Folds and faults with puff pastry and chocolate
Understanding folds and faults in cross section and on a geological map

The purpose of the activity is to observe the different shapes that form in uncooked sheets of puff pastry layered with chocolate cream when compression forces are applied. The resulting shapes can be compared to areas in the Catalonian pre-Pyrenees where the crust has folded and so shortened, (crustal shortening).

In small groups, **ask the pupils to**:

- carefully clean a surface area on which to spread the sheets of uncooked puff pastry, (to be eaten later);
- make about two or three layers of uncooked puff pastry with chocolate cream between them (chosen because of their contrasting colours);
- measure the length of the pastry;
- using their hands (in sterile gloves), gently apply inward pressure (compression) to both sides of the layers;
- as folds begin to form, take photos and draw sketches. Measure the length of the pastry now and work out the percentage of crustal shortening, (new length/original length x 100 = % crustal shortening)
  The accompanying video shows the pastry being folded by hand. If this is done, the percentage of crustal shortening can still be calculated.
- does the puff pastry and chocolate behave in the same way? *(No)*;
- if not, what is the difference. *(The stronger puff pastry makes good folds and the weaker chocolate is squeezed in between)*;
- now use the knife to cut the model in half. Place one half against the other to simulate a low angle thrust fault. This should also be photographed and sketched;
- ask some groups to model reverse faults too;
- pupils should now compare their simulations with text book labelled diagrams of folds and faults and label their own photographs or sketches accordingly.

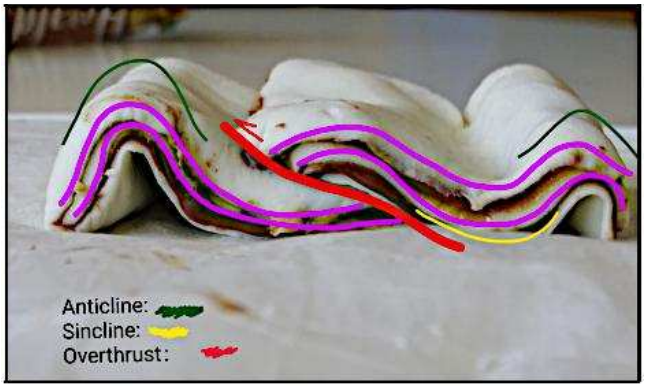

Image of the model, *Neus Alcañiz*

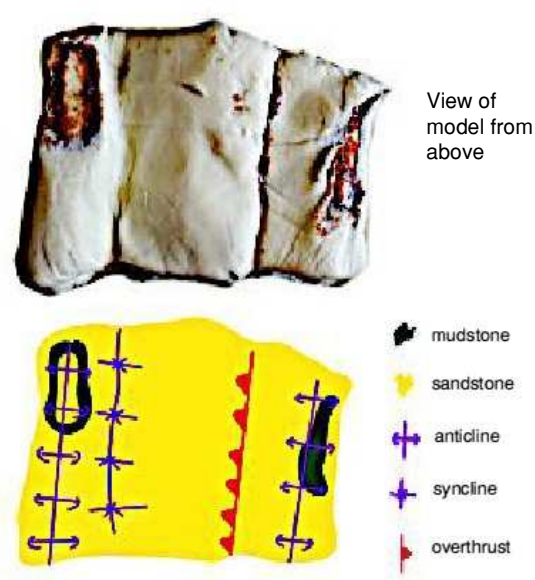

Photo of the model from above and sketch geological map
Neus Alcañiz

Using the image above, match the photo of the model taken from above to the sketch of the equivalent geological map below.

Ask the students to apply their simulation to a real area in the Catalonian pre-Pyrenees. Can they work out from the map the direction of the movement (crustal shortening)?

