



Brick Clay: Issues for Planning



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Brick Clay: Issues for Planning

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Front cover photographs: Lifting fireclay for brickmaking, Pegswood opencast coal site, Northumberland (top); extruded wirecut bricks set on a tunnel kiln car prior to firing, Kirton, Nottinghamshire; stockyard and soft-mud brick manufacturing plant at Tilmanstone, Kent; 18th Century brick and tile housing contributing to a distinctive landscape in Salisbury, Wiltshire; new homes at Melton Mowbray, Leicestershire built in buff bricks with red brick detailing; new and restored brick buildings forming a mixed-use residential/ office development, Nottingham city centre (bottom).

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1. INTRODUCTION

1.1 This report describes research commissioned by the Department of Transport, Local Government and the Regions (DTLR) on the planning issues associated with brick clay extraction and processing in Great Britain. The research was undertaken as part of the DTLR Minerals, Land Instability and Waste Planning Research Programme.

1.2 The research is based on an extensive survey of the brick industry. This considered its raw material requirements, manufacturing base, products and markets. A review of the planning process and issues arising for brick clay was also carried out at the same time. This involved wide consultation with both planning authorities and the industry. It identified a range of planning issues, including those which relate to planning in general, those generic to mineral planning and those specific to brick clay. The interpretation of the resulting information, the summary of views and the conclusions and recommendations expressed in the report are those of the research team and do not necessarily represent the views of Government or of any other party.

1.3 The purpose of the research is to review current and future issues in planning for the supply of brick clay. This is the essential raw material for the brick, tile and pipe industry within Great Britain. Relevant planning issues are identified and the effectiveness of present planning policy and guidance in dealing with these issues is assessed. Recommendations are made to address problems concerning current policy and guidance. The overall approach to the research and structure of this report is summarised in Figure 1.

1.4 In the main body of this report, the word 'bricks' refers to structural clayware including bricks, roof tiles and pipes which are manufactured from brick clay. 'Brick clay' or 'clay' refers to clays used in the manufacture of these and associated products. This includes materials known and recorded in official statistics as 'common clay and shale' and 'fireclay', but largely excludes special clays such as ball clay and china clay.

Background

1.5 Bricks are a significant construction material in the UK and are one of the most visible components of the built environment. A wide variety of products are manufactured from a diverse range of clay resources. This variety and diversity makes a positive contribution to maintaining the character of the built environment of the UK. The total quantity of brick clay extracted (annual production is about 8 million tonnes) is small in comparison to aggregates (annual production is about 220 million tonnes).

1.6 The research was prompted by concerns that existing planning guidance and policy on brick clay at both national and local level does not adequately reflect current planning issues or economic trends. This has resulted in diverse policy responses from planning authorities and, in turn, from industry. This situation has led to problems in management of resources and, perhaps, some undesirable environmental and amenity impacts.

1.7 A further issue is that existing guidance and policy needs to be reviewed in the light of emerging planning issues, developing trends in industry and new legislation

and guidance. For example, it needs to adequately reflect sustainability objectives, management of natural resources in a holistic manner, and modernisation of the planning process. It should also take account of structural changes in government (the European dimension, devolution in the UK, the development of regional administration in England) and consolidation and rationalisation in the brick clay industry.

1.8 These issues and trends will have implications on all aspects of planning, including planning for brick clay. Recommendations on future guidance for planning for brick clay cannot therefore be prepared in isolation from those considerations and policy and guidance must take them into account.

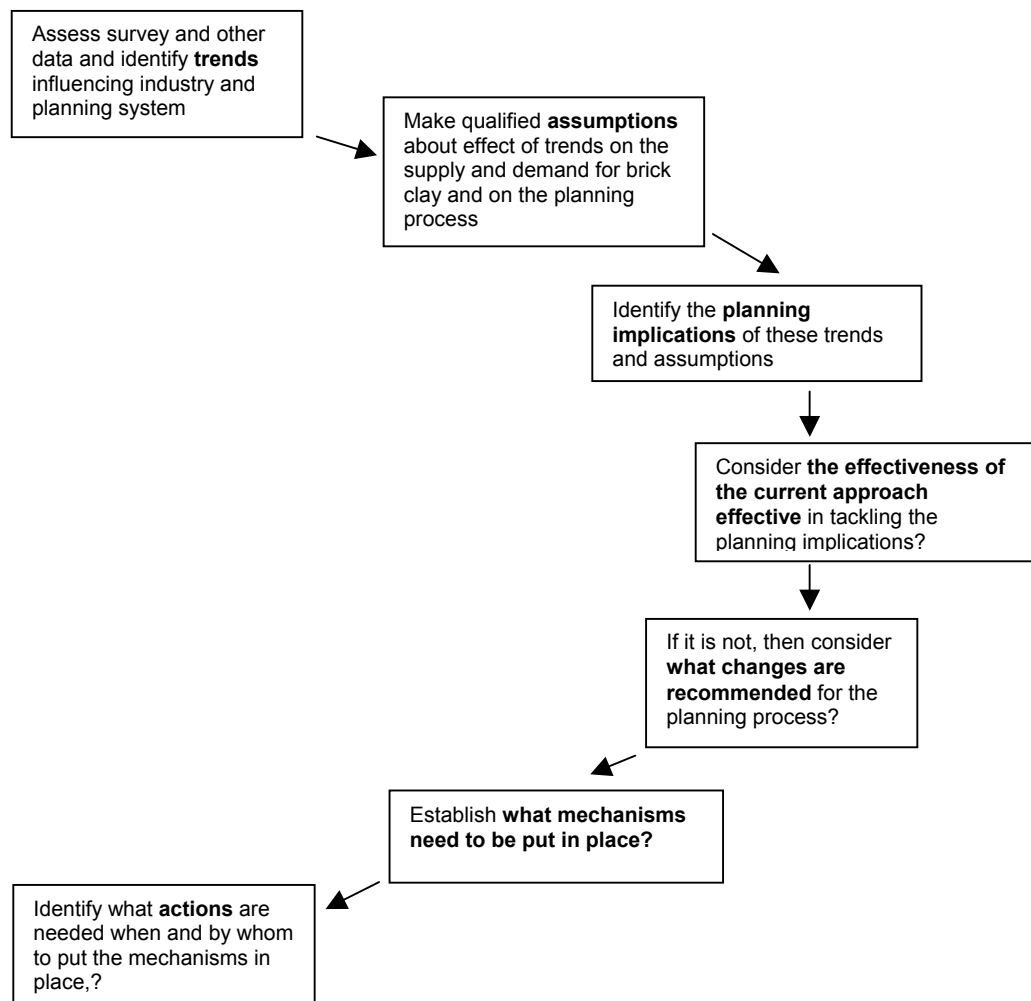


Figure 1. Brick Clay: Issues for Planning: 'Logical pathway' for research and report structure.

Sustainable development

1.9 Sustainability '.....is the simple idea of ensuring a better quality of life for everyone, now and for generations to come.' (DETR, 1999a). Sustainable development objectives now set the framework for decision making so as to ensure that economic, environmental and social goals are resolved equitably. Sustainability means taking decisions in an integrated manner and requires due consideration of all impacts on all resources both natural and man-made. The need to consider quality of life for future generations means taking a long-term perspective and not limiting ideas to the life of a parliament or the next decade (DETR, 1999a).

1.10 The Government has defined four objectives of sustainable development in the UK. These should be pursued jointly in an integrated manner (DETR, 1999a). The objectives are:

- Social progress which recognises the needs of everyone;
- Effective protection of the environment;
- Prudent use of natural resources; and
- Maintenance of high and stable levels of economic growth and employment.

1.11 Within the overall context of its sustainable development strategy, the government's specific objective for minerals is that the demand for minerals needs to met as far as practicable at the least environmental cost and, as far as possible, without exporting environmental damage to other countries (DETR, 1999a). These objectives of sustainable development for mineral planning are summarised as follows:

- to conserve minerals as far as possible, whilst ensuring an adequate supply to meet the needs of society for minerals;
- to ensure that the environmental impacts caused by mineral operations and the transport of minerals are kept to an acceptable minimum;
- to minimise the production of waste and to encourage efficient use of materials, appropriate use of high quality materials, and recycling of wastes;
- to encourage sensitive working practices during mineral extraction and to enhance the overall quality of the environment once extraction has ceased;
- to protect areas of designated landscape or nature conservation from minerals development, other than in exceptional circumstances where it has been demonstrated that the proposed development is in the public interest.

1.12 The current objectives for sustainability are a starting point for development of the concept, but they are not a definitive set of targets. Targets in planning policy to achieve more sustainable development need to be realistic as well as aspirational (DETR, 1999b). Currently research indicates that there may be no clear relationship between indicators of sustainability, the targets proposed or the planning policies adopted in development plans (Ecotec, 1999). Individual planning decisions reflect the requirements of existing development plans and, as a result, may remain out of step, with sustainability objectives. This lack of continuity and integration (which relates to many development and conservation actions) will need to be resolved if sustainable development objectives are to be attained.

The planning process

1.13 Sustainable development objectives will be delivered principally by the planning process. It is the purpose of the planning process to regulate all land-use development, including mineral development, in the public interest. This process requires the assessment of the future land-use and resource needs of society. It also requires that adequate provision is made (through allocations in development plans) to enable those needs to be met at least economic and environmental cost. The planning process is therefore focused on ensuring and conserving 'supply' for a range of economic and environmental requirements, some of which are more tangible than others. Examples include minerals, homes, transport infrastructure, attractive town

centres, landscape quality, biodiversity and 'quality of life'. Although provision has been sought for some assets (including housing land, shopping floor space and minerals) through mechanisms such as 'landbank' or 'land supply', these were generally considered in isolation from each other. The process must take account of the relationships between these supply mechanisms if sustainable development objectives are to be met.

1.14 Land-use planning legislation is implemented through statutory instruments, circulars, statements and guidance, such as Planning Policy Guidance (PPGs), Regional Policy Guidance (RPGs) and Mineral Planning Guidance (MPGs) in England, National Planning Policy Guidance (NPPGs) and Planning Advice Notes (PANs) in Scotland, and Planning Guidance (Wales) (PGW), Minerals Planning Policy Wales (MPPW) and Technical Advice Notes (TANs) in Wales which are issued and reviewed by national government (see Appendix 8). These documents are intended to assist local planning authorities (LPAs) and mineral planning authorities (MPAs) to carry out their functions. Such advice may be a material consideration in planning decisions and should therefore be taken into account by LPAs, MPAs and developers, as well as by planning inspectors and the courts.

1.15 However, advice which is out of date, or imprecise or insufficiently detailed in relation to recent changes and contemporary or emerging issues, could be contradictory or unclear. This may hinder planning authorities in carrying out their functions and make it difficult for developers to identify the necessary course of action. Advice issued by national government should be kept as comprehensive and as up-to-date as possible.

1.16 The planning process is 'plan-led'. This requires that development shall be permitted only in accordance with the development plan unless material considerations indicate otherwise. Planning authorities, including MPAs, have been under a statutory duty to prepare and complete coverage of development plans since 1992 (Planning and Compensation Act 1991). The preparation of development plans requires up-to-date information.

1.17 Government is seeking to up-date and modernize the planning process. These changes are potentially of considerable significance. The aim is to make the system more positive and proactive, and ensure that it does not become 'an end in itself, but a means to an end' (Heap, 1949; DETR, 2000c). This is to be achieved through improvements in efficiency and effectiveness of the mechanisms of the process and through better co-ordination with non-land use policy objectives. (PPG12, 1999; DETR, 2000d). A key mechanism in this process for England is improved regional planning structures (PPG11, 2000).

1.18 The planning process has, and will continue to be, affected by European legislation, devolution and the development of regional structures within England. The full implications on planning for the supply of brick clay are unclear at present, but these factors will require a more responsive planning process supported by up-to-date policy and data systems. This will enable efficient and sustainable decisions to be made at the local level within clear and effective overlying guidance.

1.19 The planning process is also currently subject to a wide debate with regard to inherent limitations caused by its sole focus on land use (Royal Commission on Environmental Pollution, 2000; Royal Town Planning Institute, 2000). While land use

planning will probably remain central to the process, reform, to include natural resource management and hence management of mineral resources, may be essential in achieving a holistic approach to sustainability. This may require a 'spatial' strategy which would not be bound by land use planning considerations alone. A strategy which takes account of natural resource impacts is now required at a regional level in England (PPG11, 2000).

The role of bricks in good design

1.20 The protection and enhancement of our built environment through good design and attention to detail is a major consideration in the planning process. Good design and the sensitive use of traditional materials can re-enforce ownership, sense of place and community. New building and structures can have a considerable positive (or negative) impact on the character and quality of townscape (DETR, 2000b). The external appearance and form of new development, and its relationship to surrounding buildings and the wider locality, can be a material consideration in determining planning applications and appeals (PPG1, 1997; PPG3, 2000; NPPG1, 2000; PPW, 1999).

1.21 Good design and use of local material is of particular concern in relation to specified designations such as Conservation Areas and National Parks. However, PPG1, PPG3, NPPG1, PPW and the 'Rural' and 'Urban' White Papers (DETR, 2000d; DETR, 2000e) note that good design should be sought and encouraged by the planning system in all situations in order to promote or reinforce local distinctiveness and sustainability. The use of bricks, in conservation, refurbishment and new construction, in landscaping and paving will, where appropriate, assist in addressing these objectives.

1.22 The need to increase the number of homes, through new build, and improvements to the existing housing stock (PPG3, 2000) will require a range of building materials. Compliance with 'good design' parameters suggests that a considerable proportion of these new homes will require a diverse range of clay-based brick, tile and pipe products.

Sustainable construction, refurbishment, reuse and recycling.

1.23 Achieving sustainable development objectives requires greater efficiency in the use of resources and an integrated sustainable construction policy framework (DETR, 2000a). Manufacturers of construction products can assist sustainability by ensuring that their products are manufactured in an energy- and resource-efficient manner. Suggested indicators for sustainable construction seek to ensure that products are also durable, easily maintained and can be produced with minimum impact on the environment, through their whole life cycle, with the potential for building refurbishment and maximising re-use and recycling when the building needs redevelopment (DETR, 2000a).

1.24 Many structures that form the historic centres of towns and villages were constructed in brick over two hundred and fifty years ago and still have considerable life remaining. Some 45 per cent of homes are more than 60 years old, with a considerable residual life remaining. Published assessments of average life of brick structures (at around 60 years) have been distorted by post-war levels of reconstruction, and tend to underestimate the real potential life of brick structures.

1.25 Brick built structures have an innate flexibility which makes them easily adaptable through refurbishment to a variety of uses. A prime objective of the policy for housing provision is to ensure that 60 per cent of new homes should utilise recycled land or buildings (PPG3, 2000, Hansard 2000). A considerable proportion of these 'recycled' buildings are likely to be constructed from brick and their sympathetic refurbishment using matching materials (including re-used and new bricks) will assist objectives for good design.

Resource management and conservation

1.26 The effective and efficient management, conservation and enhancement of natural resources, both to maximise their value and to minimize associated environmental costs in their use, are fundamental to sustainable development. This objective is applicable to all mineral resources, including brick clays. To paraphrase the conclusions of the Nineteenth Report of the Royal Commission on Environmental Pollution on Sustainable Use of Soils (HMSO 1996); 'Minerals are a vital resource. In order to achieve sustainability, minerals require detailed and sophisticated management, within the framework of a comprehensive and explicit government policy for mineral protection. Sustainability will be achieved only if there is an adequate basis of knowledge and understanding to inform and inspire management of our resources of minerals.'

1.27 Mineral resources are fixed in location and are therefore vulnerable to sterilisation by other forms of development. Sustainable security of supply and sustainability objectives require that decisions on development should, where relevant, take full account of underlying minerals. That process also needs to evaluate the environmental impacts that might arise if minerals in a less sensitive location are sterilized, creating pressure to work minerals in more sensitive areas.

1.28 Efficient use of the raw material is an important aspect of conservation and management of brick clay. This includes the appropriate use of high quality materials and recycling of waste from the manufacturing process (MPG1, 1996; NPPG4; MPPW; DETR 1999a).

Environmental Quality

1.29 Sustainable development requires systems to protect and manage resources, as well as procedures and standards to ensure the maintenance and improvement of quality of life of all citizens (DETR, 1999c). Considerable improvements have been made to environmental quality in the UK and procedures and standards are in place to maintain and build on that position. New guidance for England on environmental quality considerations (such as noise and dust) for mineral extraction operations will be set out in a revised version of MPG11.

1.30 Brick clay extraction and processing is concentrated in the countryside and the urban fringe. The environmental qualities of these areas need protection for their own sake. While our most valued countryside areas, such as National Parks, Areas of Outstanding Natural Beauty and Sites of Special Scientific Interest, need strong protection, planning objectives seek the maintenance and enhancement of amenity, by controlling pollution, visual and other impacts, throughout the countryside (DETR, 2000d).

Industry

1.31 The brick tile and pipe industry in Great Britain produces a range of products which are utilised in construction. Production is dominated by facing bricks (bricks manufactured to give an attractive external appearance). The brick industry also produces engineering bricks (used in load-bearing structures and other technically-demanding situations), paving bricks and 'common bricks' (suitable for general construction work where appearance is relatively unimportant). Other clay-based construction materials include roofing tiles and vitrified clay pipes used in sewerage systems.

1.32 Brick clay production in Great Britain has declined from some 18 million tonnes in 1974 to about 8.2 million tonnes in 1998, broadly in line with the decline in clay brick manufacture over the same period. (Figure 1). Fireclay is also used in brick manufacture and official production was recorded as 577 000 tonnes in 1998. A survey of clay and shale, and fireclay consumption in 1998 was undertaken as part of this study. The total figures were broadly in line with official data (Annual Minerals Raised Inquiry. Office for National Statistics). The decline in brick production is primarily due to the decline of the 'common' brick, because of its replacement with other building materials, but also to a general reduction in house building, the most important market for bricks. In contrast, the production of facing and engineering bricks has remained relatively stable.

1.33 The overall decline in brick manufacture appears to have stabilized recently. Although demand will remain cyclical, it is likely output will continue around the 3000 million bricks a year level.

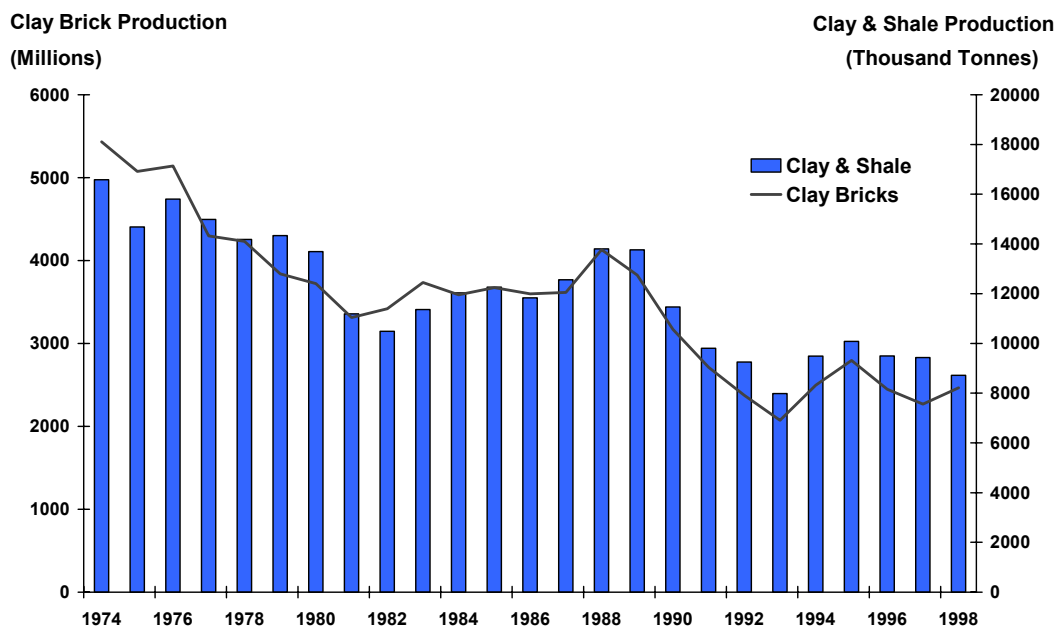


Figure 1. UK clay brick and clay & shale production since 1974.

Source: *Annual Minerals Raised Inquiry. Office for National Statistics; Monthly Statistics of Building Materials and Components. DTLR.*

1.34 Brick clay and fireclay have low unit values (some as low as £1.50/ tonne) and their total output is valued at only some £20 million a year on an ex-quarry basis. However, these raw materials support a manufacturing sector of some importance, with total annual sales of bricks, pipes and tiles valued at about £550 million. Because

of its low value there is no international trade in brick clays. The UK is also essentially self sufficient in bricks, with imports comprising less than 2 per cent of the total market. In 1998 the UK had a net trade balance of £13.55 million in clay-based constructional products, largely due to the export of ceramic pipes.

1.35 Brick, pipe and tile products contribute significantly to the development, maintenance and quality of the built environment (see previous section on ‘Role of bricks in good design’). Clay and shale are the main minerals used in the manufacture of these structural products.

1.36 In the past a wide range of clays, supplying a large number of works, have been used in the manufacture of bricks. However, the structure of the industry has changed radically over the last thirty years. Following a major rationalisation, the industry is now mainly based on a relatively small number of large production units operated by a limited number of companies, and with access to a range of raw materials. There also remain a number of individual small and/or specialist concerns sometimes with a single source of clay raw material and/or dependant upon supplies from others.

1.37 The number of companies and works producing brick has declined by about two thirds since 1979, so that the UK brick industry is now dominated by six companies which account for almost 90 per cent of brick production. Between 25 and 30 small manufacturers account for remaining brick production in mainland Britain. None of these smaller manufacturers produced more than 50 million bricks in 1998. Of the 8.2 million tonnes of clay consumed by the industry in 1998, almost 95 per cent was used in the manufacture of bricks. Vitrified clay pipes are produced by only three companies, all of which are based in Yorkshire. Two companies dominate the production of clay roofing tiles. This is the smallest sector of the UK industry and is centred in the West Midlands.

Resources

1.38 Bricks are produced in all three countries of mainland Britain, although England dominates the consumption of brick clay. The location of the industry in England reflects the distribution of the principal brick clay resources. In approximate order of tonnage consumed, these are:

- Carboniferous mudstones east and west of the Pennines in Northern England;
- Etruria Formation (Carboniferous age) in the West Midlands;
- Mercia Mudstone Group or ‘Keuper Marl’ (Triassic age) in the Midlands;
- Peterborough Member or ‘Lower Oxford Clay’ (Jurassic age) in Bedfordshire and Cambridgeshire;
- Weald and Wadhurst clays (Cretaceous age) in the Weald to the south of London;
- Fireclays (from Carboniferous coalfields in the Midlands and the North).

A detailed breakdown of the industry and the resources on which it depends (including maps and charts) can be found in Appendices 1 and 7.

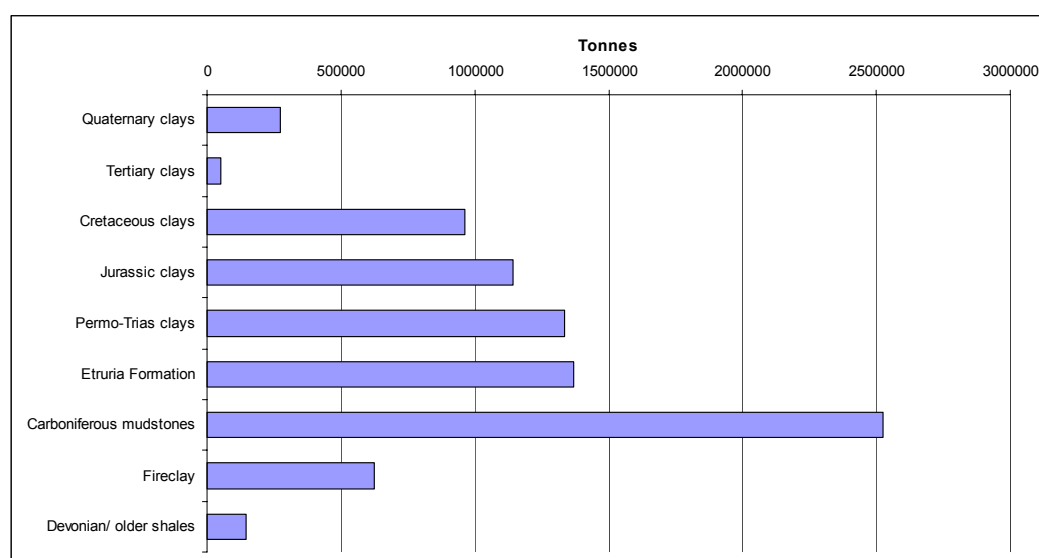


Figure 2. Consumption of brick clay in 1998 by geological unit.

1.39 A number of factors have affected the demand for brick clay over the past 20 years. These include changing technology in construction and brick manufacture, together with changes in architectural fashion and increased demand for both consumer choice and reduction in environmental impact. Modern brick making technology increasingly requires raw materials with consistent properties which can be blended to produce a wide product range in highly-automated factories with low emission levels. The highest percentage increases in consumption from 1979 to 1998 have been for the premium quality clays. Carboniferous mudstones (mostly from the Coal Measures) account for almost 30 per cent of brick clay consumption (Figure 2). The superior technical and aesthetic properties which Etruria Formation clays and some fireclays impart to clay products has led them to be loosely classified as 'Premium Quality' clays, for which there is a relatively high level of demand from the industry. The demand for fireclay (together with its unique status as a by-product of opencast coal extraction) has led to a considerable open trade in this material. A full description of resource utilisation by the industry can be found in Appendix 1.

1.40 The mineralogy, chemistry and physical properties of a clay are essential in determining its suitability as a raw material for bricks. The suitability of a clay for the manufacture of a structural clay product depends principally on its behaviour during forming (shaping), drying and firing. This behaviour will determine the final properties of the brick, including its strength, porosity and durability and thus how it will perform in service and (as important) its architectural appearance. The fundamental chemistry, mineralogy and physical properties of the clay dictate this behaviour.

1.41 Most good quality brick clays have a clay mineral component which consists of kaolinite and illite. These minerals impart desirable plastic behaviour (important in the forming of the brick) and firing properties. The quantity and particle size of the quartz (silica) component of the clay is also critical in determining forming and firing behaviour. Carbon and sulphur have a major influence on firing performance, particularly in dense, extruded bodies (see below). Low carbon and sulphur clays (usually less than 1.5 per cent and 0.2 per cent respectively) are preferred. Very pale

buff/ cream ‘through-colour’ extruded bricks are only possible with fireclays (either 100 per cent fireclay or blended with other clays). Fully-durable yellow bricks (such as London ‘Stocks’) can be made from a mixture of clay and calcium carbonate (chalk), although this is generally only possible using the soft-mud process (see below). A fuller definition of brick clay and a geological overview of principal and other brick clay resources can be found in Appendix 7.

1.42 Analysis which permitted a very crude assessment of the relative pressure on individual resources from sterilisation and/ or depletion was carried out as part of this study. The area covered by valid planning permissions for brick clay extraction (permitted reserves) is less than 0.3 per cent of the total resource area. A comparison of the distribution of planning permissions by resource type with the total resource areas shows considerable differences. The Oxford Clay has the largest proportion of permissions, reflecting its historic importance as a source of brick clay. The Mercia Mudstone Group has a much smaller area of planning permissions relative to its outcrop. This may simply reflect the very large extent of the clay and the relatively small proportion of which is actually usable as brick clay. Conversely, the Etruria Formation has a large area of permitted reserves relative to its outcrop. This is a direct consequence of the high value placed on it as a brick clay resource. A detailed description of this analysis can be found in Appendix 7.

1.43 In addition to the geological/ compositional factors which control the fundamental suitability of a clay for brickmaking, the other main constraints on supply result from ‘sterilisation’ of resources by other forms of land-use. These include

- Urban development (housing, industry, shops, schools and hospitals);
- Areas of land which are protected from development for environmental reasons. Nationally-recognised designations including:
 - ◇ National Parks
 - ◇ Areas of Outstanding Natural Beauty
 - ◇ Sites of Special Scientific Interest
- Other land-use factors such as roads, small settlements, agricultural land classification, local environmental designations and groundwater protection zones
- Quarrying and other operational constraints.

A rough assessment of the amount of sterilisation of brick clay resources by other forms of land-use was carried out as part of this research (Box 4). This highlighted the fact that a major proportion of the Etruria Formation has been lost as a brick clay resource through urban development on the outcrop. Over-estimation of the outcrop area of resources (particularly with regard to Carboniferous mudstones) may conceal the fact that other clays are also under threat from sterilisation. In the Midlands and the North, urban development is probably the most significant constraint. In South-east England, environmental designations are probably more important.

1.44 Although brick clay resources can be readily defined both nationally and regionally, at the local level their suitability as brick making raw materials may show significant variation. This is a particular problem for some clays, such as the Carboniferous clays, where mudstones and fireclays can show considerable vertical and lateral differences, although physical and chemical variations occur in all clays.

The extent of such variations across the resource outcrop is not usually known in detail, but may significantly reduce the area that can be worked economically.

Production

1.45 Most bricks are formed by either extrusion or the ‘soft-mud process’. Extrusion involves the formation of a column of clay at high pressure which is then cut into bricks. In the soft-mud process, individual bricks are moulded from clay with a relatively high moisture content. Although there are exceptions, extruded bricks tend to be produced in the Midlands, the North and Scotland, whereas the soft-mud process is much more common in the south east of England. Subsequently, the majority of bricks are fired in tunnel kilns. Modern brickmaking requires consistent raw materials to maintain the technical and aesthetic properties of the final product, as well as to facilitate mechanical (robotic) handling during manufacture and to reduce wastage. Selective extraction and blending of clays, either from within one pit or from several pits, is normally necessary to achieve a consistent feedstock and/ or to maintain the characteristics of the final product. The extrusion process tends to be more demanding of the clay raw material than the soft-mud process. This results in a tendency toward higher levels of ‘imports’ of clays at sites producing bricks by extrusion, although sites using the soft mud process tend to import considerable quantities of sand and/ or other non-clay raw materials (see Appendix 6). ‘Imported’ clays are generally premium quality materials such as Etruria Formation clays or fireclays. Some high quality Carboniferous mudstones are also utilised in this way. A full description of the processes involved in the manufacture of bricks can be found in Appendix 2.

1.46 Major changes in specifications for clay bricks are currently under discussion and an EU-wide single standard is likely to be fully implemented by the UK brick industry by 2002. This change from the current British Standard (BS) to the draft European (CEN) Standard will impact on patterns of demand for clay raw materials. The more stringent CEN Standards, together with the increasing tendency of architects and developers to opt for the highest perceived quality, means that demand for premium quality clays will increase. The impact of changes in standards and specifications for structural clay products is discussed in Appendix 4.

1.47 Likely changes in the technology of clay-based products are largely driven by the demand from the construction industry for a reduction in costs and increases in productivity. Bricklaying productivity can be increased by using larger units (as in the replacement of common bricks by larger and lighter concrete blocks). The use of prefabricated panels using lightweight cellular bricks, thin brick ‘slips’ or vertical tiles is likely to increase considerably. These products must be fully durable (frost resistant). Larger units and prefabricated panels will require clays with low drying/ firing shrinkages to meet size tolerances. Fine-grained high quality clays are required for brick ‘slips’ and vertical tiles. Signs are that the usage of these highly engineered modified bricks, panels and tiles will increase as housebuilders and other developers strive to cut costs. The implication of this is that specifications for clay raw materials will become more demanding. This, in turn, will see increased demand for clays which are already sought-after by the industry, such as Etruria Formation and certain Carboniferous mudstones, as well as (possibly) fireclays and ball clays. The reduction in demand for common bricks by the construction industry is partly responsible for the decline in demand for Peterborough Members clays (‘Lower Oxford Clay’) in

eastern England. A more comprehensive discussion of the likely impact of changes in construction technology can be found in Appendix 5.

1.48 Although the environmental impact of brick clay *extraction* is largely regulated by the mineral planning system, the *manufacture* of structural clay products is subject to additional environmental regulation. This is likely to have an increasing influence on patterns of resource utilisation by the industry. This regulation and implications for the industry are reviewed in Appendix 3. Most manufacturing plants will be regulated by the EU Directive on 'Integrated Pollution Prevention and Control' (IPPC). Indications are that environmental standards and imposed limits (particularly with regard to emissions to atmosphere) will become progressively more stringent under this regime. Both industry and regulators are developing solutions to reduce emissions to meet these limits. The initial response from the industry has been to fit 'end-of-pipe' equipment to remove pollutants such as fluoride. Other pollutants in flue gases such as SO₂ (sulphur dioxide), NO_x (oxides of nitrogen) and volatile organic carbon (VOCs) will probably prove much more costly to remove by this method. As such, industry is likely to move in the longer term toward reducing emissions at source (by changing manufacturing processes and increased utilisation of low-emission raw materials). This implies that blending of clays will become more common as companies are required to 'dilute' high emission clay produced on-site with low emission clays and other materials from elsewhere. The relative levels of emissions from different clays will become an increasingly important factor. The extent of such variations across the resource outcrop is not usually known in detail, but will significantly reduce the area of commercial interest.

1.49 The recent development of large production units reflects changes in economic, environmental and technological pressures over the last thirty years. This represents a considerable investment in plant. Further investment in plant will be required to respond to new technical specification requirements (Appendix 4), development of new products (Appendix 5) and, crucially, proposed cuts in emissions to atmosphere (Appendix 3).

Fireclay

1.50 Fireclay is valued by the brick industry for its combination of good technical characteristics allied to its cream/buff-firing characteristics. This combination of properties meets particular customer requirements. The future supply of fireclay (used in the manufacture of buff and pale-coloured bricks) has been identified as a particular problem. The background to these issues is discussed in Appendix 7. The close association of fireclay and coal means that opencast coal sites are one of the few viable sources of the clay. Consequently, the future supply of fireclay is dependent on the future of the opencast coal industry. This future is increasingly under threat, principally because of the difficulty in finding sites that are environmentally acceptable to work and also because of competition from imported coal.

1.51 The high level of demand for opencast coal in the past meant that the capacity to produce fireclay greatly exceeded demand. Unless excess, marketable fireclay could be stockpiled (either on- or off-site), the clay was backfilled along with overburden and thus irrecoverably lost. Although most opencast coal sites do not contain commercial-quality fireclay, there is no doubt that large quantities of fireclay have been lost in this way in the past.

1.52 Large local stockpiles of fireclay were built up, most notably in the South Derbyshire Coalfield. These stockpiles now form an important element of supply. Others are currently being established off-site. There are commercial and planning difficulties associated with both these options.

2. PLANNING FOR BRICK CLAY: TRENDS AND THEIR IMPLICATIONS FOR THE PLANNING PROCESS

2.1 The assessment of the background and context of planning for brick clay are set out in Chapter 1 and are detailed in Appendices 1-8. A number of administrative, economic, environmental, social, technological and other trends which are likely to influence planning for brick clay in future have been identified. Analysis of these trends has enabled assumptions to be made regarding their impacts on planning for the supply of brick clay. These assumptions have, in turn, implications for that process. The most significant trends, assumptions and implications are set out below. A 'logical pathway' leading through the trends, assumptions, implications, recommendations and mechanisms set out in this and the subsequent chapters is set out in Tables 1 and 2. An action plan for the mechanisms is set out in Table 3 (located at the end of Chapter 4).

Trend: ***National and local planning policy is increasingly defined by sustainability objectives***

2.2 Sustainable development objectives are now central to the planning function. Planning policies themselves, on which decisions in the 'plan led' process are based, will be both informed by and feed into the sustainable development strategy.

Assumption: ***The planning process will be undertaken primarily within the objectives of sustainability.***

Implication for planning: ***(a) Economic, environmental and social considerations will need to be fully incorporated in the planning process.***

2.3 Recent reports on sustainability objectives issued by central government (DETR 1999a, c; 2000a, b, d, e) examine the topic in relation to the future of society and its aims, the relationship to rural areas, the need to manage the environment and resources, as well as more specific issues such as sustainable construction. These reports stress that sustainable development is not only concerned with protecting the environment and conservation of natural resources, but also requires that planning takes a more holistic view of sustainability, including meeting demand from society for minerals.

Assumption: ***Meeting the justifiable demand for minerals is an important sustainability objective.***

Implication for planning: ***(b) Ensuring a sustainable supply of minerals is part of sustainable development.***

2.4 Baseline information on resources such as brick clay is important in the development of policies to promote sustainable development and a sustainable security of supply. Continuous monitoring of the resource will build upon baseline studies and assist in the assessment of the effectiveness of policies intended to promote sustainability. If this appraisal is not made, then there is a danger that the overall policy structure may work against sustainability.

Assumption: ***Adequate knowledge of resources is essential to achieve sustainability.***

Implication for planning: ***(c) Efficient systems to assess resources and reserves are required.***

2.5 In an urbanised society, land-use planning has often been dominated by issues such as the provision of urban development and infrastructure (such as housing, industry, schools and roads). Countryside planning has often been primarily concerned, however, with issues relating to landscape, recreation, and with limiting urban development in the countryside. As a result of this emphasis, planning for development and conservation of resources has evolved in a piecemeal and uncoordinated manner.

2.6 Most resource development or management is currently undertaken by individual non-planning agencies that have pursued particular objectives with limited consideration of the overall balance of resource capabilities. While the recent White Paper on the countryside (DETR, 2000d) acknowledges the need to co-ordinate rural policies to achieve sustainability, it does not elaborate on how co-ordinated management of resources will be achieved. Resource planning, the overall management and conservation of our natural resources, including our mineral resources, is still an uncertain process. Effective procedures will be essential in the future.

