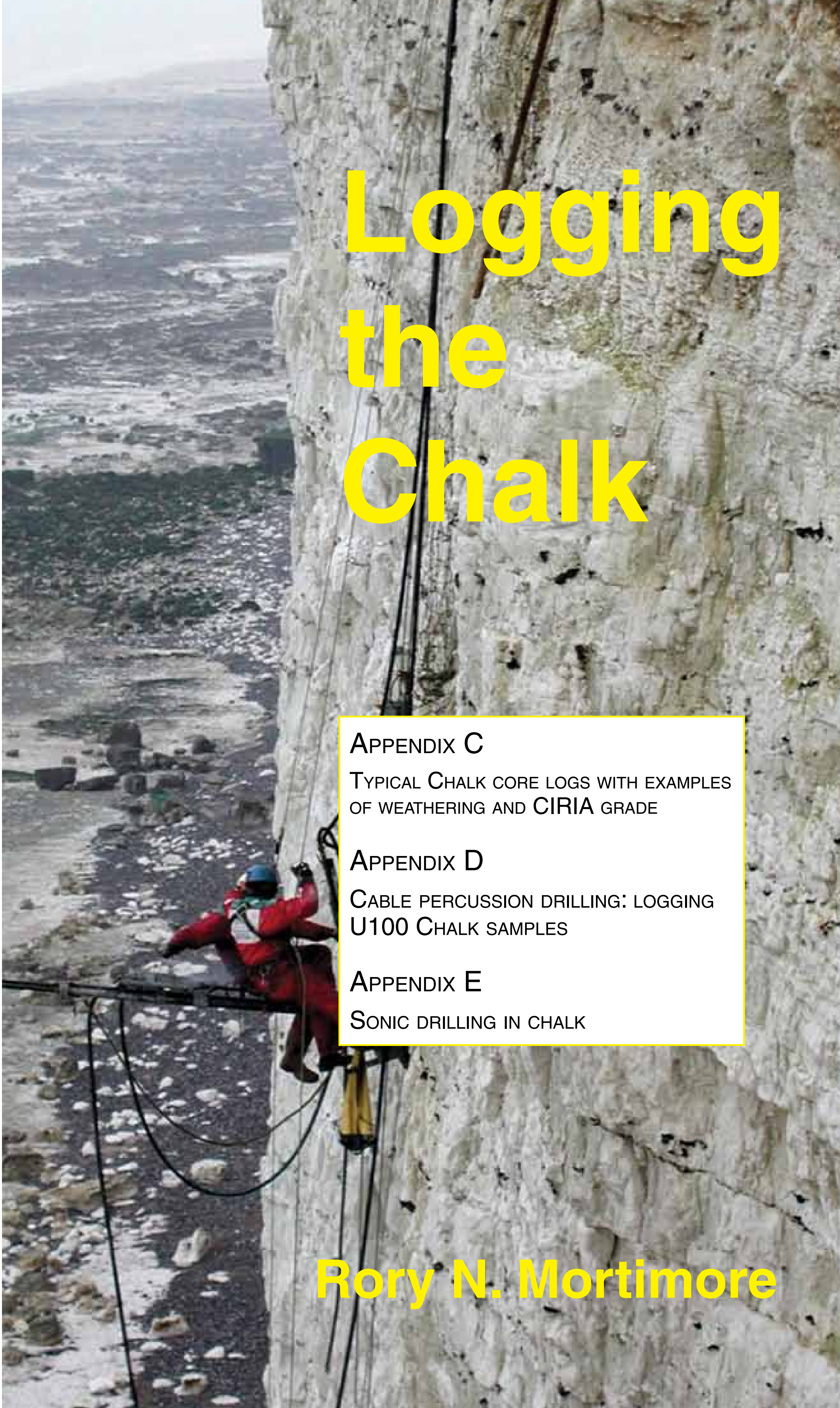

Logging the Chalk

Appendix C

Typical Chalk core logs with examples of weathering and CIRIA grade

Appendix D

Cable percussion drilling: logging U100 Chalk samples

Appendix E

Sonic drilling in chalk

Rory N. Mortimore

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Logging the Chalk

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LOGGING THE CHALK

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CABLE PERCUSSION DRILLING: LOGGING
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APPENDIX E

SONIC DRILLING IN CHALK

Rory N. Mortimore
Managing Director, ChalkRock Limited, East Sussex, UK
Emeritus Professor of Engineering Geology, University of Brighton

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APPENDIX C

TYPICAL CHALK CORE LOGS WITH EXAMPLES OF WEATHERING AND CIRIA GRADE

TYPICAL CHALK CORE LOGS AND EXAMPLES OF WEATHERING

Table C1 gives some characteristic properties and geophysical profiles of typical Chalk core logs and Figures C1–C19 show typical Chalk core logs with examples of weathering and CIRIA grade.

EXAMPLE CORE SETS FROM EAST LONDON

Selected parts of three sets of cores from East London with their graphical core logs are illustrated here as an aid to distinguishing between CIRIA grades A, B and C.

Core set 1 for Borehole 5a

Example of a typical Chalk core starting in relatively unweathered CIRIA grade B chalk passing down into CIRIA grade C chalk with filled fractures (Figures C5a1–C5a18).

Core set 2 for Borehole 5b

The second set of cores illustrate the change from filled open >3 mm, fractures (CIRIA grade C) to moderately stained slightly open <3 mm (CIRIA grade B) (Figures C5b1–C5b6).

Core set 3 for Borehole 5c

The third set of cores illustrate the change from filled open >3 mm fractures (CIRIA grade C) to moderately stained slightly open <3 mm (CIRIA grade B) and then grade A with very large flints (Figures C5c1–C5c10).

CORE PREPARATION

It is essential to clean chalk core to obtain the necessary geological detail. For much of the White Chalk Subgroup, scraping the putty skin away is usually adequate. In some instances it is also necessary to wash the core clean (using a squeezy bottle, for example). For the West Melbury Marly Chalk Formation and parts of the Zig Zag Chalk Formation, even washing the core may be inadequate and, having been washed, the core needs to dry for about two hours before the detail becomes apparent (Figures C5d1 and C5d2).

Table C1 Some characteristic properties and geophysical profiles of typical Chalk core logs

Borehole	Location	Information
BH P000	Channel Tunnel, Dover	Simplified log showing Folkestone–Dover stratigraphy in the Grey Chalk Subgroup and base of the White Chalk Subgroup
BH C1 and BH P000	BH C1 East Kent groundwater investigations	Typical East Kent 16 inch electrical resistivity geophysical wireline log for comparison with core logs
BH RC6661	North Downs, Kent, Channel Tunnel Rail Link North Downs Tunnel	Typical index properties for the Zig Zag, Holywell Nodular, New Pit and Lewes Nodular Chalk formations in the North Downs, Kent
Pyecombe West	Pyecombe, Sussex	A log through the West Melbury Marly Chalk and Zig Zag Chalk formations, South Downs
Offham B	Offham, near Lewes, Sussex	A log through the West Melbury Marly Chalk and Zig Zag Chalk formations, South Downs for comparison with core photographs
Pyecombe East	Pyecombe, Sussex	A log through the West Melbury Marly Chalk and Zig Zag, Holywell Nodular and New Pit chalk formations, South Downs
Thames Tunnel	East London	A log through the Lewes Nodular Chalk Formation typical of East London
Thames Tunnel	East London	A log through the Seaford Chalk Formation typical of East London
Margate Cliffs	East Kent	Log of a field section through the top Seaford Chalk Formation and the Margate Chalk Member
BH FB104	Friars Bay, Newhaven Sussex	Log through topmost Seaford and basal Newhaven Chalk formations
BH MTR 128	Saltdean dry valley, South Downs, Sussex coast	Log through weathered Newhaven Chalk Formation illustrating depth of weathering beneath a dry valley in the South Downs
BH Dunbridge B	Log typical of part of the Culver Chalk Formation, Hampshire	Log through weathered Culver Chalk Formation illustrating depth of weathering close to a river valley in Hampshire
BGS West Lulworth	West Lulworth, Dorset	Cored borehole Newhaven to Portsdown chalks; logged by R.N.Mortimore
West Marden BH B	West Marden, South Downs, West Sussex	Log through weathered topmost Seaford and basal Newhaven Chalk formations for comparison with core photographs in CIRIA grade C chalk
Core set 1 for Borehole 5.a (WP51R)	East London	Examples of CIRIA chalk grades A, B, C in rock core
Core set 2 for Borehole 5.b (WP43R)	East London	Examples of CIRIA chalk grades A, B, C in rock core in moderately to heavily stained and Liesegang banded chalk
Core set 3 for Borehole 5.c (WP46R)	East London	Examples of CIRIA chalk grades A, B, C in rock core in heavily stained and Liesegang banded chalk
Core preparation	Offham and Pycombe cores, Sussex	West Melbury Marly Chalk Formation, Offham and Pycombe showing differences in detail from different degrees of core cleaning

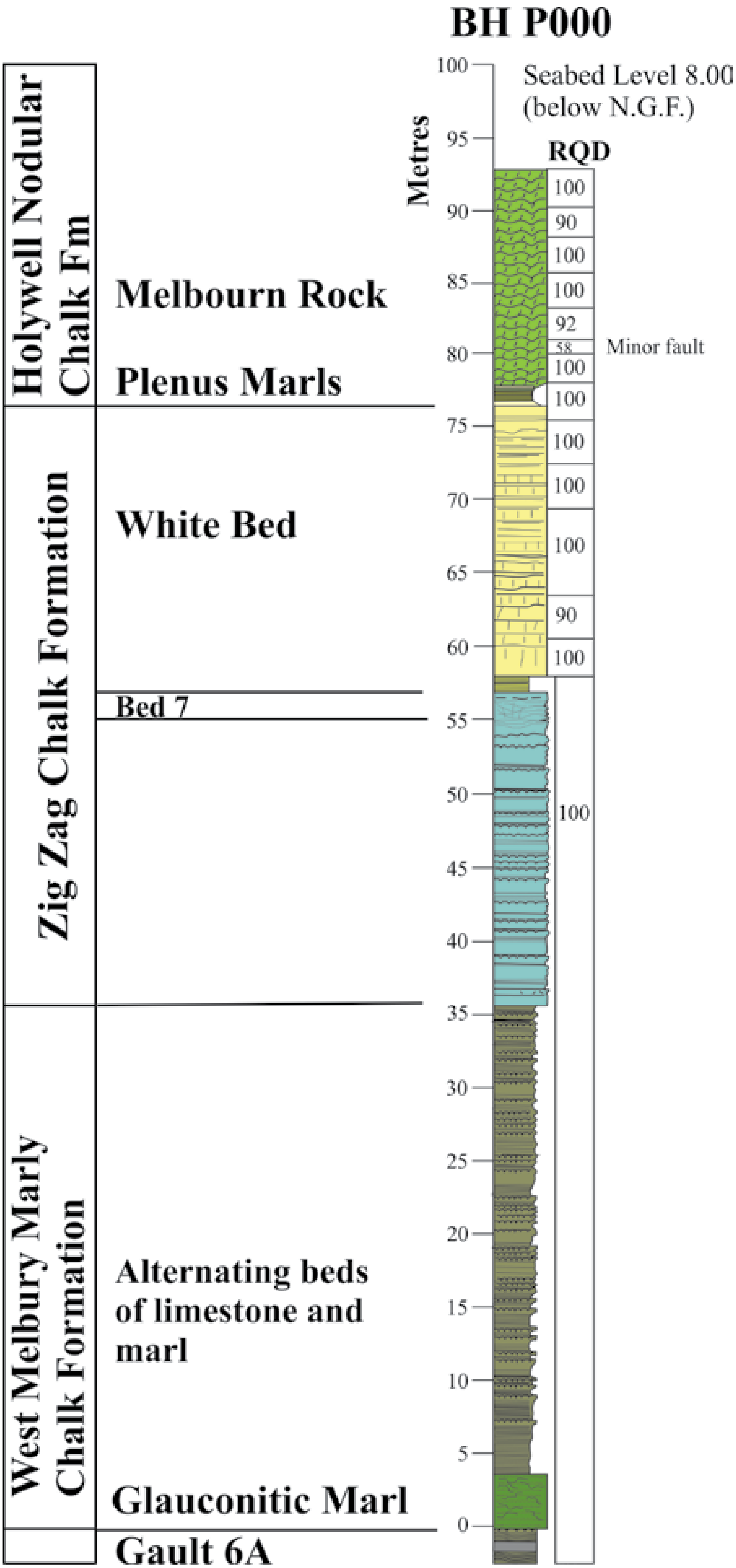


Figure C1 Simplified log of a Channel Tunnel borehole from Dover Harbour showing the typical lithologies and thicknesses of Chalk units present in East Kent.

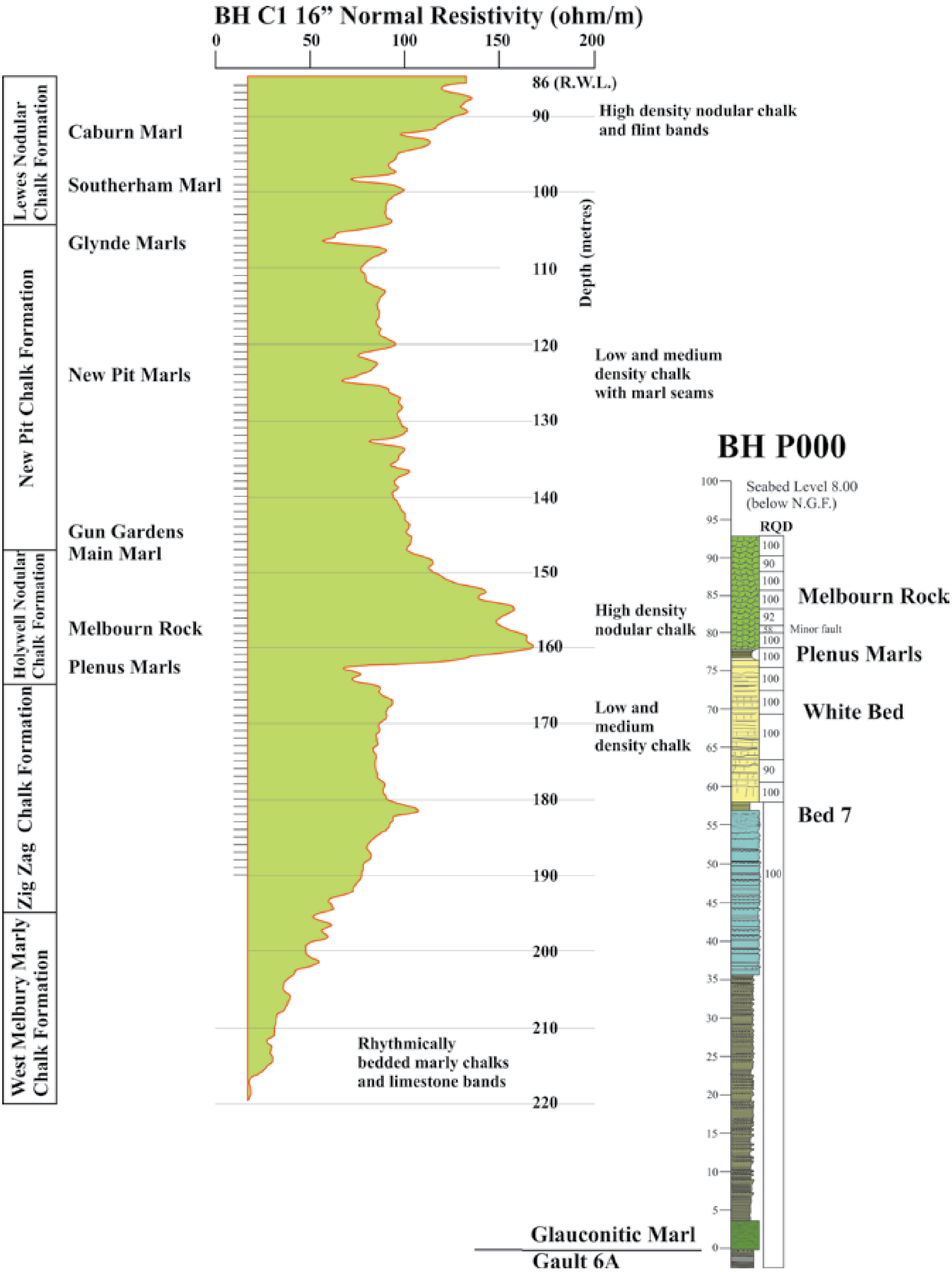


Figure C2 Channel Tunnel cored borehole from Dover harbour compared with a borehole geophysical log (electrical resistivity) from St Margaret's, east of Dover. This geophysical borehole log is typical of the North Downs Chalk of East Kent in the Chalk formations illustrated. See also Mortimore and Pomerol (1987). Published with permission of Southern Water.

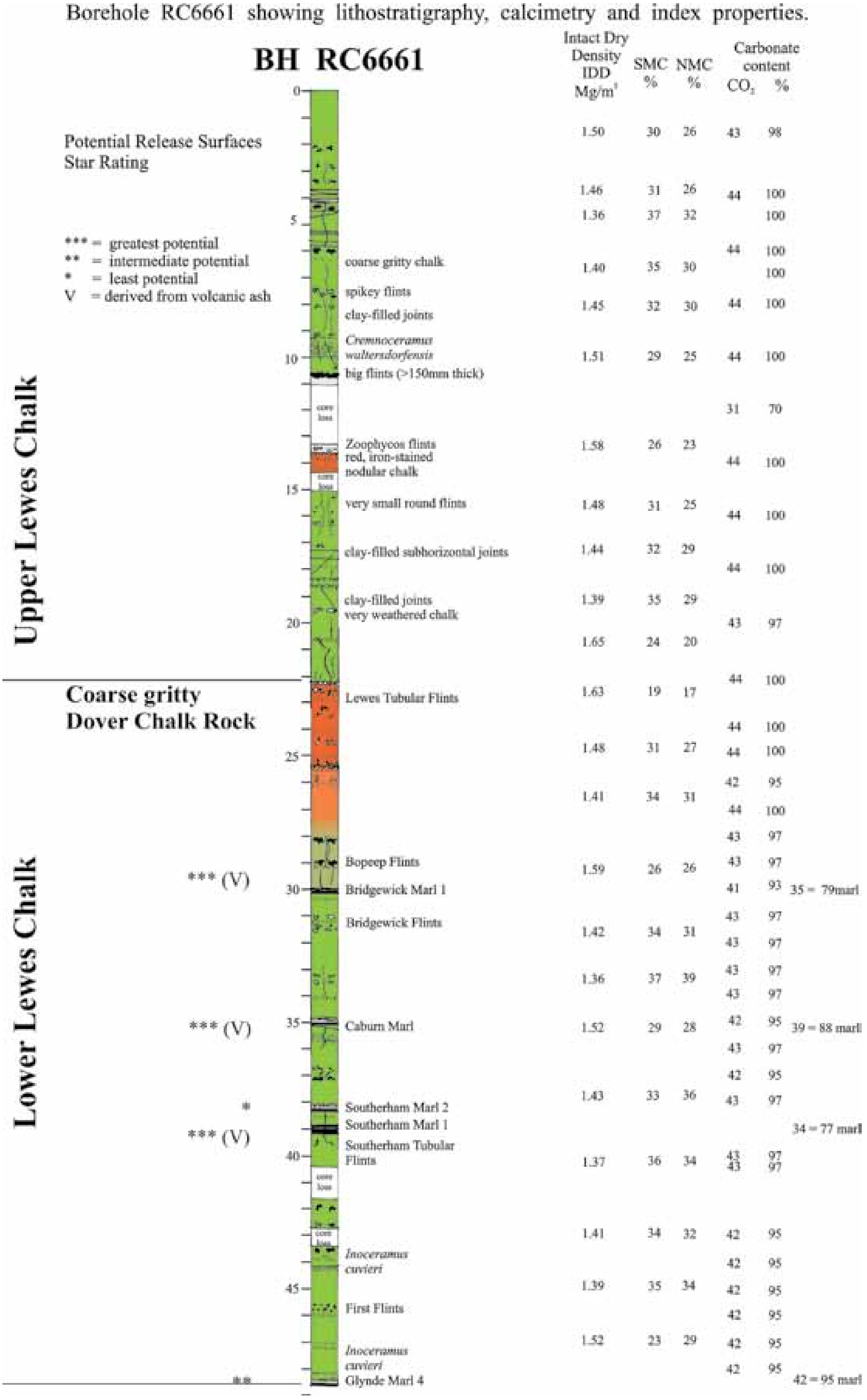


Figure C3a BH RC6661, top section, Lewes Nodular Chalk Formation.

