and gravel 2 m thick overlying till on the hillside, thickening towards the valley bottom. Much of the deposit however is below the water table and is capped by peat. A pit by the roadside [799 055] shows up to 8 m of mainly fine to medium grained sand, silty in places, with beds of sandy gravel towards the top of the mound. At Leuchar Moss (c), a pit within the City Aberdeen boundary exposes 3 m of pebbly sand, the clasts being mainly granite. The resources underlying the Moss may be about 1 million tonnes above the water table. The deposits in the Gormack Burn area (d) are known to be thin or absent between the low mounds, though small-scale resources might be found in an esker [770 017].

## Kincardine and Deeside District

Most of the sand and gravel resources in the Kincardine and Deeside District occur in the valley of the River Dee and in Strathmore. In the Dee area the deposits are of glacial and fluvio-glacial origin, and were laid down by meltwater of westward-retreating ice. Later fluvial action has reworked some of these deposits, resulting in terraces which flank the river. In some of the tributary valleys, and also in the Dee valley upstream of Braemar, the deposits are poorly sorted, and may include washed till. In the Cromar area, and also between the Water of Dye and the Water of Feugh, sand and gravel occurs extensively in the form of ridges and mounds which are associated with meltwater channels and fluvio-glacial outwash. These resources are of good quality for the most part, but in the Dee valley area may include pebbles of decomposed granite. Mudstone, lava, and sandstone pebbles which could possibly have a deleterious effect in certain types of concrete are to be found in some of the Strathmore gravels. In some areas, particularly those underlain by granite, the top few metres of bedrock is locally decomposed, and could be confused with sand and gravel in boreholes.

### DESCRIPTION OF DEPOSITS

#### 1. *Linn of Dee to Linn of Quoich*

The River Dee valley between Linn of Dee and Linn of Quoich contains several deposits of glacial and fluvio-glacial sands and gravels. Near Claybokie [NO 082 898] there is a small pit showing a thickness of 3 to 4 m of poorly sorted fine to medium grained gravel. The average grain size is approximately 2 to 5 cm. This deposit covers a very small area, around 9 hectares. Similar mounds occur on the south side of the River Dee west of Inverey [075 894] but there are no exposures.

At Linn of Quoich [116 910] there is an exposure showing 6 m of sand and gravel. This deposit is composed chiefly of poorly sorted gravel, though there appears to be bedding in a small section of the deposit. The section shows a matrix of fine gravel with pebbles up to 5 cm in diameter containing many much larger boulders, around 15 cm in diameter. The fragments are of psammite, quartzite, granite and gneiss. The deposit does not appear to be extensive, possibly covering an area of only 1 hectare though up to 15 m deep in places.

#### 2. *Glen Clunie*

South of Braemar, in Glen Clunie there are several narrow terraces of moundy sand and gravel, occurring mainly on the valley sides. These are exposed at several localities along the roadside, and faces of 4 to 5 m are

common. They are in general poorly sorted and commonly contain many angular rock fragments. Grain size is extremely variable, chiefly in the range of 5 to 30 cm. The clasts are dominantly of schist and quartzite, but there are also some of limestone.

At Balintuim [NO 152 895] there is an old pit showing up to 7 m of interbedded sand and gravel. The gravel has an average pebble size of 5 to 10 cm with a few boulders up to 30 cm diameter. This exposure has about equal proportions of sand and gravel but in other nearby sections gravel predominates.

#### 3. *River Dee Valley, Braemar to Ballater*

There are several terraces and mounds of glacial and fluvio-glacial sand and gravel on both sides of the Dee valley between Braemar and Ballater. In general the deposits thicken eastwards from Braemar (where they may be only 1 m thick) and moundy deposits of up to 10 m thickness occur near Invercauld Bridge [NO 202 910]. At this locality coarse gravels probably predominate, 50 per cent of the clasts being over 15 cm in diameter.

Near river level there are flat topped river terraces which are probably underlain by sand and gravel, for example, around Invercauld House [174 925].

Moundy deposits of coarse sand and gravel are also present near Littlemill [320 963] and at Balnacroft [285 944]. At Brachdhu [352 932] a small pit shows a face of 3 m in very coarse gravels, with many boulders up to 30 cm in diameter. The fragments are dominantly granite and quartzite, with some psammite. A few of the pebbles are decomposed.

The resources described above, which are thought to be in the order of 14 million tonnes, are however spread over a very large area and are nowhere concentrated in large deposits.

#### 4. *Cromar*

The Cromar area contains extensive spreads of glacial and fluvio-glacial sand and gravel. These are concentrated chiefly along the lower slopes on the eastern side of Culblean Hill [NJ 410 010], but considerable deposits are also to be found elsewhere in this area. The most extensive form a series of mounds and ridges extending from west of Loch Davan northwards to Groddie [407 052]. They are exposed at several places including a recently worked pit [433 022], where there is a face up to 6 m high. The deposit is poorly sorted, and is dominantly gravel with pebbles up to 15 cm in diameter, with some thin beds of coarse sand. The pebbles are mainly of granite with some of psammite. Decomposed pebbles comprise less than 1 per cent of the total. At the northern end of this belt of sand and gravel, near Milton of Whitehouse [410 042] an exposure in an esker-type feature shows 5 to 6 m of coarse sand with subsidiary lenses of fine gravel. Taken as a whole, the deposits on the eastern slopes of Culblean Hill have a surface area of approximately 400 hectares with an average thickness of around 2 m.

Many other less extensive deposits are to be found within the Cromar area. These invariably take the form of mounds and ridges. Examples of these are seen at the following localities:

- a. Blelack House [440 032] where poorly sorted coarse sand and fine gravel occurs in a kame feature approximately 8 m high.
- b. Newkirk [431 047] where a ridge of sand and gravel approximately 100 m long and 20 m wide has been

worked in a pit with a face of 3 m.

c. Mains of Kinraigie [494 044]. Here there is a small deposit of fluvioglacial sand in a ridge approximately 100 m long by 10 m wide.

d. To the north of Wester Coull [480 025] is an area (50 hectares) of low mounds 1 to 2 m in height.

e. Near Coull House [513 011] there is a mound of very coarse morainic or fluvioglacial gravel. This deposit contains many boulders up to 0.5 m in diameter, of metamorphic rocks and granite.

#### 5. *Muir of Dinnet*

To the south of Cromar there are extensive channelled terraces and mounds occupying the Muir of Dinnet, covering an area of approximately 100 hectares. An exposure in the river bank near Dinnet House [NO 440 977] shows 15 to 20 m of gravel of which the top 3 to 4 m consists of coarse, bedded gravel with clasts 10 to 20 cm in diameter mainly of granite. The remainder of the exposure shows an unsorted deposit of gravel and pebbles up to 20 cm in diameter in a silty and sandy matrix.

Development of any sand and gravel resources in the South Cromar area could be restricted by the presence of a high water table around Lochs Davan and Kinord. Part of this area has been designated as a site of special scientific interest by the Nature Conservancy.

