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D.G.H. - D. EXPLORATION
LABORATOIRE DE GEOLOGIE DE BOUSSENS

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GEO/LAB Bss n° 7/1472 RP
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11/9-1 WELL
(NORWAY)

LITHOLOGICAL STUDY AND SEDIMENTOLOGICAL INTERPRETATION OF TRIASSIC DEPOSITS

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Boussens - MARCH 1977

LISTE DE DIFFUSION

DESTINATAIRES :

DIRECTION EXPLORATION puis DIVISION OPERATIONS PARIS	1
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DISTRICT 2	1
NORVEGE	~~2~~ 1

CONTENTS

1 - INTRODUCTION

The analysis has been carried out on 31 sidewall cores and 77 dish samples between 145 m and 1930 m. Unfortunately there were no cores.

The main purpose of this study was to determine the environment of Triassic sediments in the 11/9.1 well.

Deposits appeared very similar from the top to the base of sediments studied from the Triassic, but in fact there were some substantial differences based on grain size, sand ratio and chemical relations (calcite, dolomite).

These sediments are obviously of a continental origin and are made up of alluvial fans, and fluviatile deposits under an arid climate (sabkha).

2 - LITHOLOGICAL ANALYSIS (plate 1)

In the 11/9.1 well the sediments appear undifferentiated both with respect to lithology and in well logs.

Nevertheless the laboratory study has provided a zonation based on differences in the following :

- grain size
- sand ratio
- importance and nature of calcareous deposits
- presence of clay pebbles, micas etc.
- nature of clay minerals

The zonation in the well is for practical purposes, without references to a regional zonation ; in such a type of sedimentation (continental), precise examination of samples is required for lithological correlations.

145 to 178 m Sands:The deposits are made up of medium to coarse, angular, poorly sorted sand and interbedded fine to coarse, angular, poorly sorted, sparitic cemented sandstone with drusy mosaïc, features of micritic and drusy mosaïc infilling (microkarst ?) and probable red-brown shale.

178 to 425 m : Coarse argillaceous - calcareous sandstones

Deposits are constituted by generally positive sequences and some negative sequences and levels of soils.

Positive sequences are 2 to 10 m thick and are composed of :

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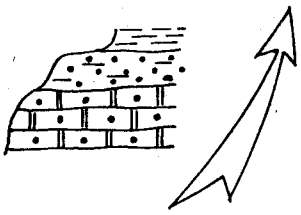


. red-brown shale

. fine to coarse, angular, poorly sorted, argillaceous to calcareous cemented sandstone

. fine to coarse, angular, poorly sorted, drusy mosaïc cemented sandstone

Negative sequences have the same facies in the reverse order. Some levels are made up of micritic microrecrystallized limestone with fine fractures infilled with drusy mosaïc and locally quartz grains.
Some beds contain numerous rounded red-brown clay pebbles cemented with drusy mosaïc.

425 to 603 m : Fine argillaceous sandstone and radioactive shales :

This zone is marked by the deflection of the Gamma Ray (radioactive shales).

The most recognizable facies are :

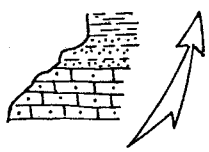
- Fine to medium, angular, poorly sorted, argillaceous-calcareous sandstone
- red-brown shale with locally abundant rhombs of dolomite, mostly sandstone in the upper part and shale in the lower part.

603 to 644 m Sands : Sediments are made up of interbedded medium to coarse, subrounded, moderately sorted sand and red-brown shales.

644 to 742 : Sandy, fine shales : This interval is mostly composed of red-brown shales with thin beds of fine to medium, angular, poorly sorted, argillaceous to sparitic sandstone. Frequent intraclasts of subrounded red-brown shale and micritic limestone with drusy mosaïc cement.

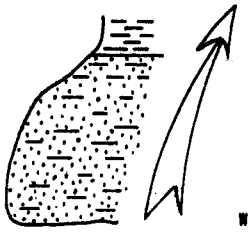
742 to 932 m : Silty shales : Red-brown shale and calcareous-argillaceous silt, rare thin levels of fine, angular, poorly sorted sandstone. Abundant chloritic grains.

932 to 1137 m : Calcareous silty shales : Positive sequences (3-5 m) composed of :



. red-brown shales
. red-brown, argillaceous, calcareous silt
. fine, angular, moderately sorted argillaceous, calcareous cemented sanstone

1137 to 1320 m : Fine, argillaceous sandstone :Positive sequences (5-25 m) composed of :



. red-brown shales
. red-brown calcareous argillaceous silt
. fine, angular moderately sorted argillaceous, calcareous cemented sandstone

with predominant argillaceous sandstone

1320 to 1477 m : Argillaceous silt : The deposits consist of interbedded light brown argillaceous silt and fine, angular, poorly sorted, argillaceous and calcareous (microsparite) sandstone.

1477 to 1598 m : Coarse argillaceous sandstone

From 1477 to 1547 m the deposits are mostly made up of medium to coarse, subangular poorly sorted sandstone with argillaceous-calcareous (microsparitic) cement and abundant feldspars and lithic fragments. There are thin intervals of fine sandstone.

