THE UPPER TRIASSIC SECTION AT CHILCOMPTON, SOMERSET, WITH NOTES ON THE RHAETIC OF THE MENDIPS IN GENERAL

by

Christopher J. Duffin

Summary

The temporary section at Chilcompton, Somerset, exposing rocks of Norian and Rhaetic age, is described and interpreted in terms of cyclic sedimentation. The Westbury Beds vertebrate fauna, which is dominated by hybodont selachians, appears to be replaced by a dominantly palaeoniscid fauna in the Cotham Beds. It is possible to correlate the cycles of sedimentation described for Chilcompton with those in sections in other parts of the Mendip area, and even further afield. In the Mendip Hills, the Westbury Beds typically contain two cycles, as do the Cotham Beds and succeeding Langport Beds. The bone-beds at the base of cycles Wb 1 and Cb 1, the mudcrack horizon at the base of Cb 2 and the contorted bed at the top of Cb 1 are particularly useful in regional correlation.

Introduction

The Chilcompton railway cutting was situated 300 m. to the east of Chilcompton village, in Somerset (ST 653523). The rocks exposed in the cutting were briefly mentioned by Woodward (1876, p.79) and Savage (1962, p.278); the former author examined the section shortly after its opening. Richardson (1911, p.66) later examined the section in more detail. The cutting quickly became overgrown, and after closure of the line, permission was granted to Clutton Rural District Council to utilise the site as a rubbish tip. It is now completely filled in.

The section comprises Triassic deposits from the Keuper to the White Lias and was one of the few exposures of these beds in the Mendip area. It was therefore decided to examine the section, prior to infill, by means of digging trenches down the cutting sides at regular intervals. More recently, the cutting sides were mechanically scraped to provide topsoil for covering successive layers of rubbish and a clean section was temporarily available for study. Sykes (1977) also examined this section, but his measurements differ considerably in certain cases to those given here (see table 1). Sykes' (pers. comm.) measurements were based on a single visit to the section made during the early stages of the mechanical scraping. The measurements given here were made over a period of time and result from the collation of data from trenches, scraped sections, and general observation of the cutting as a whole. This series of measurements revealed some degree of variability of individual units when traced along the length of the cutting.

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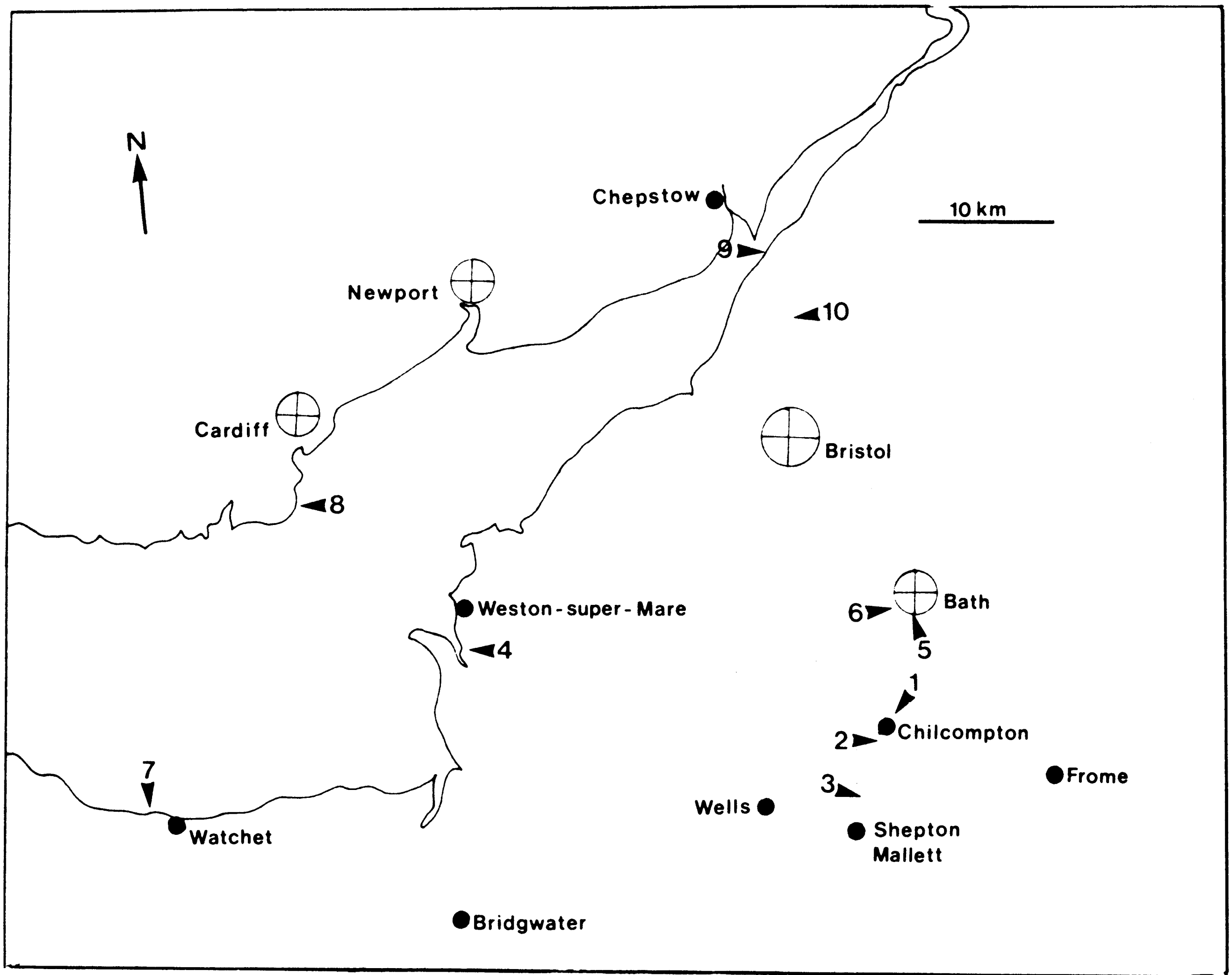
pp.251-268, 2 text-figs., plate 24.

