KS4 NATIONAL STONE CENTRE (DENE QUARRY & BLACK ROCK)

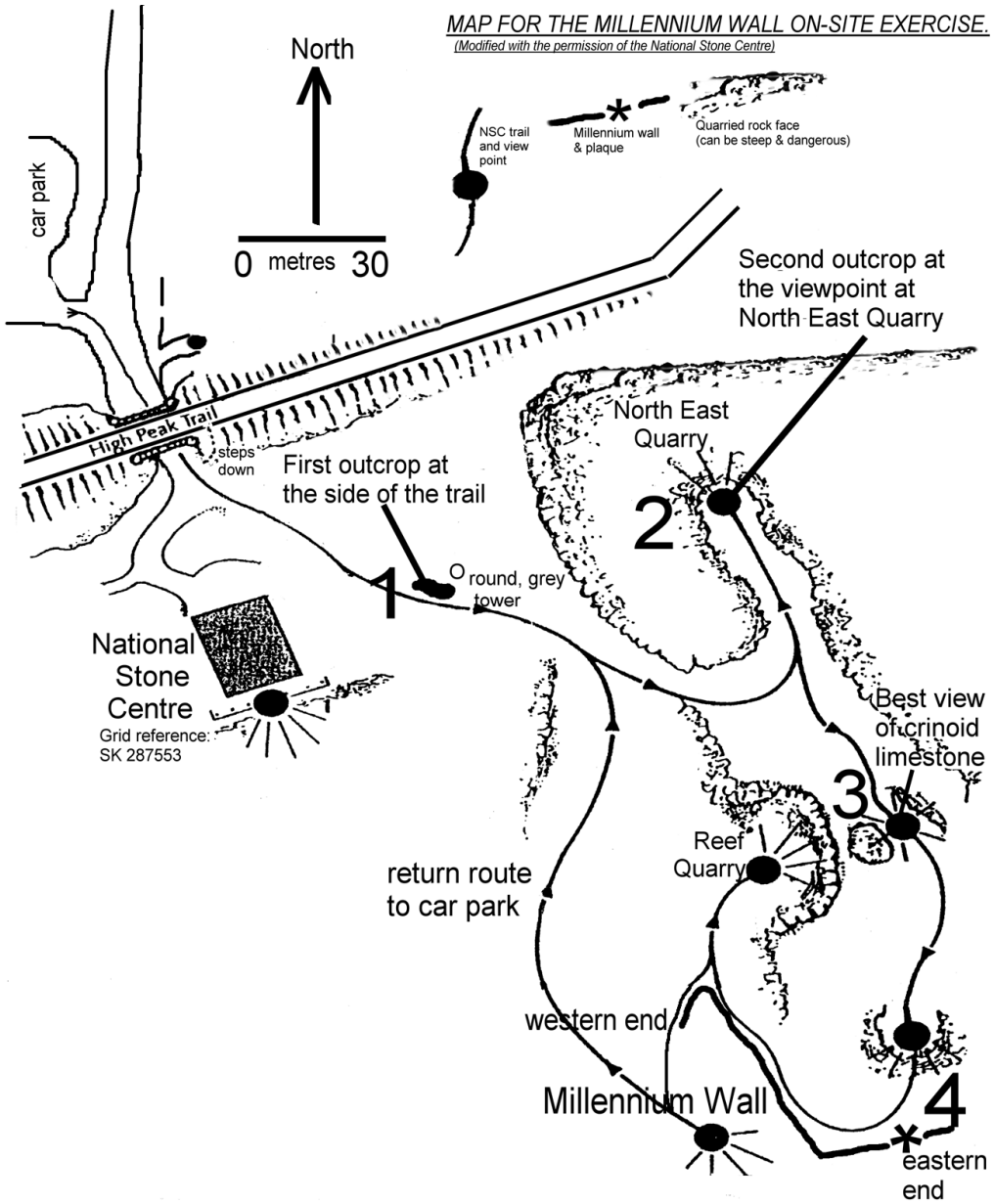
☛ Approach the site under the bridge of the High Peak Trail. The first outcrop is below the round pointed grey tower, and just east of the Stone Centre. (see **Figure 1** below)

Pupils will need: a) a clipboard with relevant extension worksheets and maps;
b) measuring tape, compass & clinometer.
Group leaders should have a plastic bottle of dilute HCl

Introduction
These exercises are the same ones as for the National Stone Centre key stage 4 ***Earth-Science On-Site*** visit, with the extension of the visit to Dene Quarry and Black Rock to examine the quarrying and overlying beds.

