Communities and Local Government

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Mineral Planning Factsheet

Building and roofing stone

*This factsheet provides an overview of natural **building and roofing stone**, including slate, extraction in the UK. It forms part of a series on economically important minerals that are extracted in Britain and is primarily intended to inform the land-use planning process.*

March 2007

Natural stone is the traditional building material of Britain and the built environment is perhaps the most visible aspect of our cultural heritage. Stone has been used for building and roofing purposes in the UK for over two thousand years and the geological diversity of the country has meant that the variety of the rock types used is probably unmatched anywhere else in the world. Production and usage of these stones has seen a decline, since the highpoint of the industry in the late 19th century, largely because of competition from cheaper manufactured alternatives such as brick, concrete, glass and steel. As a result many local sources of building stone are no longer available. However, natural stone used in prestige buildings did not experience a serious decline until the 1960s when wartime reconstruction was tailing off and economic conditions were more difficult. That period did, however, see planning requirements to maintain the local character of settlements, particularly in Conservation Areas, create a demand for local stone, which could no longer be supplied by recovery from demolition. Consequently there has been a noticeable increase in interest in, and demand for, natural stone and the prospects for the industry remain buoyant. Overall the diversity of supply of local stones has increased as planning permissions have been granted for new extraction operations since that time. Nevertheless many former important sources of building stone are no longer available.

Limestone, Corallian Group, Abbotsbury

Building and **roofing** stones, including slate, are naturally-occurring rocks of igneous, sedimentary or metamorphic origin which are sufficiently consolidated to enable them to be cut, shaped, or split into blocks or slabs for use as walling, paving or roofing materials in the construction of buildings and other structures, such as bridges and monuments. The term **natural stone** does not include manufactured products, such as reconstituted stone or 'artificial' stone, although these are an increasingly important sector of the building materials market. Flint, chert and other similar materials such as concretions and boulders can be important building materials and flint was perhaps used more widely than any single building stone. However, most of these materials are produced adventitiously as part of other mineral extraction or other operations and therefore do not come within the strict consideration of this factsheet.

A wide range of rock types is used as sources of building stone, including sedimentary limestones and sandstones, metamorphic slates and marbles, and some igneous rocks, principally granite. The suitability of a stone for building purposes depends not only on factors such as strength and durability, and commercial considerations such as the size of block or slab that can be extracted, but importantly on its aesthetic qualities, such as colour and texture. Other factors, including bed thickness, ability to polish, and ease of carving or sawing for mouldings, may also be important. Dark, rough dressed, thinly bedded sandstone slabs impart local character to the vernacular buildings in the countryside of the Pennines, Mid Wales and Cornwall but contrasts with the use of precisely cut blocks of pale granite or Portland Limestone, with considerable bed thickness, that convey monolithic grandeur in prestige buildings in our major towns and cities.

Demand

Two principal markets – **new buildings** and the **repair** of historic buildings drive demand for natural stone products.

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- **New building** involves both maintaining vernacular styles using materials that are compatible with traditional local building practices, and also use in contemporary design requirements including internal and external decoration. New build also includes prestige or major commercial projects that may have a high-tech, contemporary or classical style where the use of a specific stone may be a secondary consideration, but can add to the proposed architectural impact. It is worthwhile remembering that every stone building was at one stage a new build project. Imported stone has had a share of the prestige, new build market, since at least the 11th Century when Caen stone became widely used, for example in Canterbury, Winchester and Norwich cathedrals.

- **Repair and maintenance** of historic buildings and structures requires the use of material from the original or compatible quarry sources.

The market for stone for new building is small and specialised but relatively buoyant. Small builders have seen a growth in demand for individually designed stone-built houses that can command premium prices. However, the 'Poundbury effect' has also created demand for a wider variety of building materials, including stone, throughout the house construction industry. Even where brick or reconstituted block is the main walling material, details such as steps and lintels may be in natural stone. In addition, stone is becoming more widely used in boundary walls and street furniture.

Indigenous natural stone is also highly sought after for large and prestigious building projects such as the new Scottish Parliament Buildings (Kemnay granite), the Wales Millennium Centre (Welsh slate) in Cardiff and 'The Collection', Lincoln's new county museum (Ancaster limestone). The Welsh roofing slate industry, is an example, of an industry which was built on the basis of a low cost, high volume product that has now become a low volume, high value-added item, competing successfully with the Cumbrian green slate industry for prestigious roofing and building projects.

The conservation market is of increasing importance. Britain has a large stock of historic stone structures that are protected by legislation that demands like-for-like replacement of stone wherever possible in conservation projects. These structures form an important part of the nation's cultural heritage and are a considerable attraction for both domestic and foreign tourists. In essence they provide a 'Sense of Place' and character to our cities, towns and villages. The need to protect, restore and conserve these buildings, many of which are built of indigenous stones, is recognised as an essential objective in the maintenance of landscape and townscape.

Natural building and roofing stone products are rocks quarried for the purpose of obtaining blocks or slabs that can be used non-dressed or subsequently dressed (shaped), riven (split) or sawn (ashlared) for general building. They include:

Stone cladding – material quarried, split, sawn and/or polished for non-load bearing walling material.
Kerbstone – stone used for edging roads and footpaths
Setts – stone roughly squared for roads and paving
Flagstone – quarried, sawn and split (riven) specifically for flooring or paving.
Slate – rock with a pronounced metamorphic (slatey) cleavage allowing it to be split into thin sheets - principally for roofing but also for decorative cladding and monumental use.
Stone slate – rock (other than slate) that is thinly bedded and fissile (easily split or riven into thin slabs) and quarried specifically for roofing purposes (includes both limestones and sandstones).
Monumental stone – rock quarried cut, split, dressed or polished specifically for use in monuments, gravestones or memorial tablets.
Decorative stone – rock quarried, sawn, worked and polished for (architectural) ornamentation – fireplaces, stone mouldings
Marble – geologists only apply this term to limestones that have been altered by metamorphism. However, the building trade uses the term to include any limestone that is hard enough to provide a polished surface.