Table 1. Comparison of data and correlation of lithological units of various measured sections at Chilcompton.
a - convention used in this paper;
b - data from Richardson 1911, p.66;
c - data from Sykes 1977, p.221.

a.			b.		c.	
Cycle	Unit	Thickness	Bed No.	Thickness	Bed	Thickness
Lb 2.	d	0.13 m.	Beds recorded as present, but out of correct sequence.		not recorded	
	c	0.13				
	b	0.19				
	a	0.14-0.36				
Lb 1.	b	0.12-0.25		Total 0.94 m	not recorded	
	a	0.1 -0.19				
Cb 2.	d	0.1 -0.13	present	0.125	not recorded	
	c	0 -0.2	1	0.175		
	b	0.4 -0.9				
	a	0.19-0.38	2(?)	0.76		
Cb 1.	b	0.62			light grey marl	0.12 m
	a	0.1 -0.16	3	0.1	grey marls + limestones	0.5
Wb 2.	b	1.4 -2.0	4-6	1.22	black shales	2.075
	a	0.2 -0.24	7	0.075	limestones + mudstone	0.125
Wb 1.	b	1.1 -1.17	?8-14	0.915	shale	0.7
	a	0 -0.025	15	0.025	Bone-bed	0.025
Tea Green Marl		3.6		3.66	not recorded	

The floor of the cutting was about 20 m wide, and the sides 7 m high at the point of greatest depth during the early stages of rubbish accumulation. The exposure was oriented north east - south west, and measured vertical sections were taken along some 200 metres, on both sides of the cutting. The strata displayed a northerly dip of 3° and less.

The geographical location of the section and its relation to other Rhaetic sections in the West Country is given in text-fig. 1. Text-fig. 2 is the tabulated sequence.



Text-fig. 1: Location map for sections noted in the text.
1, Chilcompton railway cutting; 2, Old Down; 3, Three Arch Bridge;
4, Uphill; 5, Newbridge Hill; 6, Kelston Station; 7, Blue Anchor Point;
8, Penarth; 9, Aust Cliff; 10, Filton By-Pass.

Stratigraphy

Keuper Marls

The red Keuper Marls which were just visible in the floor of the south side of the cutting gave way upwards to at least 3.5 m of Tea Green Marls. The unfossiliferous Tea Green Marls comprised hard, sandy limestones alternating with shaley marls. The topmost bed of this unit was a grey/green stiff clay, 0.13 to 0.15 m thick. The Keuper Marls showed no evidence of trace fossils or evaporites.

Rhaetic : Westbury Beds

The base of the Westbury Beds was marked by a calcareous sandy bone-bed, 0 to 25 mm thick. The bone-bed was not ubiquitous in the cutting at this level, but was best exposed at the southern end. It displayed a ripple-marked upper surface, and in places filled hollows on the surface of the Tea Green Marl. Sole markings and sporadic burrows were present on the undersurface of the bone-bed, which was well sorted, medium-grained, and had a high ratio of vertebrate remains to other clastics. Some fragments and fossils derived from the Carboniferous Limestone were present. An unusual feature was the presence of large numbers of idiomorphic quartz crystals (some bipyramidal) measuring up to 2 mm in length. Kent (1970, p.365) has recognised similar crystals of localised development, and believes them to be authigenic. Antia (1979, p.146) considers overgrowths of crypto-crystalline silica on quartz crystals to be important in considering bone-bed origins, and figures silica plastering on quartz grains from the Rhaetic Beds of Blue Anchor Point, Somerset (Antia, 1979, pl.18, fig.h). In the basal bone-bed of Chilcompton, quartz crystals of purely clastic origin were fairly well rounded.

Directly overlying the bone-bed was a series of laminated black shales, 1.1 to 1.17 m thick, yielding a fairly rich fauna of typical lower Rhaetic invertebrates, and a rather sparse vertebrate fauna. The vertebrates occurred sporadically throughout these shales, whereas the tendency of the invertebrate fauna was to be located in pockets. The valves of bivalve molluscs were found in the stable position (convex surface upward) and disarticulated, although usually entire. They were occasionally found in the unstable position, and representatives of a single size and species were often concentrated together. These invertebrate remains were mostly represented by internal casts, but occasional specimens with a representation of the original shell material have been collected.

The laminated black shales were overlain by a 200 to 240 mm thick sandy limestone with shale partings. These lithologies were very poor in fossils, but badly preserved trace fossils (*Ophiomorpha* and *Rhizocorallium*) have been found.

This unit was succeeded by a thick (1.4 to 2 m) sequence of non-laminated black shales, with occasional sandstone lenses and with a somewhat richer vertebrate fauna than the underlying laminated shale, but with a less well-preserved invertebrate fauna. The shales appeared to show poorly-defined cross-bedding in places, an unusual feature.