The first and second outcrops allow an investigation of the rocks formed in the limestone seas, as well as the processes that have affected the rocks since their deposition (cementation, uplift, weathering, erosion and quarrying). See **Figure 1**

Figure 1 KS4 Map of the National Stone Centre Outcrops



1. Conducting The Fieldwork At The First outcrop. (About 30 minutes)

☛Bring the group to the first outcrop that is below the round pointed tower, and just east of the Stone Centre. (See **Figure 1**). Remind pupils of the idealised model of a reef they are investigating and ask them to inspect the outcrop.

Fi

Explain to pupils the Principle of Uniformitarianism: which state that the biological, physical and chemical processes we see today, operated in much the same way in the past, and can be used to interpret evidence in rocks. The interpretation of the limestones in this area is based on the evidence in the rocks, and on our understanding of modern reef limestone environments. This allows us (with some reservations) to use the simplified picture of a modern reef (on worksheet 1) to interpret the evidence of the ancient one in the limestones:

"What observations can you make about the rock at this exposure?"	[It is bedded, contains fossils: (brachiopod) shellfish, a coral, and crinoids (See **Figures 2 & 3.** below for assistance); it is layered (bedded); it fizzes with dilute HCl]

Figure 3. Photographs of coral, brachiopod (with broken convex shell) and crinoid from the first exposure.

See document **BR9 KS4 Info fossils** for more information

"What kind of rock is this. Is it igneous sedimentary or metamorphic?"	[It is a sedimentary limestone, (of Carboniferous age about 340 million years old, dated by the fossils it contains). It also fizzes in dilute HCl]
"What do the fossils contained in the rock tell us about its origin?"	[The shellfish (brachiopods) corals, and crinoids, are shallow marine organisms. The rock was formed in a shallow sea. The species of fossil also indicate deposition in the Carboniferous period]

"How did these once-living animals become part of a rock?"	[Died, washed around by currents leaving coral & crinoids lying on their side, until buried. All soft parts decay away leaving only the calcite skeleton]
"How can we explain why this rock is no longer beneath sea level?"	[There must have been uplift and tilting of the crust. This rock is currently about 200m above sea level.]
"Measure the dip of the bedding and mark it on your map"	[Around 10-15 degrees to the North East. See Figure 1.]
"How might this distort the evidence we are using to interpret this reef?"	[The evidence is no longer in the original horizontal. It has been tilted by earth movements]
"Which of the 3 parts of our "reef" might this outcrop represent?"	[Not the reef itself because the fossils are lying on their side (moved by currents) and there is bedding present; not the fore-reef because the deposit is not steeply dipping. So it is back-reef, but tilted 15 degrees to the NE by earth movements since deposition.]

2. Conducting The Fieldwork At North East Quarry. (About 20 minutes)

☛Walk up to the viewpoint **at North East Quarry** (see **Figure 1**) to view these limestone rocks. Remind pupils that the site is the one they plotted the crinoid orientation data for their preparation. Questions here might focus on observing evidence for the cycle of deposition, uplift, weathering and erosion. It is advised that you **do not** cross the fence and approach the quarry face.

