ROBERTSON RESEARCH INTERNATIONAL LIMITED

REPORT NO. 3090P

RESULTS OF POTASSIUM-ARGON AGE DATING OF A DITCH CUTTING SAMPLE FROM 1839-1842 METRES IN THE CONOCO NORWAY 10/5-1 WELL, NORWEGIAN NORTH SEA

by

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Project No. RRI/767/IIC/2371

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Prepared for :

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C O N T E N T S

I

INTRODUCTION

This report contains the results of a petrographic analysis and a conventional potassium-argon age determination carried out on a ditch cutting sample from 1839-1842.8 metres in the Conoco Norway 10/5-1 well, Norwegian North Sea.

Granite chips were hand picked from the ditch cutting sample for the conventional potassium-argon age determination.

The results of the age dating, and their interpretation are given in Chapters III and IV respectively.

A photomicrograph illustrating some of the petrographic features of the sample is included at the end of the report.

II

PETROGRAPHY

The ditch cutting sample largely consists of fragments of granite composed principally of feldspar with very subordinate quartz. The feldspars include twinned plagioclase and microcline, both of which have been partially altered to minerals of a sericitic type. The degree of alteration of the plagioclase is usually more intense than in the microcline. The feldspars commonly possess fine iron-stained, calcite-filled fractures which often run parallel to the cleavage. The plagioclase is locally riddled with small 'vermicules' of quartz thus displaying a myrmekitic texture.

The quartz usually occurs as small subhedral crystals, often completely enclosed within the feldspars. A very minor amount of small, altered mafic minerals is also present; these could originally have been biotite.

In addition to the granite, the sample contains some fragments of both sandstone and rare shale, both of which may be caved. The sandstone is composed almost entirely of very closely packed subrounded quartz detritals. Most of the sandstone is well sorted but occasional poorly sorted fragments occur.

From the petrographic examination of the ditch cutting sample it is not possible to determine the origin of the granite fragments. They may have originated as pebbles within a clastic sediment or they may form part of an igneous basement complex.

III

POTASSIUM-ARGON AGE DETERMINATION

The results of conventional whole rock potassium-argon age dating on the sample, uisng the methods described in the Appendix, are given in Table 1. The average K-Ar apparent age is:

689 $\pm$ 21 million years (late Precambrian)

TABLE 1

RESULTS OF POTASSIUM-ARGON AGE DATING OF A DITCH CUTTING SAMPLE FROM 1839-1842.8 METRES IN THE CONOCO NORWAY 10/5-1 WELL, NORWEGIAN NORTH SEA

Method	K_2O %	Atmospheric Contamination %	$^v/_m$	Apparent Age and Error in Million Years
K-Ar	5.31	4.7	1.46×10^{-1}	688 ± 21
85/120	5.31	4.7	1.45×10^{-1}	687 ± 21
Total rock	5.31	4.8	1.47×10^{-1}	692 ± 21
Average age and error				689 ± 21 m.y. (late Precambrian)

$^v/_m$ = volume of radiogenic argon-40 $(mm)^3$ NTP per weight of sample (g)

IV

INTERPRETATION

The granite has undergone moderate alteration and therefore, the conventional potassium-argon apparent age of 689 $\pm$ 21 m.y. (late Precambrian) must be regarded as a minimum age for intrusion.

APPENDIX

CONVENTIONAL POTASSIUM-ARGON AGE DATING

Samples are crushed and sieved and then treated as whole rocks for dating by the conventional total degassing potassium-argon method.

Each sample is split into a number of aliquants. Potassium oxide content is measured by flame photometry on six of these aliquants and a mean value computed. Argon is extracted and purified from two or more further aliquants using the method described by Miller and Brown (1964), with the addition of molecular sieve and copper/copper oxide furnace facilities. Argon isotope ratios are measured using an omegatron-type mass spectrometer (Grasty and Miller, 1965). Enriched argon-38 is employed as an internal standard (spike). The constants used in the age calculation are assumed to have the following standard values : $\lambda_e = 0.584.10^{-10}$ year^{-1}, $\lambda_\beta = 4.72.10^{-10}$ year^{-1}. Errors in radiogenic argon volume arising from uncertainties in the isotopic ratios of the argon sample and spike volume, together with those introduced in the determination of potassium oxide are combined. The analytical error in millions of years associated with each individual age determination is calculated according to the method set out by Miller and Fitch (1964). Conventional total degassing K-Ar ages are geochronometrically correct within the limits of the analytical errors quoted, but because of the possible presence of geological errors which cannot be directly measured (Fitch, 1972) all conventional K-Ar ages must be regarded as 'apparent ages' until their geochronological significance has been elucidated.

REFERENCES

FITCH, F.J., 1972. Selection of Suitable Material for Dating and the Measurement of Geological Error in Potassium-Argon Determinations. In W.W. Bishop and J.A. Miller (Eds), Calibration of Hominid Evolution. Wenner-Grenn Foundation for Anthropological Research, New York.

GRASTY, R.L. and MILLER, J.A., 1965. The Omegatron: a useful tool for an isotope investigation. Nature, Lond., Vol. 207, 1146-1148.

MILLER, J.A. and BROWN, P.E., 1964. How Old is Scotland? Adv. Sci., Vol. 23, pp. 527-529.

