A post-Flood Solution to the Chalk Problem

DR DAVID J. TYLER

ABSTRACT

The mode of formation of thick chalk beds in the Cretaceous Period of Earth history has provided numerous challenges for both uniformitarian and catastrophist geology. The field evidences present particularly acute problems for diluvialists, who over the years have made very little progress in understanding these rocks. Although the Chalk provides powerful evidences for catastrophic conditions during its formation, diluvialist interpretations have been hindered by a prior conviction that it was laid down during the one-year Flood itself Such an interpretation is untenable, as internal evidences point to a timescale significantly, longer than days, weeks or even months. By contrast, if the Chalk is understood as laid down during the unstable conditions which persisted after the Flood, as the Earth recovered from that cataclysm, it becomes possible to interpret the evidences for catastrophic deposition without strain.

INTRODUCTION

Chalk beds are a distinctive sequence of sedimentary rocks at the top of the Mesozoic. They are of such global importance that the rock type has given its name to the Cretaceous Period (from the Greek *creta*, meaning chalk). The beds are of particular interest to diluvialist geologists, as many put the Mesozoic within the Flood year and regard the chalk as forming in only a few days or weeks. In this article, I present arguments which suggest that all of the Upper Cretaceous chalk is post-Flood, formed over a timescale measured in decades.

Chalk is a soft, easily crumbled fine-grained limestone. Analysis using the electron microscope shows that it is composed largely of coccoliths and coccolith fragments[1] derived from certain types of planktonic brown algae (most of the species represented in the Chalk are now extinct). Additional carbonate material derives from mollusc shells and foraminifera.

Whereas, prior to electron microscopy, it was not clear how chalk formed at all, a different puzzle now faces contemporary geologists.

> *'The problem of the Chalk today is not so much where the material came from, as how other material was kept out. The remarkably pure organic chalk is almost completely without any trace of land-derived sediment.'*[2]

Although Ager refers to 'the problem' of the Chalk's purity, these rocks present a great variety of complex problems of interpretation for both uniformitarian and catastrophist geologists. To compensate, the Chalk also provides a rich supply of data — enough, in the experience of many geologists, to satisfy a lifetime's interest.

ENGLISH AND AMERICAN CHALK-BEDS

The classic exposures of the English Chalk are in the Wealden District of south-east England.[3,4] Three main stratigraphical sub-divisions are identified: the Lower Chalk (76 m), the Middle Chalk (70 m), and the Upper Chalk (210 m). The Lower Chalk has a relatively high admixture of argillaceous and arenaceous material, and is well supplied with fossils. The Middle Chalk has more massive beds, is purer, and has relatively few fossils. The Upper Chalk has a diverse fauna, many nodular beds, and is clearly distinguishable by its flint horizons.

Horizons known as hardgrounds have been identified in the Chalk, which Hancock[5] describes as common. They are recognized by their nodular texture, and appear to be intimately associated with *Thalassinoides* burrows and other traces made by boring and encrusting organisms.[6-8] They have a distinctive fauna, and it is thought that the firm surface for attachment allowed the assemblage to become established and stabilised. Subsequently, soft sediment deposition resumed.[9] The importance of these field evidences for catastrophists is that they suggest intermittent sedimentation, with times of colonisation and erosion during periods of non-deposition.

In the United States, the classic locality for Cretaceous chalk is the Smoky Hill Chalk Member of the Niobrara Formation, exposed in the Smoky Hill River drainage basin of Kansas. The Niobrara varies in thickness across its outcrop, but 200 m would be a reasonable average. The Smoky Hill Chalk Member has been reported to vary between 122 m to more than 198 m, with a figure of about 180 m being representative. Although extensive hardgrounds seem to be a European phenomenon, the United States chalk has its own distinctives. The published composite section by Hattin[10] has more than 100 seams of bentonite, which range in thickness from a paper-thin horizon to 113 mm. These are interpreted as the weathered remains of volcanic ash fall deposits (believed to have come from the Sevier Orogenic Belt in the West). The Smoky Hill Chalk Member is of great importance for Cretaceous vertebrate palaeontology, having yielded spectacular specimens of teleosts, sharks, mosasaurs, pleisosaurs, turtles, pterosaurs, birds and dinosaurs. It has also been an important source of invertebrate fossils, such as rudists, crinoids, oysters, cirripeds, cephalopods and giant clams.

