Climate through time

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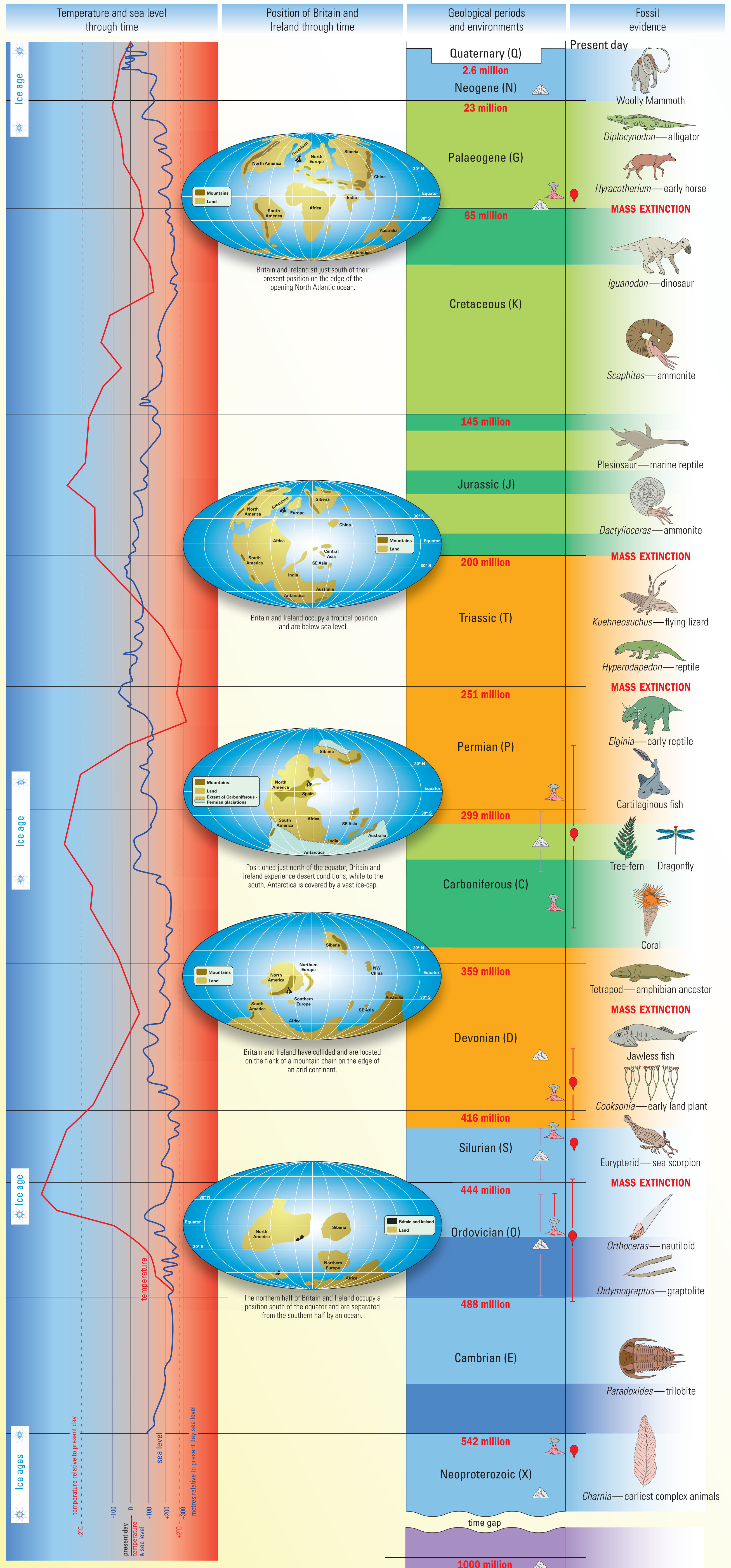
Earth Sciences for Society



Our rocks reveal the story of change

Earth's climate is predicted to change rapidly in ways that could have serious consequences for humanity. However, the climate has varied throughout the billions of years of Earth's geological history. Rocks record evidence for past climates including the extreme conditions that have been linked to mass extinctions. 'The present is the key to the past' is a vital principle of geology. As geological understanding improves, we are better able to forecast the impact future change may have on us — the past is the key to the future.