MILLER, J.A. and FITCH, F.J., 1964. Potassium-Argon Methods with Special Reference to Basic Igneous Rocks. In Harland, W.B., Smith, A.G. and Willcock, B. (Eds.). The Phanerozoic Time-Scale. Geol. Soc. London, pp. 101-1?7.

PLATE 1

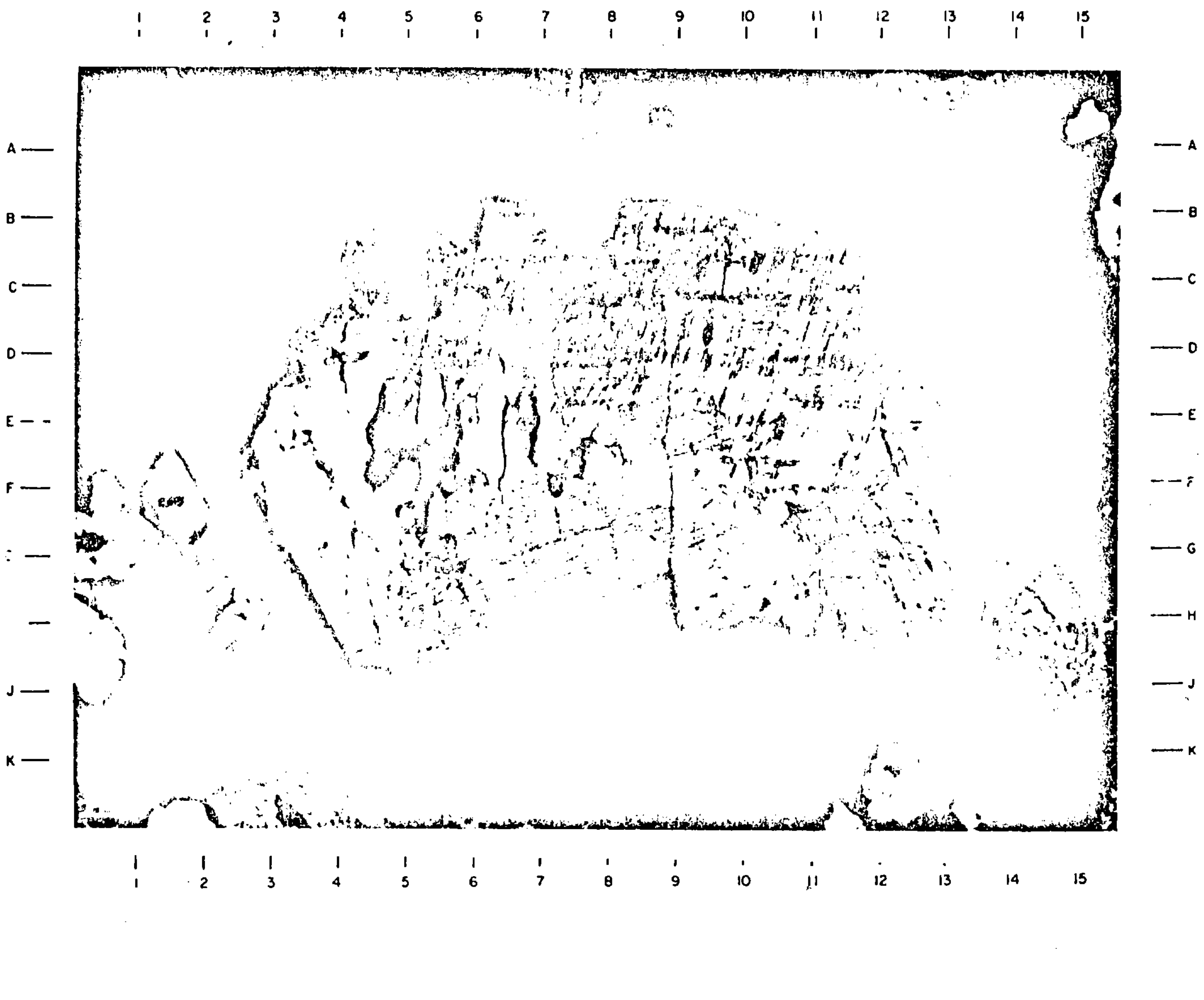
PHOTOMICROGRAPH

PLATE 1

DEPTH: 1839-1842 metres

DESCRIPTION: Fragment of granite composed largely of slightly altered microcline (B7-F11, D4), twinned plagioclase (H6-F10) showing moderate alteration along cleavage planes and untwinned plagioclase (G4-D4). Small subhedral quartz crystals, commonly completely enclosed within the feldspars (F9, C6-D6) and small, altered mafics (G11) are also present. Myrmekitic texture is visible at H5-6 and a calcite filled fracture runs parallel to the feldspar cleavage from G11-E13.

