Mineral Resources
Consultative Committee

Mineral Dossier No 21

Perlite

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Preface

The Mineral Resources Consultative Committee consisted 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 led the Committee to undertake the collation of the factual information available about those minerals (other than fossil fuels) which were being worked or which might be worked in this country. The Committee 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 in updated form are now being published for general information.

Acknowledgements

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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

Commercial perlite is a glassy rock which will expand to between three and thirty-five times its original volume when rapidly heated in a suitable furnace.

Perlite resources in the United Kingdom are confined to Sandy Braes, Northern Ireland, but glassy rocks in Scotland may prove to be sources of perlite.

Expanded perlite is used as a thermal and acoustic insulator, filter aid, filler, carrier or horticultural aggregate. The largest use for expanded perlite in the United Kingdom is as a lightweight aggregate in plasters. Crude perlite is used in the foundry and steel industries.

World production of crude perlite is about two million tonnes annually. The United Kingdom imports about 115,000 tonnes of crude perlite annually, mainly from Greece and Italy. The largest consumers in the United Kingdom are British Gypsum Limited and Tilcon Limited, both of which produce lightweight plasters. Filter aid production is dominated by Johns-Manville (G.B.) Limited and The British CECA Company Limited. Steetley Minerals Limited import Dicalite filter aids from Belgium.

Introduction

Perlite, in the commercial sense, is any siliceous, glassy igneous rock which expands to form a useful lightweight cellular product on rapid heating to a suitable point in the softening range. This expansion results from the presence in the molecular structure of water and gases which are mobilised at temperatures between 760°C and 1100°C.

Glassy rock is formed by rapid cooling of molten material, trapping water and gas in the molecular structure. Among rocks to which the term, in its commercial connotation, may apply are certain obsidians, pitchstones, vitric agglomerates, tuffs, and pyroclastic flows, as well as rhyolites, liparites, trachytes and andesites. The usual classification of crude perlite is by water content, with obsidian containing less than four per cent combined water and pitchstones above four per cent water.

Perlite is associated with recent volcanic activity, generally within the last sixty-five million years (the Tertiary and Quaternary periods), as a component of pyroclastic lava flows, and as dykes, sills, domes and other intrusive bodies. Volcanic glasses devitrify into cryptocrystalline or microcrystalline quartz-feldspar rocks over long periods of time, so perlite deposits older than the Tertiary period are not likely to be found.

Throughout this dossier, 'perlite' is used in the commercial sense, unless otherwise indicated. The unexpanded material is referred to as 'crude perlite' and the final product is referred to as 'expanded perlite'.

The term 'perlite' is also used in petrography to describe a glassy igneous rock exhibiting a perlitic or 'onion skin' structure of near concentric cracks, often recognisable after devitrification of the glass. The rock is rhyolitic to andesitic in composition, containing two to five per cent combined water, and often has a pearly or resinous lustre, hence the early name of 'perlstein' or pearlstone. Petrographic perlite may not possess the valuable property of expansibility which is the essential characteristic of commercial perlite.

History

As early as the 3rd century B.C., Theophrastus (E.R. Caley and J.F.C. Richards, 1956) described the expansion characteristics of certain rocks as follows: 'But the Liparean stone is made porous when it is burnt, and becomes like pumice, so that both its colour and density are altered; for before it has burnt it is black, smooth and compact'. The phenomenon was probably recognised when it occurred accidentally during experiments to test refractoriness and resistance to slag attack in metal-reducing and lime-burning kilns.

Expansion of igneous rock is next recorded by Basil Sewergin (1801) who experimented with 'Marekanite' from Marekanka, near Okhotsk in Siberia. By studying the behaviour of rocks in the flame of a blowpipe he showed that certain varieties froth easily. Experiments on rocks from Marekanka were also conducted by M.H. Klaproth (1816) who notes that when heated the rock expands or exfoliates to a light, foamy material, and J.W. Judd (1886) who states: 'If the temperature be now raised to whiteness, the whole mass swells up in cauliflower-like excrescences, till it has attained eight or ten times it original bulk'.

J.F. Berger (1816) noted the expansion of a 'pearlstone porphyry' from the Sandy Braes area of County Antrim, Northern Ireland, and F.-S. Beudant (1822) noted similar characteristics in vitreous and perlitic rocks from Hungary. Judd, in J. Durham (1886), notes expansion properties in a porphyritic and perlitic mica-dacite glass from Fife, and later made the following general comment on igneous glass expansion which can still be applied: 'In all these cases it is clear that the rocks contain a considerable proportion of volatile materials, which are given off at a high temperature'.

The first recorded commercial experiments on the expansion of igneous rocks were conducted in the 1930s and summarised by O.C. Ralston (1946). In the USA, A.L. Gladney noted in 1935 the expansion of pumice and pumicite granules on calcination, and H. Romberg, working in Germany, in 1936, smelted obsidian in a shaft furnace to produce a frothy slag which could be rolled or pressed into shapes. In 1939 work in the USSR by P.P. Budnikov and D.P. Bobrovnik showed limited expansion in certain varieties of obsidian from Armenia at a temperature of 980°C. The resulting material was suggested for use as a substitute for natural pumice in lightweight concrete.

The economic significance of this property of some rocks was first noted in 1941 by L.L. Boyer in Arizona, USA, (E.D. Wilson, 1944) and by 1946, after several years of pilot plant development, commercial production of expanded perlite was well established in Arizona. As a rock described petrographically as perlite was the foundation of the industry in the western states of the USA, this name has since been applied to the commercially expanded product regardless of the petrography of the source.

Crude perlite is now mined in more than twenty countries, of which the most important are the USA, the USSR, Greece, Italy and Hungary. Crude perlite is expanded in a large number of countries, one of the most important outside the USA being the United Kingdom, which imports ten per cent of world crude perlite production.

Physical and chemical properties

Crude perlite is a volcanic rock which has cooled very rapidly to a virtually non-crystalline, glassy material containing chemically combined water, trapped gases and fluxing agents. Fine grained volcanic rocks with a silica (SiO_2) content in excess of 66 per cent are called *rhyolites* and *dacites*, and those with a lower silica content (52 to 66 per cent) are *trachytes* and *andesites*.

A glass of rhyolitic composition is known as *pitchstone* if the combined water content is between 4 and 10 per cent, and as *obsidian* if it is between 1 and 4 per cent. Most crude perlites, glasses which will expand on heating, are pitchstone or obsidian, although some have been found with very low water contents or with compositions in the andesitic or trachytic ranges. Typical chemical analyses are given in Table 1.

Perlite occurs as lava flows in volcanic provinces, and as dykes, sills, domes or parts of other intrusions. Dykes and sills are generally thin bodies, but often very persistent. Lava flows and domes can cover many square kilometres to thicknesses up to 250 metres, and are the largest sources of perlite.

Table 1 Typical chemical analyses of crude perlite

	Weight per cent				
	Sardinia, Italy [A]	*Milos, Greece* [B]	*Superior, Arizona, USA* [C]	*Hungary* [D]	*Bulgaria* [E]
SiO_2	67.7	74.9	73.6	73.5	72-75
Al_2O_3	14.4	12.6	12.7[1]	13.0	13-15
Fe_2O_3	2.2	0.7	0.7	1.8	1.5
MgO	0.5	0.3	0.2	0.4	0.6
CaO	0.9	0.7	0.6	1.5	1.0
Na_2O	3.3	3.4	3.2	3.5	2.7
K_2O	5.3	4.8	5.0	3.8	4.8
H_2O>105°C	4.2[2]	2.5[2]	3.8	3.0	3-6[2]
TiO_2	0.4	0.06	0.10	–	–
TOTALS	98.9	99.96	99.9	100.5	–

1 Includes P_2O_5 and MnO

2 Total ignition loss

Sources: *A* British Gypsum Limited
B British and Overseas Minerals Limited
C F.G. Anderson and others, 1956
D *Ind. Miner., Lond.*, 1970, No. 29, p.37
E Bulgarian Chamber of Commerce

Crude perlite is generally pale grey in colour, but can be dark grey, brown, green or black. Expanded perlite is pure white or light grey in colour, with a bulk density between three and thirty-five times less than the original. The important physical properties of perlite are listed in Table 2.

Table 2 Physical properties of expanded perlite

Softening point	870° – 1100°C
Fusion point	1260°–1340°C
pH (of water slurry)	6.5–8.0
Specific heat	840 J $kg^{-1}K^{-1}$
Specific gravity	2.2–2.4
Refractive index	1.50
% free moisture, maximum	0.5
Loose weight, normal range	32–400 kg/m^3
Thermal conductivity (K)	0.02–0.50 $Wm^{-1}K^{-1}$ (-180° to +930°C)
Effective insulation range	-270° to +1100°C

Source: Perlite Institute, New York.

Expanded perlite is stable and inert, being fire resistant, rot proof and not attractive to vermin. It does not degenerate in most conditions and by special treatment can be rendered virtually impermeable to water.

Chemically, expanded perlite is a comparatively stable material. However, it is soluble in a hot, concentrated alkali or in hydrofluoric acid (HF), and moderately soluble (less than 10 per cent) in sodium hydroxide (NaOH). Solubility is slight (less than 3 per cent) in concentrated mineral acids and less than 1 per cent in water and weak acids. A typical chemical analysis of expanded perlite is given as Table 3.

Table 3 Typical chemical analysis of expanded perlite

	Range *Weight per cent*
SiO_2	71.0 – 75.0
Al_2O_3	12.5 – 18.0
K_2O	4.0 – 5.0
Na_2O	2.9 – 4.0
CaO	0.5 – 2.0
Fe_2O_3	0.5 – 1.5
MgO	0.1 – 0.5
TiO_2	0.03 – 0.2
MnO_2	0.03 – 0.1
SO_3	0 – 0.2
FeO	0 – 0.1
Cr	0 – 0.1
Ba	0 – 0.05
PbO	0 – 0.03
NiO	Trace
Cu	Trace
Be	Trace
Mo	Trace
As_2O_3	Less than 0.1 ppm
Free silica	0 – 2
Total chlorides	Trace – 0.2
Total sulphates	None

Source: Perlite Institute, New York.

