The Subsurface Mesozoic geology of SW Scania, Southern Sweden

well descriptions and annotations on stratigraphy, structural geology, depositional environments and diagenesis

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by

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INTRODUCTION

The sedimentary sequence of south-west Scania has for decades been the target for various research and exploration efforts. Deep drilling started at the end of the 1930ies and during the subsequent years until the mid-1950ies most of the deep tests were performed on which most of our present knowledge is based regarding the subsurface geology. A new exploration phase was initiated ain 1969 when exploration for hydrocarbons started resulting in a vast material of seismics and well data. Two additional campaigns for hydrothermal energy and gas storage has since added the amount of subsurface material available.

Characteristic for all investigations dealing with SW Scania is the way material has been utilized. Only selected stratigraphical levels have been treated either in connection with biostratigraphical analyses or in connection with investigations of suitable reservoir and capping horizons.Thus, most boreholes still lack a reliable stratigraphical division and lithological description.

Totally a huge amount of subsurface material has accumulated from the various investigations mentioned, including several kilometres of cores and several hundreds of kilometres of seismic profiles. Very little has been published and in general the degree of treatment is low and fragmentary. Data on e.g. sedimentological properties are almost non-existing, and few seismic structural maps or properly identified seismic markers have been published. The stratigraphical division of SW Scania is also rudimentary and has not changed much since the original well description of the Höllviken 1 and 2 boreholes by Brotzen (1945, 1950). Some additional information has been published regarding proved stratigraphical intervals within the Jurassic - Lower Cretaceous intervals in some OPAB wells, i.e. Norling & Skoglund 1977 and Norling 1981. The stratigraphical and sedimentological knowledge is comparatively advanced for the Late Triassic and Jurassic strata of the Tornqvist Zone, but this knowledge has not been transferred in an acceptable way to the sequences penetrated in SW Scania. This circumstance is quite obvious when reports from various exploratory campaigns are studied . Unfortunately, some of these reports have been referred to in various papers without critical control, which means that false data on e.g. stratigraphical divisions and thicknesses have been introduced. and been referred to.

The need for a modern comprehensive treatment of existing subsurface material has relevance for many different research projects dealing with the sedimentay and structural history of the area, e.g. the interaction between the Fennoscandian Shield and the Danish-Polish Trough along the structurally important Tornquist Zone, and also for e.g. assessments of stability properties of the bedrock for construction purposes (e.g. tunnels, bridges), environmental effects of gas and fluid storage in sedimentary reservoirs,etc.

The present project aims at a better understanding of the subsurface geology of SW Scania in order to fulfill some of the goals listed above. For practical purposes we have initially limited our study to the Upper Triassic -base Upper Cretaceous, i.e. a sedimentary record of more than 1000 m. To obtain the best core material available we have selected two cored boreholes, i.e. Höllviken 2 and Svedala 1, which both cover most of the Mesozoic sequence. Both wells are also located in two different structural settings, i.e. Höllviken 2 within a graben structure, i.e. the Höllviken Graben, and Svedala 1 on the rim of the elevated Skurup Platform. In addition, the intermediate and close position of Höllviken 2 to Höllviksnäs 1 and Ljunghusen 1 wells, which both are wire-line logged, means that biostratigraphically dated core sequences in Höllviken 2 can easily be correlated with logged but uncored sequences in the two other wells mentioned.. Consequently a more reliable stratigraphical division may be obtained in the number of uncored wells now available within SW Scania as a result of the last decades of prospecting activities. Caution is necessary,however, in carrying these wire-line correlations too far, especially in the non-marine Triassic and Jurassic/Lower Cretaceous sequences with numerous depositional breaks and facies changes. Fortunately there are some short cored intervals in most wells within the section mentioned which means that these cores together with safely correlated cuttings can be dated biostratigraphically and provide us with important key horizons for safe datings (e.g. in Norling 1981 and in unpublished OPAB well reports).

This study includes biostratigraphical investigations, petrographical and diagenetical analyses and a survey of the structural conditions of SW Scania based on seismic data. Based on the obtained results reconstructions are made of the depositional history of the sediments, their thermal history, geochemical history and age . Furthermore the structural history is outlined and assessments on reservoir conditions are performed.

Previous investigations

A comparatively rich subsurface material is available from Scania and the adjacent offshore areas, particularly from the prospecting work carried out by Oljeprospektering AB, OPAB, during the period 1969-1979. Through these investigations an abundant geological and geophysical material is available including data from a number of deep wells, Fig. 1. SW Scania and the offshore areas adjacent to Scania was covered by seismic surveys together with air-magnetic and gravimetric surveys. Totally 16 deep wells were drilled, four of these being drilled offshore. These wells were mainly concentrated to the southwestern part of Scania, but local basins as the Hanö Bay, the Vomb Basin and the Ängelholm Basin were also drilled.

Prospecting for geothermal energy was performed in the early 1980ies in the area immediately SW of Lund. Thus 12 wells have been drilled down to levels between 800 and 1000 m to reach sandstone reservoirs of Campanian age.

The most recently obtained material from the subsurface of SW Scania derives from the gas storage exploration by Swedegas AB between 1978 to 1985. Abundant seismic works was carried out and seven shallow wells to 1000 m were drilled in an area close to the NE margin of the SW Basin. Some older OPAB seismics were also reprocessed.

Earlier inverstigations, primarily by SGU, have aimed at the investigation of the Scanian sedimentary rocks for their potential for salt and hydrocarbon accumulations. Those investigations included a limited amount of geophysical recordings and some deep boreholes. The work by SGU mainly covered the SW part of Scania.

In NW Scania, coal and fire-clays of late Triassic and Jurassic age have been exploited since the late 18th century. Thus, a rich documentation from this area comprising material and data from numerous wells, mining data and data from geophysical investigations are available and now being stored and archived by SGU in Uppsala.

Additional material of importance for the understanding of subsurface conditions in Scania include hydrogeological data, partly as a result of investigations performed by SGU. The base data from these works are filed in a hydrogeological database run by SGU.

