The Edinburgh Geologist

No. 8

Autumn 1980

EDITORIAL

In case it has slipped your notice, we have decided to print this edition of the magazine in A5 format in the hope that not only will production costs be reduced but that also you will find the smaller version more convenient for carrying around with you wherever you go! Please let us have your comments on the new style.

This issue covers an interesting range of subjects and includes articles of both geological and historical aspect. We are pleased to be able to reproduce a short essay from one of the late Ian Sime's field notebooks. As many readers will know, the Sime Bequest to the Society is used primarily to promote the interests of amateur members.

As usual, we would be delighted to receive articles for the next edition of the magazine (Spring 1981) preferably by the end of December 1980. Suggestions from amateur members for topics which might be covered by future issues would be particularly welcome. Photographs and original designs, contemporary or otherwise, which would be suitable for cover illustrations, will also be gratefully accepted.

Mrs Helena Butler
9 Fox Spring Crescent
Edinburgh 10

Telephone: Home: 445 3705

Andrew McMillan
Institute of Geological Sciences
Murchison House
West Mains Road
Edinburgh EH9 3LA

Telephone: Office: 667 1000

A GEOLOGICAL VISIT TO MADEIRA

Michael F. Billett,
Department of Geology,
University College, London.

Alistair Cowden,
Department of Geology,
Chelsea College, London.

(Formerly undergraduates at the University of Edinburgh)

The volcanic island of Madeira situated 600 km west of the Moroccan coast (Figure 1), is not only interesting from a geological point of view: its inherent natural beauty and equable climate made it a very pleasant place to spend three weeks geological mapping last summer. The Madeiran archipeligo comprises the main island and its satellites Porto Santo and the Desertas Islands. They lie between the Azores to the north-west and the Canary Islands to the south, approximately 1500 km from the Mid-Atlantic Ridge (Figure 1). The volcanic nature of the island produces dramatic scenery with steep gorges radiating from the rugged central mountains, the highest peak being Pico Ruivo at 1861 m. The island also possesses some of the most spectacular coastal scenery in the world, with seacliffs reaching up to 600 m. The vegetation on the island is varied with vineyards and banana plantations in the coastal regions, lush deciduous vegetation on the mountain slopes, and eucalyptus and pine woods in the cooler mountain regions. In striking contrast to the rest of the island the eastern peninsula of Sao Lourenco is a flat semi-desert due to the influence of the Sahara.

The geological history of Madeira dates back to the Miocene when the main island-building stage took place. Intermittent and more localised volcanism probably continued up into pre-historic times. Since its discovery in 1419 by the Portugese mariner Joao Zarco the island has been volcanically quiescent, unlike its neighbours, the Azores and the Canaries. The volcanic succession has been divided into four main complexes by Mitchell-Thomé, 1976 (Figure 2). These are:

Complex 4:	Recent lavas
Complex 3:	Post-Miocene lavas
Complex 2:	Post-Miocene Pyroclastics and lavas
Complex 1:	Miocene/Pliocene Pyroclastics and lavas, the *Basement Complex.*

The spatial distribution of the volcanic complexes is somewhat tenuous, due to the uncertain nature of the criteria which define the complexes. However Complex 3 overlaps Complex 2 and lies unconformably upon

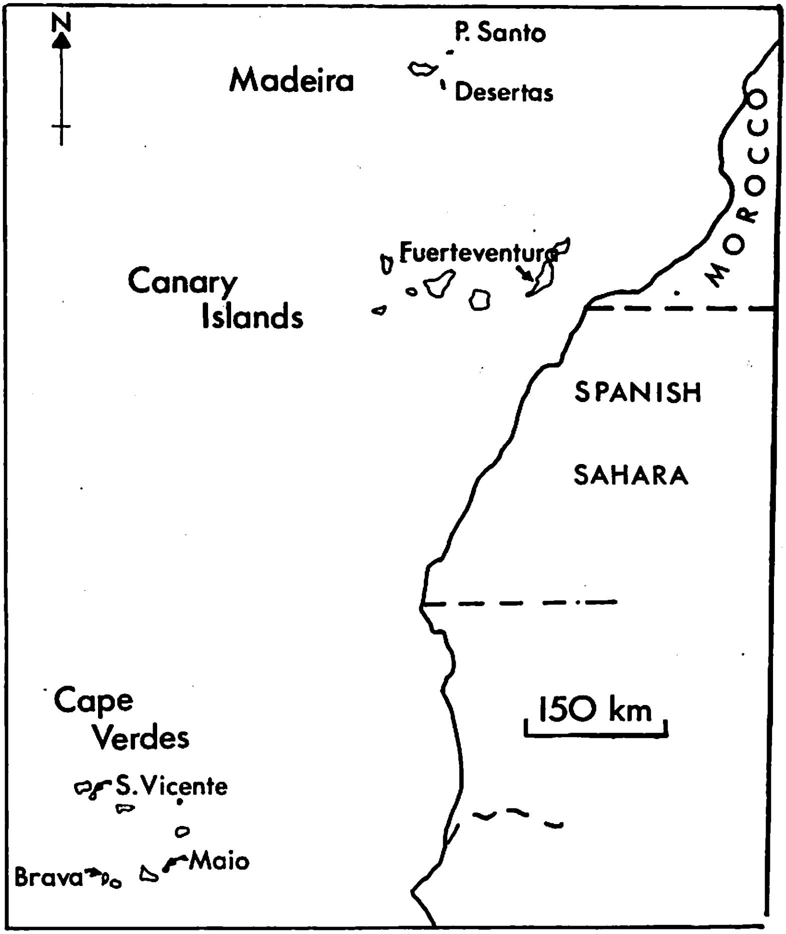


Figure 1: Location of Madeira in relation to other volcanic islands and the African coast.

