East Antrim U3A geology group report – Glenoe 2nd August 2022

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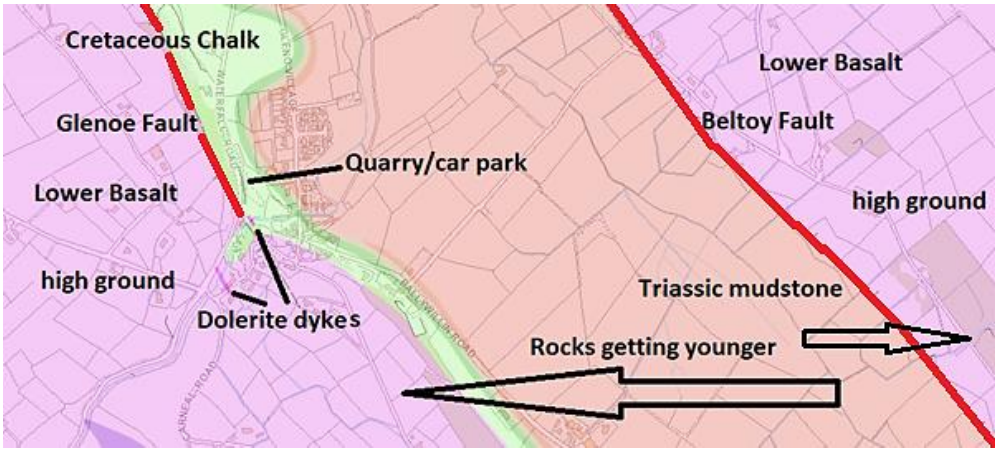
Links to all previous excursion reports can be found at https://eau3a.org.uk/geology/ (scroll down web page)

We met up at the National Trust car park off Waterfall Road. The car park is in the floor of a former limestone quarry.

The ‘plan’ was to look at the effect of major faulting on the general landscape. The nearby quarry face provided material to discuss the formation of the chalk (high purity limestone) and also the flint contained within it. Then a walk towards the waterfall to look at an unusual dolerite dyke in the chalk – as we walked from here towards the waterfall we noted the change in rock without us changing level from chalk to basalt noting that there must be a substantial fault in that area. We walked up the steps and crossed the road to look at more chalk but in particular some of the first basalt flows of the Lower Basalts and the zeolite minerals contained within the rock. We retraced our steps then walked into the village, passing a very unusual large piece of chalk (and accompanying range of alpine plants). Finally a walk along Ballywillan Road gave us a chance to look at chalk kilns and talk about their importance.