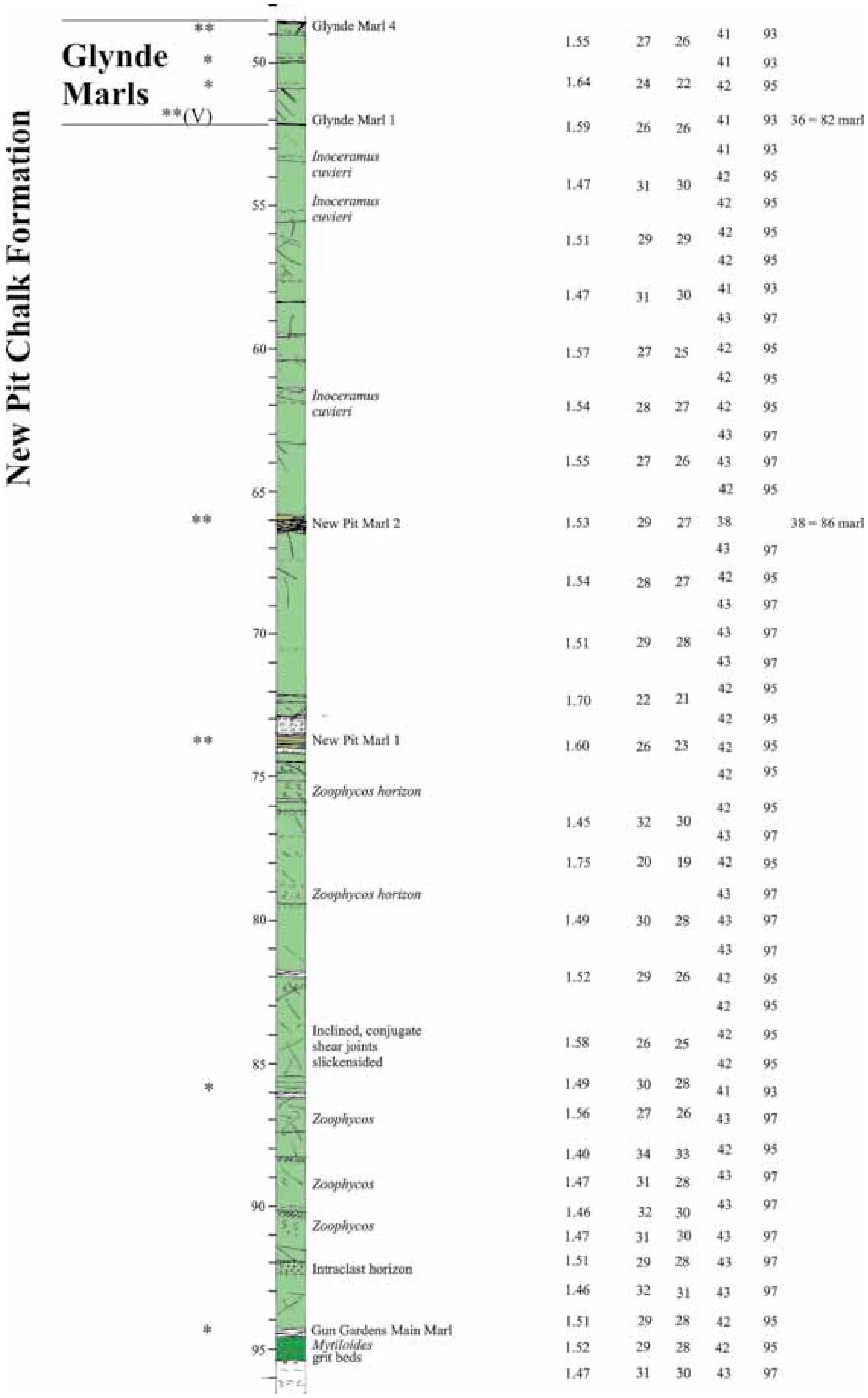


Figure C3b BH RC6661, middle section, New Pit Chalk Formation

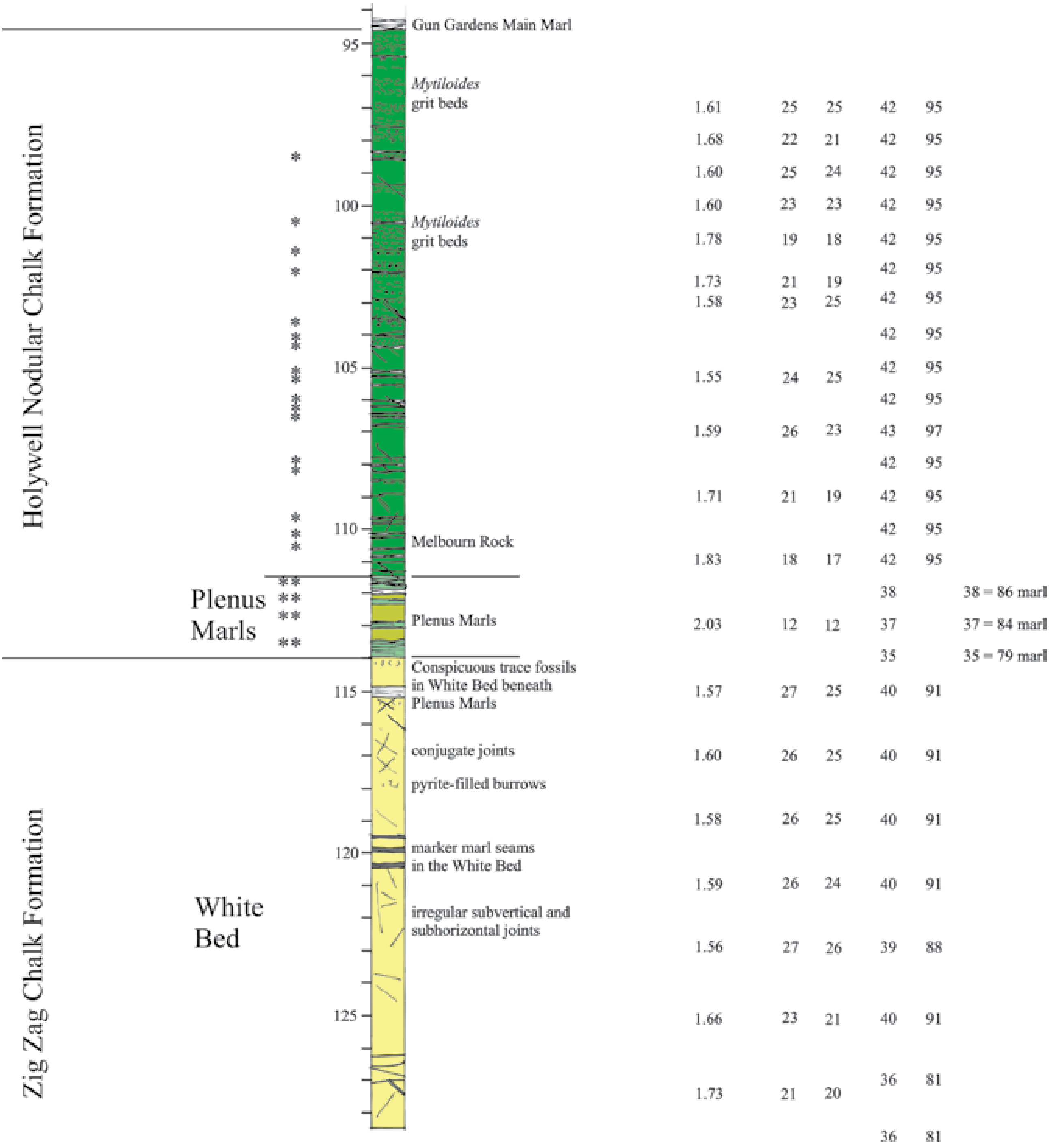


Figure C3c BH RC6661, lowest section including the top Zig Zag Chalk Formation, Plenus Marls and the Holywell Nodular Chalk Formation. Borehole RC6661 from Bluebell Hill, Kent. Published with permission of Union Railways Limited.

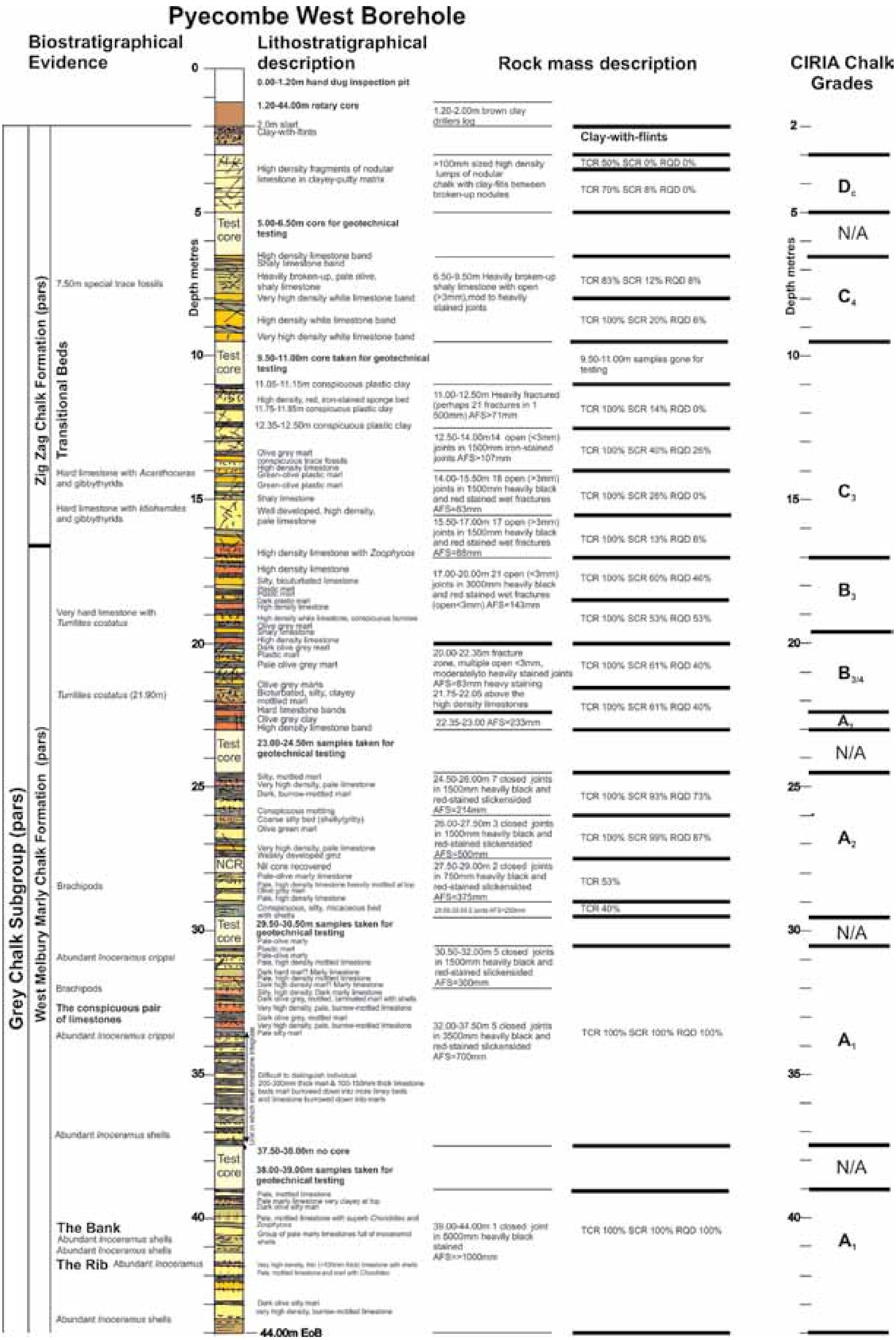


Figure C4 Typical log in the West Melbury Marly Chalk Formation and basal Zig Zag Chalk Formation, South Downs, Sussex. Published with permission of Southern Water.

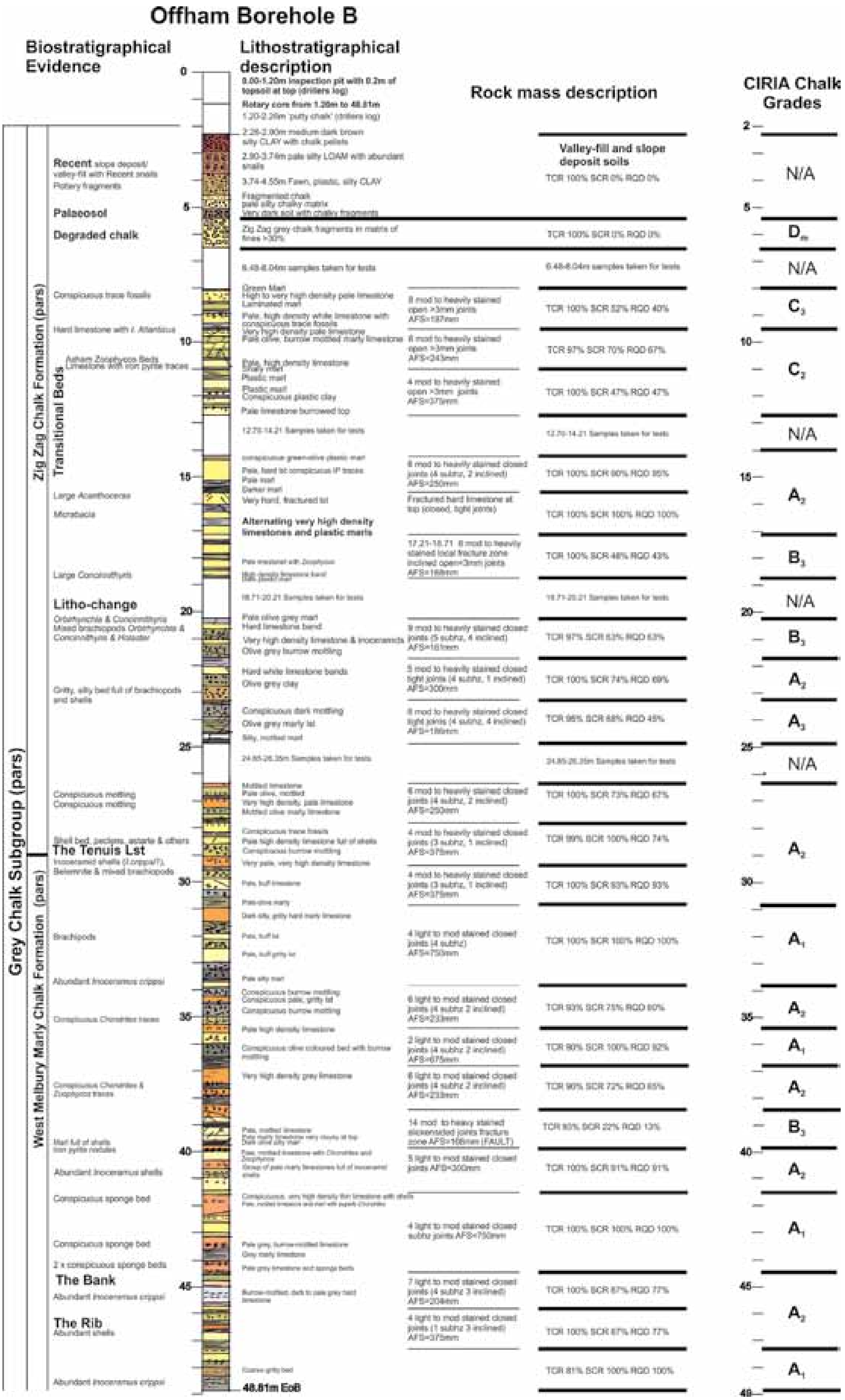


Figure C5 Offham B Borehole, Sussex, illustrates a typical log for the West Melbury Marly Chalk Formation and Zig Zag Chalk Formation. Published with permission of Southern Water.

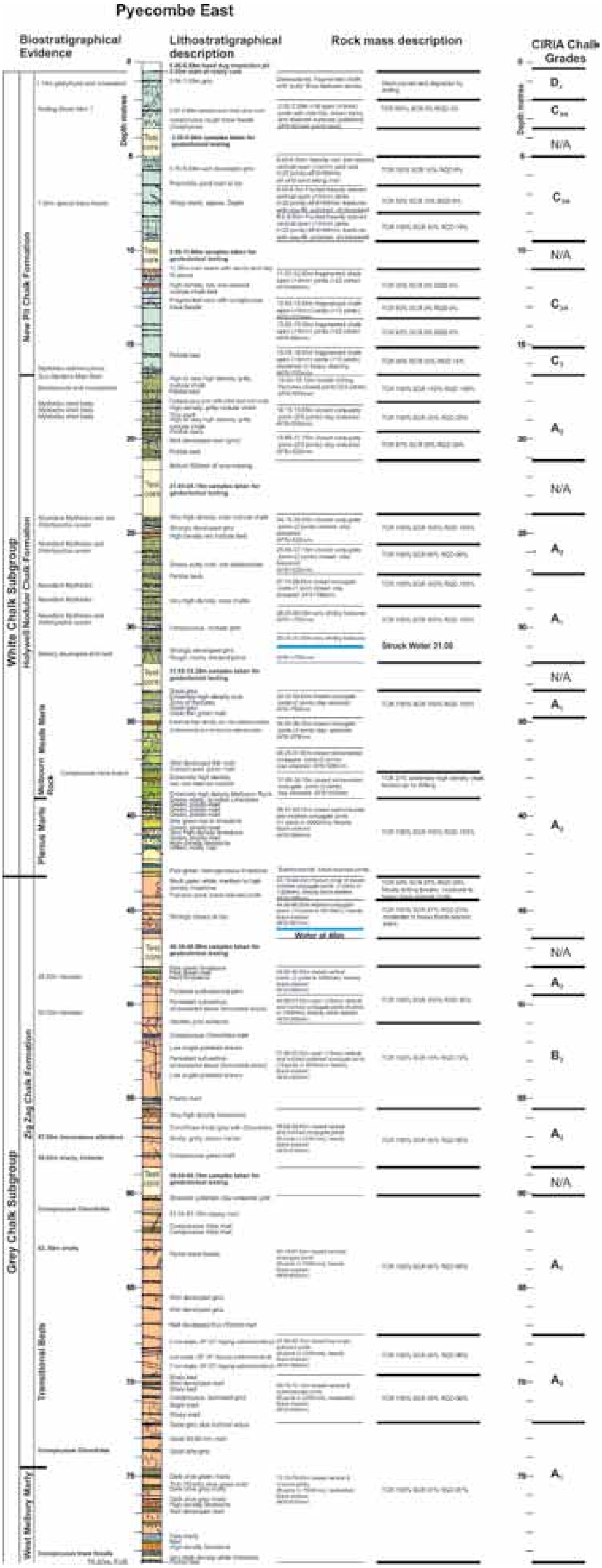


Figure C6 Log typical of the transition through the West Melbury Marly Chalk Formation to the complete Zig Zag Formation, complete Holywell Nodular Chalk Formation and basal New Pit Chalk Formation in the South Downs, Sussex. Published with permission of Southern Water.

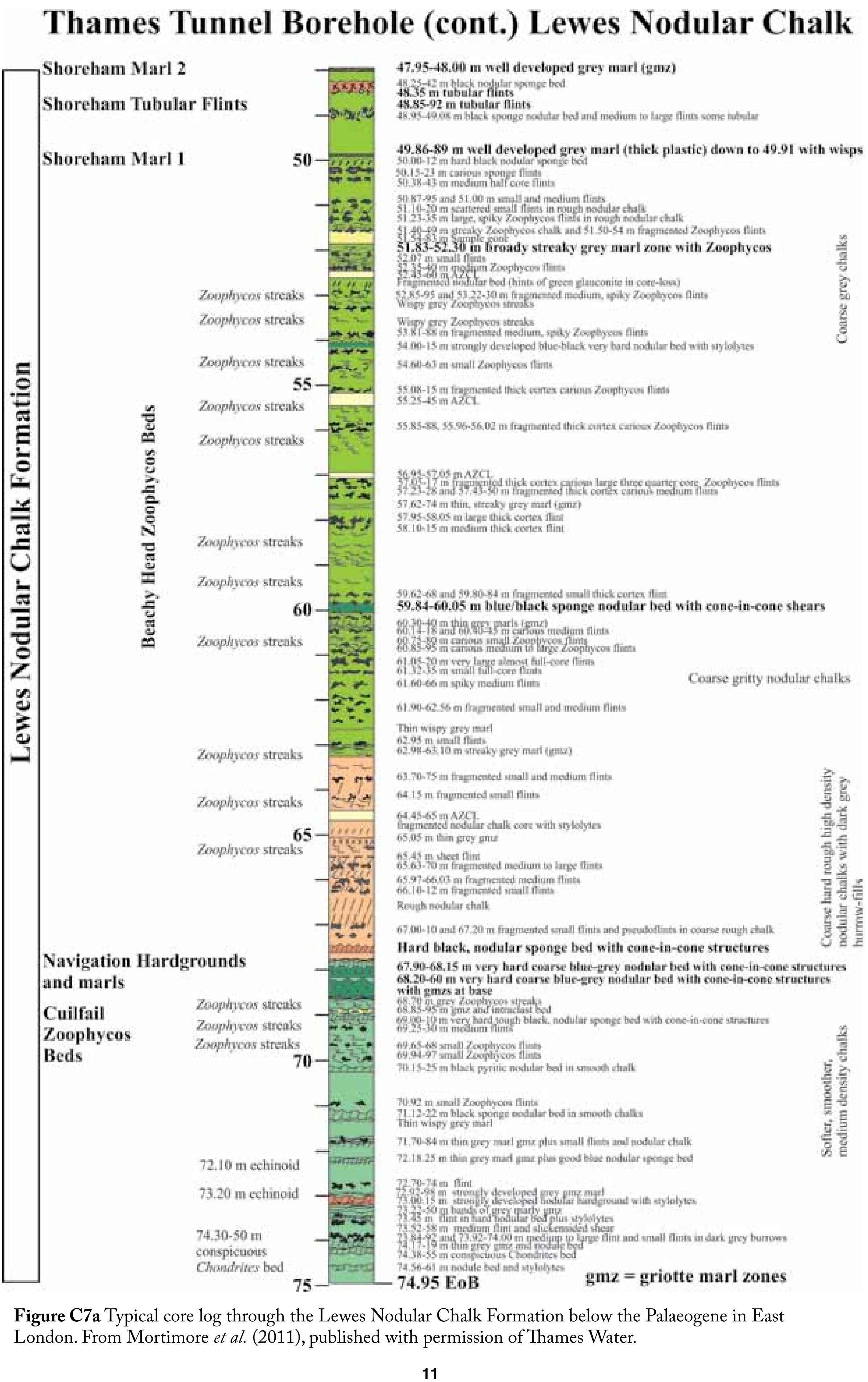


Figure C7a Typical core log through the Lewes Nodular Chalk Formation below the Palaeogene in East London. From Mortimore *et al.* (2011), published with permission of Thames Water.