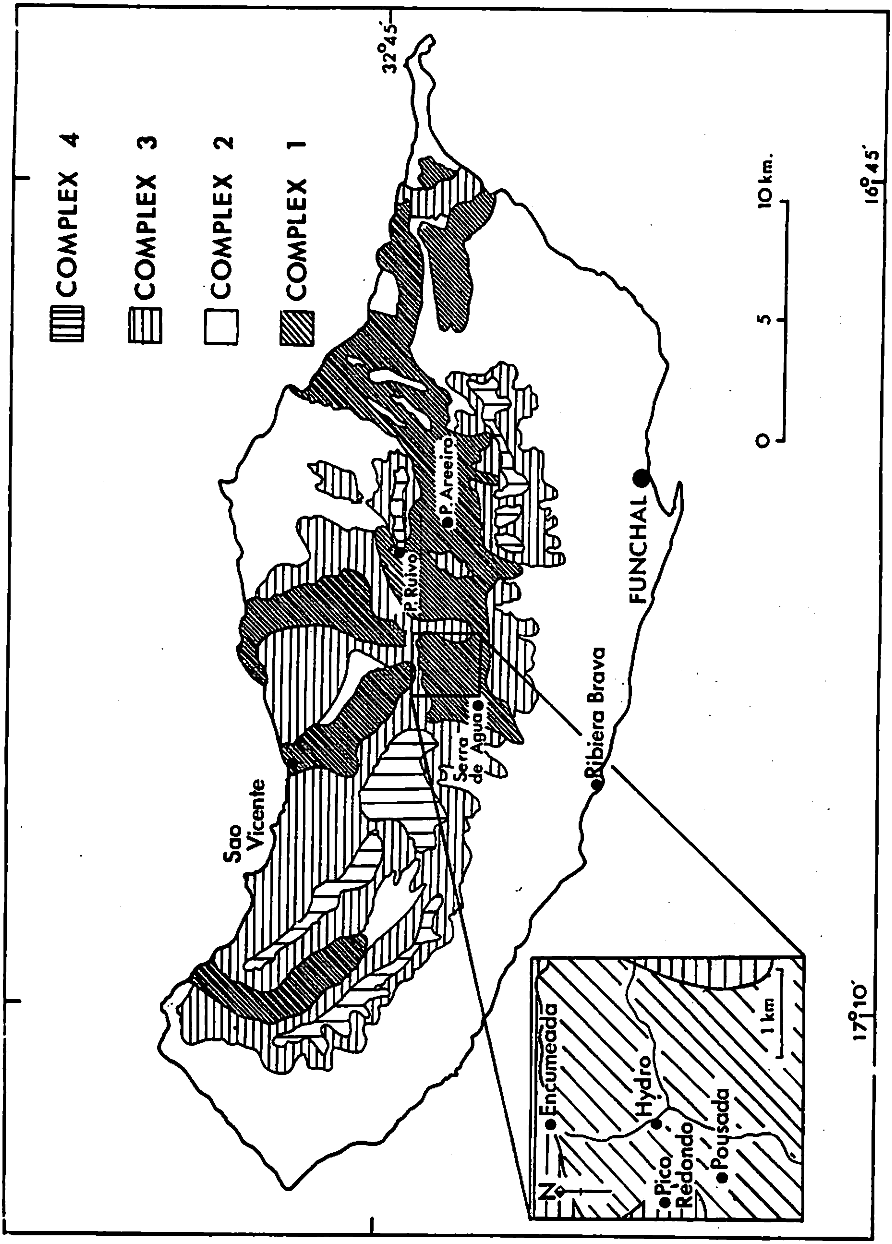


Figure 2: Geological map of Madeira after Mitchell-Thome (1976), with inset showing geology and locations within study area.

the basement complex within the area studied. The occurrence of interbedded marine sediments within the volcanic pile provide a useful but incomplete dating tool. The youngest sediments are Quaternary reef deposits on the Sao Lourento peninsula, which testify to continual uplift during the evolution of the island.

The work that we carried out last summer (1979), was mainly concerned with the central mountain region (Figure 2), in which a local volcanic stratigraphy was compiled. Our main objective was to recognise the basement complex (Complex 1 of Figure 2) and consequently unravel the early volcanic history of the island.

The main results of our fieldwork are summarised in the stratigraphical sections in Figure 3, which attempt to correlate our observations from a number of localities. This led to the recognition of three distinct volcanic units belonging to the basement complex (1) uncomformably overlain by a younger group of volcanics of Complex 3. The lowermost unit (A) is a thick sequence of altered waterlain tuffs which is overlain by a massive pile of pyroclastics and thin basaltic flows. The pyroclastics from Unit B like some of the lava flows, possess red weathered surfaces indicating sub-aerial exposure and emergence of the island above sea-level. The third unit (C) consists of huge thicknesses of vent agglomerates, tuffs, and repeated basalt flows. The presence of a diachronous volcanic boulder bed containing 1 m blocks of basalt, provides evidence for extensive erosion at this time. Unit C also contains an interesting suite of gabbroic nodules in some of the pyroclastic beds. Complex 3 is separated from Unit C by an irregular unconformity, and consists of a thick pile of ankaramitic trap basalts and interbedded air-fall tuffs, rather similar to the Tertiary trap basalts of Skye and Mull. The whole volcanic pile, excluding the trap basalts, is extensively cross-cut by a network of predominantly east-west trending basic dykes.

This systematic study of the volcanic succession has shown that the 'basement complex' cannot simply be regarded as a uniform pyroclastic pile, but as a laterally heterogeneous series of pyroclastics related to a complex volcanic cycle. The first stages in this cycle were the eruption of submarine tuffs, followed by the construction of a classic strato volcano complete with soils, lava flows, agglomerates, and volcanic bombs (Figure 4). Unit C represents a more explosive phase of volcanism before a period of volcanic quiescence, uplift, and tilting which led to the erosion of the older volcanics. The last major stage in the volcanicity, and volumetrically the most important, was the eruption of the trap basalts and associated tuffs onto the pre-existing landscape throughout the island. A number of cinder cones and thin