Specialised organisms and behaviour patterns provide additional insights into the Chalk Sea environment. Several of these are discussed later, but one enigmatic example is noted here. Palaeontologists in the United States have long noted an association between several species of small fish and giant inoceramid shells. Dunkle[11] proposed that this association was not accidental: the fish did not just happen to be preserved on shell surfaces but were preserved as a result of being inside the shells. Bardack[12] suggested that the fish died in a mass mortality event and settled on opened valves of dead inoceramids. Stewart[13] suggested that the association was far stronger than this, as the concentration of fish fossils inside shells is very high: as many as 100 fishes have been found in an individual inoceramid. Stewart considered that a symbiotic relationship existed between the fishes and the pelecypods, and that *'these fishes entered live inoceramids and died at essentially the same time as their hosts'*. The problem with this view is that fishes living inside the shells would have reduced the oxygen available for their hosts. However, it is conceivable that the fishes spent most of their time outside their hosts and only entered them for protection. Although the observations are still imperfectly understood, the fact that fish and inoceramids are found together suggests a sudden demise for both, followed by rapid fossilisation. This suggests that chalk sediment fell so rapidly that the fish had to retreat to their host, being unable to escape because of the build-up of sediment, and that death was followed by rapid fossilisation. At the very least, these evidences require non-uniformitarian conditions.

Both European and United States chalk sequences follow soon after a major erosive marine transgression which is well documented in many parts of the world. Ager comments:

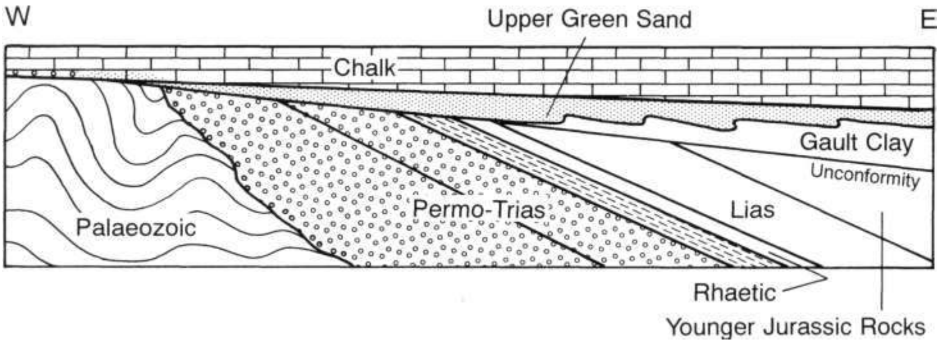

Figure 1. Cross-section of strata outcropping along the southern coast of England. A major unconformity exists between Palaeozoic and Mesozoic rocks, and also in the Cretaceous series. The Cretaceous unconformity is interpreted as part of a major marine transgression that affected many parts of the world. The unconformity is an erosive surface, although the Gault Clay immediately above it would normally be associated with low-energy environments. Above this are the Upper Green Sand strata (higher energy) and above this the Chalk (interpreted as low energy). The characteristics of this unconformity and the transition from sand to chalk deposition are not readily explained by conventional geologic models.

> *'For some reason the geologist cannot as yet explain, the seas of the world seem to have overflowed and flooded huge land areas at roughly the same moment at the beginning of Upper Cretaceous times.'*[14]

In the United Kingdom the unconformity is marked by a striking erosive horizon[15] (see Figure 1). Above it are found the Gault Clay, the Upper Greensand and then the Chalk. Thus, the Chalk rests on sands that are normally regarded as representing a relatively high-energy environment. The base of the Chalk is reported to be diachronous.[16] In the United States the Niobrara Chalk rests unconformably on the Codell Sandstone Member of the Carlile Shale (see Figure 2).[17] The significance of these observations is that the character of sedimentation changes abruptly: after the erosive event (presumed to be in shallow water), relatively pure chalk sedimentation is initiated either directly or after the deposition of some other shallow-water arenaceous sediments. The lack of evidence for a deepening depositional sequence is a further indication that the uniformitarian models of deposition are wanting. It is, however, consistent with the model proposed by Tyler.[18]

