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

INTRODUCTION

☛Field groups will need measuring tapes, compasses and clinometers if dip measurements are to be attempted, as well as clipboards, and copies of the relevant field sheets for individual pupils. Callipers for measuring pebble axes are useful, being more accurate than rulers or tapes. (See **MAQ8 worksheets**).
Group Leaders will need a plastic bottle of dilute HCl, a small plastic bottle of water. A digital camera will also be useful.
The total distance for walking in this itinerary is less than 2km and includes one uphill section on a steep footpath and steps to reach the viaduct. Depending on the precise combination of sites chosen, the whole visit should take up to about 4 .5 hours. Field leaders should have decided which combination of the following exercises their groups are to tackle before they arrive on site. (See site numbers on **Figure 1**.):

1. Meldon reservoir view (water cycle; suitable sites for dams);
2. Lime Kiln Spoil Heap and Meldon Pool (old industrial site; weathering of old buildings);
3. Boulder field description (ancient peri-glacial weathering feature);
4. Meldon Aplite Quarry (describing the dyke and its contact);
5. Red-a-ven stream exercise (stream sediment analysis; erosion and transport);
6. The Mystery Deposit (sediment description analysis of sediment, hypothesising);
7. Granite seat and capstone exercise (describing igneous rocks);
8. Viaduct view (recognising modern day Earth science processes in the landscape);
9. Railway bridge (description of weathering effects on built structures);
10. Railway cutting (sedimentary rock description and dip measurements; superposition);
11. Meldon Lane to car park. Spot that Block exercise (Summary).

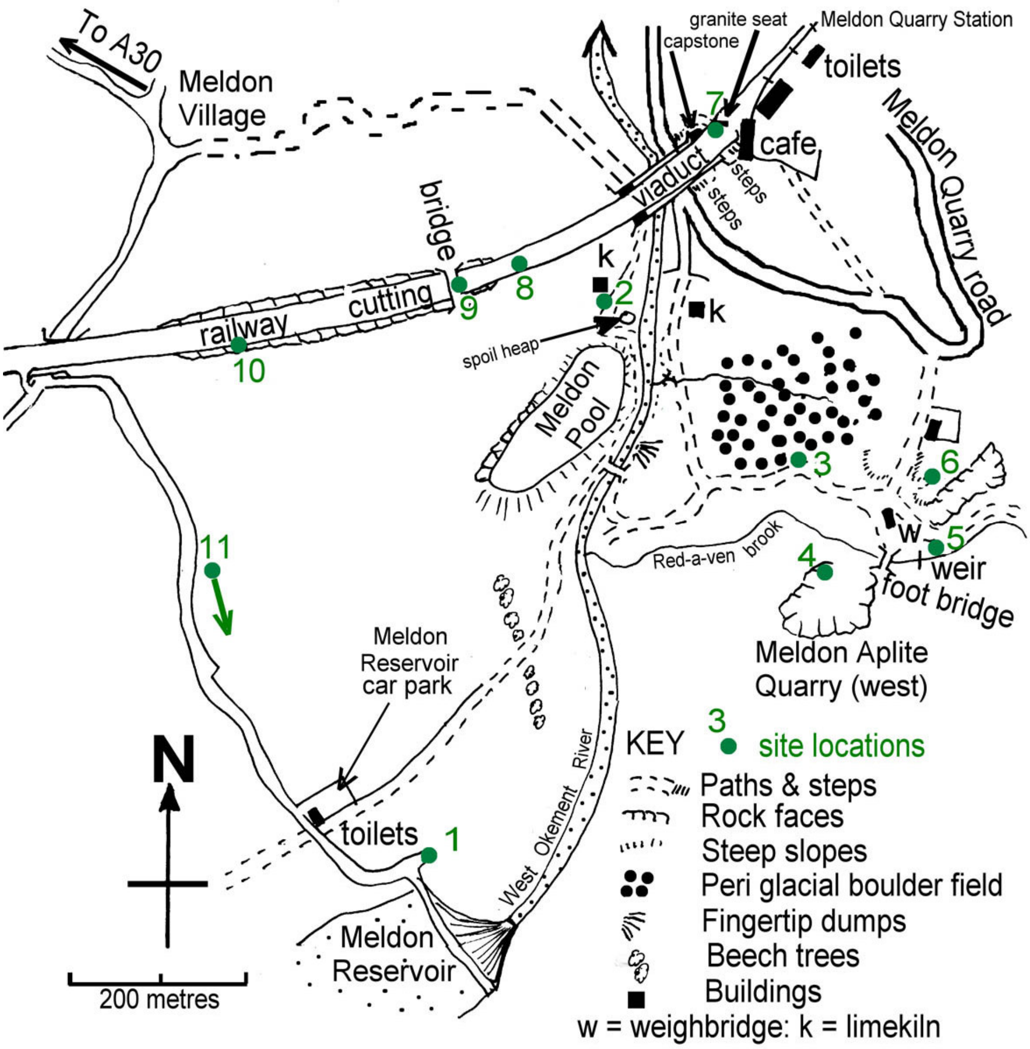


Figure 1. Sketch map of sites in the itinerary.

Site 1. Meldon Reservoir View.

☛ Leave the Meldon reservoir car park by the gate close to the public conveniences and turn left along the lane for 150 metres to the NW end of the Meldon dam, close to the electricity sub-station. Gather the group where they can see the face of the dam and the valley above and below it. The dam is 201 metres long, 44.3 metres high and supplies most of North Devon's water.

Figure 2. Site 1: Meldon Dam from viewpoint.

☛ First focus the group's attention on the water cycle.

