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

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Introduction

In order to complete these field work exercises you will need to ensure: each pupil is provided with a clipboard and copies of the worksheets; each small work group of pupils has a tape measure, a hand lens, a grain size comparator card (or graph paper), a clinometer, access to a calculator and a compass.
Group leaders will also need a small plastic bottle of water to demonstrate porosity and permeability.

☛ To get to the quarries from the car park it is necessary to walk northwards along Ercall Lane, for about 500 metres. This road is narrow, with no footpaths. Remind everyone of the need for care. Access to The Ercall quarries is through a barrier on the east (right), signposted by a Wildlife Trust marker "ERCALL WOOD NATURE RESERVE". Follow the path between the first set of quarries until you come to quarry 1. This is both locality "A" and "F" on the return section of the field visit before localities G and H. **See Figure 1.**

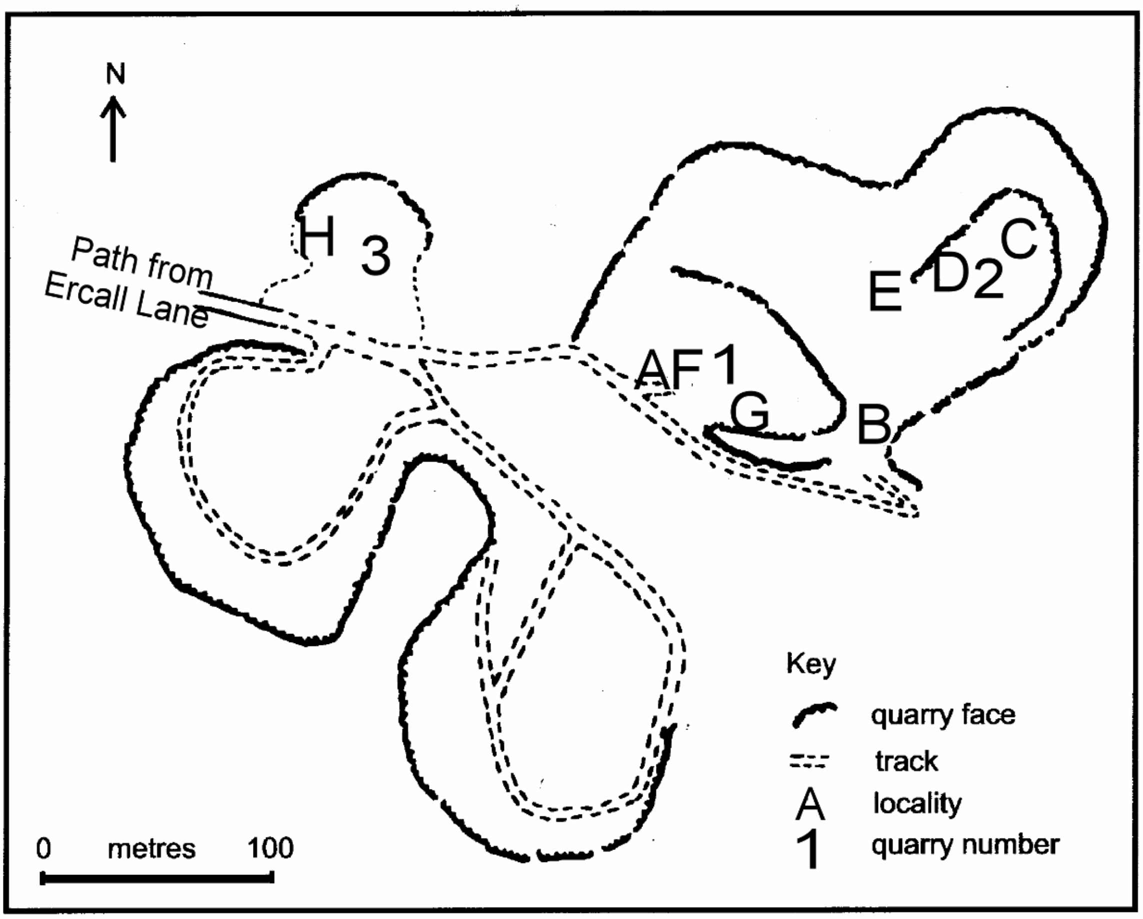


Figure 1 The Ercall Quarry Location Map

Figure 2 View From Locality "A" To The North East

Quarry 1 View To The North-East From The Engraved Rock On The Left Of The Path At Locality "A" (M.R. SJ 643 095) **Time: 10 minutes**

☛ **Locality "A":** This view point is the entrance to quarry 1. Do not enter the quarry from here.
From this point there is a view of one of the Ercall quarries, which was worked for aggregates until 1986. In 2000 the land was bought by the Shropshire Wildlife Trust to set up the Ercall Local Nature Reserve.
There are a number of reasons for visiting this locality: the viewpoint gives an introduction to the quarry and allows the pupils to see the scale of the quarry. Another reason is to allow the teacher to point out part of the route that the pupils will follow as they carry out their fieldwork around the quarry.

