Funded by Defra's Aggregates Levy Sustainability Fund, administered by English Nature.

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☛ On the journey

On the journey to Mosedale pupils should be encouraged to look out for ways in which stone is being used in the environment. This can be seen in walls, buildings, roads and concrete.

☛ Items to bring on the Visit

Appropriate waterproof clothing & stout footwear. Wellies are easy to clean, but difficult to climb steep slopes. First Aid kit. Enough copies of worksheets/notes etc:

*Map of sites in the Mosedale valley (Figure 1) plus OS maps.
*Rock Reference Sheets. There are 2 versions – use whichever is appropriate.
*Site A pupil worksheet 1 Mungrisdale Village Hall. Looking at building stones.
*Site B pupil worksheet 3 Mungrisdale Lime Kiln.
*Site C pupil worksheet 3 Drystone walls at St. Mungo's House.
*Site D pupil worksheet 4 School House Quarry.
*Site E pupil worksheet 5 Naming rocks at Mosedale Quarry (gabbro).
*Site F pupil worksheet 6 Investigating scree at Stone Ends Quarry.
*Site G pupil worksheet 7 Studying pebbles at Long Hill Quarry.

Plus: Notebook, sketchbook, camera, magnifiers, water dropper bottles, tape measure, small ruler, piece of millimeter graph paper [laminated], compass and materials for any other fieldwork activities.
Teachers and adult helpers should each have dropper bottle of water for testing porosity, and one containing dilute acid for testing limestone. Domestic lime de-scaler may be used, and should be diluted to adequately react with limestone (try x 10 dilution). Tissues should be kept handy in case of spillage. Equipment for collecting soil samples.

☛ On Arrival

Arrangements should have been made to park minibuses at the roadside opposite Mungrisdale Community Centre and for any use of the Centre facilities, including toilets (see **MOS3 Location access**). Arrangements should also have been made with the Church authorites for any visit to the church. Take care when crossing the road to the Village Hall. Remind the children of Health & Safety issues: Avoid animal poo.

☛ Using the pupil activity sheets

The Earth Science teaching trail and pupil activity sheets are very detailed, as there is a lot of information to be found in the rocks and their use. In the notes for each locality there are teaching points related to key observations and interpretations on the formation of rocks, and soils, with additional reference to wildlife. The pupil activity sheets are linked to these observations/teaching points. **Teachers will need to decide which materials are appropriate for their pupils to use and adapt the sheets accordingly.**

There are plenty of opportunities to record information by taking photographs, sketching, mapping and note-taking to aid follow-up work. When soil samples are taken, the location of each sample should be marked on the map and on the collecting container.

For some children it may be useful if an adult helper acts as a "scribe", recording the agreed answers on a copy of the activity sheet. All should complete their own sheets as part of follow-up work, as an individual record of the work they did on their visit.

☛ Earth Science On-Site Trail: Key points to investigate

We are looking at four aspects of these exposures of rock:
1 - to find out how the different rocks were formed;
2 - to find out what happened to the rocks after they were formed;
3 - to find out what is naturally happening to them today or in the recent past;
4 - to find out what they have been used for by Humans.