#### 6. *Tomnakiest to Cambus O'May*

Mounds and terraces of fluvioglacial and glacial sand and gravel occur on both sides of the Dee around Cambus O'May [NO 410 980]. Mounds of up to 8 m are seen over an area of 200 hectares. There are few exposures, but the deposits are thought to resemble those in the Cromar area.

#### 7. *River Dee Valley, Dinnet to Banchory*

In this section of the River Dee valley there are extensive spreads of gravel generally forming terrace features. These are commonly poorly exposed, and the nature and depth of the deposits are not always known. At Sluie [NO 612 970] 4 to 5 m of gravel are exposed in a terrace feature. The pebbles in the gravel are in general 5 to 15 cm in diameter, with granite the dominant lithology. There is a very small fraction of decomposed pebbles. The gravel appears to overlie sand, but exposure is too poor to confirm this.

To the south of the Dee between Allanreich [573 966] and Birse [555 970] deposits of sand and gravel cover an area of roughly 200 hectares. To the north of the Dee between Aboyne and Mill of Dess [569 994] fluvioglacial deposits may cover an area of up to 100 hectares. Mounds, possibly of sand and gravel to the south-west of Torphins [620 015] cover an area of around 1.5 by 0.5 km, but there are no exposures.

#### 8. *Water of Dye to Water of Feugh*

An area of kames stretches from Mill of Cammie [NO 690 920] to the Bridge of Bogendreip [662 911], and southwestward to a locality 500 m north of Scolly's Cross [653 880]. These mounds cover an area of approximately 300 hectares and have an average thickness in the region of 5 m. An exposure near the school [652 886] shows 5 m of poorly sorted fluvioglacial deposits of sand and fine grained gravel with pebbles up to 15 cm in diameter. The clasts are dominantly of granite with some weathered pebbles in the top 0.5 m. A similar exposure showing 10 m of sand and gravel is seen at [652 895]. These deposits appear to

extend towards the north-west to Little Ennochie [633 918]. At Templeton [679 918] there is a small pit showing 1.5 m gravel overlying 4 m sand. The clasts in the gravel are almost entirely granite and there is little evidence of decomposed pebbles. There is a possible continuation of these deposits in a small area to the north of the Water of Feugh around Waulkmill [647 922].

The resources in the Water of Feugh area are comparatively large (see Table 1). The area is however heavily forested, a factor which might hinder any development.

#### 9. *Blairydryne*

Fluvioglacial deposits occur along the burn of Sheeoch from below Westerton [NO 735 910] to Blairydryne [752 927]. These cover an area of around 100 hectares with a thickness of possibly no more than 2 to 3 m. A small pit near Blairydryne shows 1 to 2 m of coarse gravel overlying 3 to 4 m coarse sand with gravel lenses. The gravel contains many boulders up to 20 cm in diameter. The clasts are mainly of granite.

#### 10. *River Dee Valley, Banchory to Peterculter*

Spreads of sand and gravel, both alluvial and fluvioglacial, are located along both banks of the River Dee downstream from Banchory. These are fairly variable in thickness and in general they are unexposed. Moundy fluvioglacial deposits occur near Crathes [NO 750 964] and Park [785 985]. Where exposed these show gravel with granite fragments, and pebble sizes up to 5 cm diameter are common. There are extensive banks of coarse gravel in the bed of the River Dee itself; their thickness is not known.

#### 11. *South Deeside, Peterculter to Aberdeen*

River terraces on the south side of the River Dee are known to be underlain by sand and gravel, but there is no information concerning the thickness or quality. Deposits including sand and gravel are known from borehole evidence to reach at least 15 m below river level at Bridge of Dee [N] 928 036], and may extend upstream a short distance.

#### 12. *Findon*

A terrace deposit, which occurs in the area about Middleton of Findon [NO 938 985], is formed of deltaic sand and gravel derived from glacial meltwater channels to the south-west. A pit at a locality immediately north of the farm [938 987] shows 3 to 3.5 m of bouldery, poorly sorted gravel with pockets of till on top. The deposit, which appears to rest on bedrock, consists of clasts of granite (about 50 per cent) dark, fine grained pelite, local gneisses and hornblende-schist. Some of the pebbles are decomposed, and there is considerable hardpan development in places. Boulders up to 1 m across are frequent.

#### 13. *Stonehaven*

Mounds and ridges of sand and gravel occur in the valleys west of Stonehaven, but are not thought to comprise a major resource. In one such deposit at Temple of Fiddes [NO 817 818] the sand and gravel is known to be chiefly confined to the mounds and does not extend across the surrounding area.

#### 14. *Auchenblae and Bervie Water*

In this area the sand and gravel is in the form of mounds deposited in contact with glacier ice, and was

transported by glacial meltwaters flowing along Strathmore or south-eastwards from the Highland valleys. As a consequence the pebbles comprise both Highland metamorphic and igneous rocks, and lavas, sandstones and mudstones of Old Red Sandstone age. Thus, though up to 50 per cent of the pebbles are psammite, there is commonly a relatively large number of mudstone clasts (10 to 20 per cent) as well as pebbles of schist, lava, sandstone in the gravels. Some of the resources here may therefore be of lower quality than elsewhere in the Deeside and Kincardine District.

In a working pit at Drumsleed [NO 732 776] the present face exposes about 5 m of sandy gravel resting on deposits 13 m thick comprising about equal proportions of sand and gravel. In this deposit psammite and quartzite form over half of the pebbles followed by mica-schist, sandstone, lava, coarse grained igneous rocks such as granite, and mudstone.

#### 15. *Valley of the River North Esk*

Much of the resource here is to be found in fluvio-glacial outwash terrace deposits. Though extensive, the deposits are likely to be thin (of 2 m or less) at many localities. At Capo quarry [NO 628 672] the working face, 3 to 4 m high, is in well-rounded sandy gravel in which the pebbles are predominantly of quartzite and psammite (about 70 per cent), but with significant proportions of sandstone, lavas and coarse grained igneous rocks. Mudstone also occurs in small amounts.

## Moray District

The Moray District is underlain by a wide variety of rock types, many of which are found as pebbles in the gravels. Dalradian quartzite, limestone and schist crop out near the eastern boundary, Moine psammite in the west central part, granite about Ben Rinnes, and sandstones and limestones of Old Red Sandstone and Permo-Triassic age in the northern strip. Ice moving south-eastwards out of the Moray Firth covered the coastal lowlands during the last glaciation, carrying with it fragments of gneiss and granite from the Nairn area and the Great Glen, and depositing the very large accumulations of glacial and fluvio-glacial sand, gravel and silt to be seen in the Elgin district. Inland, meltwater derived from the Moray Firth glacier and ice retreating up the Spey valley laid down a complex series of sand, gravel and silt terraces which were partly reworked by the rivers. Gravels reworked from the glacial and fluvio-glacial deposits now occur in the extensive post-glacial storm beaches between Findhorn and Burghead in the west, and Lossiemouth and Portgordon in the east. Sand dunes (blown sand) cover large areas on both sides of the Findhorn estuary.

