CHALK AND FLINTS OF WILTSHIRE

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Chalk together with the Flints is a unique rock in its own right even though seasoned hard rock men and avid fossil collectors may not always display a great enthusiasm for this special Cretaceous sediment. But there can be no particular reason why Chalk should be treated with such contempt within the vast assemblages of rocks and minerals, as if it were something inferior or very dull and uninteresting.

Chalk must certainly be the best known rock in England. It is instantly recognisable and cannot be mistaken for anything else. It is readily identifiable on the geological map as a neat and uncomplicated rock structure; to the beginner of Geology, a real joy. Parts of south Yorkshire and vast areas of southern and eastern England are covered by Chalk. This then extends further to the east into Denmark and to the north German coast.

The continuation of the Chalk into northern France was utilised to build the Channel-tunnel. Any other rock structures would have probably presented considerable difficulties, perhaps not so much technical as financial. Most of the construction followed a synclinal feature through the Chalk-marl underlain by Gault Clay of the Lower Chalk formations. This proved an ideal tunnelling medium and was the deciding factor in its construction. The relatively soft rock displayed no appreciable faulting except for a short stretch on the French side.

Although now firmly linked to mainland Europe by an underwater rail link, the famous brilliant white Chalk cliffs of Dover and the imposing coastal Chalk scenery of the Isle of Wight have nevertheless lost nothing of the independence, romance and emotions to those returning from the continent by sea. Below the waves a land wedded to mainland Europe - but above the sea, Britain is still an island; Geology at its best.

Chalk determines the shape, simplicity and outstanding scenery in a large part of England. The rolling, undulating hills, the deep valleys, the apparent emptiness of the Chalklands seem to retain a precious place in English history and heritage. It is a living, breathing landscape where the present and the chequered past sit side by side in harmony and melt readily and contentedly into one.

And it is also Chalk which forms the most important part of the natural environment here in Wiltshire. Next to the Jurassic rocks it covers nearly two-thirds of the county. Thus Marlborough Downs and Salisbury Plain rising to over 300 metres above the surrounding countryside represent a major part of the local Geology.

Why a soft rock like Chalk can form such hills, such plateaux, and maintain a relative height over thousands of years, defying rapid weathering, may, at first glance, appear a mystery. The answer is found in the porosity of the rock. Rainfall sinks quickly through the various layers leaving insufficient run-off on the surface to aid and accelerate erosion.

But what is the special nature of the rock that can shape these gentle hills with their steep escarpments? What really is Chalk? Where did it come from? A brief journey some 90 million years back into time to the late Cretaceous will yield many clues as to its origin.

Still situated south from its present position, the land which was to form the British Isles was inundated by a sea encroaching slowly into the Wealden Lake. Sea levels were very high due to an increase of volcanic activity on the spreading ocean floor and the total absence of any polar ice caps. Only the highest peaks of the present British landscape like the Lake District, parts of Scotland and Wales and some other features would have risen above the ancient sea levels.

The continents were moving outwards from Eurasia and Gondwanaland, South America separated from Africa. The Atlantic Ocean opened up. Gradually, the dinosaurs became extinct as did ammonites and a host of lesser organisms. They passed from this Earth forever. It was an apparent age of great activity to shape the world we know to-day even though other parts in the life of our Planet were just as vibrant and momentous throughout time.

The untamed forces of geological influences, as well as evolution and extinctions, are an ongoing, never ending process. We are living on a living, moving planet where never ever anything stands still. What is land to-day will be sea to-morrow and what is sea to-day will soon be land again, ad infinitum.

During the late Cretaceous, the advance of the ancient sea which blanketed a large part of Britain had reached its climax. The warm, nearly tropical waters were teeming with a most prolific type of planktonic marine algae called coccospheres. These produced microscopic rosettes of scale-like crystals of calcite inside their structures, resulting in minuscule globules of overlapping rings of scales. The individual rings are called coccoliths. When the algae died their remains sank to the sea floor and formed a white sediment which in time was to become the Chalk we know to-day.

Recent research and the availability of more powerful electron microscopes have, however, indicated that the algae may have been the main food of shrimp-like creatures called copepods. It is thought that for the scales, the coccoliths, to sink to the ocean floor they had to be first consumed and passed through the copepods. In consequence the specks of digested and then excreted food, fine enough to be carried in suspension, eventually built up a dense white ooze on the sea floor to turn millions of years later into Chalk after the land was uplifted once again.

