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INTRODUCTION

☛ Individual groups will need measuring tapes, 10x hand lenses, grain size comparator cards, hand lenses (x10), compasses and clinometers if dip measurements are to be attempted, as well as clipboards and copies of the relevant field sheets for individual pupils. (See **BB8 worksheets**). Callipers for measuring long axes of pebbles will be useful.

Group Leaders will need a plastic bottle of dilute HCl (to identify any possible limestone pebbles), a small plastic bottle of water and a roll of sticky parcel tape. A digital camera will also be useful. Groups using site 5b should have hard hats as a precaution against falling pebbles.

☛ Field leaders should have decided which combination of the following worksheet exercises the groups are to tackle before they arrive on site:

1. Investigation of The Barr Beacon War Memorial - study of weathering effects on a building.
2. The Viewpoint to the SW - landscape, soil & geological links.
3. The Viewpoint to the South - landscape & geological processes.
4. A Study of the Rock In The Boundary Wall - study of the features of dolerite.
5. Pinfold Quarry sites a, pebbles study - study of pebble varieties.
6. Investigating A Break In The Rocks - a study of a small fault.
7. Summary Of Events At Barr Beacon - a graphical column of events.

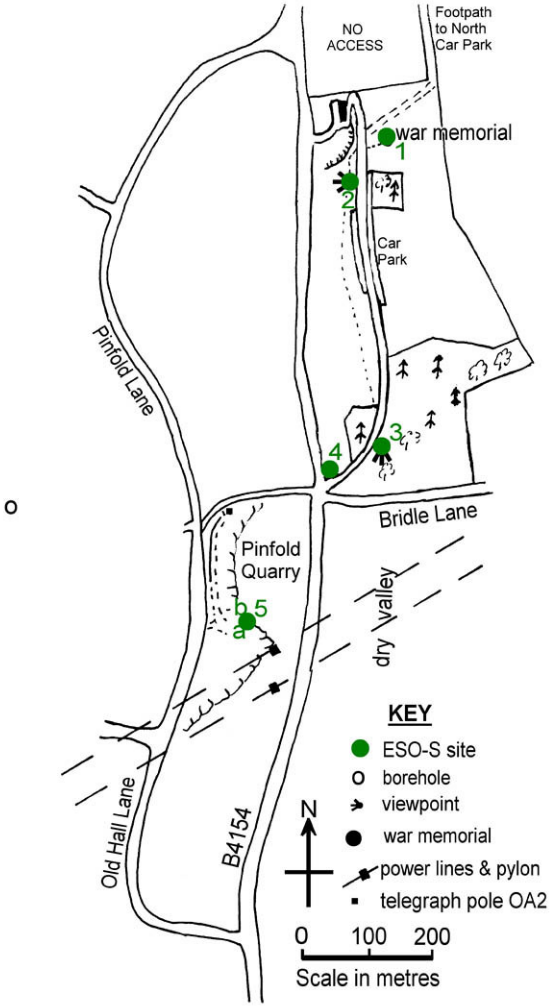


Figure 1. The field sites

☛ It is convenient to park at the north end of the car park, close to the war memorial.

Leave the vehicle and walk east for 80 metres across the grass to a point matching the view of the memorial on the worksheet, about 50 metres away on its SE side.

The intention here is to raise awareness of factors influencing the use of natural materials by humans.

Focus the group's attention on the memorial before allowing them to begin the task.

Figure 2. Site 1: The War Memorial viewed from the SE.

Worksheet 1: Investigating the Barr Beacon War Memorial.