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Walling stone – rock quarried for non-dressed (rubble) or lightly dressed blocks.
Rockery stone – stone cobbles and boulders, of varied lithological composition, used in landscaping and gardening.

Supply

Quarries primarily producing building stone in Britain vary significantly in size and output. They range from relatively large operations with areas in excess of 50 ha and operating continuously with a high face, to very small sites less that 0.5 ha in extent and worked very occasionally to recover stone from a single thin bed. In addition, almost all crushed rock aggregate quarries produce, or can produce, building stone as an ancillary product. Larger operators, controlling several quarries, commonly in different geological rock types, may serve an extensive national (and sometimes international) market with production in the order of 5-10 000 t/y. tonnes. Small producers, usually operating a single quarry, principally serve local or national niche markets and have an annual production of less than 500 tonnes.

Currently there are 439 active building stone and slate quarries in the UK - 332 in England; 50 in Scotland; 45 in Wales, 5 in Northern Ireland and 7 in the Isle of Man. The distribution of these quarries is shown in Figures 1-3. The industry is still capable, with a few notable exceptions, of meeting current demand for natural stone.

	England	Scotland	Wales	Northern Ireland	Isle of Man	Total
Building sandstone	173	18	16	1	0	208
Building limestone, incl. chalk	118	5	10	2	2	137
Granite & other igneous rocks	15	26	4	2	1	48
Slate & marble	18	1	15	0	4	38
Ironstone flint, serpentine etc	8			0	0	8

Table 1 Distribution of active building stone quarries in the UK, March 2007.
Source: BGS

Sales of building and roofing stone are shown in Table 2, some figures have had to be estimated because selected information is confidential. These figures should be treated with some caution, as they are believed to over estimate production, particularly with respect to igneous rock. An independent study by the Symonds Group on *Planning for the supply of natural building and roofing stone in England and Wales (2004)* on behalf of the Office of the Deputy Prime Minister (ODPM) concluded that annual production of building and roofing stone in England and Wales during the period 1999 to 2001 was approximately 714 000 tonnes.

Two major groups of resources dominate the supply of building stone in Great Britain; the various Jurassic limestones in the Midlands and South of England (Dorset, Wiltshire, Gloucestershire and Lincolnshire) and Carboniferous sandstones in Yorkshire & the Humber (West Yorkshire), the East Midlands (Derbyshire and the Peak District) and the North West. Scotland is the dominant source of igneous rock.

Rock type	2000	2001	2002	2003	2004	2005
Sandstone	239	280e	340e	327	439	460e
Limestone	324e	213e	191	200e	226	589
Dolomite	15	34	9	7	7e	8
Igneous rock	210e	479	217	212	189	150e
Total	788	1006	757	746		

e estimated

Table 2 Great Britain: Production of building stone, 2000–2005.
Source: Annual Minerals Raised Inquiry, Office of National Statistics.

Production of slate is shown in Table 3. Output is dominantly from North Wales and the Lake District, but there is also a small locally significant output from Cornwall and Devon.

Trade

The UK is a major and increasing net importer of dimension stone and slate, and low cost imports

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	Thousand tonnes							
	1998	1999	2000	2001	2002	2003	2004	2005
Roofing slate	26	34	34	34	34	35	c	44
Cladding and other decorative uses	7	11	17	c	c	c	128	87
Crude blocks	36	38	33	39	39	33	43	92
Total	69	83	84	na	na	na	171	223

C Confidential. Na not available

Table 3 Great Britain: Production of slate for building purposes, 1998–2005.
Source: Annual Minerals Raised Inquiry, Office for National Statistics

are seen as the biggest threat to the indigenous natural building stone industry. These imports are primarily of material used in prestige construction projects, street furniture and internal decoration.Imports have not, as yet, significantly penetrated the local market for stone house building and walling. However, imports of paving material are increasing and imports of roofing slate substantially exceed domestic production. The economies of scale achievable in Europe, which has been a traditional source of imported natural stone in the UK, has recently been increasingly challenged by imports from India, China and Brazil.

Trade is in both 'unworked' stone and slate that is roughly trimmed or cut into square or rectangular blocks, and 'worked' stone and slate, including articles thereof. Total trade in these categories are shown in Table 4. However, a large proportion of the imports of unworked stone is believed to be armourstone (for coastal protection) from Norway, which is not building stone. Imports and exports of 'worked' stone, including articles of stone and slate, are shown in Table 5 broken down by major type.

Consumption

The total market for natural stone is roughly of the order of one million tonnes a year. This figure is in sharp contrast to the 220 million tonnes of natural aggregates that are consumed in the UK each year. However, the unit

Building or monumental stone	Imports		Exports	
	Tonnes	£thousand	Tonnes	£thousand
'Unworked' stone and slate	1 616 497 (a)	92 008	10 568	1747
'Worked' stone and slate	616 165	220 205	50 667	29 165

Table 4 UK: Trade in 'unworked' and 'worked' stone and slate, 2005
Source: HM Revenue & Customs

value of building stone is much greater than for aggregate. The domestic building stone industry is broadly able to meet local demand. However, imports are required for the more specialised types of dimension stone, notably marble of which there are only minor indigenous resources, and also the many types of igneous rock widely used for cladding and flooring. However, imports are increasingly penetrating other sectors of the market.

