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

Contact: geodiversity@btconnect.com

☛ **Items to bring on the visit**

Appropriate clothing and footwear. Wellies are easy to clean.
Enough copies of worksheets/notes etc. selected, or modified, from the list below:
Map of sites at Barr Beacon and Pinfold Lane Quarries (See worksheets in **BB8 Pupil activity sheets**).

- Pupil Activity Sheet 1 – **Map Of Barr Beacon & Pinfold Quarry**
- Pupil Activity Sheet 2 – **Investigating The Memorial (Building Materials)**
- Pupil Activity Sheet 3 – **The Old Quarry & Car Park Entrance**
- Pupil Activity Sheet 4* – **Field Sketch Of Pinfold Lane Quarry**
- Pupil Activity Sheet 5* – **A Close Look At Triassic Sandstone**
- Pupil Activity Sheet 6 – **Investigating A Fault / Pebble Hunt**
- Pupil Activity Sheet 7 – **Investigating Pebbles**

*Summary Pupil Activity **Sheet 8** - **Sandstone and Pebbles at Pinfold Quarry** may be used as a possible alternative to the questions of Sheets 5 and 6.]

These worksheets can be found in **BB8 Pupil Activity sheets** and completed versions can be found in **BB9 Group Leaders Notes.** A more detailed **Rock Identification Sheet** can be downloaded from the Park Hall ESO-S materials.

Plus: Clipboard, notebook, sketchbook, digital camera, magnifiers, water dropper bottles, laminated piece of mm graph paper or grain size comparitor cards for judging grain size, tape measure, compass and materials for any other fieldwork activities [e.g. relating to wildlife]. Plus a simple clinometer for older children. Hard hats should be worn at Site F where pebbles may slip from the face above.

Teachers and adult helpers should each have dropper bottle with dilute acid for testing for limestone pebbles. Domestic lime de-scaler may be used, and should be diluted to adequately react with limestone/marble pebbles [try x 10 dilution]. A bottle of water and tissues and a roll of sticky duct tape for collecting sand grains. Equipment for collecting soil samples.
Remind the children of Health and Safety issues.
Avoid any dog poo on the site.

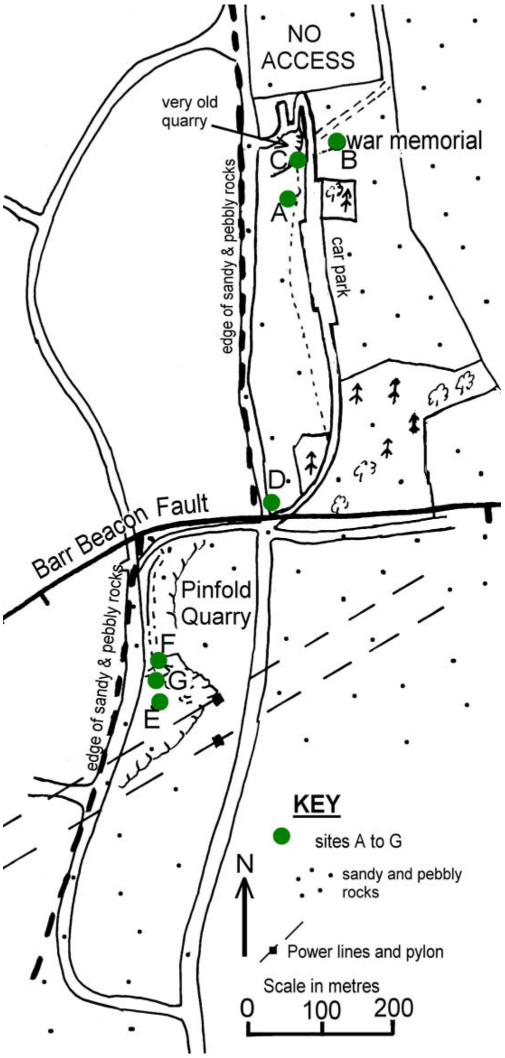
☛ **Using the pupil activity sheets**

Teachers will need to decide which materials are appropriate for their pupils to use **and adapt the sheets accordingly.** There are 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

The Earth Science teaching trail notes which follow, incorporate for each site, teaching points, questions, answers, interpretation and other comments. The separate pupil worksheets are based on the content of the teaching sheets.