Activity 1

Possible questions/tasks	**Possible answers (words in brackets indicate need or opportunity for further teaching)**
Q1. Describe the shape of the quarry.	Roughly rectangular. Wider than it is deep. (Although it is difficult to estimate the size of the quarry from this view point, the map shows the quarry is about 100m wide.).
Q2. On the evidence of different colours seen in the quarry face, how many types of rock appear to be in this quarry?	Two. (The two colours you can pick out are pink and light grey)
Q3. Can layers be clearly seen in the light-grey coloured rock in the quarry?	Yes. (The layers can be seen best on the right hand side {eastern part} of the quarry. These layers are not horizontal, they are tilted at an angle).
Q4. Can layers be clearly seen in the pink coloured rock in the quarry?	No. (This pink mass of rock is cut by fractures, giving it a blocky appearance, and doesn't show layers).

Q5. Predict whether either of the rocks in this quarry is likely to be **sedimentary** or not.	Layering is often due sedimentary bedding so the grey coloured rock is more likely to be sedimentary.
Q6. Predict whether either of the rocks in this quarry is likely to be **igneous** or not.	This is a more difficult prediction. The absence of layering in the pink rock suggests it might be igneous.
Q7. What might you predict is the nature of the contact between them **if** one is igneous **and if** the other is sedimentary.	It is likely that contact metamorphism of sedimentary rocks will dominate the answers. If so ask pupils what evidence they might look for on the site, when they get there, to confirm this. [**TEACHERS' NOTE**: In fact the contact is erosional and there is NO contact metamorphism at all, but let them find that out for themselves].
Explain that the pupils will return to a locality near this view point after a walk around the quarries. Point out that they will take a path to the east that will lead them to the upper part of the quarry where they will be able to look more closely at these pink & grey coloured rocks - & the contact between them). Point out that on their walk around the quarries they will be looking for evidence to explain: • how the rocks formed • how the rocks have been deformed • in which order the rocks were formed.	

Figure 3 View From Locality "B" To The North East

Quarry 2 Looking To The North-East From The Stile On The Path
(M.R. SJ 644 095) **Time: 20 minutes**

☛ Continue along the path past locality "A", taking the bend to the north to locality "B". This is by the stile in the fence across the path. From this point there is a view to the north of one of the lower Ercall quarries (See **Figure 3**).

The quarry at locality "B" was worked for a rock called Wrekin Quartzite. The sandstone in the Wrekin Quartzite could be broken into pieces and used as an aggregate because the rock is both physically and chemically resistant to weathering. **[TEACHERS' NOTE:** The name "Wrekin Quartzite" includes sedimentary conglomerate and quartz-rich sandstones, even though "quartzite" usually refers to metamorphic rocks].

Activity 1

Possible questions/tasks	**Possible answers** **(words in brackets indicate need or opportunity for further teaching)**
Q1. Describe the shape & estimate the size (height, length & width) of the quarry. (**Clue:** the average height of a teacher is 1.7m). Use the figures to estimate the volume of rock quarried away.	Approximate rectangular shape. Size estimates will vary! Approximate size: 50m high, 50m wide, 100m long 50 x 50 x 100 = 250,000 cubic metres (approximately)
Q2. Describe the layering seen in the quarry.	The layers are tilted at an angle. There are thin & thick layers (The layers are called **beds**; layers are separated by **bedding planes**).
Q3. Observe the rocks in the different beds. What differences do you see?	Some rocks are darker in colour. Some beds are stained with a yellow/orange colour. The beds break up/ weather in different ways. Some slabs of rock/ bedding planes (on the left hand side) are not flat/ smooth and show parallel ridges. (These ridges on the bedding planes are called **ripple marks**).
Q4. Which of the main rock groups occurs in this quarry? (Igneous, metamorphic, sedimentary).	Sedimentary (Layering (and ripple marks) indicate sedimentary bedding)
T1. Ask pupils to estimate (a) the angle of tilt of the beds & (b) the direction they are tilted towards. (The angle of tilt from the horizontal is usually called the **angle of dip.** **The True Dip** is in the direction of steepest slope. All other, smaller angled dips, are “false” dips).	45-50^0 tilt (**angle of steepest dip**) though the estimates will vary widely. Tilted towards the south east. (**direction of steepest dip**)
Q5. Would these rocks have been formed as horizontal beds?	Yes – roughly horizontal. (**Principle of Original Horizontality**)
Q6. Can you suggest how the original horizontal layers became tilted in this direction?	Tilted by earth movements. (Accept movements of the Earth’s tectonic plates)
Q7. Can you see any cracks across the layers?	Yes. (Cracks are called **joints** or **fractures**)
Q8. Can you suggest how these cracks may have formed?	Most probably formed during earth movements (uplift). (Take other suggestions e.g. quarry blasting, plate movements. Drying out is only a significant process in clay or muddy rocks)
Q9. What kind of deformation could these fractures be evidence for? (Pupils may need to be reminded of plastic deformation, elastic deformation and brittle fracture)	Brittle fracture.
Q10. Look towards bedding planes showing ripple marks on the left/ west side of the quarry. What can you see below the quarry face here?	Broken and angular rock fragments. Heaps of broken rock. (The heaps of rock fragments form a localised **scree slope**).

