Introduction.

☛ Individual groups will need 10x hand lenses, measuring tapes, compasses and clinometers if dip measurements are to be attempted, as well as clipboards, pencils, rulers and copies of the relevant field sheets for individual pupils. (See **KNO8 worksheets**).
Group Leaders will need a plastic bottle of dilute HCl, a small plastic bottle of water. A digital camera will also be useful.

☛ Field leaders should have decided which combination of the following exercises the groups are to tackle before they arrive on site. There are no toilet facilities on Wenlock Edge, so parties are advised to stop in Much Wenlock, making use of the first two worksheets in the process. Apart from a theme of human use of geological materials, the main theme is that of the **Principle of Uniformitarianism,** using present day processes to help us interpret ancient rock cycles.

1. Bus quiz: for the journey from The Ercall (for those groups linking the two sites).
2. Much Wenlock Building Stones.
3. Landscape: Ape Dale and Wenlock Edge.
4. Knowle Quarry (south).
5. Knowle Quarry (west).
6. Knowle Quarry Lime Kilns.
7. Jack Mytton Way exposure & Lea Quarry view.

It is possible to extend this ESO-S visit locally by contacting the National Trust, at Cardingmill Valley, or Bardon Aggregates at the nearby Lea Quarry. See **KNO5 Locaccess** for details.

From junction 6 on the M54 turn south along the A5223 to the junction with the A4169. Turn right and follow the road downhill into the Severn valley. Before reaching Buildwas take the left turn towards Much Wenlock, still following the A4169 into Much Wenlock.

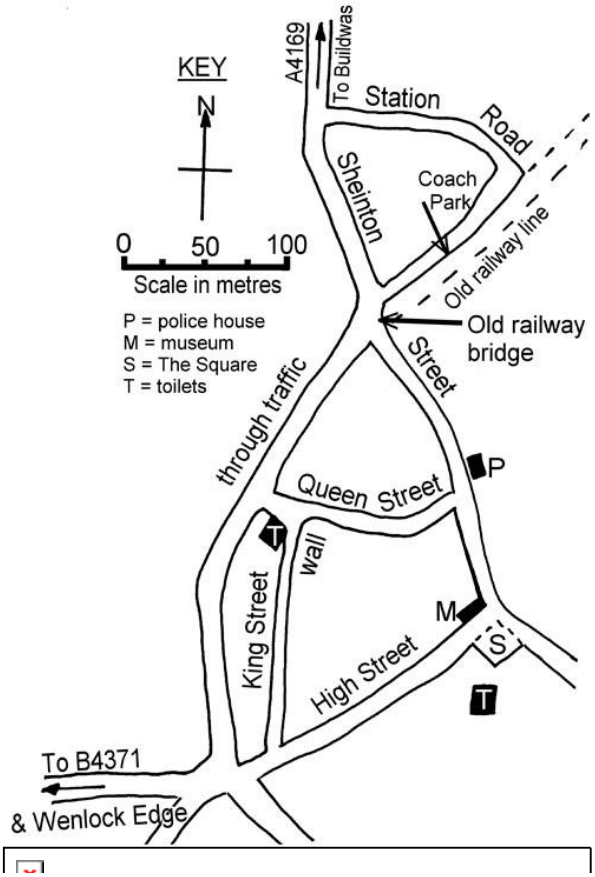

Figure 1. Map of Much Wenlock.

☛ Much Wenlock is an optional site on this itinerary. Group leaders may want to include a stop here to take advantage of the toilet facilities that are not available along Wenlock Edge. This may be combined with a worksheet exercise on the building materials used in the town. (See **worksheet 2** in **KNO8 worksheets**)

The coach park is on Station Road, which is signposted as a left turn when approaching Much Wenlock along the A4169 from Buildwas. The closest public conveniences are on the junction of King Street and Queen Street. The route on the worksheet is to turn left at the end of Station Road and walk along Sheinton Street, turning right along Queen Street. An extension could be made along King Street, turning right along High Street and then left into Sheinton Street at the Square. Pavements are often narrow or absent, so care should be taken to look out for traffic.

[Groups who want to see the museum geological display may simply visit the museum, or arrange a guided visit by contacting the Shropshire Education Officer on **01584 813650**.]

