BioStrat Ltd.

BIOSTRATIGRAPHY OF
NORWEGIAN WELL 15/9-F-1
(3270m-3632m), VOLVE FIELD.

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1. Introduction

This report presents results of palynological analyses of Mid-Late Jurassic and Early Cretaceous sediments in well 15/9-F-1 (3270m-3632m). Results are summarised in Figure 1 and detailed in the range and abundance chart (Figure 2). These include all key bioevents, together with chronostratigraphic and biostratigraphic interpretations. Lithostratigraphic boundaries and wireline logs were provided by Statoil. Age interpretations are based on the recognition palynological biozones (Appendices 1-3).

Where recovery allows, the Statoil palynological counting procedure (PCP) includes two separate counts; Count 1 includes 100 identifiable palynomorphs, including pollen, spores, microplankton, acritarchs and miscellaneous forms. Count 2 is of 100 marine taxa, miscellaneous microplankton and acritarchs, with further scanning for rare taxa.

Several hot-shot samples were analysed upon the well reaching T.D., and the results of these analyses are incorporated here (hot-shot samples marked in Figure 1). Note however, that the standard PCP was not utilised for these samples, in which exclusively dinocysts were counted.

All sample depths are given in mBRT (drilled). The following abbreviations may be used in this report;

LO	last occurrence (top, extinction, first downhole occurrence)
LFO	last frequent occurrence
LCO	last common occurrence
LAO	last abundant occurrence
LSAO	last superabundant occurrence
FO	first occurrence (base, last downhole occurrence)
FFO	first frequent occurrence
FCO	first common occurrence
FAO	first abundant occurrence
FSAO	first superabundant occurrence
PRES	present
FREQ	frequent
CMN	common
ABNT	abundant
SA	superabundant

2. Main conclusions

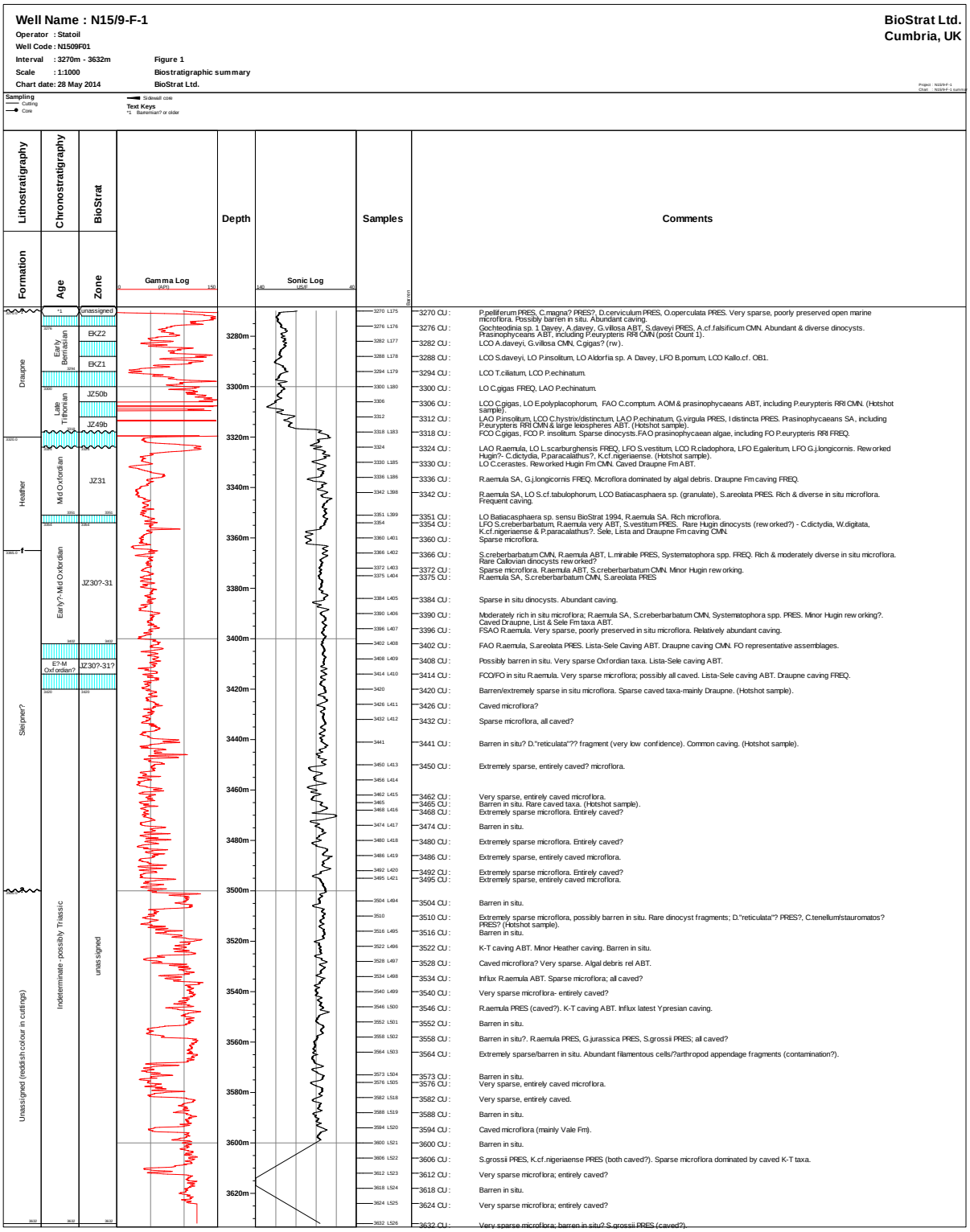
The entire lower half of the interval of study remain of indeterminate age, though a possible Triassic age is suggested.