2.7 Mineral resources, such as brick clay, are fixed in location, can only be worked where they occur and cannot always be expanded as required. Actions that sterilise mineral resources can reduce future choice and may conflict with sustainability. Existing procedures designed to protect mineral resources from sterilisation have limited force and are less effective than procedures that apply to other resources. The process needs strengthening as part of an integrated approach to resource management. This management process must also take account of the fact that the value of a resource is largely determined by economic factors which can change with time. The process should be capable of both defining resources for conservation, and carrying out periodic assessments of the continuing need for their safeguarding.

Assumption: ***The planning process contributes towards and feeds into integrated decision structures for resources.***

Implication for planning: ***(d) Develop integrated approach to resource development and conservation in the planning process.***

2.8 The achievement of a sustainable level of resource utilisation cannot be considered using short-term objectives. This is because such actions may lead to short-term non-sustainable decisions and policies. Sustainability objectives do not exclude short-term supply considerations, but these need to fit within a long-term perspective of sustainable security of supply for minerals.

Assumption: ***A long-term perspective on resources is essential in supporting sustainability.***

Implication for planning: ***(e) The planning process, including the mineral planning process for brick clay, must reflect the long-term perspective.***

Trend: *Administrative action continues to make the planning process more efficient and modern.*

2.9 Many of the social, economic and wider environmental objectives which are central to sustainability fall outside the planning process. The adoption of sustainability objectives within the planning process means that it must take account of these broader issues. This will require its continued modernisation. In particular, the plan-led process must be applied in a manner which reflects those objectives.

Assumption: *Planning continues to be a plan-led process based on land-use, but proactively incorporates and integrates other sustainability policy objectives.*

Implication for planning: *(f) The planning process remains the primary tool for controlling development, but incorporates and integrates land use policies with other sustainability policy objectives in a positive and proactive manner.*

2.10 Sustainable management of resources requires consideration of issues across administrative boundaries. This would enable rational evaluation of the spatial impact of resource development. The provision of resources should not develop solely through handing down national policies or aggregating local policies, but rather it should incorporate feedback from, and to, each level of government. National overviews within the United Kingdom and for the devolved administrations would help to secure both adequacy of supply of resources, including brick clay, and the maintenance of environmental quality. Within England, regional appraisals would be important in developing sound strategies with flexibility to take account of local circumstances. Regional appraisals may also be required within Scotland and Wales.

Assumption: *National and local planning policy evolves through a response to community, regional and national influences.*

Implication for planning: *(g) Development plans and decisions, while reflecting existing national and local considerations, broaden to incorporate influence and feedback from stakeholder interests at all levels.*

2.11 Most planning authorities have prepared development plans and there is now almost complete coverage of mineral local plans. However, Government, industry, planning authorities and environmental interests have expressed concern with the length of time taken to complete plans. This means that plans become out-of-date very soon after adoption. Unless they are reviewed frequently and promptly, it is likely that many of these plans cannot reflect current and/ or developing economic or environmental objectives.

2.12 This could lead to loss of confidence in development plans and, as a result, ad-hoc policies and decisions. If so, the plan-led system would clearly fail to operate effectively. Government has stressed that development plans must be up-to-date and be kept up-to-date. (DETR, 2000f).

Assumption: *Up-to-date development plans must be in place to enable the plan-led process to work.*

Implication for planning: ***(h) Development plans must be reviewed and kept up-to-date to reflect and respond to developing trends.***

2.13 Concerns with the effectiveness of development plans may in part relate to the form of current plans. These often seek to achieve certainty in development patterns over a relatively long time period, yet are generally based on economic and environmental conditions at the time of their preparation. However, planning, particularly with a sustainable development background, is essentially concerned with long-term implications and must have a long-term perspective. The problem is not the need for a long-term view, but lies in the attempt to provide certainty when outcomes are far from sure. Long-term plans, coupled with more frequent short-term adjustments informed by monitoring, would provide both security and flexibility.

Assumption: ***The development plan process must provide a long-term perspective but, through efficient monitoring, also reflect the need for short-term flexibility.***

Implication for planning: ***(i) Development plans should provide long-term security for objectives but will, by monitoring, simplification and prompt review, enable short-term adjustments to be made.***

2.14 Guidance to planning authorities issued by Government sets out relevant parameters which authorities should take into account in preparing policy and in making decisions. The existing brick clay planning guidance contained in MPG 1 (1996, applicable only to England) is very brief, of limited application and value, and repeats guidance in the previous (1988) version of MPG1. It does not reflect current sustainability objectives or emerging changes in the planning process and does not take account of the major changes that have taken place in the industry over the past 20 years. Recent guidance in Wales (MPPW, 2000) accurately reflects some of the key technical issues, but not the future planning considerations, identified in this research. Guidance in Scotland (NPPG 4, 1994) makes no reference to the issues, other than noting the importance of geological, environmental and economic considerations.

2.15 Given this, the planning policies formulated, and the decisions taken, by mineral planning authorities in respect of brick clay have tended to follow local perceptions and objectives. They have generally been developed without consideration of impacts beyond the authorities administrative boundaries. In a similar way, industry has developed different approaches designed to suit these local objectives. The outcome may have been a failure to ensure security of supply to industry and/or to provide certainty about the location and extent of development proposals for the public and industry.

2.16 Guidance on brick clay issued by each national administration is therefore in need of revision and needs to be updated so as to assist sustainability objectives, the operation of the plan-led process and to enable industry and other stakeholders to plan with greater certainty.

Assumption: ***Relevant national guidance is required to assist development plan production.***

Implication for planning: ***(j) Without relevant and up-to-date national guidance, on brick clay and other considerations, development plans may inadequately address pertinent issues and may pursue disparate objectives.***

Trend: ***Continuing demand for a wide product range reflecting architectural and social aspirations toward good design and conservation of the built environment.***

2.17 Although subject to some cyclical variation linked to new housing starts, current trends indicate that production of bricks will probably continue at the current level of about 3000 million bricks a year. Therefore, overall demand for brick clay is likely to remain at around the current level of 8 million tonnes per year. Continuing demand for a wide range of building products, including brick and related products, for both new developments and conservation therefore appears inevitable if predicted construction levels are to be met (PPG3).

2.18 Brick manufacture is a capital intensive process which requires continuity of supply of raw materials in order to justify return on investment. Certainty, or security of supply, to meet that demand over the long-term is a valid objective of the brick industry. Certainty in raw material supply over the long-term, so as to ensure that the environmental and amenity impacts of operations are minimised, is also an aim of the mineral planning process. Ensuring long-term security of supply therefore assists in meeting the long-term environmental and economic objectives of sustainability.

Assumption: ***Continued demand for diverse range of brick clay products.***

Implication for planning: ***(k) National guidance and policy at all levels should consider how long-term sustainable security of supply is to be achieved.***

2.19 Within the context of a relatively stable demand for brick clay, pressure on resources in some areas is likely to increase, whilst demand elsewhere will decline. This is a direct result of consumer demand for a wide product range which must also meet demanding technical specifications, increasing environmental regulations and technical innovation in manufacturing and products driven by market forces. It is probable that there will be continued (and possibly increasing) demand for clays such as Etruria Formation, fireclays and other Carboniferous mudstones in the Midlands and the North, and for Weald Clay in the South. It seems likely that there will be a reduction in demand for Peterborough Member clays in Bedfordshire and Cambridgeshire.

Assumption: ***Shifts in the relative importance of clay resources.***

Implications for planning: ***(l) National guidance on brick clay, together with policy at all levels and individual decisions, will need to reflect developing changes in the relative importance of clay resources between and within localities.***

2.20 Building materials must meet aesthetic as well as physical requirements. This is because products such as bricks may, in addition to their pure functionality, be of importance in defining the character of individual buildings, settlements, regions and

landscape areas. For example, the character of the Weald Area of Outstanding Natural Beauty settlements which significantly contribute to the overall 'Weald' character of the area, is defined primarily by the colour, texture and form of the bricks and tiles used in buildings, walling and paving. The use of different materials would remove continuity of style and sense of place and lower the perceived level of environmental quality.

2.21 Current government advice stresses the importance of good urban design in producing sustainable, attractive and high-quality places in which to live and work. (DETR 2000b). This aesthetic parameter is reflected in national planning policies (PPG 1, 1997; PPG 3, 2000; NPPG1, 2000; PGW, 1999) and in local planning policies in local plans, that require the use of specific building materials to ensure continuation of building style. The use of bricks and related materials can reflect social aspirations and define economic success and status. Their continued use today helps to retain the character and sense of place of historic settlements, but also creates new and exciting architectural forms, buildings, surfaces and townscapes. This can help to provide an attractive built environment with diversity, interest and continuity reinforcing sense of community (DETR, 2000d; DETR, 2000e).

2.22 Meeting these objectives will require a diverse range of clay-based products and may sometimes require the continuation of existing brick clay operations in, or using resources from, some environmentally-sensitive areas.

Assumption: *Continued demand for a diverse range of brick clay products from a variety of resources and locations.*

Implication for planning: *(m)The geographical location and individual characteristics of brick clays and their products should be reflected in planning policies and decisions which take into account good design, local distinctiveness and sense of place as well as technical performance.*

2.23 Industry is pursuing a range of manufacturing plant investment and resource utilisation strategies. Such strategies may require a variety of raw materials to be sourced from a number of sites, perhaps all in different MPA areas, to supply a detached plant. Alternatively, a strategy may be focussed on exploiting a single source of clay as the dominant material to feed an adjacent plant. Completely new works may be developed distanced from supply or new works might be required adjacent to a clay source. The evidence from the survey carried during this study suggests that most manufacturing sites import some raw material for blending, and that this trend is on the increase. The supply of fireclay and other mineral (sand, chalk and ball clay) may dictate the need for substantial and long-term stockpile facilities (at the manufacturing site or the quarry), or quarries to supply those minerals that may be worked at a small scale over a long period. These resources may not be in the control of the brick manufacturer. The range of development options is large. Planning for the supply of brick clay must give due recognition to the varied implications.

Assumption: *More blending and transport of clays and other raw materials.*

Implications for planning: ***(n) National guidance, policy and decisions will need to take account of increasing exports and imports of clay and other raw materials from individual sites, between planning authorities and regions.***

Trend: ***Sustainability objectives require more sustainable construction methods***

2.24 Development of more sustainable construction methods would considerably assist sustainability objectives in a variety of ways. Using more durable products and construction methods would extend the life of structures such that the energy and other environmental costs involved in their manufacture and transport are dissipated over a long period. Reducing waste in manufacturing and construction work and maximizing building refurbishment, individual component re-use, and recycling reduces the need to extract new primary raw materials.

2.25 However the extent to which the use of materials or construction methods can be said to be more or less sustainable is a complex issue. This is partly because sustainability must not only incorporate the environmental economics of materials and construction methods, but also reflect good design and the perception of the quality of the resultant built environment.

2.26 Some research on sustainability of construction materials appears to indicate that traditional 'modern' brick construction (brickwork outer leaf – concrete blockwork inner leaf) may not be as sustainable as other building techniques (BRE, 2000). This work appears to suggest more 'innovative' construction methods are more sustainable. However, as that research acknowledges, the results do not adequately reflect either the long life of brick construction in comparison with these other methods, nor its ease of use in building refurbishment and the potential to maximise re-use and recycling of individual components. Neither does it take account of the acceptability in design terms of non-brick construction. With its relatively low maintenance costs, brick construction has in reality a very low whole-life total energy and environmental cost (BRE, 1999). Improvements in technology have enabled bricks and related products to be produced which have greater durability and which can be used in more demanding climatic and use environments (Appendix 2). These improvements are continuing (Appendix 4 & 5) and will extend both the sustainability of brick construction and the potential life of brick buildings.

Assumption: ***Increase in use of the more sustainable building materials.***

Implication for planning: ***(o) Assess the contribution of brick to sustainable construction and ensure that the planning process makes adequate provision in line with that contribution and maximises recovery from available resources***

2.27 Re-use of bricks, tiles, chimney pots, terracotta and faience ware for matching style in conservation and other building work is common practice. Recovery of bricks, for re-use as bricks, is generally limited to those buildings which are more than 60 years old where lime mortars were used. Bricks of that age and older can, subject to careful selection and cleaning, have an appreciable 'new' life in new construction projects. A recent demonstration project used yellow London Stocks over 100 years old (BRE, 1997). However, re-use may cause environmental and economic costs

arising from the operation itself, as well as storage and transport. Problems may also arise due to the mismatch between imperial components in metric structures. In-service performance parameters, such as frost resistance, may be uncertain (BRE, 1997).

2.28 Brick buildings less than 60 years of age were normally constructed using Portland cement based mortars. These mortars have superior setting and bonding strength. The current UK Code of Practice does not provide a design for using single skin, lime mortar, brickwork. The removal of cement mortar to enable bricks to be reused is not practical. However, subject to the quality of the brick, the material can be recycled to produce low quality aggregate as capping layers and sub-base in road construction, and drainage blankets in civil engineering.

2.29 Renewed use of lime mortars could assist future reclamation. However, a larger mass of brickwork would be required to ensure equivalent strength to cement mortar masonry (BRE, 1999). The mortars are also slow to harden. This is a less efficient use of raw materials and gives rise to further costs and delays in construction. Greater encouragement of the wider use of lime mortar to assist reclamation of bricks in the distant future cannot therefore be justified on sustainability grounds. Given the long life of brick buildings and the low overall energy and environmental cost (BRE 1999), the continuing use of Portland cement mortars and recycling to hardcore does not appear to conflict with sustainability.

Assumption: ***Increase in reuse of bricks and buildings.***

Implications for planning: ***(p) Maximise opportunities for re-use of bricks and brick structures.***

2.30 Refurbishment, extensions and conservation of existing buildings requires the use of sympathetic materials and building methods which are often based on brick and/ or other clay products. These maintain continuity in individual structures, as well as contributing to good design, local distinctiveness, sense of place and technical performance.

Assumption: ***Continued demand for a diverse range of brick clay products from a variety of resources and locations.***

Implication for planning: ***(m) The geographical location and individual characteristics of brick clays and their products should be reflected in planning policies and decisions which take into account good design, local distinctiveness and sense of place as well as technical performance.***

Trend: ***More rigorous environmental standards for extraction and restoration***

2.31 An objective of government is to protect and enhance the quality of life of all citizens by enforcing more rigorous standards on environmental and amenity impacts arising from mineral extraction operations (DETR, 1999a). This objective will be achieved in part by using the land-use planning system to reduce conflict by

preventing development in areas which are less appropriate for development and ensure impacts are minimised in those areas where development is appropriate. Integrated evaluation of resources and baseline studies will enable the identification of areas where development should not take place. This is of particular importance in planning for brick clay as both resources and workings are commonly associated with the urban fringe, which is often under development pressure. Up-to-date development plans and integration of policy across authorities will also assist in meeting this objective.

Assumption: *Operating parameters become more constrained.*

Implication for planning: *(r)The planning process must ensure that quality of life for citizens is maintained and improved, while meeting demand for mineral, by reducing the potential for conflict between the extraction of brick clay and other interests through effective policies and responsible decisions.*

2.32 Restoration that brings worked out mineral sites into alternative use as soon as practicable assists in improving quality of life. Brick clay operations can provide opportunities for a wide range of restoration after uses including recreation, agriculture, nature conservation and built development. In the context of biodiversity objectives (DETR, 1994) brick clay sites can directly assist in meeting a wide and linked range of Habitat Action Plans, either to support adjacent habitats or in developing new habitat (particularly wetlands and reedbeds) in previously sterile areas.

2.33 Old clay workings have been a prime target for landfill because clay host rock was seen as an ideal material for retarding the migration of any leachate from the landfill. Infilling of workings was often a necessary precursor to restoration to agricultural use. The move away from agricultural restoration to a wider range of options including habitat recreation, has removed the need for infilling in all circumstances. The need to improve environmental quality will encourage actions which minimize cumulative impacts on land and communities that might arise if landfill follows extraction. Landfill can either assist or delay restoration according to the desired end use.

2.34 The introduction of EC directive 1999/31/EC (which aims to reduce the role of landfill as a main waste management disposal route) is likely to lead to a significant reduction in the need for landfill sites, perhaps down to 25 per cent of present levels. While clay workings have a perceived geological advantage for landfill, current pollution control requirements mean that all landfill sites, even those in former clay pits, have to be fully engineered to demonstrate the competence of control measures. These considerations are likely to reduce the need to keep worked out clay sites unrestored for future landfill and should provide encouragement for quicker restoration to other end uses.

Assumption: *Restoration reflects sustainability objectives and the reduction in landfill requirements.*

Implication for planning: *(s)Restoration schemes should explore the potential for after uses which are not dependant on landfill and which meet sustainability objectives.*

2.35 Some reserves of clay are held in dormant sites. These are subject to a requirement that a schedule of conditions shall be agreed with the MPA before operations can recommence. In some cases therefore, such sites may never reopen because insufficient commercial reserves remain, because of constraints imposed by planning conditions and/ or other economic constraints. The inclusion of reserves in these sites may lead to an overestimate of the amount clay that is available within planning permissions.

Assumption: ***Resolution of the status of sites with planning permissions which are, at present, dormant.***

Implication for planning: ***(t) The nature and extent of permitted reserves within dormant sites should be examined.***

Trend: *More rigorous technical specifications for products.*

2.36 Major changes in specifications for clay bricks are currently under discussion and an EU-wide single standard is likely to be fully implemented by the UK brick industry by 2002. This change from the current British Standard to the more stringent European Standard is coupled with an increasing tendency by architects and developers to opt for products with the highest specification.

2.37 This is a major factor in continued (and possibly increasing) demand for clays such as Etruria Formation, fireclays and other Carboniferous mudstones in the Midlands and the North, and for Weald Clay in the South. These clays are of consistent quality and are generally well suited to automated manufacture of highly-specified clay products.

Assumption: ***Shifts in the relative importance of clay resources.***

Implications for planning: ***(l) National guidance on brick clay, together with policy at all levels and individual decisions, will need to reflect developing changes in the relative importance of clay resources between and within localities.***

2.38 Much of the importation of clays and other raw materials to brickworks is already driven by the need to improve clays from on-site 'captive' pits to allow manufacture of bricks which meet the highest technical specifications (see Appendix 6). This tendency is likely to increase as product specifications get tighter. However, compared to movements of aggregate materials such as sand and gravel, and crushed-rock, the volumes involved are relatively small and ,with the exception of fireclay, haulage distance are generally short (see Appendix 1).

Assumption: ***More blending and transport of clays and other raw materials.***

Implications for planning: ***(n) National guidance, policy and decisions will need to take account of increasing exports and imports of clay and other raw materials from individual sites, between planning authorities and regions.***

Trend: *Demand for new products.*

2.39 Bricklaying is labour-intensive and requires considerable skill. An important driver for future changes in the technology of clay-based products is the need to improve building site productivity and reduce costs. Bricklaying productivity can be increased by using larger units (as in the replacement of common bricks by larger and lighter concrete blocks). The use of prefabricated panels using lightweight cellular bricks, thin brick ‘slips’ or vertical tiles is likely to increase considerably. These products must be fully durable (frost resistant). Signs are that the use of these highly engineered modified bricks, panels and tiles will increase as house builders and other developers strive to improve productivity.

2.40 Demand is likely to continue, or increase, for consistent-quality clays which are mineralogically and chemically well-suited to automated large-scale manufacture of new types of clay product.

Assumption: ***Shifts in the relative importance of clay resources.***

Implications for planning: ***(l) National guidance on brick clay, together with policy at all levels and individual decisions, will need to reflect developing changes in the relative importance of clay resources between and within localities.***

2.41 Moves toward the manufacture of new products will almost certainly lead to an increase in the need to ‘sweeten’ clays derived from on-site pits with imports of high-quality clays and other raw materials. New products and new manufacturing methods will tend to be more demanding of the raw materials.

Assumption: ***More blending and transport of clays and other raw materials.***

Implications for planning: ***(n) National guidance, policy and decisions will need to take account of increasing exports and imports of clay and other raw materials from individual sites, between planning authorities and regions.***

Trend: *Increasing regulation of emissions and energy consumption.*

2.42 Although the environmental impact of brick clay *extraction* is largely regulated by the mineral planning system, the *manufacture* of structural clay products is subject to additional environmental control regime. Most manufacturing plants will be regulated by the EU Directive on ‘Integrated Pollution Prevention and Control’ (IPPC). Indications are that environmental standards and imposed limits (particularly with regard to emissions to atmosphere) will become progressively more stringent under this regime. Both industry and regulators are developing solutions to reduce emissions to meet these limits. The initial response from the industry has been to fit ‘end-of-pipe’ equipment to remove possible pollutants such as fluoride which are produced when clay is fired. Other pollutants in flue gases such as SO₂ (sulphur dioxide), NO_x (oxides of nitrogen) and volatile organic carbon (VOCs) will probably prove much more costly to remove by this method. As such, industry is likely to move

in the longer term toward reducing emissions at source (by changing manufacturing processes and by increased utilisation of low-emission raw materials).

2.43 A long-term trend toward reducing emissions at source may see continued and increasing demand for clays which are relatively low in potential pollutants. A lack of detailed geochemical data on individual horizons within the principal clay resources (such as Weald Clay or Lower Coal Measures) makes it difficult to predict changes and any impact on the planning process. Overall there is likely to be a continued reduction in the exploitation of 'high emitters' such as the Peterborough Member clays.

Assumption: ***Shifts in the relative importance of clay resources.***

Implications for planning: ***(l) National guidance on brick clay, together with policy at all levels and individual decisions, will need to reflect developing changes in the relative importance of clay resources between and within localities.***

2.44 Increasingly stringent environmental regulation will encourage blending of 'low-emission' clays and other non-clay additives such as chalk, sand, metal slags and pulverised fuel ash. Addition of one or more of these imported materials might allow the continued use of an on-site clay by diluting otherwise undesirable emissions.

Assumption: ***More blending and transport of clays and other raw materials.***

Implications for planning: ***(n) National guidance, policy and decisions will need to take account of increasing exports and imports of clay and other raw materials from individual sites, between planning authorities and regions.***

Trend: ***Competition from within the industry and from related products, decline of common brick production.***

2.45 As elsewhere in the minerals and manufacturing sectors, competitive forces have led to a major rationalisation of the brick industry over the last two or three decades. Although production of facing and engineering bricks has been relatively stable, the number of brick manufacturing companies and brick factories has declined by about two thirds over the last 20 years. This has been achieved by consolidation into a smaller number of large, highly automated units. Most larger brick factories now have to serve a much wider market area and, as a consequence, must satisfy demand for a broader product range (as many as 15 products from a single factory). Competition from other (non-clay based) construction materials has, and will continue to have, a major influence on the industry. Production of common bricks (mostly from Peterborough Member clays) has declined sharply due to the large increase in the use of concrete blocks for internal walling. Conversely, there is evidence that clay roofing tiles (most likely made from Etruria Formation clays) are making increasing inroads into the market at the expense of cement-bonded roof tiles.

2.46 Consolidation within the brick industry has seen a move from utilisation of a wide range of clay resources scattered across the country towards more concentrated production based on a relatively small number of different clays. Bricks and other

products made from clays outside these principal clay resources account for less than 6% of total production.

Assumption: *Shifts in the relative importance of clay resources.*

Implications for planning: *(l) National guidance on brick clay, together with policy at all levels and individual decisions, will need to reflect developing changes in the relative importance of clay resources between and within localities.*

Trend: *Decline in the production of opencast coal.*

2.47 Fireclay is used to produce buff and cream-coloured bricks. There is currently no acceptable substitute. Most fireclay used by the brick industry is obtained as a by-product of opencast extraction of coal. The future availability of fireclay is, therefore, dictated by the fortunes, both environmental and economic, of the opencast coal industry. Recent planning guidance sets out stringent tests applicable to planning permission for new opencast coal sites (MPG3, 1999; MPPW, 2000; NPPG16, 1999). This is likely to cause a decline in the availability of fireclay.

2.48 Demand for buff and cream bricks has been strong for the past few years and remains buoyant, although the current price differential between these and red bricks is relatively small. The possible effect of higher prices on future demand for buff and cream bricks, if the supply of fireclay is reduced, is not clear.

Assumptions: *Continued demand for buff and cream coloured bricks coupled with a reduction in supply of useable fireclay.*

Implications for planning: *(t) Planning authorities and industry should seek (through policies and decisions) to address supply of fireclay (through innovative schemes such as stockpiles, 'virtual quarries', fireclay quarries) and/ or alternative raw materials*

2.49 Although domestically produced fireclay might be substituted by imports of clay from outside the UK, this seems unlikely under current economic conditions. Other options for producing buff bricks might include ball clay from SW England and/ or the use of chemical additives to modify the fired colour of the clay. If demand for buff and cream products remains relatively strong, despite price increases, then these options may become commercially viable. However, ball clay extraction has its own specific planning problems (Bristow *et. al.*, 2001) and, in addition, ball clay is valued for the manufacture of whiteware ceramics (sanitaryware, tableware, wall and floor tiles).

Assumption: *Shifts in the relative importance of clay resources; more blending and transport of clays and other raw materials*

Implications for planning: *(l) National guidance on brick clay, together with policy at all levels and individual decisions, will need to reflect developing changes in the relative importance of clay resources between and within localities. (n) National guidance, policy and decisions will need to take account of increasing exports and*

imports of clay and other raw materials from individual sites, between planning authorities and regions.

CHAPTER 3. PLANNING FOR BRICK CLAY: EFFECTIVENESS OF THE CURRENT PROCESS, RECOMMENDED CHANGES AND MECHANISMS

3.1 This chapter examines the effectiveness of the current land-use planning process in dealing with the implications for planning for brick clay identified in Chapter 2. It then uses this assessment to make recommendations on how to address the issue. The final section outlines the mechanisms that might be required to bring about those changes. This follows the ‘logical pathway’ set out in Chapter 1.

3.2 Recommendations made in this and subsequent chapters may refer to ‘short-term’ and ‘long-term’ horizons. For the purposes of this report, these periods are defined as 5 and 25 years respectively. The justification for the selected time frames is set out in Appendix 8.

Can the existing planning process for brick clay respond effectively to the trends, assumptions and implications identified?

3.3 Specific advice on brick clay contained in guidance (Annex B of MPG 1, 1996; NPPG 4, 1994; MPPW, 2000) briefly explains some issues. These include the diversity of resources, location and size of operations, products and the need to take account of aesthetic and performance properties. However, there is no substantive consideration or guidance on how the use of resources had changed, or would be likely to change in the future. There is no explanation of the economic, social and environmental factors driving these changes or their planning implications (Implications: b, c, e, j, k, l, m, n, o, p, q, s, r or t.).

3.4 General advice in guidance does not yet fully reflect current and emerging government objectives in areas such as sustainability (DETR, 1999a), sustainable construction (DETR, 2000a) and urban and rural policy (DETR, 2000d; e). These are being revised and updated as the opportunities arise. In particular, the direct and indirect impact that such emerging policies and objectives may have on the development and use of brick clay resources needs to be clarified (Implications: a, b, c, d, e, f, g, h, or i). For example, PPG 11 (2000), which sets out arrangements for regional planning in England, gives insufficient attention to the need to include minerals in an integrated approach to natural resources. Other recent documents setting out relevant objectives (DETR, 1999a; DETR, 2000a, d, e) identify a number of broad issues that have direct implications for planning and for the supply of brick clay (see Chapters 1 and 2), but generally fail to identify the relationship to minerals supply issues.

3.5 Specific national guidance on brick clay and general planning guidance does not appear to reflect the trends, assumptions and implications identified in Chapter 2. Changes are therefore required. These changes to the brick clay planning process (along with other aspects of planning) should aim to provide certainty in relation to wider, long-term objectives, as well as allowing flexibility in the short-term. The process also strive to become more efficient, as planning should always be focussed on ‘a means to an end’ and not become ‘an end in itself’ (Heap 1949, DETR 2000c).

What changes are recommended?

3.6 To ensure that planning for the supply of brick clay is ‘in step’ with current sustainable development objectives, a number of changes are needed. These changes should:

- (i) incorporate mineral resources within a framework for sustainable management of natural resources;
- (ii) modernise and make the plan-led process more efficient.
- (iii) ensure that issues specific to brick clay are addressed within the context of a planning process based on sustainable development objectives.

Further research may be required to provide information to support some of the recommended changes.

(i) Sustainable management of resources

3.7 The first requirement is to discuss and clarify a statement on the need for sustainable integrated management of natural resources and on the mechanisms needed to bring this about. The place that all mineral resources have in that management process should be set out. Statements on sustainable use of materials, the potential for the sustainable use of land through restoration and on the protection of minerals from sterilization should be included.

3.8 Ideally, this statement should be agreed between the administrations of England, Wales and Scotland, as natural resource management issues, including the geographical availability of minerals and the provision of raw materials, are not confined by administrative boundaries. Within England and, where necessary, in Scotland and Wales, regional differences should be taken into account. The implications for the mineral resource-base could then be evaluated objectively. The statement would clarify the role of the planning process in this mechanism, as well as identifying and resolving any gaps or overlaps in the management process.

3.9 This statement should therefore set the scene regarding the:

- overall need to incorporate economic, environmental and social considerations in the planning process (implication a).
- adequacy of mineral supply for (a) (implication b).
- knowledge of the mineral resource base (implication c).
- development of an integrated approach to management and conservation of resources (implication d).
- incorporation of a long-term planning perspective, including security of supply (implication e).
- incorporation of land use and other sustainability objectives in the planning process (implication f).

- incorporation of influence and feedback of mineral issues within all levels of administration (implication g).

(ii) The plan-led process

3.10 The second requirement is to ensure that the ‘plan-led’ planning process is more effective and efficient. To do this, it is necessary to clarify procedures to:

- ensure that development plans are kept up-to-date (implication h).
- ensure long-term security for mineral supply objectives and flexibility for short-term adjustments in development plans (implication i).

(iii) Issues specific to brick clay

3.11 Finally, specific brick clay issues should be addressed in order to:

- ensure that development plans take account of issues specific to brick clay (implication j).
- ensure that development plan policies provide a sustainable long-, medium- and short-term security of supply of brick clay and are informed by dialogue between the relevant interests (implication k).
- take account of geographical changes in the economic importance of clay resources, manufacturing centers and markets (implication l).
- enable a diversity of raw material supply to provide a range of products to reflect design considerations (implication m).
- take account of transport of raw materials and products and the growing import/export of clay and other minerals across administrative boundaries (implication n).
- take account of the implications of sustainable construction on supply and demand (implication o).
- take account of the implications of refurbishment, re-use and recycling for supply and demand (implication p).
- take account of the impact of more rigorous environmental standards for operations on supply (implication q).
- focus restoration in accordance with sustainability objectives (implication r).
- consider likely levels of supply from dormant planning permission (implication s)
- consider options for the supply of fireclay (implication t).

What mechanisms need to be in place?

3.12 The term ‘mechanisms’ is used here to describe legislative and administrative procedures, supporting guidance and research required to make the changes necessary for more effective planning for brick clay.

3.13 This study is explicit on matters that are directly related to brick clay, but also indicates the broad limits within which action is necessary on topics that apply to all minerals.

3.14 Some of the proposed mechanisms relate to concepts, such as integrated management of natural resources, that are difficult to define other than in broad terms. Other mechanisms only require compliance with existing requirements (such as the need to keep development plans up-to-date). In some cases, new or alternative interpretations of requirements are suggested (such as satisfying the need for security of supply by ensuring a long-term perspective in development plans).

3.15 None of the suggestions put forward in this report conflict with the current or emerging form of the planning process, or require any changes to legislation. However, additional research is required to inform the details of certain mechanisms applicable to brick clay and that requirement is therefore considered first.

3.16 The necessary actions therefore concern:

- **Additional research** – Information required to achieve objectives in other mechanisms.
- **Brick clay planning guidance** – Mechanisms to deliver specific guidance for brick clay.
- **Wider planning framework**– Mechanisms to provide the wider planning framework within which detailed guidance for brick clay should fit, incorporating an integrated approach to the management of natural resources.

Linkages between specific guidance on brick clay and the wider planning framework will need to be identified, incorporated and any conflicts resolved.

Additional research

3.17 The present work identifies a potential disparity between locations of clay resources, permitted reserves and their geographical relationship to demand. Information on resources is provided in this report. However, the development plan process requires up-to-date data on the disposition of permitted reserves if it is to work efficiently and effectively. Data on permitted reserves is not currently available (either UK-wide, or for individual MPAs). Acquisition of that data would allow the implications of changes in resource use to be assessed. It will also reduce the uncertainty regarding the quantity of clay in non-commercial or dormant permissions, or permissions for other uses (engineering works) that may otherwise imply that reserves are adequate. A survey of permitted reserves is therefore a matter of priority. It is imperative that the issues surrounding confidentiality of reserve data must be resolved in order to make this survey effective.

3.18 A survey would also help to clarify the proportion of permitted reserves within dormant permissions (see Appendix 8) which appear to constitute a significant part of the reserves base. It is considered that dormant permissions should be separately identified because they require determination of planning conditions prior to operations resuming (see Appendix 8).

3.19 Published data on the sustainability of brick construction and the refurbishment of brick structures does not yet appear to take full account of the life of brick buildings, thus giving a false impression. This is unsatisfactory, given the importance of properly understanding resource used in sustainable construction. Additional research is required to clarify the position of clay-based materials in sustainable construction.

Brick clay planning guidance

3.20 There appears to be a significant link between the problems identified in this research and inadequacies of existing planning guidance. That is partly because the existing guidance was published when current concerns particular to brick clay were not apparent and definition of broader issues, such as sustainability, were still developing. Revised guidance on planning for the supply of brick clay is required, either as part of existing minerals guidance or as a separate mineral planning guidance note. This would inform the brick clay planning process and encourage dialogue between the various stakeholders (public, MPAs, industry, environmental interests, other planning authorities) on issues and objectives.

3.21 Revised guidance should explain the environmental and economic changes affecting brick clay supply. Mechanisms to deliver the changes to the brick clay planning process should be identified and related to more general guidance. The research proposed above will assist this process.

3.22 Guidance should be sufficiently flexible to incorporate new objectives, modifications to existing objectives and to take account of the implications of new data. This requirement will influence the format for new guidance, in relation to both detail and publication form. Brevity, precision and ease of revision would be a desirable goal.

3.23 **Some objectives, mechanisms and procedures that should be addressed in new guidance for brick clay are:**

Background:

- ***Sustainability considerations.*** This should stress the overall need to undertake planning for brick clay in a manner that incorporates integration of economic, environmental and social sustainability considerations. It should be carried out within a ‘plan-led’, land-use planning process which has adopted a long-term perspective enabling the development of sustainable security of supply and conservation of clay resources. (implications a, d, e and f).

Supply:

- ***Adequacy of mineral supply.*** This should clarify the need for brick clay (including fireclay), consider future demand, as well as mechanisms to ensure security of supply. It should explain the likely effects of continuing changes in the

economics and geography of the industry in relation to the clay resources on which it depends, the manufacturing units and market areas. It should set out the planning considerations that flow from these changes, such as concentration on particular resources, increase in ‘exports’ and ‘imports’, the need for a diversity of supply of clay and other minerals to meet feedstock specifications, the need to ensure resources are available, consideration of dormant sites and methods of monitoring and feedback. Guidance should also encourage the recovery and/ or stockpiling of fireclay from opencast coal sites where this is environmentally acceptable.

Delivering sustainable security of supply requires development plans with a long-term perspective. This period should be at least 25 years, delivered through a landbank comprising permitted reserves and/ or allocations in development plans. Provision should be subject to regular short-term review to enable adjustments to be made as required. This provision should incorporate a regional ‘resource based’ perspective. (implications b, c, k, l, m, n, s and t).

Administration:

- ***The role of different levels of government.*** Guidance should clarify the elements of policy that need to be considered at UK-wide, national, regional and local levels of government in order to meet sustainability objectives. It should define the level of stakeholder involvement in a feedback process for policy development. For England, the role of regional planning boards should be defined including the responsibility for the regional ‘resource based’ perspective in relation to supply, demands and planning constraints so as to guide decisions as to the most sustainable courses of action. This should be linked to regional planning guidance(implication g).

Development plan:

- ***Development plan procedures.*** Guidance should stress the importance of ensuring that brick clay issues (including fireclay) are properly explored in up to date development plans. It should emphasise the need for an integrated long-term approach (at least 25 years) to planning a sustainable security of supply of brick clays in a landbank. It should give guidance on the objectives to be resolved over that time and stress the need for flexibility of the long-term approach and confirm the necessity of regular short-term adjustments (no longer than 5 years) to development plan policy to meet emerging circumstances. (implications h, i and j).

Sustainable construction:

- ***Sustainable construction issues.*** The majority of sustainable construction issues lie outside the scope of planning guidance. However, the contribution of brick clay products to sustainable construction, the need for products in refurbishment and options for reuse and recycling should be described and linked back to supply issues. The research recommended in the previous section would contribute to this. (implication o and p).

Development control:

- ***Development control considerations.*** This should stress the objective of ensuring better quality of life for citizens and the need to adopt high standards in relation to environmental and amenity impacts of the extraction of brick clay while ensuring adequacy and security of supply and reflecting changes in supply patterns. This should refer to other relevant published guidance. Advice on restoration options in relation to sustainable development objectives should be set out, including the status of landfill as a restoration option for clay extraction sites. The consideration of permitted reserves in relation to planning applications for extraction should be clarified (implications q, r and s).

Wider planning framework

3.24 Guidance on brick clay planning, including the suggested new guidance, will be embodied within a framework of other guidance, published policy and the requirements of the primary legislation. The extent to which the other layers of this framework impinge on the overall or detailed considerations relating to brick clay is variable. Some elements may only apply to brick clay planning in limited circumstances (such as unstable ground considerations (PPG14 in England) or the need to enhance local character in design in town centre development (PPG6 in England)). In some circumstances, these elements may affect planning for brick clay in, for example, consideration of the relationship between geography of resources and the supply of brick clay.