Figure 2. *The Niobrara Chalk overlying the Codell Sandstone Member of the Carlile Shale. The geological hammer marks the sharp boundary. This site, like so many others, has been marred by a graffiti artist. As in England, 'low-energy' chalk is separated from the 'high- energy'sandstone by an erosive horizon. Uniformitarian models of deposition do not do justice to the observations. (Photo: D. Tyler).*

THE PROBLEM OF DEPOSITIONAL ENVIRONMENTS

Today, coccolith foraminiferal muds are found in the sediments of deep oceans. Estimated maximum rates of formation are 10-30 mm per 1,000 years. Roth[19] has pointed out that there is a major mismatch between the limited thicknesses of deep oceanic sediments and the substantial sequences of chalk in continental rocks. Furthermore, it is recognized that chalk sediments accumulated in comparatively shallow epi-continental seas rather than in deep oceans, so that geologists no longer argue that present-day deep-sea muds provide an adequate analogy for chalk formation.

Hence, Hancock[20] acknowledged that no *'exact analogue of Cretaceous chalk can yet be quoted**. Hallam[21] has also commented on the inappropriateness of deep-sea analogues, but nevertheless cites estimates *'as high as 150 mm per 1,000 years'* for the Cretaceous. Despite inadequacies, the model which is in practice adopted for Cretaceous chalk production would appear to depend on these analogues. The epi-continental seas of the Cretaceous are thought to have generated chalk ooze with only an order of magnitude increase in deposition rates. For example, Hattin[22] has concluded that the Niobrara Chalk was deposited at a rate of approximately 36 mm per 1,000 years. This is uniformitarianism in practice — an example of philosophy governing scientific judgments, rather than a process of induction and the testing of hypotheses.

The problem remains: what modern analogues are relevant? Planktonic coccoliths are obviously the source of the chalk sediments; land-derived sediments are lacking. Is it feasible to postulate 'placid' flooding of continents (with hyper-low erosion) over such large areas for such long periods of time? Ager[23] is refreshingly honest when he contrasts the plentiful occurrence of carbonates in the geological record and the low level of present-day carbonate productivity. He refers to the Bahamas Banks, Shark Bay, the East African Coast, and the west side of the Persian Gulf, pointing out that they are 'overworked' in the literature, and that they are nothing compared with the vast extent of the shallow-water carbonates in the past. Scope for the exploration of catastrophist alternatives to uniformitarian models would seem to be substantial.

A CATASTROPHIST APPROACH TO CHALK PRODUCTION

In his discussion of the processes by which ocean sediments form, Roth[24] points out that biological productivity does not appear to be a limiting factor on timescales for deposition. Both coccolithophores and foraminifera reproduce rapidly, with the former being reported to have a division rate of 2.25 per day. Paasche[25] describes these organisms as *'among the fastest growing planktonic algae'*. The reproductive potential of these organisms is not attained under normal conditions because of one or more limitations in the environment: the supply of nutrients, minerals, oxygen and the water temperature. Sometimes even today the environmental constraints are eased and localised population explosions occur. These are known as planktonic 'blooms'. One possibility for a catastrophist model of chalk production is to postulate conditions which permit 'blooms' on a regional scale. Using this model, Roth[26] estimated a carbonate production rate of 540 mm per year from the surface 1,000 metres of ocean, some 104 times greater than contemporary rates.

Johns[27] has criticised Roth's approach for overlooking the factor of longevity. Little or no carbonate is produced during the first 12 hours of the organism's existence, and maturity is not reached until after about 50 days. This reduces the productivity of blooms as calculated by Roth. However, the magnitude of the reduction is debateable as there are many unknowns. For example, the species of coccolithophore involved in the Cretaceous chalks may have had different life-cycle dynamics from the modern-day species studied. Furthermore, physical and chemical conditions affecting carbonate production in a catastrophic scenario may be only partially represented by comparison with factors affecting modern-day algal blooms.

