# WORKSHOP 1

## Investigating the Structure of Ecton Hill

**The activity in brief**

Students investigate the remarkable geological structures at Apes Tor (Figure 1.1), analyse and evaluate their data. They continue to study the structures on the Hill and within Salt's Level. At home, they write a plan for further investigations that could be carried out on, and under Ecton Hill.

**Suitable for**

**WJEC**

**AS** GL1 – geological structures (p20)

GL2 – investigative geology (pg 21)

**A2** GL4, E2 – rock deformation (pg 31)

GL6 – geological investigations (pg 51)

**OCR**

**AS** F791 – geological structures (p 15-16)

F793 – practical skills in geology (p 27-28…)

**A2** F796 – practical skills in geology (p 50-51…)

**Suitable for teaching/assessing investigative skills**

Planning

Implementing

Analysing evidence and drawing conclusions

Evaluating evidence and procedures

See: GW IS1 Assessing Investigational Work for OCR Geology for details of the OCR criteria for assessing investigational work, as applied to the geology of Ecton Hill.

**Topic addressed**

Techniques of investigation of geological structures in the field

| | |
|---|---|
| **Student practical or teacher demonstration?** | Student investigation – led by Ecton Tutor, with students writing a plan as an assessed follow up.<br><br>This exercise can be used to assess all four components of investigative geological coursework stipulated by the two Awarding Bodies. It is unusual in that students do not plan the activity at Ecton, but act under instruction for most of the exercise. They devise a plan for a further investigation after they have got home, at the end. This approach has already been accepted by the Awarding Bodies on many previous occasions. It is probably best used with A2 students, who already have some field experience. |
| **Time needed to complete activity** | Half day on surface at Ecton<br><br>Mine visit at Ecton<br><br>Homework |

**Resource list**

Download and print at school before workshop:

- *GW1 SS1: Map of Ecton Hill and the mines*
- *GW1 SS2: Investigating the Section At Apes Tor*
- *GW1 SS3: Standard Deviation – Note for students*
- *GW1 IS3: The Roadside Section below Apes Tor*

For The Salt's Level visit:

- *GW IS6(C6): Salt's Level Base Map*

should be issued to students and Teacher should download:

- *GW IS7(C7): Salt's Level Geological Details*

but withhold it until after the Salt's Level visit.

Teacher may wish to download:

- *GW IS1: Assessing Investigational Work for OCR Geology*

Supply from School:

Graph paper

Compasses (magnetic and drawing)

Protractors

Clinometers

Hard hats

Field notebooks

Geological map of Ecton area

**Ideas for following up the activity**

Students should go home and write a plan. This is then collected and assessed by the teacher.

**Preparation and set-up time**

10 minutes, to organise paperwork and students' field equipment.

**Fig 1.1 Folding at Apes Tor**

## Description of activity in detail:

### At Apes Tor

Students are taken to Apes Tor, where they produce field sketches/labelled diagrams and measure strike, angle of dip and direction of dip and make any other observations they feel inclined to. (See Resource List)

They are also quizzed on the safety aspects and the problems they had so they can deal with the evaluation and plan later.

**Issues**

Students will take one reading from a limb of the fold and be happy that this is enough. They need to be challenged to consider whether they are certain that their reading is representative of the limb and then encouraged to make repeat readings on different bedding surfaces within the limb.

Students will record dip and strike of weathered surfaces and joint planes. Challenge them to consider what they are measuring.

At the most westerly part of the first exposure at Apes Tor the fold axis of an anticline is exposed. Students need to be challenged to consider what they are actually measuring here.

There is a thrust which is often misidentified as a fold. Students should be challenged about this.

## At the Centre

### Analysis

Students are encouraged to plot their graph in an appropriate way. Only rarely do they not think of a rose diagram. (See Fig 1.2)

They are then encouraged to consider standard deviation or vector analysis as a way of looking at the data. (See GW SS3 Standard Deviation – Note for Students)

They are encouraged to consider the relationship between folding and direction of compression, and to come up with a conclusion in those terms. Better students may decide that the folds are plunging, because the two limbs of the fold are not exactly diametrically opposite on the rose diagram.

Students are encouraged to consider the mean directions of the easterly and westerly dipping limbs. They may do this graphically to start with; then possibly calculate.

Students should be introduced to other mathematical techniques e.g. standard deviation and vector analysis.

This can be taught, but the students must apply it to the problem and explain why they have applied the technique to the problem. See the explanatory sheet at the end of this topic.

The students should be challenged to explain the folding in terms of direction of compression (Pmax etc.) and to explain the asymmetry, using taught materials and researched resources for the higher level.

### Evaluation

Students need to assess accuracy and reliability.

- Accuracy of equipment

The students should show an awareness of the limitations of each piece of measuring apparatus in perfect conditions, e.g. compass accurate to $\pm 1^{o}$.

- Accuracy of readings

The students should estimate the confidence they have in the readings. A good way to initiate this is to ask “Are you sure of your results to $20^{o}$ either side of your reading?” “Are you sure of your results to $1^{o}$ either side of your reading?” Then ask “When do you lose confidence?”