3.25 Other guidance provides the general context within which guidance on brick clay will need to fit. They also describe development plan considerations, actions necessary to protect minerals and other resources, and other relevant issues. As such, they should also reflect overlying sustainable development objectives, as well as other relevant issues, including the integration of resource planning, management of resources, the long-term perspective and certainty and flexibility in the planning process.

3.26 Most of these issues are not yet adequately addressed by current planning guidance. Consideration needs to be given to revised guidance for planning for the supply of brick clay. However, the overall objectives also need to be carried into more general guidance. Similar objectives may also need to be applied where appropriate to other areas of the mineral and wider planning process.

3.27 The supply of brick clay products is in effect a single, UK-wide market. The resources in one part of the nation are transformed into products to be consumed in another part of the country. This market does not accord with administrative and internal national boundaries and tends to utilise resources in geographical areas where economic conditions are most favourable.

3.28 Sustainability objectives require an integrated approach to the provision of resources which considers economic, environmental and social factors. The current structure of natural resource management, the role of agencies and the limitations of legislation do not accord with that objective. Government now requires the planning process to incorporate integration of resource management issues in its future actions.

3.29 The advent of devolution, new arrangements for regional administration in England and the greater involvement of local communities in the planning process

creates additional layers in the planning process. That should lead to greater ownership of the planning process, but may also create problems if specific issues are not addressed fully.

3.30 The administrations that constitute the United Kingdom should discuss and clarify the objectives and methods of achieving integrated natural resource management and conservation, including the management and conservation of mineral resources, within the framework of sustainability .

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 To ensure that planning for the supply of brick clay is ‘in step’ with current sustainable development objectives, a number of changes are needed. These changes should:

- (i) incorporate mineral resources within a framework for sustainable management of natural resources;
- (ii) modernise and make the plan-led process more efficient.
- (iii) ensure that issues specific to brick clay are addressed within the context of a planning process based on sustainable development objectives.

4.2 Further research may be required to provide information to support some of the recommended changes.

4.3 The mechanisms needed to bring about these changes fall into the following categories:

- **Additional research:** Information required to achieve objectives in other mechanisms. This should comprise:
 - A survey of planning permissions to assess reserves is a necessary prerequisite to assist brick clay planning objectives. It is suggested that this will need to be initiated by DTLR, in collaboration with MPAs and industry. Confidentiality issues must be resolved prior to the survey.
 - Dormant permissions should be separately identified in that survey and removed from the reserve total. It is suggested that this analysis should be carried out by DTLR as part of the above survey.
 - An assessment of research into clay-based building materials needs to be undertaken to clarify their real contribution to sustainable construction. It is proposed that this should involve DTLR, the brick manufacturers and the construction industry. This might build upon work carried out on this topic by the ‘Pioneers Group’ (a consortium of trade associations, DTLR and DTI) and by independent researchers.
- **Brick clay planning guidance:** Mechanisms to deliver specific guidance for brick clay. Revised guidance on planning for the supply of brick clay is required, either as part of existing mineral guidance or as a separate mineral planning guidance note. This should explain the environmental and economic changes affecting brick clay supply and define mechanisms to deliver the proposed changes. Guidance should include reference to the following:
 - Sustainability considerations, including conservation of resources;
 - the need for a sustainable and secure supply of brick clay;
 - the role of different levels of government, including a regional resource based perspective;

- development plan procedures, including long-term landbank and short-term flexibility;
 - sustainable construction issues, including reuse and recycling;
 - development control considerations, including supply and environmental considerations.
- **Wider planning framework:** Mechanisms to provide the wider planning framework within which detailed guidance for brick clay should fit, incorporating an integrated approach to the management of natural resources.

The UK administrations should produce a UK-wide statement on the objectives and methods of achieving integrated natural resource conservation and management within the framework of sustainability, with particular regard to minerals.

4.4 An Action Plan for the implementation of these mechanisms is set out in Table 3.

Acknowledgements

4.5 The research project was undertaken by Andrew Bloodworth (Project Leader) and David Highley, British Geological Survey (BGS), John Cowley, Mineral & Resource Planning Associates (MARPA) and Geoff Bowler, Ceramic and Environmental Technologist.

4.6 The team are indebted to the brick, clay pipe and roof tile industry, the British Ceramic Confederation and officials in mineral planning authorities and central government for their valuable help and advice throughout this project.

Trend	Assumption	Implications for planning
National and local planning policy increasingly defined by sustainability objectives	The planning process reflects sustainability.	(a) Economic, environmental and social considerations need to be fully incorporated in the planning process.
	Meeting justifiable demand for minerals is an important sustainability objective	(b) Adequate provision of supplies of minerals is a part of sustainable development.
	Adequate knowledge of resources is essential to achieve sustainability	(c) Efficient systems to assess the resource and reserves are required
	Planning process will contribute towards integrated decision structures for resources.	(d) Develop integrated approach to resources in the planning process
	A long-term perspective on resources essential in supporting sustainability.	(e) Planning process (including mineral planning) must reflect the long-term perspective.
Administrative action continues to make the planning process efficient and modern.	Planning continues to be a plan-led process based on land-use, but proactively incorporates and integrates other sustainability objectives	(f) Planning process remains primary tool for controlling development, but incorporates and integrates land use policies with other sustainability policy objectives.
	Planning policy evolves in response to new influences.	(g) Development plans and decisions broaden to incorporate influence and feedback from stakeholders at all levels.
	Up-to-date development plans in place to enable plan-led process to work.	(h) Development plans must be reviewed and kept up-to-date to reflect developing trends.
	Development plans must provide a long-term perspective, but through monitoring reflect need for short-term flexibility.	(i) Development plans should provide long-term security for objectives, but will, by monitoring, simplification and review, allow short-term adjustments to be made.
	Relevant national guidance required to assist development plan production.	(j) Without relevant and updated national guidance on brick clay, development plans may not address pertinent issues and may pursue disparate objectives.
Continued demand for wide product range reflecting architectural and social aspirations toward good design and conservation of the built environment	Continued demand for diverse range of brick clay products	(k) National guidance and policy at all levels should consider how long-term sustainable security of supply is to be achieved.
	Shift in the relative importance of clay resources	(l) Guidance/ policy and individual decisions should reflect developing changes in the relative importance of clay resources within and between planning areas.
	Continued demand for a diverse range of brick clay products from a variety of resources and locations.	(m) Characteristics and geographical location of brick clays and products should be reflected in planning policies/ decisions which take account of good design etc.
	More blending and transport of clays	(n) Guidance/ policy should reflect level of transport of clay and other raw materials between sites, planning authorities and regions.
Sustainability objectives require more sustainable construction methods.	Increase in use of the more sustainable building materials.	(o) Assess contribution of brick to sustainable construction; ensure that adequate provision in line with that contribution is made; encourage maximum recovery from available resources
	Increase in re-use of bricks and buildings	(p) Maximise opportunities for re-use of bricks and brick structures.
	Continued demand for a diverse range of brick clay products from a variety of resources and locations.	Characteristics and geographical location of brick clays and products should be reflected in planning policies/ decisions which take account of good design etc. (see (m) above)
More rigorous environmental standards for extraction and restoration	Operating parameters become more constrained	(q) Planning process must maintain/ improve quality of life and meet demand for mineral, by reducing potential for conflict between extraction and other interests.
	Restoration reflects sustainability objectives and the reduction in landfill requirements	(r) Restoration schemes should explore potential after-uses which are not dependant on landfill and which meet sustainability objectives.
	Resolution of the status of sites with planning permissions which are, at present, dormant..	(s) The nature and extent of permitted reserves within dormant sites should be examined.
More rigorous technical specifications/ Demand for new products/ Increased regulation of emissions and energy consumption	Shift in the relative importance of clay resources	Guidance/ policy should reflect changes in the relative importance of clay resources within and between planning areas. (see (l) above)
	More blending and transport of clays	Guidance/ policy should reflect level of transport of clay and other raw materials between sites, planning authorities and regions. (see(n) above)
Increased competition within industry and from related products	Shift in the relative importance of clay resources.	Guidance/ policy should reflect changes in the relative importance of clay resources within and between planning areas. (see (l) above)
Decline in opencast coal production	Continued demand for buff bricks/ reduction in supply of useable fireclay.	(t) Planning authorities and industry develop innovative solutions to supply of fireclay
	Shift in the relative importance of clay resources	Guidance/ policy should reflect changes in the relative importance of clay resources within and between planning areas. (see (l) above)
	More blending and transport of clays	Guidance/ policy should reflect level of transport of clay and other raw materials between sites, planning authorities and regions. (see(n) above)

Table 1. Trends, assumptions and implications for planning.

Implications/ recommendations for planning	What mechanisms need to be in place?		
	Research	Brick clay guidance	Wider planning framework
(a) Economic, environmental and social considerations need to be fully incorporated in the planning process.		<i>Background:</i> Leads with sustainability objectives	Other guidance updated to include provision for: <ul style="list-style-type: none"> • sustainability objectives, • integrated natural resource management, • long-term perspective • role of different levels of government Priority should be given to PPG1, MPG1 and NPPG1 ----- Over-arching UK wide statement on integrated natural resource management
(b) Adequate provision of supplies of minerals is a part of sustainable development.		<i>Supply:</i> Sets out need for brick clay	
(c) Efficient systems to assess the resource and reserves are required	Requires reserves data (see below)	<i>Supply:</i> Provision for monitoring of resources and reserves	
(d) Develop integrated approach to resources in the planning process		<i>Background:</i> Recognises need for integrated approach	
(e) Planning process (including mineral planning) must reflect the long-term perspective.	Requires reserves data (see below)	<i>Background:</i> Sets out long-term approach	
(f) Planning process remains primary tool for controlling development, but incorporates and integrates land use policies with other sustainability policy objectives.		<i>Background:</i> Wider sustainability issues incorporated	
(g) Development plans and decisions broaden to incorporate influence and feedback from stakeholders at all levels.		<i>Administration:</i> Defines role of levels of govt. + stakeholder/ feedback process in policy development	
(h) Development plans must be reviewed and kept up-to-date to reflect developing trends.		<i>Dev. Plan:</i> Defines how brick clay issues set out in plan + regularly reviewed	
(i) Development plans should provide long-term security for objectives, but will, by monitoring, simplification and review, allow short-term adjustments to be made.	Requires reserves data (see below)	<i>Dev. Plan:</i> Set out need for certainty /security + regular adjustment	
(j) Without relevant and updated national guidance on brick clay, development plans may not address pertinent issues and may pursue disparate objectives.		<i>Dev. Plan:</i> Prepare guidance -see rest of column	
(k) National guidance and policy at all levels should consider how long-term sustainable security of supply is to be achieved.		<i>Supply:</i> Provision should be at least 25 years	
(l) Guidance/ policy and individual decisions should reflect developing changes in the relative importance of clay resources within and between planning areas.		<i>Supply:</i> Promote flexibility to account for change in resources	
(m) Characteristics and geographical location of brick clays and products should be reflected in planning policies/ decisions which take account of good design etc.		<i>Supply:</i> Recognise that diverse clays needed to feed diverse market	
(n) Guidance/ policy should reflect level of transport of clay and other raw materials between sites, planning authorities and regions.		<i>Supply:</i> Recognise that raw material transport often needed	
(o) Assess contribution of brick to sustainable construction; ensure that adequate provision in line with that contribution is made; encourage maximum recovery from available resources	Assess contribution of brick to sustainable construction objectives	<i>Sust. Const:</i> Feed sustainable construction info into guidance & link to supply	
(p) Maximise opportunities for re-use of bricks and brick structures.		<i>Sust. Const:</i> Feed sustainable construction info into guidance & link to supply	
Characteristics and geographical location of brick clays and products should be reflected in planning policies/ decisions which take account of good design etc. (see (m) above)		<i>Supply:</i> Recognise that diverse clays needed to feed diverse market	
(q) Planning process must maintain/ improve quality of life and meet demand for mineral, by reducing potential for conflict between extraction and other interests.		<i>Dev. Cont:</i> Sets out procedures to minimise conflict & sterilisation	
(r) Restoration schemes should explore potential after-uses which are not dependant on landfill and which meet sustainability objectives.		<i>Dev. Cont:</i> Sets out status of landfill & other restoration options	
(s) The nature and extent of permitted reserves within dormant sites should be examined.	Assess reserves and analyse.	<i>Supply:</i> Feed reserves info into guidance	
Guidance/ policy should reflect changes in the relative importance of clay resources within and between planning areas. (see (l) above)		<i>Supply:</i> Promote flexibility to account for change in resources	
Guidance/ policy should reflect level of transport of clay and other raw materials between sites, planning authorities and regions. (see(n) above)		<i>Supply:</i> Recognise that raw material transport often needed	
Guidance/ policy should reflect changes in the relative importance of clay resources within and between planning areas. (see (l) above)		<i>Supply:</i> Promote flexibility to account for change in resources	
(t) Planning authorities and industry develop innovative solutions to supply of fireclay		<i>Supply:</i> Suggest possible stockpiling/ fireclay quarries	
Guidance/ policy should reflect changes in the relative importance of clay resources within and between planning areas. (see (l) above)		<i>Supply:</i> Promote flexibility to account for change in resources	
Guidance/ policy should reflect level of transport of clay and other raw materials between sites, planning authorities and regions. (see(n) above)			

Table 2. Implications/ recommendations and mechanisms.

Mechanism	Timetable		
	Actions (18 months)	Actions (18-36 months)	Actions (36 months +)
Research	<ul style="list-style-type: none"> • Carry out reserves survey (DTLR/ industry/ MPAs; • Assess results and inform draft guidance (DTLR) 		
	<ul style="list-style-type: none"> • Carry out research on contribution of brick to sustainable construction (DTLR/ industry); • Assess results and inform draft guidance (DTLR) 		
Brick clay guidance	<ul style="list-style-type: none"> • Draft guidance and consultation (DTLR/ industry/ MPAs/ other stakeholders) 	<ul style="list-style-type: none"> • Issue guidance (DTLR) • Use guidance to institute regional planning framework for brick clay (DTLR/ regional bodies/ PAs/ industry) 	<ul style="list-style-type: none"> • Monitoring and feedback (MPAs, regional bodies/ DTLR/ industry/ other stakeholders) • Revise guidance (DTLR)
Wider planning framework	<ul style="list-style-type: none"> • Consultation on format of general planning guidance (DTLR/ industry/ regional bodies/ MPAs/ other stakeholders) 	<ul style="list-style-type: none"> • Draft guidance and consultation (DTLR/ industry/ regional bodies/ MPAs/ other stakeholders) • Issue guidance (DTLR) 	<ul style="list-style-type: none"> • Monitoring and feedback (MPAs, regional bodies/ DTLR/ industry/ other stakeholders) • Revise guidance (DTLR)
	<ul style="list-style-type: none"> • Advice statement on UK-wide integrated natural resource management (DTLR/ Scottish Executive/ Welsh Assembly) 	<ul style="list-style-type: none"> • Monitor compliance (DTLR/ Scottish Executive/ Welsh Assembly) 	<ul style="list-style-type: none"> • Monitor compliance (DTLR/ Scottish Executive/ Welsh Assembly)

Table 3. Action plan.

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GLOSSARY

Areas of Search	Broad areas within which mineral resources may occur and within which sites suitable for mineral extraction would be appropriate.
Brick (facing-) slips	Thin units manufactured or cut to resemble the sides ('stretchers') or ends ('headers') of facing bricks.
Cellular brick	Lightweight unit made by extruding a brick with a large number of perforations.
Common brick	Bricks suitable for general construction work where appearance is unimportant.
Constraint	A term used in land-use planning to indicate the restrictions that may be placed on the use of certain areas of land.
Deposit	Indicates a mineral occurrence of some significance but which is not closely defined.
Engineering brick	High strength, low porosity bricks used in load-bearing structures and other technically-demanding situations.
Extrusion	Process where bricks are formed by forcing stiff clay through a die using an auger. Typical bricks have sharp, straight outlines. Most commonly used manufacturing method in the Midlands and the North. Pipes and roof tiles are also manufactured using this method.
Facing brick	Bricks manufactured to give an attractive external appearance
Fireclay	Kaolinitic mudstone of economic interest which underlies a coal seam. Originally used for making refractories, fireclays are now valued for use in the manufacture of buff and pale-bodied extruded bricks.
Fletton brick	Semi-dry pressed bricks made from organic-rich Peterborough Member clays in eastern England.
Landbank	The sum of all permitted reserves at active and inactive mineral sites at a given point of time, and for a given area.
Lithology	The general characteristics of a rock.
MPG	Mineral Planning Guidance (England)
Mathematical tiles	Tiles hung vertically on outside walls to resemble bricks.
Mineral deposit	Generally synonymous with mineral resources but usually applied to a readily identifiable mineral body i.e. more geographically or spatially confined.
Mortar	A mixture of cement, water and fine aggregate, usually sand, and may contain lime. Mortar is used for brick and blockwork and for plastering and rendering.
Mudstone	Fine-grained clay-rich sedimentary rock rich with no pronounced lamination.
NNPG	National Planning Policy Guideline (Scotland)

Opencast	A form of surface mineral working in which the void can be backfilled with overburden or waste as working proceeds.
Outcrop	The area over which a particular rock unit occurs at the surface, whether visibly exposed or not.
Overburden	Waste rock, either loose or consolidated, overlying a mineral deposit, which must be removed prior to extraction.
PPG	Planning Policy Guidance (England)
Paving brick	Bricks of special composition and dimensions to serve as paving; designed for hard wear, low porosity and resistance to frost.
Planning conditions	Conditions attached to a planning permission for the purposes of regulating the development.
Preferred Areas	Areas of land in which economically workable mineral is likely to occur and where there is a presumption in favour of development.
Quarry	An open-pit mining operation.
Reserve	That part of a mineral resource that is economic to work and has been fully evaluated on a systematic basis by drilling and sampling and is free from any legal or other obstruction that might inhibit extraction.
Reserves, permitted	Reserves that have the benefit of planning permission for extraction.
Resource	Natural accumulations of minerals, or bodies of rock, that are or may become of potential economic interest as a basis for the extraction of a commodity.
Shale	Fine-grained clay-rich sedimentary rock with pronounced lamination.
Soft-mud	Process where bricks are formed by throwing 'wet' clay into a sand-lined mould. Typical bricks have soft and slightly irregular outlines. Most commonly manufacturing method in south east England.
SSSI	Site of Special Scientific Interest. An area of land of special interest by virtue of its flora, fauna, geological or physiographical features. In England, English Nature is responsible for the selection of SSSIs.
Stock brick	A brick produced by the soft-mud process
Structural ceramics/ clayware	Products such as bricks, roof tiles and pipes which are manufactured from fired clay and used in construction
Tunnel kiln	Refractory-lined, insulated tunnel in which a track runs to carry 'kiln-cars' loaded with bricks or other ware. Process in continuous as cars are pushed through the gas-fired kiln at regular intervals. Most bricks are fired using this method.
Wirecut	A brick produced by the extrusion process.

APPENDIX 1: RESOURCE UTILISATION

1.1 A detailed independent survey of brick, tile and pipe manufacturers in England, Scotland and Wales was carried out by the project team to assess clay consumption at individual producing works in 1998. This has enabled analysis of the relationship between the industry and the clay resources on which it depends.

1.2 All companies producing structural clayware were contacted, with an approximate response rate of 95 per cent. We estimate that those responding produced over 98 per cent of structural clayware manufactured in Great Britain in 1998. The survey covered a total of 91 manufacturing sites operated by 35 companies. Of these, 80 sites produced bricks, pipes were produced at 4 sites and roof tiles at 7 sites.

Elements of the industry

1.3 This short description is based on the survey of brick clay consumption in 1998. The description does not take into account any changes since that date.

1.4 The brick industry is dominated by six manufacturing companies (Ambion Brick, Baggeridge Brick, Chelwood Brick, Hanson Brick, Ibstock Building Products and Marshalls Clay Products). These companies account for almost 90 per cent of UK brick production, with Hanson and Ibstock each having a much larger share of production than the other four.

1.5 Ibstock has the greatest geographic spread of production sites. This company produces bricks in all the English Regions except the East of England. It is the only one of the major companies to produce bricks in Scotland, although it has no production site in Wales. Production sites operated by Hanson Brick have a more restricted geographic spread. They are the only company producing bricks from Peterborough Member clays ('Lower Oxford Clay') at three very large sites, one near Bedford in the South East and two near Peterborough in the East of England. They are the only company producing bricks in Wales, but have no sites in the West Midlands.

1.6 Ambion Brick operate sites in the south west (near Plymouth), the South East (Horsham) and two sites in County Durham. Baggeridge Brick are dominantly based in the West Midlands, although, in common with other producers, they now have a producing site in the Weald area of the South East. Chelwood Brick produce bricks at sites in the south east and in the Manchester area. They also have a site in the West Midlands. Marshalls have a strong regional base, with no production units outside the North West and Yorkshire and the Humber regions.

1.7 Between 25 and 30 small manufacturers account for remaining brick production in mainland Britain. None of these smaller manufacturers produced more than 50 million bricks in 1998. These are scattered across all English regions except the East of England. There are three of these smaller companies producing bricks in Scotland, but none in Wales. The smallest production sites produce bricks which are predominantly hand-

made. Others have highly-automated production methods which are similar to those used by the 'major' companies. Most depend on the principal brick clay resources described in Appendix 7, although a significant number utilise other resources which are of local significance only.

1.8 Vitriified clay pipes are produced by at least three companies. Production is dominated by Hepworth Building Products and Naylor Brothers Clayware. The bulk of manufacturing by Hepworth takes place near Penistone in South Yorkshire, although there are two smaller production units located near Swadlincote in south Derbyshire. Naylor Brothers Clayware is also based in the Penistone area.

1.9 The clay tile industry is the smallest. Among companies which responded to the survey, Eternit Building Materials and Redland Roofing Systems dominate production. These companies operate two production sites each in the West Midlands. Remaining companies operate in the South East and in Yorkshire.

Brick clay consumption and location of the industry

1.10 Total clay tonnage consumed by the industry in 1998 was just under 8.5 million tonnes, of which approximately 95 per cent was used in the production of bricks. Four per cent was consumed by the pipe industry and the remaining one per cent used in roof tiles. Figure 1 shows that England dominates the consumption of brick clay, with the industry in Scotland and Wales accounting for less than ten per cent. Consumption is spread across the English regions, although the industry in the West Midlands and the South East are the largest users of clay, reflecting the concentration of working around Birmingham and Stoke-on-Trent, and in the Weald. The location of the industry largely reflects the distribution of the principal brick clay resources described in Appendix 7. Figure 2 shows the location of production sites in England, Wales and Scotland which were identified in the survey. Large and very large production units are concentrated in relatively restricted areas. They are associated with the coalfields of Yorkshire and Lancashire, the North East and the Midland Valley of Scotland. A major concentration is based on the Etruria Formation and the Mercia Mudstone in the Midlands. A small number of very large works are based on the Oxford Clay of eastern England. The Sussex Weald is the main concentration of production in the South East.

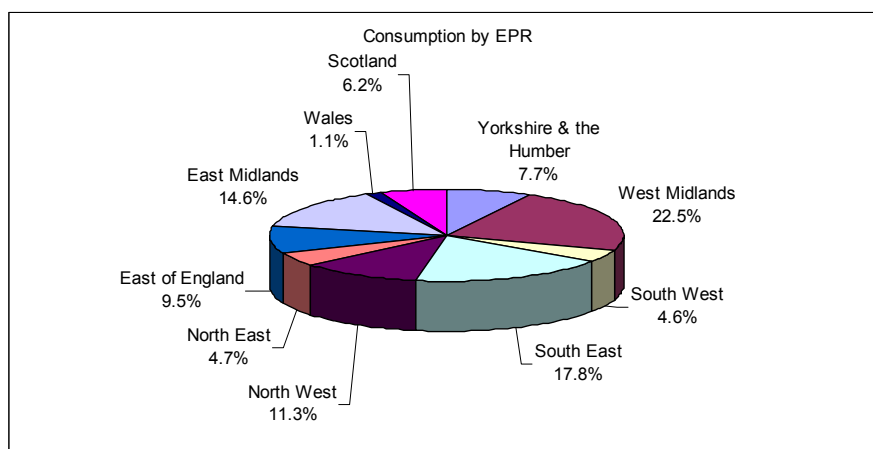


Figure 1. Consumption of brick clay by region, 1998.

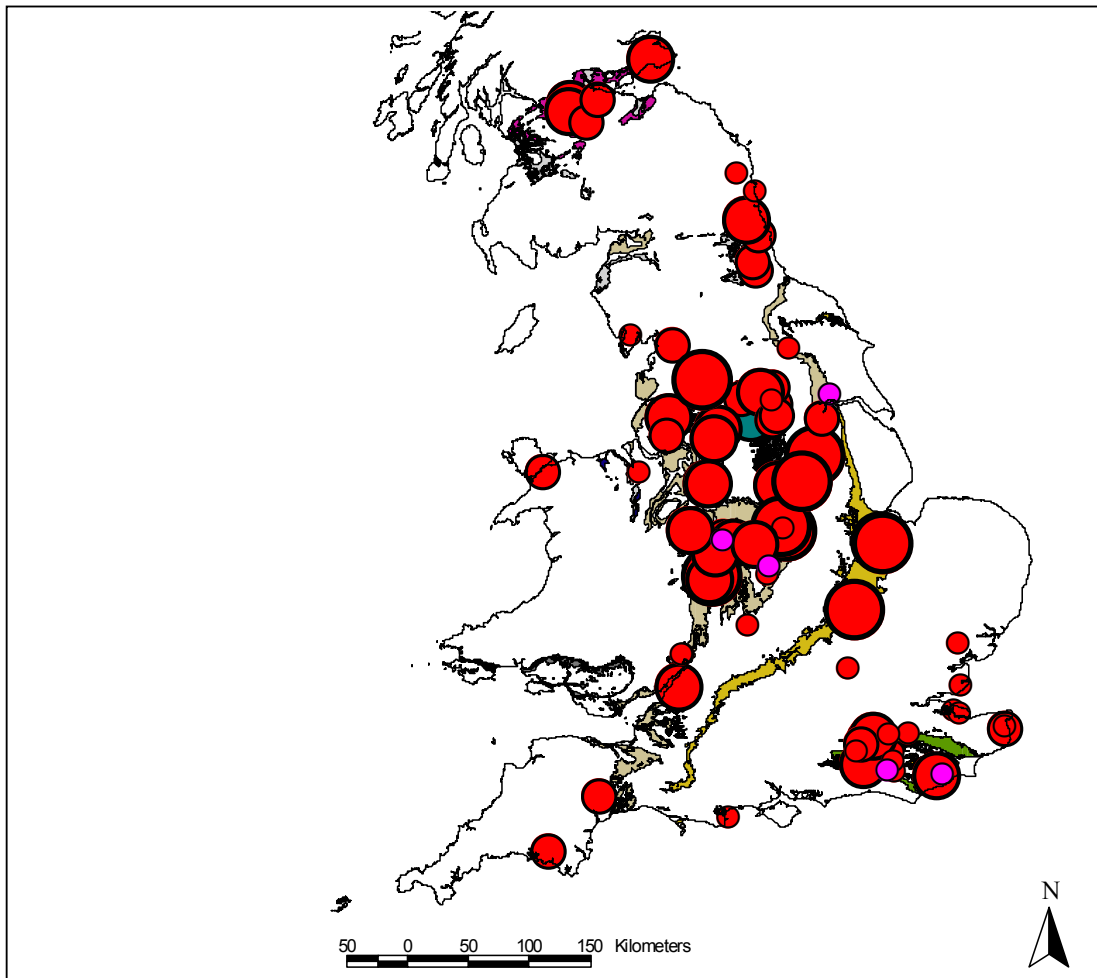


Figure 2. Map showing location of brick, pipe and tile production sites in England, Wales and Scotland, together with the distribution of the principal brick clay resources. Size of circle denotes approximate brick clay consumption by site; red – bricks; purple – tiles; blue – pipes.

1.11 The survey also allowed the breakdown of clay consumption by resource. Figure 3 shows utilisation of brick clay in 1998 broken down by geological units. The graph illustrates the relatively restricted nature of the clay resources on which the industry depends. Carboniferous mudstones (chiefly from the Coal Measures) dominate the resource base of much of the industry, with over 2.5 million tonnes consumed in 1998. Coal Measures comprise the principal brick clay resource in the North of England and in Scotland. Figure 4 shows the location of the industry around the southern Pennines. The principal brick clay resource for all these sites is Carboniferous mudstone, mostly from the Coal Measures. Although less extensive, the industry in the North East (Figure 5) and the Midland Valley of Scotland (Figure 6) is also principally dependent on Coal Measures mudstone.

1.12 Fireclays are also derived from the Coal Measures, although almost exclusively as a by-product of opencast coal extraction. Although comprising less than 7 per cent of total

consumption, these are important premium quality clays which are used extensively in relatively high-value buff brick products manufactured at sites across the Midlands, the North and Scotland.

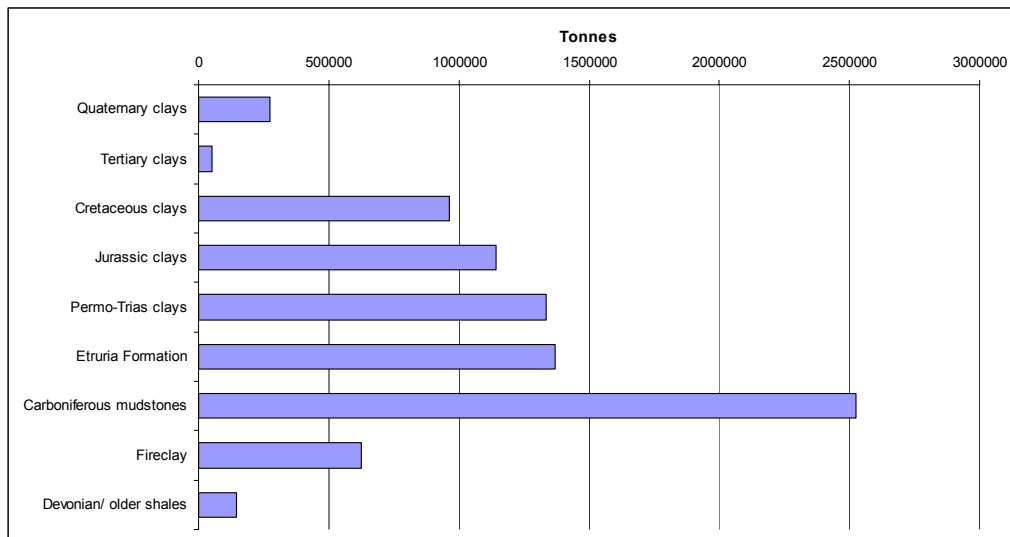


Figure 3. Consumption of brick clay in 1998 by geological units.

1.13 The demand for premium quality raw material is also reflected in the high level of consumption of clay from the Carboniferous Etruria Formation which is separately identified on the graph. This resource is extracted and utilised almost entirely within the West Midlands (Figure 7). The outcrop area of this clay is very restricted and large parts has been sterilised by other development (see Appendix 7). Roughly similar levels of consumption (around 1 million tonnes each in 1998) are recorded for geologically ‘younger’ clays of Permo-Triassic, Jurassic and Cretaceous ages. Extraction and utilisation of Permo-Triassic clays (almost all from the Mercia Mudstone Group) is confined to the Midlands, principally in the Leicester –Nottingham area and, to a lesser extent, to the south west of Birmingham. Figure 7 shows the location of the industry in the Midlands.

1.14 Clays of Jurassic age are extracted almost entirely from the Peterborough Member (Lower Oxford Clay) in Cambridgeshire and Bedfordshire. Exploitation of Peterborough Member clays has shown a marked decline and manufacture of bricks is now restricted to only three large production units (Figure 8).

1.15 Cretaceous-age clays comprise the principal brick clay resource in south east England. Most production in the south east is based on Weald Clay and Wadhurst Clay and takes place in the Weald (Figure 9).

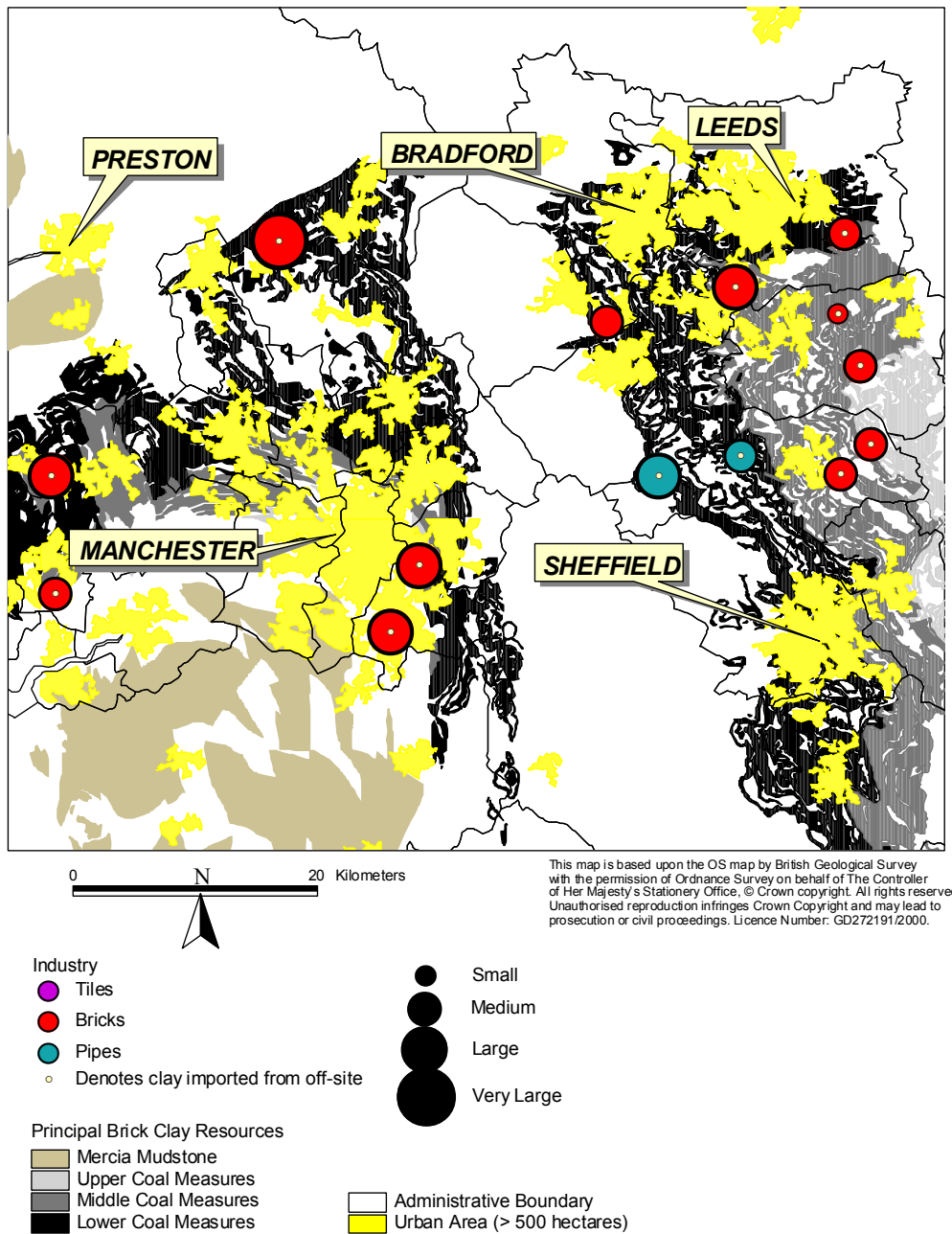


Figure 4. Location of production sites in Yorkshire and Lancashire. Coal Measure mudstone is the principal resource for most of these sites.