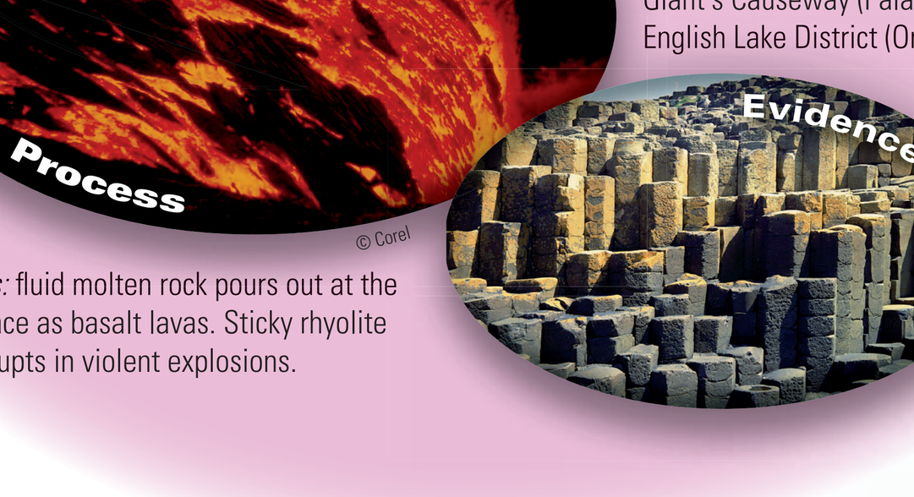
Many environments, and therefore the rocks formed in them, are directly influenced by climate. On this poster each environment is represented by a particular colour. Orange areas on the map, for instance, show where rocks that formed in ancient deserts may now be found. On the timeline, orange represents those geological periods when the climate was hot and arid in Britain and Ireland. The same colour is used to highlight photographs of a present-day desert and examples of ancient desert sandstones.

In other cases, however, rocks are formed by geological processes regardless of climate. For example, igneous intrusions, shown in red are formed during episodes of tectonic activity, independent of surface conditions.

The formation of some rocks may influence climate. For instance, thick sequences of coal 'locked up' atmospheric carbon dioxide as they formed. This greenhouse gas is now being released as we burn fossil fuels such as coal and oil. As another example, ash-filled skies from large volcanic eruptions block the Sun's rays and cause global cooling.