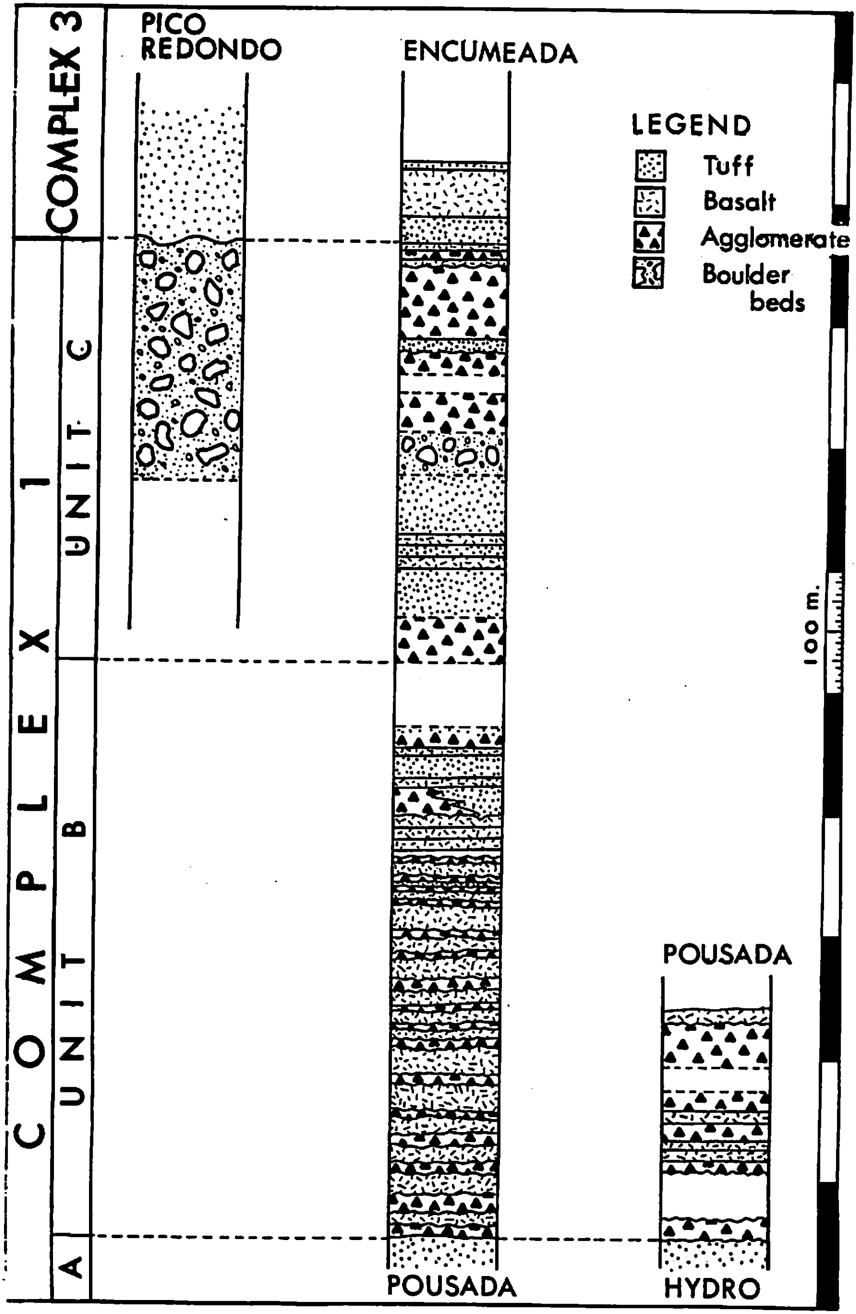


Figure 3: Correlation of stratigraphy within study area. (For locations see figure 2.)

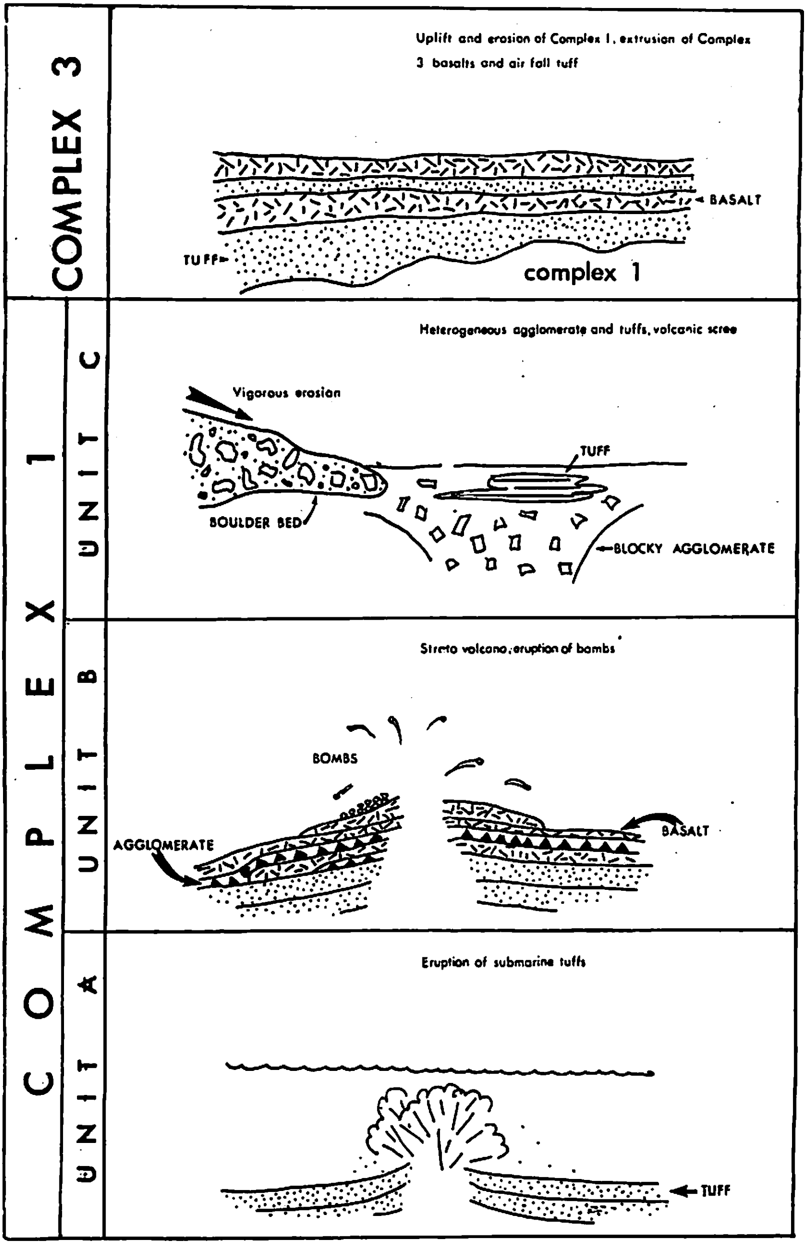


Figure 4: Schematic cartoon showing the early evolution of the Madeira volcano.

'a-a' flows scattered throughout the island are the most recent evidence of volcanic activity.

We would like to thank the Clough Fund of the Edinburgh Geological Society and the Weir Fund of the University of Edinburgh for financing our fieldwork in Madeira, and expanding our geological horizons, besides improving our sun tans.

As a footnote it should be said that the South Orkney Islands (November 1979 edition *Edinburgh Geologist)* is not the only place to have mythical graptolites. During our stay in the mountains we were shown by a group of excited locals a fine specimen of 'Dendroidea'. If this were true it would have grave consequences for current sea floor spreading theories of the Atlantic. However after intense geological examination it became clear that it was nothing more than a dendritic iron stained surface much to the consternation of the locals.

The only introductory article upon the geology of Madeira of use to readers who wish further background is by Mitchell-Thomé and consists of a chapter in his book *The Geology of the Middle Atlantic Islands,* published by Gebruder Borntraeger of Berlin, 1976, and is available in Edinburgh University Library.

SOME RECOLLECTIONS FROM THE NOTEBOOKS OF THE LATE IAN SIME

Ian Sime was honorary president of the Edinburgh Geological Society from 1959 to 1961 and a Fellow from 1951 until his death in December 1976.. His lifelong interest in natural history and geology was not affected by the Second World War. While attached to RAF 60 Group, Ian Sime was responsible for the installation of radar aerials in the North of Scotland and particularly in Orkney and Shetland. During these wartime years Ian Sime recorded his experiences and observations in a series of notebooks or diaries which he gave to me shortly before his death. It is appropriate that these essays are made available to the Society through the pages of the *Edinburgh Geologist* since the Ian Sime Bequest contributes to its production. The first extract is of a culinary nature.

R. J. Gillanders.

THINGS TO EAT December 1940

First things first. Most people remember the places they have visited by the buildings, the palaces, and the 'sights' they have seen: though few could give an accurate description of their own town-hall: and few of the inhabitants of the hill-foots have visited Wallace's Monument. Let us therefore leave the Cathedral of St Magnus, and the Bishops Palace, and the Earls Palace to the guide books of Kirkwall. We have seen them all: and would only remark that if they are to achieve any dignity, they must have removed from their roots the perfectly hideous rickle of houses which has grown round them, and in particular, the absolutely foul reproduction of the monument to the Deerness covenanters must be cast (like the covenanters) into the sea.

Let us turn to more pleasant topics, leaving entirely alone all mention of the curious gateway opening unexpectedly onto a small courtyard, with a cannon in it. Food in the North! apt theme for the approved poet. Porridge and eggs, Scotch Broth and scones: these we expect, and we are not disappointed: but the thick oatcakes of former years are gone: and the thinner ones now obtainable have a bitter taste which their nobler fore-runners had not. We are told that in the old days the oats were cut greener, with some of the 'milk' in the grain, but this is not the modern method, and the sweet meal is found only in remote crofts. The cheese of Orkney is often soft and unmatured: but in the Royal Hotel at Kirkwall we met with a noble cheese: fair women sat opposite and smiled: but we regard them not: the cheese was the main objective, and many biscuitloads of it fell ere the battlefield was cleared.