To summarize, it can be concluded that the available documentation from Scania from the activities mentioned gives a fairly good picture of the subsurface geology. It must be stressed, however, that the treatment of this documentation varies considerably, and much material is still poorly investigated or compiled. Partly this circumstance depends on the fact that various prospecting activities have been limited geographically and the quality of the material is variable. The last note is especially relevant for the geophysical material. The low degree of treatment of some material is also dependent on the philosophy behind the prospecting work. Thus, OPAB' s main work was directed towards levels below the base of the Upper Cretaceous, while, e.g. the exploration for hydrothermal energy and sites for gas storage mainly investigated clastic levels in the Upper Cretaceous, while other levels were disregarded despite the existance of relevant data.

STRUCTURAL FRAMEWORK

Numerous papers treat the regional structural framework of South Scandinavia. For comprehensive accounts reference is made to e.g. Ziegler 1978, Pegrum 1984, Bergström 1985, Norling & Bergström 1987, Liboriussen *et al.* 1987,EUGENO-S 1988, and Bergström *et al.* 1990a, 1990b . A regional seismic mapping of the area was presented by Baartman & Christensen (1977) when the main lineaments were identified.

The modern structural concept of the region includes the designation of three main structural units. Thus, the stable Fennoscandian Shield area is separated from the more mobile Danish-Polish Trough by the Tornquist Zone, previously partly referred to as the Fennoscandian Border Zone (Fig. 2). This Zone forms a complicated tectonized zone with a history extending at least back to the Late Carboniferous - Early Permian with several later periods of reactivation during the Kimmerian (Jurassic- Early Cretaceous) and Laramidian (Late Cretaceous - Early Tertiary) tectonic phases. Inversion movements are especially characteristic within this zone. There are reasons to believe that some tectonic lineaments were also formed already in the early Palaeozoic, later being rejuvenated during Variscan and Kimmerian movements.

The Tornquist Zone

The Tornquist Zone (TZ) forms a 50-70 km wide zone oriented NW-SW across Scania from the Båstad area to Landskrona in the NW to Åhus-Ystad in the SE. The Zone continues towards the NW into Kattegat here designated as the Sorgenfrei-Tornquist Zone (EUGENO-S 1988) and in the SE into the Baltic (Pegrum 1984), here also being referred to as the Tornquist-Teissyre Zone. The TZ shows a characteristic development of the bedrock surface into a mosaic pattern of rock units of different ages, mainly due to tectonical activity during several phases of the Phanerozoic era. The zone is characterized by numerous NW to SE oriented faults , resulting in the formation of mutually dislocated blocks, i.e. a horst and graben pattern. Commonly the basement blocks are tilted towards the southwest. It may be assumed that these dislocations occurred in connection to the Variscan orogeny in Late Carboniferous - Early Permian time. Further evidences of crustal activities are demonstrated by numerous dolerite dikes of Permo-Carboniferous age which characterize the entire TZ in Scania . These dikes are all clearly directed NW-SE. No dikes of similar age has been recorded SW of the Tornquist Zone. Only one occurrence of a penetrated dolerite is known, i.e. in the Barsebäck 1 well where a dolerite is reported between the crystalline gneissic basement and the red-beds of assumed Keuper age (unpublished OPAB well report). No dating has been attempted yet of this dolerite. It should also be added that reworked late Palaeozoic palynomorphs have been proved in Jurassic strata in Scania (Guy-Ohlson et al. 1987) and on Bornholm (Nielsen & Koppelhus 1991) indicating that Carboniferous strata may occur not far away from the Tornquist Zone .

Compared to the Danish-Polish Trough, the TZ exhibits a different development of the Triassic, as Early and Middle Triassic deposits are lacking entirely. The TZ also lacks the thick cover of Upper Cretaceous carbonates, however, scattered Cretaceous outliers and flint erratics in northern Scania and southern Småland suggest a more northward distribution earlier of Cretaceous strata (Lidmar-Bergström 1982). There are furthermore main differences in the facial development of the Upper Cretaceous as mainly clastic sediments were deposited compared to the Danish-Polish Trough. These near-shore deposits occupy two minor basins, i.e. the Båstad and Kristianstad Basins, each with a basement surface dipping gently towards the south where the basins are limited by faults. These faults commonly define the northern limit of the Tornquist Zone, which broadly can be recognized as a major inversion axis . The south-western boundary of the Tornquist Zone is formed by the important Romeleåsen Fault and Flexure Zone (RFFZ) and by the Fyledalen Fault and Flexure Zone (FFFZ). Basement rocks are exposed in the Romeleåsen Horst and in some small horsts along the Fyledal Fault and Flexure Zone and within the Lower Palaeozoic rocks of southeasternmost Scania. The area between the Romeleåsen Horst and the Fyledalen Fault and Flexure Zone forms a northeaterly down-faulted basin,i.e. the Vomb Basin, exposing a sedimentary sequence of approximately 1000 m of Upper Triassic to Upper Cretaceous sediments resting directly on the crystalline basement.

The Danish-Polish Trough

The area south-west of the major lineament forming the Romeleåsen Fault and Flexure Zone (RFFZ) and the Helsingborg-Grenå Fault, i.e. the Danish-Norwegian Basin only constitute a western part of the Trough, which extends from the North Sea in the NW via Jutland, Zealand, and SW Scania joining southeasterly up with the Polish Trough. The age of this structural unit is not entirely clear. The fact that thick beds of Permian volcanics and younger Permian sediments occur at the base of some deep wells in Denmark, e.g. Rödby 2 on Lolland, has been interpreted by Danish geologists as an evidence of a Permian origin of this basin. It is known that the Permian period was tectonically very active (the Variscan orogeny), thus giving the hypothesis of a Permian age of the Danish-Polish Trough a certain credability. The bottom of the basin correspond to the major sub-Permian unconformity, i.e. resting on tilted Cambro-Silurian sediments occupying down-faulted blocks.