The sand and gravel resources of the Moray District are probably the largest in the Grampian Region, the raised beach gravels together with the alluvial and fluvio-glacial terrace gravels of the Spey and Lossie basins in particular comprising an easily worked, high quality, resource. Exploitation of some of the glacial and fluvio-glacial deposits elsewhere, however, is rendered more difficult because of the presence of beds of silt and a major part of this resource may consist of soft sand. Superficial hardpan and organic matter can be expected in many deposits.

Deeply weathered Old Red Sandstone conglomerate which crops out at localities south-east of Fochabers [NJ 345 587] and between Fochabers and Longmorn

[235 583] could also be worked for gravel in places, but the quality is lowered by the high proportion of partly decomposed pebbles. This type of resource is not considered further here.

## DESCRIPTION OF DEPOSITS

### 1. *Culbin and Findhorn*

A tract of dune sand covers some 1900 hectares of land on the west side of the Findhorn estuary (the Culbin Sands), and another 400 hectares on the east, both to a depth of 20 m in places. No figures are available for the grain size of this deposit, but much blown sand in general is fine to medium grained (0.1 to 0.4 mm), with smaller proportions of silt-size particles and a 'tail' of fine grained gravel and shell fragments. The Culbin Sands are known to be underlain by raised beach gravel at several localities.

### 2. *Dyke and Kinloss*

In general, storm beach sandy gravel underlies the blown sand and passes landwards into sand, especially around Kinloss. The ground north of Kinloss is known to be underlain by over 20 m of silty sand in places, but much of this, which is of doubtful economic value, is sterilised by the airfield. Storm beach gravels extending north-east from Kinloss cover an area of about 90 hectares. In the neighbourhood of Kincorth [NJ 014 612] the deposits contain rounded pebbles of psammite, granite and vein quartz. The estimated resources are of the order of 300 million tonnes.

### 3. *Forres*

Along the River Findhorn near Forres there is a large flat spread of coarse bedded gravel with rounded pebbles up to 15 cm across consisting of psammite, pelite, granite, sandstone and porphyry. The spread varies in thickness from 1 to 5 m, and covers an area of about 1200 hectares.

### 4. *Darnaway to Rafford*

Moundy glacial sand and gravel extends from Darnaway across to Rafford, and also up the Findhorn valley. Sections at Rafford [NJ 062 560] show 60 per cent of fine grained, clean sand, the remainder being fine grained to coarse grained, cobbly gravel, with pebbles of psammite, pelite, granite and sandstone. The sand and gravel is known to reach a thickness of 5 m or more locally, and a conservative estimate for the resource is 300 million tonnes. Further deposits occur adjacent to the upstream tributaries of the River Findhorn, such as the Dorback Burn.

### 5. *Roseisle Forest and Hopeman*

Another large tract of dune sand fringes Burghead Bay. Some dunes reach 12 m in height. The blown sand is known to be underlain by late glacial and postglacial raised beach gravel, for example, at localities [NJ 117 675] and [118 665]. Similar gravel underlies Burghead and the area east of Hopeman [145 695].

### 6. *Roseisle*

This area is underlain in part by coastal sandy shingle of late glacial and postglacial age, and in part by sand of marine and glacial origin. The latter is overlain in places by clay, silt and peat. The raised beach shingle could be worked to a depth of at least 4 m at some localities.

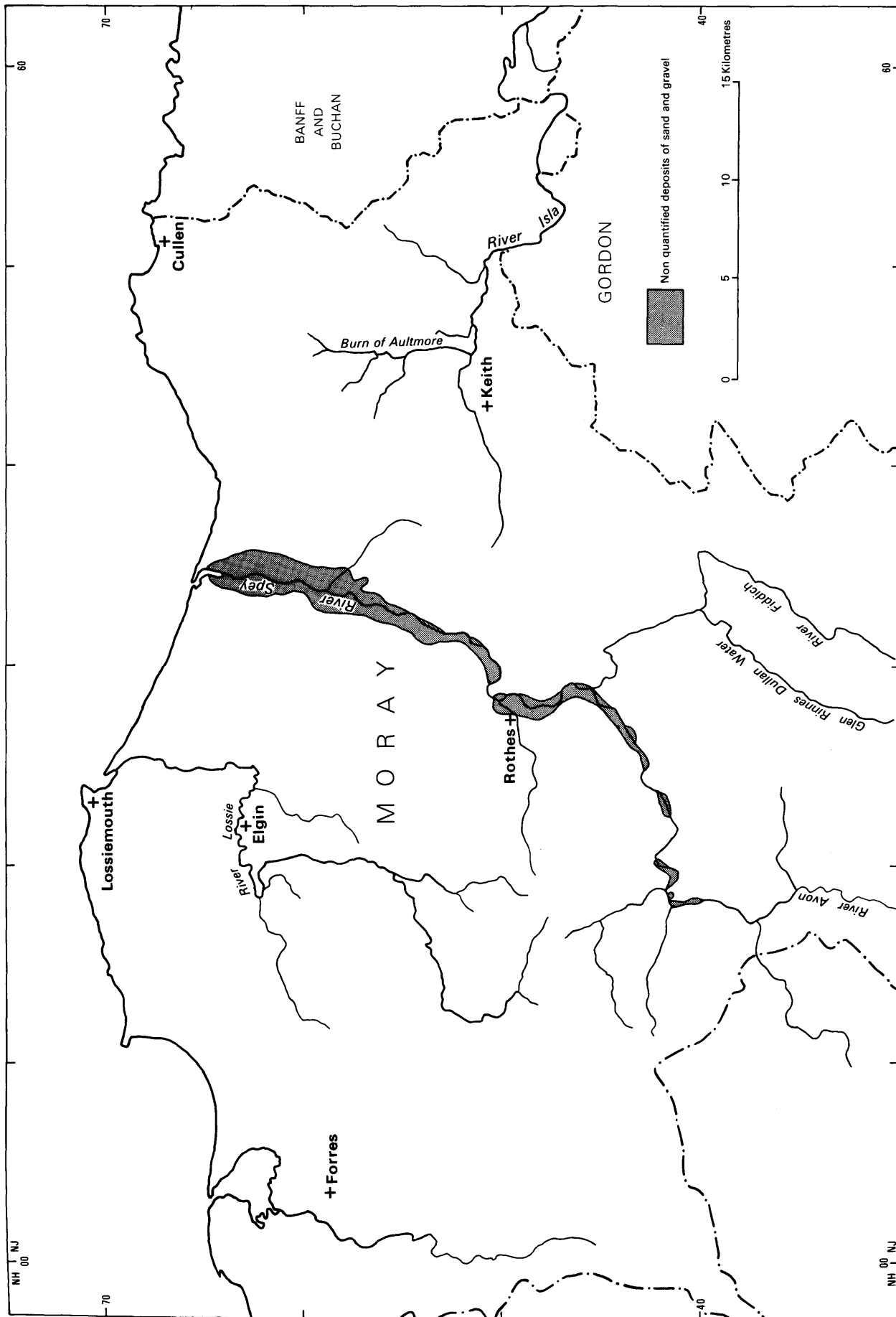


Fig. 3. Resources of sand and gravel below the water table in the Spey valley.

