## Blasts from the past: 3 Geology of Roadstones

## Background

“Blasts from the past” is the section of Teaching Earth Sciences where some of the teaching ideas and activities, originally produced for early publications of ESTA and the Association of Teachers of Geology (the precursor to ESTA), are re-published.
Teaching ideas and activities have been updated and revised before re-publication in the magazine. Copies of earlier publications of ESTA and the Association of Teachers may be accessed in the archive section of the ESTA website, although PDFs of TES 26.3 onwards may be downloaded from the website.

## Geology of Roadstones

This activity was produced by Mike Tuke (Tuke, 1985). The original diagrams have been updated and two photographs added. The references have also been revised to reflect present highway construction methods

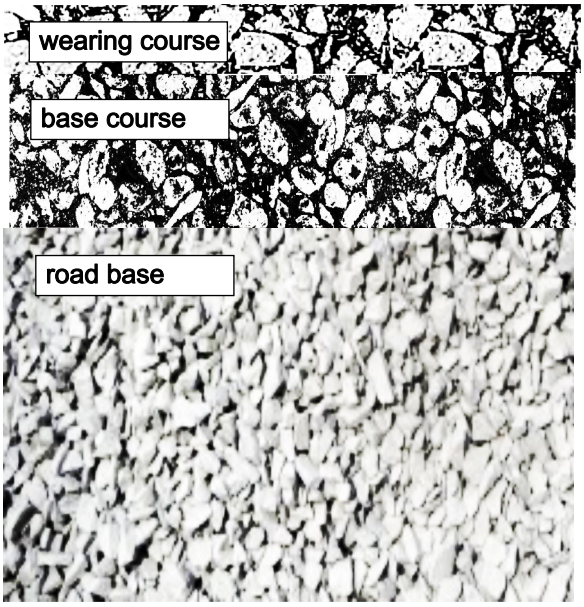
# Background to the topic

Quarries provide the aggregate (crushed rock) used in the construction of our roads. The rock type has to be carefully chosen so that it has suitable properties for the job it has to do. Testing procedures make sure that the aggregate meets the standards. (See reference 3. A guide to aggregates testing)

**Figure 1** photograph of Bardon Hill Quarry (photograph P.Williams)

# Cross section through a road surface

A road is made up of a number of different layers, each with a different function.




Provides a skid- and wear-resistant surface for the traffic and protects the lower layers. Bitumen-bonded aggregate.

Distributes the traffic loads on to the road base. Bitumen-bonded aggregate.

Main load-bearing layer. Made of rocks with high crushing strength.

Thickness of these layers are typical values and depend on the amount of traffic the road has to take. The rock aggregate and the bitumen matrix that holds it together are called asphalt.

**Figure 2** A cross-section through a typical road surface.

Most rock types are suitable for the lower two layers providing they have sufficient strength and are packed in such a manner as to be permeable.
The top layer on which the traffic runs, the wearing course, takes much higher pressures and all the wear and tear of the traffic and of the weather. It must provide a durable, skid-resistant surface and must prevent water percolating down to the lower layers. A much higher quality of rock is needed for this layer than for the other layers; only a few rock types are suitable, especially for motorways and other roads carrying much traffic.

## Cross section through the wearing course

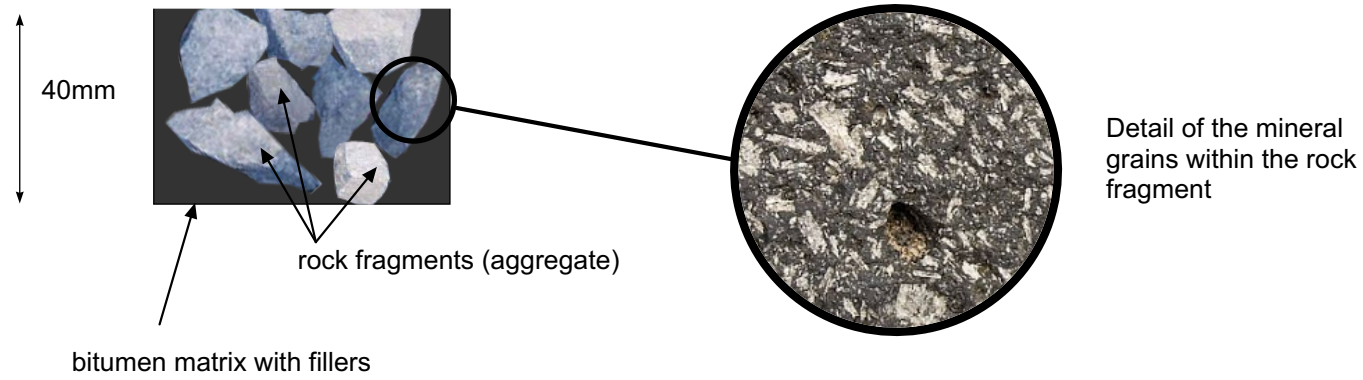



**Figure 3** Cross section through the wearing layer of a road with a detail of a rock fragment

### Good roadstone for making the wearing course of roads must have the following properties:

- The majority of the minerals in the rocks must have a hardness greater than 5 so that the rock is able to resist the abrasion caused by the tyres of the vehicles.