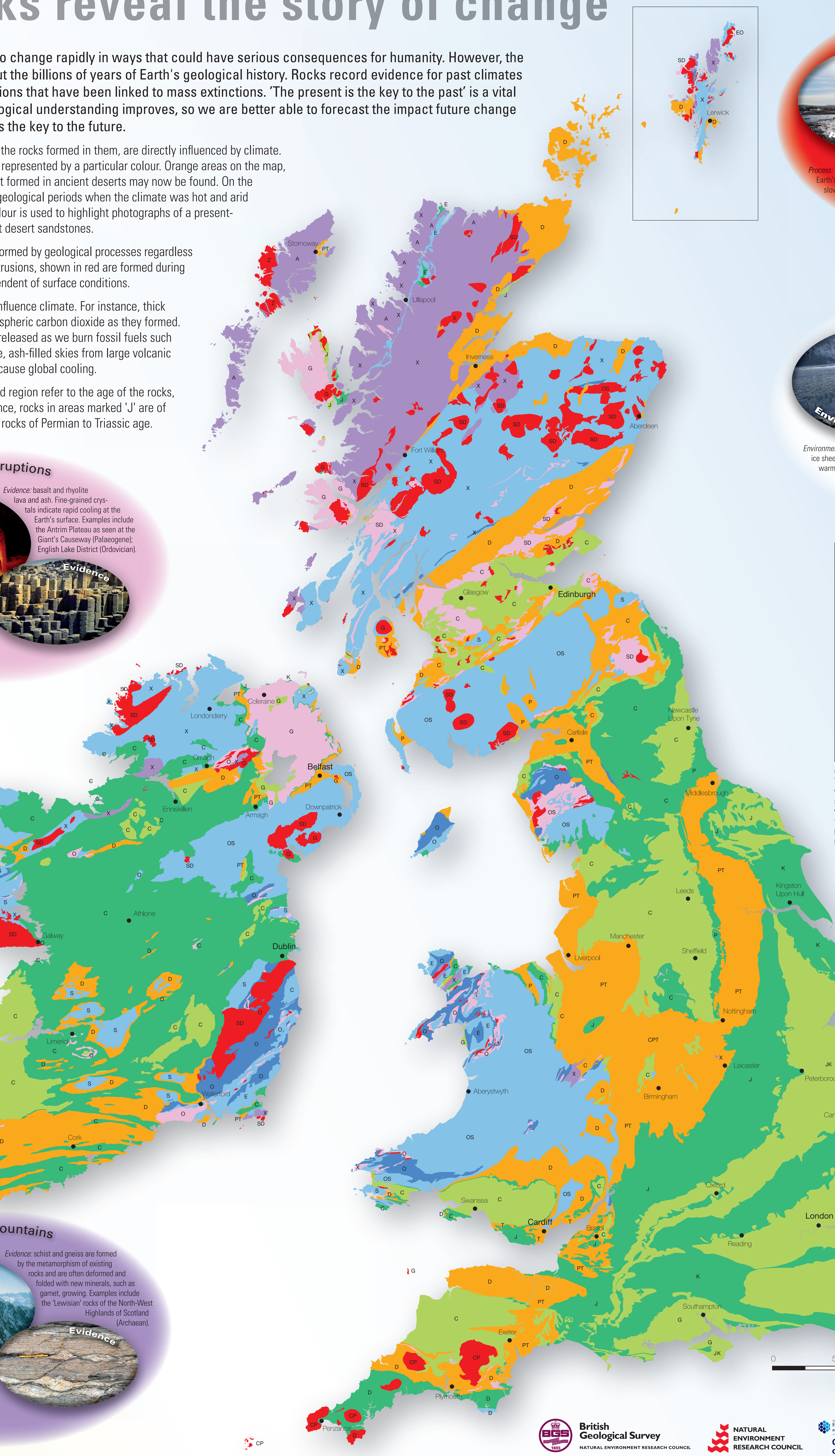
On the map, letters in each coloured region refer to the age of the rocks, as shown in the timeline. For instance, rocks in areas marked 'J' are of Jurassic age, while 'PT' represents rocks of Permian to Triassic age.

