

# **BioStrat Ltd.**

## **BIOSTRATIGRAPHY OF NORWEGIAN WELL 15/9-F-10 (5030m-5316m)**

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# 1. INTRODUCTION & MAIN CONCLUSIONS

This report presents results of palynological analyses of Jurassic and Cretaceous sediments in well 15/9-F-10 (interval 5030m-5316m). The report also includes a summary of results from hotshot samples analysed prior to the routine analyses (Appendix 3)

Results are summarised in Figure 1 and detailed in the range and abundance chart (Enclosures 1 & 2). These include all key bioevents, together with chronostratigraphic and biostratigraphic interpretations. Lithostratigraphic boundaries and wireline logs were provided by StatoilHydro.

Age interpretations are based primarily on the recognition of palynological biozones (Appendices 1-2), employing the Statoil South Viking Graben Palynological zonation scheme for the Jurassic and Statoil 2008 scheme for the Cretaceous.

The palynological counting procedure 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.

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)
LCO	last common occurrence
LAO	last abundant occurrence
LSAO	last superabundant occurrence
FO	first occurrence (base, last downhole occurrence)
FCO	first common occurrence
FAO	first abundant occurrence
FSAO	first superabundant occurrence

## Main conclusions

- Data from the Smith Bank Formation is poor, with no *in situ* palynomorphs observed. A questionable Triassic age assignment is based on the regional age of the Smith Bank Formation.
- The Hugin Formation is assigned a Late Callovian (JZP24a) age on good palynological evidence. The absence of younger Callovian assemblages indicates erosion of the uppermost Hugin Formation.
- The Heather Formation yielded good Late Oxfordian-Early Kimmeridgian microfloras and is overlain by the Draupne Formation, which is dated on good evidence as Kimmeridgian to Early Volgian, possibly Mid Volgian in the uppermost part.
- A Late Oxfordian aged sandstone is present at the base of the Heather Formation; informally named “Heather Sandstone” and can be correlated to nearby wells 16/7-3 and 16/7-8S (BioStrat 2009).
- The Åsgard Formation is assigned an Early Barremian age on good evidence and caved Early Aptian taxa are also recorded. This unit is unconformably overlain by Early-Mid Cenomanian sediments, equivalent in age to the lowermost Shetland Group, Svarte Formation.

