NATIONAL STONE CENTRE: KS4 PREPARATION AND FOLLOW-UP IDEAS (1)

PREPARATION WORK.
This Earth-Science On-Site exercise is based on the hypothesis that the orientation of the crinoid stems in these rocks is not random, but is the result of being aligned by the effects of wave action before being buried and cemented into the rock. Pupils might also rightly suggest that the alignment could also be the result of rolling down an underwater slope.

The hypothesis suggests that we can infer the main wave direction in these, now vanished, Carboniferous seas by measuring the orientation of the fossil crinoid stems. Their orientation seem to be mainly parallel to the wave crests or at right angles to the wave direction., but this is not perfect since some crinoids are lodged at other angles.

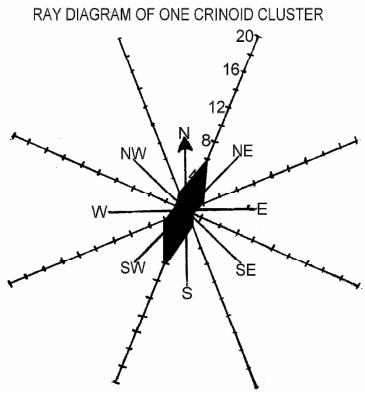
The exercise uses data on the orientation of the crinoid stems measured in North East Quarry. See **Figure 1.** These beds are interpreted as a back-reef "lagoon" environment to prompt investigative thinking about wave directions in shallow seas of the Carboniferous lagoons. It is important to stress that the "lagoon" is no longer there: it is the interpretation of the evidence in the limestone that there once was a lagoon with waves moving across it, and washing the crinoid stems around. Only the solid limestone can be seen in the quarry today.
The data plotting exercise (see **figure 5**) is also an introduction to pupils devising a laboratory experiment to model the processes of wave action on short linear fragments of crinoid stem (e.g. spaghetti pieces in shallow water in a tilting fish tank?); pencils on a tilting tray?) and hence how to interpret the data (i.e. were they aligned parallel to the waves or across them?)
Is the data sufficient to come to a conclusion/ If not what other data is needed?

Direction	N to NE	NE to E	E to SE	SE to S	S to SW	SW to W	W to NW	NW to N
Number of stems (Frequency)	**6**	**2**	**1**	**2**	**6**	**2**	**1**	**2**

Notice the data repeats as each crinoid has another "end" pointing in the opposite direction.

Figure 1. Photograph of one Crinoid Cluster

Figure 2. Ray Diagram Plot of the same cluster



Using measurements from **Figure 1**. (the crinoid stem cluster above) produces the pattern in **Figure 2**.

This ray diagram is produced from only part of the data to be used by pupils in the introductory exercise.

Discuss with pupils how convincing this pattern is of “alignment”. Would they agree with an inferred “direction” of NW or SE for the waves which “aligned” these stems? What other information would they want to help them be more sure of their inferences? For example would they like more Crinoid measurements?