Methods of testing

Differences in the character of crude perlites from different deposits require that thorough testing of the source should be undertaken. The optimum expansion characteristics are best determined in a large expansion furnace, but some information can be obtained from laboratory testing. The essential parameters are chemical composition, softening or fusion temperature, expanded bulk density and the losses between mining and marketing. Before expansion tests it is useful to determine water content, which can be related to specific gravity and refractive index, and the amount of crystalline material present in the glass. After expansion the ultimate use of the product will depend on a wide range of properties.

Chemically, perlite should be high in silica and low in any toxic or discolouring elements such as arsenic, lead or iron. A range of typical chemical analyses for crude perlite from some of the world's sources is given in Table 1. An important feature of any chemical analysis will be the chemically combined water content, but it does not follow that the higher the water content, the better the expansibility. Some obsidians containing less than 0.2 per cent combined water will expand satisfactorily due to the fact that other trapped gases have a marked effect on expansion properties.

The softening point temperature of crude perlite must be determined before expansion tests can be made. The principle of perlite expansion is that the volatile materials, particularly water, bloat the glass particles when they are soft. Below the softening point the crude perlite will shatter, and above the softening point it will tend to fuse into a vesicular glass. This temperature is critical for any single ore sample or deposit and can vary from 760°C to 1100°C for perlites from different deposits. For example, perlite from Greece is expanded in the United Kingdom at temperatures of 900°C to 1000°C, while that from Italy is expanded at 800°C to 900°C.

An important factor in determining the viability of a deposit is the loss of material in processing. As well as the loss of volatiles, non-expansible materials and dust in the expansion process, large amounts of crude perlite can be lost as fines in the handling, grinding and classifying processing prior to expansion. The weight difference between the initial mine quantity and the final product, which can be as high as 50 per cent, should always be taken into account when assessing perlite deposits.

Before expansion the amount of crystalline material present in the perlite glass can be determined by conventional petrographic techniques. This crystalline material should preferably be less than two per cent by weight as it will not expand, and must be regarded as generally deleterious to the value of the raw perlite. During expansion of the perlite the unexpansible material tends to drop out of the furnace as waste.

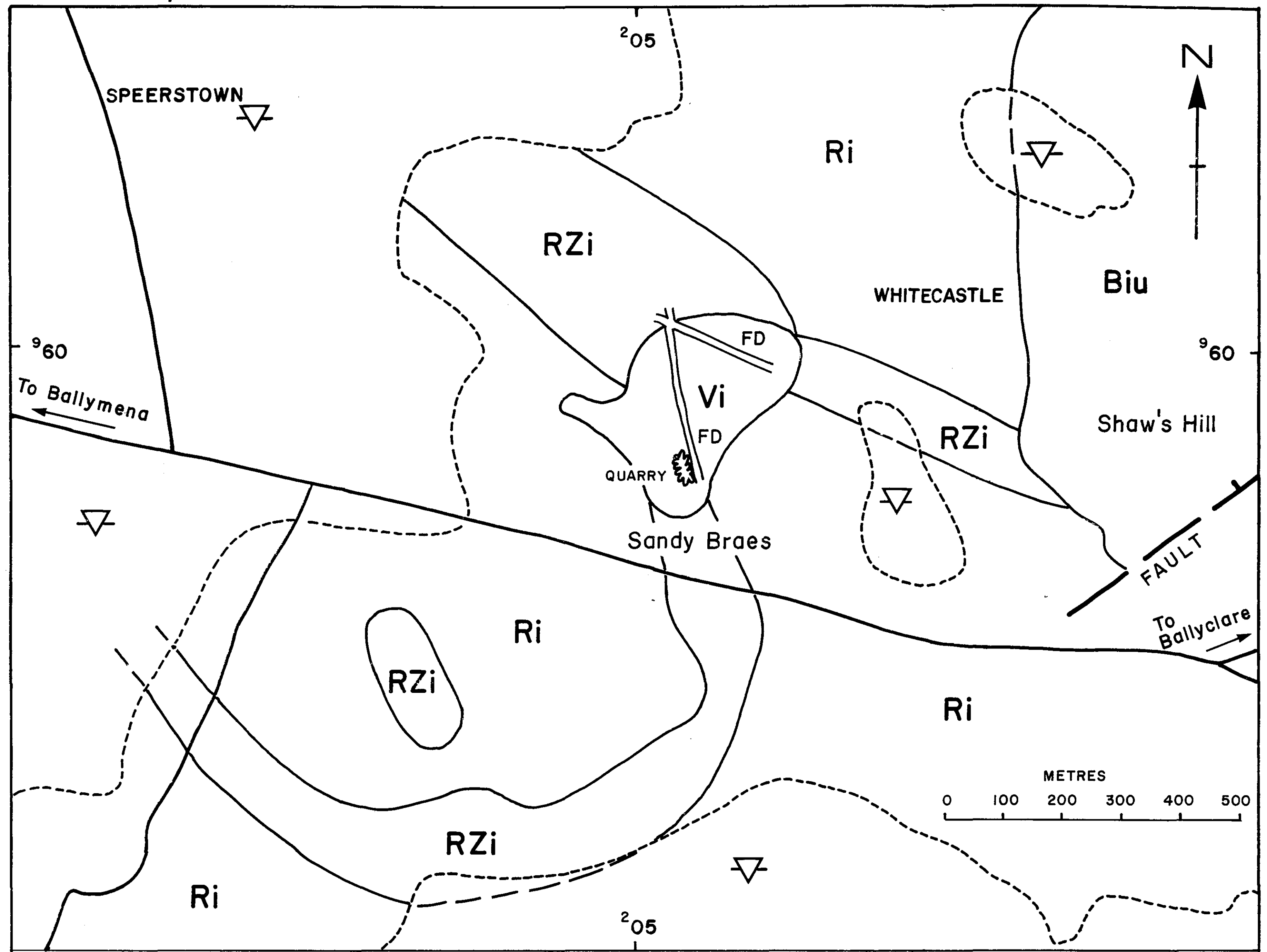
To a large extent the efficacy of crude perlite as a source of expanded perlite is determined by its performance in final production tests. Variables such as the size grading and feed rates of the crude perlite, preheating and operating temperatures, and the design and size of the furnace affect quality. By varying the parameters in the operation of an expansion plant the optimum conditions for a particular perlite can be obtained.

In the testing of a crude perlite sample the ultimate determinant of quality is the bulk density of the expanded product from a commercial furnace. However, such factors as dust content, size grading, hardness and colour can be important in determining the end use of an expanded perlite sample.

United Kingdom resources

Known resources of perlite in the United Kingdom are confined to Sandy Braes, County Antrim, Northern Ireland. Glassy igneous rocks of a similar kind are known throughout the Tertiary volcanic province of western Scotland but, although some are known to expand when heated, no resources of perlite have been recognised. As volcanic rocks devitrify with time it is unlikely that workable perlite will be found outside this province, although there are records of glassy igneous rocks of various ages occurring in the Cheviots and in the Midland Valley of Scotland.

In Irish Grid Square J



KEY

▽	Drift, mainly Boulder Clay		— Pleistocene and Recent
Biu	Upper Basalt Formation		Tertiary Antrim Lava Group
Ri	Rhyolite Flows	Inter-Basaltic Formation	
RZi	Rhyolitic Pyroclastics, including Ash Flows		
Vi	Vent Agglomerate		
FD	Multiple Dykes		
———	Geological Boundary - Solid		
--------	Geological Boundary - Drift		
━━━	Road		

Figure I. Geological map of the Sandy Braes district, County Antrim.

NORTHERN IRELAND

Sandy Braes

In the United Kingdom the only perlite deposit which has been worked is Sandy Braes near Tardree, Co. Antrim (Figure 1). Sandy Braes lies in the townlands of Maxwell Walls and Barnish about 6.5 km east-south-east of Kells, Co. Antrim. The deposit is a vertically banded, welded-tuff agglomerate composed almost wholly of variously sized fragments of porphyritic obsidian irregularly distributed in a tuff matrix, and is overlain by an obsidian agglomerate.

The obsidian fragments are up to 4.5 m long, and the tuff matrix, commonly glassy, shows various degrees of welding. A petrographic perlitic texture is often developed in the obsidian blocks, and phenocrysts of quartz and feldspar are common throughout the deposit. The specific gravity of the crude perlite is 2.42. A typical chemical analysis is given in Table 4.

Table 4 Chemical analysis of Sandy Braes perlite

	Weight per cent
SiO_2	74.95
Al_2O_3	11.77
Fe_2O_3	1.03
FeO	0.72
MgO	0.01
CaO	1.02
Na_2O	2.82
K_2O	4.70
$H_2O > 105°C$	2.76
$H_2O < 105°C$	0.44
TiO_2	0.12
P_2O_5	0.06
MnO	0.04
CO_2	n.d.
Cl	–
F	–
S	0.01
Cr_2O_3	tr.
BaO	0.02
Li_2O (S)	0.002
Rb_2O (S)	0.01
Cs_2O (S)	n.d (<0.01)
	100.48

n.d. = not detected; tr. = trace; (S) = Spectrochemical determination

Source: I.B. Cameron and P.A. Sabine, 1969.

The approximate mineralogical composition of the porphyritic obsidian from a borehole is given in Table 5.

Table 5 Anhydrous norm of Sandy Braes porphyritic obsidian

	Weight per cent
Quartz	38.36
Orthoclase	27.78
Albite	23.86
Anorthite	4.71
Magnetite	1.49
Others	1.06

Source: I.B. Cameron and P.A. Sabine, 1969.

