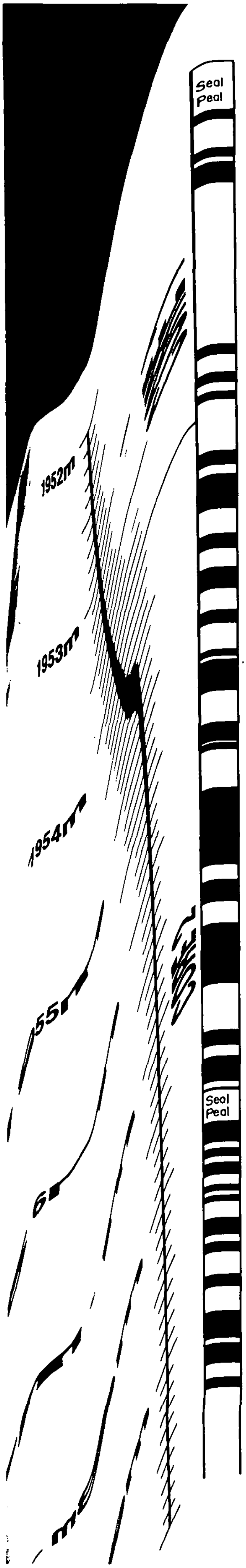

SHALE TUFF

WELL 30/2-1

PRELIMINARY DESCRIPTION AND INTERPRETATION OF CORES FROM THE LOWER TERTIARY TUFF SEQUENCE

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Requested by

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Subtitle

Co-workers

Title

WELL 30/2-1

PRELIMINARY DESCRIPTION AND INTERPRETATION OF CORES FROM THE LOWER TERTIARY TUFF SEQUENCE

STATOIL
EXPLORATION & PRODUCTION LABORATORY

by

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JULY 1982 LAB.82.28

Prepared

Approved

9.03.21 A

CONTENTS

INTRODUCTION

According to the drilling program for well 30/2-1 cores were taken of the Paleocene sequence.

The two cores (1952-1969 m)contained no detrial sand but abundant tuff layers (40%) interbedded with finely laminated shales (60%). The limited amount of conventional poro-perm data indicated extremely good porosities (35-40%) but very low permeabilities (below 3 mD).

In connection with recommendations for testing, Statoils geological lab. were asked to make a rapid description and interpretation of the cores and evaluate their reservoir properties. This was done during the week 28 June - 1 July and is reported here. During the study an additional 15 plugs of tuff-beds were sampled for poro-perm measurement. These confirmed the earlier data giving very high porosities (40%) and low permeabilities (< 1 mD) (Table 1).

DESCRIPTION OF THE CORES

The two cores cover a continous interval of about 17 meters (1952-1969 m).

A preliminary description showing the distribution of shale and tuff-layers are given in Fig. 1.

A rough estimate of tuff to shale volume gives 40% tuff and 60% shale. Some of the thicker tuff layers in Fig. 1. consist of 2-3 individual tuff-beds. Altogether 85 tuff-beds have been counted in the cores, and still some thinner ones (< 1 cm) probably have not yet been recognised.

THE TUFF-BEDS

The thickness of each tuff-bed ranges from a couple of centimeters up to 30 cm.

Each bed has a sharp base and boundary to underlying shales and, with rare exceptions, show a strong normal grading in grain-size, from medium at the bottom to clay-size at the top.

The contact with overlying shale is mostly sharp and easy to identify due to differences in colour and laminations.

Except for the grading the tuff beds show no other sedimentary textures (such as laminations). They are massive with dark grey-green colours except where calcite-cementation give them a light-grey colour.

The amount/degree of calcite-cementation varies considerably. Many beds show no sign of cementation. The cementation if often found at the bottom and the top of the tuff-beds indicating that the cementing solutions had their origin in the interbedded shales. In a few cases massive cementation is observed through the whole tuff-bed. In such beds one occasionally observes mm thick vertical veins/fractures, filled with calcite. One thicker bed (at 1956.1-3 m) show strong slumping with a large overturned slump fold. This is strongly cemented by calcite.

