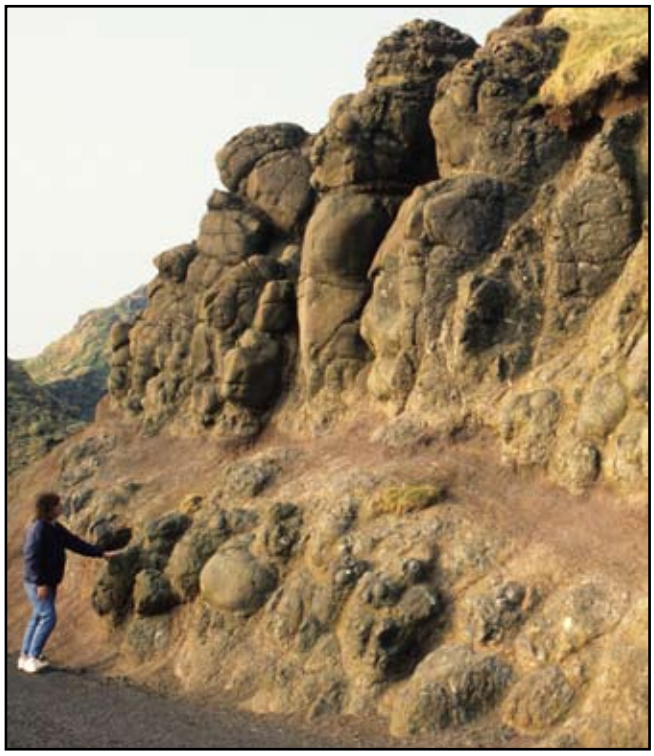
HOLIDAY GEOLOGY

Giant's Causeway

In geological terms, the United Kingdom has made its mark on the world scene with its history of the science and consequently with some of the nomenclature, though its small size gives it little chance to offer world-beating sites. The Giant's Causeway, on the northern coast of Northern Ireland has neither the largest nor the tallest basalt columns in the world. However, its magnificent columns are so well exposed, so numerous and with so many of them perfectly formed that it can lay claim to being an unbeatable geological site. It is the World Number One that is nearest to the East Midlands, and if you have not already been there, it is well worth the journey.

Columns at the end of the Middle Causeway.

The Causeway lies on the eroded northern edge of the extensive pile of Palaeogene flood basalts that form the Antrim Plateau. Cliffs at the site expose three major rock units, but great ramps of grass-covered scree obscure the relationships, which are not just of three parallel beds.