- Evaluation of sources of error

Initially students should list all the sources of error they can think of. They may need prompting. They should then suggest the most significant sources and perhaps estimate a numerical value for the error.

Improvements should reflect the main sources of error and give a reason, e.g. a clipboard on the surfaces would make the results more accurate because it would even out the irregularities.

- Reliability is the consistency of the results.

The students should be encouraged to compare their results with the group results and possibly with previous group results. If appropriate, they could suggest improvements.

Anomalous results need to be recognised and explained (probably in terms of joints, weathered surfaces or the fold axis mentioned above).

The students should be encouraged to consider whether the errors in their measurements are so large that they bring their conclusions into doubt. Students might be prompted to consider how valid their results might be if applied to the rest of the hill.

## Preparation for students writing their own plan

Following the Apes Tor activity the students should be encouraged to consider the wider issue of folding and mineralisation over the whole of Ecton. The students will have a tour of interesting features on and under the hill which will help them develop a plan for an investigation.

**Features on the surface of Ecton Hill:**

- Entrance to Dutchman's Mine to see an anticline and to relate that to the position of the Apes Tor folding. (SK 097582)
- Entrance to Fly Mine to see steeply easterly dipping rocks (SK 098581)
- Stile (with sandstone gatepost above Engine House) to look down on the mine openings and to relate the distribution of the mines to the position of Apes Tor and the direction of the folding at Apes Tor.
- Encourage the students to comment on this relationship. Hopefully someone will pick up on this and it can be made into an investigation into the relationship between the folding and mineralisation. The students will plan this only and will not carry it out.
- The mines on the ridge can be looked at to see the steep bedding planes.

**Features in Salt's Level:**

- Study the faults and use evidence of slickensides to show sense of last phase of movement. Does the stress field relate to that seen at Apes Tor?
- Study the crosscut to see the two zoned veins and to measure the trend of the veins.
- Go along to the pipe. Consider (and measure?) the change in dip along the tunnel towards the pipe. Look at the state of the rocks at the pipe and the mineralisation.
- Briefly, mention the flowstone discussion, about material dissolving and crystallising under changed conditions. (See Activity 4, Limestone weathering in the mine). Compare with conditions under which the ore-bearing mineral veins would have been formed and modified. (See Activities 2, Modelling primary mineralization and 3, Investigating secondary mineralization).

## Ideas for introducing/leading into the activity:

Before coming to Ecton, teachers may wish to consult the web-based Earth Science On-Site project on the geology of Apes Tor at www.ukrigs.org.uk. This site describes the structures at Apes Tor in some detail, but the exercises are devised for GCSE students, taking Science courses. Students should be issued with copies of Students sheets listed under Resource List. These can be used in preparation for the visit.

Well before students are brought to Ecton, they should have been made familiar with the following techniques:

### Measurement of dip and strike

Students must be shown in class and in various areas of the school how to take strike, angle of dip and direction of dip. All of these MUST be measured as bearings.

We always use the Right Hand Rule. This means that the students establish the strike, then place their right hand such that the thumb is pointing down dip and the fingers along the strike. Strike is measured along the direction the fingers point. Students should be aware that strike doesn't have a single direction.

In the context of Ecton this serves two purposes apart from the standardisation of strikes so that information can be shared.

The beds with an easterly dip always have a southerly strike and the beds with a westerly dip always have a northerly strike. When plotted on a rose diagram there is a trend which becomes obvious.

