S. N. E. A. (P)
DIRECTION EXPLORATION
DIVISION RECHERCHES et APPLICATIONS en GEOLOGIE
LABORATOIRE
ETABLISSEMENT DE BOUSSENS

15 OKT. 1984/18

EP/S/EXP/RAG-Lab. Bss n° 062/84 RP
/om


WELL 3/7-3

# LITHOSTRATIGRAPHY AND RESERVOIR ASPECT OF THE PRE-CHALK SEDIMENTS (PERMIAN - LOWER CRETACEOUS ; CENTRAL GRABEN) SOUTHERN DISTRICT - OFFSHORE NORWAY

J.M. BOIRIE
ASSISTANCE TECHNIQUE : A. JEANNOU

Boussens - Septembre 1984

No COMMANDE : 103103157

---

LISTE DE DIFFUSION

DESTINATAIRES HORS DEX :

| | |
|---|---|
| EXPLO. DIG EUROPE | 2 |
| EXPLO. ELF AQUITAINE NORGE | 12 |
| S.I.D. BOUSSENS | 2 |

## ABSTRACT

. The pre-Chalk sediments of the 3/7-3 well have been subdivided into the following lithostratigraphical units :

- Zechstein evaporites : 3452 (TD) - 3507 m.

  Salt and anhydrite, deposited in subsiding and desiccated areas of the Zechstein Sea.

- Upper Jurassic shales : 3507 - 3432 m.

  Shales and associated dolomitic beds deposited in an anaerobic marine environment (euxinic type) with high organic productivity and restricted bottom circulation.

- Undifferentiated Upper Jurassic - Early Cretaceous

  clastic Unit : 3432 - 3380 m.

  Littoral to sublittoral sandstones deposited as lenticular sheets or slope apron bodies and interbedded with shaly and dolomitic sediments.

- Berriasian brown sandstone : 3380 - 3325 m.

  Thick and massive sequence of marine sandstones accumulated as lenticular sheets and slope apron bodies down a slope.

- Lower Cretaceous clastic and carbonate unit : 3325 -3280 m.

  Alternating sandstones, shales and carbonate sediments deposited in an open marine environment.

. From a reservoir point of view, the Upper Jurassic and Lower Cretaceous sandstones show favourable characteristics. Obviously the Berriasian thick-bedded and porous brown sandstone is the best reservoir encountered in spite of the following restrictive factors : noticeable silica and kaolinite cementations, compaction and probable small lateral extension of the sand bodies.

CONTENTS



-o-o-o-

# 1 - INTRODUCTION

This sedimentological study has been carried out on the pre-chalk sediments -Permian to Lower Cretaceous- of the 3/7-3 well (see location map, Fig. 1) from 3542 m (TD) to 3280 m.

Cores, sidewall cores, ditch cuttings and wireline logs have been examined. Our study also takes into account the geochemical and biostratigraphical* results.

This study allows us to propose a lithostratigraphical zonation (Pl. 1) and to give an integrated account of the lithology, the depositional environment and the reservoir potential of the encountered sediments.

# 2 - LITHOSTRATIGRAPHICAL ZONATION

## 2.1 - ZECHSTEIN EVAPORITES : 3542 (TD) - 3507 m

From base to top, massive and whitish translucent salt (3542 -3521 m) and white to cream, thin-layered anhydrite (3521 - 3507 m).

Deposition occurred in subsiding and desiccated areas of the Zechstein Sea.

## 2.2 - UPPER JURASSIC SHALES : 3507 - 3432 m

Essentially light-grey to black and brown shales, admitting rare thin-bedded grey to dark-brown dolomite.

The shales are thinly laminated and composed dominantly of illite (about 60 % of the clay Fraction) and to a lesser extent of smectite, kaolinite and chlorite. They are rich in organic matter and are, commonly, slightly silty and dolomitic. They also contain mica flakes, planktic microfauna remains, carbonaceous chips and phosphatic debris. Pyrite, glauconite and feldspars also occur. Some small fractures are visible and are filled by drusy mosaic dolomite.