Site "A". View from Barr Beacon car park.

☛ Give out the equipment and organise the group whilst on the grass at the edge of the carpark.

Head to the northern end of the car park and then **west** onto the grass to a clear place to take in the view to the west and southwest. Other views from here are obscured by trees.
This is **Site "A".**

Use compasses to orientate the site map.

Figure 1. Map of the Barr Beacon/Pinfold Quarry sites.

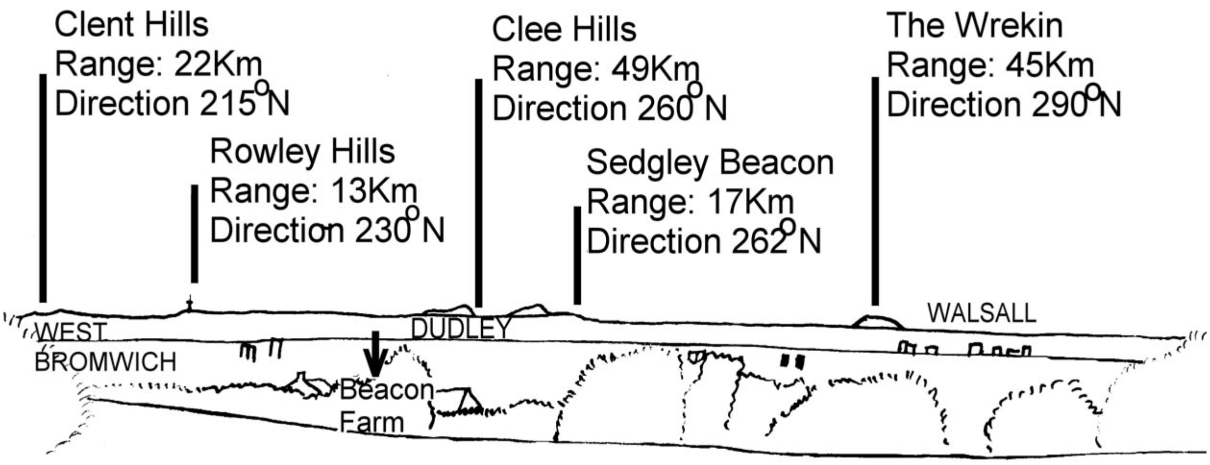


Figure 2. View from Site "A".

Site A: View from Site "A". [Equipment needed: Activity Sheet 1 and magnetic compass.]

Questions/Teaching Points	**Answers/Interpretation/Comments**
Pick out man-made features/parts of the landscape.	Towns with buildings – churches & masts are easy to spot. **Dudley** [slightly S of W], **Walsall** [NW], **West Bromwich** [SW]. Below the low ground are rocks containing coal, iron, clay & limestone for industry lie below the lower ground. Farmland is man-managed.
Pick out natural features/parts of the landscape. Why are the hills and lowlands here?	Hills and lowlands. See sketch: **Figure 2**. Harder rocks are more resistant to weathering and erosion, so stand out as hills. The lowlands have been eroded by rivers and ice. Sediment gets carried by rivers to the sea.

☛ Carefully move the group across the road (watch out for traffic) to **Site "B"**, about 50 metres SE of Barr Beacon Monument.

Figure 3. The War Memorial from Site "B".

