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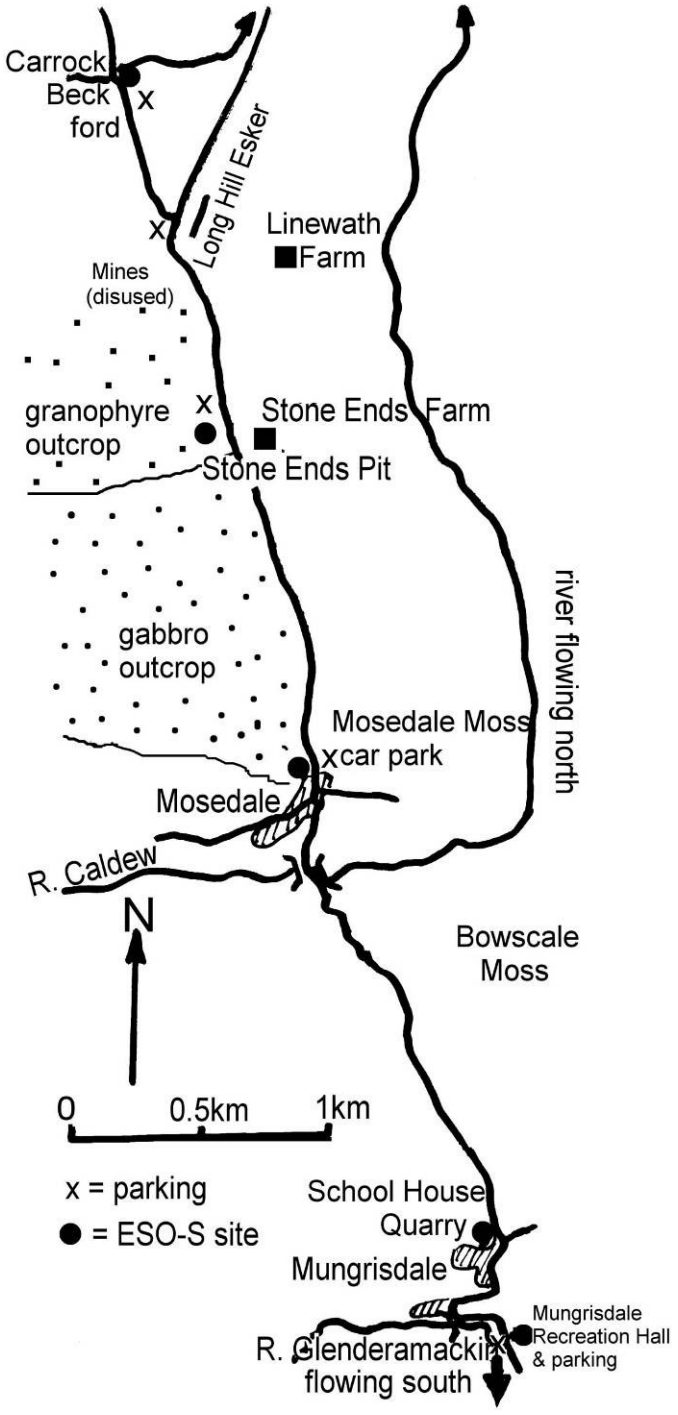
## INTRODUCTION

☛ Field groups will need measuring tapes, compasses and clinometers if dip measurements are to be attempted, as well as clipboards and copies of the relevant field sheets for individual pupils. Callipers for measuring pebble axes are useful, being more accurate than rulers or tapes. (See **MOS8 worksheets.**)
Group Leaders will need a plastic bottle of dilute HCl, a small plastic bottle of water; a flexible sheet of foam rubber to demonstrate the shape of folds. A digital camera will also be useful.

☛ Field leaders should have decided which combination of the following exercises their groups are to tackle before they arrive on site: School House Quarry is in Ordovician slates; Mosedale Moss is an igneous exposure; Stone Ends Quarry is a scree deposit; Long Hill Quarry is in a melt water deposit; Carrock Beck Ford has a modern river sediment (washed out of glacial till); and Howk Gorge is a Carboniferous limestone exposure.




☛ Park on the left side of the minor road opposite the newly built Mungrisdale Village Recreation Hall. (GR **NY 36353025**). This minor road is quite busy and the space by the village hall is narrow, so groups will need to be careful as they cross the road and make observations on the building material.

**Mungrisdale Recreation Hall**
Before drawing the group's attention to the building ask them in which direction the river is flowing. It is flowing southwards along the valley, (but the other river in this valley flows northwards.)

Split the group into two smaller groups, one to work at the southern end of the building, and one towards the north.
From the safety of the car park ask the group to observe the materials used to build the village recreation room.

| Suitable questions at this site | Acceptable responses. |
|---|---|
| Ask "Is the recreation room all made of the same material?"<br>Why not? | No it isn't.<br><br>Because different parts of the building need materials to do different jobs: be strong; be waterproof; be attractive; be transparent etc. |
| What is the roof made from? | Slates (Not tile. Tiles are man-made, slates are natural.) |
| Where do we get slates from? | They are quarried from the ground. |
| What is it about the properties of slates that make then useful for roofs? | They split into thin shapes to lay on the roof and they are non-porous i.e. are waterproof. |
| What are the windows made from? | Glass. |
| Where do we get glass from? | It is made from melted and fused quartz sand. |
| What is it about the properties of glass that makes it useful for windows? | It is transparent, waterproof and can easily be cut into useable shapes. |
| What are the windows edgings made from? | Square cut blocks of red stone. |
| What is it about the properties of this stone that make it useful? | It is easily cut to shape, it is strong enough to support the weight of the building above, and it is an attractive colour. |
| Ask the group to complete the table on **worksheet 1**. Be careful when crossing the road. | (See **MOS8 worksheets.)** |