In Orkney, too, we first met thick sandwiches of brown bread and stewed apple: a curious combination but a good one. In the same house we got another sandwich combination—cheese and onion, highly seasoned. Wick provided many surprises. Fresh lemon sole—orange fritters—and a curious pudding like a fried scone, with treacle and coarse oats in it, with custard sauce—served piping hot.

We leave Wick by 'plane on a stormy day. We pass over the chequered board that is Sinclair's Bay, every detail showing, all the Nissen Huts and the litter of war showing like bananas in a coal-scuttle. We pass over Duncansby Head at a thousand feet, and fly into storms of rain. We dip to 500 ft and are flying above the whirling spray torn off the tops of the waves by the raging wind: the white caps below are not in parallel lines as we expect but are vast white patches on a grey background. Two drifters appear below tossing like toy boats in a stream: the wireless operator gets in touch with the 'drome: the mail 'plane has had enough and has turned back into Wick. It is not very bumpy, though the wind howls like a fiend and the windows and the dome overhead rattle like machine guns. Suddenly the rear gunner points ahead, and we see Sumburgh Head appear through the flying cloud. Round the 'drome we circle: once, twice, and again: down we come, but the 'plane does not lose much speed: we hit the tarmac with a sickening thud and bounce off towards the medical hut: just miss it, hit the sand and bounce in a new direction: the 'plane is still going like mad: we hit the sand again and bounce over the edge of the cliff, are caught in the downdraught and down goes the plane: we are left in mid air two feet above our seats. The pilot frantically opens her out and at the last moment she begins to rise again. We are in our seats again with a sickening bump, and our instruments return to the floor of the plane, one by one. The plane rises slowly–ten–twenty–a hundred feet above the sea: soon we are at a thousand feet circling the 'drome again. This time we land safely, and step out of the 'plane looking quite unconcerned. The aerodrome, however, is much shaken. At last we are in Shetland.

Here we are in a different land–and the food, too, is not the same. What a large part the sheep plays in the menu: we follow the example of the author of 'News from Tartary' and disguise the too frequent mutton with small doses of sauce. But here we meet with the thick oatcake–which we thought we had lost–how pleasant to meet them. Thence to Unst–and Buness–but the food there is not the food of Shetland but the food of the most intelligent civilisation, where food is an art, and not a dull necessity.

THE POLTON LANDSLIDE OF DECEMBER 1979

Bill Baird
Royal Scottish Museum,
Edinburgh

John Smellie
Institute of Geological Sciences,
Edinburgh

The River North Esk runs from Roslin to Polton in a deep gorge cut into the Passage Group sandstones of the Carboniferous by melt-water, at least in part, during the period of the last deglaciation. The sides of the gorge in this area are up to 200 feet high and in several places almost vertical. It is not unusual under these conditions to find rockfalls and small landslides and there is evidence of several having taken place in this area during recent years. However, the sandstones in the gorge, although friable and containing thin shaly intercalations, are horizontally bedded and therefore such falls as have occurred in the past have been of relatively small size and limited to areas where the exposed faces were waterlogged or undercut.

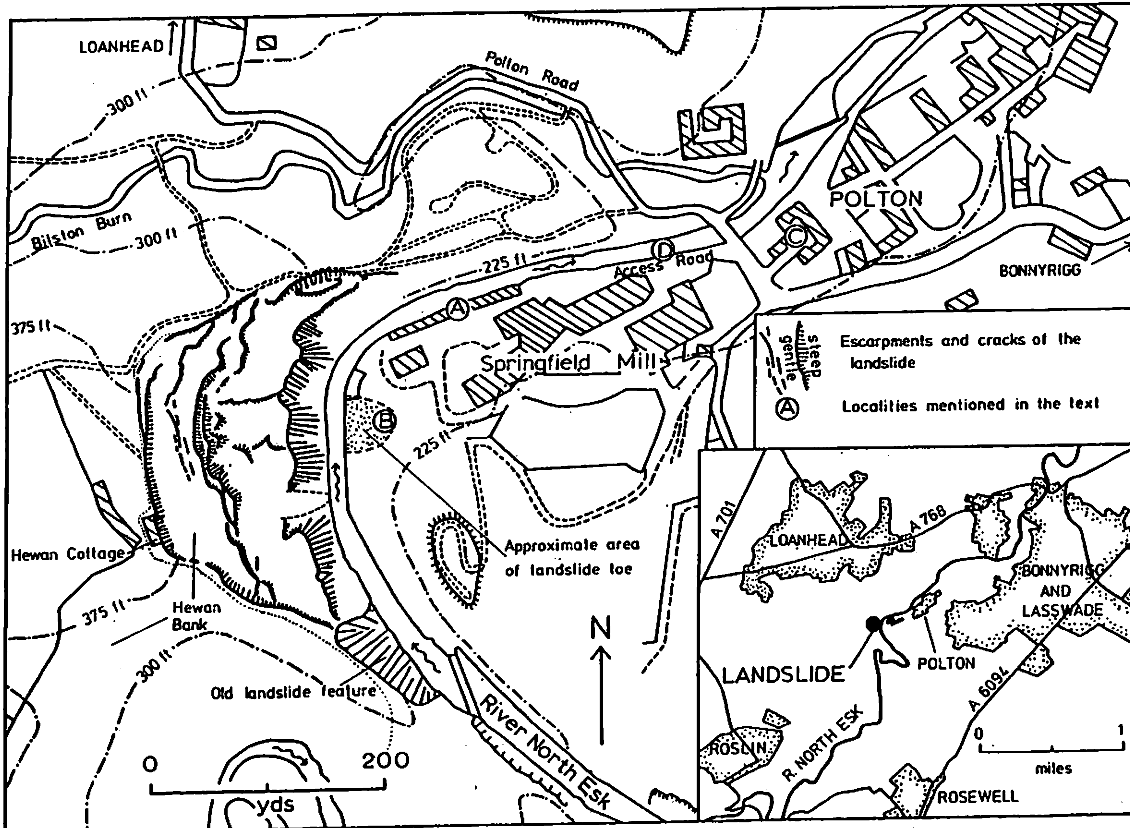
Just south of Polton the gorge widens out a little and at Springfield, on the flood plain of the river, are the buildings of an old paper mill (Springfield Mill). The buildings are on the east side of the river facing a high bank on the west. This area, called the Hewan Bank, is well wooded with many mature trees and it slopes towards the river at an angle of about forty five degrees. It is only when the geology of this slope is examined that one can understand why it should be prone to a major landslide while the much steeper walls of the gorge remain relatively undisturbed. In place of the horizontally bedded sandstones of the Passage Group there is a bank almost 200 feet high which seems to consist entirely of unconsolidated glacial sediments. After the landslide of December 1979, fresh exposures of the sediments showed that beds of glacial till occur beneath the lower slopes, but the upper and least stable part of the bank consists of loosely bound sand with clay partings capped, at the crest of the slope, by a thin layer of gravel. Moreover, the existence of a spring line half way up the slope must have greatly added to the overall instability of the of the area. All it required was a trigger.