The market for new building projects has fluctuated in recent years. The prestige sector has maintained a steady rate of production, recently boosted by involvement in numerous national and local regeneration projects, many being undertaken with Lottery Heritage Funding. The heritage repair market for stone is also growing. Stricter national and local planning regulations encourage, wherever possible,

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	2001	2002	2003	2004	2005	2001	2002	2003	2004	2005
Imports	**Tonnes**					**£thousand**				
Marble & other calcareous stone	64 637	48 237	60 473	69 921	77 698	28 291	32 555	40 413	46 702	52 805
Granite	37 533	57 885	66 177	81 551	88 917	26 334	37 543	45 125	50 080	57 884
Other stone	21 256	27 063	31 600	42 132	42 394	10 947	13 552	14 987	16 989	17 780
Paving and flagstone	47 501	75 640	88 509	88 204	16 548	8 161	10 754	12 652	22 402	28 825
Roofing & walling slate	112 325	125 257	139 819	160 921	165 790	35 162	40 572	45 227	51 248	53 385
Other worked slate	8 581	21 162	15 601	60 720	55 854	2 761	4 825	4 486	9 847	10 237
Total	291 833	355 244	543 178	603 449	599 201	111 656	139 801	162 890	197 268	220 916
Exports	**Tonnes**					**£thousand**				
Marble & other calcareous stone	526	946	1 073	1 657	2 906	1 456	1 893	3 320	3 726	4 951
Granite	53	732	290	489	607	99	755	399	545	623
Other stone	3 596	3 820	4 602	3 686	5 688	1 914	2 269	2 850	2 661	5 070
Paving and flagstone	5 029	5 057	4 980	4 690	6 709	780	1 217	1 105	1 103	2 035
Roofing & walling slate	10 814	7 146	11 978	16 917	24 963	4 687	3 990	7 070	9 445	12 331
Other worked slate	2 119	1 658	2 314	1919	2868	4 102	2 500	2 675	2 140	2 515
Total	**22 137**	**19 359**	**25 236**	**29 358**	**43 741**	**10 802**	**8 731**	**17 419**	**19 620**	**27 525**

Table 5 UK: Trade in 'worked' dimension stone and slate, 2001 – 2005
Source: HM Revenue and Customs

like-for-like replacement of stone in building conservation. Mineral planning policy in the England specific to building stone, for example, has recently been revised (MPS 1 Annex 3 Nov. 2006) to emphasise the need to supply stone both for new construction and also for conservation and restoration. New building, extensions to existing buildings, paved areas and walls within Conservation Areas are required to use materials compatible with the surrounding historic built environment. In addition, the desire to create a diversity of building form with a wider range of materials in new housing outside Conservation Areas has increased new build demand for natural stone.

The diverse nature of our stone built heritage has, however, meant that many local stones are now no longer available. This shortage of local materials has already reached a critical point in some areas of Britain, e.g. Reigate Stone, Bromsgrove Sandstone, Craigleith Sandstone, Pennine stone roofing slates, Collyweston stone slate, Scottish slate, and the problem is likely to become even more acute in the future. However, the area and likely level of demand for some stones will only be extremely local. This may not justify either the environmental or the economic costs in opening disused or new operations, such that an alternative material might need to be used.

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Economic importance

Building stones have an inherently higher unit value than most other minerals produced in Britain. Prices can range from a few tens of pounds per tonne to several hundreds of pounds, with the ultimate price of a building stone being essentially a function of the degree of processing that the rock has undergone.

Total sales of building stone in Great Britain are reported by the Office for National Statistics as £67 million in 2004, of which sandstone accounted for some 59%. This figure probably relates to the value of crude blockstone production (stone *roughly* squared at the quarry) and thus underestimates the true value of the industry. The value of roofing and cladding slate sales was about £27 million in 2003.

The total value of sales of worked or monumental stone and slate that has been cut, shaped or finished, was £347 million in 2005. Although this value includes sales of material imported into the UK for 'finishing' it provides a better indication of the true value of the industry. Building stone is a construction material and its ultimate value resides in the final product – the built environment.

Structure of the Industry

The industry is characterised by a relatively large number of fairly small producers. For example the Symonds report for ODPM identified 335 active and intermittently active quarries in England and Wales. However, the study indicated that some 70% of building and roofing stone production was derived from 34 quarries, and half of total building stone output was obtained from just 15 sites.

The Stone Federation Great Britain is the trade association that represents the industry in its widest sense. It has 166 members, which include importers of stone and stone products, and processors and masons, in addition to domestic natural stone producers. The largest UK natural stone producers are;

Limestone

Albion Stone Quarries Ltd
Stone Firms Ltd (*formerly Hanson Bath & Portland Stone)*
Bath Stone Group

Sandstone

Stancliffe Stone Company Ltd
Realstone Ltd
Johnsons Wellfield Quarries Ltd
Woodkirk Stone Ltd
Ennstone Breedon Ltd

Slate

Alfred McAlpine Slate Ltd
Welsh Slate Co Ltd
Burlington Slate
Delabole Slate Co Ltd.