Site 1: Building Stones of Much Wenlock

☛ Using **worksheet 2** groups could be asked to observe and record the geological building materials in use in the town, as they walk past. If there are large numbers of people on the streets it will be advisable to subdivide a large group, and supervise them closely when crossing roads.
The bridge abutment at the junction of Station Road and Sheinton Street is an opportunity to see large blocks of limestone in use, as well as highlighting the building of the rail link which allowed exploitation of the southern Wenlock Edge limestone quarries (including Knowle Quarry) from the 1860s onwards. A range of other building stones is on view, including local Wenlock Limestone.

Close inspection of the limestone wall at the north end of King Street, exposed to weathering for many years, reveals an excellent range of Silurian fossils, much more clearly than will be seen in the quarries. There is no footpath here and groups will need to be aware of traffic. Remind groups to be considerate of the people who live and work in the town, and of course, not to remove or damage any parts of the walls, or cars parked close by them.

Presthope Car Park (Wenlock Edge)

☛ Return to the coach and travel south along the A4169 to the junction with the A458. Turn right onto the A458 and within 500 metres turn left onto the B4371. After 2.25 km the site office of Bardon Aggregate is on the right. A further 1.5 km along the B4271, just before the right turn to Hughley, the Wenlock Edge (Presthope) car park is on the right. This is big enough for a coach, although it is a very tight fit. Do not block the gate to the track from the car park onto Wenlock Edge when parking here.

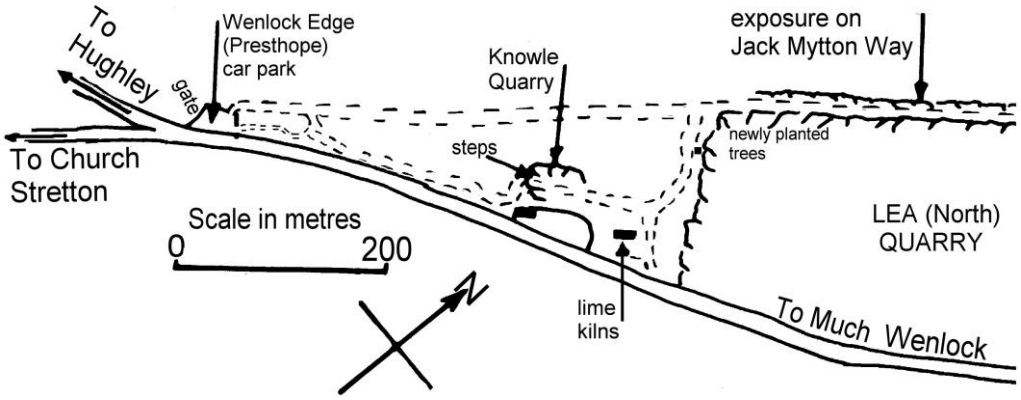

Figure 2. Map of the Knowle Quarry sites.

☛ Warn the group that sensible behaviour is required on the footpaths which are along the top of Wenlock Edge, and also become slippery when wet. Lead the group uphill out of the car park and then north eastwards along the footpath signed as **Lime Kiln Walk**, on the crest of the scarp slope of Wenlock Edge. After a hundred metres or so the view point to the NW is revealed where the trees have been cut. The landscape here is classic scarp and vale topography, heavily influenced by the geology of dipping, alternating more and less resistant rocks. The first task is to orientate the group and get them thinking about the landscape.

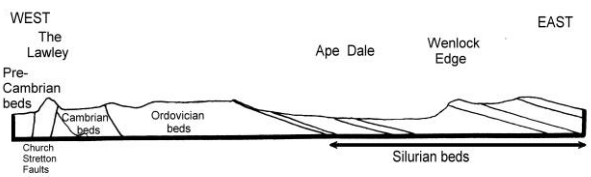

Figure 3. Section across Wenlock Edge.

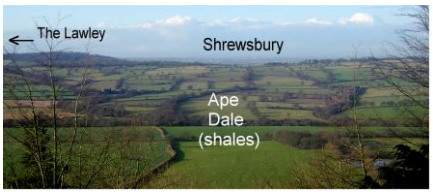

Figure 4. Site 2: Presthope view point.