Site "B": [Equipment needed: Activity Sheet 2, plastic bottle of dilute acid]

Questions/Teaching Points	**Answers/Interpretation/Comments**
Describe the roof of the monument. Do you know what metal the roof is made from?	Green colour, indicates weathered copper [the green is the mineral malachite].
What can you tell about the columns and base?	White rock, strong, looks nice.
What can you tell about the steps?	Grey rock, probably hard-wearing.

☛ Now walk up to the monument and investigate the two main rock types of the white columns and base and the grey steps.

Questions / Teaching Points	Answers/Interpretation/Comments
Look at the white rock of the columns and base. What are the "white bits" it contains?	Contains shell fossils (including oysters.)
What rock is it?	Sedimentary Limestone. [It is Jurassic in age, from Portland in Dorset].
Look at the grey rock of the steps. What is it made of?	Hard sand grains [quartz], cemented together by quartz cement and "dressed"
What rock is it?	Sandstone [sedimentary]. It is Triassic in age from Tixall in Staffordshire. Same rock used in steps of Dudley Town Hall.
What damage has the weather done to the memorial since it was built about 100 years ago?	Copper is no longer shiny, but has weathered to green mineral, malachite. Limestone has dissolved in acid rain, leaving fossil shells standing out from the rest of the rock.
Check which side of the columns has suffered most weathering by looking at how far the fossils "stick out" from the stone. Try to explain your findings.	More weathering on SW side, from the direction of the prevailing [usual] wind direction, carrying acids in the rainwater.
Can you find other rock used in and around the memorial?	The small central plinth is made of reddish sandstone, possibly Triassic in age.

All the materials used to build the war memorial have been brought here from elsewhere because the rocks below Barr Beacon are crumbly and not suitable for cutting and shaping.

To Site "C". Very old quarry. [Equipment needed: Activity Sheet 3.]

☛ Move the group westwards from the memorial towards the fenced-off area full of trees, mainly silver birch. This is a very old and overgrown quarry. The rocks aren't exposed any more.

Questions/Teaching Points	Answers/Interpretation/Comments
Look at the soil at the top of the old quarry. What is the soil made of?	Mostly sand and pebbles, with grass roots and remains of dead plant material.
How has the soil formed?	From the weathering of the underlying rocks. The weather, plants and microscopic animals break them down to produce soil. Soil contains sand and pebbles from the rocks below, plus water and air.
Why can't we see the rocks in this old quarry?	Soil has formed and plants have grown to cover the old faces with trees [silver birch] and grass.

To Site "D" car park entrance. [Equipment needed: Activity Sheet 3, handlenses]

☛ Move south along the path adjacent and just to the west of the car park. (See **Figure 1**). Notice the soil is thin, sandy with pebbles. The vegetation includes grass, gorse, bracken, silver birch, oak, conifers. Before leaving the Nature Reserve remind the group that, although the pavement is quite wide, there is a busy road very close by.

At the entrance/exit to the car park notice the dark, crystalline rock used to make the retaining boundary wall along the main road and the back of the pavement. This rock is dolerite, a local igneous rock, possibly from Rowley or Barrow Hill.

Questions/Teaching Points	Answers/Interpretation/Comments
Look at the wall. Describe the rock used to build it. (Handlenses).	Hard, dark/black colour, made of small/medium crystals.
Can you see any fossils in the blocks?	No - these are not sedimentary rocks!
What kind of rock is it? Is the wall dry-stone or has mortar been used? Suggest a reason.	Igneous [Dolerite/basalt]. This may have been seen in preparatory work. Mortar been used for added strength, to hold back the soil. It is a retaining wall.

☛At this point the north-south outcrop of red Triassic rocks of Barr Beacon is cut by an east-west fault [see the map on **Figure 1**]. This fault drops the beds to the south downwards by 4 or 5 metres compared with those on the north side. This means that south of the fault these rocks lie on the west side of the road, where they have been extensively quarried.

☛ Move the group slightly to the right, away from the Bridle Lane junction and then cross the B4154 to the path down to Sites "E" , "F" and "G" in Pinfold Quarry. Take care across this busy road. Continue down the steep path over many rounded pebbles.