---

* - 3/7-3 well : Biostratigraphical report - J. DUCAZEAUX, J.L. VOLAT, F. DERES May 1982 - n° 2/2272 RP.

- Biostratigraphical and structural relationships between the Permian, Jurassic, Cretaceous and Danian sequences in wells 2/5-6, 3/7-2, 3/7-3 and Lulu 1 - J. DUCAZEAUX, J.L. VOLAT August 1982 - n° 2/2312 RP.

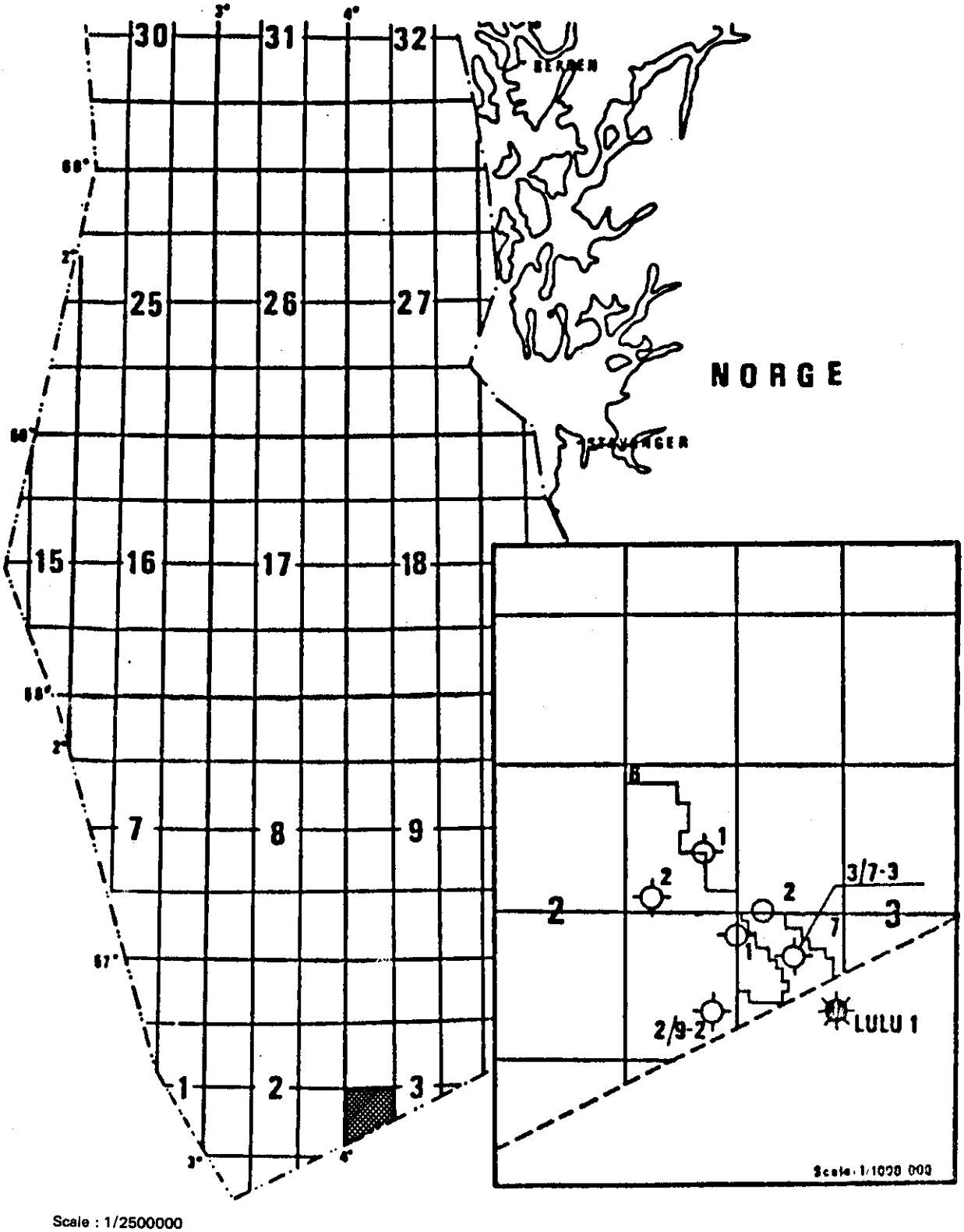



Fig. 1 - LOCATION MAP OF 3 /7 - 3 WELL.