Suitable questions at this site.	**Acceptable responses.**
The columns are made of stone. How many reasons can you think of to explain why this particular stone was chosen?	1. Strong enough to support the weight (Compressive strength) 2. Easily shaped. 3. Could be cut into long enough pieces (i.e. few natural joints). Each column is in 3 pieces. 4. Attractive colour.
Where did the metal and the stone come from?	They were both taken from the ground, either in a quarry, or a copper mine.
Is the building new? How can you tell? [NOTE: Copper first oxidises and the copper oxide is then attacked by weak carbonic acid in rain water to form the green carbonate.]	No, because the copper has weathered to the green carbonate (malachite) which has washed down onto the walls and the steps are blackened and have grass growing through them.
Summarise: Humans take materials from the ground and use them in buildings for particular purposes according to their special properties. Once built, the structures are attacked by weathering. Ask the group to work in pairs to facilitate discussion whilst completing **Worksheet 1.**	
After 15 minutes bring the groups together to inspect the columns. Have they been weathered evenly all the way around? Are all of the columns affected in the same way?	No. The fine grained and porous calcite matrix has weathered leaving the coarser fossils standing proud. Yes. The fossils stand proud more on the SW side on all of the columns, not just the ones on the SW side.
Ask for hypotheses to explain the uneven pattern of weathering	Prevailing wind direction exposes all of the columns to greater weathering on the SW side.
Draw in an arrow showing the main wind direction on the worksheet diagram.	

Site 2: The viewpoint to the SW.

☛Take the group across the road to the west of the memorial, and along the path to the left beside the fenced woodland. After 30 metres stop across from the north end of the car park, and look to the south west. See **Figure 3.**

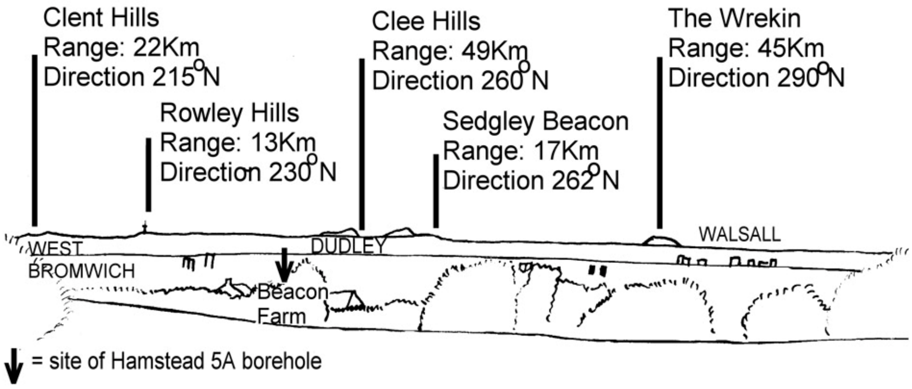


Figure 3. The view to the South West.

Worksheet 2: The View to the South West.

Suitable questions at this site.	**Acceptable responses.**
Use the sketch to identify the hill masses on the horizon. Ask why these areas are highpoints. [NOTE: **Wrekin** / Cambrian sandstone; **Sedgley Beacon** / Silurian limestone**;** **Clee Hills** / Devonian Sandstone; **Rowley Hills** / dolerite; **Clent Hills** / Permian Sandstones.]	The hills indicate more chemically and physically resistant rocks, and will take longer to weather down to the current surface level of the less resistant rocks.
What will eventually happen to the rocks being eroded and transported to the west of Barr Beacon?	Weathering, erosion by slipping and slumping on slopes and rain wash will move material down slope to the rivers. To the west is the R. Thame, which flows south & then east to the Blythe, which then joins the Trent east of Alrewas which flows to the Humber estuary and the North Sea.
If a geologist in millions of years' time was able to study these rocks in the North Sea forming today, what "fossils" might be found in them?	Apart from marine organisms with bony or shelly parts, there might also be human debris, such as hulls of sunken ships, plastic bags, beer cans, ipods, etc. Emphasise the importance of more resistant elements to allow fossilisation: so no jelly fish or paper, for example.
Look at the housing visible to the west. What materials have been used to make it?	**House Roofs:** Tiles from clay fired in a kiln. The clay is dug from the ground like slates which are natural stones, not man made. There are no slates on this housing estate. **House walls (inside and out**): Bricks from clay fired in a kiln. Inside will be plaster board made from gypsum or anhydrite. **Cement & concrete:** sand, limestone, gypsum. Also clay and aggregate (stone fragments) **Windows:** Pure silica sand, melted and cooled rapidly to a glass.