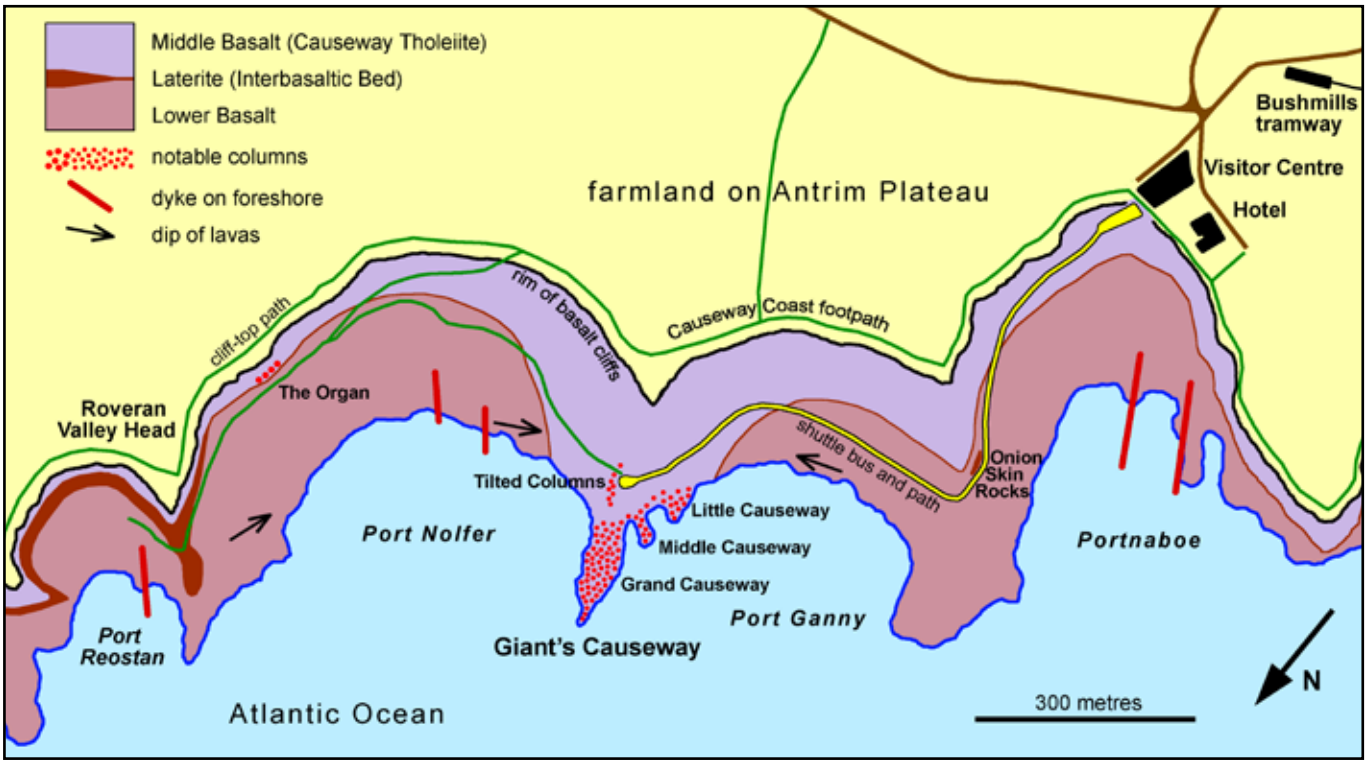


Onion Skin Rocks, formed by spheroidal weathering of the Lower Basalt just below the laterite horizon.

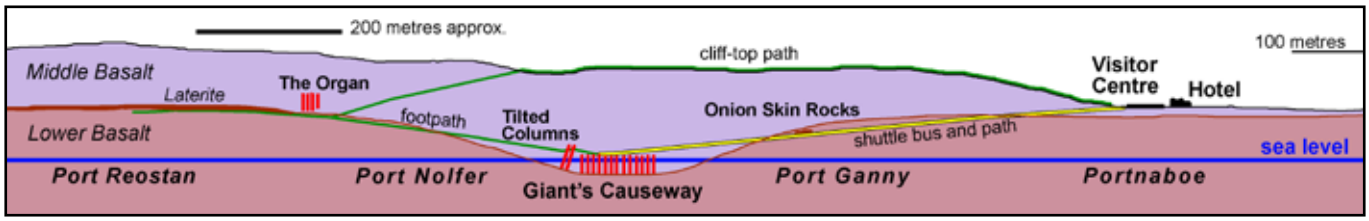
The oldest unit is the Lower Basalts, dating from around 61 Ma and formed of a series of flows that are not generally with columnar jointing. Some of it is notable for its spheroidal weathering, which developed largely beneath a soil cover during the many thousands of years before the first lavas of the Middle Basalts were produced. This weathering is well exposed at Onion Skin Rocks, beside the road and path from the Visitor Centre down to the Causeway.

Separating the two basalt sequences is a unit of laterite (previously known as the Interbasaltic Bed, and now formally known as the Port na Spaniagh Member). This is up to 20 metres thick where it forms a conspicuous

View from the Middle Causeway, with people on the Grand Causeway and the headlands of Port Reostan in the distance.



Simplified geological map of the coast around the Giant's Causeway, showing only those features that are relevant to this text.