## Well Name : N15/9-F-10

Operator : StatoilHydro

Well Code : N1509F10

Interval : 5030m - 5316m

Scale : 1:1000

Chart date: 04 January 2010

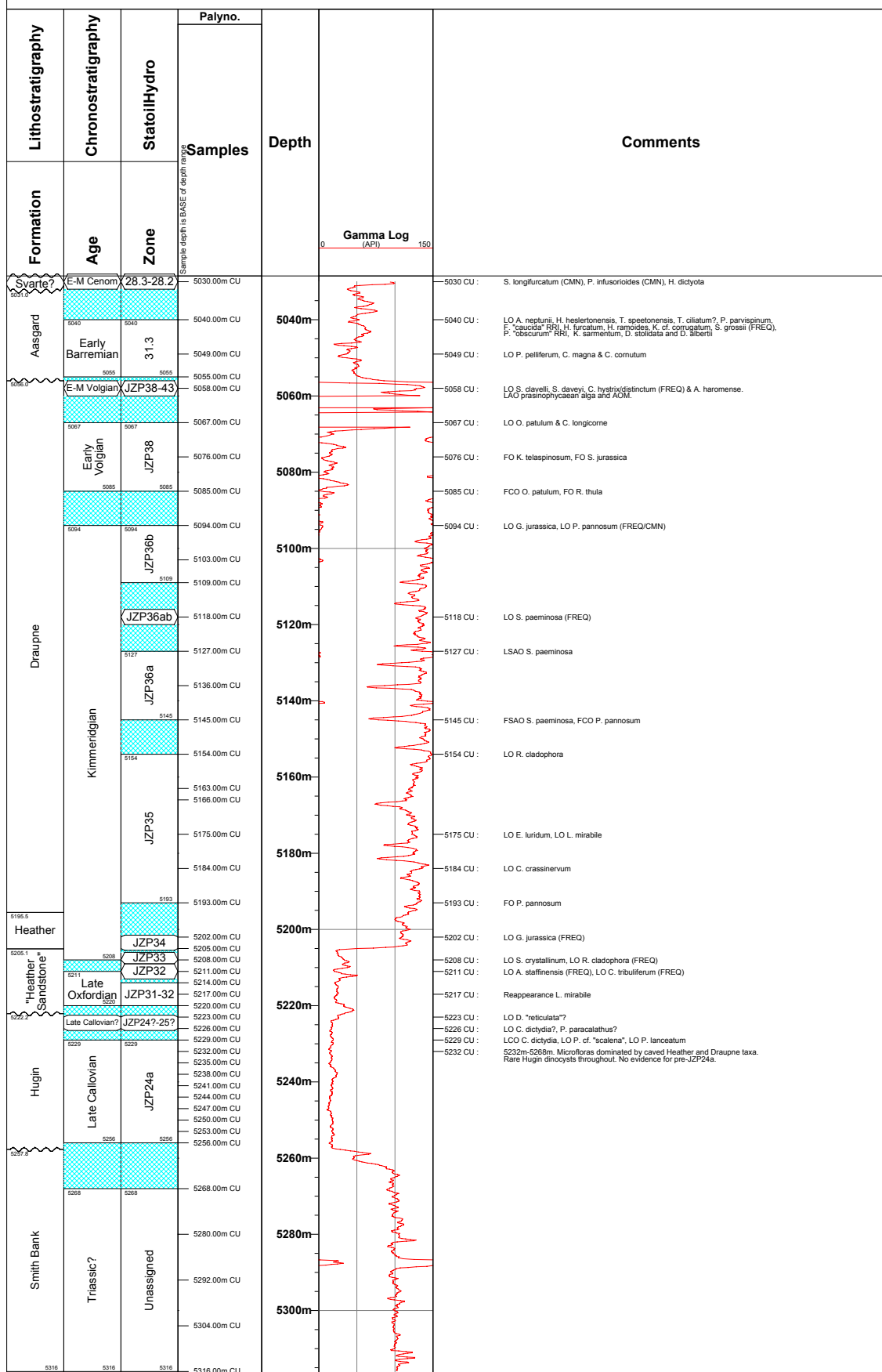
Figure 1

Biostratigraphic Summary Chart

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Cumbria, UK

Project : VOLVE  
Chart : N15/9-F-10 Strat

## 2. RESULTS

### **Early-Mid Cenomanian 5030m (single sample) Svarte Formation?**

The 5030m sample contains a moderately rich and diverse Early-Mid Cenomanian marine microflora, including *Surculosphaeridium longifurcatum* (CMN), *Palaeohystrichophora infusorioides* (CMN), *Hapsocysta dictyota* and *Heterosphaeridium difficile* (Zone **28.3-28.2**). The recorded microflora is consistent with the lowermost Shetland Group, Svarte Formation.

### **Early Barremian 5040mm-5055m Åsgard Formation**

The age and biozone assignments are based on the following good evidence;

LO *Achomosphaera neptunii*, *Heslertonella heslertonensis* and *Hystrichodinium furcatum* at 5040m (**Zone 31.3**).

LO *Cerbia magna*, *Cribroperidinium cornutum* and *Pseudoceratium pelliiferum* at 5049m (**Zone 31.3**).

Samples from the Åsgard Formation yielded extremely rich and diverse marine microfloras. Additional dinocysts recorded include *Diphasiosphaera stolidota*, *Cribroperidinium edwardsii*, *Kleithriasphaeridium cf. fasciatum*, *Batioladinium micropodum*, *Sirmiodinium grossii* and *Apteodinium granulatum*.

The records of *Hystrichodinium ramoides* and *Trichodinium speetonense* at 5040m indicate the presence of Mid-Late Barremian sediments in the overlying sample gap. Furthermore, records of *Pterodinium "obscurum"* RRI (FREQ) and *Florentinia "caucida"* RRI indicate the presence of Early Aptian sediments above.

### **Early-Mid Volgian 5058m (single sample) Draupne Formation (pars)**

The age interpretation is based on the LO of *Senoniasphaera clavellii*, *Systematophora daveyi* (FREQ) and *Circulodinium hystrich/distinctum* (FREQ) at 5058m and the age of the underlying interval (**JZP38-43**).

The 5058m sample contains a relatively sparse microflora, dominated by miospores and prasinophycean alga. Additional dinocysts recorded include *Sirmiodinium grossii*, *Atopodinium haromense* and *Systematophora areolata*.