There is no reliable palynological evidence for the presence of the Hugin Formation and none at all for the Sleipner Formation.

The Heather Sandstone Formation is probably no older than Mid Oxfordian at this location. It was deposited above a significant unconformity in a near-shore, open marine environment. The time-span represented in the hiatus is uncertain as the ages of the underlying units are unknown. Representative *in situ* assemblages are associated with frequent reworked Callovian taxa.

The upper boundary of the Heather Sandstone Formation is also represented by a significant hiatus, with the oldest Draupne Formation being of latest Tithonian age. Early Berriasian microfloras are present above, and indicate deposition in an open marine, periodically anoxic environment. No Late Berriasian assemblages are recorded, suggesting that the uppermost Draupne Formation was eroded at BCU, or not deposited.

Figure 1. Stratigraphic Summary, 15/9-F-1



2. RESULTS

Barremian? or older
3270m

The age assignment is based on the presence of *Pseudoceratium pelliferum, Dingodinium cerviculum* and *Odontochitina operculata* at 3270m. The sample yielded an extremely sparse, poorly preserved marine microflora, also including a questionable record of *Cassiculosphaeridia magna* (fragment), *Hystrichodinium pulchrum* and *Cribroperidinium edwardsii*. The assemblage is not representative and no biozone assignment is possible.

Early Berriasian
3276m-3294m

Age and biozone assignments are based on;

LO *Systematophora daveyi*, LO *Gochteodinia* sp. 1 Davey 1982 at 3276m (**EKZ2**).

LCO *Apteodinium daveyi* & at 3282m (**EKZ2**).

LCO *S.daveyi* and LO *Perisseiasphaeridium insolitum* at 3288m (**EKZ1**).

LCO *Pilosidinium echinatum* at 3294m (**EKZ1**).

A major palynofacies change is observed at 3276m, associated with the upper boundary of the Draupne Formation at 3270.0m (log). Samples from this interval yielded moderately rich and diverse open marine assemblages. These include diverse dinocysts, together with abundant prasinophycean algae, the latter indicating predominantly anoxic conditions. In particular there are significant numbers of *Pterospermella eurypteris* RRI, which are characteristic of the upper Draupne Formation.

Of the dinocysts, *Circulodinium comptum* is the most abundant species, especially in EKZ2. Whilst it was also abundant during EKZ1 times, *Pilosidinium echinatum* was more predominant.

