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EAST QUANTOXHEAD, SOMERSET, ENGLAND; A POTENTIAL GLOBAL STRATOTYPE SECTION AND POINT (GSSP) FOR THE BASE OF THE SINEMURIAN STAGE (LOWER JURASSIC)

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INTRODUCTION

Recent re-examination of key early Jurassic sequences in Britain has revealed probably the most stratigraphically complete known sequence across the Hettangian-Sinemurian stage boundary in Europe. This section, on the coast of west Somerset, near East Quantoxhead, has a uniquely well-developed sequence of ammonite faunas and six successive and potentially correlatable biohorizons are recognisable in the basal subzone of the Sinemurian alone (the Conybeari Subzone of the Bucklandi Zone). In addition, the thickness of the basal subzone on the Somerset Coast is a remarkable 14 m, nearly five times as thick as the next best documented sequence, near Lyme Regis in Dorset (the latter traditionally considered in Britain as being a reference section for the base of the Sinemurian Stage). The Somerset section therefore has potential as an international reference locality for the base of the stage.

The use of ammonites as correlative tools is not, however, the only technique potentially available, and International Commission on Stratigraphy (ICS) guidelines recommend that other methods ace assessed, in particular micropalaeontological and magnetostratigraphic. Neither of these techniques has been adequately investigated on the Somerset coast and such study is necessary in order to fully assess the potential of the area for including an internationally recognised Global Stratotype Section and Point (GSSP) for the base of the Sinemurian Stage. Once such results are available, a formal proposal can then be made to the International Subcommission on Jurassic Stratigraphy (ISJS) to recognise the section near East Quantoxhead as the global standard for the base of the Sinemurian Stage.

A SHORT HISTORY OF THE SINEMURIAN STAGE FROM BURGUNDY TO SOMERSET

The Sinemurian Stage was proposed by Alcide d'Orbigny in 1842, as the lowest division of the Jurassic System and was named after the town of Semur-en-Auxois, in northern Burgundy (eastern France), where canal construction and other excavations had Yielded many characteristic fossils, especially ammonites. The establishment of the Hettangian Stage by Renevier (1884) for the basal part of d'Orbignys' Sinemurian, restricted the latter as the second stage of a conventional Jurassic System (Arkell, 1933).

The basic framework of correlative zones for the Sinemurian Stage was originally established by Oppel (1856) and subsequent refinement led to the standard scheme of Donovan in Dean *et al.* (1961). The base of the stage is drawn at the base of the lowest subzone of the lowest zone, namely the Conybeari Subzone of the Bucklandi Zone, the type area of which is south-west England, including Somerset (Tutcher, 1918). Donovan in Morton (1971) proposed that sections near Lyme Regis, on the Dorset coast, described by Lang (1924) (Figure 1) should be established as a stratotype for the Sinemurian Stage (although Sinemurian-type faunas have now been recorded slightly lower than the original boundary proposed in 1971; Palmer, 1972a; Page, 1992, p.136).

Recent study of coastal sections in West Somerset, described by Palmer (1972a) and Whittaker and Green (1983), has revealed a considerably expanded Hettangian-Sinemurian boundary sequence nearly five times thicker than at Lyme Regis, near East Quantoxhead, east of Watchet. In addition it has been possible to demonstrate that the earliest Sinemurian-type fauna at Lyme Regis is preceded by another, earlier fauna near East Quantoxhead (Page, 1992, p.136). The Dorset section is therefore not considered to be a suitable stratotype for the base of the Sinemurian, whereas the Somerset succession has great potential. The combination of a good faunal sucession and expanded sequence (c.14 m for the Conybeari Subzone alone) makes the locality unusual in Europe. Elsewhere, for instance near Bristol (e.g. Saltford Cutting; Donovan 1952a and b; 1956; Donovan and Kellaway, 1984), in South Wales (Nash Point, Glamorgan; Trueman 1922, 1930; Wilson *et al.,* 1990; pers. obs .1994), southern Germany (Bloos, 1985 a, b) and south-east France (Corna, 1985, 1987; Elmi and Mouterde, 1965), sequences are usually much thinner and much less complete even at the historical "type" locality for the stage near Semur-en-Auxois itself (Corna and Mouterde, 1988).