Here it might be useful to point out the sandy and pebbly nature of the soil [as at Barr Beacon], a reflection of the pebbly underlying rock. It would be useful to collect a soil sample here, where the soil is older and more matured than in other parts of the quarries.
Aspects of the ecology of the old quarries can be investigated. It is likely all species will be self-seeded. Tree species include silver birch, oak and sycamore. Shrubs include hawthorn and bramble. Grasses and wild flowers form much of the bround cover, as well as mosses and lichen in damp areas. Look out for evidence of animals, including rabbit droppings and holes, molehills, bees holes in the sandstone faces etc.

Figure 4. The access gate.

Figure 5. The approach to the quarry face.

☛ Near the foot of the slope, at telegraph pole OA2, (See **Figure 4**) turn left along the narrow path through the small quarry gate. Turn right and follow the path along the quarry fence to the clearing by the yellow and black barrier. Fork left and head for the quarry face just north of the pylons visible through the trees. (See **Figure 5**)

The two Pinfold Quarry sites.

Figure 6. Sites "F" and "G."

☛Before reaching the overhead power lines, assemble at the open area, about 20 metres south of the steel fence. This is **Site "E"** and gives a good view of **Sites "F"** and **"G".** (See **Figure 6**). This position gives a good view of the thick red sandstone, with the conglomerate [pebble bed] on top, all of Triassic age.

Remind the group that they have just walked down to the base of the Barr Beacon ridge and are now looking at the rocks that lie underneath the park and that they are about 250 million years old. Also remind the group of Health and Safety aspects, including avoiding contact with all dogs and their poo, and any cans and broken glass left by other visitors.

☛ **Teacher reference note on key observations in the quarries.**

Five key observations give clues to interpreting the formation of sandstones and pebble beds during lower Triassic times, about 248 – 241 million years ago. These beds were formed in a desert basin, about 250 million years ago, when rivers swept, first sand with a few pebbles, and then many pebbles with some sand into the are and laid them down in layers.

Observation	Interpretation
- The rocks are layered in beds.	- The layering indicates that the sediments were deposited in water.
- There are layers of rounded pebbles, with sand in between.	- Rounded pebbles indicate long-distance transport in water, [but not as well-rounded as beach pebbles]. From the South. This is the Kidderminster Conglomerate, on top of the sandy bed.
- There are layers of sandstone made of sand grains and angular fragments stuck together by quartz cement, with **red** iron oxide.	- The sand grains are mainly made of quartz, a hard mineral. **Red** clay/mud is rarely found with beach sand, but is common in deserts, e.g. Australia and California. [This is the Hopwas Breccia. Breccias contain angular pebbles]
- The rocks are mostly red in colour	- The red colour is due to the iron oxide mineral, haematite, coating the sand grains and also in the fine red clays mixed in the sandstones. This is evidence that the sediments were deposited in an oxidising environment on land.
- No fossils have been found.	- Most fossils are found in rocks formed in the sea or in lakes. Hot, dry desert conditions with occasional flash floods are not the best environments for living things, and any fossils are quickly destroyed.
- The beds slope [dip] gently eastwards. - They are faulted.	- Long after they were laid down, the rocks were uplifted and tilted by great Earth movements,. Older children could use a clinometer to measure the angle: 5 - 10 degrees dip to E. These later Earth movements also caused the rocks to break and move, forming faults.

Site "E" Pinfold Lane Quarry. [Equipment needed: Activity Sheet 4, compass]

☛ This first activity is about setting the scene for the close – up work by observing the main fetautres of the exposure.