**Early Volgian**  
**5067m-5085m**  
**Draupne Formation (pars)**

The age and biozone assignments are based on the following good evidence;

LO *Oligosphaeridium patulum* and *Cribroperidinium longicorne* at 5067m (**JZP38**)

FO *Kleithriasphaeridium telaspinosum* and *Senoniasphaera jurassica*  
at 5076m (**JZP38**).

FCO *O. patulum* and FO *Rotosphaeropsis thula* at 5085m (**JZP38**)

Microfloras from this interval are dominated by low diversity miospore assemblages and prasinophycean alga and are associated with abundant amorphous organic material (AOM).

**Kimmeridgian**  
**5094m-5208m**  
**Draupne Formation (pars)**  
**Heather Formation (pars)**

The age and biozone assignments for this interval are based on the following evidence;

LO *Gonyaulacysta jurassica* and *Perisseiasphaeridium pannosum* (FREQ/CMN) at 3140m (**JZP36b**)

LO *Subtilisphaera paeminosa* (FREQ) at 5118m (**JZP36ab**)

LSAO *Subtilisphaera paeminosa* at 5127m (**JZP36a**)

FSAO *Subtilisphaera paeminosa* and FCO *Perisseiasphaeridium pannosum* at 5145m (**base-JZP36a**)

Top **JZP35** at 5154m based on FCO *Perisseiasphaeridium pannosum* in overlying Sample.

FO *P. pannosum* at 5193m (**base-JZP35**)

LO *Gonyaulacysta jurassica* (FREQ) at 5202m (**JZP34**)

LO *Scriniodinium crystallinum* and *Rhynchodiniopsis cladophora* (FREQ) at 5208m (**JZP33**)

The interval is characterised by rich, or moderately rich and diverse marine microfloras and are typical of the lower part of the Draupne Formation. The upper boundary of the Heather Formation is observed at 5205.1m (log), within the earliest Kimmeridgian.

**Late Oxfordian**  
**5211m-5220m**  
**Heather Formation (pars)**

The age and biozonal interpretation for this interval is based on the following evidence;

LO *Ambonosphaera staffinensis* (FREQ) at 5211m (**JZP32**).

Reappearance *Leptodinium mirabile* at 5217m (**JZP31-32**)

Samples from this interval are characterised by abundant miospores, associated with sparse, moderately diverse marine microplankton. Additional *in situ* dinocysts include *Systematophora areolata*, *S. fasciculigera*, *Rhynchodiniopsis cladophora* (FREQ) *Gonyaulacysta jurassica* (FREQ), *Sentusidinium* spp. (ABT), *Epiplosphaera gochtii*, *Chytroeisphaeridia chytroeides*, *Prolixosphaeridium granulosum*, *Glossodinium dimorphum* and *Cleistosphaeridium tribuliferum* (FREQ).

The recorded microfloras are consistent with the upper part of the Heather Formation. In this well a Late Oxfordian sandstone is developed, informally named the “Heather Sandstone”, with the upper boundary seen at 5205.1m (log). An equivalent sandstone is also present in nearby wells 16/7-3 and 16/7-8S (BioStrat 2009). This unit represents the basal transgressive sandstone of the Heather Formation. And is equivalent regionally to the Piper Formation (pars) in the UK Outer Moray Firth Basin, the Fulmar Formation (pars) of the UK Central Graben and the Ula Formation (pars) of the Norwegian Central Graben.

The apparent Kimmeridgian age for the uppermost part of the “Heather Sandstone” is probably attributable to caving.

**Late Callovian?**  
**5223m-5226m**  
**Hugin Formation (pars)**

The age interpretation for this interval is based on the following poor evidence;

LO *Durotrigia “reticulata”* ? at 5223m (**JZP24?-25?**)

LO *Cassiculosphaeridia dictydia?* and *Polystephanophorus paracalathus?*  
at 5226m (**JZP24?-25?**)

Microfloras from this interval are dominated by caved Heather and Draupne Formation taxa, whilst the *in situ* assemblages contain extremely sparse dinocysts, including the questionably identified fragments listed above.

The upper boundary of the Hugin Formation is observed at 5222.2m (log). The absence of any Early-Mid Oxfordian and latest Callovian microfloras indicates erosion of the uppermost Hugin.