### 7. *Alves to Bishopmill*

A tract of variable, mounded sand and gravel extends eastwards from the Alves district, around Quarry Wood Hill, to north and east of Elgin. A pit near Aldroughty [NJ 168 625] shows 6 m of soft sand with silty partings, but other exposures, for instance at Knockfarm [166 627] and Oakwood [186 627] show coarser deposits of sand, gravel, cobbles and boulders. The sediments are interbedded locally with silt. Thus, though the estimated resources are comparatively large (Table 1), the quality may be poor at many localities.

### 8. *Black Burn and upper River Lossie valleys*

Strips of mounded and terraced sand and gravel and silty river alluvium run along both of these valleys. In the Black Burn valley, the flight of terraces extends for a kilometre south of Barnhill [NJ 142 573], but the maximum recorded thickness of deposit is no more than 3 m. The Lossie alluvium about Dallas may be mainly gravel, similar to that in area 10, and terraced deposits including sand and gravel occur on the higher ground south-west of the village, for example, at Leonachhill [113 500], where a thickness of 6 m is recorded.

### 9. *Miltonduff*

A fluvioglacial terrace underlain by soft sand, gravel and rounded pebbles lies on the west side of the River Lossie south of Elgin, with smaller terraces on the east bank. The pebbles are up to 15 cm across, and consist of pelite, psammite, sandstone, granite and porphyry.

### 10. *Middle River Lossie*

A river fan of probable late glacial age extends from Upper Bogside [NJ 202 571] northwards to the outskirts of Elgin. A large working pit at Cloddach [590 200] reveals 4 m of coarse gravel with sandy lenses, under 1 m of sandy alluvium with patchy ironpan. The pebbles are of low to high sphericity, subangular and subrounded, and up to 15 cm across. They are mainly unweathered, and consist of psammite, pelite, sandstone, porphyry and granite, and make up some 40 per cent of the total volume of the deposit.

### 11. *Covesea to Speymouth*

Storm beach shingle ridges extend along the coast from Burn of Tynet to Covesea. A section at Sunbank [NJ 234 695] shows 6 to 8 m of coarse sandy gravel with lenticles of clean, fine grained sand. The pebbles, up to 15 cm across, are ovoid and very well rounded. They consist of quartzite, psammite, and semipelite, with a few of basic igneous rocks, granite, porphyry and sandstone. Other sections are recorded by Anderson (1943) and by Peacock and others (1968). This deposit has already been worked in several pits, but the resources remaining above the water table are roughly 100 million tonnes. West of Lossiemouth the deposit lies on rock, but south of the town a borehole passed through 16 m of deposit without reaching bottom (Anderson, 1943). Resources below the water table are thus likely to be significant.

### 12. *Elgin to Lhanbryde*

Glacial sand and gravel extends from the middle River Lossie valley north-eastwards to Garmouth. Although of lower relief towards Garmouth, most of the country underlain by this material is characterised by mounds and ridges. Many pits have been dug into these features, and one at Duffushillock [NJ 216 596] shows up to 15 m of fine grained bedded sand, gravel and cobbles with

sand predominating. The gravel consists of quartzite, psammite, pelite, granite and sandstone. Details of other sections are given in Peacock and others (1968, pp. 102-104). In general, gravel is probably of greater significance in the south of the area but sand, including beds of fine grained sand and silt, probably predominates overall.

### 13. *Lower Spey Valley*

Fluvioglacial and alluvial sand and gravel is widespread in the Spey valley from near Orton House [NJ 313 540] northwards to Garmouth. Most of this material occurs in terraces, but there are probably considerable deposits below the water table, particularly north of Fochabers (Fig. 3). South of Fochabers the terraces are cut into till and old glacial lake deposits consisting of silt and sand, and the terrace gravel itself varies in thickness up to 4 m. Working such deposits would therefore probably involve the temporary sterilisation of large areas of arable land. The largest deposit is thought to underlie the broad terrace extending northwards from Mosstodloch [335 597]. In the southern part of the area a series of at least five terraces at Inchberry [315 555] are underlain by gravel. There are no good exposures, but a temporary pit at a locality [309 552] shows 2 m of clean gravel with well rounded clasts up to 20 cm across. The pebbles in the Spey gravels consist of quartzite, psammite, granite, with smaller proportions of sandstone, porphyry and basic igneous rocks. Schist and other soft pebbles are uncommon.

### 14. *Dallachy*

A triangular patch of raised beach deposits lies inland from the coastal shingle ridges. Borehole information from Nether Dallachy [NJ 362 644] shows that the deposits consist of a small thickness of sand on 3 m of coarse grained gravel. This in turn rests on sandstone. Near the coast there is a belt of storm beach gravels extending eastwards from Spey Bay almost to Portgordon, which could probably support working for sand and gravel to a depth of 5 m or more at some localities.

### 15. *Buckie*

The Old Red Sandstone strata south-west of Buckie are covered by boulder clay which is, in places, capped by glacial sand. Around Portgordon (15a) the sand forms undulating ground, and in an old pit at Mains of Tannachy [NJ 383 638] 7.6 m of off-white sand showing small-scale cross-bedding are seen. A similar thickness of sand with pebbly seams is seen in a pit [406 647] near the mouth of the Burn of Gollachy.

An old sand pit [390 620] near Bridge of Tynet (15b) formerly exposed 3 m of cross-bedded, pebbly sand, the pebbles being mainly quartzite, psammite and granite.

The gently undulating ground north of Clochan (15c) contains sand with an estimated average thickness of at least 2 m. In places the water table probably reaches to within 1 m of the surface.

There is evidence of gravel forming a deposit which may be workable at Buinnach (15d). It is poorly exposed, but a small pit [421 605] is cut in gravel with rounded pebbles up to 8 cm. The matrix contains brown ferruginous material.

Between Fochabers and Bridge of Tynet [384 615] there are numerous hillocks of pebbly sand interspersed with mounds of till (15e). A pit [355 593] formerly exposed about 3 m of poorly sorted somewhat clayey



gravel, and another [383 609] exposed sand and silt partly enveloped by till.

#### 16. Cullen

The ground south and south-west of Cullen is underlain by Dalradian metamorphic rocks and a small outlier of Old Red Sandstone. Except on the Hill of Maud and Bin of Cullen the bedrock is almost everywhere concealed by boulder clay. A deposit of fluvio-glacial gravel resting on the boulder clay occurs immediately south of the town (16a) where it was formerly worked in two pits on the west side of the main road. The pits were recorded as exposing 6 m of coarse gravel in a matrix of distinctly clayey sand. The stones are mainly quartzite but it was concluded that the gravel is too dirty to be used for building or concrete.

