Mineral Resources
Consultative Committee

Mineral Dossier No. 12

Slate

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Preface

The Mineral Resources Consultative Committee consists of representatives of interested Government Departments, and specialist advisers. It was set up in 1967 to keep present and future requirements for minerals under review and to identify problems associated with the availability, exploitation and use of mineral resources, both inland and offshore, having regard to competing demands on land use and other relevant factors.

Widespread and increasing interest in the mineral resources of the United Kingdom has led the Committee to undertake the collation of the factual information at present available about those minerals (other than fossil fuels) which are now being worked or which might be worked in this country. The Committee has produced a series of dossiers, each of which was circulated in draft to the relevant sectors of the minerals industry. They bring together in a convenient form, in respect of each of the minerals, data which had previously been scattered and not always readily available. These dossiers are now being published for general information.

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Penrhyn Quarries Ltd;
Pen-yr-Orsedd Slate Quarry Co Ltd;
Solite Ltd;
Tanner and Hall Ltd.

Metric units are employed throughout this document except where otherwise stated. In most cases this has necessitated the conversion of originally non-metric data. The units and conversion factors used are as follows:

millimetres (mm)	= inches x 25.4
metres (m)	= feet x 0.3048
kilometres (km)	= miles x 1.609344
hectares (ha)	= acres x 0.404686
kilogrammes (kg)	= pounds x 0.45359237
tonnes (1000 kg)	= long tons x 1.01605

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Summary

True slates, that is to say rocks of sedimentary or volcanic origin possessing the property of slaty cleavage, are widely distributed within older, folded geological strata of the northern and western areas of the United Kingdom. The slate resources of the United Kingdom are large but their exploitation is now confined to Cornwall, Devon, North Wales and the Lake District.

The traditional use for slate is as roofing tiles, but the material also finds application for other architectural purposes. Crushed slate is sold as a filler and coarser granulated slate can be used in a number of building applications. Architectural slate is a costly material to produce. Slate roofing tiles, for example, may cost as much as £107 per tonne. This price is, however, inclusive of quarrying and subsequent dressing costs. Finer grades of slate powder may cost as much as £14 per tonne.

Slate is produced from open quarries or, exceptionally, from underground mines. Methods used for removal of slate from the working face are conditioned by the need to reduce the amount of waste produced. The production of large quantities of waste in the past has stimulated a search for possible markets, particularly in the form of crushed slate. Dressing of slate for architectural purposes can be mechanised to some degree but production of roofing tiles has become increasingly expensive owing to the continued necessity to employ skilled labour for their fabrication.

Domestic production of slate is now a mere fraction of its former magnitude. In 1898 650,000 tonnes of slate were produced in the United Kingdom but this had declined to 64,000 tonnes in 1973.

The effect of trade in slate on the United Kingdom balance of payments is small but is at present favourable.

Of the surviving slate producers the largest operation is the massive Penrhyn Quarry in North Wales. The largest concerns in the Lake District and in Cornwall have recently amalgamated. About ten other producers are known to be active in Cornwall, Devon, North Wales and the Lake District. No slate production is now recorded from Scotland.

Definition

According to F J North the word 'slate' is related to an old English word *slat* or *sclat* and may have been derived originally from an old French verb *esclater* meaning 'to split' or to 'shiver to pieces'. From this origin a colloquial usage for the word grew up which referred to rocks of any kind which could be split into thin sheets and, in particular, could be utilised as roofing tiles.

Latterly, the word slate has come to be used in a more strictly scientific sense in which it is applied to particular kinds of rock showing evidence of a rather singular genetic history. Conforming to this more restricted usage of the word, the following definition is given in British Standard 812:1967;

> Slate: 'A rock derived from argillaceous sediments or fine-grained volcanic ashes by metamorphism and characterised by cleavage along planes independent of the original bedding'.

The property of cleavage as developed in slates is their single most characteristic feature and, to distinguish it from certain other varieties of cleavage, it is described as *slaty cleavage.*

Despite this characteristic property of true slates, there is still some tendency for the stone and building industries to apply the word to almost any kind of rock which is capable of being cleaved into thin sheets irrespective of whether this fissility is the result of true slaty cleavage or not. Thus, for example, such rock types as the Collyweston and Stonesfield Slates, of south-central England, are thin-bedded Jurassic limestones which split easily along bedding planes. Consequently, they are not, in a geological sense, to be regarded as true slates. Confusion is accentuated by the converse situation typified by the Skiddaw Slates of Cumberland which, in spite of possessing an acceptable geological name, rarely yield commercial-grade slates.

Other misleading applications of the word slate are its use to denote the shaly material accompanying coal and, more recently, as applied to certain types of manufactured roofing tiles.

It must be emphasised that, unless stated otherwise, this dossier deals with slate defined in the more precise geological sense.

Origin, nature and mode of occurrence

Most slates originated from muds or fine-grained silts deposited in shallow seas close to continental margins. The alternation of slates with coarser-grained beds indicates that the relief of adjacent continental areas may have undergone periodic rejuvenation associated with mountain building movements. The association of slate producing muds with unstable continental margins is also emphasised by their subsequent incorporation in belts of great structural complexity. Some slates are derived from accumulations of fine-grained volcanic ash rather than detrital matter of purely continental and sedimentary origin. The existence of a long-continued episode of volcanism, such as that indicated by the volcanic green slates of the Lake District, can also be regarded as symptomatic of unstable tectonic conditions.

Following burial, accumulations of mud, silt or volcanic ash may be converted, or metamorphosed, to slate as the result of having been subjected to a relatively mild degree of heat and pressure during the process of mountain building (orogenesis). The slaty cleavage is imposed upon the rocks in a plane normal to the direction of greatest stress. This is believed to result from the orientation of sub-microscopic flakes of certain minerals, notably micas and chlorites, in response to the stresses to which the rock was subjected in such a way that their crystallographic cleavage directions are parallel.

Fortuitously, the slaty cleavage may be parallel to the original bedding of the rock but, in fact, it is often difficult to discern the original bedding due to the lithological monotony of many slates. One direction of slaty cleavage may predominate over very large areas. For example, in Snowdonia and the Corris district, slaty cleavage strikes in a persistent south-west to north-east direction and this is very little affected by local variations in geological structure.

Slates vary somewhat in their mineral composition but differences in colour and general appearance within single quarries or between adjacent quarries may be the result of quite minor mineralogical variations. The most important mineral constituents of slate are:

	Weight per cent
Sericite mica	38-40
Quartz	31-45
Chlorite	6-18
Haematite	3-6
Rutile	1-1.5

Pyrites, pyrrhotite, limonite, magnetite, ilmenite, graphite, calcite and other minerals may additionally be present, generally in accessory quantities. To some extent the mineral composition is related to the external forces to which the rock has been subjected so that, for example, sericite mica and chlorite are seldom present in the sediments from which slates are derived.

At the same time the gross chemical composition of slates tends to remain stable during metamorphism and most slates fall within the following ranges of composition:

	Weight per cent
$Si0_2$	45-65
Al_20_3	11-25
$Fe0$	0.5-7
Na_20	1-4
K_20	1-6
$Mg0$	2-7
$Ti0_2$	1-2

Although the specific gravity of slate is around 2.85, slate tiling does not exert a high load pressure due to the thinness to which it can be cleaved. Welsh slate is possibly the best in the world in terms of a favourable combination of fissility and structural strength. It also tends to be somewhat more durable in urban areas owing to the very low calcite content. Slates containing appreciable quantites of calcite or pyrites, such as those from the Lake District containing up to 8 per cent calcite, may be affected by chemical weathering, particularly in industrial areas where rainfall may be polluted by dilute acids.

Although texturally slates are generally rather homogeneous, the trend away from mass production of cheap roofing tiles has been paralleled in an increasing awareness of the aesthetic appeal of slates which display certain irregularities of appearance on cleaved or sawn faces. 'Rustic slates' show irregular zones of brown colouration due to the presence of iron oxide minerals. The cleavage in some slates, in particular, is at an acute angle to the bedding direction and the latter shows up on cleaved faces as bands of variable colour. Other slates have a mottled appearance due to the irregular distribution of constituent minerals or the incipient formation of certain metamorphic minerals, such as andalusite. The appearance of distorted fossils, such as the so-called 'Delabole Butterflies' *(Spirifer verneuli)*, has a novelty value in some slates.

