

**Biostratigraphic Analysis
Micropaleontology**

**Statoil, Desoto Canyon Block 231, OCS-G-33780 #1
[Perseus]**

Interval: 7976.5' – 23085'

**Prepared for
Statoil Gulf Services LLC**

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1. INTRODUCTION

This report provides a biostratigraphic analysis of cuttings samples within the depth range of 7976.5 feet to 23085 feet in the subject well. In total, 525 washed residues were prepared from cuttings samples by ALS Ellington for microfossil analysis. Raw cuttings that were sampled from the wellbore at 10-foot intervals were composited for preparation of residues as follows: 30-foot intervals from 8000'-18020', 20-foot intervals from 18020'-19200', and 30-foot intervals from 19200'-2308'. The first and last samples in the set were not composited with others.

All residues were examined to determine occurrence and relative abundances of all foraminifera, ostracods, and any other identifiable microfossils, along with general lithologic characteristics of the residues, in order to determine ages and paleoenvironments. Significant biostratigraphic events are presented below in Section 2. Age interpretations are based primarily on the correlation of occurrences of key forams and ostracods in samples with their accepted age ranges. Paleoenvironmental interpretations are summarized in Section 3, and are based on the occurrence of environmentally diagnostic fossil groups combined with dominant lithologic characteristics. Definitions and descriptions for the paleoenvironmental zonation used in this report are shown in Appendix 1. Figures 1 and 2 in the appendix show the environmental codes used in this report for carbonate and terrigenous paleoenvironmental interpretations.

A key explaining relative abundance designations for fossil taxa used in this report and in Addendum 1 is found below in this document (Appendix 2). Addendum 1 included as a companion to this document is a digital Excel file containing 2 data spreadsheets. The first spreadsheet, Appendix 3, provides the relative abundances of all observed fossil taxa per sample. Appendix 4, the second spreadsheet, contains a detailed sample-by-sample listing of lithologic observations and resulting paleoenvironmental interpretations. It should be noted that the lithologic descriptions of samples relate to the processed sample residues only, and will differ from any descriptions of bulk cuttings made outside this study, for the reason that a substantial amount of rock matrix is washed away during processing.

ATTACHMENT:

Addendum 1: ALS-EA Statoil DC Blk 231 #1 Perseus - Addendum 1 Datasheets 2-12-2015

2. BIOSTRATIGRAPHIC INTERPRETATIONS

Significant biostratigraphic events are presented below. Age interpretations are based primarily on the correlation of occurrences of key forams and ostracods in samples with their accepted age ranges. The older units are sparsely fossiliferous to unfossiliferous, and so unit identifications and ages are based mainly on general correlations of characteristic lithologies.

Abbreviations:

LAD = Last Appearance Datum (first downhole occurrence)

FAD = First Appearance Datum (last downhole occurrence)

(F) = Foram, (O) = Ostracod

Sample Depth	Biostratigraphic Events	Age [Formational Unit]
7976.5' – 8000'	First sample examined. Key fossils present: <i>Dictyoconus walnutensis</i> (F), <i>Cytheridea brevis</i> (O), <i>Cytheridea goodlandensis</i> (O)	No younger than Middle Albian [In Fredericksburg]
9140' – 9170'	FAD <i>Dictyoconus walnutensis</i> (F)	
9230' – 9260'	LAD <i>Lituola camerata</i> (F)	Middle Albian [Lower Fredericksburg]
9710' – 9740'	LAD <i>Eocytheropteron trinitiensis</i> (O)	Early Middle Albian [Upper Trinity]
10160' – 10190'	FAD <i>Cytheridea goodlandensis</i> (O) FAD <i>Eocytheropteron trinitiensis</i> (O) FAD <i>Lituola camerata</i> (F)	[possible base Upper Trinity]
10250' – 10280'	LAD <i>Dictyoconus sunnilandensis</i> (F) - rare	Early Albian [Lower Trinity]
10340' – 10370'	LAD <i>Orbitolina texana</i> (F)	Early Albian [Lower Trinity]
12500' – 12530'	LAD <i>Choffatella decipiens</i> (F) FAD <i>Orbitolina texana</i> (F)	Early Aptian-Barremian [Coahuilan/Sligo equivalent]
13220' – 13250'	LAD <i>Pseudocyclammina lituus</i> (F)	No younger than Barremian
15290' – 15320'	LAD <i>Lenticulina busnardoii</i> (F)	Early Hauterivian or older
15440' – 15470'	LAD <i>Eponides caracolla</i> (F), <i>Lenticulina nodosa</i> (F)	No younger than Valanginian [Upper Cotton Valley]
15770' – 15800'	LAD <i>Lenticulina ouachensis</i> (F) - rare, depressed (can be as young as early Aptian).	
15830' – 15860'	LAD <i>Schuleridea acuminata</i> (O) FAD <i>Choffatella decipiens</i> (F)	Valanginian
16190' – 16220'	FAD <i>Eponides caracolla</i> (F)	No older than Valanginian
16280' – 16310'	LAD <i>Sigmomorphina (Ellisina) spatula</i> (F) - rare	No younger than Berriasian
16550' – 16580'	LAD Calpionellid bearing wackestone	(no younger than early Valanginian)