A large area of fluvio-glacial material north of the Bin of Cullen (16b) appears to be mainly sand. Several sand and gravel pits, all now abandoned, are recorded although no thicknesses are available. An exposure [NJ 481 652] near Woodside shows 1 m of gravel with sandy lenticles: The pebbles, up to 5 cm diameter, are mainly quartzite, granulite and granite.

At Shirralls Wood (16c) gravel has been mapped by both the Geological and Soil Surveys, but there are no exposures and the thickness and lithology of the deposit are unknown, although the size of the area (183 hectares) and the hilly topography suggest that potentially workable deposits are present.

There is fluvio-glacial sand and gravel at Milton (16d), but there are no exposures to give an indication of the thickness or quality.

A fluvio-glacial terrace in the valley of the Burn of Deskford (16e) was formerly worked in a pit [503 604] near Mains of Skeith. The deposit is recorded as 3 m of bouldery gravel capped by sandy gravel. It is now completely overgrown, but 100 m to the east-north-east there is a good section in the river bank showing 5 m of gravel containing clasts up to 20 cm in diameter, mainly quartzite and schist, the latter commonly decomposed. The matrix is highly micaceous sand. The presence of decomposed schist and the abundance of mica indicate the poor quality of the material, which is probably only suited to low-grade uses.

#### 17. The Isla-Deveron Valley

The rivers traverse an area underlain by a wide variety of Dalradian metamorphic rocks and also a basic igneous complex (The Huntly Gabbro). There is a widespread covering of boulder clay and the bedrock is only exposed at the surface on a number of hills and in the more deeply incised streams. Sand and gravel deposits are locally developed, notably as fluvio-glacial terraces.

A much eroded terrace near Keith (17a) is intermittently worked in the Auchanacie Quarry [NJ 399 485]. The working face is up to 5.5 m high but the bottom 1.8 m is boulder clay. The gravel is cross-bedded with poorly rounded pebbles up to 10 cm diameter, mainly quartzite and schist, the latter commonly decomposed. Lenticles of sand containing abundant flaky particles and also some silt are present.

At Stripeside (17b) and Waulkmill (17c) there are no exposures and no information available on lithology and thickness, but at Milltown (17d) borehole evidence indicates between 5 and 8 m of gravel below 2 to 4 m of boulder clay.

A terrace at Turtory (17e) mapped as gravel by the Soil Survey probably contains useful deposits, but there

are no exposures to indicate quality and thickness.

#### 18. Rothes

In this area Moine granulite and Dalradian quartzite are unconformably overlain by Middle Old Red Sandstone conglomerate. In most places the bedrock is concealed beneath a covering of boulder clay, but much has been removed by erosion during late glacial times, particularly by the Spey and its tributaries. Successive stages in the lowering of the Spey are marked by a series of terraces of sand and gravel. Major diversions in the drainage pattern during deglaciation also affected the deposition of sand and gravel; for example, large quantities of gravel were transported by meltwater flowing through the Glen of Rothes, the flow being to the north or south at different times.

The Glen of Rothes (18a) is floored by an extensive deposit of fluvio-glacial gravel which was formerly quarried near Coleburn. This pit [NJ 244 547] is partly filled in, but at one time exposed 9 m of sand and gravel containing boulders of granulite and conglomerate up to 1 m in diameter.

Another terrace, about 15 m higher, is well developed on the south-west side of the glen between Netherglen and the Rothes Glen Hotel. The total thickness of the deposit is probably in the 9 to 12 m range and it rests on boulder clay. The coarse gravel making up this terrace is presently worked in the Rothes Glen Quarry [254 527]. It is fairly well washed although in places the pebbles have a silty coating. Boulders up to 1 m are present and ones up to 0.5 m are abundant. They are mainly Moine granulite, commonly in a shattered and re-cemented condition. Granite and diorite pebbles also occur.

The lower terrace of Glen Rothes extends south-eastwards and is well developed around Smallburn (18b). A disused gravel pit [272 505] has a face up to 3 m high suggesting that the deposit may be of this thickness. The gravel is well washed although the upper part shows local iron staining. The pebbles are fairly well rounded, up to 15 cm in diameter, mainly granulite, quartzite and granite. Bedding is picked out by lenses of coarse pebbly sand.

The summits of two gravel mounds at Auchinroath lie about 15 m above the general level of the terrace. A pit [271 515] in the eastern mound has a face 7.6 m high in gravel with abundant thin layers of sand which are displaced by numerous small faults. The pebbles are fairly well rounded, up to 10 cm in diameter and mainly of psammite and quartzite.

A series of four terraces at Rothes (18c) are divided into three sub-areas by the deeply incised Back Burn and Burn of Rothes. The valley sides are overgrown and exposures are not sufficient to allow an estimation of the thickness of the deposit comprising each terrace. In the north a disused pit [270 500] near Drumbain is largely overgrown, but 1.8 m of well washed gravel overlying horizontally bedded sand with silty layers is still visible. Two metres of sandy shingle was formerly worked in a pit [276 489] near Rothes Castle. The limited evidence suggests that the terraces consist of material ranging from well washed gravel to fine grained silty sand.

High-level terraces at Cairnty (18d) are much eroded and appear to be mainly sand.

Fluvio-glacial terraces between Orton and Dundurcas (18e) are probably mainly composed of gravel which can be seen in an old pit [299 511] at Kirkhill. The pit is about 1.8 m deep and the gravel contains well rounded

pebbles up to 10 cm in diameter. Just south of the Church of Dundurcas boulder clay with cross-bedded sand and shingle on top was formerly exposed in the terrace feature, showing that erosion has extended down into the boulder clay and that the height of the features in this area do not give a true indication of the thickness of the terrace deposits.

A high-level terrace about 45 m above the River Spey at Broadfield extends eastwards along the south side of the Glen of Mulben (18f). It has been deeply dissected by small streams, but fluvio-glacial sand with bands of gravel has been reported to attain a thickness of 30 m (Hinxman and Wilson, 1902). No good sections were seen during the present survey.

At Aikenway (18g) a terrace deposit about 6 m thick is exposed at [290 500]. It is a gravel with pebbles up to 15 cm in diameter, mainly of granulite, quartzite and granite. A short distance to the south 1.2 m of the same deposit is exposed in a small disused pit [291 495], but here it consists of coarse pebbly sand with horizontal bedding. Further south sands and gravels about 30 m thick and resting on boulder clay were formerly well exposed in a river cliff at Sandy Hill [290 493].

#### 19. Aberlour

The bedrock of the Spey valley consists of Moine granulite and granite, the latter forming the Ben Rinnes complex. There is an extensive covering of boulder clay and a series of fluvio-glacial terraces which constitute the main sand and gravel resource of the area. During late glacial times ice-impounded lakes allowed the deposition of fine grained sand and silt, particularly in the Knockando area.

Terraces cover an area of 32 hectares at Easter Elchies (19a) but no details of the lithology or thickness of the deposits are available. Near Aberlour (19b) 1.2 m of fluvio-glacial gravel are exposed in the side of a small valley [NJ 280 438] which has been eroded through a terrace. The exposure, which is immediately below the surface of the terrace, shows that the pebbles are well rounded, up to 10 cm in diameter and mainly of granulite, granite and porphyry. A pit [262 421] south-east of Tombain exposes 4.5 m of coarse, pebbly cross-bedded sand with gravel lenses.