There were several small slides prior to 1979 and one such slide is shown on old maps at the south end of the bank; this probably dates back to the last century. However, during the wet summer of 1979, an observer noticed that the floor of the ruined Hewan Cottage had split and part of the floor on the side nearest the river had dropped by about a foot relative to the other. Whether such movement was of a creeping type caused by waterlogging and the constant pull of gravity, or whether it was initiated by one of the small-magnitude earthquakes which are common in this district is uncertain, but obviously the area was potentially unstable and had already begun to move during the latter half of the year. And then it rained in December. How it rained. By the end of the first week almost as much fell as would normally have fallen during the entire month. An inch of rain fell on the 7th of December and it was this which may have finally prepared the unstable sediments for movement. Still nothing happened, although it rained almost continuously on the 8th and again the following day, and then something set the whole wet, soggy mass in motion. At 3.30 pm on Sunday 9th December a hundred thousand tons of debris plunged down the hill and across the river towards Springfield Mill.

David Tuddenham, the property officer at the mill, was in the store (A) at the time the slide took place and his impressions were of 'several heavy lorries going past just outside your living room window'. It is of interest that he noted both noise and vibration. This has been confirmed by other observers and it strongly suggests that the slide moved with great speed. The site was examined immediately and it was discovered that the toe of the landslide had swept across the river and travelled some 50 yards further, reaching and overwhelming a large building (B) used as a store by Midlothian District Council. The mass of debris now on the east bank, estimated at 5000 tons and containing many full-grown trees uprooted and snapped like twigs blocked the river to a maximum depth of 25 feet. The river was in flood and rapidly built up a large lake behind the dam. There was now the possibility of much greater damage being caused by a dam burst.

The village of Polton now had its first bit of good luck that grim December day. Mr Tuddenham, who is also a civil engineer, rallied the Midlothian District Council staff and those from the other businesses in the various buildings at the mill. They all set to work with a will but already water was flowing around the dam. It flooded through some of the buildings nearest the river to a depth of 3 feet. Worse still, it was pouring down the mill access road and out towards a small estate of new houses (C) in Polton. At this point, the flood water was running parallel to the original river bed, separated from it only by a low but substantial stone wall. Something had to be done quickly. A large fork-lift truck was brought out of one of the buildings and used to smash a hole in the wall (D). With the wall down and a small diversionary dam built, the river was channelled back to its old course. The danger was further reduced when the River North Esk itself managed to cut a channel through the temporary dam of tangled trees, sand and clay to resume its original bed.

With the help of a large dragline, work began clearing the remainder of the dam from the river and the east bank, even though it was realised that this could disturb parts of the slide higher up, and possibly cause a further fall. Within a few days the major portion of the dam had been removed. A month later the site of the smashed building was fully cleared and the only evidence of the landslide was on the west bank of the river. It had been of a composite nature in that it



LOANHEAD
Pollon Road
300 ft
Bilston Burn
300 ft
225 ft
Access Road
POLTON
BONNYRIGG
375 ft
Springfield Mill
225 ft
Escarpments and cracks of the landslide
steep
gentle
Localities mentioned in the text
A
B
C
D
Hewan Cottage
Approximate area of landslide toe
Hewan Bank
375 ft
300 ft
Old landslide feature
N
River North Esk
0
200
yds
A 701
A 768
LOANHEAD
BONNYRIGG AND LASSWADE
LANDSLIDE
POLTON
A 6094
R. NORTH ESK
ROSLIN
ROSEWELL
0
1
miles

involved both rotational downslope movement of large fairly cohesive blocks of tree-covered gravels and sandy soils in the upper portion, and several smaller mudflows from point sources below the spring line. Movement over the whole area of the slide was uneven. Near the middle of the slope this caused compression ridges and folds at right angles to the direction of movement. The head scarp showed a drop of between 20 and 30 feet and many similar scarps and transverse cracks were visible between it and the river. The sheer power exerted by the slide could be seen where cracks had occurred under the roots of mature trees, ripping them in two from the base of the trunk upwards. In other parts great roots could be seen strained from the ground like giant hawsers trying to anchor an ocean liner in a storm.

With hindsight, it seems the most likely factor controlling the timing of the landslide was the unusually heavy rainfall, which occurred during the days immediately preceding the event. The situation was undoubtedly aggravated by the nature of the sand and gravel covering the slopes and by the presence of an active spring line midway up the bank. Earthquakes are unlikely to have been a contributing factor in this case since the official records of the period show only a small-magnitude tremor on the 4th December; the now well-known Boxing Day earthquake, which affected much of southern Scotland and northern England, occurred some two weeks after the Polton landslide. (Neilson, 1980).

The sketch map included with this article is a record of the landslide as it existed on 11th January 1980. Comparison of this with the bank as it currently exists will immediately show many changes, mostly caused by fresh falls and an overall creep downslope. Many of these modifications probably passed quietly and unnoticed but a few were spectacular, such as the muddy slurry, witnessed at close hand by one of us (B.B.), which charged noisily and quickly down the steep 40 foot slope of the escarpment nearest the river at its north end. The Hewan Bank is obviously still very unstable and, short of expensive drainage and replanting work, it is difficult to see how this type of occurrence can be prevented in the future. It may be that the most economical method would be to quarry the remainder of the bank for sand and gravel, thus removing the unstable material.

The authors wish to acknowledge the help of the following for information used in this article:

The Superintendent, the Meteorological Office, Edinburgh.
Seismology Unit, Institute of Geological Sciences, Edinburgh.
The staff at Springfield Mill, in particular Mr Burnett, Mr Campbell and Mr Tuddenham.

Further reading:

Bolt, B. A., *et al*, 1975, *Geological Hazards*, Springer-Verlag, Berlin; Heidelberg, New York.

Edinburgh Evening News, 'Latest' Edition, Monday 10th December 1979. A front page article and photograph (photograph job no. 243552 a-d).

Neilson, G., 1980, The Recent Carlisle Area Earthquakes *Edinburgh Geologist*, 7, pp.20–25.

Sissons, J. B., 1967, *The Evolution of Scotland's Scenery*, Oliver and Boyd, Edinburgh and London.

SANDSTONE QUARRYING IN ANGUS– SOME THOUGHTS ON AN OLD CRAFT

by

Alexander Mackie

Visits to numerous old sandstone quarries in Angus suggested that a historical survey of what was once a thriving industry would be interesting. Those which were known as 'pavement' quarries, owing to the suitability of much of the excavated material for use as paving stone, are the oldest and most extensive of their kind in Scotland, and there is no doubt that sandstone quarrying within the county reached considerable proportions, especially in the first half of the 19th century.