Q11. Can you suggest where these rock fragments came from?	Weathering of rock layers higher on the slope. (The rock fragments are **angular** and were probably weathered by physical weathering [**freeze / thaw weathering** produces angular fragments]. These fragments have remained angular because they have not moved far [have only moved here by **gravity**]). Rounding requires long periods of abrasion during processes of transportation.
T2. Ask pupils to complete and label the field sketch on worksheet 1. (See **ERC12 pupil worksheets**)	
T3. Ask pupils to add to their field sketch **one** other observation they have made about differences in the rocks / rock layers in this quarry. Ask students to suggest a reason for the difference they have noted.	Most likely observations are: * Changes in colour. REASON: caused by different minerals in the rocks or by weathering. * Thick & thin beds. REASON: caused by different amounts of sediment being deposited or by different amounts of compaction (although compaction is not significant in sandstones) * Older rock layers lie on the western side of the quarry. REASON: older rocks lie under younger rocks: (**Law of Superposition**)
Point out pupils will now look more closely at the rocks in this quarry.	

Locality "C": On The Floor Of Quarry 2 At The Warning Signpost On The Quarry Floor.
(M.R. SJ 644 096) **Time: 15 minutes**

☛ Cross the fence by using the stile and advance up the slope to the warning sign which is locality "C" **See Figure 1.**
Stop at the warning sign. There is no need to go nearer to the quarry faces. Loose pieces of rock can be picked up from the quarry floor here for pupils to test / look at. Explain that the exercise here (and at locality "**Ei**") is to compare two different sedimentary rocks and summarise the information on worksheet 2. Point out that these rocks can be traced uphill from this quarry into the quarry they viewed at locality "A" at the start of their field visit.

Activity 1

Possible questions/tasks	**Possible answers** **(words in brackets indicate need or opportunity for further teaching)**
T1. Look at loose blocks and pieces of rock on the quarry floor. Collect a loose sample of sedimentary rock (sandstone). Describe the colour and feel of the rock when you rub your fingers over its surface. (**Clue: Conglomerate** is a rock that has grains more than 2mm in size; **sandstone** is the rock that has grains between 0.06 & 2mm in size).	White to light grey colour. Shows some staining - mostly yellow-brown. Feels rough to the touch. The grains don't rub off and are strongly held together i.e. are well-cemented.
T2. Use a hand lens to look at the size of the grains in the grey sandstone. Are the grains about the same size?	Responses will vary depending on the sample chosen, but most of the grains are about the same size. (The grains are about the same size {like sugar grains} so the rock is described as **well sorted**).
T3. Compare the grains against a sheet of 1mm graph paper, or grain size comparator card. What is the average size of the grains? **Identify** the rock.	Estimated grain size = 0.5mm. It is a sedimentary rock, a sandstone made of grains smaller than 2mm cemented together.

Q1. Now relate to what we saw in the class demonstration to the size of the sandstone grains. Was the deposit laid down in low, medium or higher energy conditions?	Medium to low energy conditions.
T4. Use a hand lens to look at the shape of the grains. Are the grains **rounded,** or **angular** or **between rounded and angular**? [**NOTE:** "Rounded" does not mean "spherical". It means there are no sharp edges, whatever shape the grain happens to be.]	Responses will vary depending on the sample chosen. Most grains are between rounded & angular, but are nearer rounded than angular. They are usually described as sub-rounded.
Q2. Now relate to what we saw in the class demonstration to the grain shape. What does the grain shape tell you about the length of time for which they were transported?	The grains were transported for a long period of time. (Grains start out more or less angular and **abrade** (rub against) one another as they are transported. The longer time this goes on the more rounded they become).
Q3. Are most of the grains made of the same mineral? What is the evidence?	Yes - on the basis of similar colour (pale or clear) and similar hardness (scratch steel). (Most of the grains are made of the mineral quartz.)
Q4. Can you see any fossils in the rock? What does this tell you about how the rock was formed?	No. Nor does it tell you much about how the rock was formed! Either organisms (a) couldn't live in the environment at the time the rocks formed or (b) the hard parts weren't preserved because they were destroyed before deposition, or (c) because the organisms were soft bodied and unlikely to become fossilised.
T5. Use the water dropper bottle. Does a small drop of water sink in or run off the surface of the rock? What does this tell you about the rock?	Water runs off the rock surface. It is a **non porous** rock. It does not allow water to pass through it so it is an **impermeable** rock. (However, joints and cracks in such rocks may allow water to pass through them)
T6. Ask pupils to summarise the evidence for the sedimentary processes that probably formed the sandstone by completing the table in worksheet 2. (See **ERC12 Pupil worksheets**)	Refer to the relevant part of the completed worksheet for localities "C" & "E". Remind pupils they will complete this comparison exercise at locality "**Ei**"

Locality "D": At A Warning Sign On A Track Along A Bench (A Quarry Level) On The North Western Side Of Quarry 2. (M.R. SJ 644 096) **Time: 10 minutes**

☛ Turn south west from locality "C" and follow the path rising from the quarry floor. The path passes alongside the bedding planes dipping at 45º SE. Stop on the path at the warning sign. Do not climb the quarry faces. Explain that there is more evidence to be investigated here that the rock is a sedimentary one and not a metamorphic "quartzite".