To summarise, whereas today high rates of deposition are experienced locally, subject to conditions being appropriate, comparable rates during catastrophic episodes of Earth history may have been possible over large areas. During these times not only may abundant nutrients have been available (from decaying organic matter), but also* minerals (carbonate input from the erosion of continental deposits), elevated temperatures (from cooling igneous bodies) and plentiful oxygen (from turbulent water, rainfall and runoff).

ALTERNATIVE CATASTROPHIST MODELS FOR THE FORMATION OF THE CHALK

It has been noted that the Lower Chalk in southern England is very fossiliferous, particularly near its base,[28] that the Middle Chalk is generally less fossiliferous, and that the Upper Chalk has a great variety of fossils. In the context of catastrophism, this distribution is suggestive of three major phases of deposition. The explanation of the distribution is not addressed here, but various possibilities can be explored: for example, many organisms may not have been able to survive in the environmental crisis caused by the widespread algal blooms and perished early, and as conditions persisted, organisms adapted to the unusual conditions came to dominate.

Detailed sedimentological work has shown that the beds do not present a picture of uniform quiet sedimentation, for the Chalk shows bedding planes from 0.5 to 2.0 m apart, and was sometimes piled into heaps or banks before lithification. Erosive phases are represented, and some sediments are known with cross-bedding (signifying strong current action). Soft-sediment slumping has also been reported.[29,30]

Snelling[31] rejects the idea that chalk sediments were reworked from the pre-Flood deposits, pointing out that if this were the case, *'chalk deposits should be found sooner rather than later during the Flood event'.* This is worth emphasizing, as some diluvialists have argued that the chalk is a redeposited antediluvian sediment. If this were the case, a prediction could be made that these marine deposits should be found at many levels of the geological column. However, chalk makes its first appearance in Cretaceous rocks. This is totally enigmatic within a Flood model that has high levels of coccolith production in pre-Flood times.

There has been a tendency for diluvialists to propose large-scale transportation and redeposition of chalk sediments. This creates many problems for diluvial models which are generally not identified or discussed by those making the proposals. Whilst evidences for significant current activity are not absent (at least in Europe), their importance should not be overstated. The bedding characteristics of chalk indicate relatively low-energy environments, and this evidence is particularly compelling when considering the United States bentonite data. Higher-energy environments and major transportation would create turbidity, and the introduction of a significant clastic component from other areas would be expected. The purity of major parts of chalk sequences is a strong argument for the chalk having been deposited where it was formed.

Snelling[32] argued that chalk sequences should be understood as late-stage Flood deposits. Although Froede[33] does not address specific issues relating to the Niobrara Chalk, he does identify the Late Cretaceous of North America as a phase late in the Flood year, linking it to the retreat of the Flood waters. However, as has been pointed out above, the Chalk is associated in both Europe and the United States with a marine transgression, not a retreat of Flood waters. The geologic evidences worldwide provide an equally serious objection to Snelling's and Froede's positioning of the Chalk in the late stages of the Flood: as indicated above, the Late Cretaceous is regarded as a time of global marine transgression.

Snelling suggests that a succession of three algal blooms could have produced *'the three main chalk beds'* of southern England in as little as six days. One purpose of this paper is to dispel the notion that there are three main 'beds'. There are three divisions of the English Chalk, but each division is composed of many beds, as indicated previously. These beds have a variety of characteristics which must be addressed in any discussion of depositional environments and timescales: marly horizons and evidences of cyclicity in deposition, bioturbation, hardgrounds, distinctive marker beds, and so on. To reduce the problem of chalk deposition to one of explosive productivity is liable to result in error. In relation to timescales measured in days, Johns'[34] pertinent comments on longevity and the maturation of blooms serve to turn a highly speculative argument into an indefensible one.

It is not my purpose to dispute Roth's claim that there is no biological limitation to forming the chalk beds rapidly, but to draw attention to the fact that even with algal blooms, environmental factors put limits on carbonate production. Furthermore, it is not enough to argue the theoretical point that chalk production is little constrained by biological considerations. One needs to examine the specific field evidence which may determine whether the 'possibility' constitutes a substantial 'explanation'.