Practically all the quarries are situated within the Dundee Formation in the Arbuthnott Group of the Lower Old Red Sandstone (Figure 1) which in eastern Angus is composed mainly of cross-bedded sandstones with intercalations of shale and flagstones (Armstrong and Paterson, 1970). Many interesting fossils including entire specimens of the eurypterids *Pterygotus anglicus*, *Pagea sturrocki*, and *Tarsopterella scoticus*, were found by the quarrymen when stone was being won. The men were encouraged to look for such specimens by gentlemen collectors like James Powrie of Reswallie and Sir Charles Lyell of Kinnordy. It may be true, however, that the fossil remains of smaller animals were less highly prized by the quarrymen. Fortunately it is still possible to collect these and fragments of larger plants and animals from the spoil of some of the quarries, and good specimens of agnathan and acanthodian fish, and plants have been found in recent years.

Sandstone from the Angus quarries was put to a variety of uses. Fissile sandstones (flagstones known as 'pavement') were used mainly for paving and for flooring of buildings. More massive, thickly bedded sandstones were hewn for general building purposes as well as more specialised needs such as columns, balusters, lintels, coping stones and gravestones. Coarse-grained sandstones were used for millstones, and slates (tilestones) for roofing houses. The coarse sandstones occurred in brown or grey bands of varying thicknesses: finer grained varieties were white, blue or green.

Records show that quarrying in Angus had been pursued from the 16th century. Wellbank or Legsland quarry about 7 miles north-east of Dundee, must have been in operation at least 400 years ago as the Rev. Samuel Miller (1842) quotes from the Session Record: '3rd June 1574, Donald Robartsone in Laigislande fand [found] ye Lard of Umoquhy cation [bail], yt gif [if] ye witnesses convicks hym, he sall pay ane thousand sklaittis [slates]'.

Despite the loss of many quarry records it is known that much stone was shipped from Angus not only to other Scottish ports but also to England, the Continent, North and South America, Australia and the Colonies. As early as 1678 Robert Edward, Minister of Murroes, about five miles NE of Dundee wrote that there were many quarries in Angus, producing high quality stone, some of which was shipped to Fife and the Lothians, Holland, and to North America, and he adds, 'No part of Scotland can boast of better, few so good'. Other authors write of the early history of the industry. For example, John Ochterlony (*ca* 1682) states, 'The country aboundeth in quarries of freestone, excellent for hewing and cutting, especially one at the Castle of Glammes, far exceeding all others in the shyre, of a blewish colour, excellent milne-stones; great abundance of sklait and lymestone in divers places; ane excellent lead myne in Glenesk, belonging to the Laird of Edzell'.

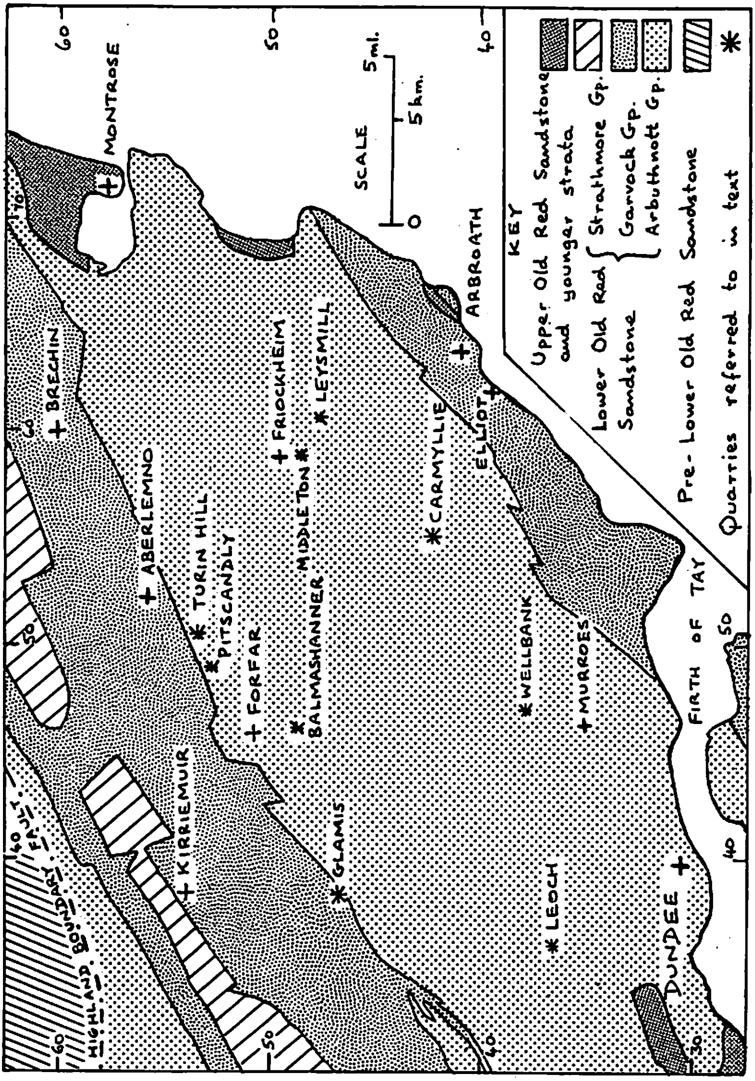


Fig. 1 Geological sketch-map showing the location of the principal towns, villages and quarries mentioned in the text (Geology after Armstrong and Paterson, 1970).

About 200 years later, George Hay (1876) indicates that the Carmyllie quarries, six miles from Arbroath, had been worked for centuries, and are the oldest in Scotland.

Quarrying in the late 18th century and 19th century

'The Statistical Account of Scotland' and 'The New Statistical Account of Scotland' give a good account of the quarrying industry in Angus towards the end of the 18th century, and the first half of the 19th century respectively. According to the Rev. Thomas Wright (1795), 'the neighbourhood abounds in excellent materials, especially the hills of Turin and Pitscandlie, which contains inexhaustible stores of stones of various kinds, and of every dimension fit for use; and where there are quarries now working, astonishing to look at, and affording ample subject for contemplation and amusement to the naturalist and virtuoso'.

Several quarries in the Parish of Aberlemno, between Forfar and Brechin, were worked for paving stones and slates and the Rev. Andrew Mitchell (1792) states that towards the end of the 18th century slates were sent to London and to other places. It appears that the quarries were worked as far back as 1755 at least, since the Rev. James Crombie (1842) points out that between 1755 and 1842, the population fluctuated slightly, depending on the number of quarrymen required.

Forfar was fortunate in having several quarries on Balmashanner Hill, just one mile south of the town. Some of the stones were used in the building of the houses in Forfar, and the sandstone flags were used for the pavements. The Rev. W. Clugston (1843) points out that immense quantities of 'pavement' from the Balmashanner quarries were conveyed to Arbroath and Dundee, and to different parts of the United Kingdom.

The 19th century brought improvements in the quarrying industry with a concomitant increase in trade. Planing, cutting, and dressing machines were introduced. In 1833 James Hunter of Leysmill, near Arbroath, son of a reed and shuttle maker, was experimenting with stone-planing machines, and in 1834 had patented his first invention. Some years afterwards, he invented a circular saw of cast iron for stone cutting, but it had a number of faults. These were replaced by the stone cutting and dressing machines, invented by his son, George. The machines were made in Arbroath. According to Bremner (1869), 'The machines are of great strength, and consist of a series of chilled iron tools, placed in revolving discs, by means of which great slabs of stone are cut through or split up'. George died comparatively poor, but other men reaped the benefits of his efforts.