☛ Move the group to the north end of the village hall where a view of the limekiln can be seen. The signboard gives all the information. There is no need to approach the kiln itself.

| Suitable questions at this site | Acceptable responses. |
|---|---|
| When was the limekiln used and what was the lime used for? | Eighteenth century limekiln.<br>The lime was used for rendering stonework, whitewashing houses and for putting on fields that had acidic soils to make them more fertile. (Calcium carbonate is an alkali) |

☛Take the group along the signposted footpath just behind the north end of the village recreation hall. This cuts across the fields to the road through the village. [The telephone box is 200m away to the left, on the roadside]. Continue north along the road, keeping alert for traffic as there are no pavements, past the churchyard on the right and round the right, then left hand bend. It is probably best to be on the left side of the road here, away from traffic coming round the bend. 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 and draw attention to the wall.

| Suitable questions at this site | Acceptable responses. |
|---|---|
| What is the wall on the left made from? | It is made from pieces of slate. |
| What is holding it together? | It is a dry stone wall, made from flat pieces of rock. Gravity and friction are the forces holding it together. |
| What is the track made from? | Fragments of slate. |
| Why has slate been used? | Quarried nearby, is relatively strong, although will break into flat pieces along the cleavage. |

☛Go through the gate and assemble the group close to the large block in the centre of the quarry face.

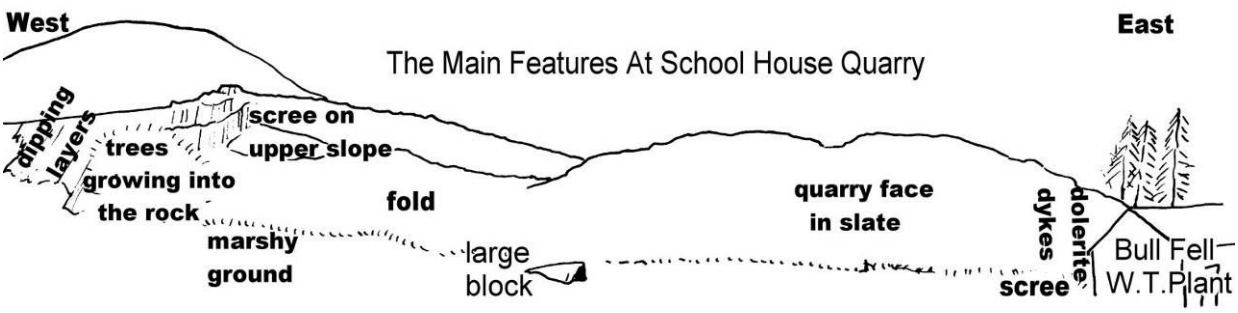



**Figure 2. School House Quarry.**

| Suitable questions at this site | Acceptable responses. |
|---|---|
| What has caused this rock to be exposed here? | It is a quarry face created when the stone was extracted. The hill slope has also been affected by river and ice erosion in the past. |
| What is the evidence that this rock is being weathered today? | There are rock fragments on the upper face of the quarry suggesting physical weathering (by frost or by humans!)<br>Iron staining indicates chemical weathering.<br>To the west there is evidence of trees growing into the joints in the rock face (biological weathering). |
| How do we test if this rock permeable ?<br>[**NOTE:** This simple test can be followed up in the lab by weighing a piece of the slate before and after immersion in water. A piece of porous sandstone could be used as a comparison.]<br><br>What is the evidence for this in the quarry? | Pour water into a bead on a flat and horizontal fragment. It does not sink in. The rock itself is not porous or permeable.<br><br>This agrees with the observation that the west end of the quarry floor is a little marshy. |
| Describe the rock and identify it if you can: igneous, sedimentary or metamorphic? | It is a fine grained dark coloured rock.<br>It splits into thin plates, but it is too resistant to be shale. It is a metamorphic slate. |
| Remind the group that the rock cycle can be thought of in three repeating stages:<br>**i) deposition** of sedimentary rocks;<br>**ii) deformation**, including tilting, folding, metamorphism, igneous intrusion;<br>**iii) uplift, weathering and erosion.**<br><br>What was this rock before it was metamorphosed, and what kind of metamorphism has affected it? | It was deposited as fine grained mud.<br>Later it was affected by regional metamorphism (i.e. a fold mountain building event which compressed the rocks forming the new splitting direction (cleavage).<br>Later it has been uplifted to about 240m above sea level.<br>NOTE: Under some circumstances fossil evidence may survive low grade metamorphism. The rare fossils found here are graptolites indicating a marine environment of deposition and an age (dated by other means) of about 470 million years. |
| Can the group see any evidence of tilting or folding? | Just to the west (left) of the large boulder the rock face exhibits a set of cleavages which dip to the southwest and are curved into a fold. (See **Figure 3.)** [NOTE This "folding" is in fact caused by low angle thrusting visible in the lower face of **Figure 3**.] |
| What kind of forces can create these effects in the Earths crust? | Plate tectonic forces. Fold mountains are interpreted as evidence for a closing plate boundary and the squeezing of sedimentary rocks between two continental pieces of lithosphere. |
| There is also an igneous intrusion in this quarry. Can you find a dyke, or two?<br><br>NOTE: Guide the search to the east behind the Bull Fell Works. | The dykes (one dyke split into two) are hard to pick out (See **Figure 4.**) as they weather almost to the same colour as the slates, but they don't split into thin sheets. Concentrate on the westerly of the two: it is some 30 cm across and doesn't split as finely as the slates. |
| How can you tell this is an igneous rock? | This is confirmed by observing the medium sized interlocking dark crystals on fresh surfaces. (It is a dolerite.) |
| Is the dyke older or younger than the slate? How can you tell? | The dyke is younger because it cuts through the slates and bakes them, making them dark. |
| Return to a point close to the gate and ask the group to complete and label the field sketch of school House Quarry on **worksheet 2.** | (Worksheet 2 in **MOS8 worksheets**) |