16910' - 16940'	LAD <i>Reinholdella</i> A (F) break - consistent through 17060'.	No younger than Berriasian [Cotton Valley/Bossier equivalent]
17000' - 17030'	FAD <i>Lenticulina nodosa</i> (F)	No older than basal Berriasian
17090' - 17120'	17090'-18060' break of consistent <i>Sigmomorphina</i> (<i>Ellisina</i>) <i>spatula</i> (F)	
17180' - 17210'	LAD <i>Pentasculeridea pentagonalis</i> (F) FAD Calpionellid bearing wackestone	Tithonian (No older than Lt. Tithonian)
18020' - 18040'	FAD <i>Sigmomorphina</i> (<i>Ellisina</i>) <i>spatula</i> (F)	
18420' - 18440'	LAD <i>Epistomina uhligi</i> (F) - sporadic occurrences	Early Tithonian or older [Haynesville equivalent?]
18820' - 18840'	LAD <i>Everticyclammina virguliana</i> (F) - rare/depressed (can be as young as Valanginian).	
19200' - 19230'	Well developed oolitic grainstone.	Oxfordian - by correlation [Smackover] (based on lithologic character)
20370' - 20400'	Blue-green algal "boundstone" (fenestral matrix) dominates interval 20370'-20820' - indicates microbial bioherm development.	
21090' - 21120'	Consistent dark calcareous marine shale and argillaceous lime mudstone, pyrite indicative of poorly oxygenated conditions.	[Lower Smackover/ "Brown Dense" equivalent?] (based on lithologic character)
21960' - 21990'	Consistent tidal flat anhydrites and laminated anhydritic dolomite, with mix of higher energy bioclastic and oolitic grainstone shoal deposits.	
22690' - 22690'	Red claystone - first indication of non-marine, continental deposits.	
22750' - 22780'	Coarse, red sand - non-marine, continental.	E. Oxfordian - by correlation [Norphlet] (based on lithologic character)
23080' - 23085'	Last sample examined.	

3. SUMMARY OF PALEOENVIRONMENTAL INTERPRETATIONS

Paleoenvironmental interpretations of analyzed samples are summarized below, by well. Interpretations were based on dominant lithologic characteristics combined with the occurrence of any environmentally diagnostic biogenic material, if present. The key to environment codes is found in Appendix 2.