A detailed description of James Hunter's stone-planing machine is given in the 'Prize Essays and Transactions of the Highland and Agricultural Society of Scotland' (1837). The Committee of the Society met at Leysmill in June, 1835, examined the machine and its capabilities, and praised its construction and performance very highly. Three rough pavement stones of unequal thicknesses and covering a total area of 47 square feet were reduced to the required size and polished by the machine in 30 minutes at a cost of 1/7d. Mr Donald Mackay, master mason and builder in Arbroath, said that working in the ordinary way, by hand, this would take a good mason 5½ days at a cost of 15/9d. Harder stones from other quarries were successfully dressed. There is no doubt that the Hunters' inventions greatly improved the sandstone and slate industries, not only locally, but also throughout Britain.

The Carmyllie Quarries

Perhaps the most famous and extensive of the Angus quarries were those situated in the Parish of Carmyllie, and it has been possible to obtain more information about them than about any of the others. During the 18th century the land of the parish was divided into small farms and pendicles. The latter were small pieces of land attached to larger areas. Each farmer was allowed to quarry on his own farm on condition that he paid the landlord a certain proportion of the value of the sandstone and the slates quarried. The farmers worked the quarries after seed time and stopped just before the harvest, this being a common custom in the early years of the 19th century.

Stone from Carmyllie was advertised as far back as 1809 and 1810. By then production had increased to a considerable output of paving stones, and thick sandstone slabs which were shipped from Arbroath not only to Leith, but also to London and other English towns. There was also a great demand for heavy rough roofing slates, and these were transported to Dundee, and neighbouring towns, and were also shipped to Leith.

As the quarries became deeper, great difficulty was experienced in removing ground water, and for this operation windmills with moveable wooden frames were employed. Hugh Miller (1841) describes his impression on approaching the workings:

> ... the quarries, as may be supposed are very extensive, stretching along a moory hillside for considerably more than a mile, and furnishing employment to from sixty to a hundred workmen. The eye is first caught, in approaching them, as we surmount a long flat ridge, which shuts them out from the view of the distant sea, by what seems a line of miniature windmills, the sails flaring with red lead, and revolving with the slightest breeze at more than double the rate of the sails of ordinary mills.

According to Miller they threw up a considerable body of water. Windmills were also employed in other quarries, but if there were no wind, work had to cease.

By about 1830, the problem of drainage at Carmyllie became so critical that a culvert was constructed at a cost of £3,000. This ran through a large part of the parish, part of it being tunnelled through the sandstone at a depth of 40 feet. The tunnel was 180 yards long, 3 feet wide, and 3½ feet high and its construction proved to be difficult, since the sandstone was hard.

By the late 1830s there was a considerable demand for workers, the only mechanical device available being a small crane, which could lift a ton: otherwise it was all hand labour, but according to the Rev. W. Robertson (1836), the workers were 'industrious, moral, and religious'. J. Carmichael (1837) gives an interesting description of the work being done at the Carmyllie quarries at that time. He states that some of the flags removed were 60 feet long, and raised by crowbars and mattocks. Large plates of sandstone were sent to London, France, and America. He describes the material as 'greenish-brown and very hard', and before they were sold all the stones were squared to uniform dimensions. Sixty men were employed, some at 10/- to 12/- per week, and others at £4 to £6 per 1,000 feet of pavement. Carmichael quotes typical prices obtained for the stone delivered at Arbroath, e.g.:

Common pavement, 1½" to 4" thick, £15 per 1,000 feet;
Stair steps, 4' to 6' long, 7" to 8" thick, and 14" to 15" broad, 1/2d per foot;
Roof slates, £4:10s per 1,000 slates of 15" to 20" by 9" to 12" each.

The best common pavement and slates could be split into plates, 1" to 14" thick and 1" to 1¼" thick respectively. Thirty or more carts were employed in conveying the pavement stones from the quarries to Arbroath for shipment at a rate of 4/- to 6/- per 100 square feet. The annual sales for pavement stones and slates in the 1850s averaged £4,000 to £5,000. In 1854 a mineral railway was opened for the purpose of transporting the stone from the quarries to the coast at Elliot, near Arbroath, a distance of five miles.

Bremner (1869) states that by then about 300 men were employed and gives a list of the machinery used: 'eight planing machines, several cutting machines, eight saws for jointing pavement, one machine for making steps, coping, and tabling; two polishing machines, six steam engines, and from twelve to fourteen steam and other cranes'. Any weight or size of stone was quarried, some weighing 20 tons and measuring 200 square feet. Output was estimated at 150 tons per day.

Orders poured in from all parts of the country and consequently the harbour trade boomed. Occasionally large masses of stone were raised, some of the blocks measuring 30 to 40 feet long, 10 to 20 feet broad, and several feet thick. According to J. M. McBain (1887), by the late 1880s the windmills had been displaced by eight engines. Ten of Hunter's planing machines were in use at Carmyllie, and thirty in other parts of Angus, besides the cutting and moulding machines.

The quarries continued to expand and at their peak period, about 1890, the total number of men employed reached 700, and the industry was in a very flourishing state and directed by a capable management. According to a local paper, 'The Telegraph and Post', many men were attracted to the quarries from neighbouring towns and villages, as well as from the Parish of Carmyllie. As the paper states, 'in the summer time the place resembled a hive of busy bees'. There was naturally a shortage of housing and even farm bothies were used to accommodate the men. The population of the parish reached a maximum in 1871, *viz.*, 1,309. By 1901 numbers had fallen to 1,063. Some fifty years later the demand for stone had practically ceased. The quarries were finally closed in 1951, although for some years prior to this date more than 30 men were employed.

The 'pavement' rock of Carmyllie known for its high quality throughout the world, was fine-grained and bluish-green. Large quantities of machine-dressed stone ready for use as paving were exported to many European countries, Australia and North and South America. The stone which was easily worked has also been put to a variety of other uses including billiard tables, mangle stones, and cisterns for paper-makers, chemical works, and bleach-fields. A light coloured sandstone, with dark cloudy spots and veins, was occasionally found. When this was polished and varnished, a beautiful product was obtained, which had all the appearance of dark marble, and was used for window jambs, and lobby tables.

The most famous building floored with Carmyllie (Slade Quarry) stone is Cologne Cathedral. Stone from the Brechin quarries was also used in the Cathedral's construction. Although the corner stone was laid in 1248, the building was not completed until 1880. After 1447, the work on the edifice was discontinued for 400 years, and it was not until 1842, following resumption of building that Carmyllie stone for the floor was shipped from Arbroath.

In Scotland, many towns have been paved with Carmyllie flagstones. Sandstone from Carmyllie has also been used for several notable buildings including the Head Office of the Bank of Scotland, Edinburgh; New College, Edinburgh; the piers and abutments (over 40,000 tons) of the Forth Railway Bridge; University of Glasgow; some of the principal buildings in Aberdeen; Perth Railway Station.

Some other quarries in Angus

According to the Rev. James Lyon (1836) one of the Glamis quarries, near the village, had been known, long before that year, for its millstones, some of which were exported. The stone had excellent fire resistant properties, and was much in demand in Dundee and elsewhere for oven soles. Lyon states that the thin grey flagstones were worked many years before, and the demand exceeded that required for Dundee and the neighbouring country. It is suggested that the old town of Edinburgh and other towns in the Lothians may have used stone from some of these quarries.

