Deformed Trilobites
Using fossils to estimate the distortion of rocks

Geologists can work out the stresses that rocks have undergone by looking at the ways in which fossils have changed shape. The deformed fossil trilobites from the Ordovician rocks of North Wales show the effects of stress on the rocks in which they are found.

A deformed trilobite *(©M. Walsh, courtesy of the National Museum of Wales*)

Show the students the images of deformed trilobites on the resource sheet. The students can then predict what types of stress (tension, compression or shear) have caused the deformation shown. The change in shape from the original, undeformed trilobite will indicate the stress that the rock has been subjected to.

Give each student some Play-doh™ and a cast of a fossil trilobite (or other suitable shell or object). They should form the Play-doh™ into a small block and the fossil trilobite (shell/other object) can then be pressed into it to create an undeformed "mould" of the fossil.

The student should apply stress to their Play-doh™ block to deform their fossil in the same way as **Fossil A** on the resource sheet. They can then consider the following questions:

- How did you deform the trilobite?
- What type of stress was applied?
- What is the effect on the fossil?
- Why did the fossil get wider?
- In which direction was the maximum stress (σ_{max}) applied?
- In which direction was there least stress (σ_{min}) applied?
- How do you know?

The students should now reform their blocks of Play-doh™ and make a fresh imprint of an undeformed fossil (or object). Now they should deform the block in the same way as **Fossil B** on the resource sheet and consider the following questions:

- How was the stress applied, was it similar to the first time this was done?
- If so, how was the stress different?
- What is the relationship between σ_{max} and σ_{min} for this fossil?
- How do you know?

The student should now remake an undeformed trilobite (or object) with their Play-doh™. This should be deformed in the same way as **Fossil C** on the resource sheet and then the following questions considered.

- What is different about Fossil C compared to Fossils A & B?
- What type of stress was applied to replicate Fossil C?
- Why is the result of the stress you applied different from the other fossils?
- Could examples of all 3 fossils (A, B & C) be found on the same bedding plane? *Answer: If trilobites A and B had been preserved lying at right angles to each other, then one would have been lengthened and the other shortened at the same time when the stress was applied. Fossil C, showing the result of shear stress, would probably not be found alongside A and B.*

This could lead to a discussion about the relationship between the orientation of stresses and geological structures such as folds and faults. The possibility of using other indicators of stress could also be discussed.

……

The back up

Title: Deformed Trilobites.

Subtitle: Using fossils to estimate the distortion of rocks.

Topic: Rock deformation, deduced from included fossils.

Age range of pupils: 16-18 years

Time needed to complete activity: 30 minutes

Pupil learning outcomes: Pupils can:

- model the effect of deformation of rocks;
- understand the concept of principal stress orientations;
- determine the principal stress orientations that have created the observed deformations.

Context: This activity can be used as an introduction to the concept of principal stress orientations as part of a scheme of study on rock deformation.

Following up the activity:
The resource sheet could be used to calculate ratios of long:short axes for each of these fossils to quantify the deformation.

Links from this activity can be made to the different types of faulting, with the orientation of the stress that caused the fault to move.

Underlying principles:
- Different types of stress can deform rocks.
- The orientation of the stress can determine the deformation that the rock is subject to.

Thinking skill development:
By using the fossil images to predict the stress to which each fossil was subjected before any modelling with Play-doh™ takes place, students get the opportunity to test their ideas. Many students will interpret Fossil B as having been deformed by tensional stress but will be unable to model this. The subsequent experimentation will show that the orientation of stress is an important determinant of the deformation of a rock. By measuring the effects of deformation on the photographs on the resource sheet and on their deformed models, students will be able to quantify the deformation.

Resource list:
- Play-doh™ or moist clay
- fossil/shell/object to make an impression
- images of deformed trilobites on resource sheet
- as an alternative to commercially available Play-doh™, the following recipe can be used to make enough for four students:

32 tablespoons plain flour (1 kg approx.)
8 tablespoons salt (250g approx.)
240ml warm water
food colouring
4 tablespoons vegetable oil

1. Mix the flour and salt together in a large bowl. Mix the water, a few drops of food colouring and oil separately.
2. Pour the coloured water into the flour mix and bring them together to form the dough.
3. Put a little flour onto a work surface and knead the dough until it is smooth and pliable.
4. Store the dough in a sealed plastic bag in the fridge to keep it fresh.

Useful links:
A simpler approach to this activity is shown at: https://www.earthlearningidea.com/PDF/51_Squeezed_out_of_shape.pdf
A discussion of these trilobites has been published by: Fortey, R.A. & Owens, R.M. (1992). The trilobite *Angelina* unstretched. *Geology Today*, Nov-Dec 1992, pp.219-221.

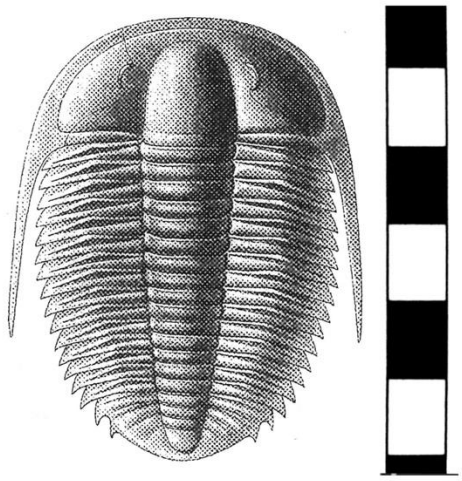
Source:
Diagram of undeformed *Angelina sedgwicki* from Salter, J.W. (1864). Figures and descriptions illustrative of British organic remains. Decade XI. Trilobites (chiefly Silurian). *Memoirs of the Geological Survey of the United Kingdom*.

All photographs by Michael Walsh. Thanks are due to the staff at the National Museum of Wales, Cardiff (particularly Dr. Lucy McCobb) for access to the fossil specimens.

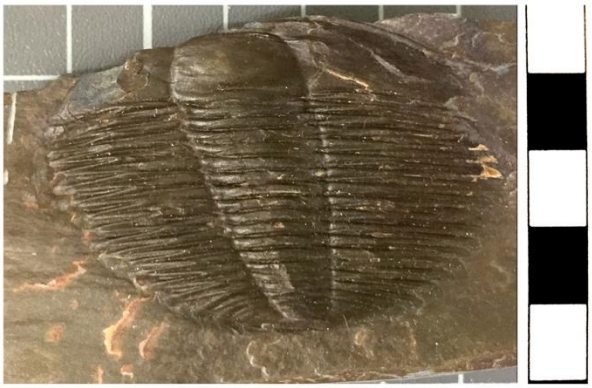
DEFORMED TRILOBITES
Resource Sheet

The images below show a reconstruction of an undeformed trilobite (*Angelina sedgwicki*) and three photographs of the same species of trilobite from rocks of Ordovician age from North Wales, U.K.

Undeformed trilobite



Fossil A



Fossil B

Fossil C

Scale bars show a centimetre scale.