Resources

Britain has an extensive range of geological formations that are potentially suitable for use as building stone. Reflecting the geology, different parts of the country have distinctive rock types, which also bring a distinctive local character to the built environment in these areas. This can make it difficult for building stones to be matched from alternative sources.

The principal building stones resources are listed in Table 5 and their distribution is shown in Figures 1–3. The apparent extensive nature of these resources disguises the fact that rocks suitable for use as building and roofing stone may be highly localised. This is a direct function of local geology where bed thickness and extent, incidence of discontinuities, such as fractures and joints, and degree of cementation of the rock all have a fundamental affect on the suitability of the rock for building stone. As a result workable deposits may be difficult to find and where they do occur may be very restricted in extent. Subtle or substantial lateral differences in stone properties can significantly affect the characteristics of the product. Minor changes in shell content, cementation or grain size may have aesthetic impacts but also affect weathering properties and thus durability, which may be particularly important in restoration work or where a large façade needs to maintain a consistent effect. Changes in bed thickness alone within the same rock unit can

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Sandstones	**Principal producing counties**
Palaeogene	Dorset (Heathstone), Sarsen Stone (Wiltshire)
Lower Cretaceous	Sussex, Wiltshire; Norfolk (Carstone)
Middle Jurassic	North Yorkshire
Triassic (red & white)	Gloucestershire (red), Somerset (red), Staffordshire, Shropshire (white), Cumbria (red), Dumfries (red), Fife and Moray
Permian (red)	Cumbria; Dumfries
Carboniferous	Northumberland, Durham, Lancashire, Yorkshire, Derbyshire; Gloucestershire & South Wales (Pennant)
Devonian (Old Red Sandstone - red purple) (Grey Grits)	Devon, Herefordshire; Caithness (black)South Wales
Lower Palaeozoic (dark grey-green)	Wales
Limestones	
Upper Cretaceous	Cambridgeshire, Bedfordshire (chalk / clunch)
Lower Cretaceous	Dorset (Purbeck); Kent (Kentish Rag)
Upper Jurassic	Dorset (Portland); Wiltshire (Chilmark)
Middle Jurassic	Wiltshire, Somerset (Bath); Gloucestershire (Cotswold); Oxfordshire, Buckinghamshire; Lincolnshire & Rutland (Lincolnshire Limestone);Dorset (Corallian, Forest Marble, Inferior Oolite)
Lower Jurassic	Somerset (Lias); Warwickshire & Oxfordshire (ironstone)
Permian	Nottingham, Yorkshire, Northumberland, Durham, (Magnesian Limestone)
Carboniferous	Derbyshire, Cumbria, Durham
Slate (metamorphic)	
Devonian	Devon, Cornwall
Silurian	Cumbria, Denbighshire,
Ordovician	Cumbria, Carmarthenshire, Pembrokeshire
Cambrian	Gwynedd
Granites & other igneous rocks	Cornwall, Devon, Derbyshire, Leicestershire, Cumbria; Aberdeenshire, Argyll & Bute, Fife, Highland; Gwynedd

Table 5 Principal building stone resources in Britain

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create a different building product (block as opposed to thin slab), which, if used together, can totally alter the aesthetic aspects of structures and have an incongruous impact.

The major rock types that are used as sources of building stones are;

- **Sandstones** are formed by the weathering and erosion of all types of pre-existing rocks. They consist of small fragments or grains held together by natural cements such as calcium carbonate (calcite), silica, iron oxide or clay minerals. Most sandstones consist of grains of quartz, feldspar and lithic (rock) fragments. It is their high quartz content that makes them hard, durable building stones. Sandstones can be divided into fine, medium or coarse-grained types by measuring the average size of the grains. Sandstones from the Devonian, Permian and Triassic are characteristically red because of the presence of iron-staining on the grains. Some sandstones can be identified by the presence of distinctive mineral components e.g. green glauconite (iron silicate). The sedimentary structure and mineralogy of a sandstone can often distinguish whether it is of eolian (wind-blown dunes), fluvial (river channel) or marine origin.

- **Limestones** are principally composed of calcium (calcite) and/or magnesium (dolomite) carbonate and are relatively soft in comparison to sandstones. Most limestones are formed by the accumulation on the seabed of the broken shells of marine organisms, in tropical or sub-tropical settings. These bioclastic grains are cemented together by natural calcium carbonate. In coarse-grained limestones, fossil shell fragments are easy to see with the naked eye. In contrast Chalk is an example of a fine-grained limestone composed entirely of the calcitic skeletons of microscopic organisms known as coccoliths. A distinctive group of building limestones are the ooidal limestones formed at the seabed as concentrations of millimetre-sized spherical ooids. Also included in this group of rocks are the magnesium-rich or dolomitic limestones. Dolomitic limestones are principally formed by the chemical alteration of an original calcium-rich limestone. This alteration process may preserve any original shelly or ooidal limestone fabric or completely destroy it to produce a crystalline rock.