These sediments were deposited in an anaerobic marine environment (euxinic type) with high organic productivity and restricted bottom circulation.

## 2.3 - UNDIFFERENTIATED UPPER JURASSIC - EARLY CRETACEOUS CLASTIC UNIT : 3432 - 3380 m

This unit consists of dominant sandstone deposits with some shaly and dolomitic interbeds.

Sandstones are light grey to greenish grey, medium to coarse grained, occasionally microconglomeratic and may be cemented by a mosaic of dolomite crystals. They commonly contain very abundant glauconite (as detrital and authigenic particles), lithic debris (dolomitic pebbles) and feldspars. Quartz grains are poorly sorted, subrounded, corroded and coated by a highly developed dolomite cement ; locally they can be tightly packed and present microstylolitic sutured contacts. Silica cement and clayey to dolomicritic matrix have also been observed. However these sandstones often exhibit good visual porosities (principally due to the dissolution of carbonate minerals).

Sandstones commonly grade into white to buff sandy and glauconitic dolomites (dolosparite to dolomicrite). Dolomites are more or less argillaceous, contain abundant rounded glauconite grains, silicified spicule fragments and planktic fauna remains.

Sandstone beds and dolomite stringers also admit thin intercalations of dolomitic and glauconitic shales and siltstones. These muddy sediments are dark grey to brownish or greenish coloured, are dominantly composed of illite, illite-smectite mixed layers and show noticeable amounts of organic matter.

Sedimentation occurred in a shallow marine (littoral to sublittoral) environment. Sandstones result from coarse and immature clastic discharges down a coastal slope and were probably deposited as lenticular sheet or slope apron facies.

## 2.4 - BERRIASIAN BROWN SANDSTONE : 3380 - 3325 m

This unit essentially consists of brown, massive and coarse grained sandstones (cf. the description of cores 2 and 3 ; Pl. 2). Lighter coloured sandstones and white chalky, sandy limestone are interbedded within this dominant lithofacies.

The sandstones are generally thick-bedded, massive and poorly sorted with dominant coarse to medium quartz grains (but very coarse grains and granules are common). They are immature with abundant lithic debris (essentially quartzitic and dolomitic clasts) and feldspars. Mica flakes and glauconite grains occur in smaller amounts.

Clasts are commonly cemented by a highly developed secondary silica ; quartz overgrowths are also visible. Kaolinite cement (up to 80 % of the clay fraction), carbonate patches and a residual clay matrix also occur to a lesser extent. But in spite of cementation and some compaction (sutured grain contacts), these sandstones have preserved a favourable intergranular porosity in most cases.

The sedimentary environment of the Berriasian brown sandstone is closely comparable to the one already discussed for the inderlying deposits. Sands were transported seawards from an uplifted littoral and down coastal slopes ; then they built subtidal lenticular sheets and slope apron bodies. No important lateral extension can be expected for this type of deposit.

## 2.5 - LOWER CRETACEOUS CLASTIC AND CARBONATE UNIT : 3325 -3280 m

Hauterivian to Albian unit composed of alternating sandstones, carbonates and shales, and arranged into a well-defined thinning-up sequence. It begins with coarse to very coarse grained sandstones and grades upwards (especially above 3305 m) into more carbonated and shaly deposits.

Light-grey to beige sandstones are coarse to very coarse grained and poorly sorted. The detrital components include subangular to subrounded quartz grains, lithic debris and feldspar grains. Very thin and stylolitic clay laminae are often visible. Locally (especially from 3310 m to the top of the unit) finer grained and better sorted sand facies with dominant subrounded quartz can also be observed. Clasts are generally coated by an important carbonate cement (dolomite) and by an argillaceous matrix. Quartz overgrowths, corroded and sutured grain contacts, and authigenic glauconite are also noticeable in this type of sand facies.