Questions/Teaching Points	Answers/Interpretation/Comments
Orientate the map (**Activity Sheet 1**) with the quarry and label your position as **Site "E".**	
Is the quarry landscape natural or man-made?	Man-made! It was a quarry, now partly reclaimed/overgrown by vegetation.
What types of rocks can you see?	Gravel/pebbles & red sand/sandstone.
Are the rocks mostly layered or jumbled-up?	Mostly layered, in **beds.** Relate this observation to the experiment on sedimentation/settling in water. **They are sedimentary rocks.**
Which rock is older? Which is younger?	Sandstones at the bottom [with a few angular pebbles] are older. The beds of rounded pebbles on top are younger. [**Conglomerate** is the correct geological term for pebble bed. Most conglomerates are well-cemented, but these are fairly loose gravels.]

What is on the very top of the quarry?	Soil, with grass and trees. [Too exposed to collect a sample!]
Estimate the height of the face. [The steel fencing is about 2 metres high].	10-12 metres
There is a slope between the base of the cliff and where you are standing. It is called scree. What do you think it is made of? How do you think it formed?	The scree slope is made of broken rock materials [including pebbles] that have fallen from the cliff face since work ceased in the 1960s. Gravity has been assisted by weathering processes, including rain, freeze-thaw and the growth of plant roots [some plants even grow on the faces]. Relate to **Working With Rocks** from your preparation.
What is happenning to the scree slope both today and over recent years?	Weathered rock material is being broken down to form thin soil and colonised by plants, especially grass and sycamore trees.
Why do you think part of the face has been fenced off?	For safety! Falling pebbles, children climbing etc!!
Look out for cracks in the rocks. What are they? How do you think they formed? Later we can look at the one on the left [north] of the fence.	Near-vertical features, where the rocks have been broken by Earth movements. Where the sides have moved they are called **faults**. Where they are simply cracks they are called **joints**.
You may notice vertical streaks down the faces of the sandstone. Suggest what might have caused this streaking.	Rainwash – excess water flowing down the face.
Ask the group to complete **activity sheet 4**.	

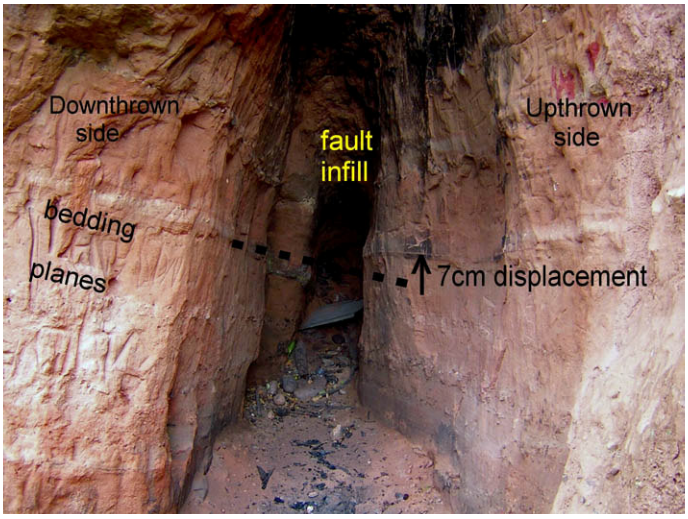


Figure 7. Site "F."

☛ If the group is large, then **split the party into two groups**, one to look at sandstone at Site "F" and the other to look at pebbles at Site "G."

Site "F" - A close look at Triassic Sandstones. [Equipment needed: Hard hats Pupil Activity Sheet 5, water dropper bottle, hand lenses, grain size comparator cards, roll of sticky duct tape.]

☛ Make sure the group understands that they could slip if they are not careful and then the top of the face group them around the "cave" scooped into the rock face. (See **Figures 7 & 8**). Through the cave and its upward continuation a small fault can be traced.