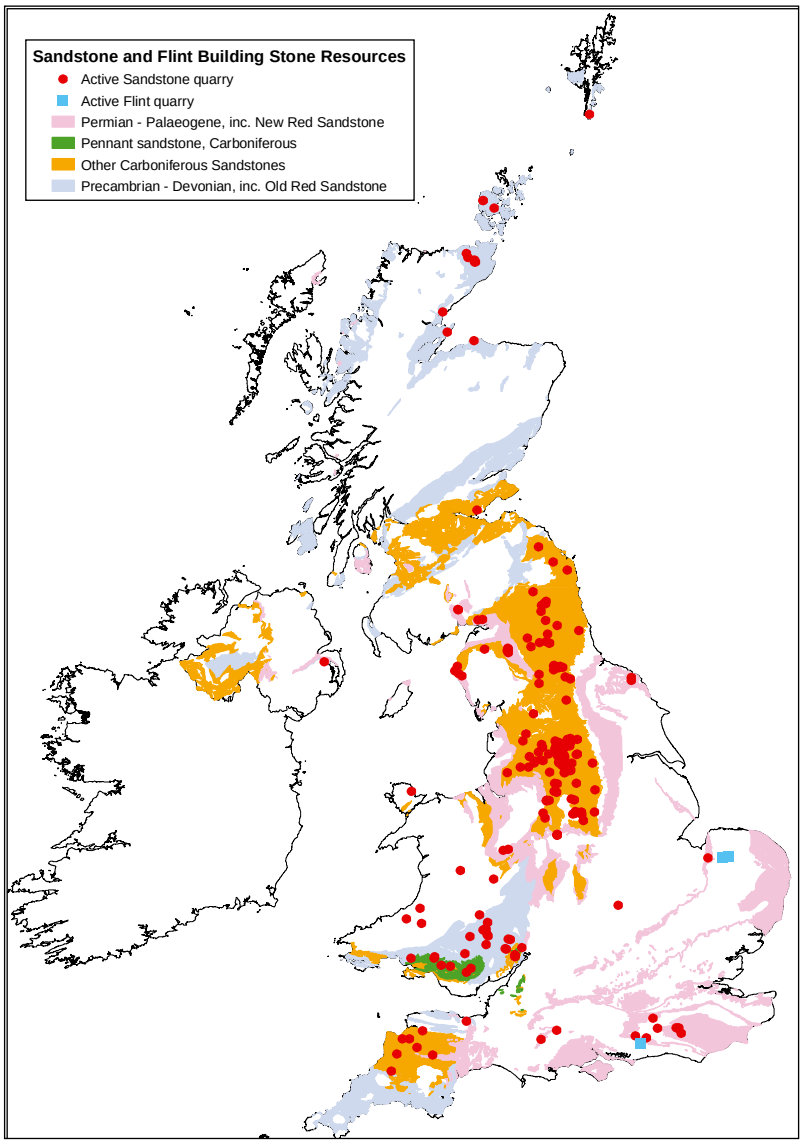

Figure 1 Distribution of building sandstone resources and active quarries.

- **Slate** is a fine-grained, low-grade metamorphic rock showing strong fissility (i.e. slatey cleavage) which allows the rock to be split into thin sheets of consistent lithology. Slates are formed by the recrystallization of fine-grained sedimentary or igneous rocks (usually volcanic ash) under extremes of temperature and pressure. Under such con-

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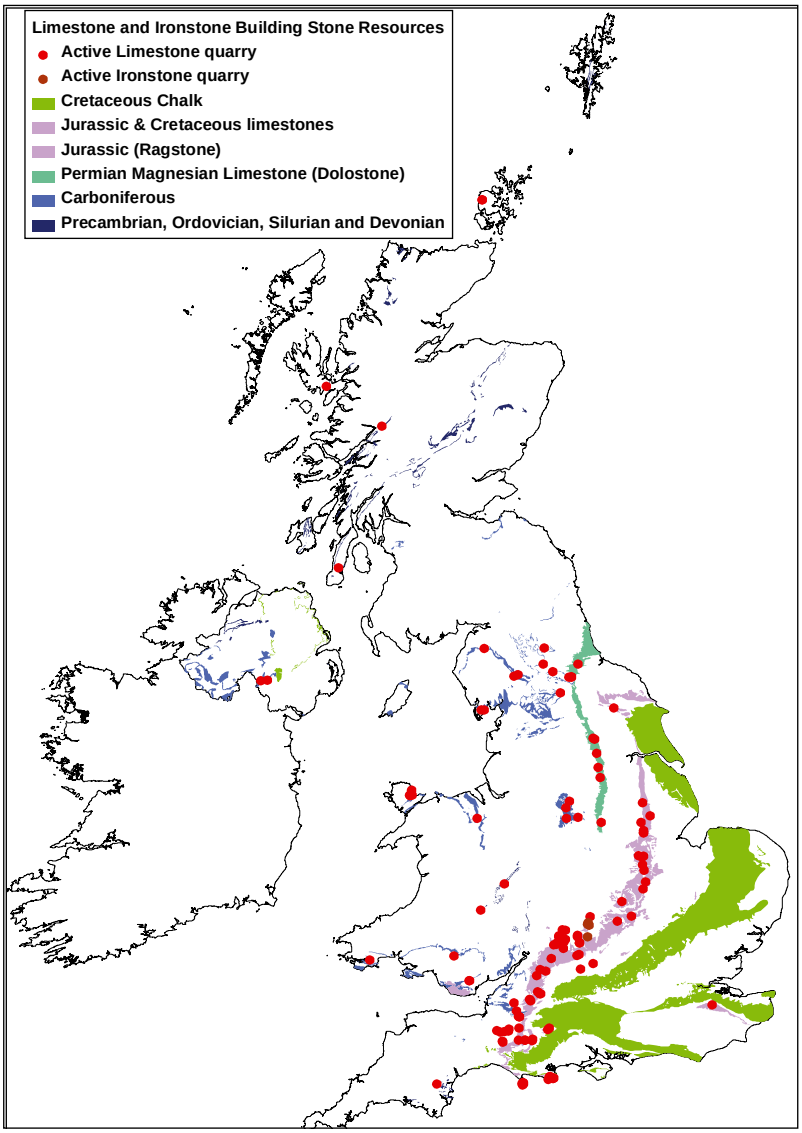

Figure 2 Distribution of building limestone resources and active quarries.

ditions, which develop over many millions of years, new minerals, most notably micas, grow and the characteristic slatey cleavage is formed. It is the alignment of these new minerals that enables the slates to be easily split into thin sheets. An important feature of metamorphic slates is their lack of porosity, which makes them impervious to fluid flow.