From 1547 to 1598 m these deposits consist of the same coarse sandstone as above and interbedded grey-brown fine, angular, poorly sorted, argillaceous-calcareous sandstone with fine, subrownded clay gravel, abundant feldspars and lithic fragments, and volcanic debris.

1598 to 1682 m ; Fine, micaceous sand : Grey brown, very fine, angular, well to poorly sorted argillaceous and calcareous (microsparite) sandstone with abundant micas. Local porosity (5%).

1682 to 1730 m : Coarse, argillaceous sandstone : Deposits are mostly of fine coarse subangular, poorly sorted argillaceous to calcareous (local fibrous microsparite) sandstone and fine medium, subangular, poorly sorted argillaceous to calcareous cemented sandstone with lithic and volcanic fragments and local silty shales.

1730 to 1834 m : Upper silty sandstone brown, argillaceous, micaceous silt with abundant argillaceous chips and interbedded brown shale. Deposits become coarser upwards.

1834 to 1930 m : Lower silty sandstone : Interbedded, fine to medium, angular, poorly sorted argillaceous to dolomitic cemented sandstone, silty sandstone with centimetric graded bedding and micaceous red-brown shales. Deposits are progressively argillaceous downwards.

.../...

3 - MINERALOGICAL ANALYSIS

Analysis of the major minerals provides a certain amount of information :

- abundance of feldspars in sandstone deposits (5-15%)
- zone of calcite 737-1706 m ; zone of dolomite down to 1835 m.
- abundance of clays in sandstone.

Analysis of the clay minerals provides a good zonation

852 - 1585 m predominant illite (40-60%) and chlorite (20-35%) with smectite up to 1350 m (10-20%)

1625 - 1813 m predominant corrensite (50-80%) with chlorite (10-20%) and illite (5-30%)

1813-1940 predominant interlayered chlorite-smectite (30-60%) with illite (20-45%) and chlorite (20-30%)

4 - SEDIMENTOLOGICAL INTERPRETATION (fig. 1)

4.1 - Environments

The Triassic deposits of the 11/9.1 well are obviously continental under arid climatic conditions (sabkha)

- lack of microfauna
- oxydized red colour
- presence of mud cracks, minikarstic features
- abundance of lithic fragments and feldspars
- film of clay around sands and gravel materials
- lack of sorting
- presence of abundant milky quartz grains

There are however constituted by various sediments as seen in the

- change in grain size
- change in sand ratio
- various types of elementary sequences
- zonation of clay material
- zonation of major mineral material

The different characteristics of the sediments indicate that they are not linked to fluviatile deposits but alluvial fans or sebkha deposits. The presence of alluvial fans is shown by :

- the thickness of sediments
- irregular deposition of various types of sediments
- the lack of sorting and the varying morphoscopy (angular to subrounded)
- presence of red-brown soil (also in sebkha deposits and flood plain)
- abundance of feldspars and lithic fragments

..../...

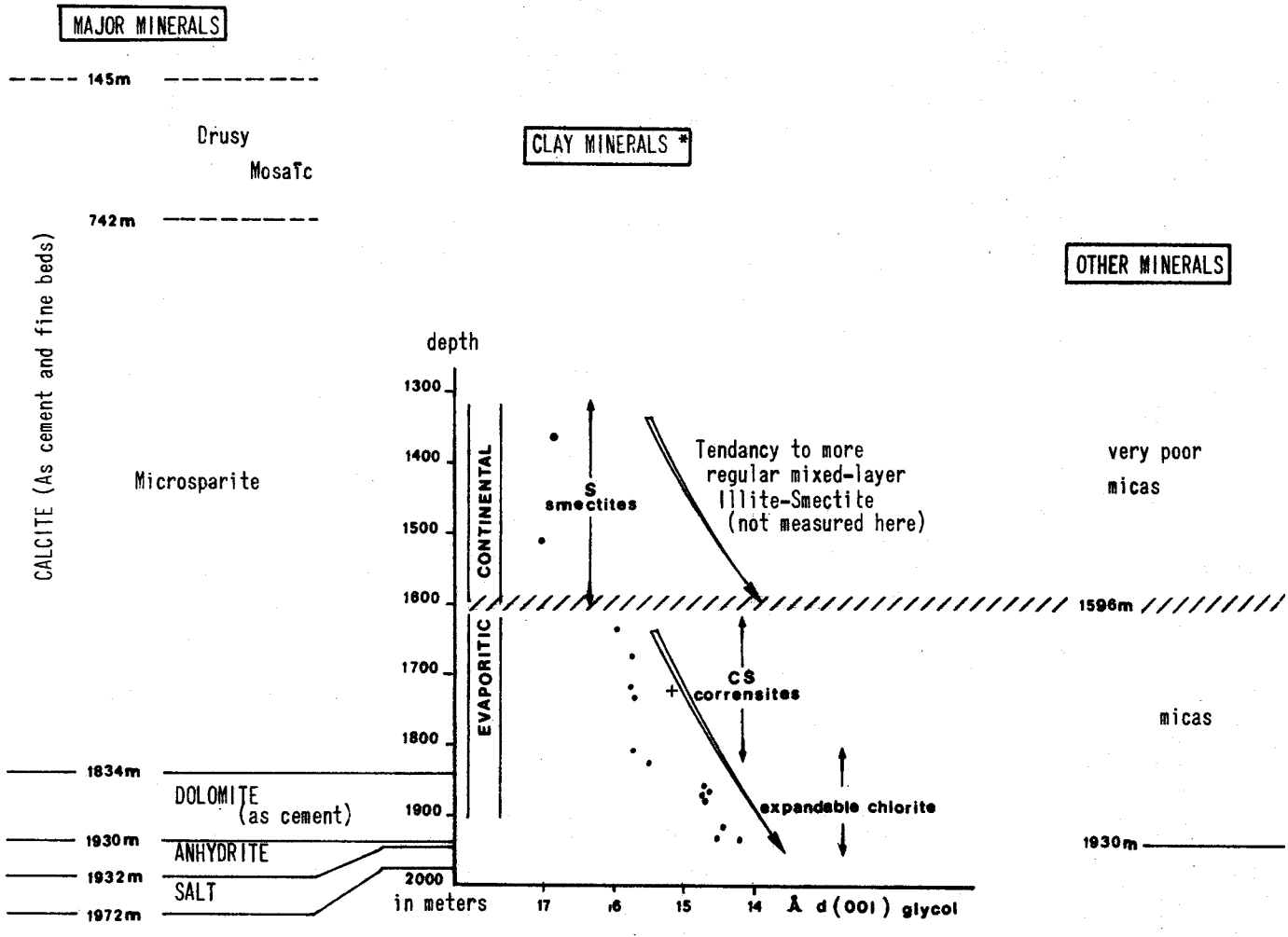
- presence of graded bedding
- film of clay around sands and gravel
- presence of clay pebbles and probably of boulder-clays
- abundance of sequences fining upward (significant for fluviatile or margin littoral deposits aswell).
- lack of well-characterized sequences of fluviatile deposits (bed-load, channel, levee, flood plain).