Questions/Teaching Points	**Answers/Interpretation/Comments**
First ask the group to look closely at the rock (preferably with a lens). What is it made of? **(NOTE**: Using a short length of sticky duct tape on the face will collect a suitable and easy to manage sample when peeled off).	Sand grains and larger angular pieces [2cm across].
What happens when you rub the sandstone face with your fingers?	Some sand grains & larger pieces break away, but rest are stuck together by a quartz cement.
Describe the sand grains – size, shape etc.	1-2mm, fairly angular, quartz grains.
Describe the larger pieces (pebbles).	Sizes vary – the pebbels are about 2cm, angular, hard rock.
Can you find any fossils in this rock?	No (when they were formed it was too hot & mostly too dry for animal life).
Use a water dropper bottle to see if the sandstone is porous. Why might this be useful to humans?	Yes, porous. Porous rocks often contain water which can be useful for Man. Water is pumped from wells and boreholes in those rocks.
Look carefully at the layering in these rocks. Is the main layering flat or sloping?	Looks flat on face, but check round the corner in 3D. The layers slope [dips] gently eastwards by about 10 degrees.
What does layering tell us about how these rocks were formed? You may have tried an experiment in school.	Formed under water by sand settling in layers on the bottom.
Some of the layering is not flat, but shows signs of regular sloping within the thicker layers. This is cross-bedding and indicates settling in flowing water [see above]. It can be used to determine the direction of flow as it slopes in the downstream direction. Which way was the water flowing?	The direction of flow is mostly from south. Ripple marks may also be seen. [See the animation file in the ESO-S Park Hall materials].

☛Rocks can tell their story of life in the past if we ask the right questions from what we already know about our Earth today.

Questions/Teaching Points	**Answers/Interpretation/Comments**
What colour are these rocks?	Red. This colouring is due to the iron mineral, haematite, usually found in oxidising environments on land.
Where on planet Earth today do we find red landscapes?	The most probable answers are Australia and Colorado deserts. These beds were formed in deserts like that 250 million years ago.
Ask the children where deposits of sand & pebbles are naturally found today, [other than in quarries!].	Depending on the extent of preparation and prompting, the children will suggest beaches and rivers (and perhaps deserts) as places where these sediments can be found and actively be transported in modern environments. For completeness, teacher might like to add the sediments deposited by ice, if nobody suggests it.
You may have done an experiment to show how pebbles become rounded. The conglomerate [pebble beds] above are mostly made of large rounded pebbles. Suggest a reason for this difference.	Assuming the sugar cube shaking experiment has been done it should be possible to interpret that the large rounded pebbles have travelled a long way. This happened in Triassic times about 250 Million years ago.

You may have done an experiment to show how pebbles become rounded. The conglomerate [pebble beds] above are mostly made of large rounded pebbles. Suggest a reason for this difference.	Assuming the sugar cube shaking experiment has been done it should be possible to interpret that the large rounded pebbles have travelled a long way. This happened in Triassic times about 250 Million years ago.
Ask the group if they can seen "layers" or "beds" in the red sandstone? Are they horizontal or sloping?	Yes there are layers. Yes they are sloping (although they may look horizontal at first glance.)
What does this tell us about how the beds were deposited. (Remind them of settling experiments done in the classroom).	They were laid down in water.
Can you see any fossils in these rocks?	No.
From the evidence you have found we can say things about what it was like at the time these sandstones and pebble beds formed? 1. What do layers suggest? 2. What does rounded pebbles suggest? 3. What does red colour suggest? 4. What might **no** fossils suggest?	1. The beds were deposited in flowing water. 2. Long transport by rivers. 3. Red iron oxide [haematite] indicates a desert land not a sea. 4. Deserts don't have many animals to become fossilised. NOTE: This suggests rivers in desert areas, with periodic storms and flash floods between long periods of drought.
Ask the group how they could test if the rock is porous (i.e. has spaces) and permeable (i.e. lets water into it).	Use a dropper to add water to the surface and watch it sink in. A flat, loose piece of red sandstone would be best to use, but it works on the vertical face too.)
Is the rock porous and permeable? What useful substance might be found in porous rocks?	Rainwater in permeable rocks (which are called aquifers), although someone might mention gas or oil.
Look at the hole made in the face. Look inside and look in the face above. What else can you besides sandstone?	The first view from further back indicates a fault or fracture which has broken the rock layers. Close inspection shows it is filled with pebbles, possibly fallen in from above.