Towards the top of the interval, sandstones become thinner bedded and finer grained, interfingering with dark grey to brownish red shales and carbonate beds.

Shales and marls are thinly laminated, slightly dolomitic and sometimes sandy. Clay minerals are dominantly illite-smectite mixed layers and illite. They also contain abundant bioclasts (echinoid fragments, planktic microfauna remains), lithic debris, glauconite grains and rare mica flakes.

White to buff associated mudstone-wackestone and light grey dolomudstone occur as thick (metre scale) to thin interbeds with abundant planktic microfauna remains, silt-sized quartz and small amounts of organic matter.

The deposits suggest sedimentation in an open marine environment where sands were probably reworked as sublittoral sheet bedforms.

## 3 - CONCLUSION

This study has enabled the following lithostratigraphical zonation to be given for the 3/7-3 well :

- (Late Permian) Zechstein evaporites : 3542 (TD) - 3507 m.

- Upper Jurassic shales : 3507 - 3432 m.

- Undifferentiated Upper Jurassic - Early Cretaceous clastic unit : 3432 - 3380 m.

- Berriasian brown sandstone : 3380 - 3325 m.

- Lower Cretaceous clastic and carbonate unit : 3325 - 3280 m.

From a reservoir point of view , the Upper Jurassic and Lower Cretaceous marine (littoral to sublittoral) sandstones show favourable characteristics. The Berriasian brown sandstone is obviously the best reservoir encountered in spite of some restrictive diagenetic events (especially the silicification) and probable small lateral extension.

sneap

# POWDER ANALYSES BY X RAY DIFFRACTION

Laboratoire de Géologie de Boussens

WELL 3/7-3 — Code

Country NORWAY — Code — Age

Basin CENTRAL GRABEN (OFFSHORE NORWAY) — Formation

Analyses termination date January 1984

## OBSERVATIONS

Sheet N°

APPENDIX n°1 a

Core 2

Core 3

Core 3

| CARD N° | IDENTIFICATION OF THE SAMPLE from | to | M P | K C D T | MAIN MINERALS weight % Anhydrite | Barytine | Aragonite | Quartz | Orthoclase (potas.) | Plagiocl. (calc.-sod.) | Gypse | Calcite (1) | High Mg Calcite (2) | High Ca Dolomite (2) | Dolomite (1) | Halite | Siderite | Magnesite | Pyrite | Fluorite | Crist-Trid. | Others | in thousands of cps Hématie | Fluorapatite | mole % (mod.) Calcite (1) Mg | Calcite (2) Mg | Dolom. (2) Ca | Dolom. (1) Ca |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 015 | | 3212515.510 | M | C | | | | 42 | 14 | 14 | | | | | 15 | | 11 | | | | | 34 | | ?x | | | | |
| 015 | | 3310515.510 | | | | | | 29 | 1x | 11 | | | | | 19 | | | | 1x | | | 61 | | | | | | |
| 015 | | 3312525.510 | | | | 1x | | 57 | 15 | 17 | | | | | 1 | | | | | | | 31 | | | | | | |
| 015 | | 3313717.710 | | K | | 1x | | 62 | 14 | 15 | | | | | 7x | | | | | | | 29 | | | | | | |
| 015 | | 3314019.710 | | K | | ?x | | 78 | 16 | 16 | | 1x | | | | | | | | | | 16 | | | | | | |
| 015 | | 3314415.510 | | K | | ?x | | 76 | 15 | 16 | | | | | | | | | | | | 13 | | | | | | |
| 015 | | 3315017.010 | | C | | ?2 | | 74 | 17 | 14 | | | | | 14 | 17 | | | | | | 19 | | | | | | |
| 015 | | 3315515.510 | | | | | | 11 | | | | 77 | | | | | | | | | | 12 | | | | | | |
| 015 | | 3316016.910 | | | | 1x | | 48 | 15 | 15 | | 1x | | | 11 | | | | 1x | | | 31 | | | | | | |
| 015 | | 3416516.910 | | | | | | 27 | 11 | 16 | | | | | 12 | | | | | | | 54 | | | | | | |
| 015 | | 3412616.010 | | | | | 4 | 24 | 1x | 12 | | | | | 14 | | 7x | | 1x | | | 16 | | | | | | |
| 015 | | 3414414.010 | | | | | | 16 | 1x | 11 | | | | | 15 | | | | 4 | | | 74 | | | | | | |
| 015 | | 3515014.010 | | | | | | 18 | 1x | 11 | | | | | 13 | | | | 5 | | | 73 | | | | | | |
| 015 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 015 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 015 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 015 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 015 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 015 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 015 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