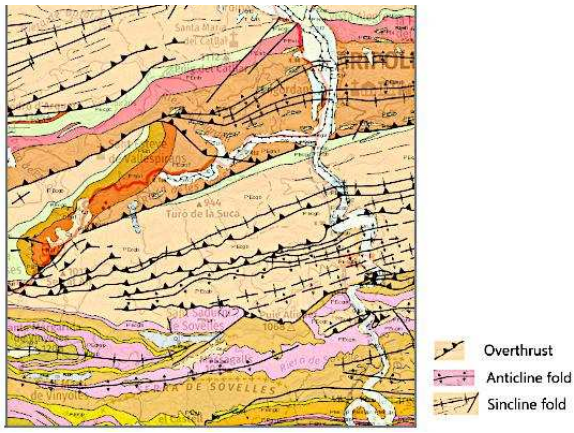

Image from a geological map from Pre-pyrenees showing structures such as those that have been reproduced in the model
CGC. (n.d.). Instamaps. Instamaps.Cat. Retrieved 5 December, 2022, from https://www.instamaps.cat/#/.

Last of all, cook the pastry and chocolate and eat it!

The back up:

Title: Folds and faults with puff pastry and chocolate

Subtitle: Understanding folds and faults in cross section and on a geological map

Topic: This activity models the formation of folds and then of faults using the Catalonian pre-Pyrenees as an example in the real world.

Age range of pupils: 12-16 years

Time needed to complete activity: 60 minutes

Pupil learning outcomes: Pupils can:
- compress layers of uncooked puff pastry and chocolate cream;
- observe how the two ingredients behave;
- see that the layers fold into upfolds and downfolds;
- relate the pastry to a stronger, more competent rock like sandstone;
- relate the chocolate to a weaker, less competent rock like mudstone;
- cut the model and create faults, thrust or reverse;
- apply this to rocks and understand that rocks must be at depth and in a plastic state in order to fold like the uncooked puff pastry;
- realise they must be brittle to break causing faults;
- annotate the photographs or sketches with accurate labels using textbook diagrams for reference;
- calculate the percentage of crustal shortening;
- study a map of the Catalonian pre-Pyrenees and relate their models to the structures evident on the map;
- realise that their photographs or sketches are the equivalent of cross sections of folds and faults.

Context:
Students often have problems understanding geological cross-sections and in interpreting geological maps. Modelling simple folds and faults and being able to see what has happened in cross section helps them to interpret what they can see on a geological map, even a complex one like that of the Catalonian pre-Pyrenees

Following up the activity:
This activity could be extended by making more complex structures in the uncooked puff pastry and chocolate.
The students could develop other methods to explain complex tectonic structures. e.g. the accompanying video demonstrates the surface outcrop of plunging folds, by cutting off the tops of the anticlines in the puff pastry.
They could try to make a model of a particular area on a geological map.

Underlying principles:
- Lateral compression is the force that creates folds in rocks.
- Rocks must be sufficiently plastic, so at depth, to fold.
- When rocks can no longer fold, they break, often creating low angle thrust faults.
- Rocks fold into anticlines and synclines and can make complex shapes.
- Weak or incompetent rocks follow the competent rocks and fill in any gaps.
- When rocks are subjected to both increased pressure and heat, crystals grow in the solid state and they become metamorphic rocks.
- Lateral compressive forces in the outer layers of the Earth are usually caused by plate tectonic movement.

Thinking skill development:
A pattern develops as the pupils layer their uncooked puff pastry and chocolate and then observe what happens when they apply lateral compressive force. Discussion about what will happen involves metacognition. Cognitive conflict may occur if the materials do not behave as expected. Making an accurate cross section of their model and then applying their three-dimensional structure to structures on a geological map is a bridging skill.

Resource list:
- uncooked puff pastry
- chocolate cream, Melted chocolate can be used but it may set before the model is finished and then it is too rigid to show what is required.
- knife
- sterile gloves
- cleaning equipment
- oven

Useful links:
Video by the author explaining briefly how to carry out the activity. Alcañiz, N. (neusalcanizsolanas9038). 2022, December 9. Pràctica de simulació de plecs amb xocolata. Youtube. https://www.youtube.com/watch?v=COtKe5q95oo
ICGC. (n.d.) Instamaps. Instamaps.Cat. de https://www.instamaps.cat/#/
Whihen, B. (1993). Diccionario de geologia. Alianza.

Source:
This activity was originally devised by Neus Alcañiz Solanas, a geologist and a secondary school teacher from Barcelona (Catalonia) 2018, and developed by the ELI Team.