Resources

With very few exceptions, slate within the United Kingdom occurs in the upland areas of the north and west of the country where it is associated with highly folded and mildly metamorphosed older rocks of Palaeozoic and Precambrian age.

Currently the main slate-producing centres are in Cornwall, North Wales and the Lake District. The formerly extensive Scottish slate industry is now defunct.

In Wales fine-grained rocks with a cleavage sufficiently well developed to allow commercial exploitation for roofing and allied purposes are found mainly in rocks of the Cambrian and Ordovician Systems. A few occurrences exist in the Silurian and Devonian formations.

The Lower and Middle Cambrian slate belt of central Caernarvonshire* containing the famous Penrhyn and Dinorwic Quarries is relatively narrow and ranges south-westward for about 18 km from near Bethesda to Nantlle and Penygroes. Beds, or 'veins', as they are known locally, of workable slate are separated by poorly cleaved argillaceous rocks as well as massive grits. The thickness of the whole slate-bearing series may amount to as much as 1,200 m. The slates vary in colour, lithological character and degree of perfection of the cleavage.

In the Upper Cambrian, slates occur in the Tremadoc Group and in the Dolgellau Beds around the Harlech Dome. These have been quarried to the northwest of Arenig, on Rhobell Fawr and near Arthog. The slates of the Dolgellau Beds are black on a fresh surface, but the presence of finely disseminated pyrites results in a distinctive rusty-brown hue in weathered rocks; in consequence, quarrying ventures in this formation have not proved very successful.

Slates are also found in the somewhat older Cambrian horizons within the Harlech Dome; an example is the succession of green and purple slates developed near Llanbedr. Although these slates are similar to those found in the Llanberis region the presence of interbedded grits renders any possible exploitation uneconomic.

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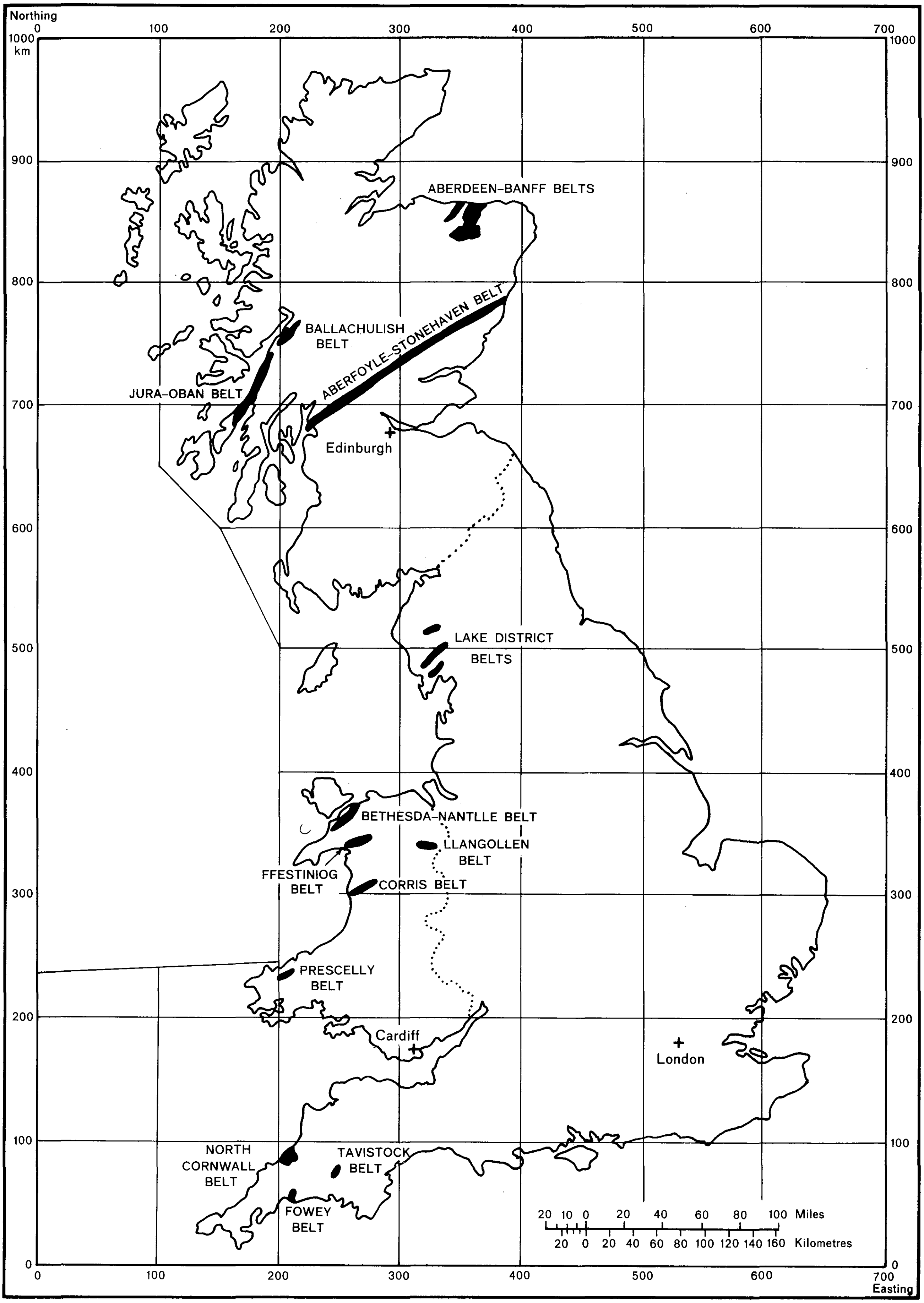
* County names used in Wales prior to the Local Government re-organisation of April 1974 are retained in this report as they permit a more precise definition of locality to be indicated.



Slate producing belts in Great Britain

Slates of Ordovician age occur throughout Snowdonia and in the adjoining country to the south-east. Over the whole of this area there are workings ranging in size from small diggings to the large quarry and mine complexes at Blaenau Ffestiniog, where the best Ordovician slates in North Wales occur. They are finer-grained than the Cambrian slates of Caernarvonshire and are mostly blue-grey in colour with lustrous surfaces. There are at least seven 'veins' of workable slate separated by grit bands. A few of these 'veins' are more than 50 m thick in places. The quality of their cleavage is such that it is possible to obtain exceedingly thin sheets. The most valuable slate horizon at Blaenau Ffestiniog is the so-called 'Old Vein' which for many years has yielded top quality slates.

In southern Merionethshire and in the adjacent part of Montgomeryshire the outcrop of a sequence of mudstones, some 500 m thick and belonging to the Bala Series of the Ordovician, can be traced from Towyn in the south-west to Dinas Mawddwy in the north-east. This belt of mudstones, in which slaty cleavage is well-developed at certain horizons, includes the well-known quarrying area around Corris. The two most important slate horizons in this belt are the 'Broad Vein', up to 300 m thick, and the 'Narrow Vein' some 20 m thick. Slates of Ordovician age were also formerly worked at Llangynog in Montgomeryshire, near Llandrillo and Arthog in Merionethshire and near Amlwch in Anglesey.

In northern Pembrokeshire and in the adjoining parts of Carmarthenshire and Cardiganshire workable Ordovician slates are found in the Prescelly Hills and their environs. They belong for the most part to the Llandeilo and Bala Series and range in colour from olive-green to silvery-grey. They may be derived in part from volcanic ash. Cambrian and Ordovician slates occur in the coastal regions of northern Pembrokeshire and they have been worked in the past near Porthgain and on Abereiddy Bay.