The most coarse sediments may be assigned to the debris flow of an alluvial fan. The finest material is linked to sandy sebkha facies and mud flow (distal part of the fan).

4.2 - Vertical succession

The vertical succession of deposits is characterized by :

1 A mineralogical evolution



* Clay minerals interpretation after Pr. Dunoyer de Segonzac - Strasbourg University

The succession which has been observed is related in particular to carbonates and clay minerals.

1 Carbonates : the presence of drusy-mosaïc structures between 145 and 742 m is evidence of fresh water influences, perhaps during the Jurassic age or later.

Below this, between 742 and 1834 m, there is a substantial recrystallisation of calcite.

2 Clay minerals : the mineralogical assemblage of detrital origins, composed of Illite/chlorite/smectite, undergoes a diagenetical evolution of two sorts, from the top to the base :

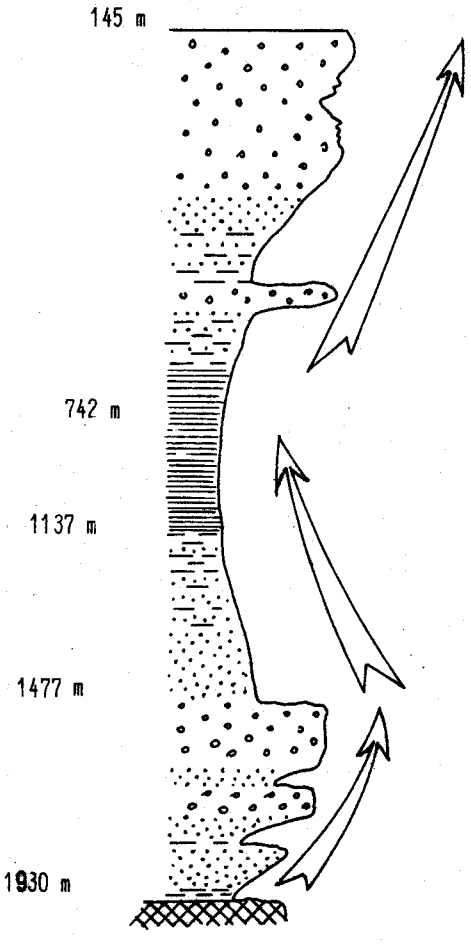
- above 1596 m an alkaline potassium diagenesis in the continental deposits, with a tendancy for the mixed layers Illite/Smectite to become more regular

- below 1596 m, a magnesium diagenesis in evaporitic deposits, with :

