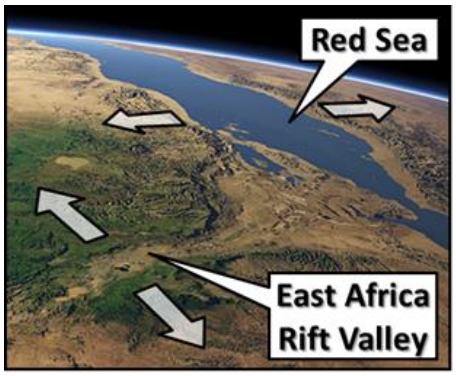
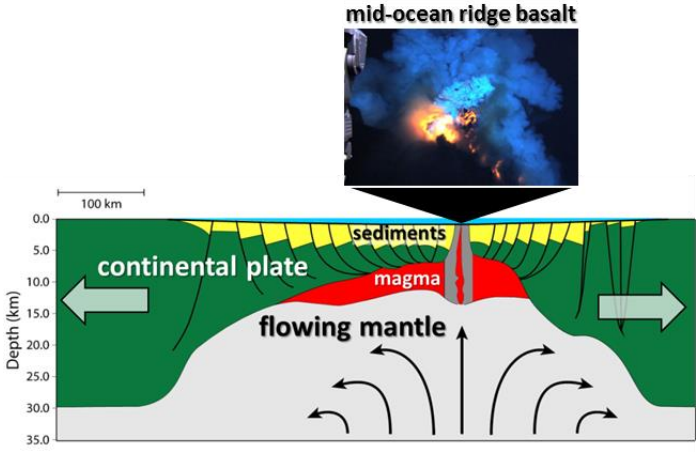
What is the connection between Manx glens, Mars bars, basalt and the Atlantic Ocean?

Plate tectonics gained acceptance in the 1960's and revolutionized geological science. The basic premise is that the Earth is composed of plates, many tens of kilometres thick, which float and move on fluid mantle. But there was a problem with the theory - specifically how continental plates break apart to form oceans.

We will start with an analogy: if you stretch a Mars Bar it thins and the surface sinks - until it breaks. Similarly, when continental plates are stretched depressions are formed known as rift valleys, a modern example being the East Africa Rift Valley. 170 million years ago, during the Jurassic, the North Sea was initiated as a rift valley.



If stretching continues, the continental plate can break to form an ocean. Further to the east of the East Africa Rift Valley, the plates have indeed separated to form the Red Sea. In the same way, 60 million years ago North America broke from Europe to form the North Atlantic. The gap between the two continents fills with magma from the mantle to form new oceanic plate composed of basalt. The oceanic plate widens as the two continents continue to separate.

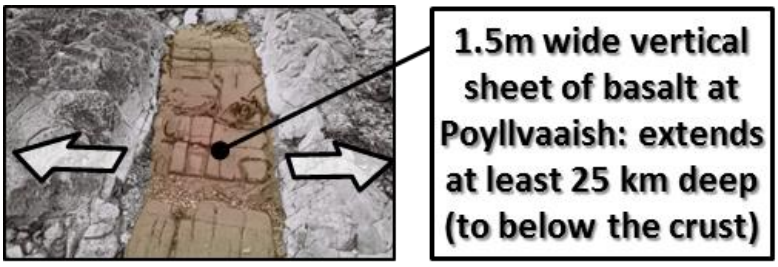


Oceanic plate lies 3 km deeper than continental plate because it is thinner and is therefore less buoyant, for the same reason that thin ice floats lower than thick ice. Continental plate should also sink below the sea as it stretches and gets thinner. Herein lies the problem. All continental margins are strangely elevated when break-up occurs - by as much as 2-3 km. This conundrum has been around for more than 40 years, ever since the physics behind rifting was understood.

Using mathematical experiments, we[1] investigated existing theories but none of these replicate the elevation. Instead we came up with a new explanation involving magma in the mantle.

If you take the top of a fizzy drink, bubbles of gas are released. Likewise, when the plate gets thinner from rifting, the pressure in the underlying mantle is reduced causing bubbles of magma to form. This magma is relatively light and so keeps the plate buoyant – enough to elevate its surface by 2-3 km. When the plate breaks huge amounts of basalt are erupted causing the margins then to subside.

Evidence supporting this new model can be seen in the Isle of Man. When the North Atlantic was formed, the Irish Sea region rose a couple of kilometres. While the land rose, rivers cut downwards resulting in the distinctive Manx glens. Some of the magma which caused the region to rise is seen as vertical sheets of basalt exposed in places along the coast. These sheets are only a few metres wide but are connected to the mantle, tens of kilometres below the surface.



We have now turned out attention to the North Sea where again existing models do not fully match the data - magma in the mantle may provide an explanation for some puzzling observations made there by the oil industry. Watch this space!

Dave Quirk, 19 July 2019.

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[1] Quirk and Ruepke, 2018 - https://www.nature.com/articles/s41598-018-27981-2