The Chalk is not a uniform series of sedimentary beds. Consequently, these rocks cannot be explained using sedimentological mechanisms alone. In particular, features such as hardgrounds, burrowings, borings and bentonite horizons are inconsistent with the depositional model advocated by Berthault.[35]

Field evidences suggest that the Chalk was formed over a period of time several orders of magnitude longer than six days. These evidences relate to lithological and palaeontological data and are further discussed below. They are consistent with a post-Flood model for the formation of the Chalk, although one that has nothing in common with Johns'[36] hypothetical post-Flood scenario.

CONSTRAINTS ON CATASTROPHIST TIMESCALES FOR THE FORMATION OF THE CHALK

Hardgrounds

This first line of evidence is mentioned by Snelling[37] in an appendix, who rightly points out that borings, burrows and other colonisation features do not require thousands of years to form. However, Snelling does not do justice to the evidence when he writes,

'In whatever moments they had before expiring, it is

not inconceivable that some of these creatures would try to re-establish their living positions on whatever momentary surfaces they found themselves in'.

These hardgrounds are not adequately described as 'momentary surfaces', for the field evidence indicates soft sediment burrowing followed by hardening, erosion and encrustation.[38] Timescales for these processes are appropriately measured in weeks and months, even years, rather than in minutes and hours.

Scheven's[39] analysis, which Snelling cites, points out that hardgrounds characterise Mesozoic and Cainozoic strata and are extremely rare in Palaeozoic strata. The chalk hardgrounds are not qualitatively different from many other Mesozoic hardgrounds and must be understood, chronologically, in relation to this overarching pattern of the Phanerozoic record — a pattern which suggests that the Flood/post-Flood boundary be placed before the Mesozoic.

Macrofaunal Evidences

The second line of evidence is provided by specialised European macrofossils, of which there are two associations. One group appears to be adapted to living in soft sediment. The bivalve *Spondylus,* for example, has special spines to prevent the animal sinking into soft mud. One species of the bivalve *Inoceramus* uses a different technique: it has a large surface area to support its weight and prevent sinking (see Figure 3). The irregular echinoid *Micraster* has a morphology which has been interpreted as favouring a burrowing mode of life (see Figure 3). Further examples of specialised inhabitants of soft chalk sediment are in McKerrow,[40] who distinguishes the mid-Cenomanian Argillaceous Chalk Community and the Santonian M*icraster* Chalk Community.

By contrast, a separate group of organisms are found associated with the hardgrounds. These organisms are colonisers which attach themselves to a hard substrate, or bore into lithified sediment.[41] The distinctiveness of these epifaunal colonisers suggests that timescales were sufficient for organisms to move, feed and grow in an environment that favoured their existence. Again, further examples of specialised inhabitants of hardgrounds are in McKerrow:[42] such as the Late Turanian Hardground Community.

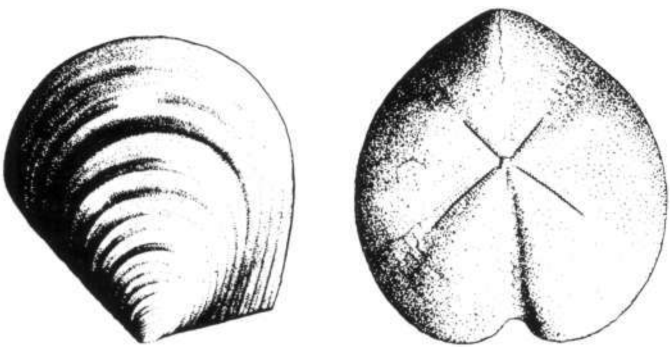

Figure 3. Inoceram us *(left) and* Micraster *(right), fossils discussed in the text. Chalk has a distinctive macrofauna which display adaptations to their environment. In some cases, changes in morphology can be traced which have led to studies of speciation trends. Such data have a bearing on the timescales of chalk deposition.*

This pattern of fossil evidence, with its correlation of recognisable communities and substrate character, requires the recognition of a cyclical geological history involving numerous stationary surfaces.