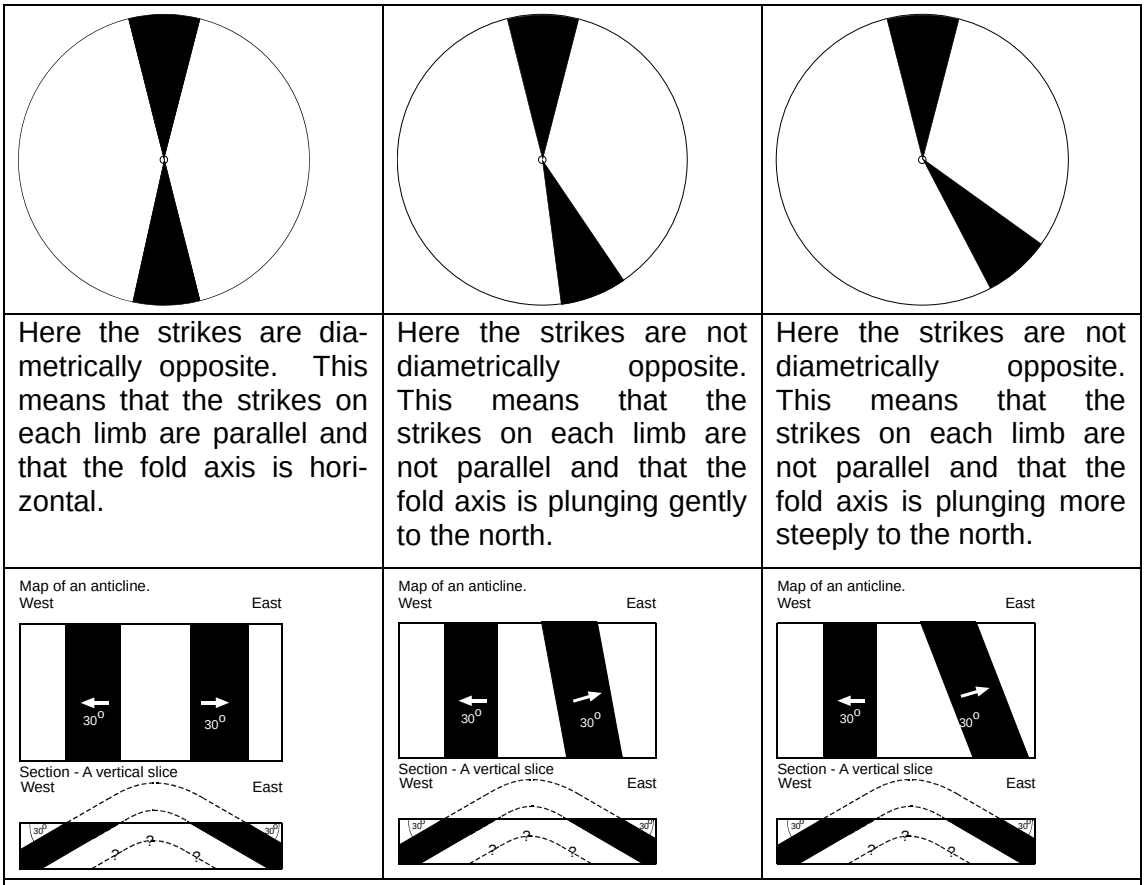


Fig 1.2. The relationship between strike measurements and the geometry of folds.

The other benefit is that the students can find the average dip of the westerly dipping limbs and the easterly dipping limbs. The students can then have a measure of the asymmetry of the fold. They can then use this to discuss sense of rotation and the direction of the force.

**Field sketching and drawing of labelled diagrams**

Students must have had some experience of making field sketches and should be trained to include:

- Location (Grid reference and description of location)
- Aspect
- Date
- Weather
- Scale
- Outline diagrams
- Labels which show geologically significant features

To give students more confidence in drawing diagrams, a good approach is to start with pictures of folds projected on to a whiteboard, tracing features and labelling them. The projector is then switched off and the diagram evaluated and improved. Then repeat with a diagram on paper from the photograph then finally try drawing standing up, with a clipboard for support.

**Grid References**

Students should be taught Grid References in the form SK123456.

**Safety**

Students discuss potential hazards they can think of and less obvious hazards are pointed out. (Hazards include: Falling rocks at Apes Tor, slipping on wet grass, traffic on the narrow road.

Students are primed that they need to consider what they do at the sites during the whole day, so they can later make a plan to carry out a further investigation.

## Ideas for following up the activity:

Students should then go home and write a plan. This is then collected in and assessed by the teacher.

**Planning**

This is carried out after the students have been to Ecton and have taken measurements and have some experience of the area. In principle, this is no different from planning before visiting Ecton, it's just that the students have some experience and the plan is building on that experience to describe in detail what they might investigate next.

The students should write up their analysis and their evaluation of the data they obtained while at Ecton.

As part of the analysis they should be encouraged to consider what other investigations they might carry out given that they know about the folding at Apes Tor and the distribution of the mines along the top of Ecton Hill. If the two are superimposed on one map then even the least perceptive of students should be able to suggest that there might be a link between the folding and the mineralisation.

Having identified a relationship the students can explain the relationship using their knowledge of structure and mineralisation. This allows a lot of scope. The least able/motivated regurgitate notes or textbook (P3a). The more able/motivated try to use secondary sources and apply them in a vague way (P5a). The most able/motivated use secondary sources effectively (P7a).

The students then need to consider exactly how they might go about investigating the relationship. They might suggest taking dips and strikes where rocks crop out on the hill, using the mine workings (both at the surface and underground). They might suggest revisiting Apes Tor to look for evidence of mineralisation there. There are all sorts of justifiable activities which they could suggest.

The least able/motivated just say they'll measure dips and strikes on the top of the hill and that they'll use compass clinometers and a map. (P3b). The more able/motivated try to think about an organised strategy and consider problems they highlight in their evaluation and try to address them. (P5b). The most able/motivated have an organised strategy, are aware of the problems, highlight the limitations of their strategy/equipment/method and make it clear how their equipment and strategy limit their accuracy (rightness) and reliability (sameness) (P7a).

There should be a clear statement of how they will take a dip and strike with reference to issues with the original exercise, i.e. have they learned from their experience?

They should all list equipment and its accuracy for P1b and a risk assessment for P1a.

REMEMBER:

You will need to download and print all of the materials listed under: Resources List.
Remind your students to bring their Student Sheets on the day.