Depth Interval (feet)	Environment Code	Paleoenvironment
7976.5' - 8000'	OH/RL	High energy, oolitic shoal intermixed with restricted, low-energy subtidal, carbonate dominated
8000' - 8030'	RL/SH	Shallow, low-energy, restricted subtidal intermixed with high energy, bioclastic shoal, carbonate dominated
8030' - 8060'	TE/SH	Evaporitic tidal flat intermixed with high energy, bioclastic shoal, carbonate dominated
8060' - 8180'	RL/TE	Shallow, low-energy, restricted subtidal intermixed with evaporitic tidal flat, carbonate dominated
8180' - 8210'	RL/BH	Shallow, low-energy, restricted subtidal intermixed with shallow, moderate to high-energy biostromal, carbonate dominated
8210' - 8270'	TE/BH	Evaporitic tidal flat intermixed with shallow, moderate to high-energy biostromal, carbonate dominated
8270' - 8420'	TE	Evaporitic tidal flat, carbonate dominated
8420' - 8510'	RL	Shallow, low-energy, restricted subtidal, carbonate dominated
8510' - 8660'	TE/RL	Evaporitic tidal flat intermixed with shallow, low-energy, restricted subtidal, carbonate dominated
8660' - 8690'	RL/OH	Shallow, low-energy, restricted subtidal intermixed with high energy, oolitic shoal, carbonate dominated
8690' - 8720'	TE	Evaporitic tidal flat, carbonate dominated
8720' - 8750'	RL/OH	Shallow, low-energy, restricted subtidal intermixed with high energy, oolitic shoal, carbonate dominated
8750' - 8780'	RL/TE	Shallow, low-energy, restricted subtidal intermixed with evaporitic tidal flat, carbonate dominated
8780' - 8810'	OH	High energy, oolitic shoal, carbonate dominated
8810' - 8870'	TE/OH	Evaporitic tidal flat intermixed with high energy, oolitic shoal, carbonate dominated
8870' - 8960'	RL/OH	Shallow, low-energy, restricted subtidal intermixed with high energy, oolitic shoal, carbonate dominated
8960' - 8990'	RL/TE	Shallow, low-energy, restricted subtidal intermixed with evaporitic tidal flat, carbonate dominated
8990' - 9020'	RL	Shallow, low-energy, restricted subtidal, carbonate dominated
9020' - 9050'	RL/TE	Shallow, low-energy, restricted subtidal intermixed with evaporitic tidal flat, carbonate dominated
9050' - 9230'	RL	Shallow, low-energy, restricted subtidal, carbonate dominated
9230' - 9260'	RL/SH	Shallow, low-energy, restricted subtidal intermixed with high energy, bioclastic shoal, carbonate dominated
9260' - 9290'	RL	Shallow, low-energy, restricted subtidal, carbonate dominated
9290' - 9320'	RL/SH	Shallow, low-energy, restricted subtidal intermixed with high energy, bioclastic shoal, carbonate dominated
9320' - 9350'	RL	Shallow, low-energy, restricted subtidal, carbonate dominated
9350' - 9440'	RL/SH	Shallow, low-energy, restricted subtidal intermixed with high energy, bioclastic shoal, carbonate dominated
9440' - 9470'	RL	Shallow, low-energy, restricted subtidal, carbonate dominated
9470' - 9500'	RL/SH	Shallow, low-energy, restricted subtidal intermixed with high energy, bioclastic shoal, carbonate dominated
9500' - 9560'	RL/OH	Shallow, low-energy, restricted subtidal intermixed with high energy, oolitic shoal, carbonate dominated
9560' - 9590'	RL/SH	Shallow, low-energy, restricted subtidal intermixed with high energy, bioclastic shoal,