Suitable questions at this site.	Acceptable responses.
Ask the group to use a compass to establish which direction they are facing.	West.
Using the section on **worksheet 3** ask the group in which direction the beds are dipping?	To the east.
Ask the group to predict what kinds of rock lie below Wenlock Edge.	The beds are layered, a good indicator of sedimentary rocks.
Ask the group to use the **Principle Of Superposition** to work out in which direction the younger beds lie.	To the east (i.e. in the direction of dip in rocks that are not overturned.).
Ask the name of the ridge on which they are standing.	Wenlock Edge.
Ask the group the name of the valley in front of them.	Ape Dale.
Ask the group to explain why the land I the valley is lower than on the ridge.	Hills are formed by more resistant rocks, whilst less resistant rocks are eroded to lower levels. Ape Dale runs north–south along a less resistant bed of shales.
Ask the group why Ape Dale has a steeper side and a more gently sloping side.	The western slope is the dip slope of the beds below, whilst the steeper eastern slope is cut into beds protected on top by more resistant rocks.
Summarise the predictions the group have made about the rocks beneath their feet. They are sedimentary, they are dipping eastwards, and they are more resistant to weathering.	

☛ Take the group on the path away from the ridge, a right fork, along the **Lime Kiln Walk**. The wide and surfaced path, suitable for wheelchairs, then gives way to a narrow track, off to the left, parallel to the road. After 200 metres the path descends a flight of wooden steps into Knowle Quarry. These steps can become very slippery when wet, so descend with care. At the bottom of the steps turn immediately to the right to find the southern face of the quarry. This is **Site 3**. It is owned by The National Trust and is a protected site. There is no need to damage the face, as specimens may be found along the foot of the face. Please do not remove them from here, as opportunities for some collecting occur later.

Figure 5. Site 3: Knowle Quarry (South).

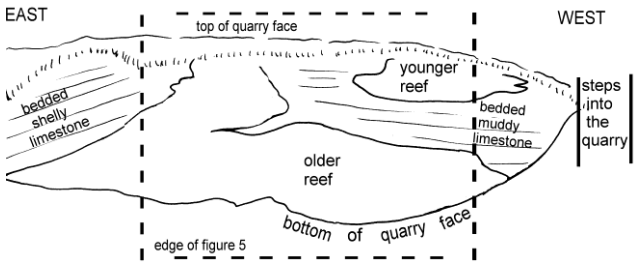

Figure 6. Sketch of main features at Site 3.

Site 3: Knowle Quarry (South).

☛ First focus attention of the rock type and the evidence it contains of the conditions at the time of deposition (about 400 million years ago).

Suitable questions at this site.	Acceptable responses.
Remind the group of their prediction at **site 2** and ask them to look closely and describe the features of the rock in the face.	The rock shows bedding, in places. It contains shelly fossil fragments. It also reacts with dilute HCl. It is a sedimentary rock: a limestone.
Ask the group to inspect the bedded parts of the face to the right and then to the left of the large un-bedded part in the centre of the face. What differences can they see?	The beds to the left are coarser grained with shelly fragments. The beds to the right are finer grained and contain more mud.
Ask the group what might have caused the differences they have found?	The coarser beds were laid down in a stronger current (wave action) whilst the finer grained ones were laid down in quieter conditions.
What might have caused these differences in current strength in places so close together?	The reef may have sheltered the beds to the right.
Measure bedding plane dip on the left of the face. Use a clipboard as a convenient extension of the bedding to create a surface to measure.	18^0 to the SE (160^0 north).
Tell the group that the large un-bedded "ballstones" are reefs of fossilised coral and other marine animals, and are 420 million years old. Ask "In what kind of environment the rock must have formed?"	Today shelly reefs form in warm shallow seas, so they are likely to have done that 420 million years ago. [Point out that the reefs grew upwards from the base as the bedded layers were deposited next to them.]
Ask the group how many "ballstone" reefs they can see in the face	Two
Ask the group if the two reefs are exactly the same age, or if one is younger?	The smaller, upper one is younger (**Principle Of Superposition**), although it co-existed with the upper parts of the larger one.
Ask the group to describe what happens to the older (larger) reef as it grew upwards?.	It was laterally more extensive in its younger part. The upper part is narrower, continuing to grow after the lower parts died.
Ask what might have caused this to happen?	Something caused the lower parts to die and stop growing. (Reefs are made up of animals that are sensitive to water clarity / muddiness, salinity, depth, and temperature.)
Which of these factors might have been responsible here?	Not depth, temperature or salinity changes, which would have killed all of the reef animals. The muddiness of the limestone might have killed off the right hand side of the reef.
Ask the group what deposits from a warm shallow tropical seas are doing in Shropshire?	Plate tectonic forces moving the crust northwards since they were deposited.
What else has happened to these beds since they were deposited (below the sea)?	Uplift and tilting.