  The grains must wear in such a way that the exposed surface of the rock fragments (aggregate) does not become polished, otherwise the traffic would skid. This means that the rock must be made of two or more minerals with different hardnesses.

  **Figure 4** detail of crystal wear in a rock fragment.

  When the rock fragments are made of several mineral grains with different hardnesses, then the crystals in the rock fragments wear to a stepped surface which is skid-resistant.

- The rock needs to be fine-grained so that fragments 0.5cm in diameter contain several mineral grains.

- The individual grains need to be strongly held together so that the aggregate does not crumble under the pressures and stresses exerted by the vehicles. This means the rock must be either well-cemented or made of interlocking crystals.

- The aggregates must have rough surfaces so that the bitumen can adhere to them. Bitumen does not adhere well to glassy surfaces e.g. flint and obsidian, but it does adhere to most other rocks.

- The rock of which the aggregate is made must not be porous otherwise frost would shatter it in winter.

**Introduction to the practical exercise**
In the following practical exercise students are asked to work out which rocks are the most suitable for use as roadstone.
The students must have been given the information above and for some students it is necessary to provide additional information on the mineral composition of the rocks and on the hardness of minerals, (**Tables 1&2)**. The most satisfactory lithologies are basalt and greywacke. However, because of the high cost of transporting aggregate, slightly inferior rocks are often used. Limestone, although not suitable for motorways is extensively used because it is readily available. The composition of greywacke causes problems at all levels.

The practical is most satisfactory if the students have samples to study while they are filling in the Table 3. Alternatively, if no samples are available and no information on the composition and hardness is given, then the practical can be used as a revision exercise. The practical has been used for A level and degree teaching and, in modified form, for 12 year-olds in science lessons.

**Table 1: Composition of rocks**

| **Igneous rocks** | **Mineral content** |
|---|---|
| Andesite | feldspar, hornblende, augite |
| Basalt | feldspar, augite |
| Dolerite | feldspar, augite |
| Gabbro | feldspar, augite |
| Granite | feldspar, quartz, mica |
| Rhyolite | feldspar, quartz, mica, volcanic glass |
| Obsidian | volcanic glass |
| Pumice | volcanic glass |
| | |
| **Metamorphic rocks** | |
| Marble | calcite |
| Gneiss | quartz, feldspar, mica, hornblende |
| Metaquartzite | quartz |
| Schist | mica |
| Slate | mica |
| | |
| **Sedimentary rocks** | |
| Flint | quartz |
| Greywacke | quartz, feldspar, clay minerals |
| Limestone | calcite |
| Sandstone | quartz |
| Shale | clay minerals |

**Table 2: Hardness of Minerals and Volcanic glass**

| | |
|---|---|
| Augite | 6 |
| Calcite | 3 |
| Clay minerals | 2.5 |
| Feldspar | 6 |
| Hornblende | 6 |
| Mica | 2.5 |
| Quartz | 7 |
| Volcanic glass | 6 |

## References

1.http://community.dur.ac.uk/~des0www4/cal/roads/index.html The design and construction of roads.

2.http://www.highwaysmaintenance.com/design.htm An idiot's guide to road maintenance.

3.http://www.northstonematerials.com/filestore/documents/aggregate-tests.pdf A guide to aggregate testing.

**Figure 5** Photograph showing a worn road surface with aggregate raised above the bitumen matrix. £1 coin for scale. (photograph M. Williams)

**Table 3: Geology of Roadstone**

*Examine each sample and for each:-*

1. Measure its grain size (if it is too small to measure, put < 0.5mm)
2. Look up its mineral composition and list the minerals in the table below
3. Look up the hardness of each mineral and write it beside the mineral on the table
4. Complete the table by putting a tick where the rock satisfies the criteria (a – f) and a cross where it does not

a) most minerals with hardness > 5
b) two or more minerals
c) grain size < 2mm
d) strong rock
e) tar adheres well
f) low porosity

| Rock | Grain size | Minerals with hardness of each | a | b | c | d | e | f |
|---|---|---|---|---|---|---|---|---|
| Granite | | | | | | | | |
| Gabbro | | | | | | | | |
| Basalt (not vesicular or amygdaloidal) | | | | | | | | |
| Quartz porphyry | | | | | | | | |
| Quartz sandstone, poorly cemented | | | | | | | | |
| Quartz sandstone, well cemented | | | | | | | | |
| Shale | | | | | | | | |
| Oolitic limestone | | | | | | | | |
| Micrite | | | | | | | | |
| Flint | | | | | | | | |
| Schist | | | | | | | | |
| Slate | | | | | | | | |
| Greywacke | | | | | | | | |

**Which are the best two rocks for making roadstone?**