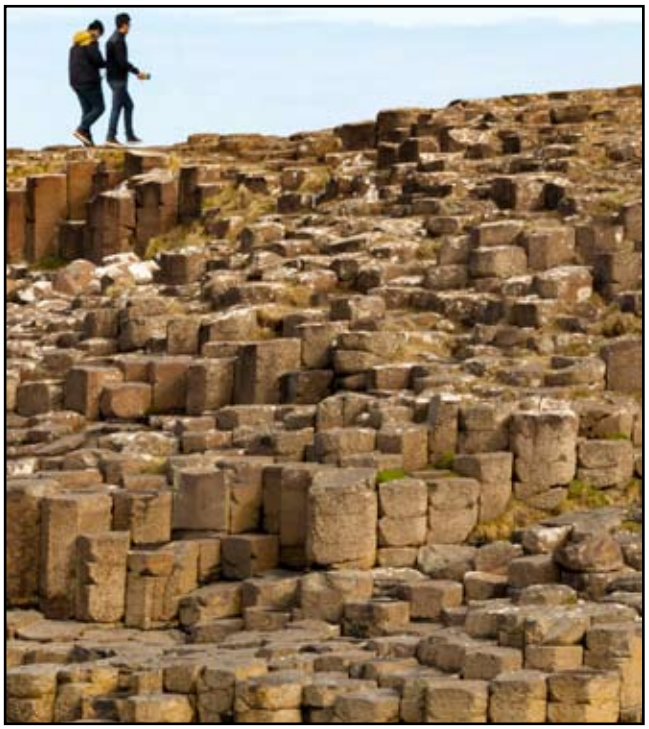


Sketch profile of the geology around the Giant's Causeway, effectively a view of the cliffs as they would be seen from a passing boat, but with the Causeway columns and geology extending below sea level.

orange layer in the cliffs east of the Causeway, though is thinner and largely hidden by screes elsewhere. It developed by prolonged humid weathering of the upper flows of the Lower Basalts.

The Middle Basalts (also known as the Causeway Tholeiite) is the unit with the columns, and is again formed of multiple flows, these dating from around 60 Ma. The local cliff tops are formed of nearly horizontal Middle Basalts, which generally have their base at about 50 metres above sea level. Except at the Causeway, where this base of the Middle Basalts descends to below sea level, and the lowest of its lava flows reaches more than 70 metres thick. This is where the best of the columns are the 40,000 or so exposed to form the actual Giant's Causeway just above the level of high-tide. For many years this local thickening of the Middle Basalts has been ascribed to the filling of a palaeo-valley that had been cut into the Lower Basalts by fluvial erosion between eruption events.

However, the site has recently been re-interpreted by Mike Simms (Subsidence, not erosion: revisiting the emplacement environment of the Giant's Causeway, Northern Ireland, 2021, *Proc. Geologists' Association*, v. 132, pp. 537-548, doi.org/10.1016/j.



Some of the finest columns on the Grand Causeway.

pgeola.2021.07.001). His diligent mapping of the rounded and eroded Lower Basalts exposed along the foreshore has revealed that they dip towards the Causeway on both of its flanks by as much as 15° or 20°. There is no erosion of any valley into horizontal Lower Basalts. Instead a limited area of the entire sequence of older lavas subsided prior to the Middle Basalts filling in the newly-formed depression. The Giant's Causeway occupies the heart of this subsidence bowl, which appears to be at least 800 metres across (though its limits are obscured out to sea and beneath the cliffs). Dips are difficult to discern in the subsided lavas, but some measure of the profile of the floor of what became a lava lake can be seen in the orientation of the columns, which developed at right angles to the cool rock floor. Columns are vertical in most of the Causeway, above the central level floor; but the Tilted Columns are inclined at 15° because they rise from the sloping floor near the edge of the subsidence bowl.

The Tilted Columns, which formed at this angle perpendicular to the sloping floor of the subsidence bowl.