Figures 4 and 5 Measuring The Ripple Marks At Locality "D"

Activity 1

Possible questions/tasks	**Possible answers (words in brackets indicate need or opportunity for further teaching)**
T1. Using a clinometer and compass, measure the dip amount and direction of this bedding plane. (This is an optional activity if the instruments are available. If so add 15 minutes to the time for the activity. If not draw attention to the dip and lead into the next question).	Dip measurements, depending on exactly where they are taken, should be close to 45-50^0 tilt (**angle of dip**) towards the south east, or 135 degrees magnetic. **TIP:** Use a clipboard to get a plane surface for measurement. First use the clinometer to find the "horizontal" across the bedding plane (dip= 0), then measure the **true dip** \mount and direction at **right angles** to this horizontal.
Q1. Are the beds here older or younger than the rocks you can see on the opposite side of the quarry? What is the reason for your answer?	Older. The layers at this locality are tilted to the SE so the beds at locality "D" must lie below the rocks on the opposite side (**The Principle of Superposition:** in a succession of sedimentary layers, the oldest layers were deposited first and are found below younger layers, which were deposited later).
T2. Observe the ripple marks on one of the bedding planes. What do you notice about: (a) their shape (in plan view & in cross sectional view)? (b) their spacing? (c) their height?	(a) Ripples in plan view have the shape of long & narrow ridges. In cross section they have one side slightly steeper than the other/ have a slightly asymmetrical shape. (b) Ripples approximately evenly spaced. (The average ripple **wavelength** is 170mm). (c) Ripple **height** is approximately 15mm.
Q2. Are the ripple marks running in the same direction. What might that mean? (Remind pupils of the fish tank demonstration during the preparation for the visit.)	Yes – the ridges roughly run in the same direction. It may give an approximate indication of current or wave direction perpendicular to the ripple crest.
Q3. Where can you see ripple marks forming today? (Possibly relate to what they saw in the class demonstrations about how ripple marks can be formed).	Ripple marks are formed by wind or water currents flowing over sand grains on **beaches**, on the top of **river deposits**, on surfaces of **sand dunes** in deserts, or by wave action on the bed of **shallow seas or lakes**. **[NOTE:** These ripples are likely to have been formed in moving water, not wind, as the Ripple Index is less than 15.]
Q4. Why may this sort of information about ripples help you to work out how this particular rock was deposited?	The present is the key to the past. (**The Principle of Uniformitarianism:** the biological, physical & chemical processes we see today, operated in much the same way in the past).
T3. Ask pupils to complete the worksheet 3 for locality "D". (See **ERC12 Pupil worksheets**)	Teachers may refer to the completed worksheet for locality "D" in **ERC13 Teachers' Notes**.
T4. Ask pupils to look back towards the previous locality "C" and along the bedding plane with the ripple marks. Draw pupils' attention to an apparent shift of approximately 4 metres in the position of this bedding plane. (You may need to walk 5m back along the track towards locality "C"). Can they see any evidence that these rock layers have been altered in any other way at this point?	(Although the two bedding planes with ripple marks may not be of the same age, this apparent shift in the position of the bedding plane may mark the position of a brittle fracture (**fault**) along which the rocks on one side have slipped or moved relative to those on the other side.) There is evidence for a zone here where the rocks: - change to a yellow/brown colour (perhaps greater weathering of iron minerals where rainwater has seeped along fractures in the rock) - become soft clay (perhaps where rock material was ground to a rock flour by mechanical fracture during faulting) - show shiny, grooved and scratched surfaces (perhaps formed when rocks were moved along a fracture)

T6. Ask pupils to suggest how these rocks have deformed.	Rocks were under stress, or the stress increased. The rocks suffered brittle fracture, and have not suffered plastic deformation.

Locality "Ei" View Of The Quarry Face In Quarry 1 Looking North East From A Point Close To The Information Plaque. (M.R. SJ 644096)

Time:20 minutes

☛ Follow the path back to the floor of quarry 2 and take the track to the north. The track climbs uphill, heading towards the lower part of quarry 1 and passes alongside the edge of the quarry. Stop at the warning sign near the information plaque. Keep to the path and do not climb over the barrier fence or onto the quarry faces. Loose pieces of rock can be picked up from the path here for pupils to test / look at.