Smectite ⟶ (Corrensite) ⟶ expandable Chlorite ⟶ Chlorite

/2/ A detrital evolution

The vertical is characterized by grain size change and/shale ratio change



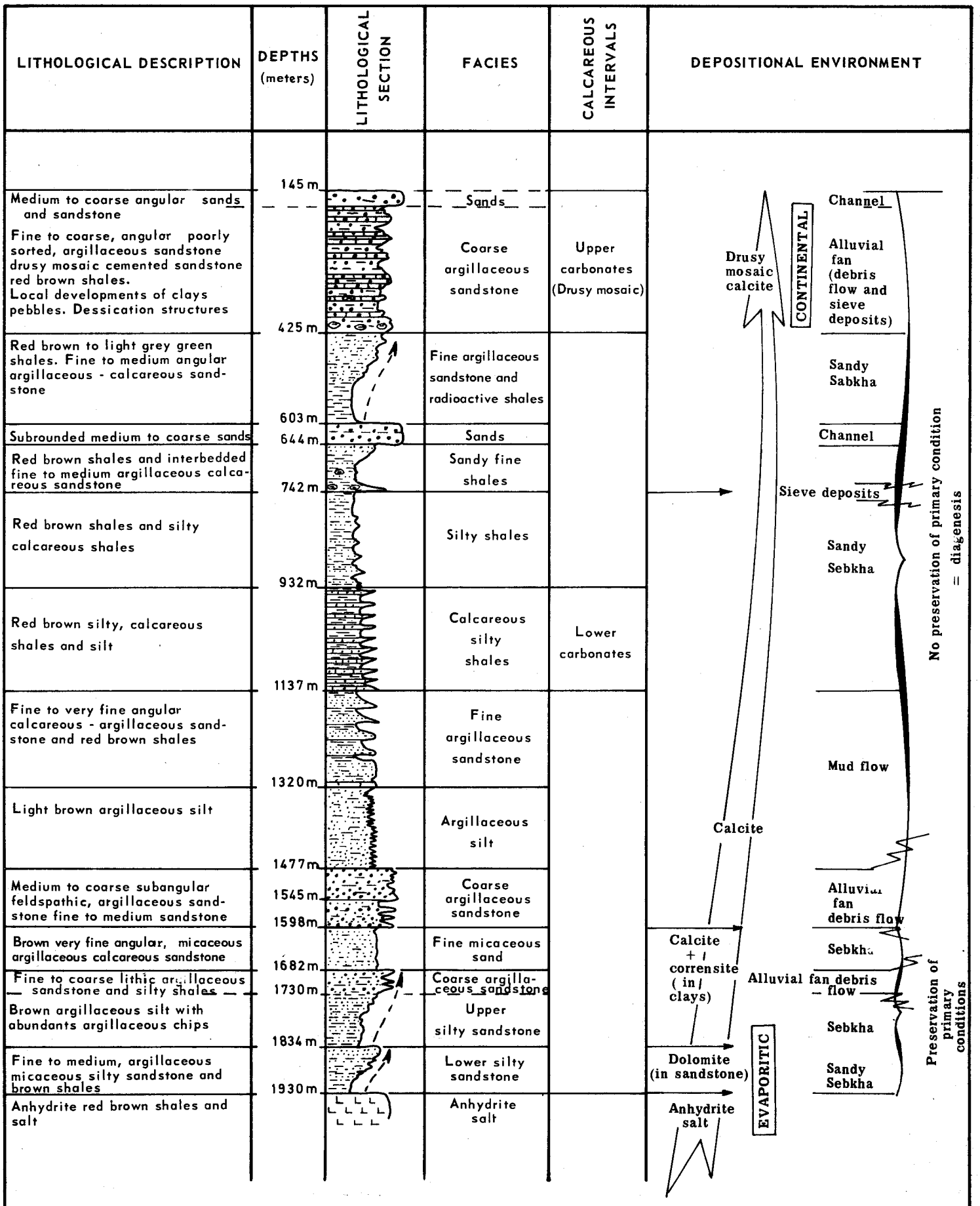


Fig. 1 : 11/9-1 WELL - SEDIMENTOLOGICAL INTERPRETATION OF TRIASSIC SERIES

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Scale : 1/10.000

The vertical sedimentological evolution can be summarized as follows (fig. 1) :

- 1930-1834 m : Fine detrital sedimentation with substantial chemical influence = sandy sebkha in pre-evaporitic conditions
- 1834-1598 m : Fine detrital sedimentation with local coarse deposits ; noticeable chemical influence (correnSite) = sandy sebkha or lacustrine deposits with some alluvial fan debris flow.
- 1598-1477 m : Coarse material = alluvial fan debris flow
- 1477-1137 m : Fine detrital sedimentation which could be linked to a mud flow at the distal part of the alluvial fan.
- 1137-425 m : Very fine sediments (mostly argillaceous) of sebkha (flood desertic plain) with only one level of coarse sand (probable fluviatile channel).
- 425-145 m : Coarse material = alluvial fan debris flow with some sands of probable fluviatile channels.

5 - CONCLUSION

In this well the Triassic deposits are linked to a characteristic alluvial fan sedimentation with mid fan (debris flow) or distal fan under an arid climate (Sabkha) explaining the thickness of the series, the abundance of clay material even in sand, and the very poor development of reservoirs. This sedimentation is a part of the massive development of detrital series around the norvegian shield (fig. 2)
In these conditions it seems difficult to disclose an interesting prospect related to the Triassic deposits in such an area.

Very poor conditions exist for the presence of :

1 - organic matter (continental depositional environment, oxydization, fresh water diagenesis)

2 - reservoirs (abundance of clay material)

3 - entrapment of hydrocarbons (lack of reservoirs, difficulties as regards dismigration such thick heterogeneous material and lack of overlying shales).