**Late Callovian**  
**5229m-5226m**  
**Hugin Formation (pars)**

The age and biozone assignment is based on the following good evidence;

LCO *Cassiculosphaeridia dictydia* at 5229m (**JZP24a**)

Samples from this part of the Hugin Formation are dominated by caved Late Oxfordian dinocysts and miospores. Extremely sparse Hugin dinocysts are recorded, including *C. dictydia* (CMN), *Pareodinia* cf. “*scalena*”, *Ctenidodinium tenellum/stauromatos*, *Durotrigia* “*reticulata*”, *Kallosphaeridium* cf. *nigeriaense*, *Evansia evittii* and *Polystephanophorus paracalathus*.

**Triassic?**  
**5268m-5316m**  
**Smith Bank Formation**

The age assignment for this interval is based on the regional age of the Smith Bank Formation.

Samples from the interval are barren of *in situ* palynomorphs and yield only caved taxa. These are mainly from the Heather Formation, though increasing amounts of Late Cretaceous and Tertiary cavings are observed. Rare Late Callovian palynomorphs are recorded and are also considered to be caved.



## REFERENCE

**BioStrat 2009** Biostratigraphy of selected intervals in Norwegian wells 15/9-A-23B, 16/7-5 and 16/7-8S. BioStrat report No. 09/08.

# MIDDLE JURASSIC ZONATION (WITH STATOIL ZONES)

CHRONOSTRATIGRAPHY			BIOSTRATIGRAPHY						SOURCE TEXT (modified Berggren et al 1995)	
PERIOD	AGE/STAGE		AMMONITE ZONES		BIOS TRAT LTD.		STATOIL			
			BOREAL	SUBMED.	PALYNOLOGICAL ZONES		PALY			
MIDDLE JURASSIC	CALLOVIAN	late	lamberti		M. groenlandicum PJ22		JZP25		J44	
			athleta		E. acollaris PJ21		b a	JZP24	J42	
		mid	cororatum		N. pelucida PJ20		JZP23		J36	
			jason							
		early	calloviense		C. hyalina PJ19		JZP22			
			keonigi							
			nordenskoeldi	herveyi	A. aldorfensis PJ18	b a	JZP21	J34		
		BATHONIAN	late	apertum	discus					
				calyx	orbis	E. 'inflata' PJ17		JZP20		
				variable						
	cranocephal.			hodsoni						
	mid.		alvina	morrissi	C. 'edentulum' PJ16		d c b a	JZP19	J33	
				subcontractus					J32	
			progracilis							
	early		greenlandicus	tenuiplicatus	D. willei PJ15		JZP18		J31	
			arcticus	zigzag	D. omentifera PJ14				J26	
	BAJOCIAN	late	pompeckji	parkinsoni	N. gracilis PJ13		c b a	JZP17	J24	
				garantiana						
			indistinctus	subfurcatum						
			borealis							
		early	humphriesianum		N. gracilis acme PJ12		JZP16			
			sauzei		D. wilkii biofacies (SVG)	N. ambonis PJ11				
			laeviuscula			N. tricerat PJ10		J22		
			discites							
		AALENIAN		concarum		N. plegas PJ9		c b a	JZP15 JZP14 JZP13	J21
				bradfordensis						
	murchisonae									
	scissum									
	opalinum			Parvocysta spp. PJ8		JZP12				

