Environmental Studies
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Non Metal Minerals

Non-metal minerals such as granite are vitally important to the UK economy; we have many important uses for them, such as for roadstone, building stone, bricks and glass. As the UK population increases, more and more houses and roads are going to be needed, hence a greater volume of non-metal minerals will be required.

The term **mineral** is defined as *"a naturally-occurring element or compound, often in the form of crystals"*. The arrangement of **atoms** within any one mineral can vary – the arrangement, and the bonds between the atoms, control the minerals hardness and strength which in turn controls its use (see case study 1).

A rock containing at least one mineral is called a **mineral deposit,** and those which are exploited commercially are known as **ores**. The UK has a good **mineral base** (a large supply of minerals). The sand, gravel, crushed stone and quarried rock used for construction purposes are known as **aggregates**.

The main non-metal economic minerals in the UK are *granite*, *basalt, limestone*, *sand (or sandstone)*, *gravel*, *clay* and *china clay*. These are distributed unevenly across the UK (Fig 1) and therefore different mineral deposits are used for the same purpose; for example, in Huddersfield the local sandstone is used as a building stone (and ornamental cladding) for houses, whereas in Cornwall, granite is used. As non-metal minerals are bulky goods, *transportation costs* are a major consideration for their use, hence local stone is often utilised. These minerals are extracted by the process of **quarrying** as they lie on or near the surface.

Case study 1: graphite and diamond

Both graphite and diamond have the same chemical composition – carbon. However, graphite consists of sheets of hexagonally-arranged carbon atoms linked by covalent bonds. Within the layers, each carbon atom is strongly bonded to the three adjacent atoms, but bonds between the widely spaced layers are very weak – this means that graphite splits easily and can be used in drawing pencils. Diamond meanwhile, has its carbon atoms arranged in a strong framework made up of tetrahedra with each atom surrounded by four others; all have the strongest chemical links - covalent bonds. Diamond therefore is an extremely hard mineral and can be used in drills (such as in the drill bits in the oil industry).

Case study 2: Sand and gravel extraction

Sand and gravel was laid down by glacial rivers across Essex 500,000 years ago during the Pleistocene epoch. The deposits are large-scale and occur approximately 2 metres below the surface; These factors make the area ideal for ***quarry extraction****. In Essex, the Kesgrave Gravels are an important commercial strata and numerous quarries operate. This deposit is a mix of good quality coarse gravels and clean fine sands.*

The Kesgrave sands and gravels from Colchester Quarry are extracted and processed (washing and screening into different size ranges) before being sold for aggregates. Sands and gravels from this quarry are currently being used to build the new Terminal 5 at Heathrow Airport - sands for concrete and the larger gravel particles as a roadstone

Fig 1 Rock types UK

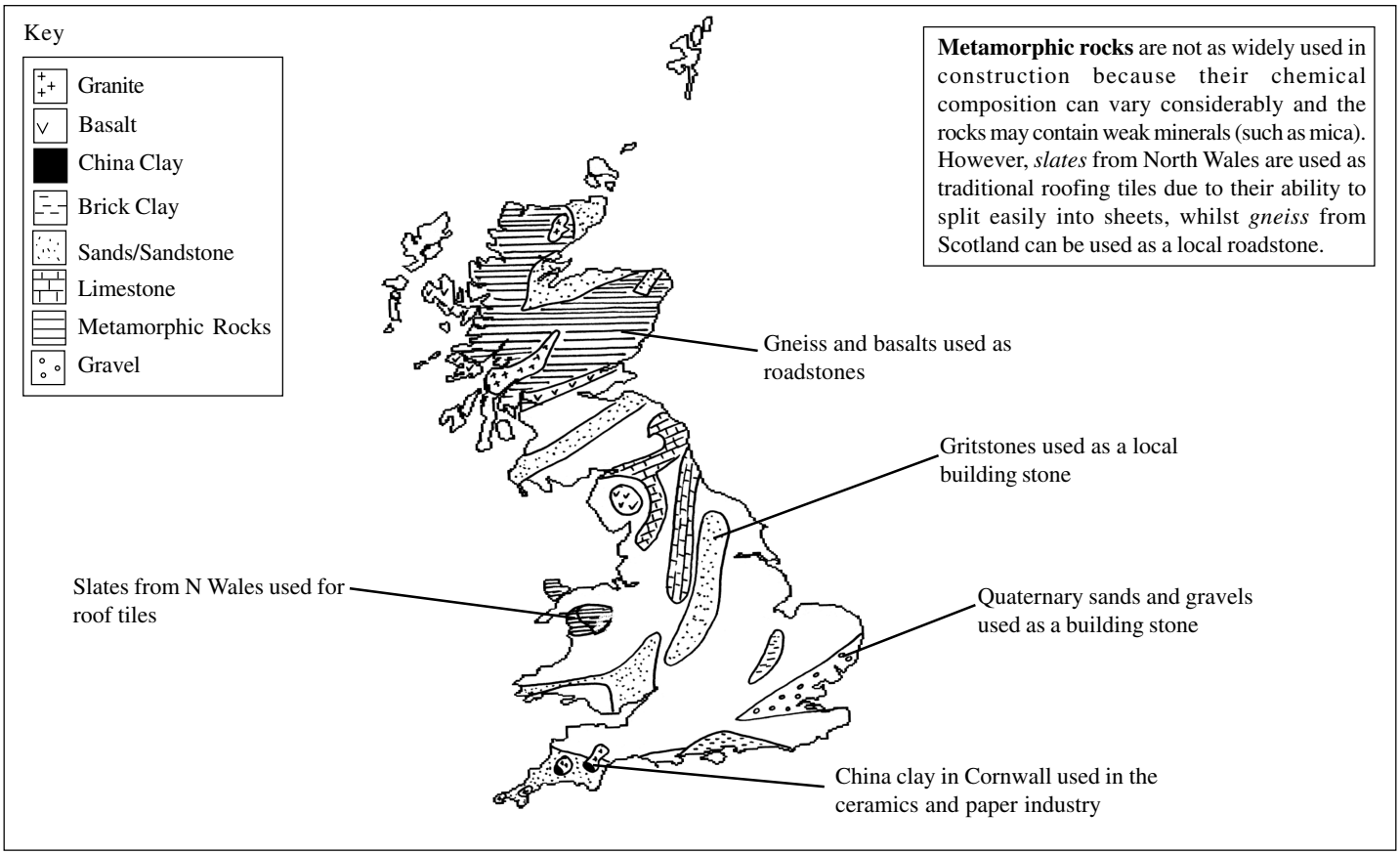
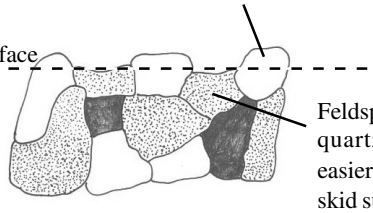