Suitable questions at this site	Acceptable responses.
How did the water get into the reservoir?	A little by direct as rainfall into the reservoir; some arrived as river flow; some by soaking through the soil. (NOTE: The underlying rocks here are relatively impermeable, although they do have fractures that may locally allow some groundwater flow to the reservoir.
How will the water get out of the reservoir?	Via the outflow, but also by evaporation.
Where will the water go, after it flows out of the reservoir?	Along the West Okement and the Torridge rivers to the sea at the north Devon coast. (Even if it flows through the people in Devon's settlements, it will still end in the sea.)
Then where?	Evaporation to the atmosphere and then to condense as rain somewhere else.
Ask the group why the dam was built?	To supply water to north Devon. (i.e. human interruption to the water cycle to create a local surplus for storage.)
Ask the group what was suitable about this spot, for the dam to be built here?	An area of adequate rainfall / streamflow. A narrow, deep valley suitable for backing up the water without it spreading out and evaporating more quickly. Suitable geological foundations: impermeable, and strong enough to support the weight of the dam and the water.

☛ Now focus on the Rock Cycle.

Suitable questions at this site	Acceptable responses.
Ask the group to describe the view.	Answers will probably focus on the large features and include: the dam, the opposite hill slope and valley.
Ask the group to explain why the valley is here.	Answers should be linked to the rock cycle: weathering of rock on the valley sides, rivers eroding away the weathered material (mud, sand and gravel, plus soluble weathering products), and cutting down into the landscape.
Ask the group where this river is taking the sediment ***downstream*** from the dam?	The sediment trail is northwards to the River Torridge and the estuary and sea at Barnstable, on the north Devon coast.
Ask "What will happen to the sediment when it arrives at the sea?"	Eventually it will be deposited. Push the group to go further: eventual cementation into layers into rock some time in the future.
Ask the group what fossils a geologist from a million years in the future might find in these rocks?	Accept present day fossils with shelly skeletons, but not jelly fish etc. Also ask what signs of human remains might be found: e.g. shipwrecks, skeletons of drowned people, cans, bottles, etc.
Ask the group where the sediment ***upstream*** from the dam is now being deposited	In the lake, behind the dam, where the river current slows down, eventually filling up the reservoir with sediment – instead of water. i.e. the reservoir interrupts the rock cycle as well as the water cycle.
Ask pupils to complete **worksheet 1** in **MAQ8 pupil worksheets**	Completed copies of each worksheet can be found in **MAQ9 Field Leaders' Notes**

Site 2. Lime Kiln, Spoil Heap and Meldon Pool.

☛ Return westwards along the road and take the bridle Path to the right, signposted "To Meldon Viaduct". The path is downhill, just before the car park. Continue along the path through the line of beech trees, and between the River West Okement and Meldon Pool. The pool is not easily viewed through the trees and is surrounded by steep slopes. **At 40 metres deep it represents a hazard. Keep away from it**. At the NE end of Meldon Pool the path swings left and then right around a mound of tipped material towards the lime kiln. Halt the group close to the base of the lime kiln (see **Figure 4**).

Figure 3. Meldon Pool.

Figure 4. Site 2: Lime Kiln.

☛ Focus on the Lime kiln as a weathered human artefact, as well as a sign of human exploitation of a geological resource.

Suitable questions at this site	**Acceptable responses.**
Ask the group "What was this building used for?"	It was a lime kiln built and used from about 1850 (i.e. 150 years old).
Crushed limestone, $CaCO_3$, was burned (with coal, or, originally, more probably charcoal). What, chemically, would you expect to happen to the limestone?	CO_2 would be driven off leaving Calcium Oxide, (CaO) or lime.
What would the lime have been used for?	Traditionally lime was used to lime wash buildings. Calcium oxide mixed with water was used as an alkali dressing for fields where the soil was acidic to improve fertility.
What is different about the kiln now compared to when it was first built?	Trees and vegetation have colonised the structure; blocks of stone are missing, particularly from the top. It has been re pointed.
Why did it need re-pointing? What happened to the original cement?	Attacked by acidic rainwater the lime in the cement was carbonated (to the soluble calcium bicarbonate) and then and dissolved away.
Ask the group to complete the first part of **worksheet 2.**	
Ask the group "Where do they think the limestone which was roasted in the kiln came from?"	It would not have been transported far. In fact it was excavated from Meldon Pool, about 80 metres to the south.
Why might the quarrying have stopped?	The limestone deposit was small and the void of Meldon Pool represents almost the entire limestone deposit, now quarried away.
What does the fact that the quarry is now full of water tell us about the rocks in this area?	They are impermeable.
What would have happened to the waste material from the quarry?	It would have been dumped – quite close by. One spoil heap is visible 50m back, by the bend in the path. There are others.
Move the group back to the spoil heap: Ask the group to investigate the quarry waste and describe the material in the spoil.	Angular blocks of pale and dark rock.
Describe the rock types. [Be prepared to use dilute HCl to test for carbonates]	The hard (high silica content (SiO_2)) dark rock, sometimes showing bedding, is in fact a metamorphic rock called Hornfels. It has no reaction with dilute HCl. The limestone fragments will react with acid.
To what rock type do these rocks belong? [NOTE: The sedimentary rocks in the area have been metamorphosed twice: once by the heat of granite intrusion and once by heat and pressure in the heart of a fold mountain range.]	They are metamorphosed sedimentary rocks. [NOTE Sedimentary structures (even fossils) can survive low grades of metamorphism.]
What are the differences between a limestone and a metamorphic marble?	Limestones have sedimentary features (bedding, fossils, ooliths etc.) whilst marble is recrystallised into even-sized interlocking calcite crystals.
If it was a limestone quarry, why is there so little limestone here in the spoil heap?	They used every bit of limestone as it was a rare resource in this area of acid soils.
Can you see any difference in the vegetation of the spoil heap and the surrounding area?	The limestone loving flora is more rich than that on the acidic soil weathered from the hornfels.
Complete **worksheet 2** in **MAQ8 pupil worksheets.**	

☛ To get to **Site 3** retrace your steps back along the path for 200 metres and cross the West Okement River on the narrow footbridge (close the gate behind you). Turn right and follow the narrow track bending to the left up the slope. After about 250 metres the boulder field will be visible on your left. Halt the group 100 metres beyond, where there is also the view of the viaduct (see **Figures 5 and 6**).