**Figure 3. Folds at School House Quarry.**

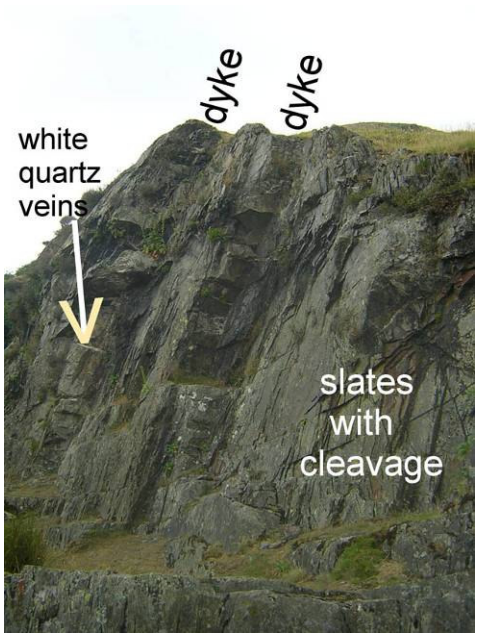



**Figure 4. Dykes at School House Quarry.**

☛Return to your parked vehicle by the same route, and drive north through Mungrisdale village and on to the village of Mosedale. When crossing Bowscale Moss remind the group the there is a much more recent, glacial, story in the valley. Ice once over - topped Carrock Fell and flowed north through the valley and then melted, filling the valley bottom with hummocks of moraine, across which the post glacial rivers had to find their way. This is the reason that the River Glenderamackin, south of Mungrisdale, flows south, whilst the River Caldew (to be crossed just south of Mosedale) flows northwards.
In Mosedale the telephone box is on the left as you enter the village. The village roads are narrow and the corners are tight. After passing through the village of Mosedale you may park in the informal car park area on the right just after the Dalemain Estate sign. (GR NY357325).
Mosedale Moss Quarry is the roadside exposure across the road. Take care when crossing the road.

**Mosedale Moss Exposure.**

☛ This exposure of igneous rock (gabbro) is very variable in colour. Some parts are quite white (more feldspar) and parts are darker (more iron & magnesium silicates). This reflects a difference in chemical composition of the magma during crystallisation. Use the freshly broken pieces lying on the ground to observe the interior of the rock, and contrast with the weathered exterior.

| **Suitable questions at this site** | **Acceptable responses.** |
|---|---|
| Examine the rock pieces on the ground. Describe the rock and suggest what kind of rock it is. (See **Figure 5**.) | It is made up of black and white crystals, up to a centimetre across. They are interlocking crystals. There is no bedding or fossils. It is an igneous rock. |
| By the trees, 100 metres to the south, and up the slope, is a baked contact with the slates you have seen at School House Quarry. (It is very difficult to get to when the vegetation is high). What does this tell you about the age of the igneous rock (gabbro)? | If it cuts the slates and bakes them then it must be younger **(Principle of Cross Cutting Relationships).** Dating by radiometric methods gives an age of around 468 million years. |
| What does the crystal size tell you about the rate of cooling? | It cooled slowly in a large underground mass (batholith). It is quite large. Most of the hill above is underlain by this gabbro). |
| What evidence is there here that this rock is being chemically weathered?<br><br>What evidence is there here that this rock is being biologically weathered?<br><br>What evidence along the slope that this rock is being physically weathered? | The outer surface can be of a different colour (See **Figure 6.**) which suggest chemical weathering.<br>The outcrop also has trees and other vegetation which indicate biological weathering with roots growing into the joints.<br>Along the slope there are many large boulders which appear to have fallen from the cliffs above, suggesting physical weathering. (they are also of igneous gabbro). **NOTE**: Beneath the bracken are many concealed scree slopes. |

**Figure 5. Gabbro from Mosedale.**

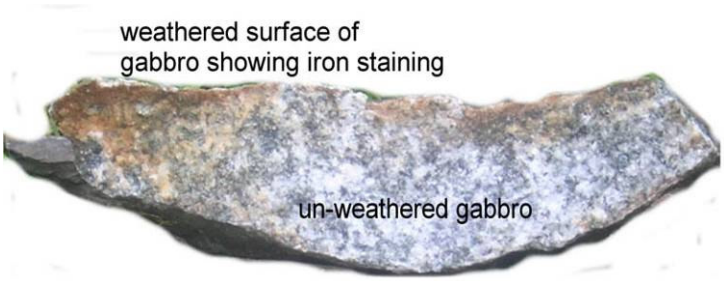



**Figure 6. Weathered Gabbro.**

☛Continue driving north along the road pointing out the screes of very large boulders of gabbro on the left. After 1.5 kilometres, about 200 metres past the well named Stone Ends Farm, park on the left on roadside grass by the unfenced track which leads up the slope to Stone Ends quarry.

Point out to the group that this part of the geological story is of a much younger rock cycle than the one they have just been studying. It dates from the last 20,000 years when ice covered much of northern Europe, and the UK. (i.e. the weathering and erosion part of the rock cycle would have been very different from today). At its height, ice flowed over the top of Carrock Fell, making the ice in the valley about 1500 metres thick. When the ice melted all the weathered rock (moraine) in the ice would be deposited where the glacier lay: unsorted.