MICROTEXTURES AND RESERVOIR-PROPERTIES

The micro-textures of the tuff-beds and tuff-grains have been examined in a normal rigg-microscope, in thin-sections and on the scanning electron microscope.

The descriptions given here are only preliminary as time has not permitted detailed investigations of textures and mineral-compositions.

Under a rigg-microscope the volcaniclastic nature of the medium-grained ash-particles are easily recognized on the slabbed core. The glassy, white-grey-green-black grains are mostly angular with irregular shapes though weakly rounded grains also are present. The primary intergranular porosity seems very high. Characteristicly most grains have internal spherical vesicles/-vugs formed through expansion of gasses in the low viscous magma during pressure release and explosive eruption. These included the total porosity of the ash/tuff just after deposition must have been in the range of 50% volume. In the fresh state such ash would have extremely good reservoir-properties also with respect to permeability, and fields producing from volcaniclastic deposits are known from outside the North Sea. Unfortunately in this case, textural and mineral - transformations after deposition have had severe effects on reservoir-properties of the ash-beds. This has led to a redistribution of porosity on the micro-scale and a simultanous obstruction of permeability.

The tuffs still have a very high porosity (35-40%) but this largly occurs as interclay microporosity which is considered unproductive. The high clay-content of the tuffs is secondary and a result of insitu transformations of ash particles.

Originally the ash-particles consisted of glass formed through rapid chilling of magma during eruption. In contact with water these meta-stable glass-grains are very reactive and easily transformed into water-bearing minerals like clays and zeolites. In thin-sections textural evidence for such transformations is widespread.

Characteristicly these minerals grow perpendicular out from the ash grain surfaces into the pore-space. The overgrowths from neighbouring grains meet and thereby more or less completely fills up the original pores and their connections. Though a high total porosity is retained this is now composed of inter-clay microporosity and the porosity of isolated macropores. In the calcite-cemented beds these isolated macropores are filled with calcite.

THE SHALE-BEDS

The shales show fine (mm-cm) and delicate flat laminations. Weak small-scaled (< 0.5 cm) bioturbation are occasionally observed. The shales are dominantly grey with darker laminae (thin finegrained tuff -beds?). Very dark shale, probably rich in organic matter, is also observed.

The shales are very clean and free from detrial quartz feldspar and mica. Probably they are made up of finely suspended, slowly deposited, ash particles. Characteristically two poro-perm measurments on shales also give very high porosities (35%). The shales contain abundant pyrite present in scattered up ½ cm large aggregates of pyrite-microcrystals. Ash of basaltic composition could primarily have high iron-contents and thereby potential for pyrite-formation.

DEPOSITIONAL ENVIRONMENT/SETTING

Paleodating and environment interpretation give upper paleocene - lower eocene ages and indicate a bathyal to sublittoral depositional setting for the shales and tuffs.

The lack of detrital minerals (quartz, feldspar and mica) in the sequence indicates a distal basinal setting with respect to sand source and deposition along the western margin of the Viking Graben.

The strong normal grading of the tuff beds could be the result of gravity settling from turbidity currents, but the lack of stream-indicating structures (like ripple-marks) are not in favour for such an interpretation.

It is therefore concluded that the tuffs represent first-generation air-fall deposits and that their grading results from sorting during gravity settling through the atmosphere and the water-coloumn.

RECOMMENDATIONS FOR FURTHER STUDIES

To our knowledge these are the first cores available from the paleocene-eocene tuff-sequence in the Norwegian sector of the North Sea. As such they give an unique oportunity for detailed investigations and understanding of this important geophysical and geological marker horizon.

It would be of wide practical and theoretical value to make detailed studies of as many aspects of these cores (geological, geophysical and petrophysical) as possible .

This includes detailed petrographic descriptions and interpretations of the tuffs and shales, detailed paleo-investigations, and detailed studies of organic geochemistry to evaluate their potentials as source rocks.