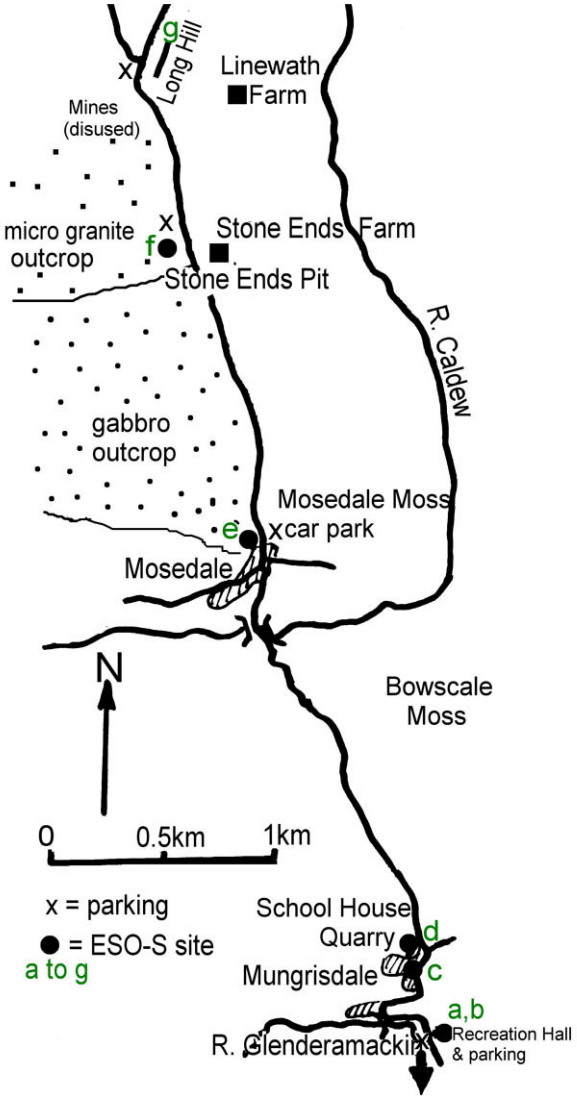


Figure 1. Map of sites in Mosedale Valley.

☛ Managing larger groups could be made easier by splitting the groups into two to ease overcrowding at the roadside at this site. Half could go left to Site B, Mungrisdale Lime Kiln at the north end of the building and then swap with the group working on Site A.

The main focus here is to **c**onsider where stones come from!!

Along with soil, stones are part of the weathered rock material found at the Earth's surface. Mountains and the entire landscape around us are being attacked by rain (including acid rain), rivers, frost, ice, snow, plant roots and animals. Local stone boulders clearly show signs of weathering, being different in colour on the outside, from freshly broken inside. This can be seen here.

The village hall has been recently built of mainly re-cycled materials from the local area. The lintels and corners are new blocks of red sandstone. There are a few thin pieces of marble [probably Italian], most likely recycled from an old worktop. Most of the other rocks occur naturally in the Mosedale valley, as will be seen later.

In the walls of this building there are several types of limestone, the most common sedimentary rock. There is a creamy coloured sandstone. The commonest igneous rock is dolerite. The commonest metamorphic rock is slate. There are two versions of the Rock Reference Sheet, one below and one on worksheet 2 – to suit different ages/abilities. However, it will be a great help if the children have already done rock identification in reparation for this visit. (See **MOS6 Preparation & follow up** and **Working With Rocks**.)

All worksheets referred to here can be found in **MOS8 worksheets**. Teachers may want to decide on the appropriate labelling of photos and worksheets when the features have been identified. Suggested answers occur in this trail and in **MOS9 Teachers notes**.

Site A: Mungrisdale Village Recreation Hall – Looking at building stones.

We are going to look at the stones to see how they have been used and try to identify them. Use the questions below to draw pupils attention to the nature of the wall and the stones used to build it.

Questions/Teaching points	Answers/Interpretation/Comments
Look out for fresh new rocks in the walls of the building. What colour are they? How are they different from the other rocks?	Red colour. They have been cut to exact size and shape to fit.
What parts of the building are they used for?	Used for lintels, corners and bases.
Note the shape of the other rocks in the wall. Are they flat [easy to lay], blocky [need fitting] or round [difficult to lay].	Mostly flat sides and are easy to lay one on top of the other.
Some have been broken and reveal fresh rock. How it the fresh face different from the rest of the rock?	Clearer to see what it is made of, often darker. Outer sides have been changed by being in contact with air, water, soil etc – weathered!!
Has any mortar (a human made stone) been used to hold them in place?	Yes, but behind the stone faces, not right at the front.

Site A – Worksheet 1 – Mungrisdale Village Hall - Identifying the building stones.
Try to match the rock description given in the Rock Reference Sheet below with examples of rocks used to build the Village Hall. Look for freshly broken surfaces of rock. Use a hand lens**. Keep an eye out for traffic.**

Rock Reference Sheet. (Worksheet 2 has an alternative Rock Reference Sheet)

Rock description	Type	Group
Sand grains, rusty or cream colour, layers.	Sandstone	Sedimentary
Medium pinkish & white crystals.	Microgranite	Igneous
White sugary crystals, fizz with acid.	Marble	Metamorphic
Small crystals mostly dark green/black.	Dolerite	Igneous
Large crystals, mostly dark green/black & white.	Gabbro	Igneous
Creamy/white lime mud & shells, layered.	Limestone	Sedimentary
Splits into layers, dark grey/purple/green.	Slate	Metamorphic