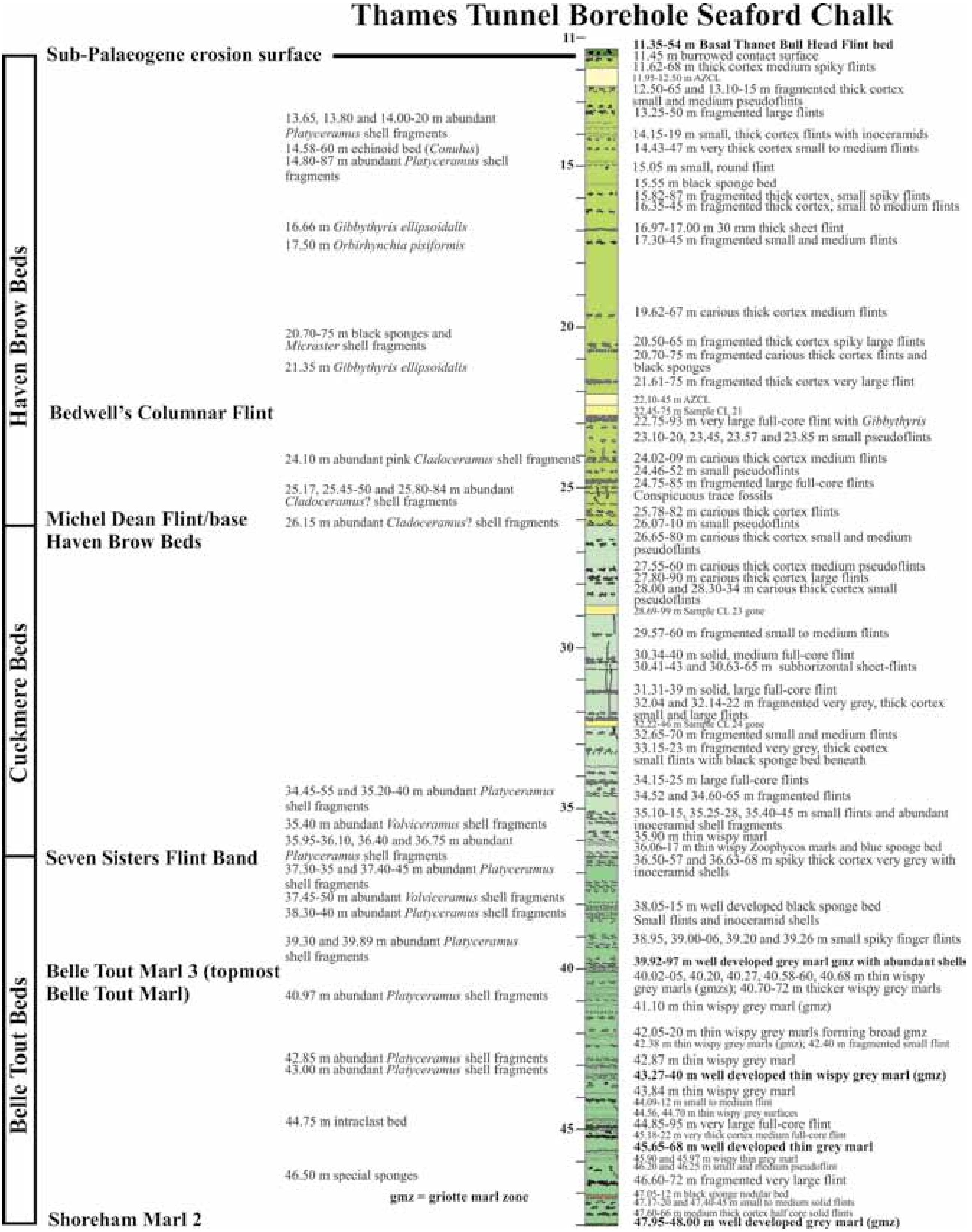


Figure C7b Typical core log through the Seaford Chalk Formation below the Palaeogene in East London. From Mortimore *et al.* (2011), published with permission of Thames Water.

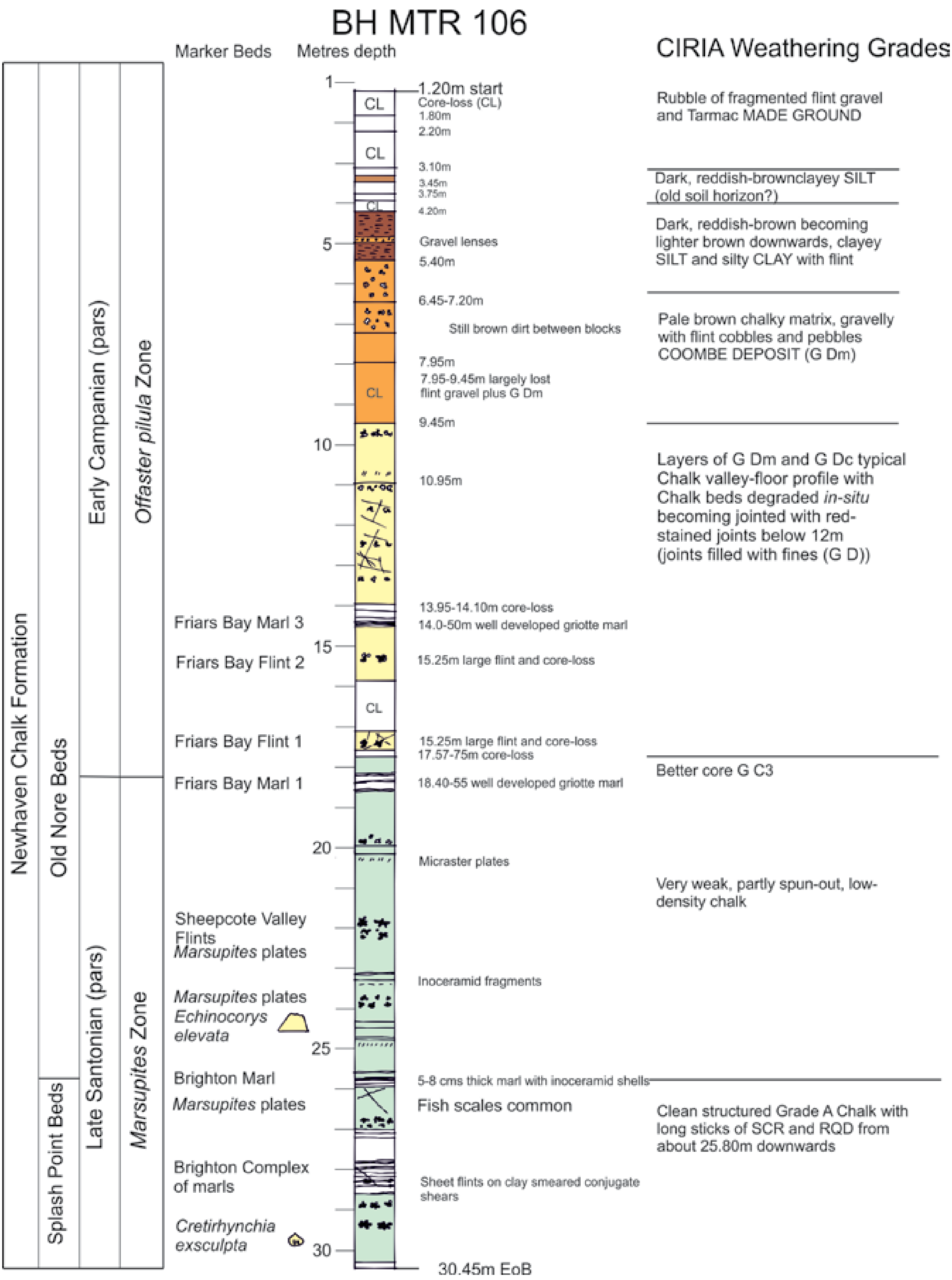


Figure C8 Core log through the floor of a Chalk dry valley and into the lower part of the Newhaven Chalk Formation. Published with permission of Southern Water.

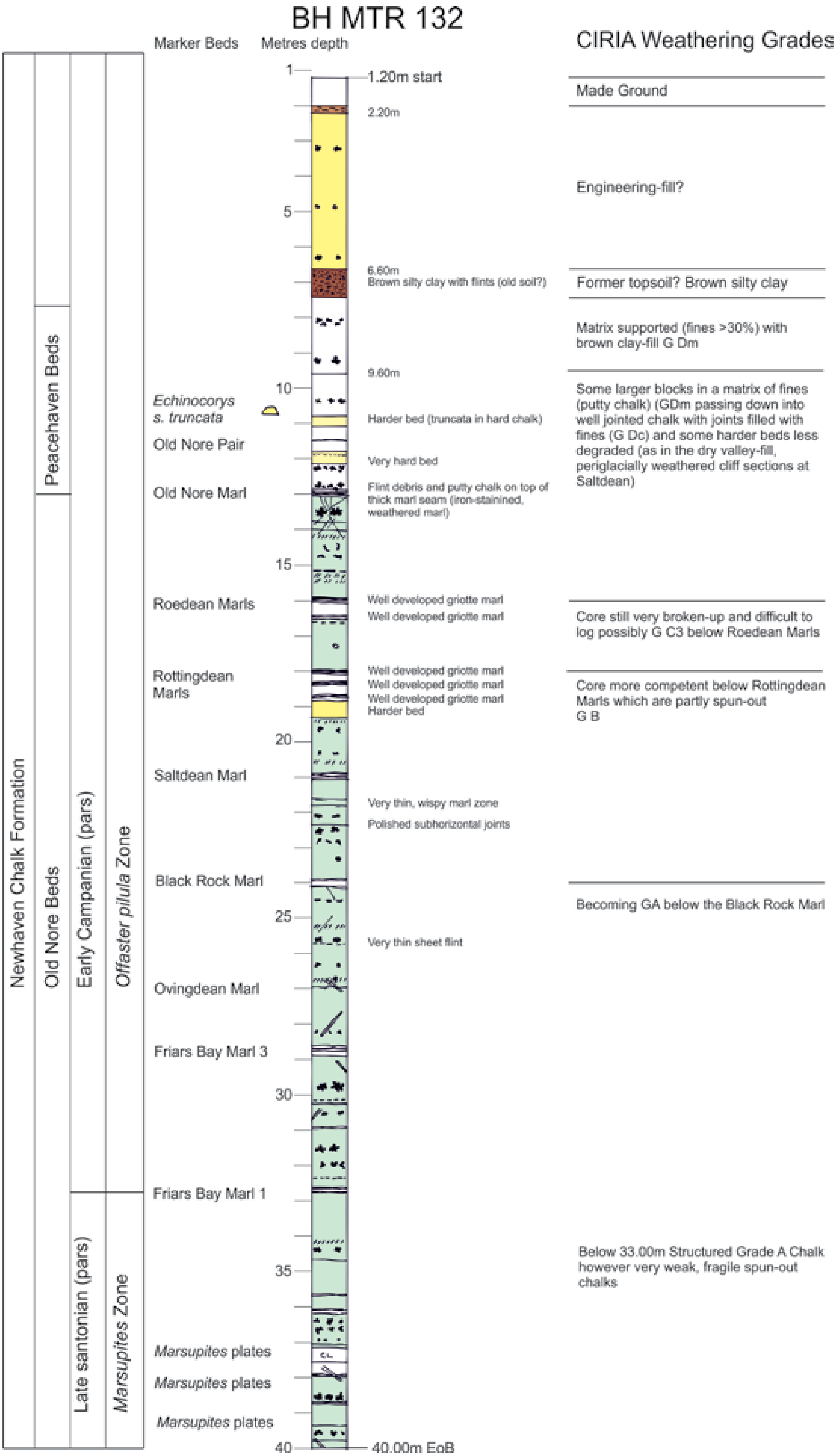
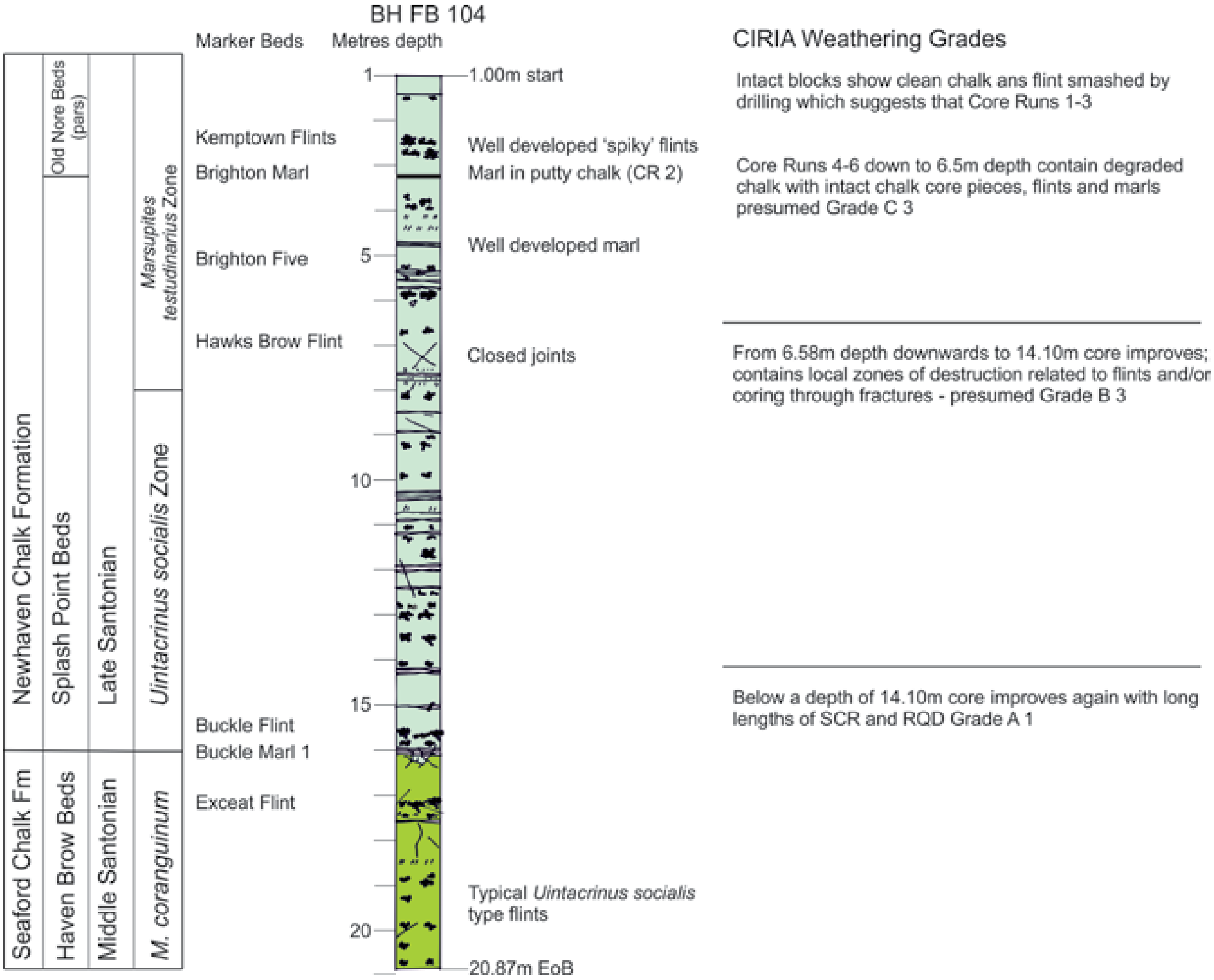


Figure C9 Simplified core log through an engineered chalk embankment and into the lower part of the Newhaven Chalk Formation on the flanks of Saltdean dry valley, Sussex. Published with permission of Southern Water.



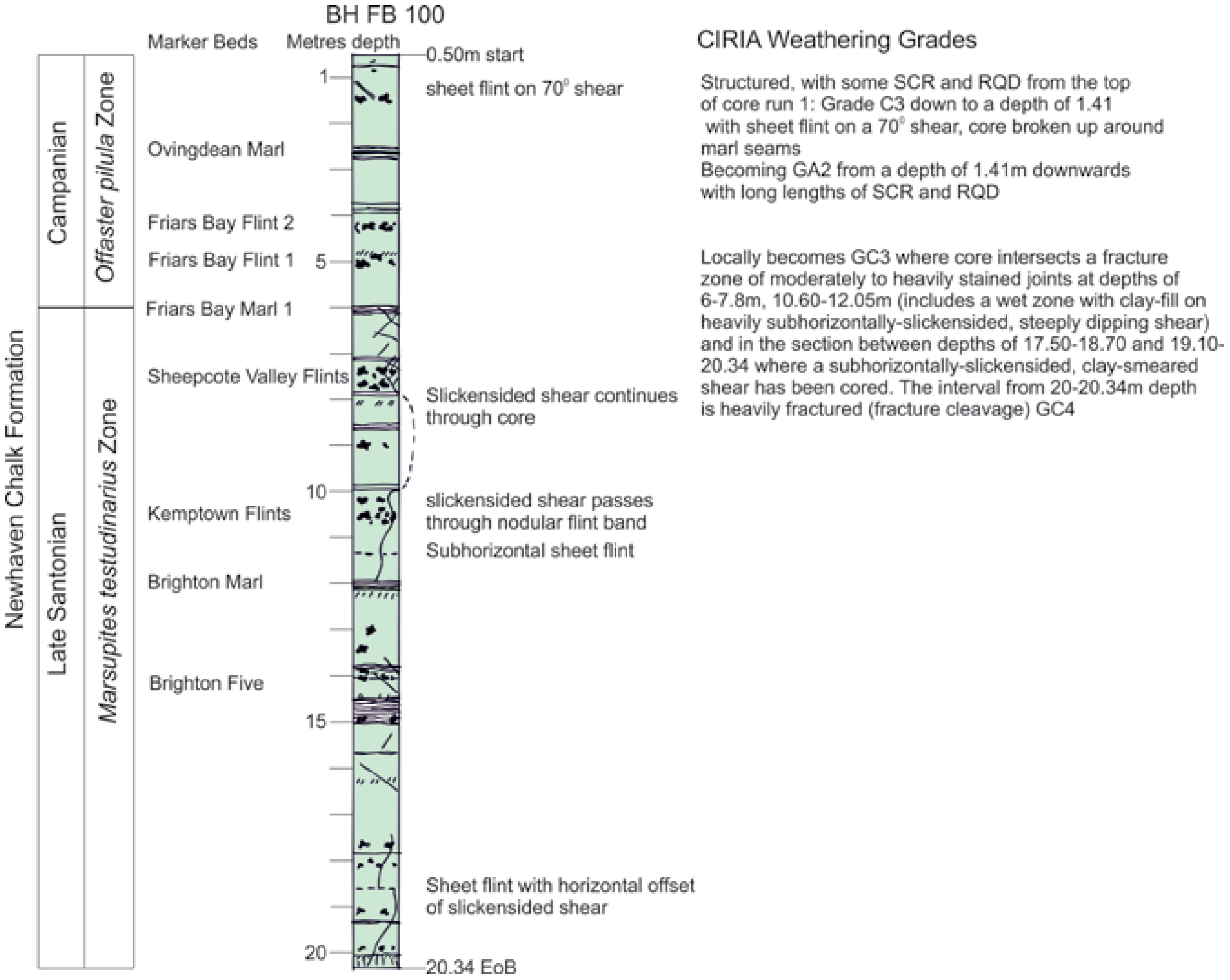
Intact blocks show clean chalk ans flint smashed by drilling which suggests that Core Runs 1-3

Core Runs 4-6 down to 6.5m depth contain degraded chalk with intact chalk core pieces, flints and marls presumed Grade C 3

From 6.58m depth downwards to 14.10m core improves; contains local zones of destruction related to flints and/or coring through fractures - presumed Grade B 3

Below a depth of 14.10m core improves again with long lengths of SCR and RQD Grade A 1

Figure C10 Simplified core log typical of the basal Newhaven Chalk Formation and top Seaford Chalk Formation, Sussex coast. Published with permission of Southern Water.



Structured, with some SCR and RQD from the top of core run 1: Grade C3 down to a depth of 1.41 with sheet flint on a 70° shear, core broken up around marl seams
Becoming GA2 from a depth of 1.41m downwards with long lengths of SCR and RQD

Locally becomes GC3 where core intersects a fracture zone of moderately to heavily stained joints at depths of 6-7.8m, 10.60-12.05m (includes a wet zone with clay-fill on heavily subhorizontally-slickensided, steeply dipping shear) and in the section between depths of 17.50-18.70 and 19.10-20.34 where a subhorizontally-slickensided, clay-smeared shear has been cored. The interval from 20-20.34m depth is heavily fractured (fracture cleavage) GC4

Figure C11 Simplified core log in the lower part of the Newhaven Chalk Formation with weathered chalk horizons associated with fracturing. Published with permission of Southern Water.

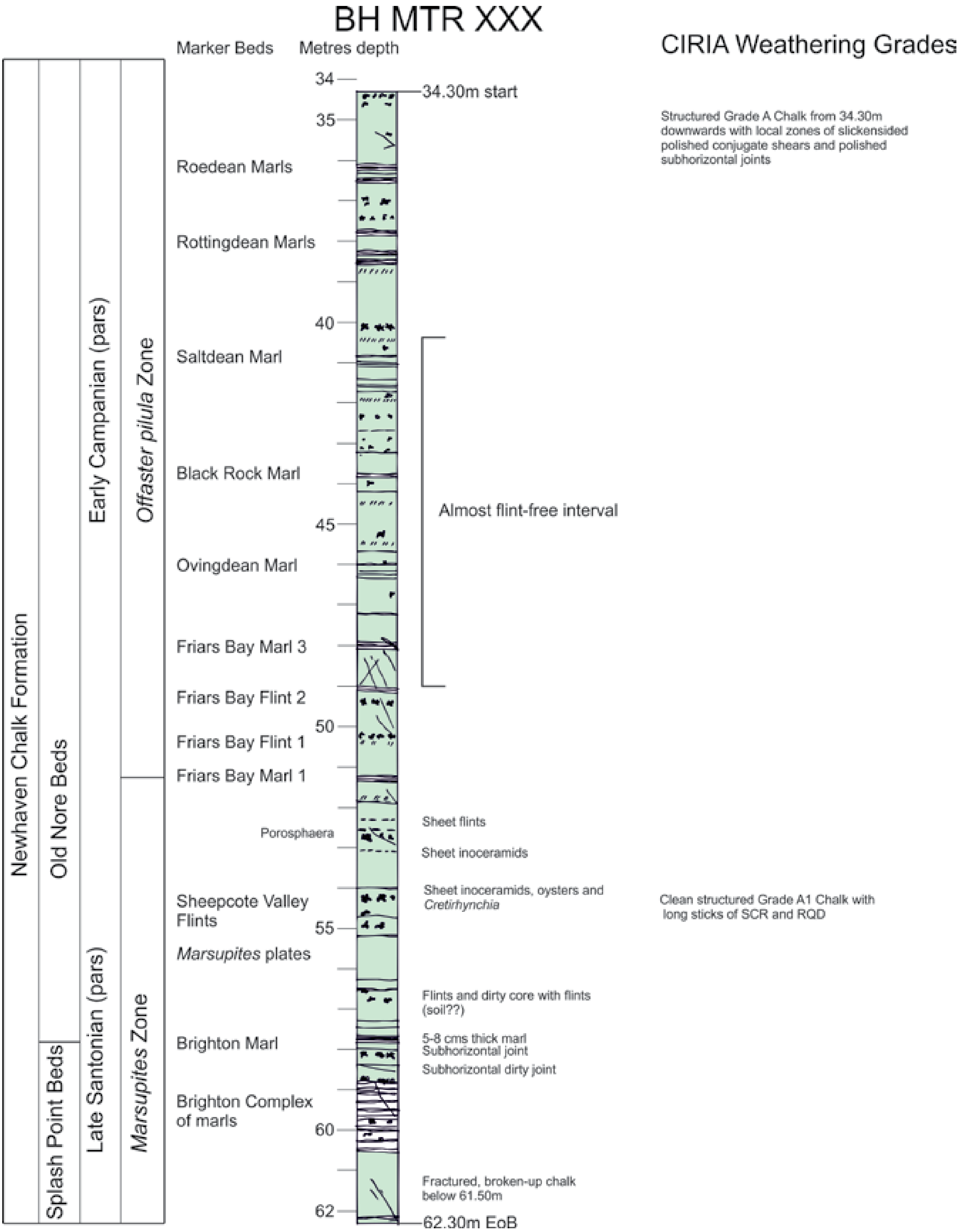


Figure C12 Simplified core log in the lower part of the Newhaven Chalk Formation in clean. CIRIA grade A chalk. Published with permission of Southern Water.