Table 1. Properties and uses of the non-metal minerals

	Source of mineral	Main mineral component	Properties for economic use
Igneous rocks	Granite	Quartz SiO_2 Alkali Feldspar $KAlSi_3O_8$ Plagioclase Feldspar $(Na, Ca)AlSi_3O_8$	Both quartz and feldspar have strong bonds and therefore are hard and resistant to wear and abrasion. The crystal size is greater than 5mm and this combined with the fact that the two minerals have slightly different rates of erosion makes granite ideal for use in the roadstone industry – Quartz is a hard and resistant mineral so stands proud of the road surface. Does not polish. road surface  Feldspars are slightly weaker than quartz so are eroded by tyres easier – creates an irregular, non-skid surface The sodium feldspars however are prone to chemical weathering over time (Kaolinisation) and will break down to form **china clay**. Kaolinisation is defined as the "replacement or alteration of feldspars to form kaolin as a result of weathering or hydrothermal alteration."
	Basalt	Plagioclase Feldspar $(Na, Ca)AlSi_3O_8$ Pyroxene $(CaMgFeAl)_2(SiAl)_2O_6$	Plagioclase and pyroxene are strong, hard-wearing minerals. The crystal size is less than 1 mm; this does not make it quite as good a roadstone as granite (surface will be too smooth) but it is commonly used.
Sedimentary rocks	Limestone	Calcite $CaCO_3$	Limestone is the main mineral used in the cement and glass industries, and as agricultural lime. It has the advantages of being relatively soft and easily powdered. In the cement industry, the calcium carbonate is roasted (in order to drive off the CO_2) – this creates calcium silicates which rapidly hydrate and set when water is added.
	Sand and sandstone	Mainly Quartz SiO_2	Quartz and other silica-rich minerals such as flint, are the hardest and strongest of the main rock-forming minerals. They are extremely resistant to weathering and erosion (therefore rough surfaces are common), will not chemically react with water, are non-porous and have high load strength – this makes sand ideal for use in concrete, mortar, as a filler in the construction industry and for glass. Concrete is made by mixing the cement with sand. The cement can adhere itself well to the rough surfaces of the silica grains.
	Gravel	Quartz / flint SiO_2 (but can be variable)	A coarser version of sand, gravel is ideal as a filler for the construction industry and for concrete. It has the same properties described above. The product has to be washed and graded but needs little pre-treatment before use.
	Clay	Illite $KAl_2(OH)_2AlSi_3O_{10}$ Clay minerals have a very complex chemistry and vary enormously. Illite is only one of many individual minerals which may be present in a clay. Hence, not all "clays" are the same!	Clays have been used as bricks for hundreds of years but not any clay will do! Good brick clays must become plastic when damp so they can be easily pressed and they must keep their shape through manufacture. When baked, the clay should be hard and should not absorb too much water (or may disintegrate). The rock should ideally also contain 5% calcium carbonate to prevent shrinkage during firing.
	China clay	Kaolinite $Al_4Si_4O_{10}(OH)_8$	China clay is formed by the chemical weathering of feldspar – it is a weak deposit and so can be washed out of the rock by powerful high pressure hoses. China clay is inert (non-reactive), very fine-grained and smooth so it is commonly used in the ceramics (pottery) industry and to fill paper. It can also be used as a filler in pharmaceutical products and paints.

Exam Hint:- *The physical properties of non-metal minerals are usually examined as short-answer questions, often in a table format requiring candidates to identify their uses. Candidates do not need to learn the individual components of the non-metal mineral (such as plagioclase and pyroxene) (Table 1).*

Further reading:
Byrne, K. 2001 *Environmental Science* (second edition). Nelson Thornes, pages 84-4,88
Mcleish, A. 1992. *Geological science.* Nelson, pages, 9-11, 294-299.
Lucy, G. 1999. *Essex rock.* Essex Rock and Mineral Society, ISBN: 0953483207

Useful websites
China clay and ball clay: http://www.wbb.co.uk/web/website.nsf
http://www.cornwall.gov.uk/Transport

sand and gravel: http://resourcescommittee.house.gov/subcommittees/emr/usgsweb/materials/sand.html

limestone: US University website: http://www.mme.state.va.us/DMR/DOCS/MinRes/CARB/carb_lim.html

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