Speciation Data

The *Micraster* fossils in the Chalk have long been regarded as a good example of a speciating lineage. Details of interpretation have changed over time and, of course, there have been claims that the data provide a good example of evolutionary change. However, creationists have long pointed out that speciation *per se* is an integral part of a creationist framework for interpreting the diversity of life, and that only changes which link basic types constitute evidence for the theory of evolution. The *Micraster* data have been reviewed by Ward,[43] who interprets them as variation within the boundaries of a created kind.

The significance of these data for the present discussion is that the orderly sequence of fossils in the Chalk requires a timescale for deposition which allows speciation events to take place. Since the organisms were living and breeding in the Chalk, a depositional period of six days is quite unrealistic. This is not to say that long periods of time are needed: many examples of rapid speciation over periods measured in years have been recorded in historic times.[44]

Bentonite Horizons

Although bentonites are absent from European chalks, they are a characteristic feature of the Niobrara Chalk (see Figure 4). In the field, they generally weather orange and brown as a result of the formation of iron oxides. More than 100 seams are recognized, with many of them of major importance for understanding the stratigraphy of the Smoky Hill Member. Most of the marker units identified by Hattin[45] include bentonites. As confirmed by personal observation and discussion with a palaeontologist working in these rocks, the bentonite sequences provide reliable markers and are useful in field studies.

Like hardgrounds in the European chalks, bentonites in the Niobrara Chalk identify stationary surfaces. The length of time represented by each bentonite cannot be determined by observation. Since these beds were not destroyed by burrowing or by bottom currents reworking the sediment, long timescales are improbable. However, this constraint on time intervals is not tight as bioturbation is not a common phenomenon, despite being obvious in some horizons. The generally-held explanation for this lack of bioturbation is that these chalks were deposited at greater depths, and the environment was less conducive to benthic faunas.

The conclusion of many geologists has been that much

Figure 4. *One of the many bentonite seams in the Niobrara Chalk. Volcanic ash from a distant source forms well-defined layers like this within the chalk beds. Bentonities provide evidence for quiet conditions of deposition, as the ash fall is not dispersed, scoured or reworked by currents. These horizons are interpreted in the text as evidence for stationary surfaces within the chalk, with implications fordepositional timescales. (Photo: D. Tyler).*

of the Niobrara Chalk deposition was at depths greater than the European chalks. Currents were weaker and the bottom of the basin had less oxygen and nutrients to support life. If this conclusion is accepted, the bentonites provide evidence for over 100 stationary surfaces within the Niobara Chalk which, in turn, is evidence against catastrophic scenarios involving turbulent waters and few cycles of deposition. If Snelling's six-day model[46] for the three units of European Chalk is indefensible in Europe; it is equally deficient in the United States. The evidences, however, are consistent with catastrophic post-Flood chalk formation over a period measured in decades.

CONCLUSION

Despite lacking any appropriate modern analogue, most geologists are unwilling to move away from uniformitarian principles in seeking to understand Cretaceous chalk formation. The major features of the Chalk (purity, thickness, wide geographical occurrence, clear evidences of deposition in thick beds rather than laminae, erosive horizons, sedimentary structures of mounds and slumping, uneven distribution of fossils) are not adequately explained by uniformitarian models. Catastrophism involving algal blooms and short timescales offers a much more satisfying explanation of these diverse phenomena. It is suggested here that field evidences of hardgrounds, macrofaunal variations, speciation trends and bentonites limit the extent to which timescales can be shortened. Periods measured in decades are suggested to be realistic, rather than periods of days. This conclusion has a bearing on the location of the Flood/post-Flood boundary, for the longer timescales require the Chalk to be interpreted as a post-Flood phenomenon.

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Dr David Tyler has a B.Sc. in Physics from the University of Southampton, an M.Sc. in Physics (by research) from the University of Loughborough, and a Ph.D. in Management Science from the University of Manchester. He is a senior lecturer at a British university and is Secretary of the Biblical Creation Society (UK).