The EKZ1 microfloras also include significant numbers of *Trichodinium ciliatum, S.daveyi* and *Gonyaulacysta cretacea.* In the following EKZ2 interval, *Gochteodinia villosa, Sirmiodinium grossi* and *Avellodinium cf. falsificum* are common or abundant. The occurrence of frequent *Batioladinium pomum* at 3288m represents the minor acme of this species in lower EKZ2 and are probably caved from the overlying sample gap.

A fragment, possibly of *Cribroperidinium gigas* was observed at 3282m, though is not considered to be *in situ* even if the tentative identification is correct.

Regionally, deposition of the Draupne Formation continued until the Late Berriasian (EKZ4) times. However, sediments of EKZ 3-4 age were not deposited, or were subsequently eroded to BCU , which occurs at 3270.0m (log).

Late Tithonian
3300m-3318m

Age and biozone assignments are based on;

LFO *Cribroperidinium gigas* at 3306m (**JZ50b**).

LCO *C.gigas* and FAO *C. comptum* at 3306m (**JZ50b**).

LAO *P. insolitum* and LCO *Circulodinuim hystrix/distinctum* at3312m (**JZ49b**).

Microfloras include rich and diverse dinocysts, together with abundant prasinophycaean algae and amorphous organic material (AOM). This association is characteristic of the upper Draupne Formation and indicates deposition in an open marine environment under predominantly anoxic conditions.

The diverse dinocyst assemblages also include *Cribroperidinium gigas, Gochteodinia virgula, Gochteodinia* sp. 1 Davey 1982, *Leptodinium cf. subtile, Epiplosphaera gochtii, Isthmocystis distinctaEgmontodinium expiratum, Rotosphaeropsis thula, Kallosphaeridium cf.* OB1 and *Apteodinium daveyi.*

Also of note is the LO of *Egmontodinium polyplacophorum* at 3306m. Historically, the extinction datum of this generally rare species has been used to mark the upper limit of the old "Mid Volgian" (top *opressus* ammonite zone). In this area however, *E.polyplacophorum* appears to persist, and is often seen above or close to the LCO *C.gigas* event.

The LAO of *Pilosidinium echinatum* is also recorded at 3306m. This form is often superabundant in Late Jurassic sediments, but numbers declined rapidly at the onset of the Cretaceous Period, Berriasian Stage.

Significant unconformities are present at both the upper and lower boundaries of the Draupne Formation. The top of the Heather Formation is within the underlying sample gap at 3320.0m (log), and the palynological evidence indicates that the entire Late Oxfordian, Kimmeridgian and Early Tithonian, together with a substantial part of the Late Tithonian are omitted.

Mid Oxfordian
3324m-3351m

Age and biozone assignments are based on;

LAO *Rigaudella aemula*, LFO *Leisbergia scarburghensis* 3324m (**JZ31**).

LO *Chytroeisphaeridia cerastes* at 3330m (**JZ31**).

LO *Stepanelytron cf. tabulophorum* & LCO *Batiacasphaera* sp. (granulate) at 3342m (**JZ31**).

LO *Batiacasphaera* sp. *sensu* BioStrat1994 at 3351m (**JZ31**).

A major palynofacies change is seen at 3324m, associated with the upper boundary of the Heather Sandstone Formation at 3320.0m (log). The microfloras recovered from this interval are typical of those observed regionally in the Heather Formation, though they are sparser and include significant quantities of reworked taxa. They also differ from Heather Fm s.s. assemblages by exhibiting 3D preservation (though the overall state of preservation is generally poor).

The sporadic records of *Polystephanophorus paracalathus, Kallosphaeridium cf. nigeriaense, Cassiculosphaeridia dictydia, Mendicodinium groenlandicum, Durotrigia "reticulata"* and *Surculosphaeridium vestitum* from throughout this interval are considered to be reworked. This interpretation is based not only on comparison with nearby wells, but by the overall composition of the assemblages, which is very characteristic of the lower Mid Oxfordian.

Typical species include *Gonyaulacysta jurassica , G. jurassica longicornis, Stephanelytron redcliffense, Nannoceratopsis pellucida, Batiacasphaera* sp. (granulate), *Scriniodinium crystallinum, Tubotuberella eisenackii, Endoscrinium galeritum* and *Rhynchodiniopsis cladophora* ABT. The interpretation is further substantiated by common and consistent records of *Systematophora* spp., mostly *S. areolata* and *S.fasciculigera*, together with the presence of *Leptodinium mirabile*.