Volcanic eruptions

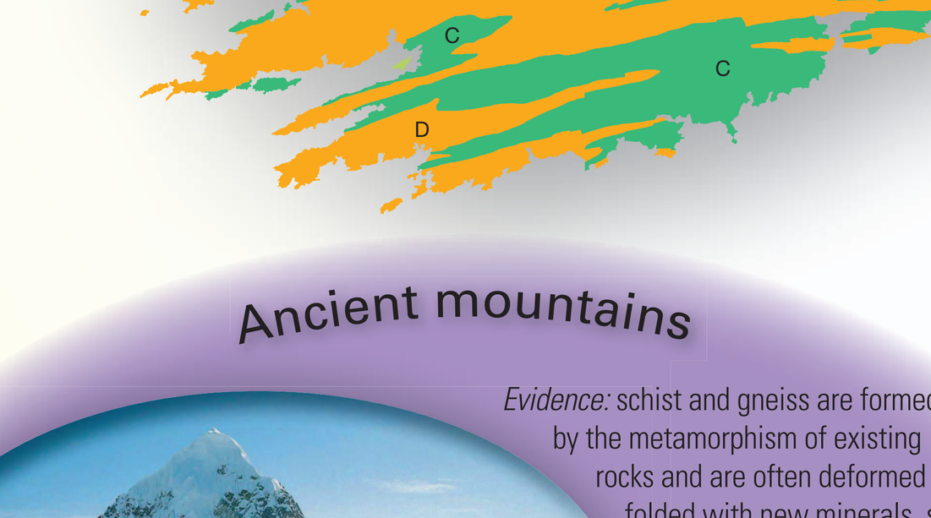


Evidence: basalt and rhyolite lava and ash. Fine-grained crystals indicate rapid cooling at the Earth's surface. Examples include the Antrim Plateau as seen at the Giant's Causeway (Palaeogene); English Lake District (Ordovician).

Process: fluid molten rock pours out at the surface as basalt lavas. Sticky rhyolite erupts in violent explosions.



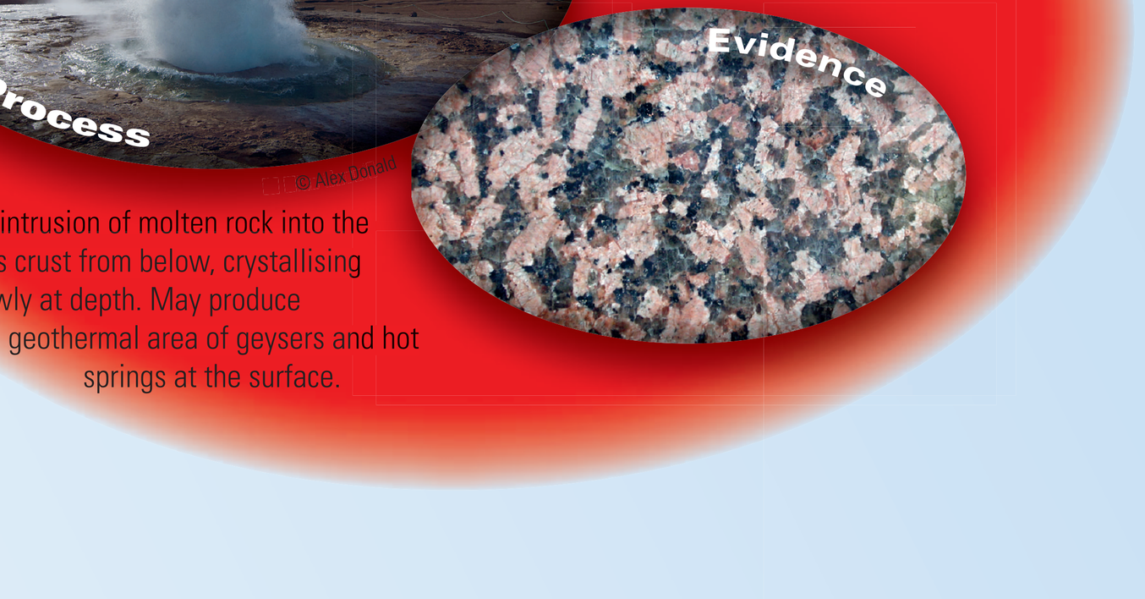
Ancient mountains



Evidence: schist and gneiss are formed by the metamorphism of existing rocks and are often deformed and folded with new minerals, such as garnet, growing. Examples include the 'Lewisian' rocks of the North-West Highlands of Scotland (Archaean).

Process: ancient rocks of varied origin, deformed and baked under high temperatures and pressures during collision of Earth's tectonic plates, forming the roots of mountain ranges.

Igneous intrusions



Evidence: coarse-grained granite and gabbro are evidence that magma crystallised slowly beneath the Earth's surface. For example Cairngorm Mountains, Donegal, south Connemara (Silurian to Devonian) and Dartmoor (Carboniferous to Permian).