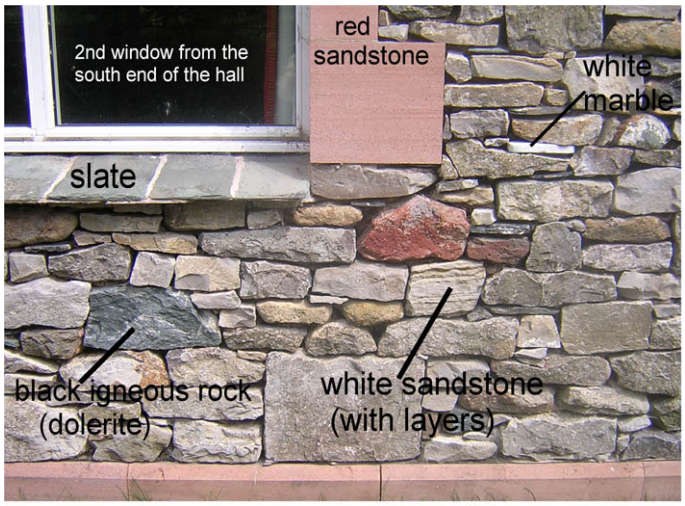


Figure 2. The Wall of Mungrisdale Village Recreation Hall.

Test with a water dropper to see if the rock is porous, but please **do not** test the walls of the brand new hall with dilute acid to see if the rock, a limestone or marble, fizzes!!

Site B. Worksheet 3 – Mungrisdale Lime Kiln
To the north and rear of the Community Centre is a restored limekiln with a useful display board explaining how local limestone was burnt to make quicklime. There is no need to approach the kiln itself. This kiln was used to make the raw material for plaster, mortar, whitewash, antiseptic and a dressing spread on fields to neutralise acid soils. Alternating layers of limestone and fuel (charcoal or coal). were tipped in at the top of the kiln and burnt over several days to 1,000 $^{\circ}$C, before being extracted from the “eye” at the base.
Use **worksheet 3** and the information on the notice board to guide the pupil’s observations of the lime kiln.

Figure 3. Mungrisdale Limekiln.

Questions/Teaching points	Answers/Interpretation/Comments
Describe the shapes of the stones used to build the limekiln.	Many are large slabs, some are round, of different rock types. The archway has thinner, flatter, slabs, probably slate.
Use the display board to help to answer these questions. What fuels were used in the kiln?	Charcoal or coal.
What was put in the kiln along with the fuel?	Crushed limestone.
How long did it take to burn the limestone in the kiln?	Several days.
What was produced in the kiln?	Quicklime.
What was the burnt limestone used for?	Plaster, mortar, whitewash, antiseptic and spread on fields to neutralise acid soils..
Complete the first part of worksheet 3	

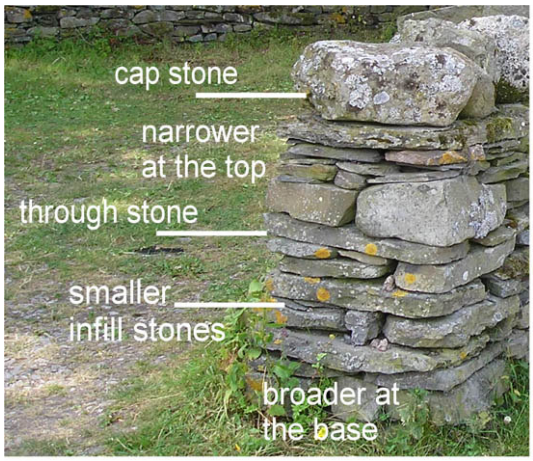
If the group has been split, swap sites with the group who have been working on the Village Hall and do the building stone activity.

☛ Take the group to **Site C: The Dry stone Wall Opposite the Church.**
Walk up the steps by the limekiln and turn north (an opportunity to use a compass), keeping to the footpath across the field. (A soil sample could be collected from this field). This route cuts off a lengthy walk along narrow lanes in the centre of the village.
The gate is a useful place to ask the children to look at all the walls from now on! Notice the use of slabs of slate in the steps and most of the walls in the village, including those round the gate.
They are dry stone walls, without mortar! Materials used vary in shape and rock type.

Go through the gate, keeping to the right hand side of the road, to the church, passing a wall with several very large stones at the base, smaller ones higher up. Site C is the dry stone wall across the road from the church by St. Mungo's House**. Keep an eye out for traffic.**
Please note that the space beyond the wall is not public access.

Site C. Worksheet 3. Dry stone Walling at St Mungo's House.

☛ Take care by this roadside. Look at the walls on either side of the church gate. Notice that the one on the right (to the south) is made mostly of slabs of slate. The one on the left (north) has more rounded boulders. Then take the group across the road to St Mungo's House and to the dry stone wall by the lane where a more detailed study can occur.