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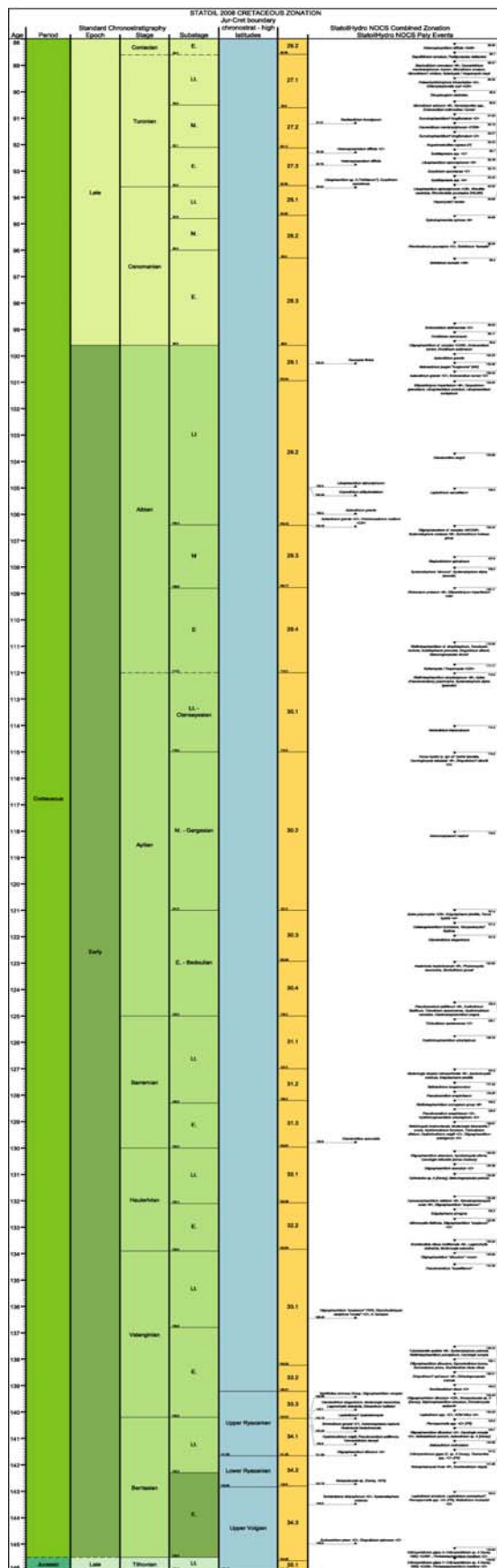
## Appendix 1. Middle Jurassic zonation

**BIOSTRAT ZONATION SCHEME FOR THE OXFORDIAN  
TO EARLIEST VALANGINIAN (WITH STATOIL ZONES)**

CHRONOSTRATIGRAPHY				BIOSTRATIGRAPHY					SOURCE OF STATOIL ZONES (Berggren et al. 1995)
PERIOD		AGE/STAGE		AMMONITE ZONES	BIOSTRAT ZONES PALY		STATOIL ZONES		
CRETACEOUS	EARLY	VAL. (pars)			early	par	E. pharo PK4	KZP4	—J76— —J74— —J73— —J72— —J71— —J66B— —J66A— —J64— —J63— —J62— —J56— —J54— —J52— —J46— —J45—
		RYAZANIAN	late	alb	D. spinosum PK3	KZP3			
			iceni	G. sp. A Dawey PK2	KZP2				
				kochi	R. thula PK1	KZP1			
			rumc						
JURASSIC	LATE	VOLGHIAN	late	lamb	G. virgula PJ44	JZP48	c	—J73— —J72— —J71— —J66B— —J66A— —J64— —J63— —J62— —J56— —J54— —J52— —J46— —J45—	
				pre	C. gigas acme PJ43		b		b
				prim			a		a
				opp	E. polyphacoplerum PJ42		b		JZP47
			ang	C. pannonum PJ41	PJ40	JZP46			
			kerb	M. simplex PJ39	b	JZP44			
			oku		a				
			gla	M. simplex acme PJ38	c	b			
			alb		b	a			
					a				
			late	fitt	O. patulum PJ37	d			
				rot		c	b		
				pall		b			
				pect		a	a		
				hud	O. patulum 'acme' PJ36	JZP39			
				wheat	C. longicorne PJ35				
		scit		P. pannosum PJ34	b	JZP38			
		eleg			a				
		early	aut	E. luridum PJ33	d	JZP37			
					c				
			eud		b	a			
			mut		a	b			
			cym	G. jurassica PJ32	JZP34	a			
			bay	S. crystallinum PJ31	JZP33				
			ros	S. crystallinum PJ30	JZP32				
			reg	E. galenitum PJ29	JZP31				
		OXFORDIAN	late	sen	E. galenitum acme PJ28	b	JZP30		
						a			
				glos	C. polonicum PJ27				
				ten	R. aemula PJ26	JZP29			
			middle	den	R. aemula acme PJ25	JZP28			
				cord	W. fimbriata PJ24	JZP27			
early	mar			S. vestimacra PJ23	JZP26				

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**Appendix 2. Late Jurassic zonation**