Figure 6 View Of The Quarry Face At Locality "Ei".

☛ Explain that at locality "**Ei**" the exercise is to complete the comparison between two sedimentary rocks (Worksheet 2) which was started at locality "C". So first find a sedimentary rock which is **different** from the one described at locality "C"

Figure 7 Conglomerate Specimen From Locality "Ei"

Figure 8 The Exposure of Conglomerate

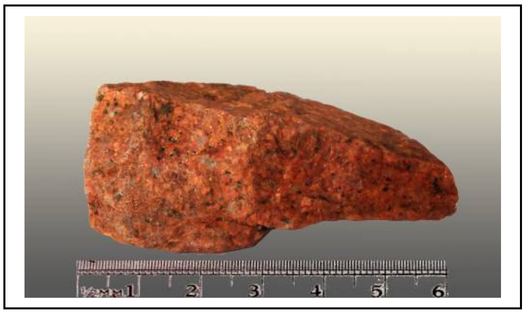


Figure 9 Specimen of Granophyre.

Activity 1

Possible questions/tasks	**Possible answers (words in brackets indicate need or opportunity for further teaching)**
T1. Look at the loose blocks and pieces of rock on the path. Collect a loose sample of a sedimentary rock different from the one seen at locality "C" **(It's a conglomerate. Clue: Conglomerate** is a rock that has grains more than 2mm in size)**)**. Describe the colour and feel of the rock when you rub your fingers over its surface.	Light grey colour. Shows some staining (yellow-brown or green). Feels rough to the touch. The grains don't rub off and strongly held together i.e. are well-cemented.
T2 Use a hand lens to look at the size of the grains. Are the grains about the same size?	No, they are of different size. (The grains are of different sizes so the rock is described as **poorly sorted**. The grains are a mixture of **pebbles** (grains 4 - 64mm across) and **granules** (grains 2-4mm across).
T3. Compare the grains against a sheet of 1mm graph paper. What is the average size of the pebbles?	Responses will vary depending on the sample chosen. Estimated average grain size in the range 15 to 50mm. (The grains are described as coarse sized grains).
Q1. Relate to what we saw in the class demonstration to the size of the grains in the conglomerate. Was the deposit laid down in low, medium or higher energy conditions? (Give a reason for your answer).	Relatively higher energy conditions. It takes more energy to move larger (heavier) grains or pebbles into the sedimentary basin to deposit them.
T4. Use a hand lens to look at the shape of the grains. Are the grains **rounded, angular** or **between rounded and angular**? [**NOTE:** "Rounded" does not mean "spherical". It means there are no sharp edges, whatever shape the grain happens to be.]	Responses will vary depending on the sample chosen. Most grains are between rounded & angular. (The grains are described as subangular to subrounded).
Q2. What rock type is it?	Sedimentary. (It is a conglomerate, made up of sub-rounded fragments larger than 4mm in size, cemented together).
Q3. Now relate to what we saw in the class demonstration to the grain shape. What does the grain shape tell you about the length of time over which the grains were transported?	The grains were not carried for extremely long periods of time. Grains **abrade** one another as they are transported and the longer they are in motion the more rounded they become. These pebbles did not have time to become well rounded.

Q4. Most of the pebble-sized grains are pieces of rock. Are these pebbles made of the same type of rock? What evidence can you see for your answer?	No - on the basis of different colours (striped red/pink, pale grey, black, red/pink or green) and different patterns in the pebbles (e.g. banding/ no banding) they are of different rock types. (Most of these grains are pebbles of the following rocks: **rhyolite** {striped red/pink (to be seen again at locality "H"}, **quartzite** {pale grey}, **igneous rock** {black}, **granophyre** {dark red}).
Q5. Can you see any fossils in the rock? What does this tell you about the rock?	No fossils seen. This tells us very little. It may be that organisms (a) couldn't live in the environment at the time the rocks formed or (b) were not preserved because they were soft bodied, or their shells (hard parts) were easily broken up by pebbles rolling over them.
T5. Use the water dropper bottle. Does a small drop of water sink in or run off the surface of the rock? What does this tell you about the rock?	Water runs off the rock/ doesn't sink in It is a **non-porous** rock. (It doesn't allow water to pass through it so it is a non-porous & **impermeable** rock).
T6. Students asked to complete part of the table in worksheet 2 summarising the evidence for the sedimentary processes that probably formed the conglomerate.	A completed worksheet 2 for localities "C" & "E" can be found in **ERC13 KS4 Teachers' Notes.**

Locality "E(ii)"

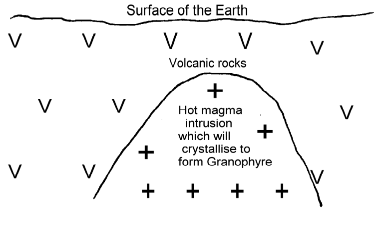
☛ From the warning sign and information plaque retrace your steps and follow the path downhill for about **3 metres** until you reach a low quarry face to your left running parallel to the path on its eastern side. Stop at this point. Make sure you stay on the path. There is a steep slope away from the path to the south west. At this point here is a good view of the contact between the granophyre and the conglomerate.