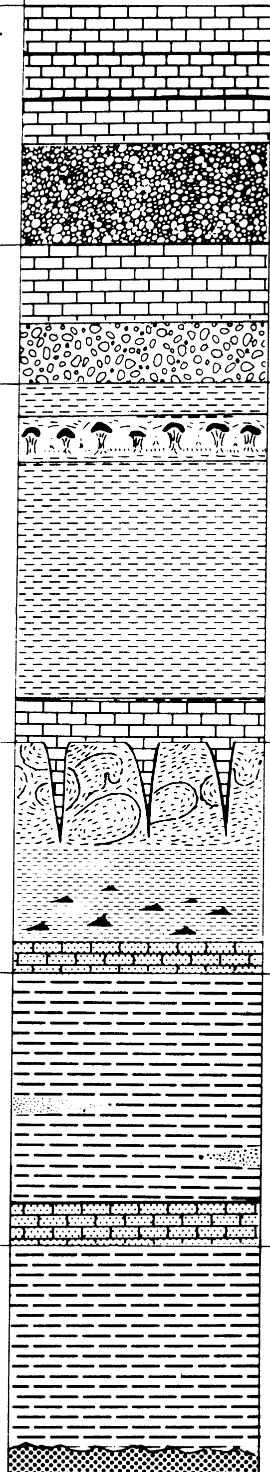
Cotham Beds

The base of the Cotham Beds is usually defined as the level at which the predominantly black shale sequence of the Westbury Beds gives way upwards to a more calcareous series of rocks which are lighter in colour; they usually comprise grey, greenish or creamy marls, mudstones or siltstones (cf. Hamilton, 1962; Savage, 1962; Kellaway & Oakley, 1934, for reference to local sections, and Ivimey-Cook, 1975, for sections in South Wales). With reference to the procedure in earlier works, the junction between the Westbury and Cotham Beds at Chilcompton was placed at the very top of the non-laminated black shales (text-fig.2).

The non-laminated shales were overlain by 100 mm to 160 mm of thinly bedded sandy limestones, with occasional black shale or stiff black clay lenses. Invertebrate remains were uncommon in this unit, the top of which was marked by a thin, locally fissile, calcareous sandstone with a very rich vertebrate fauna and invertebrate fauna.

Above this bed, the sequence continued with 620 mm of thinly laminated grey marls and limestones, with ripple lenticles of calcareous sandstone occurring near the base. The top 100 mm or so of the grey marls exhibited a marked reduction in the number of lenticles, and there was evidence of penecontemporaneous deformation.

The next unit was a 190 mm to 380 mm thick, apparently unfossiliferous creamy limestone with calcite cement. The crude bedding of this unit was distorted, although to a lesser extent than that exhibited by the underlying lithology. The most prominent feature of this horizon was the preservation of large mudcracks, which extend downwards into the grey marls beneath. The mudcracks were deep (200 mm to 250 mm on average) and taper downwards to a fine point (pl.24, fig.d). They were spaced horizontally at fairly regular intervals (220 mm apart on average). The grey marls immediately underlying and adjacent to the mudcracks were usually soft and clayey with a brown colouring, presumably a weathering effect. In places the contorted bedding of the grey marls appeared to pass through the mudcracks, although the substance of the latter was consistently a hard, fairly massive limestone. A series of horizontal shrinkage cracks was usually located in and directly above the mudcracks. The shrinkage cracks extended vertically through the thickness of the bed above the mudcracks. In some cases, the lines of shrinkage cracks tended to deviate from the vertical, and in these instances the sense of the deviation was towards the north east in all of the examples found. The shrinkage cracks themselves were almost always filled with calcite and occasional lines of them occurred where there was no mudcrack. Sporadic examples of vertical shrinkage cracks have been seen in this lithology.



Formation.	Cycle.	Unit.	Thickness.	Succession.	Description.
Langport Beds	Lb 2	d	13 cm.		3 Creamy limestones.
		c	13		
		b	19		
		a	14 - 36		Coarse limestone rubble.
	Lb 1	b	12 - 25		Creamy limestone.
		a	10 - 19		Limestone rubble, clay matrix.
Cotham Beds	Cb 2	d	10 - 13		Brown clay.
		c	0 - 20		Cotham Marble.
		b	13 40 - 90		Grey clay.
		a	19 - 38		Creamy limestone with mudcrack fills.
	Cb 1	b	50 12		Thinly laminated clay & siltstones with penecontemporaneous folding. Grey clays and siltstones – ripple laminated toward base.
		a	10 - 16		Thin sandy limestones.
Westbury Beds	Wb 2	b	140 - 200		Unlaminated black shale with occasional sandstone lenses.
		a	20 - 24		Sandy limestone with shale partings.
	Wb 1	b	110 - 117		Laminated black clay shales.
		a	0 - 2·5		Bone bed, rippled surface.
Tea Green Marl			360		Green clay (13-15cm.), underlain by shaley and occasional sandy marls.

Text-fig. 2: The Rhaetic succession of Chilcompton railway cutting.

Above the creamy limestone a 400 mm to 900 mm thick grey clay unit was found, with occasional sandy limestones and siltstones. Towards the top of the sequence, siltstones became less common, and the lithology graded into a brown clay, 130 mm thick. The fossil content of this clay was poor, although a thin layer of well preserved invertebrate remains was found near the top.

Next in the sequence came the Cotham Marble, which was very variable in thickness, ranging from 0 to at least 200 mm thick within a distance of less than 5 m along the cutting face. The upper surface was usually mammillated, the individual protuberances on the upper surface of the bed being greatly pronounced in the thicker portions of the bed, elongate, and often oriented. The various features of the Cotham Marble have been shown to be algal in origin for the 'landscape type', and of sedimentary origin for the 'crazy Cotham type' (Hamilton, 1961). Examples of double landscape features (one landscape feature overlain by another within the same bedded unit) have been found at this locality. Thinly bedded mudstones showing sporadic evidence of small-scale channelling were common at this level. No mudstone flakes were preserved within the channels. The impression was obtained, however, that the mudstones were lateral equivalents of the landscape Cotham Marble, although the precise field relationships of the two lithologies was difficult to judge because of the state of the section at the time of examination. No fossils have been found in the Cotham Marble at this locality.

