

ON THE WHITE CHALK OF YORKSHIRE. BY REV. E. MAULE
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THE following notes are supplementary to the papers already published on the Red Chalk (1878), and on the origin and formation of the Wold Dales (1879.)

The white chalk of Yorkshire differs considerably from the chalk of Kent and Sussex. In the first place, it is much harder, and in places almost crystalline. Then, the flint-bearing beds are the lowest in the Yorkshire series, whereas they are the highest in the southern; the upper beds in Yorkshire, forming the inner edge of the Wolds, have not a trace of flint. The flints too are different; in the north they are light-coloured and can be shattered by a blow into a thousand pieces, whilst in the south they are black, tough, hard, and compact.

Numerous flint weapons, knives, arrow-heads, spear-heads, scrapers, &c., have been picked up on the surface of the Wolds, or extracted from the numerous tumuli, but they are almost invariably of foreign flint picked up probably on the sea shore, washed out of the Boulder Clay, the flint of Yorkshire not being adapted for the manufacture of flint weapons.

A Frenchman, Mons. Barrois has attempted to divide the Chalk beds into a series of zones, containing characteristic fossils, but enough attention has not yet been paid to the subject, in Yorkshire at least, to prove or disprove the truth of his theory.

It is certain, however, that very large *ammonites* are only found in the lower beds, and *marcupites* only in the highest, whilst on one horizon *inocerami* are very plentiful, and on another scarcely any fossils are found at all. So far this favors his views.

The chalk itself is very variable. Sometimes it is quite slaty, and splits up into thin layers; sometimes it occurs in massive beds without a trace of parting. Wherever a parting occurs there is almost always found a thin deposit of fuller's earth, which seems

to have been the primary cause of the non-coherence of the layers above and below ; sometimes as many as twenty of these partings will occur in one or two inches of chalk, dividing it into as many thin plates. On the other hand, layers of fuller's earth from one to three inches thick are occasionally found, and also beds of chalk one or two feet thick, without any parting at all.

Where masses of chalk have been rolled about on the sea shore and rounded, remarkable wavy lines like the sutures of a skull, may be traced on the surface. These are due to extremely fine layers of fuller's earth. We call it "fuller's earth" for lack of a better word, but it seems to have been a fine sediment of mud, deposited over the ocean floor as the chalk was accumulating, representing a certain amount of denudation carried on by the waves, much the same as the lagoons of coral atolls in the Pacific receive muddy deposits from the disintegration of the reefs.

If this idea is correct, it follows that chalk was not deposited in a deep sea, as once supposed, but in comparatively shallow waters, where coral reefs existed in all directions, with no neighbouring land, and no rivers bringing down sand and muddy impurities to stain the pure whiteness of the chalk.

This peculiar rock is doubtless composed largely of the calcareous skeletons of foraminifera which swarmed in the warm waters, which then covered Central Europe, much the same as they now contribute to the formation of the grey ooze of the Atlantic, but the formation of chalk was probably greatly accelerated by the disintegration of coral reefs, which, in the form of minute calcareous sediment, would assist in the accumulation of the beds known as Chalk.

The chalk area extends, with occasional breaks from Ireland to the Crimea, and from Sweden to the Pyrenees. It is absurd to suppose that this area ever formed a *deep* sea. Continents grow like everything else, and materials from the land, brought down by rivers and carried out to sea, are invariably deposited within

about 150 miles of the shore line. Europe had certainly attained a continental form long before the deposition of the chalk, and there is no reason to suppose that a *deep* sea, such as the Atlantic, occupied its area in cretaceous times. It is more probable that a slight depression allowed the waters of the Atlantic to pour over its central portion, the constant flow, eastwards, of a stream similar to the present Gulf Stream, supplying an enormous quantity of foraminifera, which, by their decay, aided by the disintegration of coral reefs, caused the accumulation of calcareous sediment known as chalk.

It may be added that the fossils found in chalk, are indicative of animal life, existing not in deep, but shallow water.

The beds of chalk which constitute the Wolds dip in various directions, owing probably to irregularities of pressure or compression in the process of elevation, but the general dip of the whole semicircular mass is in the direction of a central point somewhere about Hornsea, consequently the beds on the N. ridge running from Acklam to Speeton dip southwards, whilst the beds on the W. ridge from Acklam to Hessle dip eastwards. The base of the chalk is met with all round the N. and W. edges at varying elevations, marked by the line of springs, (*vide* Red Chalk, 1878).

As a rule the higher the hills, the thinner the chalk. But the very fact of the chalk being thin, at most 200 feet on high elevations, shows that we are in the lower flint-bearing beds all round the N. and W. area, whilst we only reach the upper beds without flints on the inner and lower circle of ground, seawards.

A line drawn from the S. landing at Flambro' Head through Burton Agnes, Kilham, Cottam Warren to Life Hill, Sledmere, on the one hand, and from thence south through Wetwang, Tibthorpe, and Leckonfield, to the Westwood pits at Beverley, will separate the two areas of flint-bearing and nonflint-bearing chalk; that to the N. and W. containing flints, that to the S. and E. apparently without. A reference to the numerous chalk pits all

over the country, will confirm this statement, but it is also proved by the presence or absence of flints on the surface of the ploughed fields. Chalk readily decays under atmospheric denudation, but not so flints. Hence, wherever the subsoil contains flints, they rapidly accumulate on the surface, and sometimes have to be picked off by hand.

We have spoken of flints as if they were all alike, but this is not the case, there are "flints and flints" according to the French proverb, in fact the different kinds of flints are so persistent over different areas, that they are useful in classifying and identifying zones of chalk, even without the help of fossils. For instance, in the lower beds, just above the Grey Chalk, the flints are *nodular*. This term however does not adequately describe the peculiar shape, so we must coin a word "finger-like" meaning thereby that the flints are rounded, tapering, resembling in appearance a thumb or fingers; another feature to be noticed is that unlike other flints, these are mostly found in a vertical or upright position. Good examples may be met with in the railway cutting immediately facing Burdale station.