The activity at locality "**Eii**" is to examine the contact (or line of separation) between different rock types. Whilst rocks themselves are important, the nature of the "contacts" between rocks is a vital piece of evidence for Earth Scientists in their interpretation of events. They ask questions like "Is this contact: a bedding plane?; or is it cross-cutting?; or is it intrusive?; or is it faulted?; or is it caused by erosion?".

Explain that pupils will inspect the contact between the pink rock (granophyre) and the Wrekin Quartzite and complete Worksheet 4 here. **(**See **ERC 12wksheets** and **ERC13 Teachers Notes** for completed examples of the worksheets).

Activity 2

Possible questions/tasks	**Possible answers** **(words in brackets indicate need or opportunity for further teaching**
Q1. Closely observe and describe the rock in the upper part of the quarry face. (**Hint:** You will need to get **very** close to the rock face to see the details of the rock composition).	Layering: shows thick and thin layers; layers tilted to the south east. Colour: light grey Composition: made up of pebbles
Q2. What is the rock type in the upper part of the quarry face? How does the rock change in grain size towards the top of the quarry face? Can you suggest a reason for this change in grain size?	Sedimentary rock. (mainly Conglomerate). There are some sandstone layers towards the top of the quarry face, so the grain size decreases. The sediment was deposited in lower energy conditions. (Smaller grains take less energy to move. Not enough energy to transport larger grains to the area for deposition).
Q3. Observe and describe the rock in the lower part of the quarry face.	**Layering**: none, but it breaks along joints. **Colour**: dark pink/red **Composition**: interlocking crystals not pebbles or grains cemented together.
Q4. What is the rock type in the lower part of the quarry face?	Igneous (It is called a Granophyre)

T1. Collect a loose sample of granophyre. Use a hand lens to look at the shape and size of the **crystals** in the rock. Are the crystals about the same size? What does this tell you about the rate of cooling and crystallisation.	The crystals have irregular shapes & fit together like the pieces of a jigsaw puzzle. (Two different minerals form the crystals in granophyre: quartz {greasy-looking and a pale grey colour} and feldspar {pink}). Responses will vary depending on the sample chosen. In most samples the crystals are approximately the same size, showing the crystals formed in a single stage of cooling. Occasionally samples show a few crystals larger than others, indicating that the magma may have cooled in two stages. {Initial slower cooling allowing larger crystals to form}.
T2. Compare the crystals against a sheet of 1mm graph paper. What is the average size of the crystals?	2mm. (Crystals of this size are described as medium sized crystals)
Q5. Relate to what we saw in the class demonstration to the size of the crystals in the granophyre. What does this crystal size tell you about how this igneous rock formed?	The rock formed as magma cooled fairly slowly in the Earth's crust. Depending on the sample, either one or two stages of cooling. (See above)
T3. Encourage pupils to find and put a hand on: a bed, a bedding plane, a joint, the boundary (or contact) between the conglomerate and the granophyre.	Explain that the kind of contact (boundary) between rock types is very important evidence and we need to look at the contact as much as we look at the rocks themselves and ask: "Is this contact: a bedding plane?; or is it cross-cutting?; or is it intrusive?; or is it faulted?; or is it caused by erosion?". **NOTE:** This does not apply to joints where it is the **same** rock on each side.
Q6. Which of these two rocks (conglomerate or granophyre) is the oldest (formed first)? (Give reasons for your answer)	Granophyre. - lies underneath layers of conglomerate - pebbles of granophyre may be found in the conglomerate (Law of Included Fragments)
Q7. What do you notice about the contact between the conglomerate and the granophyre?	It is tilted downhill. It is uneven and not flat or planar.
Q8. Remind pupils of the prediction they made whilst at locality "A" about the nature of the contact between the igneous and the sedimentary rock. Have they found evidence of contact metamorphism? What evidence **have** they found?	No evidence of contact metamorphism of the overlying sedimentary rocks. What they have found is that the sedimentary rock was in part formed from the weathered fragments of the igneous rock, and that the contact is an irregular surface. The contact is an erosion surface, representing a long period of time when rock (i.e. evidence) was removed from the geological record. [**NOTE**: the granophyre formed deep underground, but is now well above sea level suggesting the crust has been uplifted as well as eroded]
Explain that this irregular contact marks an erosion surface. The granophyre was formed under the Earth's surface but after the layers above it were worn away by erosion whilst the granophyre in the crust was being uplifted above sea level it was eventually exposed on the Earth's surface. The conglomerate layers were originally deposited as horizontal layers on top of the granophyre, which by then was cold and solid. (This called irregular contact is described as an **unconformity**).	**Stages in formation of the unconformity:** **A** 