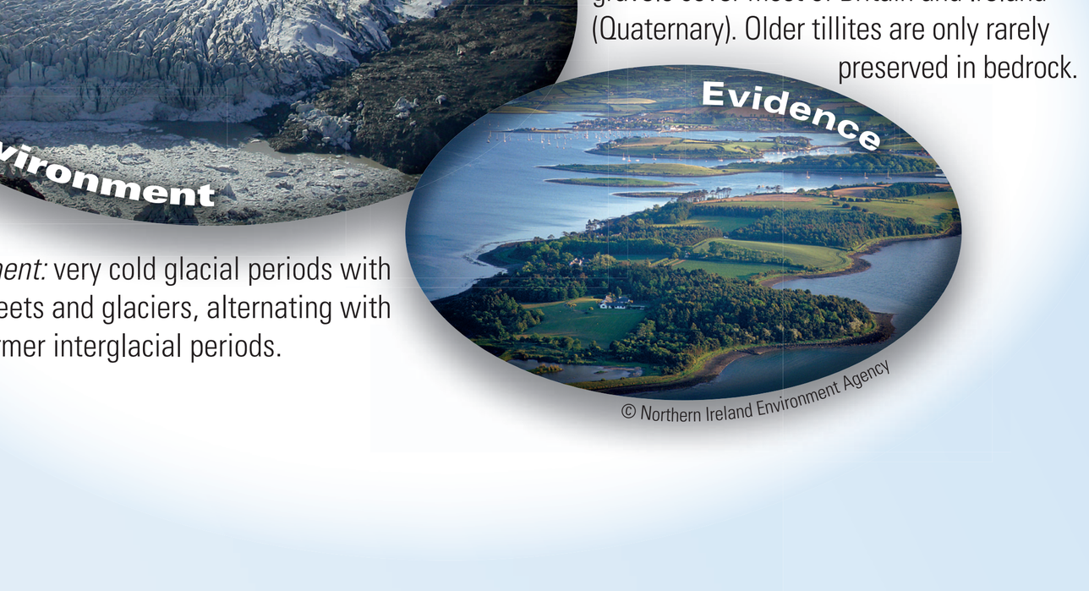
Process: intrusion of molten rock into the Earth's crust from below, crystallising slowly at depth. May produce geothermal area of geysers and hot springs at the surface.

Tropical swamps, rivers and seas

Evidence: sandstone, mudstone and coal. Beds rich in marine fossils alternate with beds containing land and freshwater species. Examples include South Wales, the Midland Valley (Carboniferous) and the Weald (Cretaceous).

Environment: tropical swamps, rivers and shallow seas. Sand and mud accumulate in layers, sometimes rich in plant remains.