Workable slates occur in the Llandovery Series (Lower Silurian) near Esgairgeiliog between Corris and Machynlleth. In the succeeding Wenlock and Ludlow Series slates have been worked between Corwen and Llangollen and in the adjoining parts of southern Denbighshire and north-eastern Merionethshire. Immediately north-west of Llangollen the Ludlow beds consist of a rapidly alternating series of cleaved mudstones and uncleaved laminated siltstones. These rocks split readily between the cleaved and uncleaved layers into huge slabs of uniform thickness and were formerly extensively quarried for slabs, cisterns and flags. These beds exhibit cleavage, but are more in the nature of flagstones than true slates as they split most readily in the direction of the bedding.

Fine-grained mudstones lying about 350 to 500 m above the base of the Old Red Sandstone on the island of Skokholm, off the Pembrokeshire coast, have been cleaved to a varying degree. Some beds have yielded pink, lilac and pale green slates which were once worked for roofing local farm buildings.

In the Lake District the slates of the Skiddaw Group are of Ordovician age. Although they have found some local application as building stone and for dry-walling, the presence of several distinct directions of cleavage has, in general, rendered them unsuitable for the production of roofing tiles.

The overlying Borrowdale Volcanic Group, which is also of Ordovician age, comprises thick accumulations of lava and pyroclastic rocks. Some of the tuffs included in the sequence have been quarried under the local name of 'green slates'. The tuffs workable as slates crop out in two main belts, one lying near the base of the Group and the other near the top. The lower slates are currently worked at Honister Pass and were formerly quarried at other localities; the upper slates crop out south-eastwards from near Ambleside towards the Broughton region and are quarried at a number of localities. The 'green slates' vary in colour from light and dark green to purple-green. They are regularly cleaved and are suitable for roofing, although they have found wider application as well-cladding and, more recently, as ornamental stone. South of the crop of the Borrowdale Volcanic Group, slates are quarried from Lower Silurian formations, notably the Brathay Flags. In colour, these Silurian slates vary from grey to blue-black and, unlike the Ordovician slates, are not of volcanic origin. The largest workings in the formation are the Burlington Quarries near Kirkby-in-Furness.

Devonian slates have been extensively quarried in northern Cornwall, where workable slates occur along the south of Boscastle and Tintagel, and in the immediate hinterland. The largest excavation is the Old Delabole Slate Quarry which has been worked continuously for at least 400 years and is now about 310 m long by 210 m wide and 150 m deep. In addition, much smaller workings are presently active in the Tintagel area. The Delabole slates vary in colour from greenish grey to dark blue-grey and are notably fissile, resonant and elastic. They are renowned for the occasional spectacular fossils that are found. Devonian slates have also been worked in the Fowey area.

Elsewhere in England rocks of Carboniferous age possessing slaty cleavage are worked at Mill Hill about 2.5 km north-west of Tavistock, Devon; the classification of this quarry as a slate producer is somewhat arbitrary, however, since none of its products are, at the present time, dependent upon the existence of this cleavage. A small production of slate has also been recorded from the Precambrian rocks of the Charnwood Forest area of Leicestershire.

The Scottish slate industry was based on the Dalradian Series of late Precambrian or Cambrian age cropping out in the Grampian Highlands and in the Inner Hebrides. Within this region production was concentrated in four distinct belts. The Ballachulish Slates were worked in the district north and south of Loch Leven. These are black with a fine surface and are characterised by the presence of large crystals of iron pyrites which, in roofing tiles, may fall out leaving conspicuous voids without, however, weakening the tile.

The Easdale Slates were formerly worked at a number of places between Oban and the island of Jura. They are almost invariably blue-grey in colour and are again characterised by the presence of large pyrites crystals.

Along the north-western side of the Highland Boundary Fault the Aberfoyle Slates have been exploited at numerous sites between Bute and Stonehaven. They tend to be lighter and more variable in colour than the Ballachulish and Easdale Slates and are not characterised by the presence of pyrites.

Finally, several small slate workings formerly existed around a number of centres in Banffshire and northern Aberdeenshire.

In the Isle of Man, the Manx Slates, of probable Cambro-Ordovician age, have provided a local source of building material.

Small amounts of slate were produced in the Eighteenth Century from a number of localities in the lower Palaeozoic rocks of the northern Ards Peninsula, Northern Ireland.

Beyond the limits of the districts in which slate is being worked or has been worked in the past there is little likelihood of new deposits being found. Within the known slate districts adequate reserves exist and extensions to known deposits might well be found in country covered by blanket bog or glacial drift. With the present state of the market for slate, however, there is little incentive for developing new resources.

One of the main problems that has long been associated with the winning of slate concerns the very large proportion (up to 95 per cent) of quarried material that has to be rejected during the manufacture of roofing tiles or other dressed slates. Very large waste tips characterise many of the slate producing regions and increasing attention is being given to the exploitation of this rejected material.

Land use

Information on the amount of land affected by current or derelict workings for slate and also that covered by planning permissions is only available from certain areas.

Current slate workings in Wales, including extraction areas, tipping zones and processing sheds are estimated to cover around 810 hectares (2000 acres). Less than a tenth of this area embraces land actually being utilised for present-day mining or quarrying operations. Existing planning permission areas, both for slate extraction and waste disposal, total 1,620 to 2,020 hectares (4,000-4,990 acres) but about half this area now involves quarrying or mining units no longer functioning.

The area of land covered by current planning permissions for slate working in the Lake District is estimated as being at least 610 hectares (1,510 acres), mostly in southern Cumbria. In addition, land allocated in the County Development Plan as intended for slate working (which includes a small proportion of land for which planning permission has subsequently been granted) is estimated at about 990 hectares (2,445 acres), mostly in the former county of Cumberland. No estimate of the total area of the Lake District covered by actual workings is available. However, it is known that at least 240 hectares (590 acres) of land in the area is affected by active or recently derelict quarries and their tipping sites.

The area of land covered by current planning permissions in Devon and Cornwall is in excess of 190 hectares (470 acres). No estimate of the total area covered by actual workings is available.

Figures are also unavailable as to the area covered by derelict slate workings in Scotland.

In general slate workings are situated in country of marginal agricultural value and the disturbance of, for example, sheep farming in Wales and the Lake District is not great. A much wider problem is related to the fact that most operations are carried on in rural areas of high landscape value. The Snowdonia and Lake District National parks are particularly affected by the results of present and former production of slate. An extreme situation is perhaps exemplified by Blaenau Ffestiniog, a small Merionethshire town surrounded by ugly waste tips, which had to be excluded from Snowdonia National Park in which it is an enclave. The objections to slate workings in these areas are mainly visual and are associated with the presence of large waste tips and deep open quarries. Dust and noise have a lesser, but not insignificant, bearing upon amenity values.

On the other hand, a social cost has been imposed by the decline of the slate industry as in some areas, notably North Wales, the slate industry at one time provided the only means of full-time employment for thousands of men. The rapid growth of tourism in these areas during the past two decades has only partially offset the unemployment problem which persists following the sudden contraction of the industry during the same period. Some surplus labour was absorbed in North Wales during the construction of the Tan-y-Grisau pumped storage scheme and the Trawsfyndd power station but the eventual completion of these projects did not result in any reversal in the decline of the local slate industry.

Some consideration has been given to the problem of land restoration in areas left derelict by slate quarrying. Existing workings are subject to permission under the Town and Country Planning Acts, which normally contain restoration conditions. The major dereliction is by the tipping, as waste, of a high proportion of the material quarried. Although most quarries are at present being worked at a small proportion of their total capacity, the legacy of waste from large-scale working in the past is still much in evidence. The total amount of waste that still remains in the United Kingdom as a whole is estimated to be around 300-500 million tonnes.

Little attempt has as yet been made to solve the problems raised by the possibility of restoration of waste piles left derelict by slate working. The possible restoration of a few sites in the Blaenau Ffestiniog and Corris areas has been considered. Small-scale experiments undertaken by Liverpool University at Penrhyn Quarry and by the Forestry Commission have indicated that where the slate is well-weathered, or mixed with overburden, conifers, such as Scots, Corsican and Lodgepole Pine, record a slow rate of growth on the waste heaps. Botanical research has also been undertaken at Liverpool University with the aim of finding hardy varieties of grasses and other plants having some ability to establish themselves upon sterile slate waste with a minimum of cultivation.