Where did these materials come from?	**Gas/oil for central heating:** Drilled from oil traps and piped in. These fuels represent fossilised energy, created by organisms from sunlight, millions of years ago **Roads and driveways**: petroleum (oil) products like tarmac, mixed with stone fragments. **TV aerials, wires, garage doors, and cars:** Metals smelted from metal ores. **Garden Soil:** Formed when feldspars are chemically weathered to form clays. Soils are mixtures of naturally weathered products including sand and clay, plus some organic material. **Grass and trees:** Grow in soil. (Also use gasses from the atmosphere and sunlight). All of these products have their origins in the ground, either quarried or mined, or are growing in it.

Site 3. Viewpoint to the South.

☛Walk the group southwards along the nature trail to the exit road. Cross the road and stop on the grass looking southwards along the valley towards Pheasey. (See **Figure 1**).

Worksheet 3: The view to the South.

What forces cut the valley?	Water. Not ice which would have made it deeper and wider, with a flatter bottom. i.e it is a post glacial valley.
What reasons might explain why the river does not flow along the valley bottom?	1. Less rain now than in the past. 2. Rocks less permeable at the end of the Ice Age when they were frozen solid.
How can we test if the soil is permeable?	Pour water onto it. It soaks in very quickly.
Where has the water gone?	Into the tiny pore spaces between the sand grains. NOTE: take care to dispel ideas of “underground lakes”. The water is in spaces usually much less than 1mm across.
What do we call a layer of rock that contains a lot of water?	An aquifer. The rock below is an important source of water for the area.
Look carefully at the soil (without digging holes) and describe what you see.	The soil is very sandy, with rounded pebbles. It has grass and other plants growing in it.
How has this soil been formed?	Weathering of the rock below (which is, therefore, likely to contain sand and pebbles).
How has weathering attacked the rock below?	Chemical weathering by acidic rain water will attack the cement holding the sand grains together. Also repeated frost action breaking up the rock.

Site 4: The boundary wall.

☛ Carefully take the group through the exit to the Barr Beacon Nature Reserve and onto the pavement to the right of the gate. Ask the group to inspect the blocks in the wall and describe them.

Worksheet 4: Study of the boundary wall.

Suitable questions at this site.	**Acceptable responses.**
Look at the angular blocks in the wall and describe them.	Fine grained, interlocking crystals. Dark coloured, with no bedding or fossils.
Are they sedimentary, igneous of metamorphic?	Igneous. Dolerite, probably from the Rowley Hills area.

Figure 4. The access gate

Figure 5. The approach to the quarry face

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

Bring the group together about 30 metres south of the metal fence at the foot of the face. (See **Figure 6)** 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 dip underneath, below the park. Here the focus is on interpreting the evidence for an ancient rock cycle where deposition took place about 245 million years ago.

☛ First help the group to get an overview of the face.

Figure 6. The two Pinfold Quarry sites.

Worksheet 4: Sketch of Pinfold Quarry.