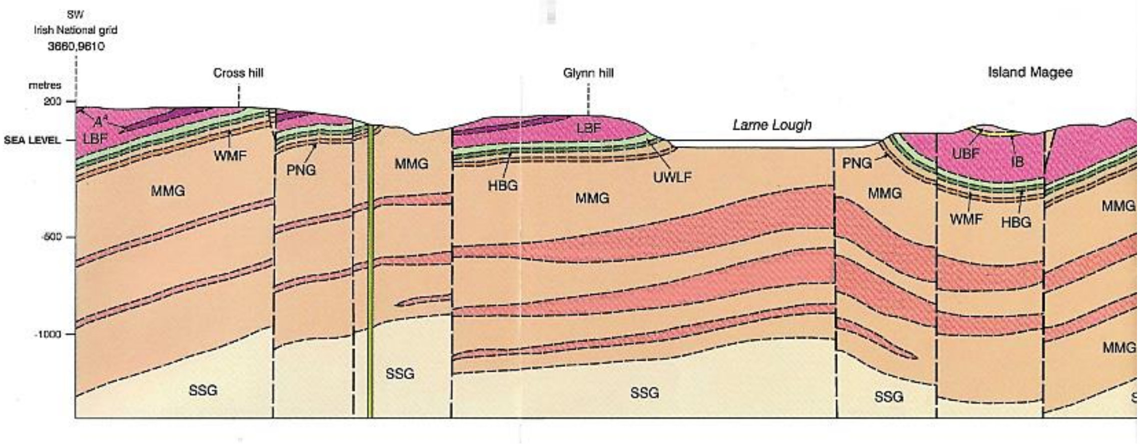
Faulting and landscape



The summary solid geology map is shown above. Standing at the picnic area we had a clear view of the landscape to the east. Comparing this with the geology map, we can see that the flat valley floor equates to the Triassic mudstone while the high ground beyond is formed by Lower Basalt. That tells 2 things – firstly that the usual rock series is not present (we are missing the Upper Triassic – Penarth – the Jurassic and all of the Cretaceous series) and secondly the terrain matches is explained by each rocks resistance to weathering/erosion – the soft mudstones occupying the valley floor and the more resistant basalts forming the higher ground. But why are the intervening rocks missing? The reason is due to movement along the major Beltoy Fault. Mainly vertical movement along the line of fault means that the ground east of the fault ‘downthrown’ bringing the Lower Basalt down to the approximate level of the Mudstones. The usual rock series will be present below the Basalt but everything above Mudstones has been eroded away.

Ground again rises to the west of the car park but here the fault line (the Glenoe Fault) retains the full pre-basalt rock series bringing the Basalt up against the chalk – vertical displacement will have been less on this side of the valley.

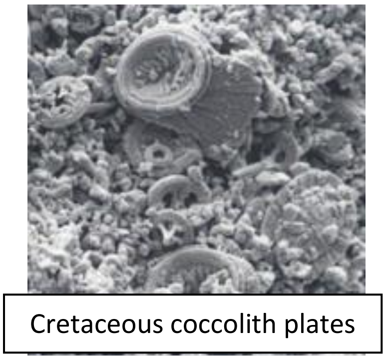
Movement along these faults will have been gradual. A cross section of the Larne map from west of Glenoe to Islandmagee, shows a series of these faulted blocks, typically with the ‘downthrow’ to the east making the Glenoe fault an exception. An estimation of total movement along the faults can be estimated – in some cases this exceeds many 10’s of meters – perhaps around 100m in some cases.



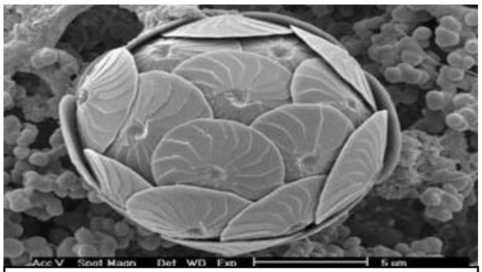
Faulting is thought to mainly date to the period of basalt eruptions, especially the period post dating this activity. This may relate to large scale movements related to the continued opening of the North Atlantic but also to more localised 'settling' as ground above now empty magma chambers at shallow depth collapsed. At least some of the faults represent older, reactivated faults i.e. existing areas of weakness.

Chalk and Flint

We have dealt with the pre-chalk rocks in other excursions and they really are not easily seen at Glenoe. We have also 'done' chalk (see the Portmuck report) before but a quick recap never does any harm!