Early?-Mid Oxfordian
3354m-3402m

Age and biozone assignments are based on;

LFO *Sentusidinium creberbarbatum* at 3354m (**JZ30?-31**).

FO *Systematophora fasciculigera* at 3366m (**JZ31** or younger).

FO *Systematophora areolata* at 3402m (**JZ31** or younger).

Evidence for penetration of Early Oxfordian sediments is very minor, based on a small downhole increase of *S.creberbarbatum*, which occurs close to the Early-Mid Oxfordian boundary.

Although modified by variable degrees of caving and/or reworking, most samples yielded representative assemblages typical of the lower Mid Oxfordian (lower JZ31). Characteristic species include *R. aemula* SA, *Systematophora* spp., *G.jurassica longicornis*, *Batiacasphaera* sp. (granulate) FREQ, *Stephenelytron redcliffense*, *Sentusidinium creberbarbatum* FREQ and *Endoscrinium galeritum.* In particular, the consistent, or common occurrence of *Systematophora* spp. throughout the interval suggests a Mid Oxfordian age is most probable.

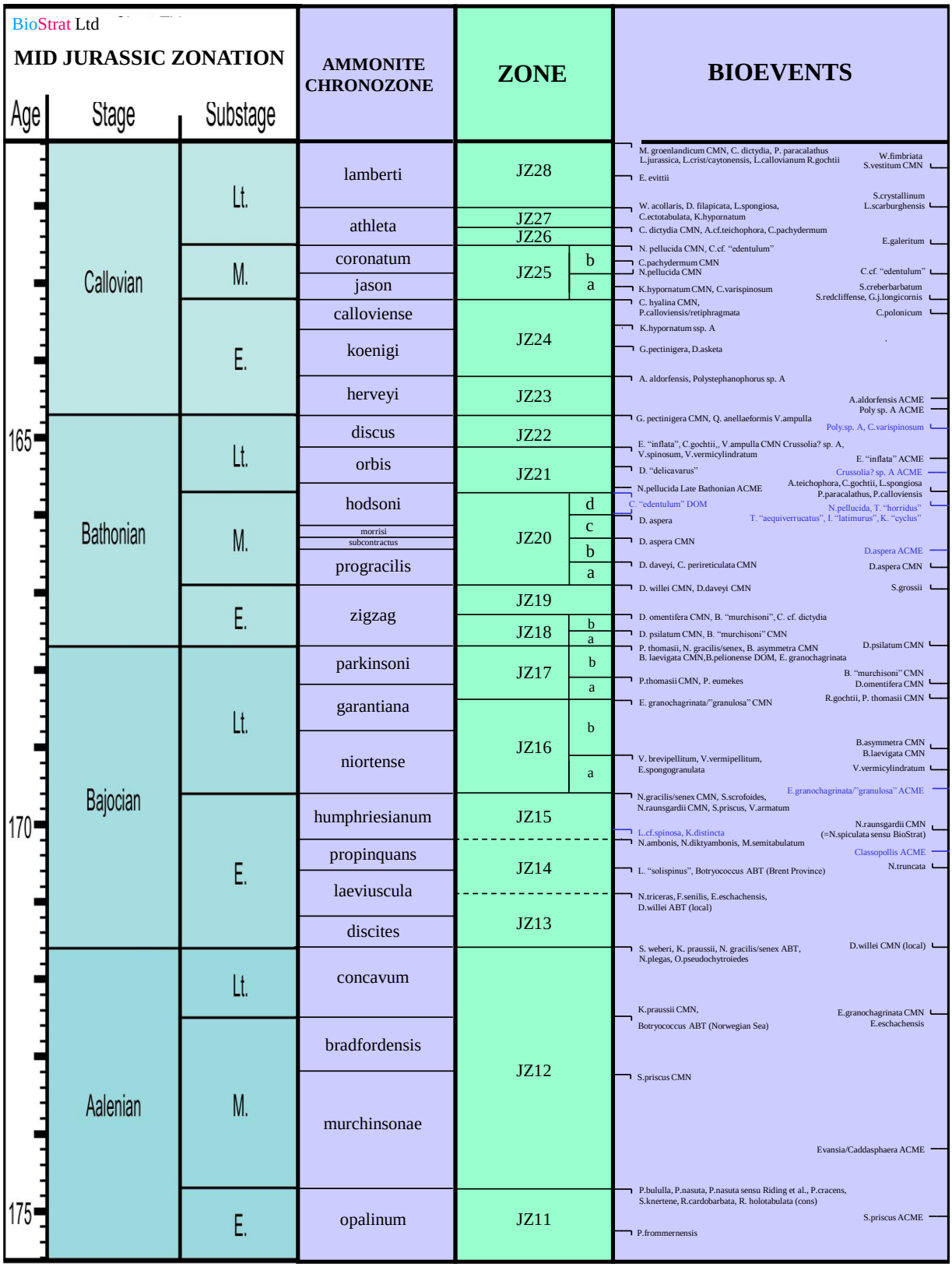
Early?-Mid Oxfordian?
3408m-3414m

The age and biozonal interpretation is based on the age of the overlying interval, together with the consistent, though sparse Heather Formation dinocysts. Clearly these may be caved, and the assignment should be considered as very tentative.

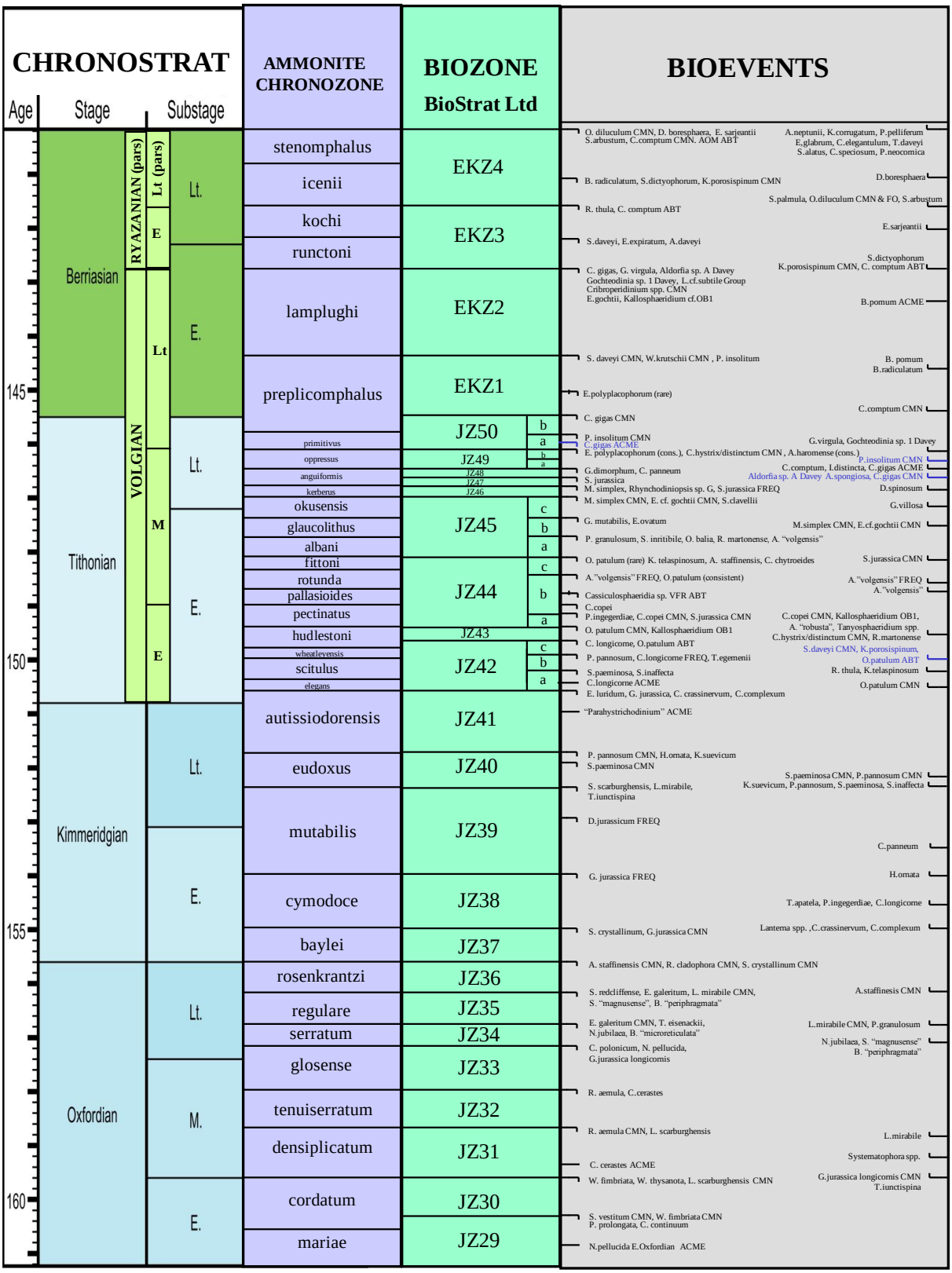
Indeterminate interval, possibly Triassic?
3420m-3649m