Ice ages



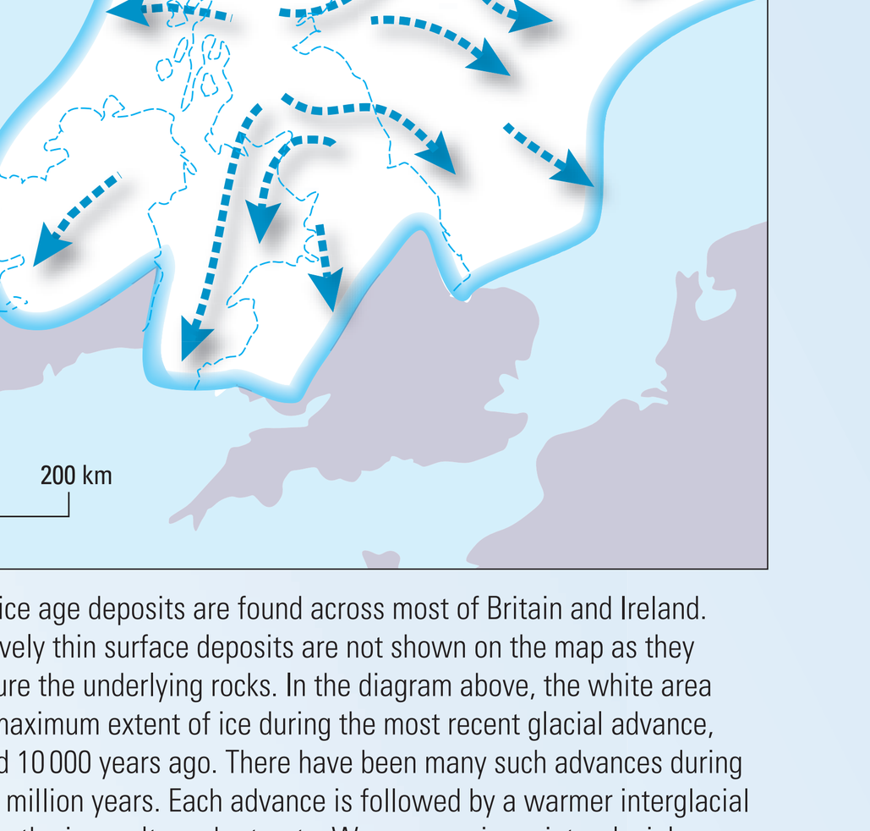
Evidence: rock surfaces polished and grooved by ice; U-shaped valleys and corries eroded by glaciers; drumlins moulded out of glacial debris; eskers formed by meltwaters; tills, sands and gravels cover most of Britain and Ireland (Quaternary). Older tillites are only rarely preserved in bedrock.

Environment: very cold glacial periods with ice sheets and glaciers, alternating with warmer interglacial periods.

Warm seas

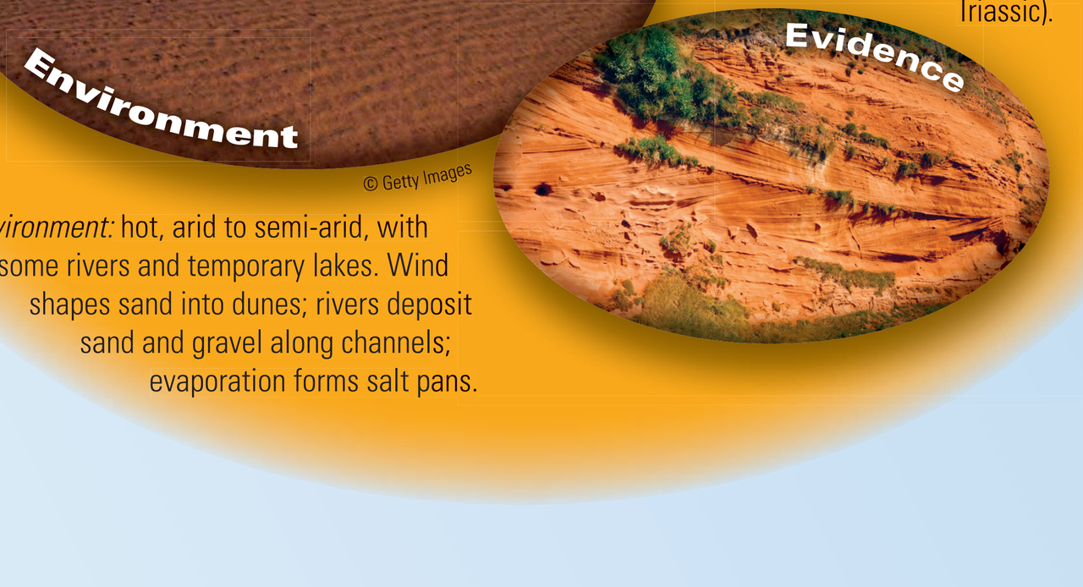
Evidence: sandstone, mudstone and limestone (including chalk), containing abundant fossils of warm-water species. For example Central Plain of Ireland, Peak District and Pennines (Carboniferous); North and South Downs (Cretaceous).

Environment: warm, shallow to deep seas. Sand, mud and calcareous 'oozes' accumulate and reefs build up.