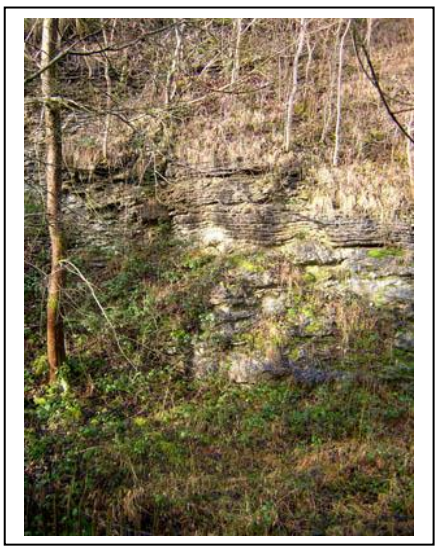

Figure 8. Site 4. Knowle Quarry (west).

Site 4: Knowle Quarry (west).

☛ Take the path from the bottom of the steps, northwards for 20 or 30 metres and stop the group where there is a good view of the face to the west (left). Do not cross the fence or approach the face.

Here ask the group to recall and apply the ideas they have used at **Site 3** about reef development.

Suitable questions at this site.	**Acceptable responses.**
Describe the differences between the upper and lower parts of the face.	Upper parts are thinly bedded and appear almost horizontal (in fact they are dipping slightly towards you, but it is hard to see from this angle.) The lower parts are un-bedded "ballstone" reef.
Describe the top surface of the "ballstone" reef.	It is almost horizontal with two coral "mounds" on the left. (The beds above have been compacted during burial, over the corals, they have not been folded.)
What does this mean about when growth on this reef ended?	It all died back together, at the same time and does not re colonise higher up the face.
Tell the group that the black line on the worksheet sketch is a layer of volcanic ash. Ask how this might be related to the ending of the reef growth?	Volcanic eruption (from a place not identified) created ash clouds which were blown across the sea, until they settled out and smothered the filter-feeding reef animals.
Ask the group what was worth quarrying from this area?	Limestone. The "ballstones" were particularly pure forms of limestone.

☛ Focus the group's attention on the rock cycle, with particular emphasis on the carbonate cycle.

Suitable questions at this site.	**Acceptable responses.**
Ask the group to identify the ways in which the limestone is being attacked by weathering?	**Biological** weathering due to the effects of plant and tree growth. **Physical** weathering due to frost action. **Chemical** weathering by the effect of acidic rain.
What evidence can be seen for physical weathering of this face?	There is a small scree at the foot, but it is grown over indicating it is not currently active.
What force brought the solid lumps of rock onto the scree?	Gravity
What happens to the soluble products of chemical weathering? (e.g. breakdown products such as hydrogen carbonate and calcium ions).	They will be removed in solution by groundwater
Assuming these ions are not precipitated, where will they end up?	Springs will feed them into river flow and then to the sea.
Water will evaporate from the sea, but what will happen to the dissolved salts in the seawater?	Eventually precipitated directly when evaporation is strong and circulation is weak, or used by animals to make shells.
When the animal dies what happens to the shell?	Accumulates in the sediment, and may form part of a shelly limestone in the future.
If these new limestones become buried how will they become exposed to weathering at the surface to start a new rock cycle?	Uplift by Plate Tectonic forces
Point out to the group that **The Principle of Uniformitarianism** suggests this same re-cycling happened to the calcite which now forms these limestone rocks. Ask how long is this last rock cycle, approximately? [Emphasise the constant re-cycling of crustal material through geological time, via the rock cycle and that the evidence for several cycles are missing because of erosion]	At least 420 million years between chemical weathering of the ancient rock to form these limestones and the weathering today.