Sand and gravel occurs in a series of terraces at Delmore (19c). An old pit [248 424] shows pebbly sand and some gravel extending from the bottom to the top of a terrace feature 9 m high. A temporary section in the side of a silage pit [246 423] in the same terrace shows 1 m of well washed gravel with boulders of granulite and granite up to 50 cm in diameter.

A terrace at Carron (19d) and a series of terraces at Culquoich (19e) probably contain potentially workable sand and gravel but the lack of exposures prevents an estimation of the quantities.

The deposits of about seven terraces at Phones (19f) probably vary considerably in thickness and quality, but the gravel seen in a cliff [190 413] above the River Spey appears to be typical of at least the lower terraces. The complete section is as follows:

	m
Bouldery gravel, well washed, boulders up to 60 cm, mainly granulite, granite and quartzite	9
Sandy till with stones up to 30 cm	5.5
Quartzite	3.6
(River level)	

Large quantities of fluvio-glacial sand and gravel are present around Knockando (19g). A system of terraces which extends up the valley of the Knockando Burn is probably associated with glacial meltwater which escaped across the main watershed from the north-west. The deposits include much fine grained sand.

Road cuttings at [189 426] and [189 420] expose up to 5.4 m of fine grained sand with layers of coarse pebbly sand and gravel lenticles. Small-scale cross-bedding is common. From the position of the exposures about halfway up the valley side it is inferred that the total thickness of the deposit is about 12 m.

Gravel seen in a disused pit [181 430] at Upper Knockando contains clasts up to 20 cm in diameter, mainly of granulite and granite, and also layers of coarse, cross-bedded pebbly sand. The pit is 4 m deep and the top is level with the surface of a terrace which extends for several hundred metres to the east and north. Sand exposed in a pit [174 447] 4 m deep near Lyne of Knockando shows excellent climbing ripple cross-lamination. Both fine and coarse sand with pebbly seams are present.

Fine grained silty sand, 6 to 10 m thick, resting on boulder clay, is exposed in the high banks of Allt Arder [176 415].

The wide alluvial flats of the River Spey as far south as Aberlour are probably underlain by several metres of gravel, mostly lying below the water table. An overburden of soil and silty sand about 0.5 to 1.0 m thick is likely to occur in most places and layers of sand and silt may be present at deeper levels. Upstream from Aberlour the alluvial flats are of more limited extent.

#### 20. Spey Valley from Phones to the confluence with the River Avon

East of the River Spey there are extensive fluvio-glacial terraces which are probably underlain by sand and gravel but no exposures are known. The terraces cover an area of some 200 hectares and the highest terrace level is some 30 m above the level of the River Spey.

West of the river fluvio-glacial terraces are also well developed. A small roadside excavation near Bishop Croft [NJ 178 394] reveals about 3 m of flat-bedded sand with virtually no gravel content. This small pit is some 50 m above river level. Further small exposures nearby reveal a higher gravel content but medium to fine grained sand is the dominant material seen. The gravel clasts are formed of rounded and subrounded fragments of psammitic granulite, granite and quartzite. These terrace features on the west bank of the Spey extend south-wards in a narrow band as far as the confluence with the River Avon. They cover an area of some 100 hectares. No sand and gravel workings are known in this part of the Spey Valley.

#### 21. The lower reaches of the Avon Valley

From Ballindalloch, at the confluence of the River Avon with the Spey, to Drummin [NJ 184 304] thick fluvio-glacial deposits form narrow but well defined terraces along both sides of the Avon Valley. West of the river these terraces form almost continuous features and cover an area of at least 150 hectares. The material forming the terraces is, however, poorly exposed, the ground being under cultivation or wooded. Small natural faces and burrows indicate that at least the upper 3 m of each terrace is formed from sand and gravel. Three terrace levels can generally be recognised, the level of the highest is some 20 m above river level,

that of the middle terrace some 10 to 12 m, while that of the lowest generally some 2 to 3 m above the level of the river.

East of the river, and as far south as Drumin, the terraces are less continuous. North of the confluence of the Water of Livet with the River Avon an isolated terraced mound covering some 14 hectares of ground is made up of sands and gravels at least 10 m thick. Near Craggan [186 323] and Dalmenach [192 335] similar terrace features extend over an area of at least 16 hectares with a minimum thickness of sands and gravels of at least 10 m.

#### 22. *Avon Valley—Drumin to Glen Lochy*

There is a well developed terrace at Drumin Castle [NJ 184 304] which extends eastwards for some 1.5 km along the south bank of the Water of Livet. It is at least 10 m in height above the present river level and extends over an area of some 30 hectares. No good exposures of the material of the terrace are known.

Fluvioglacial terraces continue southwards along both sides of the Avon valley. Near Dalrachie farm [178 295] these terraces cover some 10 hectares, and in the vicinity of Lyne farm [161 284] the same terraces extend over an area of 11 hectares. Roadside cuttings near Dalrachie Loch [173 290] east of the River Avon indicate that at least the upper 5 m of the same terrace features are formed of sand and gravel in which boulders up to 30 cm in diameter occur. The pebbles are formed from rounded to subrounded fragments of quartzite, psammitic granulite, granite, black schist and soft friable sandstone. In a small abandoned roadside quarry about 1 km south of Drumin a working face of 5 m height was developed immediately east of the present road level.

At Mains of Inverourie farm [152 267], and extending from Kinardochy [146 262] to Knock [151 272], a flat topped terrace some 7 m in height covers an area of 20 hectares. Small natural faces in the terrace indicate that it is formed of sand with subordinate gravel. In the gravel fraction fragments up to 10 cm in length are common. The gravel consists of rounded and subrounded fragments of quartzite, psammitic granulite, granite and black schist. The whole terrace is at present under cultivation. Working faces at least 5 m in height could probably be maintained for nearly the whole area of the terrace.

At Ballintruan [147 252], east of the River Avon, there is a flat-topped fluvioglacial terrace at least 10 m high extending over some 7 hectares of ground. The deposits of the terrace are poorly exposed, the ground being under pasture.

Fluvioglacial sands and gravels occur in Glen Lochy from Tomlay [125 222] to Inverlochy farm [139 242]. They form well developed terraces along both valley sides and cover some 50 hectares of ground. The high terrace level is about 20 m above the present stream level. Small natural faces reveal that the terraces are formed of medium to fine grained sand with some gravel, but because of poor exposure the nature of the material is not apparent.

#### 23. *Mid Fodderletter*

Near Mid Fodderletter [NJ 144 213] fluvioglacial terraces underlie about 30 hectares of ground. The deposits forming the terraces are not exposed, the ground being either cultivated or under pasture.

