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SITE 1 [NOTE: The site numbers are different for KS3 and KS4 itineraries]

Here alternating beds of sandy limestone (Ragstone) and sandstone (Hassock) are dipping towards the NNE (014 degrees magnetic) at around 40 degrees from the horizontal.

WEATHERING:
Physical: Any unaltered fragments of a rock is evidence of physical weathering. Here it is the limestone that breaks into lumps at the foot of the slope, probably along irregular joint planes. It may be the result of frost action, but is likely to be the result of children movement over the exposure (a form of biological weathering?) rather than quarrying which stopped around 1980.

Chemical: Chemical alteration of rock varies according to the minerals involved. The weathering of the iron mineral glauconite results in the brown colour of these beds, due to iron hydroxides. The quartz in these rocks, in our climate, is chemically very stable i.e. chemically resistant, but the calcite isn't. It is affected by carbonation and solution in acidic rain water.
The effect on the limestone is to produce a thin weathering crust where the calcite is depleted. It is also a slightly different colour from the fresh rock.
The effect on the sandstone is much more obvious. Here the calcite cement is chemically weathered releasing the many grains of quartz to form the sandy soils of the area.

Biological: The penetration of the rocks by roots is obvious in many of these sites. As the root increases in diameter it exerts a force on the rock and will eventually break them up.

Weathering and Erosion: Draw the distinction when dealing with the answers between "weathering", (the breakdown of rocks), and "erosion" (the movement of the weathered fragments by gravity, water, ice, or wind).

Resistance to weathering and erosion: It is wise to avoid the word "hard", and focus pupils attention on chemical or physical "resistance". This is best thought of as a relative term, so the sandy limestone is "more resistant" than the sandstone, the evidence being that the beds stand proud from the more worn down sandstone beds.

Preliminary Inspection of the Exposure: Although there is no substitute for close examination of the rocks, a preliminary observation from a small distance can be useful to focus attention on significant features. The main features here are alternating layers of two very different rocks: one darker, more resistant, the other paler and less resistant. These layers dip consistently in the same direction, i.e. They are parallel.
These observations suggest the rocks are sedimentary. Igneous rocks tend not to be layered, but have strong joints, and are made up of interlocking crystals, which are difficult to break off into smaller grains.
This preliminary identification will need confirming shortly by closer observations

Collecting Evidence From Rocks: This exercise asks pupils to collect information methodically, moving from the older beds to the younger ones. For each bed they are recording evidence to support an identification of rock type. This will repeat from limestone to sandstone across the six beds. The evidence will include:

i) Bedding planes (the cross bedding in the sandstone is present, but not easy to see)
ii) Permeability, (of the sandstone) can be demonstrated by pouring a small amount of water onto a specimen. This is less easy to demonstrate with the limestone as the pore spaces contain crystallised calcite.
iii) Grain size of the sand grains (using a sediment scale) is medium sand. The sandstone also has brown and black grains which include the now-weathered pieces of the green iron mineral glauconite. This mineral only forms in oxygenated marine environments and is further evidence of the beds being deposited in a marine area..
iv) Effervescence with dilute HCl (although BOTH rocks effervesce in HCl). The sandstone is cemented by calcite, and this is what reacts when the sandstone is tested.
v) Fossils: a poorly preserved marine bivalve is present at the base of bed 6 (at point "a" on the field sketch). (See **Figure 1**) It has been separated from its other shell by currents after the animal died.

Figure 1 Interior of Bivalve Shell from Underside of Bed 6

Summary of these pieces of evidence: Conditions alternated between deposition of sandstone and limestone. It was a marine environment, the evidence being the presence of bivalves, (and glauconite). The currents were strong enough to bring medium sand grains, but not strong enough to re erode them (ie moderate currents). These were originally laid down horizontally, but Earth forces (Plate Tectonic forces) have tilted them towards the North. (014 degrees magnetic).

Predicting The Folds: From the introductory work they completed, pupils should remember the rule: that beds dip towards a syncline and away from an anticline. So any syncline would be to the north, and an anticline to the South (Site 2)
Why is This Quarry Here?: It was dug into a stone which was suitable for building and road aggregate. The Ragstone has been widely used since Roman times for building and has proved remarkably resistant to weathering (for a limestone). Later it was also quarried for aggregate.