In the slaty beds of chalk, which succeed next in order, the flints, as might perhaps be expected, appear in thin horizontal slices here and there.

Next above these are found *tabular* flints, *i.e.* solid compact beds of flint, of variable thickness, extending over a large area. On the sea coast, at the N side of Flambro' Head, the setabular beds present level, but pitted surfaces, many yards in diameter, which have resisted the denudation of the waves, whilst the chalk which once covered them has long since been removed. In the interior, a fine example, 9 inches thick, has been exposed in a quarry on the top of the hill, between Fimber Station and Sledmere, by the roadside.

In the higher beds of the flint-bearing chalk, occur large angular masses of flint, partaking partly of the *tabular*, partly of

the nodular form, of great thickness, but not wholly composed of flint; that is to say, streaks and patches of chalk are imbedded in the flint. Examples may be seen in several quarries in a straight line between Wetwang, North Dalton, and Middleton. This horizon is styled by Mr. Blake (Proceedings, Geol. Association, Jan. 1878) the "Zone of *immature* flints". He considers, it seems, that the process of the development of flint was arrested by the elevation of the chalk, and removal of pressure. It may be so, but the whole question of the formation of flint in chalk is still *sub judice*.

Above these last lies the flintless chalk, but curious to say, though there are no flints, the chalk, on analysis, yields nearly twice as much silica as the chalk which has flint. The silica seems to be dispersed throughout the mass, instead of being aggregated in tabular or nodular patches.

Now what is the origin of all these various forms of flint, including the huge "paramoudra" or "potstones" which are met with in the cliff at Flambro' and Speeton, 3 to 4 feet in height, and 1 to 2 feet in diameter?

One thing is clear, that, in a large majority of cases, they represent a mass of silica, which, by attraction or affinity, has been absorbed from the sea water which contains a quantity of silica in solution, round a nucleus of some decaying animal or vegetable.

Siliceous sponges, whose nutrition is contained wholly in the seawater, which passes through their pores, naturally form a basis for the accumulation of flint, and accordingly we find many flints bearing the exact shape of cup-shaped zoophytes, such as *spongites* and *ventriculites*. But in addition we not unfrequently find such a form as an Echinus, or "Sea Egg" completely transformed into flint, the external rays being as clearly delineated on the surface, as in the living specimens. Here, the decaying animal was evidently replaced atom by atom by silica.

The foregoing observations, meagre as they are, do not account for the large masses of *tabular* flint, though they may help to explain the origin of *nodular* flints. What can we say more? only this, that just as *calcareous* foraminifera are contributing by their decay to form the ooze of the Atlantic, as, in times gone by, they mainly formed the Chalk, so another class of life, the *siliceous* diatoms are busily engaged, at great depths, in secreting flint. Hence these may possibly form beds of flint.

But it cannot be denied that this is an unsatisfactory explanation, for beds of tabular flint occur in the middle of the chalk, deposited, as presumed above, at no great depth. Bearing, however, the fact in mind, that flint may be formed during the decay of vegetable matter, may it not be that *tabular* flints mark areas of greater or less extent, where masses of dead seaweed were accumulated?

The only argument to be urged against this hypothesis is, that dead seaweed is mostly washed up on a shore line. But what, if these areas were shore lines, or, in other words, surfaces of coral reefs? and what know we how much may settle at moderate depths out at sea? our contention throughout being that chalk was not formed in a deep, but in a shallow sea.

A word more must be added on *banded* flints; banded flints are not infrequent in the chalk. They resemble agates in showing concentric rings of silica of different alternate colours, and clearly point to a nucleus of attraction, round which layers of flint accumulated, much the same as stalactites are formed by successive coatings of liberated carbonate of lime.

At the recent meeting of the British Association at York, (1881) bottles containing silica in gelatinous forms, into which certain solutions of metallic salts had been introduced, were exhibited, showing in a beautiful manner how, in course of time, agates and banded flints *might* be produced, but the difficulty presented itself at once, that silica in a gelatinous form is not

known to exist in nature, and that, for the formations in question, we must seek not for an artificial, but for a natural process of development.

In conclusion, we wish to draw attention to certain remarkable needle-shaped structures, which occur all over the chalk area of Yorkshire, but not apparently in the South of England, and which are to be met with immediately below and above the thin layers of fuller's earth, alluded to above, as interfering with the coherence of the chalk. They have been called "slickensides" by men of repute, not intimately acquainted however, with the phenomena—but they are *not* slickensides; and a thorough examination will prove convincingly that some other explanation must be sought. Either they mark an incipient form of crystalization, or they are the remaining traces of some low form of animal life of the coral type, which was arrested in its growth by the muddy deposits of fuller's earth, and began its work again as soon as the water was once more clear.

This is a question which deserves further attention in describing the Chalk of Yorkshire.

GLACIAL SECTIONS NEAR BRIDLINGTON. BY G. W. LAMPLUGH.
PART II. CLIFF SECTION EXTENDING 900 YARDS SOUTH
OF THE HARBOUR.

IN pursuance of my plan of describing sections in this neighbourhood which are likely to be closed to the geologist, it is desirable that some account should be given of the cliff-section which lies immediately to the south of the Harbour at Bridlington Quay, as this is already partly hidden. I have therefore drawn to scale a section of the cliff for a distance of 900 yards from the South Pier, as is shown in the accompanying plate, and this I now supplement, as before, with a description and notes of some deductions I have drawn whilst at work on the section.