Good sandstone was obtained from Leoch Quarry, situated 5 miles NW of Dundee. Harry (1952) describes this sandstone quarry in detail, which was last worked in 1952 for building purposes, when thirty men were employed. It had been worked since 1832, when the Newtyle Railway which passed through the quarry area was constructed. Massive sandstone was encountered, and the railway company used it for pad stones (stone templates) for the permanent way. The sandstone was bluish-grey and fine-grained, and occurred in beds 3 to 8 feet thick. It does not weather readily and has been used in many buildings, including the Usher Hall, Edinburgh; the Glasgow Art Galleries; Gleneagles Hotel, Perthshire; and Mandal Town Hall, Norway. Sandstone was also won at Middleton Quarry, situated on the west side of the Arbroath–Friockheim Road (A933), $^{3}/_{8}$ mile SE of Friockheim, which supplied stone for the piers of the Old Tay Railway Bridge. The quarry face is of massive cross-bedded sandstone, about 40 to 50 feet high.

There are many other old quarries in Angus including those worked for whinstone (andesitic and basaltic lavas and intrusive dolerites). Although these quarries never attained the importance of the sandstone industry during the 18th and 19th centuries, they are currently the only active hard rock workings in the district, the stone being used principally as crushed rock for roads.

All the sandstone quarries are now silent, but the remains speak of past great activity, and show in no uncertain manner that two world wars have wrought phenomenal changes in our social habits and tastes. Structures using the natural stone blended in with the surrounding scenery and were very pleasing to look upon. The replacement of sandstone by brick and concrete in the construction of modern buildings dealt a great blow to quarrying in Angus. Figure 2 illustrates the decline of the industry in terms of employment during the early decades of the twentieth century.

When a few retired quarrymen were interviewed, they spoke of their work in such a way as to show that they were not only interested, but had been dedicated workers. It is indeed a sad experience to survey the weathered remains of a great industry and a noble craft.

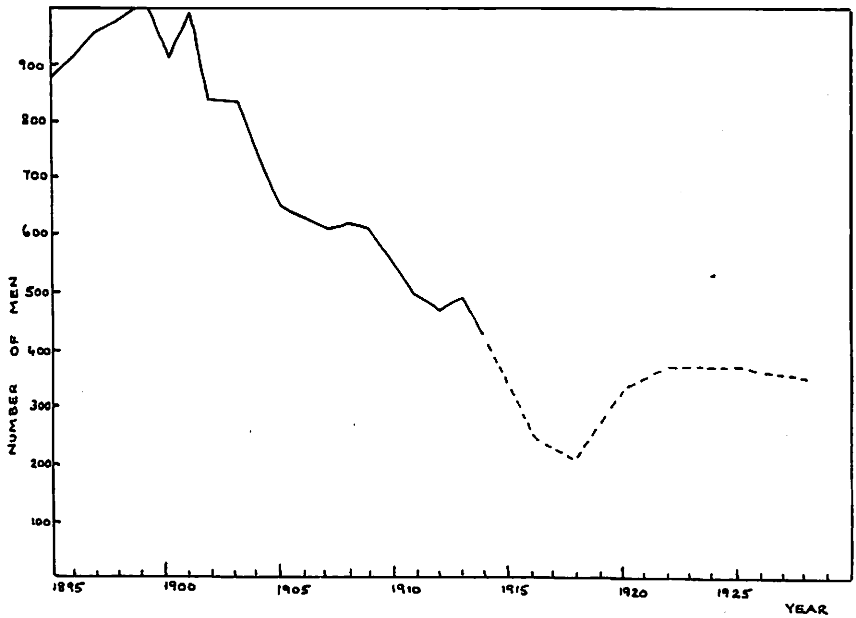


Fig.2 Total number of men employed in Angus quarries from 1895 to 1928.

The figure shows how the number of men employed has varied between the year 1895, when official figures first became available and 1928. No figures were given for the years 1915, 1917, 1919, 1921, 1923, 1924, 1926, 1927, 1929, and 1930. Since the graph includes employment in whinstone as well as sandstone quarries the increase after 1918 may be due to increased requirements for road metal.

The author wishes to thank Dr C. D. Waterston of the Royal Scottish Museum, Edinburgh, for suggesting this research, and for his continued help and encouragement. His presence in the field was always a great stimulant for further effort.

References

Armstrong, M. and Paterson, I. B., 1970, The Lower Old Red Sandstone of the Strathmore Region, pp.23, *Rep.Inst.Geol. Sci.*, No. 70/12.

Bremner, D., 1869, *The Industries of Scotland*, Edinburgh, A. and C. Black, p.416.

Carmichael, J., 1837, 'An Account of the Principal Marble, Slate, Sandstone, and Greenstone Quarries in Scotland', *Prize Essays and Transactions of the Highland and Agricultural Society of Scotland*, New Series, v.5, p.409.

Clugston, W., 1843, *The New Statistical Account of Scotland*, Edinburgh and London, W. Blackwood & Sons, 1845, v.11, p.691.

Crombie, J., 1842, *ibid.*, p.626.

Edward, R., 1678, (English translation, 1793), *A Description of the County of Angus*, Dundee, T. Colville, 1793.

Harry, W. T., 1952, 'The Geology of the Dundee District from its Quarries', *The Quarry Managers' Journal*, p.489.

Hay, G., 1876, *History of Arbroath*, Arbroath, T. Buncle, p.410.

Lyon, J., 1836, *The New Statistical Account of Scotland*, Edinburgh and London, W. Blackwood & Sons, 1845, v.11, p.337.

McBain, J. M., 1887, *Arbroath Past and Present*, Arbroath, Brodie & Salmond, p.135.

Miller, H., 1841, *The Old Red Sandstone*, Edinburgh, W. P. Nimmo, Hay & Mitchell, p.162.

Miller, S., 1842, *The New Statistical Account of Scotland*, Edinburgh and London, W. Blackwood & Sons, 1845, v.11, p.439.

Mitchell, A., 1792, *The Statistical Account of Scotland*, Edinburgh, W. Creech, 1795, v.4, p.47.

Ochterlony, J., *ca.* 1682, *An Account of the Shire of Forfar*, reprinted for the Forfar and District Historical Society, Forfar, O. McPherson, Ltd., 1969.

Prize Essays and Transactions of the Highland and Agricultural Society of Scotland, New Series, 1837, v.5, p.160.

Robertson, W., 1836, *The New Statistical Account of Scotland*,

Edinburgh and London, W. Blackwood & Sons, 1845, v.11, p.350.
Wright, T., 1795, *The Statistical Account of Scotland*, Edinburgh, W. Creech, 1795, v.14, p.594.

The Grizzly Bears

Readers may be interested to learn that Hercules was by no means the first bear to visit the Outer Hebrides. The cover illustration is a cartoon of a Geologists' Annual Dinner circa? 1880 taken from the "Grizzly Bear Books" which record in cartoon, verse and prose, the unofficial history of the Geological Survey in Scotland.

Reproduced by kind permission of the Assistant Director, Institute of Geological Sciences, Edinburgh.