What Volume of Rock Was Removed?: The full size of this quarry is difficult to appreciate, extending well beyond the boundaries of the Nature Reserve. However, **Site 1** is of a manageable size. The scale on the map indicates it is approximately 12.5 m by 12.5 m, or 156.25 square metres.
The average depth is about 3 metres, giving a volume of 468.75 cubic metres.

Since it was only the limestone that was wanted, (see the measurements made by the pupils) about half of that volume was wasted sandstone.
[This could be simplified to 10m x 10m x 3m = 300 cubic metres, with half being waste, leaving 150 cubic metres of limestone removed (assuming no waste)]

SITE 2:

Here alternating beds of sandstone and limestone are folded into a syncline (not the predicted anticline). The dip of the beds in the syncline indicate that an anticline would be to the north (i.e. towards **Site 1**) as well as to the south. Given a little prompting pupils should be able to deduce that they have walked past the anticline, the axis of which runs below the footpath running between site 1 and site 2. When the vegetation permits, the near horizontal beds at the axis can be seen dangerously close to the edge of the path to the north of **Site 2**.

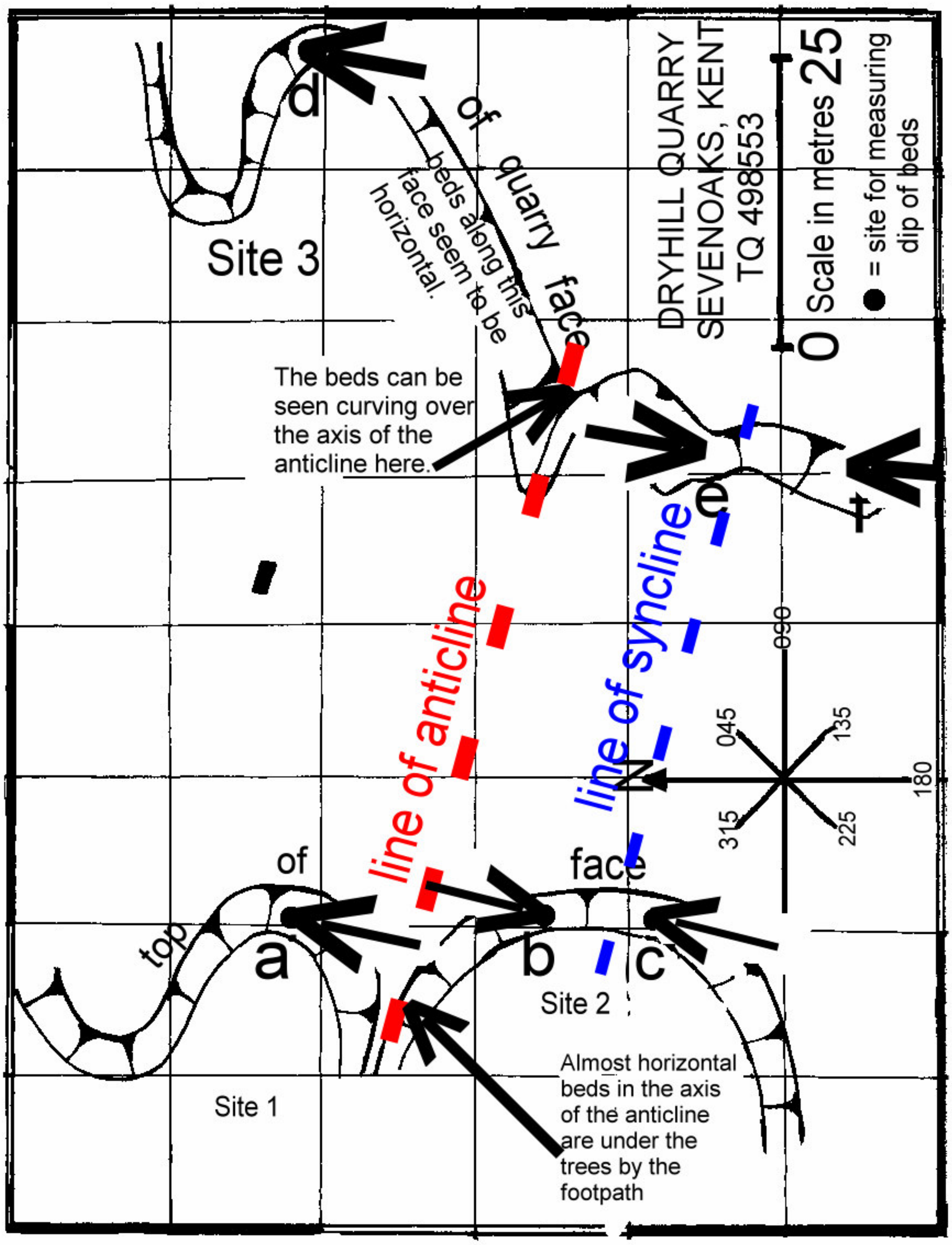
It is a feature of these small quarries that the quarrying left the tightly curved parts of the folds behind, and dug out the straight parts of the folds instead. This is presumably because this made winning the stone more easy, or that the stone in these parts of the folds were more suitable for their purpose. This also happens at **Site 3**.