Langport Beds

The Langport Beds comprise a number of beds of limestone of rather uniform thickness. The basal bed was a rubbly limestone, 100 mm to 190 mm thick, with interstitial clay and abundant invertebrate remains. It was overlain by a 120 mm to 250 mm thick creamy limestone, again rich in invertebrates. A second rubbly limestone bed with fairly numerous specimens of *Ophiomorpha* and invertebrates followed, measuring 140 mm to 360 mm thick. The remainder of the Langport Beds comprised three well-bedded limestones, 190 mm, 130 mm, and 130 mm thick respectively, veined with calcite and devoid of fossils.

Discussion of the stratigraphy

Sedimentary cycles, defined by repetitions of lithological types, or the recurrence of specific sets of sedimentological conditions throughout a succession of beds, were apparent in the Chilcompton section. The concept of cyclicity in the Rhaetic sequence has been previously considered by Ivimey-Cook (1962, 1974), who related sedimentary cycles to faunal composition and diversity in the Penarth area (near Cardiff), and also by Hamilton (1962, 1977) in describing the rocks exposed in the construction of the Filton By-Pass Substitute, and those exposed in the cliff section at Aust, Avon. Hallam (1969, p.159) considered that the entire Rhaetic sequence was itself a cyclothem, while Hamilton (1962, p.285) made the interesting comment that in this case, the lithological sequence of individual cycles within the Rhaetic is the reverse of that of Hallam's Rhaetic cyclothem. Cyclicity may prove a useful tool in the correlation of Rhaetic sediments over a limited geographical area, since it must reflect local variation in either tectonic or climatic control of sedimentation. The cycles observed in the Rhaetic sediments at Chilcompton relate primarily to the energy conditions prevalent at the time of deposition, as reflected in a repetition of certain lithological types.

Two cycles were recognised in the Westbury Beds at Chilcompton. Cycle 1 (Wb 1) has the well sorted bone-bed at its base (text-fig. 2), and is completed by the overlying laminated black shales. The sandy limestone with shale partings marks a return to rather higher energy conditions, and forms the base of cycle 2 (Wb 2). The remainder of this cycle comprises the overlying non-laminated black shales, the absence of laminations possibly suggesting that energy conditions were greater for the deposition of this lithology than for the shales of Wb 1.

Cycle 3 (Cb 1) deposition opens with a thin sandy limestone overlain by a mudstone sequence with ripple laminations at the base (plate 24, fig.B), and gradually decreasing in incidence through the unit. This gradual reduction records the change from an initial higher energy depositional phase toward quiet water deposition with little clastic influence. The penecontemporaneous folding at the top of this cycle (plate 24, fig.B) marks an isolated interference with the quiet water sedimentation, perhaps related to tectonic activity.

Cotham Bed deposition continues after a period of subaerial exposure, as evidenced by the presence of large mudcracks at the base of the 4th cycle (Cb 2) (plate 24, figs.A,D). The basal creamy limestone is overlain by a grey clay, which is followed by the Cotham Marble. The 'landscape type' of development of this lithology can be interpreted as representing low energy, extremely shallow water conditions (Hamilton, 1961). In contrast, the 'crazy Cotham' development represents high energy conditions. At Chilcompton, the Cotham Marble horizon appears to be composed entirely of low energy components - 'landscape' marble and well bedded mudstones. For this reason, it is probably best to consider that this horizon, plus the overlying brown clay, represent the closing stages of Cb 2.

The Langport Beds displayed well developed cycles of rubbly limestone and well bedded limestone layers. Two cycles of this type are discernible in the Langport Beds at Chilcompton (Lb 1, Lb 2).

Discussion of the palaeontology

As much collecting of palaeontological material was made as time would allow, but because of the progress of the tipping, the Upper Rhaetic succession was best sampled. The distribution of fossils throughout the Chilcompton Rhaetic section is shown in Table 2, p.258.

Invertebrates

Invertebrate remains were totally lacking from the basal bone-bed (Wb 1) of Chilcompton. This is not always the case at other localities of Rhaetic age.

The black shales of Wb 1 yielded a reasonably good invertebrate fauna comprising *Rhaetavicula contorta* (Portlock), *Protocardia rhaetica* (Mérian), *Palaeocardita cloacina* (Quenstedt), *Eotrapezium* sp. and ? *Placunopsis alpina* (Winkler). This assemblage differs somewhat from the shales of Wb 2, from which *Rhaetavicula contorta*, *Palaeocardita cloacina*, *Eotrapezium concentricus* (Moore), *Plicatula intusstriata* Emmrich and ? *Modiolus hillanus* (J. Sowerby), were obtained. The basal limestone of Wb 2, which separates these two shale members was devoid of fossils, with the exception of the trace fossils mentioned above.

The limestone at the base of Cb 1 showed a slight difference in the invertebrate fauna, as compared with beds lower in the sequence. *Protocardia rhaetica* and *Plicatula intusstriata* survive from the previous cycles, and valves of *Chlamys valoniensis* (Defrance), *Isocyprina ewaldi* Bornemann and internal casts of gastropods appear as new faunal elements. In the case of the latter, two species - *Promathilda nitida* (Moore) and *Cylindrites fusiformis* (Moore) - are represented in almost exactly equal proportions.

The occurrence of *Plicatula intusstriata* in the Westbury Beds is interesting. This small bivalve is often regarded as more typical of the Upper Rhaetic, but has been recorded in the Lower Rhaetic at various localities (Richardson, 1905). Michalik (1975) reports *Plicatula intusstriata* as epifaunal components on the valves of *Rhaetina gregaria* (Suess), a brachiopod typical of the European Upper Triassic. The valves found in the bone-bed at the base of Cb 1 and in the shales of Wb 2 are isolated, but others from the Langport Beds occur as epifaunal elements on larger bivalves. Such commensalism has not apparently been reported from other British Rhaetic localities.

The occurrence of echinoid spines at the base of Cb 1, and higher in the Cotham Beds is interesting. Very few echinoderms are reported from the British Rhaetic. Those recorded and described so far are all ophiuroids. The spines found at Chilcompton, and also retrieved by the present author from the Westbury Beds of Penarth, and the Holwell fissure fauna collected by Moore (now held in the Bath Geology Museum), belong to a regular echinoid.