However, melt water running across the surface and through the crevasses in the ice and out across the moraine on the valley bottom, would transport and deposit fragments in beds, sorting them and rounding them in the process. After the ice had gone the climate would still be very cold, and freeze thaw (physical weathering) would be much more powerful than today on the exposed steep crags in the valley. The large stones lying across the valley floor (see **Figure 11.**) will include glacial erratics, brought by ice from the central Lakes area, whilst others might be post glacial fallen blocks from the cliffs. (See **MOS4 Briefing** for more details.) Tell the group it is these superficial deposits they are to investigate at the next three sites.

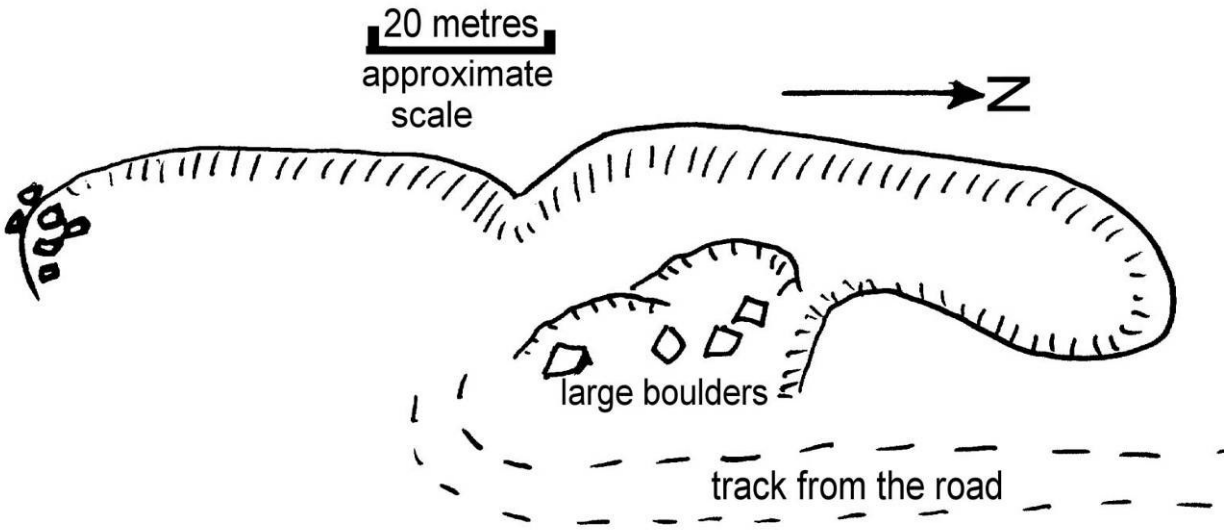



**Figure 7. Sketch map of Stone Ends Quarry.**

**Stone Ends Quarry**

☛ Walk upslope for about 250 metres along the unfenced track to the pit, arriving about half way along the exposure, but continuing to the southern end, close to the large boulders. (See **Figure 7.**) Ask the group to investigate the deposit in the quarry. There is no need to climb the slopes.

| Suitable questions at this site | Acceptable responses. |
|---|---|
| What is the deposit made of? | Lumps of rock, with some finer sandier material visible, especially near the top of the slope. |
| Can they tell what rock type the lumps have been weathered from? | Almost all of the boulders and lumps here are igneous made of interlocking black and white minerals,: i.e. the gabbro at Mosedale. |
| Ask the group to describe the shape and angularity of the pieces. | They are blocky shaped, with sharp edges and corners. |
| What does this tell them about the amount of transport in water these fragments have experienced? | Almost no transport in water. |
| Ask if all of the pieces are of similar size? | No, the sizes vary from quite large pieces down to sand size. (i.e. it is unsorted.) |
| Ask the group to speculate: Where did these pieces of rock come from? | The likely answers will refer to scree processes, with pieces falling from the cliffs on the fell, above. [NOTE: The crags just to the south are of gabbro, but it is quite possible that some of these are moraine deposits left over when the (northwards flowing) ice melted and dumped these sediments here – after bringing them from the exposures of gabbro to the south. |
| What weathering processes are likely to have been involved in forming these fragments? | Physical weathering, probably freeze-thaw, followed by falling down the slope under gravity, or some combination of all three. |
| Is there evidence that freeze thaw is still going on? | The currently active scree slopes are higher on the slopes of the fell (They have no vegetation cover.) The deposits here, with their grass cover, seem to be much older. |
| Is this a bedded deposit? | No |
| What name do we give to this kind of deposit? | Sedimentary. If there is any doubt remind the group that any rock made of weathered fragments of other rocks is called sedimentary. |
| What has formed this exposure? | The track and the shape of the faces suggest it is quarried, not a natural face. |
| What use does the group think this material will be put to? | It is probably an aggregate for the repair of farm roads. |
| What are the characteristics of this sediment which make it suitable for this purpose? | It is a physically resistant rock with few lines of weakness. |

☛ Walk the group back along the face towards the north. Ask them to inspect the fragments at intervals and see if they notice any changes. Stop the group at the point where the track enters the quarry, about at the midpoint of the excavation. (See **Figure 8**.)