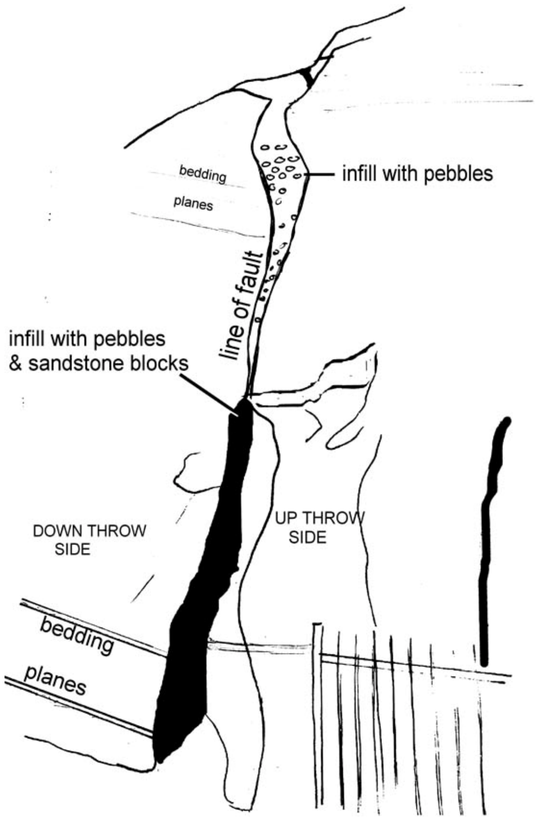


Figure 8. Sketch details of Site "F"

☛Group leaders may want to go on and draw attention to the fault running upwards through the rocks and then go on to investigate it.

A fault is a "crack" in the rocks where one side has slipped compared with the other.

A joint is a crack where no movement has occurred. Here the task is to established if the beds have slipped on one side.

Investigating a fault at Site "F". [Equipment needed: Hard hats, Pupil Activity Sheet 6**].**

Questions/Teaching Points	Answers/Interpretation/Comments
Ask the group to find the bedding planes (paler coloured beds show this best. (See **Figures 7 & 8**) and explain to the group how to tell the difference between a fault and a joint.	
Ask the group to check to see if the thin lighter layer of sandstone continues straight across the gap. Does it continue or has it been broken?	It has been broken by fault, with movement down to the North [left] by about 5 – 10 cm.
Do you think the rocks broke before, during or after they were formed.	After, and the gap filled by material falling in from above.
What forces might be able to break rocks?	Earth movements can lift rocks up, breaking them and causing earthquakes.

Site "G" - A pebble hunt. [Equipment needed, Pupil Activity Sheet 6, plastic bottle of dilute acid (for any limestone pebbles), (plus the Triassic Pebble Identity sheet from the Park Hall ESO-S material, if more detailed identification is needed.)]

☛ **Key Points for Teacher Reference**

1. The pebbles are well-rounded - relate this observation to sugar cubes experiment.
2. Hard pebbles survive long distance transport. Less hard ones are rapidly destroyed.
3. Many pebbles show contact points, and often split through them. This is due to the immense pressure of the weight of sediment and later rock lying on top over millions of years since they were deposited.

☛ Move the group to the pebbly scree slopes below the steel fencing. Remind the group to watch their footing. After the childen have hunted and collected a range of different pebbles (suggest they try for "one of each"), the teacher should help in the identification, perhaps with the aid of the additional **Triassic Pebbles Identity Sheet** available from the KS3 Park Hall ESO-S materials. There will always be some pebbles classed as "don't knows."