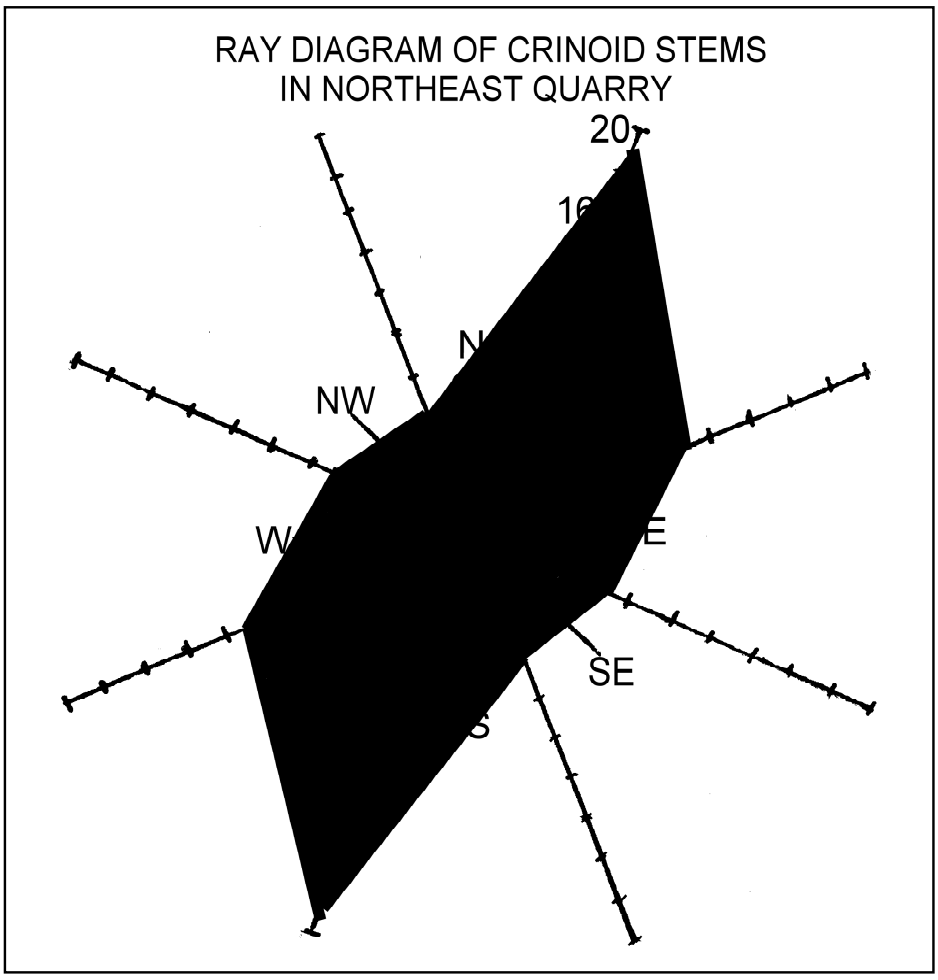
When setting up the preparatory homework, remind pupils that they will be visiting North East Quarry, the site where these measurements were made, and will be using their answers to help them interpret what happened at the site about 240 million years ago. If a suitable spreadsheet software option is available pupils might be invited to use it instead of plotting the data manually.

Below is the full data and the plot that pupils will be using in the exercise.

Figure 3. Full Crinoid data from North East Quarry.

Direction	N to NE	NE to E	E to SE	SE to S	S to SW	SW to W	W to NW	NW to N
Number of stems (Frequency)	**19**	**11**	**7**	**6**	**19**	**11**	**7**	**6**

Figure 4: Plot of Full Crinoid Data from North East Quarry



TEACHERS' NOTE:

The sequence is deduced by using these geological principles:

1) T**he Principle of Uniformitarianism "The Present is the Key to the Past"** means that we can interpret similar conditions in the past in the light of what happens today. Today most corals live in warm clear shallow seas. **The Principle of Included Fragments** states that fragments of rock or fossil in a sedimentary rock must have existed before being cemented into the strata, so the fossils must have been alive first before being fossilised in the rock. (So **C** is first.)
2) Live animals must die, and their soft parts decay, in order to leave the hard skeleton as fossil material. (So **D** next)
3) Rocks then become lithified with the fossils embedded. The most common process being cementation. (Compaction is less important in limestones) (So **E** is next)
4) After deposition the next stage in the Rock Cycle is uplift and deformation. (**F**)
5) Exposure to the atmosphere results in weathering and soil formation. (**G**)
6) Exposed at the surface makes it easy to quarry (**A**)
7) Quarrying is no longer going on, this is a protected site. (**B**)

Youngest event
B Restoration of the site followed by protection as an SSSI
A Quarrying of limestone
G Weathering and soil formation
F Uplift of the limestone and tilting by tectonic forces
E Cementation of the sediment into limestone rock
D Burial of the animals and decay of the soft parts (muscles and connective tissue)
C Warm clear shallow sea with reefs, crinoids, brachiopods and corals
Oldest event