Figures 4 & 5. End section of wall by St Mungo's House.

☛ **Background to the Teacher-led discussion – main points:**

Construction: The stones are laid out beside where the wall is to be built (or rebuilt) and the ground levelled & turf removed, to provide firm footing. Originally stones were collected from local fields and rivers and only later quarried when more were needed.
Large flat shapes best for stability are placed in the base layer. No mortar used – hence the name **dry-stone wall.** Smaller flat stones follow, sloping inwards to stop later stones slipping off.
Throughstones bind the wall together, stopping it from bulging. Larger blocks are used at ends, next to where gatepost stone would normally be to give it strength.
Smaller stones are then fitted between larger stones.
As work progresses, the wall is built **narrower towards the top**, again to help stability.
Finally top or **coping or cap stones** are placed on top, wedged together to prevent them being dislodged. May be same rock type and shape as the rest of the wall or may be different – you may have plenty of rounded boulders left! A hammer is only used occasionally.
Dry stone walls are expensive to build as this skilled job takes a long time.
One alternative is hedgerows which take time to grow, need more looking-after, laying, cutting.
The other alternative, fences and wire, give no protection for animals against the weather.
Purposes: As boundary between landowners. As a divide within a farm holding to keep crops & stock apart. To keep animals penned in, off roads, and to provide sheltered from bad weather.

Questions/Teaching points	**Answers/Interpretation/Comments**
Look at the wall to see how it was built, starting from the base! What does "dry-stone" mean?	 Built without wet mortar sticking it together.
Why are the walls usually wider at the base than at the top?	Stable shape (harder for cattle to push over).
What is the name given to the long stones passing through the wall? How many can you see at the end here?	Throughstones. Four.
What is the name given to the stones wedged together on top of the wall?	Capstones.
On the sketch on worksheet 3 draw arrows to examples of moss and lichen growing on the wall.	White and yellow lichen as well as moss are present. Note the abundance of moss in damp areas under trees.
Using your rock reference sheet, try to identify the types of stone used in this wall and label them on the photograph.	Several types: long flats are slates, larger blocks may include limestone, rounded are likely to be dolerite & microgranite. The coping stones on the wall to the School House, behind the post box (see **Figure 4**) are red sandstone, covered in moss!
Complete worksheet 3 by labelling the sketch and trying to identify some rocks in the wall using the most appropriate Rock Reference Sheet.	

☛ Take the group to **Site D**. **School House Quarry**.

Assemble the group at Site C, opposite the Church at the dry stone wall, prior to the 100m walk along the road to the north. Go round the right, then left, hand bends. It is probably best to be on the left side of the road here, away from traffic coming towards you. At the Bull Fell Water Treatment Works, take the track to the left. School House Quarry is on the right across the grass behind the Treatment Works. Pause at the gate. This is a good spot to discuss the need for water treatment.
Then draw attention to the wall on the left.

Questions/Teaching points	**Answers/Interpretation/Comments**
Ask the pupils to describe the rock shapes in this wall.	They are flat pieces. The way they split can be seen on the edges of the pieces (a little like pages in a book)
What rock is the wall on the left made from?	It is made from pieces of slate, a metamorphic rock.
What is holding it together? Is it a dry stone wall?	It is a dry stone wall, made from flat pieces of rock with no mortar.
What is the track made from?	Fragments of slate.
Why has slate been used?	Quarried nearby, and so is easy and cheap to obtain. It is relatively strong, although will break into flat pieces which are useful.

Site D. Worksheet 4. School House Quarry

☛ Go through the gate and turn right into the small quarry. It is called School House Quarry after the School behind you, now restored as a residence. Move the group part way towards large block in the centre of the face and stop.