X = traces P feet M meters C = side-wall cores K = cores T field survey sample D cuttings

A 90/4

sneap

# CLAY MINERAL ANALYSES BY X RAY DIFFRACTION

Laboratoire de Géologie de Boussens

WELL 3/7-3 Code

Country NORWAY Code Age

Basin CENTRAL GRABEN (OFFSHORE NORWAY) Formation

Analyses termination date February 1984

## OBSERVATIONS

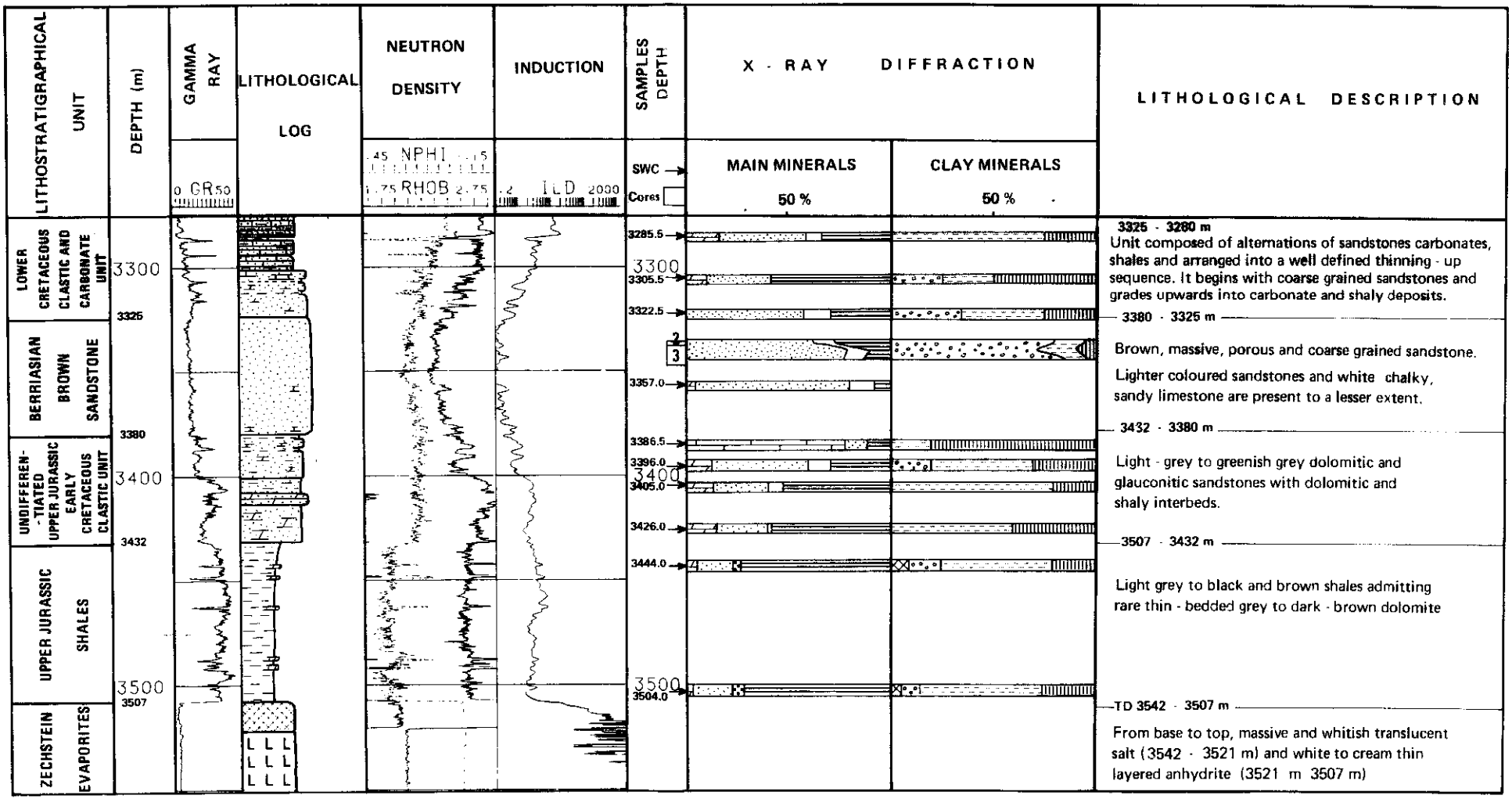
Sheet N°

APPENDIX n°1 b

| CARD N° | IDENTIFICATION OF THE SAMPLE from | to | MP | KCDT | CLAY MINERALS (relative %) * Code Chlorite | expandable Chlorite | * Code Kaolinite | Chlorite and or Kaolinite | * Code Illite | expandable Illite | Illite Smectite | Allevardite | Chlorite Smectite | Corrensite | * Code Smectite | Smectite ↑ Illite-Smect. | Smectite ↓ Chl.-Smect. | Attapulgite | Sepiolite | Vermiculite (Chl.-Verm.) | Talc | Pyrophyllite | | Illite-Smectite : d(001) Å | 002/001 of Illite | Width at half height in mm Illite : Kubler's ind | Illite + Ill.-Smect. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 014 | | 3285 50 | M | C | | | | | 75 | | 25 | | | | | | | | | | | | | | | | | |
| 014 | | 3303 5.50 | | | | | 25 | | 30 | | 45 | | | | | | | | | | | | | | | | | |
| 014 | | 3322 .50 | | | | | 35 | | 40 | | 25 | | | | | | | | | | | | | | | | | |
| 014 | | 3337 .70 | | K | ?x | | 80 | | 10 | | 5 | | | | 5 | | | | | | | | | | | | | Small quantities of clay |