The Tardree rhyolite complex, of which the Sandy Braes perlite is a part, has been dated at 65.2± 0.8 Ma (F.J. Fitch and A.J. Hurford, 1977) and is associated with the Interbasaltic Formation of the Antrim Lava Group and related intrusive rocks.

Historically, the Sandy Braes perlite was first recognised by J.F. Berger (1816), who noted the expansion of 'pearlstone porphyry' with the following comments 'Fragments, exposed to the blowpipe, intumesce to four or five times their first volume, fusing into a foamy and light glass, not unlike pumice stone'. Other geologists repeated the experiments on the Sandy Braes volcanic rocks, but the value of the deposit was not recognised until 1848 when the reference to Berger's experiments was communicated by Dr K.C. Dunham and Dr P.A. Sabine of the Geological Survey to Mr R.H. Blattner of Vermiculite (London) Ltd. Resource delineation followed, and the extraction of perlite from Sandy Braes took place between 1952 and 1968. The deposit is not at present economically workable as the properties of the perlite are variable, often with the inclusion of much non-expansible material.

WESTERN SCOTLAND

Arran

The dykes and sills of pitchstones on the Isle of Arran were described by G.W. Tyrrell in 1928. The rocks vary in appearance from clear glass to coarse pitchstone porphyry, and the bodies are irregular in local composition and extent. The dykes and sills can be split into three types; the Corrygills, Glen Shurig and Tormore types. The Corrygills type is non-porphyritic, while the other types contain phenocrysts of quartz, feldspar and ferromagnesian minerals.

All three types are chemically similar, although the Corrygills type is the most siliceous and has soda subordinate to potash. None of the dykes can be traced for a great distance and all are closely associated with felsite. Analyses of Scottish pitchstones are given as Table 6.

Corrygills-type pitchstones occur as dykes and sills of varying thickness. On Clauchland Shore NS 052336, south-east of Brodick Bay, a sill 6 m thick is traceable for 300 m. Two sills, respectively about 3.7 m and 6 m thick, outcrop between Dun Dubh and Dun Fionn, South Corrigills NS 045337, about 3 km south-east of Brodick Pier. One of the sills is traceable for at least 275 m and may be up to 640 m long. Three sills, each up to 7.6 m in thickness, outcrop at Croc, Monamore Glen near Lamlash NS 015299. Glen Shurig and Tormore type pitchstones occur as dykes and sills 1.5 m to 7.6 m wide. A 1.5 m wide dyke is exposed in the bed of the road leading from the String Road to the most westerly house in Glen Shurig NR 995 365.

A sill in the Schoolhouse Garden,Brodick NS 009365, and in the wood to the west, can be followed for 320 m, although the thickness is not known. Two dykes, 7.6 m and 3.7 m wide, outcrop near the head of the main western headwater of Lag a'Bheith NS 008331, 3 km south-south-west of Brodick Pier, and another pitchstone dyke outcrops by Lag a'Bheith at NS 017342, about 2 km from Brodick Pier (M. Macgregor, A. Herriot and B.C. King, 1972). On the Tormore Shore, south of Machrie Bay, Judd's No. 1 dyke is exposed. This body is about 9 m wide and is exposed for about 550 m. At the northern end it is entirely composed of pitchstone, and at the southern end contains some felsite and tholeiite.

Table 6 Chemical analyses of Scottish pitchstones

	Weight per cent						
	A	*B*	*C*	*D*	*E*	*F*	*G*
SiO_2	73.20	72.33	71.51	66.06	64.13	62.37	65.81
Al_2O_3	10.75	10.45	10.55	13.14	13.15	12.04	14.01
Fe_2O_3	0.95	1.00	0.79	2.27	1.08	1.87	4.43
FeO	1.02	2.14	2.22	2.84	6.31	5.81	–
MgO	0.15	0.11	0.52	0.77	1.08	0.97	0.89
CaO	0.76	1.44	1.52	2.75	3.62	3.51	2.01
Na_2O	3.78	4.09	4.12	4.28	3.64	3.47	4.15
K_2O	4.20	3.49	3.48	1.54	2.32	2.34	6.08
H_2O>105°C	4.52	4.02	4.07	3.38	2.71	5.54	2.70*
H_2O<105°C	0.18	0.16	0.19	0.74	0.36	0.44	
TiO_2	0.16	0.30	0.33	1.08	1.19	1.06	–
P_2O_5	0.19	0.16	0.24	0.09	0.31	0.30	–
MnO	0.37	0.50	0.42	0.31	0.27	0.24	–
CO_2	–	–	–	0.37	–	–	–
SO_3	–	–	–	0.16	–	–	–
BaO	0.05	0.08	0.08	–	0.09	0.07	–
TOTALS	100.28	100.27	100.04	99.78	100.26	100.03	100.08

A Pitchstone (Corrygills Type). Dun Fionn, South Corrygills, Arran. NS 045337.

B Pitchstone (Glen Shurig Type). String Road, Glen Shurig, Arran. NR 995365.

C Pitchstone (Tormore Type). Judd's No.2 dyke, Tormore Shore, Arran. NR 884312.

D Pitchstone, allied to inninmorite. Ben Hiant, Ardnamurchan. NM 542624.

E Inninmorite-pitchstone. Beinn an Lochain, Mull. NM 513246.

F Inninmorite-pitchstone. Tom a'Choilich, Mull. NM 511254.

G Pitchstone. Sgurr of Eigg, Island of Eigg. NM 511254.

* Loss on ignition

Sources: A - F. E.M. Guppy and others, 1931.

G. A. Harker and G. Barrow, 1908.

Eight samples of the Arran pitchstones were tested in the USA at a temperature of about 840°C. While this temperature was sufficient for expanding an American perlite, the expanded products of the Arran pitchstones had a bulk density of around 500 kg/m^3. The optimum expansion temperature for the Arran pitchstones is probably much higher than 840°C. (R.H.S. Robertson, 1963).

Mull

Most of the pitchstones of the Island of Mull are non-porphyritic andesites, classed petrographically as glassy leidleites, but there are also a few porphyritic andesites classed as glassy inninmorites. In any sill the glasses are associated or interbanded with crystalline or stony forms, and they are generally not thicker than 1.5 m. An analysis of a glassy porphyritic inninmorite pitchstone is given in Table 6. The majority of the pitchstones of Mull are found in the Loch Scridain district, the analysed sample being from Pennyghael, Loch Scridain. Most of the sills are remote and inaccessible.

Ardnamurchan

In the Ardnamurchan peninsula pitchstone lavas are known. For example, on Ben Hiant there is one large outcrop of porphyritic inninmorite pitchstone of about 8 ha, and two smaller ones. An analysis is given in Table 6. The rocks contain small phenocrysts of plagioclase feldspar and pyroxene. On the west side of Kilchoan Bay a 1.5 m dyke can be traced westwards for over 1.5 km. The dyke is composed of spherulitic pitchstone with a few small feldspar phenocrysts. Although no analysis is available the rock is probably more siliceous, and contains more combined water, than the Ben Hiant pitchstone.

Eigg

On the Island of Eigg there is the largest known pitchstone mass in the United Kingdom, as well as a few pitchstone dykes. The Sgurr of Eigg consists largely of a sheet-like mass of pitchstone over 3 km long and up to 400 m wide. The lower surface is sharply undulating and the maximum thickness is about 120 m. The pitchstone is a single sheet containing some felsite or stony material and exhibiting a marked columnar structure. Although the pitchstone is generally conspicuously porphyritic, containing phenocrysts of feldspar and pyroxene, the basal part is a glass of trachytic composition. It is similar to the pitchstones of Ben Hiant, Ardnamurchan, but is higher in alkalis. An analysis is given in Table 6, the loss on ignition being an approximation to the combined water content. The specific gravity varies from 2.42 to 2.496.

The small island of Hyskeir (Oigh Sgeir), about 15 km west of the Island of Rhum, is composed of pitchstone similar to that of the Sgurr of Eigg.

Skye

Pitchstones on the Isle of Skye are relatively rare, but very distinctive. They form small dykes, some of which are only partly composed of pitchstone. The only analysis available shows a loss on ignition, probably representing combined water content, of less than one per cent.

OTHER OCCURRENCES

Midland Valley of Scotland

At Eerie Point, Great Cumbrae an 8.8 m Tertiary dyke, which can be traced inland for about 1.5 km, is in part stony and in part glassy (G.W. Tyrrell, 1917). The partial composition of the rock, which is described as a hyalo-andesite, is as follows:

	Weight per cent
SiO_2	60.46
$H_2O > 105^{\circ}C$	1.41
$H_2O < 105^{\circ}C$	0.63

The chemical composition of the glassy fraction is higher in silica than the whole rock, but the combined water content of the glass is not known. Other glassy andesites of a similar type are known to occur in Cowal, and at Eskdalemuir in Dumfriesshire.

An occurrence of expanding pitchstone was noted by Judd in 1886 near the Tay Bridge, about ¾ km north-east of Scroggieside Farm. In tuffs and tuffaceous conglomerates of Lower Old Red Sandstone age Judd found that "a vitreous variety of rock occurs in scattered nests in the midst of the ordinary stony form", and that this rock expands when heated. The occurrence of glassy expanding rocks of this age is extremely rare.

Cheviots

Glassy andesites and pitchstones have been recorded from several areas within the outcrop of the Cheviot lavas in England. As the lavas are of Lower Old Red Sandstone age it is very likely that original glassy material will have been completely devitrified and that the rocks will not expand when heated.

Land use

The only working for perlite in the United Kingdom, at Sandy Braes, Co. Antrim, occupied less than 1 ha at its closure in 1968. Trial digging and pitting has taken place around this site. The area underlain by the igneous intrusion is only about 5 ha and it is unlikely that significant planning problems would arise from revived exploitation of Sandy Braes.

Uses

Expanded perlite is used as a thermal and acoustic insulator, filter aid, filler, carrier, and horticultural aggregate, the particular use depending on the different bulk densities and granule sizes which can be achieved in processing. Crude perlite is used in the foundry and steel industries.

