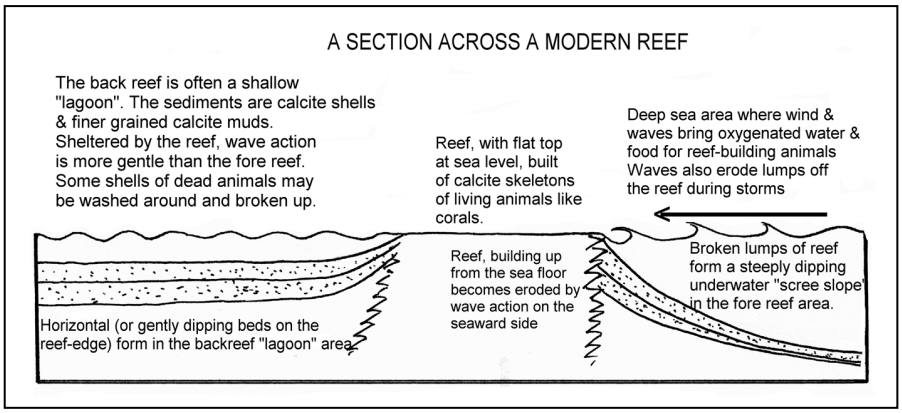
EARTH SCIENCE BACKGROUND FOR GROUP LEADERS

The geological and geomorphological story of the NSC area is based on the interpretation of evidence from the rocks and from the landscape, some of which may not be visible in this area. This is the story and the evidence for it.

The rocks deposited in the area are limestones of various kinds. They are made of calcite (calcium carbonate) in the form of fossil shells and other fragments cemented together. The species of fossils indicate that these rocks were deposited in the Carboniferous period, about 340 million years ago. These fossils are mainly the remains of corals, crinoids, algae and brachiopods, which, by analogy with living forms, are interpreted as living in a shallow, clear, warm marine environment. Some of these fossils formed wave-resistant mounds, called reefs, whilst others are bedded limestones, which were deposited in quieter water behind the reefs.

This ***Earth-Science On-Site*** exercise uses the Principle of Uniformitarianism, which states 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 this limestone area is based on the evidence in the rocks, and from our understanding of modern reef environments. This allows us (with some reservations) to use the simplified picture of a modern reef to interpret the evidence of the ancient one in the limestones. A simplified picture of a modern reef is of three parts: reef; fore-reef; and back-reef.
See Figure 2. (See **NSC8 KS4 Info reefs** for more detailed information.)

Figure 2 A section across a modern reef

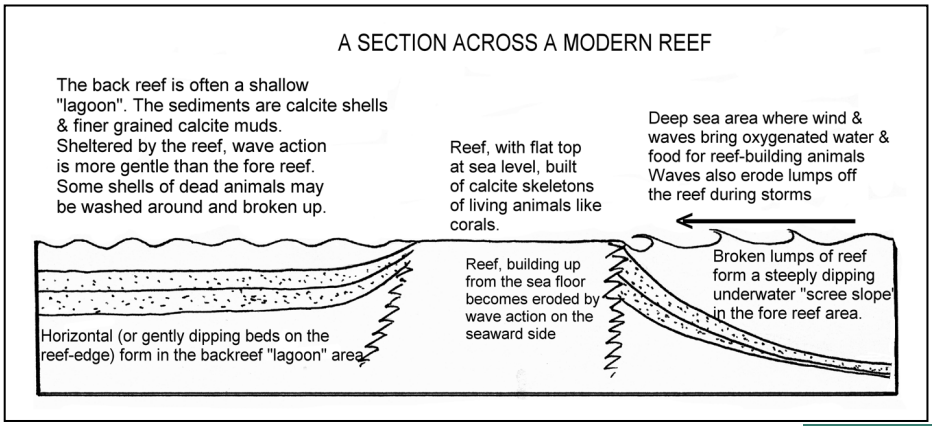


INTERPRETING THE EVIDENCE: although there are good reasons for trusting the Principle of Uniformitarianism, when interpreting ancient environments, this exercise should also encourage pupils to think carefully about the limits of that trust. Reasons for caution include; these ancient reefs have a very different structure to modern reefs; the corals in ancient limestones are different from modern corals; some modern coral reefs do occur in cold water as far north as Norway; geological processes have altered the evidence in the rocks after they were deposited. (chemical changes during cementation; uplift; tilting; faulting; weathering; erosion, and, of course, evidence not yet uncovered)

THE LIMESTONES OF THE NATIONAL STONE CENTRE

Using the evidence from the rocks, and the simple model of a reef, the interpretation of these limestone beds is as shown in **Figure 3**. and should be compared with **Figure 2** above.