In Scania no Permian deposits have been proved, but undoubtedly the NE limit of the extension of Permian sediments is very close to the Swedish territorial boundary.
The Danish-Polish Trough is dissected by a major elevated area running W to E, i.e. the Ringkøbing-Fyn High (RFH). It has no representation at the bedrock surface , however, but is clearly obseved in wells with the crystalline basement being penetrated at depths between 800 and 1000 m and is also easily discernible from seismic surveys. At some parts this high is transected by north-south running grabens. The RFH partly extends into Swedish territorial waters by the Mön Block being cut in the east by the Carlsberg Fault and also being penetrated by one of the OPAB offshore wells, i.e. Falsterborev 1. In this well thin Upper Triassic sediments rests directly on Silurian shales. Some authors consider the Arkona High as the easternmost continuation of the RFH (e.g. Pegrum 1984), which infers that the half-graben defined by the Carlsberg and Svedala Faults could correspond to the north-south transecting troughs dissecting the RFH in the west, e.g. the Horn and Brande Grabens (EUGENO-S 1988). A Variscan age of the RFH is inferred from the onlap conditions of Triassic sediments on the crystalline basement. No reactivation of the RFH seems to has taken place during the Mesozoic. Two subbasins

can be distinguished on either side of this high, i.e. a northern Danish Subbasin and a southern German Subbasin.

During the Triassic, the Danish-Norwegian Basin subsided continuously and thick clastic deposits were formed: in SW Scania almost 700 m, in central parts of the basin 1700 m or more. At the end of the Triassic a new phase of tectonic activity is significant for the area with extensive faulting of the sedimentary sequence. This active period persisted through the Jurassic into the Lower Cretaceous and is known as the Kimmerian orogeny (cf. Norling & Bergström 1987). It also included volcanic activity in Scania as can be seen from the occurrences of numerous basalts within the TZ. The Kimmerian movements are the main causes for the variable development of the Jurassic and the Early Cretaceous deposits in Scania, and undoubtedly, they also influenced the sedimentary pattern in the southern Kattegat area. The typical development of the bedrock surface with alternating horsts and grabens oriented in a NW-SE direction, strongly controlled the sedimentation within the area.

The next period of tectonical disturbances occurred in Late Cretaceous time due to the subhercynian orogenic phase. The influence on the Danish-Norwegian Basin involved a continuous subsidence of the area, especially towards the Tornquist Zone, which made the accumulation of very thick Upper Cretaceous deposits possible.

In the Tertiary, the tectonic movements influencing the area comprised a rejuvenation of existing fault zones, but new faults were formed as well. Thus, the final structural outline as seen today was created, especially emphasizing the flexure development of the Romeleåsen Fault and Flexure Zone and its continuation towards the NW. A general uplift of the area resulted in denudation of existing sediments and the migration of the shoreline towards the south-west. Since then, Scania and parts of the adjacent offshore areas have formed positive areas.

South-west Scania may be divided into different structural units delimited by major faults. A major basin is formed by a down-faultad area between the Carlsberg and Svedala Faults, herein called the Höllviken Graben. This basin is terminated southwards in the Baltic at the intersection between these two major faults. The northern limit is less well defined due to poor seismic coverage, but it is likely that the graben shallows up northwards thus in fact forming a half-graben . Lower Palaeozoic and possibly also Early-Middle Triassic deposits have been eroded as suggested by the penetrated section in Barsebäck 1 and Norrevång 1 where Upper Triassic red-beds rest directly on the crystalline basement. Possibly,this northern part should be regarded as a separate structural unit, which, in fact, bears several common features with the Skurup Platform. It could tentatively be referred to as the "Landskrona Platform". Within the Höllviken Graben minor tilted blocks occur in association with minor faults.

The area east of the Svedala Fault comprises an elevated area with a basement tilting towards the Romeleåsen Fault and Flexure Zone and with most of the Palaeozoic rocks eroded. This area extends eastwards to the Rönne Graben west of Bornholm and it has been called the Skurup Platform. Due to few wells and inferior quality of the seismic records not much is known about the nature of this elevated area.

REVIEW OF THE MAJOR GEOLOGICAL FEATURES OF SW SCANIA

The Crystalline Basement

In SW Scania crystalline basement rocks have only been proved in four onshore wells, i.e. Barsebäck 1, Norrevång 1, Mossheddinge 1 and Svedala 1 (Fig 1). Significantly these wells occur within an area where Lower Palaeozoic rocks are lacking or are rudimentary developed due to late Palaeozoic inversion movements. In these wells partly weathered gneisses and granites (Mossheddinge 1) form the basement. Depth to basement varies between 1600 and 2000 m below mean sea level. A deeper basement is recorded in the southwesternmost Scania, i.e. within the Falsterbo Peninsula ,where a depth of around 3000 m b.m.s.l may be suggested in Höllviksnäs 1 (TD 2608 m subsea in top Lower Cambrian). The deepest parts occur along the major faults delimiting the Höllviken Graben, i.e. the Carlsberg Fault with depths exceeding 3000 m and along the Svedala Fault where depths of 2900-3000 m are indicated by the seismics.

The Lower Palaeozoic

Lower Palaeozoic strata are only partly preserved in SW Scania. From seismic investigations and from well data it is clear that Palaeozoic beds are missing along a wide zone adjacent to the Romeleåsen Horst and Flexure Zone and also within the Vomb Basin (Larsson 1984). The preservation of Palaeozoic strata in the Höllviken Graben is clearly dependent on existing major faults and their activity during the Late Palaeozoic. This can be seen from two wells drilled on either sides of the basin, i.e. Falsterborev 1 and Svedala 1, in which the former well exhibits a rudimentary Palaeozoic sequence (172 m+), the latter well with only 30 m of assumed Palaeozoic strata remaining. Towards the E and the NE the seismics show that thin Palaeozoic beds are developed across the Svedala Fault into the Skurup Platform, but the uplifts caused by Variscan movements have tilted the strata causing a denudation boundary towards the N-NE.

Reflecting the trend of the basement surface, the top Palaeozoic is dipping towards the major faults. Within the Höllviken Graben, several small fault-blocks are tilted causing differential erosion of the Palaeozoic strata. In the various wells, where the sequence has been penetrated, different ages of the youngest Palaeozoic are found.