Photomicrograph, x 20; crossed nicols



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BIOSTRATIGRAPHICAL ANALYSIS CHART

DATE	CHART No.	LOCATION
Sept. 1976.	8 1750m-1812m.	Norwegian North Sea 10/5-1 Well

FOR	ANALYST
Conoco Norway Inc.	CGL, CND

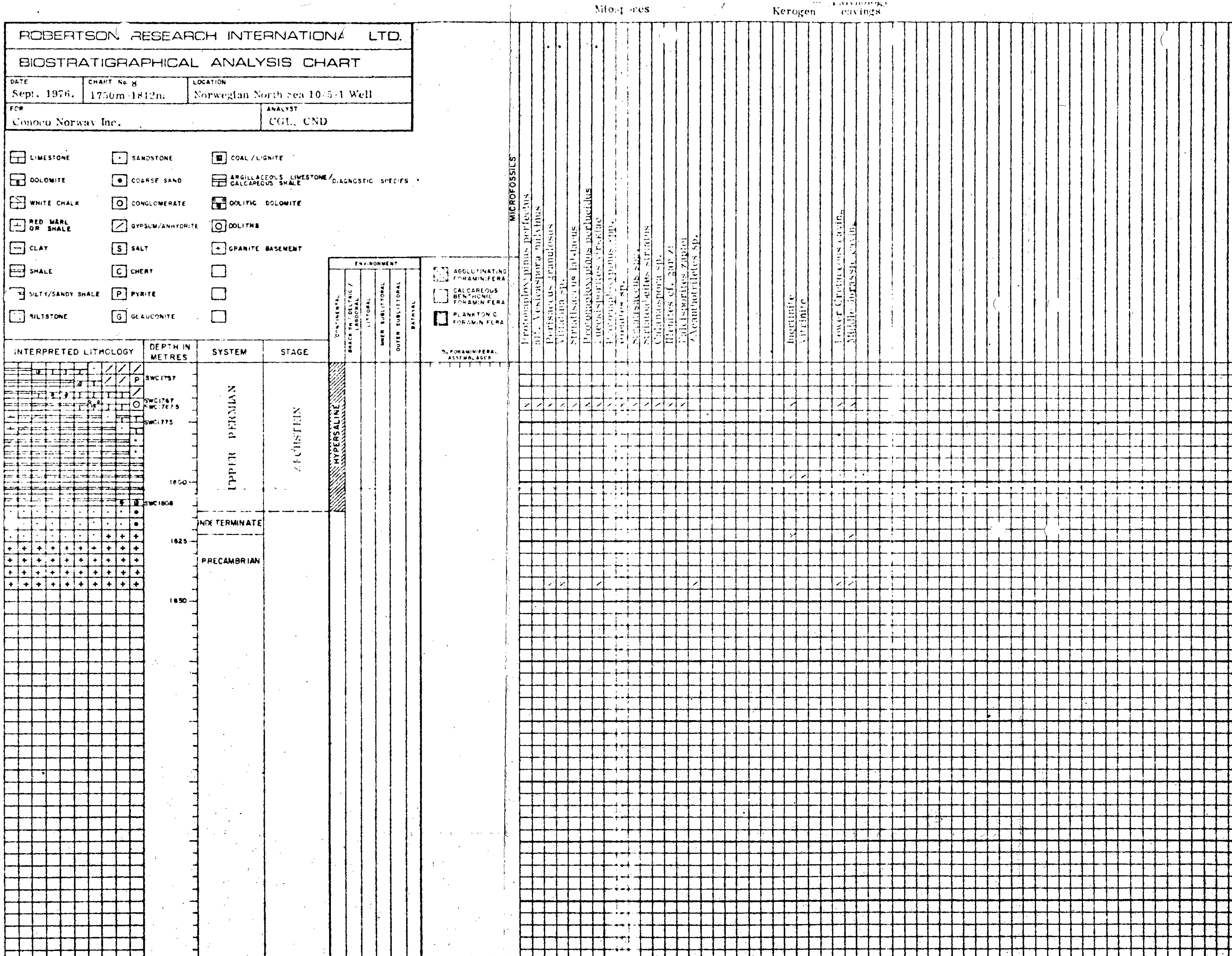
LIMESTONE · DOLOMITE · WHITE CHALK · RED MARL OR SHALE · CLAY · SHALE · SILTY/SANDY SHALE · SILTSTONE