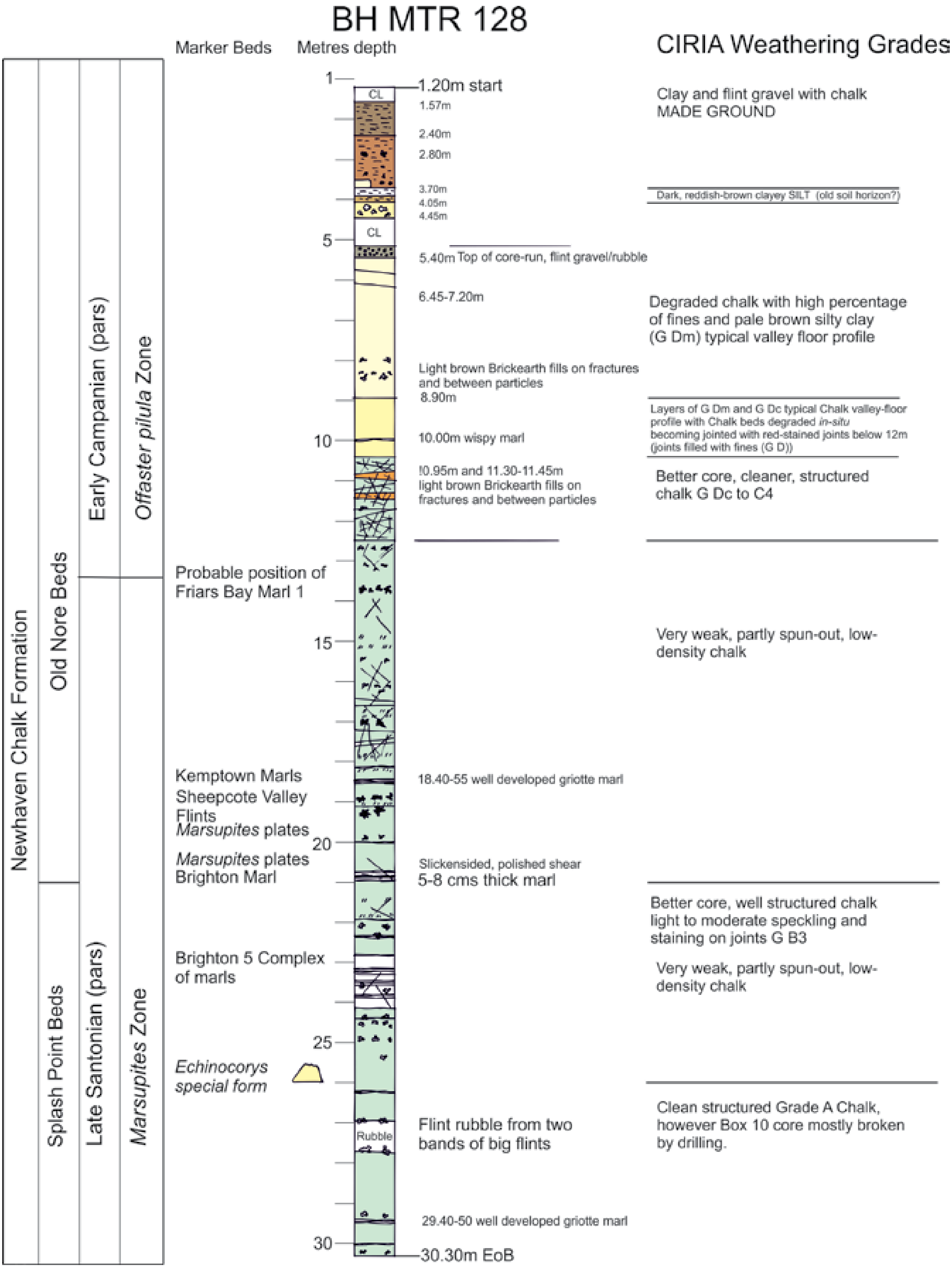


Figure C13 Simplified core log in the lower part of the Newhaven Chalk Formation through valley floor weathered CIRIA grade Dm to Dc chalk and then into structured CIRIA grades C to A. Published with permission of Southern Water.

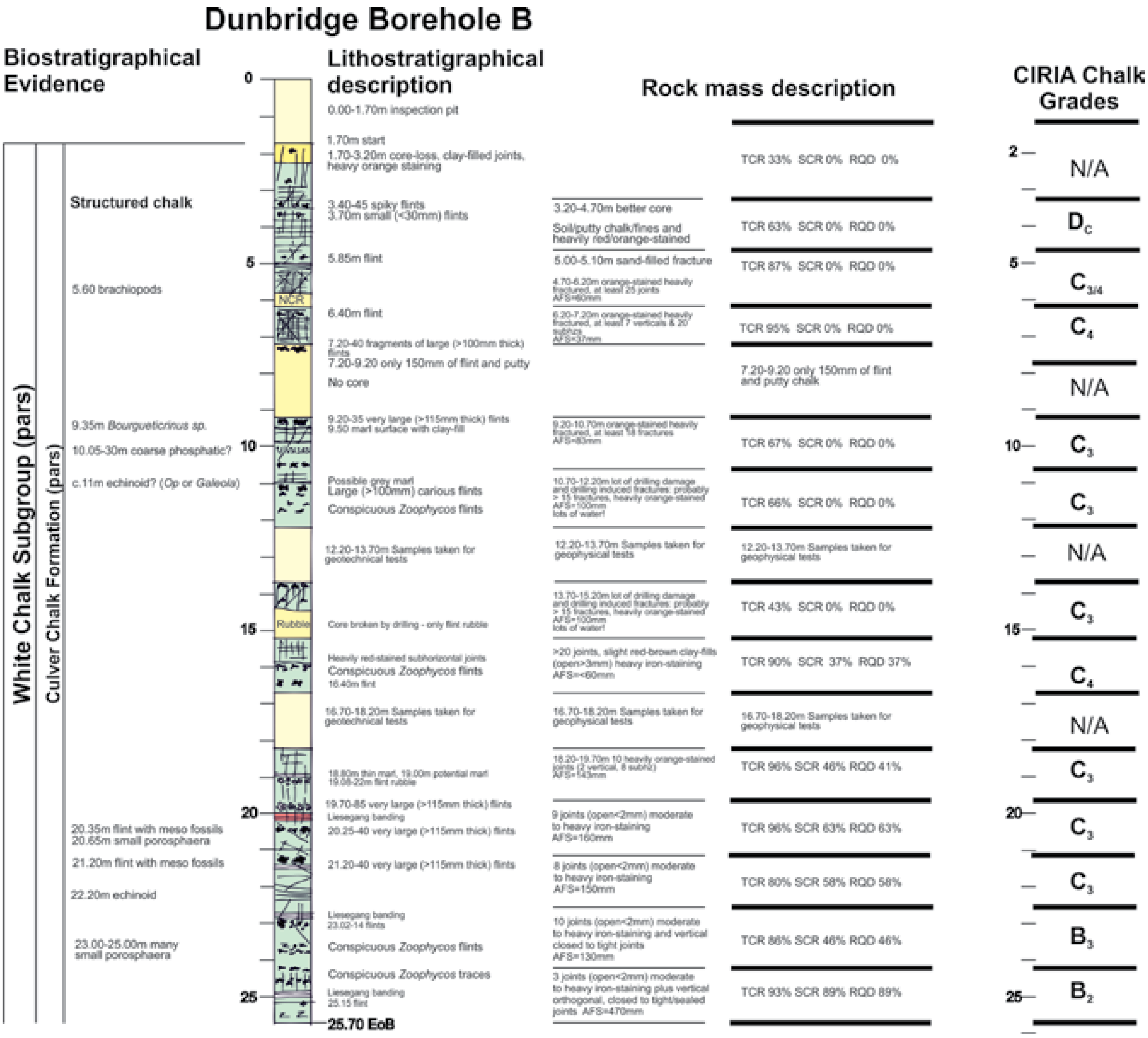


Figure C14 Simplified core log typical of part of the Culver Chalk Formation, Dunbridge B Borehole, Hampshire grading downwards from CIRIA grade D through grade C to B. Published with permission of Southern Water.

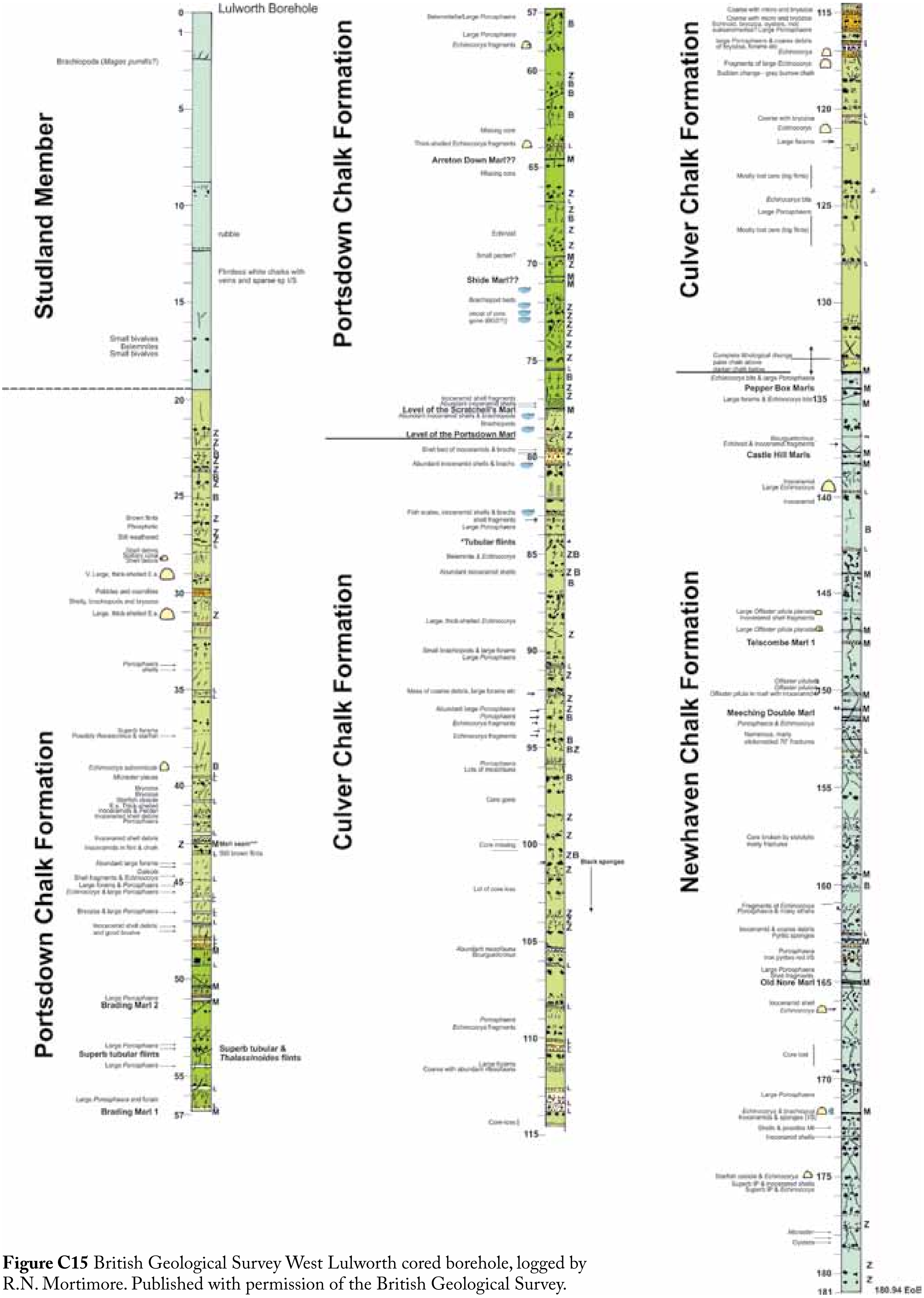


Figure C15 British Geological Survey West Lulworth cored borehole, logged by R.N. Mortimore. Published with permission of the British Geological Survey.

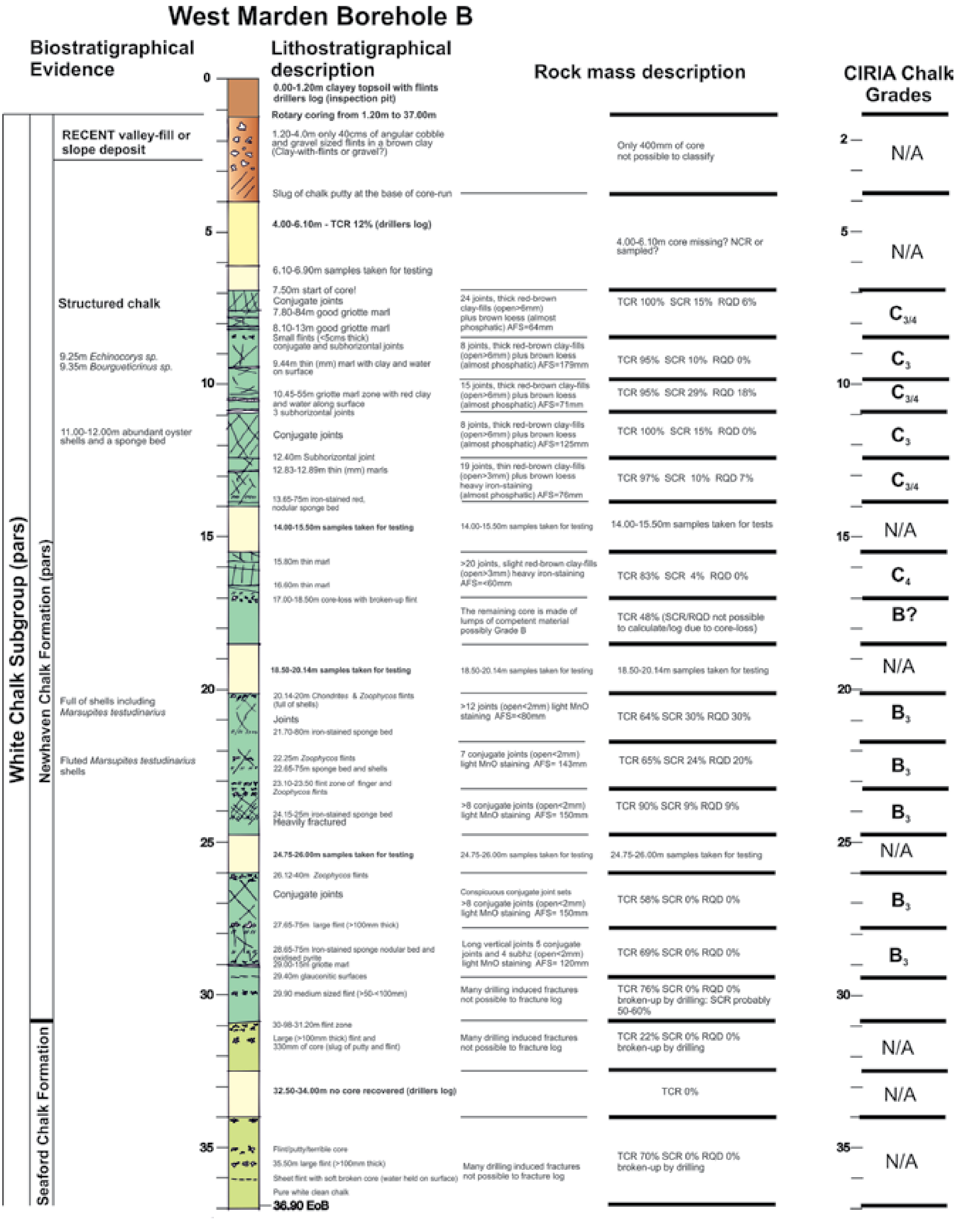


Figure C16 West Marden Borehole, West Sussex core log to compare with core photos in Figures C17 and C18. Published with permission of Southern Water.

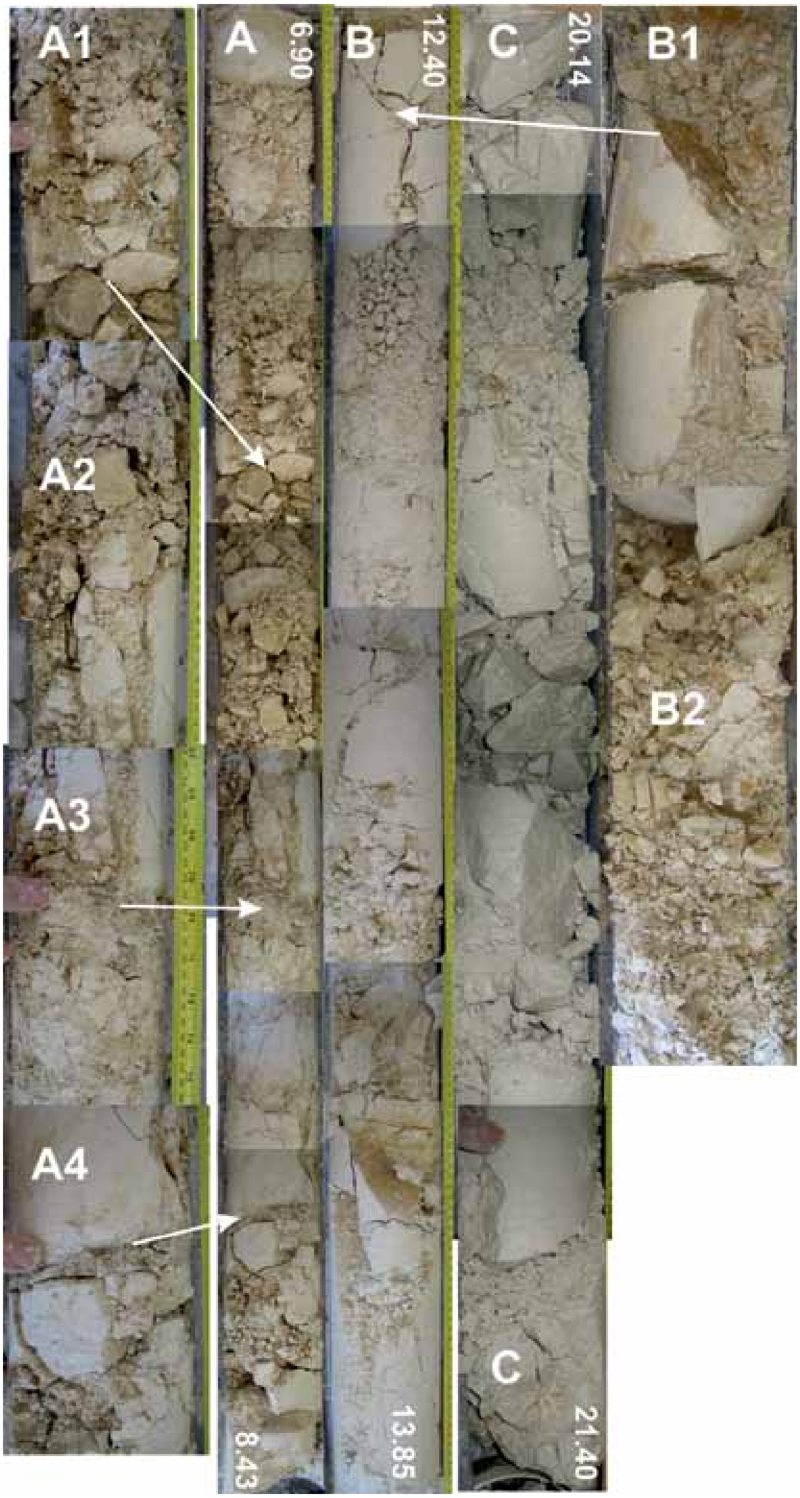
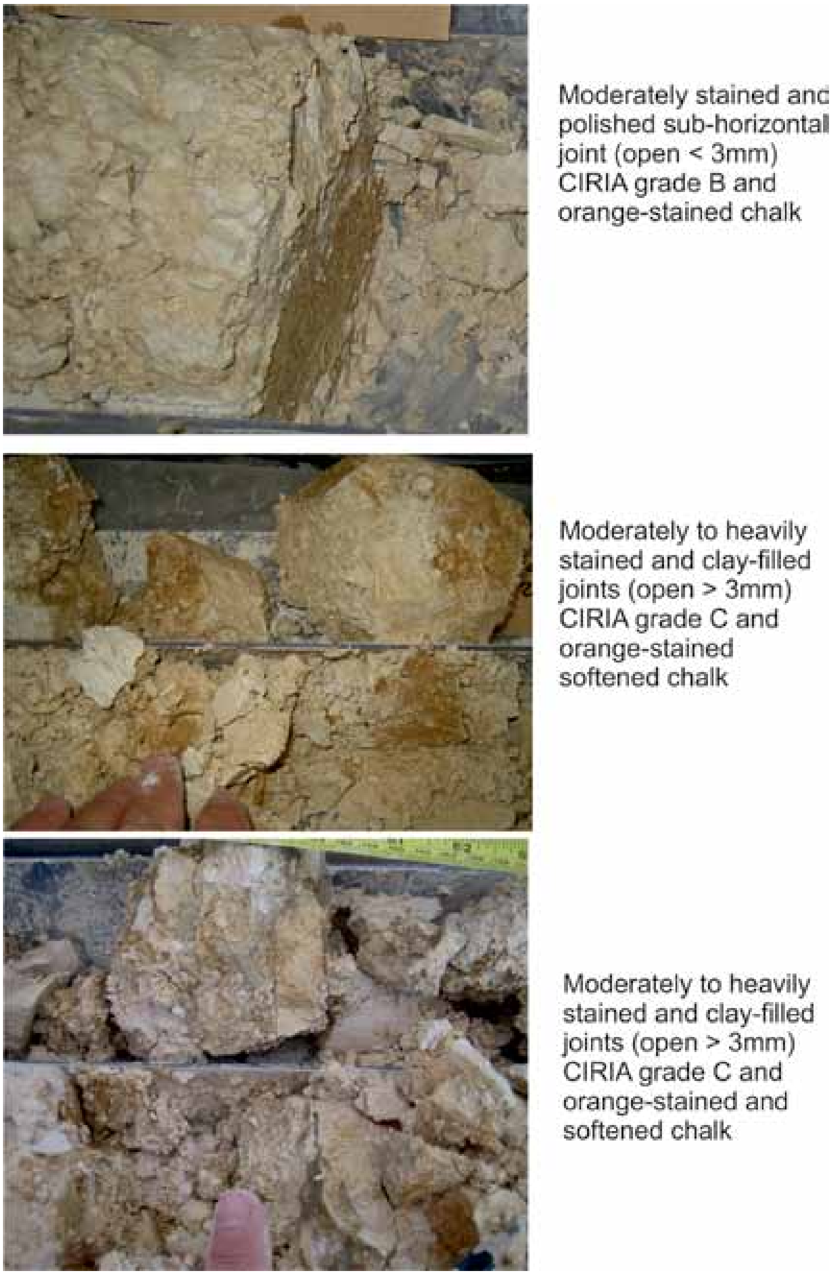


Figure C17 West Marden Borehole, West Sussex illustrating core recovery in beds subjected to Quaternary cold-period freeze–thaw in beds of different density. (A1, A2, A3, A4) close ups of core A; and (B1, B2) closeups of core B. Higher density beds retain their blockiness and lower density beds are more fragmented. Chalk is more structured CIRIA grade B in core run C. Compare this core with the core log of Figure C16 and the field section at Saltdean.