In most wells where these strata have been recorded a good agreement with outcrops within the Tornquist Zone in lithostratigraphical and facial development may be observed and a satisfying correlation may be obtained.

The Upper Palaeozoic

No Upper Palaeozoic rocks have been proved in the wells drilled in SW Scania. The extensive Late Palaeozoic denudation seems to have removed any possible deposits of this age, but still it may not be excluded that some remains may be left in the deepest parts of the Höllviken Graben, i.e. along the Carlsberg Fault where thick beds of pre-Keuper age are indicated by seismics. A more fully representation of Silurian strata may, however, also be inferred for these accumulations. The possibility for remaining Carboniferous-Permian strata is supported by the presence of reworked palynomorphs of this age in Jurassic strata as shown by Guy-Ohlson *et al.* (1987).

The Triassic

In SW Scania , the most complete development of Triassic strata is found in the Höllviken Graben, whereas only Late Triassic, i.e. Ladinian and Carnian beds represent the Triassic in other parts, commonly resting directly on weathered Proterozoic crystalline rocks. Commonly the full sequence amounts to some 500-550 m thickness, e.g. in the Ljunghusen 1, Höllviksnäs 1 and Håslöv 1 wells. Outside the Höllviken basin representative thicknesses of 100 - 150 m are commonly recorded, eg. in Falsterborev 1, Svedala 1 and Mossheddinge 1. Significantly these wells are located on elevated blocks. From the seismics it is obvious that thicknesses increase towards the major faults, indicating their active role during the deposition of e.g. the Late Triassic Kågeröd Beds developed as coarse arcosic sandstones and conglomerates. From occurrences of Kågeröd Beds of Keuper age in the type area in NW Scania it has been suggested that Early Palaeozoic sediments and Proterozoic Basement rocks have been elevated in tilted fault-blocks as a result of active crustal movements in Late Triassic time (Keuper). Thus, in the Tornquist Zone, thick coarse arkosic sandstones and conglomerates were deposited as alluvial cones along the faults. It is likely that the Triassic beds of SW Scania derive not only from the Fennoscandian Shield , but also from western source areas, e.g. from The Ringköbing-Fyn High which was elevated in the Late Palaeozoic.

The youngest Triassic of SW Scania comprises Rhaetian coal-bearing clays, siltstones and sandstones, which form transitional beds towards the succeeding Jurassic deposits.

The Jurassic

Our knowledge of the Jurassic of SW Scania derives from the investigations of the Höllviken cores (Brotzen 1945, 1950) and some additional analyses of core intervals in scattered wells (Norling 1978, 1981). As these contributions show, Jurassic strata are unevenly distributed with major depositional breaks developed. Most of the sequence is characterized by coal-bearing continental or deltaic deposits. At least the Middle and Upper Jurassic part are represented by most formations distinguished within the Tornquist Zone (Norling 1981; Norling & Bergström 1987).

The Lower Cretaceous

The continental - deltaic sedimentation continued into the Lower Cretaceous and similar lithologies and facial conditions prevailed as in the Jurassic. Gradually marine deposits formed towards the end of the Lower Cretaceous with deposition of dark, organic shales and glauconitic sandstones. The latter exhibit a wide extent in SW Scania, showing a more argillaceous development towards the Tornquist Zone. This greensand deposition prevailed into the Cenomanian, i.e. the basal stage of the Upper Cretaceous.

The Upper Cretaceous

Upper Cretaceous strata form the major part of the sedimentary column in SW Scania with thick carbonates forming the dominant rock type. Active subsidence during the Upper Cretaceous has permitted a deposition amounting to 1200 m in the Falsterbo region to almost 1750 m in the area adjacent to the Romeleåsen Fault and flexure Zone. Partly this increase depends of two interbeds of clastic material, i.e. in the Campanian and the Maastrichtian, where deltaic sandstones form significant bodies.

The Tertiary

Tertiary carbonates of Danian age and minor remains of Paleocene-Eocene clastics form the youngest sedimentary rocks of SW Scania and also form the bedrock surface of the area except for the narrow belt along the Romeleåsen Fault and Flexure zone where older strata rest below the Quaternary overburden.

MATERIAL AND METHODS

Sampling procedures

Certain core intervals within this study have an unevenly distributed core coverage and status of core preservation. Well preserved and securely levelled and labelled sequences are herein referred to with a centimetre precision (1479.12 m for example). Other core-pieces, which are in correct sequential position, may have moved within a one metre interval in its core case, and are accordingly referred to by us with a lesser precision (1479 m or 1479.1 m). In core intervals where the drillers have recovered and saved only one or two metres out of a 10 m or 20 m interval, we refer to the samples as (for example) 1479.12-1489.12 m, or 1479-1489 m. During the sampling procedure, all samples were registred in a computer spread-sheet. Further, they were taken as longitudinal core splits and the void of each sample was labelled in the core cases in accordance with the labelling presented herein (including notes of sampling date, person and project).

Although the cores from Svedala 1 and Höllviken 2 have been the prime targets for our investigation, samples from other wells, e.g. Höllviken 1 and Trelleborg 1 have been utilized for complimentary biostratigraphical material to samples from the longer and more complete Höllviken 2 core. This was particularly useful in intervals of poor core recovery or missing core portions in the available core boxes.

Biostratigraphical methods

For palynomorph preparation, ten grams of each sample have been prepared using standard methods (Mädler, 1984; Guy, 1971; Batten & Morrison, 1981 and Guy-Ohlson *et al.* 1984). Ten slides were prepared from each organic residue and were examined using transmitted light microscopy. Strew stubs were also made from each organic residue for examination in the scanning electron microscope (SEM). Foraminifera were studied in thin sections as the involved lithologies mostly comprise well lithified limestones.

Petrographical methods

The detrital mineralogy and geochemistry was determined by means of thin section point counting (250 points per section, see Fig. 12), powder X-ray diffraction (XRD), scanning electrone microscopy (SEM) on mounted chips, energy-dispersive X-ray analysis (EDX) and backscatter images (BSE) on polished thin sections. Clay mineralogy was determined by the means of XRD analysis on untreated, preheated and glycolated oriented clay size fraction samples, in accordance with standard methods summarised by Tucker (1988). Determination of sulphur content of coals was done using a Leco S analyzer. Selected whole rock main and trace element analysis was performed utilizing inductively coupled plasma spectrophotometry (ICP; cf. Thompson & Walsh 1983). Where necessary, carbonate content was determined by the aid of EDTA titration.