Cretaceous coccolith plates

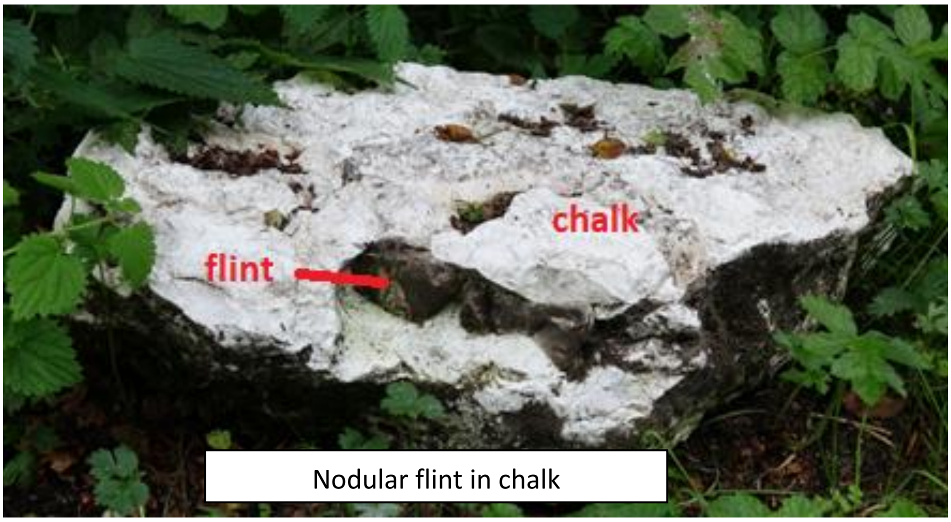


Modern coccolithophore

Cretaceous white limestone can be seen in the old quarry face in the car park. The chalk formed in a warm seas, the result of a progressive increase in global sea-levels. The reason for this global increase is unclear. The ocean was very productive, dominated by microscopic algae called coccolithophores. These algae formed protective plates made of calcium carbonate called coccoliths. When the plant died, the plates fell to the sea floor where enormous thicknesses accumulated, eventually forming the chalk we see today. The chalk is more formally known as the Ulster White Limestone. Mainly present today in NE Ireland, there is evidence that these Cretaceous seas were present over most of Ireland, at least part of the time. The limestone elsewhere was subsequently eroded, but was preserved in the north-east by the presence of the overlying basalts.

Chalk outcrop – quarry face

The other rock type, present in the chalk, is flint. Its presence raises some interesting questions, namely what is it, how did it get there and where did the material come from that constitutes the flint.



Nodular flint in chalk

This really has been a 'head scratcher' for geologists for a long time and there is probably more to learn. As noted above, the Ulster White Limestone (chalk) is mainly made of calcium carbonate. In contrast flint is 100% silica – not a bit of calcium carbonate. So where did the silica come from? Through detailed analysis of fossil fragments in the chalk, we know that sponges were abundant at various times in these Cretaceous seas. These sponges had a skeletal structures made of silica spicules which provide structural support and also a defence against predators (it would be like eating glass). Under certain chemical conditions on the seabed, silica from dead sponges fragments can go into solution. A range of other marine organisms would also have contributed silica to the marine environment.

This seabed was covered in carbonate muds, formed mainly from the 'rain' of dead and fragmented coccolithophores. As material accumulated, burrowing creatures excavated chambers. These were subsequently infilled by finer sediment and, as they were buried by more material from above, decomposition of organic material in sediments, reduced and eventually exhausted the oxygen content. The chemical reactions were complex – see below if you want to know more – but suffice to say in these conditions silica in seawater infiltrated micro spaces in the sediment. When it reached the oxygen depleted zone, the silica came out of solution and replaced the sediment infilling the former burrows grain by grain. This explains the formation of nodular flint – we saw flint partially infilling a burrow at the roadside section above the disused quarry. The fact that flint forms after the chalk explains why fossils can be found part entombed in chalk and part in flint. By the way, flint is a form of quartz.

Flint can take other forms - tabular (laterally extensive flint bands that resemble a very large table top) and the strange giant flints known as paramoudras (a name originating from an encounter between visiting English geologists and Irish speaking quarrymen in the Belfast Hills – whatever the quarrymen were saying with regard to these giant, cylindrical flints when asked about them by the geologists, was duly written down and is now part of the geological lexicon).

