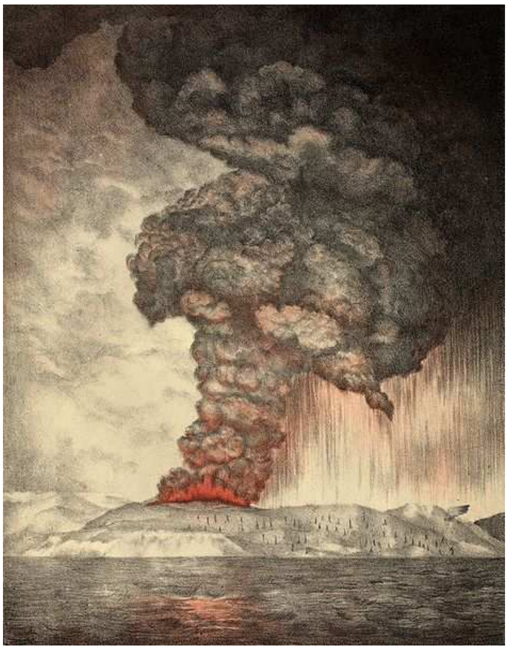
The balloon goes up at Krakatoa
Using a tank and balloon to simulate the huge tsunamis caused by the eruption of Krakatoa

The eruption of Krakatoa in Indonesia in 1883 was truly awesome.

- The sound was, by far, the loudest sound ever recorded; the loudest sound in modern history.
- It travelled more than 3000 km to central Australia, where it woke up sleeping people, and 4800 km to islands in the Indian Ocean, where they thought there was a gunbattle offshore.
- Atmospheric pressure waves were recorded on barometers all over the world.
- Ash was blasted more than 40 km into the sky.
- The ash caused total darkness during the day in a city 160 km away and fell at least 1850 km distant.
- Ash was carried right round the world over the next few days, and then circled the Earth several times.
- This caused glorious sunsets worldwide and in some places the sun first appeared bright green and later, bright blue.
- The ash and gases from the eruption reflected radiation from the sun, causing the Earth to be cooler by 0.25 ^{o}C the following year.
- Where there had been a 300m high island – a crater (or caldera), 300m below the sea surface, was created by the eruption.
- At least 36,000 people (and possibly 120,000) were killed by tsunamis caused by the eruption.
- The largest tsunami may have been 40 m high near its source, and was still about 15 m high at the shoreline.
- The tsunamis were recorded by tide gauges on the far side of the Indian Ocean.



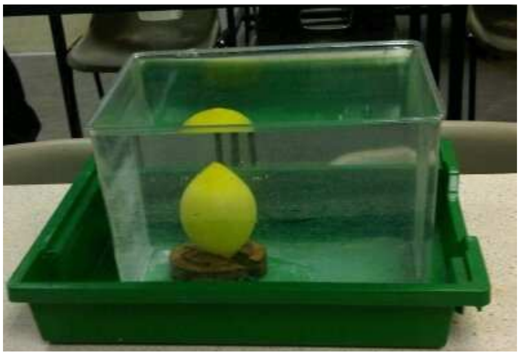
The eruption of Krakatoa in 1883, drawn BEFORE the big eruption.

While the eruption itself was awesome, it was the tsunamis that caused all the deaths – so how were these tsunamis formed? Nobody really knows the exact mechanism, since no one was there at the time. One theory is that, after the caldera had been formed, a side of the volcano slumped into the sea, causing the tsunamis. A second theory is that, when the magma chamber collapsed, huge volumes of sea water poured into the space and then slopped out again, causing the tsunamis.