Methods for depositional facies analysis

The depositional facies analysis was conducted by means of petrographical and geochemical investigations (see above), core mapping of sedimentary and ichnological structures of the two key boreholes, Svedala 1 and Höllviken 2 (Figs. 31 and 32). Additionally, ecological aspects of fossil microflora and fauna were utilized to enhance the resolution of the facies analysis. In addition to petrographical methods described above, detailed palaeopedological investigations were carried out with the aid of ICP main and trace element analysis, XRD clay mineralogical analyis, TOC measurements and standardized macroscopical soil horizon descriptions in accordance with the FAO-UNESCO soil classification system (FAO, 1977).

Methods for analysis of organic matter

Organic matter was analyzed at IFE (Institutt for Energiteknikk), Kjeller, Norway, by the means of programmed pyrolysis (Rock-Eval analysis) and vitrinite reflectance. Sulphur content of coals was analyzed at the Geological Survey of Sweden (see chapter on deposition). TOC (total organic carbon percentage) was determined at IFE and at the Department of Geology in Lund.

Programmed oxygen-free heating of organic matter (Rock-Eval analysis) roughly mimics natural organic maturation processes, i. e. the cracking of long-chain kerogen molecules to hydrocarbons (HC´s) of shorter chains and carbon dioxide (Larter 1985, Peters 1986). The Rock-Eval detectors measure released HC´s and (with some devices) CO_2 (Fig. 39). During initial heating (up to 300°C) any naturally matured hydrocarbons initially present in the rock are released and the amount is detected as area of the S1-peak. During continued destillation at increasing temperatures (up to 600°C), artificial cracking of remnant immature kerogen to short-chained HC's is induced and the HC's are detected and quantified as the S2 peak area. Consequently, S1 is increasing on the expense of S2 during thermal maturation. A second detector is measuring the total amount of CO_2 released during each analysis, the S3-peak. The temperature at which the highest amount of HC's is generated and detected is defined as Tmax, normally found at the apex of the S2 peak. Tmax tends to increase with increasing thermal maturity. Other parameters indirectly given during Rock-Eval analysis are the Hydrogen Index (HI; (S2/TOC)*100, expressed in mg HC/g TOC), the Oxygen Index ((S3/TOC)*100, expressed as mg CO_2/g TOC) and the Production Index (PI; S1/(S1+S2)). TOC was measured with the aid of $K_2Cr_2O_7$-oxidation and $Ba(OH)_2$-titration. Additional measurements was performed by the means of loss on ignition (LOI; 550°C/4h or 950°C/2h) on carbonate deficient samples. Vitrinite reflectance measurements was carried out on polished bulk samples. At least 25 points were measured in each sample and the results were expressed as Rm (% mean random vitrinite reflectance in oil).The sulphur contents of coals were determined in a Leco oven.

Methods for diagenetic analysis

Diagenetic processes that have influenced the petrography of the four main stratigraphical units have been analyzed and related to the various geological settings.

Reconstructions of diagenetic processes were conducted by the means of standard polarization microscopy; powder X-ray diffractometry (XRD); scanning electrone microscopy (SEM) on mounted rock chips; backscatter electrone image analysis (SEM/BSE), electrone microscope cathodolumenescense analysis (SEM/CL) and energy-dispersive X-ray analysis (SEM/EDX) on polished thin sections. Additionally, fluid inclusion work is in preparation.

BIOSTRATIGRAPHY

Upper Triassic - Lower Cretaceous of Svedala 1

Palynostratigraphy

From the interval 1514.25-1578.20 m twelve samples have been selected. Details of the exact depth and lithology of each sample in the sequence studied are to be found in Fig. 31.

The palynomorph content was found to be exceptionally well preserved and dominated by spores and pollen grains. A brief general description of the palynomorph content and palynofacies of each sample is summarised in Fig. 3. Thirty-eight palynomorph species have been recorded during the transmitted light microscopic analysis. Their occurrence and distribution are to be found in Fig. 4. An alphabetical list of the palynomorphs, including author names, is to be found in Appendix 1. In Fig. 5 the palynomorphs found at Svedala 1 have been arranged according to their known published stratigraphical ranges.

Although, in the samples investigated, the stratigraphical ranges of many of the palynomorphs are long, the presence of several species, e.g. *Ricciisporites tuberculatus* and *Limbosporites lundbladii* with shorter ranges, narrows the relative age dating to Middle Rhaetian for samples in the interval 1538.37-1577.75 m. A definite change in palynomorph content occurs both qualitatively and quantitatively at 1535.83 m. No index fossils so far recorded give a narrow well-defined age assignment for this sample.

This Midde Rhaetian palynoflora found at Svedala-1 has been compared with palynofloras of similar age in adjacent and neighbouring areas, e.g. Denmark (Lund, 1977); Germany (Schulz, 1967), Austria (Morbey, 1975) and Britain (Warrington, 1977-81).

Foraminifera

In a stratigraphical study of the Lower-Upper Cretaceous boundary (Larsson & Solakius in prep), samples from the Greensand, 1490-1514 m, and the basal 40 metres of the succeeding pelagic limestone with varying amounts of flint concretions and siliciclastic fines (1449-1489 m) have been investigated for foraminifera. In the "Greensand" no foraminifera were found, but in the limestone, foraminifera indicative of the two uppermost foraminiferal zones of the Turonian, i.e. the *Marginotruncana pseudolinneiana* zone and *Helvetoglobotruncana helvetica* zone could be proved (1480-1489 m). One sample studied from 1449 m shows foraminifera typical for the Coniacian. The boundary between the two stages cannot be established at present due to insufficient sampling.