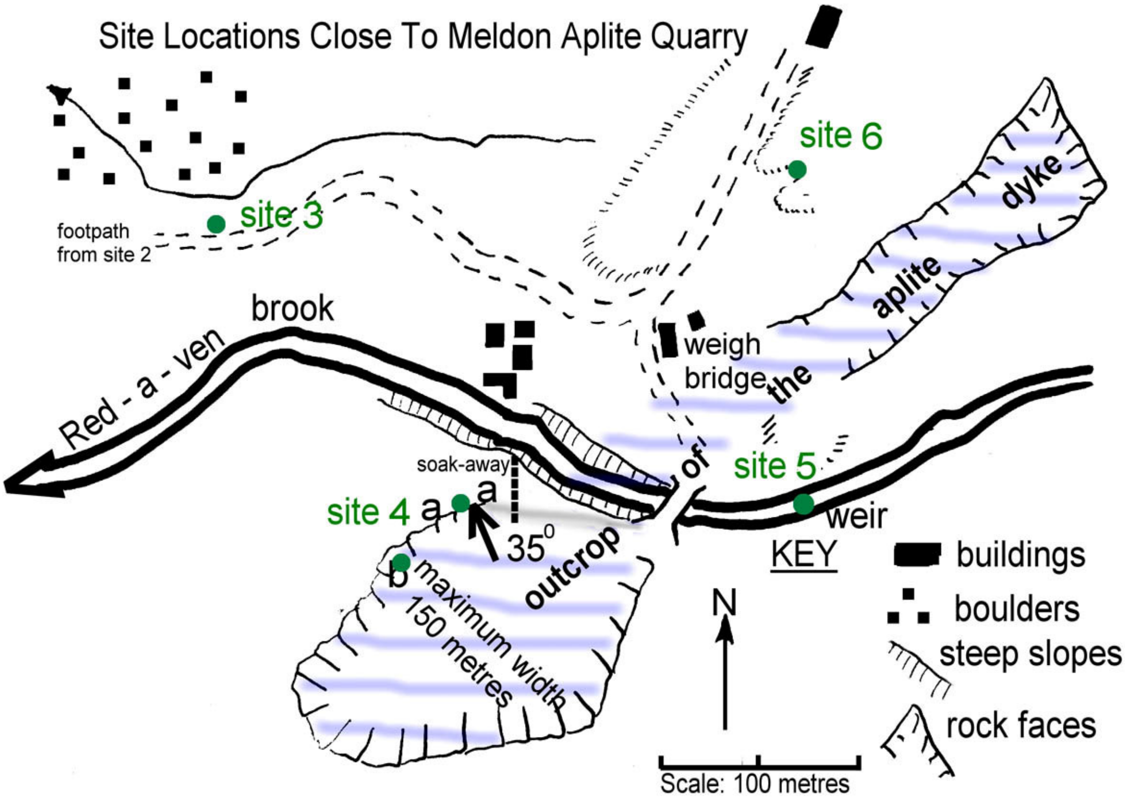


Figure 5. The location of sites 3, 4, 5, and 6.

Figure 6. Site 3: The Boulder Field.

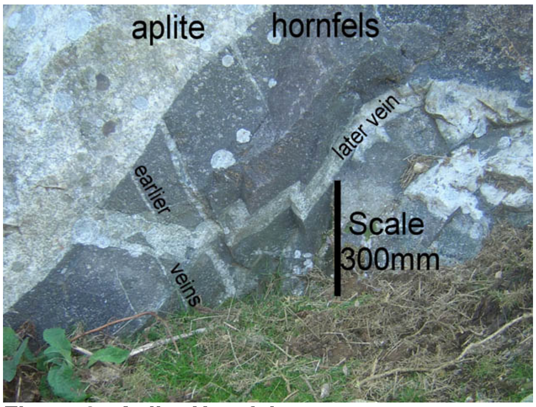
☛ Here the focus is on getting the group to see deposits as evidence of weathering and erosion processes in the past, and ways in which they might be interpreted. It is a preparation for the thinking needed at **Sites 5 and 6,** rather than an exercise in itself, although worksheet 5 may be adapted to this site if required.

Suitable questions at this site	Acceptable responses.
Point out the boulders in the grass and ask the group to describe them.	Large, over 1m in length. Sub-angular edges. Coated with lichen, and half covered by grass (indicating they haven't been moved recently).
Ask: "Where do (any) boulders come from?"	They are physically weathered from bedrock along planes of weakness.
Can they see a nearby exposure of bedrock these boulders might have come from?	No. Upslope there is no cliff or scree. Any quarry face is much more recent than these boulders.
Were they brought here by rivers?	No. They are not rounded enough, nor is there any sign of a large enough river channel. [Allow them to explore why human activity wouldn't bring so many boulders here and leave them scattered.]
Allow the group to conclude that present day processes can't account for this material being here. Then ask what **ancient** processes might have been responsible for physically weathering these boulders from the bedrock? They may eventually need a hint about glacial conditions.	See how far they can get on their own, but then you will probably need to explain: Freeze – thaw in permafrost conditions, related to the end of the last glacial period about 11, 000 years ago. Frost heave would have brought the blocks to the surface, and sliding on top of sloping frozen ground would have moved them down slope. Now they are a "fossilised" piece of late glacial landscape processes.
Although no suitable granite tor is visible from this spot, point out that tors, and the boulder fields below many of them, were formed by similar processes. Ask the group how a tor can be formed from a granite that crystallised in a batholith several kilometres below the surface?	The crust must have been uplifted whilst the top surface was progressively removed by weathering and erosion. [The granite of Dartmoor, formed at depths of 3 to 4 Km is now at 300 to 400 metres above sea level – and only 1.5 kilometres to the south east.] Frost shattering along the joints released the boulders, leaving the residual tor behind.

