Fluids, friction and failure

How can unseen fluids affect the movement along faults and glacier beds?

Ask your pupils to investigate how a fluid may affect the friction between two surfaces as follows:
Provide the equipment as shown in the photograph and diagram. One empty drinks can is normal: the other one has had several small holes punched in the base. Add water to the normal can until it is about ¾ full of water. Place it on the board and then gently tilt the board until the can begins to slide down. Mark the angle against the inside of the tray using a pencil or a felt tipped pen. Repeat the tilting several times and work out the mean angle at which the can slides.
Now add water to the can with the holes in the base, to the same level as the first one, and find out the angle at which it begins to slide. You will need to be quick, before the water all drains out!
Dry off the board and repeat the test several times, and calculate the mean angle.
Ask the pupils to explain the differences in the cans' behaviour. (*The water has reduced the frictional forces between the can and the board).*
Ask them if they can think of any events in the landscape or under the Earth which this activity might be modelling, where surfaces held by friction have been lubricated and so failed. (*Pupils may suggest that the water content of loose material could affect slope failure, e.g. in old mine dumps. Slip along fault planes below ground might also be made more likely by the presence of water in the rocks. Some may realise that many glaciers flow faster when meltwater is present along the base of the glacier.)*

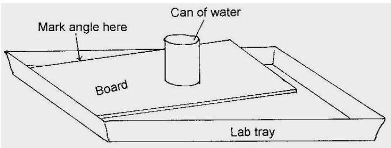

Diagram showing how the angle is marked, once the can begins to slip.


The apparatus ready for use. (It is worth having a beaker of water ready, rather than waiting for the can to fill up under the tap).


Meltwater emerging from the bed of a glacier in Norway. (Photos: *P. Kennett*)

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The back up

Title: Fluids, friction and failure

Subtitle: How can unseen fluids affect the movement along faults and glacier beds?

Topic: A simple test of the angle at which friction is overcome and a drinks can begins to slide down an inclined board. Using a drinks can with small holes at the bottom results in water seeping out onto the surface of the board which reduces the friction.

Age range of pupils: 11 -18 years

Time needed to complete activity: 15 minutes

Pupil learning outcomes: Pupils can:

- manipulate simple equipment carefully and measure an angle in an unusual setting;
- explain that friction is reduced by the presence of a fluid on the surfaces in contact;
- appreciate that the presence of fluids below ground might reduce friction and possibly cause catastrophic failure of rock masses;
- accept that the presence of melt water beneath a glacier could increase the flow velocity of the glacier.

Context: This activity could be used in investigations of geological hazards, such as faulting and landslip in a science or geography lesson.

Following up the activity:

- Discuss the balance of forces whilst the object is a) not moving; b) starting to move (e.g. friction versus gravity).
- Carry out some of the activities listed in 'Useful links' below.
- From the internet, find examples of slope failure where penetration of water may have played a part, e.g. the fatal collapse of the coal waste heap at Aberfan in South Wales in 1966.
- From the internet, find flow rates of glaciers and ice sheets, e.g. the fastest moving glacier in Greenland, Jakobshavn Glacier, moving at 40 metres per day where melt water pouring off the surface down to the bed of the glacier has greatly speeded up its movement
- Find examples of 'seismic gaps' in earthquake zones from the internet or from television. These are where fault planes have 'locked' owing to high friction and where stresses are building up prior to future catastrophic failure. In other areas, fluids in the rocks allow slow but frequent tremors along the fault plane, with less likelihood of a sudden major earthquake.

Underlying principles:
- Friction is usually reduced by the presence of fluids between the surfaces in contact.
- Beneath many glaciers, flow rates are increased by the presence of liquid water between the rock bed and the base of the ice.
- Within rock masses, the strength of the rocks is reduced by raised pore-water pressure forcing individual grains apart when the rock is saturated, rather than there being a film of water along the junction, as suggested by the model in the activity.
- Fluids pumped down fault zones have been shown to increase the number of small, mostly harmless tremors, possibly avoiding the build up of sufficient stress to result in a damaging earthquake. This was discovered by accident when waste fluids were being pumped into a fault zone in the western U.S.A. – when pumping was going on, many small tremors were observed on seismographs: when pumping stopped, the tremors stopped, and stresses accumulated.

Thinking skill development:
Pupils build up a cognitive pattern by repeated measurements of the slope angle. Applying the results to the natural world involves bridging skills.

Resource list:
- lab tray or similar flat container
- two similar empty drinks cans, one with three or four small holes punched in the base, e.g. by using a long nail and a hammer, but without denting the base
- a flat board to fit into the tray
- protractor
- felt-tipped pen or pencil
- beaker of water

Useful links: Earthlearningidea activities: Danger – quicksands! - why do some rocks give way when it rains hard?: Earthquake prediction – when will the earthquake strike? Landslide through the window – what would you see, what would you feel?

Source: A long-established demonstration.

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