#### 24. *Tomintoul Area*

The village of Tomintoul is sited on a terrace of fluvioglacial sands and gravels that extends over about 90 hectares. Small pits near Fordmouth farm [NJ 162 187] reveal some 2 to 3 m of sand and fine grained sand with subordinate gravel, but the maximum thickness of the deposit is probably of the order of 10 to 12 m. The ground is poorly exposed, however, and the nature of the material of the terrace feature is not fully known.

East of Tomintoul village sand and gravel underlies about 4 hectares of ground near to the confluence of Allt nan Gamhain with Conglass Water [172 195]. Some 4 m of the sand and gravel is exposed in a small pit. The gravel pebbles are seen to consist of rounded to subrounded fragments of quartzite, psammitic granulite, coarsely crystalline granite, black shale and soft red-brown sandstone.

At Delnabo [160 170] south-west of Tomintoul, a flat topped terrace some 3 m high covers an area of about 17 hectares. The terrace deposits are not exposed. At Delavorar [166 158] a remnant high terrace at least 10 m high extends over some 3 hectares. The material is not exposed and the lithology of the material is unknown.

#### 25. *Croft Bain*

A deposit exposed in a quarry at Croft Bain [NJ 214 247] is made up entirely of flat-bedded sand with only occasional lenses of gravel. The quarry is worked only intermittently and no machinery is on site. A curved working face some 70 m in length has been developed with a maximum height of about 8 m. Resources are difficult to estimate but it is possible that the deposit covers a further area of about 2 hectares.

#### 26. *Dullan Water*

Sand and gravel deposits within the valley of Dullan Water, south-west of Dufftown, underlie an area of some 100 hectares and form the undulating ground along the lower slopes of the valley. The deposit is exposed in two abandoned quarries, at Convalleys farm [NJ 304 371] and Pittyvaich [322 390]. Near Convalleys farm a roadside sand and gravel quarry reveals flat-bedded medium and fine grained sand with gravel and cobbles occurring in local thick lenses. The gravel and cobble fractions are formed of rounded and well rounded clasts of psammitic granulite, quartzite and coarsely crystalline granite. The clasts are of moderate to high sphericity. At Pittyvaich the deposits are still exposed in the former working face which is about 30 m in length and 10 m in height. Sand forms the bulk of the material but there is present a substantial but subordinate gravel fraction. Cobbles are present, generally not more than 15 cm in diameter. The gravels are formed of rounded or well rounded fragments of psammitic granulite, quartzite and granite.

In Lynemore quarry [295 361], worked intermittently, the deposit is dominantly sand with a little gravel. A benched working face about 30 m in height and approximately 100 m in length has been opened at the level of the present road. The deposit consists of cross-bedded flat-lying medium and coarse grained sand with irregular lenses of cobbly gravel. The gravel pebbles and cobbles are made up of coarsely crystalline red and white granite, quartzite and psammitic granulite, and are well rounded and of moderate to high sphericity.

The full extent of this deposit is not clear. Active exploitation is taking place to the west and south of the

present face and it is probable that the deposit will maintain the same order of thickness to the south for an area of at least 5 hectares.

### 27. *Cabrach*

At Cabrach [NJ 386 269] sand and gravel form a flat topped terrace some 8 m in height that occupies an area of about 80 hectares. The deposit has not been worked and is exposed only in small natural faces or in material derived from animal burrows. Sand appears to be the main constituent but gravel may be significant locally. Cobbles up to 20 cm in length are present. The gravel fraction consists of rounded to well rounded fragments of quartzite, psammitic granulite, basic igneous rock, black schist and dark limestone.

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## INSTITUTE OF GEOLOGICAL SCIENCES MAPS

The following one-inch-to-one-mile geological sheets cover the Grampian Region:

Sheet		
57. Forfar	2nd edition 1897 (Hand coloured)	Solid and Drift
64. Kingussie	1913 Reprinted 1964	Solid and Drift
65. Balmoral	1911 Reprinted 1962	Solid and Drift
66. Banchory	1897 (Hand coloured)	Solid and Drift
67. Stonehaven	3rd edition 1929 Reprinted 4th edition 1968	Solid and Drift
75. Tomintoul	1895 (Hand coloured)	Solid and Drift
76. Inverurie	1886 (Hand coloured)	Solid and Drift
77. Aberdeen	1885 (Hand coloured)	Solid and Drift
85. Rothes	1898 (Hand coloured)	Solid and Drift
86. Huntly	1923 Solid and Drift 1954 Drift edition	
87. Peterhead	1885 (Hand coloured)	Solid and Drift
94. Cromarty	1972 Drift edition	
95. Elgin	1969 Drift edition	
96. Banff	2nd edition 1923 Solid and Drift 1954 Drift edition	
97. Fraserburgh	1881 (Hand coloured)	Solid and Drift

## SOIL SURVEY OF SCOTLAND (MACAULAY INSTITUTE OF SOIL RESEARCH, ABERDEEN)

The following one-inch-to-one-mile sheets cover parts of the Grampian Region

Sheet		
57 and 57A. Forfar and part of Benholm	1963 Colour printed	
66 and 67. Banchory and Stonehaven	1966 Colour printed	
76. Inverurie	1959 Colour printed	
86. Huntly	1954 Colour printed	
87 and 97. Peterhead and Fraserburgh	1962 Colour printed	
95. Elgin	1956 Colour printed	
96. Banff	1954 Colour printed	

## ORDNANCE SURVEY MAPS

The following 1:50 000 topographical sheets cover the Grampian Region:

Sheet		
27. Nairn	First Series	1976
28. Elgin	First Series	1976
29. Banff	First Series	1976
30. Fraserburgh and Peterhead	First Series	1976
36. Grantown-on-Spey	Second Series	1976
37. Strathdon	First Series	1976
38. Aberdeen	First Series	1976
43. Braemar	Second Series	1976
44. Ballater	Second Series	1976
45. Stonehaven	First Series	1976

Table 1A. Estimates of the possible resources of sand and gravel above the water table: Banff and Buchan District

Occurrence	Area (ha)	Thickness(m) Reported		Quantity tonnes × 10 <sup>6</sup>
		Av.	max.	
1. Sandend Bay	13	5.5	20	1.0
2. Newpark	34	3	6	2.0
3. Portsoy-Tillynaught	109	2.5	10	4.5
4. Troup Head	40	3.7	7	2
5. Banff-Boyndie	680	4.7	20	50.0
6. Blackhills	218	3	12	11
7. Alvah-Rosyburn	11	2.7	10	0.5
8. Lower Deveron Valley		Not quantified		
9. King Edward	40	2	10	1.5
10. Tippercowan	19	4	10	1.5
11. Glenbarry		Not quantified		
12. Auchintoul	56	2.7	5	2.5
13. Upper Deveron Valley	80	6.5	20	9.5
14. Turriff Area	196	6.1	17	21.0
15. Balquhindachy	35	3	5	2.0
16. Fyvie-Woodend	90	2	7	3.0
17. 'Pliocene' Gravels				
a. Windyhills	85	2.5	3.5	4.0
b. Delgaty	15	2	3	0.5
c. Hospital Wood	5	2	3	0.2
18. Auchterless	7	3	4	0.3
19. Easterton	4	2	3.5	0.1
20. New Aberdour	600	2	12	20
21a. Rosehearty	550	2.5	5	23
b.	1200	2	20	43
c.	400	2	10	14
22. St Combs		Not quantified		
23. Satyrhills		Not quantified		
24. North Ugie Water	500	3	5	27*
25. Rora	100	2.5	4	4.5
26. Longside	1000	3	6	54
27. South Ugie Water	100	2	4	3.5
28. Boddam	10	3	3	0.5
29. Cruden Bay	400	2	8	1.5

\* Including about 5 million tonnes sterilised by buildings.