SANDSTONE · COARSE SAND · CONGLOMERATE · GYPSUM/ANHYDRITE · S SALT · C CHERT · P PYRITE · G GLAUCONITE

COAL / LIGNITE · ARGILLACEOUS LIMESTONE / CALCAREOUS SHALE · OOLITIC DOLOMITE · OOLITHS · + GRANITE BASEMENT

/ DIAGNOSTIC SPECIES

AGGLUTINATING FORAMINIFERA · CALCAREOUS BENTHONIC FORAMINIFERA · PLANKTONIC FORAMINIFERA



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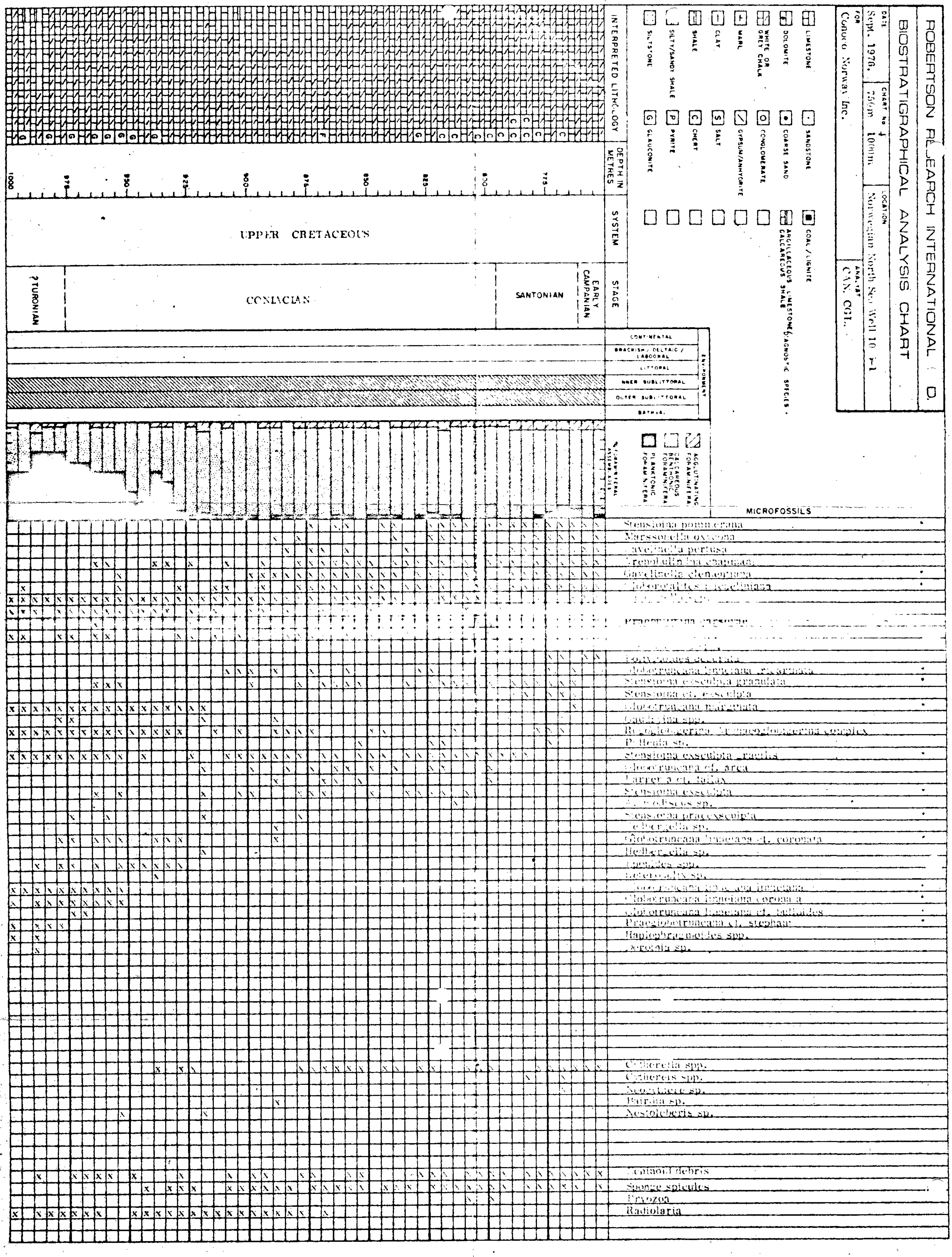
BIOSTRATIGRAPHICAL ANALYSIS CHART

DATE	CHART No	LOCATION
Sept 1976	7 1500m - 1750m	Norwegian North Sea 10/5-1 Well

FOR	ANALYST
Conoco Norway Inc.	CGL..ND

ROBERTSON RESEARCH INTERNATIONAL LTD.
BIOSTRATIGRAPHICAL ANALYSIS CHART
Sept. 1976
1250m - 1500m
Norwegian North Sea 10/5-1 Well
Conoco Norway Inc
CGL, JWC, DND
LIMESTONE
DOLOMITE
WHITE CHALK
MARL
CLAY
SHALE
SILTY/SANDY SHALE
SILTSTONE
SANDSTONE
COARSE SAND
CONGLOMERATE
GYPSUM/ANHYDRITE
SALT
CHERT
PYRITE
GLAUCONITE
COAL, LIGNITE
SIDERITE
SHELL FRAGMENTS
DIAGNOSTIC SPECIES
REWORKED SPECIES R
INTERPRETED LITHOLOGY
DEPTH IN METRES
SYSTEM
STAGE
ENVIRONMENT
AGGLUTINATING FORAMINIFERA
CALCAREOUS BENTHONIC FORAMINIFERA
PLANKTONIC FORAMINIFERA
MICROFOSSILS
LOWER CRETACEOUS
UPPER JURASSIC
MIDDLE JURASSIC
HAUTERIVIAN
VALANGINIAN
RYAZANIAN
VOLGIAN(o)
KIMMERIDGIAN(P.)
BATHONIAN
BAJOCIAN
Foraminifera
Ostracoda
Microplankton
Miospores
Kerogen
Palynology
Other fossils
Callialasporites dampieri group