Table 2. Distribution of vertebrate and invertebrate fossils in the Rhaetic section at Chilcompton

Unit	
Lb 2. b-d.	Rare *Ostrea liassica.*
Lb 2. a.	Bivalves - *Myloconcha psilonota, Chlamys valoniensis*; indeterminate gastropods; trace fossils - *Ophiomorpha.*
Lb 1. b.	Bivalves - *Modiola langportensis, M. laevis, Pseudomonotis fallax, Pleurophorus elongatus, Pleuromya* sp., *Protocardia phillipiana, Atreta intus-striata*; indeterminate gastropods; rare, indeterminate insects.
Lb 1. a.	Barren.
Cb. 2. d.	Bivalves - *Pseudomonotis* sp.
Cb 2. c.	Barren.
Cb 2. b.	Regular echinoid spines; indeterminate internal casts of gastropods.
Cb 2. a.	Barren.
Cb 1. b.	Ostracods - *Rhombocyethere penarthensis.*
Cb 1. a.	Bivalves - *Chlamys valoniensis, Isocyprina ewaldi, Protocardia rhaetica, Atreta intus-striata*; gastropods - *Promathilda nitida, Cylindrites fusiformis*; hybodont sharks - *Acrodus minimus, Polyacrodus* sp.; palaeoniscid chondrosteans - *Birgeria acuminata, Saurichthys longidens, Gyrolepis albertii*; holosteans - *Sargodon tomicus*; reptiles - *Ichthyosaurus* sp.; dermal denticles, euselachian vertebrae echinoid spines, coprolites.
Wb 2. b.	Palaeoniscid chondrosteans - *Saurichthys longidens, Gyrolepis albertii,* fin rays; rare plant remains.
Wb 2. a.	Badly preserved trace fossils - *Ophiomorpha, Rhizocorallium.*
Wb 1. b.	Palaeoniscid chondrostean - *Gyrolepis albertii*; bivalves - *Eotrapezium* sp., *Protocardia rhaetica, Rhaetavicula contorta*; fin rays, coprolites.
Wb 1. a.	Hybodonts - *Acrodus minimus, Hybodus minor*; euselachians - *Nemacanthus monilifer*; palaeoniscid chondrosteans - *Birgeria acuminata, Saurichthys longidens, Gyrolepis albertii*; holostean - *Sargodon tomicus*; reptile - *Rysosteus oweni*; dermal denticles, fin rays.
Tea Green Marl	Barren.

Ivimey-Cook (1962) reports that ostracods, when present in the Lower Rhaetic, are typical of cycle 3 in the Westbury Beds. *Rhombocyethere penarthensis* Anderson occurs in the grey siltstones of the Chilcompton succession (Wb 3), and is the definitive lower Rhaetic ostracod (Anderson, 1964).

The invertebrate remains of the lower Rhaetic appear, for the most part, to occur at definite levels in the sequence, and as such, appear to reflect specific communities, with little or no transport involved (i.e. autochthonous).

Apart from the echinoid spines and internal casts of gastropods found in the clay beneath the Cotham Marble, the Cotham Beds are relatively poor in fossil content. The only exception is a thin layer rich in *Pseudomonotis* sp. in the brown clay directly overlying the Cotham Marble.

In the Langport Beds, the lower rubbly bed is devoid of recognisable fossil remains. However, the succeeding limestone contains a rich invertebrate fauna comprising *Modiola langportensis* Richardson and Tutcher, *Modiola laevis*, *Pleuromya* sp., *Pseudomonotis fallax* Pflücker, *Pleurophorus elongatus* Moore, *Protocardia phillipiana* Dunker, *Plicatula intusstriata*, internal casts of gastropods, and sporadic indeterminate insect remains. The overlying well-bedded limestones yield only sporadic examples of *Ostrea liassica.*

Vertebrates

The vertebrate remains from the basal Rhaetic bone-bed at Chilcompton were highly fragmented, abraded and polished. Reif (1971) used density, fracture patterns and polish to determine that remains from the Muschelkalk bone-beds of Southern Germany were fossilised prior to their incorporation into those deposits. He termed these remains 'prefossilised' (cf. also Duffin & Gaździcki, 1977; Sykes, 1977). This interpretation has recently been challenged by Antia (1979, p.98 *et seq.*) who states that the criteria used by Reif are either unsatisfactory, or could be the products of diagenesis in all cases.

In the example of the Wb 1 bone-bed, the presence of idiomorphic quartz crystals may be used as evidence for typical diagenetic effects within a stabilised bone-bed deposit composed of vertebrate remains which are primary components of the sediment (Antia & Whitaker, 1978; Antia, 1979). On the other hand, the well sorted nature of sediment and the fact that it was laid down under relatively high energy conditions, opening a sedimentary cycle at the base of a sequence, which is discrete in terms of stratigraphy and environment of deposition, does not preclude the possibility that this bed may indeed be comprised of prefossilised vertebrate remains.

The vertebrate remains occurring in the bone-bed which sees the commencement of deposition of cycle Cb 1, however, although disarticulated, are beautifully preserved, and are thus less likely to have been reworked than those in the basal bone-bed of Wb 1.

The Wb 1 and Cb 1 bone-beds yielded good samples of vertebrate remains, from which a faunal comparison can be made. In order to facilitate this, 100 remains were identified and recorded from the residues of material broken down in 10% acetic acid, and graded through four sieve sizes (850, 600, 500 and 420 micromillimetres mesh sizes). This gave a total of 500 vertebrate fragments counted from each of the two horizons (see table 3).

Table 3. Frequency distribution of vertebrate remains in bone-bed deposits at the Rhaetic section of Chilcompton.