Suitable questions at this site.	**Acceptable responses.**
Ask the group to estimate the height of the face.	About 10 – 12 metres.
What features can be seen in the rocks?	Joints and bedding. Lots of pebbles near the top.
What kind of rocks are these: igneous, sedimentary or metamorphic?	Rocks made up of weathered fragments and deposited in beds, are sedimentary.
Which bed is the oldest, and which bed is the youngest in this sequence of beds?	**Principle of Superposition**: Younger beds are on top of older beds.
Ask the group what changes occur in the rock beds as they look up from the base. And what doesn't change?	The lower beds are finer grained and bedded. At the top there are many pebbles and fewer bedding planes. The beds are red / orange all the way up.
Explain that the colour is due to staining by haematite (Fe_2O_3). In our climate iron weathers to limonite (familiar as rust) and is browner in colour. Can the group recall any TV pictures of a landscape coloured red and deduce in what kind of place these beds were deposited?	Most familiar red landscapes are likely to be American or Australian. Red sediments are indicative of arid terrestrial oxidising conditions of deposition. [Fragments of minerals containing reduced iron and mixed with the sediment, become chemically oxidised]
Tell the group that these rocks are Triassic in age about 245 million years old, and that the pebbles are evidence of events taking place over millions of years of Earth history.	

Site 6 a.: The Pebble Scree.

☛ Larger groups of pupils can be split into two smaller groups here and rotated between the sites.

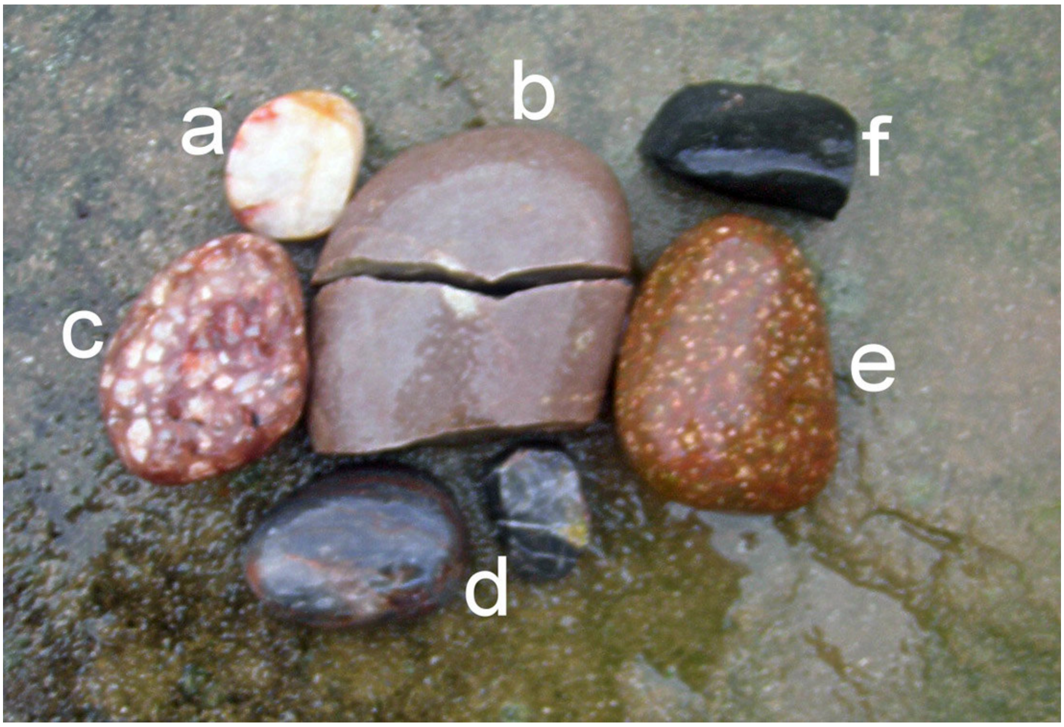


Figure 7. A quick pebble identification summary.

Although there are many pebbles, the bulk (about 80%) are **(a)** white vein quartz and **(b)** quartzite (metamorphosed sandstone).

Of the others the most common are **(c)** conglomerates and **(d)** cherts.

Pebbles of **(e)** igneous porphyry and fine grained black basalt pebbles **(f)** may also be found.

NOTE: The pieces inside a conglomerate are rounded and uneven fragments, whilst those in a porphyry are regular and rectangular crystals in a fine grained igneous matrix.