Field Sketch at Site 2: This exercise asks pupils to observe the structure closely and draw the bedding planes on the south side of the fold.
[Really observant pupils will notice that the beds do not "match up" on the two sides. There are probably two reasons for this. One is that some of the beds are covered over by the slipped sand washed down from higher on the slope, and that they are faulted, but the faults are also covered over.]

Predicting Where the Fold Goes: Remind pupils that folds are three dimensional, and that folds formed at the same time tend to be more or less parallel, since they form with axes at right angles to the same direction of compression. (A demonstration with foam rubber, or a sheet of paper may be appropriate here.) Point out that the axis (line) of the anticline runs through the northern edge of **Site 2**, below the footpath. Ask them to work in small groups to predict where the axis (or "line") of the anticline goes across the map to the east. (See **Figure 3**.)

Warn pupils to stay on the flat grassy surfaces as they move to **Site 3** to check the results of their prediction, as the slopes can be slippery. There is no need to climb amongst the trees to see the beds.

Figure 3 The Fold Axes And Dips At Dryhill Nature Reserve



Confirming the dip of the beds can be done at point "d" without climbing onto the sandy scree. (points "e" and "f" are usually closely grown with saplings, and difficult to approach).

Walking round the northern edge of **Site 3**, reveals that the rocks (and any fold that might have been there) have been quarried away. This could be an appropriate place to remind pupils that the original quarry was much larger than the small pits they have seen, and that quarrying stone and aggregate has always been an important economic activity.

Discussions about what should be done with old quarries could be conducted.

Site 4.
Site 4 is towards the entrance to the nature Reserve, about 250 metres to the west, along the road to the car park. It can be used as an opportunity to set a short investigation task for pupils working in small groups.
Bring the party to the northern edge of the exposure, on the grass below the face. Point out the fence and that they are not to cross it. They may walk around to the south side if they want to, but are to be careful whilst on the car park access road.
[Noticing that the beds by the road appear to be horizontal, but in fact dip northwards, whilst those in the main face dip southwards, is the key observation to identifying the concealed syncline. Do not draw attention to this as the party passes.]

Remind pupils that in Earth Science it is not unusual to have important evidence that you cannot see, or get access to. (e.g. it is in the Earth's interior, or buried, or eroded away, or was never deposited in the first place.)
Ask them to use observational skills to confirm:
a) if the beds are folded or not and;
b) if they are what kind of a fold is it, and;
c) if it is folded, then where is the "line" or axis fold.

Pupils are asked to record their observations on the field sketch on Worksheet 4 (See **Figure 4**).

It is worth reminding pupils that these rocks were not at the surface when they were folded. Folds are evidence of plastic behaviour and that the rocks were buried far below ground and were much warmer (and more plastic) when they were actually folded. If they had been "cold" or brittle, at the surface they were more likely to have "broken", or faulted.

Figure 4 Site 4 - Completed Field Sketch