Moderately stained and polished sub-horizontal joint (open < 3mm) CIRIA grade B and orange-stained chalk

Moderately to heavily stained and clay-filled joints (open > 3mm) CIRIA grade C and orange-stained softened chalk

Moderately to heavily stained and clay-filled joints (open > 3mm) CIRIA grade C and orange-stained and softened chalk

Figure C18 Details from the West Marden Borehole chalk cores illustrating structured weathered chalk CIRIA grades C to B.

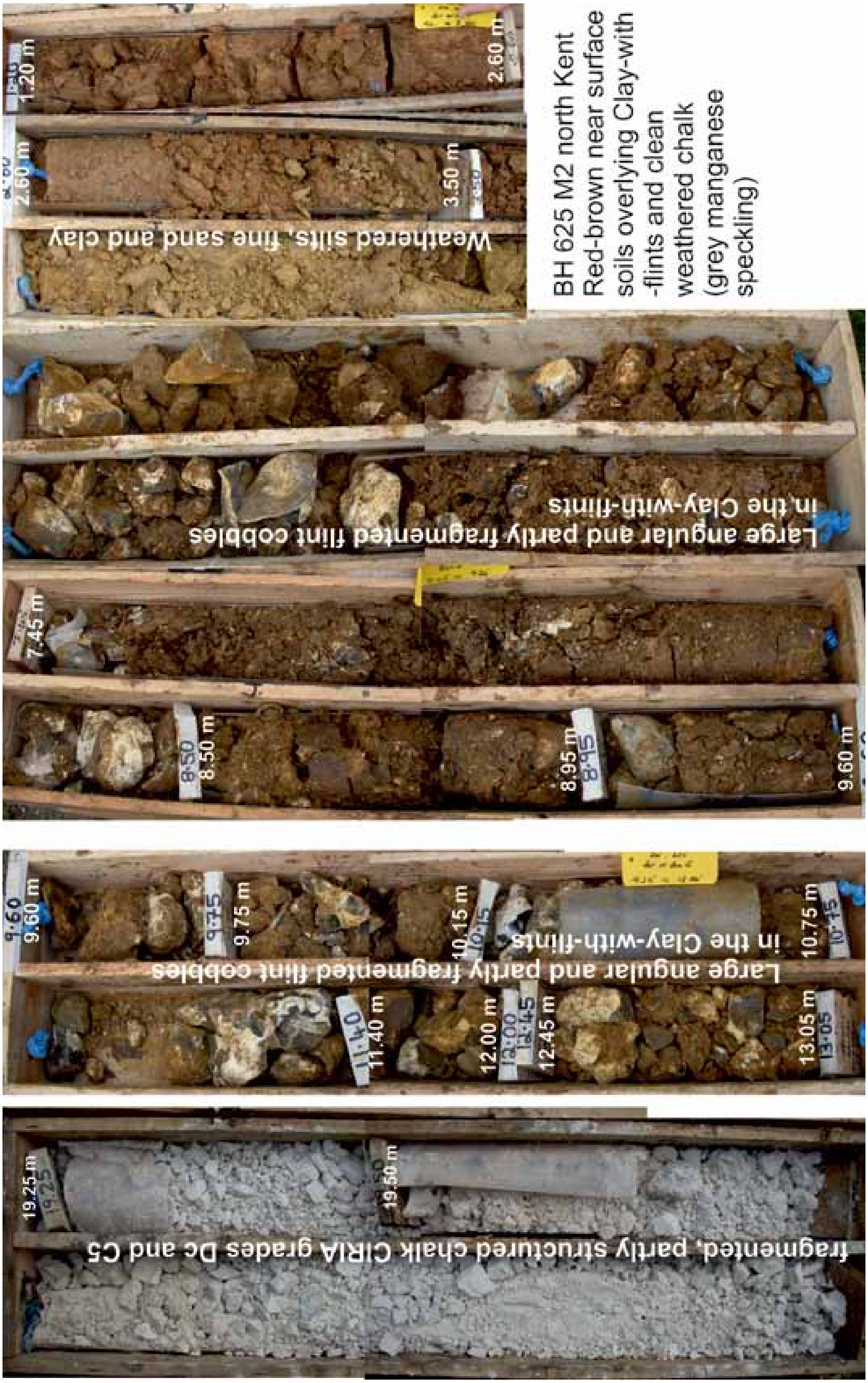


Figure C19 Fragmented chalk core from destructured CIRIA grade D chalk from beneath Quaternary clay-with-flints.

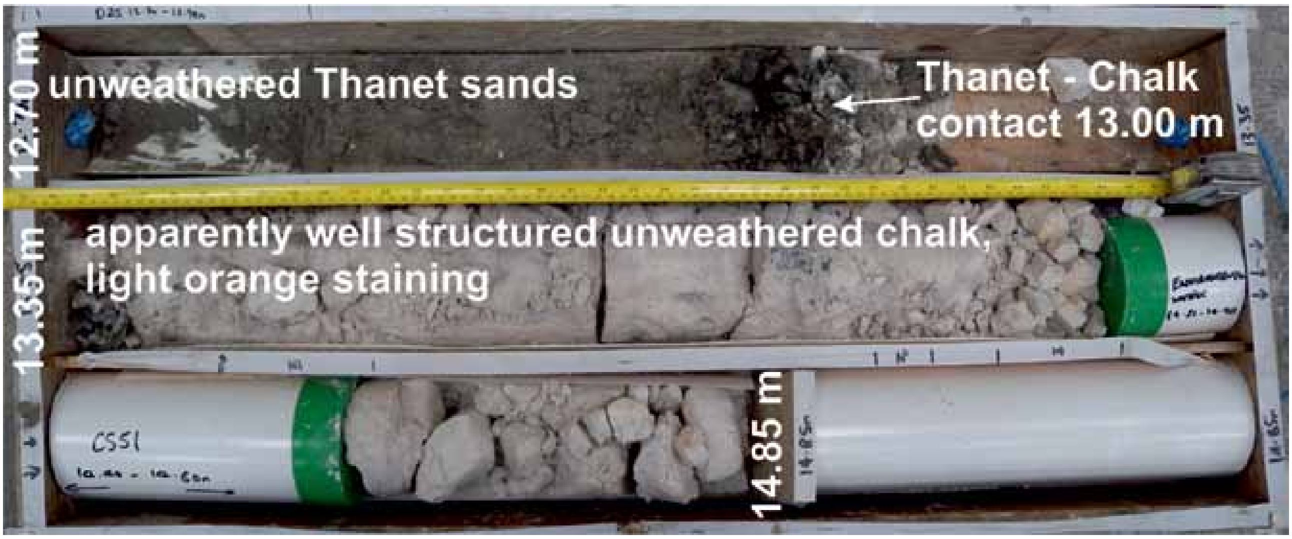


Figure C5a1 Relatively unweathered chalk at the contact between the Chalk and Thanet Sand. Core loss and drilling-induced fractures make definitive grading not possible. Based on the light orange staining on the joints and within the chalk, this is assumed to be CIRIA grade B at worst.

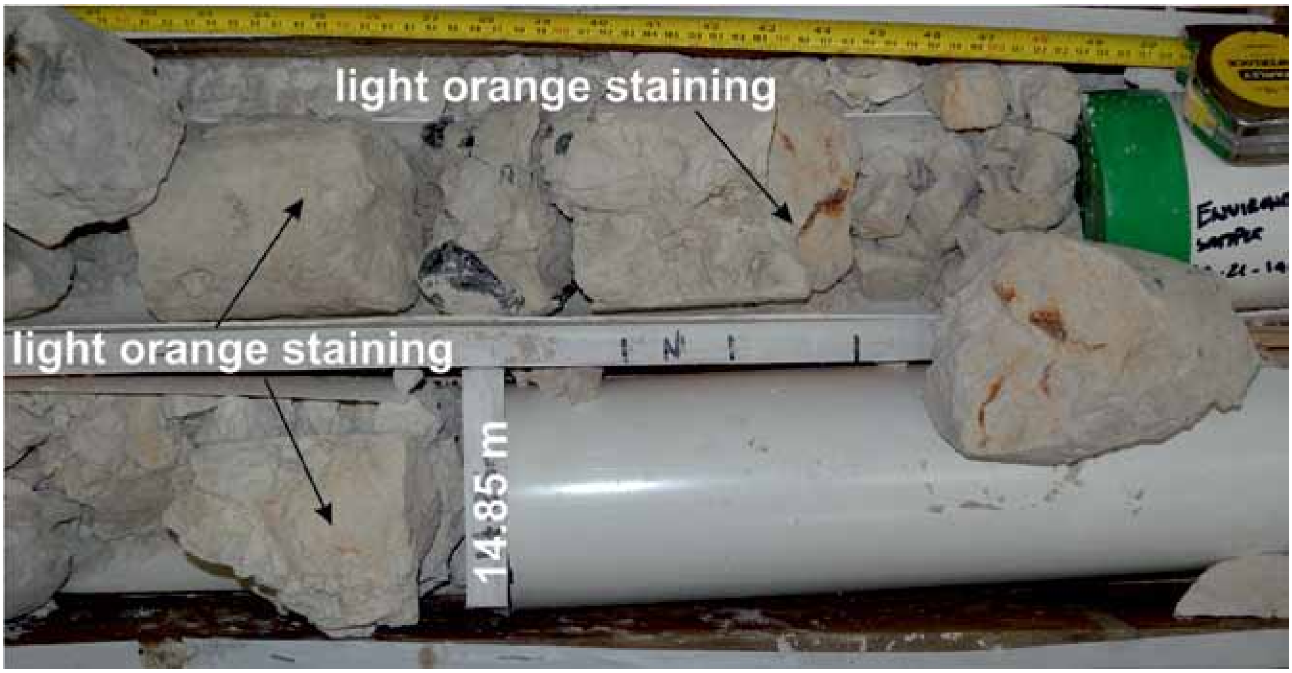


Figure C5a2 Close-up of relatively unweathered chalk at the contact between the Chalk and Thanet Sands (CIRIA grade B) and core destructured by drilling. Light orange staining on joints and internally in the Chalk.

Figure C5a3 Relatively unweathered chalk at the contact between the Chalk and Thanet Sands (CIRIA grade B) and core destructured by drilling. Light orange staining on joints and internally in the Chalk.

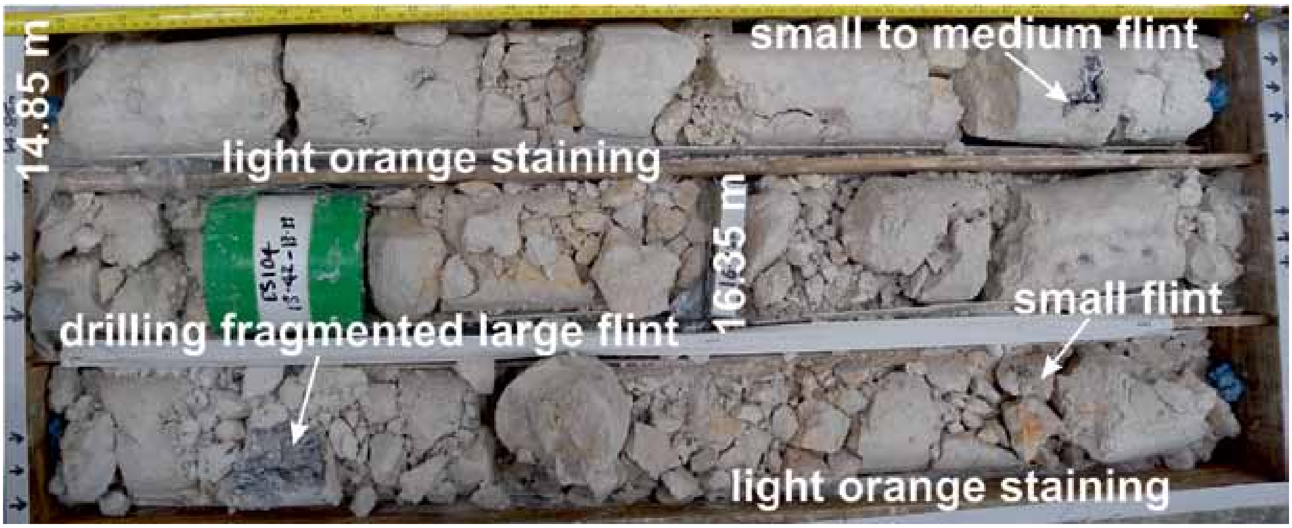


Figure C5a4 Relatively unweathered chalk at the contact between the Chalk and Thanet Sands (CIRIA grade B) and core destructured by drilling. Light orange staining on joints and internally in the Chalk.

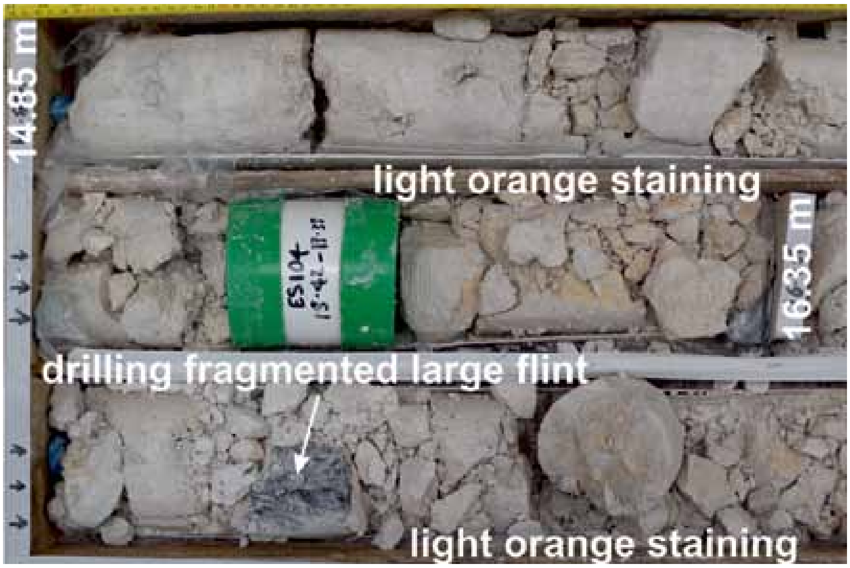
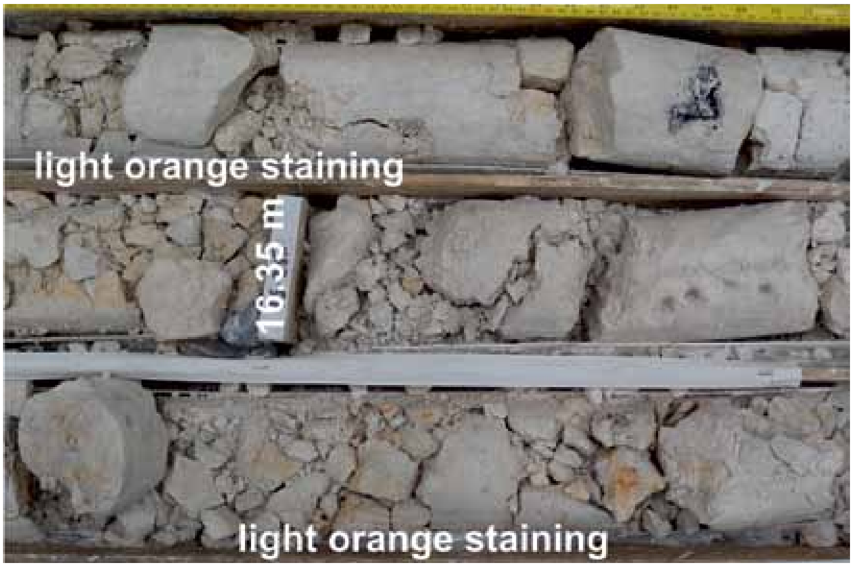


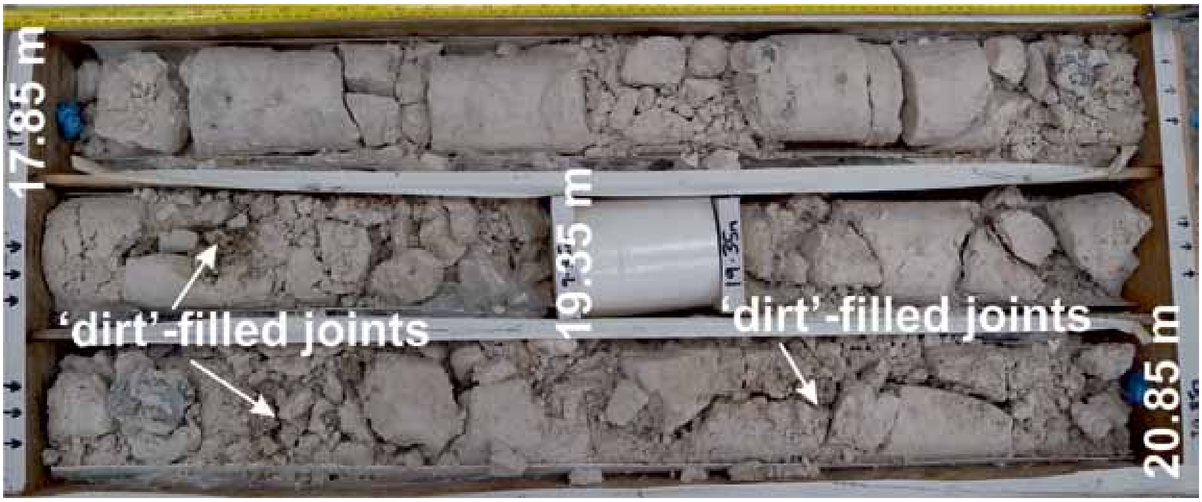
Figure C5a5 Relatively unweathered chalk at the contact between the Chalk and Thanet Sands (CIRIA grade B) and core destructured by drilling. There is light orange staining on joints and internally in the Chalk core.



[Left] Figure C5a6 Relatively unweathered chalk (CIRIA grade B) and core destructured by drilling. Light orange staining on joints and internally in the Chalk.

[Below] Figure C5a7 Relatively unweathered chalk, light orange staining on joints and internally in the Chalk (CIRIA grade B), becoming dirt-filled open joints (CIRIA grade C), core destructured by drilling.

[Bottom of page] Figure C5a8 Close-up of Figure 5a7. Dirt-filled 'open' joints, CIRIA grade C.



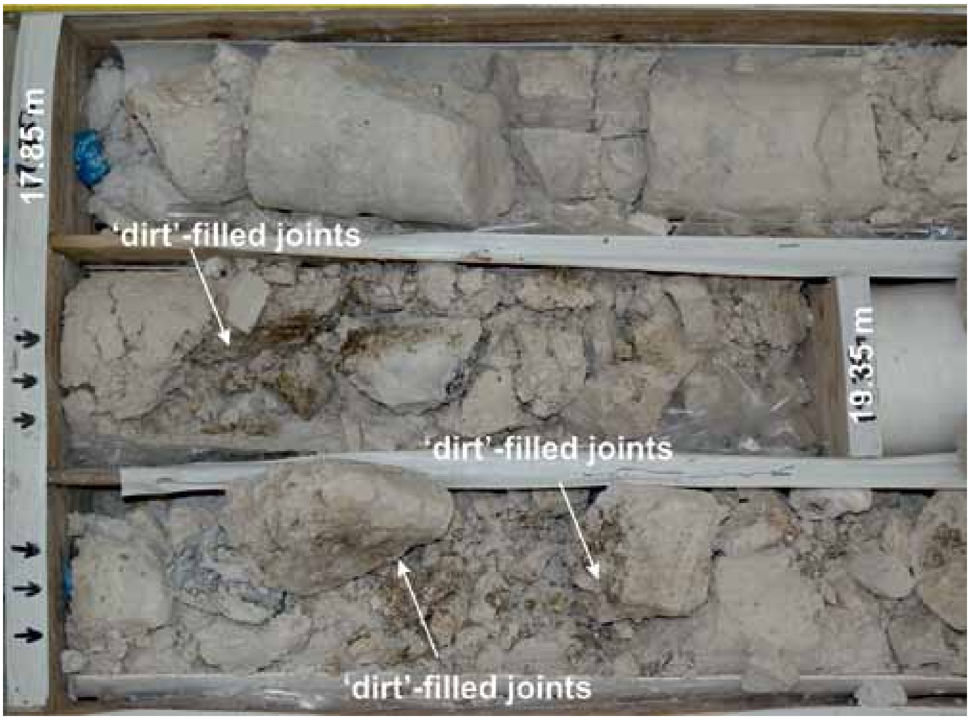


Figure C5a9 Dirt-filled 'open' joints, CIRIA grade C.

Figure C5a10 Moderately stained 'slightly open' joints, CIRIA grade B chalk.