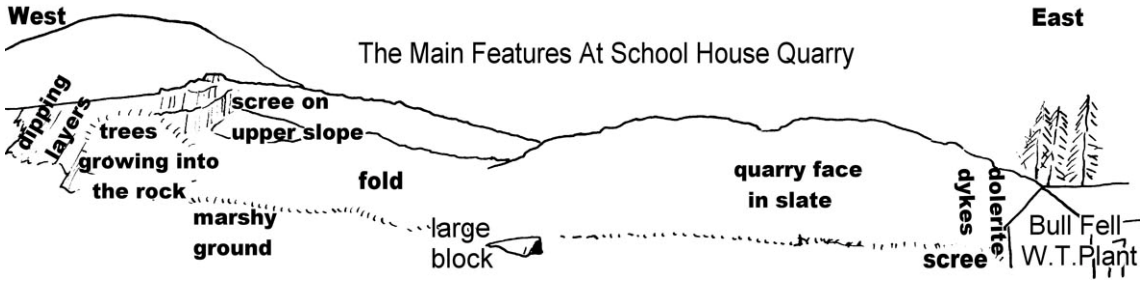


Figure 6. Sketch Of School House Quarry

☛ **Background to the quarry.**

The original muddy and sandy sediments were deposited in deep water early in the Ordovician Period. After the sediment hardened igneous activity took place pushing molten magma up through cracks in the Earth's crust. This cooled and solidified to form two dykes of dolerite, 25 – 50 cm wide.

During a period of fold mountain building, about 400 million yeas ago this area of Britain was involved in plate collision, causing metamorphism, resulting in the rocks being compressed and folded, trending almost east-west. As a result of the pressure these muddy and sandy rocks were not only squashed, but were turned into slates. If the straw squeezing activity has been done as part of preparation for the visit the idea of minerals lining up to form cleavage in rocks should be easier to understand.

The dolerite dykes, formed when hot magma forced its way through cracks in the rock, were harder and suffered less alteration. Over millions of years of erosion they are now exposed at the surface and have been quarried for use as aggregate and building stone. The best place to view the dolerite dykes is to the right, behind the Water Treatment Works. They can be recognised as different from the slate, having no cleavage, but having fractures at right angles to their sides, often filled with the glassy white mineral, quartz. Freshly hammered surfaces show a dark greenish surface with visible crystals.

Questions/Teaching points	Answers/Interpretation/Comments
Point out the left hand end of the face beyond the trees and ask if the group can see the dipping layers. Remind the group of the preparation work they did with settling sediment in jars. Are the layers in sedimentary rocks dipping when they form, or not?	No they are horizontal.
Ask the group what could have made the horizontal layers become tilted?	Earth movements (about 400 million years ago) when a fold mountain range like the Alps was formed across this area.
Tell the group that the mountains were eroded away many millions of years ago. Can they see any signs of weathering of the rocks going on today?	Bits of broken rock on the scree above the face suggest physical weathering. Trees growing into the rock on the left suggest biological weathering.
Ask the group why the ground to the left might be marshy?	The rock is not letting the rainwater drain through it. It is not porous.
Ask the group if this looks like a natural cliff or a human made one (a quarry).	It has a steep face, nearly vertical, clean rock, not weathered much, and a flat floor. It is a quarry which was cut for stone used in buildings, walls and road stone.
Ask the group to label the sketch on worksheet 4.	

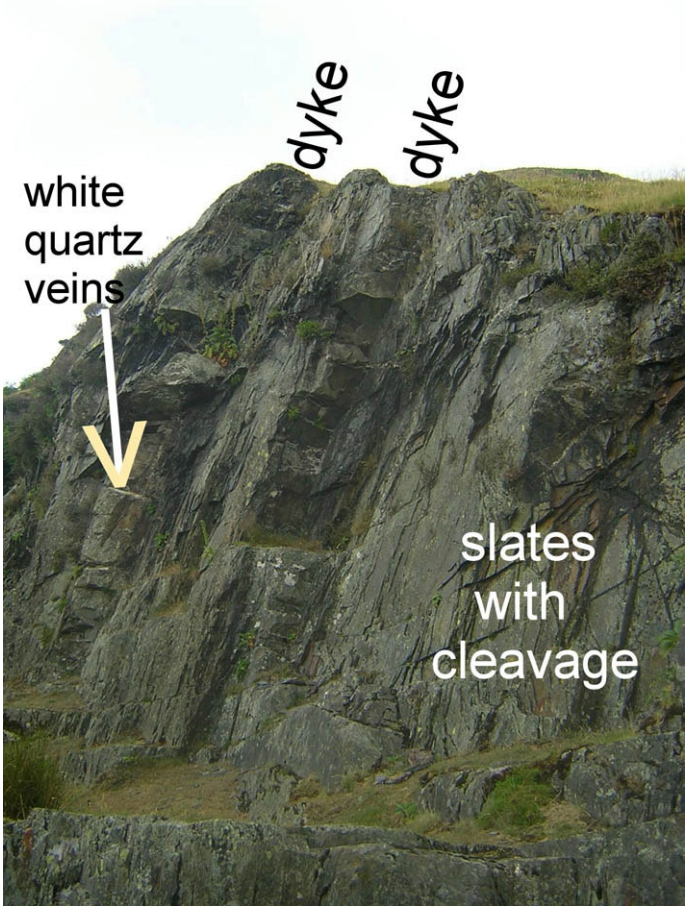


Figure 7. The Dykes At School House Quarry.

