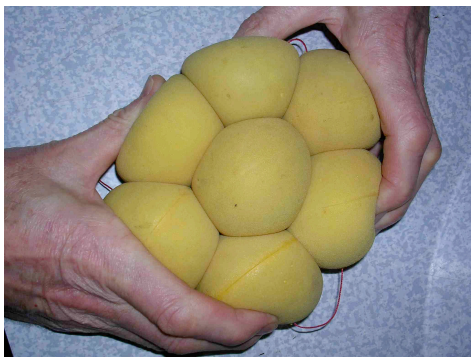
Metamorphism – that's Greek for 'change of shape', isn't it?
What changes can we expect when rocks are put under great pressure in the Earth?

It is very hard for scientists to 'make' metamorphic rocks, even in big laboratories, because such high temperatures and pressures are needed. But we can show how pressure changes rocks and the minerals in them, like this:

a) **in fine-grained rocks made of flaky minerals**. Take about twenty used matchsticks, or something similar, to represent the flaky minerals in a rock like a mudstone. Drop them onto a table so that they scatter randomly. Take two school rulers (or similar strips of wood) and ask pupils what will happen when these are brought slowly together, 'compressing' the matchsticks between them. (*The matchsticks will tend to line up parallel to the rulers*). This shows the way in which the flaky minerals become aligned as they recrystallise under intense sideways pressure in the Earth, to produce a slate. Use another ruler to split the aligned matchsticks down the middle, like the way in which a slate may be evenly cleaved.

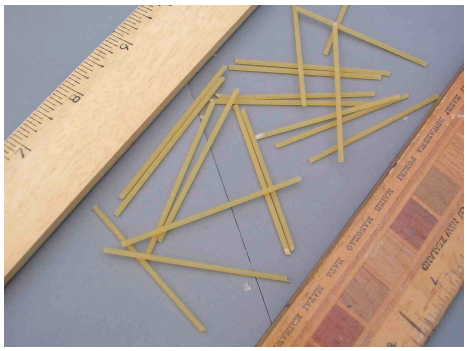
b) **in coarser-grained rocks composed mainly of one mineral**, e.g. a sandstone or a limestone. Take seven soft spherical objects, such as foam tennis balls, and place them on a table so that they are touching each other. This is like the grains of sand in a sandstone, or the grains of calcite in a limestone. Now ask pupils what will happen when all the balls are squeezed together, until there is no space between them. (*They will form roughly hexagonal shapes, representing the texture of a quartzite rock [from the sandstone] or a marble [from the limestone], where the original minerals have recrystallised under greatly increased pressure in the Earth*).

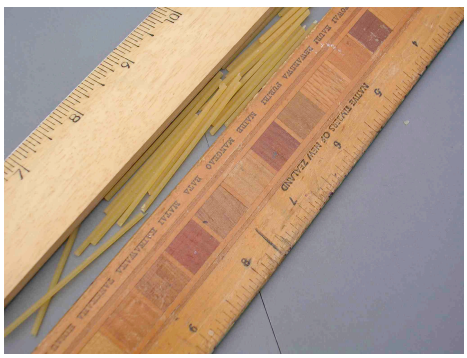


Foam balls before and after squeezing

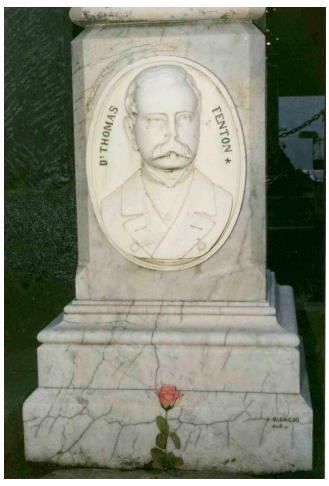
A Welsh craftsman splitting roofing slate (like 'splitting' aligned matchsticks with a ruler)

(J.W. Greaves & Sons, Blaenau Ffestiniog)





Spaghetti pieces before and after squeezing



A marble tomb, set up in 1886, Punta Arenas, Chile (made of 'squeezed grains' of calcite with no spaces between them)

(All photos by P. Kennett, except where stated

The back up

Title: Metamorphism – that's Greek for 'change of shape', isn't it?

Subtitle: What changes can we expect when rocks are put under great pressure in the Earth?

Topic: A demonstration of the formation of two common textures seen in metamorphic rocks

Age range of pupils: 10-18 years

Time needed to complete activity: 10 mins

Pupil learning outcomes: Pupils can:
- explain how long thin objects can become aligned under pressure;
- explain why rocks such as slate can be evenly split (cleaved) along preferred planes;
- explain how once spherical objects may become near-hexagonal under pressure;
- state that quartzite is formed from sandstone and marble formed from limestone by metamorphic processes.

Context: The concept of metamorphism is a difficult one to explain because the processes happen at considerable depth in the crust or mantle and cannot be readily reproduced in a school laboratory. The activities given here demonstrate the principle of the effects of pressure on particles of different shape and composition, but cannot reproduce the recrystallisation that accompanies real metamorphism. However, slate and marble are important constructional and decorative materials and it is useful for pupils to have some understanding of their origins.

Following up the activity:
- Ask pupils to draw 'before and after' pictures of the matchsticks and the foam balls.
- Ask pupils to look out for examples of slate and of marble in use in town centres etc.
- Study broken pieces of marble to see if the tightly interlocking crystals of calcite can be seen.

Underlying principles:
- Metamorphism involves the recrystallisation of an original rock, without melting taking place.
- The original rock may be of sedimentary, igneous, or metamorphic origin.
- Metamorphism may be caused by increased temperature (e.g. >300^{o}C), and/or by increased pressure.
- The increased pressure mostly comes from plate tectonic forces, which act on the rocks
- Flaky minerals in a mud-rock (such as clay minerals) recrystallise into other flaky minerals (such as micas) to lie perpendicular to the forces which affected the rock.
- Larger, more equi-dimensional grains, as in sandstone or limestone, tend to recrystallise together in roughly hexagonal shapes when metamorphosed.
- Quartzite and marble can be formed by metamorphism by increased heat OR pressure (or both), however, directed pressure is essential to form a slate, with its characteristic cleavage.

Thinking skill development:
- A pattern is established that lateral pressure produces alignment of long thin minerals: equi-dimensional minerals form near-hexagonal textures under pressure.
- Appreciating that the same principle applies to real rocks is a bridging skill.

Resource list:
- about twenty used matchsticks, similar slivers of wood, or 5cm lengths of spaghetti
- 3 school rulers, similar wood strips, or the edges of exercise books
- 7 soft tennis balls or similar compressible spherical objects, e.g. balls of wool or of paper
- optional – a piece of slate and a piece of marble

Useful links:
http://www.uky.edu/AS/Geology/webdogs/javagems/metamorph/metamorph.html
http://www.lessonplanspage.com/ScienceMetamorphicRockPancakes25.htm

Source: Earth Science Teachers' Association (1990) *Science of the Earth 11-14: Hidden changes in the Earth.* Sheffield, Geo Supplies Ltd.