At Blaenau Ffestiniog some of the underground chambers in one undertaking where slate is no longer mined have been opened up as a tourist attraction. In the Nantlle Valley a scheme has been announced recently for flooding old slate workings for the purpose of sailing and fishing. Old waste tips would be landscaped and within the complex houses and hotels would be built.

Although large-scale dereliction from the past is still a major problem, there is hope that in future the problem can be minimised. Close planning control would undoubtedly be imposed on any future extension of slate working. Back-filling of exhausted workings is practised in some places and waste has been stored underground in some mines. Improvements in sawing, trimming and splitting techniques would also cut down on the quantities of waste to be discarded. At Aberllefenni Quarry in North Wales, the introduction of chain-saws instead of blasting for extraction is said to have reduced the waste factor from 87:1 to 12:1.

A further contribution to the problem of dereliction by waste might be made if new uses could be discovered for the material. Much of this waste, however, has been deposited in remote rural districts from which the cost of transport would be high. A notable proportion of the waste is also made up of large blocks which would be difficult and costly to handle. Many of the waste heaps have peripheral slopes of 30 to 38 degrees so that stability problems would be encountered if relatively minor quantities of material were removed from the toes of these slopes.

Despite these handicaps a small, but growing, proportion of the slate left after the removal of the better grade material for building purposes can be sold and transported in the form of powder. This, however, is a low price commodity and the demand for it is always likely to be outstripped by the vast amount of waste available. Other possible outlets for slate waste are noted in the following section but again these are unlikely to make more than than a marginal contribution to the problem of tip disposal.

Uses

The most familiar use of slate is as thin but extremely durable roof tiles and the large number of buildings in cities and towns throughout the country possessing slate roofs testifies to an immense demand in the recent past for such tiles in preference to local roofing materials which had hitherto been utilised before the construction of the canals and railways. The enormous quantites of dark bluish or purplish grey slates that have been used, particularly in urban industrial centres, has given slate an undeserved reputation for being visually unattractive. In recent years, the use of less well-known colours, such as green, red or purple and, in the case of roofs, the use of diminishing courses, has demonstrated that, used imaginatively, slate is a highly attractive material for roofing and other architectural purposes.

Although the market for roofing slate is now a mere fraction of its former extent, a continuing demand exists for architectural slate in other, more decorative, fields. Different coloured slates are valued for their aesthetic appeal in such situations as wall cladding, flooring, paving, sills and thresholds. Slate also finds application in damp courses. A small but steady demand exists for slate for restoration work. Padstow parish church in Cornwall, for example, was recently re-roofed with Delabole slate.

Another small but continuing use of slate has a surprising antiquity. This is its use for memorials; certain tombstones are known in Cornish churchyards whose lettering remains clearly legible after 400 years. Dry-walling is another, relatively minor, consumer of slate.

Usually it is no longer economic to produce roofing slate alone and even in the heyday of the roofing slate industry the fact that only about 5 per cent of the material quarried actually finished up as tiles resulted in consideration being given to the possible uses of slate waste. As far back as 1908 plant was installed at the Old Delabole Quarry in Cornwall for producing crushed and ground slate. Since that time the demand for slate powder and the number of its applications has grown.

Crushed slate is marketed under various trade names such as 'Fullersite' (Penrhyn) and 'Delafilla' and 'Delagranules' (Delabole). Initially such crushed slate was used as a substitute for brick clay in areas such as Cornwall where the latter commodity was scarce. More recently the use of crushed slate has shown an increasing diversity. The finer grade slate powders have found applications as a filler in a number of industries where chemical inertness is required. Examples of products using such powder include bituminous solutions, bitumen, coal tar coating materials, roofing and damp course felts, motor car underseal, terrazo tiles, concrete products, insecticides, adhesives, paints, paper, rubber plastics and fertilisers. The coarser, granulated slate is used for artificial stone manufacture, surfacing, roofing felts and concrete tiles and can be supplied in natural or tinted colours.

Within the context of an increasing market for crushed slate a number of subordinate trends can be noted. As an example, the use of slate powder in gramophone records ceased in the 1950's. Although the use of slate powder as a filler and dusting agent for roofing tiles has declined somewhat, this has, to some extent, been replaced by its use as a filler in protective coatings for natural gas pipes.

Crushed material derived from some slates is capable of being expanded in rotary kilns. Some of this partly fused material can be sold as filter media in sewage treatment works and more, after crushing, can be used as an aggregate in lightweight concrete. Research into the utility of various slates for lightweight aggregate was carried out intermittently by the Building Research Station since before the Second World War. In recent years a small amount of expanded slate has been sold under the name 'Solite'.

The Building Research Station has also investigated the possibility of producing bricks by autoclaving mixtures of lime and crushed slate. Such slate-lime bricks are, however, found to have a high drying shrinkage and to be susceptible to frost damage under severe conditions.

A concrete brickmaking plant using slate waste as aggregate was installed at the Ballachulish quarry in 1954 but this did not prove competitive with blocks using a granite aggregate.

Small amounts of waste are sold from some quarries for fill in road and other construction. For example, fill used in the construction of the approaches to the new Tamar road bridge was obtained from the Mill Hill quarry near Tavistock.

In 1973 about 27 per cent of slate produced was for roofing, and just over 1 per cent for damp proof courses, both these uses accounting for a decreasing proportion of production in recent years. Slate used for other purposes, however, has tended to increase, both in proportion and in tonnage. There are no official figures specifying the remaining uses of slate, which in 1973 accounted for 72 per cent of production. These uses include the making of slate slabs, slate for cladding, and slate granules and powder for use in the manufacture of roofing and damp course fabrics, fillers, tiles and lightweight aggregates.

65 per cent of recorded Welsh production in 1973 was used for roofing slate, providing 77 per cent of total roofing slate produced in Great Britain. Most slate for other uses is produced in England, although Welsh slate is also used for a variety of purposes, for example, the dust plant at Penrhyn Quarry was producing 400 to 500 tonnes of inert filler and 250 to 300 tonnes of granules per week at the end of 1971. Approximately 21 per cent of slate produced in 1973 was exported, either as worked or unworked products.

Specifications

There are a number of British Standard specifications referring to slate, its definition (see p 2) and its applications. The following cover various applications:

160:1936	Slate and marble insulating slabs for electric power switchgear (confirmed 1957)
680:Part 2 1971	Roofing slates

3797:1964	Lightweight aggregates for concrete
4374:1968	Sills of clayware, cast concrete, cast stone, slate and natural stone

The following Code of Practice also refers:

142:1968	Slating and tiling

It is difficult to quantify desirable qualities of slate. 'Good' slate depends upon an interplay of variables such as mineralogical composition, porosity, potential cleavability, degree of other fracturing and, inevitably a subjective factor, aesthetic appeal. Slate may vary widely in quality within the confines of a single quarry and it is usually only the long experience of the quarrymen themselves which can determine what will constitute a 'good' slate.

Architectural slates require a persistent cleavage direction but must not be too broken by other potential directions of fracturing which might be given, for example, by joints, faults, or 'kink bands'. If fractures such as these are too abundant only small uneconomic blocks of unsuitable shape can be quarried. At Delabole, for example, it was found that quarried blocks up to about 2 tonnes in weight (approximately 2.4 m length x 1.2 m width x 0.4 m thick) were most suitable for further reduction to roof tiling. Roofing slates themselves are, ideally, around 3/16 inch (4.6 mm) thick. Thus Welsh slate, which can be cleaved at 5 or 6 to the inch (25 mm), is very suitable for this purpose but Lakeland slate, which can in general only be cleaved at an average of about 2½ to 3 to the inch is not so satisfactory.