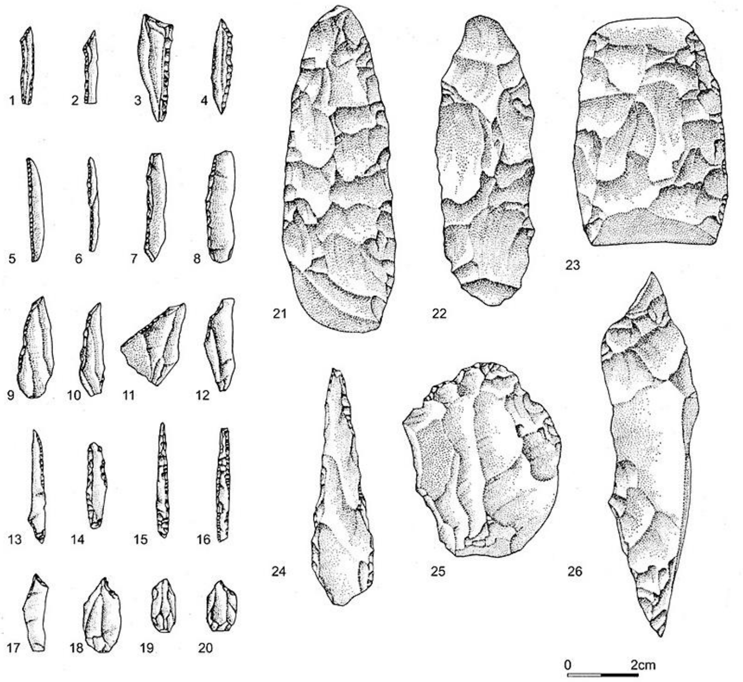
Cylindrical paramoudra flint

Bands of nodular flint

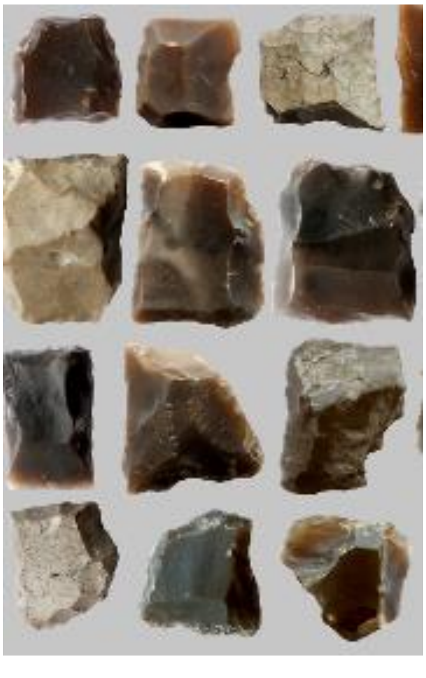
Flint – what is it good for?

Flint has had a marked influence on early human movements, settlement patterns and technology. This was a key raw material for early (Mesolithic and Neolithic) settlers. These people where highly skilled in working flint to produce a range of tools used in their daily chores.

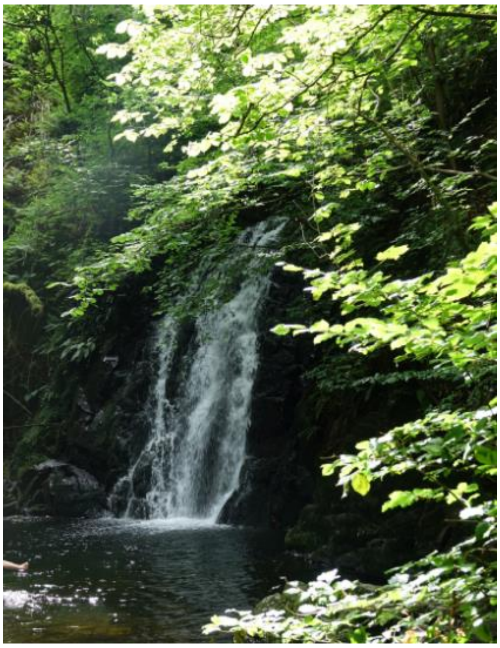
More recently flints were used as a key element in flint-lock weapons



Range of Mesolithic flint tools from Mount Sandel; 1-20 microliths and related forms; 21-3 & 26 axes and related forms; 24 micro awl; 24 scraper



Next stop was just after the bridge where a vertical recess was evident in the rocks. While a lot of the rock was covered in the geologists number one enemy (vegetation) we could see the contrast between white rocks (chalk) on either side of the 'slot' and the dark rock within. The dark rock was dolerite – intruded into the chalk as a vertical sheet dyke (we have seen these intrusions at a number of other sites). This may have been a 'feeder' taking molten magma to the surface where it would have been erupted as a lava flow. As the feeder loses pressure (no additional material being pumped from below), residual magma fills the fissure, cools and solidifies. Here, unusually, the dolerite has been less resistant to erosion than the chalk, leaving the latter standing out and the former worn back. The magma making its way up the fissure would have been at a temperature of 1000^{0}C – hot enough to alter the adjoining chalk. This thermal metamorphism has converted the chalk to marble but only for a distance of a few cms from the intrusion – this will then be an example of thermal contact metamorphism.



As we walked towards the waterfall, it was clear (despite the vegetation) that the rock next to the path had gone from chalk to basalt. Clearly the main fault on this side of the valley (the Glenoe Fault) cuts through this area bringing the basalt down to the level of the chalk.

The waterfall shows well the stepped nature of the successive lava flows making up the basalt series with each flow boundary marked by a horizontal levelling out of the river.