"These rocks are all limestones. Which is the oldest bed in this quarry?"	[The lowest layer visible. The other beds are progressively younger to the top. Here, the quarry floor is the top of the oldest rock layer, and is the sea floor surface from which the crinoid measurements used in the preparation work, were taken .]
"These layers of rocks were all deposited horizontally, under the effect of gravity in a shallow sea. What has happened to them since?"	[Uplift to about 20m above sea level, and slight tilting to the east.]
"Which way would you walk to move onto younger rocks?"	[Uphill, as older beds of rock are deposited first, with younger rocks on top. (The exception to this principle is in areas where the beds are inverted)]
"In which of the 3 parts of the reef do you think these beds were deposited?"	[Not the reef because the fossils are lying on their side and there is bedding; not the fore-reef because the deposit is not steeply dipping. So it is back-reef, but tilted 10 - 15 degrees to the NE by earth movements since deposition.]
"Can you remember from your crinoid ray diagram preparation work which direction you think the waves were coming from in the Carboniferous seas?"	[Either from SE or NW. Main wave train, and deeper water probably from the right and behind (SE)]

3. The Reef Quarry: from the west. (About 30 minutes)

☛ Bring the group to a point west of Reef Quarry and point out the salient features. (See **Figure 1**)
This site is a rare example of a small circular (patch) reef, with the surrounding beds complete with the fossil animals that lived there. These animals include corals, crinoids, and brachiopods. This is a very important site, do not cross the fences, or stand on, or damage the outcrop, nor attempt to collect any material. Good examples of the fossils can be seen in the lose blocks by the path.
Here the reef itself has been quarried away, and the beds at the edge were deposited on a slope, around the central reef. They have not been tilted, they were deposited more or less at this angle.

Figure 4. Reef Quarry From the West (location 3)

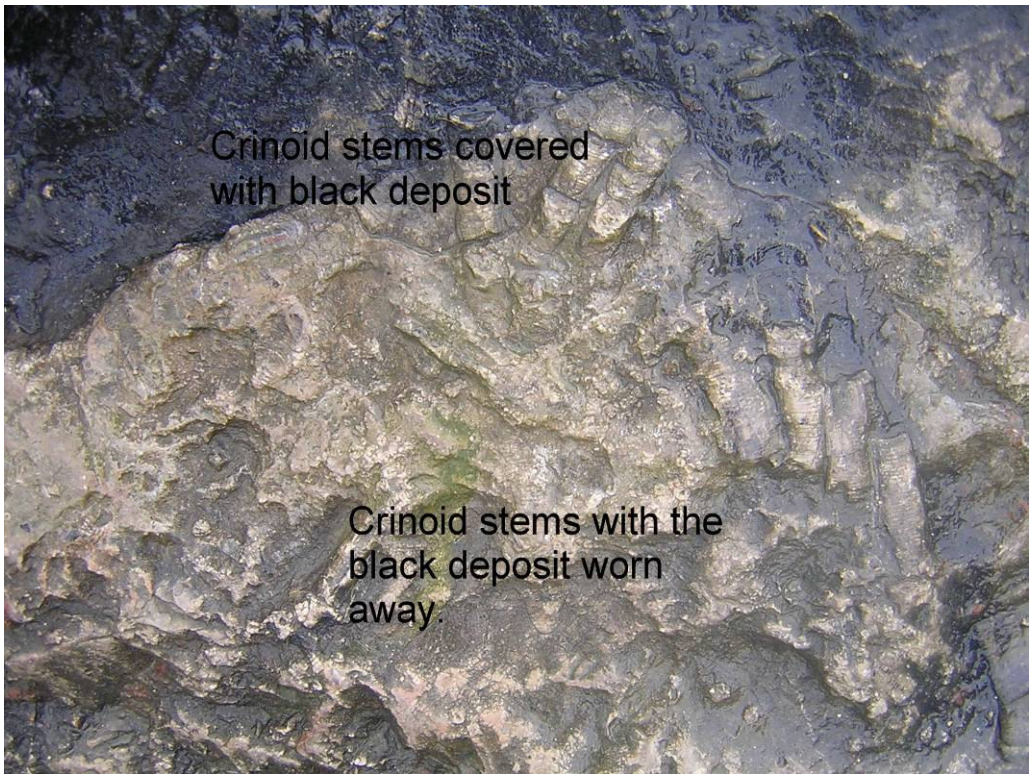
"What shape and size (height & width) do you think this reef was?"	[Almost circular, called a "patch reef", about 10 metres height exposed, and about 70 metres across]
"Which direction do you think the fore-reef might be found?"	[The back-reef is to the north (left) so the fore-reef would be expected to the right (south)]
"What animals might you expect to be found here as fossils?"	[Corals, although these have been largely quarried away, and also brachiopods and crinoids, from the worksheets.]