The largest use for expanded perlite, accounting for three-quarters of consumption, is in thermal and acoustic insulation, both as a lightweight construction aggregate and as loose fill. In plasters, mortars, plaster boards and ceiling tiles the commonest grade of expanded perlite is used, having a bulk density of 80 to 240 kg/m^3. The addition of perlite, generally as a part or complete replacement for sand, gives a lightweight, plaster-based product with good thermal and acoustic insulation and fire resistance.

Loose or bitumen-coated expanded perlite is used in lightweight, insulating floating floor construction, and bitumen-coated perlite can be the basis of thermally insulating roof-screeding. Expanded perlite can also be used to produce low strength, lightweight, insulating concrete roof decks.

Silicone-treated expanded perlite is suitable for cavity wall thermal insulation as it has good thermal and water repellence properties. Loose, untreated expanded perlite can be used as a core filler in wall boards, in refrigeration plants and in cryogenic applications. Cryogenics, involving the storage of liquid gases at temperatures approaching absolute zero, requires the use of a very low bulk density expanded perlite, between 30 and 60 kg/m^3, and the absence of free moisture, which reduces thermal efficiency.

For high temperature insulation of pipes, kilns, furnaces or boilers, expanded perlite can be mixed with a hard setting binder or used in quilted mattresses.

Very high temperature applications of expanded perlite include the insulation of ladles for molten metal and use in foundry cores and moulds to reduce shrinkage. Expanded perlite is used in bricks, tiles, lightweight refractories and calcium silicate hydrate products for its refractory and insulating properties.

Crude perlite also finds a use at very high temperatures. In the foundry and steel industries it is employed as a slag coagulant and insulator on top of molten metal, and also in special casting sands and mixtures.

After milling and air classification into a variety of grades, expanded perlite is used for liquid filtration. Perlite filter aid grades are determined by particle size distribution, filtration speed and clarify of the filtrate. The loose bulk density of perlite filter aids generally lies between 50 and 80 kg/m^3. The mean particle size can range from 10 to 30 microns, the speed of filtration varying broadly with the size of the particles. Perlite filter aids can be used both for precoating the filter septum and for body feed in the liquid being filtered. Precoating is achieved by adding filter aid to a clean liquid which is passed through the filter septum, giving a clean coat of filter aid. Small amounts of filter aid (body feed) are then regularly added to the liquid to be filtered, and this forms a further coat on top of the precoat, trapping the undesirable particles. The precoat improves the flow of liquid by preventing particles from reaching and blocking the filter septum. The body feed continuously creates a new filtering surface as the liquid is filtered, preventing blockage of the filter aid. By comparison with other filter aids commonly in use, perlite is said to give a wide range of filtration speeds and to be best for rotary vacuum filters.

The slow grades of perlite filter aid are suited to beer polishing, and the filtration of wine and hydrogenated vegetable oil. The medium grades will filter citric acid, sugar, oils and pharmaceuticals, and the fastest grades can also be used for these liquids when rapid filtration is required and a small loss of clarity can be tolerated. The fast grades are also used for swimming pool water, beer wort, chemicals, glucose and fruit juices.

Expanded perlite is used as a filler, sometimes called a bulking agent or extender, in a variety of materials. The four important characteristics of perlite fillers are the fine particle size, high brightness, very light weight and mild abrasiveness. Perlite is used as a filler in plastics, paint, rubber, polishes, cleansers and paper products. As well as a filler and flatting agent in paints, the coarser grades of perlite can be used for paint texturing. In polishes and cleansers, perlite reduces bulk density, minimizes compaction, and its mild abrasiveness improves the scouring action. High brightness and low bulk density make perlite a useful filler in paper products.

Expanded perlite has excellent absorption properties which, combined with its low bulk density, make it a suitable carrier of pesticides, herbicides, catalysts and other chemicals. The absorption properties are also utilised in small scale oil pollution control in refineries and factories.

As expanded perlite has an inorganic, essentially neutral and sterile nature it is suited to horticultural applications. The lightweight nature, insulation and absorptive properties are utilised in plant rooting, seed composts, growing media, soil conditioning, hydroponics, packing and flower support. Normal industrial grades of perlite are not suitable for horticultural use because of the large amount of fine particles which cause problems in compost formulation. Horticultural grades of expanded perlite are sieved to give a tight particle size distribution range.

Specifications

There is no British Standard (BS) for crude perlite or expanded perlite, but compositions including expanded perlite can conform to several British Standards. The quality of perlite and perlite products is established in the USA by the Perlite Institute Inc., New York through standards and specifications. The Perlite Institute collaborates with the American Society for the Testing of Materials (ASTM) in setting standards. Several perlite expanding companies in the United Kingdom are members of the Perlite Institute, and some quote its specifications for their products.

Lightweight perlite plasters are made to conform to BS 1191, Part 2: 1973, 'Gypsum Building Plasters. Premixed Lightweight Plasters'. The fire rating of these plasters will conform to BS 476, Part 1: 1953, 'Fire Tests on Building Materials and Structures'. Expanded perlite used as a concrete aggregate should conform to BS 3797: 1964, 'Lightweight Aggregates for Concrete'. Under this standard the maximum bulk density of expanded perlite used as a concrete aggregate is 240 kg/m^3. Grading limits of coarse and fine aggregates are also given in this B.S. specification.

Expanded perlite is also referred to by the British Standards Institution in BS 3533:1962, 'Glossary of terms relating to thermal insulation', CP 211:1966, 'Internal Plastering', and BS 2028, 1364:1968, 'Precast Concrete blocks'.

Product data, performance and specification sheets can be obtained from many of the United Kingdom importers, producers and users of perlite. However, some data, particularly in the field of filter aid manufacture, are not made available for commercial reasons.

Price and cost

The transport costs of crude perlite imports into the United Kingdom, almost entirely from the Mediterranean area, are an important component of total costs and probably amount to 50 per cent of the cif price. Consignments usually take the form of 1000 to 2500 tonne bulk shipments, but smaller amounts are imported from a variety of small producers for testing purposes. There is no import duty on the raw material.

Imports of expanded perlite tend to be of the higher value filter aids which can bear the higher freight charges resulting from the high bulk. These products cannot be distinguished in trade statistics but producers and agents quote figures of around £180 a tonne delivered.

Aggregate grade expanded perlite varies in price according to application and the size of consignment, but is generally a little over half the price of filter aids. Most of the aggregate grade requirements are produced in the United Kingdom from imported crude perlite, but Steetley Minerals Limited imports some Dicalite fillers from Belgium. A large proportion of the aggregate produced is used captively by the same company, such as British Gypsum in 'Carlite' plasters and Tilcon Limited in roof and floor screeds and 'Limelite' plasters, so the cost of the expanded perlite is not made known.

Table 7 gives a broad breakdown of prices which can be expected in the United Kingdom market.

Table 7 United Kingdom prices of perlite and perlite products in 1978

	£ per tonne
Raw loose in bulk, cif	23 – 28
Filter aids, delivered	180 – 190
Expanded aggregate, ex-works	90 – 180

Source: Ind. Miner., Lond.

Recent trends in the prices of perlite products are summarised in Figure 2. The raw material price has shown little movement over the past decade and has only recently been subjected to regular rises. Production of crude perlite around the Mediterranean has been little affected by the high inflation encountered in the United Kingdom, and freight charges have been depressed. In contrast, both perlite filter aids and expanded aggregate have shown marked price rises since the oil crisis in 1974 as production is energy intensive and fuel costs have had a marked influence on total costs.