Site 4. Meldon Aplite Quarry (West).

☛ Continue up the hill and turn right past the old weighbridge. Cross the Red-a-ven brook on the footbridge. (See **Figure 5**). Turn right and continue downstream, parallel to the brook, but at a safe distance from the steep crumbling bank, to the far end of the Meldon Aplite Quarry. There is a drier path along the foot of the whole face, but keep the group at this end, as the face is particularly steep at the south-western end.
Bring the group to the area **a-a** on **Figure 7** and draw their attention to the two different rock types in the face.

Figure 7. The Meldon Aplite site.

Suitable questions at this site	Acceptable responses.
Using **worksheet 3** as a guide, ask the group to summarise the differences between the two rock types and decide what they are called. [Have small plastic bottles of dilute HCl and water available for tests on suspected carbonates and fro porosity].	The aplite is a white, crystalline, fine grained and un-bedded igneous rock. The hornfels is dark, bedded, fine grained and metamorphosed rock dipping 35° to the north-northwest. Neither react with HCl. Both are non porous.
Ask the group if they can tell whether the beds are horizontal or dipping.	The beds are dipping (to the NNW).
Ask the group to take a dip measurement on the bedding in the hornfels. [NOTE: carefully align a clipboard with a bedding plane and take the dip measurement from its flat surface.]	Use the clinometer to find the line of the horizontal across the clipboard. Then take the amount of dip perpendicular to this direction. Use a compass to measure this direction of steepest dip. Measurements should be close to 35^0 to 335^0 N (the NNW).
Ask the group if beds are normally deposited at this angle. If not why not?	Beds are normally deposited close to the horizontal under the effect of gravity in water. The dip is therefore evidence of how much the rocks have been deformed by earth movements since they were deposited. [**Principle of Original Horizontality**.]
Ask the group to deduce which direction the beds get younger in this area, (assuming they have not been overturned by earth movements).	The **Principle of Superposition** states that younger beds are on top. This means the beds get younger in the direction of dip (i.e. NNW)
Ask the group to draw the line of contact between the two rocks on the sketch on **worksheet 3** in **MAQ8 pupil worksheets.**	See the answer sheet in **MAQ9 Field Leaders Notes.**
Move the group to site **b** (see **Figure 8**) and ask them to describe the contact between the two rocks at this point. Complete the sketch of the contact between the aplite and the hornfels on **worksheet 5** in **MAQ8 pupil worksheets.** Two directions of cross cutting veins indicate two periods of veining occurred.	Veins of the aplite cut through the hornfels, demonstrating that the aplite was liquid (an igneous melt) when it was formed.  **Figure 8. Aplite-Hornfels contact.**
Draw the group's attention to the floor of the quarry and ask them why it is so wet? (If it happens to be a dry period point out that the tufts of grass are characteristic of areas which are normally wet).	The rock is impermeable, and rainwater is kept at the surface till it evaporates, or drains away. [The quarry floor has been drained at its north east end by a soak-away, and on the other side, by a stream].
Tell the group that the quarry was worked for the igneous rock and that the "void" left behind reveals the shape of the igneous body. Ask them to describe the shape and what name they would give to this igneous body? **NOTE:** Remind the group that they are in fact viewing the contact of the dyke from **"inside"** the igneous body. Some of the hornfels they can see are lumps on the uneven contact sticking **into** the magma.	The quarry is elongate SE to NW and is much narrower than it is long i.e. "sheet" shaped. It clearly cuts across the bedding seen at **a-a**, and so must be a dyke. In fact it dips to the south at about 50^0, as is suggested by the slope of the north wall.
Ask them to predict, by using the map on **worksheet 4**, and from the shape of the quarry, the	It extended to the northeast, getting narrower, until it became too thin to quarry economically.

Ask them to shade in the map area they think the aplite once covered. Ask them to predict from their shaded map whereabouts in the river bed they would expect to find the aplite. (Stay in the quarry and keep them away from the steep banks of the brook).	Just downstream from the footbridge. (See **Figure 5** above)
The aplite was quarried for use as an abrasive. What qualities of the rock made it suitable for this use?	It was hard (physically resistant).
The aplite was also quarried as a raw material for glass making in the 1920s. What qualities made it suitable for this use?	Very rich in silica (SiO_2).
Ask for speculation about why the glassmaking stopped? [NOTE: In fact it was due to technical difficulties the factory could not guarantee the consistent quality of the glass.]	Following the thinking from Meldon Pool economic explanations are likely. These often fall into two categories: The raw material was worked out, or working the remainder became too expensive (often due to drainage problems, or the declining quality of the resource). In fact quarrying stopped in the 1970s after being worked for another 50 years as a source of abrasives, enamelling and road metal.
Ask the group to complete **worksheets 3 and 4.**	Completed copies of the worksheet are in **MAQ9 Field leaders' notes**.