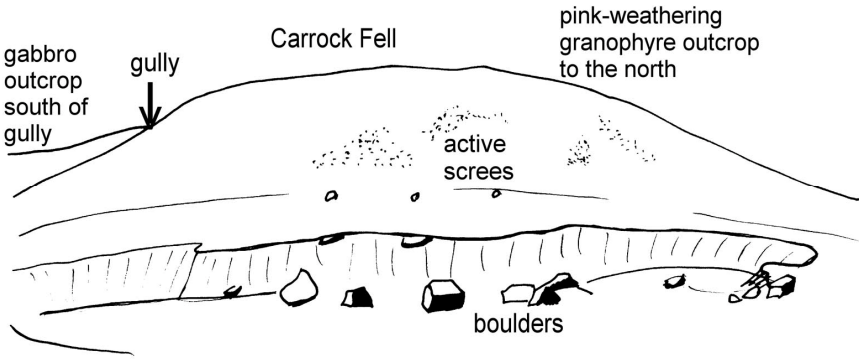



**Figure 8. View of Stone Ends Quarry from the Track.**

**Figure 9. Stone Ends Quarry.**

**Figure 10. Active scree slopes.**

| Suitable questions at this site | Acceptable responses. |
|---|---|
| Ask the group what they have noticed about the fragments making up the quarry? | The proportion of pink weathering rock (granophyre) increases rapidly, although the white and black (gabbro) is still noticeable. (See **Figure 10.)** |
| What hypotheses can they suggest to explain the changing proportions of the two rock types? | 1) Either the rocks have been moved and mixed up during quarrying operations (some certainly have) or 2) The rock type in the cliffs above changes from south to north (which they do).<br>NOTE: A further possibility is that this is re-worked moraine deposited as the ice melted from the valley, and another is a combination of all three. |
| Encourage the group to use the information on **worksheet 3** to describe the edges of the fragments, and remind them that increased rounding suggests increased time spent being transported by water.<br><br>What shape are the edges of the fragments?<br>Have they been transported far by water. | <br><br><br><br>Very angular to Sub Angular.<br>Transport by water very unlikely |
| Ask the group to summarise their findings and draw a field sketch using **worksheet 3** | |
| Direct the group's attention to the north to Long Hill, the low ridge lying towards the middle of the valley floor. Point out that this, Long Hill, is also a more recent deposit with some similarities and some differences – that need explaining. (See **Figure 11**.) | |


**Figure 11. Long Hill Esker viewed from Stone Ends Quarry.**

☛ Before leaving the site point out Long Hill to the north, the next site to be visited. It too has superficial deposits, but they are different from the ones at Stone Ends. Return to the vehicle and continue north, about 400 metres along the road to the junction with another minor road off to the left. (GR NY352345). Park on the grass on the left side of the road. Long Hill Esker is the long low ridge, about 80 metres away to the east. Walk the group eastwards across the marshy flat ground (underlain by till) to the low ridge, then walk along the crest to the quarry cut into the northern end. (See **Figures 12 & 13.**)

| Suitable questions at this site | Acceptable responses. |
|---|---|
| Ask the group why the ground they have crossed is marshier than the ridge. | Flat and less permeable ground, (underlain by moraine containing a lot of clay.) |
| Why is this exposure here? | Again quarried for aggregate materials used to repair farm roads. |
| Ask the group to investigate the deposit in the quarry by using **worksheet 4**. Then summarise their findings as below. | |
| What similarities can they see with the Stone Ends Quarry? | Made up of un-cemented fragments with sand. |
| Is the deposit bedded? | Yes. On the east side there are traces of bedding, where the deposit is mainly pebbly. |
| Ask if all of the fragments in the quarry are of similar size? | No, the sizes vary from quite large cobbles down to sand size. |
| Ask the group to describe the shape and angularity of the pieces. | They are of various shapes, with more rounded edges and corners than at Stone Ends Quarry. |
| What does this tell them about the amount of transport in water these fragments have experienced? | Rounding of the edges of fragments indicates a great deal of transport by water. |
| What does the size of the largest fragment tell them about the speed of the current that deposited these fragments? | A very powerful current (of which there is no sign today!)<br>(See **Table 1.**) |
| Point out that Earth Scientists often don't know the answers to questions and have to use observations to create hypotheses they can test.<br>Tell the group that this is an exercise in observation and hypothesising.<br>Ask the group where the flowing current that deposited these rounded pebbles came from? | They will probably be unsure. Encourage logical observation and hypothesising. For example: the deposit is a ridge not in a channel and lies some distance away from the present drainage channel – which isn't powerful enough to transport this material.<br>See how far their thinking takes them, then you will almost certainly need to explain about esker deposits in ice tunnels (See **MOS4 Briefing and Table 2.**). |