The size of the individual components in the formation of Chalk and the time scales involved are truly impressive. Most of the particles, fossils in their own right with a distinct order and design, are less than one thousandth of a millimetre in size and require a magnification above 5000 times to be visible. Furthermore, the build up rate of Chalk was extremely slow. A mere 25-30 metres in a million years. A time frame of such magnitude equates to a nearly negligible sedimentation rate of only one centimetre in 500 - 800 years or one millimetre in 50 - 80 years! On the human scale of things nearly a non-event. Even fingernails and hair grow faster and the dance of the continents around the globe due to plate tectonic activity seems to be rather rapid in comparison with the deposition of Chalk.

The various Chalk horizons which have been neatly divided into Upper, Middle and Lower Chalk also contain other and slightly larger fossil remains in addition to the planktonic marine algae. Sea urchins, brachiopods, bivalves and belemnites are widespread throughout the Chalk. The Lower Chalk is further supplemented by some sponges and ammonites and the Upper Chalk by some sea lilies, or crinoids, as they are better known.

But there are other micro-organisms which have greatly contributed to the formation of Chalk. Foraminifera of the Protozoa group are a very important constituent and Bryozoa, referred to as creeping sea mats, are another.

For many years, geologists were unable to decide whether Chalk had essentially an organic or inorganic origin. But the arrival of the electron microscope has changed all that - well nearly. It is now thought that the main constituent of Chalk resulted from the extraction of calcium carbonate from seawater by marine algae and the rest contains precipitated calcium carbonate, fine shell material and impurities. But opinions vary greatly. The debate continues as to the exact origin of Chalk.

Chalk is an unadulterated limestone, nearly 98% pure calcium carbonate, a form of calcite, with no modern equivalent forming anywhere in the world. It is soft, permeable, extremely fine-grained and whitish to greyish in colour. Touched with a weak acid it 'fizzes', giving off bubbles of carbon dioxide.

As mentioned above, the great thickness of Chalk deposits have been conveniently separated into Upper, Middle and Lower Chalk determined in the main by the fossil horizons. But nature has provided a further indicator in keeping the three formations apart by placing the hard band of Melbourne Rock between the

Lower and Middle Chalk and the compact Chalk Rock between the Middle and Upper Chalk. (Melbourne is a small village on the Chalk in Cambridgeshire.)

During the start of the upper Cretaceous, most of western Europe was under the sea. The land which was to make England was far away from any rivers which might have brought land-derived sand and clay sediments into the clear waters. Thus the only deposit in the sea at that time came from organic and inorganic processes and from the micro-organisms which were able to extract calcium carbonate from the sea water.

This process, over millions of years, brought about the formation of a very pure limestone we know as Chalk. Its brilliant whiteness is a result of its most unusual purity and the very small particles which increase the rock's reflectivity .

The deposition of Chalk was not a continuous, uninterrupted event during the many millions of years in the Cretaceous. Climate changes and plate tectonic activity would have triggered long periods of sediment removal and non-deposition whilst sea levels were advancing and retreating. Laminations of impurities and hard nodular bands of Chalk rock within the massive Chalk formations bear witness to such turbulent times.

But, as might perhaps be expected, Chalk in its purest form was not immediately deposited at the base of the Lower Chalk formation. There was a gentle transition from land based sediments to Chalk producing a mixture of clay, sands and Chalk known as Chalk marl. However, such transgression in reverse does not exist at the top of the Upper Chalk formation, i.e. from pure Chalk into the overlying sediments. There was a gap of some 20 million years before any further appreciable deposits were draped over the well-eroded pure Chalk surface. Over time, these deposits have also been subjected to erosion and only pockets of clay with flints remain on top of the local Chalk hills.

Pure white Chalk is not a deep sea deposit nor an accumulation in shallow water. The planktonic marine algae required sunlight to thrive. This suggests deposition at a depth of some 200 - 500 metres and far away from any contaminating river or shoreline sedimentation debris. It could be said that the extraordinary brightness of Chalk is due to the captured sunshine of those far away days being eternally locked in by the white ooze on the ocean floor.

Flints are an integral part of Chalk deposits. Although there is a scarcity of flints in the Lower Chalk and at the base of the Middle Chalk, their presence increases dramatically in the succeeding Chalk formations. As the accumulation of flint increases, the impurities and clay content within the Chalk decrease. The layers of flint appear to be parallel with the not-always-distinguishable bedding of the Chalk, but they are also randomly distributed throughout the sequences. They are tough and inert and survive the weathering and erosion of their host rock.

Flint is really a variety of chert but sometimes also put together with the chalcedony family. All are extremely hard, of micro-crystalline or crypto-crystalline structure, and formed from pure silica, (98% silicon dioxide). In other words, flint is formed from quartz. But flints also contain some interstitial water trapped within the crystal structures.