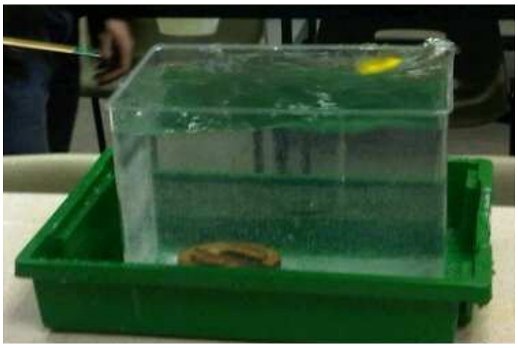
If this last theory is correct, you can recreate your own 'Krakatoan tsunamis' in the classroom, as follows:

- partly inflate a round balloon, to a diameter of 8 – 10 cm;
- put it into the bottom of a tank, attached to a heavy mass, to keep it down when the tank is filled with water;
- put the tank into a tray to catch at least some of the 'tsunamis' created;
- fill the tank with water to the top;
- create a 'Krakatoan eruption' by bursting the balloon with a needle (or stand back and ask a pupil to do it).

When the balloon bursts, some water is thrown into the air (simulating the eruption?) but the larger effect is caused by the water slopping into the space caused by the exploding air, and then slopping out again as 'tsunamis' that throw water out of the tank and over the table.



The 'Krakatoa tank' before eruption.



The 'Krakatoa tank' creating tsunamis.

'Before' and 'after' photos by Lucy Greenwood.

The back up

Title: The balloon goes up at Krakatoa.

Subtitle: Using a tank and balloon to simulate the huge tsunamis caused by the eruption of Krakatoa.

Topic: A simulation, using a balloon in a tank of water, of one of the theories thought to have caused the devastating Krakatoan tsunamis.

Age range of pupils: 5 years upwards

Time needed to complete activity: About 10 minutes to set up the tank beforehand; microseconds to burst the balloon and see the effects.

Pupil learning outcomes: Pupils can:
- describe one mechanism for triggering tsunamis;
- describe the power of some cataclysmic Earth events.

Context: The eruption of Krakatoa (or Krakatau to use its Indonesian name) was the first major volcanic eruption that was investigated and recorded scientifically. It is described as 'colossal' on the Volcanic Explosivity Index (VEI), having ejected more than 10 km^3 of material. (The eruption of Tambora in 1815, also in Indonesia, is described as 'super-colossal' on the VEI, having ejected more than 100 km^3 of material, whilst the eruption of Taupo, New Zealand about 28,000 years ago, was 'mega-colossal', ejecting more than 1000 km^3 of material – but both of these erupted before scientific records). Thus we have reasonably good scientific evidence for the effects of the Krakatoan eruption, even if we still don't understand the exact mechanisms of eruption and tsunami-generation.

The arrival of the Krakatoa tsunamis was described by N. van Sandick on the Dutch ship *Loudon*:

"Like a high mountain, the monstrous wave precipitated its journey to the land. Immediately afterwards another three waves of colossal size appeared. And before our eyes, this terrifying upheaval of the sea, in a sweeping transit, consumed in one instant the ruin of the town. Where a few minutes ago lived the town of Telok Belong, was nothing but open sea."
(taken from, McGuire, M, (2002) *Raging Planet*. Hove, East Sussex: Apple, p 63.)

Following up the activity:
Pupils could research the effects of other major volcanic eruptions, in libraries or on the internet.

Underlying principles:
- When magma is expelled suddenly from a magma chamber, the void formed can collapse catastrophically into a caldera.
- Either the sea slopping into the void, or the side of the volcano slumping into the void, can create tsunamis.
- Once generated, tsunamis can travel long distances over the ocean and devastate low-lying coastal areas.

Thinking skill development:
This activity involves bridging between the demonstration and the 'real thing', together with empathising with those involved.

Resource list:
- a tank, such as a plastic fish tank about 40 cm long by 30 cm wide and 25 cm deep
- a tray to put the tank in (to catch the overflowing water)
- a round balloon (and some spares)
- a large mass to weigh the balloon down
- a needle

Useful links:
Many detailed accounts of volcanic eruptions and their effects can be found on the internet, by using a search engine like Google.

Source: Devised by Chris King of the Earthlearningidea Team.