| 014 | | 3340 .70 | | | | | 70 | | 20 | | 10 | | | | | | | | | | | | | | | | | Core 2 Smal quantities of clay |
| 014 | | 3344 .50 | | | | | 85 | | 10 | | 5 | | | | | | | | | | | | | | | | | Core 3 |
| 014 | | 3357 . | | C | | | x | | x | | x | | | | | | | | | | | | | | | | | Core 3 Clay in traces |
| 014 | | 3385 .50 | | | ?x | | | | 20 | | 80 | | | | | | | | | | | | | | | | | |
| 014 | | 3396 . | | | | | 20 | | 50 | | 30 | | | | | | | | | | | | | | | | | |
| 014 | | 3405 . | | | | | 1 | | 80 | | 19 | | | | | | | | | | | | | | | | | |
| 014 | | 3426 . | | | | | | | 60 | | 40 | | | | | | | | | | | | | | | | | Small quantities of clay. |
| 014 | | 3444 . | | | 10 | | 15 | | 55 | | 20 | | | | | | | | | | | | | | | | | |
| 014 | | 3504.00 | | | 5 | | 10 | | 60 | | 25 | | | | | | | | | | | | | | | | | |
| 014 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 014 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 014 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 014 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 014 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 014 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 014 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

* See particular remarks on back of sheet X - traces P - feet M - meters C - side-wall cores K - cores T - field survey sample D - cuttings