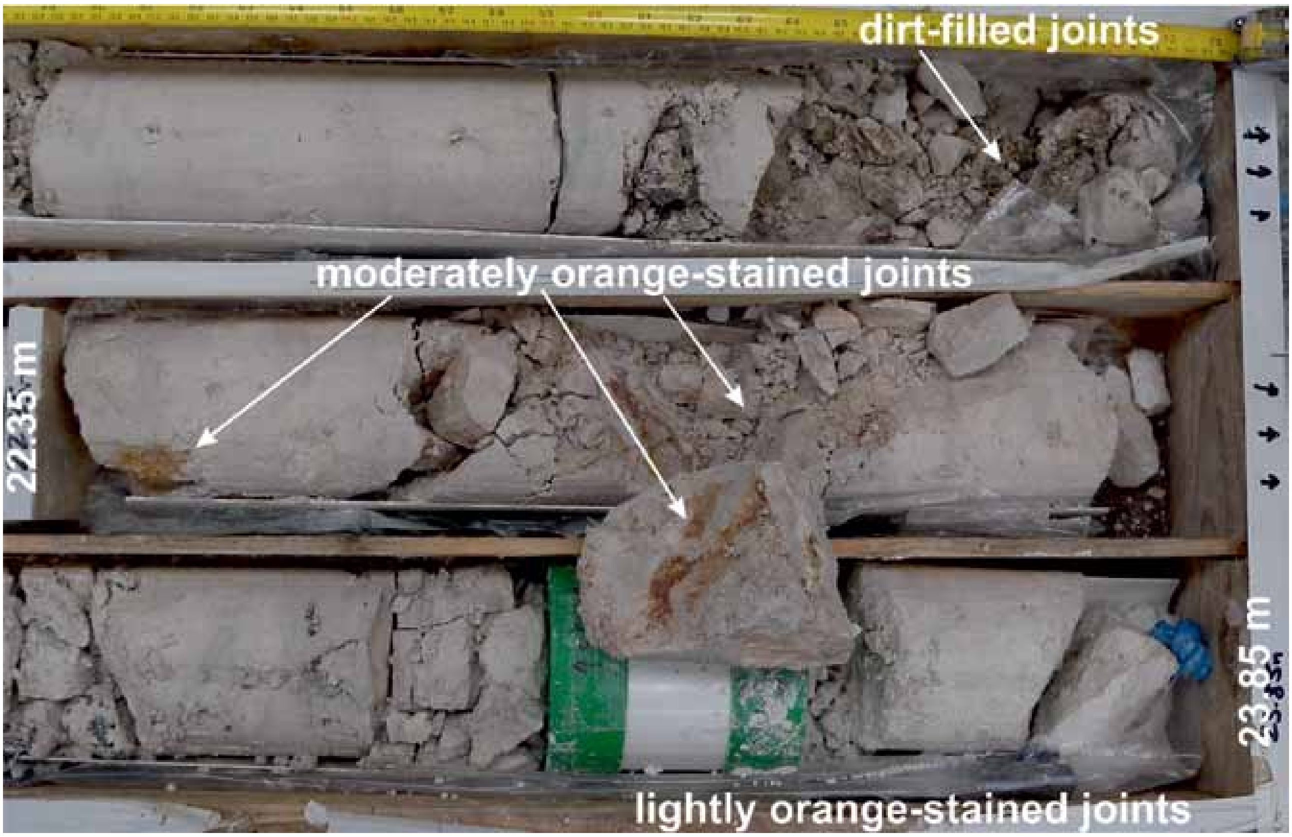


Figure C5a11 Moderately stained 'slightly open' joints, CIRIA grade B and dirt-filled open joints grade C chalk.

Figure C5a12 Moderately stained 'slightly open' joints, CIRIA grade B, and dirt-filled open joints, grade C. Liesegang banding internally in the chalk is parallel to a fracture (indicating groundwater movement).

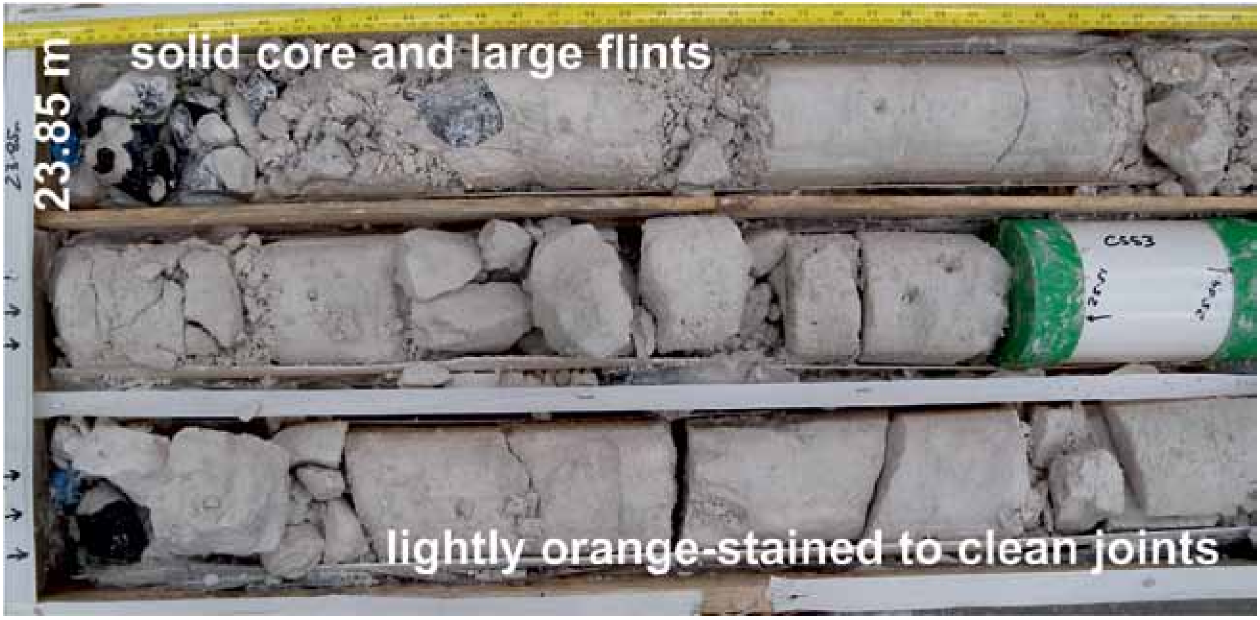


Figure C5a13 Continuously solid core (mostly drilling-induced fractures) with large flints and clean, closed joints, CIRIA grade A.

Figure C5a14 Continuously solid core (mostly drilling-induced fractures) with large flints and clean to lightly orange-stained closed joints, CIRIA grade A.

Figure C5a15 Continuously solid core (mostly drilling-induced fractures) with large flints and clean closed joints, CIRIA grade A.

Figure C5a16 Continuously solid core (mostly drilling-induced fractures) with large flints and clean closed joints, CIRIA grade A.

Figure C5a17 Continuously solid core (mostly drilling-induced fractures) with large flints and clean closed joints, CIRIA grade A with abundant light grey trace fossils (burrow-mottled chalk).

Figure C5a18 Borehole 5a log (East London), illustrating change of CIRIA grade with depth for the borehole cores illustrated in preceding figures.

Figure C5b1 Fractures in first 2 m below Thanet contact are open >3 mm, stained and filled, hence CIRIA grade C.

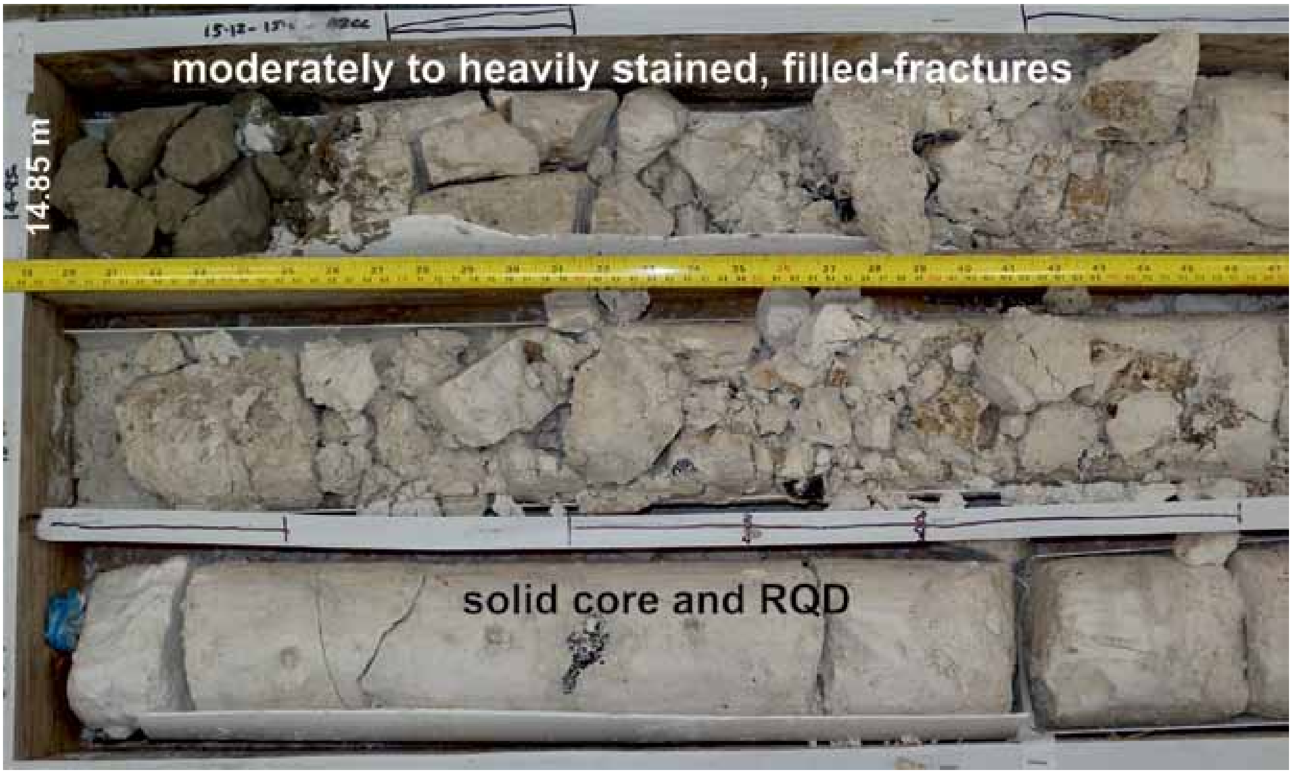


Figure C5b2 Fractures in first 2 m below Thanet contact are open >3 mm, stained and filled, hence CIRIA grade C.

Figure C5b3 Fractures in first 2 m below Thanet contact are open >3 mm, stained and filled, hence CIRIA grade C.

Figure C5b4 Next box fractures are open <3 mm, moderately stained, hence CIRIA grade B.

Figure C5b5 WP43R: next box fractures are closed to open <3 mm, clean or lightly stained, hence CIRIA grade A/B.

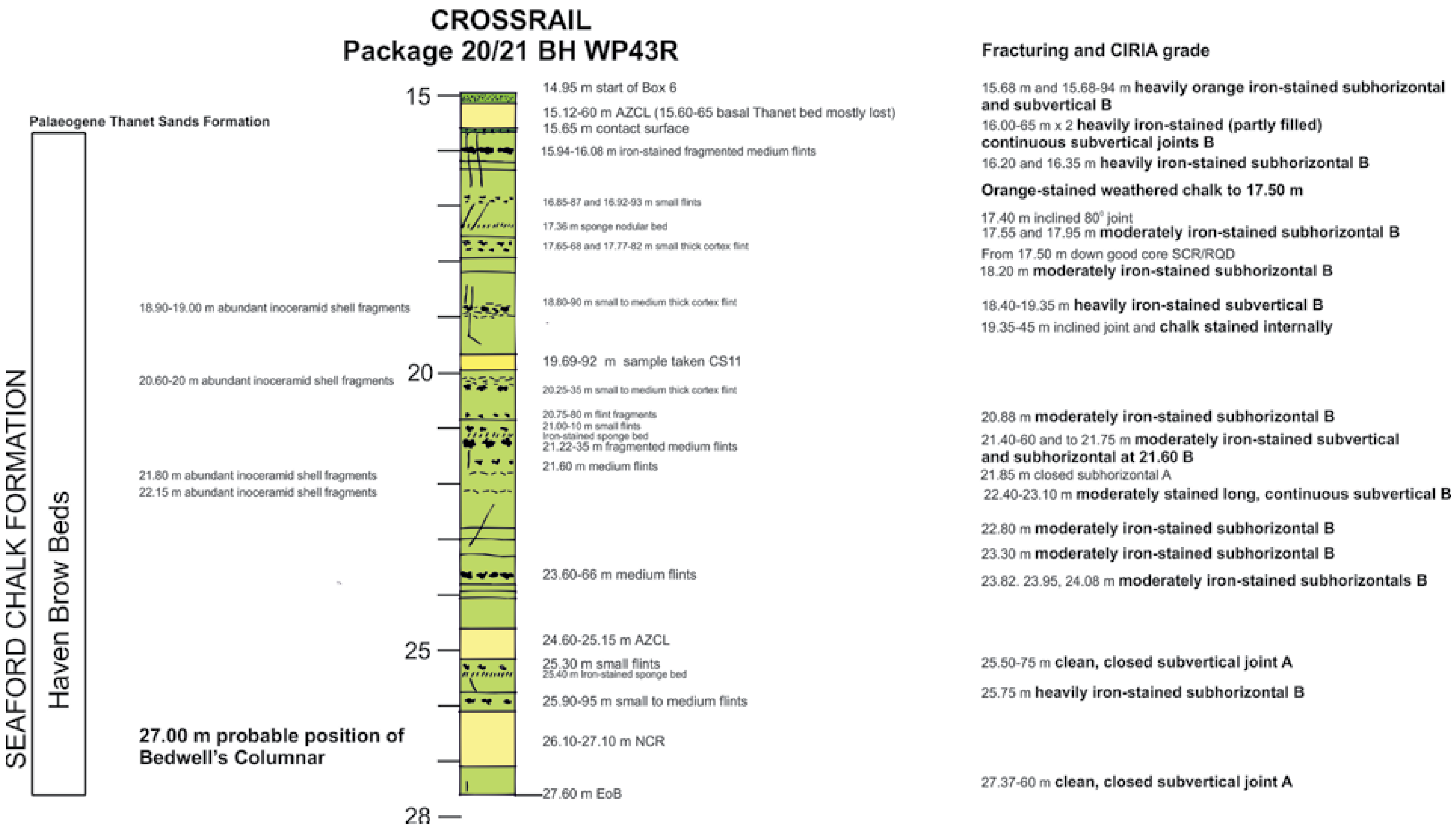


Figure C5b6 Graphical log for core set 2.

Figure C5c1 Box 2, heavily stained chalk and core loss. Despite the poor core recovery, a ‘blocky’ structure is retained and, combined with the staining, suggests CIRIA grade C.

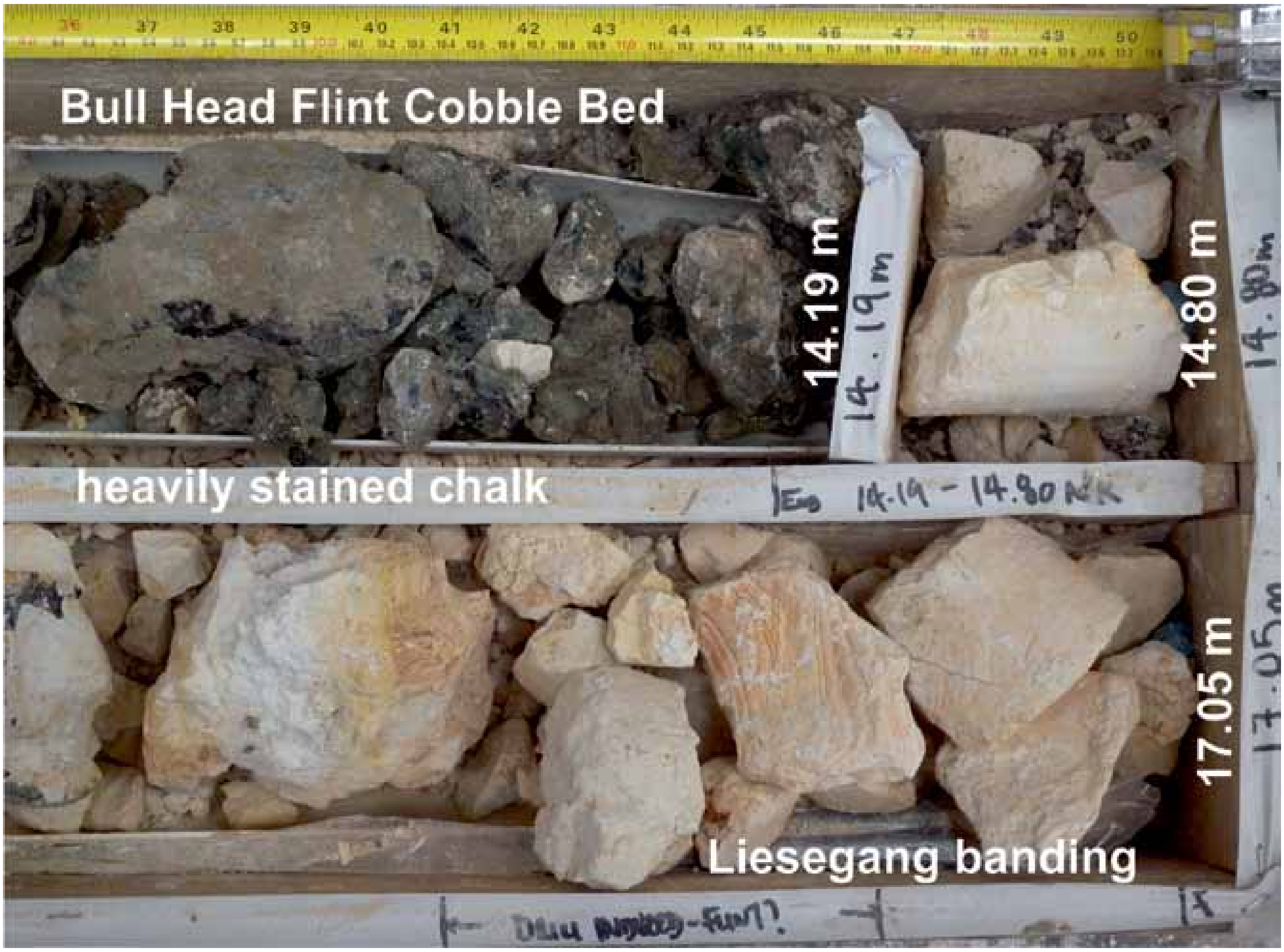


Figure C5c2 Close-up of box 2, heavily stained and Liesegang banded chalk. Core fragmentation makes it impossible to provide accurate thicknesses or provide a fracture log. Despite the degree of core fragmentation, the presence of ‘blocky’ chalk with stained joints suggests weathered CIRIA grade C.

Figure C5c3 Box 3, heavily stained chalk with drilling-induced fractures and fragmentation and some solid core indicating structured chalk, CIRIA grade B.

Figure C5c4 Close-up of box 3, heavily stained and banded chalk and vertical joint and some solid core with a closed vertical joint, CIRIA grade B, locally A.

Figure C5c5 Box 4, heavily stained and Liesegang banded chalk and disintegrated core where flints are present. Some solid core with stained fractures, CIRIA grade B, locally C.

Figure C5c6 One core run with completely fragmented chalk with flints and heavily stained chalk (CIRIA grade B). Below 22.30 m depth the core runs comprise clean chalk with large flints and mostly drilling-induced fractures (CIRIA grade A).

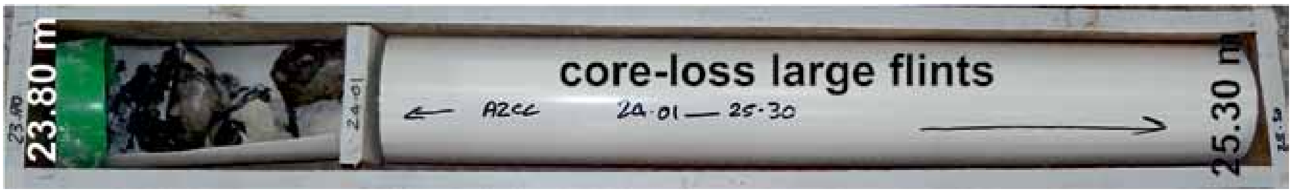


Figure C5c7 Box 6, 1.50 m of core loss and very large flints.

Figure C5c8 Box 7, very large flints in CIRIA grade A chalk. Core fragmentation due to drilling through flints.

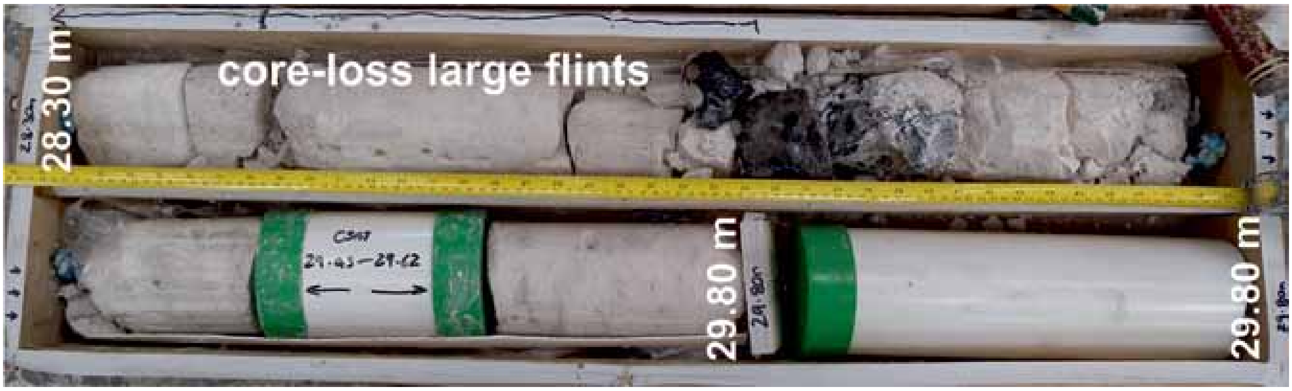


Figure C5c9 Box 8, very large flints in CIRIA grade A chalk.