ROBERTSON RESEARCH INTERNATIONAL LTD
BIOSTRATIGRAPHICAL ANALYSIS CHART
Norwegian North Sea 10/5-1 Well
Conoco Norway Inc
Sept. 1976
CHART No 5
1000m - 1250m
LIMESTONE
DOLOMITE
WHITE OR GREY CHALK
CLAY
SHALE
SILTSTONE
SANDSTONE
COARSE SAND
CONGLOMERATE
GYPSUM/ANHYDRITE
SALT
CHERT
PYRITE
GLAUCONITE
COAL/LIGNITE
PINK CHALK
SIDERITE
DIAGNOSTIC SPECIES
INTERPRETED LITHOLOGY
DEPTH IN METRES
SYSTEM
STAGE
LOWER CRETACEOUS
UPPER CRETACEOUS
HAUTERIVIAN
BARREMIAN
TURONIAN
?TURONIAN
CONTINENTAL
LITTORAL
INNER SUBLITTORAL
OUTER SUBLITTORAL
BATHYAL
PLANKTONIC FORAMINIFERA
CALCAREOUS BENTHONIC FORAMINIFERA
AGGLUTINATING FORAMINIFERA
MICROFOSSILS
Praeglobotruncana cf. stephani
Dorothia sp.
Marssonella cf. oxycona
Dentalina spp.
Gavelinella cf. baltica
Pleurostomella obtusa
Marginulina gracillima
Gavelinopsis tourainensis
Verneuilinoides neocomiensis
Citharina sp.
Epistomina cf. stelligera
Pseudoglandulina sp.
Epistomina cf. caracolla caracolla
Conorotalites intercedens
Nubeculinella sp.
Lenticulina guttata guttata
Lenticulina meridiana
Marginulina robusta
Cytherella sp.
Cythereis sp.
Foraminifera
Ostracods



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BIOSTRATIGRAPHICAL ANALYSIS CHART
DATE Sept. 1976.
CHART No 4
750m - 1000m
LOCATION Norwegian North Sea
FOR Conoco Norway Inc.
ANALYST CAN. CGL.
LIMESTONE
DOLOMITE
WHITE OR GREY CHALK
MARL
CLAY
SHALE
SILTY/SANDY SHALE
SILTSTONE
SANDSTONE
COARSE SAND
CONGLOMERATE
GYPSUM/ANHYDRITE
SALT
CHERT
PYRITE
GLAUCONITE
COAL / LIGNITE
ARGILLACEOUS LIMESTONE / CALCAREOUS SHALE
DIAGNOSTIC SPECIES
INTERPRETED LITHOLOGY
DEPTH IN METRES
775
800
825
850
875
900
925
950
975
1000
SYSTEM
UPPER CRETACEOUS
STAGE
EARLY CAMPANIAN
SANTONIAN
CONIACIAN
?TURONIAN
ENVIRONMENT
CONTINENTAL
BRACKISH / DELTAIC / LAGOONAL
LITTORAL
INNER SUBLITTORAL
OUTER SUBLITTORAL
BATHYAL
% FORAMINIFERAL ASSEMBLAGE
AGGLUTINATING FORAMINIFERA
CALCAREOUS BENTHONIC FORAMINIFERA
PLANKTONIC FORAMINIFERA
MICROFOSSILS
Stensioina pommerana
Marssonella oxycona
Gavelinella pertusa
Gavelinella clementiana
Stensioina exsculpta granulata
Stensioina cf. exsculpta
Globotruncana marginata
Pullenia sp.
Stensioina exsculpta gracilis
Globotruncana cf. arca
Stensioina exsculpta
Stensioina praeexsculpta
Hedbergella sp.
Heterohelix sp.
Globotruncana linneiana coronata
Praeglobotruncana cf. stephani
Haplophragmoides spp.
Cytherella spp.
Cythereis spp.
Bairdia sp.
Crinoid debris
Sponge spicules
Bryozoa
Radiolaria
Foraminifera
Ostracoda
Other fossils

ROBERTSON RESEARCH INTERNATIONAL LTD.

BIOSTRATIGRAPHICAL ANALYSIS CHART

DATE: Sept 1976	CHART No. 2	25m - 500m	LOCATION: Norwegian North Sea 10/5-1 Well
FOR: Conoco Norway Inc.			ANALYST: CGI, NJPM, CAN

Lithology key: Limestone; Dolomite; White or grey chalk; Marl; Clay; Shale; Silty/sandy shale; Siltstone; Sandstone; Coarse sand; Conglomerate; Gypsum/anhydrite; Salt (S); Chert (C); Pyrite (P); Glauconite (G); Coal/lignite; Volcanics (V); Fossil fragments (F)

Diagnostic species †

Columns: Interpreted lithology | Depth in metres | System | Stage | Environment

Depth in metres: 275, 300, 325, 350, 375, 400, 425, 450, 475, 500

System	Stage
?Lower Eocene	
Palaeocene	
Lower Palaeocene	Danian
Upper Cretaceous	Maastrichtian

Environment: Continental; Brackish, deltaic / lagoonal; Littoral; Inner sublittoral; Outer sublittoral; Bathyal

Key: Agglutinating foraminifera; Calcareous benthonic foraminifera; Planktonic foraminifera; % foraminiferal assemblage