The presence of free sulphide (usually iron pyrites) and carbonate (usually calcite) minerals may be undesirable in architectural slate since these constituents are reactive to dilute mineral acids which may exist, for example, in rainfall over industrially polluted areas. In practice, however, the deleterious nature of these minerals may only be serious in certain, more porous, slates or where the minerals concerned are finely disseminated through the matrix. In the Ballachulish slates, for example, the presence of a few large crystals of pyrites is not specially disadvantageous since, on weathering, these crystals simply fall out leaving the matrix of the slate unaffected. Once again, experience is the best guide as to the potential degree to which a particular slate may suffer chemical weathering. Occasionally certain compositions of pyrites are susceptible to attack by water alone. The pyrites in Glyn Cieriog slate (quarry now closed) may fall into this category since it fails on wetting and drying. Slate powder containing pyrites or calcite would not, however, be suitable for use as an inert filler. As an example, 'Fullersite' from Penrhyn consists mainly of the inert minerals quartz, illite and chlorite.

On the other hand, the production of expanded slate or 'Solite' was dependent upon the presence of some 3-5 per cent iron pyrites since on heating this mineral gives off hydrogen sulphide thereby facilitating the expansion or 'bloating' process. A further factor contributing to the rapid dispersal of hydrogen sulphide is that the parent material contains up to five directions of potential fracture which act as channels for gas transport.

The size and shape of the slate granules used for asphalt roofing felts is important. Flat disc-shaped grains between 8 and 24 mesh are ideal for this purpose.

Price and cost

Prices quoted for slate by various undertakings invariably include the cost of some degree of processing on site. Thus the newly quarried material cannot be said to carry a distinctive price of its own. The actual price, ex-works, of the products vary widely according to the amount of processing required, the vagaries of demand for a particular type of slate and also to some extent, from the location. The figures given below, therefore, can only be at best a rough indication. All prices quoted are ex-works.

Roofing Tiles

The price of slate roofing tiles varies according to thickness and size. For Standard slates approximately 1/5 inch (5 mm) thick, one large manufacturer quotes (April 1974) prices ranging from £38.00 per tonne for slates 10 x 6 inches (250 x 150 mm) to £107.00 per tonne for slates 26 x 14 inches (650 x 350 mm). For Heavy slates, approximately ¼ inch (6.5 mm) thick, the prices are as listed less 20 per cent. For Extra Heavy slates, approximately 1/3 inch (8 mm) thick, the prices are as listed less 25 per cent.

The variation in price reflects the increasing difficulty of cleaving thinner slates and of making large flawless tiles.

The movement of prices for roofing slate in earlier years is indicated in the following table:

Table 1 Price of slates for roofing. Average import and export values, 1923-1970

	Imports (cif) (£/tonne)	*Exports (fob) (£/tonne)*
1923	7.24	11.84
1930	6.08	10.86
1938	4.46	11.22
1950	19.42	25.46
1960	17.20	na
1970	30.33	na

na: Information not available
Source: 'Overseas Trade Accounts of the United Kingdom'

Other architectural slate

The following are examples of prices quoted by one large producer in April 1974. Again price variations reflect thickness and size and the consequent labour element in production costs. All prices are ex-quarry and do not reflect transport or installation costs.

Flooring and paving	£0.54 - £0.65 per m^2
Wall cladding	£2.69 - £9.15 per m^2
Blocks for walling	£6.00 - £28.00 per tonne
Coping and capping	£5.90 - £9.48 per m length
Damp proof course slates	£23.40 - £36.80 per tonne

Slate powder

Slate powder is produced in many different mesh sizes. Examples of prices (May 1974) are:

100 mesh	£3.75 per tonne
300 mesh	£13.75 per tonne

Slate granules

Prices are in the range £5 - £6 per tonne.

Expanded slate

Production of this commodity has recently ceased, possibly temporarily. In November 1971 the manufacturers quoted a price of £2 per cubic yard ($0.76m^3$) or £3.94 per tonne.

Other considerations

The variation in the final cost of using slate products depends also upon transport and installation as well as production costs. The latter, whilst obviously dependent upon the particular use for which the slate has been purchased, is complicated by the fact that, for architectural and roofing use, the higher production costs of larger worked slate is offset by cheaper installation costs. In roofing slate, for example, there tends to be an optimum economic size reflecting the inverse proportion of production and installation cost. As a rough indication this optimum occurs in tiles with dimensions of around 18 x 10 inches (450 x 250 mm).

Technology

No clear distinction can be drawn between the 'winning' of slate and the 'processing' of the material. The technique of removing slate from a quarry face is to some extent conditioned by the ultimate intended end-use.

Most slate is worked opencast although some is won underground. Most quarries were initiated in hill sites on steeply-dipping slate strata but, notably in North Wales and in North Cornwall, these have tended to develop into deep open pits as more material is removed. Large open quarries are often worked in a series of benches each around 18 m high; the enormous Penrhyn Quarry is an outstanding example. The Blaenau Ffestiniog slate mines are examples of workings developed in a mountainous area where the dip of the slate strata is less than 45 degrees. In these circumstances underground mining was more economic than open quarrying and large underground galleries were developed. This method obviated the necessity of removing huge amounts of unproductive overburden material but suffered from the disadvantage of the need for leaving up to 50 per cent of the good slate as roof pillars.

Removal of overburden is the first stage in slate quarrying. Apart from the normal layers of topsoil and poor-quality weathered rock, removal of the cover may additionally involve the disposal of slate waste dumped haphazardly during the earlier phases of quarrying. Until comparatively recently removal of the overburden was a laborious process involving hand excavation and loading into tram wagons. The advent of modern earth-moving machinery has considerably simplified this task.

Blasting is invariably involved at some stage in the removal of slate from the working face. In the simplest case this may involve drilling a series of shot holes 1 to 2 inches (25-50 mm) in diameter and to a depth of about 15 feet (4.6 m) at right angles to the cleavage. Nowadays compressed air percussion drills using tungsten carbide bits are normally used. For primary blasting gunpowder is used on good rock so as to avoid undue fragmentation. Waste rock can, however, be broken up with high explosives. After the primary blast, the larger masses of rock are further broken down by drilling holes parallel to the cleavage and using small powder charges. Further reduction is done by hand.

Various attempts have been made to improve extraction methods, particularly with a view to reducing the amount of fragmentation, and therefore, loss of good slate. The use of the wire saw has attracted some attention. At the Broughton Moor Quarry, near Coniston, heading blasts are used in conjunction with wire saw cuts. A brief description of one method of using the saw serves to illustrate the use of this machine.

Adits are driven into the rock face at right angles to the cleavage for a distance of approximately 50 feet (15.2 m). The heading is then turned at right angles and driven along the cleavage. Thereafter a wire cutting technique using a three-strand wire rope 3/16 inch (4.6 mm) in diameter is used to cut horizontally into the face level with the bench. Vertical wire cutting on both sides of the heading is sometimes necessary in addition so as to retain a vertical face and thereby avoiding damage to higher bench levels. The steel wire is held against the rock face by ratchet tensioners and a sand slurry is fed into the cut to act as the abrasive. Sawing rates of 1 to 2 inches (25-50 mm) per hour are achieved and the wire, which may be up to ½ mile (0.8 km) long and driven via pulleys from a drum house, is discarded every few days and a new one fitted. Following wire cutting, gunpowder is placed in the heading parallel to the cleavage and the adit is back-filled prior to detonation. Huge blasts have been produced using this method but, in practice, less fragmentation occurs with smaller blasts. Recently it has been found possible to reduce the amount of waste to a negligible level by using a chain saw which is capable of making a rapid 6 foot (1.8 m) horizontal cut into the rock. Holes are then drilled at right angles to this cut and a relatively small and unfragmented block of the rock is blasted out.

Haulage of slate within the quarry or mine areas was formerly achieved by various methods including tramways or aerial ropeways. In North Wales workings such as those at Penrhyn or Blaenau Ffestiniog were characterised by large internal narrow gauge railway systems which, in turn, were connected to feeder lines running to the coast. The famous Ffestiniog Railway, dating back to 1836, is an example. All such systems have now vanished or are used for other purposes and movement of quarried material is now by means of trackless earth-moving vehicles.