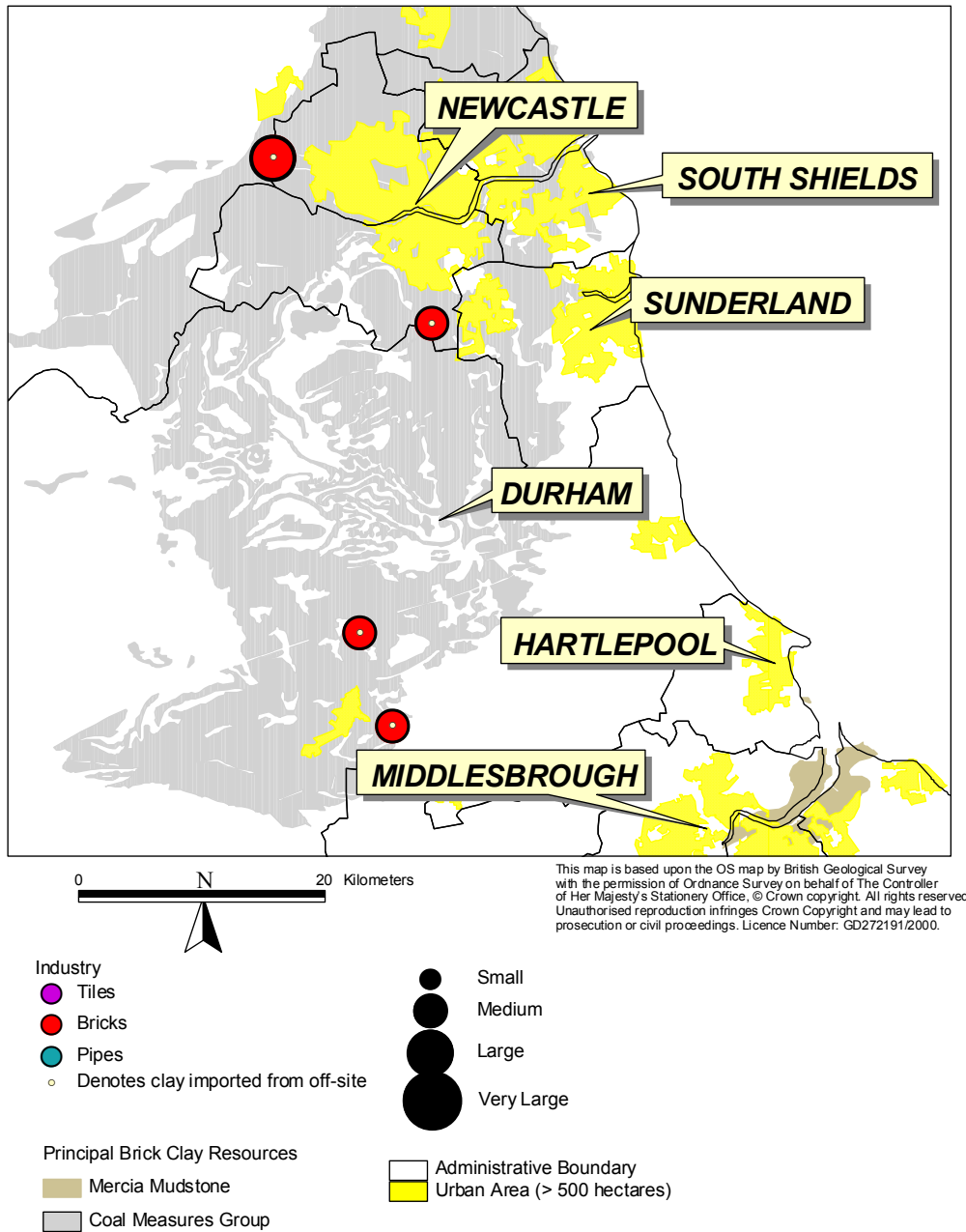


Figure 5. Location of production sites in the north east of England. Coal Measure mudstone is the principal resource for most of these sites.

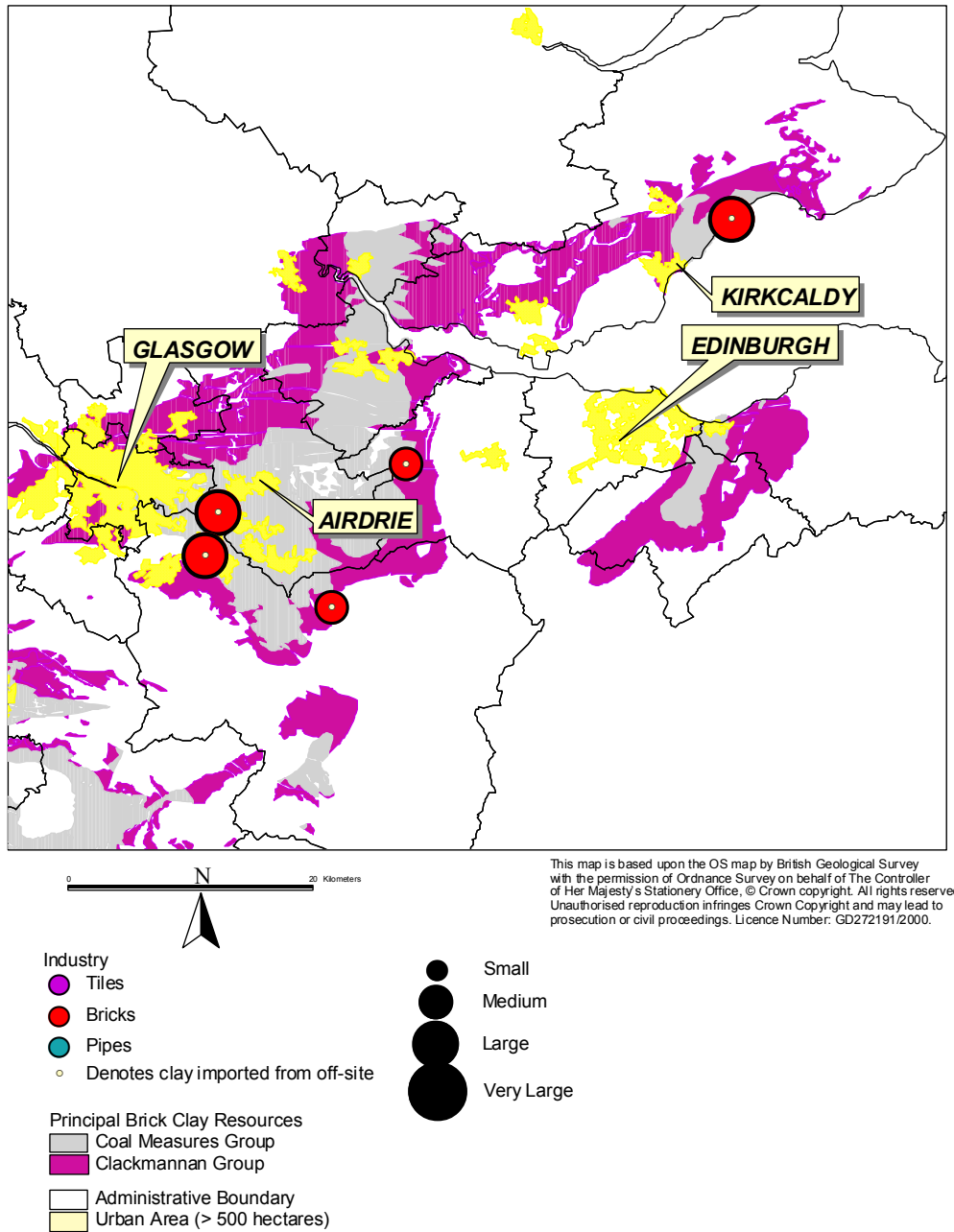


Figure 6. Location of production sites in central Scotland. Most of these sites utilise Carboniferous mudstone 'imported' from off-site.

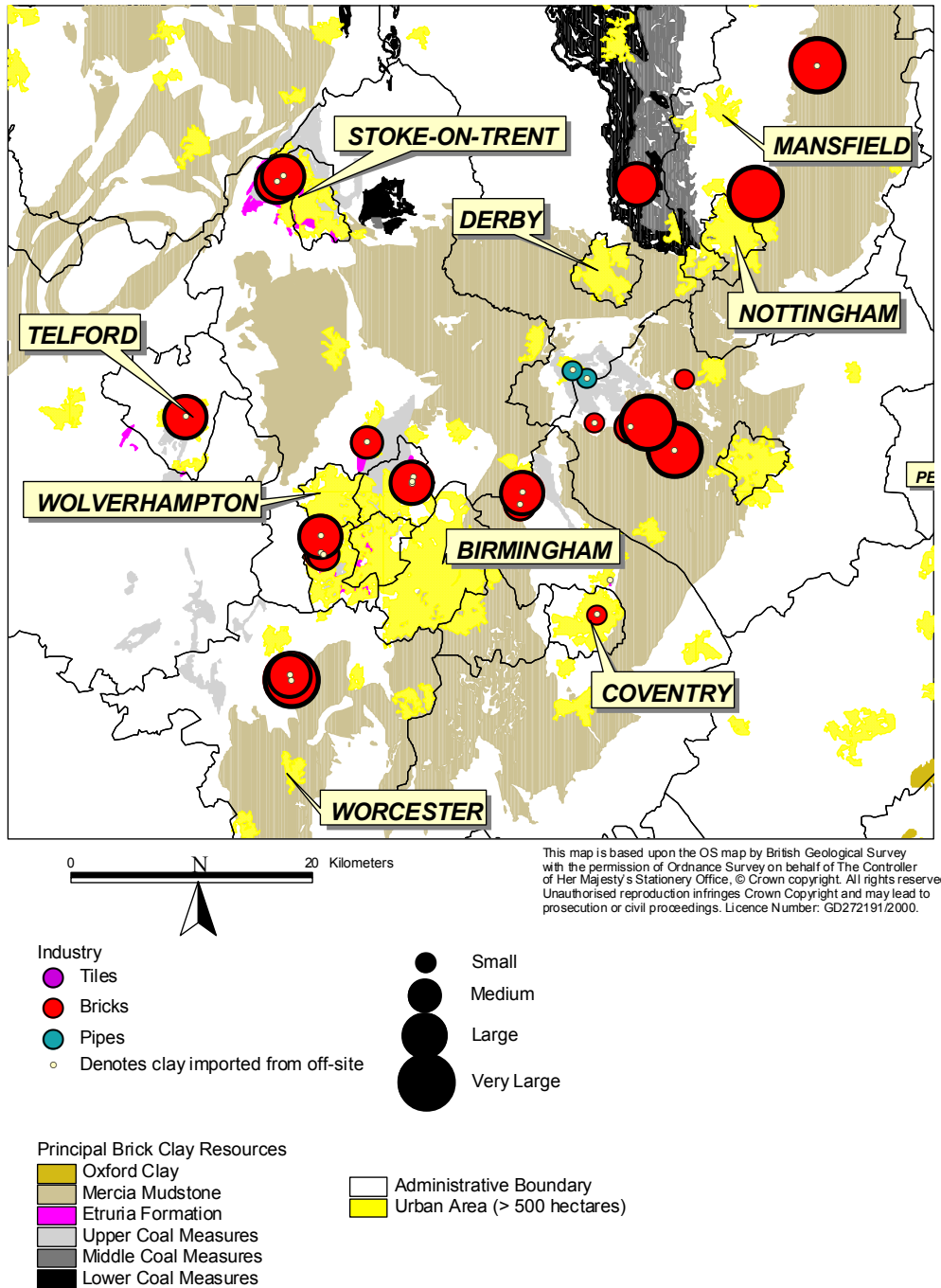


Figure 7. The Midlands represents the highest concentration of brick clay working in Britain. The large units to the west of Leicester, the north of Nottingham and south west of Birmingham are dependent on Mercia Mudstone Group clays. Most of the remaining sites around Birmingham and in Stoke-on-Trent utilise premium quality Etruria Formation clay as their principal raw material.

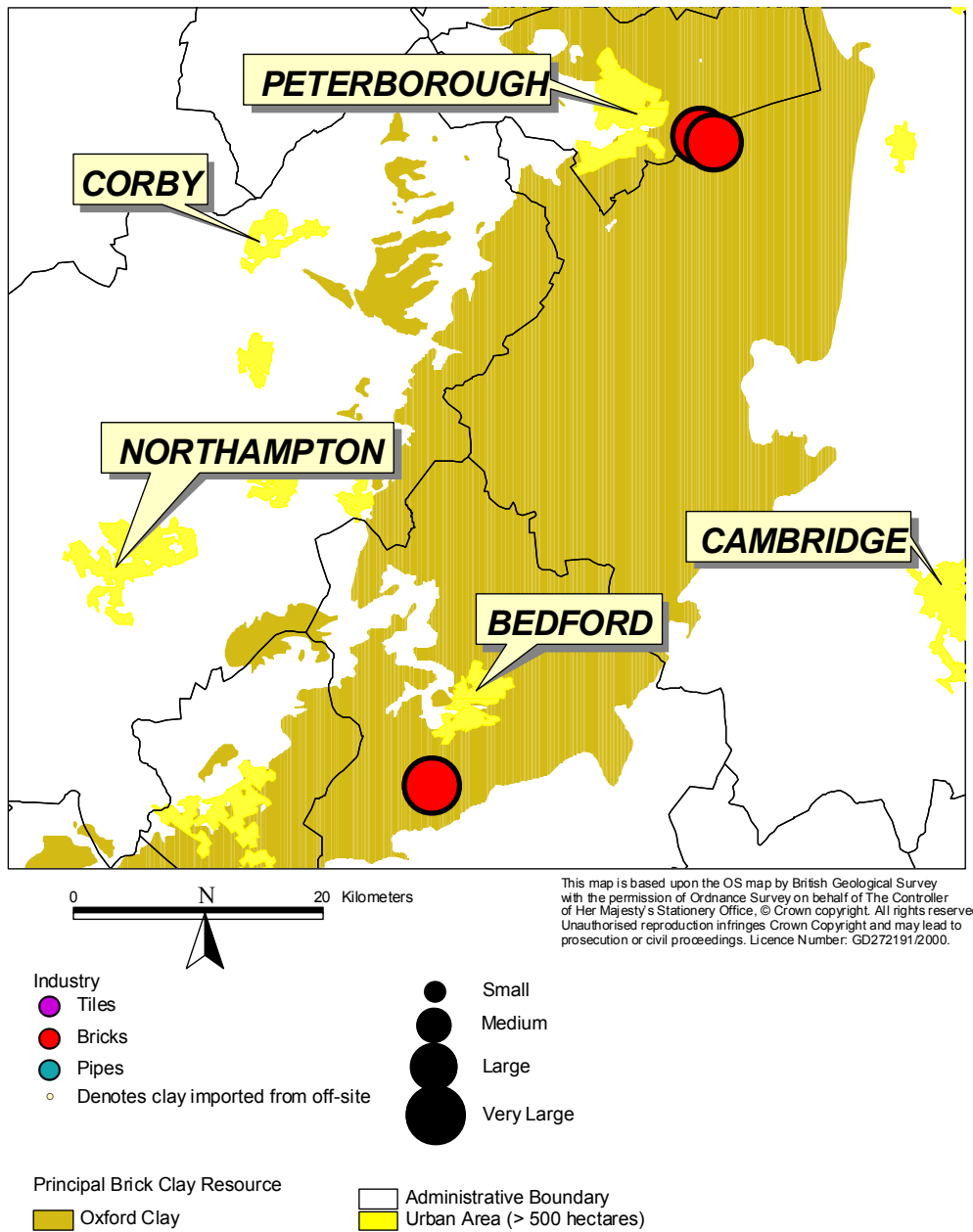
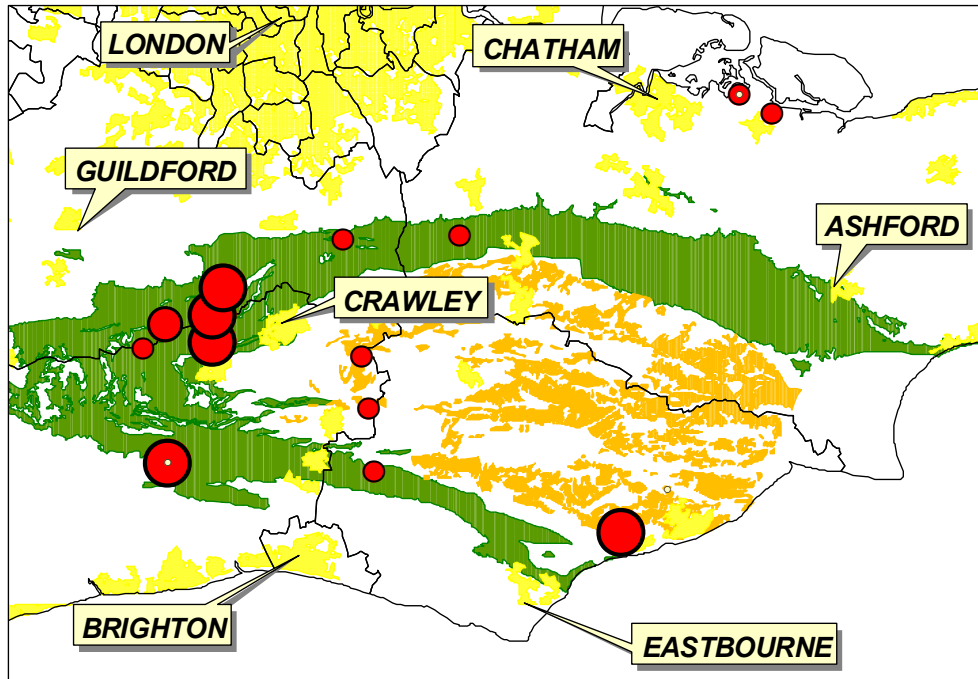


Figure 8. Only three production units which depend on Peterborough Member clays (Lower Oxford Clay) now remain., although all three are very large consumers of brick clay.



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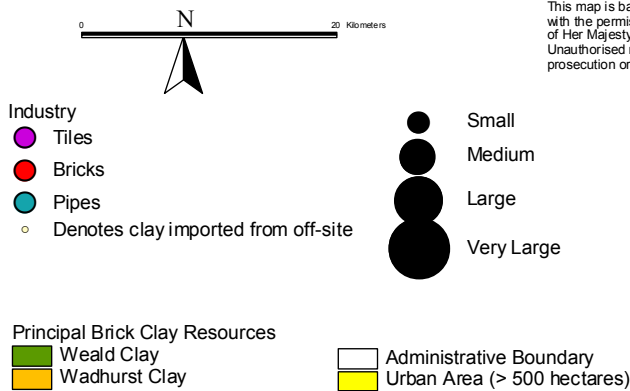


Figure 9. Most production in the South East is concentrated in Horsham-Crawley area in the western part of the Weald and is dependent on the Weald Clay. A number of other sites further east utilise the Wadhurst Clay. Note the absence of clay imports to most of these sites. The two small sites in north Kent produce traditional yellow London stock bricks from Brickearth and Chalk.

Fireclay consumption

1.16 Patterns of fireclay consumption are somewhat different to those shown by other clay raw materials used by the brick industry. This reflects the source of fireclay as a by-product of opencast coal mining, and its high value compared to other clay raw materials. Figure 10 shows the consumption of fireclay by the brick industry in 1998, broken down by coalfield of origin. The graph shows the importance of the Leicestershire/ South Derbyshire Coalfield. This coalfield supplied over 35 per cent of the fireclay used by the industry in 1998. The Northumberland Coalfield supplied just over 15 per cent of the total fireclay consumed. Remaining production originates from a wide geographical spread of coalfields in England and Scotland. Because of their association with opencast coal, almost all fireclays require transport by road to brick production sites. Transport distances vary, but the relatively high intrinsic value of fireclay and the ephemeral nature of their supply, ensure that some fireclays travel considerable distances. Although we have no information to allow direct comparison, evidence suggests that the average transport distances for fireclay is considerably greater than for other clay raw materials which are imported into production units.

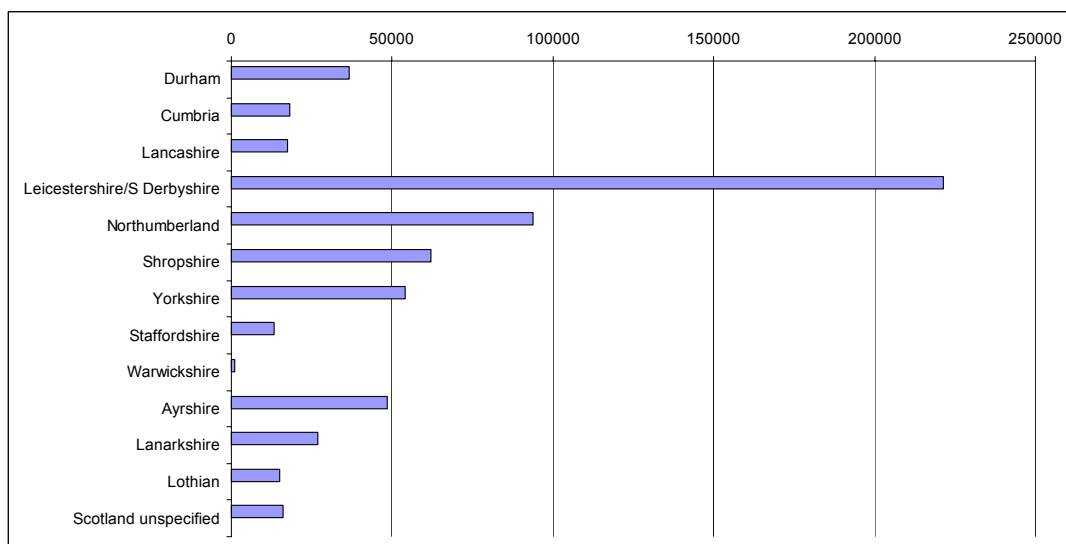


Figure 10. Consumption of fireclay by coalfield of origin, 1998.

1.17 Analysis of data for fireclay from the Leicestershire/ South Derbyshire Coalfield shows that it 'exported' in roughly equal amounts to the West Midlands and the North West regions in 1998, with a lesser amount going to Yorkshire and the remainder consumed in the East Midlands (Figure 11). Almost all of this clay will have been transported by road. Distances to consuming sites vary from 50-60 km (West Midlands) to 120-140 km (Yorkshire and the North West).

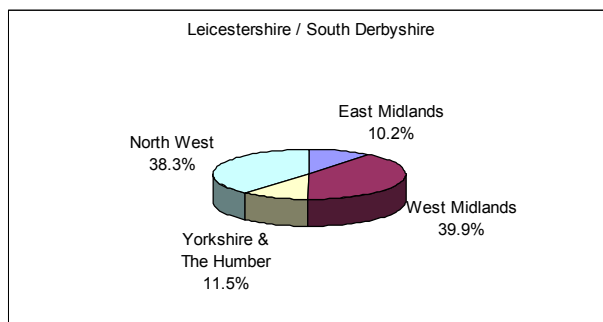


Figure 11. 1998 consumption of Leicestershire/ South Derbyshire Coalfield fireclay by region.

1.18 Both the North West and the West Midlands were net importers of fireclay in 1998 (Figure 12). The North West drew in almost 90 per cent of its requirements from outside the region, whilst the West Midlands imported about 65 per cent for outside the area, the bulk of which originated from the Leicestershire/ South Derbyshire Coalfield.

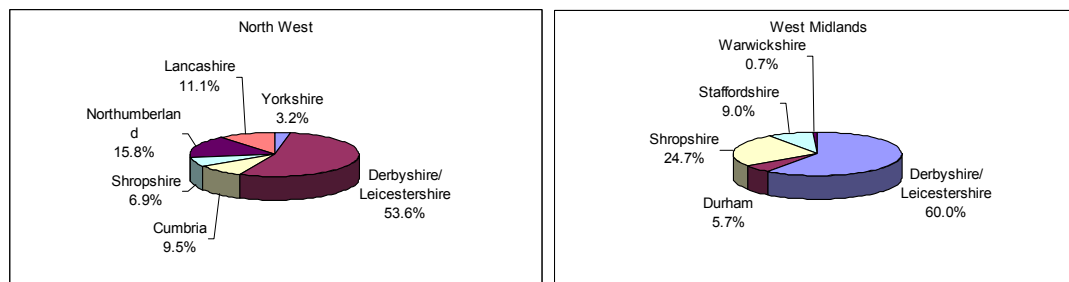


Figure 12. 1998 consumption of fireclay in the North West and West Midlands regions by coalfield of origin.

Changes in the pattern of demand for brick clay

1.19 Changes in the pattern of demand for brick clay over the past 20 years can be made by comparison of data on consumption by geological unit in 1998 with similar data gathered in 1979 (Ridgway, 1982). Figure 13 shows that the biggest change in the pattern of consumption of brick clay since 1979 has been the decline in importance of the Jurassic clays. This change principally reflects the decrease in the utilisation of Peterborough Member clays ('Lower Oxford Clay'). This decline has been largely offset by increases in the percentage consumption of all the other principal brick clay resources since 1979.

1.20 Interviews carried out during the industry survey suggest that these trends have been driven by a number of factors, including changes in construction methods resulting in a decline in demand for common bricks (see Appendix 6). These were mostly made using Peterborough Member clays. Increased demand for higher specification bricks and higher levels of consumer choice, changes in architectural fashion, changes in technology and increasing environmental regulation have also been contributing factors. These changes have pushed manufacturers toward materials with consistent and predictable properties

which can be blended to produce a wide product range, suitable for highly automated manufacture with low emission levels. The highest percentage increases in demand from 1979 to 1998 have been for premium quality materials such as Etruria Formation clay and fireclays.

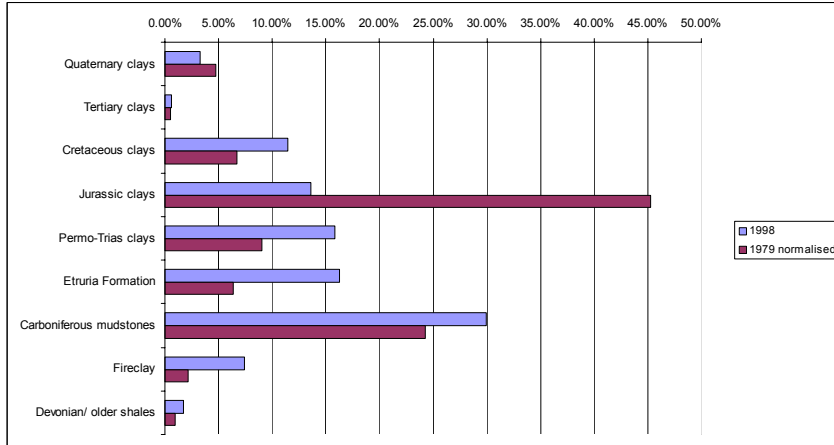


Figure 13. Consumption of brick clay by geological unit, 1979 and 1998.

APPENDIX 2: MANUFACTURE

2.1 This section describes the processes used in the manufacture of clay bricks (and, to a lesser extent, pipes and tiles). The process is also shown schematically in Figure 14.

Clay extraction

2.2 In the manufacture of bricks and other structural clay products, the term 'clay' is relatively loose, since the clay mineral content of the raw materials may vary from 80 per cent to 20 per cent. Non-clay minerals, such as quartz, iron oxide and calcium carbonate, can profoundly affect the colour and properties of the fired bricks.

2.3 Prior to the Industrial Revolution, all brick clays were extracted by hand from pits, immediately adjacent to the brickmaking operation. The Industrial Revolution led to increasing mechanisation of all aspects of brickmaking, including the clay winning. A range of machines has evolved to meet the very differing demands of deep or shallow quarries, uniform or heterogenous deposits, soft clays or hard shales.

2.4 Homogenisation of the clay raw material can be achieved by scraping the complete vertically exposed face of the deposit using a drag-line or a shale-planer. More commonly, different strata of clay are often deposited as superimposed layers in stockpiles, which are later removed vertically to ensure a consistent mix. Many stockpiles are allowed to 'sour', a process of weathering over several months to increase plasticity. This process is particularly common in works producing moulded ('soft-mud') products. Primary crushing and stone removal are sometimes necessary at the quarry site.

2.5 The widespread use of powerful crushing and grinding machinery in modern brickmaking has made possible the use of freshly-dug clay, even when this may be relatively dry and hard. Accordingly, clays of differing properties (from an on-site, 'captive' quarry, or transported from off-site) may be stockpiled separately. These clays can then be blended to produce the desired technical and aesthetic properties in the final product.

Non-Clay Raw Materials

2.6 A range on non-clay raw materials can be incorporated with brick clay to modify and improve the technical and aesthetic properties of the final product. Sand is added to highly plastic clays to aid drying and reduce shrinkage. Yellow London stocks achieve their distinctive colour through the incorporation of fine calcium carbonate (chalk) which bleaches the red-burning clay by chemical reaction with the iron oxides present in the clay. Stock bricks may also contain town-ash. This is a carbon-rich material reworked from pre-20th Century domestic refuse tips, where coal cinders make up the bulk of the waste. The carbon present in this material acts as an internal 'body-fuel' and improves the overall appearance of the brick. Fine-grained coal slurry (waste from coal washing plants) is used extensively by the brick industry for the same purpose.

2.7 Various pigments may be added to brick clays to modify body colours. These include manganese dioxide (producing brown and grey bodies) and titanium dioxide (intense yellow bodies). Anti-scumming agents (usually based on barium compounds) are used to prevent dulling of surface colours, especially in the case of red facing bricks. These materials are expensive and their use will be avoided wherever possible by careful selection of clay raw material. The use of a range of secondary (by-product) materials has increased recently. Materials include pulverised fuel ash (PFA) and steelmaking slags, as well as fine 'burnout' material such as sawdust and chopped straw.

Clay preparation

2.8 Clay bricks are supplied to meet very demanding national or European technical standards, which specify tolerances for such properties as dimensions, shape, strength, absorption, soluble-salt content and durability (frost resistance) (see Appendix 4). Increasing mechanisation and robotic handling in manufacturing also requires very close dimensional tolerances. This requires tight control throughout the manufacturing process. The clay preparation stage is vital to this control. The incoming raw materials must undergo size-reduction, moisture adjustment and thorough blending.

Size Reduction

2.9 Different grinding techniques have evolved to suit the clay type and the brick-forming technique to be employed.

2.10 Coarse primary crushing of relatively dry (hard) clays and shales may be effected by Kibbler rolls (large toothed rolls, sometimes located in the quarry) which reduce lump-size to about 75 mm. Large jaw crushers serve a similar purpose. Further size reduction of these harder, more brittle clays is carried out using hammer mills, which shatter the incoming lump clay to around 25 mm or under. Wet, or dry pan-mills perform a similar function, depending on the type of clay and its moisture content. Smooth crushing-rolls are widely adopted for clay preparation in extrusion (wire-cut) works.

Screening of Clay

2.11 The grinding processes described above result in varying degrees of size reduction, but it is often necessary to introduce a screening stage to control the final grain-size. This is especially important if the clay contains impurities such as limestone nodules, as coarse lime particles can expand and disrupt the fired brick. Hammer-mills and dry-pans inevitably produce some oversize material, so removal of the fine usable material and return of oversize for re-grinding improves the efficiency of the system.

Mixing and Feeding of Raw Materials

2.12 It is essential to ensure thorough mixing of the clay (together with other constituents such as sand, coal-slurry and/ or anti-scumming agent), and to achieve the desired plasticity by adjusting the moisture-content of the mix prior to forming and firing.

Proportioning of additives is often via simple box-feeders placed over conveyor-belts, although more modern plants often use more sophisticated devices. Pigments and anti-scumming agents are usually supplied in slurry form and dosed via metering pumps. A few works employ weigh-batching of materials with mechanical mixers – particularly where accurate proportioning is essential.

2.13 The fletton process used to produce bricks from Peterborough Member clays ('Lower Oxford Clay') relies on the grinding, screening and conveying of granular clay for mixing, and feeding of presses is achieved by ploughing from a conveyor belt into gravity hoppers located above the individual presses.

2.14 The rotating shafts of trough-mixers lift and throw the clay and additives and homogenise the mix. The moisture content can be adjusted at this stage.

Forming

2.15 Most clay minerals are characterised by fine (<2 micron) particle-size and by a lamellar (plate-like) structure. Individual clay plates attract a layer of water-molecules when moistened. They also attract each other by weak bonds, so that even finger pressure causes the platelets to slide. This gives the characteristic greasy feel of moist clay. Stiff pastes of clay-water can be shaped by applied pressure. These then retain their shape when the pressure is removed. This property (known as plasticity) enables bricks, tiles and pipes to be formed and to retain their shape prior to firing.

2.16 After clay preparation, the raw material comprises a mixture of solid, liquid (water) and gas (air). In order to achieve maximum density and physical strength, it is necessary to remove as much air as possible during the shaping process. Three main techniques have evolved for brick forming.

Soft-mud process

2.17 Essentially the clay mix is prepared wet and quite free-flowing (up to 30 per cent moisture content). Clots of the clay are thrown into mould boxes (pre-coated with sand or sawdust to act as release agent). Surplus clay is struck off level, and the thrown brick carefully de-moulded onto a drying rack. The high water content displaces air from the mix. Considerable amounts of sand are usually added to the clay to reduce subsequent drying shrinkage.

2.18 This process produces bricks of soft, slightly irregular outline, often showing surface creases and sanded on all surfaces. The aesthetic properties of these bricks has resulted in a resurgence in their popularity, and a marked increase in market share. Although a very high proportion of soft-mud bricks are produced by machine, hand-making is still widespread, especially in producing premium-quality facing bricks, or awkwardly-shaped 'specials'.

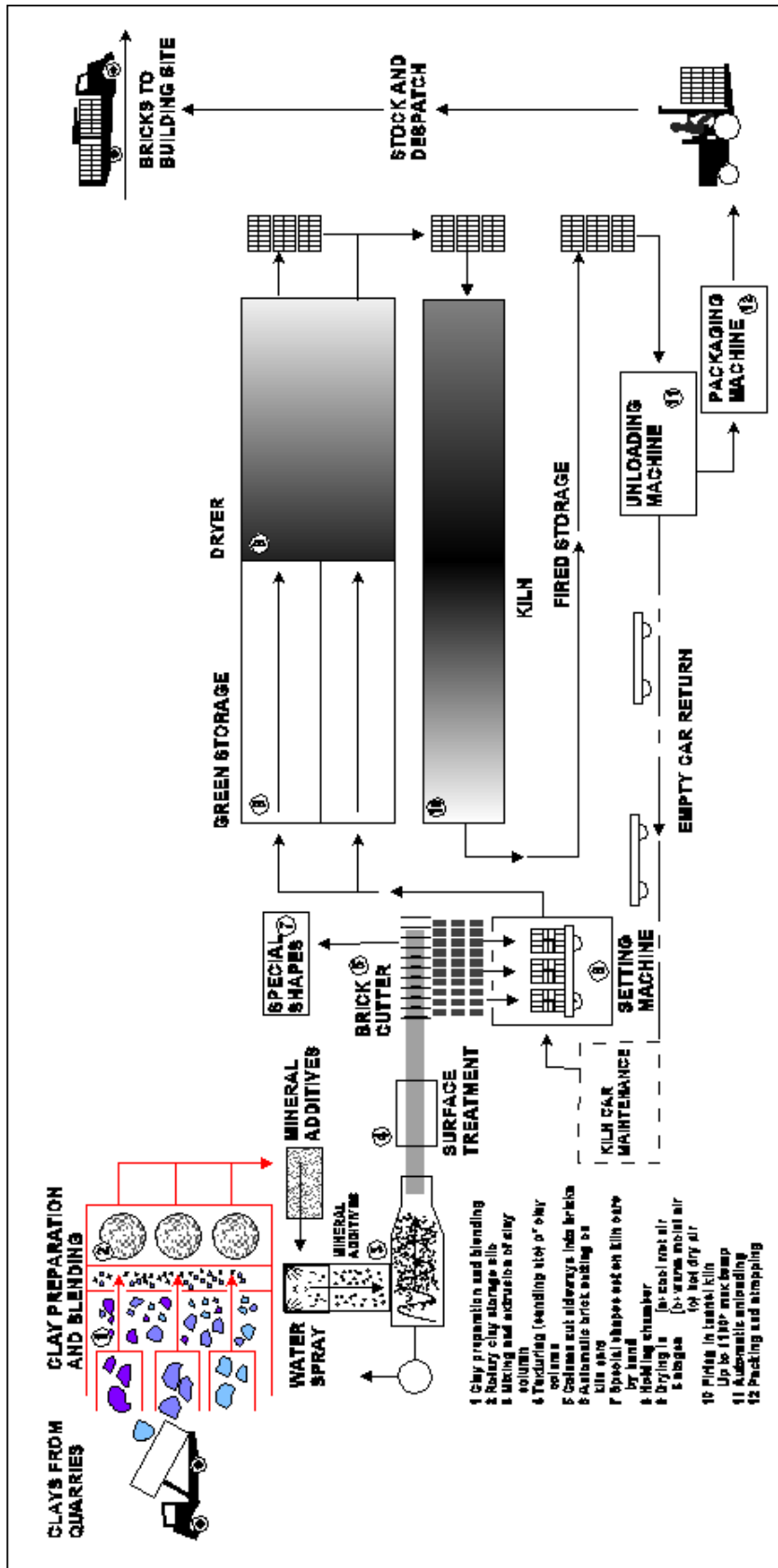


Figure 14. Schematic diagram showing typical automated brick manufacturing process.

Extrusion process

2.19 In extrusion, clay is forced by an auger through a lubricated die, forming a continuous column of relatively stiff clay. Clay usually enters the rear of the extruder via a pug-seal from the mixer, and undergoes vacuum de-airing in order to obtain a consolidated column. This results in bricks having superior physical properties. Core-bars (usually round in section) are generally employed to produce the characteristic perforations in these bricks. Most clay pipes and tiles are also formed using this method.

2.20 The clay preparation for extrusion allows addition of pigments, scum preventatives, so a through-coloured brick can be achieved. The extruded column passing along a conveyor belt can then be 'faced' (by roll-texturing, sand-blasting, pigment spraying) to produce a range of textures and other aesthetic effects. Modification of the surface colour of the brick using small amounts of pigment and/ or sand is a low-cost alternative to body colouration. However, the appearance of such bricks can be degraded significantly if the body colour becomes exposed through chipping.

2.21 Following surface treatment, the clay column is cut into bricks using tightly-strung steel wires, hence the alternative name for extruded bricks is 'wire-cuts'. The extruded bricks are then mechanically fed into racks for transfer to a dryer.

Pressing

2.22 Although more widespread in the past, mechanical pressing of clay bricks is now almost entirely confined to the manufacture of fletton bricks from Peterborough Member clays (Lower Oxford clay). The Fletton Process refers to the semi-dry pressing technique first developed in the village of Fletton in Cambridgeshire. Pressed bricks are generally manufactured from relatively dry, free-flowing granules of clay. A size grading of 3 mm down is ideal for fletton bricks, but coarser granules are permissible if the clay type is free from limestone particles and pyrite nodules. In order to ensure optimum contact and bonding between particles, it is again necessary to remove virtually all air from the system. It is important to ensure a clean release of green brick from the mould-box, and moving parts can be sprayed with a release oil. Pressed bricks are very regular in shape and size, with square edges. Traditionally, pressed bricks were sufficiently stiff and strong to be set in stacked units and placed directly into chamber kilns to undergo drying and firing.