Next we took to the steps to the top and crossed the road to have a look at the rock outcrop (cleared as part of road works but now succumbing to the inevitable colonisation of plants. Here we looked at the basalt with (limited) outcrop of chalk nearby suggesting that the basalt is the first flow of the Lower Basalt in this area. Basalt formed from cooling lava flows – the lava being erupted through fissures – the latter marked by the presence of dykes. The first flow will then have been erupted and flowed over the weathered chalk surface. This surface will have been vegetated, probably also with damp (soils) or other wet areas (ponds or streams). The lava will have been erupted at temperatures of 1000^{0}C, so when this comes in contact with organic material or moisture/water, there is going to be an interesting interaction with any water being instantly vaporised and organic material being incinerated – all of which generates a lot of gas. The basalt was initially very crumbly (referred to by geologists as a rubbly bottom) but became more intact/competent higher up the basalt pile. The rubbly bottom was then filled with gas filled bubbles or small pipes, trapped as the lava cooled. These voids later became the site for crystals to develop, formed as warm mineral rich waters circulated through the basalt, gradually cooling to the point where minerals came out of solution. These minerals were mainly different forms of zeolite for which the Antrim Basalts are internationally famous. While zeolites can be a challenge to identify in the hand, we did see specimens which had a radiating needle form – these were Natrolite – not quite of the quality shown here. We discussed zeolites in more detail at Black Head.

Natrolite

We retraced our steps down to the river, crossing the bridge and stopping at the front garden belonging to the former production site for Mauds Ice Cream – now a private house.

A peculiar lump of limestone was the centrepiece of the garden adorned with a range of alpine plants including Eidleweiss! The limestone could easily be identified as Cretaceous chalk and so is likely to have been of local origins. What made it so unusual was the nature of the surface weathering – a range of features known as water worn limestone. More typically found developed on the older Carboniferous limestones of Fermanagh and in particular the Burren, your leader was unaware of any instances where this could be found on our younger chalk. As the name suggests these features are formed by the action of rainfall (slightly acidic from dissolving CO_2 as it falls through the air) on the base rich (calcium carbonate) chalk. Cracks are enlarged to develop channels known as grykes, separated by remnant upstanding sections called clints. The block probably formed part of the original chalk surface prior to quarrying and was set aside for its ornamental value.

In situ waterworn limestone has been badly impacted by human activity, through quarrying but also from the gardening sector. When a rockery was the must have component in gardens great and small, huge quantities of water worn limestone were quarried out (a practise that unfortunately continues today in places) destroying a rare and remarkable habitats. The areas of waterworn limestone in Ireland and Britain (and some in Sweden) appear to have a unique origin. Glacial activity over these limestone areas left behind shallow soils. These became naturally vegetated eventually supporting scrub woodland or forest. The action of acids generated from decaying vegetation, combined with the natural carbonic acid (rain) accelerated the rate of desolution of the buried limestone. Along came our first farmers who cleared the woodland leaving the exposed soils vulnerable to erosion. This slowly resulted in huge areas of former woodland and scrub being 'converted' to amazing waterworn limestone (also known as limestone pavement) that we now value so highly.

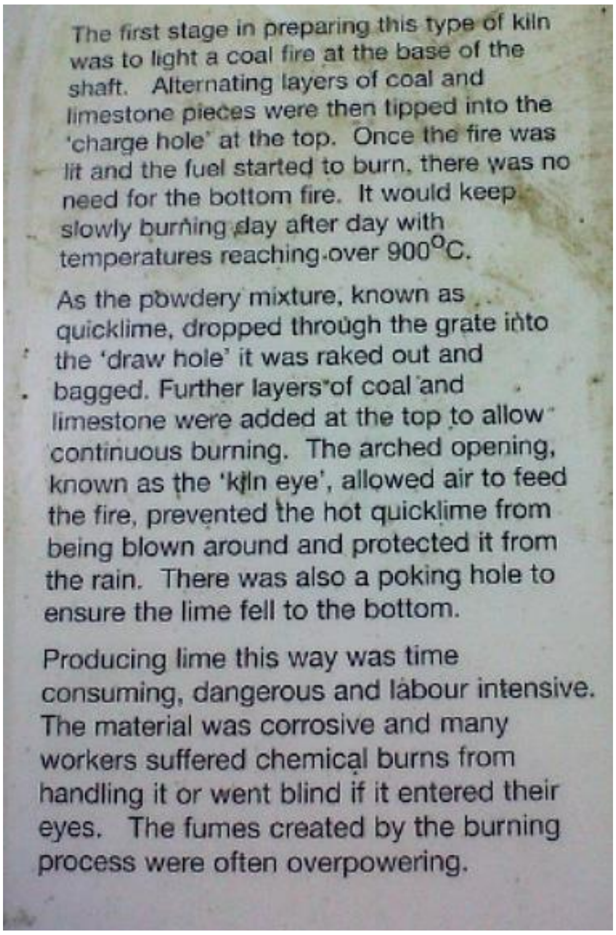
Limestone pavement, Co. Fermanagh

Our final stop was at the disused lime kilns on Ballywillan Road.