MICROFOSSILS

Foraminifera

Haplophragmoides spp.
Nodosaria/Dentalina spp.
Cibicides spp.
Bathysiphon spp.
Trochammina globigeriniformis
[illegible] pedunatus
[illegible]
[illegible]na sp.
[illegible]
[illegible]
Nodosaria latejugata
Pulleniina palaeocenica
[illegible] midwayensis
Bulimina sp.
Ammodiscus incertus
Gavelinella spp.
Pullenia americana
Alabamina [illegible]
Globorotalia compressa
Pullenia cf. cretacea
Globigerina cf. pseudobulloides
Gyroidina spp.
Cibicides succedens
Lagena/Lenticulina sp.
Gavelinella [illegible]llingensis
Polymorphinids
Allomorphina halli
[illegible]
Globigerina pseudobulloides
[illegible] cf. [illegible]
[illegible]
[illegible]des sp.
Ceratobulimina sp.
Marssonellaphragmoides [illegible]
Gavelinella [illegible]mensis
Stensioeina pommerana
Gavelinopsis voltziana
Gavelinopsis complanata
Gavelinopsis cf. bembix
Osangularia [illegible]lens
Anomalinoides velascoensis
Marssonella oxycona
Stilostomella spinosa
Cibicides beaumontiana
[illegible]ina cf. murchisoni
Dorothia spp.
Gyroidinoides nitida
Planularia harpa
Bolivina incrassata gigantea
Pullenia cretacea
Gavelinella pertusa
Haplophragmium cf. trochoides
Praebulimina [illegible]
Ammodiscus sp.
Rugoglobigerina rugosa rugosa
Ataxophragmium trochoides
Discorbis/Stensioeina [illegible]
Karreria cf. fallax
Gyroidinoides octocamerata
Stensioeina cf. exsculpta
Bolivina incrassata incrassata
Heterostomella [illegible]
Heterohelix globulosa
[illegible] mavaroensis
Gaudryina cretacea
Reussella cristata
Pullenia sp.
[illegible]

Ostracoda

Bairdia spp.
Krithe sp.
Cytherella spp.
Cytherelloidea spp.
Cythereis sp.

Other Fossils

Radiolaria
Large flattened radiolaria
Coscinodiscus sp. 1
Coscinodiscus sp. 2
Fish teeth
Echinoid debris
Bryozoa
Brachiopoda

Depth: 500, 475, 450, 425, 400, 375, 350, 325, 300, 275

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BIOSTRATIGRAPHICAL ANALYSIS CHART

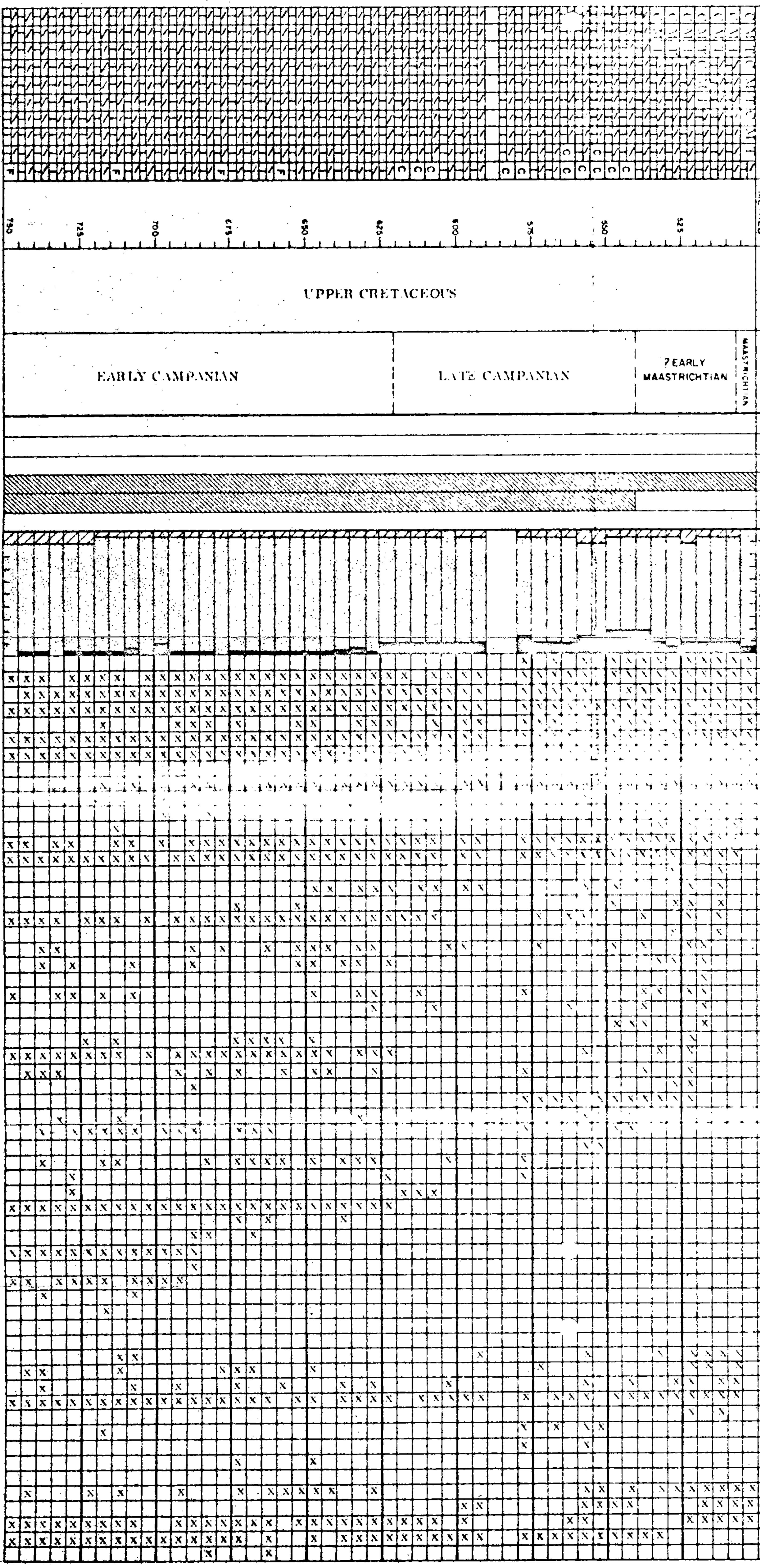
DATE	CHART No	LOCATION
Sept. 1976.	3 — 500m – 750m	Norwegian North Sea Well 16/5-1

FOR: Conoco Norway Inc.