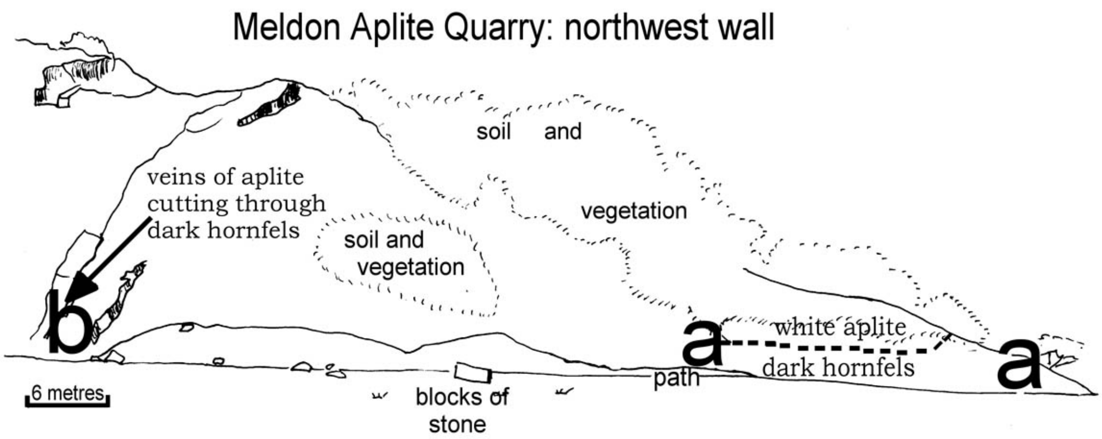


Figure 9. View of Meldon Aplite Quarry.

Site 5. Red-a-ven Brook

☛ Go back to the footbridge and cross the Red-a-ven brook. Continue upstream for about 30 metres, to the broken weir. Just above the weir is a site suitable for a stream study, provided the river is not in spate. If it is in spate move on to **Site 6.**

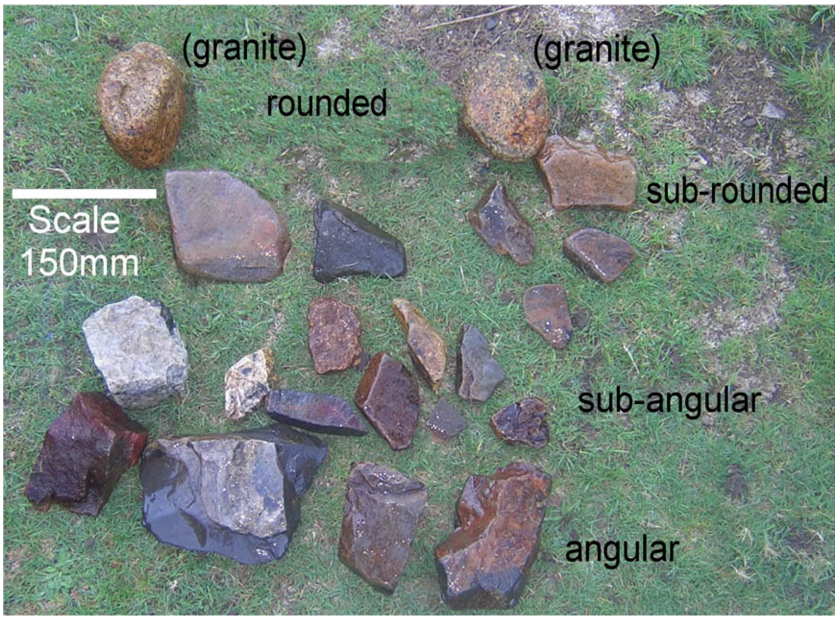


Figure 10. Samples from Red-a-ven brook.

☛ Again focus on how this deposit might have been formed, using the four steps in **worksheet 5** (See **MOS8 KS3 worksheets**) to guide the investigation. But first try to get the group to look at a stream with new eyes.

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

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

Suitable questions at this site	**Acceptable responses.**
Which part of the Rock Cycle is represented here?	Transport of weathered fragments.
In which direction is the water flowing?	Westwards (to the West Okement).
Is the water transporting any sediment today? [The answer depends a little on how lucky you have been with the weather].	Probably not, unless there has just been a downpour. However, there just may be some fine sand being rolled over the bottom. Look carefully.
Ask where the pebbles and gravel are likely to have come from?	Eastwards, upstream weathered from rock outcrops and washed into the stream.
Use step 1. **worksheet 5.**	The sediment is not cemented together. It is not bedded but it is sorted (sand together, pebbles together). It is clearly in a channel and being transported along it.
Use step 2. **worksheet 5.** Form the group into parties of about 3 or 4, and allocate them a position along the stream. Ask them to select 20 of the largest fragments and decide on the angularity / rounding and the size of the largest fragment (longest axis). What does this evidence tell us about the formation of this sediment?	The fragments (pebbles) are mainly metamorphic with some granite. There are many angular and sub angular fragments (maybe 60% or more) with the rest being mainly sub rounded or rounded. (Very few, if any, are well rounded). The longest pebbles will exceed 64mm, indicating deposition in a minimum velocity of well over 300 cm per second. i.e. they were brought down at a time of very high stream flow.
As these pebbles continue to be moved downstream what changes would be expected to happen to them?	Pebbles move as traction load. The rolling effect would abrade, or chip off, pieces making them smaller. The edges on such pebbles would also become more rounded. The amount of sand and grit would increase.
Bring the group together and discuss their findings.	There will be no pebbles of sedimentary rocks. Most of the pebbles from upstream are metamorphic rocks of various kinds. These tend to be more angular, indicating they have not been transported far by the river. A few (around 10%) are coarse grained igneous granite pebbles. These tend to be more rounded perhaps because they have travelled from the granite outcrops further upstream, but also because they are made up of minerals like feldspar and mica which can break (cleave) more easily. There may be one or two pebbles of mineralised deposits
Ask the group to complete **worksheet 5**.	See **MOS8 KS3wksheets.**

Site 6. The Mystery Deposit.

☛ Return downstream to the footbridge and turn right past the old weighbridge. Instead of turning left downhill, continue straight on until a small low and grassy quarry opens out on the right. Continue into the small quarry to the exposed low face at the back See **Figures 5, 11** and **12.**

Figure 11. Site 7: The quarry.

Figure 12. The quarry face.

☛ Remind the group that the deposit at **Site 3** just down the hill was evidence for ancient freeze-thaw processes, and then focus on how this deposit, only a few hundred metres away, might have been formed. Its origin is something of a mystery, see if they can unravel its origins. Use the four steps in **worksheet 6** to guide the investigation (see **MAQ8 KS3 worksheets**).