Appendix 3. Cretaceous zonation

# Well Name : n15/9-F-10 hotshots

**BioStrat Ltd.**  
**Cumbria, UK**

Operator : StatoilHydro

Well Code : N1509F10HOTSHOTS

Interval : 5088m - 5298m

Scale : 1:1000

Chart date: 01 December 2009

Appendix 4

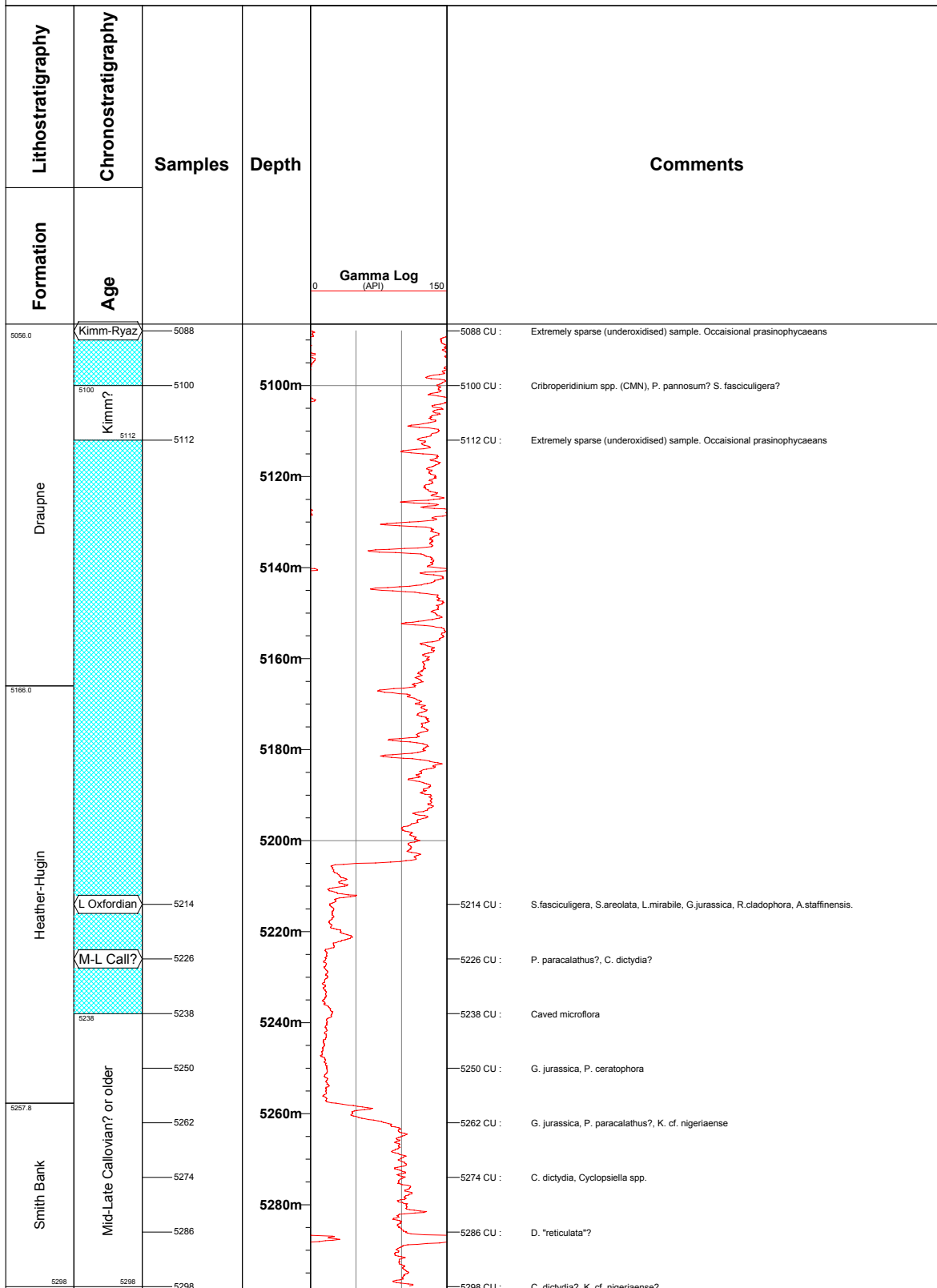
Summary of hotshot analyses

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Project : VOLVE  
Chart : n15/9-F-10 hot

Sampling  
— Cutting  
● Core

Side wall core



[illegible]