WELL 30/2-1

DESCRIPTION OF LOWER TERTIARY SHALE AND TUFF DISTRIBUTION IN CORE 1 AND 2

☐ SHALE ■ TUFF

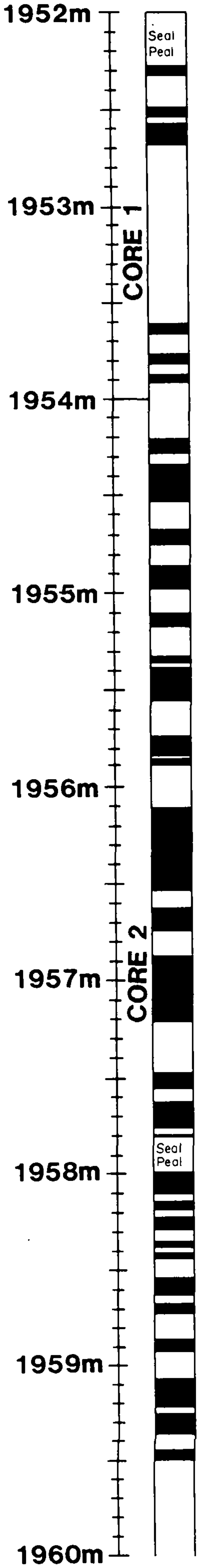

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FIG. 1

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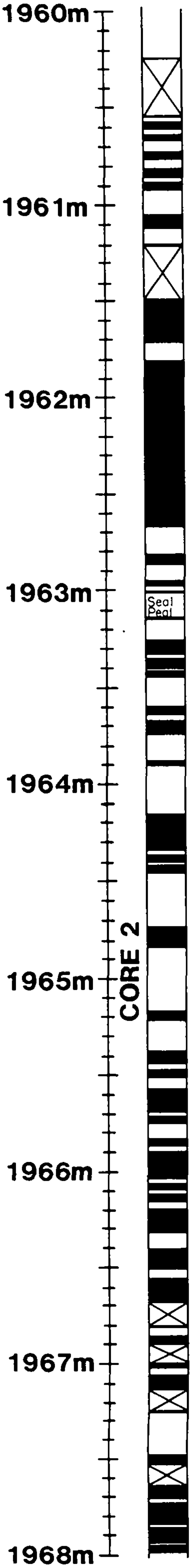
DESCRIPTION OF LOWER TERTIARY SHALE AND TUFF DISTRIBUTION IN CORE 1 AND 2

☐ SHALE ■ TUFF



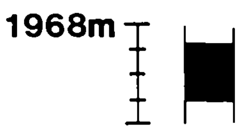


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TABLE 1.

Porosity, permeability and grain density of plugs from tuff-beds in 30/2-1 (measured by Geco).

DEPTH (M)	PLUGG NR.	HOR.PERM KA (mD)	KL	HEL.PO 0/0	G.DENS G/CC
1952.73	-	0.013	0.01	6.9	2.64
1953.60	1A	NMP	-	38.2	2.76
1954.69	2A	0.080	0.05	38.2	2.81
1954.91	3A	0.198	0.12	37.9	2.77
1955.14	4A	0.83	0.56	37.3	2.81
1955.45	5A	0.082	0.05	34.5	2.81
1956.49	6A	NMP	-	41.4	2.71
1957.45	8A	0.23	0.14	38.4	2.78
1957.90	9A	0.157	0.09	35.8	2.75
1959.24	10A	NMP	-	36.9	2.74
1961.61	-	0.31	0.19	28.5	2.67
1962.39	11A	NMP	-	39.0	2.74
1962.53	12A	0.113	0.07	40.1	2.75
1964.35	13A	NMP	-	44.3	2.78
1965.48	14A	NMP	-	40.2	2.75
1965.78	15A	0.125	0.07	37.3	2.77
1966.49	16A	NMP	-	29.2	2.68
1966.63	-	3.7	2.7	31.6	2.76
1967.68	17A	NMP	-	38.0	2.81
1968.03	-	0.05	0.03	32.1	2.78