Suitable questions at this site.	**Acceptable responses.**
First ask them to concentrate on what is **different** from the boulder field location, **Site 3.** Ask the group to inspect the face and describe the rock. Use step 1. **worksheet 6.**	There are no very large sub-angular blocks. The deposit is loosely cemented grit; it is sorted and bedded; it has angular fragments, up to 5mm across; they are fragments of igneous and metamorphic rocks. It has no fossils embedded in it. The deposit has a "flat" top surface but it forms a sheet and is not in a channel (see **Figure 12**). The group may also notice rough bedding and "cross bedding" indicating deposition in water.
What kind of rock is this: igneous, metamorphic or sedimentary?	Any rock made up of loosely cemented weathered fragments of other rocks is a sedimentary rock.
Use steps 2 and 3 on **worksheet 6**. Form the group into parties of about 3 or 4, and allocate them a position along the scree below the low face. Ask them to select 20 of the largest gritty fragments (in the <u>**scree**</u>, not the face) and decide on the angularity / rounding and the size of the largest fragment (longest axis). What does this evidence tell us about the formation of this sediment?	The amount of rounding varies proportionately with the amount of transport as bed load in water. These are angular and so haven't been moved "very far". The size of the largest fragment indicates minimum velocity needed to deposit the sediment, about 300 cm per second for a 5mm piece of gravel (see **Table 1**). i.e. it is not a freeze-thaw deposit.
Ask the group how they think the table of depositional velocities for fragments was obtained?	By experimentation today, and then applying the results to deposits formed in the past. This is an application of the **Principle Of Uniformitarianism.**
What can be inferred about the age of the deposit?	It is un-cemented and lying on top of the landscape, so it is very "young" (but in geological terms that's not very helpful). There has been time for some soil forming processes to begin, but this may happen over a few decades.
Remind the group that hypothesising is regularly performed by Earth scientists when they don't know how a deposit is formed. Invite the group to hypothesise about how this deposit was formed using the observations and evidence they have collected?	Of course they won't know, but insist that hypotheses make reference to the observed evidence. [It is unclear exactly how this deposit was formed. It is too high above the Aplite quarry and too far away from Meldon quarry to have anything to do with sediment washed from those workings. It is just possible that the deposit is related to the glass works which briefly operated in the area in the early 1920s (making the deposit about 90 years old). That is, there are better and worse hypotheses, but not right and wrong answers.]
Ask the group to complete **worksheet 6.**	

☛ Return towards the old weighbridge and turn right back down the path past the boulder field. This time take the fork to the right, towards the viaduct in the distance (see **Figure 1**). Pass the (other) limekiln and go through the gate to the Meldon Quarry Road. Be **very careful** crossing this road as it carries very large lorries. Go up the steps up around the piers carrying the viaduct itself. Take great care managing the group through the ascent to the viaduct. Follow the steep path beneath the viaduct and then back again to take the steps to the left, emerging at the NE end of the viaduct, close to the Dartmoor Railway buffet car.

☛ Groups which have arrived by train from Okehampton will probably want to start and finish the itinerary here.

☛ **Site 7** is directly across the viaduct from the steps: the polished granite seat and the capstone on the opposite pillar of the viaduct (see **Figure 1**).

Figure 13. The granite seat.

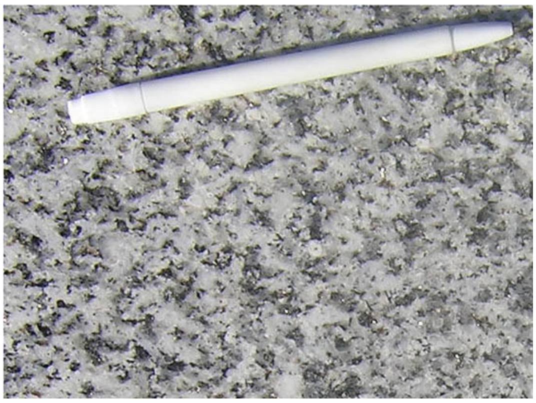


Figure 14. The polished granite.

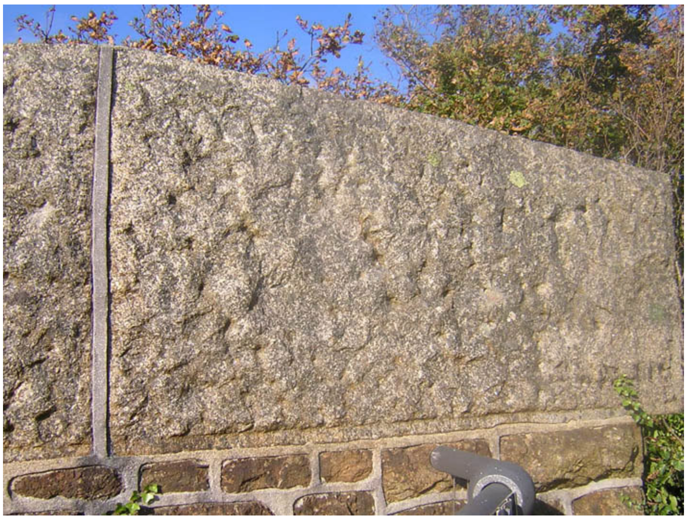


Figure 15. The granite capstone.