A more detailed pebble identification sheet is available in the ESO-S material for Park Hall.

Worksheet 5: Pinfold Quarry pebble study.

Approach the scree in an orderly fashion and conduct a pebble survey, using the pebble identification sheet to help with identification. Stress the need to be **as random** as possible in selecting the 20 pebbles for the survey! (One way is to drop a marker and pick the 20 pebbles closest to it.)

☛ NOTE: In the process group leaders should find and retain a sedimentary rock for later: preferably a conglomerate pebble, but a sandstone pebble will do.

Site 6 (a): The Pebble Scree. Summary

These pebbles are extremely well rounded. This implies a very long period being transported in water. The maximum long axis should be around 200 mm. (make sure an unbroken specimen is measured) implying a very high flow velocity of the current. (Studies with modern sediments indicate a flow in excess of 400 cm per second to transport this material. NOTE **Principle Of Uniformitarianism**).

☛ Then help the group to reach conclusions about the Rock Cycle from this exercise.

Worksheet 5: A summary of two Rock Cycles.

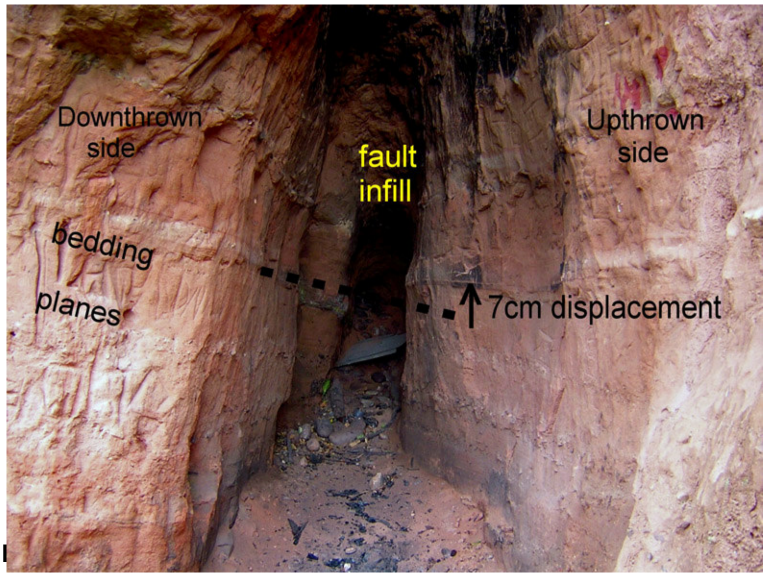
Suitable questions at this site.	**Acceptable responses.**
How have these pebbles arrived on the scree?	They have been weathered from the beds at the top of the quarry face and brought here by gravity.
Are all the pebbles the same size?	No.
Are all the pebbles of the same rock type? How can you tell?	No: they have different colours; some are banded; some are streaked, etc.
Use the worksheet to help you describe the shape of these pebbles.	They are very well rounded.
What does the fact that they are well rounded tell us about the transport of these pebbles?	They have been transported by water (waves or flowing current) for a long period of time, and rough edges have been worn away (abraded).
Ask the group what rock types have been strong enough to survive this rough treatment?	Metamorphic quartzite, white vein quartz, and some igneous rocks mainly.
Why are there no soft rocks, like shale or clay amongst these pebbles?	The violent river flow would have broken them up. Only physically resistant rock types have survived.
Many of these pebbles have rock types that suggest they have been transported from Brittany in France. If so, in what direction would the river have been flowing?	Northwards. (It has been given the name of the "Budleighensis River).
Are these individual pebbles older or younger than the bed they were deposited in – and now exposed at the top of this quarry?	**Principle of Included Fragments**: fragments contained within a sedimentary rock must be **older** than the rock itself.
Remind the group they are referring to the Rock Cycle, and ask them how many times "deposition" occurs in one cycle?	Only once. [This means more than one deposition event means more than one Rock Cycle.]
Show the group a conglomerate pebble, and ask the group to work backwards through the story of that "pebble which also contains pebbles" to deduce two (or 3) rock cycles. Start with the present rock cycle and work backwards through a simplified sequence of: 4. Deposition 3. Erosion &Transport 2. Weathering 1. Uplift Remind pupils that each cycle is started / ended by a period deposition and burial. NOTE: **Principle of Included Fragments** allows us to suggest that these pebbles reveal evidence of at least **three** rock cycles, but KS3 group leaders may feel the point has been made after two: i) the (modern) cycle that **deposited** the pebble on the scree; ii) the cycle that **deposited** the conglomerate; iii) The cycle which **deposited** the conglomerate which now forms the "pebbles inside the pebble." The oldest cycle may be 400 million years old (Devonian).] [In summary emphasise the <u>endless</u> recycling of rock material through many Rock Cycles.]	A. PRESENT DAY ROCK CYCLE (0 Ma) **12. Deposition** on the scree slope today. **11. Erosion & Transport** by gravity. **10.** Present day **weathering** from the quarry face releasing the conglomerate pebbles (and others). **9. Uplift** B. TRIASSIC ROCK CYCLE (245 Ma) **8. Deposition** in a bed with other pebbles (& sand grains) and deep burial to form a conglomerate. **7. Erosion and transport** by river flow, minimum velocity 400 cm p sec., which rounded them off. **6. Weathering** from an older rocks – mainly quartzites and white vein quartz, but also an older conglomerate. **5. Uplift** of an even older rock ***KS3 Group Leaders may want to stop here.*** C. EVEN EARLIER ROCK CYCLE (400Ma) **4. Deposition** of that older rock as the conglomerate that is "inside the pebble". **3. Erosion and transportation** in water, rounding off the pebbles **2. Weathering** from an even older rock to form the pebbles that are now "inside the pebble". **1. Uplift.** And so on……..