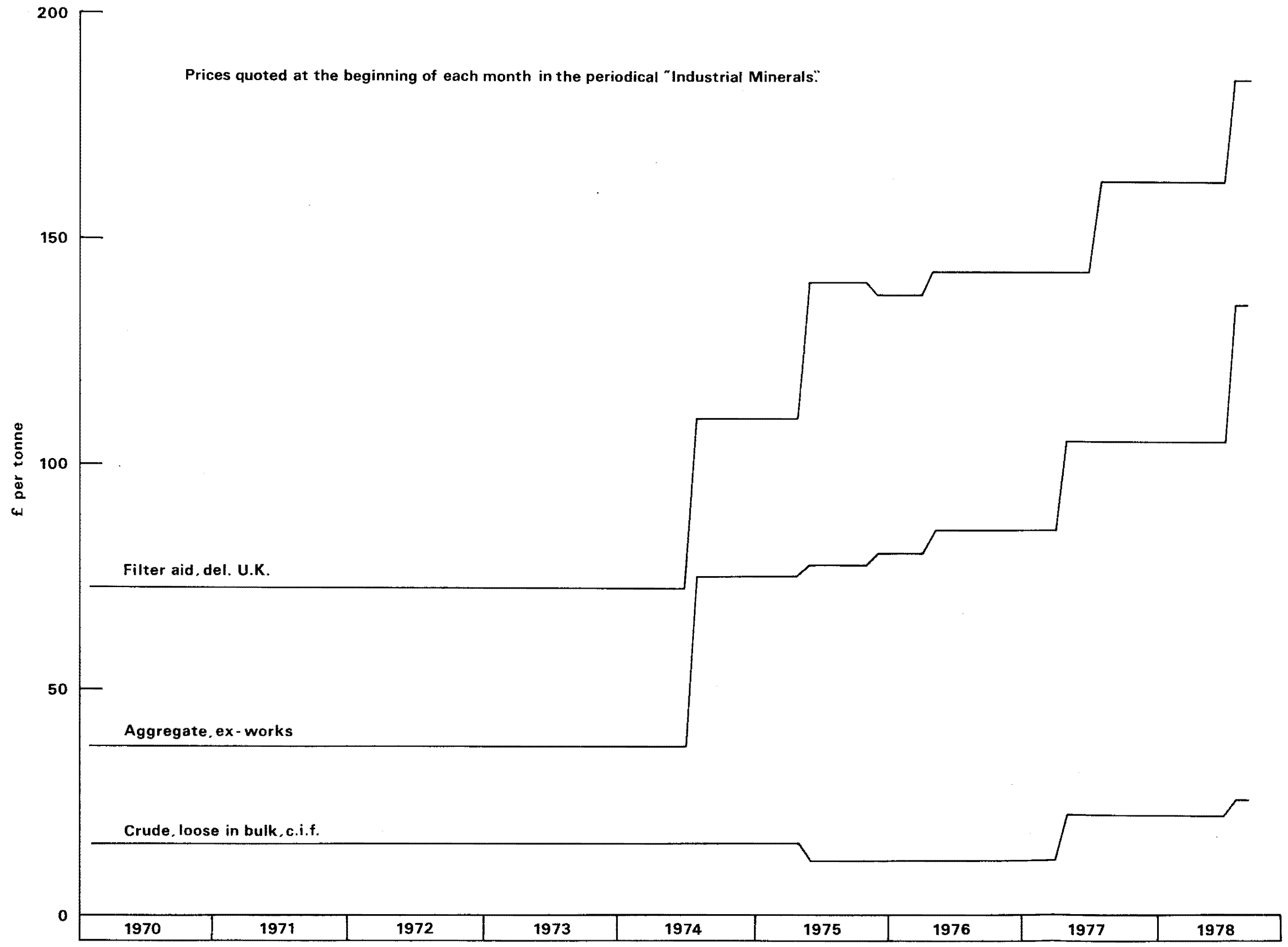


Fig. 2 United Kingdom: price of perlite products, 1970-1978

Technology

Perlite is invariably mined by openpit methods and undergoes crushing and grading on site. The graded ore is shipped in preference to the high bulk expanded product. Further processing of the ore may take place at the expansion plant, particularly blending different ore grades. After expansion in a vertical or horizontal furnace, air classification, screening and milling can be important controls on the quality of the final product. Figure 3 is a simplified flow diagram of perlite processing and handling.

Mining

Deposits of perlite have generally been formed in sub-horizontal layers so that, in order to maintain uniformity of the mine product, stripping is usually carried out in the plane of the layering. Blasting is rarely used as the ore can be removed by ripping the face. The crude perlite is then taken to a storage site to await further processing.

Processing

Ore from the storage site is crushed to -15 mm in a primary jaw crusher, and is then usually dried in a kiln to a moisture content of less than 1 per cent. Secondary grinding, by rod mill, hammer mill or cone crusher, is part of a closed-circuit system including screens and air classifiers. At this stage fines, particles less than 0.15 mm across, are removed and usually dumped as waste. The crude perlite ore, classified according to particle size, is stored on site to await shipment.

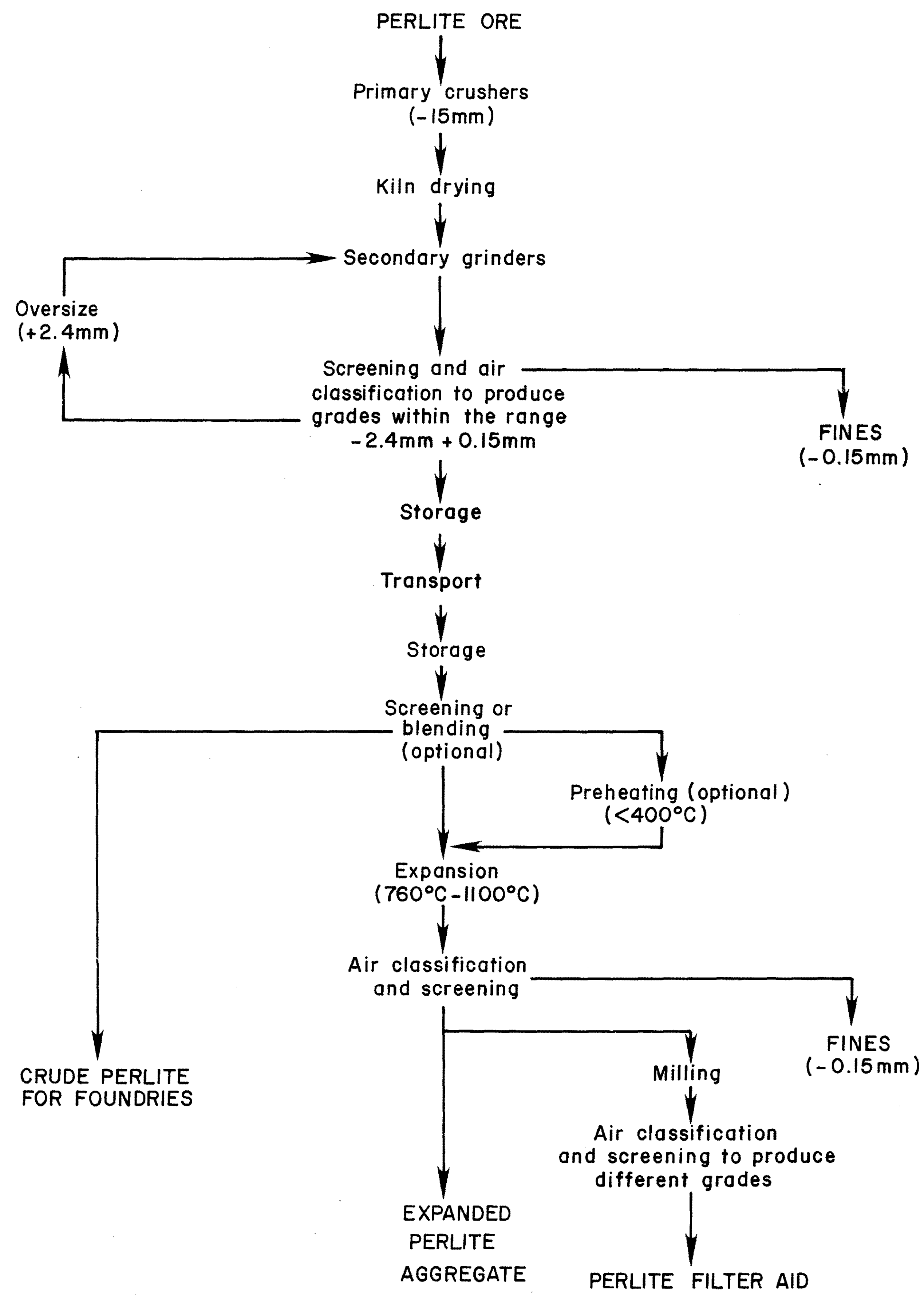
For Western European markets crude perlite is usually carried in bulk ore carriers to a convenient port of entry and then by road or rail a comparatively short distance to the expansion plant. The perlite is stored in the various grades on site and sometimes blended prior to expansion. Crude perlite for plaster aggregate generally has a size distribution of -1.5 mm to +0.15 mm.

Crude perlite is fed into an oil or gas fired furnace where it is rapidly expanded. Furnace temperatures are between 760°C and 1100°C, depending on the type of ore used and the product required.

The mixture of hot gases and expanded perlite is removed from the furnace by an extraction fan, and the product is then removed by air classifiers. Any material which does not expand is too heavy to be carried up to the classifiers and drops out of the furnace.

The furnace used for perlite expansion may be one of two types: with the stationary vertical furnace, crude perlite is dropped into the flame, which is at the bottom, and on expansion is carried up and out of the furnace. The horizontal rotary furnace employs screws to feed the crude perlite round the outside of the furnace and then into the flame (see Figure 4). After expansion the perlite is carried along the furnace and then up to a cyclone.