Drying

2.23 In order to optimise brick drying in terms of speed, thermal efficiency and low wastage, it is necessary to maintain close control of heating rates, air circulation, temperature and humidity. Heat for drying-air is mainly supplied via gas-burners, supplemented with waste heat from kilns. Most works are now highly automated, and freshly-formed 'green' bricks are assembled as uniformly spaced one-brick-high rows on

drying pallets. The latter in turn are stacked vertically onto finger-cars, which transfer the bricks to the dryer.

2.24 Clays vary in their sensitivity to drying, but all benefit from an initial warming-up period in high humidity conditions (and little or no moisture removal) followed by the main drying stage where the bricks meet hotter and drier air. The last few percent of water is harder to remove, requiring the hottest and driest air.

2.25 In tunnel dryers, drying racks (or in some cases, brick-on-brick settings) are placed on flat-bed cars and drawn through a tunnel, encountering warm air at a high humidity level close to the exhaust fan. Hot, dry air enters the opposite (exit) end of the tunnel at which point the bricks have almost dried and can withstand the high temperature. It is crucial to ensure that uniform conditions exist through the cross-section of the dryer, so recirculatory fans are provided at intervals.

2.26 Tunnel-dryers are well suited to sensitive clays and large throughputs of bricks with the same body composition.

2.27 Chamber dryers consist of a battery of chambers, in which the drying pallets are stacked vertically with uniform spacing. The chamber doors are then closed, and a programmed drying cycle commenced. Air movement may be provided by internal or external fans, moving or stationary, continuous or intermittent. Recirculation of air is normal; and both temperature and humidity are measured. An initial warming-up period with introduction of recirculated hot-air and low exhaust rates, followed by a progressive increase in exhaust volume to remove water.

2.28 Chamber dryers are particularly suited to works which make a range of products based on different clay mixes, or where continuous 3-shift systems are not operated. It is easier to increase drying capacity by building an extra drying chamber than it would be to enlarge a tunnel-dryer.

2.29 There is constant pressure to speed up drying and to reduce energy costs. Future methods of drying may considerably reduce the 36 – 60 hour range which is usual in current chamber or tunnel dryers. These improvements are likely to require highly modified and specified brick bodies, as well as changes in drying technology.

Firing

2.30 Raw materials used in brick manufacture are usually complex mixtures of clay minerals, plus other minerals such as quartz, feldspars, calcite, gypsum, various iron oxides, oxyhydroxides and carbonates, pyrite (iron sulphide) and organic matter..

2.31 When dried bricks are fired in a kiln, any remaining free moisture is driven off between 100°C and 200°C. Where these materials are present, oxidation of organic matter and pyrites takes place between about 300°and 500°C. Water combined within the

structure of clay minerals is driven off at between 500 and 600°C. Calcium carbonate dissociates to produce lime and carbon dioxide (gas) at about 800°C.

2.32 The important changes relating to the development of brick properties result from the breakdown of the lattice structure of the original clay minerals, followed by the formation of new crystalline materials and glass phases. The temperature at which vitrification (glas formation) occurs depends on the mineralogy of the clay. Vitrification usually commences at about 900°C, and is completed by about 1050°(or up to 1100°C in the case of more refractory fireclays).

2.33 A range of firing techniques are used by the structural ceramics industry.

Clamp firing

2.34 This ancient method is still employed to a limited extent in the production of traditional stock bricks. No kiln as such is involved. Dried bricks (generally produced using the soft-mud process), which contain added fuel such as coke breeze, are built into large, dense rectangular settings called clamps on a foundation of fired bricks. Flues are left in the bottom layers, with layers of coke to initiate firing. Around 25 courses of dried bricks are set on edge above the fuel bed, and the clamp is finally clad with fired brick, sloping the outer walls inwards for stability.

2.35 Once ignited, the fire progresses slowly by combustion of the fuel within the bricks. Firing of the clamp takes several weeks, including time for cooling, after which the clamp is stripped down manually and the bricks sorted into various defined grades. Clamp firing requires a high degree of control over the raw material used and skill in setting the clamp. The operator has little control once the clamp is ignited. A single firing will produce a range of brick grades because of the relatively wide temperature variation in the clamp.

Intermittent kilns

2.36 These are used for firing specialised high-value products such as special-shape bricks and pipe fittings which are made in relatively small numbers. The shuttle-kiln comprises a short tunnel which can be charged with a few loaded kiln-cars. Entry and exit doors on the ends are designed to form a tight seal. A variant is the hood-type 'top-hat' kiln, consisting of an insulated refractory box which is lowered onto an individual kiln-car (charged with dried clayware) and forms a seal with the perimeter of the car. Gas burners are generally employed and good control of temperature and kiln atmosphere (oxidising or reducing) can be achieved. Uniform gas flow and heat transfer are obtained. This is useful for components with thick walls or complex shapes.

Semi-continuous and continuous chamber kilns

2.37 These kilns were developed in the 19th Century and are based on the linking of a number of chambers so that the hot fire-gases were drawn from one chamber to the next

in order to dry and preheat the clayware. This results in improved thermal efficiency and lower costs compared to intermittent kilns. Bricks are set into a series of chambers, where they experience (in sequence) drying, heating up, firing and cooling as the fire travels around the circuit.

2.38 Large rectangular brick-built Hoffman kilns, typically with about 18 chambers along both sides and an output of 1.25 million bricks per week are used in the Fletton process based on the high organic matter clays of the Peterborough Member. This embodied organic matter leads to a two-thirds reduction in external fuel requirement. Tall chimneys (usually placed in the centre of the kiln) enable such kilns to operate entirely by natural draught.

Tunnel kilns

2.39 In the UK, most heavy-clay ware is now fired in tunnel kilns, modern versions of which are virtually gas-tight, well insulated and refractory-lined. As the name suggests, the kiln is essentially a tunnel served by rail-tracks carrying kiln-cars. The latter have refractory decks on which dried bricks or other ware are set in defined patterns. The cars are pushed at regular intervals through the kiln, countercurrent to a flow of air supplied by a fan located at the exit end of the kiln. Most tunnel-kilns are now gas-fired using top or side burners, with maximum temperature in the firing zone near the centre of the kiln. Combustion gases are drawn to exhaust flues and stack near the (brick) entry end of the kiln. Hence, incoming bricks etc are preheated by hot gases from the firing zone whilst the incoming air cools the fired ware and is itself preheated for its combustion role. Instrumental and computer controls have enabled tight definition of kiln temperature and atmosphere, with considerable gains in product consistency and fuel economy.

Fast-firing kilns

2.40 Conventional tunnel-kilns normally require a 2-3 day firing cycle for heavy clayware. Because of the shape and nature of its products, the wall and floor-tile industry was constrained by very shallow setting patterns and the need for clean kiln atmospheres. To meet these requirements, rapid-firing kilns were developed with firing-cycle times as low as 30 minutes. In roller-hearth kilns, individual tiles are fed onto a roller conveyor. The rollers are driven at the requisite speed to convey the ware through the kiln in the stipulated cycle-time. The kiln is highly insulated, and the short heating/ vitrification/ cooling cycle leads to marked fuel economy. Roller-hearth kilns are also used in the UK for firing much larger units such as vitrified clay pipes. Rapid-firing kilns have been used in Australia to manufacture building-bricks. It seems certain that rapid firing will be increasingly adopted by the heavy-clay industry. Energy use will become more expensive and subject to taxation. Additionally, rapid firing reduces overall emissions from kiln gases.

2.41 The technological advances in firing now commonly used by the tile and vitrified clay pipe industry rely heavily on careful control of the body composition. Many natural clays are unsuitable for rapid heating/cooling cycles. As a result, blending of clays and

other minerals in order to avoid these problems is likely to increase, with consequent increase in the transport of raw materials between sites and particular demand for premium quality brick clay raw materials such as Etruria Formation, certain Carboniferous mudstones and (possibly) fireclays.

2.42 Pre-calcination (principally to reduce and/or modify the organic matter content of a clay) is a further technological response to the need to reduce firing times and improve product quality. This technologically-advanced method has been used in the vitrified clay pipe industry for some time, where the need to ‘engineer’ the raw material to enable production of products to very close finished tolerances is paramount. Pre-calcination seems likely to extend into some parts of the brick industry, although the principal driving factor in this sector may be the need to reduce kiln emissions. The implication of this technology is that existing resources might be maintained by process change, despite increasing environmental regulation.

APPENDIX 3: IMPACT OF ENVIRONMENTAL REGULATION

Introduction

3.1 EU Directive 96/61 'Integrated Pollution Prevention and Control' (IPPC) was incorporated in the national legislation of member States by 30/10/99. The UK already operated an integrated pollution control (IPC) system covering processes judged to have the potential for significant environmental impact. These are classified as Part A prescribed processes under Part 1 of the Environmental Protection Act 1990 (and will be classed as Part A(1) under IPPC). They will continue to be controlled by the Environment Agency (EA).

3.2 Processes with less pollution potential (classed as Part B) fall under Local Authority pollution control. The DETR has estimated that around 1600 Part B installations will also have to meet IPPC requirements and will be re-classified as Part A(2) processes. Part A(1) and Part A(2) processes will be controlled in respect of air, land and water impacts. In Scotland, all installations will be regulated by the Scottish Environmental Protection Agency (SEPA). The more minor Part B processes will retain that classification and be regulated by Local Authorities for the air medium only.

3.3 Most clay brick, roofing tile and pipe manufacturing plants will be regulated under the IPPC regime.

Overview of IPPC requirements

3.3 The IPPC Directive requires operators to prevent or reduce pollution using Best Available Techniques (BAT) which will be defined by the regulator for the particular sector/installation. Different industries are currently drafting 'BAT Reference Notes' (BREFs) on a European basis to provide relevant information to regulators and operators.

3.4 Operations governed by IPPC require permits, which have to include Emission Limit Values (ELVs) for a range of pollutants. ELVs are to be based on BAT taking account of proven technical viability and economic (cost/benefit) factors.

3.5 Unlike the UK IPC/LAAPC legislation, the IPPC Directive specifies a comprehensive list of 'environmental' factors which must be considered when defining BAT for any particular sector.

3.6 A crucial aim of IPPC is to set standards which are site-specific, taking account of factors such as plant variation, raw materials, topography and local environmental impacts. However, if a need for community action has been identified, emission limit values may be imposed at an EU wide level. Furthermore, the IPPC Directive allows Member States the option of applying General Binding Rules requiring identical permit conditions for similar installations.

Likely UK position on IPPC

3.7 In August 1999 the DETR issued its 'Fourth Consultation Paper on the Implementation of the IPPC Directive'. This is the final such paper and the following points reflect the likely UK position:

- National sector guidance should be based on European BAT Reference documents (BREF notes);
- Guidance notes will be non-prescriptive allowing site specific flexibility;
- Proposed to use a simplified permitting procedure for installations judged to have a trivial environmental impact (EA to advise on latter);
- The Government will also encourage the EA to develop proposals for General Binding Rules in close consultation with stakeholders. Sectors may volunteer to adopt Standard Permit Conditions;
- IPPC regulations will apply to an installation (as defined in the Directive) rather than to a process;
- Government has proposed that the review period for permitted installations should vary for different sectors;
- In the case of contamination of IPPC sites, remediation will be required to restore the site to its original condition;
- The EA is likely to be asked to set conditions relating to noise for installations which they are to regulate. However, Local Authority recommendations (based on their expertise in this field) must be considered;
- Energy efficiency is to be met via site specific permit conditions using the expertise of the Energy Technology Support Unit (ETSU).

Likely impact of IPPC requirements on the UK structural clay industry

3.8 The main impact is in the area of emissions to air. Potential air pollutants listed in the IPPC Directive which are associated with the structural clay industry are as follows:

- Sulphur dioxide and other sulphur compounds (chiefly SO₂);
- Oxides of nitrogen and other nitrogen compounds (NO_x);
- Carbon monoxide;

- Volatile organic compounds (VOCs);
- Dust;
- Chlorine and its compounds;
- Fluorine and its compounds;

3.9 Substances and preparations which have been proved to possess carcinogenic or mutagenic properties, or properties which may affect reproduction via the air may be triggered if crystalline silica is classed as a carcinogen.

3.10 The IPPC listed substances which relate to stack emissions are virtually identical to those covered by UK legislation for heavy clayware processes. However, to date, the only pollutant which has (in some cases) exceeded the UK emission limit is fluoride, and this has been largely dealt with using dry scrubbers charged with calcium carbonate granules.

3.11 The impact of IPPC will depend on the Emission Limit Values drafted for the ceramic sector (with guidance from BREF notes). It is not yet decided whether the structural clay sector BREFs will be finalised in 2000 or 2001.

3.12 It is likely that pollutants such as SO₂, NO_x and VOCs will attract tighter emission limits, with significant cost implications should treatment of flue gases become necessary. Change of raw materials might become attractive. This might include the increased demand for low-sulphur clays and/or an increase in the practice of incorporation of fine calcium carbonate to the clay blend. SO₂ and fluorine emitted from the clay is 'fixed' within the brick as it reacts with calcium carbonate during firing.

3.13 Removal of very fine particulate matter from stack gases could prove difficult and costly.

3.14 The only item listed in the IPPC Directive under 'WATER' which may be relevant to the heavy clay sector is 'Substances which have an unfavourable influence on the oxygen balance (and can be measured using parameters such as BOD, COD etc.)'. Contamination of water or land is not likely to be a real problem in this sector of industry, although wastes from flue gas scrubbing plants can have high biological/ chemical oxygen demand (BOD/COD) values. The monitoring of water (and land if relevant) will add to operating costs.

3.15 The IPPC Directive lists (in Annex IV) 'Considerations to be taken into account generally or in specific cases when determining best available techniques, bearing in mind the likely costs and benefits of a measure and the principles of precaution and prevention.' These are as follows:

I. Use of low-waste technology

3.16 Modern brick, tile and pipe plants generally achieve very low product waste, although older plant, and certain clay types are subject to higher wastage rates. Blending 'lean' clays with very plastic clays can reduce cracking. Unfired waste is usually recycled within the process.

3.17 The industry has shown increasing use of waste/secondary materials from other industries (such as PFA, and steelmaking slags).

II. Use of less hazardous materials

3.18 Clays and minerals used in the sector are generally non-hazardous, provided dust control measures are employed where appropriate. Minor constituents of clay bodies such as barium compounds (anti-scum) and manganese oxides (used as body pigment) may be potentially toxic, but modern practice is to add them in the form of aqueous suspensions, avoiding dust.

III. Furthering of recovery and recycling of substances generated and used in the process and of waste where appropriate

3.19 This was partly dealt with in paragraph 3.16. Pressure to maximise recovery/recycling of fired waste brick, pipe as secondary aggregate is growing. There is also a potential for finely ground waste fired brick as a pozzolanic (cementitious) material for use in mortars and concrete. Reductions in energy use can be achieved by replacing a proportion of the Portland cement required by these materials

IV. Comparable processes, facilities or methods of operation which have been tried with success on an industrial scale

3.20 Depending on the emission limits finally imposed, the brick industry may have to 'borrow' emissions reduction methods already in use in other industries. These include NO_x reduction as employed in the cement and electricity industries. SO₂ removal by modified dry scrubbing or wet scrubbing, as used by electricity generators. VOC/CO reduction by regenerative thermal incineration), already used in continental Europe in the lightweight (burnout) block industry; Particulate removal by electrostatic precipitation, as used in coal fired power stations and by the cement industry.

3.21 These 'end-of-pipe' solutions are difficult and expensive. In time, some brick manufacturers may prefer to adopt technology already used by the wall-tile and vitrified clay pipe industries which is based on sophisticated formulation and/ or pre-calcination of the clay body to facilitate very rapid drying and firing with low wastage (see Appendix 2). Reduction of both emissions and energy consumption would result from these changes. This implies an increase in the demand for low-emission clays.

V. Technological advances and changes in scientific knowledge and understanding

3.22 This is a very open-ended consideration. Recent EU-funded research on the reduction of fluoride emissions by means of process change is an excellent example. Research on modification of kiln operating parameters based on T-T-T (Time-Temperature-Transformation) criteria can also demonstrate reduced emissions and energy usage.

VI. Nature, effects and volume of the emissions concerned

3.23 Although Emission Limit Values (ELVs) are prescribed in terms of the concentration of substances in stack gases, this item suggests that BAT for specific sites may be influenced by the volume of the gaseous emissions, as well as by their potential environmental impact. This could lead to differing standards being applied to large and small works operating the same basic process.

VII. Commissioning date for new or existing installations

3.24 Essentially, new plants will attract stricter control limits sooner than existing plants. This is logical since building in pollution abatement is far more economic than retrofit. New heavy clay works represent high capital expenditure, so process change within existing works is attractive. However, this could be interpreted as 'major change', leading to review of permit conditions.

VIII. Length of time needed to introduce the best available techniques (bat)

3.25 The presumption is that this relates to the timing of the imposition of IPPC regulations on specific sectors.

IX. Consumption and nature of raw materials (including water) used in the process and their energy efficiency

3.26 Although relatively abundant compared to some other minerals, the resource base of the industry has become restricted. A number of factors discussed elsewhere in this report are leading to problems of supply of particular clay raw materials such as Etruria Formation clay and fireclay

3.27 Although fired clayware requires embodied energy, this is more than balanced by the extreme longevity and low maintenance requirement of the products.

3.28 Clays with a high organic content can contribute greatly to the energy efficiency of the process. This will apply to the Peterborough Member ('Lower Oxford Clay') and under IPPC should be an important 'plus' in the overall assessment of BAT.

X. The need to prevent or reduce to a minimum the overall impact of the emissions on the environment and the risks to it

3.29 Emissions to water or land are negligible. Fluorides have been identified as the most significant air pollutant and emission limits are stringent. SO₂ and NO_x from the industry have not been associated with damaging effects, but the likely introduction of stringent limits on short-term concentrations in the atmosphere may have an impact on structural clay works. This would be more likely in areas where other sources of SO₂ are present, and might result in the need to blend 'imported' low-sulphur clays with indigenous material.

XI. The need to prevent accidents and to minimise the consequences for the environment

3.30 The nature of clay brick/pipe/tile manufacture is not hazardous provided gaseous and liquid fuels are dealt with according to recognised good practice.

XII. The information published by the Commission pursuant to article 16 (2) or by international organisations

3.31 This refers to the organisation by the Commission of an exchange of information between Member States and the industries concerned on BAT, associated monitoring and developments in these fields.

3.32 The Commission intends to publish the results of the information exchanges every 3 years. This could lead to continuous pressure to upgrade BAT - with a real risk of making expensive abatement plant obsolete. As stated before, change to less polluting clays/clay blends and process change might become attractive.

Summary

3.33 The effects of these changes can be summarised as follows:

- The EC IPPC Directive will apply to virtually all UK installations firing heavy clayware;
- The definition of BAT and setting of emission limits should be carried out by regulators on a localised site-specific basis;
- However, community, national or commercial motives can be expected to gradually 'harmonise' requirements;
- Environmental standards and imposed limits will probably become progressively more stringent;

- This in turn means regulators and industry must look ahead when deciding what abatement plant to install;
- The costs of ‘end-of-pipe’ technology and the creation of secondary wastes makes process change logical;
- Accordingly, more importation of suitable clays will be necessary, emphasising the need to maintain and enhance flexibility of supply to the industry;
- The wide range of considerations to be taken into account when determining BAT for a sector will demand qualitative judgments by regulators. This is new territory and the system will need time to evolve.

APPENDIX 4: IMPACT OF CHANGES IN STANDARDS AND SPECIFICATIONS FOR STRUCTURAL CLAY PRODUCTS

Introduction

4.1 Major changes in the standards and specifications for clay bricks are currently under discussion. An EU-wide single standard is likely to be fully implemented in the UK brick industry by 2002. The change from the current British Standard Specification for Clay Bricks (BS3921:1985, Amended 15/12/95) to the draft European (CEN) Standard For Clay Masonry Units (Pr En 771-1) is likely to impact on patterns of demand for clay raw materials.

4.2 Technical committees responsible for producing CEN standards were instructed to aim for performance-related standards and to develop laboratory test methods for all the required properties.

4.3 For the purposes of comparison, brick properties are considered in the same order in which they appear in BS3921, then extra properties (required only by the CEN standard) are briefly summarised. The implications of the introduction of the CEN standard for clay raw materials are discussed in each case.

I. Size

4.4 In view of the widely differing brick sizes used within Europe, member states are allowed to retain their national traditions in this respect. However, the bricks have to comply with defined dimensional tolerances (Table 2).

4.5 The measurement of 24 bricks 'in a row' can mask a lot of variation between individual units (BS3921). The CEN Standard introduces classes for size tolerance and range. Some UK brickmakers may have difficulty in achieving the quoted T2 and R2 limits. This is especially the case for those using clays with a short vitrification temperature range, and for some production sites using the soft-mud process.

4.6 Specifiers often opt for the highest perceived quality, resulting in the need to use blends of clays and other minerals to improve brick properties. Much of the importation of clays into individual sites is already driven by this need. This is likely to increase as the more stringent limits are demanded.

II. Geometry

4.7 Requirements of the BS and CEN Standard are summarised in Table 3.

4.8 If lightweight, highly-perforated units utilised in continental Europe become widely accepted in Britain, the life of clay reserves for a given number of units would be extended. Other environmental benefits should include energy and transport savings.

BS3921	prEN 771-1												
<p><u>Works Size (WS)</u></p> <p>215mm x 102.5mm x 65mm Measurement: length (L), width (W) and height (H) of 24 bricks placed in a row</p> <p>Dimensional Deviations</p> <table border="1"> <thead> <tr> <th></th> <th>MAX(mm)</th> <th>MIN(mm)</th> </tr> </thead> <tbody> <tr> <td>L</td> <td>5235</td> <td>5085</td> </tr> <tr> <td>W</td> <td>2505</td> <td>2415</td> </tr> <tr> <td>H</td> <td>1605</td> <td>1515</td> </tr> </tbody> </table>		MAX(mm)	MIN(mm)	L	5235	5085	W	2505	2415	H	1605	1515	<p>Work Size (WS) [as specified]</p> <p>Measurement sample of 10 bricks measured individually for length, width and height</p> <p>Tolerances (declared by manufacturer)</p> <p>Designation</p> <p>$T1 = \pm 0.40 \sqrt{WS}$</p> <p>$T2 = \pm 0.25 \sqrt{WS}$</p> <p>T0 = deviation in mm declared by manufacturer</p>
	MAX(mm)	MIN(mm)											
L	5235	5085											
W	2505	2415											
H	1605	1515											

COMPARISON OF DIMENSIONAL TOLERANCES (UK BRICK SIZES)

BS3921	prEN 771-1																				
<table border="1"> <thead> <tr> <th></th> <th>Tolerance</th> </tr> </thead> <tbody> <tr> <td>L</td> <td>$215 \pm 3\text{mm}$</td> </tr> <tr> <td>W</td> <td>$102.5 \pm 2\text{mm}$</td> </tr> <tr> <td>H</td> <td>$65 \pm 2\text{mm}$</td> </tr> </tbody> </table>		Tolerance	L	$215 \pm 3\text{mm}$	W	$102.5 \pm 2\text{mm}$	H	$65 \pm 2\text{mm}$	<table border="1"> <thead> <tr> <th></th> <th>T1</th> <th>T2</th> </tr> </thead> <tbody> <tr> <td>215</td> <td></td> <td>$\pm 6\text{mm} \pm 4\text{mm}$</td> </tr> <tr> <td>102.5</td> <td></td> <td>$\pm 4\text{mm} \pm 3\text{mm}$</td> </tr> <tr> <td>65</td> <td></td> <td>$\pm 3\text{mm} \pm 2\text{mm}$</td> </tr> </tbody> </table>		T1	T2	215		$\pm 6\text{mm} \pm 4\text{mm}$	102.5		$\pm 4\text{mm} \pm 3\text{mm}$	65		$\pm 3\text{mm} \pm 2\text{mm}$
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TOLERANCE RANGE

BS3921	prEN 771-1
<p>No dimension (length, width or height) of any individual brick in the sample (of 24 bricks) shall exceed the work-size WS by more than 10mm</p>	<p>Limit on variation (ie difference between largest & smallest determined dimensions) within the 10 brick sample:-</p> <p>$R1 = 0.6 \sqrt{WS}$</p> <p>$RS = 0.3 \sqrt{WS}$</p> <p>RO = range in mm declared by the manufacturer</p>

COMPARISON OF TOLERANCE RANGES (UK SIZES)

BS3921	prEN 771-1												
(Individual Units)	<table border="1"> <thead> <tr> <th></th> <th>R1</th> <th>R2</th> </tr> </thead> <tbody> <tr> <td>Length + 10mm</td> <td>9mm</td> <td>4mm</td> </tr> <tr> <td>Width + 10mm</td> <td>6mm</td> <td>3mm</td> </tr> <tr> <td>Height + 10mm</td> <td>5mm</td> <td>2mm</td> </tr> </tbody> </table>		R1	R2	Length + 10mm	9mm	4mm	Width + 10mm	6mm	3mm	Height + 10mm	5mm	2mm
	R1	R2											
Length + 10mm	9mm	4mm											
Width + 10mm	6mm	3mm											
Height + 10mm	5mm	2mm											

Table 2. Dimensional requirements of the BS and CEN Standard.

	BS3921	prEN 771-1
Solid	Solid	No reference
Perforations	<25% volume	No limit
No perforations	>10% area	
Material	>30% width	
Frog(s)	<20% volume	<20% volume
		Declaration: Shape and perforation direction Declaration (as required): Volume and shape of perforations Volume of frog Wall and web thickness

Table 3. Geometry requirements of the BS and CEN Standard.

III. Durability

4.9 BS3921 classifies bricks in terms of both frost-resistance and soluble salts content, combined in the following table:

Designation	Frost Resistance	Soluble salts content
FL	Frost resistant (F)	Low (L)
FN	Frost resistant (F)	Normal (N)
ML	Moderately frost resistant (M)	Low (L)
MN	Moderately frost resistant (M)	Normal (N)
OL	Not frost resistant (O)	Low (L)
ON	Not frost resistant (O)	Normal (N)

Table 4. Durability designations in BS3921.

4.10 Guidance on selection of bricks (and mortars) for various exposure conditions is given in the relevant Code of Practice (BS5628: Part 3). BS3921 allows manufacturers to declare the frost resistance of their products on the basis of proven experience, but usually laboratory testing is conducted using a panel freezing test.

4.11 pr EN 771-7 deals with freeze/thaw resistance separately, and categorises bricks according to their applicability in various exposure conditions:

FO	Passive exposure
F1	Moderate exposure
F2	Severe exposure

4.12 Again, the manufacturer can declare the category for his product based on proven experience, or make use of a traditional laboratory test. However, the European test method is now at an advanced stage of development and once approved will become the mandatory reference test for assessing freeze/thaw durability. The test is a more stringent version of the panel freezing test commonly used in the UK.

4.13 Adoption of the European test method will allow performance-related measurement. A significant proportion of UK bricks which have a history of good durability do not always achieve the full 100 freeze/thaw cycles required to meet the F2 designation. Many specifiers now insist on 'F' grade bricks (to BS3921) which is F2 in CEN terms. In order to achieve this quality it is often essential to blend in premium quality clays (such as Etruria Formation or certain Carboniferous mudstones). This may have to be imported from off-site.

4.14 In the longer term, revision of the CEN standard may impose more stringent requirements for the F1 category bricks ('M' grade in BS 3921) which may require an increase in blending of clay.

IV. Water soluble salts content

4.15 BS3921: 1985 (as amended 15 December 1995) specifies two categories of soluble salts level: Low (L) and Normal (N), with stipulated limits for specific (water soluble) ions.

4.16 prEN 771-7 shows three categories based on active soluble salts content expressed as cations of magnesium, sodium and potassium. A comparison of the requirements of both standards is shown in Table 5.

	BS3921	prEN 771-1
	L(ow) category	S2 category
Na ⁺ K ⁺ Mg ²⁺ SO ₄ ²⁺	<0.03% <0.03% <0.03% <0.50%	Combined Na ⁺ , K ⁺ <0.06% <0.03% no test
	N(ormal) category	S1 category
Mg ²⁺	Combined Na ⁺ , K ⁺ , Mg ²⁺ <0.25%	Combined Na ⁺ , K ⁺ <0.17% <0.08%
		S0 category
		No requirements

Table 5. Soluble salt limits set by the BS and CEN Standard.

4.17 The cation limits for equivalent categories in the two standards are very similar, but the potential for up to 0.06 per cent Na⁺ or K⁺ in the S2 grading could have implications for efflorescence (Na⁺). On the other hand, the S1 category imposes more specific limits than the equivalent BS3921 'N' grade, especially in the case of Mg²⁺, which can potentially cause erosion of brick surfaces.

4.18 Unless more onerous limits are introduced in later revisions, practical implications the UK brick industry are minimal.

V. Compressive strength

4.19 British Standard 3921 classifies bricks according to their compressive strength and water absorption (Table 6).

Class	Compressive strength	Water absorption
Engineering A Engineering B	N/mm ² ≥70 ≥50	% by mass ≤4.5 ≤7.0
Damp proof course 1 Damp proof course 2	≥5 ≥5	≤4.5 ≤7.0
All others	≥5	No limits

Table 5. Classification of bricks by compressive strength and water absorption in BS 3921.

4.20 Note that two grades of engineering brick and two grades of damp proof course (dpc) bricks are classified, with defined limits for both compressive strength and water absorption. Otherwise, the mean compressive strength of a 10 brick sample must be not less than the declared value.

4.21 prEN 771-1 does not define ‘engineering bricks’, but again the mean strength of a 10 brick sample must be equal to, or greater than, the declared strength. Furthermore, for certain uses the brick manufacturer has to declare whether all 10 test bricks met at least 80 per cent of the declared strength.

4.22 The CEN Standard specifies a different sample preparation technique for test bricks, resulting in most cases in higher numerical values for compressive strength than might be obtained using the BS3921 test.

VI. Water absorption

4.23 BS3921 requires a declaration of water absorption (measured as the mean value of a 10 brick sample subjected to a 5h boil). Specific limits are imposed for Class A and Class B Engineering bricks, and for dpc1 and dpc2 bricks. prEN 771-1 specifies the same test method, but only for dpc bricks, for which the manufacturer declares the value.

4.24 The introduction of a compressive strength category with a range limitation (no individual value below 80 per cent of the declared strength) represents a considerable tightening. Manufacturers will have to minimise firing variation within the kiln setting, or opt for a declared value well below the mean strength.

4.25 Higher apparent strengths resulting from the CEN testing technique will have to be accommodated by numerical changes in the Codes of Practice for masonry.

4.26 Limitation of water absorption measurements to dpc bricks in prEN 771-1 will disadvantage UK brickmakers and designers. BS5628 ‘Code of Practice for use of

masonry' relates three ranges of water absorption to the characteristic flexural strengths to be used in design of masonry. Brickmakers may need to produce bricks of lower water absorption to ensure they meet the flexural strength requirements via panel tests, so blending of premium quality clays may well be necessary.

VII. Other properties

4.27 The CEN Standard includes reference to properties such as density, moisture expansion, thermal, acoustic and fire properties not covered in the British Standard: The inclusion of requirements not contained in the British Standard will add to the pressure on brick producers to tighten manufacturing regimes and to reduce variability in the product. To this end, more sophisticated blending of clays and other raw materials looks inevitable.

APPENDIX 5: IMPACT OF FUTURE TECHNOLOGICAL TRENDS

Introduction

5.1 Patterns of demand for raw materials for bricks, pipes and tiles are driven by a number of technical, economic and environmental factors. The purpose of this section is to briefly examine the likely effect on clay demand of future technical changes in the structural clay products industry and the construction sector which it serves.

5.2 In 1996 the Brick Development Association published 'Bricks at the Crossroads'. This was a review of factors affecting the market for bricks, and measures required to keep the material to the forefront as a construction material (especially in housing). A shortage of skilled bricklayers in the construction sector was identified as a particular problem.

5.3 'Re-thinking Construction' (Egan, 1998) was published following concerns about lack of co-ordination and modernisation in the construction industry. The Egan report called for radical changes, and includes the challenging target of year-on-year cuts in the costs of construction whilst increasing profit and turnover. These seemingly contradictory objectives can only be achieved through massive improvements in productivity. This will require tighter planning and co-ordination, better designs, reduced wastage of materials and (crucially) much speedier and cleaner construction operations on site.

5.4 In the 1960s, the UK turned to prefabrication in an effort to meet urgent housing needs. The problems this created led to a swing back to traditional masonry construction. However, factory production is increasingly seen as an answer to problems of quality control and productivity. In parallel, improved site construction methods are being developed, which in some cases will make use of new or modified building units made from fired clay. Environmental pressures are also influencing changes in fired clay products.

Changes to improve site productivity

5.5 Bricklaying productivity can be increased by using larger units. This has been demonstrated by the wide scale replacement of fired clay common bricks by concrete blocks (each equivalent in size to six bricks). Larger units also require less mortar, and attractive facing blocks (or large-format bricks) are already used within continental Europe. Current manual handling regulations would not encourage heavier units, so perforated (or porous lightweight) bricks/blocks are necessary. Storey-height clay planks are employed in continental Europe. These are designed to be handled by two operatives.

5.6 External walls of most house and other new buildings are of cavity construction, with clay bricks often forming the outer leaf. Double-width clay units, which can be pressed, extruded or thrown, will allow the wall to be built in a single operation. These units are designed to minimise risk of rain penetration and can be insulated by applying a lining material to the inner face of the wall. A variation on the double-width brick is a

brick/block composite. In this case the block can be lightweight and cement-based, with a foamed insulant bonding the two units together.

Prefabrication

5.7 Prefabricated panels constructed with conventional bricks have been assessed for site-assembly. Apart from their weight, which demands mechanical lifting and placing, low flexural strength is a problem. Brick-mortar bond can be improved by keying of the bed-faces of bricks (pressed or extruded). Weight can be reduced by pressing cellular bricks, or by extruding what are effectively square-section pipes with keyways in the bed faces. Both options result in thin section profiles at the face of the walls.

5.8 Various panelling systems rely on clay facing-slips (typically 15 mm thick) to provide attractive, low maintenance weathering surfaces. The slip-tiles can be bonded directly by casting cement-based panels onto the back of the spaced tiles, or by an equivalent technique using foamed rigid plastics such as polyurethane. If the market moves significantly in this direction, most brickmakers will have to modify or replace existing plant.

5.9 There is a growing market for clay brick-slips for application to existing buildings, often using stainless-steel support mesh which can also fix in place sheets of foamed plastic insulant (between slips and wall). This is an effective way of upgrading/refurbishing older properties.

5.10 The same system can be applied to new buildings, erected swiftly from pre-cast panels then slip-faced on site by specialist contractors.

5.11 Clay facing units can be highly perforated to reduce weight (especially when the CEN Standard EN771-1 'Clay Units' is adopted, since this imposes no limits on web-thickness of the units). Incorporation of burnout material in the clay will further reduce the fired density. Large-format bricks or blocks made in this way can be assembled into panels in a factory using quick-setting strong adhesives, so that flexural strength is perfectly adequate for transportation and site handling.

5.12 A recognised problem with panel construction is the sealing of the joints at edges. Vertical dry-tiling using 'mathematical tiles' offers a proven means of making walls weather-resistant and aesthetically attractive with low long-term maintenance costs.

Implications of future technological trends on clay demand

5.13 Clays used in the manufacture of both modified and prefabricated units must produce fully-durable (frost resistant) products. Prefabricated panels will have to meet increasingly stringent thermal insulation requirements, so the external surface layer will have to contend with periods of saturation and extreme cold. Larger units will demand clays with low drying/firing shrinkage to meet size tolerances. Through-the-Wall units require limited Initial Rate of Suction (IRS) to optimise brick/mortar bond and reduce the risk of rain penetration. The type of clay raw material used is a major factor in controlling

IRS in the finished product. Low-shrinkage clay materials will also be required to achieve tight size tolerance in prefabricated panels. Fine-grained, high-quality clays will be required for thin-walled units and vertical tiles. The implications of this trend toward increasing specification of raw materials is that demand for premium clays will be sustained or show some growth. Premium clays are likely to be from those resources which are already sought after by the industry, Etruria Formation clays, certain Carboniferous mudstones, as well as (possibly) fireclays and ball clays. These clays will be need to be imported on-site to improve existing blends to enable them to meet specification, or to be used as the principal component in the production of highly engineered modified bricks, panels or tiles

APPENDIX 6: SUPPLY AND DEMAND FOR BRICK CLAY

Production

6.1 The production of clay and shale for the manufacture of bricks, pipes and tiles appears under the heading 'Common clay and shale' in official production statistics and has been separately recorded since 1974. Production data for the period 1974 – 1998 are shown in Figure 15. Brick manufacture is the largest tonnage use, accounting for over 90 per cent of the clay extracted in this sector. The decline in clay and shale production from 18 million tonnes in 1974 to 8.2 million tonnes in 1998 is broadly in line with the decline in clay brick manufacture during the period (see Figure 16) assuming that the manufacture of 1000 bricks uses some 3 tonnes of clay. Clay and shale extraction occurs principally in England reflecting the location of brick manufacturing capacity.