☛ Move the group to the right, on the path behind the Bull Fell Water Treatment Works. The best view of the dykes is to go nearly to the far end of the building and then turn and look back to the west. See **Figure 7.**

NOTE: See **MOS9 KS2 Teacher's Notes** for a photograph showing the edge of the second dyke.

Questions/Teaching points	**Answers/ Interpretation/Comments**
Look at the quarry face (& the photograph) and trace the two dykes down from the skyline to the ground. Trace the line on their photograph on worksheet 4.	
Ask the group to describe these dykes.	There is a pair of near-vertical dykes, running parallel to the main face, east-west. They are 25-50 cm wide, with cracks (cooling joints) running across them (some filled with white quartz).
Ask the group to describe the rock (try to find a fresh surface. If this isn't convenient tell the group it is **dolerite** and go on to the next question).	Freshly hammered surfaces show a dark greenish surface with visible crystals. Dolerite.
Use your Rock Reference sheet to help you to explain how dolerite got here.	Igneous rock, once molten magma, squeezed its way up cracks in the existing slate rocks.
Check to see if there is much weathering of the rock faces here, with broken rock forming scree at the bottom.	Not much. There is a little scree at the base, some higher up, possibly waste. Some lichen.
Ask the group to complete worksheet 4.	

Site E. Mungrisdale Gabbro Quarry, at Mosedale Moss.

Figure 8. Mungrisdale Gabbro Quarry.

☛ Take the group back to the minibus at Mungrisdale Village Hall. Drive to Site E, which is 2 Km north of Mungrisdale, just beyond the settlement of Mosedale.

Notice different styles of walling and the uses of stone in the buildings. Several old buildings have the red Penrith Sandstone for corner blocks and around windows and doors. New buildings have breeze blocks on the insides, with slate and blocks of dolerite and granophyre on the outside.

Park on the Mosedale Moss car park, on the right, just after the village. Carefully walk the group across the road to the exposure (see **Figure 8**). The faces here are somewhat overgrown, but there are large blocks on the ground showing typical gabbro (see **Figure 9**).

Figure 9. Microgranite and Gabbro.

North of Mosedale the mountains are mainly made up of two igneous rocks: gabbro and microgranite. The extensive scree slopes of broken weathered rock material are largely relic screes of a colder past, showing the effects of weathering of ice and water. This exercise is to help pupils look observantly at rocks and begin to understand how to describe them. See Worksheets 2 and 5.

The best exposures of rocks are high up and dangerous, but we shall look at fallen blocks, close to the road, first at Mosedale and then at Stone Ends.

At **Site E, Mosedale quarry,** match the description on your Rock Reference sheet and identify the rock. Use a hand lens. Part of Carrock Fell is made of this rock, but the colour varies to lighter and darker varieties. Complete the first part of worksheet 5.	Gabbro. Large black/dark green crystals (of augite) and a white mineral, (feldspar). My minerals interlock because they crystallised together from molten magma. Larger crystals indicate slower cooling at greater depth in the Earth's crust.

☛ **Site F Stone Ends Quarry (Microgranite boulders)**
Return to the minibuses and drive northwards for 1.5 Km. At grid reference NY 353336, park on the left, just beyond Stone Ends farm. Walk along the track uphill to the quarry in the gravel at the foot of the scree slope (see **Figure 10**).