Figure 3 Simplified flow diagram of perlite handling and processing



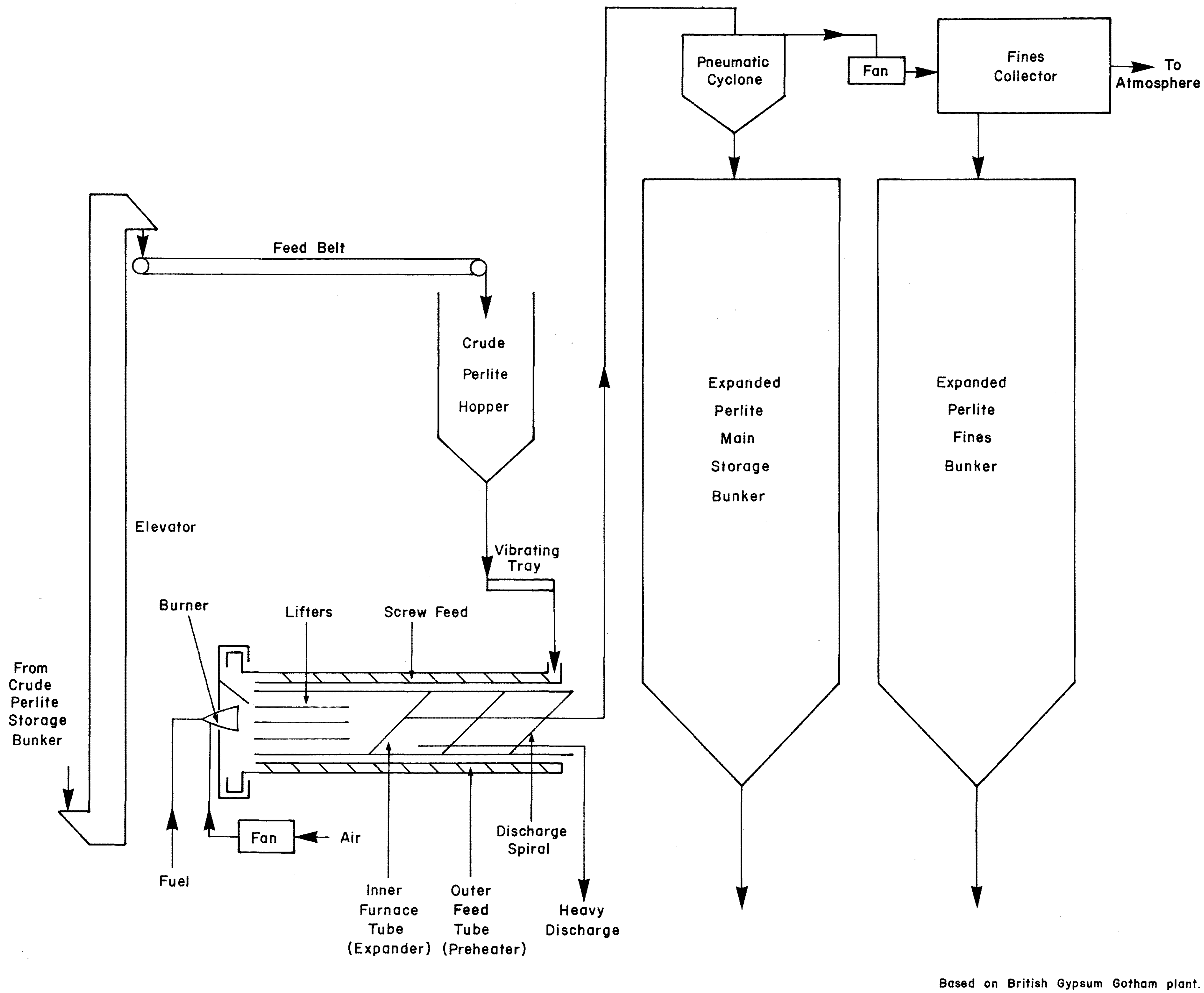


Figure 4 Sketch of a simple perlite processing plant using a horizontal rotary furnace.

Preheating, using waste gases from the furnace, is sometimes employed to increase production capacity, give some control over the production of excessive fines and greater control over the final density of the expanded perlite by preconditioning the larger particles. The preheat temperature is below 400°C and residence time in the preheater varies considerably, depending upon the type of plant used.

The expanded perlite passes through a series of cyclone classifiers which remove the fines to dust collectors for bagging or storage, discharge the relatively clean waste gases, mainly water vapour, to the atmosphere and send the product either to a hopper or to screens for size separation. The dust, sometimes a saleable product, can be as much as 5 per cent by weight of the final product. Electrostatic precipitators are used in some systems to aid dust extraction from the cyclone classifiers.

Depending on the final application, the expanded perlite can be bagged when sufficiently cool, milled for filter aid use or stored in silos. As transport of a high bulk, low weight product is to be avoided as far as possible, expansion plants tend to serve local markets or produce on site the higher density compositions such as plasters and acoustic tiles containing expanded perlite.

World production and consumption

In the United Kingdom crude perlite was produced only at Sandy Braes in the period between 1952 and 1968, so that the figures in Table 8 relate to that operation.

Table 8 United Kingdom: Production of crude perlite, 1952 to 1968

	Tonnes		*Tonnes*
1952	1,056	1961	867
1953	630	1962	1,758
1954	–	1963	3,957
1955	–	1964	1,793
1956	903	1965	259
1957	447	1966	262
1958	115	1967	118
1959	420	1968	71
1960	1,153		
		TOTAL	13,809

Source: Northern Ireland Department of Commerce

Production of expanded perlite, currently over 100,000 tonnes a year, uses crude perlite entirely from sources outside the United Kingdom.

World production of crude perlite is dominated by the USSR, USA, Greece, Italy, Japan and Hungary (Table 9). Estimated production in the USSR exceeds 700,000 tonnes a year, and is about 100,000 tonnes a year in Japan. Italy, for which recent production statistics are not available, probably produces around 125,000 tones of crude perlite a year. Total world production is estimated at around two million tonnes a year.

Expanded perlite is produced on a large scale in the USA , Western Europe, and the USSR. Table 10 gives a breakdown of the trade in crude perlite in Western Europe. The largest consumer in Western Europe is the United Kingdom, consuming about 6 per cent of world production, but other important consumers are the Federal Republic of Germany, France, Belgium, Luxembourg and Italy. Total Western European consumption of crude perlit is currently around 350,000 tonnes a year, while that in the U.S.A. is about 500,000 tonnes a year and in the USSR probably around 700,000 tonnes a year.

Table 9 World production of crude perlite by major producing countries, 1970-1976

Tonnes

Country	*1970*	*1971*	*1972*	*1973*	*1974*	*1975*	*1976*
USA	551,000	449,000	589,000	689,000	613,000	640,000	660,000
Greece	168,588	160,614	123,816	257,948	213,017	161,019	235,687
Italy	76,705	47,833	...	...	...	...	...
Hungary	...	60,900	63,930	95,730	93,000	72,040	96,180
Turkey	...	9,180	30,400	14,740	963	10,530	22,000 *(e)*
Mexico	12,307	11,146	12,868	13,479	12,136	19,066	15,000
Australia	838	2,122	1,807	2,342	2,061	3,447	...
New Zealand	2,000	2,000	2,540	1,599	465	1,500	1,500
Philippines	...	...	...	825	1,131	665	1,649

... Not available

(e) Estimated

Figures for production in Japan and the USSR are not available.

Source: Institute of Geological Sciences.

Table 10 Major imports of crude perlite into Western Europe, 1970-1976

Tonnes

	1970	*1971*	*1972*	*1973*	*1974*	*1975*	*1976*
United Kingdom from:							
Italy	70,207	70,907	82,045	90,252	96,512	74,813	84,225
Greece	25,346	20,977	20,691	27,011	33,655	28,364	32,877
Turkey	–	816	5,020	2,415	3,300	2,400	4,629
Total	95,553	92,700	107,756	119,678	133,467	105,577	121,731
Federal German Republic from:							
Greece	24,953	32,173	44,425	60,867	55,711	62,341	72,314
Hungary	13,964	17,077	16,838	13,688	12,274	12,172	13,154
Bulgaria	1,071	5,458	7,685	5,566	1,469	–	–
Total	39,988	54,708	68,948	79,121	69,454	74,513	85,468
France from:							
Greece	45,127	...	40,929	46,154	39,634	28,357	34,854
Turkey	–	...	7,155	3,445	4,462	–	4,091
USSR	–	...	888	3,942	9,549	8,974	6,369
Total	45,127	...	48,972	53,541	53,645	37,331	45,314
Belgium/Luxembourg from:							
Greece	3,392	4,240	3,214	3,300	5,610	3,780	9,482
Turkey	–	–	–	–	–	12,816	12,860
USSR	19,810	18,762	24,005	23,115	16,156	36,283	19,388
Total	23,211	23,002	27,219	26,415	21,766	52,879	41,730
Italy from:							
Greece	6,975	7,815	2,881	1,425	3,074	...	10,420
Turkey	–	2,420	5,550	3,050	30	...	8,030
USSR	16,454	16,640	1,620	10,441	7,880	5,063	11,132
Total	23,429	26,875	10,051	14,916	10,984	...	29,582
Netherlands from:							
Greece	1,356	1,828	509	2,254	1,208	2,288	3,280

... Not available

Source: Institute of Geological Sciences.

Overseas Trade

The United Kingdom has for many years been a major importer of crude perlite, the most important sources being Italy and Greece (Table 11). Prior to 1970 perlite was not specified in United Kingdom trading accounts. From 1970 to 1975 crude perlite was listed in the United Kingdom Tariff and Overseas Trade Classification as follows:

2532 0182 Perlite, obsidian and pitchstone, crushed, ground, powdered or graded.

In 1976 and the first half of 1977 the crude perlite trade classification was as follows:-

Perlite, obsidian and pitchstone, crushed, ground, powdered or graded.

2532 0129 Perlite

2532 0264 Other

Other

2532 3029 Vermiculite, perlite and chlorite (unexpanded).

Most, if not all, of the trade under the classification 2532 3029 was believed to be in vermiculite during this period.

From 1 July 1977 the United Kingdom classification has been aligned with NIMEXE, the classification system of the European Economic Community, and all of the trade in crude perlite is classified under:

NIMEXE 25.32-30: Vermiculite, perlite and chlorite (unexpanded)

The United Kingdom code number corresponding to this is 2532 3000.

The reason for the inclusion of perlite and vermiculite in the same category is found in the Explanatory Notes to the Customs Co-operation Council Nomenclature (part of the NIMEXE system) as follows:

25.32 Vermiculite, a mineral allied to mica and similar in colour but usually in the form of smaller flakes; also chlorites and perlite, minerals chemically related to vermiculite. These minerals expand when heated and then constitute heat-insulation materials; in the expanded (or exfoliated) forms they are, however, classified in heading 68.07.

Although vermiculite and perlite are combined under code number 2532 3000, imports of each mineral can be deduced from the knowledge that vermiculite is obtained mainly from the USA and Republic of South Africa, and perlite largely from Italy, Greece, and Eastern Europe. Further deductions can be made on the basis of unit value, as vermiculite is over twice as expensive as perlite. Although imports of perlite into the United Kingdom (Table 11) increased from about 95,000 tonnes in 1970 to about 138,000 tonnes in 1974, this upward trend was not sustained and imports fell back to an estimated 106,000 tonnes in 1977. From 1970 to 1977 the annual increase in imports averaged only 1.4 per cent in quantity but 14 per cent in cost. The depressed state of the building industry, the largest market for expanded perlite, accounts for the generally slow growth of perlite trade in recent years.

Italy provides nearly three quarters of United Kingdom imports and Greece most of the remainder. The only other consistent supplier to the United Kingdom market is Turkey, with about 2 to 4 per cent of the market. Small amounts of perlite come from Iceland and Eastern Europe, and via other Western European countries without indigenous mine production.

Exports of crude perlite are listed in Table 12. The amounts and values concerned are very small by comparison with imports. Where very small quantities of perlite have been recorded, both in export and import categories, they have probably been used for testing purposes.