THE SUCCESSION OF AMMONITE FAUNAS ACROSS THE HETTANGIAN-SINEMURIAN BOUNDARY IN SOUTHWEST ENGLAND

The change from typically "Hettangian" to typically "Sinemurian" faunas is conventionally indicated by the virtual replacement of faunas dominated by *Schlotheimia* spp. (Schlotheimiidae) of the Angulata Zone (Upper Hettangian), by faunas dominated by Arietitidae (Arietitinae including *Vermiceras, Epammonites,* and *Metophioceras)* of the early Bucklandi Zone (Lower Sinemurian). In north-west Europe

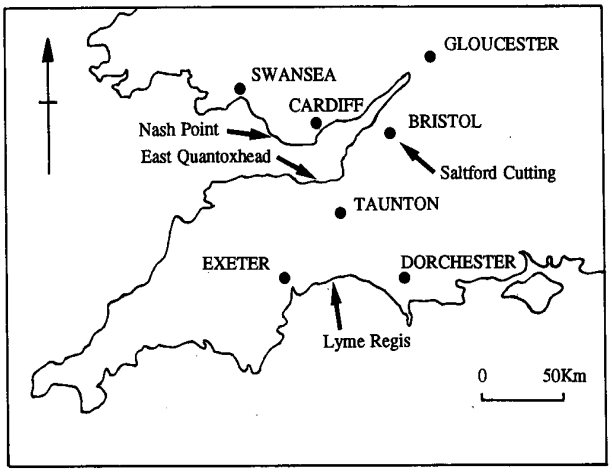

Figure 1. The location of key Hettangian-Sinemurian boundary localities in South West Britain.

(i.e. within the North West European palaeo-biogeographical Province sensu Dean et at ,1961 and other authors) this change is sudden, earlier Arietitidae being rather rare (excepting Alsatitinae in the older Liassicus Zone (middle Hettangian). Schlotheimiidae persist into the Conybeari Subzone (lowest Bucklandi Zone) and at higher levels as *Charmasseiceras* and its descendants, but usually at a relatively low abundance when compared to contemporary Arietitidae.

There is an assumption that this faunal changeover was virtually synchronous wherever it is observed and that it is therefore an important event with which to globally correlate the base of the Sinemurian Stage. Nevertheless, elsewhere in Europe and North America, there is apparently evidence of earlier faunas with frequent Arietitidae, for instance *Paracaloceras*, *Gyrophioceras* and *Schreinbachites* (Bloos 1983, 1994; Taylor, 1986). Stabilisation of the boundary at an agreed level is therefore required, and the historical context of north-west European sites with the clear and accepted position for the stage boundary is probably still the best region for establishing a GSSP.

The faunal sequence in south-west England is perhaps the most completely known in north-west Europe and can form a standard with which to correlate sequences elsewhere. Late Hettangian faunas are presently best known near Lyme Regis, but this is due largely to inadequate sampling on the West Somerset coast. In contrast, the sequence of early Sinemurian faunas is best developed in West Somerset and classifying this and the former sequence of faunas as a series of potentially correlatable infra-subzonal units or *biohorizons* (sensu Callomon, 1985; Page 1992; Dommergues *et al*., 1994), the following scheme is proposed:

LOWER SINEMURIAN	{Turneri Zone		
	{Semicostatum Zone		{5: *conybeari* Biohorizon
	{	{Bucklandi Subzone	{4: *rotator* Biohorizon
	{Bucklandi Zone –	{Rotiforme Subzone	{3b: *rouvillei* Biohorizon
		{Conybeari Subzone	{3a: *rotarium* Biohorizon
			{2b: *Metophioceras* sp.2 Biohorizon
			{2a: *Metophioceras* sp.1 Biohorizon
			{1: aff.*rougemonti* Biohorizon
		{Depressa 'Subzone'	- *Schlotheimia* sp. 2 Biohorizon
		{	
		{	{*pseudomoreana* Biohorizon
			{*Schlotheimia* sp. 1 {Biohorizon
	{Angulata Zone ——	{Complanata ——	{cf. *complanata* Biohorizon
	{	(Subzone	{*similis* Biohorizon
	{	{	
HETTANGIAN	{	{	
	{	{Extranodosa	
	{Planorbis Zone	{Subzone	

The zonal framework follows Donovan in Dean et al. (1961). The proposed new biohorizonal scheme for the upper part of the Angulata Zone and a revised scheme for the Conybeari Subzone is described below:

HETTANGIAN; ANGULATA ZONE; COMPLANATA SUBZONE

similis Biohorizon. *Index. Schlotheimia similis* Spath. *Reference:* Bed H91- ?Bed la, "Blue Lias" *sensu* Lang (1924), Lyme Regis, Dorset. *Correlating Fauna*: *Schlotheimia similis* Spath (including the holotype as figured by Spath, 1924, p1.18), *Sc*. aff. *lymense* Spath. *Comment*: This is the lowest characterised fauna in the Complanata Subzone of Dorset. Macroconchs typically have relatively closely ribbed inner whorls and smooth, sub-triangular sectioned middle and outer whorls. Coiling is relatively evolute (cf. specimens figured by Donovan, 1952a, p1.1.23, Figs 1, 2). Similar forms to *Sc similis* apparently also occur in the lower part of Bed 1 (Bed la and possibly also Bed lc) but comparison is presently difficult due to a paucity of available material from these levels.

cf *complanata* Biohorizon. Index: *Schlotheimia* cf *complanata* von Koenen. *Reference*: Beds 1d-3, "Blue Lias" sensu Lang (1924), Lyme Regis, Dorset. *Correlating Fauna*: *Schlotheimia* spp. including Sc. cf. *complanata* (similar to the holotype figured by Dean *et al*., 1961, p1.64, Fig 2), *Sc. angulosa* Lange and *Sc*. cf. *stenorhyneha* (Lange). *Comment*: The presence of evolute forms including relatively smooth morphologies (*Sc*. cf. *complanata*, etc.) is typical.

Schlotheimia sp.1. Biohorizon. *Index*: *Schlotheimia* sp.1. *Reference* Bed 7, "Blue Dias" *sensu* Lang (1924), Lyme Regis, Dorset. *Correlating Fauna*: *Schlotheimia* sp .1 and *Schreinbachites* cf *vaihingensis* Bloos (rare). Although presently poorly characterised, the fauna of Bed 7 includes very large macroconchs 45 cm+ in diameter, some of which have relatively coarse secondary ribs on their inner whorls. The presence of the rare early arietitid *Schreinbachites* (Bloos, 1994) is noteworthy.

pseudomoreana Biohorizon. *Index: Schlotheimia pseudomoreana* (Spath). *Reference*: Beds 14-16, Blue Lias, *sensu* Lang (1924), Lyme Regis, Dorset. *Correlating fauna*: *Schlotheimia pseudomoreana* Spath (probably including the holotype figured by Wright, 1879-1884, P1.17. Fig.1), Sc. *polyeides* Lange, *Sc. postangulata*, also *Schreinbachites* sp. (rare). *Comment*: The presence of relatively involute, medium sized macroconchs and common sharply ribbed and more evolute microconchs, characterises the most conspicuous schlotheimiid fauna on the Dorset coast.

COMPLANATA OR DEPRESSA SUBZONE

Schlotheimia sp. 2 Biohorizon. *Index*: *Schlotheimia* sp 2. *Reference*: (alternatives): Bed C100 (0 to 75 cm above base), Blue Lias *sensu* Palmer (1972; = Bed 146 of Whittaker and Green 1983), north of East Quantoxhead, West Somerset coast or Bed 17, Blue Lias *sensu* Lang (1924), Lyme Regis Dorset. *Correlating Fauna*: *Schlotheimia* spp. (poorly characterised but including fragments of macroconchs with coarse secondary ribbing recalling *Sc. depressa* (Wähner)). *Comments*: Above the rich fauna with *Sc. pseudomoreana* at Lyme Regis, and only 0.5 m below the first recorded *Metophioceras* is a poorly characterised schlotheimid fauna. Similarly, only around 30 cm below the earliest arietitid fauna on the Somerset coast, a fauna of *Schlotheimia* sp. occurs but is currently not well characterised. Whether the two faunas include the same species is not yet known, nevertheless, the very high level in the Angulata Zone of both is indisputable. In Germany, a Depressa Subzone has been used above the Complanata Subzone (Bloos, 1979) although the division is generally not clearly distinguishable elsewhere and subsequently has been reduced to the level of a 'Horizon' (e.g. by Mouterde and Corna, 1991). Whether the late but poorly characterised faunas in Dorset and Somerset include Sc. *depressa* is not clear but is nevertheless possible, as some English shell fragments show morphological affinities to German specimens.