The first stage in the production of roofing slates involves the cutting of the larger blocks of material by means of diamond saws and various hand tools. When the quarried blocks have been reduced to an easily handled size, use is made of the unique fissility of slate to split the slabs into even slices which are then further trimmed to the appropriate roofing tile sizes. All attempts to mechanise the process by which slate slabs are split parallel to their cleavage direction have failed and this operation is still carried out by skilled craftsmen using mallets and chisels. The need for high-cost skilled labour at this stage can be pinpointed as one of the prime causes for the decline of the economic viability of slate as a roofing material.

Processing methods can be partially mechanised in the production of architectural slate other than roofing tiles, for which diamond saws, frame saws and polishing buffers may be used. Specialised work, including grooving, rebating and edge-grinding is, however, still carried out by a variety of hand tools.

A brief description of the plant at the Penrhyn Quarry will illustrate the manufacturing processes involved in the production of slate powder and granules. Green slate granules are preferred for surfacing asphaltic roofing felt but as little of this colour is available on the dumps at Penrhyn it is quarried especially for the plant. Blue slate waste from the production of roofing tiles is also fed, by conveyor belt, to the powder and granule plant. The vast amounts of purplish-coloured slate available on the dumps are not at present in demand for crushing.

Waste slate from the sheds and green slate from the quarry are reduced to - 2 inches (50 mm) in a jaw crusher and then to - ½ inch (12.5 mm) in a hammer mill before passing through a rotary drier to remove excess moisture. The slate is further crushed, in a closed circuit, to - 8 mesh before again passing through a rotary drier. Screens then remove the - 8 + 24 mesh granules which are stored in silos according to colour. Slate particles in the - 24 mesh range are further reduced in size by either a ball mill or a Hardinge Mill and the resultant powders ranging from 100 to 300 mesh are stored in silos prior to bagging or delivery in bulk.

'Solite', a trade name for expanded slate, was produced until recently at a plant at Bwlchgwyn, near Wrexham, from large reserves of slate waste available at the abandoned slate quarries on Moel-y-Faen on the Horseshoe Pass near Llangollen. The slate, of Silurian age, was transported by lorry approximately 7 miles (11.2 km) to Bwlchgwyn and was stockpiled prior to crushing and screening to - ¾ inch (18.5 mm). The crushed slate was fed into a rotary oil-fired kiln in which it expands at a temperature of 1170°C. The kiln was lined with abrasion-resistant silica firebricks at the feed end and was also equipped with crossbars to dissipate heat to the charge. The remainder of the kiln was lined with alumina bricks (45 per cent Al_2O_3) and high alumina bricks (65 per cent Al_2O_3) in the combustion zone. The discharged bloated slate was then cooled and the larger lumps, exhibiting a porous structure and consisting of about 15 per cent of the total output, were separated and sold as filter media. The remainder was further crushed and screened to the various sizes required as lightweight aggregate.

Further advances in the technology of the production and use of slate are possible although comparatively little research is being carried out in this direction. The Building Research Station is exploring the possibility of manufacturing new building products from slate waste. Research would also be desirable into the possibilities of transporting slate waste to areas of high demand for aggregate.

Production

There is evidence of the production and use of Welsh slate since the Roman occupation. In 1187 it was recorded that 800,000 slates were shipped from Devon for the King's Buildings at Winchester. The market for roofing slate, mainly destined for some public buildings and larger private dwellings, grew slowly from Tudor times until the later Eighteenth Century when, following the development of a considerable coast-wise and canal traffic in slate, its suitability as a cheap roofing material became known in areas remote from the centres of production.

In North Wales slate quarrying had developed as a major industry by the end of the Eighteenth Century. F J North quotes the records of production at the Penrhyn Quarry which, although amounting to only 1,800 tonnes in 1780, had grown to 20,200 tonnes by 1800, 75,000 tonnes in 1836 and 124,000 tonnes in 1854.

The phenomenal growth of roofing slate production during the Nineteenth Century can be directly attributed to the increase of urban population and a consequent need for new housing following the Industrial Revolution. Annual output of slate rose rapidly to about 500,000 tonnes by the 1880's and reached a peak of 650,000 tonnes in 1898, of which nearly 80 per cent came from Wales. By 1918, however, production had fallen to 111,000 tonnes and, although there was a post-war recovery to around 300,000 tonnes in the 1920's and 1930's, production did not keep pace with the expansion of building activity. The increasing use and popularity of manufactured roofing tiles was a major factor responsible for the diminishing share of the market filled by slate tiles. National slate production was halved following the outbreak of the Second World War. Repairs to bomb-damaged buildings were responsible for a minor revival of the industry during the years immediately following the war but from about 1951 an almost continuous decline has been recorded to an output of only 64,000 tonnes in 1973. This decline in production during the last quarter of a century can be mainly attributed to the increasing cost of the labour intensive methods that are still required for the manufacture of slate roofing tiles.

The annual production of slate in Great Britain is summarised in Table 2. This, together with Table 3 showing production by counties in England and Wales from 1967 to 1973, suggests that the proportion of Welsh production relative to the whole has considerably declined but, as there is some doubt as to the comparability of English and Welsh data (q.v.), the significance of this is difficult to assess. Few data of Scottish production are available since 1938 when output was about 6 per cent of the British total but it is known that this finally ceased in 1966. There has been no recorded production in Northern Ireland during the currency of Table 2.

The proportion of slate production destined for the traditional uses of roofing and damp courses has declined steadily in recent years, from 51 per cent of output in 1967 to 28 per cent in 1973, and this decline is largely responsible for the overall fall in total production (see Table 4).

There are no official statistics specifying the remaining uses of slate which in 1973 accounted for 72 per cent of recorded production but it is believed that much of this production may be in the form of granules and powder. There is reason to believe also that recorded output may not include Welsh production of such forms of slate. In 1971 it is known, for example, that Penrhyn quarry in Caernarvonshire produced over 20,000 tonnes of slate granules and powder. Official statistics, therefore, may considerably overstate the decline of Welsh slate production, and understate total output.

Quarterly statistics of sales of slate and slate products have been collected since 1973 and relate to establishments in Great Britain employing 11 or more persons classified to the Stone and Slate Quarrying and Mining Industry (Minimum List Heading 102 of the Standard Industrial Classification). Results available to date are shown in Table 5. Production figures in metric tons are included for comparison.

Table 2 Great Britain: Production of slate 1895-1973

Thousand tonnes

Year	Wales	England	Scotland	Great Britain
1895	435	89	45	569
1896	468	70	38	576
1897	469	76	44	589
1898	515	92	43	650
1899	501	83	42	626
1900	451	88	37	576
1901	369	75	37	481
1902	402	71	37	510
1903	418	71	34	523
1904	435	66	42	543
1905	411	65	26	502
1906	386	61	31	478
1907	360	52	21	433
1908	332	50	22	404
1909	320	54	19	393
1910	328	55	19	402
1911	333	65	11	409
1912	311	49	11	371
1913	306	43	11	360
1914	254	59	8	321
1915	180	41	6	227
1916	152	25	0	177
1917	107	15	0	122
1918	101	10	0	111
1919	145	15	2	162
1920	196	18	3	217
1921	206	24	9	239
1922	200	26	9	235
1923	163	28	14	205
1924	241	29	16	286
1925	249	30	17	296
1926	256	31	13	300
1927	258	29	14	301
1928	251	32	14	297
1929	244	30	23	297
1930	212	32	15	259
1931	197	33	13	243
1932	205	29	18	252
1933	210	37	21	268
1934	230	38	15	283

Year	Wales	England	Scotland	Great Britain
1935	232	39	19	290
1936	226	37	21	284
1937	230	39	13	282
1938	222	44	17	283
1939	na	na	na	258
1940	na	na	na	123
1941	na	na	na	147
1942	na	na	na	146
1943	na	na	na	117
1944	na	na	na	121
1945	84	40		124
1946	105	64		169
1947	94	74		168
1948	108	59		167
1949	104	59		163
1950	101	49		150
1951	101	64		165
1952	91	54		145
1953	86	56		142
1954	82	65		147
1955	77	63		140
1956	75	53		128
1957	70	63		133
1958	55	57		112
1959	47	48		95
1960	53	42		95
1961	46	52		98
1962	41	53		94
1963	34	91		125
1964	36	87		123
1965	38	47	17	102
1966	36	44	5	85
1967	40	45	—	85
1968	33	45	—	78
1969	24	46	—	70
1970	22	38	—	60
1971	18	42	—	60
1972	18	41	—	59
1973	20	44	—	64

na: Information not available
Data for Great Britain, and England, may include small production in the Isle of Man during the years 1914-18 and 1939-48. Otherwise the Isle of Man is excluded. There has been no production of slate in Northern Ireland during the period 1895-1973.