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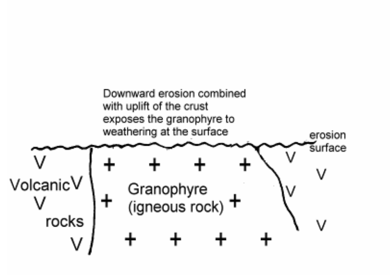

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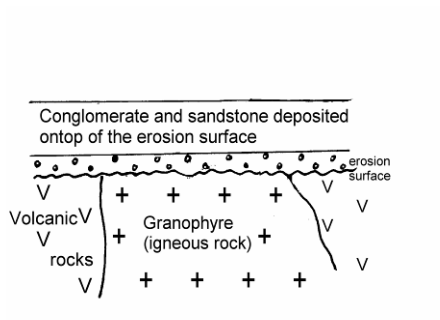

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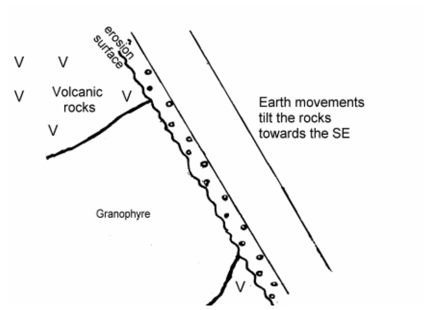

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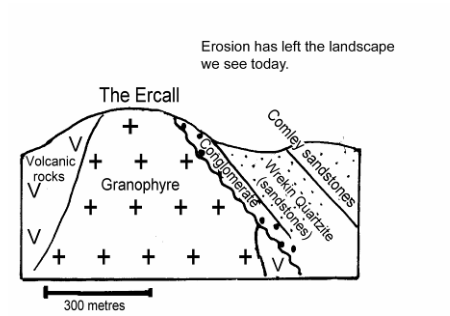

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<td>Q9. Can you suggest a reason why:
a) the unconformity is uneven
b) the unconformity and the layers above it are no longer roughly horizontal?</td>
<td>a) The original erosion surface was irregular.
b) Earth movements have tilted the unconformity and the rocks layers.</td>
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<td>T4. Ask pupils to complete the worksheet 4 for locality “E”. (See ERC12 Pupil Worksheets)</td>
<td>Refer to the completed worksheet for locality “E”, in ERC13 Teachers’ Notes..</td>
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Figure 10 View of quarry 1

Locality "F": View Of Quarry 1 Looking North East From The Information Board To The Right The Path. (M.R. SJ 643 095) **Time: 15 minutes**

☛ From locality E follow the path back down the slope. Cross the stile marking locality "B" and retrace your steps towards the engraved rock beside the path (locality "A"). Stop at the information board that is close to the path and approximately 20 metres before you reach the engraved rock.

Locality "F": Explain that at this locality the pupils will complete a field sketch of the view of quarry 1 looking to the north east.

Activity 1

Possible questions/tasks	**Possible answers (words in brackets indicate need or opportunity for further teaching)**
T1. Allow pupils to view the quarry.	
Q1. Relate the features to what they saw in their walk around the quarries and summarise their observations so far. What did they find out about: a) the pink coloured rock and how it formed? b) the grey coloured rock and how it formed? c) which of these two rocks formed first? (Ask for the evidence) d) The contact between the pink coloured rock & the grey coloured rock?	a) Made up of interlocking crystals and has joints but no bedding. This is therefore an igneous rock (called granophyre) formed by the cooling of underground magma b) Made up of grains, showing bedding and ripple marks. This is therefore a sedimentary rock, (conglomerate and sandstone). c) Granophyre, because the conglomerate and quartz sandstone lie on top of it and the conglomerate contains some pebbles of granophyre. d) It is uneven, formed by erosion before the grey rock was deposited. It is an unconformity
T2. Ask pupils to complete the field sketch of quarry 1 looking to the north east from this view point.	A field sketch is included on the completed worksheet for locality F. (See **ERC12 Pupil Worksheets)**

T3. Draw pupils' attention to the information board that gives the information they will need to complete the worksheet. (Pupils may wish to read the information on the board and make additional notes about the Ercall quarries).	A table summarising some of the information about the Wrekin Quartzite & the granophyre is shown on the completed worksheet for locality "F" & "G" is in **ERC13 Teachers' Notes**)
T4. Point out that the information board shows an inclined bedding plane in Wrekin Quartzite to the north west of the quarry. This bedding plane also shows ripple marks. Ask pupils to identify the ripple marks on the bedding plane to the north west and ask pupils to estimate how far these ripple marks are from the ones they measured at locality "D". If these ripple marks are of the same age as the ones they measured at locality "D", can they suggest a reason why the ripple marks appear in two places 100m apart? (**Clue:** Remind pupils about the apparent shift of approximately 4 metres in the position of the bedding plane with ripple marks that they noted at locality "D").	Assuming the two separated bedding planes with ripple marks are **the same** bedding plane, then they have been moved apart by approximately 100m. This is the result of **faulting.** A **tear fault** running from NW to SE cuts through the quarry. Faults such as this have **horizontal** displacements which have moved the ripple-marked bedding plane by 110m on this side compared with the other side.