Triassic to Early Cretaceous in Höllviken 2

Pre-Rhaetian Triassic

In his description of the Höllviken 2 core, Brotzen (1950) clearly pointed out that very few biostratigraphical criteria could be presented for the lowermost variegated sequence below 1496 m down to TD at 1924 m. His division of the sequence in four units (Fig. 6) referred to as the Upper Keuper (1496-1755 m), Lower Keuper/Muschelkalk (1755-1862 m), "transitional beds" (Muschelkalk/Bunter) at 1862-1886 m, and Bunter from 1886 to TD, was based on the general lithostratigraphical development of the strata with a reddish, coarse-clastic, arcosic upper part, a grey argillaceous middle part and a lowermost variegated sandy part. In Brotzen (1945) these colour changes were regarded to reflect climatic changes and alternating marine/non-marine conditions. His strongest arguments for a mid-Triassic age of the interval 1755-1862 m were fish remains, ostracods and plant remains. These organic remains were considered to show features similar to European Muschelkalk faunas and floras, especially in Germany. Abundant occurrences of charophytes occur in this interval, but obviously their stratigraphical value is poor (Horn af Rantzien 1953). The charophytes are good environmental indicators, however, mainly reflecting fresh water or slightly brackish conditions.

Lithostratigraphically the "Upper variegated unit" of Brotzen (1945), i.e. 1496-1755 m, shows many features similar to the Kågeröd Formation forming the bedrock surface in parts of NW Scania (Fig. 1). These beds have been assigned a Keuper age (Troedsson 1942). A similar age has been suggested by Jacobsson (1993) and Arndorff (1994b), who inferred Ladinian to Carnian ages for the interval, basing their conclusions on regional and local palaeoclimatological and lithostratigraphical data.

Although well oxidized red-beds are predominating, more mature clastic beds with organic matter were observed at some levels (Jacobsson 1993). Fifteen samples from 1807 to 1919 m were palynologically investigated, and though most of the samples were barren or only contained amorphous debris, a poorly preserved palynoflora was found at 1807 m (cf. Fig. 7). It contained stratigraphically diagnostic species which permitted a Ladinian-Carnian age to be confirmed for this sample. The assemblage found also allows correlation with the Danish Basin (lower part of the Oddesund Formation).

Rhaetian - Lower Cretaceous

This interval comprise siliciclastic coal-bearing strata which were initially considered to belong to the Rhaetian, Wealden , and Barremian-Aptian, and marine Aptian - Albian/Cenomanian (Brotzen 1945, 1950) with an angular unconformity inferred between the Rhaetian-Wealden at 1445 m.

Based on the lithostratigraphical characteristics of the interval 1445-1496 m with alternating argillaceous sandstones, clays, shales and coal seams, Brotzen (1950) referred the interval to the Rhaetian. This was corroborated by occurrences of fish remains, agglutinated foraminifera, ostracods and plant remains which were considered to show a Rhaetian affinity. Lundblad (1949) also referred some of the plant remains to the Rhaetian.
Although stratigraphically diagnostic palynomorphs are absent in many samples from this interval, it has been possible to confirm a Rhaetian age for the 1466.75 - 1477.95 m interval and correlate it with parts of the Vinding and Gassum Formations of the Danish Basin (Fig. 7).

The beds above the angular disconformity at 1445 m up to 1274 m were referred to the Wealden by Brotzen (1950). In his description of the Höllviken 1 core (Brotzen 1945) the presence of *Sphenolepidium sternbergianum,* a typical plant from the Wealden sequence in Europe, could be demonstrated from these arenaceous and argillaceous sediments. In Höllviken 2, plant remains of "Wealden" affinity were reported from 1422-1428 m. Samples from these beds in Höllviken 1 were studied by Tralau (1967) and Mahin (1968) who suggested that the palynomorphs reflected a Middle Jurassic age.

In the present investigation, it can be demonstrated that the 1291.40-1443.40 m interval contains a palynoflora typical of the Early Jurassic, whereas a sample at 1287.00 m indicate a palynoflora more typical of the Jurassic-Cretaceous transition (although diagnostic species are absent, see Fig. 7).

It is obvious that the Jurassic is incompletely developed in both Höllviken cores and several levels with conglomerates, e.g. at 1328, 1330, 1380 and 1400 m in Höllviken 2, suggest depositional breaks and/or erosional events. This is also in good agreement with the conditions in Svedala 1, where Jurassic strata are missing completely (Fig. 8).

The Lower Cretaceous interval between 1245 -1275 m shows a marine development with black, grey and red shales, glauconitic and argillaceous sandstones. All beds contain marine fossils, e.g. foraminifera, bivalves, gastropods , ammonites and fish remains. In Höllviken 1 Brotzen (1950) distinguished seven units, the uppermost being characterized by stratigraphical important ammonites as *Parahoplites bodei* and *Deshayesites deshayesi*, typical for the two lowermost zones of the Aptian. In Höllviken 2 this unit is missing, but ammonites occur which are typical for the lower Aptian, i.e. *Parahoplites bodei* and *Oppelia nisoides*. The lowermost part of the marine sequence shows few stratigraphically diagnostic fossils but was assumed to represent the Barremian (Brotzen 1950), cf. Fig. 9.

Our studies of palynomorphs from the organic rich black shale at 1245 m indicate a Hauterivian - Barremian to Early Aptian age (Fig.7).