Quaternary ice age deposits are found across most of Britain and Ireland. These relatively thin surface deposits are not shown on the map as they would obscure the underlying rocks. In the diagram above, the white area shows the maximum extent of ice during the most recent glacial advance, which ended 10 000 years ago. There have been many such advances during the past 2.6 million years. Each advance is followed by a warmer interglacial period, when the ice melts and retreats. We are now in an interglacial period — a temperate phase within a continuing ice age.

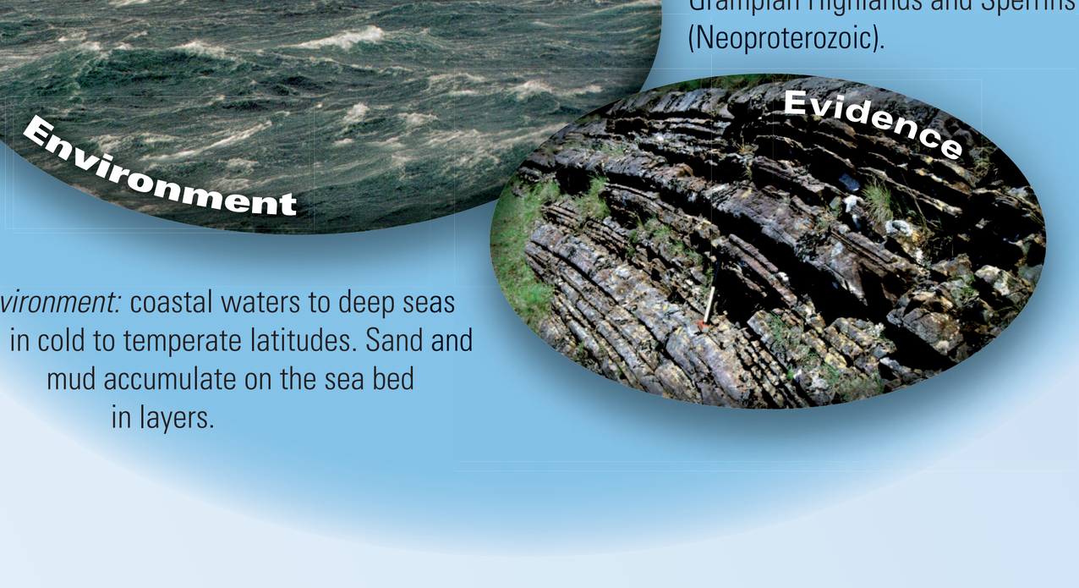
Deserts



Evidence: desert dunes are preserved as 'cross-bedded' sandstones with a rusty red colour. Desiccation cracks, salt and gypsum deposits indicate an arid climate. Examples are seen in Cork and Kerry (Devonian) and Cheshire (Permian to Triassic).

Environment: hot, arid to semi-arid, with some rivers and temporary lakes. Wind shapes sand into dunes; rivers deposit sand and gravel along channels; evaporation forms salt pans.