Table 1B. Estimates of the possible resources of sand and gravel above the water table: City of Aberdeen District

Occurrence	Area (ha)	Thickness Reported		Quantity tonnes × 10 <sup>6</sup>
		Av.	max.	
1. Dyce	10	5	13	9
2. Stoneywood		Not quantified		
3a. Corby Loch	30	3	10	1.5
3b. Leuchlands	20	6	15	3.5
4. Nigg	50	2	5	1.8
5. Deeside	200	4	-	14.0
6. Anguston	100	1.5	2	2.5
7. Brimmondside		Not quantified		
8. Leuchar Moss	70	2	3	2.5

Table 1C. Estimates of the possible resources of sand and gravel above the water table: Gordon District

Occurrence	Area (ha)	Thickness(m) Reported		Quantity tonnes × 10 <sup>6</sup>
		Av.	max.	
1. Ruthven-S.Rothiemy	82	5.1	12	8.0
2. Kinnoir		Not quantified		
3. Kirkstile	12	4	10	1.0
4. Gartly-Cults	29	3	7.5	1.5
5. Blairindinny	3	2	3	0.1
6. The Shevock	3	3	6	0.15
7. Lumsden	100	5	15	9
8. Cock Bridge		Not quantified		
9. Water of Nocht		Not quantified		
10. Water of Buchat		Not quantified		
11. Blairdaff	140	4	5	11
12. Kemnay	30	6	8	3
13. Dalriach	20	6	8	2
14. Ton Burn and Cunningar Wood		Not quantified		
15. Haddo and Michael Muir	450	4	20	30
16. Ellon	450	3	-	24
17. Collieston	350	2	12	12
18. Newburgh	7	3	15	0.3
19. Whiteford	100	4	5	7
20. Balhalgardy and Inverurie	150	3	-	8
21. Mill farm and Glenhead	100	3	20	5
22. Kintore	280	5	10	25
23. Halton and New Machar	60	3	10	3
24. Potterton	330	4	10	20
25. Garlogie and Leuchar Moss	30	2	3	1

Table 1D. Estimates of the possible resources of sand and gravel above the water table: Kincardine and Deeside District

Occurrence	Area (ha)	Thickness(m) Reported		Quantity tonnes × 10 <sup>6</sup>
		Av.	max.	
1. Claybokie	9	2	4	-
2. Glen Clunie		Not quantified		
3. Braemar-Ballater	400	2	10	14
4. Cromar (Culblean Hill)	400	2	6	14
5. Muir of Dinnet	100	3	15	5
6. Tomnakiest-Cambus O'May	200	2	8	7
7. River Dee, Dinnet-Banchory	400	2	6	14
8. Water of Dye-Water of Feugh	300	5	10	27
9. Blairydryne	100	2	5	3
10. River Dee Valley, Banchory to Peterculter		Not quantified		
11. South Deeside, Peterculter to Aberdeen		Not quantified		
12. Findon		Not quantified		
13. Stonehaven		Not quantified		
14. Auchenblae and Bervie Water		Not quantified		
15. Valley of the North Esk		Not quantified		

Table 1E. Estimates of the possible resources of sand and gravel above the water table: Moray District

Occurrence	Area (ha)	Thickness(m) Reported		Quantity tonnes × 10 <sup>6</sup>
		Av.	max.	
1. Culbin and Findhorn	2400	7	20	300
2. Dyke and Kinloss	3650	5	9	330
3. Forres	1200	2	5	40
4. Darnaway to Rafford	9200	2	15	300
5. Roseisle Forest	550	5	10	50
6. Roseisle		Not quantified		
7. Alves to Bishopmill	3900	3	15	200
8. Blackburn and upper Lossie valleys		Not quantified		
9. Milntoduff	350	3	10	30
10. Middle River Lossie	1500	4	7	100
11. Covesea to Spey Mouth	1500	4	8	100
12. Elgin to Lhanbryde	7400	3	15	200
13. Mosstodloch	1500	3	10	80
14. Dallachy	400	5	7	36
15. Buckie				
a. Portgordon	342	4	-	24.5
b. Bridge of Tynet	37	3	-	2.0
c. Clochan	125	2	-	4.5
d. Buinnach	66	-	-	-
16. Cullen				
a. Cullen	35	2	-	1.3
b. Bin of Cullen	349	3	-	19.0
c. Shirrals Wood	183	-	-	-
d. Milton	35	-	-	-
e. Deskford	69	3	-	3.7
17. Isla-Deveron valley				
a. Broadfield	38	-	-	-
b. Stripeside	54	-	-	-
c. Waulkmill	10	-	-	-
d. Milltown	45	-	-	-
e. Turtoy	79	-	-	-
18. Rothes				
a. Glen of Rothes	140	6	-	15.0
b. Smallburn	47	3	-	2.5
c. Rothes	129	3	-	7.0
d. Cairnty	40	-	-	-
e. Orton-Dundurcas	100	3	-	5.5
f. Glen of Mulben	102	10	30	18.0
g. Aikenway	83	6	30	9.0
19. Aberlour				
a. Easter Elchies	32	-	-	-
b. Aberlour	61	3	5	3.3
c. Delmore	97	5	9	8.5
d. Carron	70	-	-	-
e. Culquoich	73	-	-	-
f. Phones	101	5	10	9.0
g. Knockando	755	5	12	68.0
20. Spey valley		Not quantified		
21. Lower reaches of Avon valley	180	8	20	25
22. Avon valley-Drumin-Glen				
Lochy	125	8	20	18
23. Mid Fodderletter	30	7	15	3.5
24. Tomintoul	65	6	12	7
25. Croft Bain		Not quantified		
26. Dullan Water	5	15	30	1.2
27. Cabrach	80	7	10	10

Table 2A. Estimates of the possible resources of sand and gravel below the water table: Banff and Buchan District

Occurrence	Area (ha)	Thickness Reported		Quantity tonnes × 10 <sup>6</sup>
		Av.	max.	
5b. Deveron Mouth	60	7	15	7.0

Table 2B. Estimates of the possible resources of sand and gravel below the water table: Gordon District

Occurrence	Area (ha)	Thickness (m) Reported		Quantity tonnes × 10 <sup>6</sup>
		Av.	max.	
1. Ruthven-Littlemill	15	5	12	1.3

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Printed in England for Her Majesty's Stationery Office by Commercial Colour Press, London, E.7.



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