When broken open, flints display a brown, glassy colour inside but the outer surface is pale grey or porcelain white, sometimes referred to as patina. The difference in colour is due to the escape of water which had filled the tiny voids between the crystals leaving a porous layer of particles (microscopic air spaces] on the outside with different light reflecting properties resulting in white or grey. Some broken pieces of flint may weather to a delicate shade of blue after lengthy exposure to the elements.

The name chert is usually applied to the black, dull coloured, sometimes opaque varieties forming massive or stratified features in the country rock, whereas the flints in Chalk are found as irregular-shaped nodules or as extremely weird and fanciful configurations. Flints have a slightly more conchoidal fracture with very sharp edges as opposed to the even and flat fracture of chert.

Chemically, flints are certainly different from the calcium carbonate of Chalk and many theories abound as to their origin. Nevertheless, it is generally accepted that the concentrations of silica have been derived mainly from the siliceous skeletons of animals such as sponges that grew on the seafloor, but also from other siliceous micro-fossils and plankton. However that particular type of silica, akin to opal which is a hydrous silica and contains more water, was not very stable.

The silica was subsequently dissolved in the sea water and dispersed within the soft Chalk sediments. Eventually the silica came out of solution and re-crystallised into a more stable structure within the Chalk around areas of organic concentrations to form flints once the Chalk was uplifted above sea level. Thus the sedimentation of Chalk and the formation of flints were two separate events.

All river and seawater contains a small percentage of both iron and sulphur. During the formation of the Chalk the sulphur, about 0.2%, tended to combine with the iron to form iron pyrites, better known as 'fools' gold'. The rusty looking nodules of blade-like, sharp pointed crystals radiate from a central core but pyrite also occurs as minute crystals scattered throughout the Chalk. In the passage of time, some of these nodules and individual crystals would have been completely oxidized forming slightly yellow, brown or red patches within the Chalk.

Not entirely unexpectedly, weathered-out pyrite nodules are sometimes found on the surface of the Chalk or even on the beach. Locally they have acquired the name of 'thunderbolts' and their formation and location has spawned some fanciful ideas. The radiating crystal nodules have even been associated with UFOs and 'Aliens'. Perhaps they were put there by the same strange creatures from outer space who are responsible for the proliferation of corn circles on the Chalklands! After all, the internal radiating arrangement of the crystals does bear a close resemblance to the mysterious features making their annual appearance in the cornfields of Wiltshire!

Chalk, at first assessment, is far too soft to be used as a building stone. But throughout history, mankind has always made use of the materials which were close to hand. And Chalk, and indeed flint, are no exceptions. There was nothing else in the local Chalklands.

The Chalk Rock and the hard nodular bands of the Melbourne Rock have been much used in the past in the outer walls of some old cottages, for garden walls and also for the inside walls in some churches. The stone is known as Clunch.

Chalk has also been ground up and mixed with clay, water and straw and sometimes even manure to produce a form of layered cob. Each layer was allowed to dry before the next was added. Although quite an acceptable and lasting building material, the resistance to moisture proved a problem if left unprotected. In consequence, a good thatch was always required to protect any outside structures from rain. A solid foundation, mainly of local sarsen stone, was also put into place to guard against rising damp.

A variation of cob was known as wattle, daub and pug, where the mixture was pasted into a wooden framework or into a box-like shuttering similar to modern concrete techniques.

The very hard weather-resistant flints have been utilised extensively for buildings and walls. In some cases they were simply used in their original shape and 'cemented' into place with mortar. (Modern cement will not adhere to flints and sarsen stones). Another building technique involved splitting and knapping of the flints which produced a flat surface. These were then set facing outwards into alternating squares of brick or stone to achieve not only a highly decorative effect but also to add extra strength to the walls.

Good examples of all the above can be seen throughout Wiltshire, in particular along the B4507 east of Swindon from Bishopstone to Wantage; also along the narrow side road following the Salisbury Avon from Amesbury to Lower Woodford.

The name 'flint glass' is an American term. It refers to fast-repeat-press-moulded glass popular at the end of the 18th century. Glass saucers, simple to produce on presses, were the initial product but the range soon widened to more complicated designs. Although no flint as such was used in its manufacture the name probably relates to the conchoidal fracture of the glass when broken. And coloured pressed glass resembled flint even more so. Early pressed 'flint glass' items are much sought after by collectors.

In one particular manufacturing process at Swanscombe in Kent, flints are automatically colour sorted and used as a pure form of silica in the manufacture of bone china.

