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The geological controls on quarries

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RUSSELL, V. (1990). The geological controls on quarries. *Proceedings of the Shropshire Geological Society*, **9**, 4–6. Summary of a talk describing the geological influences on quarrying utilising examples drawn primarily from quarries being actively worked within Shropshire.

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BACKGROUND

The author's talk began by tracing the history of quarrying. The Romans had been major quarry workers. In medieval times most quarrying was in the Jurassic limestone because it is easy to work. It was used for churches and cathedrals. However, in the industrial revolution demand increased dramatically and production became mechanised.

Quarries reflect the demand for their products. A normal 3 bedroomed house uses 50 tons of aggregate; a kilometre of motorway 80,000 tons. Cost per ton increases dramatically with distance from source to destination. This consideration is much less important for minerals such as lead and tin, or even coal. However, even aggregates must be appropriate for the job as well as being nearby. The characteristics of an aggregate are controlled by its mineralogy and by the geological structure of the quarry.

CLASSIFICATION

Aggregates are classified using various tests. Physical properties are measured by impact and crushing tests to specific British Standards (BS). Thus Bayston Hill greywackes have good crushing and impact values but Wenlock Edge and Grinshill rocks have poor values. Some rocks are sound until water is absorbed, e.g. with clays where smectite will absorb moisture and break a rock from inside – these are useless as aggregates.

Other important properties include abrasion and polishing resistance – particularly important for road and pavement use. Criggion and Bayston Hill products are good in this respect. Aggregates may have a high value in one and not in the other. Resistance to polishing may be due to a rock breaking frequently and thus constantly producing a fresh surface. Resistance to abrasion may be because the rock is very hard and does not break, but may take a polish. Specific tests have been devised for measuring polished stone value and for abrasion value – the latter uses the Lower Cretaceous Leighton Buzzard sand as the standard.

A porous rock usually has a poor impact value but a good Polished Stone Value (PSV) whereas a more dense rock may give a good polished stone value because the rock is homogeneous as well as having a good impact value. High clay content gives poor Aggregate Impact Value (AIV) and poor abrasion but good polished stone values. A shale will have poor strength but better PSV.

The relative quantities of quartz, feldspar and clay in a rock directly affect the nature of the aggregate, reflecting the properties of these minerals. Vikings used feldspars to sharpen their swords!

The combination of all these parameters means that good aggregate is fairly difficult to find. Such rock will be expensive to work but can demand a high price and therefore be taken a greater distance (e.g. Bayston Hill material goes as far as the Home Counties and the South West).

QUALITIES

A summary of the qualities of various geological materials:

Gritstone (a non-geological term meaning sandstone to quartzite) – good PSV, AIV and Abrasion Value.

Arkose – fair PSV, good AIV and Abrasion Value.

Flint – poor PSV, poor AIV and Abrasion Value.

Limestone – poor PSV.

Millstone Grit – very good PSV, reasonably good AIV and Abrasion Value have optimum mixture of quartz with some feldspar which makes it valuable and therefore economically possible to export to France.

Granite – also good except that mica makes PSV value less good. However, some Scottish granite is being exported to South America.

Basalt – fair PSV. Only suitable for minor roads.

Other properties of an aggregate which are important for specific markets include:

Colour – stringent controls when aggregates are used in paper and food products (e.g. bread).

Brightness – this is measured against magnesium oxide as the standard for 100% brightness.

Natural size and shape – important in sand and gravel market when used in horticulture, etc.

Texture – especially in monumental stone and dimension stone when used for building blocks, etc.

Chemical composition – this reflects mineralogy but is assessed as bulk chemistry, e.g. purity of calcium carbonate in limestone.

Cement works are built where limestone and shale occur together as these are the main ingredients required to form a variety of calcium aluminium silicates.

A pure form of dolomite is required for the refractory industry, as found at Llynclys near Oswestry, making bricks for the steel industry. Under 0.5% iron oxide and under 2% silica is required. A bulk analysis was done for every metre from boreholes because the material must be right when it goes into the kiln. This requires very selective quarrying. Substitution of Mg ions for Ca ions gives an increase in porosity which is very important in the oil industry.

QUALITIES

Geological Controls concern the macrostructure of the quarry. This will affect how the material is won. Such controls include:

Faulting – which can make estimating reserves difficult and also causes problems for drilling. Drilling fractured rock is difficult and faults may transfer the energy of the blast (which is chiefly compressed air) a considerable distance.

Folding – also causes complications both in drilling holes for blasting and for face working. It is easier to work along the strike rather than along the dip for the latter can give a dangerous overhang. Folding may also bring unwelcome material into the quarry.

Fragmentation – the cheapest way of fragmenting the material is to use explosives at the rock face thereby saving on transport and excessive wear on crushers. In doing this full use is made of tension gashes, joint planes and fissures though sometimes these will absorb the energy of the explosives. The mineralisation associated with faults can cause complications, both in the actual winning of the rock and also when chemical purity is important.

Variability – variations include change in facies (e.g. the reef at Steetley Quarry which gives a good white limestone whereas the surrounding siltstone is less good). Equally, igneous intrusions sometimes provide the rock which is required but variations within the intrusion are difficult to predict and make assessment of the quality difficult.

Most aggregates are quarried and the assessment is done from surface outcrop.

SHROPSHIRE EXAMPLES

The author finished his talk by providing an overview of local quarries followed by a series of slides of a variety of quarries in other parts of the country. Information on the current state of local quarries can be summarised as follows:

Llynclys Quarry, nr. Oswestry: dolomitic limestone produces normal single size aggregate for roads, and coated material for estate roads together with calcium magnesium lime which is given to sheep to prevent staggers.

Shadwell, Much Wenlock: aggregates; not good enough to produce lime.

Lea Quarry ECC on Wenlock Edge: aggregates and calcium carbonate lime.

Grinshill ECC: dimension stone – good fractures, good texture.

Bayston Hill: the major quarry in this area – greywacke with recrystallisation making it suitable for pre-coated chips which are rolled in the asphalt on top of roads. Very good quality.

Callow Quarry: Mytton Flag group – aggregates suitable for pre-coated chips; high PSV.

Leaton, near Telford: igneous intrusion produces coated material.

Criggion: dolerite used locally for surface dressing but inferior to Bayston Hill.

Clee Hill: dolerite sold as pre-coated chips but only working the overburden of coal makes the quarry financially viable.

The diversity of these quarries reflects the geology of the County.

WORKING THE QUARRIES

The industry is capital-intensive but, as most natural stone aggregates are in the North West and most demand is in the South East, the cost of transport is important. Leicestershire and the Mendip quarries supply the South East.

The author then showed slides of various quarries including a large limestone quarry at Worksop showing how the quality of the rock influenced the way it was quarried (e.g. a very pure bench of only 4 metres height contrasted with an old quarry near Alston where variation makes the reserve unworkable).

Also shown were slides of drilling equipment, faces which had just been fired, and quarry equipment and the controls the rock may have on this. He emphasised the alertness required by drillers and showed how new faces are now surveyed with lasers to try to anticipate hazards.

The talk was followed by a lively question and answer session. Topics discussed included the heights of benches, the effect of economics - we use local stone because it is cheaper but we therefore have quarries on our doorsteps. Also the tension between wanting better roads, housing and, in particular, runways which require a vast amount of aggregate and yet not wanting quarries and big lorries on the road.

Also mentioned was the recycling of railway ballast and foundry sands. Perhaps the ultimate example is to be found in America where machines remove road surfaces and relay them with the same material in one operation.

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