Figure 3. Section through the National Stone Centre Limestones.



The Reef Quarry is almost circular and quarried to a depth of 10 metres. Although sometimes called “reefs” these structures are better referred to as “mud mounds” because they seem to be wave resistant mounds of calcium carbonate mud and lack the coral framework of modern reefs. The surrounding beds have many brachiopods in life position, (best seen in the blocks along the footpaths) as well as many large crinoid-stem fossils that have not been transported far, if at all. These beds were deposited at a slight angle against the reef and so do not indicate the original horizontal.

To the north, in North East Quarry, are the bedded limestones of the back-reef “lagoon”, which were deposited horizontally by gentle wave action. These waves washed crinoid and other shelly material around before final deposition. These beds are exposed in North East Quarry, the floor of which represents the ancient lagoon floor at one moment in time. To the south lie the fore-reef deposits, now largely quarried away, but which show the steep dips of the “underwater scree slopes” in the walls of South East Quarry. This implies that the deep water, and main wave direction, lay to the south, with more gentle waves washing into the lagoon (from the SE?) affecting the alignment of the crinoid stems (data used in the KS4 preparation exercise.)

In the area to the east, towards Black Rocks, these limestones are overlain by younger shales, containing fossil goniatites, (marine fossils which swam, a little like modern Nautilus). The shale indicates a more muddy marine environment not conducive to reef formation. On top of the shales are sandstones with coarser grain size and cross bedding suggesting that they were deposited by a stronger current (a river), carrying weathered sand and grit from a land area into the “limestone” sea. These sandstones and shales can be seen at Black Rocks [SK 294557] and the ***Earth-Science On-Site*** exercises for that site can be included as an extension to this visit.

Earth movements have disturbed all of these rocks, producing some tilting and faulting, which was followed by the emplacement of minerals, like calcite, ($CaCo_3$) fluorite (CaF_2) barite ($BaSO_4$) and galena (PbS), with some Zinc Blende (ZnS) along the natural breaks in the rocks. Uplift has moved these layers of rock to about 200 metres above sea level and exposed them to weathering and erosion. They must have been covered by ice during the last Ice Age, but there is little evidence of this in the area. Since the last Ice Age, streams have cut valleys, and weathering and erosion have resulted in landslips, as on the wooded hillside area southeast of Bolehill [SK2954].

More recently Man has affected the landscape by building settlements, quarrying the limestone, and building roads and railways.

EARTH SCIENCE PRINCIPLES
In this area it is possible to demonstrate the following Earth Science principles.

1) **The Principle of Uniformitarianism:** The biological, physical and chemical processes we see today, operated in much the same way in the past. “The present is the key to the past”
2) **The Principle of Original Horizontality**: bedding planes represent the original horizontal at the time of deposition of sedimentary rocks. Their current angle shows the accumulated amount of distortion caused by earth movements since deposition. An exception to this principle is the underwater scree slopes at this locality which were deposited at a steep angle.
3) **The Principle of Superposition**: in a bedded sequence of strata, the oldest layers were deposited first, and are found below the younger layers, which were deposited later.
4) **The Principle of Strata Identified by their Included Fossils**: Species are believed to have evolved, or changed, over time. This means that, once the sequence has been worked out, rocks must have been deposited at the same time as the fossils in them were living. Here the fossil corals and brachiopods, suggest a Carboniferous age.
5) **The Principle of Cross-Cutting Relationships:** Structures, like faults and joints, which cut through rocks must be later, and therefore, younger than the structures they cross cut. They must also be older than the ones that cut across them.

NATIONAL CURRICULUM LINKS
In this area it is possible to:

1) Recognise, sort and compare rock types (sandstone, shale and limestone) [Science]
2) Collect evidence relating to the formation of sedimentary rock layers. [Science]
3) Use instruments in the field to collect data: tape measure, compass, clinometer, and plot them on maps. [Science]
4) The ideas of sustainable development explored through environmental and resource issues [Geography].