- Included in the metamorphic rocks are the true **marbles**. Geologists apply this term only to limestones that have been recrystallised by metamorphism. However, the building trade uses the term to cover any hard, polishable, limestone. Metamorphosed limestones (marbles) are texturally and colourfully distinctive but they are still principally composed of calcium or magnesium carbonate.

- **Igneous rocks** are hard and crystalline and made up of the primeval material of the earth. They are formed directly by the cooling of hot molten magma of varying composition and under variable conditions of temperature and pressure that consequently produce a very wide spectrum of rock types. They are widely used as building stone but are commonly termed '**granites**' by the trade. Scientifically, however, igneous rocks show a range from pale-coloured, coarsely-crystalline, quartzo-feldspathic varieties, that include the true granitic rocks, to dark coloured, finely crystalline basic or basaltic rock types. Other igneous rocks used for building or decorative purposes include coarse grained granodiorites, diorites, syenites, gabbros and monzonites (Larvikite) and fine grained dolerites.

Reserves

Total reserves of building and roofing stone with planning permission are not available for reasons of commercial confidentiality. However, quantifying building stone reserves is difficult. This is because of variations in the physical quality, geometry and lateral continuity of different rock units, inclusions of chert, clay or country rock, and variable joint and bedding plane pattern, all of which can markedly affect yields. Indeed yields may not be quantifiable until the stone is extracted.

Accessing new reserves because of the difficulty of obtaining planning permissions for quarrying extensions and new sites has been highlighted by the industry as a key obstacle to the future development of the industry.

Relationship to environmental designations

Large areas of Britain are now covered by national landscape and nature-conserva-

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tion designations. Any development in these areas is subject to rigorous examination and it is increasingly difficult, therefore, to obtain planning permission for minerals extraction. Many of these areas coincide with building stone resources and current and former operations. Notable examples include granite on Dartmoor, slate in the Lake District, sandstone in the Peak District and limestone in the Isle of Purbeck. There is, therefore, concern in the industry that sterilisation of building stone resources by these designations may eventually prove to be a serious threat to future building stone supply and, as a result, the conservation of the nation's stone-built heritage.

Stone used in buildings, walling and other structures frequently forms a prominent element in the visual character and cultural history of protected landscapes. As the objective of planning policy in such designations is to maintain and enhance that character, adequate provision of local building materials is a necessary function of the planning process. It is also probably in the public interest that materials necessary to maintain and restore buildings of national importance and to provide new prestige buildings may need to be provided from such designated landscape areas.

In addition supply of stone for conservation and repair might require reopening long neglected sites now designated as important for wildlife conservation or of value as part of our industrial heritage. This concern has been recognized and addressed, in part, in England in Annex 3 of revised Minerals Policy Statement 1 (MPS1 – Nov. 2006) where MPAs are advised to consider this position with care.

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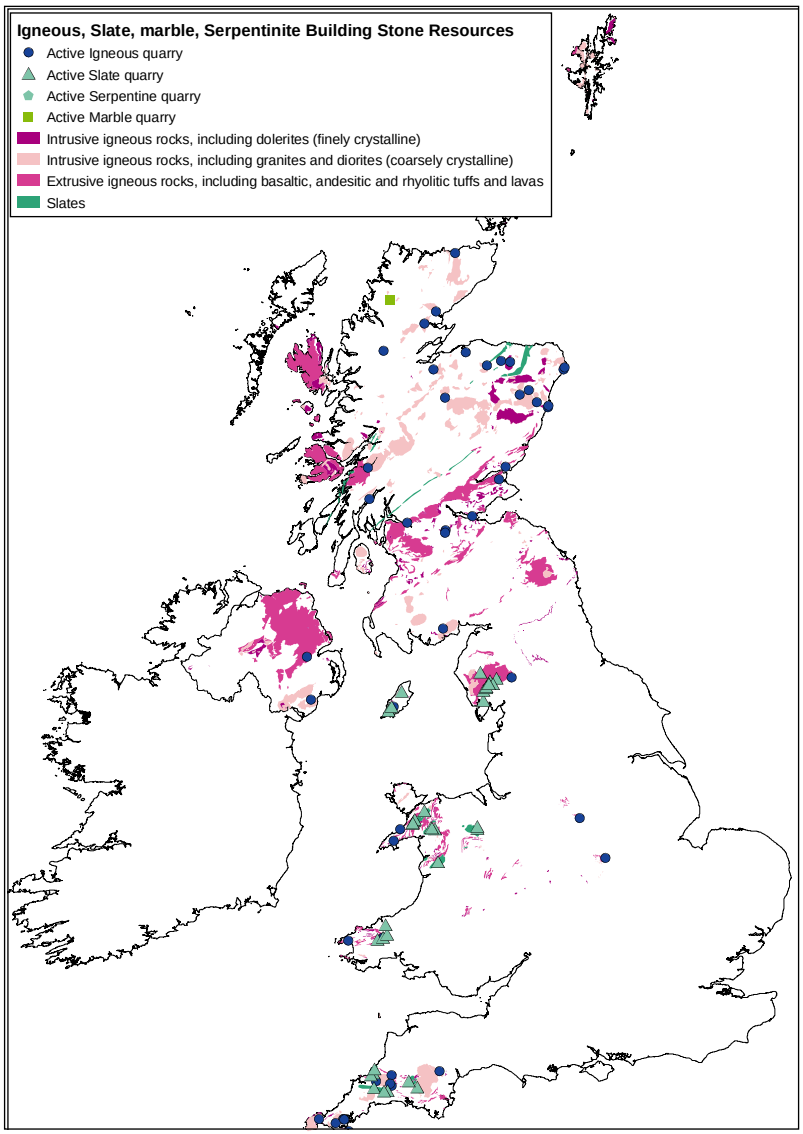