To explain the origins of the Causeway's lava pond, Mike Simms neatly discredits the previous story of a fluvial valley, and then eliminates all but one of the processes that could cause the local ground subsidence. Largely on the basis of size and shape of the subsidence bowl, he ascribes it to the draining of a magma reservoir some few hundred metres directly beneath. There is some evidence for prior inflation when magma intruded the underlying mudstones, but a magma reservoir at that depth would commonly be a transient feature. It is likely that magma escaped from this reservoir and caused the 50 metres of ground subsidence within just a few days, as part of the same eruptive phase that produced the lavas that flowed into, and ponded within, the subsidence bowl. Ponding of the lava provided optimum conditions for the columns to form as they cooled past the critical temperature of a little below 900°C when shrinkage fractures develop.

Many of the columns on the Causeway are beautifully regular. Each is bounded by contraction fractures that developed around a cooling centre, which then extended as the cooling front migrated into the hotter core of the lava flow, so that the columns grew along their lengths. They grew upwards from the cold floor of the flow. Other, generally less perfect, columns grew downwards from a top surface cooled by the atmosphere and rainfall, as can be seen high in some of the cliffs above the Causeway. About half of the columns at the Causeway have six sides, but not all of those are the regular hexagons that would form where cooling centres have optimum, uniform spacing. Columns are broken by cross joints, of which nearly all are curved, so they are known as ball-and-socket joints. These also originate from cooling shrinkage, and it would be logical to expect the curvature to relate to the direction of cooling. However, the many joints exposed to form column tops on the Causeway have a random distribution of concave against convex curvature, and this currently remains unexplained.

The Causeway is accessible from the cliff-top road-head and Visitor Centre, with the old road down to the shore now restricted to walkers and a shuttle bus. This offers an enjoyable stroll of a kilometre that descends gently some 50 metres to end right in front of the three

One perfect hexagonal column among many polygonal columns; the boot gives scale.

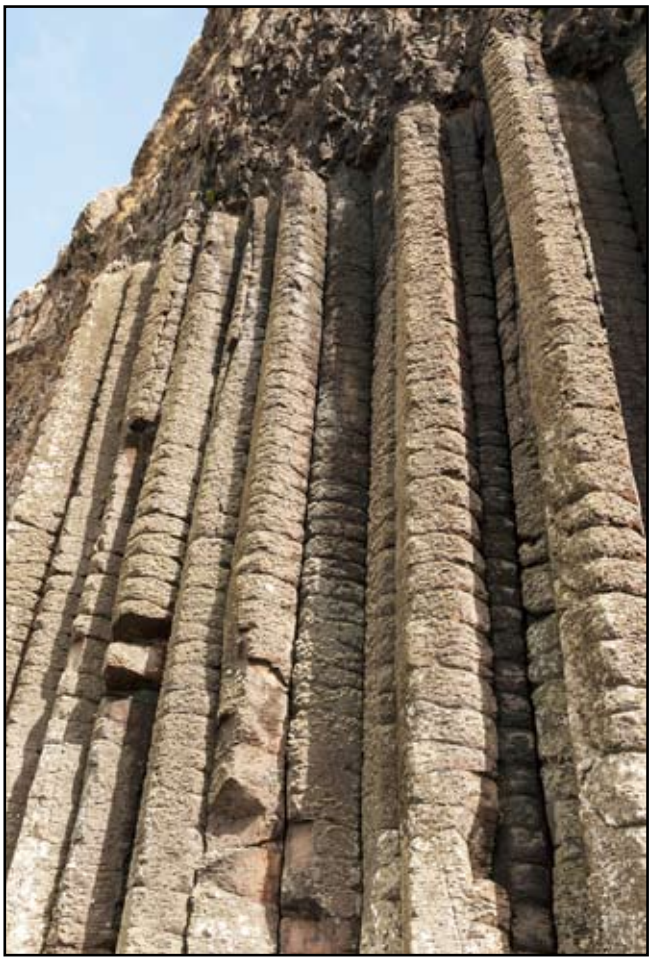
Nearly perfect columns on the Grand Causeway.