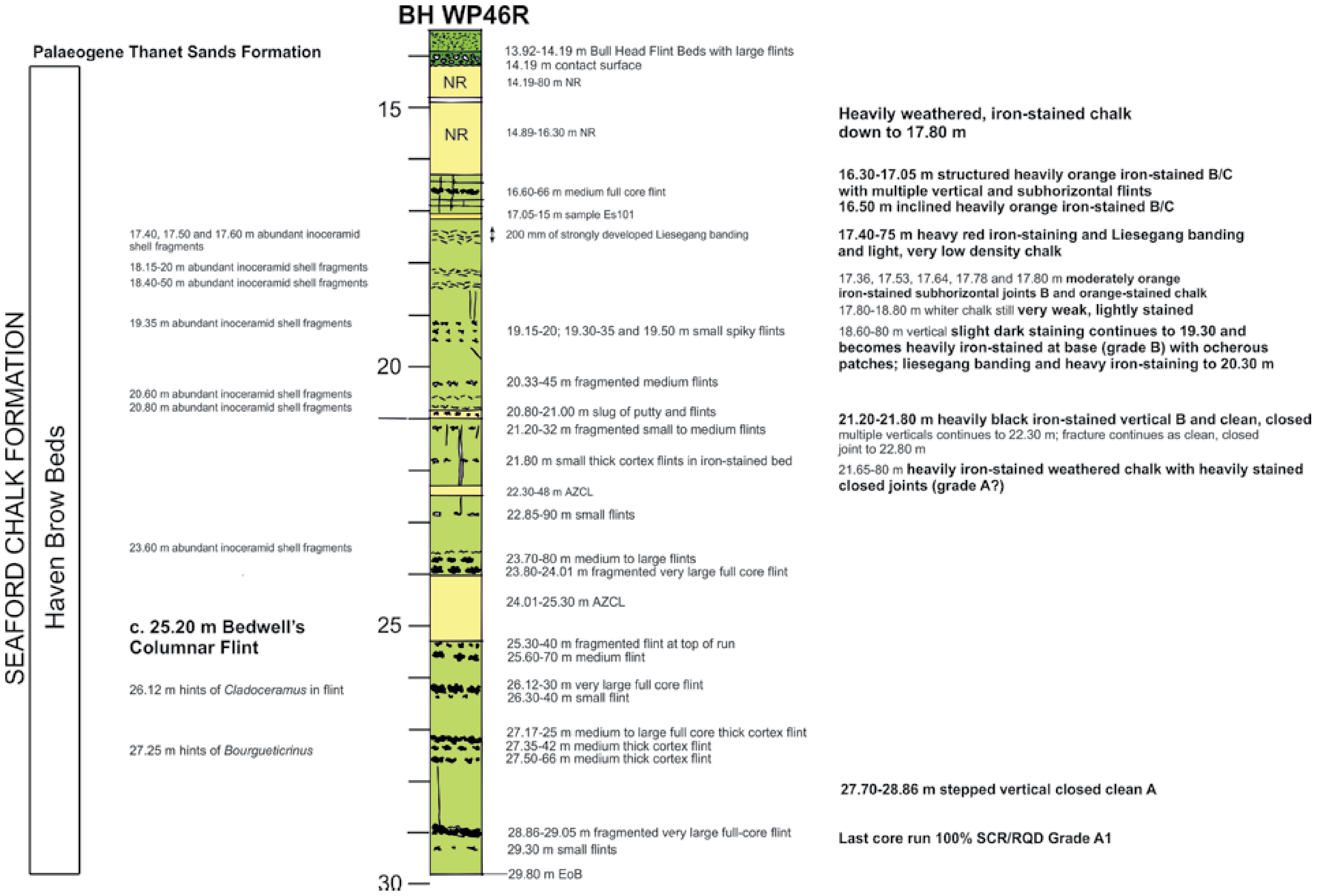


Figure C5c10 Graphical log for core set 3.

Figure C5d1 West Melbury Marly Chalk Formation core from Offham B borehole, Lewes, Sussex illustrating the enhancement of lithological detail as the core is scraped clean, washed with a squeezy bottle and allowed to dry.

Figure C5d2 Shears, joints and calcite-filled cracks in the West Melbury Marly Chalk Formation, Offham B borehole, Lewes Sussex.

APPENDIX D

CABLE PERCUSSION DRILLING: LOGGING U100 CHALK SAMPLES

For many onshore site investigations for housing and industrial developments, where only shallow foundations are required, the cheapest and quickest methods of ground investigation are deployed. These include trial pits and cable percussion drilling to obtain U100 tube samples (Figure D1). These U100 tube samples (100 mm in diameter and 500 mm long) are sometimes mistakenly called 'undisturbed'. In CIRIA grade D or grade C4/5 chalks where fractures are very closely spaced (Appendix A), recovery inside the 100 mm diameter tube can be sufficient to recognise the grade and describe the material and its structure. In more structured CIRIA grades C to A chalk with more widely spaced fractures, the effect of hammering the tube and its front-end cutting shoe through blocks of chalk, particularly where flints are present, yields highly disturbed samples (Figure D2).

A continuous core is rarely obtained using this cable percussion method. The U100 tube samples are usually interspersed with standard penetration tests (SPTs). The SPTs also disturb the chalk (Mortimore, Reading and Smith, 1990). The degree of interpretation required to arrive at a CIRIA grade or to determine structure makes this method of drilling and sampling inadequate for major construction projects such as tunnels. For other projects, such as water chemistry sampling, the method has been deemed adequate. However, even in these circumstances, if a geological model of a site is also required based around stratigraphy, lithology, geological structure and weathered profile, then rotary core is also required.

The examples of two core logs constructed from U100 tubes (Figures D3 and D4) show that it is possible, with specialist knowledge, to arrive at a broad stratigraphic interpretation and weathered profile. Using such specialist knowledge, several boreholes across a site have been correlated to illustrate the stratigraphy of the Chalk (Figure D5). The weathered ground profile determined from U100-interpreted CIRIA chalk grades has also been constructed (Figure D6). Such correlations are less certain than those determined from fully cored boreholes obtained by rotary coring methods.

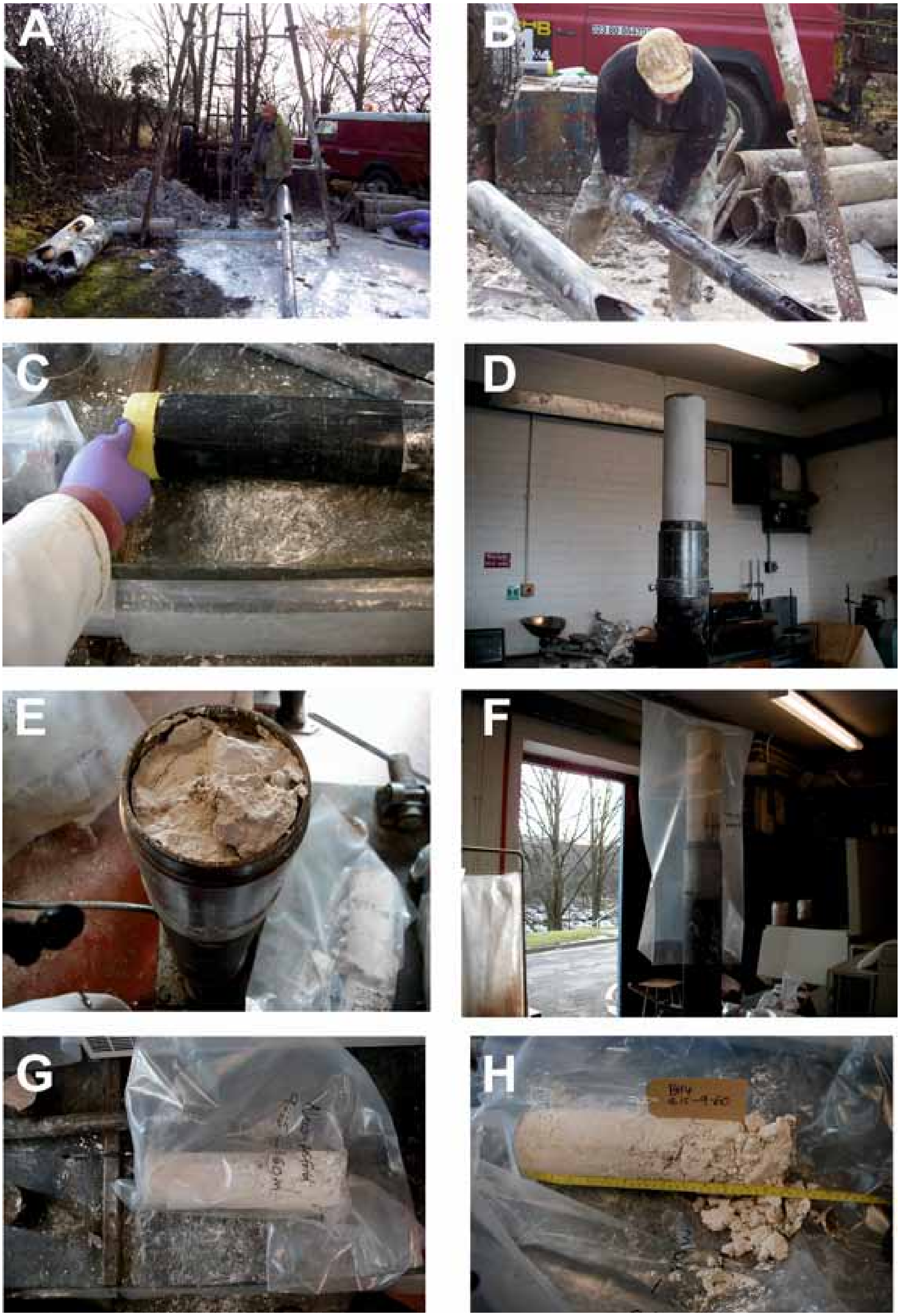


Figure D1 (A) Percussion drilling yields white chalk slurry (a bucket of water is often tipped into the borehole to ease progress). (B) The cutting shoe is unscrewed and the U100 tube released. This is then wax-sealed at either end and capped. (C) The U100 tube is unpacked in the laboratory and the seals to the caps checked. (D) The chalk core contained in the U100 tube is extracted. (E) Sometimes the base chalk sticks to the extruder; this should also be recorded and logged as it can contain vital evidence of structure and lithology. (F) The extruded chalk sample should be wrapped in a plastic bag to retain moisture. (G) The bag should be labelled clearly. (H) The bag should be cut open and the sample photographed before splitting, core and logging and subsampling.

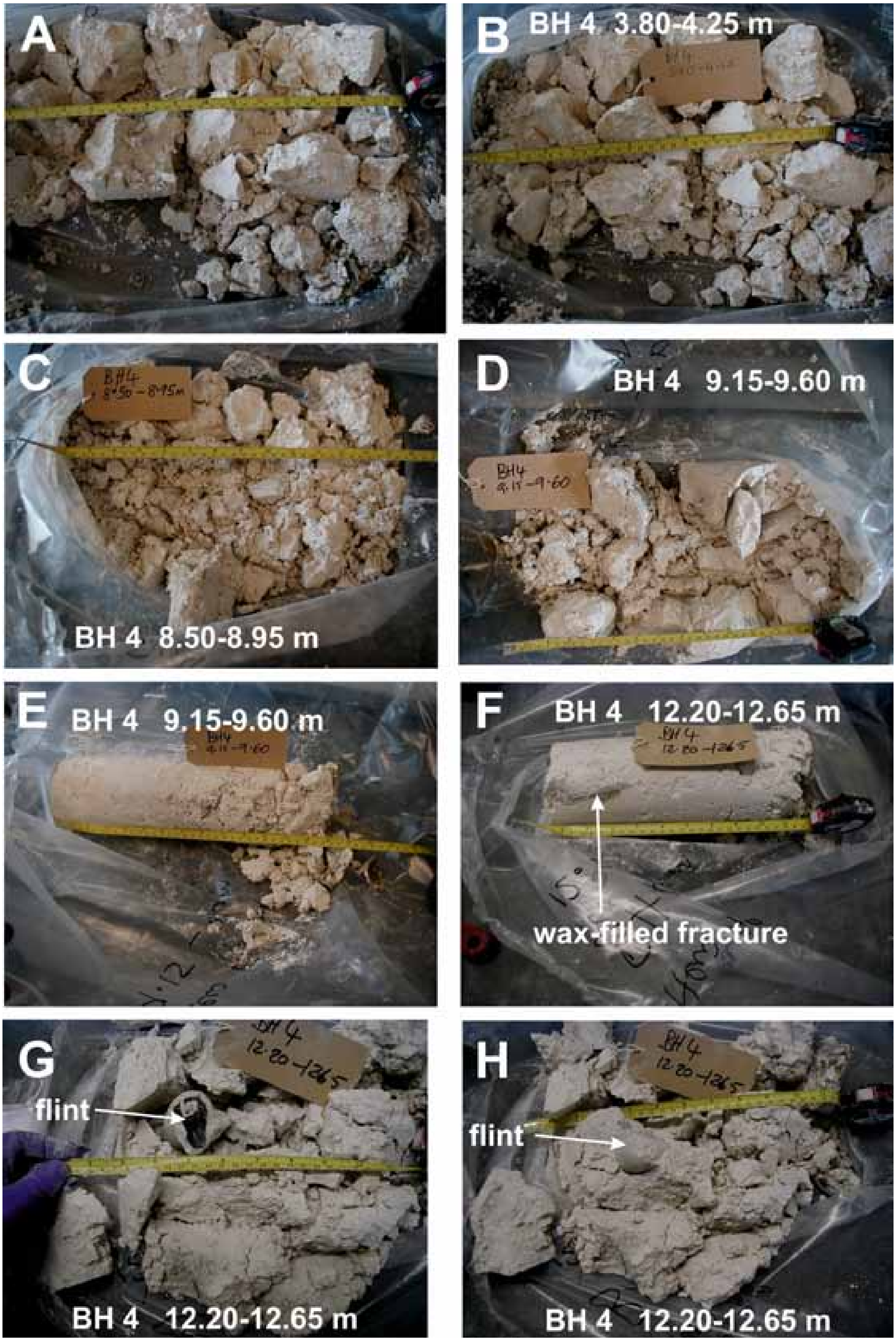


Figure D2 New Alresford Borehole 4 (BH4). (A, B) Opened U100 sample depth 3.80–4.25 m. (C) Opened U100 sample depth 8.5–8.95 m. (D) Opened U100 sample depth 9.5–9.60 m, split to show degree of fragmentation of core. (E) Opened U100 sample depth 9.5–9.60 m before splitting looks like good, slightly orange-stained core. (F) Opened U100 sample depth 12.20–12.65 m before splitting looks like good, clean white core. (G) Opened U100 sample depth 12.20–12.65 m after splitting looks like good, clean white core that has been turned to putty by percussion drilling and a flint. (H) Opened U100 sample depth 12.20–12.65 m after splitting looks like good, clean white core that has been turned to putty.

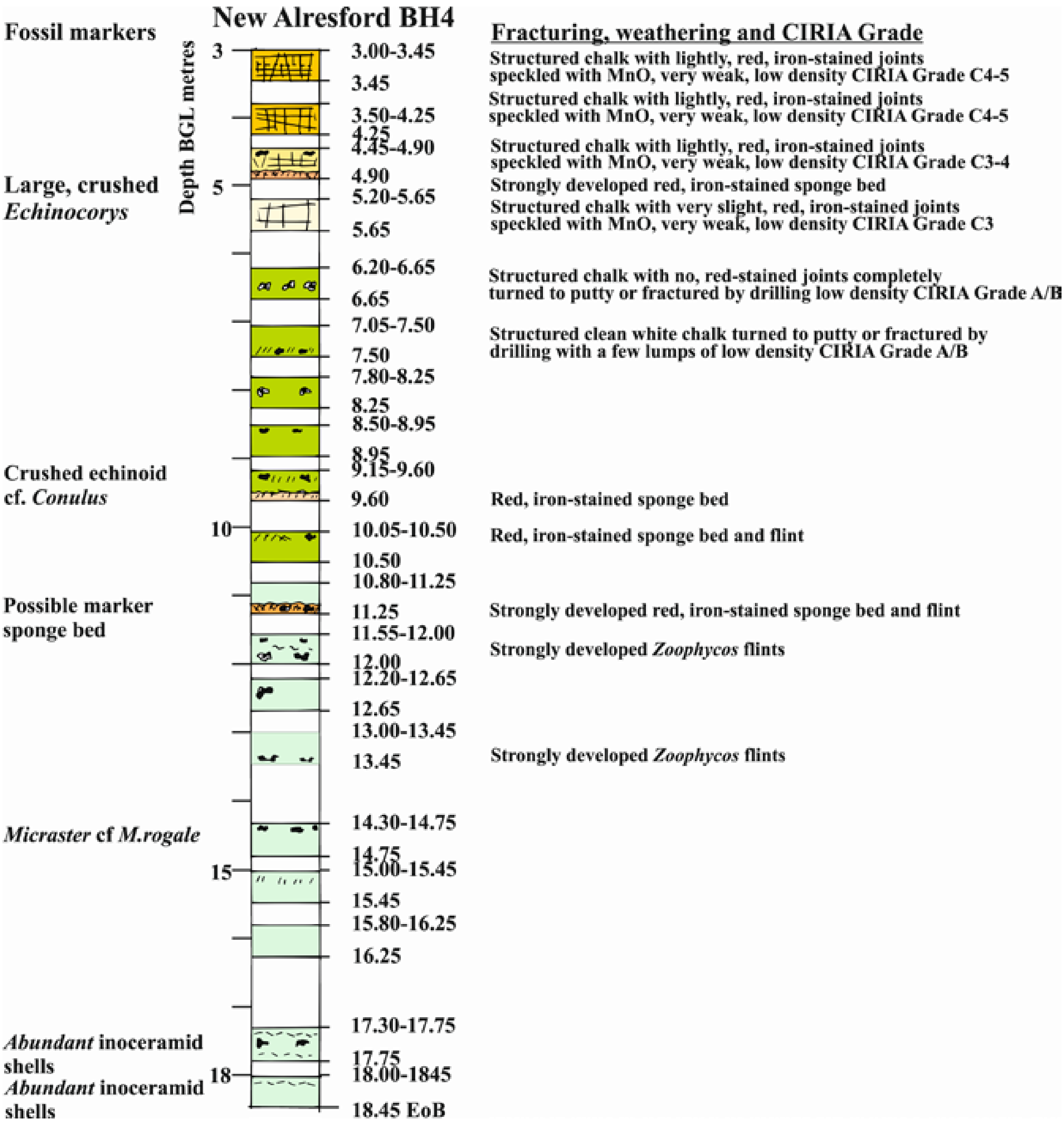


Figure D3 New Alresford Borehole 4 illustrates the problems with assessing CIRIA chalk grade with depth as the solid chalk becomes more pulverised to putty by the drilling and U100 sampling method; assessment of the structure therefore becomes more speculative. The CIRIA grade potentially improves with depth, but the U100 samples yield poorer quality material. With care, fragmentary evidence of fossils and lithology such as sponge beds and types of flint can also be found in the core. Such evidence for stratigraphic level, vital when constructing a ground model, is rarely, if ever, recorded on such logs.

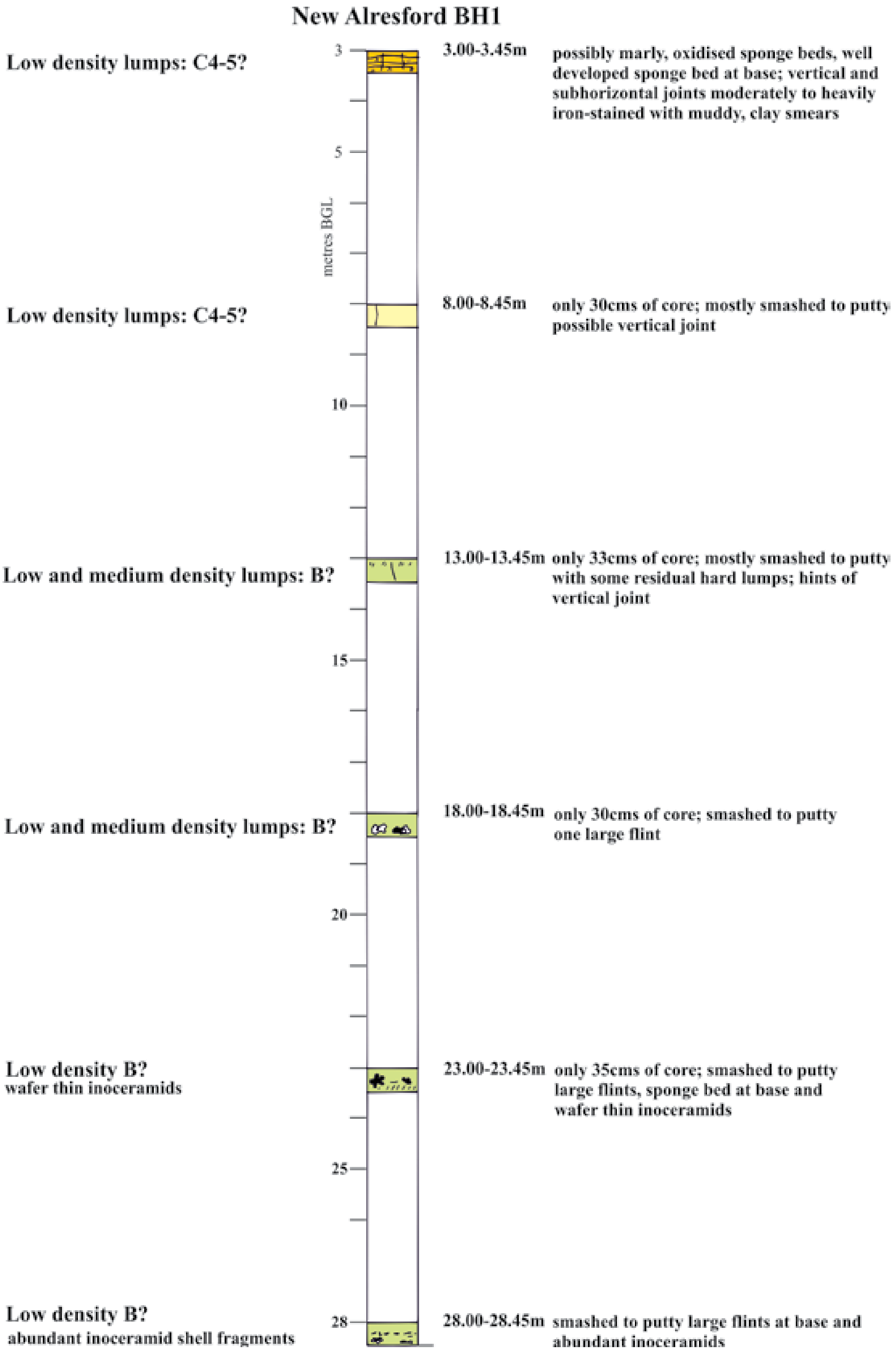


Figure D4 New Alresford Borehole 1, illustrating the often widely spaced U100 samples around which the geology for a site is assessed. As the CIRIA chalk grade improves with depth, so the solid chalk becomes more pulverised to putty by the drilling and sampling method and the assessment of structure becomes more speculative.