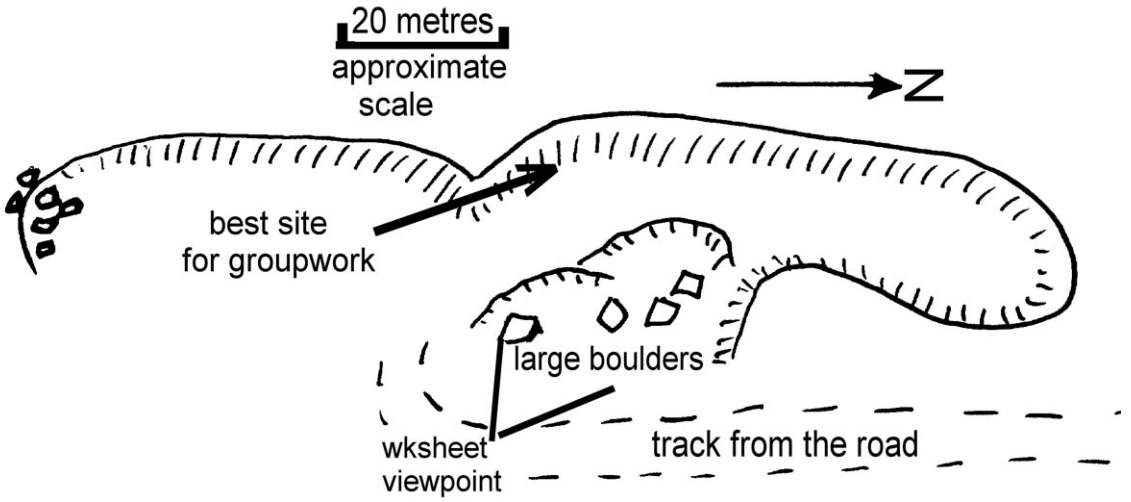


Figure 10. Map of Stone Ends Quarry.

The rock forming the cliffs above is different from the one at Mosedale. Discuss with the group how weathering of bare rock, particularly freeze-thaw, breaks off angular chunks, which fall by gravity down mountain sides. They accumulate as sloping masses of debris, called scree, which continues to accumulate and break up. They are commonly found in areas where the climate has been cold, as at the end of the last Ice Age, 11,000 years ago.

In more recent warmer times many have become colonised with plants and have a soil layer. These are no longer active. At Stone Ends some of this angular scree material has been excavated for use as aggregates. Only the smaller fragments were removed, leaving larger blocks of microgranite behind. With plenty of small pieces available it was not worth the cost of bringing in a crushing machine!

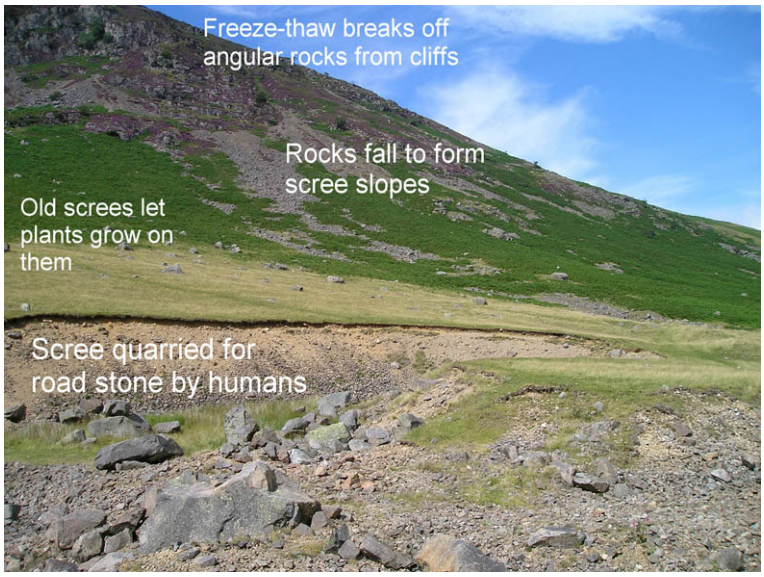


Figure 11. View of the screes from Stone Ends Quarry.

☛ Bring the group to a suitable part of the face with the pink micro granite close to the floor to avoid clambering. Use the Rock Reference sheet to identify the rock, and complete worksheet 5.

The more observant members of the group will no doubt notice that there are also lumps of gabbro in the quarry. They have been brought here from further south.

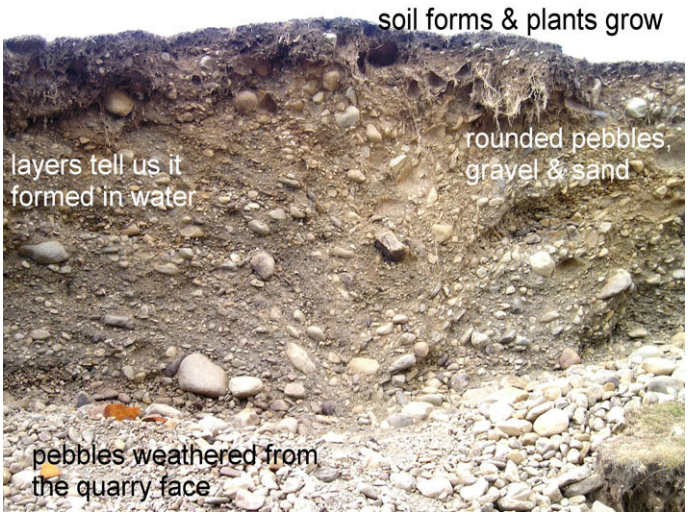
At **Site F, Stone Ends**, match the description on your Rock Reference sheet and identify the rock. Use a hand lens. Most of the mountain is made of this rock, with lighter and darker varieties.	Microgranite Medium pinkish crystals of feldspar, and shiny black crystals. The minerals interlock because they crystallised together from molten magma. Larger crystals indicate slower cooling at greater depth in the Earth's crust.