Figure 3 Distribution of igneous rock and slate resources and active quarries.

Extraction and processing

Building stones are mainly extracted by surface quarrying. Underground mining, although formerly more widespread, is still carried out in a number of places for limestone extraction, for example Bath Stone in Wiltshire. Jurassic limestone is also mined at Chilmark near Salisbury and mining has recently been introduced on the Isle of Portland for the extraction of Portland Stone.

Unlike operations in aggregate quarrying, where the objective is to reduce the stone to small fragments, blasting is now almost never used in the extraction of building stone. Here the requirement is to recover large, undamaged blocks from the quarry face that can be subsequently dressed. Blasting could have a serious detrimental effect on the structure

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of the softer stone varieties if not undertaken with care. The quarry face is initially opened up by exploiting the naturally occurring lines of weakness, provided by joints and / or bedding planes, in the rocks. These determine the maximum size of the blockstone that can be produced. Large blocks produced are reduced in size by hammer and chisel, drilling and the use of iron wedges ('plug and feathers') or by diamond wire saw techniques. However, for some monumental and prestige work very large blocks (more than 2 m on bed) may be specifically sought. In most sedimentary rocks, blocks are recovered directly from the face by mechanical excavators. Joint and bedding plane surfaces rarely provide a near cubic/rectangular block and more typically will produce rhombic shapes that need careful cutting to maximise saleable block and minimise waste.

Underground working of building stone takes place at relatively shallow depths accessed by adits or, more commonly in the past, by steep inclines and narrow vertical shafts. Stone production relies on the room and pillar method of extraction, where pillars of stone are left in place to support the excavation at the working face. Extensive, interconnecting underground gallery systems can be developed by this method. Depending on the hardness of the stone, bed height and block size, the blocks may be removed using a range of mobile, mechanised saws or alternatively by removing a top waste band and then lifting blocks by plug and feathers or drilling.

In some cases the material to be used as a building stone will be in the form of nodules (flint, chert or septaria) or cobbles which require minimal dressing or shaping.

Processing of the stone begins at the quarry or following transportation to centralised cutting sheds depending on the requirements of the contract. Softer stones, such as limestones, can be shaped and roughly dressed by hand or cut using a handsaw or mechanical guillotine at the quarry. Harder stones may need to be sawn using frame-saws, gang-saws, diamond rotary blades, diamond wire saws or high pressure water-jets. Surface finishing of some stones can involve polishing using abrasives and flame-jet texturing. Riven stone is produced by hand.

By-products

The extraction and processing of building stone generally involves the production of a large proportion of mineral waste, sometimes in excess of 80% of the raw material extracted. Because of the nature of most of the building stone produced, which tend to have low impact resistance, this material is only suitable for less demanding aggregate applications. Nevertheless, aggregates are produced, to a greater or lesser extent, at the majority of building stone operations. The total quantities involved are not known but for many sites the amount will considerably exceed the tonnage sold as building stone. Use of this material improves overall resource utilisation, replacing primary aggregate that might be extracted elsewhere. However, it may also result in greater impact on the environment, than would be associated with building stone production on its own. This is largely through increased lorry movements. However, using mineral waste removes the disproportionately large and sometimes prominent, stockpiles that may be visually intrusive, delay restoration or will be tipped on other land. Some building stone quarries also produce armourstone and stone for landscaping projects.

In the case of slate production, as little as 5% of the material extracted is used for quality slate products. It has been estimated that nearly 6 million t/y of slate waste is generated each year in North Wales. The slate waste is increasingly being used as crushed rock aggregate mainly in road construction but also in ready-mix concrete and for decorative aggregate. Slate granules are also produced for coating roofing felt and slate powders for a number of filler applications, for example in rubberoid products.

In 2005, 0.55 and 0.15 million tonnes of slate were sold for aggreagate use in Wales and England respectively.

Building stone is also produced as a by-product of an increasing number of aggregate quar-

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ries and also a few sites producing cement raw materials.

Alternatives/recycling

Building stones are valued for their physical properties, such as colour, texture, strength and durability. These properties are generally unaltered in use and thus building stones can be readily recycled into other structures. Building stones were one of the very first products to be recycled by man, a fact that has destroyed or damaged many historical structures. It continues to be a problem today with the theft of building and roofing stone from existing structures. Stone recovered by recycling derelict buildings was formerly a major source of local stone for house building, although qualities of useable recovered stone were and are lower due to weathering.