Expanded perlite is not separately recognised in the trade classification but expanded minerals appear under NIMEXE 68.07:

NIMEXE	
	Exfoliated vermiculite, expanded clays, foamed slag and similar expanded mineral materials:
68.07-20	Expanded clays
68.07-30	Other
	Mixtures and articles of heat-insulating, sound-insulating or sound-absorbing mineral materials:
68.07-81	With a basis of kieselghur or similar siliceous earths
68.07-89	Other

Most expanded perlite is probably included in 68.07-30 and 68.07-89 (for which the corresponding United Kingdom codes are 6807 3000 and 6807 8900 respectively). Statistics of United Kingdom imports and exports under these headings in 1977 are shown in Table 13 together with the most comparable data available for the preceding five years (the latter also include trade under 68.07-20 and 68.07-81 but this is believed to be relatively small).

Milled and graded expanded perlite, used specifically as a filter aid, is included with other materials under the NIMEXE heading 38.03-90:'Activated mineral products', for which the corresponding United Kingdom code number is 3803 9000. Before 1977, and strict alignment with the NIMEXE classification, there were United Kingdom headings which separately distinguished activated alumina, activated diatomite, and a comparatively small group of miscellaneous products. The relevant code numbers and descriptions of this miscellaneous group, in which perlite is included together with activated clays and earths, were as follows:

1973 and before

3803 0332 Activated clay, bauxite and other natural mineral products other than activated carbon, aluminium oxide or diatomite.

1974-1976

3803 0866 Activated natural mineral products other than activated carbon, aluminium oxide and diatomite.

Table 14 gives United Kingdom imports under these codes from 1970 to 1976. Over 90 per cent of imports under the miscellaneous section up to 1975 came from the USA, Belgium and Japan. The exports to the United Kingdom from Japan are believed to be almost entirely activated clay, and exports from the USA and Belgium, about 3500 and 1200 tonnes a year respectively, are thought to be mainly perlite filter aids, the latter from the Dicalite plant at Ghent. For 1977 it has not been possible to distinguish perlite from the wider range of activated mineral imports. Exports of perlite filter aids cannot be distinguished because of the wide distribution of small quantities of natural activated minerals.

Table 11 United Kingdom: imports of perlite (a), by countries, 1970-1977

	Tonnes								£ per tonne
	1970	*1971*	*1972*	*1973*	*1974*	*1975*	*1976*	*1977*	*Average cif value in 1977*
From:									
Italy	70,207	70,907	82,045	90,252	96,512	74,813	84,225	71,838	13.76
Greece	25,346	20,977	20,691	27,011	33,655	28,364	32,877	30,789	21.29
Turkey	–	816	5,020	2,415	3,300	2,400	4,629	3,050	19.52
Iceland	–	136	–	–	–	–	–	–	
Spain	–	–	–	2,800	–	–	–	–	
USSR	–	–	–	2,818	1,241	–	–	–	
Hungary	–	–	–	–	–	19	–	–	
Bulgaria	–	–	–	–	–	3	–	–	
Other countries	19	–	10	42	3,280	48	254	850	19.64
TOTAL	95,572	92,836	107,766	125,339	137,988	105,625	121,985	106,527	16.28
Value, cif, thousand £	667	690	622	778	1,238	1,161	1,583	1,720	

(a) The official description also includes obsidian and pitchstone from 1970 to 1975.

Source: HM Customs and Excise from 1970 to 1976. The imports for 1977 have been estimated by the Institute of Geological Sciences based on interpretation of HM Customs and Excise data.

Table 12 United Kingdom: exports of perlite (a), 1970-1976

	1970	*1971*	*1972*	*1973*	*1974*	*1975*	*1976*
tonnes	115	527	187	129	142	53	248
£ fob	5,319	13,979	7,535	3,714	7,779	3,623	36,323

(a) The official description also includes obsidian and pitchstone from 1970 to 1975.

Source: HM Customs and Excise

Table 13 United Kingdom: imports and exports of expanded mineral materials, mixtures and articles, including perlite, 1972-1977

Imports	*1972*	*1973*	*1974*	*1975*	*1976*	*1977*
tonnes	14,132	25,679	16,365	10,961	18,924	21,735
Thousand £ cif	1,556	2,665	3,486	3,047	6,175	8,920
Exports						
tonnes	10,713	8,895	8,707	10,716	14,558	23,229
Thousand £ fob	1,472	1,242	1,732	2,992	6,107	12,370

Source: HM Customs and Excise

Table 14 United Kingdom: imports of activated natural mineral products (excluding activated carbon, activated aluminium oxide and activated diatomite) 1970-1976

Tonnes

	1970	*1971*	*1972*	*1973*	*1974*	*1975*	*1976*
Belgium	2,323	2,648	1,920	2,663	1,906	1,233	35
USA	4,021	3,321	3,728	4,307	4,812	3,559	760
Japan	6	3,766	3,061	5,561	6,663	1,796	5,816
Others	1,375	1,295	1,027	1,335	480	314	343
TOTAL	7,725	11,030	9,736	13,866	13,861	6,902	6,954

Source: HM Customs and Excise

Substitutes

The perlite industry is young by comparison with many of its competitors, but expanded perlite has been readily adapted to a wide range of markets, and has become the dominant material in such uses as filtration and cryogenics. Perlite, which generally finds a niche in specialised sectors of the markets for which it is ideally suited, has been susceptible to only limited substitution.

In the construction industry, the main field of application of perlite, its most direct competitor is vermiculite, a flaky mineral which swells or exfoliates when heated, producing a similar lightweight aggregate. For lightweight plasters, expanded perlite is cheaper and has better working properties than exfoliated vermiculite, but vermiculite plasters give superior adhesion, and the water in the structure of exfoliated vermiculite provides extra fire retardation. Sand-based plaster, which is currently little used, is an alternative to lightweight plaster. Although considerably cheaper, sand-based plaster has poor crack resistance, low thermal insulation and is not easy to apply.

The expanded or exfoliated ultra-lightweight aggregates, perlite and vermiculite, are used in construction materials other than plasters for their insulating properties. Low load structures such as concrete blockwork represent an important use of lightweight aggregates, but the market is dominated by lightweight aggregates manufactured from pulverised fuel ash (PFA), colliery shale, blast furnace slag and clay, and by furnace bottom ash (FBA) and furnace clinker as greater strength and lower cost can be achieved by comparison with ultra-lightweights such as expanded perlite. However, recent trends to improve insulation are making expensive materials such as perlite more attractive in low strength blockwork. Load bearing structures use normal dense aggregates or structural lightweight aggregates, mainly from sintered PFA.

For cavity fill insulation, plastic foams, granules and beads, and mineral fibres are widely used. In this application siliconised perlite, which is water repellant, has not found favour. In domestic loft insulation, glass fibre, mineral wool and exfoliated vermiculite are important. Loose expanded perlite, although non-compacting, is unsuitable for exposed areas such as lofts, as it is too easily disturbed or blown about. Floor and roof screeds are minor uses of insulating materials in which expanded clays are in competition with expanded perlite.

In the normal to high temperature insulation field, competition from asbestos is small because of the health problems associated with that mineral. Similar problems are currently being encountered with diatomite, which takes a small sector of this market.

As a component of insulating sleeves (feeders) in foundry moulds, exfoliated vermiculite or diatomite can substitute for expanded perlite. In cryogenic insulation, laminae of aluminium and glass fibre mat, or silica aerogel can substitute for expanded perlite.

Diatomite is the principal alternative medium in filtration, but silica sand and organic fibres are also used. Perlite has made a substantial impact on the filter aid market, the substitution of diatomite by perlite being largely a result of increasing unacceptability of diatomite on health grounds and the lower cost of perlite. The lower density (greater bulk) of perlite also permits a reduction in consumption by weight. However, by comparison with diatomite in certain high clarity applications, perlite filter aids cannot be made into sufficiently fine filters. Moreover, as diatomite is composed of pure silica it is chemically more resistant than perlite and suited to the filtration of certain chemicals.

In the field of fillers, extenders and carriers a range of minerals can be used in place of expanded perlite. These include ground talc, sand, clay, diatomite, chalk and ground limestone. In agricultural and horticultural applications exfoliated vermiculite, peat, sawdust and sand can substitute for perlite. Although more efficient, perlite and vermiculite are considerably more costly than their competitors, so they can compete only in the specialised, high return horticultural markets.

Demand trends

Although the quantity of expanded perlite used in the construction industry in the USA has increased, the proportion of the total perlite market accounted for by construction declined from 100 per cent when production began in 1946 to 60 per cent in 1973. A similar diversification from constructional uses may be anticipated in Western Europe. In the United Kingdom the use of expanded perlite in plaster aggregates is well established and should remain dominant, taking 70 to 75 per cent of market.

Demand for perlite filter aids and cryogenic grades should continue to grow, and comparatively new materials, such as insulation board containing perlite, may take an increasing, but small proportion of the market.

Horticultural applications account for about 20 per cent of perlite consumption in Japan and 10 per cent in the USA, but so far for only a very small proportion of Western European and United Kingdom markets where there is considerable room for growth.

As the demand for expanded perlite aggregates increases, suppliers of crude perlite will be under increasing pressure. Currently, Greece and Italy are dominant in the European market, but Iceland, Turkey and COMECON countries such as Hungary, Bulgaria and the USSR will also find their raw material in greater demand over the next decade.

World reserves of crude perlite, estimated at 1,000 million tonnes in 1975, are very large in relation to current demand. Total resources may amount to about 3,500 million tonnes. Greece could maintain current production levels for at least 250 years, and Italy for at least 35 years. Shortage of reserves is therefore unlikely to be a factor which will adversely affect production capacity in the foreseeable future.

Industry structure

There are six companies expanding imported crude perlite in the United Kingdom. These are British Gypsum Limited, Tilcon Limited, Johns-Manville (G.B.) Limited, The British CECA Company Limited, Armstrong Cork Limited and L. Slack and Sons Limited. The locations of perlite expanding plant in the United Kingdom are shown in Figure 5.