Sources:

1895-1896	Mineral Statistics; Home Office
1897-1919	Mines and Quarries: General Report with statistics; Home Office
1920	Mines and Quarries: General Report with statistics; Mines Department, Board of Trade
1921-1938	Annual Report of the Secretary of Mines; Mines Department, Board of Trade
1938-1949	Statistical Digest; Ministry of Fuel and Power
1950-1973	United Kingdom Mineral Statistics; Institute of Geological Sciences
1945-1966	Digest of Welsh Statistics; Welsh Office

Table 3 Great Britain: Production of slate by counties 1967-73

Thousand tonnes

County	1967	1968	1969	1970	1971	1972	1973
ENGLAND							
Cornwall	33	24	20	24	24	25	26
Devon		6					
Lancashire	6	8	26	14	12	8	7
Cumberland	6	7			6	8	11
Westmorland							
Total	45	45	46	38	42	41	44
WALES							
Flint	–	–	–	–	–		
Caernarvon	31	26				18	20
Merioneth				22	18		
Pembroke	9	7	24				
Montgomery					–	–	–
Denbigh				–	–	–	–
Total	40	33	24	22	18	18	20
Grand Total	85	78	70	60	60	59	64

Source: United Kingdom Mineral Statistics; Institute of Geological Sciences

Table 4 Great Britain: Production of slate by use type 1967-73

Thousand tonnes

Use type	1967	1968	1969	1970	1971	1972	1973
Roofing							
England	6	6	6	4	3	3	4
Wales	33	26	18	15	16	13	13
Total for roofing	39	32	24	19	19	16	17
Damp proof course	4	3	2	1	1	1	1
For other purposes	41	43	44	40	40	42	46
Total all uses	84	78	70	60	60	59	64

Source: Department of the Environment

Table 5 Great Britain: Sales and production of slate and slate products 1973-74

£'000

	1973 Year	1973 1st Qtr	1973 2nd Qtr	1973 3rd Qtr	1973 4th Qtr	1974 1st Qtr	1974 2nd Qtr
Slate	1,634	425	426	417	366	357	458
Slate products	2,128	457	510	569	592	566	568
Production (tonnes) (a)	64,244	16,487	16,740	15,251	15,766	14,238	17,062

Source: Business Statistics Office

(a) *Source:* Department of the Environment

Consumption

Although there are no official consumption statistics for Great Britain, data relating to deliveries of slate are collected, and home deliveries can be regarded as approximating to consumption. Details from 1967 to 1973 are shown in Table 6.

Table 6 Great Britain: Deliveries of slate by use type, 1967-73

Thousand tonnes

Use Type	1967	1968	1969	1970	1971	1972	1973
Total deliveries:							
Roofing	32.3	34.4	24.7	21.7	19.2	19.7	20.1
Damp proof course	3.6	2.5	1.4	1.2	0.9	1.0	1.1
For other purposes	42.0	42.5	43.2	40.5	40.0	40.8	46.5
Total	77.9	79.4	69.3	63.4	60.1	61.5	67.7
Home deliveries:							
Roofing	27.3	28.8	21.1	19.8	17.7	18.1	19.2
Damp proof course	3.6	2.4	1.4	1.2	0.9	1.0	1.0
For other purposes	41.9	41.7	40.3	37.1	37.3	36.4	40.0
Total	72.8	72.9	62.8	58.1	55.9	55.5	60.2
Deliveries to export:							
Roofing	5.0	5.6	3.6	1.9	1.5	1.6	0.9
Damp proof course	0.0	0.1	0.0	0.0	0.0	0.0	0;1
For other purposes	0.1	0.8	2.9	3.4	2.7	4.4	6.5
Total	5.1	6.5	6.5	5.3	4.2	6.0	7.5

Deliveries from quarries destined for export do not necessarily compare to the actual quantities shipped as recorded in the same year by H M Customs and Excise (see Table 9).

Source: Department of the Environment

Consumption of slate at the turn of the century was generally about 95 per cent of domestic production, as there was a fairly important export trade in roofing slates of between 20,000 and 40,000 tonnes annually. By the inter-war period slate was being imported to meet demand, and consumption exceeded output, but in recent years home deliveries have been less than production, and about 10,000 tonnes of slate is annually exported.

Overseas Trade

The United Kingdom has relied largely on domestic supplies of slate and it was only in the building boom of the 1930s and in the immediate post-war period of construction that imports exceeded 10 per cent of domestic production. In recent years imports have been very small, probably consisting mainly of special types of grades for decorative use.

Imports from 1960-1973 are shown in Table 7.

Table 7 United Kingdom: Imports of slate 1960-72

	Crude slate		Worked slate: For roofing		Worked slate: Other (1)		Total	
	Tonnes	Value £ (cif)	Tonnes	Value £ (cif)	Tonnes	Value £ (cif)	Tonnes	Value £ (cif)
1960	703	19,722	1,968	34,408	2,134	55,894	4,805	110,024
1961	519	16,382	1,363	33,154	1,888	53,940	3,770	103,476
1962	384	14,345	4,517	166,187	1,946	55,990	6,847	236,522
1963	514	18,732	4,135	176,130	3,332	76,794	7,981	271,656
1964	522	14,410	2,319	106,132	3,467	90,447	6,308	210,989
1965	406	14,564	520	24,219	2,169	60,584	3,095	99,367
1966	706	25,127	405	19,905	1,435	44,386	2,546	89,418
1967	868	32,259	302	13,955	1,011	28,176	2,181	74,390
1968	na(2)	na	117	3,046	694	28,487	na(2)	na
1969	na(2)	na	92	2,203	289	9,822	na(2)	na
1970	588	25,000	291(3)	8,943(3)	na	na	879	33,943
1971	408	24,234	261(3)	11,096(3)	na	na	669	35,330
1972	502	28,199	644(3)	31,551(3)	na	na	1,146	59,750
1973	151	17,428	439(3)	31,385(3)	na	na	590	48,813

na: Information not available
Source: H M Customs and Excise

NOTES

1. For 1961 and 1962 described as 'Slate in blocks ground or polished but not further manufactured'.
2. Imports of crude slate in 1968 or 1969 were included under SITC (R) heading 27334 'Building or monumental stone (dimension stone, not further worked than roughly split, roughly squared or squared by sawing) - other (including slate)'.
3. Since 1970 all worked slate for roofing and other purposes has been included in SITC(R) heading 661.33 'worked slate and articles of slate including articles of agglomerated slate'.

Since 1971, imports and exports of crude and worked slate have been described under the United Kingdom Tariff and Overseas Trade Classification as follows: Code number 2514 0177 'Slate, including slate not further worked than roughly split, roughly squared or squared by sawing' and code number 6803 0199 'Worked slate and articles of slate, including articles of agglomerated slate'. Imports for the period 1971-1973 are shown in Table 8.