ANALYST: CGL. CAN.

Lithology key: LIMESTONE, DOLOMITE, WHITE OR GREY CHALK, MARL, CLAY, SHALE, SILTY/SANDY SHALE, SILTSTONE, SANDSTONE, COARSE SAND, CONGLOMERATE, GYPSUM/ANHYDRITE, SALT, CHERT, PYRITE, GLAUCONITE, COAL / LIGNITE, FOSSIL FRAGMENTS, DIAGNOSTIC SPECIES •, CMT Cement

Foraminifera key: AGGLUTINATING FORAMINIFERA, CALCAREOUS BENTHONIC FORAMINIFERA, PLANKTONIC FORAMINIFERA



MICROFOSSILS

Foraminifera:

- Bolivina incrassata gigantea •
- Praebulimina carseyae
- Gyroidinoides spp.
- Stensioina pommerana •
- Bolivina incrassata incrassata •
- Polymorphinids
- [illegible]
- [illegible]
- [illegible]
- [illegible] •
- Gavelinella pertusa
- Ataxophragmium trochoides
- [illegible] cf. murchisoni
- Cibicides beaumontiana
- Spirillina subornata
- Marssonella oxycona
- Reussella cf. prolixa
- Pullenia spp.
- Ammodiscus sp.
- Gavelinopsis bembix
- Stensioina cf. exsculpta
- Globotruncana arca •
- Rugoglobigerina rugosa rotundata
- Karreria cf. fallax
- Arenobulimina chapmani
- Neoflabellina spp.
- Globotruncana spp.
- [illegible] gracilis •
- [illegible]
- [illegible]
- Spiroplectammina cf. flexuosa
- Reussella szajnochae szajnochae •
- Globotruncana linneiana cf. tricarinata •
- Alabamina spp.
- Globorotalites michelinana •
- Gaudryina spp.
- Globotruncana fornicata •
- Gavelinella clementiana •
- Tritaxia cf. dubia
- Bolivinoides laevigata
- Heterohelix spp.
- Globotruncana linneiana tricarinata •

Ostracoda:

- Cytherelloidea spp.
- Cythereis spp.
- Bairdia spp.
- Cytherella spp.
- Cythereis cf. foersteriana
- Paracypris sp.
- Krithe sp.
- Neocythere sp.

Other fossils:

- Bryozoa
- Radiolaria
- Echinoid debris
- Sponge spicules
- Fish teeth

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BIOSTRATIGRAPHICAL ANALYSIS CHART

DATE	CHART No.	LOCATION
Sept. 1976.	1 186m. - 250m	Norwegian-North Sea Well 10/5-1

FOR	ANALYST
Conoco Norway Inc.	NJBH. CGL.

Lithology key: LIMESTONE; DOLOMITE; WHITE CHALK; MARL; CLAY; SHALE; SILTY/SANDY SHALE; SILTSTONE; SANDSTONE; COARSE SAND; CONGLOMERATE; GYPSUM/ANHYDRITE; SALT (S); CHERT (C); PYRITE (P); GLAUCONITE (G); COAL / LIGNITE