If no one has already mentioned it, point out that many of these hard rocks are broken, some with their halves still together. Were these broken during transport in the violent river, or after deposition?	If broken during transport the halves would become widely separated and rounded. These fractures, and the marks on many of the pebbles, indicate pressure from adjacent pebbles during very deep burial since Triassic times. **Figure 8: A Fractured Quartzite Pebble**. 

Suitable questions at this site.	**Acceptable responses.**
Ask how this quarry face came to be here today?	It isn't natural – there is no river, and it isn't fresh enough to be glacial. It is a quarry face.
Ask what was useful to be quarried from this site?	Pebbles for aggregate and building sand.

Site 5b: The fault plane.

☛ Group leaders should pick up half a dozen grey quartzite pebbles and take them to **site 5b**. After use these pebbles should be returned to the scree on the way back. Bring the group up the left side of the fencing to **site 5b**. NOTE: this site is close under the face. Hard hats should be worn and care taken to avoid any pebbles falling from the face.



NOTE: It is the fault infill that has been removed to form the "cave".

☛ The first task is to establish the differences between a metamorphosed sandstone (the rock type in the pebbles) and the un-metamorphosed one in the quarry face.

Worksheet 6: Investigating a break in the rocks

Suitable questions at this site.	**Acceptable responses.**
Describe the rocks at **site 5b**	They are red, bedded, and tilting. They are made of sand grains cemented together, with pebbles (about 1 to 2 cm across). These pebbles are smaller and not as rounded as the ones in the scree.
Ask what kind of rock it is.	Sedimentary (sandstone, with some pebbles).
Pass around the quartzite pebbles brought from **site 5a**. (about 4 pupils to a specimen). Ask the group to recall the name of this rock type from **site 5a** and ask how it was formed.	The rock type of the pebble is quartzite – a metamorphic rock. It is formed by metamorphism (by heat) of a sedimentary sandstone.
Ask the group to list as many **differences** as they can see between the sedimentary sandstone in the quarry, and the metamorphosed quartzite pebble. [NOTE: Stress it's the rock <u>inside</u> the pebble, not the pebble itself that is being inspected – so "rounded" is not relevant for example.]	**Sandstone** / **Quartzite** Red / Grey Porous / Not porous Less dense / More dense Permeable / Not permeable (test with water from bottle) Mechanically weak / Mechanically strong Cemented grains / Interlocking crystals Shows bedding / Bedding unclear.
Ask the group to explain the differences they see.	The quartzite was a sedimentary sandstone that has been subjected to heat allowing the quartz grains to re-crystallise into interlocking crystals, eliminating pore spaces.
Ask the group what **similarities** there are between the two rock types.	1. Both are chemically SiO_2 (Quartz). 2. Neither have fossils (they would be destroyed during metamorphism, and they are not found in the sandstone).
Tell the group that the redness of the sandstone is caused by the mineral haematite (Fe_2O_3) which is formed during weathering in hot desert environments. (In out climate we get brown rust!). How might this explain the absence of fossils in the red sandstone?	Very few animals live in desert environments (not enough food or water). Any plants or animals which died there would oxidise very quickly, or be abraded away by sandblasting in the wind.