The worksheet asks the children to sketch a pebble, but alternatively, the teacher might wish to take a selection of pebbles back to school to do this as part of follow-up work and for display.
As a conservation measure, unused pebbles should always be returned to the scree.

Site "G" Investigating pebbles. [Equipment needed, Pupil Activity Sheet 7].

Questions/Teaching Points	Answers/Interpretation/Comments
Describe the shape of most of the pebbles.	Rounded.
What does the shape indicate about how they were transported to here?	Rounded by contact with other pebbles rolling along bed of a river [Relate the observation to sugar cubes demonstration which involved dry contact].
What does the large size of many of the pebbles tell us abou the current strength?	Very strong currents of water needed to move them a long way.
What are the two most common types of pebble made of? Suggest why they are the most common.	Quartz and quartzite They are the hardest. The soft ones would be broken up.
Why does hardness improve a pebble's chances of survival?	Resists attack, with less hard ones breaking up sooner on the journey
From the information on the pebble identity sheets, in which direction were the pebbles heading?	From south (southern England and northern France) to north
Look out for contact points on many of the pebbles. Some of the pebbles have been broken through these contact points. What do you think might have caused this?	Great weight of overlying sand/sandstone and pebbles/conglomerate when they were buried for millions of years.

☛ **Teacher information:**
The Triassic Pebble identity sheets give details of eight types of pebble commonly found at Triassic sites in many parts of Britain. Photographs and sketches have been made of cut samples of pebbles, together with a short description and suggested age and source for each.

The following table gives a typical analysis of pebbles from Midland Triassic sites.

23% Vein quartz [white]	Mineral
66% Quartzite [grey/red, often layered]	Sedimentary rocks now metamorphosed.
2% Sandstone [quartz & other grains]	Sedimentary
2% Conglomerate/Breccia [larger bits]	Sedimentary
2% Limestone[decalcified]	Sedimentary
1% Granite [large coloured crystals]	Igneous rocks
1% Porphyry [few large crystals in finer]	Igneous rocks
1% Rhyolite [fine, may show banding]	Igneous rocks
1% Basalt[hard, black, fine crystals]	Igneous rocks
Others may include: Schist [thin bands of quartz & mica crystals]	Metamorphic rock

These pebbles were eroded from localities further south during Triassic times, from areas including South Wales, and SW England and NW France (millions of years before the English Channel existed), then transported by rivers to the Midlands and beyond. For follow-up work, use could be made of the UK Geology Wall Map to identify present day outcrops of the source of some of these pebbles.

☛ Move the group back to the flatter ground of **Site "E"** – for discussion and review.

At this point it might be useful to ask the children what was worth the effort of quarrying it out of the ground here, and what they think it was used for.
Discussion of the uses of sand and gravel should bring out these points: The hard pebbles were used as aggregates for roadmaking and for concrete. Large ones would probably need to be crushed to a smaller size. (An **aggreagte** is material all graded to the same size). The sands could be used to make mortar or in concrete. All of these products are used by the building and construction industries.

Follow-up work could include research on uses of sand and gravel, including water supply.

Group leaders may want to finish the trip by working out the sequence of events from the evidence seen in the quarry.

OLDEST EVENT
1. Deposition of sandstone and angular fragments by flash flood rivers in a desert environment: – angular fragments indicate less transport.
2. Deposition of conglomerate [pebble beds] and sand by larger flash flood rivers in a desert environment. Eroded from mountains far away to SW. Pebbles rounded by long distance transport.
3. Earth movements – uplift and tilting gently to east [about 10°], with fractures and faults.
4. Later weathering and erosion over millions of years to produce landscape with hills and valleys. Evidence from elsewhere indicate that later rocks were deposited on top and have been eroded.
5. Man has quarried the pebbles and sand for use as aggregate, concrete and mortar.
6. Weathering and soil formation is allowing Nature to reclaim the quarries.

YOUNGEST EVENT

☛ Return by the same route to the car park or alternative pick-up point.