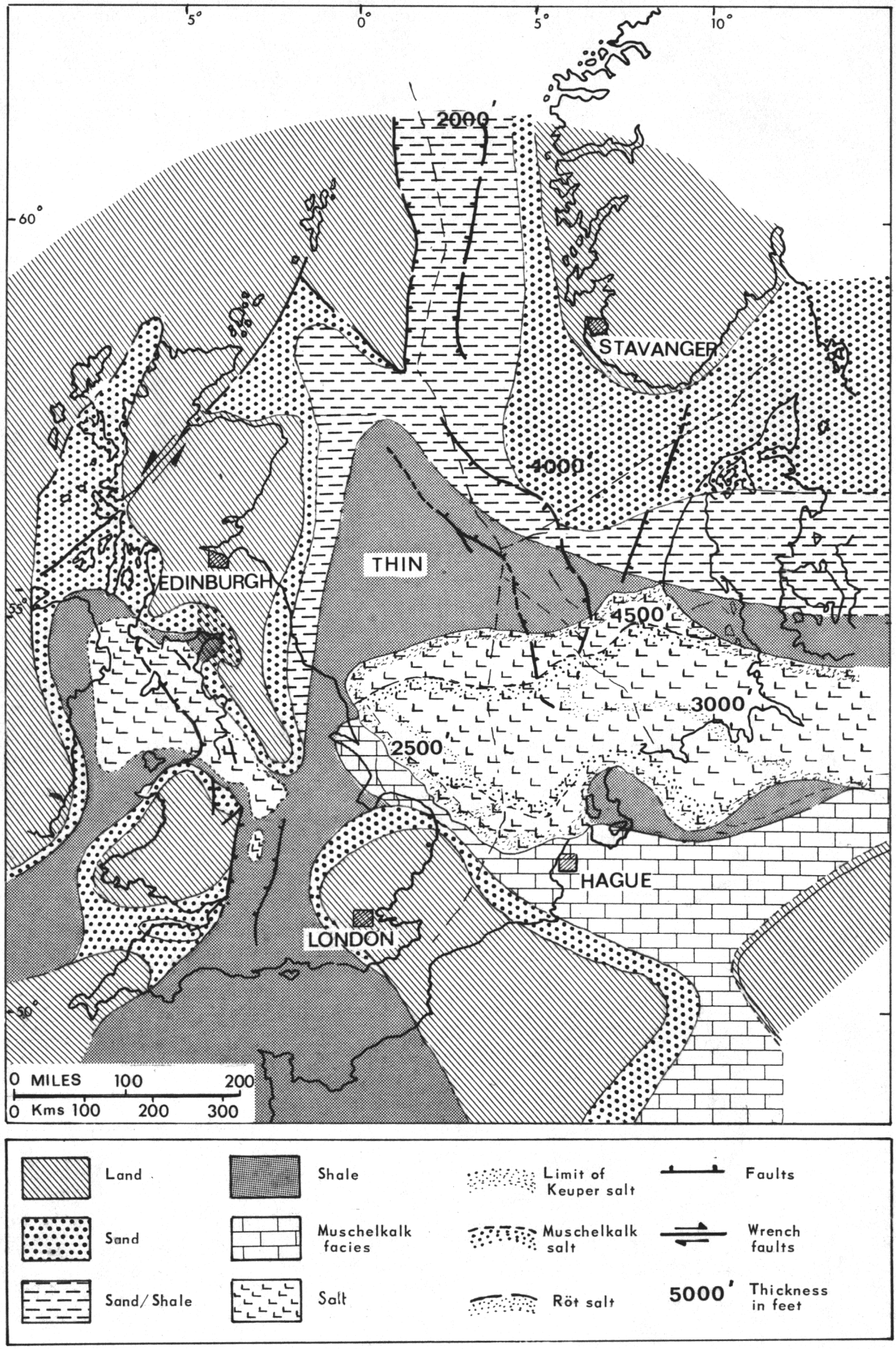

Fig.2 : MIDDLE/UPPER TRIASSIC PALAEOGEOGRAPHY (by W.H. ZIEGLER)