The uppermost part of the Lower Cretaceous, 1187-1245 m, is developed as a glauconitic sandstone, partly being loosely consolidated. This sandstone rests with a well developed conglomerate containing pebbles of quartz, shale and granite, on the Aptian black shale. Additional conglomeratic levels occur at 1219 and 1230 m. The uppermopst meter of sediments is separated from the major part of the sandstone by a phosphatic conglomerate. Brotzen assigned this glauconite sandstone to Gault-Cenomanian mainly from lithostratigraphical considerations, but also on the presence of foraminifera in the top 5 metres. The sequence above the phosphatic conglomerate was referred to the Cenomanian *sensu stricto.*

Our study shows that the lower part of the "Greensand" comprises palynological evidence of an Aptian-Albian age (1244.00-1240.15 m). This conclusion is based on the presence of *Gleicheniidites bulbosus*, *Lycopodiumsporites clavatoides*, *Perinopollenites elatoides, Sestrosporites pseudoaveolatus;* all Lower Cretaceous species (cf. Figs. 10 and 11). The presence of *Clavifera triplex* excludes a pre-Aptian age. Also, the lack of typical pre-Aptian genera such as *Trilobosporites* and *Cicatricosisporites* (only one specimen found) indicates a post- Barremian age . At the very top of the "Greensand" (1191.00 m) a Cenomanian age is inferred because of the presence of triporate pollen wich have their first apperance in the Cenomanian of Europe. This is also corroborated by foraminiferal records from 1190 m where the Cenomanian species *Gavelinella cenomanica* occur. The same conditions are also found in Höllviken 1 where the interval 1230-1234 m with conglomerate and phosphatic sandstone have yielded Cenomanian foraminifera (Brotzen 1945; Larsson & Solakius in prep). The presence of *Rotalipora* would infer that the uppermost foraminiferal zone of the Cenomanian, i.e. the *Rotalipora cushmani* zone, is present, however, in a very incomplete way. Some redeposited pebbles with slightly older Cenomanian foraminifera occur in the phosphatic sandstone showing evidence of a destroyed older Cenomanian sequence.

Basal Upper Cretaceous

In the present study only basal levels of the Upper Cretaceous have been investigated mainly to elaborate the stratigraphic conditions around the Lower-Upper Cretaceous boundary, which means that some 30-40 metres of cores in each well have been studied and sampled. In both Höllviken 1 and 2 it is obvious that only parts of the Turonian stage is developed.

Brotzen (1945) distinguished Upper Turonian between 1185 and 1230 m in Höllviken 1 and 1136-1187 m in Höllviken 2. He based his stratigraphical division on the presence of *Cibicides turonica* and *Spiroplectinata jaekeli.* He also considered the presence or absence of flint concretions for his stratigraphical division, the flint thus characterizing the Turonian strata. The upper boundary of this stage was located at the level of disappearance of *Cibicides turonica.*

Our study of the boundary levels (Larsson & Solakius in prep) shows that the two uppermost foraminiferal zones of the Turonian, i.e. the *Helvetoglobotruncana helvetica* zone (samples between 1213-1231 m in Höllviken 1 and 1140-1190 m in Höllviken 2) and the *Marginotruncana pseudolinneiana* zone (samples between 1200 and 1210 m in Höllviken 1 and at 1137 m in Höllviken 2) are present. In both wells only the top part of the *H. helvetica* zone seems to be developed. Coniacian strata have been identified from 1197 m upwards in Höllviken 1 based on the presence of *Archeoglobigerina cretacea.*

The obtained results show that in agreement with the conditions in Svedala 1 there is a major stratigraphical break between the Cenomanian-Turonian stages, but the hiatus is slightly smaller in the Höllviken wells.

Other wells of interest

Among other deep wells in SW Scania only Trelleborg 1 has been examined for the stratigraphical development around the Lower-Upper Cretaceous boundary. This well has only been drilled to 1201.5 m, i.e. 12 m into the "Greensand". No fossils have been recorded from the sandstone, but foraminifera from the succeeding 50 metres of limestone show that approx. one meter of the the *H. helvetica* zone and most of the succeeding *M. pseudolinneiana* zone is developed. The first evidence of Coniacian strata appear at 1163.5 m as shown by *Archaeoglobigerina cretacea.* Judging from the development in Trelleborg 1, the Lower Turonian hiatus seems to be of the same magnitude as seen in Svedala 1, i.e. slightly larger compared to Höllviken 1 and 2.

Biostratigraphical investigations were performed at occasional levels within the Mesozoic sequence in several OPAB wells at the time of their initial evaluation by OPAB geologists. These analyses are based on short cored sequences and cuttings. A summary of the stratigraphical levels identified is presented in Figs. 6,8 and 9. Some of these data have previously been briefly reported in Norling 1978 and 1981. In Höllviksnäs 1, the Fortuna Marl (Middle Callovian) is recorded at 1374-1377 m and upper Fyledal Clay (Oxfordian/Kimmeridgian) at 1341-1344 m. In Håslöv 1 samples from 1563-1569 m are referred to the Rhaetian and 1410-1413 m to the Glass Sand/Fortuna Marl. In Hammarlöv 1 samples from 1428-1431 m have been determined as Rhaetian, and 1338-1392 m to the upper Rydebäck - Fuglunda interval, i.e. Upper Liassic-Lower Dogger. The levels between 1299-1332 m are referred to the Oxfordian Fyledal Clay, and 1290-1293 m to Upper Jurassic.In the Lower Cretaceous the presence of Barremian strata has been recorded at 1278-1281 m and Aptian-Albian at 1269-1272 m. From these scattered age determinations it is obvious that most of the Lower - Middle Liassic is missing in Hammarlöv 1 as well as the Hauterivian-Valanginian and Berriasian stages.

In Barsebäck 1, the Fuglunda Member occurs down to 1945 m, the Glass Sand occurs between 1860-1880 m, and Fyledal Clay, Nytorp Sand and Vitabäck Clays occur between 1800-1860 m. Pre-Aptian Lower Cretaceous has been determined for the 1764-1800 m interval, Aptian between 1741 and 1764 m and Aptian-Albian between 1734-1741 m. Thus, most of the Liassic - lower Dogger is missing,while Upper Jurassic - Lower Cretaceous stages seem to be rather well developed.

In Norrevång 1 most biostratigraphical data obtained are inconclusive, but foraminifera and ammonites from levels around 1835 m show the presence of Aptian strata. Above this level available data indicate Lower Cretaceous but no separate stages can be identified at present.

DETRITAL PETROGRAPHY AND LITHOSTRATIGRAPHY

Svedala 1

The basement below the Mesozoic sedimentary column in Svedala 1 consists of a 33 m thick sequence of Palaeozoic(?) quartz cemented quartz arenites and conglomerates with a very strong diagenetic overprint, which is resting on Precambrian gneiss.