A confident age, or biozonal assignment is not possible for the entire lower half of the interval studied from the well due to the absence of palynological evidence. Most samples are significantly contaminated by caved taxa, especially from the Lista, Sele and Draupne formations. By implication, it is also likely that sporadic occurrences of Callovian-Oxfordian taxa encountered are also caved. No representative microfloras were observed and we consider that the majority, or all of the samples are probably barren of *in situ* palynomorphs.

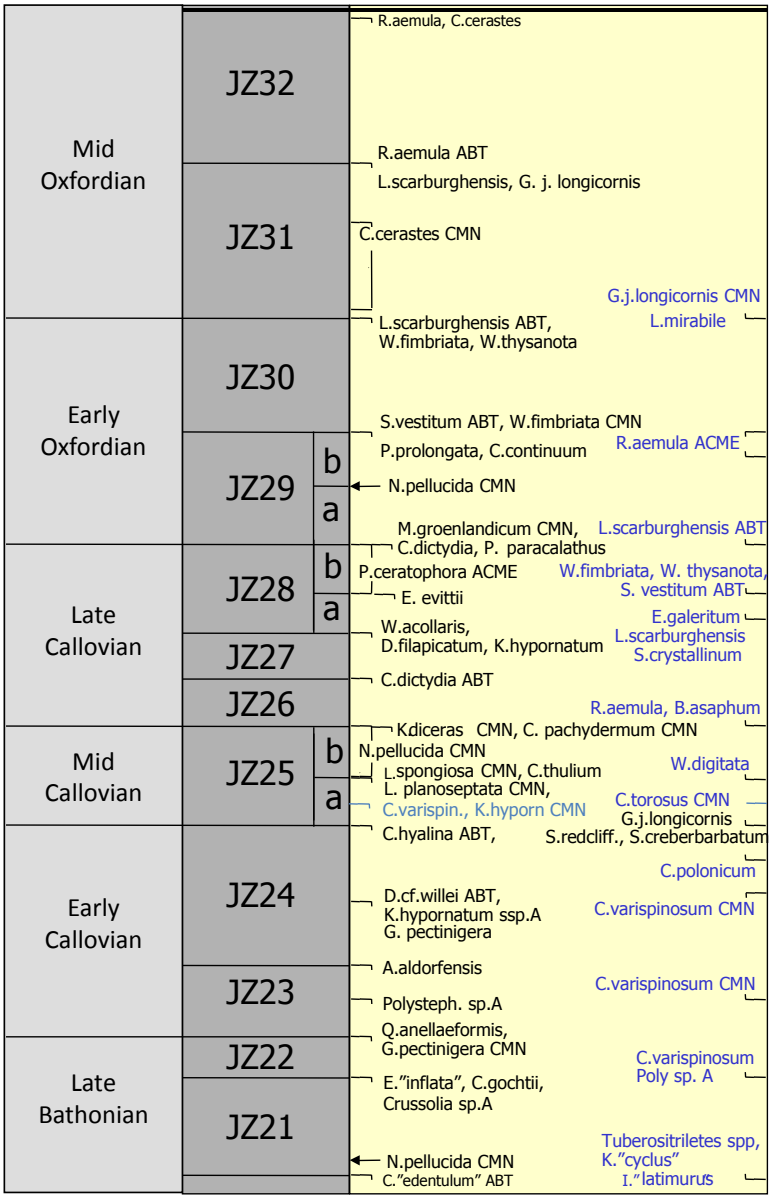
The only lithostratigraphic units in the area that is consistently barren, or yield severely impoverished microfloras are the Skagerrak and Smith Bank formations. This is the only basis on which to suggest a possible Triassic age for the interval.