Look up the slope on the west side of the valley and match it with the photograph on worksheet 6. The viewpoint site for the photograph is marked on **Figure 10** above. Then ask the questions below.

Questions/Teaching points	**Answers/ Interpretation/Comments**
In which part of the hillside is the quarry?	At the bottom of the slope.
Describe the size and shape of the rock pieces found in this scree slope.	Vary from boulders a metre across to small pebbles and sand. Very angular.
Where do you think these rock pieces came from?	From the solid rock on the mountainside, up the slope.
How do you think they get from up there down to here?	Fell, rolled, slid down slope by gravity. Washed down by rain/water.
Why do you think the rock pieces are angular and not rounded?	Not travelled far (unlike river and seashore pebbles).
You may have done an experiment to show how rocks can break up. Is it to do with heating and cooling, or freezing and thawing?	Freezing and thawing. (see Working with Rocks)
What type of severe climate conditions has Britain suffered in the past?	Ice ages/glaciations.
During very severe conditions the ice carried the rock fragments away, but as the climate warmed there was less ice. What happened to the broken rocks when there was no ice?	They fell to form scree slopes.
Even today the conditions on mountains can be severe in which season?	Winter.
Most of the scree slopes are now covered in thin soil and plants. Try to identify two types of plant. Your teacher may wish to collect a soil sample.	Grass and bracken.
Does this vegetation tell us that the climate today is just as cold as it was, or is it warmer and less severe?	Warmer and less severe.
What do you think the rock is used for?	Aggregates – road stone. A small scale operation as there is no crusher for large rocks!

Site G. Long Hill Quarry

☛ Return to the minibuses and drive 1 Km north, parking on dry ground on the left, by a road junction. In the field to your right is a long narrow hill sitting on the wet valley floor.
This hill is composed of rounded pebbles and sand deposited by a river flowing in or under a melting glacier. The gravels are used locally as aggregates. Unfortunately builder's waste has also been tipped here. Walk east to the northern end of the hill, at grid reference NY 353345, where the gravels have been quarried. This is a contrast to the previous locality of angular scree.



This quarry is at the northern end of Long Hill. The photograph was taken looking southwards.

Figure 12. The Gravel At Long Hill Quarry.

Questions/Teaching points	**Answers/ Interpretation/Comments**
Describe the shape of Long Hill.	Long, narrow, lies on the valley floor of the River Caldew, but uphill from the river itself.
What is it made of?	Pebbles, sand and gravel of many types of rocks.
Describe the shape of most of the rocks.	Mostly rounded to some extent [not as rounded as beach pebbles!]
Suggest a reason why they have become that shape.	Travelled some way in water/river.
Can you see signs of layering in the quarry face? What does this suggest? (You may have done an experiment about layering, using sand).	Yes. Layering suggests that the sand and pebbles were deposited in water.
There isn't much water here today. What were the severe climates in the past, as we found out about at Stone Ends?	Ice ages/ glaciations.
What happens to the ice in Summer and when the climate warms?	Ice melts.
Do you think a river of water from melting ice could carry sand and pebbles, rounding them as it flowed along?	Yes!
The river might have flowed under the ice, or in a tunnel through the ice or on top of the ice. What do you think?	In the discussion try to develop the idea that freezing, thawing, and melt water flow, vary as the climate warms up.
Now that the ice and melt water have gone, the hill is now covered in soil and plants. Suggest why the hill is drier than the surrounding area. Your teacher may wish to collect two soil samples from here.	It dries because sands & gravels are porous, rainwater soaks in. Surrounding area is not & has a range of water-loving plants.
What do you think the rock is used for?	Aggregates – local, small scale road stone extraction.
Complete worksheet 7.	

☛ Return to the minibuses at the road side.