**Figure 12. Long Hill Quarry looking south.**

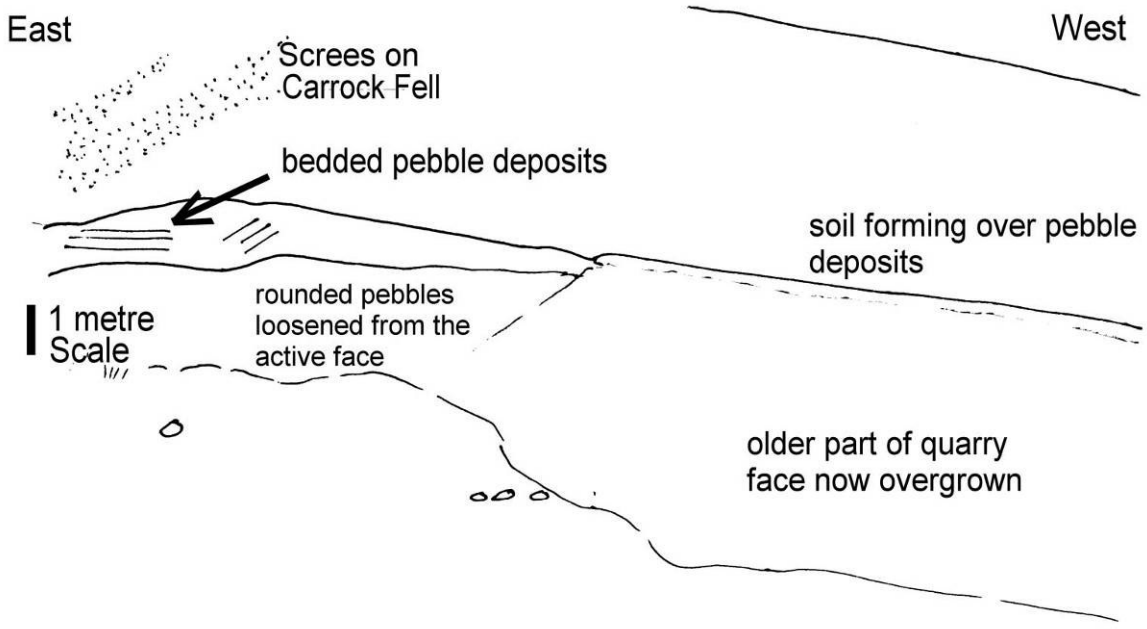



**Figure 13. Sketch of Long Hill Esker.**

☛ If group leaders do not wish to compare present day river deposits with the Long Hill esker deposits then omit the next section and follow the directions past Carrock Beck ford to Caldbeck. Alternatively, return to the vehicle and take the left turn up the hill. About 20 metres before the ford park on the grass to the right side of the road(GR NY 34953505) carefully avoiding the rocks. Bring the group to the south bank of the beck. (See **Figure 15**.)

Remind the group of the need for suitable and safe behaviour. Also that this is common land and to ignore any horses etc. that might appear to want feeding or petting.
[**NOTE:** Carrock Beck responds rapidly to precipitation. **After very heavy rain this site may not be safe to use for this exercise, nor to cross in a vehicle.** In such conditions take the low road past Long Hill to Lonning Head and on to Heskett Newmarket in order to get to Caldbeck and Howk Gorge.]

**Figure 14. Sediment in Carrock Beck ford.**

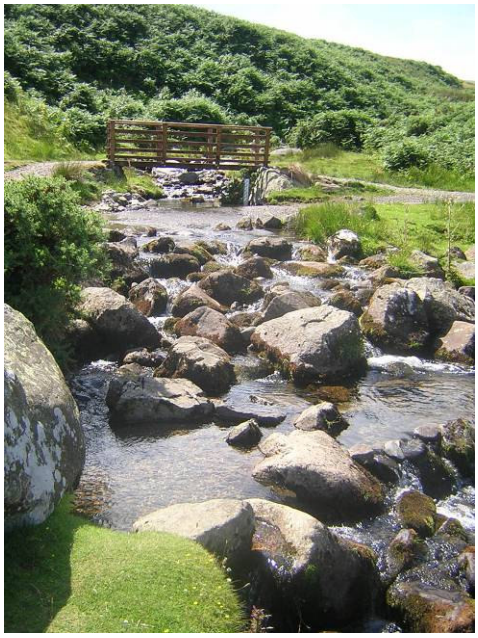


**Figure 15. The ford at Carrock Fell Beck.**

| Name of Fragment | Diameter of Fragment in mm. | Approximate Minimum Flow Velocity to Deposit this Sized Fragment |
|---|---|---|
| COBBLE | Over 100 mm | 400 cm per second (extremely high shooting flow) |
| COBBLE | Over 64mm | 300 cm per second. (extremely high flow) |
| PEBBLE | 4mm to 64 mm | 100 cm per second (very strong flow) |
| GRAVEL | 2mm to 4 mm | 60cm per second (fast flowing stream) |
| COARSE SAND | 2mm to 0.5 mm | 12 to 15 cm per second (more normal stream flow) |

**Table 1. Depositional Threshold Velocities for coarse grained fragments in water.**

| Suitable questions at this site | Acceptable responses. |
|---|---|
| Which part of the Rock Cycle is represented here? | Transport and deposition of weathered fragments. |
| In which direction is the water flowing? | Eastwards. |
| Is the water transporting any sediment today? [The answer depends a little on how lucky you have been with the weather]. | Probably not, unless there has just been a downpour. However, there may be some fine sand being rolled over the bottom. |
| Ask where the gravel is likely to have come from? | Westwards, upstream, possibly from the moraine, or weathered from outcrops. |
| What evidence can you see that the stream sometimes flows faster than it is today? | In the stream are banks of gravel with long axes up to 80mm. These would require a current velocity of over 60 cm per second. (See **Table 1.**) |
| Ask the group how far they think the larger boulders fragments have been moved by the river? | They are unlikely to have been brought too far by the river, apart from their size (weight), they tend to be sub angular i.e. they have not had much rolling to round the edges off. |

| | |
|---|---|
| Ask where these boulders might have come from? | They are most likely to have been washed out of the glacial moraine. |
| Set the group the task to describe these river gravel deposits. (See **worksheet 5.)** | See **MOS8 KS3 worksheets.** |
| Bring the group together and discuss their findings. | The Stone Ends deposit has many characteristics of scree and few rounded fragments.<br>Most of the gravel in Carrock Beck has not been transported far enough to become very rounded, whilst many of the Long Hill fragments have – even though this probably happened more than 10 thousand years ago. |
| Ask the group what changes they think will happen to these fragments as they are transported down the river. | Become broken into smaller pieces and become more rounded. |
| If humans do not interfere, then what will eventually happen to the weathered fragments from this exposure. | Transported to the River Caldew in the main valley and then via the River Eden to the Solway Firth and the sea. |
| What kind of fossils might be found in these new rocks by geologists millions of years in the future? | Accept most answers that recognise the need for resistant parts: e.g. boats, cars, cans, ipods, shellfish, dolphins, washed – in trees, drowned birds, (and maybe even human skeletons) etc. but not jelly fish etc. |