Table 8 Imports of slate by countries 1971-73

		1971		1972		1973	
		Tonnes	£(cif)	Tonnes	£(cif)	Tonnes	£(cif)
Crude slate (2514 0177)							
From:	Portugal	293	15,537	115	4,721	5	226
	Spain	–	–	254	12,627	–	–
	Italy	26	2,067	84	4,690	105	9,425
	Netherlands	22	1,930	43	5,125	20	4,379
	West Germany	21	1,294	0	173	3	431
	Norway	13	1,572	6	786	17	2,760
	India	33	1,573	–	–	–	–
	USA	0	261	0	77	0	115
	Other countries	–	–	–	–	1	92
	Total	408	24,234	502	28,199	151	17,428
Worked slate (6803 0199)							
From:	Portugal	192	5,540	210	6,499	78	4,583
	Spain	–	–	301	14,021	264	15,357
	Italy	42	3,273	65	6,142	55	6,666
	Netherlands	7	1,210	21	1,744	–	–
	France	–	–	20	1,512	10	686
	Norway	15	847	11	691	12	733
	Canada	–	–	16	799	–	–
	Other countries	5	226	0	143	20	3,360
	Total	261	11,096	644	31,551	439	31,385

Source: H M Customs and Excise

During the Nineteenth Century there were substantial exports of roofing slate reaching a peak of over 53 million slates (possibly 80,000 tonnes) in 1889, since when exports declined gradually, averaging only 27,000 tonnes annually during the period 1901-1910. With the decline of domestic production in subsequent years exports have continued to fall, and in the early 1950's exports of manufactured slate averaged only 2,000 tonnes a year. From 1956-1969 slate was not specified separately in export statistics, but in 1970, following a recovery of slate exports from the low level of previous years, separate identification was resumed. From 1970 statistics are available for the first time of exports of both crude and worked slate, and in 1973, 11,000 tonnes of crude slate, and nearly 3,000 tonnes of worked slate was exported, with a total value of nearly £0.8 million.

Exports from 1971-1973 are shown in Table 9, by major countries of consignment.

Table 9 Exports of slate, by countries 1971-73

		1971		1972		1973	
		Tonnes	£(fob)	Tonnes	£(fob)	Tonnes	£(fob)
Crude slate (2514 0177)							
To:	West Germany	4,854	110,895	5,224	101,981	6,089	227,337
	Denmark	427	33,274	729	51,615	880	84,941
	Irish Republic	611	13,928	566	12,695	582	6,358
	Netherlands	2,601	23,247	455	21,745	673	50,262
	France	113	8,209	386	16,796	1,360	68,073
	Belgium	96	1,736	331	16,460	20	2,192
	Hong Kong	–	–	92	16,934	150	31,594
	USA	174	20,713	82	8,549	984	109,700
	Kenya	105	11,000	–	–	–	–
	Other countries	262	20,123	117	12,303	117	14,795
	Total	9,243	243,125	7,982	259,078	10,855	595,252
Worked slate (6803 0199)							
To:	France	969	45,554	1,590	59,784	912	44,744
	West Germany	377	26,478	419	41,481	326	44,217
	Irish Republic	392	25,771	236	14,886	264	17,015
	Netherlands	107	6,330	176	12,622	249	15,314
	Belgium	65	3,345	189	6,279	221	11,361
	Hong Kong	–	–	87	16,318	34	6,699
	USA	245	22,605	95	9,011	51	6,045
	Denmark	91	7,381	73	6,485	324	30,909
	Other countries	265	20,913	195	16,845	227	22,542
	Total	2,511	158,377	3,060	183,711	2,608	198,846

Source: H M Customs and Excise

The effect of trade on the balance of payments is small but is at present favourable. In 1973 exports earned some £794,000 (fob) compared with the cost of imports at £48,000 (cif).

Substitutes

Slate roofing tiles have suffered most from the competition of substitutes. Tiles manufactured from brick clays have long been utilised and enjoyed a considerable share of the market even when the roofing slate industry was working at its highest production level. Latterly concrete tiles with numerous colours and finishes have come to predominate in the building industry. Other possible substitutes for slate as a roofing material include corrugated sheet metal and asbestos sheeting. These, although of negligible domestic importance, may have had a very marginal effect on export markets for British slate. Slate was once a common roofing material used in small semi-permanent and rapidly constructed buildings such as railway ganger's huts, to take one of many possible examples, which nowadays would be roofed with asphaltic felt or similar materials.

The use, as roofing tiles, of certain flaggy limestones such as the Stonesfield and Collyweston 'Slates' derived from the Jurassic rocks of central England and also of flaggy sandstones such as the Millstone Grit of the Pennine region can be regarded as a substitution for true slate in the sense that this might have been utilised had the local materials not been available. Nevertheless, the expense of hand dressing these materials is as great as is the case with true slate. In the case of the Stonesfield Slate roofs which are a characteristic part of the classic Cotswold architecture, a substitute has had to be found since the original quarries are now defunct. Some re-use has been made of 'slates' from dismantled buildings but increasingly, Cotswold-type roofing tiles are an artificial product made by a moulding process.

Slate is only one of several types of building stone which can be utilised as a wall-cladding. Products which specifically simulate slate can be made by a process developed by Plastic Research Laboratories Ltd which involves the processing and moulding of concentrated paper mill effluent mixed with certain additives including china clay waste products. This material has the disadvantage of being less dense than true slate.

Modern flooring materials such as thermoplastic tiles can be substituted for slate blocks. However, it is probable that slate would still be specified where appearance rather than cost is considered important.

Strictly speaking slate powder is utilised as a substitute for other material such as talc rather than the other way round. For example, slate powder can replace talc as a mineral filler in the paints and plastics industry and can also be used as a dusting agent.

Expanded slate is only one of many materials that can be used as lightweight aggregates. Other natural materials that can be used are untreated pumice and, after heat treatment, such materials as vermiculite, perlite and clay. Such artificial products as pulverised fly ash can also be used for this purpose.

Industry

During the past 10 to 15 years there has been a great contraction in the British slate industry. Until recently slate production was entirely in the hands of locally-based private companies but there are signs that these concerns are seeking injections of capital from outside.

The Old Delabole Slate Company Ltd dominates the Cornish slate industry. A few other very small concerns operate in north Cornwall. In Devon, Mill Hill Quarry Ltd are active at their working near Tavistock.

In North Wales the largest remaining slate operations are at Penrhyn quarry near Bethesda. Penrhyn Quarries Ltd is now 100 per cent owned by Marchwiel Holdings Ltd the principal subsidiary of which is Sir Alfred McAlpine and Son Ltd. The other large producer in northern Caernarvonshire, Dinorwic Slate Quarries Ltd of Llanberis, although benefiting from a short-lived boom around 1960 has subsequently gone into liquidation. Penrhyn Quarries Ltd now own the Dinorwic mineral rights and it is possible that production will be revived here.

Slate production continues on a much smaller scale in the Blaenau Ffestiniog area. The Llechwedd quarry of J W Greaves and Sons Ltd is essentially an open working. The only slate mine currently in operation in the district is that belonging to Maenofferen Slate Quarry Co Ltd. The Maenofferen mine is of modern design and enjoys a steady demand for its products. Apart from some limited activity at the Oakeley Quarry no production has been recorded recently from any of the other formerly extensive workings around Blaenau Ffestiniog.

In the Nantlle valley the Pen-yr-Orsedd Slate Quarry Company Ltd operate the quarry of that name and this is the only unit now working in this formerly important slate quarrying area.

Wincilate Ltd are concerned with surviving slate industry of the Aberllefenni-Corris region where they operate the Aberllefenni Mine. Slate ornaments, sills and slabs are produced by the company at a small factory at Braichgoch, Corris.

On the Pembrokeshire and Carmarthenshire boundary the Gilfach Quarry near Maenclochog employed a very small labour force until recently.

The largest Lake District concern is Broughton Moor Green Slate Quarries Ltd operating four quarries and accounting for about 60 per cent of the total production of the area. In April 1973 this company was purchased by the Cornish Old Delabole Slate Co. About five other smaller firms operate seven workings in the Lake District.

Although production of worked slate products has ceased in Scotland, small amounts of slate and slate waste are still removed and used as fill by, for example, the Forestry Commission which uses it for the construction of logging roads.

Despite the long-continued decline of the Welsh slate industry, a decline that, in relative terms, has not been matched in the Lake District or even in Cornwall, the large size of the Penrhyn undertaking is responsible for the continuing dominance of the region in the British slate industry. During 1973 the turnover at Penrhyn was probably as much as for the Lake District quarries as a whole. Although only a few years ago published comment could suggest that the Welsh industry was hampered by outmoded methods and equipment more appropriate to the roofing boom, recent expenditure at Penrhyn at least, has overcome any such disadvantage.

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