Built in a range of forms and sizes, kilns such as these can be found anywhere that the Ulster White Limestone is present and suitable for quarrying. Kilns are particularly abundant around the coast. The kilns were used to 'burn' limestone – heating it to produce lime [$CaCO_3$ (limestone) -> CaO (lime also known as quicklime) + CO_2 (gas)]. The resultant lime had many uses including direct application to agricultural land to reduce soil acidity. It continues to be important in cement and concrete production. When water is added, slaked lime results which has been used as a mortar, plaster and whitewash.

The functioning of a kiln is outlined below – these excellent information panels can be seen beside the kilns at Carnfunnock Country Park.

To simplify filling the kilns (charging) they were typically built into a hillside to allow limestone and coal to be directly discharged into the top.



The first stage in preparing this type of kiln was to light a coal fire at the base of the shaft. Alternating layers of coal and limestone pieces were then tipped into the 'charge hole' at the top. Once the fire was lit and the fuel started to burn, there was no need for the bottom fire. It would keep slowly burning day after day with temperatures reaching over 900°C.

As the powdery mixture, known as quicklime, dropped through the grate into the 'draw hole' it was raked out and bagged. Further layers of coal and limestone were added at the top to allow continuous burning. The arched opening, known as the 'kiln eye', allowed air to feed the fire, prevented the hot quicklime from being blown around and protected it from the rain. There was also a poking hole to ensure the lime fell to the bottom.

Producing lime this way was time consuming, dangerous and labour intensive. The material was corrosive and many workers suffered chemical burns from handling it or went blind if it entered their eyes. The fumes created by the burning process were often overpowering.

The location of many limestone quarries and kilns around the coast is related to one of the main export markets – western Scotland. With limited supplies of coal available locally, ships taking untreated limestone and lime + related products out would return with coal. The distribution of Southern Scotland's coalfields shown below made this exchange of goods relatively straightforward. Untreated limestone (probably part crushed) was an important ingredient in iron smelting, the limestone acting as a flux to draw out impurities.

Quarrying and processing of limestone is still an important industry in SE Antrim with major operators at Kilwaughter and Glenarm

More on how flint is formed

Siliceous organisms (sponges and radiolaria/diatoms) manufacture skeletal biogenic opal. On death organic parts decay and the microscopic silica is scattered on the sea bed and becomes incorporated in the accumulating sediment.

At depths of 1 to 5m within this sediment, the biogenic opal breaks down, enriching the water between the sediment particles (sediment pore water) with silica.

At sediment depths of less than 10m, there is an oxic-anoxic boundary where hydrogen sulphide rising from the decomposing organic material within the sediment diffuses upwards meets oxygen diffusing downwards from the water column above. At this interface, the hydrogen sulphide is oxidised to sulphate with hydrogen ions as a by-product. The hydrogen ions lower the local pH, dissolving the chalk and thereby increasing the concentration of carbonate ions. These act as a seeding agent for the precipitation of silica.

Silica precipitates by the molecule-by-molecule replacement of chalk. The silica is initially in the form of crystalline opal but gradually transforms to quartz (flint) during later burial and with time.

The chalk sea bed is deeply burrowed by many different organisms, such as shells, echinoids and worms etc. Some of these burrows are quite deep or branching, or have open living spaces. The burrows fill with sediment after the organism has died, this is slightly different material from the sediment around it. These filled burrows act as preferential pathways (conduits) for the chemical reactions to occur. Flint formed within these old burrows often has a nodular shape which reflects the whole, or part of, overgrown remnants of such burrow systems.

There are two possible explanations for why flint forms in bands or layers. Firstly because chalk sedimentation occurs in cycles and secondly because the process above exhausts the silica within a given depth of sediment and flint formation can only recommence when there is enough silica to start the process again.