	Wb 1 basal bone-bed	Cb 1 bone-bed
Gyrolepis albertii Ag.	140	390
Hybodus minor Ag.	78	-
Acrodus minimus Ag.	200	5
Birgeria acuminata (Ag.)	25	34
Saurichthys longidens Ag.	51	70
Sargodon tomicus Plieninger	6	1

In the basal bone-bed (Wb 1) residues, the selachians *Acrodus minimus* Agassiz and *Hybodus minor* Agassiz together form almost three-fifths of the vertebrate remains. Scales and teeth of the palaeoniscid chondrosteans *Gyrolepis albertii* Agassiz are well represented, with *Birgeria acuminata* (Agassiz) and *Saurichthys longidens* Agassiz making a small contribution. The teeth of these latter three species have been greatly confused in the literature, but have been recognised as distinct from each other by Griffith (MS), Sykes, Cargill & Fryer (1970) and Duffin (1974). The teeth of the holostean *Sargodon tomicus* Plieninger are very subordinate faunal elements in this horizon. Other sporadically occurring remains from the basal bone-bed (Wb 1) include a single vertebral centrum of the archosaur *Rysosteus oweni* Owen (Duffin Collection, Bristol City Museum - the genus never yields fin spines, as reported by Antia, 1979, p.142), and a few examples of the fin spines of the selachian *Nemacanthus monilifer* Agassiz. Dermal denticles of placoid morphotype (cf. Reif, 1978; Sykes, 1974) are also present. Vertebrate coprolites (cf. Duffin 1979) also form a subordinate component of the fauna.

Selachian remains are virtually absent from the Cb 1 bone-bed residues. There is, however, a concomitant increase in the representation of the palaeoniscids, especially *Gyrolepis*; remains of *Sargodon tomicus* are once again very rare. No examples of *Rysosteus* or *Nemacanthus* were recovered from the Cb 1 bone-bed, but a single large limb bone of *Ichthyosaurus* sp. was identified (plate 24, fig.E). Dermal denticles from the Cb 1 bone-bed belong to the hybodontid and placoid morphotypes (Reif, 1978) and include several new forms which will be described elsewhere. Additional remains from the Cb 1 bone-bed include sporadic examples of a new hybodont shark, to be described elsewhere, and fragments of selachian prismatic cartilage (cf. Applegate, 1967).

It is possible that the faunal differences between the two bone-beds is an artifact of sampling, reflecting slightly differing depositional conditions. An alternative possibility is that the significant selachian population of the Wb 1 deposit was replaced by a palaeoniscid dominated community preserved in that of Cb 1. The present author is conducting a detailed investigation of Rhaetian vertebrate faunas in an attempt to resolve this problem.

Vertebrate remains were uncommon in the black shales of Wb 1 and Wb 2 cycles, comprising only sporadic palaeoniscid remains and coprolites. It is interesting to note that the faunal list made by Richardson (1911, p.66) does not include any Upper Rhaetic species (i.e. Cotham Beds), and only a few lower Rhaetic forms are recorded by that author from the basal bone-bed (Wb 1) and beds number 7 and 5b of his designation.

Palynology

A representative series of samples from various levels in the Chilcompton succession are being examined by Dr. G. Warrington for palynological content.

Regional Correlation

Many records of Rhaetic sections in the Radstock area were made at the turn of the century, during the construction of expanding road and rail networks. Until recently, the Chilcompton railway cutting was one of the few remaining Rhaetic sections available for study in the Mendip area, the others having become overgrown or lost in some way. Those sections which can be compared with Chilcompton vary in usefulness according to the method of measurement and presentation of data employed by the original researcher, but in some instances, correlation can be made between the cycles of deposition at Chilcompton and those at other localities.

(i) Old Down, Emborough (ST 626509)

A temporary exposure at this locality, 2.5 km west of Chilcompton (text-fig. 1), was reported by Savage (1962). Two cycles (Wb 1, Wb 2) are apparent in the Westbury Beds, two cycles (Cb 1, Cb 2) in the Cotham Beds, and a single cycle in the Langport Beds. At this locality, Wb 1 begins with a bone-bed, as at Chilcompton, although at Emborough this is succeeded by a thin calcareous sandstone, and is of greater thickness. The black shales overlying the sandstone contains intercalations of fine micaceous sandstones with ripple marks and trace fossils. A "beef" layer towards the top of this shale sequence is peculiar to the Old Down locality. A thin, yellow-brown decalcified sandstone with a rich bivalve fauna (moulds only) interrupts this shale sequence. Wb 1 deposition continues with further shales and subordinate sandstones. The Wb 2 cycle opens with the deposition of a hard calcareous shelly limestone, succeeded by black shales and mudstones. According to Savage, the next bed, a grey-white, thinly-bedded limestone (bed 10 of his designation), crowded with vertebrate fragments, marks the beginning of the deposition of the Cotham Beds. Bed 10 compares favourably with the bone-bed located at the base of Cb 1 at Chilcompton. Emphasising the probability of this correlation, the bed at Old Down is succeeded by a sequence of grey marls and limestones. The mudcracks characterising the horizon basal to Cb 2 at Chilcompton appear to be absent at Old Down. Instead, Cb 2 appears to begin with a 150 mm thick grey-white limestone (bed 12 of Savage's designation). Higher in cycle Cb 2 at Old Down, the Cotham Marble is noted by Savage as including the landscape type, some of the specimens found showing a double landscape feature, as is the case with certain specimens from Chilcompton. The Cotham Marble is succeeded by a yellow-brown clay. The Langport Beds have a fossiliferous rubbly limestone at their base, giving way upwards to bedded creamy limestones, as at Chilcompton.