But above all, flint is the forerunner of modern technology. Not only did it provide the spark to make fire but once pre-historic man had discovered the art of flaking and chipping (knapping) the flint it was used to make almost all his sharp edged tools and weapons. As a matter of fact, for the greater part of human history such implements consisted not of steel or iron, not of bronze or copper, but of flint. Nature has served mankind well.

Chalk for agricultural lime was dug locally from 'borrows', small pits, dug into the hillsides. It was then crushed or 'burnt' in kilns to be spread on the land in fine powder form to counteract the natural acidity of the soil or break up the heavy clays in the vales. Evidence of worked-out pits can be seen throughout the Wiltshire Chalklands.

An equally large quantity of Chalk was 'burnt' in limekilns to drive off the carbon dioxide to produce quicklime which is the main ingredient of mortar. With the advent of Portland cement however, the limekilns have now become part of the industrial heritage.

Cement is made locally at the Westbury plant. Chalk comes from the huge quarry at the edge of the escarpment above the plant south of Beggar's Knoll, where it is crushed, mixed with water and transported down a pipe to the drying kilns. Clay from the adjacent pit is added to the Chalk along with some gypsum to control the setting time.

The Westbury Chalk pit offers the best example in the local area of the Upper, Middle and Lower Chalk formations and also shows the Melbourne rock band in parts of the access road into the bottom of the quarry. The quarry can be viewed extremely well from the top road leading to the M.O.D. check point on the edge of Salisbury Plain. Permission to enter the quarry on the spur of the moment can prove difficult to obtain.

Chalk, in addition to being the main ingredient of cement, also plays a vital role in other sectors of the economy. It is widely used in the building industry for the production of plaster boards and similar materials. As filler in agricultural fertilizer, in many kinds of paints, in paper manufacturing and in the tyre industry. But rather surprising, not in blackboard chalk. That is made from gypsum! A wide range of chemical and pharmaceutical preparations also contain Chalk as their main ingredient.

Indigestion tablets may immediately come to mind to relieve excessive stomach acid. But there is no need to purchase expensive brand names. A nice piece of clean, white Chalk will do the same trick, i.e. a good dose of pure calcium carbonate straight from the ground. A strong mint chewed at the same time will disguise the sort of earthy taste of Chalk. There is no secret ingredient in branded indigestion tablets. They are Chalk with a little flavouring!

Whilst nibbling that gleaming white piece of Chalk just imagine all the locked-up sunshine from many millions of years ago waiting to be released. But your elation might be slightly tempered by the thought that this insignificant little piece of Chalk has already passed through thousands of other digestive systems before it finally reached your own to settle an upset stomach !

The natural porosity of Chalk absorbs any rainfall very quickly, leaving in effect no surface water or run-off. This has always proved a problem on the Chalk lands for man and beast alike. To overcome such scarcity of water in days gone by, dewponds lined with clay were constructed on the higher ground to provide an adequate supply throughout the year. Some very good examples can still be seen dotted around the local Chalk lands.

Although Chalk appears to have a certain compact, nearly immaculate uniformity, there are nevertheless a considerable number of irregular minor clay and marl bands at various horizons within the main formations, as well as large fissures and many small joints.

Surface water works its way slowly down these larger spaces to the Gault Clay of the Upper Greensand forming huge underground reservoirs referred to as aquifers, or it may flow in the direction of any outflow to emerge as a spring. However, the movement of water within the Chalk is extremely slow. It can take about three months between periods of precipitation and the increasing height of the watertable in the aquifer.

The uppermost level of an aquifer, the watertable, rises and falls depending on the amount of surface water seeping through the Chalk. In consequence springs and spring lines at the foot of the Chalk escarpments are not always a permanent feature. They come and go, especially those on slightly higher horizons within the Chalk. But due to extremely heavy precipitation at the end of last year (2000) and the beginning of this year, all Chalk springs have been very active and springs have also appeared where there have been none before - not for quite some time, anyway. The village of Compton at the foot of the neighbouring Berkshire Chalk Downs is an extreme example of re-activated springs where the water has risen through the floorboards of many houses. The last time this happened, but to a much lesser extent, was over 45 years ago.

The rise and fall of the water table also explains the many local 'bournes'; chalk streams with crystal clear water, which flow throughout the winter and spring but may be dry for the rest of the year. However, here again, due to the exceptionally long periods of intense rainfall this year (2001) the Chalk streams may not dry up until late autumn, if at all.