		carbonate dominated
9590' - 9650'	RL	Shallow, low-energy, restricted subtidal, carbonate dominated
9650' - 10220'	RL/SH	Shallow, low-energy, restricted subtidal intermixed with high energy, bioclastic shoal, carbonate dominated
10220' - 10430'	OL	Shallow, low-energy, open circulation, carbonate dominated
10430' - 11000'	RL/TE	Restricted, low-energy subtidal intermixed with evaporitic tidal flat, carbonate dominated
11000' - 11150'	TE/SH	Evaporitic tidal flat intermixed with higher energy shoal, carbonate dominated
11150' - 11210'	RL/TE	Shallow, low-energy, restricted subtidal intermixed with evaporitic tidal flat, carbonate dominated
11210' - 11600'	OL-RL	Shallow, low-energy, open to restricted circulation, carbonate dominated
11600' - 11630'	SH	Shallow, high energy, bioclastic shoal, carbonate dominated
11630' - 11840'	OL/BH	Shallow, low-energy, open circulation intermixed with higher energy biostromal, carbonate dominated
11840' - 11960'	OL	Shallow, low-energy, open circulation, carbonate dominated
11960' - 12110'	RL	Shallow, low-energy, restricted subtidal, carbonate dominated
12110' - 12140'	OL-RL	Shallow, low-energy, open to restricted circulation, carbonate dominated
12140' - 12200'	OL	Shallow, low-energy, open circulation, carbonate dominated
12200' - 12230'	OL/OH	Shallow, low-energy, open circulation intermixed with high-energy, oolitic shoal, carbonate dominated
12230' - 12500'	OL/SH	Shallow, low-energy, open circulation intermixed with high-energy, bioclastic shoal, carbonate dominated
12500' - 12590'	OL	Shallow, low-energy, open circulation, carbonate dominated
12590' - 12650'	OL/SH	Shallow, low-energy, open circulation intermixed with high-energy, bioclastic shoal, carbonate dominated
12650' - 12770'	OL	Shallow, low-energy, open circulation, carbonate dominated
12770' - 12830'	OL/SH	Shallow, low-energy, open circulation intermixed with high-energy, bioclastic shoal, carbonate dominated
12830' - 13130'	OL	Shallow, low-energy, open circulation, carbonate dominated
13130' - 13190'	OL/SH	Shallow, low-energy, open circulation intermixed with high-energy, bioclastic shoal, carbonate dominated
13190' - 13490'	OL	Shallow, low-energy, open circulation, carbonate dominated
13490' - 13610'	OL/SH	Shallow, low-energy, open circulation intermixed with high-energy, bioclastic shoal, carbonate dominated
13610' - 13850'	RL	Shallow, low-energy, restricted subtidal, carbonate dominated
13850' - 14420'	RL/SH	Shallow, low-energy, restricted subtidal intermixed with high energy, bioclastic shoal, carbonate dominated
14420' - 15200'	RL	Shallow, low-energy, restricted subtidal, carbonate dominated
15200' - 15380'	RL/OH	Shallow, low-energy, restricted subtidal intermixed with high energy, oolitic shoal, carbonate dominated
15380' - 15440'	OH	High energy, oolitic shoal, carbonate dominated
15440' - 15920'	IN	Inner shelf, terrigenous dominated
15920' - 15980'	IN/OL	Inner shelf terrigenous intermixed with shallow, low-energy, open carbonates
15980' - 16130'	IN	Inner shelf, terrigenous dominated
16130' - 16370'	IN/RL	Inner shelf terrigenous intermixed with shallow, low-energy, restricted carbonates
16370' - 16490'	IN	Inner shelf, terrigenous dominated
16490' - 16910'	OL	Shallow, low-energy, open circulation, carbonate dominated
16910' - 17090'	IN-r	Inner shelf, restricted circulation, terrigenous dominated
17090' - 17900'	RL/IN-r	Shallow, low-energy, restricted subtidal carbonates intermixed with restricted, inner shelf terrigenous
17900' - 18060'	IN-r	Inner shelf, restricted circulation, terrigenous dominated