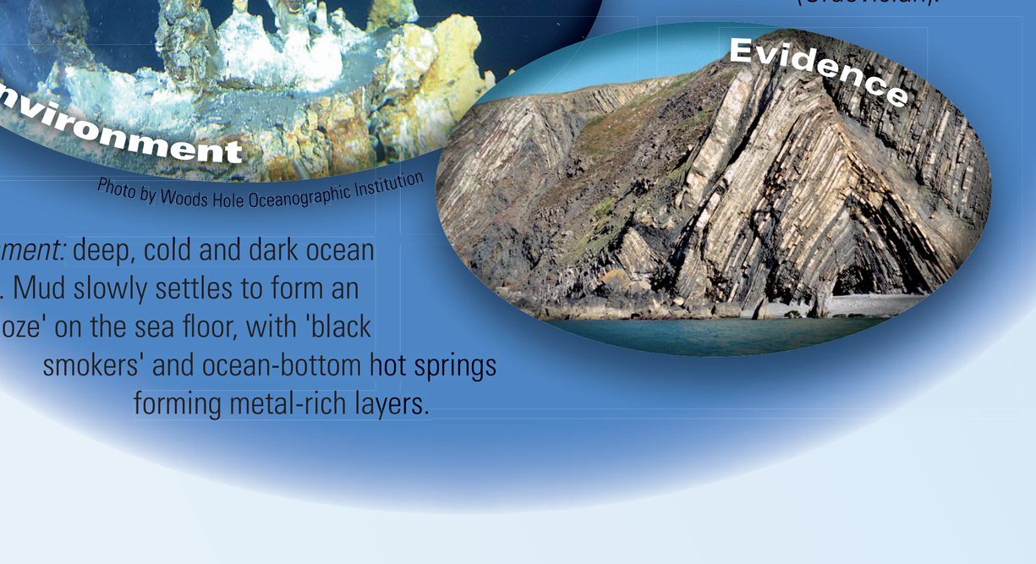
Cold and temperate seas



Evidence: sandstone and mudstone containing fossils of marine plants and animals, for example Central Wales and Southern Uplands (Ordovician to Silurian); Grampian Highlands and Sperrins (Neoproterozoic).

Environment: coastal waters to deep seas in cold to temperate latitudes. Sand and mud accumulate on the sea bed in layers.

Ocean depths



Evidence: thick sequences of fine-grained sedimentary rocks, mainly mudstone, containing fossils such as graptolites and trilobites. Examples are found in North Wales (Cambrian); Wicklow–Wexford (Ordovician).

Environment: deep, cold and dark ocean floor. Mud slowly settles to form an 'ooze' on the sea floor, with 'black smokers' and ocean-bottom hot springs forming metal-rich layers.

Sea level

The **blue curve*** shows the average sea level compared to its present level for the whole Earth through geological time. This global sea-level may be affected by, for example, changes in the volume of water in the oceans or the changing shape of the ocean basins. However, relative sea-level changes affecting Britain and Ireland may have differed markedly from this 'global' curve. For example, there are localised vertical changes of the land caused by the movement and interaction of the plates that make the Earth's crust, and by the formation and melting of ice-sheets. We cannot measure sea level in the ancient past directly, and a variety of techniques are used to estimate it, including the evidence of erosion by the sea, and fossil reefs approximating to sea level.

* *The sea-level curve is simplified from one compiled by Joel Collins (1996 to 1998) for the article 'The carbonate analogs through time (CATT) hypothesis and the global atlas of carbonate fields. A systematic and predictive look at Phanerozoic carbonate systems' found in the SEPM (Society for Sedimentary geology) Special publication, No 89. 2008. 'Controls on carbonate platform and reef development' edited by Jeff Lukasik and J A T Simo.*

Temperature

The **red curve**† shows the average global temperature back to the Cambrian period. We cannot directly measure past temperatures, instead we use evidence preserved in the rocks that records temperature in a predictable way. One such method uses the proportion of the oxygen-18 isotope found in carbonate fossil shells; a high oxygen-18 content is associated with cold sea temperatures and times of glaciation.

The white 'bars' next to the curves shows ice ages — when ice caps covered the polar regions. Note that although the Earth experienced an ice age during the Permian, Britain and Ireland were enjoying tropical conditions.

† *The temperature curve is derived from the article 'Celestial driver of Phanerozoic climate?' by Nir J Saviv and Jan Veizer published in July 2003 in the journal GSA Today.*

Globes

The **reconstructed globes** show how the continents have moved across the surface of the Earth through geological time as a result of plate tectonic activity, variously splitting apart and reassembling elsewhere in changing patterns.

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The timeline before 542 million years is not drawn to scale but condensed to fit the poster. Time gaps indicate where the rock sequence is incomplete.

Phases of:
- Volcanic eruptions
- Igneous intrusions
- Mountain building

Colour banding on the timeline indicates the predominant environment or process.

Typical examples of life-forms preserved as fossils in the rocks of Britain and Ireland.

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