SINEMURIAN: BUCKLANDI ZONE, CONYBEARI SUBZONE

aff.*rougemonti* Biohorizon (1). *Index*: *Vermiceras* aff. *rougemonti* (Reynès). *Reference*: Bed C100 (upper c.90 cm), "Blue Lias" sensu Palmer (1972) (= Bed 146 of Whittaker and Green 1983), north of East Quantoxhead, West Somerset coast. *Correlating Fauna*: Ve. aff. *Rougemonti* (Reynès) (= Ve. *solarioides sensu* Ivimey-Cook and Donovan 1983 non Da Costa) relatively small form, up to around 15-18 cm diameter, with very evolute whorls and close ribbing. Although showing some similarities to the lectotype of Ve. *rougemonti* (as figured by Guèrin-Franiatte, p1.64, Fig 1) the Somerset specimens appear to have slightly curved ribs unlike the straight ribs of the former.

Comment: This is the earliest Sinemurian-type fauna in Somerset and although specimens are crushed, they are sufficiently distinct to be recognised on the basis of ribbing style and coiling. Equivalent to the cf. *rougemonti* Horizon (1) of Page (1992).

Metophioceras sp. 1. Biohorizon (2a). *Index: Metophioceras* sp.1. *Reference*: Bed C101, "Blue Lias" *sensu* Palmer (1973) (= Bed 147 of