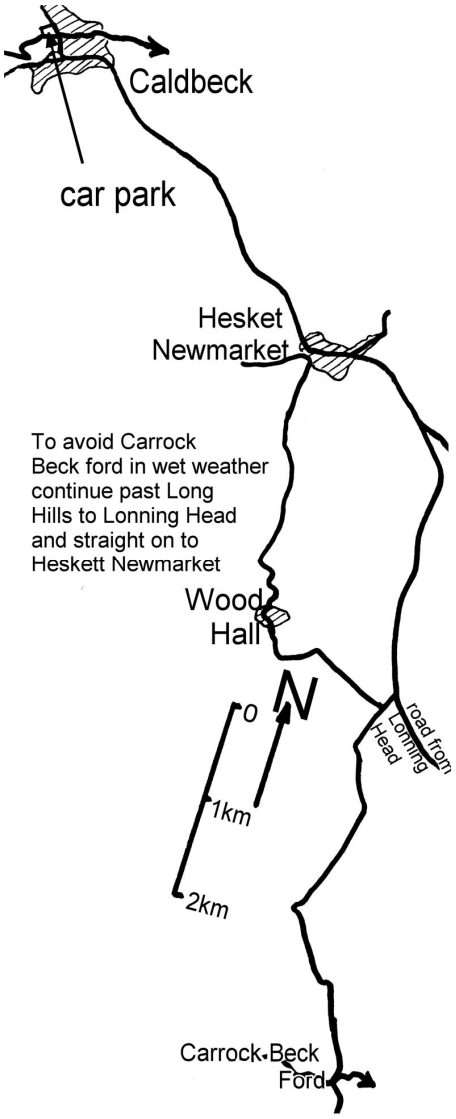



**Figure 16. The route to "Howk" Gorge.**

☛ **Route to The Howk Gorge. (grid reference NY 320397)**

To go directly to Caldbeck take the minor roads up the hill from Long Hill through the Carrock Beck Ford. Continue past the left turn to Wood Hall and the right turn soon after. Bear left to Hesket Newmarket at the next road junction. Continue through the village on to Caldbeck. The total journey from Carrock Beck Ford is 4 miles (6.5km). In the village, at the Oddfellowes Arms turn right and, after crossing the bridge, turn left and park in the free car park. (See **Figure 20.)**

[NOTE **In very wet weather** avoid the ford and continue past the Long Hills location, for 1.5 kilometres. Following the signs for Heskett Newmarket turn left over the cattle grid, and go through Lonning Head, rejoining the route 2km south of Heskett Newmarket.] (See **Figure 16.**)

Leave the car park on foot along the exit road at the north western corner. At the junction turn left for 50 metres. At the road junction, cross the road and enter the gate Howk Mill footpath, through the cobbled yard.
After about 200 metres the ruins of the Howk Bobbin Mill and the limestone quarry exposures can be seen.

The main limestone exposure is at the north eastern corner of the Howk Mill site, to the right of the path.

Remind the group that the Rock Cycle can be thought of in three stages: i) deposition of sedimentary rocks; ii) deformation (folding, faulting, metamorphism, intrusion) followed by iii) uplift and weathering and erosion.

**First focus on identifying the rock type.**

| Suitable questions at this site | Acceptable answers |
|---|---|
| What observations can you made about these rocks? | They are in almost horizontal layers; grey in colour; are fine grained; contain fossils (coral and brachiopod). |
| What does the fossil evidence tell us about the conditions under which these beds were formed? [NOTE: **Stage i** of the rock cycle.] | The corals suggest a warm marine environment of normal salinity, well oxygenated and fairly shallow. Since the corals are found lying on their side, (i.e. not perpendicular to the bedding which indicates the horizontal of the time) they must have been washed around by currents after death. |
| Do they react with dilute HCl? (Group leaders should demonstrate using HCl from a small plastic bottle.<br>What do you conclude from this test? | Yes it does.<br><br>It is a rock made of calcium carbonate: a limestone. |
| To which rock group do these rocks belong: igneous, metamorphic or sedimentary? | Layered rocks with fossils are sedimentary. |
| How did the calcium carbonate get into the sea water to be of use to the organisms? | Mainly as soluble products of chemical weathering, brought to the sea by rivers. |
| What sedimentary rock is made of calcium carbonate?<br>What non-sedimentary rock is also made of calcium carbonate? | Limestones.<br><br>Marble. |
| How is marble formed? | By heat and pressure in the earth's crust acting to metamorphose limestones.<br>(But notice, this part of the rock cycle has not happened here. Nor has melting to form igneous rocks.) |
| What are the main differences between marble and limestone? | Marble is made of interlocking crystals of calcite, and all fossil remains have been destroyed. |
| **TASK 1:** Complete **worksheet 6**, describing the grey limestones. | See **MOS8 KS3 worksheets.** |

**Next focus on uplift and deformation of these rocks.**

| Suitable questions at this site | Acceptable answers |
|---|---|
| **Remind the group they have deduced that the grey rocks were formed under the sea:**<br>If these grey limestones were formed below sea level, and are now at about 190 metres above sea level, what must have happened to them ?<br>[NOTE: **Stage ii** of the rock cycle.] | The rocks have been uplifted and tilted. (Large vertical changes in sea level can be discounted due to the vast amount of water involved in flooding land to this height). |
| What forces could have done this? | Plate tectonic forces, when plates collide, are the only known forces strong enough to tilt and uplift large volumes of crustal rocks. |
| If the rocks of the lithosphere were not being repeatedly uplifted by plate tectonic forces, what would happen to the landscape? | Weathering and erosion would reduce the continental areas to a sea – level plain. |