As individual types of building stone often have very distinctive characteristics they cannot be easily matched by stone from alternative sources. Maintaining a supply of local stone is, therefore, important in preserving the continuity of local vernacular styles of architecture.

Concrete, brick and steel are alternative construction materials, although they cannot be viewed as alternatives to natural stone, which supplies a valued-added market. The production of 'artificial stone' or 'reconstituted stone' products has increased substantially in recent years and poses a potential commercial threat to the industry. Crushed rock fragments bonded together by lime, cement or organic resins are now a common, cheaper alternative to natural building stone. The roofing industry has used concrete tile products for some time but recently the use of 'tiles' made by blending of natural rock fragments or synthetic materials with cements or resins to replace both natural stone and metamorphic slates has become more commonplace. Similar products are also produced for paving. In many cases the raw materials used in these products are derived from the waste produced at building stone quarries. However, all these 'alternatives', although cheaper, lack the aesthetic qualities of natural stone products.

Effects of economic instruments

The Aggregates Levy was introduced in April 2002 at the rate of £1.60/t. Although building and roofing stone are exempt, sales of waste rock from building stone quarries as aggregate are subject to the Levy, irrespective of whether the aggregate is a mineral waste from quarrying or processing. It is reported by the industry that the introduction of the Levy has had an adverse effect on sales of these low-quality aggregates, which can command only low prices, this is causing disposal problems at the quarry.

Slate, including slate waste, is exempt from the Aggregates Levy. The rationale for this is the legacy of hundreds of millions of tonnes of slate waste on tips, particularly in North Wales, but also the Lake District and Cornwall which are potentially available for use as aggregate. Slate waste has been used for aggregate purposes for many years and most is quarry and processing waste from active operations. However, there has been an increase in the use of slate as aggregate from 440 000 tonnes in 2001 to 690 000 tonnes in 2005. Most of this production is in North Wales, but the options for greatly increased usage is limited by the cost of transport. A study – *North Wales slate tips – a sustainable source of secondary aggregate* – carried out for the Welsh Assembly Government concluded that only transport by rail was a feasible option for moving slate waste but major investment in infrastructure would be required.

Planning issues

With such a wide variation in the scale of operations, the impacts and planning issues associated with building stone extraction show marked differences. This variation is further increased by locational considerations. Quarries may have to be located prominently in exposed uplands or coastal situations where climatic conditions are more severe making operational conditions, landscaping and restoration more difficult. Alternatively it may be possible to locate a new quarry where topography and vegetation screen can operate successfully.

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Quarries, particularly those with a long history, may now suffer from urban encroachment constraining options for development and sterilising valuable and scarce resources. Shifting economic conditions may now mean that nearby property is no longer occupied by the quarry workforce but by those who have no interest in the continuation of production. Underground extraction may offer a way forward in some situations, although that must be tempered by concerns as to recovery rates, recoverable block size and waste, all of which may be of significance according to the value, rarity and geology of the stone.

The impacts of the extraction of building and roofing stone cannot, therefore, be simply categorised. Generally, although by no means always, impacts are much less than for the quarrying of aggregates mainly because the scale of extraction is much smaller. Associated impacts on amenity, such as noise, dust, mud and transport, are also not so great, although transport of block may actually only involve a small tonnage per movement thus increasing the total number of movements. Actual impacts will vary from site to site, depending not only on output but also location with respect to sensitive designations and the rock type being produced and the amount of associated waste. For example, slate extraction and processing involves the production of a large proportion of waste. One large slate quarry in North Wales extracts some 3-4 Mt/y of raw material but less than 10% is finally used in quality products. Concern with the cumulative impact of a number of small sites working close together can arise, although geological constraints may prevent a dispersal of operations.

Under the Town and Country Planning (Environmental Impact Assessment (England and Wales) Regulations 1999, formal Environmental Assessments (EAs) are only required for quarrying operations that exceed 25 ha in surface area. Most building stone operations are much smaller than this but EAs can be requested if the site is in a sensitive area. In addition, MPAs often expect supporting environmental studies even though a formal EA is not required. For smaller operators the associated costs are perceived as a disincentive to making a planning application for a new quarry or even an extension. However, the evidence for this appears to be contradictory. A major planning problem for the industry was the lack of association in local planning policy and decisions between the objective of maintaining local character and therefore the need for local materials, sterilisation concerns and unrealistic requirements on operations and restoration. Government planning policy on the provision of natural building and roofing stone in England is set out in:

Mineral Policy Statement 1: Annex 3 Natural building and roofing stone.

Further information

Planning for the supply of natural building and roofing stone in England and Wales. *A report for the Office of the Deputy Prime Minister by the Symonds Group Ltd, 2004.*

See also www.odpm.gov.uk/stellent/groups/odpm_planning/documents/page/odpm_plan_027901.pdf

Technical Advice Note. Identifying and sourcing stone for historic building repairs. English Heritage [2006).

Minerals Policy Statement 1 : Planning and Minerals. Annex 3. www.communities.gov.uk/index.asp?id=1144132

Other useful websites

Stone Federation website
www.stone-federationgb.org.uk

Building Research Establishment
www.bre.co.uk/

Stone Roofing Association
www.stoneroof.org.uk/

English Stone Forum
www.englishstone.org.uk/

Natural Stone Institute
www.nsiuk.org

Building and roofing stone

Welsh Stone Forum
walespast.com/en/364/

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Mineral Planning Factsheets for a range of other minerals produced in Britain are available for download from www.mineralsUK.com