Some of the surface water percolating through the smaller joints is trapped in pockets or layers above the minor clay and marl bands to form zones of saturation at higher levels within the Chalk. As a result, springs may also emerge for brief durations well above the normal springline after prolonged spells of heavy precipitation.

It would not be unreasonable to expect the watertable within the Chalk to be level but capillary forces and the resistance to the flow of water within the network of fissures and small interstices creates a dome-shaped reservoir which has its highest point below the top of hills. The smooth down-flow of water may also in places be retarded by the minor clay and marl bands within the Chalk adding to the irregular level of the 'reservoir'.

But natural processes are one aspect. The removal of water by the water companies is another. Continuously high extraction rates have a dire effect on the long-established environment within the Chalk lands. Somehow, man's needs have got to be balanced with what nature can provide. With this in mind it has been suggested to pump surplus water from springs which flow throughout the year, or after prolonged wet periods, back up on to the high ground to maintain the water level within the aquifers. Well, it might just work. Costs could be the deciding factor.

Water taken from Chalk aquifers is very hard due to the high calcium carbonate content. This is very noticeable in domestic plumbing where the calcium salts come out of solution forming a hard 'limescale' inside pipes and utensils. The accumulation of such deposits is most severe in hot water systems and, if left untreated, can lead to many problems.

The story of Chalk and flints is an absorbing, fascinating one. The connections with the past - the ancient monuments like Silbury Hill, Avebury, Stonehenge and Woodhenge, the outline of former field systems etched into gentle slopes of the Chalklands and burial mounds standing proud of the horizon, the seemingly never-ending Ridgeway on the crest of Chalk hills, the old trackways across the Downs and the mysterious White Horses carved into the steep escarpments. Also to be included are the flora and fauna, agriculture and the once thriving local wooltrade, the steep sided coombes, broad vales, dry valleys and clumps of trees on windswept hills. It is all there; a story book of many pages steeped in natural and human history.

And it is Chalk, sculptured over many millions of years by ice and water and the restless forces within our Planet, which has produced the mature and gentle outlines of the Marlborough Downs and Salisbury Plain and the scenery throughout the Chalklands. Chalk was also influential in dictating the diverse ways of life of those who lived and still live in such wonderful surroundings.

Chalk may be a neglected treasure, common place stuff at first glance. But Chalk, and all that goes with it, is indeed a unique rock.

Example locations of some features mentioned in text:

Dewponds		*Flints*	
106 642	Milkhill	803 347	Fields, White Sheet Hill, Mere
254 726	Ramsbury	135 712	Fields, Marlborough Down
138 718	Marlborough Downs	008 645	Fields, Roundway
Springs		*Clay with Flints*	
913 518	Bratton Church	105 644	Milk Hill
925 521	Luccombe Bottom	031 668	Furze Knoll
102 682	Swallowhead, Silbury Hill	225 668	Savernake Forest
Bournes		*Chalk exposures*	
265 755	Aldbourne	129 718	Mariborough Downs
990 314	Teffont Evias	304 700	Littlecote
100 720	Winterbourne Monkton	032 600	Etchilhampton Hill
		890 505	Westbury

REAL TEXAN GEOLOGISTS

Real Texan geologists - - -

• don't eat quiche! They don't even know what it is. Real geologists like raw meat, beer and tonsil-killer chili.

• don't need rock hammers. They break samples off with their bare hands.

• don't sit in offices. Being indoors makes them crazy. If they had wanted to sit in offices, they would have been geophysicists.

• don't need geophysics. Geophysicists measure things nobody can feel or see, make up a whole lot of numbers about them, then drill in all the wrong places.

• don't go to meetings, except to point at a map and say'' drill here!'- and leave.

• don't work 9 to 5. If any real geologists are around at 9.00 a.m. it's because they're going to meetings to tell the managers where to drill.

• don't like managers. Managers are a necessary evil, for dealing with bozos from human resources, bean counters from accounting, and other mental defectives.

• don't make exploration budgets. Nervous managers make exploration budgets. Only insecure mama's boys try to stay within exploration budgets. Real geologists ignore exploration budgets.

• don't use compasses. That smacks of geophysics. Real geologists always know exactly where they are and the nearest place where beer is available.

• don't make maps. Maps are for novices, the forgetful managers and pansies who like to play with coloured pencils. A real geologist will only draw a map to show the ill-informed managers where to drill.

• don't write reports. Bureaucrats write reports, and look what they're like.

• don't have joint venture partners. Partners are for wimpy bedwetters who are unable to think big.

This article from 'The Dudes of Diagenesis' was submitted for the Journal by Bruce Buswell.