Site 7. The Granite Seat

☛ Bring to the group's attention the polished section of the seat (see **Figures 13 & 14**).
The main focus here is examination of the rock characteristics and its suitability as a material for constructing a seat. **Should this rock be tested with dilute HCL, please wash the area tested with water immediately afterwards.**

Suitable questions at this site	Acceptable responses.
Study the polished section of the seat. How many different minerals can you see? Describe them.	Three: Opaque white (feldspar); Black flakes (mica) and glassy (quartz).
How are the minerals being held together to form the solid rock?	They are interlocking (i.e. not cemented fragments, and no pore spaces).
What kind of rock is this igneous, metamorphic or sedimentary – and how was it formed?	Igneous, formed by crystallisation from a liquid magma.
What does the size of the crystals tell you about the cooling of this magma?	The rock is made of coarse crystals, up to 5mm in size. This means the rock is coarse grained and cooled slowly (in a large batholith, deep underground) allowing the crystals to grow large.
Why has this rock been chosen to be used as a seat?	It is a large piece which has no joints, bedding or other splits in it. It is relatively resistant to chemical and physical weathering. It is attractive and takes a polish.
Of what rock is the nearby capstone made?	It is also granite (rough dressed, so it looks very different).
The capstone has been here since 1874. What signs of weathering does it show?	Very little, indicating chemical resistance to weathering. (Although the viaduct is a listed monument, and it may have been recently cleaned!)
Why is this rock suitable for use as a capstone?	It is chemically and physically resistant to weathering; it is a large (heavy) piece not split by joints (or bedding as it is an igneous rock), and difficult to dislodge; it is impermeable and prevents water attacking the stonework below. It was also local to the site and cheap to transport here.
Ask the group to complete Worksheet 7.	

Site 8. The viaduct viewpoint.

☛ Take the group over the viaduct and close to the SW end stop to look over the view to the south-east of the area just visited (see **Figure 16)**. [NOTE: Groups starting the itinerary at the viaduct might want to continue to the next site along the cycle track, and do this exercise last, before getting the train back to Okehampton.]

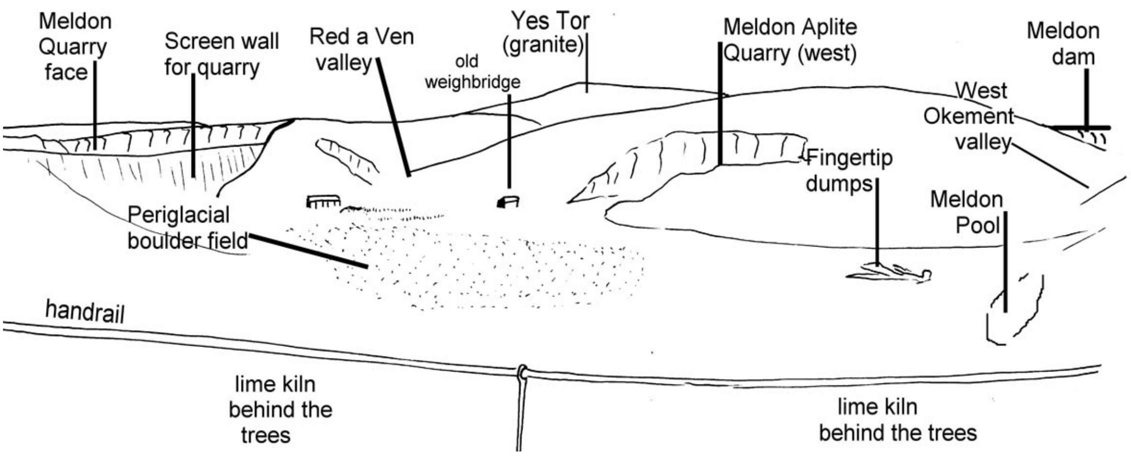


Figure 16. Sketch of the view from the viaduct.

☛The focus of this exercise is to obtain an overview of the area the group has just walked through, and then develop an appreciation of the physical, chemical and biological processes at work in the landscape.

Suitable questions at this site	**Acceptable responses.**
Using **worksheet 8** assist the group in identifying the main features of the view. When they are familiar with the area from this vantage point, then continue.	**Worksheet 8** is to be found in **MAQ8 pupil worksheets.**
What evidence can the group see for human activity in the area?	Many buildings, the viaduct, walls etc. The now disused Meldon Aplite quarries – both east and west, and the Meldon aggregate quarry off to the left (east).
What evidence can the group see for freeze-thaw activity in the area?	The area of large boulders broken by frost activity at the end of the last glacial period.
What evidence can the group see for river erosion?	The valleys of the Red-a-ven and West Okement have been excavated by rivers. Material is washed down the valley sides and moved downstream by the flow.
What evidence can the group see for uplift of the rocks of the Earth's crust?	Yes Tor is on the coarse granite exposure of Dartmoor. It formed in a batholith perhaps 3 or 4 kilometres below the surface, but is now 300 metres above sea level. As the top layers of crust are weathered and eroded away, in places the crust below is uplifted to continue the process. Without crustal uplift most land would be eroded away, very close to sea level in height.
What evidence can the group see for the action of chemical weathering?	The grey coating on the metal parts of the viaduct is there to protect against chemical weathering.
What evidence can the group see for photosynthesis?	Any green leaves.
What evidence can the group see for biological growth?	Leaves, twigs, grass, flowers, birds, humans, etc.
What evidence can the group see for biological decay?	Dead leaves, branches etc. (depending on the season).
Ask the group to complete **worksheet 8.**	

Site 9. The Railway Bridge

☛ Continue along the cycle path towards the bridge, 150 metres to the SW. The bridge was completed in 1874, and exhibits the weathering characteristics of human made structures.

Figure 17. Weathering features under the bridge.

☛ The focus here is on the effects of weathering on an artificial structure over 140 years.