CMT Cement

DIAGNOSTIC SPECIES •

REWORKED SPECIES R

ENVIRONMENT: CONTINENTAL; BRACKISH / DELTAIC / LAGOONAL; LITTORAL; INNER SUBLITTORAL; OUTER SUBLITTORAL; BATHYAL

AGGLUTINATING FORAMINIFERA; CALCAREOUS BENTHONIC FORAMINIFERA; PLANKTONIC FORAMINIFERA

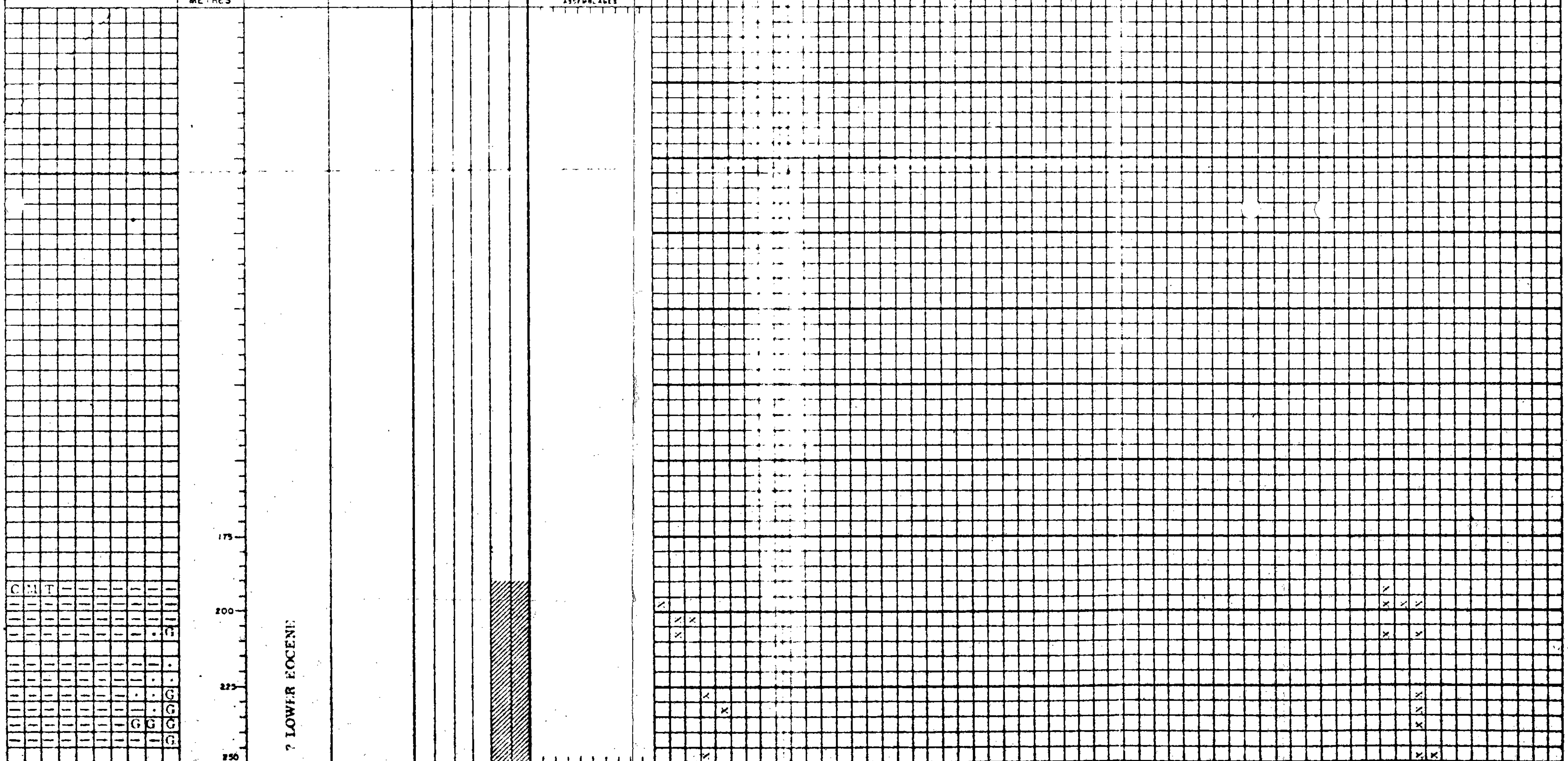
% FORAMINIFERAL ASSEMBLAGES

INTERPRETED LITHOLOGY | DEPTH IN METRES | SYSTEM | STAGE

MICROFOSSILS

Foraminifera: Turrilina brevispira; Nodosaria spp.; Bulimina sp.; Haplophragmoides sp.; Bathysiphon sp.

Other fossils: Bryozoa (R); Bivalves; Radiolaria; Fish teeth



ROBERTSON RESEARCH INTERNATIONAL LTD
BIOSTRATIGRAPHICAL ANALYSIS CHART
DATE Sept. 1976
LOCATION Norwegian North Sea 10/5-1 Well
FOR Conoco Norway Inc.
LIMESTONE
DOLOMITE
WHITE CHALK
MARL
CLAY
SHALE/CLAYSTONE
SILTY/SANDY SHALE
SILTSTONE
SANDSTONE
COARSE SAND
CONGLOMERATE
GYPSUM/ANHYDRITE
SALT
CHERT
PYRITE
GLAUCONITE
COAL/LIGNITE
DIAGNOSTIC SPECIES
REWORKED SPECIES R
INTERPRETED LITHOLOGY
DEPTH IN METRES
1250m
1285m
1347m
1475m
1510m
1520m
1542m
1565m
1600m
1636.5m
1683m
1709m
1715m
1757m
1767m
1767.5m
1775m
1800m
SYSTEM
LOWER CRETACEOUS
UPPER JURASSIC
MIDDLE JURASSIC
TRIASSIC
UPPER PERMIAN
STAGE
HAUTERIVIAN
VALANGINIAN
RYAZANIAN
VOLGAN - KIMM
KIMMERIDGIAN
BATHONIAN
BAJOCIAN
ZECHSTEIN
CONTINENTAL
BATHYAL
OUTER SUBLITTORAL
INNER SUBLITTORAL
ENVIRONMENT
AGGLUTINATING FORAMINIFERA
CALCAREOUS BENTHONIC FORAMINIFERA
PLANKTONIC FORAMINIFERA
% FORAMINIFERAL ASSEMBLAGE
MICROFOSSILS
Foraminifera
Kleithriasphaeridium sp.
Gonyaulacysta jurassica
Gen. et. sp. indet.
Endoscrinium cf. eisenacki
Gonyaulacysta filapicata
Scriniodinium sp.
Microplankton
Callialasporites dampieri group
Miospores
Vesicaspora schaubergeri
Kerogen Fossils