18060' - 18080'	SH/IN-r	Shallow, high-energy, bioclastic shoal carbonates intermixed with restricted, inner shelf terrigenous
18080' - 18240'	OH/IN-r	Shallow, high-energy, oolitic shoal carbonates intermixed with restricted, inner shelf terrigenous
18240' - 18280'	MM/OH	Marginal marine terrigenous intermixed with high energy, oolitic shoal carbonates
18280' - 18300'	TE/MM	Evaporitic tidal flat intermixed with marginal marine, mixed carbonate/terrigenous
18300' - 18380'	MM/OH	Marginal marine terrigenous intermixed with high energy, oolitic shoal carbonates
18380' - 18420'	TE/MM	Evaporitic tidal flat intermixed with marginal marine, mixed carbonate/terrigenous
18420' - 18460'	IN-r	Inner shelf, restricted circulation, terrigenous dominated
18460' - 18540'	TE/MM	Evaporitic tidal flat intermixed with marginal marine, mixed carbonate/terrigenous
18540' - 18580'	TE/OH	Evaporitic tidal flat intermixed with high energy, oolitic shoal, carbonate dominated
18580' - 18620'	MM/OH	Marginal marine terrigenous intermixed with high energy, oolitic shoal carbonates
18620' - 18720'	MM	Marginal marine, terrigenous dominated
18720' - 18740'	TE/MM	Evaporitic tidal flat intermixed with marginal marine, mixed carbonate/terrigenous
18740' - 18780'	IN-r	Inner shelf, restricted circulation, terrigenous dominated
18780' - 18800'	IN-r/RL	Restricted, inner shelf terrigenous intermixed with shallow, restricted, low-energy carbonates
18800' - 18840'	IN-r	Inner shelf, restricted circulation, terrigenous dominated
18840' - 18960'	IN-r/TE	Restricted, inner shelf terrigenous intermixed with evaporitic tidal flat carbonates
18960' - 19100'	MM	Marginal marine, terrigenous dominated
19100' - 19180'	TE/MM	Evaporitic tidal flat intermixed with marginal marine, mixed carbonate/terrigenous
19180' - 19200'	TE/OH	Evaporitic tidal flat intermixed with high energy, oolitic shoal, carbonate dominated
19200' - 19380'	OH	High energy, oolitic shoal, carbonate dominated
19380' - 19560'	OH/RL	High energy, oolitic shoal intermixed with restricted, low-energy subtidal, carbonate dominated
19560' - 19650'	OH	High energy, oolitic shoal, carbonate dominated
19650' - 19740'	RL/SH	Shallow, low-energy, restricted subtidal intermixed with high energy, bioclastic shoal, carbonate dominated
19740' - 19860'	TE/SH	Evaporitic tidal flat intermixed with high energy, bioclastic shoal, carbonate dominated
19860' - 19920'	RL	Shallow, low-energy, restricted subtidal, carbonate dominated
19920' - 19980'	RL/TF	Shallow, low-energy, restricted subtidal intermixed with tidal flat, carbonate dominated
19980' - 20100'	RL	Shallow, low-energy, restricted subtidal, carbonate dominated
20100' - 20370'	RL/OH	Shallow, low-energy, restricted subtidal intermixed with high energy, oolitic shoal, carbonate dominated
20370' - 20820'	RL/BH	Shallow, low-energy, restricted circulation intermixed with higher energy biostromal, carbonate dominated
20820' - 21090'	RL/SH	Shallow, low-energy, restricted subtidal intermixed with high energy, bioclastic shoal, carbonate dominated
21090' - 21960'	IN-r	Inner shelf, restricted circulation, terrigenous dominated
21960' - 22050'	IN-r/SH	Restricted, inner shelf terrigenous intermixed with high-energy, bioclastic shoal carbonates
22050' - 22110'	TE	Evaporitic tidal flat, carbonate dominated
22110' - 22200'	TE/OH	Evaporitic tidal flat intermixed with high energy, oolitic shoal, carbonate dominated
22200' - 22260'	TF/SH	Evaporitic tidal flat intermixed with high energy, bioclastic shoal, carbonate dominated
22260' - 22330'	TF/RL	Tidal flat intermixed with shallow, low-energy, restricted subtidal, carbonate dominated
22330' - 22690'	TE	Evaporitic tidal flat, carbonate dominated
22690' - 22750'	TE/NM	Evaporitic tidal flat carbonates intermixed with non-marine terrigenous
22750' - 22780'	NM/TE	Non-marine terrigenous intermixed with evaporitic tidal flat carbonates



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22780' - 22840'	NM	Non-marine, terrigenous dominated
22840' - 22900'	TE/NM	Evaporitic tidal flat carbonates intermixed with non-marine terrigenous
22900' - 22990'	NM	Non-marine, terrigenous dominated
22990' - 23085'	NM/TE	Non-marine terrigenous intermixed with evaporitic tidal flat carbonates

APPENDIX 1: Paleoenvironmental Zone Definitions

A. Carbonate Paleoenvironmental Zones

The following paleoenvironmental classification is used for stratigraphic sequences that are principally comprised of carbonates deposited in rimmed platform or carbonate ramp settings.