In overall view, the Westbury Beds appear to be more arenaceous at Old Down than at Chilcompton (note the thick, coarse bone-bed, extra sandstone horizons, and apparently more frequent sandstones in the shale sequence at Old Down). This is reasonable, since the nearest land areas in Rhaetic times were closer to the Old Down cutting than to Chilcompton (cf. Emborough Quarry and Gurney Slade fissure deposits, Robinson, 1957).

(ii) Three-Arch Bridge, Shepton Mallett (ST 618446)

This section (text-fig. 1) (Richardson, 1911), 7.8 km south west of Chilcompton, also demonstrates the influence of a nearby land area on the nature of the Rhaetic deposits (cf. Windsor Hill fissure, Kühne, 1956). It is possible to see some similarity in cyclicity with Chilcompton, but it is difficult to correlate the two sections precisely. The sequence at Shepton Mallett (Wb 1) does not commence with a bone-bed, but with a series of shales and pyritised limestones (beds 8 to 15 of Richardson, 1911). These beds are here considered to represent cycle Wb 1 of Chilcompton. The probable equivalent of Wb 2 at Shepton Mallett begins with bed 7 of Richardson, a 100 mm thick limestone, overlain by black and occasionally marly shales. Next in the succession is what Richardson terms "Thin hard grey layers with many quartz grains and fish remains, passing down into a hard conglomeratic limestone with small pebbles of Carboniferous Limestone" (Richardson, 1911, p.60). This horizon is very reminiscent of the bone-bed which opens Cotham Beds deposition at Chilcompton, with which it is probably equivalent. The conglomeratic nature of the deposits at Shepton Mallett emphasises the intertidal nature of deposition, and the Carboniferous Limestone pebbles indicate the proximity of an area where active erosion was taking place.

(iii) Uphill (ST 327583)

This cutting, 32 km west of Chilcompton (text-fig. 1) has received a good deal of attention in the literature (Wright, 1860; Moore, 1860; Woodward, 1870; Bristow & Etheridge, 1873; Sollas, 1880; Richardson, 1911; Kellaway & Oakley, 1934). The succession exposed at this locality has a closer affinity to those of the Blue Anchor to Lilstock coast section (north Somerset coast), and the Lavernock to Penarth coast section (South Wales), rather than to Rhaetic sections in the Mendips. This is highlighted by the presence beneath the Westbury Beds of Uphill and the coastal sections, of a series of Grey Marls (Sully Beds of

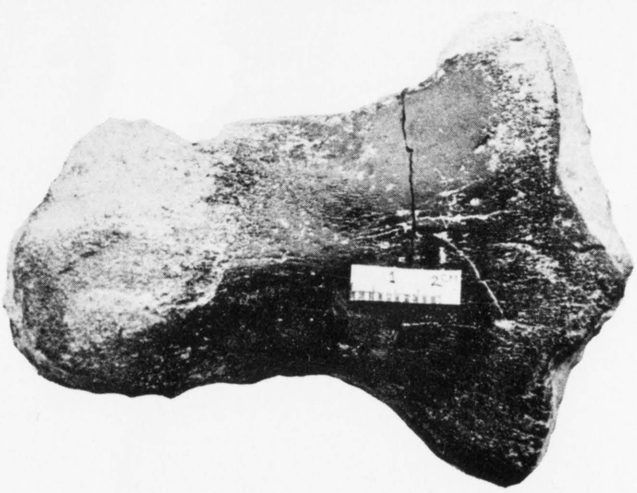
Explanation for Plate 24

Fig. A	Part of the Upper Rhaetic succession at Chilcompton railway cutting (north face).
Fig. B	The siltstones of cycle Cb 1, showing penecontemporaneous folding.
Fig. C	General view of the Rhaetic succession of the north face of Chilcompton railway cutting.
Fig. D	The junction of cycles Cb 1 and Cb 2, showing the development of a mudcrack descending into the contorted siltstones of Cb 1.
Fig. E	Ichthyosaur left humerus recovered from the Cb 1 bone-bed.


A


B


C




D

Richardson, 1911). Kellaway & Oakley (1934) take the base of the Westbury Beds as the base of the first series of black shales, which underlie a bone-bed. These shales could, however, represent a continuation of Grey Marl deposition, and the bone-bed itself may more reasonably be taken to represent the base of Wb 1, which is then followed by 2 m of black shales. Three cycles of deposition can be recognised in the Westbury Beds, the basal beds for each cycle being taken as the bone-bed mentioned above, the 'Lower Pecten Bed' and 'Upper Pecten Bed' for Wb 1, Wb 2 and Wb 3 respectively (thus comparing closely with the cliff section at Aust, Avon - ST 567895 - cf. Hamilton, 1977, p.116). The beginning of Cotham Bed deposition is marked by a colour change as the black shales of the Westbury Beds are succeeded by thinly-bedded marls and a limestone (Cb 1). Cb 2 begins with an 'argillaceous, sun-cracked deposit (Kellaway & Oakley, 1934, p.473), very reminiscent indeed of the mudcrack horizon opening Cb 2 deposition at Chilcompton, with which it is almost certainly equivalent. The Cotham Marble equivalent is fairly confidently identified as Bed 19 of Kellaway & Oakley, and the overlying brown calcareous clay-shale is similar to that overlying the Cotham Marble at Chilcompton.

(iv) Newbridge Hill, Bath (ST 718658)

This section (Winwood 1871; text-fig. 1) compares very well with that of Chilcompton, even though Newbridge Hill is situated 14.9 km north of Chilcompton. Wb 1 opens with a basal bone-bed, followed by a sequence of grey shales. The shales are overlain by a 'Marlstone' band (Winwood, 1871), which is here interpreted as the base of Cb 1. If this interpretation is correct, Wb 2 of Chilcompton is missing from the sequence at Newbridge Hill. According to Winwood, the marlstone band contains fish remains, an observation which might strengthen correlation of this bed with the bone-bed at the base of Cb 1 at Chilcompton. Cb 2 deposition began with a thin limestone, succeeded by further grey shales, directly overlain by the Cotham Marble. The Cotham Marble at this locality is reported by Winwood to be of the 'landscape type', and to contain *Pseudomonotis fallax*. The Cotham Marble is here succeeded by a brown clay, as at Chilcompton, terminating Cb 2 deposition. A well-bedded limestone gives way upwards to a series of rubbly beds which must be equivalent to the Langport Beds at Chilcompton.