Site 5: Knowle Quarry Lime Kilns.

Figure 9. Site 5: Knowle Quarry Lime Kilns.

☛ Continue along the path in a northerly direction until the refurbished bank of Knowle Quarry Lime Kilns appears on your right. View the circular holes in the tops, for loading the kilns and then go on past the end of the bank of kilns and follow the path round to the right until you arrive at the front of the kiln bank. (See **Figures 2 & 9**).

These kilns have recently been refurbished by the National Trust, but date from the early twentieth century. Kilns have operated on this area for more than 500 years, but the last one was fired in the mid 1960s.

Suitable questions at this site.	**Acceptable responses.**
Ask the group the chemical composition of limestone?	**$Ca\ CO_3$**
Ask the group "What this construction was used for?	It was a lime kiln built and used from about 1920 (i.e. almost 100 years old).
Limestone, $CaCO_3$, was burned (with coal, or, originally, charcoal) at temperatures around 900^0C. What, chemically, would you expect to happen to the limestone?	**CO_2** would be driven off leaving Calcium Oxide, (**CaO**) or "quicklime". [Some may remain in the bottom of the kilns. DO NOT TOUCH IT.]
What would the lime have been used for? [Reference here is made to the bulk uses of limestone. In fact it is used in a vast number of products from toothpaste to a dietary additive in bread.]	Traditionally lime was used to **lime wash buildings** and in **mortar**. Calcium oxide mixed with water was used as an alkaline **field dressing** to improve fertility where the soil was acidic, or had been leached by acid rain. It was used as a **building stone** in Much Wenlock, and also as a **road ballast**. It was also used as a **flux in iron making** (in Coalbrookdale) to form a slag with impurities in the ore. **Cement** was made from Wenlock Limestone from 1890 to the 1930s. Slaked lime (quicklime plus water) is also used to **counteract acidity in lakes** caused by acid rain.
How was the limestone moved out of the area, and the coal for the kilns moved into the area from Coalbrookdale?	By the railway line completed as far as Much Wenlock by 1862 and extended to Presthope soon after. [It ran along just the other side of the B4371].
Why might the quarrying have stopped? [Lea Quarry, the last active site in the area, was "mothballed" in July 2007]	There is a lot of limestone in reserve here. The main reason is reduction in demand: e.g. closure of iron works, little road building since the M54.
Inspect the stone work in the front of the kiln.	Chemical weathering of the mortar between the

Site 6. The Jack Mytton Pathway.

☛ Return round the northern end of the lime kilns and then follow the path uphill to the Jack Mytton pathway along the crest of Wenlock Edge (See **Figure 2**).

Take the path northwards along the western edge of Lea Quarry for about 200 metres towards the top of the rise. **Site 6** is along the left hand side of the pathway. Do not cross the fence into the quarry to the east.

Figure 10. Approach to Site 6: Jack Mytton Pathway.

☛ Group leaders might want to use **worksheet 7** to summarise the sequence of events at this point. It is permissible to collect specimens from this site, however, restrictions should be placed on the amount removed. The rule is "**as many pieces as can be carried in one hand**". Moderate collecting should be allowed with an emphasis on understanding the pieces are evidence of earth science events and should not be removed from context in ignorance.

☛ Return southwards along the path to the end of Lea Quarry, and then continue straight on, along the crest of Wenlock Edge until you return to Presthope car park. (See **Figure 2**). Take care as there are several flights of wooden steps along the route, which can become slippery.

☛Extensions can be made in **advance of the visit** to this ESO-S visit to the National Trust at Cardingmill Valley and to the Lea Quarry, run by Bardon Aggregates.
Contact details are: **National Trust** website, **www.cardingmillvalley.co.uk**
Contac**t Bardon Aggregate** to discuss any safety issues and which features of the geology or quarrying activities you wish to see: **Telephone: 01743 709287, or email the Quarry Manager: mark.ford@aggregate.com or Aggregate Industries Geologist: thomas.clifford@aggregate.com**