Code	Description
TE	<u>Evaporitic Tidal Flat</u> : supratidal flats (sabkha), marginal marine in an evaporative setting.
TF	<u>Tidal Flat</u> : supratidal, intertidal, and subtidal elements of carbonate tidal flats.
RL	<u>Shallow Shelf, Low Energy, Restricted</u> : subtidal to intertidal areas, between tidal flat and open shelf, restricted circulation.
OL	<u>Shallow Shelf, Low Energy, Open</u> : inner shelf ramp, or lagoon behind higher energy shoals or biostromes, open circulation.
SH	<u>Shallow Shelf, High-Energy, Bioclastic</u> : carbonate shoals, beaches, reef-associated sands.
OH	<u>Shallow Shelf, High-Energy, Oolitic</u> : ooid shoals, banks, and bars over which currents freely ebb and flow.
BH	<u>Shallow Shelf, High-Energy, Biostromal</u> : shallow reefs, skeletal build-ups, and associated flank deposits.
OS	<u>Middle Shelf, Open</u> : moderately deep open shelf, good circulation, between shallow platform and shelf basin.
OB	<u>Deep Shelf, Open</u> : deep intra-shelf basin or outer shelf ramp; good circulation, well oxygenated.
RB	<u>Restricted Shelf/Basin</u> : closed, moderate to deep intra-shelf basin, restricted circulation, dysaerobic to anoxic conditions.
EB	<u>Evaporitic Basin</u> : enclosed intra-shelf basin; anoxic and evaporitic conditions.
SL	<u>Foreereef Slope</u> : relatively steep slope in front of shelf margin, dominated by bioclastic debris, gradational with deep marine.
DB	<u>Deep Basin</u> : open marine, deepwater basin, seaward of platform or shelf margin.

Figure 1: Environmental codes for carbonate paleoenvironmental interpretations.

B. Terrigenous Paleoenvironmental Zones

The following paleoenvironmental classification is used for stratigraphic sequences that are principally comprised of terrigenous sediments deposited on a typical continental shelf-slope system.

Code	Description
NM	<u>Non-Marine</u> : continental, supratidal, delta plain
MM	<u>Marginal Marine</u> : brackish bay, lagoon, tidal, littoral
IN	<u>Inner Neritic</u> : shallow marine, shelf, proximal delta, 0-60' (0-20m)
MN	<u>Middle Neritic</u> : middle shelf, marine, distal delta, 60-300' (20-100m)
ON	<u>Outer Neritic</u> : deep shelf, marine, 300-600' (100-200m)
UB	<u>Upper Bathyal</u> : oceanic, upper continental slope, 600-1500' (200-500m)
MB	<u>Middle Bathyal</u> : oceanic, middle slope, 1500-3000' (500-1000m)
LB	<u>Lower Bathyal</u> : oceanic, deep slope, 3000-6000' (1000-2000m)
AB	<u>Abyssal</u> : deep, oceanic basin, continental rise, fans, 6000'+ (2000m+)

Figure 2: Environmental codes for terrigenous paleoenvironmental interpretations.

C. Mixed Zones

Combinations of paleoenvironmental zones may be indicated within a sample. The following coding convention is used in those cases:

AA-BB – environments gradational from one to another are noted as a pair of zone codes separated by “-”. For example, “OL-OS” is interpreted as “shallow to middle low energy shelf, carbonate dominated”.

AA/BB – Intervals interpreted as predominantly one principal environment with an intermittent secondary environment are noted as a pair of zone codes separated by “/”. For example, “OL/SH” may be interpreted as “shallow low energy, intermixed with high energy shoals, carbonate dominated”.

Mixed carbonate and terrigenous strata will use similar notations as those above, but will be noted as mixed. For example, “OS/MN” may be interpreted as “low energy, middle shelf, mixed carbonate/terrigenous”.

D. Approximate Terrigenous/Carbonate Zone Equivalents

Terrigenous Environment	Water depth	Carbonate Environment
NM	Continental	TE, TF
MM	Littoral	TF, RL, OH, SH
IN	0-60' (0-20m)	OL, RL, SH, OH, BH, EB
MN	60-300' (20-100m)	OS, RB, EB
ON	300-600' (100-200m)	OB, RB
UB	600-1500' (200-500m)	SL
MB	1500-3000' (500-1000m)	SL, DB
LB	3000-6000' (1000-2000m)	DB
AB	6000'+ (2000m+)	DB

APPENDIX 2: Key for Relative Abundance Abbreviations

The following key explains the relative abundance designations for all observed fossil taxa noted in Addendum 1 (Companion Excel File with datasheets Appendix 3 & 4).

Code		Numeric range
R	Rare	1-2 specimens
F	Few	>2-10 specimens
S	Several	>10-20 specimens
N	Numerous	>20-50 specimens
C	Common	>50-100 specimens
A	Abundant	>100-500 specimens
D	Dominant	>500 specimens

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