☛ Investigation of the blocks by the footpath will reveal brachiopods in life position (although the blocks have been moved and may be on their "side") The crinoids are best seen on the far side of Reef Quarry.
The far side (north and North Eastern side) of Reef Quarry is approachable by the footpath. The slope of the rock here represents the seafloor at the edge of the reef and the animals that lived on it at one point during the Carboniferous period. Inspection of the surface of the limestone reveals many crinoid stems, some apparently still rooted and fossilised where they died and fell. This indicates that they were living here in some profusion on the edge of the reef, in shallow water.

4. The Reef Quarry: from the north east. (About 20 minutes))

"Using the worksheet to help you, can you identify these fossil animals?"	[They are crinoids, related to starfish and echinoids. They are not plants.]
"What kind of conditions would allow such a high density of crinoids (and the corals, now quarried away) to exist?"	[See document **btKS4**: Plenty of food, appropriate depth, oxygen, sunlight, salinity, temperature, and current strengths not strong enough to uproot them or sediment to bury them. Lack of predators, steady rise in sea level allowing the reef to build up.]
"What possible reasons could there be for all of these animals dying at more or less the same time?"	[Reverse the answers to the previous question, and then ask them to look at the fossils and suggest which one they think is likely – and why. The evidence is not clear, although there is a black coating over the rock which might have smothered the filter feeders (see **Figure 5** below)

Figure 5. Crinoid Fossils at Reef Quarry. (location 4.)



5. The South East Quarry viewpoint. (About 15 minutes)

☛Bring the group to the last viewpoint above South East Quarry and examine the wall ahead on the left for signs of the steeply dipping fore-reef beds. These can be difficult to see in poor light. See **Figure 6** Take this opportunity to summarise the evidence for these reefs.

Figure 6. The Fore-Reef beds from the viewpoint above Deep Quarry. (location 5.)

"How high is the quarry face here?"	[About 30 metres. i.e. a good section through the beds]
"Why is it difficult to see the steeply dipping fore-reef beds?" (Remember, these were deposited close to this angle, and have been little affected be earth movements much, which tilted the area 15 degrees to the NE)	[Much of the beds have been quarried away, thereby making access and interpretation more difficult. Other factors interfering with the evidence are: earth movements; erosion, and other possible nearby examples of reefs still being buried. The lighting conditions are also important, a sunny afternoon is best]

Ask pupils to summarise their notes on their section across the National Stone Centre reef on Worksheet.

"How closely do the limestones in this area match the ideal picture of a reef that we were using?"	[The fossils suggest warm, shallow marine environments; The area to the north shows rolled fossils and bedding, suggesting some current action & could be back-reef; The Reef Quarry evidence is partly missing, but the surrounding beds suggest deposition against a slope (the reef), and they suggest conditions that allow many animals to survive; the currents here were not strong, as the fossils have not been transported far from their life positions (i.e. sheltered by the reef); There is some evidence of steeply dipping fore-reef beds, suggesting deep water lay to the south]
"Which way would you walk to get onto younger rocks?"	[Uphill – to the east. The younger rocks outcropping on the hills to the east are shales, sandstones and coal seams deposited in a delta environment]

☛ However, first we go north to see a working limestone quarry. Take the group back through the bridge and past the car park. Use the footpath and turn right on the footpath along the roadside to Dark Lane. Take care crossing the road.
At the end of Dark Lane cross the stile and the (often muddy) field to the Dene Quarry viewpoint. The route is marked in Figure 2 in **BR3 locaccess.**

This transfer should take about 20 minutes.