Figure 11 Rock Face At Locality "G". (The white scale is 1m long)

Locality "G": View Of Quarry 1 Looking Towards The South At M.R. SJ 643 095

Time: 10 minutes

☛ From the information board at locality "F" follow the minor track on the floor of quarry 1 heading towards the east. After approximately 20 metres you will reach a rock face, which is about 8 metres high. Stop at this point. (See **Figure 11**)

Locality "G": Explain that at this locality the pupils will complete a field sketch of this view of quarry 1 looking to the south.

Activity 1

Possible questions/tasks	**Possible answers** **(words in brackets indicate need or opportunity for further teaching)**
T1. Allow pupils to view the quarry face and encourage them to rub their hands over the rock surface here.	
Q1. Are the rocks similar to the rocks at locality "E"?	No – at locality "E" there were 2 different rocks, here there is only one rock type (a light-grey coloured rock)
Q2. Describe and name the rock in the quarry face	It is a pale grey colour, with a rough feel, a medium grain size. The grains are hard and can scratch steel. The rock is a quartz –cemented sandstone (Wrekin Quartzite).
Q3. What is different about the vertical surfaces of the Wrekin Quartzite here compared with those in quarry 2?	The rock surface looks as if it is smoother and has been scratched.
T2. Draw pupils' attention to the grooved surface on the rock face. Explain that the rock at this locality is the Wrekin Quartzite, but that the rocks here have been affected by faulting (brittle fracture). Q4. Using the grooves as evidence can pupils suggest a direction of movement along this fault? (In practice more reliable evidence than first impressions are required to confirm the fault movement !) Q5. Can they suggest which formed first, the sedimentary rock or the fault?	These rocks have been moved along a fracture called a **fault**. The grooves on the rock face (are called **slickensides)** and are thought to be caused when the two sides of the fault slipped past each other almost horizontally. **Principle of Cross-cutting Relationships:** structures, like faults, which cut through layers of rocks must be **later** than the rocks they cross cut.
Q6. Invite pupils to relate these observations to what they saw in other parts of the Ercall quarries. What other evidence have you seen to suggest that earth movements affected the rocks in the Ercall quarries?	Various possible answers: - tilted layers of rock - small fault cutting the ripple marked layers of sandstone - granophyre formed below the surface is now exposed on the surface - faulted repetition of beds (e.g. the ripple marked surfaces appearing to the NW and SE of the Ercall summit).
T3. Ask pupils to complete the field sketch of quarry 1 on worksheet 6. (See **ERC12 Pupil Worksheets**)	A completed copy of worksheet 6 for locality "G" can be found in **ERC13 Teachers' Notes**.

Locality "H": View Of Quarry 3 Looking South (MR SJ641096) **Time: 30 minutes**

☛ From locality "G" return to locality "F" and back onto along the main path, west, towards Ercall Lane for about 120 metres until you reach a smaller track leading off to the right of the main path. (See **Figure 1**) Follow this track into a small quarry where locality "H" is to be found on the north west side. Stop at this view point. (See **Figure 12**)

Figure 12 View Of Quarry 3 Looking North West. (M.R. SJ 641 096)

Locality "H": Explain that at this locality the pupils will investigate the rocks in the low quarry faces on the western edge of this quarry.

Activity 1

Possible questions/tasks	**Possible answers (words in brackets indicate need or opportunity for further teaching)**
T1. Allow pupils to closely look at the rocks in the western edge of the quarry.	
Q1. Are the rocks similar to the rocks at locality "G"?	No – at locality "G" there was only one rock type (a light-grey coloured rock). Here the rock is a different colour (pink/ red brown colour) and shows thin (1 -1.5mm wide) bands (paler & darker colours). (Several samples from the quarry floor may be needed in order to find pieces with more clear banding).
Q2. Where did they see a similar rock on their tour of the Ercall quarries?	Pupils may need some prompting here! Pieces of a similar rock might have been found at locality "E" as pebbles in the conglomerate in the Wrekin Quartzite immediately above the unconformity.
Q3. Is the rock igneous or sedimentary?	Expect a range of answers. It is igneous, although it does have rough layering this isn't bedding and it is made up of very small crystals not grains. (It is a **rhyolite,** formed at the surface during volcanic eruptions).
T2. Refer the group to worksheet 7 for site "H" See **ERC12 Pupil Worksheets.** Here the exercise is on logical inference and deduction from the observations made during the visits to the other localities. Ask the party to discuss in small groups what evidence they have seen to establish the relative age of these rhyolites to the other events in the quarries, and then fill in the table on worksheet "H"	A completed copy of worksheet 7 for locality "H" can be found in **ERC13 Teachers' Notes**.

☛ Return to the path and on to Ercall Lane. Turn left and proceed back to the Forest Glen car park.