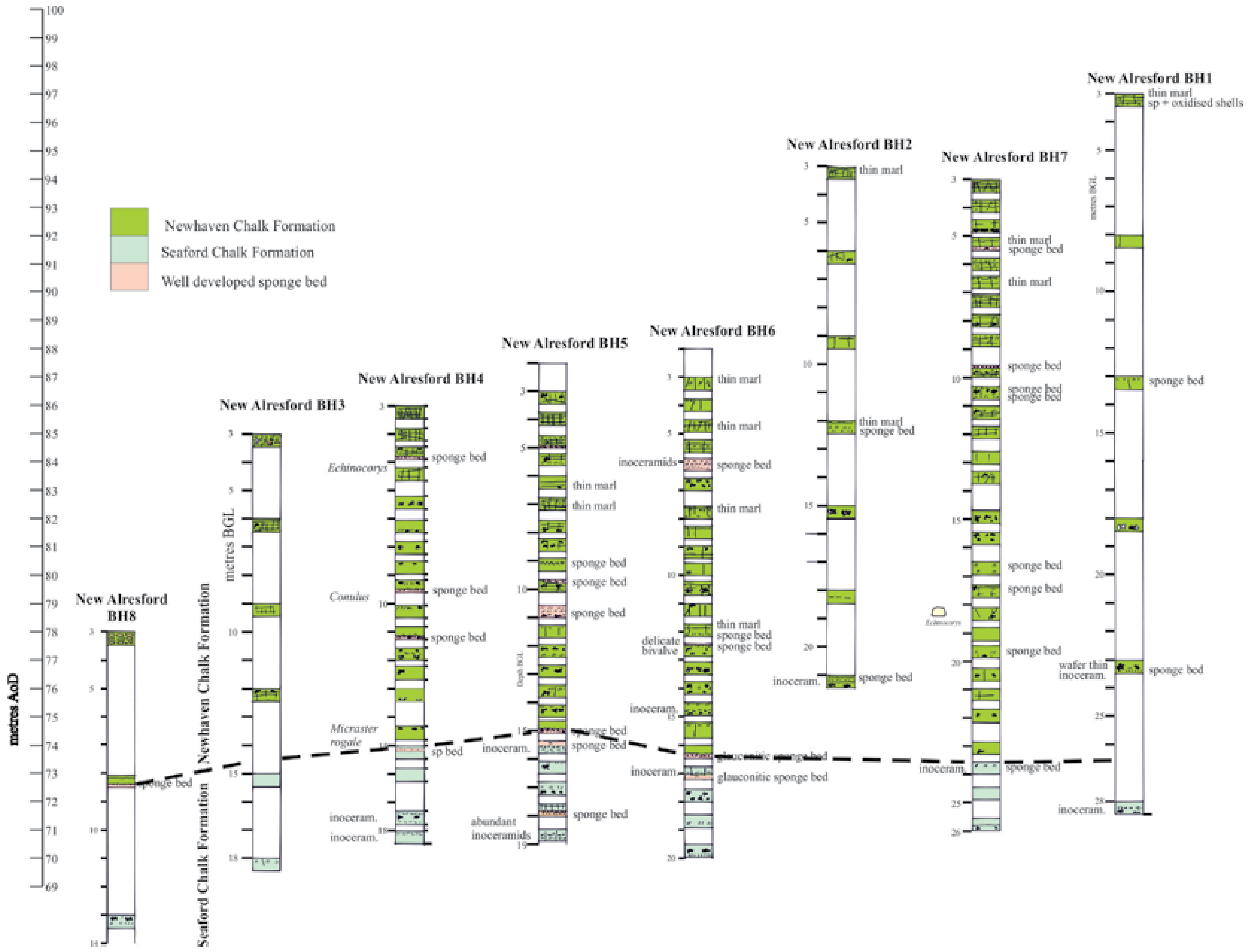


Figure D5 Stratigraphic profile determined from U100 samples from boreholes drilled by cable percussion showing the approximate boundary between the Seaford Chalk Formation and Newhaven Chalk Formation. Samples taken where strongly developed, glauconitic sponge beds are found.

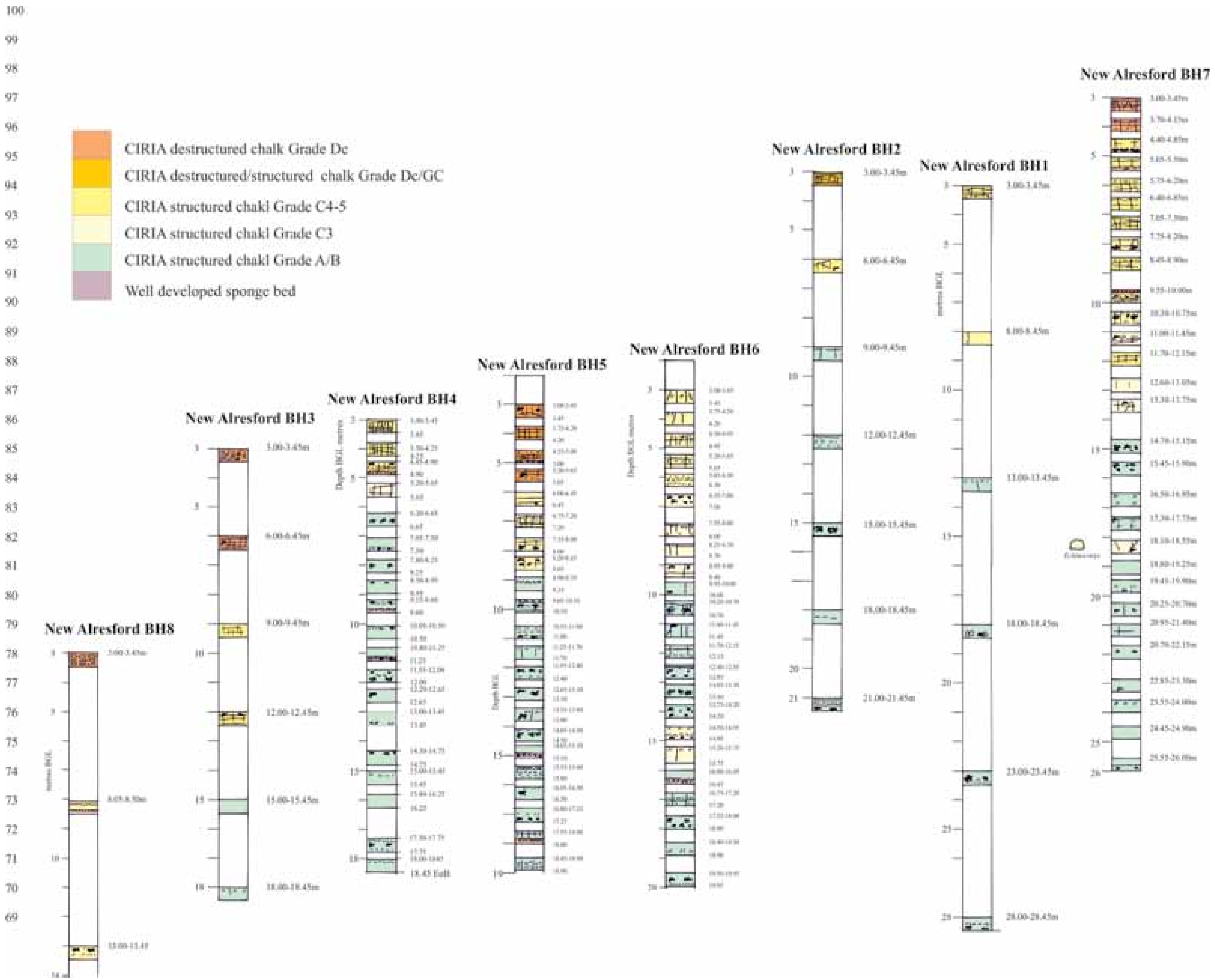


Figure D6 CIRIA chalk grades determined from U100 samples from boreholes drilled by cable percussion on the side of a Chalk dry valley.

APPENDIX E

SONIC DRILLING IN CHALK

Sonic borehole-drilling uses variable, high frequency (up to 150 Hz) resonate energy to advance the core barrel and/or casing. The resonate energy reduces sidewall friction between the drill string and the surrounding formation and focuses energy at the drill bit, increasing drill-bit progress by up to twice that of conventional drilling methods. Sonic drilling can also progress without the addition of drilling fluids such as water. Although sonic drilling has been around for some years it has only recently been applied in site investigations in the UK and is only just being considered as a method for use in chalk. Sonic drilling has been successfully developed for recovering core samples of poorly consolidated sediments traditionally considered very difficult to obtain by conventional rotary methods including gravels, loose sands and alluvium.

Potential advantages of sonic drilling include:

1. Dry-drilling could potentially be an advantage in chalk as additional water can increase degradation resulting in a putty texture and some environmental conditions require the Chalk aquifer to be protected. Also, dry drilling would be useful where the chalk pore-water chemistry needs to be analysed for potential contaminants.
2. It has also been suggested that as sonic core recovery is close to 100% and depth deviations are less than 1%, difficult interfaces between poorly consolidated sediments and bedrock such as chalk can be recovered intact at correct depths. The engineering condition of chalk at this interface is often critical to assessment of tunnel-crown stability, foundation design including pile depth required and slope stability. Defining CIRIA grade correctly at this interface is, therefore, vital.
3. Similarly, it is suggested that CIRIA grade D chalks that have been degraded to a mixture of fragments of various sizes in a matrix of fines can be recovered by this method.
4. Most sonic drill rigs have the facility to change directly from sonic drilling to conventional geobore-S coring as soon as structured chalk is encountered, without loss of core over the change-over interval.

The problem with chalk is that the pore structure breaks down readily with the introduction of any energy. Water molecule Van der Waals bonds that link chalk grains break under stress and resonate energy is likely to break these bonds. As an example, sonic baths are frequently used to clean chalk fossils and merely two seconds in a sonic bath can reduce enclosing chalk to fines. So far, few examples of chalk core obtained using sonic drilling methods have been seen and it is uncertain how much degradation resonate energy causes. The cores that have been seen are suspected to have come from already degraded chalks. A trial drilling exercise is needed where well-structured CIRIA grades A, B and C chalks are known to be present to see if these grades can be recovered and adequately logged to define the boundaries to the CIRIA grades using sonic drilling.

Known issues with sonic drilling that might affect the quality of recovery in chalk include:

1. At depths of around 18 m and 30 m 'resonance' can cause damage to the liner as well as the core (Figure E1)
2. Inclined boreholes may have greater difficulty in recovering intact chalk because the wave energy will focus along the drill string rather that at the drill bit head causing more extensive chalk degradation in comparison to a vertical borehole.

As a relatively new technology the technique of sonic drilling is bound to develop and it may be that experiments with different ranges of resonate energy, sizes of bits, drill string and liner will eventually yield reliable results in chalk. The relatively small diameter core so far studied (Figure E2) may be a partial cause of the almost complete destruction of the chalk sections of core using the sonic method. Larger diameter coring may be part of the answer. Conventional cores from a borehole nearby and from similar depths illustrate the presence of structured chalk throughout (Figure E3).

Sonic drilling has successfully recovered highly disturbed chalk mixed with sandy sediments that might have otherwise been washed away in the flush during conventional rotary coring. This has provided the evidence for a highly disturbed zone of geology at unusual depths that might otherwise have been lost.

To prove that the sonic drilling method can successfully core Chalk to provide adequate material for determining lithology, stratigraphy and CIRIA grade a site needs to be chosen where *the in situ* structure of the Chalk is known and compared with conventional core from an adjacent borehole.

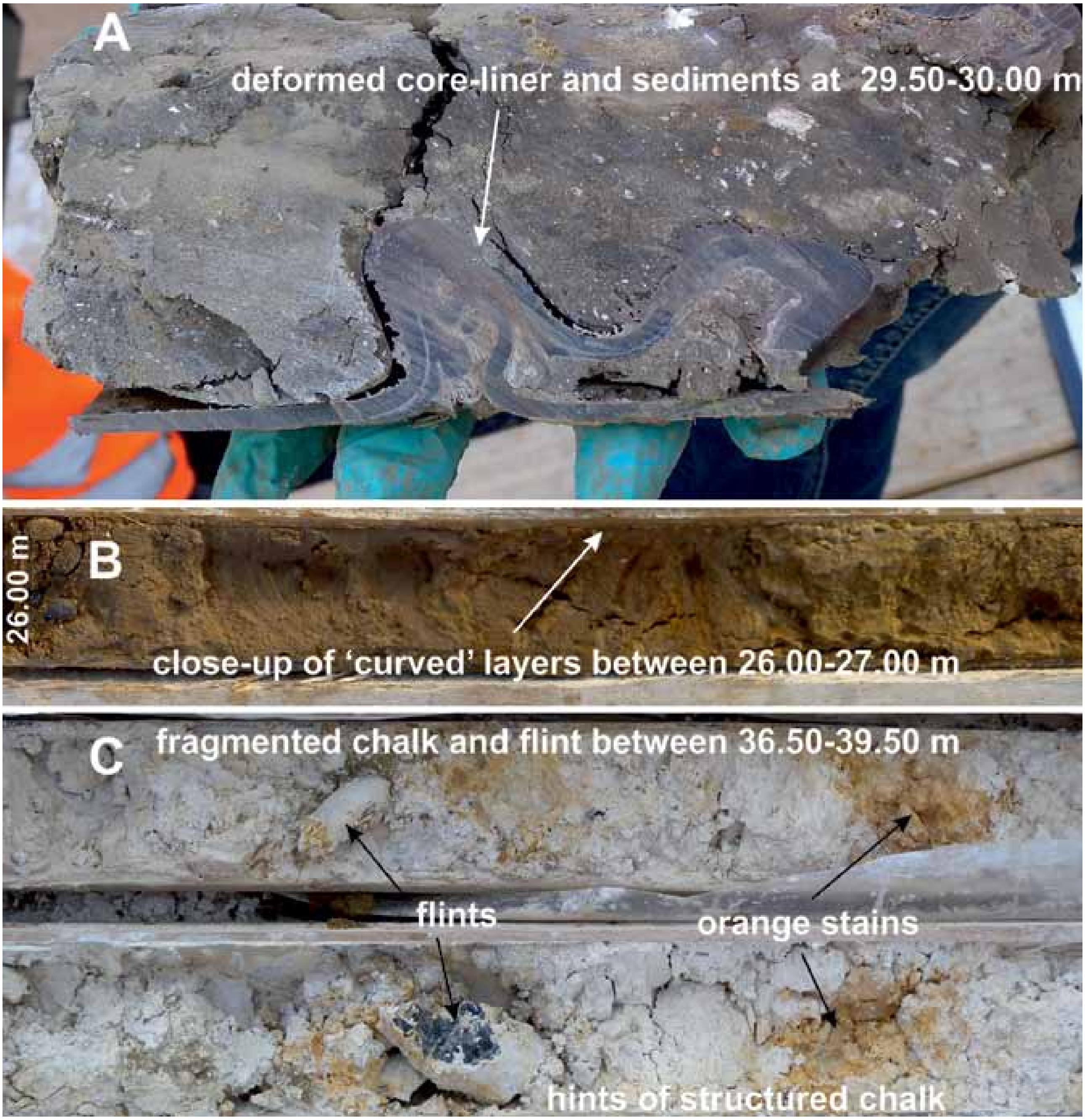


Figure E1. Types of core 'disturbance' produced by sonic coring. A. Core-liner and sediment disturbed by 'resonance' at around 30 m depth. B. Fine sands between gravel horizons showing signs of disturbance that may be related to drilling. C. Degraded white chalk with flints (CIRIA grade Dm) that may have had more structure not recovered by this drilling method.

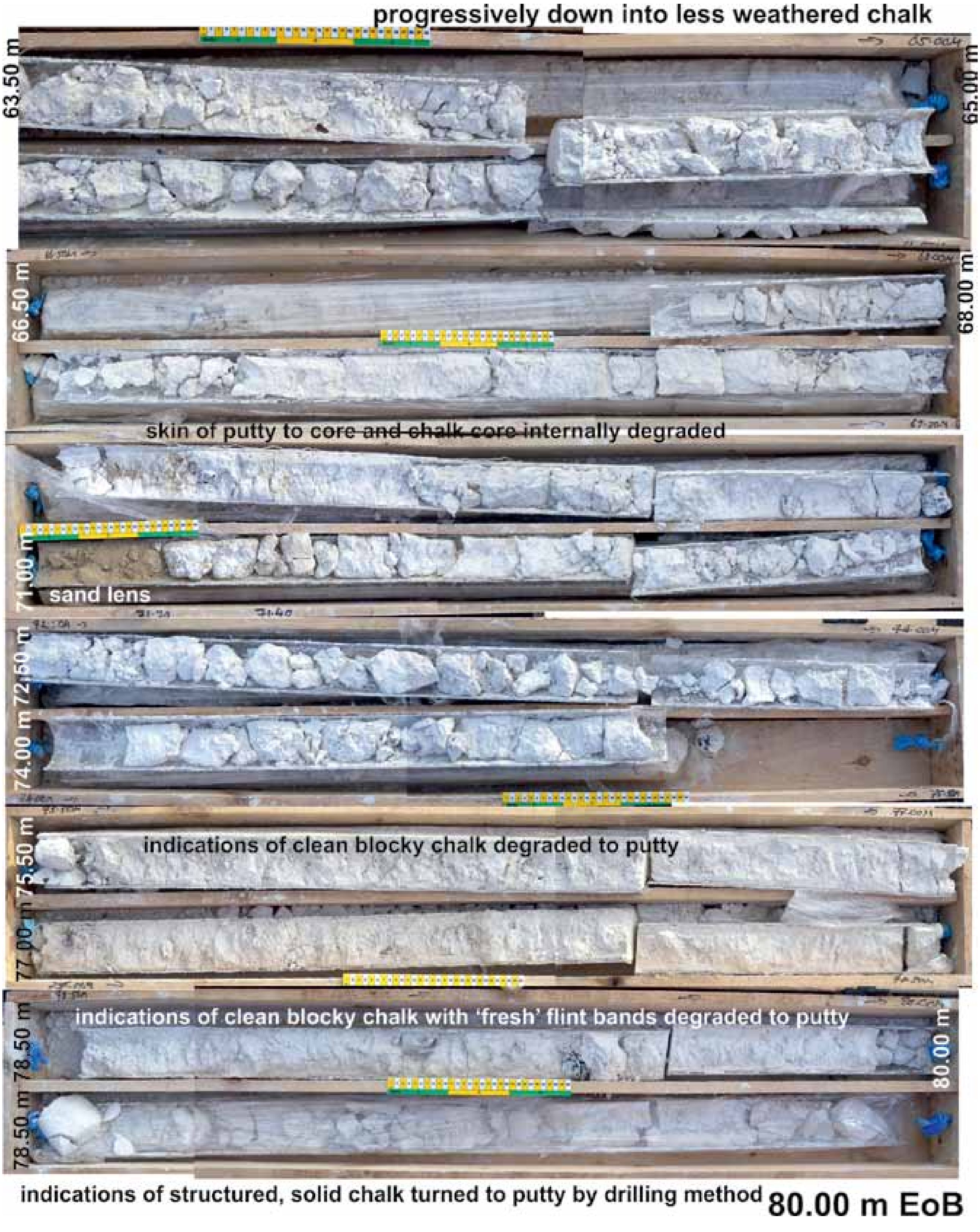


Figure E2. Examples of sonic core from chalk with 100% core recovery. However, there is little evidence of any structure in the chalk and the 'putty' matrix of fines increases downwards into what was probably better grades of chalk.

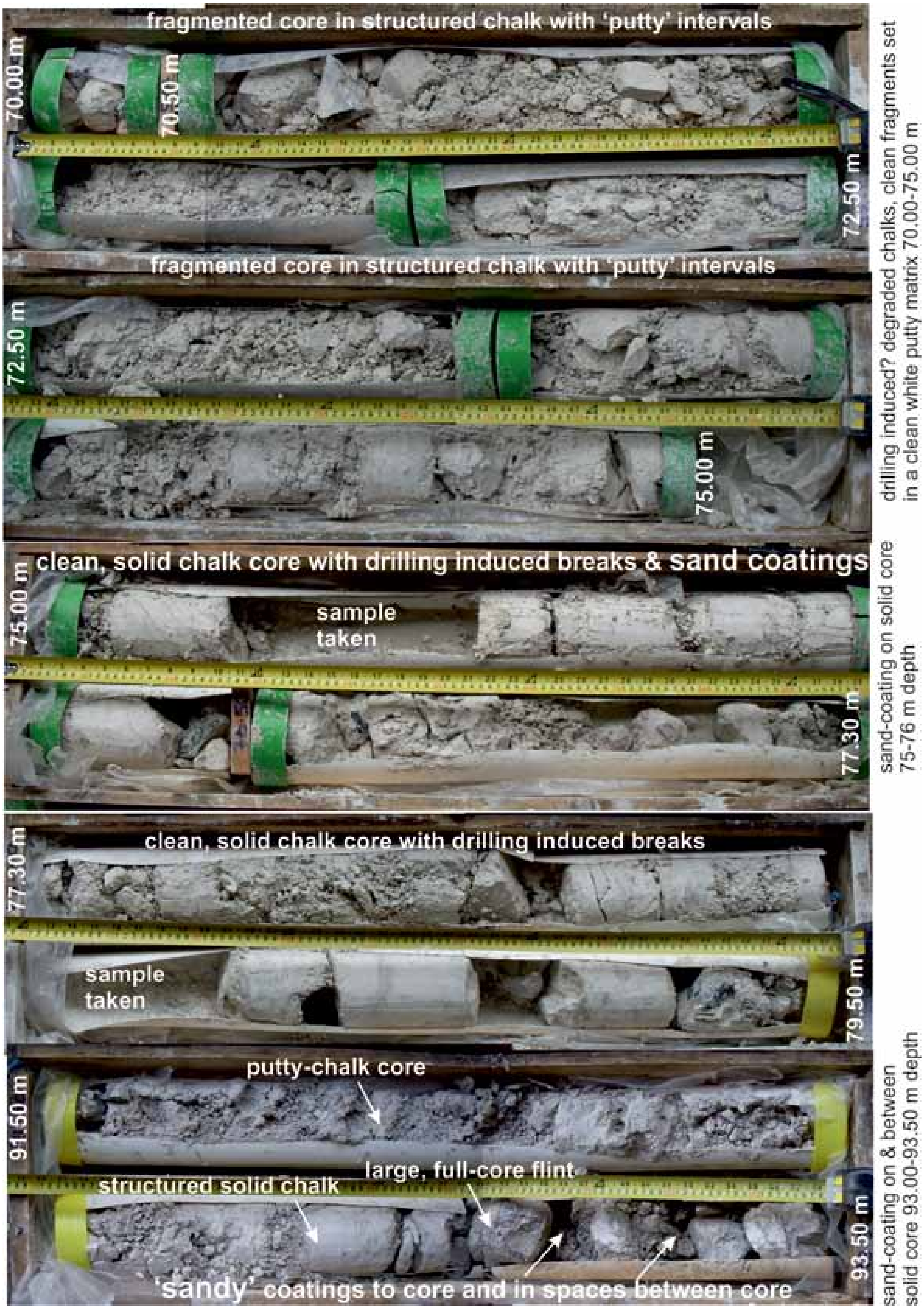


Figure E3. Traditional rotary core from a borehole near the sonic cored hole shown in Figure E2 illustrates structured chalk even where the core is degraded by drilling through flints or weaker beds.