Suitable questions at this site.	Acceptable responses.
Ask the group to inspect the bridgework and describe the materials used to make it.	The lower stonework is blocks of granite, the underside of the bridge is red brick. They are bonded by the use of cement (a form of human made limestone).
Ask the group to describe the differences between the granite here and the granite seen at the seat.	This granite has very large white crystals (of feldspar) mixed with the other coarse crystals.
What does this variation in crystal size tell about the rate of cooling of the part of the granite from which these blocks were taken?	A slower period of cooling allowing the large crystals to grow followed a faster, but still slow, period of cooling allowing the rest of the crystals to form.
Why has the granite been used for the lower part of the bridge?	Here it is the strength of the rock that is important, along with chemical and physical resistance.
Ask the group to spot any signs of physical weathering and explain how it is occurring.	The red brick on the lower parts of the bridge roof are flaking due to water draining through the structure and frost action.
Ask the group to spot any signs of chemical weathering and explain how it is occurring.	The leaching of the cement onto the lower stone work is caused by acid water draining through the cement and attacking the calcium carbonate by carbonation and solution. The white stains are caused by re-deposition of the calcium carbonate as the water evaporates.
Ask the group to spot any signs of biological weathering and explain how it is occurring.	The roots of plants like ivy growing up and into the stonework are breaking it loose as they grow.
Ask the group to complete **worksheet 9.**	

Site 10. The Railway Cutting

☛ Continue along the cycle track for about 130 metres, noticing along the way the exposures of well bedded rocks on the right. However, **Site 10** is on the left further along, and is a more accessible bedding plane of the local rock (see **Figures 1** & **20**).

The bedding plane is sloping towards the camera, and two sets of joints at right angles can clearly be seen. This is an easily accessible site for dip measurements made actually on the bedding plane (no need for clipboards).

Figure 18. The railway cutting exposure.

Suitable questions at this site	Acceptable responses.
Describe the features of the outcrop.	Dipping bedding planes and joints with growing plants.
Describe the rock type.	A well bedded, fine grained mudstone (only slightly baked by the granite which is nearly 2km away from this point).
Ask the group to measure (or estimate) the dip on the bedding plane and draw it in on the section across the cutting on **worksheet 9. (**See **Figure 19)** [Note: when taking a dip measurement, first use the clinometer to find the horizontal direction across the bedding plane. The true dip is then at right angles to this direction.]	The beds are dipping at 35^0 towards 010^0 north. Emphasise that these beds continue underground in one direction, whilst above ground they have been eroded and quarried away. (**Principle of Lateral Continuity of Beds**).
In which part of the cutting are the youngest and the oldest beds exposed?	The youngest beds are on top i.e. at the top of the north side of the cutting, whilst the oldest are at the bottom of the south side of the cutting. (NOTE: **Principle of Superposition)**
Ask the group to look back down the cutting and estimate the volume of rock that was removed.	Estimate: 200m long x 10m deep x 10 m wide = 20,000 cubic metres. [Assuming a density of around 2.8 gm ^{3} cm about 56,000 tonnes in weight.]

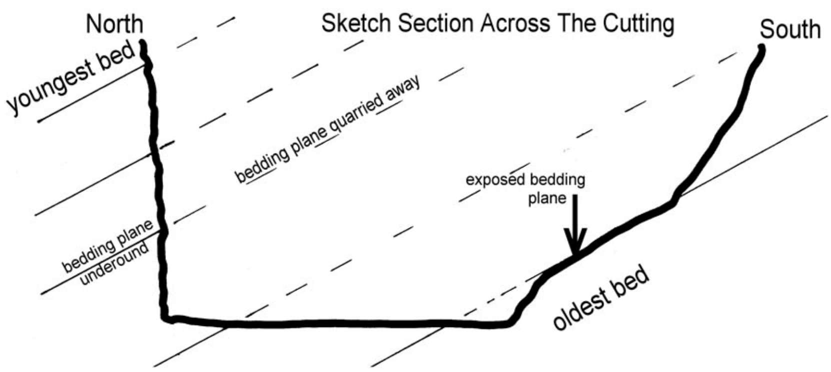


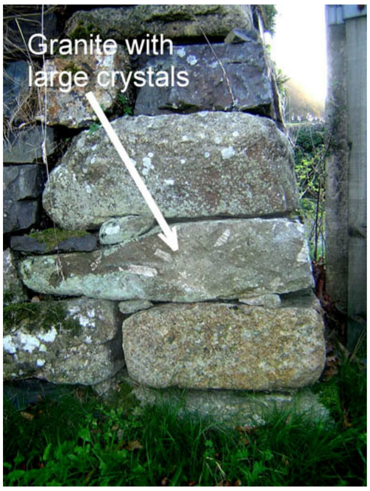
Figure 19. Sketch section across the railway cutting.

☛ Continue along the cycle track to the next exit 250 metres further SW signed "Meldon Reservoir and Dartmoor". After joining the road, take the left turn and walk along the road towards the Meldon Reservoir car park.

Site 11. Spot those blocks.

☛ Where the road reaches its highest point, stop the group and prepare them for the last exercise. Remind them that this is a road that gets busy during the tourist season and that they should be aware of traffic at all times.

Tell the group this is an exercise in observation, using the information they have acquired during the visit. Direct the group to use **worksheet 10** to help them locate and describe the blocks used in the walls and gateways between here and the car park. Gentle competition between work groups of 3 or 4 pupils, often works well at times like this. Group leaders' should be on hand to assist with problems of recognition (see **Figure 20**).

Example of block	Brief notes
	**Granite.** **This piece is in the first gateway into the car park. It is behind the westernmost gatepost. It is easily recognised by the big white feldspar crystals about 50mm long.**
	**Hornfels showing bedding.** **Almost any dark block showing layering. Layers are up to 15mm thick.** **[Dark blocks without layers just might be dolerite – a complication too far!]**
	**Mineral veins.** **Don't worry too much about identifying the mineral. Cross cutting is evidence of two events – the first veins are cut by the later. (Principle of Cross Cutting Relationships).**
	**Man-Made "rock" or cement!** **This example is on the right about halfway back to the car park.** **It is made of rock fragments in cement.**

The final **worksheet 11** may be used in the Meldon Reservoir car park to summarise the important aspect of the geological time context, or it might be used as a follow-up homework.