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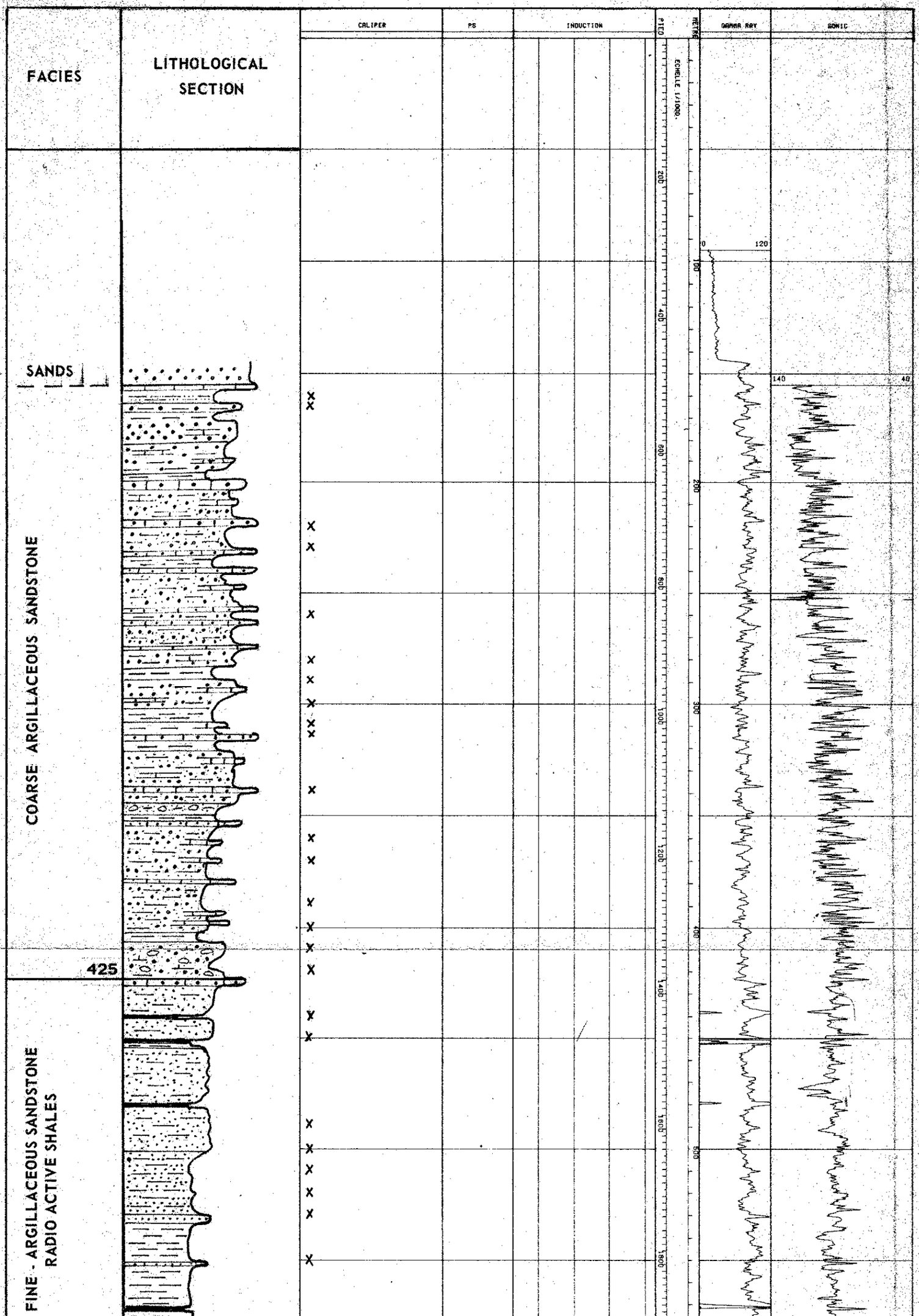
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CALIPER
PS
INDUCTION
PIED
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ECHELLE 1/1000.
GAMMA RAY
SONIC
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40
SANDS
COARSE ARGILLACEOUS SANDSTONE
425
FINE - ARGILLACEOUS SANDSTONE
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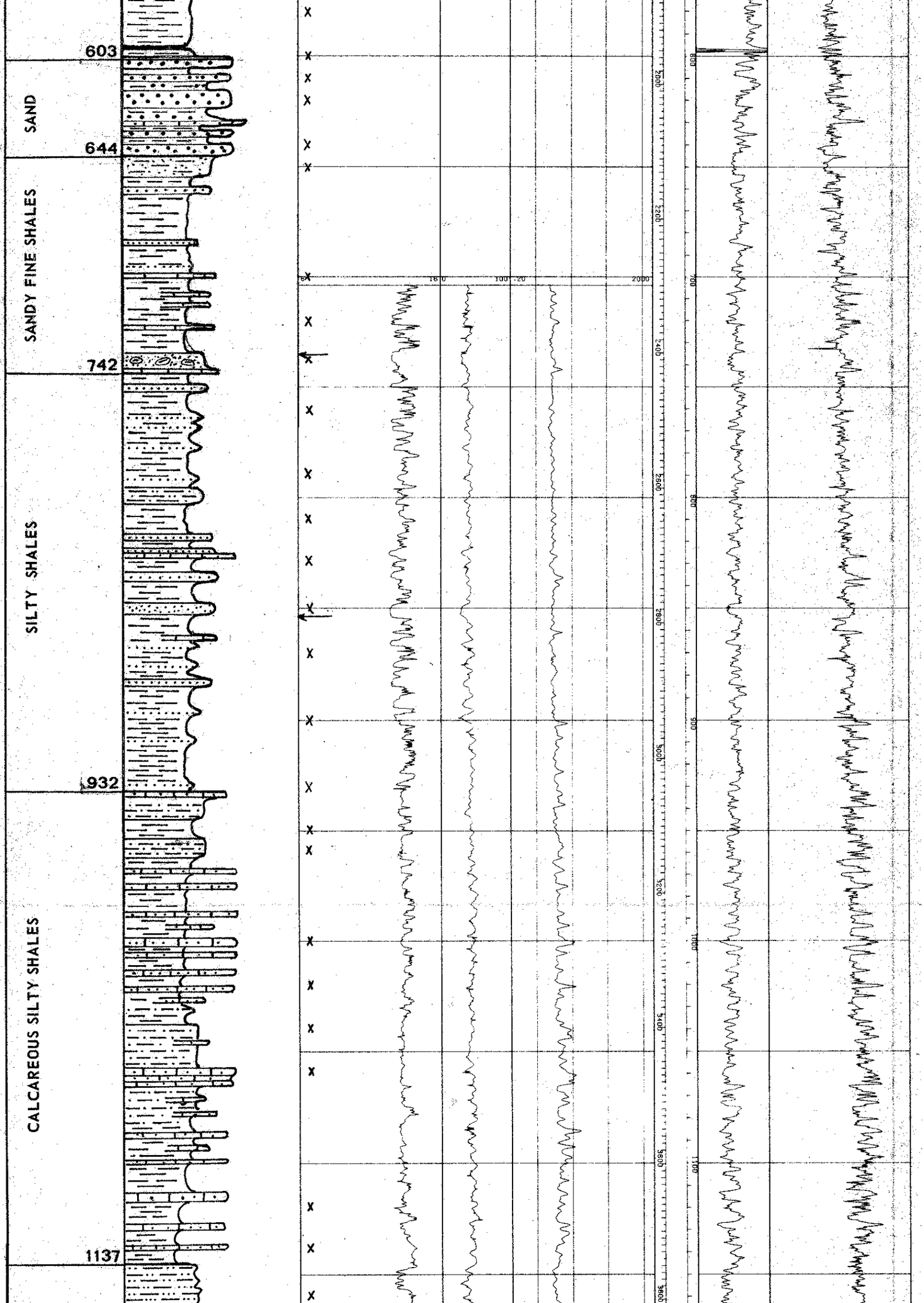