☛ Now draw the group's attention to the "cave" hollowed out along a break in the rocks. (See **Figure 9**) This is **site 5b.** Here the grassy slope is a little steeper, and requires care. Ask the group to inspect the "joint" in the rock, hollowed out into a cave in its lower part, but traversing the upper slope as well.

Suitable questions at this site.	**Acceptable responses.**
Ask the group if they can see any joints in the rock.	Yes. Especially higher up the face.
Ask the group the difference between a joint and a fault.	Both are breaks in the rock, but a fault has movement of one side compared with the other.
Ask the group if they can confirm movement on one side compared with the other by "projecting" a bedding plane across the gap, and thereby prove its a fault, not a joint.	It is a fault. The right (south) side is up-thrown by a few centimetres. (See **Figure 9**)
Try to measure the amount of down throw and which side has gone down.	There is a small downward movement of about 7cm of the rocks on the left (north) side compared with those on the right.
When did the faulting occur, before or after the red sandstone was deposited?	**Principle of Cross-Cutting Relationships**: the cross-cutting fault came after the bed was formed.
If you had been standing on the surface when this fault moved what might you have felt?	An earthquake.
Ask the group to look at the upwards continuation of the fault. What can they see?	It is in-filled with rounded pebbles and blocks of bedded sandstone.
How might this infill have formed?	Then faulting opened up gaps along the fault plane and material ripped off the sides fell down into the space.

☛ Before leaving the site use the event column on **Worksheet 7** to help pupils to summarise the geological evidence into a sequence (oldest even at the bottom and youngest at the top of the list.)

Summarise the geological events you have seen today.

7. Human use of stone as aggregate, cement, brick, and building stone.
6. Weathering and erosion of the surface today, including soil formation.
5. Recent (since the Ice Age (12,000 years ago) erosion of dry valleys.
4. Faulting of the rocks e.g. Barr Beacon fault.
3. Deposition of red sandstone and conglomerates in a desert environment 245 million years ago. This material being brought in by flash flood first from the SW (and later from the south.)
2. Uplift and erosion of older rocks with flash floods bringing sediment into a desert basin.
1. Deposition of older rocks underlying the Triassic rocks, including Coal Measures.

Emphasise that there have been many rock cycles, not just one, endlessly repeating throughout geological time. The end products of one cycle (rocks) become the raw material for the next cycle, and the most resistant materials (sand and hard pebbles) can become re-cycled several times without becoming physically or chemically degraded.

The initiation of each cycle is the uplift of the crust caused by Plate tectonic movements, without which the continental crust would by now be eroded almost to sea level.

☛ Return to the car park by the same route you came into Pinfold Quarry. **Worksheet 8** may be used as a homework summary.