Giant's Causeway seen from the top of the cliffs; Little Causeway is on the left partly covered by surf, Middle Causeway is the short headland in the centre, Grand Causeway is on the right, and the Tilted Columns are bottom right.

mini-headlands that constitute the Causeway. The Grand Causeway to the east is the most extensive and has the most perfect columns; the Middle Causeway is the one in the classic photographs, and the Little Causeway to the west may be largely awash at high tide. It is a delight to walk out over them, and they largely remain pristine apart from a little polishing by visitors' footfall.

The return walk is easy enough, or can be avoided by taking the shuttle bus. A rewarding longer walk is on good footpaths east from the foreshore end of the old road, and offers escape from the crowds even on the busiest of days. The path cuts through the Tilted Columns, then rises gently across scree slopes, passing beneath the 12-metre-tall columns of The Organ, until it reaches the level of the laterite between the lava groups. There are great views from the corner below Roveran Valley Head, but the vertiginous path beyond has been closed for many years due to rockfalls and landslides along the terraced cliffs. The return walk is best on the path that rises to the top of the cliffs west of The Organ. This gives a different view down to the Causeway, and then descends gently back to the Visitor Centre.

Whereas the Giant's Causeway is undoubtedly a magnificent geo-site, it is sad that it is marred by the appalling new Visitor Centre, dating from 2012. The grass-roofed building is architecturally commendable in the way it is almost lost into the landscape. The tragedy is its contents, which have been dumbed down to the level of awfulness. The Centre is largely



Tall columns forming The Organ.

a shop full of tourist-tat and the ubiquitous cafe, along with various displays of trivia. Minimal information on the geology is overshadowed by endless details of mythological rubbish about the non-existent Finn McCool. Initially, there was even a horribly politically-correct panel on the Creationist viewpoint, but this has since been removed. Visitors are likely to come away believing the nonsense legends more than learning the real story of volcanoes, lavas and world-beating basalt columns. This is not appropriate for a World Heritage Site. The current visitor hand-out is a footpath guide with almost no mention of volcanoes. A version from 1982 was twice the size; maybe it lacked in style, but it provided a wealth of data on the geology and natural history of the site. Replacing geology with legends is not progress.

The Causeway's footpaths are public rights-of-way, with free access, and the only fee sites are the car park and the Visitor Centre. However, both on-line and at the site, the National Trust does everything possible to confuse visitors and drive them towards paying large fees. Best is to park a car somewhere else, walk a few kilometres, and avoid the dreadful Visitor Centre.

A major tourist site, with the obligatory selfie.

Besides the Causeway there is a wealth of other features along the splendid Antrim Coast Road. Quarries in the Causeway area have yielded plenty of basalt columns that now adorn the local houses and gardens. Not to be missed is a terrace of cottages in Bushmills, alongside the road to the Causeway, with hexagonal columns used as pre-formed window sills.

A little farther west, Portrush has its own gem of geological history. The town stands on a low headland formed by the dolerite of the Portrush Sill. Its eastern foreshore exposes the sill and the overlying country rock of Liassic mudstone, which has been baked to a hornfels. That fine-grained black rock looks rather like the chilled margins and basaltic stringers of the sill, but also very like the finer-grained of the Antrim basalts. Furthermore, the hornfels contains recognisable ammonites, mainly *Paltechioceras*. When these were first seen in 1799, arguments were at a height between

Cottages in Bushmills with basalt columns as ready-made window sills.

Fine-grained dolerite of the Portrush Sill above Liassic mudstone that was baked by the intrusion to look very similar, except for its ammonites (bottom right).

Neptunists and Vulcanists over the origin of lava (at a time when few, if any, of the arguing geologists had ever left the shores of Britain to see a volcano). The Portrush hornfels was then misinterpreted as basalt, and the Neptunists seized upon the ammonites as proof that lavas were sedimentary. It did not take long before Vulcanists visited the site and correctly re-interpreted the ammonites' host rock as baked mudstone. Ammonites are still visible on the foreshore just below the car-park, which is now a protected site where any collecting would be illegal and highly inappropriate. Portrush is a classic site to complement a visit to the Giant's Causeway.

Tony Waltham