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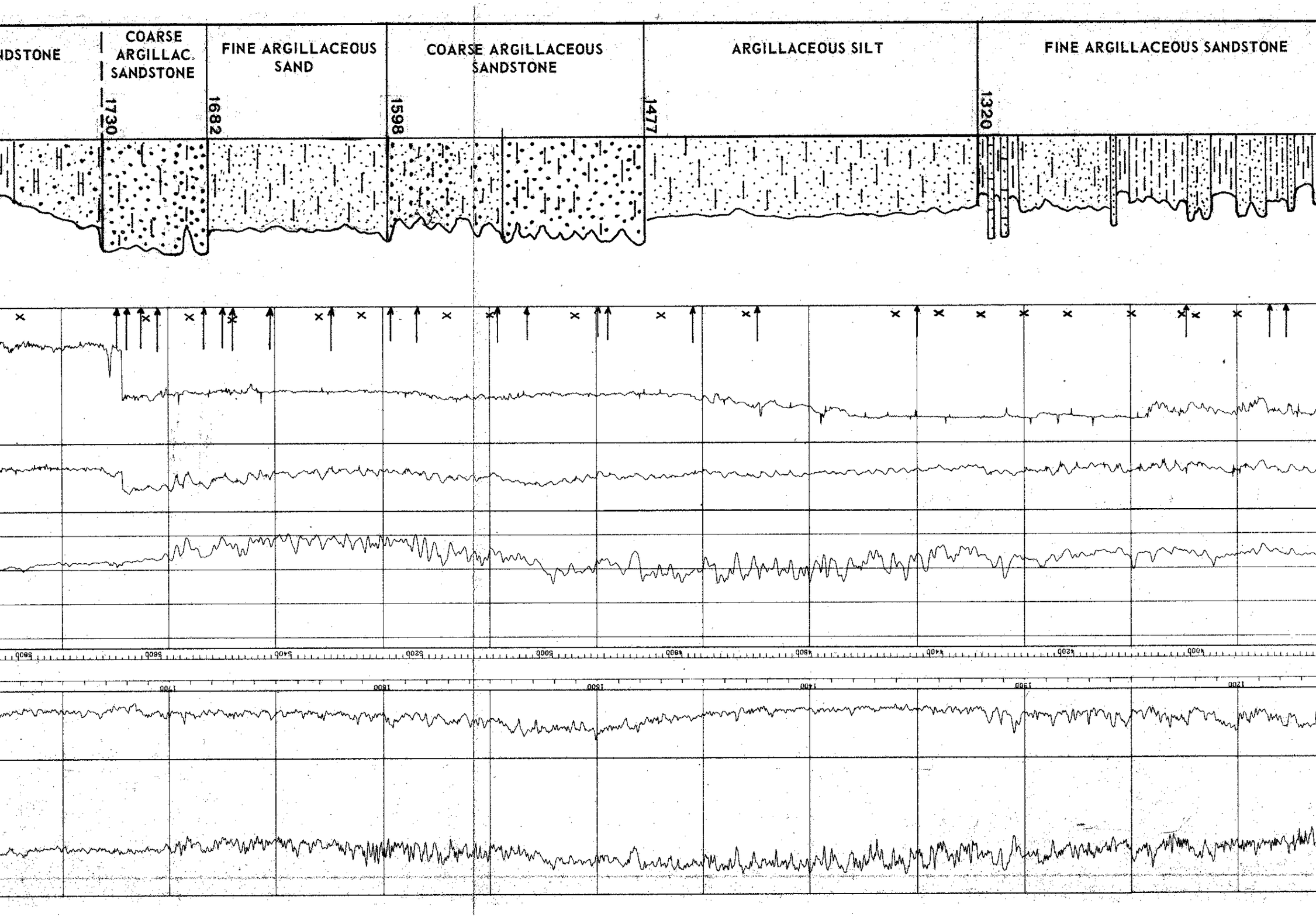
SANDY FINE SHALES
742
SILTY SHALES
932
CALCAREOUS SILTY SHALES
1137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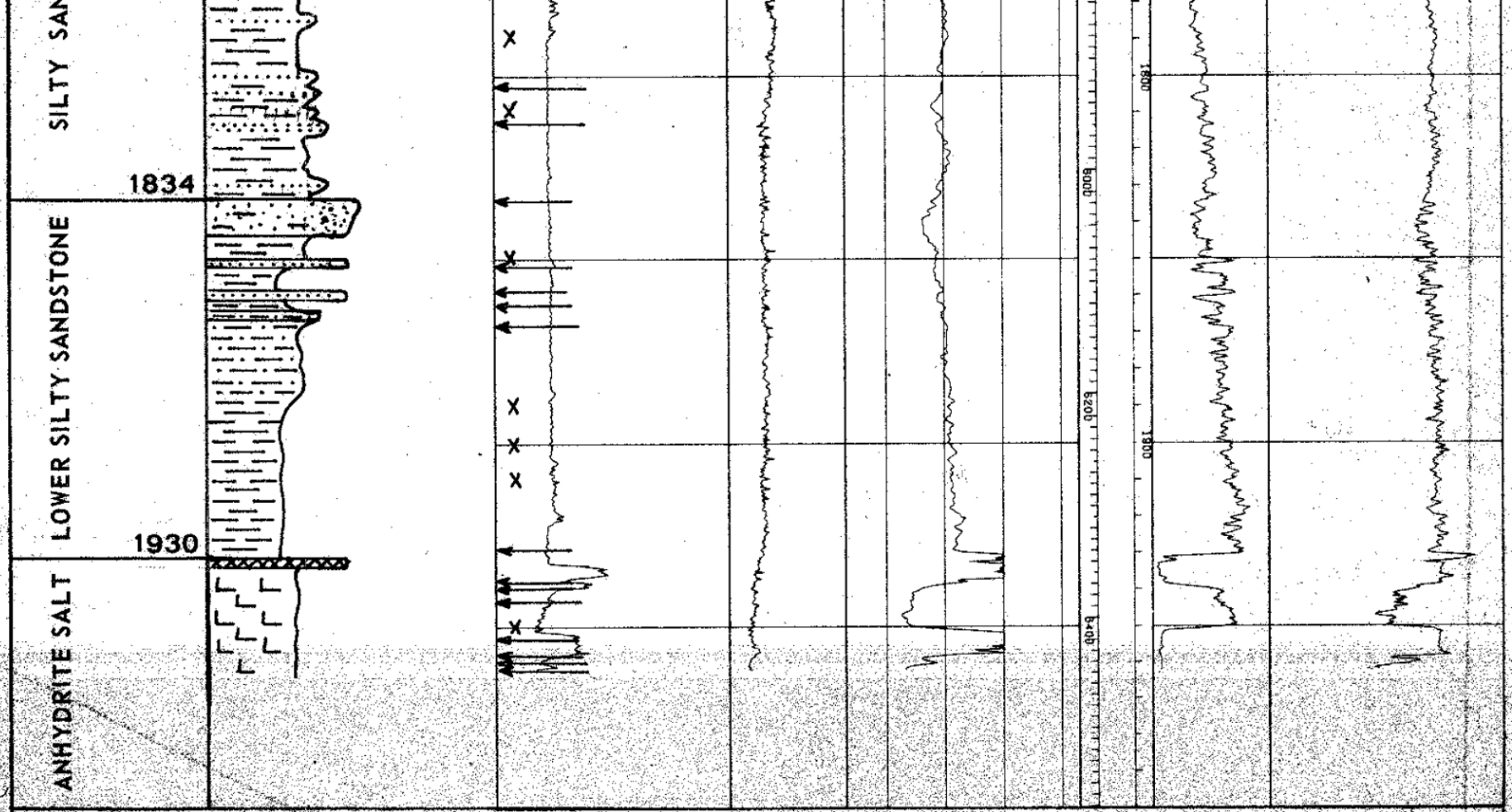

- Shale
- Argillaceous pebbles
- Fine sandstone
- Fine argillaceous sandstone
- Medium to coarse sand
- Fine to coarse argillaceous sandstone
- Silty sandstone
- Fine calcareous sandstone

elf	Secteur: NORWAY OFF SHORE	PETRONORD
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	Permis ou Concession: Block 11/9	

11/9-1 WELL

LITHOLOGICAL ANALYSIS OF TRIASSIC SEQUENCE

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SNEA ENTREPRISE DE RECHERCHES ET D'ACTIVITES PETROLIERES	PL.1	Date: Mars 77
DIRECTION EXPLORATION		CUSSEY
LABORATOIRE		Dossier: CH 176