4 90/5




elf aquitaine

Pays OFF SHORE NORWAY

Permis ou concession

DIRECTION EXPLORATION - PRODUCTION

DIRECTION PRODUCTION DEPART[T] GISEMENTS

Date Juillet 1984

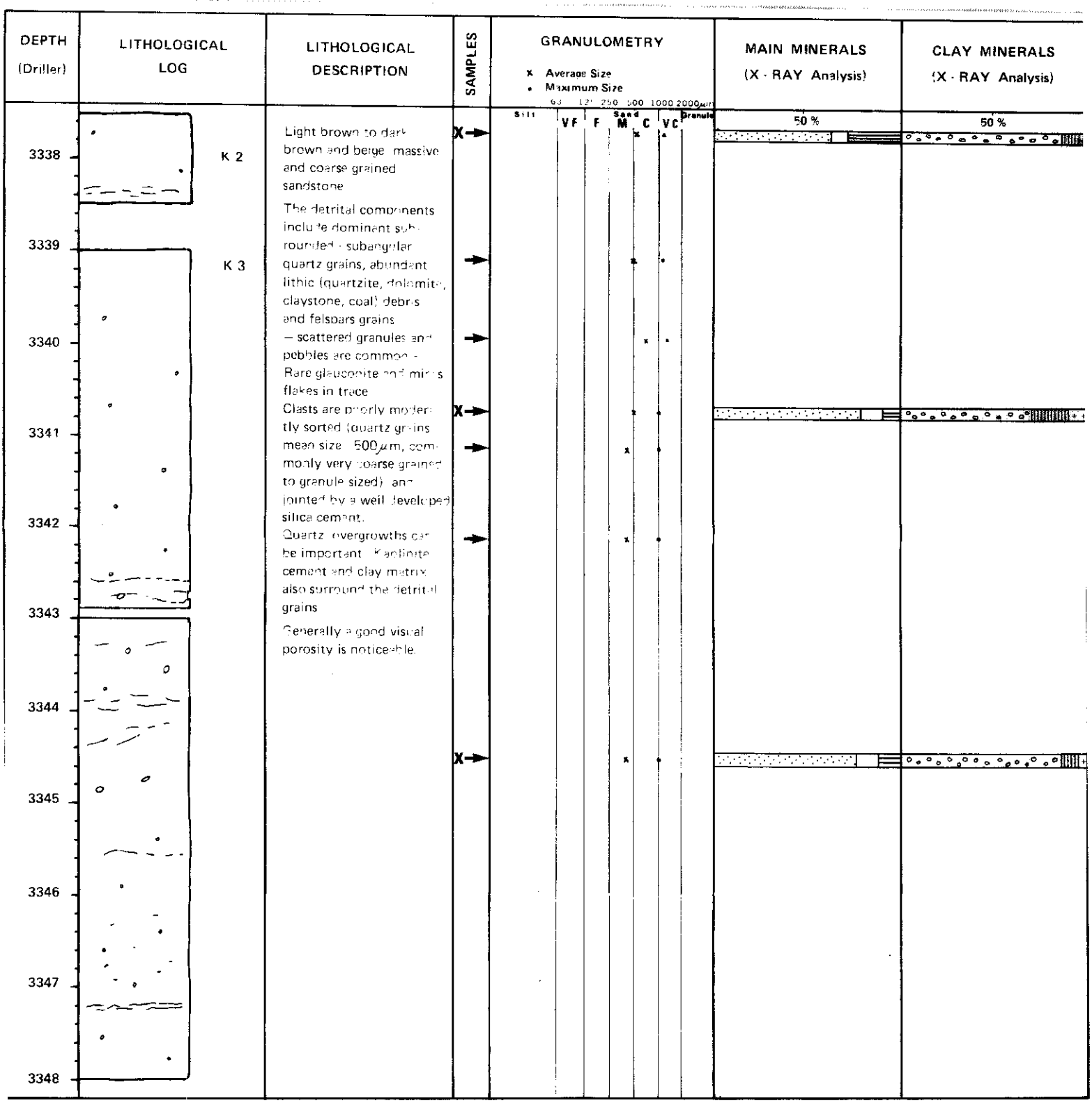
Auteur Bolde

N°Classt Jeannou

PL.1

WELL 3/7-3

LITHOLOGY OF THE PRE - CHALK SEDIMENTS




elf aquitaine

Pays OFF SHORE NORWAY

Permis ou concession

DIRECTION EXPLORATION - PRODUCTION

DIRECTION PRODUCTION DEPART! GISEMENTS

Date Juillet 84

Auteur Barrie

N°Class Jeannou

PL. 2

WELL 3 / 7 - 3

LITHOLOGICAL DESCRIPTION OF CORES 2 AND 3

Scale 1/40