Thousand Tonnes

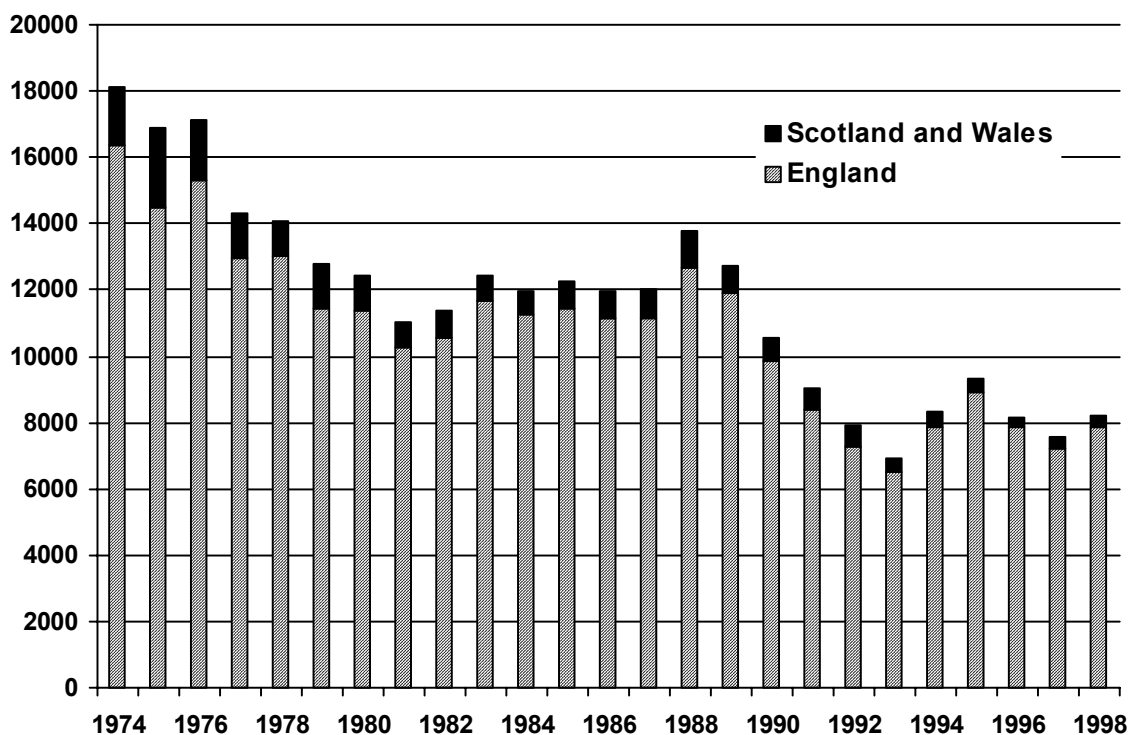


Figure 15. Great Britain: Production of clay and shale for bricks, pipes and tiles, 1974-98

Source: *Annual Minerals Raised Inquiry*. Office for National Statistics.

6.2 Fireclay is also used in the manufacture of bricks and pipes, and extractor's sales for these uses have also been separately recorded under the overall heading of 'Fireclay' since 1974. According to official statistics fireclay production for the manufacture of 'bricks, pipes and tiles' apparently declined from 802 000 tonnes in 1974 to 168 000 tonnes in 1997. The latter figure is considered to be a gross underestimate, because it excludes sales from stockpiles, which are a major source of supply. Official figures for the production of fireclay in 1998 were 577 000 tonnes. The collection of reliable data on

fireclay production is complicated by the mineral being primarily a by-product of opencast coal production. Opencast coal sites have short lives and whilst most do not produce fireclay others may only produce fireclay intermittently. At a few sites large tonnages of fireclay have been stockpiled for subsequent sale long after coal production has ceased. Recording production has thus proved difficult. In view of the importance of fireclay to the brick industry, together with impending supply difficulties, it was felt that obtaining accurate data on production was imperative. An independent survey of the clays, including fireclay, used in brick, pipe and tile manufacture was carried out as part of this study (see Appendix 1).

Value

6.3 Clay and shale, and fireclay, used in the manufacture of bricks, pipes and tiles have a low unit value, which does not truly reflect their importance to the national economy. The value of common clay and shale, and fireclay production was placed at £16.8 million and £1.7 million, respectively, in 1997 implying unit values of £1.5/t and £5/y on an ex-quarry basis. However, with the increasing trend towards blending and the consequent movement of clay raw materials, transport costs may more than treble these values, particularly in the case of fireclay. Nevertheless clay remains a relatively low-cost raw material but one that supports a manufacturing industry of considerable importance and which has a high value-added content. The value of the sales of the principal products of the clay bricks, tiles and construction industry was £548 million in 1996. Thus clay with an ex-pit value of some £20 million gives rise to sales of £548 million. The value of specific sectors of this industry is shown in Table 6 highlighting the value of the brick manufacturing sector.

Prodcom commodity code	Product	£ thousand			
		1993	1994	1995	1996
26401110	Clay bricks	446,575	511,297	508,846	446,798
26401250	Clay roofing tiles	30,668	29,251	35,019	32,269
26401300	Clay pipes	53,781	57,273	S	S
26401270	Clay constructional products	18,922	18,936	18,776	19,665

Prodcom: The term 'Prodcom' is derived from PRODUCTS of the COMMUNITY and is an EU-wide survey.

S Suppressed data.

Source: Product Sales and Trade. Office for National Statistics.

Table 6. Sales of clay bricks, tiles, pipes and construction products (Standard Industrial Classification Code 26400), 1993–1996.

Demand

6.4 Clay-based building bricks account for well over 90 per cent of the total brick market, with concrete and sandlime bricks being of comparatively little importance. The major decline in brick production since the mid-1960s has been almost entirely due to the

demise of common bricks (Figure 16). In contrast, production of facing and engineering bricks has shown some modest growth (Figure 17). The declining use of common bricks is due to their replacement with other building materials, such as breeze blocks, lightweight blocks and timber-frame plasterboard for the inner leaf of cavity walls and for these materials or stud partitioning for internal walling in housing construction. There has also been a steady decline in the use for clay roofing tiles in favour of concrete roofing tiles, although this situation is now being reversed. Recent data for clay roofing tile manufacture are not available.

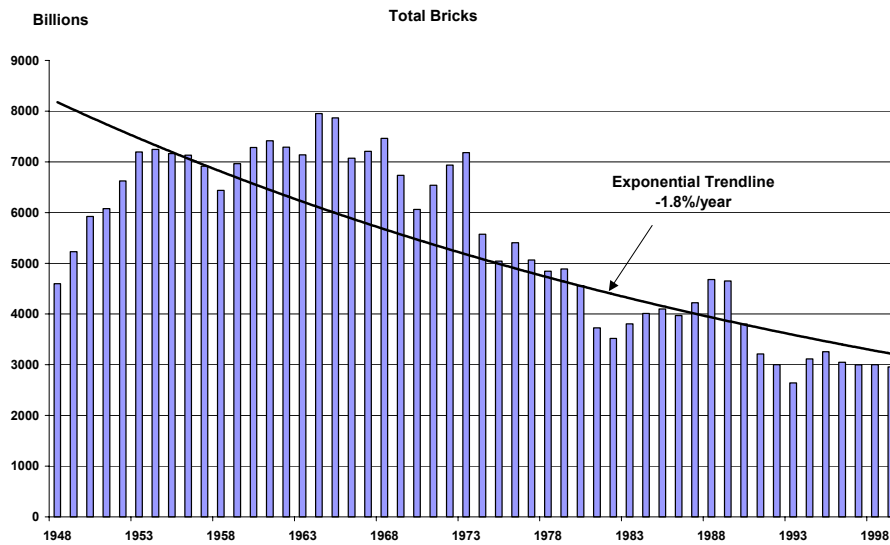


Figure 16. UK: Brick production, 1948 – 1999.

Source: *Monthly Statistics of Building Materials and Components. DETR.*

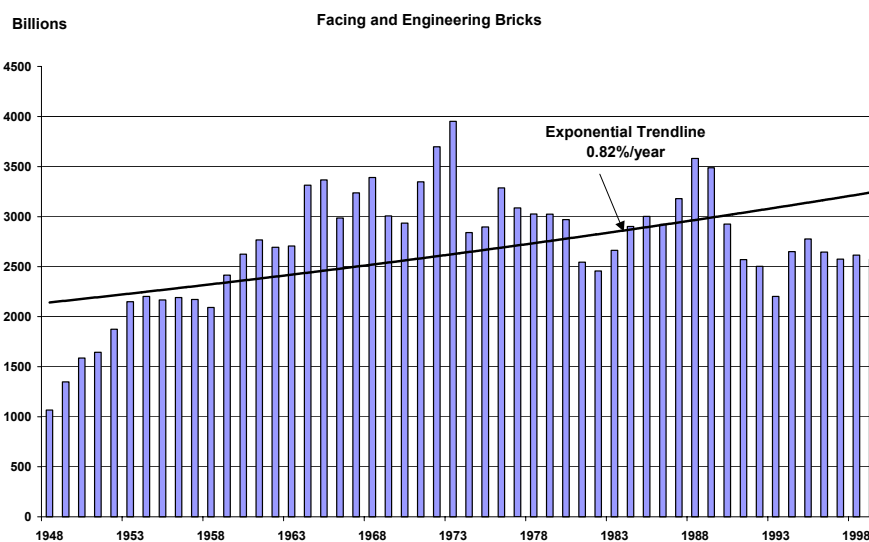


Figure 17. Production of facing and engineering bricks 1948-1999.

Source: *Monthly Statistics of Building Materials and Components. DETR.*

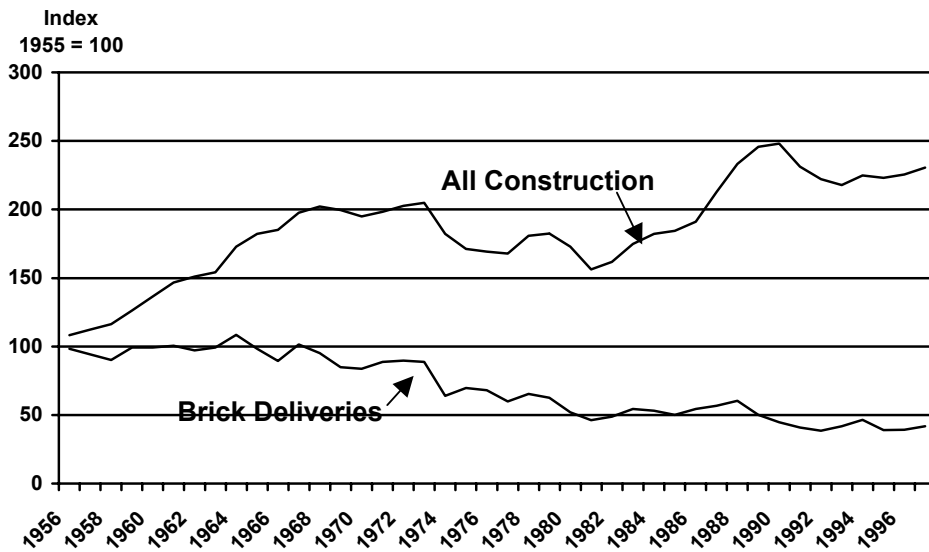


Figure 18. Relationship between construction output (at constant 1990 prices) and brick deliveries
 Source: *British Geological Survey*

6.5 Production and consumption (deliveries) of building bricks largely reflects activity in the construction industry. Construction output, including new and repair/maintenance work, although highly cyclical, has been on rising trend. There is, however, a poor correlation between brick deliveries and construction output (Figure 18) resulting in a decline in brick deliveries per unit of construction output (Figure 19). This relative decline appears to have ceased during the last decade or so suggesting that production might now have stabilised roughly at its current level (3000 million bricks / year). There are a number of factors for this loss of market share. Firstly an important element in the overall increase in construction activity has been infrastructure (including roads) and industrial building, in which bricks are little used. Secondly, the major market for bricks is house building which has also generally declined since the late-1960s (Figure 20).

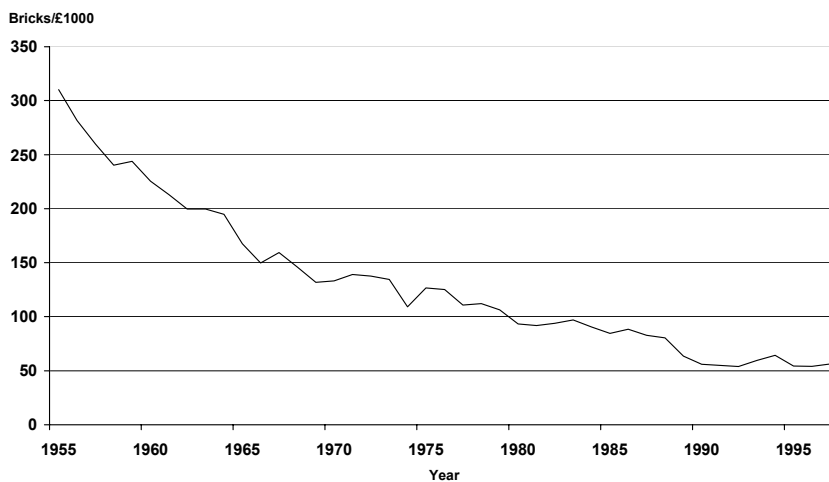


Figure 19. Brick Deliveries/£1000 Construction Output (at 1990 constant prices), 1955-1997
 Source: *British Geological Survey*

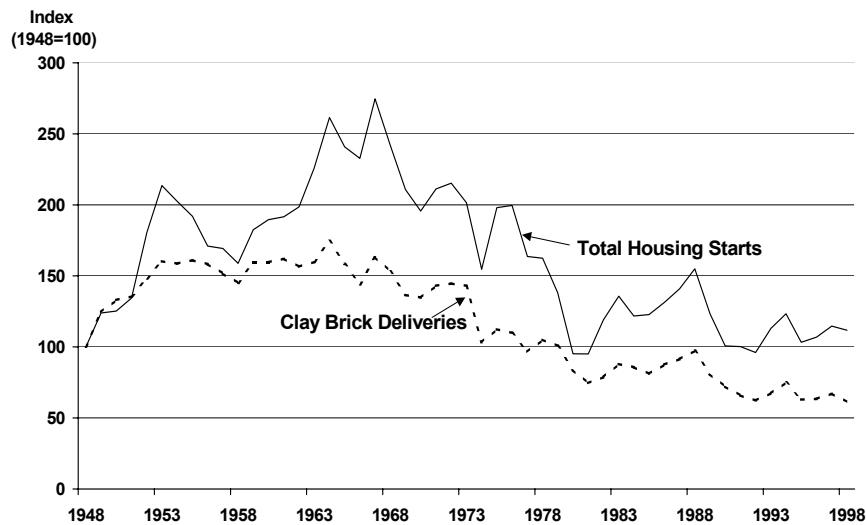


Figure 20. GB: Relationship between Total Housing Starts and Clay Brick Deliveries, 1948-1998.
Source: *Housing and Construction Statistics. DETR.*

Future

6.7 The future demand for clay and shale, including fireclay, will probably be dominated by the demand for bricks, with pipe manufacture, by comparison, requiring relatively modest tonnages of raw materials. Requirements for clay roofing tiles are uncertain, but could increase significantly (in France for example, clay roofing tiles have increased their market share to around 70 per cent compared with less than 10 per cent in Britain). The future demand for bricks will continue to primarily reflect activity in the housing building sector, although bricks are also increasingly being used for office development, supermarkets, hotels and filling stations. An average three-bedroom house requires some 8500 bricks (approximately 25 tonnes of clay) in its construction. Despite an increase in the number of households required in England, the industry anticipates that brick production is likely to stabilise at around 3000 million bricks a year, equivalent to some 9 million tonnes a year of brick clay.

6.8 A feature of housing starts is the increasing importance of private housing compared with public building, which is now almost non-existent. In 1998, 87 per cent of housing starts were private with almost all the remainder being housing association building. By comparison in 1980 and 1970 64 and 52 per cent of total housing starts, respectively, were in the private sector. One important feature of this is that there has been an increasing demand for bricks valued for their architectural appearance, in addition to their functional properties. Continued pressure from consumers and planners for new housing and other buildings to have a 'traditional' appearance (sympathetic to local vernacular styles) has important implications for the future demand for clay raw materials. This will be driven not only by the quantity of demand but also by the quality of the raw materials. Blending different clays to achieve improved durability and to provide a range of fired colours and aesthetic properties will become an increasingly common feature of brick

manufacture. This will require flexibility to be maintained in brick clay supply to ensure a wide range of materials is available for blending.

International trade

6.9 Common clay and shale are not separately recorded in the trade statistics, but the mineral is not thought to be traded because of its low value. Fireclay is traded in small quantities; imports were 3007 tonnes in 1998 and exports 1234 tonnes. The high unit value of the clay suggests that it is material for specialised refractory applications. Trade in clay construction products is recorded under the Standard International Trade Classification (SITC) heading *Non-refractory ceramic bricks, tiles, pipes and similar products*. Trade in the main sub-divisions is shown in Table 7.

Product and commodity trade code	Year	IMPORTS		EXPORTS	
		Tonnes	Value £000	Tonnes	Value £000
Building bricks and related products (6904 1000 + 6904 9000)	1988	226 843	15 053	16 724	2 243
	1989	257 792	17 735	19 936	2 593
	1993	75 369	5 611	24 564	4 756
	1994	103 827	9 761	61 645	8 577
	1995	88 886	8 634	80 594	10 487
	1996	75 309	7 203	93 038	25 460
	1997	99 422	7 743	50 148	7 061
	1998	142 526	6 444	63 013	7 005
Roofing tiles and related products (6905 1000 + 6905 9000)	1993	4 843	1 149	2 317	1 737
	1994	4 903	1 104	3 513	1 226
	1995	14 371	3 505	6 338	1 999
	1996	12 145	3 049	7 843	2 938
	1997	14 782	3 861	5 737	2 740
	1998	17 153	7 856	8 734	3 629
	Ceramic pipes and fittings (6906 0000)	1993	345	182	18 627
1994		194	270	33 431	5 992
1995		1 097	320	49 097	9 573
1996		1 156	351	58 913	17 457
1997		1 469	946	67 437	17 359
1998		923	408	58 569	13 958

Table 7. UK: Trade in constructional clay-based products, 1993 – 1998.

Source: HM Customs & Excise. *Overseas Trade Statistics of the United Kingdom*

6.10 Trade in clay construction products is relatively small because of their comparatively large bulk and low unit-value. The UK is a small net importer of building bricks in tonnage terms and the brick industry is essentially self sufficient with imports comprising only 1-2 per cent of the total brick market even at the height of the construction boom in the late 1980s. In 1998 the UK had a net trade balance of £13.55 million in clay-based constructional goods, largely due to exports of ceramic pipes.

‘Trade’ in clay and other raw materials for brick manufacture

6.11 With the exception of fireclay, brick clays are not normally sold on the open market, although there is considerable movement of clay between sites within companies. In addition to clay, other raw materials for blending into the brick body (including sand, calcium carbonate, coal and coke, and pulverised fuel ash) are imported by a large number of manufacturing sites (Table 8). Returns from 81 brick manufacturing sites were obtained from the 1998 survey. Of these, 48 were extrusion plants, 25 soft-mud or hand-made and 8 produced bricks by pressing. Of these 81 sites, only 8 were completely self-sufficient in brick making raw materials (clay and non-clay). In contrast, 17 sites had no captive raw materials adjacent to the works and were totally dependent on imported raw materials to maintain production.

Manufacture method	Clay imports		Non-clay imports (sand etc.)	
	% of sites importing	Average import level as % of total raw material used at site	% sites of importing	Average import level as % of total raw material used at site
Extrusion	81	53	33	4
Soft-mud/ hand-made	32	57	76	14
Pressed	0	n/a	20	14

Table 8. Contrasting levels of clay and non-clay imports to sites manufacturing by different methods.

6.12 Manufacturing method is a major factor influencing the level and type of raw material imports to brick production sites. Table 8 show that over 80 per cent of sites producing bricks by extrusion import clay, whilst only 32 per cent of sites making soft-mud and hand-made bricks import clay. However, the ratio of ‘imported’ to ‘captive’ clay is about the same for both manufacturing methods (on average, 50-60 per cent of clay used is imported from off site). In contrast, the number of soft-mud and hand-made sites importing non-clay raw materials is much higher (76 per cent) than sites producing by extrusion (33 per cent). Imported, non-clay raw materials also tend to form a significantly smaller proportion of total raw material usage at extrusion sites (average 4 per cent as opposed to average 14 per cent at soft-mud/ hand-made sites).

6.13 The extrusion process tends to be more demanding of the clay raw material than the soft-mud process (see Appendices 2 and 7). Higher quality clays (such as Etruria Formation material, fireclays or particular Carboniferous mudstones) are often imported and blended with the clay produced on site to improve the technical performance and appearance of the finished brick. The drive toward higher specification products (see Appendix 4), together with the need to maintain and enhance aesthetic properties, has increased the level of clay blending, particularly in extrusion plants.

6.14 Because of their close association with opencast coal, fireclays are almost always imported into a production unit from off-site sources. They are the only brick clay raw material traded commercially on a large-scale. Fireclay usage is largely confined to sites in the Midlands, the North and Scotland.

6.15 Blending of clays is less common in plants producing bricks using the soft-mud process. This process is generally more ‘forgiving’ than extrusion in tolerating a wider

range of clay compositions (see Appendix 7). Although imports of clay to improve the technical and aesthetic qualities of brick products are made at many soft-mud sites, this practice is not nearly as common as it is at sites making extruded bricks. However, because of the need to control shrinkage of soft-mud bricks during the drying phase, sand must be added to the mix (see Appendix 7). This is imported from off-site to almost every soft-mud works. Many soft-mud works also produce yellow stock bricks by blending red-firing clay with calcium carbonate. This material (usually in the form of ground chalk) is also imported. Other non-clay 'body' additives such as coal, coke and PFA are imported from off-site, more commonly at sites that use the soft-mud process rather than extrusion.

6.16 The number of extrusion sites importing clay for blending is appreciably higher than that of soft mud sites. However, the number of soft-mud sites importing non-clay raw materials is much higher than that for extrusion sites. In all, transport of raw materials from off-site occurs at over 90 per cent of the producing sites surveyed. However, soft-mud sites generally import smaller tonnages of raw material than extrusion sites.

6.17 Another factor which may influence the level of clay imports to sites is their location in relation to other development. The industry in the Midlands and the North has historically been associated with urban and industrial development, whereas the industry in the South East has developed in predominantly rural areas. This has led to a higher proportion of sites in the Midlands and North being dependent on imported clay because resources adjacent to the site have been sterilized by other forms of development. Planning restrictions which forbid the import/export of clay from particular sites are relatively common in the South East.

APPENDIX 7: RESOURCES AND RESERVES

Definition of brick clay

7.1 The mineralogy, chemistry and physical properties of a clay are essential in determining its suitability as a raw material for the manufacture of bricks, pipes and / or tiles. These factors affect the forming behaviour of the clay (the process prior to firing in which the ware is shaped from the clay) and also the behaviour of the ware during the firing phase. They will be the main determinant of the technical properties of the final product (how it will perform in service), as well as its aesthetic properties (colour and texture).

Forming behaviour

7.2 The mineralogy of a brick clay is a major determinant in the type of forming process used. High inherent moisture content in a brick clay is generally a reflection of clay mineralogy and texture. Relatively high levels of the clay mineral smectite (montmorillonite) will give rise to high moisture contents. Fine particle size will have a similar effect. The extrusion process requires clay with a relatively low moisture content (less than 12%). This can be difficult to achieve in geologically 'younger' clays, such as those in the south east of England. Clay mineralogy and texture of these clays often gives inherent moisture contents greater than 15%. These clays are therefore more suited to the soft mud process, which generally utilises much higher moisture contents (up to 30%). Plastic behaviour is essential to the extrusion process. The presence of the clay mineral kaolinite (particularly the fine-grained 'b'-axis disordered variety) will enhance the plasticity of a clay. Plasticity is less critical to the soft mud process, which is more tolerant of non-plastic additives, including 'waste' materials such as PFA. High moisture contents give rise to higher shrinkage between the 'green' (wet) state and the dry state which must be achieved prior to firing. The amount of green to dry shrinkage is important, with high rates of shrinkage causing more failures due to cracking. This is minimised by adding sand to many soft-mud bodies.

Firing behaviour

7.3 In the firing process, clays which contain the clay minerals illite (mica) and b-axis disordered kaolinite are generally preferred. The potassium within the crystal structure of illite is an excellent flux which reduces the temperature of glass formation during the firing process. Kaolinite is relatively refractory and will extend the vitrification range of the clay. A mixture of illite and kaolinite tends to show optimum firing characteristics. Clays with this mineralogy include portions of the Coal Measures Group mudstones, Etruria Formation, Peterborough Member (Lower Oxford Clay) and the Weald Clay Formation.

7.4 The quantity and particle size of the quartz (silica) component of the clay is also a major determinant of firing characteristics. Fine-grained clays (which generally have a

relatively low silica content) tend to mature at lower temperatures than coarser –grained clays with a higher quartz sand or silt content.

7.5 Carbon and sulphur contents are also critical to firing performance. Excessive carbon can cause the interior of the ware to ‘heart’ or turn blue as the carbon reduces iron oxides from the ferric to the ferrous state. In extreme cases this can lead to ‘bloating’ as gases generated within the body are trapped in a viscous glass, resulting in distortion of the ware. These reactions are more likely to occur where fast-firing cycles are used, particularly in dense, extruded bodies. This reduction reaction is widely used in the industry to achieve a variety of technical and surface colour effects, although the reactions are also commonly promoted by control of kiln atmosphere. An excess of carbon can also lead to continued burning within the cooling zone. This is difficult to control and can result in undesirable emissions being transmitted to the dryer via the waste heat recycling system. Low carbon clays are generally preferred, since the effect of carbon added to a previously low carbon-clay is easier to predict than the behaviour of a clay with a natural carbon content. Carbon levels up to 1.5% are generally acceptable (whether natural constituent or additive). Maximum sulphur is about 0.2%

Raw materials for buff and yellow bricks

7.6 Very pale buff/ cream through-colour extruded bricks are only possible with fireclays. The proportion of fireclay used in the body varies from 50 to 100 per cent, depending on the properties of the fireclay(s) and other clays used in the blend, and the technical and aesthetic properties required in the final product. The manufacture of fully-durable yellow bricks from a mixture of clay and calcium carbonate (or dolomite) is generally only possible using the soft-mud process. These can utilise ‘younger’ clays which generally have an inherent CaCO_3 content, although CaCO_3 is generally added (generally in the form of finely-ground chalk) in proportions which vary up to about 22%. Addition of CaCO_3 to Coal Measure shale to produce an extruded buff brick is considered impractical. This would require the addition of a relatively large amount of CaCO_3 which degrades the technical properties of the brick, particularly with regard to strength and durability.

Geological overview of brick clay resources

7.7 The brick, tile and pipe industry in Britain is largely dependent on a relatively restricted range of resources (see Appendix 1). These consist of:

- Cretaceous clays: chiefly the Weald and Wadhurst clays of the Weald in South East England;
- Jurassic clays: chiefly Peterborough Member (formerly known as the ‘Lower Oxford Clay’) in Bedfordshire and Cambridgeshire;
- Permo-Triassic clays: chiefly Mercia Mudstone Group (formerly known as ‘Keuper Marl’) in the Midlands;
- Etruria Formation clays (formerly known as ‘Etruria Marl’): West Midlands and North Wales;

- Carboniferous clays: chiefly mudstones from the Coal Measures Group and Millstone Grit Group in the English and North Wales coalfields, and from the Coal Measures Group and the Clackmannan Group in central Scotland. The Carboniferous also hosts all the fireclay utilised by the industry

7.8 A geological overview of each of these principal brick clay resources is given below. A brief description is also given of the other clay resources that are utilised on a more minor scale by the industry.

Principal brick clay resources

Wadhurst and Weald clays

7.9 The Cretaceous Wadhurst and Weald clays are largely confined to the Weald of East and West Sussex, Kent and southeast Surrey. Their outcrop is the result of the denudation of the Wealden Anticline. The Weald Clay underlies a gently dissected lowland tract in an arc around the Weald. Within the Hasting Group the Wadhurst Clay has a similar arcuate distribution but one which has been considerably modified by faulting. (Figure 21). The two clays form part of the 'Wealden Beds' deposited within the Weald Basin in the Lower Cretaceous. The formal lithostratigraphy for the Lower Cretaceous of the Weald area is shown in Table 9.

Group	Formation
Chalk	
Upper Greensand	
Gault	Upper Gault
	Lower Gault
Lower Greensand	Folkestone
	Sandgate
	Hythe
	Atherfield Clay
Weald Clay	Weald Clay (upper Division)
	Weald Clay (lower Division)
Hastings	Upper Tunbridge Wells Sand
	Grinstead Clay
	Lower Tunbridge Wells Sand
	Wadhurst Clay
	Ashdown
Purbeck	

After Ruffell *et al.*, 1996

Table 9. Lithostratigraphy of the Lower Cretaceous of the Weald area.

Wadhurst Clay

7.10 The Wadhurst Clay is about 70 to 80 m thick at its maximum in the Horsham and Tunbridge Wells area, but is known to thin in all directions away from here to as little as 27 m. Locally the thickness may be greatly affected by valley bulging and faulting.

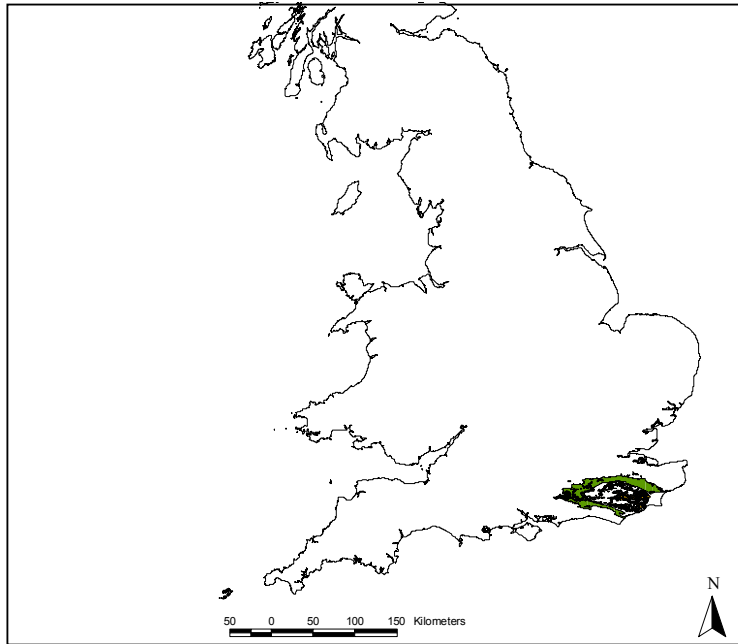


Figure 21. Outcrop distribution of the Weald Clay and the Wadhurst Clay.

7.12 The deposit comprises dark grey mudstones and silty mudstones (often described as shales in the literature, because of their partial lithification and thin bedding). The clay mineralogy is dominated by kaolinite and illite, with some mixed-layer mica-vermiculite. The sequence is divided by thin clay-ironstone (mainly in the lower part of the sequence), shelly limestone, calcareous sandstone, sandstone and rare lignite beds. When freshly exposed the beds are generally seen in shades of drab grey tinged bluish or greenish with only the highest parts taking on a bright red colour. Weathering imparts an ochreous greenish grey colour. 2 to 3 m thick discrete beds and lenses of calcareous sandstone occur within the sequence. The non-calcareous sandstone, siltstone, clay-ironstone and lignite beds are usually less than a metre thick.

Weald Clay

7.13 The Weald Clay has a maximum recorded thickness of 456 m at Shalford, but is known to thin to the north and east to approximately 110 m and 150 m respectively.

7.14 The Weald Clay comprises predominantly thinly bedded clay, shale and compact mudstones with beds of sandstone, shelly limestone and clay-ironstone. These beds are often laterally persistent. The deposit also contains disseminated pieces of lignite. In freshly exposed sections the Weald Clay is drab pale to dark grey with blue, green and brown tinges. Illite and kaolinite dominate the clay mineral assemblage. At some

horizons, most commonly associated with sands, the deposit takes on a distinct bright reddish hue or becomes mottled bright red and green, these are thought to represent periods of emergence. This feature is commonly referred to as ‘catsbrain’ mottling. The deposit weathers to yellow and shades of yellow brown, often with secondary gypsum. Weathering can penetrate up to 20 m, although it is generally seen only to a depth of 2 to 6 m.

7.15 The fine-grained crystalline dark grey-brown limestone beds are generally thin usually in the range 0.1 to 0.3 m. The sandstones are uniformly fine- to very fine-grained and generally thinly bedded and most have a calcite cement. These rock-types are avoided by brickmakers, as are clays which contain abundant calcareous fossils or secondary gypsum.

Peterborough Member (‘Lower Oxford Clay’)

7.16 The Oxford Clay Formation is a mudstone-dominated unit of Middle to Upper Jurassic age, that occurs at outcrop from the Dorset to Yorkshire. In the past, the succession of strata that makes up the formation, typically about 70 m thick in central England, has been divided into three parts, the Lower, Middle and Upper Oxford Clay, each of which has somewhat different lithological characteristics. These three units have recently been formalised as members of the same formation, being named the Peterborough Member, Stewartby Member and Weymouth Member in ascending order.

7.17 The Peterborough Member (the Lower Oxford Clay) includes brownish grey, fissile, kerogen-rich mudstones (bituminous shales) which distinguish it from the overlying members of the Oxford Clay, which are dominated by mid- to pale-grey blocky mudstones

7.18 The approximate outcrop and distribution of the Oxford Clay Formation is shown in Figure 22. Much of the outcrop of this clay is concealed beneath drift deposits (including river alluvium, terrace gravels and glacial deposits).

7.19 The Peterborough Member is around 39 m thick in the Swindon area of Wiltshire, thinning gradually north-easwards being c. 28 m in the Oxford area, c. 24 m at Milton Keynes, c. 21 m at Bedford, and c. 17 m at Peterborough. It possibly thickens slightly to c. 20 m in the Spalding-Lincoln district, from where it thins substantially northwards being only a few metres thick around Brigg and zero just north of the Humber.

7.20 The Peterborough Member is made up of brownish-grey, fissile, organic-rich (bituminous) mudstones with subordinate beds of pale-medium grey, blocky mudstone. The clay mineralogy is dominated by illite, with subordinate kaolinite. The basal beds of the member are commonly silty, with shelly beds. In addition, argillaceous limestone (‘cementstone’) nodules occur scattered throughout the member, often as nodule bands. The nodules, flattened spheroids which may be up to 1 m in diameter, typically make up no more than 10 per cent by volume of the host bed.

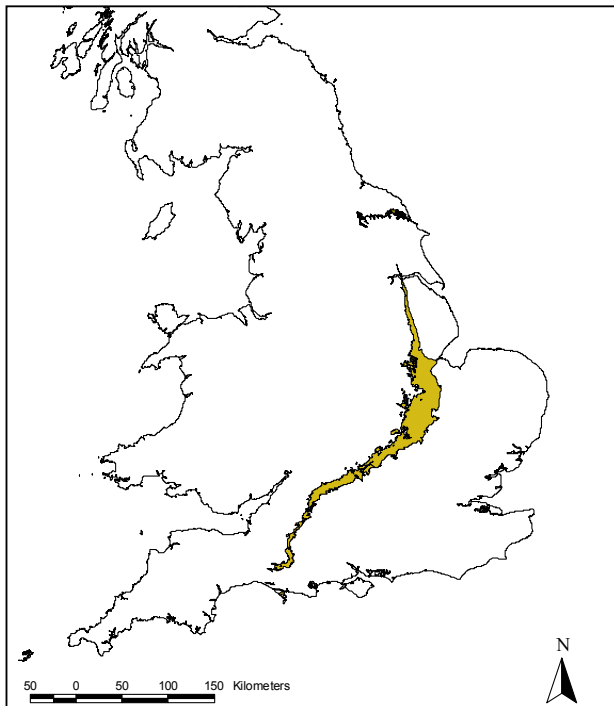


Figure 22. Outcrop of the Oxford Clay Formation.

7.21 In the near-surface zone the Peterborough Member weathers to a pale grey clay with ochreous mottles (known as ‘callow’). This weathered material is characterised by the presence of selenite (crystalline gypsum) which has formed as a result of the oxidation of pyrite in the presence of calcium carbonate.

7.22 Peterborough Member clays differ from the other principal brick clay resources in their high inherent carbon content (about 5 per cent) which acts as an internal fuel in the firing process (see Appendix 2).

Mercia Mudstone Group (‘Keuper Marl’)

7.23 The Mercia Mudstone Group crops out extensively in the English Midlands, forming a continuous belt from Teesside to Gloucestershire. Southwards, it occurs in South Wales, Somerset, East Devon and Dorset. Westwards, it extends in to Derbyshire, Staffordshire, Cheshire, south Lancashire, and south Cumbria. The Group also crops out in north Cumbria and the Scottish Borders, the Isle of Man and Northern Ireland.

7.24 The Mercia Mudstone Group is generally more familiar to the brick industry as the ‘Keuper Marl’, although the latter is no longer acceptable as a stratigraphic term. The outcrop area of the Mercia Mudstone Group in England is shown in Figure 23.

7.25 In the eastern part of the outcrop, between Humberside and eastern Worcestershire, the group maintains a consistent thickness of around 200 m. Elsewhere, the thickness is

more variable owing to deposition in contemporaneously subsiding basins. A maximum thickness in excess of 1500 m occurs in the Cheshire Basin.

7.26 The Group consists of five formations, the Blue Anchor (youngest), Twyning Mudstone, Arden Sandstone, Eldersfield Mudstone and Tarporley Siltstone (oldest). The current extraction by the brick industry is confined to the part of the Mercia Mudstone beneath the Arden Sandstone. This consists of the lower part of the Eldersfield Mudstone Formation and the Tarporley Siltstones Formation. A summary of Mercia Mudstone Group stratigraphy is given in Table 10.