Several companies, including British and Overseas Minerals Limited, Gammount Limited, Otavi (UK) Limited, and Silvaperl Products Limited, act as distributors or agents for perlite and perlite products. Steetley Minerals Limited, agents for Dicalite, Johns-Manville (G.B.) Limited and The British CECA Company Limited handle some of the higher value perlite products in the European market.

Most of the perlite imported into the United Kingdom from Italy, currently about 80,000 tonnes a year, goes to British Gypsum Limited, a division of BPB Industries Limited, making this company the largest user of perlite in the UK. British Gypsum supply the building industry with a lightweight, ready-mixed, factory-controlled plaster, and have no other products which contain expanded perlite. Perlite shipped into Boston, Erith and Workington is supplied to expansion plants at Gotham (Nottinghamshire), Fauld (Staffordshire), Robertsbridge (Sussex), and Kirkby Thore and Cocklakes (Cumbria). One grade of crude perlite, with a size distribution in the range of 0.15 to 2.4 mm, is imported and expanded to about 100 kg/m^3 prior to mixing with plaster. The lightweight plaster produced is part of the 'Carlite' range. 'Carlite Browning' plaster contains expanded perlite as the lightweight component, while 'Carlite Metal Lathing' plaster employs expanded perlite and exfoliated vermiculite. Other plasters in the 'Carlite' range use only exfoliated vermiculite to achieve greater adhesion.

British Gypsum Limited have investigated the deposit at Sandy Braes. The central research establishment near Nottingham conducted a mineral dressing investigation with a sample of about 100 tonnes to determine whether phenocrysts and other lithic elements could be simply separated. There was also an extensive programme of testing the expanded perlite in lightweight plaster formulations. However, as far as can be determined, no further work has been done on the deposit recently.

Tilcon Perlite Products and Tilcon Insulation Services are part of the Mortar Division of Tilcon Ltd, a member of the Thomas Tilling Group of Companies. Tilcon have a factory at Buxton, Derbyshire, for the production of 'Limelite' cement-lime-perlite based plasters or mortars. In addition, Buxton produces 'Limelite Renovating Plaster' and perlite cement floor and roof screeds for use in the restoration of older properties. Tilcon operate two other plants for the production of expanded perlite, at Kirkby near Liverpool, opened in 1974, and at Falkirk in Scotland.

Tilcon offer a wide range of expanded perlite grades ranging from a fine ultra-light grade with a density as low as 40 kg/m^3 to a super coarse grade, the main density range being between 40 and 180 kg/m^3. The product quality is determined by the customer's specification. In addition a range of horticultural grades are available. Other expanded perlite products marketed by Tilcon include fillers, dust supressed 'Trulay' and siliconised 'Trufill' for use in floating floor applications and in the cavity wall insulation market. A range of raw perlite grades are also supplied for markets including the steel and foundry industries.

Perlite Insulation Services was acquired by Tilcon in 1974 and is now known as Tilcon Insulation Services. This section specialises in all aspects of cryogenic and low temperature insulation with on-site expanded perlite processing equipment operating worldwide.

Briggs Amasco Limited started importing about 4,000 tonnes of crude perlite per year from Greece into Grangemouth for expansion at Falkirk, Central Region, in August 1976, the expanded product being used in 'Amascolite', a site mixed perlite bitumen dry roof screed. Early in 1978 the facility at Falkirk, consisting of a stockpile, single vertical expander and bagging plant, was acquired by Tilcon. Briggs Amasco still produce 'Amascolite', but the expanded perlite is now purchased from Tilcon.

Johns-Manville (G.B.) Limited produce and distribute Johns-Manville perlite filter aids, lightweight fillers and extenders. The first Johns-Manville plant in Europe was built at Hessle, Hull, and uses crude perlite from Greece. The plant has two multipurpose vertical expanders and currently produces twelve grades of filter aid, four grades of milled perlite and six grades of expanded unmilled perlite (EUP). The Hull plant supplies markets in the United Kingdom and Europe, and currently exports about 30 per cent of its production. Johns-Manville have a cryogenic grade of perlite, 'Perlox', and a horticultural grade, 'Loam-a-lite', as well as the 'Celite' range of filter aids and fillers.

The British CECA Company Limited is a subsidiary of CECA SA of France. In the United Kingdom, the company expands perlite for insulation uses and filter aids at Strood, Kent. The crude perlite comes mainly from the eastern Mediterranean area. The company produces 'Clarcel Flo' filter aid in three grades, and 'CECAPERL CP40' for cryogenic applications.

Steetley Minerals Limited are distributors for Grefco Inc., Los Angeles, USA, and handle perlite filter aids and fillers sold under the trade name of 'Dicalite' made by Dicalite Europe Nord, Brussels, Belgium (a Grefco subsidiary company). Nine grades of filter aid and two grades of filler are supplied, although the majority of sales in the United Kingdom are filter aids.

Armstrong Cork Company Limited of Gateshead produces an insulation board containing perlite which is imported from Greece and expanded in a vertical stationary furnace. L. Slack and Son Limited, Pontypridd, Mid-Glamorgan, have an expansion and exfoliation facility for perlite and vermiculite with a combined annual capacity of five hundred tonnes. The company produces thermally insulating materials. Silvaperl Products Limited, Harrogate, is a recently established company distributing horticultural grade perlite and perlite composts. British and Overseas Minerals Limited, Harrow, Middlesex, the agents for Silver and Baryte Ores Mining Company Limited of Greece, handles nearly all the crude perlite imported from Greece and supplies several of the United Kingdom expanding plants. Ganmount Limited, London, handle Turkish ores in the United Kingdom and European markets and to date have supplied 50,000 tonnes of crude perlite. At present the ore is neither crushed nor graded before export from Turkey. Otavi (UK) Limited, a company in the Otavi Mining Group of the Federal Republic of Germany and the Republic of South Africa, imports crude perlite from Greece and Eastern European countries for expansion by various companies in the United Kingdom.

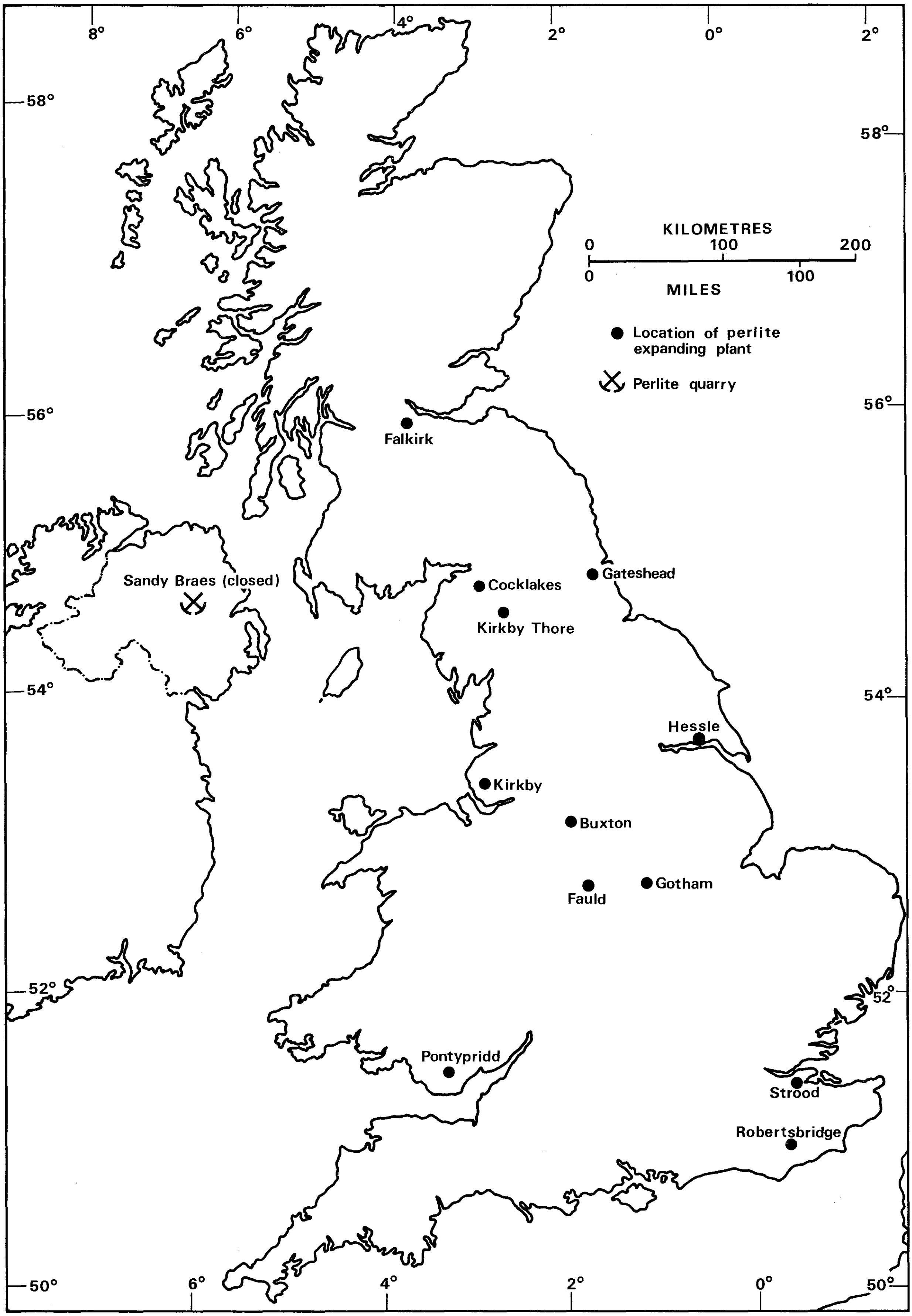


Fig 5 Location of the Sandy Braes deposit and of perlite expanding plant in the United Kingdom

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