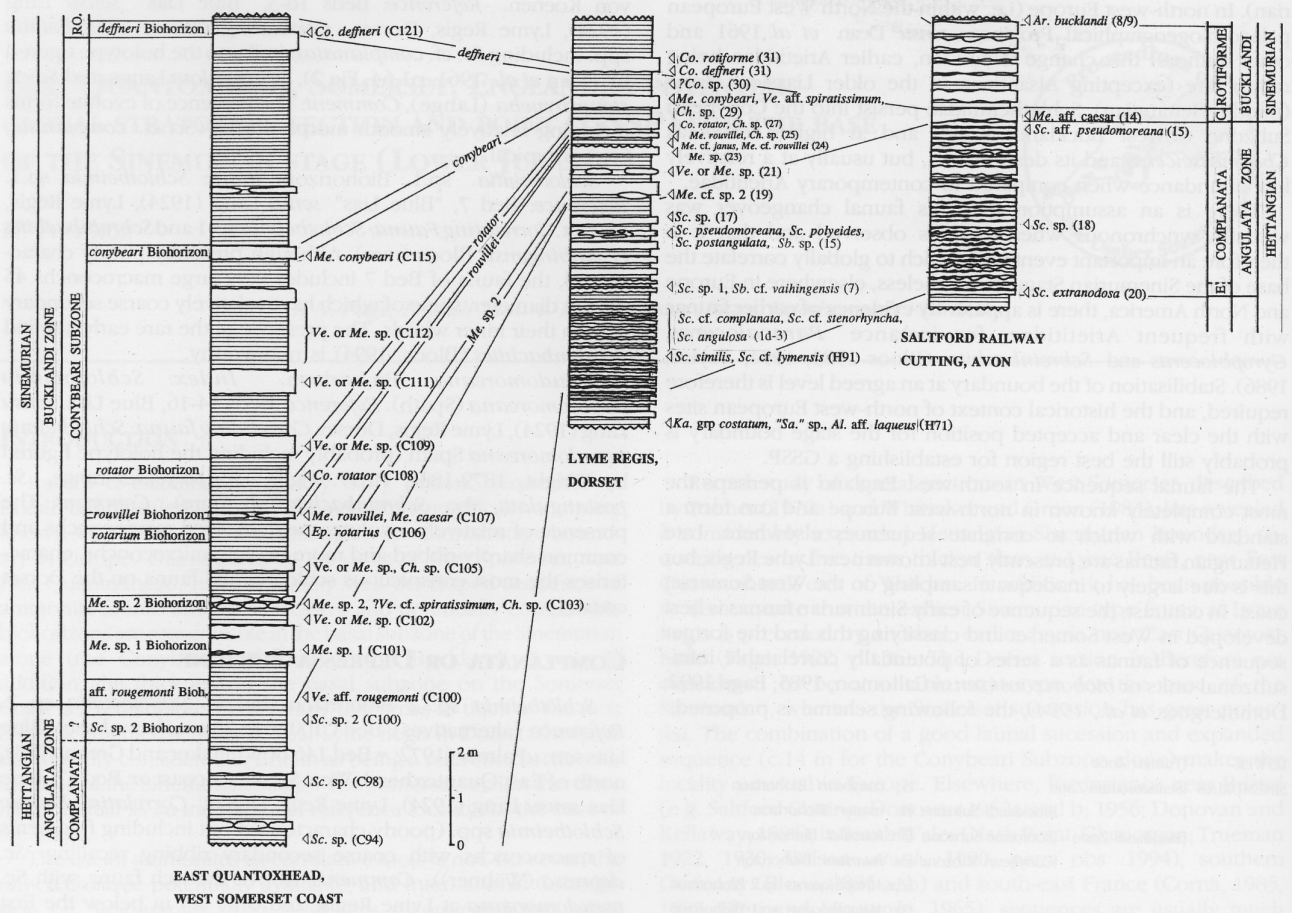

Figure 2. The sequence of ammonite faunas across the Hettangian-Sinemurian boundary at key sites in South West England. Abbreviations as follows: Ar. = Arietites, Al. = Alsatites, Co. = Coroniceras, Ep. = Epammonites, Me. = Metophioceras, Ve. = Vermiceras, Sb. = Schreinbachites, Sc. = Schlotheimia, Ch. = Charmasseiceras, "Sa." = "Saxoceras", Ka = Kammerkarites. Bed numbers (in brackets), sections and faunas from the following sources: East Quantoxhead -Palmer (1972), Whittaker and Green (1983), pers. obs.; Lyme Regis - Lang (1924), M. Foster collection (National Museum of Wales), pers. obs.; Saltford Cutting - Donovan (1956), Donovan and Kelloway (1983), Bristol City Museum collections, University of Bristol collections, S. Carpenter collection (Hanham, Bristol).

Whittaker and Green 1973), north of East Quantoxhead, West Somerset coast. *Correlating Fauna: Metophioceras* sp.1 - a large species, 40 cm+ in diameter, with close straight ribs on inner whorls and a compressed rectangular whorl section.

Metophioceras sp. 2 Biohorizon (2b). *Index: Metophioceras* sp. 2. *Reference:* Bed 103, "Blue Lias" *sensu* Palmer (1972) (= Bed 149 of Whittaker and Green, 1983), north of East Quantoxhead, West Somerset coast. *Correlating Fauna: Metophioceras* sp. 2 (large forms with compressed rectangular sectioned outer whorls and ribbing tending to fade relatively early on middle whorls), *Ve.* cf *spiratissimum* (Quenstedt). *Charmasseiceras* sp. (giant and occasional). *Comment:* A general correlation between biohorizons 2a and 2b (Beds C101-C102) on the west Somerset coast and Bed 19 of the 'Blue Lias' *(sensu* Lang 1924) at Lyme Regis - the earliest recorded Sinemurian fauna at that locality is likely (cf. Page, 1992, p.136). Equivalent to the *longidomus* Horizon (2) of Page (1992).

rotarium Biohorizon *(3a). Index: Epammonites rotarium* (Buckman). *Reference:* Bed C106 (upper c.30 cm), "Blue Lias" *sensu* Palmer (1972) (= Bed 152 of Whittaker and Green 1983), north of East Quantoxhead, West Somerset coast. *Correlating Fauna: Ep. rotarium* (small evolute forms 10-12 cm in diameter, ribbing and coiling very close to the holotype as re-figured by Guèrin-Franiatte, 1966, p1.66). *Comments:* Bed 24 at Lyme Regis contains a fragmentary fauna used as the reference for the *janus* horizon (3) of Page (1992). This fauna may correlate with the *rotarium* Biohorizon, as described here, but available specimens are inconclusive.

rouvillei Biohorizon (3b). *Index: Metophioceras rouvillei* (Reynès). *Reference:* Bed 107, "Blue Lias" *sensu* Palmer (1972) (= Bed 153 of Whittaker and Green 1983), north of East Quantoxhead, West Somerset coast. *Correlating Fauna: Me. rouvillei* (close to the holotype figured by Guèrin-Franiatte 1966, p1.65, i.e. evolute forms with a quadrate whorl section and strong curved ribs), *Me. caesar* (Reynès) (close to the holotype figured by Guèrin-Franiatte 1966, p1.20; a distinctive close ribbed form), *Charmasseiceras* sp. (giant, occasional). *Comment: Me. rouvillei* occurs in Bed 25 at Lyme Regis (`Blue Lias' *sensu* Lang, 1924) indicating a correlation.