(v) Kelston Station, Bath (ST 677668)

This section presents a fuller exposure of Rhaetic deposits (Winwood, 1884), situated to the west of Newbridge Hill, and 15 km to the north of Chilcompton (text-fig. 1). Like the Newbridge Hill section, that at Kelston appears to represent only one cycle in the Westbury Beds (Wb 1), which opened with a bone-bed overlying the Tea Green Marl, and was succeeded by black shales. The fact that the lower portion of the shales is laminated, and the upper part apparently non-laminated suggests that this shale sequence may be correlated with both Wb 1 and Wb 2 of Chilcompton. At Kelston, Cb 1 begins with a grey marl directly overlying the non-laminated black shales, and is succeeded by a well-bedded limestone, followed by a further marl band. A second limestone band, possibly the lateral equivalent of the limestone filling mudcracks at Chilcompton and Uphill, opened Cb 2 deposition. This is succeeded by a series of marls, followed in turn by the Cotham Marble, once again of the 'landscape type'. A thick (over 1 m) series of rubbly beds directly overlies the Cotham Marble, marking the transition to Langport Beds deposition. Cyclicity is not easy to discern in the Langport Beds at this locality, the rubbly beds giving way upwards to a series of well-bedded limestones.

(vi) Other localities

Certain sections in the area cannot, because of facies variations induced by nearby contemporary land masses be closely correlated with the Chilcompton section. These sections include a cutting at ST 631512 (Winwood, 1876 - records only a small patch of 'blue Rhaetic clays'), Luckington Quarry (ST 695497, Winwood, 1890), Vallis and Hapsford Hill (Moore, 1860; Richardson, 1911), Marston Road, near Holwell (Moore, 1867), and Milton Lane near Wells (Brodie, 1866; Woodward, 1873; Richardson, 1911).

Well documented sections such as those of the west Somerset coast and the Filton By-Pass Substitute can be usefully compared with Chilcompton, however. In a critical review of Richardson's (1911) work on the Blue Anchor Point to Lilstock coast sections, Whittaker (1978) successfully correlates the Upper Triassic and lowermost Liassic strata of these sites with the Glamorgan outcrops. Particularly interesting is the fact that Whittaker (1978, p.64) notes the presence of "contorted, deformed and possibly slumped calcareous siltstones" in the lower part of the Cotham Beds exposed on the west Somerset coast. Furthermore, the top of these contorted beds "commonly shows a crudely polygonal network of presumed shrinkage cracks" which penetrate the underlying strata to various levels. This is exactly the case at the transition between cycles Cb 1 and Cb 2 at Chilcompton.

At the temporary section of the Filton By-Pass Substitute (ST 797570 to ST 835606) (Hamilton, 1962), four cycles are recognised in the Cotham Beds. Deformed mudstones with sand lenticles are present at the base of Cb 2, and desiccation cracks are present at the base of Cb 4. This section therefore shows similar features to that of Chilcompton and the west Somerset coastal exposures, but differs in stratigraphical detail.

Conclusions

The temporary section at Chilcompton Railway cutting exposed rocks of Keuper (Tea Green Marl) to Rhaetic age. The stratigraphy is interpreted in terms of cyclic deposition. Two cycles (Wb 1, Wb 2) are present in the Westbury Beds, two in the Cotham Beds (Cb 1, Cb 2) and two in the Langport Beds (Lb 1, Lb 2). Both Westbury Bed and Cotham Bed deposition began with a bone-bed. A distinctive mudcrack horizon marks the base of Cb 2, and landscape Cotham Marble is present higher in the cycle. Invertebrates collected from the section are typical of the Rhaetic of the West of England. The selachian fauna may be replaced by a dominantly palaeoniscid fauna at the base of Cb 1.

The sedimentary cycles recognised at Chilcompton can be correlated with moderate success with previously reported sections in the Mendip area. Facies variation hinders such correlation in a number of cases, due to the proximity of contemporary land masses. With the exception of the Three-Arch Bridge section at Shepton Mallett, cycle Wb 1 commences with a bone-bed, as is the tendency with Cb 1. Two cycles are usually present in the Westbury Beds, except at Kelston Station and Newbridge Hill, near Bath, in which only one cycle survives, and at Uphill, near Weston-super-Mare, where three cycles are present. Two cycles are consistently encountered in the Cotham Beds, and the mudcrack horizon at the base of Cb 2 is also present in this position at Uphill, and coastal sections in South Wales and west Somerset (also at Selworthy, south Devon and the Winterbourne Kingston borehole, Whittaker pers. comm.). The Cotham Marble is consistently of the landscape type. The Langport Beds always show development of limestone rubble at cycle bases, succeeded by well-bedded limestones.

The small scale fining upwards sequences represented by the cycles, were laid down in a marine environment, as proved by the fossil content. Some fresh or brackish water influence may have been present at the top of the Cotham Beds, but conditions were once again thoroughly marine in the Langport Beds.

The probability of tectonic activity influencing Cb 1 deposition is illustrated by the presence of penecontemporaneous folds in the upper part of that cycle. As is the case with the mudcrack horizon, these contorted beds are of considerable use in fairly long range correlations. Such folding is also known from the Cotham Beds of the west Somerset coast and sections in Avon.

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C. J. Duffin
126 Central Road
Morden
Surrey, SM4 5RL