Appendix 1. Middle Jurassic zonation



Appendix 2. Late Jurassic zonation



Appendix 3. Quad 15 zonation.

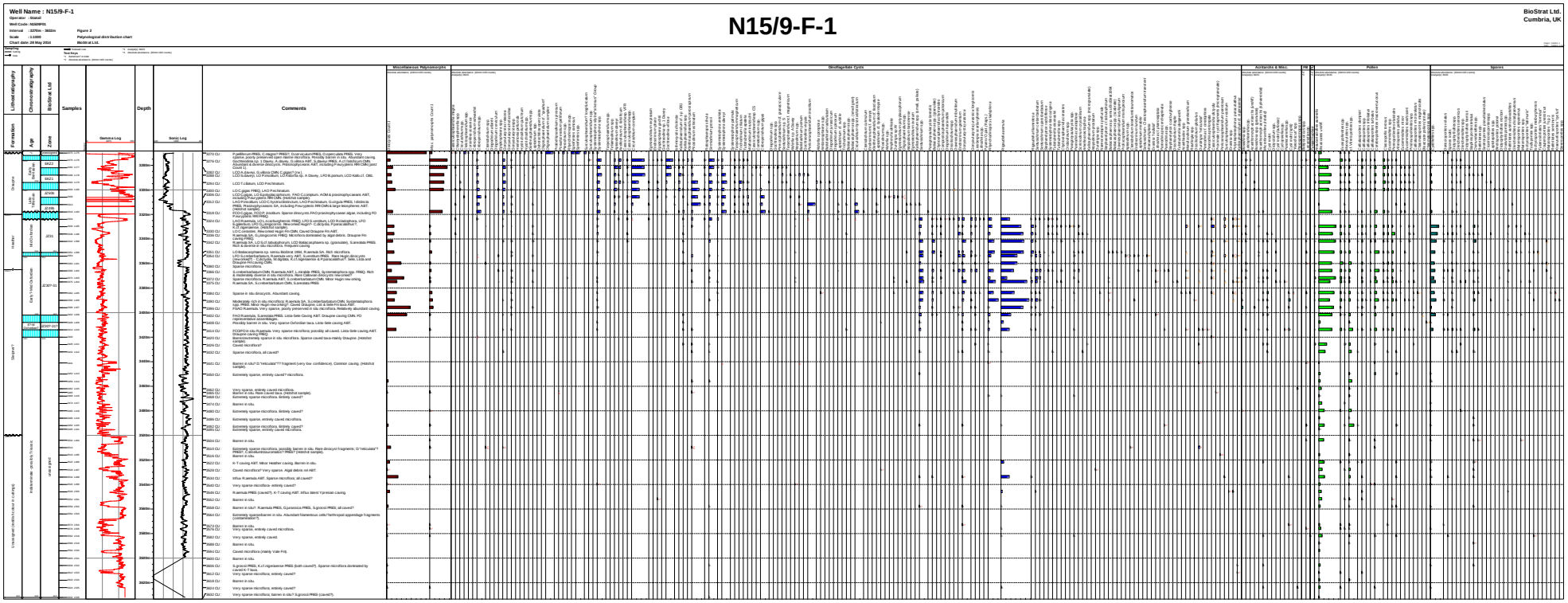


Figure 2. Palynological distribution chart

Well Name : N15/9-F-1

Interval : 3270m - 3632m
Scale : 1:1000
Chart date: 28 May 2014

Figure 3
Palynomorph Eco-Groups
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N15/9-F-1

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Text Keys
^ Bioturbation? or older