rotator Biohorizon (4). *Index: Coroniceras rotator* (Reynès). *Reference:* Bed 27, 'Blue Lias' *(sensu* Lang, 1924), Lyme Regis, Dorset (Page, 1992). *Correlating Fauna: Co. rotator* (Reynès) (a very early species of *Coroniceras* with strong curved ribs and strong nodes and a relatively compressed whorl section) *Charmasseiceras* sp. (large, infrequent). *Comments:* The first occurrence of *Coroniceras* has been conventionally taken as indicating the base of the Rotiforme Subzone, nevertheless evidence from both Dorset and Somerset (the latter in Bed C108) indicates that the index of the Conybeari Subzone occurs *above* this first *Coroniceras* (Page, 1992, see also below).

conybeari Biohorizon (5). *Index: Metophioceras conybeari* (J.

Sowerby). *Reference.* Bed 29, "Blue Lias" *sensu* Lang (1924), Lyme Regis, Dorset (Page, 1992). *Correlating Fauna: Me. conybeari* (J. Sowerby); large forms with relatively compressed whorls and a high keel; inner whorls close to the holotype as re-figured by Dean, *et al.,* 1961, P1.64, figs 4), *Vermiceras* aff. *spiratissimum* (Quenstedt) (uncommon), *Charmasseiceras* sp. (uncommon). *Comments:* The last characterised fauna of the Conybeari Subzone in both Dorset and Somerset (the latter in Bed C115) includes the index species of the subzone. The lowest fauna of the overlying Rotiforme Subzone (= the *defneri* Biohorizon (6) of Page, 1992), includes very large *Coroniceras* with relative straight, weakly noded ribs and smooth, *Metophioceras* -like outer whorls. This fauna has been recovered both in Dorset (on the lower surface of Bed 31, the reference level) and in Somerset (on the top surface of Bed C121).

THE SUITABILITY OF THE SECTIONS NEAR EAST QUANTOXHEAD AS A GSSP FOR THE BASE OF THE SINEMURIAN STAGE

The effective communication of the relationships in time and space between different rock bodies and events and processes during the evolution of the Earth requires an unambiguously defined chrono-stratigraphic nomenclature. The establishment of such standards is the responsibility of the International Commission on Stratigraphy (ICS) a project of the International Union of Geological Sciences (IUGS) and hence UNESCO. Established practice defines a standard scale using boundary stratotypes for component units by defining the base of a division at a unique point in a specified sequence at a specified locality, chosen because of its potential for global scale correlation (Cowie *et al.,* 1986; Salvador, 1994). These *Global Stratotype Sections and Points* or GSSPs unambiguously and objectively define the boundaries between successive divisions of a chronostratigraphic scale at the chosen stratotype locality - recognising the boundary at other localities becomes, therefore, simply a problem of correlation and not one of subjective interpretation.

The selection of GSSPs is the responsibility of subcommission of the ICS, and for the Sinemurian Stage, the International Subcommission on Jurassic Stratigraphy (ISJS) is the appropriate body. The ICS however, has established guidelines and recommendations which must be followed when proposing a GSSP, as discussed by Cowie *et al.* (1986) and Salvador (1994). These guidelines relate to the stratigraphic completeness of the sections and their potential for world-scale correlation using multidisciplinary techniques (macro- and microfossils, magnetostratigraphy, chemostratigraphy, etc.).

The large scale of the exposures at East Quantoxhead and the relative stratigraphic completeness (including the great thickness of the trans-boundary sequence) would make the section ideal as a candidate GSSP for the base of the Sinemurian Stage.

Although it is presently possible to demonstrate that the ammonite faunas present have *potential* for international correlation (certainly around northern Europe and perhaps also including North America) no other techniques have yet been fully assessed. A formal proposal as a candidate GSSP is not therefore currently possible under ICS guidelines. Nevertheless, the lithologies present (mudrocks and limestones, frequently argillaceous) would be expected to yield good results. It is therefore of paramount importance that additional studies are completed thereby facilitiating the compilation of a formal proposal as a candidate GSSP.

Should such a proposal be acceptable to the ISJS and the ICS, the cliffs and foreshore near East Quantoxhead in Somerset could become one of the most important geological sites in the world, rigorously defining and stabilising the interpretation of a division of the global geological timescale, as the Global Stratotype Section and Point for the base of Sinemurian Stage of the Jurassic System.

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