**Next focus on weathering and erosion.**

| Suitable questions at this site | Acceptable answers |
|---|---|
| How have these rocks become exposed at this particular site? | River erosion has excavated the valley, but then the rock has also been quarried by human activity. |
| Are these grey beds porous?<br>How can we test for porosity?<br>[**NOTE:** This simple test can be followed up in the lab by weighing a piece of the limestone before and after immersion in water. A piece of porous sandstone could be used as a comparison.] | Use a few drops of water in a depression in the grey beds. The water does not sink in. These beds are relatively non porous. |
| Can you see joints at right angles to the bedding planes? | Yes, there are many. |
| When rain falls onto these grey beds, where will it go? | Either run off to the stream, or flow down the joints underground. |
| How might these joints affect the rate of weathering of this rock? | It divides the rock into blocks to allow physical weathering (freeze-thaw) and also increases the surface area to acidic rain and chemical weathering of the limestone. |
| What evidence of weathering of these rocks can you see?<br>[NOTE: **Stage iii** of the rock cycle.] | There are signs of soil formation near the top of the face, and evidence of biological weathering with tree roots growing into the joints and bedding in the exposure. |

☛ Continue along the footpath through the gorge, up the steps and onto the footbridge.

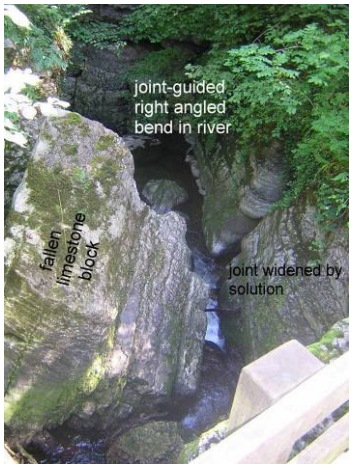



**Figure 17. The "Howk" Gorge.**

**Figure 18. Joints and pebbles in the Gorge.**

**Here focus on the present day geological processes.**

| Suitable questions at this site | Acceptable answers |
|---|---|
| Ask the group how do they think this gorge was formed. | Eroded by the down cutting river: chemical processes, and also by eroding limestone fragments. Collapsed block of limestone. |
| Ask for the evidence they can see for these processes.<br>Remind them to look down on **both** sides of the bridge. (See **Figures 17 & 18.**) | Pebbles in the river bed are evidence of erosion of physically weathered fragments.<br>Solution of joints in the limestone forming the bed is evidence of chemical weathering. |
| If humans do not interfere, then what will eventually happen to the weathered fragments from this exposure? | They will form new sedimentary rocks in the future (i.e. the next Rock Cycle). Sediment in the River Caldbeck will be taken to the River Eden and then into the Solway Firth. |

| | |
|---|---|
| What kind of fossils might be found in these new rocks by geologists millions of years in the future? | Accept most answers that recognise the need for resistant parts: e.g. boats, cars, cans, ipods, shellfish, dolphins, washed – in trees, drowned birds, (and maybe even human skeletons) etc. But not soft bodied jelly fish etc. |
| Ask the group to complete the field sketch on **worksheet 6.**<br>**Worksheet 7** may be completed here to summarise the visit, or be used as a follow up piece of work afterwards. | See **MOS8 KS3 worksheets.** |

☛ There is a circular return walk across the footbridge to the B 5299 turning left back to the car park in Caldbeck village. (see **Figure 20.**) or return back along the footpath to the vehicle through the gorge, the way you came.

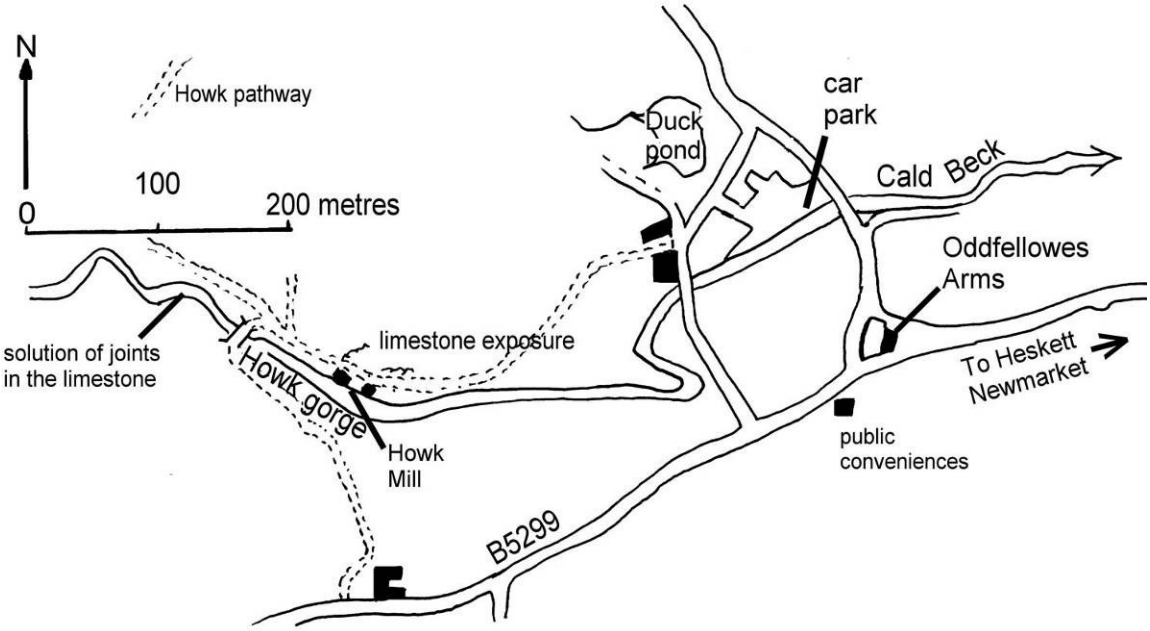



**Figure 20. The "Howk" Gorge at Caldbeck.**