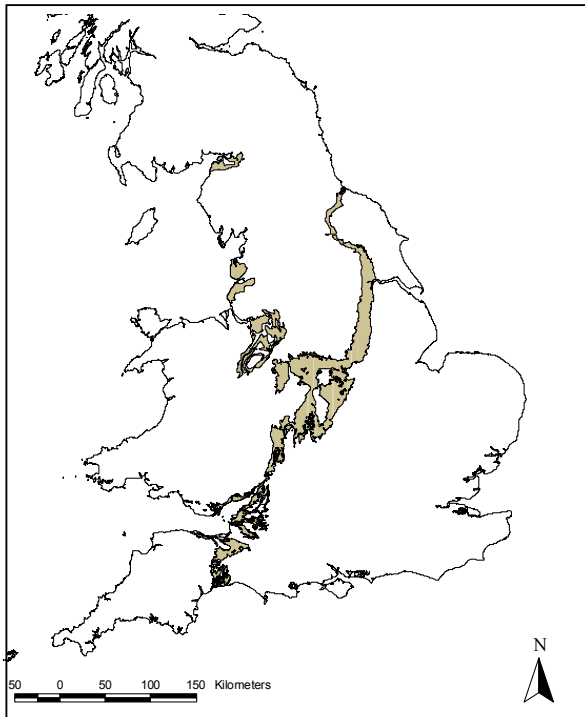


Figure 23. Outcrop of the Mercia Mudstone Group

7.27 The Tarporley Siltstone is the lowermost unit of the Mercia Mudstone Group. It varies in thickness from 40-60 m in the east to up to 270 m in Cheshire. It forms a distinctive unit composed of red-brown, micaceous mudstones and siltstones interbedded with micaceous sandstones. The clay mineralogy of the mudstones is dominated by illite. The sandstones are generally impersistent and subject to local thickness variations. Gypsum is usually absent but calcite may be present as small nodules.

7.28 The overlying Eldersfield Mudstone Formation shows wide variations in thickness across the country. In the east, it is generally around 120 m thick, thickening rapidly in the various basins to around 400 m in Worcestershire and to over 1000 m in Cheshire. It is characterised by red-brown, structureless, locally sandy mudstones and siltstones. The clay mineralogy of the lower part of this formation is dominated by illite. Gypsum occurs throughout the formation but is rarely abundant. It occurs mostly as thin veins and small

nodules, but may be present as thin beds up to about 0.1 m thick. It is usually leached out to a depth of around 30 m.

7.29 The presence of carbonate minerals (mainly dolomite) in many of the Mercia Mudstone Group clays produces bricks with a distinctive pale body colour which provides an ideal substrate for a range of applied facing finishes (see Appendix 2).

	EAST MIDLANDS	CHESHIRE	LANCASHIRE
BLUE ANCHOR FORMATION			
TWYNING MUDSTONE FORMATION			
ARDEN SANDSTONE FORMATION			
ELDERSFIELD MUDSTONE FORMATION	Edwalton Member Cotgrave Sandstone Member Gunthorpe Member Radcliffe Member	Wych Mudstone Member Byley Mudstone Member Bollin Mudstone Member	Breckells Mudstone Member Kirkham Mudstone Member Singleton Mudstone Member
TARPORLEY SILTSTONE FORMATION			

Table 10. Lithostratigraphy of the Mercia Mudstone Group, showing the principal local names. Halite units are not shown.

Etruria Formation ('Etruria Marl')

7.30 In the West Midlands, the principal brick clay resource is the Etruria Formation, a red bed sequence of Upper Carboniferous age. The main outcrops occur in Staffordshire, from where the formation was originally named (Etruria Marl), but there are comparable deposits in all the exposed coalfields in the area (Figure 24 and Table 11).

7.31 The formation consists chiefly of unbedded, structureless mudstone, dominantly reddish brown, but variegated in shades of yellow, grey, green and purple, together with sandstones and conglomerates. Thin, poor quality coals and volcanic rocks may also be present.

7.32 Over most of the region the formation succeeds the Coal Measures conformably, the lower boundary being defined at the incoming of more or less persistent red beds. In practice, exact definition is difficult, as commonly there is upwards transition from grey to red measures which can involve complex patterns of interdigitation. The base is strongly diachronous and lies at progressively lower horizons southwards. The top is marked by a widespread erosional unconformity, above which the sequence reverts to predominantly grey measures. Thickness variations are large, and reflect the tectonic instability of the period. The different boundary relationships are illustrated schematically in Figure 25.

7.33 Brick clay operations exploit the mudstones and silty mudstones that make up 50 per cent or more of most sequences. In these fine-grained sediments, distinctive zones of colour banding and mottling occur at discrete intervals. These zones mark periods of non-deposition, when the sediment was subject to sub-aerial modification, and oxidation by soil forming processes (pedogenesis). This commonly takes the form of red and ochre mottling, due to oxidation of iron, which frequently highlights root traces. More established pedogenic processes are indicated by the presence of soil profiles with sharp tops, gradational bases, and persistent paler leached horizons. Intercalations of yellow-grey mudstone and carbonaceous mudstone occur in association with thin coals, particularly towards the base of the sequence.

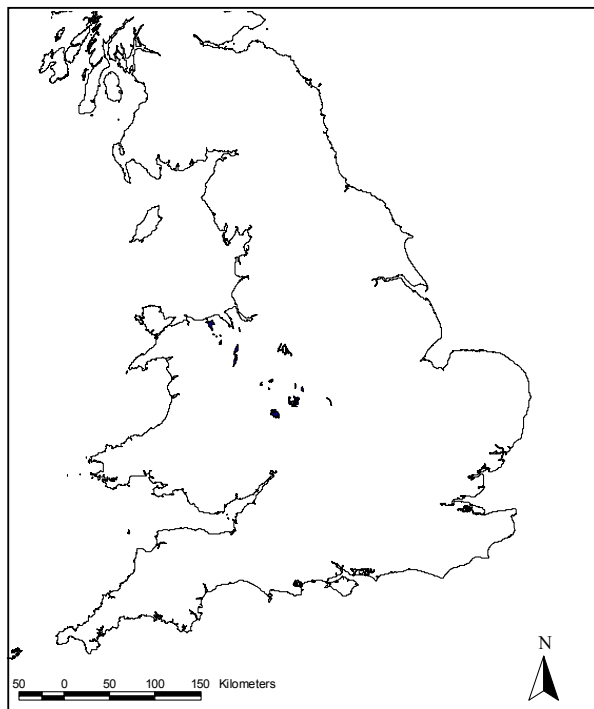


Figure 24. Outcrop of the Etruria Formation.

7.34 Sandstones and conglomerates, known locally as ‘espleys’, occur throughout the sequence. They are generally unsuitable for brick making and often discarded or avoided in quarries. The proportion of sandstone increases towards the top of the succession, and also towards the south of the region.

7.35 The observed sequences are interpreted as having formed on an alluvial plain, that became progressively more elevated and free-draining with time. The mudstones represent overbank deposits and the sandstones, drainage channels that were generally fixed and constrained in their flow direction by active faults. Around the uplifted basin margins, coarse detritus is thought to have accumulated as debris flows on sloping alluvial fans. In at least two coalfields (Warwickshire and South Staffordshire) alluvial deposition was interrupted by volcanic activity leading to local dispersal of air-fall tuffs.

7.36 Etruria Formation mudstones consist of three principal mineralogical components; silt grade quartz, disordered kaolinite, and haematite. Goethite and calcite are present locally, and illite, chlorite and anatase form minor components. The bulk mineralogy and the lack of deleterious impurities, such as carbon, sulphur, and soluble salts, make many Etruria Formation mudstones a high quality raw material for the manufacture of bricks, pavers and tiles. In addition, the high iron oxide content of these clays renders them especially suitable for the production of blue bricks. Compositional variation in the mudstones facilitates blending and, under differing firing conditions, enables production of premium-quality bricks of various colours and textures.

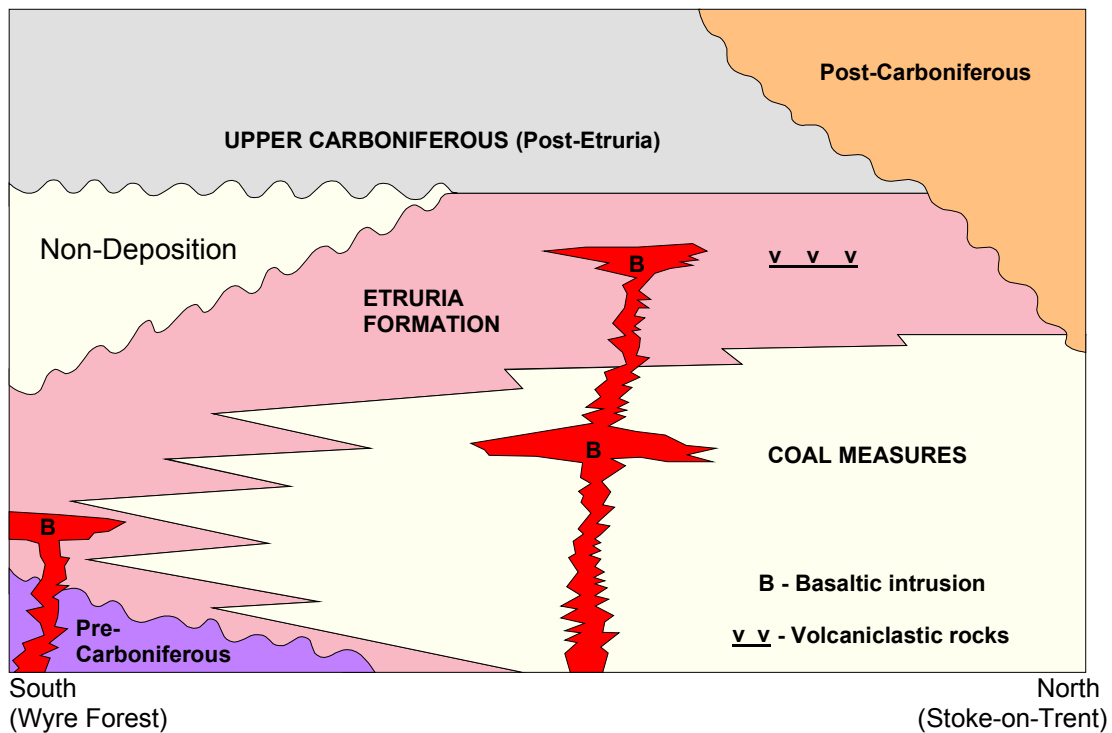


Figure 25. Schematic diagram illustrating boundary relationships of the Etruria Formation.

Coalfield	Local formation name	Thickness (m)	Additional comment
North Staffordshire (Potteries Coalfield)	Etruria Marl	210-430m	Informal tripartite division of sequence: Upper division (78-115m): sandstones rare, calcareous nodules common in top 20m Middle division (105-167m): Sandstones impersistent, numerous disused and some working quarries Lower division: (60-80m): Persistent sandstones limit exploitation, some greenish grey mudstones and thin coals; rarely worked Future resources are mainly in the upper and middle divisions
South Staffordshire	Etruria or Old Hill Marl	0-207m	Cannock area: 0-160m Upper sandstone-rich and lower mudstone-dominated units recognised; upper boundary difficult to identify where overlying Halesowen Formation in red-bed facies; formation locally eroded over anticlinal axes. Aldridge area: up to 140m Actively worked for at least 170 years, . Substantial sandstone and thick drift cover (up to 30m) limit development potential 'Black Country': up to 207m Southward increase in sandstone and conglomerate at all levels; considerable thickness variation
Warwickshire	Etruria Marl	30-170m	Eastern outcrop extensively worked until the late 1960s, reserves largely exhausted; western outcrop still exploited locally
Wyre Forest	Kinlet Group (upper part)		Etruria Formation not separately differentiated from Coal Measures on published maps, included in upper part of Kinlet Group Mottled clays formerly worked in the lower part of the Group at Billingsley, and in the upper part at Bradley for bricks and tiles
Coalbrookdale Coalfield	Hadley Formation and Ruabon Marl	0-120m	Tile and refractory clays formerly worked in the south of the coalfield; current exploitation at Hadley
Flintshire Coalfield	Ruabon Marl	>200m	
Denbighshire Coalfield	Ruabon Marl	200m	Economic deposits restricted to the lower and middle parts of the formation; much of the outcrop obscured by thick drift; worked resources around Hafod and Ruabon

Table 11. Summary of Etruria Formation resources.

Coal Measures Group and Millstone Grit Group (England and Wales)

7.37 The Coal Measures occur at outcrop in a series of coalfields. In England and Wales, these include the coalfields of Northumberland and Durham, Cumberland, Lancashire, North Wales, Yorkshire, Nottinghamshire and North Derbyshire, North and South Staffordshire, Leicestershire and South Derbyshire, Warwickshire, South Wales, Bristol and Somerset (Figure 26). The Coal Measures Group is thickest in the North Staffordshire and Lancashire coalfields (up to 1900 m). Thickness diminishes towards the south, so that in the South Staffordshire Coalfield there is a total of only 100 to 150 m. Typically, the Coal Measures rest upon Millstone Grit strata. This occurs at outcrop over an extensive area of the Pennines and Peak District and to a lesser extent in North Wales. The Millstone Grit is 2100 m thick in Lancashire. It decreases southwards to less than 200 m in North Wales and the East Midlands. Underlying the Millstone Grit is a thick mudstone succession known as the Bowland Shale Group in northern England, and the Edale Shale Group in the Midlands. These are up to 350 m thick.

7.38 The Coal Measures are a heterogeneous succession of interbedded grey mudstones, siltstones and sandstones, with subordinate, but economically-important coal seams, seatearths and ironstones. The strata show a cyclicity, with a typical upwards-coarsening succession (or *cyclothem*) shown below, with youngest strata at the top. Typical components of a cyclothem are as follows:

- **Coal**, typically up to 2 m thick, often jointed, sometimes with thin films of pyrite and ankerite,
- **Seatearth**, rooted mudstones and siltstones, pale to dark grey to ochreous with ironstone nodules, typically 1 to 3 m thick. **Fireclays** are kaolinite-rich seatearths.
- **Sandstone**, pale grey, weathering buff, fine- to very fine-grained, commonly has gradational base, 1 to 8 m thick. Linear channel-fill sandbodies, up to 20 m thick, have bases on erosive surfaces, which may cut down through the underlying succession.
- **Siltstone**, medium grey, laminated often with abundant plant remains, typically up to 10 m thick, usually with a gradational base.
- **Mudstone**, medium to dark grey, well bedded, with a variable carbon content. They are typically up to 5 m thick, but much thicker (20 to 30 m) in places. The clay minerals comprise disordered kaolinite with variable amounts of illite and chlorite, together with quartz. **Ironstone** may occur as thin beds or flattened nodules of iron carbonate (siderite) within the mudstone.
- **Shale**, dark grey, fissile claystone, typically 1 to 3 m thick. The shales are dominantly illitic clays and generally have high carbon and sulphur contents.

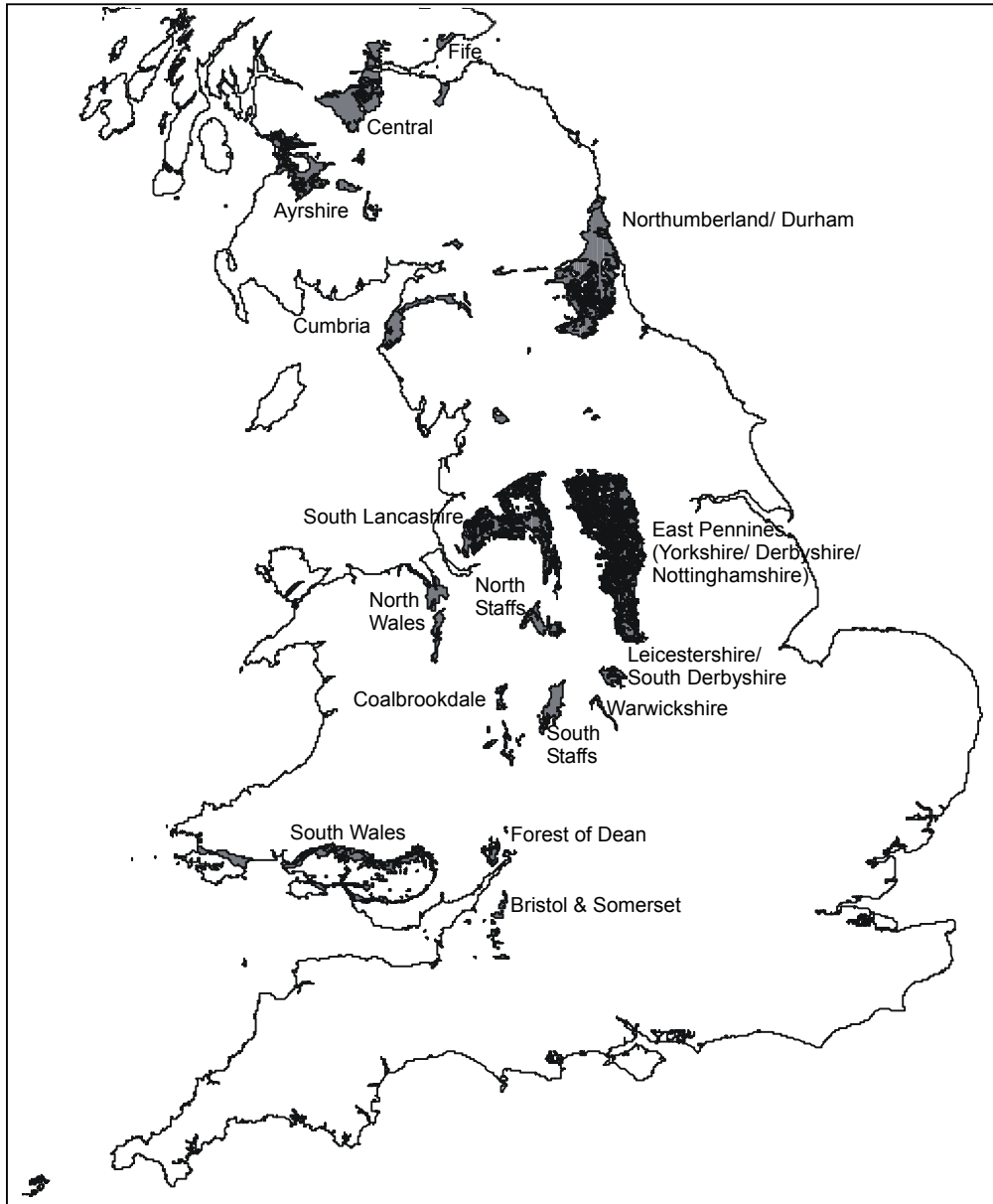


Figure 26. Outcrop of Coal Measures Group (with coalfield names).

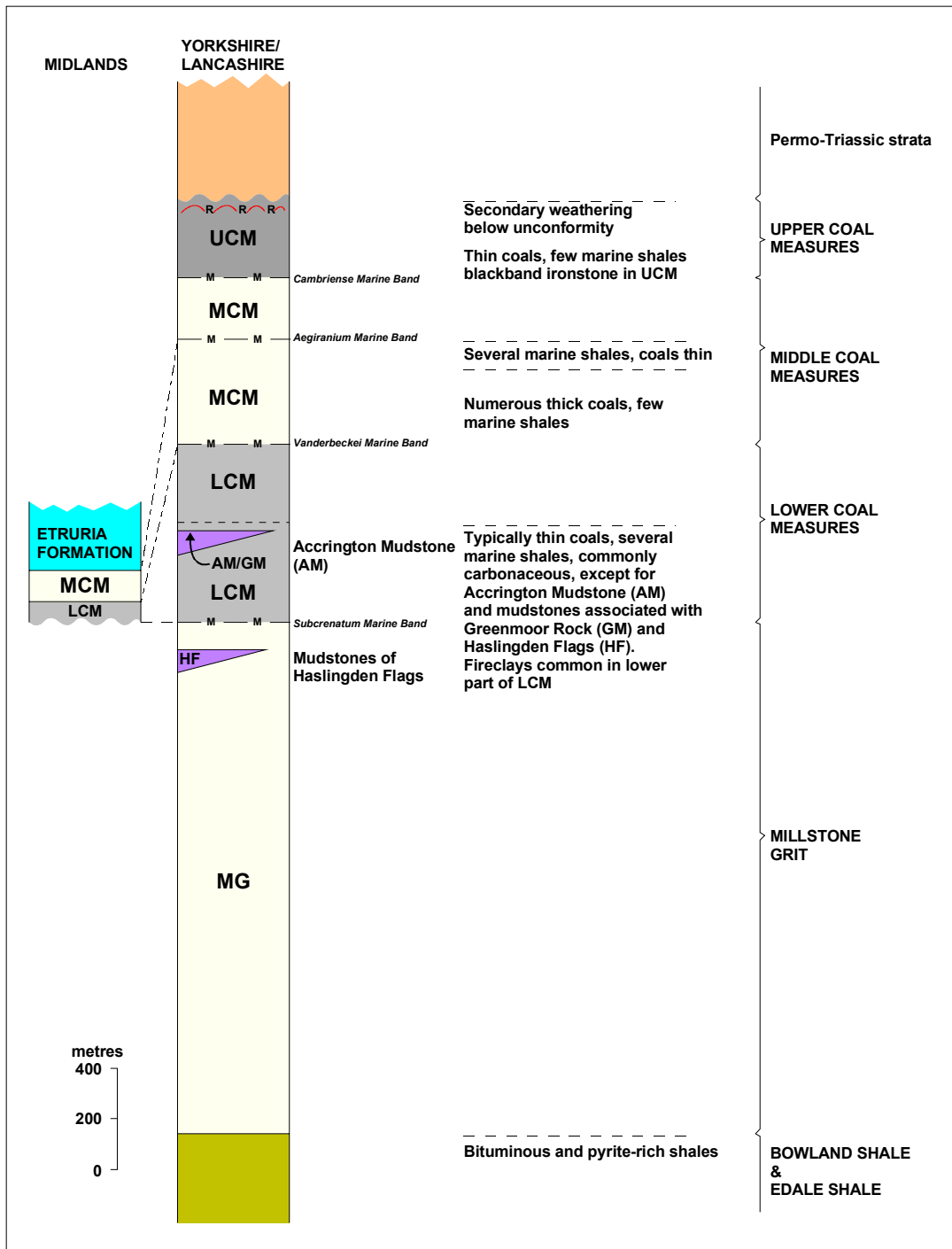


Figure 27. Generalised vertical section of the Upper Carboniferous in Yorkshire, Lancashire and the West Midlands.

7.39 The Coal Measures are subdivided into Lower, Middle and Upper Coal Measures, the bases of the units defined as the bases of the *Subcrenatum*, *Vanderbeckei* and *Cambriense* marine bands, respectively (Figure 27). There is a greater abundance of marine bands and fireclays in the lower part of the Lower Coal Measures and upper part of the Middle Coal Measures. Coal seams are more concentrated in the upper part of the Lower Coal Measures and lower part of the Middle Coal Measures. The Upper Coal Measures generally lack marine bands and have few workable coals, but do contain blackband ironstone layers and nodules. The mudstones of the lower part of the Lower Coal Measures are typically carbonaceous. The Accrington Mudstone of the Lancashire Coalfield is an exception. This is a greenish grey mudstone which is higher in illite and lower in carbon than other Coal Measures mudstones. Immediately beneath the sub-Permian unconformity, the Coal Measures have been weathered, oxidised and reddened to depths of a few metres, exceptionally to 20 m. At the present-day surface the mudstones weather to an orange-brown and pale grey clay, to depths of up to 10 m.

7.40 The Millstone Grit is subdivided into an undifferentiated succession of micaceous, grey mudstones and siltstones, interbedded with laterally-extensive sandstones. The stratigraphical position of mudstones is determined with reference to named marine bands, which, typically occur within cyclic successions comparable to that described for the Coal Measures. Seatearths and coals are relatively minor components of the Millstone Grit, whereas marine shales are common and often relatively thick. Greenish-grey mudstones similar to the Accrington Mudstone occur at the level of the Haslingden Flags of Lancashire.

7.41 The Bowland Shale and Edale Shale are typically too bituminous and pyritic to be suitable as a brick clay resource.

7.42 In Lancashire the principal brick clay is the Accrington Mudstone. The equivalent mudstone in Yorkshire, associated with the Greenmoor Rock, has also been extensively worked. In North Staffordshire brick clay workings have concentrated on mudstones of the Upper Coal Measures. In South Staffordshire former workings were small, concentrating at the level of the Thick Coal (lower Middle Coal Measures) and New Mine Coal (upper Lower Coal Measures). In Bristol the Middle Coal Measures have been worked in a zone of folding and faulting, factors which result in increased depths of weathering of the mudstones and shales.

Carboniferous (Midland Valley of Scotland)

7.43 Extensive mudstone resources suitable for the manufacture of bricks exist throughout the Carboniferous succession in central Scotland, although extraction is now largely restricted to the Upper Carboniferous rocks of the Central and Fife coalfields (Figure 28 and Table 12). These rocks (Clackmannan Group and Coal Measures), rather than those of the Lower Carboniferous, are the most likely sources of mudstone to be used for brick manufacture. However, a small amount of mudstone is currently taken from the Lower Carboniferous Lawmuir Formation near Hamilton. Scottish Carboniferous mudstones are generally low in sulphur, except where oil shales are

present or the mudstones are of marine origin. Carbon contents also tend to be low, again except where oil shales and canneloid mudstones occur in the succession.

7.44 Upper Carboniferous mudstone resources occur in the Lower Limestone (maximum thickness 240 m), Limestone Coal (maximum thickness 550 m) and Upper Limestone (maximum thickness 600 m) formations of the Clackmannan Group, and from the Lower Coal Measures (maximum thickness 240 m) and Middle Coal Measures (maximum thickness 350 m). The Upper Coal Measures are of very limited extent in central Scotland, but have been worked in the past for mudstone and low-alumina fireclay. The Passage Formation (Clackmannan Group) is an important source of high alumina fireclay for refractory applications.

Subsystem	Lithostratigraphical Units				Groups
	Formations				
	Central Coalfield	Fife Coalfield	West Lothian	East Lothian	
Upper Carboniferous	Upper Coal Measures				Coal Measures
	Middle Coal Measures				
	Lower Coal Measures				
	Passage Formation				Clackmannan Group
	Upper Limestone Formation				
	Limestone Coal Formation				
	Lower Limestone Formation				
Lower Carboniferous	Lawmuir Formation	Pathhead Formation	West Lothian Oil Shale Formation	Aberlady Formation	Strathclyde Group
	<i>Kirkwood Formation</i>	Sandy Craig Formation	Gullane Formation		
	<i>Clyde Plateau Volcanic Formation</i>	Pittenweem Formation			
		Anstruther Formation			
	<i>Fife Ness Formation</i>	<i>Arthur's Seat Volcanic Formation</i>	<i>Garleton Hills Volcanic Formation</i>		
	<i>Clyde Sandstone Formation</i>				Inverclyde Group
	Ballagan Formation				
	<i>Kinnesswood Formation</i>				

Table 12. Classification of the Carboniferous strata in the Midland Valley of Scotland. Names in bold currently exploited for brick manufacture; italicised formations unlikely to be of interest.

7.45 Red-firing mudstones of the Lower Limestone Formation are worked at Brotus Quarry in Fife. The Limestone Coal Formation is host to numerous coal opencast sites and at some, such as Climpy opencast coal site (OCCS) near Forth in South Lanarkshire, mudstone is extracted for use in the brickworks at Carluke. The Upper Limestone Formation produced mudstone for the defunct Niddrie Brickworks, Edinburgh. Mudstone

for brick manufacture is extracted from the Coal Measures Group in the Central Coalfield at Armadale and at Northrigg, near Bathgate. The group is also host to opencast sites where mudstone and fireclay for brick manufacture are or have been worked together with coal (such as at Laigh Riggend OCCS, Airdrie).

Fireclays

7.46 Fireclays are non-marine sedimentary mudstones and occur as seatearths, which underlie almost all coal seams. They represent the fossil soils on which vegetation once grew and their occurrence is, therefore, mainly confined to coal-bearing strata. Fireclays are named after the overlying coal. Fireclays were originally valued as refractory raw materials, because of their relatively high alumina and low alkalis contents. The close association of coal, ironstone and fireclay was of considerable economic importance during the Industrial Revolution. Today the term 'fireclay' is used to describe seatearths of economic interest for both refractory and non-refractory applications (Highley, 1982).

7.47 Seatearths include all grades of sediment from mudstone (seatclay) to sandstone (ganister) and are distinguished from associated sediment by the presence of rootlets and the absence, or extreme disruption, of bedding, and the presence of highly polished (listric) surfaces. Ganisters, or high silica sandstones, are comparatively rare, although they were formerly locally worked for refractory applications. Clay-rich seatearths, (seatclays), are much more common. However, not all seatclays can be considered as commercial fireclays. Seatclays are typically thin, and usually less than 1m in thickness. There appears to be no relationship between the thickness of a coal seam, and the thickness and properties of its associated seatearth.

7.48 As fireclays are closely associated with coal, resources in Britain are mainly confined to Coal Measures strata (Figure 26). A characteristic feature of the Coal Measures is the pronounced cyclicity of the sedimentation with seatearths and coals appearing at irregular intervals (see paragraph 7.38). The occurrence of fireclays as relatively thin, widely-spaced beds in close association with coal means that opencast coal sites provide one of the few viable sources of the mineral. Fireclay resources in Britain are, therefore, with a few exceptions, largely coincident with opencast coal resources. The future of the opencast coal industry has, therefore, a considerable bearing on the future supply of fireclays

7.49 Although fireclays occur in similar geological environments, they exhibit a wide range of mineralogical compositions and properties. They consist essentially of the clay minerals kaolinite and hydrous mica, together with fine-grained quartz. Typically these three minerals make up some 90 per cent of the rock. There would appear to be an almost continuous series between kaolinite-rich and quartz-rich end members together with variable amounts of mica. Siderite, present as both clay ironstone nodules of variable size and sphaerosiderite less than 1 mm in diameter, and carbonaceous matter, present as coaly matter and fossil debris, are also common constituents. They may represent serious impurities in commercial fireclays and restrict their use. Pyrite may also be present as an impurity and is often associated with carbonaceous material. Seatearths may exhibit rapid

vertical and lateral variations in composition and thus properties. All are contaminated to a greater or lesser extent by impurities rendering part of, or the whole, of a seam unusable. The majority of seatearths are, therefore, unsuitable for use, and fireclay production is localised both geographically and geologically. However, blending does allow lower quality clays to be used thus maximising the use of the resource, but is dependent on the availability of a range of clays.

7.50 The variable composition of British fireclays means that they exhibit a wide range of properties in terms of their vitrification characteristics and fired colour, the latter being largely a function of iron content. In addition to carbon and sulphur, which should normally be less than 1.5 per cent and 0.1 per cent respectively, fired colour is the main criterion on which the suitability of a fireclay is judged for facing brick manufacture. Iron oxide contents should normally be less than 2.5 to 3.0 per cent Fe_2O_3 and on firing the fireclay should give a uniform colour. However, depending on how the iron occurs, higher iron contents may be tolerated. Fireclays are invariably blended with red-firing mudstones to give a range of fired colours.

Opencast Coal and Fireclay

7.51 The close association of coal and fireclay means that opencast coal sites provide one of the very few viable sources of fireclay. With the demise of the underground mining of fireclay, opencast coal sites have become an increasingly important source of supply and currently account for some 90 per cent of supply, both from operating sites and stockpiles associated with former sites. By far the most important of these are the Donington Island stockpiles in the South Derbyshire Coalfield which alone account for approximately 25-30 per cent of the market. The future of the opencast coal industry is thus crucial to the future supply of fireclay by making available, as a low cost by-product, clay that would not otherwise have been economically recoverable.

7.52 However, only a small proportion (about 20 per cent) of opencast coal sites normally produce fireclay. This may be due to the variable quality of the fireclay, as the majority of seatearths will not have the desired properties for buff brick manufacture, or may be the result of operational or planning restrictions. However, the size and speed of opencast coal mining invariably creates a mismatch between potential supply and demand. Unless marketable fireclays can be stockpiled, either on or off site, they are usually backfilled with overburden and thus irrecoverably lost. As selective extraction and stocking of fireclays is more costly than removing them as overburden, there is only an incentive to undertake stockpiling if a market has been identified. There are a number of examples where fireclays have been stockpiled but have not been utilized. An early commitment to purchase clay is therefore an important aspect to ensuring that mineral is not wasted.

7.53 With some notable exceptions, which are restricted to the Pottery Clays Formation of the South Derbyshire Coalfield, most fireclays are relatively thin (< 1 m). Extraction in their own right would, therefore, not be economically viable because of high overburden to mineral ratios. In addition, the amount of fireclay recovered from a site is, in general, small in comparison with the coal recovered. Again the exception is the South Derbyshire

Coalfield where a concentration of relatively thick fireclays has meant that very large tonnages of fireclay have been produced. For example, the current Hicks Lodge site will ultimately produce some 1 million tonnes of fireclay and sales from the former Donington Island site, and its associated stockpiles, will yield be about 5 million tonnes.

7.54 There is no direct relationship between opencast coal reserves and fireclay reserves. Commercial fireclays have a more restricted distribution because the majority will not be of commercial quality. Nevertheless, the future supply of fireclay will be dependent on the future of the opencast coal mining industry. This future will depend on (1) a continuing market for indigenous opencast coal and (2) adequate permitted reserves.

7.55 Estimating the remaining resources of coal that can be recovered by opencast mining is difficult. At the time of privatisation at the end of 1994 there were reported to be over 300 million tonnes of coal in sites proved by exploration with more than 300 million tonnes of unexplored potential in those sites, and more than 250 million tonnes identified separately by desk studies. Cumulative production since the Second World War, when opencast coal production first began, has been some 550 million tonnes. A recent report concluded that there is no shortage of shallow, technically and economically viable coal in Great Britain (Minchener and Barnes, 1999). Resources are spread across the country but will be small in some coalfields such as Coalbrookdale, Lancashire, and North and South Staffordshire. What is very much more uncertain is the likelihood of these resources being granted planning permission.

7.56 Mineral Planning Guidance on opencast coal (MPG3) states that there should normally be a presumption against development unless the proposal is environmentally acceptable, or provides local and community benefits which clearly outweigh the impact. Opencast coal mining has provided considerable benefits in the past by being linked to land regeneration schemes for the reclamation of derelict land. However, the number of brownfield sites, although still available, is declining and with increasing resistance to working greenfield sites the prospect of a steady stream of new planning permissions to replace depleting reserves is unlikely. It is probable that, subject to a continuing market for coal, opencast production will decline from recent levels of 15-16 Mt/y to 10-12 Mt/y in the relatively short term.

7.57 However, the availability of fireclay will depend on a number of other factors, not least that identified resources will also be granted planning permission. MPG 3 encourages planning authorities to explore the possibilities of working associated minerals, particularly fireclay or brick clay, with opencast coal. This will have the benefit of reducing the need to extract the mineral elsewhere and prevent the unnecessary sterilization of valuable mineral resources. There is growing evidence that brick manufacturers, as well as clay factors, are increasingly working closely with opencast coal operators to ensure that clays are evaluated and marketing opportunities identified. Currently some 50 per cent of total fireclay supply is derived from four sites, those in the South Derbyshire Coalfield (Donington Island stockpiles/Albion and Hicks Lodge) being of strategic importance. The importance of the Pottery Clays Formation within the South Derbyshire Coalfield to supply cannot be overemphasized. However, planning conditions

attached to the stockpiles in the area indicate that all operations will cease in 2013 and with no more sites available this source of supply will cease. It is difficult to foresee 'conventional' opencast coal sites with their much thinner fireclay seams being able to substitute for this large supply. Nevertheless the strategic importance of specific sites as suppliers of fireclay will increase. The strategic importance of specific sites as suppliers of fireclay will, therefore, increase

Other brick clay resources

7.58 This section briefly describes a range of other, more minor brick clay resources in specific areas. One or more active production sites (mostly in England) are based on these resources. Some resources are not included here, notably those which comprise very localised alluvial or glacial material.

Brickearths: Thames estuary

7.59 'Brickearths' are silty loams, usually found in association with river gravels and similar deposits in fossil (terraces) and active fluvial systems (alluvium) in the area around the Thames Estuary. They are Quaternary to Recent in age. Some are also closely associated with the deep, cryogenic weathering of some rock types (head deposits), whilst some around Southend and in east Kent may be derived from loess (wind blown dust associated with glaciation). Deposits are generally thin, but can be persistent, particularly where associated with extensive river terrace and flood plain sediments.

Reading Formation: Chilterns

7.60 The Tertiary-age Reading Formation occurs along the western and northern margins of the London Basin. It is typically 10 to 15 m thick but locally can reach up to 22 m. Lithologically it is highly variable but is generally dominated by clay, usually mottled in colour due to post-depositional pedogenetic processes. The clay mineralogy of the Reading Beds is dominated by smectite, with illite and subordinate kaolinite.

Thanet Formation: east Kent

7.61 The Tertiary-age Thanet Formation in east Kent is composed of predominantly of silty, fine-grained sand which becomes more clay- and silt-rich its lower part. The clay mineralogy of is dominated by smectite, with lesser amounts of illite and trace amounts of kaolinite.

Lias group: south Midlands

7.62 The Jurassic-age Lower and Upper Lias the Midlands are dominated by clay-rich sediments. The Middle Lias is characterised by more sandy/ calcareous lithologies. Total thickness of the Lower Lias recorded in boreholes in the south Midlands varies from 200 to 300 m. The Middle and Upper Lias are much thinner. The clay mineralogy of the Lower Lias in Gloucestershire is dominated by illite, with minor chlorite and vermiculite. Non-clay phases include quartz, pyrite, siderite and calcite.

Culm: Exeter area

7.63 'Culm' is a term used to describe Carboniferous-age sediments found in SW England which were deposited in deeper water than equivalent Millstone Grit and Coal Measures group sediments found further north and east. The Upper Carboniferous Crackington Formation includes the 'Exeter-type' Culm sequence which comprises a series of shales interbedded with thin sandstones. This sequence is strongly folded. Clay mineralogical analysis for red-purple Crackington Formation shales from Pinhoe near Exeter shows the presence of both kaolinite and illite, with the non-clay fraction dominated by quartz, with trace amounts of calcite.

Devonian slate: Plymouth area

7.64 The Lower Devonian Dartmouth slates lie to the south of Plymouth and comprise at least 550 m of shaley slates, clay - slates, siltstones, grits, sandstones, conglomerates and some pyroclastic rocks. Thicknesses are very variable with condensed shale sequences on intra-basin highs and thicker sandy sequences within basins. Locally the slates used for brickclay are called 'shillet'. Clay mineralogy of the slates is dominated by illite (50-80 per cent), with subordinate chlorite.

Ordovician mudstone: Caernavon area

7.65 Ordovician-age mudstones occur in this part of North Wales as part of a extensive and thick sequence of shales, mudstones and flaggy sandstones. Thicknesses vary but are in the order of several thousand metres. The clay mineralogy of typical mudstones is dominated by illite, with low to moderate chlorite and small amounts of kaolinite. Non-clays consist predominantly of quartz, hematite and feldspar.

Skiddaw Group mudstone: Barrow-in-Furness area

7.66 The Skiddaw Group represents a Lower Ordovician (Arenig) aged sequence of shales, mudstones, sandstones and grits deposited within a marine basin. They crop out predominantly in the northern Lake District and estimates of thickness vary from 1800 m up to 9000 m. Brick clays are extracted from a small inlier of Skiddaw Group mudstones at Greenscoe, near Barrow-in-Furness. The clay mineralogy of these mudstones is dominated by illite.

Secondary resources

7.67A range of secondary materials and waste types are, or have the potential to be, used in the manufacture of bricks.

Colliery waste

7.68 Although extensive in the past, the use of colliery waste by the brick industry is now very limited. The survey carried out in this report indicates that only about 42 000 tonnes was consumed by the industry in 1998. Most colliery wastes are extremely heterogeneous, with carbon contents ranging from less than 5 per cent to over 30 per cent. This causes particular problems in mechanised brick manufacture where consistency of the raw material is vital in maintaining product quality. These materials tend to show particularly high levels of emissions on firing. The brick industry in Scotland was

formerly a major user of colliery waste (known as 'bings'). This material was used to produce pressed common bricks which were generally rendered. These bricks were generally of low- and variable quality, susceptible to both frost damage and severe efflorescence. Clays from bings are no longer utilised by the Scottish brick industry.

Pulverised Fuel Ash (PFA)

7.69 This glassy, silt-grade material is a by-product of coal incineration in thermal power stations. It is composed predominantly of alumina, silica and ferric iron, along with about four per cent fixed carbon. This material is finding increasing usage in the manufacture of both pressed and soft-mud bricks where it typically replaces between 10 and 20 per cent of the clay. PFA acts as a flux during the firing process and it tends to 'open' up the body of the brick to ease drying and firing. It can also reduce overall emissions by diluting the clay component. The brick industry used about 52 000 tonnes of PFA in 1998. Other furnace ashes such as Fluidised Bed Ash (FBA) and Municipal Incinerator Ash might also be used in a similar way by the brick industry.

Blast furnace slag

7.70 This material is largely composed of glassy calcium and magnesium aluminosilicates. Granular slag can be used as a low-shrinkage diluent ('grog') in extruded bricks. This material reduces emissions by dilution and by reaction with gases emitted by the clays. This material is likely to be utilised by at least one major production site in the near future.

'Town-ash'

7.71 This is a carbon-rich material reworked from pre-20th Century domestic refuse tips, where coal cinders make up the bulk of the waste. The carbon present in this material acts as an internal 'body-fuel'. The carbon and glassy material present in town ash produce the characteristic black spotting on the face of some stock bricks.

Coal slurry

7.72 Fine-grained coal slurry (waste from coal washing plants) is blended with clays such as Mercia Mudstone at 3 to 5 per cent to act as a body fuel. This material will also reduce the atmosphere in the kiln and thus improve the strength and durability, as well as modifying the colour of the bricks.

Other organic wastes

7.73 Waste organic materials such as sawdust, chopped straw or foamed polystyrene can be used to decrease the density of the brick body and induce a favourable pore-size distribution. These are known as 'burnout' materials because of their behaviour on firing. Coke 'breeze' (grit size coke) is widely-used by the industry for this purpose, as well as acting as a fuel within the body of the brick. Other wastes which might be utilised include paper mill waste (currently used by one brick production site in the South East and more widely in continental Europe) and, after incineration, water treatment sludge and sewage sludge.

Reserves

7.74 A brief survey of the extent of valid brick clay planning permissions was carried out in 1999. A Geographical Information System (GIS) was used to calculate the area of brick clay planning permissions and the outcrop of principal brick clay resources, and to spatially-relate these to environmental constraints such as National Parks, AONBs, SSSIs, NNRs and National Scenic Areas (Scotland), and areas of urban development. This analysis has permitted a very crude assessment of the relative pressure on individual resources from sterilisation and/ or depletion. A calculation of planning permission areas has been used to give a rough measure of the area of permitted reserves in relation to the total outcrop areas of the principal clay resources. The relationship of the resource outcrop and permitted reserves to land-use and environmental designations was also assessed. Data from individual operators on reserve tonnages and likely life were not gathered. Following discussion with the BCC, this information was deemed too commercially-sensitive to be disclosed to third parties at the time of the survey in spring-summer 1999.

7.75 The total outcrop area of the principal brick clay resources in England, Wales and Scotland is over 2.6 million hectares. Relative outcrop areas for each resource are shown in Figure 29. The Mercia Mudstone Group cover the largest area and the Etruria Formation the smallest. These data are derived from the BGS digital 1: 250 000 geological map and take no account of the lithological variations within these classifications described in the previous section on resources. True values for the outcrop area of clay that is potentially suitable for brick manufacture are likely to be considerably lower, particularly for Carboniferous mudstones, Mercia Mudstone and Oxford Clay.

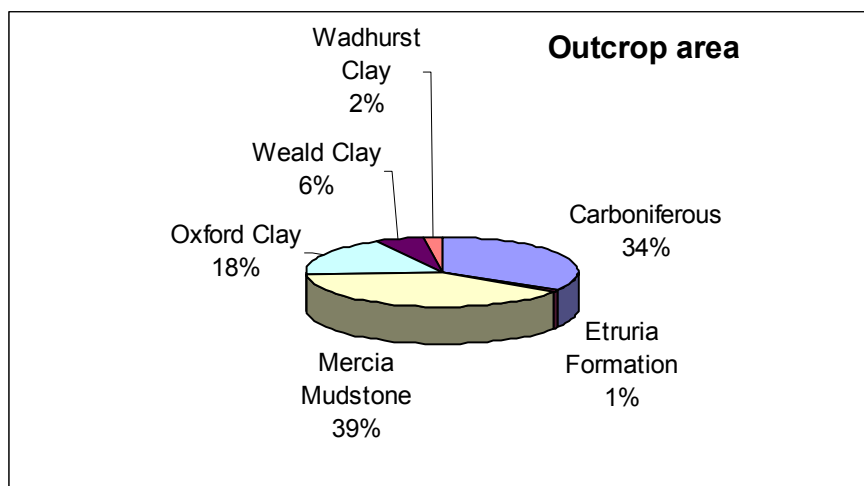


Figure 29. Relative outcrop area of principal brick clay resources in Great Britain.

7.76 The total area of valid brick clay planning permissions gathered in this study was 7500 hectares. Figure 30 shows the relative area of planning permissions on each of the principal resources. The Oxford Clay has the largest proportion of permissions. This probably reflects the large stock of historic permissions on this clay. The Mercia

Mudstone Group has a much lower proportion of planning permissions relative to its outcrop area. This may be simply a reflection of the very large outcrop area of this clay and the relatively small proportion of which is actually usable as a brick clay. Conversely, the Etruria Formation has a large area of permitted reserves relative to its outcrop. This is a direct reflection of its high value as a brick clay resource despite its small outcrop area.

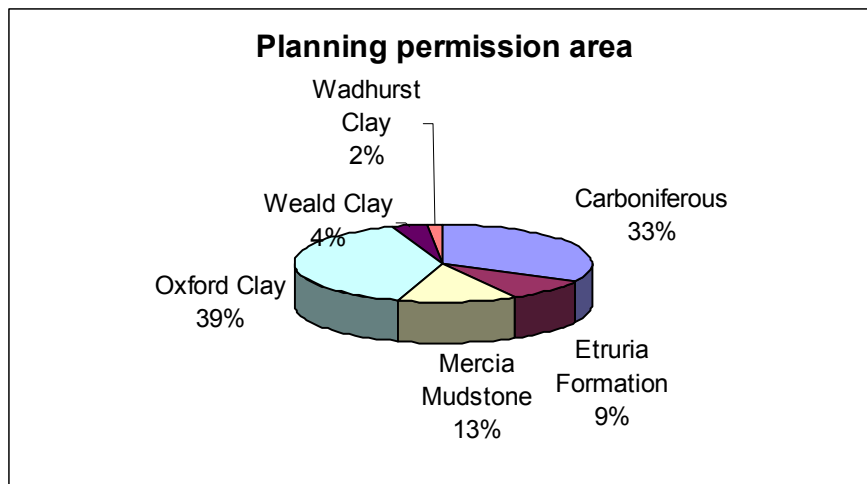


Figure 30. Relative area of planning permission for brick clay in Great Britain.

7.77 An indication of the degree of ‘sterilisation’ of clay resources by urban development and selected environmental designations is shown in Figure 31. Over 20 per cent of the total outcrop area of all the principal brick clay resources is sterilised by urban development (14 per cent) and environmental designations (7 per cent). Only 0.3 per cent of this area is covered by planning permissions for brick clay. In contrast, over 35 per cent of the outcrop area of the Etruria Formation is sterilised, mostly by urban development (Figure 32). Planning permissions for brick clay occupy over 3 per cent of the outcrop area of the Etruria Formation. Comparative data for the remaining principal brick clay resources are shown in Figure 33. Note that the Etruria Formation and Carboniferous mudstones show the highest degree of sterilisation by urban development. This reflects the relatively high population densities found in the West Midlands and the coalfields of northern England. Lower population densities and higher perceived landscape value are reflected in the smaller areas of urban development and larger areas of environmental designations covering the Weald and Wadhurst clays in south east England. In particular, over 80 per cent of the outcrop area of the Wadhurst Clay is covered by environmental designations (principally the High Weald AONB).

7.78 The implication of this analysis might be that large areas of clay resource outcrop remain unaffected by sterilisation. However, the real availability of outcrop area for mineral extraction is likely to be much lower. As stated above, the lithological variation in the resources described in the previous section will considerably reduce usable outcrop areas, as will land-use factors such as roads, small settlements, agricultural land designations, local environmental designations and groundwater protection zones. Further reduction in available area will be caused by operational and other constraints, as well as

physical factors such as fragmented outcrop. This study does highlight the particular vulnerability of the Etruria Formation to sterilisation and depletion (Figure 34). This resource of premium quality clay has a relatively small and fragmented outcrop which is almost exclusively in a area with a high population density.

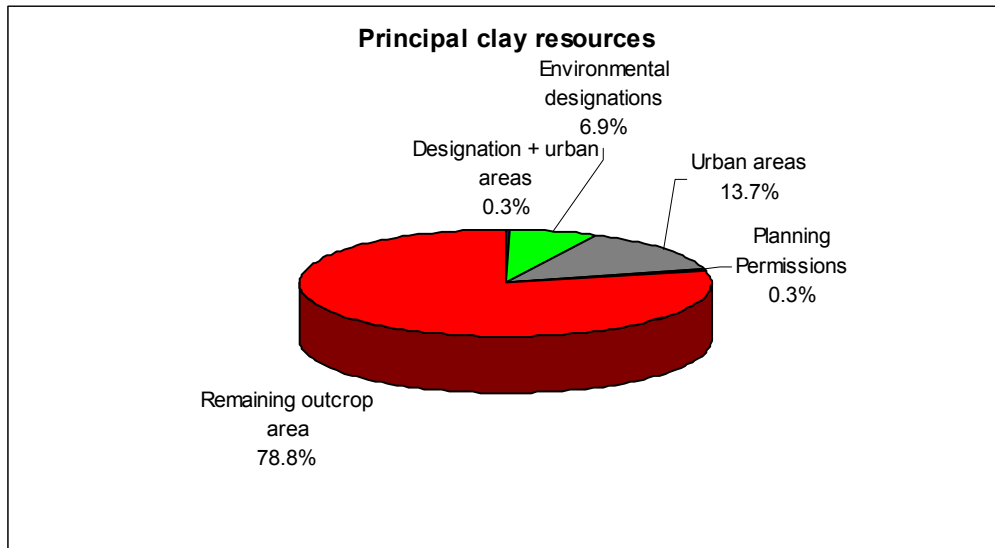


Figure 31 Land-use on all principal brick clay resources.

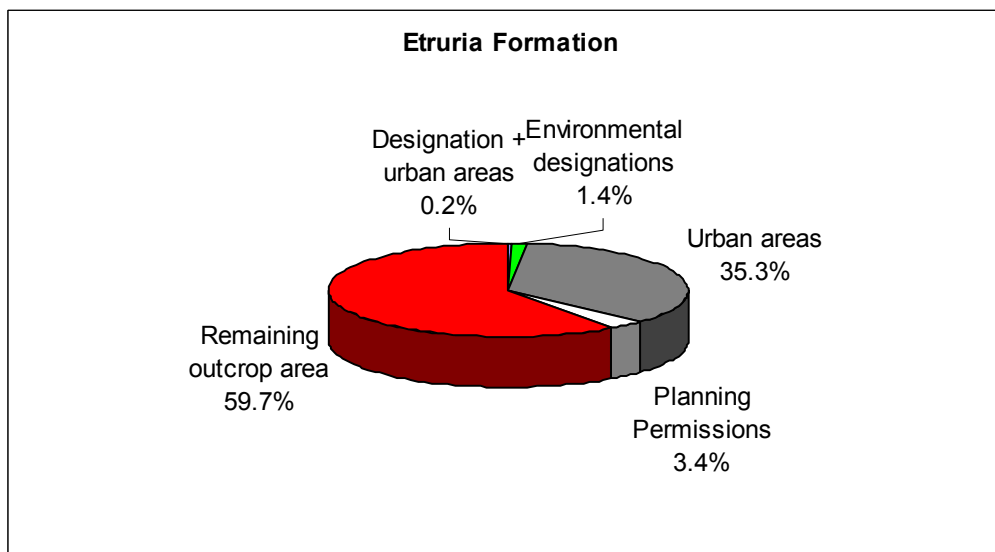


Figure 32. Land-use on Etruria Formation.

7.79 The resolution of this study is too low to make any meaningful assessment of the vulnerability of the other principal clay resources to depletion and sterilisation. As stated in the previous section, a large proportion of the mudstones which occur in the Carboniferous are unsuitable for use as brick clays. Anecdotal evidence from industry and MPAs suggests that certain horizons (such as the Accrington Mudstone and the Halifax Hard Bed in the Lower Coal Measures) are under threat from sterilisation by

other development and/ or environmental designation and may require more protection from the planning system.

7.80 If the recommendations made elsewhere in this report regarding landbank (Chapter 3) are to be implemented, then a national survey of reserve tonnages will have to be carried out in order for the system to operate effectively.

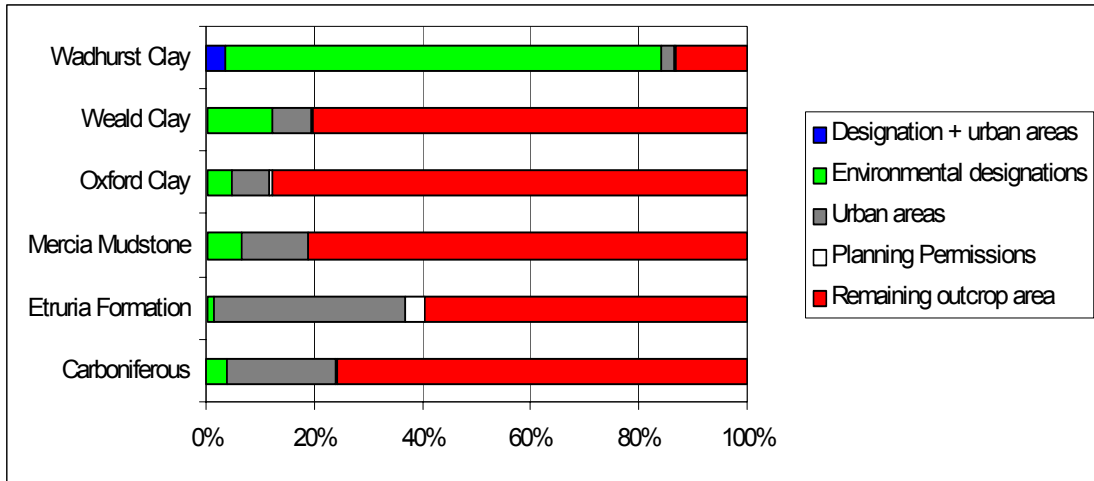


Figure 33. Percentage areas of land-use in each principal clay resource.

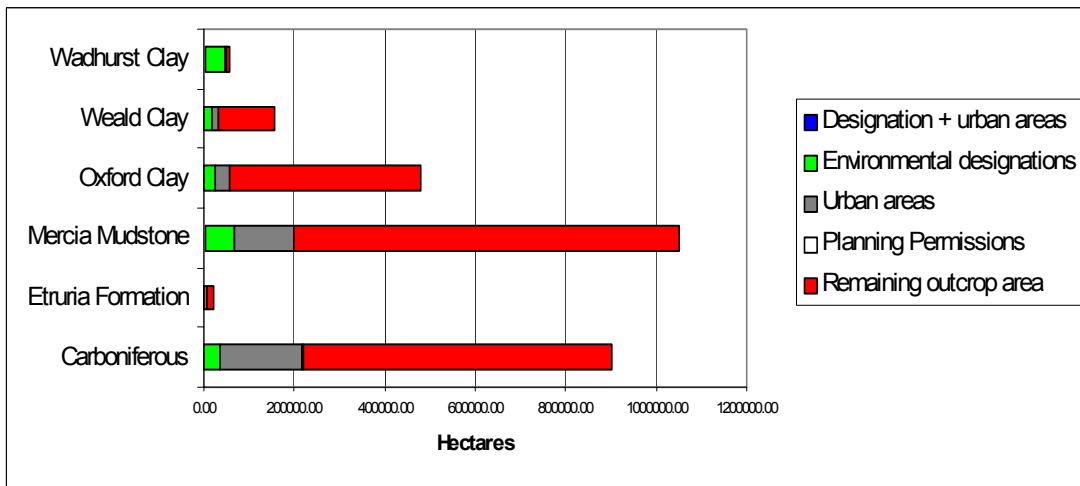


Figure 34. Absolute area of land-use in each principal clay resource.

APPENDIX 8: PLANNING BACKGROUND

THE PLANNING PROCESS

8.1 The process of managing land and resources to meet the sustainable needs of society requires legislation, procedures and an administration to take decisions. In the UK, the primary legislation is the Town and Country Planning Act, administered principally by local authorities. Use of this primary, enabling legislation requires further clarification on procedures. This is provided through Statutory Instruments, Circulars, Guidance, policy statements and the decisions of the courts. Such advice cannot cater for all circumstances and the legislation and procedures require a discretionary approach. Mineral development is subject to the planning process and procedures for managing and conserving mineral resources and reserves form part of that process.

8.2 The planning process relates to the use of land. It removes the development rights of individuals and businesses, except for certain limited operations that are defined as ‘permitted development’. It requires development proposals to be submitted as a planning application, with such necessary supporting information, to a planning authority for determination. Applications are considered and determined by elected members of the planning authority in accordance with policies in the statutory development plan unless material considerations indicate otherwise. Development plans are prepared by the planning authority in accordance with national policy and incorporate public consultation.

8.3 Decisions also consider the requirements of non-statutory plans, as well as the comments of consultees, both statutory (such as English Nature) and non-statutory (such as local pressure groups or individuals). The local authority must consider all such comments and make its decision balancing all the relevant considerations. Inevitably, this decision may therefore not meet the demands of particular groups or interests. Private interests may or may not equate to the public interest.

8.4 Unfavourable decisions of the planning authority are subject to the right of appeal by the applicant to the relevant secretary of state or the courts. There are limited opportunities for third parties to challenge a decision. Planning policies and decisions should not become involved with subjects such as pollution control, which may affect environmental quality or amenity, unless land use planning issues are involved.

8.5 The planning process has to provide certainty so that society can plan for other economic and environmental objectives. Section 54a of the 1990 Act requires the process to be ‘plan led’, where decisions on applications are primarily determined by reference to policies in the development plan unless material considerations indicate otherwise. To meet the needs of society the process needs to frequently re-evaluate policies included in development plans and to monitor and manage decisions made in accordance with those policies. Evaluation of future needs and monitoring of decisions is imperative, otherwise it is impossible to ascertain if decisions would cause an under- or over-provision of particular facilities. Such a situation might cause environmental damage, or prejudice economic objectives, or compromise sustainability objectives.

8.6 Although the planning system will probably develop a more proactive role, it remains a regulatory process. It is therefore important to ensure that planning, through development plan provisions and decisions on individual proposals, is responsive and relevant to the pressures of a market-based but sustainable economy.

MEETING FUTURE NEEDS

Development Plan Provisions and Maintenance of Supply

8.7 The objective of the planning process is to assess future needs of society, as they may impinge on the use of land and resources, and to secure supply for those needs in a sustainable manner. The development plan policies that may be relevant to a particular development may be contained in a series of separate documents, (structure plan, local plans, minerals local plans) or a single unitary development plan.

8.8 Development plans should demonstrate how the competing demands for development and protection of the environment and amenities will be achieved over a particular period. In England this is at least 15 years for structure plans and Part I of UDP's and 10 years for local plans, (PPG 12). Policies relating to some types of provision may need to reflect a period longer than 10 or 15 years. Such circumstances may arise where there is uncertainty about the precise timing of development initiation, where major investment in development is proposed, or where there is a continuing requirement, as with the need to protect mineral resources from unnecessary sterilisation. Guidance requires development plans to be reviewed at regular intervals to keep policies up to date. Local plans should be reviewed at least once every 5 years, with partial reviews as appropriate more frequently, (PPG 12).

8.9 The development plan process therefore contains requirements to assess demands relating to both the long-term (at least 10 years and sometimes an un-quantified much longer period) and the short-term (at least every 5 years and sometimes more frequently). The short-term reviews should make only those adjustments necessary to the long-term strategy following monitoring.

8.10 Currently there is considerable concern in relation to effective compliance with these requirements. In many instances the adopted development plan does not provide at least 10 years guidance, because a significant part of the plan period may have expired before adoption. In administrative terms this has now been resolved in England by the requirement that the at least 10 years commences from adoption date (PPG 12), although in practice it may be some considerable time before all adopted development plans comply with that requirement. Considerably longer periods than 5 years may elapse before a plan is reviewed. Sometimes a review may not be undertaken before the plan period has expired. The result is that a development plan will be out-of-date, will carry less weight in the determination of applications and will lead to a potential policy vacuum that will be filled by ad-hoc development.

8.11 These are not recent problems as concerns with regard to the lack of up-to-date plans have been an issue for many years. However it has proved difficult to resolve this

situation. Particular concerns arose in relation to the provision of land for housing and reserves for minerals, primarily aggregate, in the 1960's. To overcome the potential policy vacuum, and the resulting lack of security of supply, caused by out-of-date or expired development plans, planning authorities were subsequently required to demonstrate that permissions enable a requisite level of provision for housing and minerals and, in addition, that permissions plus allocations enable that provision to be maintained, throughout and beyond the plan period, if necessary, for a specific length of time. That provision was commonly termed the "land supply" in relation to housing and, for minerals specifically referred to as, the "landbank".

Mineral Landbanks

8.12 The requirement to provide landbanks for minerals has therefore formed a significant element of mineral planning policy for many years having first been stipulated in guidance in DoE Circulars 50/78 and 22/84 and more recently in Mineral Planning Guidance Note MPG 1, General Considerations and the Development Plan System (relevant to England), National Planning Policy Guideline NPPG 4, Land for Mineral Working (relevant to Scotland) and Mineral Planning Policy Wales MPPW. This requirement relates to all non-energy minerals. To ensure compliance with national guidance, landbank policies for clay, and all other non-energy minerals, should have been included in relevant development plans. This requirement has not been complied with by all MPAs. There is however, no published national guidance on the relevant landbank period that an MPA should adopt for brick clay.

8.13 Published guidance on landbanks for minerals seeks different periods for different minerals sometimes with specific provisions extending the landbank provision in relation to major new investment or other relevant circumstances. The basis for selecting different periods for landbanks for different minerals primarily reflects variation in the scale of downstream plant investment (by the mineral operator or their customers), but may also take account of the need to maintain continuity of supply of a particular grade, or grades, of product to feed that plant. However, the periods adopted in published national guidance are generally a pragmatic compromise and do not appear to be based on a detailed specific evaluation of the requirements of a particular sector of the minerals industry.

8.14 While landbank policies have been a useful tool and central to mineral planning, certain concerns have been expressed with the landbank requirement for aggregate and the requirement that it should apply to all non-energy minerals. Those concerns have focussed on, for example, the prospect that landbanks may be a target which reinforces supply trends which are unsustainable overall (due to difficulties in taking account of recycled materials, or alternative materials or products), or unsustainable for particular MPA areas (because unconstrained resources in that area are becoming scarce, whereas unconstrained resources may be more extensive elsewhere), because the landbank may be a combined total (including for example clays with different properties and end use potentials together) or because the landbank for an MPA area, for clay or similar minerals, may relate only to one or two sites (in effect creating site specific provision).

8.15 Concern has also been expressed in relation to the requirement to maintain housing land supply. That requirement was seen as creating some difficulties, particularly in parts of England. This was because allocations for housing were frequently being taken up, with the housing completed, in the early stages of the plan. That created a shortfall in the available land supply for housing, requiring further sites to be identified in the development plan or leading to permission on unallocated land. The land supply requirement was seen as therefore not assisting in managing a sustainable release of housing land.

Alternatives to Landbanks

8.16 Various alternative procedures are being investigated to resolve some of the concerns with the present landbank concept noted above. Some of the alternatives are at the conceptual stage and may not reach a practical conclusion. Even if a potentially practical alternative may appear to be available it will be a number of years before an alternative can be demonstrated to be effective, or to be more in accordance with sustainability and economic objectives.

8.17 To resolve the concern in relation to housing supply the 'land supply' concept has been replaced, in England, by a new approach known as 'Plan, Monitor and Manage' ('PMM'). This indicates medium term demands but only provides short-term allocations (circa 5 years), that will then be monitored and adjustments made as necessary. The concept is now embedded in guidance on housing planning policy in England (Planning Policy Guidance Note 3: Housing (PPG3) 2000), but not in Scotland or Wales where the land supply requirement remains in place.

8.18 It has been suggested that the PMM approach may be applicable to the planning of aggregate supply and, by natural extension, the supply of all minerals. No procedures, structures or timeframes have as yet been identified. While housing and mineral development are regulated by the planning system these are radically different activities and this gives rise to uncertainty regarding the relevance and value of the PMM approach in relation to mineral development.

8.19 One major difference is that the overall take up of mineral allocations through permissions does not normally lead to such permissions being worked out quickly. Mineral permissions are normally worked over a considerable period of years whereas housing permissions can be converted into completed buildings in a very short time. Housing is 'foot loose' compared to the fixed opportunities for mineral development. Housing can also be brought on stream quickly compared to the long lead time for minerals and a significant proportion of housing can be undertaken within the developed framework whereas such opportunities are very limited for minerals. There are also significant potential conflicts with the need for security of supply for minerals and the period for which allocations will be made in PMM style development plans which at circa 5 years for housing (PPG3) is not adequate for minerals.

8.20 There are considerable differences in the number of permissions granted within each discrete planning authority area for housing as opposed to minerals, or granted

specifically for brick clay. On average, for the whole of England, there is one decision on a mineral application (for all minerals) for every hundred decisions for the construction of dwellings. The numerous individual permissions that are granted for housing may by effective management enable errors in location and extent of permissions to balance out without significant negative impacts on the environment or the economy (Planning To Deliver- The Managed Release of Housing Sites: Towards Better Practice, Draft for Consultation, DETR 2000).

8.21 However, due to the very limited number of mineral applications determined the PMM approach could give rise to errors in provision that may be difficult to resolve. This may lead to a more ad-hoc and uncertain process. If the PMM approach is to be adopted widely in the minerals area then a longer and more flexible time-scale may be required but that fundamentally conflicts with the concept. In the light of these difficulties in applying the PMM approach to minerals the “landbank” approach still has considerable merits.

8.22 Other alternatives have been or are being considered for minerals in general or for brick clay in particular. Site specific provision has been suggested as an option but that may ensure continuation of operations in unacceptable locations and also prevent long-term sustainable planning as resources around a site become restricted. An approach considering the application by MPAs of a new power to limit production capacity has been proposed by CPRE. However, that approach may seriously inhibit competition and the rights of businesses and individuals, may be unlikely to respond in sufficient time to meet market conditions and would require not only the removal of permitted development rights granted by parliament but, in addition, further restrictions on the use of fixed and mobile plant. The Consultation Paper by DETR on the review of MPG6 for the supply of aggregate, published in October 2000, raised in discussion the value of landbanks in achieving a balance between a sustainable level of production and the need for security of supply. It is understood that the Quarry Products Association and the Planning Officers Society are considering individually and jointly such questions. At this time the potential for continued support for landbanks, in principle or subject to modification, for aggregate, or for the need to replace landbanks by an alternative concept, is unknown.

8.23 In default of any suitable alternative the landbank concept may need to be retained and be applied to clay. However, if maintained as the mechanism to achieve security of supply, the application of landbank policy for clay within development plans will need to fit within the objectives of sustainability as a “sustainable security of supply” and in this reflect the long-term nature of sustainability objectives within a relevant time frame.

A TIME FRAME FOR SUSTAINABLE SECURITY OF SUPPLY

Existing advice

8.24 There is currently no specific advice or consensus on what would be the relevant long-term time frame to provide a sustainable security of supply for clay. It is clearly longer than the next decade. Guidance in PPG 12 indicates that where a long-term

strategy consideration may apply a period in excess of 10 years may be appropriate. The concept of ensuring adequacy for the next generation might normally imply a time scale of between 20 to 30 years.

Existing practice

8.25 The following table sets out policies on providing security of supply, including the application of specific landbanks for clay, in selected mineral local plans. “On merits” may mean the lack of any specific policy or guidance. It may also mean a specific presumption against granting further permissions in some circumstances, not just the general presumption against permission that arises where a site does not benefit from an allocation.

MPA	Plan period	Landbank
Barnsley	1994-2001	No – ‘on merits’
Durham	1997-2006	15 years
Northumberland	1996-2006	No – ‘on merits’
Shropshire	1996-2006	10 years
Staffordshire	1994-2006	15 years
Surrey	1993-2001	No – ‘on merits’
West Sussex	1994-2006	No – ‘on merits’
Wrexham	1997-2011	No – ‘on merits’

8.26 The above table demonstrates that where landbanks are provided this enables long-term planning and security of supply for periods between 21 to 28 years. This is a similar period to the 20 to 30 years noted in paragraph 8.23 and, at a median period of circa 25 years, may also equate to the long-term security of supply in clay sought by industry.

Other relevant indicators

8.27 In considering soil resources, which share with minerals a virtually fixed nature, the Royal Commission on Environmental Pollution noted that to judge the sustainable impact of human actions on soils required the assessment of present trends “...over a long period, at least 25 years ahead, and on a fundamental issue like this preferably 100 years ahead.” (Nineteenth Report: Sustainable Use of Soils)

8.28 Similar timescales have been considered in relation to the assessment of resource and environmental assets in the environmental capital approach to sustainability. In “Environmental Capital: A New Approach, A Provisional Guide” prepared by consultants for the Countryside Commission, English Heritage, English Nature and the Environment Agency in 1997 it is noted that “...sustainable management of environmental capital requires a long-term perspective, beyond the typical time horizon of a statutory development plan.” and that a time frame of at least 20 to 30 years, or 50 to 100 years in certain circumstances, should be used.

8.29 Devon County Council is preparing a strategy for sustainable development of mineral and other development issues for the important ball clay producing Bovey Basin. This seeks to provide guidance for such issues over a period extending to 100 years.

A Possible Time Frame for Sustainable Security of Supply

8.30 Recent reports prepared by different agencies and current practice of MPAs indicate that a period of at least 25 years is the minimum period for considering the sustainability impacts of resource, including mineral resource, management and development. That period also reflects the 25 year security of supply sought by industry. A period of at least 25 years should therefore be adopted for long-term planning for clay.

RESOURCE PROTECTION

8.31 The general requirement to protect mineral resources from sterilisation has been recognised since at least the 1951 “Green Book” which noted (Part I. General Policy – Aims of Control, paragraph 5) that a primary aim must be “(a) To ensure that mineral deposits needed, or likely to be needed, to meet future production requirements are not *unnecessarily* sterilised by surface development...”. General policies to protect mineral resources were included in subsequent development plan documents. How such policies were to be put into practice and enforced was not spelt out.

8.32 However, specific procedures were adopted to protect certain rare minerals, or minerals with limited outcrops (such as ball clay, celestite, china clay). Such procedures related to a defined area within which an application, for say non-ball clay development, would be the subject of consultation between the developer, the planning authority and the relevant mineral trade association/producers. Exploration works might be undertaken, funded by industry, to evaluate the commercial, as opposed to the geological, prospects. Where it was demonstrated that a commercial deposit was threatened with sterilisation the application for the non-ball clay development might be refused, if it was not withdrawn. Provisions existed for referral to the Minister to adjudicate if necessary. These procedures continue to operate today.

8.33 Prior to April 1974 there was mainly a single tier of county planning authorities and therefore in general no perceived problems in ensuring that decisions did not sterilise minerals. The reality was somewhat different and while policies to protect minerals from sterilisation featured in both national and local planning there were, except for the specific examples noted, no procedures in place to ensure compliance. The development of the two-tier planning system after 1974 split planning functions such that counties undertook strategic planning, which included all aspects of mineral development, while districts normally dealt with the development control of most built development. The two-tier system has subsequently been replaced in Scotland, Wales and most of “urban” England by a unitary district planning structure.

8.34 Shortly after the two-tier system commenced it became apparent that there was no process to ensure that decisions made by districts on built development took any or adequate account of mineral interests. Even where informal procedures existed for the

district to consult with the county, that was only as a consultee, and while the district as 'the planning authority', is required to take such consultations (and any other comments) into account, it is not required to abide by comments of any consultee.

8.35 In its deliberations between 1972 and 1976 the Stevens Committee considered comments of industry and planning authorities on this matter, referred to the procedures in place for China clay, etc., and recommended that "mineral consultation areas" should be defined and that consultation should take place between industry and planning authorities on any application that would sterilise mineral in such areas. Circular 58/78 noted that consultation areas can be useful in the prevention of sterilisation but proposed that matters should be left to local arrangements. Neither the Stevens report nor 58/78 explored or addressed the mechanics of that process and the complications caused by the two-tier system.

8.36 The 1980 Local Government, Planning & Land Act sought, in part, to resolve the situation. It required mineral planning authorities to define mineral consultation areas, to advise district councils of such areas and required that district councils consult with the mineral planning authority when they receive an application in those areas. The application would then be determined by the district, taking account of the comments of the MPA. The process made no provision for formal industry involvement.

8.37 Mineral Consultation Areas (MCAs) are defined in this process by counties and shown on development plans. MPG 1 states that "MCAs should not be necessary" in unitary authorities. This research has shown that only some 'county' mineral local plans refer to and show MCAs and that most unitary local plans exclude reference, both on the proposals map and in policy, to MCAs and the need to protect mineral resources from sterilisation.

8.38 Currently there is no requirement or advice stating the need for district local plans to show or refer to MCAs or policies to protect minerals from sterilisation. There was no reference to such matters in any of the district local plans considered by this research. This is a significant anomaly because the majority of mineral sterilising applications in 'county' areas are determined in accordance with the provisions of district local plans by a district planning authority.

8.39 MCAs in some mineral local plans are primarily defined around an existing operation or permission. They may relate to little more than the potential area of working plus a buffer zone. MCAs can play an important part in ensuring that sustainability objectives are reached, because they enable the maximum options for future generations by preventing the unnecessary sterilisation of minerals and thereby ensuring that future mineral supply can be obtained at least environmental and economic cost. MCAs should therefore relate to the wider mineral resource area.

8.40 With the exception of those minerals for which consultation procedures were adopted prior to the 1980 Act there few provisions in 'county' mineral local plans or in development control procedures for involvement of the minerals industry, either as individual firms or a trade association, in the designation or operation of the procedures.

Exceptions include specific reference to involving the trade associations in the Devon mineral local plan and more informal processes elsewhere.

8.41 Procedures for the evaluation of the mineral deposit that might be sterilised by other development are not defined. Commonly evaluation to confirm the presence, quality or quantity of the mineral is neither required or takes place. The absence of such data may undermine actions taken to prevent a mineral resource from sterilisation. In those instances where evaluation takes place the cost falls to industry, individual concerns or trade associations, and without the potential for support from a national agency. This contrasts dramatically with the normal planning procedures required to evaluate development impacts on ground instability, archaeology, agricultural land, visual impact, etc., where such evaluation is a requirement of the planning authority and, in many situations, a national agency, and where all the costs, and risks, are borne by the developer. If a developer were not prepared to undertake such expenditure to support an application in those other circumstances then such an application would normally be refused, unless it was withdrawn.

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