The Mesozoic commence with some 35 m (1575-1612 m) of mudstones, arkosic greywackes, arkoses and arkosic conglomerates (i.e. red-beds). Brotzen (1949-1951, unpublished well diary) described this interval as a mixture of reddish and greenish muddy to coarse grained clastic sediments. The clay mineralogy comprises kaolinite and, notably, variable amounts of smectite-illite mixed layer minerals (Fig.13). Arkose and subarkose typically dominate in the sand size fractions (Fig. 14). Microcline is the most frequent feldspar whereas plagioclase occur in abundances of 10-15% of the entire feldspar population. The pebbles of the conglomerates are mostly well rounded. Consisting of gneiss and/or quartzitic arenites, the conglomerate clasts strongly denote affinity to underlying Precambrian and Palaeozoic rocks. The red-bed interval of Svedala 1 is virtually devoid of organic matter as a result of a life-hostile dry palaeoenvironment with strongly oxidizing conditions during and after deposition. Early diagenetic haematite cement rims support this interpretation (see chapter on diagenesis below). In conclusion, the immature detrital composition and the presence of smectitic fine-grained rocks signify dry, alkaline weathering conditions with restricted chemical weathering. Overall, the petrology and facies of this interval show striking similarities to equivalent strata of NW Scania. Hence, this interval of the Svedala 1 borehole should be assigned to the Kågeröd Formation (Norian) of NW Scania.

At the transition from the Kågeröd Formation red-beds to the Middle Rhaetian beds (see chapter on biostratigraphy), a clear petrographic shift is recorded in the Svedala 1 core, as it is in the Höganäs basin of NW Scania (Sivhed 1984) and in other strata of equivalent age within the Tornquist Zone (cf. Norling & Bergström 1987; Norling *et al.*

1993). This change was caused by a regional climatic shift from dry to humid conditions which plausibly was related to the opening of water-ways (rifting) in association with Post-Hercynian plate reorganization in the Tethys and Arctic-North Atlantic domains (cf. Ziegler 1988). As a consequence, organic matter of plants (now coal) was abundant from the Rhaetian and onwards as the flora thrived in the humid climate (see chapter on organic matter below). Brotzen (1949-51, unpublished well diary) described the rocks of the Rhaetian interval of the borehole Svedala 1 as black to dark-brown coaly mudstones, coal seams and fine-grained white sandstones with minor amounts of pyrite. Hence, the sparsely weathered and texturally immature clastic sediments of the Kågeröd Formation were followed by texturally mature quartz arenites (sensu Pettijohn *et al.* 1973; cf. Figs. 12 and 14 herein) which had been subjected to a dramatic increase in chemical weathering as CO_2-rich acid waters flushed the soils (i.e. acid waters in equilibrium with H_2CO_3). By the same token, leaching organic acids promoted kaolinite formation and completely supressed the formation of smectite (Fig. 15). The biostratigraphy, detrital composition and facies association of the interval 1520-1575 m are clearly equivalent to those of the Bjuv Member (Höganäs Formation) of the Höganäs basin in northwestern Scania, and the coal-bearing interval of Svedala 1 should therefore be assigned to this formal unit.

The Rhaetian interval is followed by a thin transitional marly deposit, and a subsequent 28 m thick interval of Lower Cretaceous glauconitic wackes and arenites (cf. Figs. 12 and 14). The siliciclastic sand size fraction is mineralogically mature and the clay mineralogy comprises, except for glauconite, predominantly illite and kaolinite (Fig. 16).

From 1487 m and upwards, the glauconitic interval is followed by a thick monotonous sequence of fine-grained limestone (mostly mud- and wackestones *sensu* Dunham 1962). With small variations in siliciclastic content (some intervals are slightly muddy or sandy), this lithology extends upwards beyond the -700 m level in the borehole Svedala 1 (the shallowest level seen by us). Clay mineral compositions of muddy interbedded laminae are typically dominated by illite and smectite, which is to be expected in the alkaline marine depositional setting (Fig. 17). Some levels within the limestone interval are rich in flint concretions whereas others show abundant discrete evidences of bioturbation.

Höllviken 2

The Höllviken-2 well is the longest cored well (depth 1924 m) and most important core of southwestern Scania. As noted above, it can be divided threefold into a "Lower to Upper Triassic" part (of which the Middle-Upper Triassic portion is treated), a "Rhaetian-Lower Cretaceous" part and an "Upper Cretaceous-Tertiary" part (of which the basal Upper Cretaceous portion is treated herein).

The Middle to Upper Triassic sequence, about 400 m thick, is largely dominated by red-beds. Immature conglomerates, arkoses, arkosic wackestones (with low textural maturity) and mudstones predominate, whereas more mineralogically and texturally mature clastic strata (quartz arenites, kaolinitic mudstones) are in minority (cf. Figs. 12 and 14). The clay mineral suites of this interval typically comprise various blends of smectite, kaolinite, illite and chlorite (Fig. 18). The sediments are normally deficient in organic matter although some levels with coal particles and palynomorphs were recorded. Carbonates (calcite and dolomite) within calcrete profiles (with vadoids and calcified rootlets) were recorded at numerous levels within the this sedimentary sequence.

The transition to the subsequent "Rhaetian-Lower Cretaceous" interval, about 200 m thick, is obscure due to poor core recovery within that interval. The lithologies are those typical of Jurassic/Lower Cretaceous strata in the Tornquist Zone, i.e. texturally and mineralogically mature siliciclastic strata such as fine grained arenites, heterolites and mudstones. In addition, plant detritus in the form of coal beds and particles are abundant as well as coalified fossil rootlets. The mudstones invariably comprise kaolinite and illite with traces of chlorite (Fig. 19), i.e. no smectites.

The Lower Cretaceous marine interval of the Höllviken 2 sedimentary sequence commences with the glauconitic "Greensand" interval which comprises an interbedded organic rich shale, the so called "Aptian Shale". The "Greensand" should be considered as a glaucony rich siliciclastic wackestone (*sensu* Pettijohn et al. 1987). The detrital sand and clay constitutents of this unit has much in common with the detrital mineralogy of the underlying Rhaetian-Jurassic interval (Figs. 12, 14 and 20). The considerable organic contents of the "Aptian Shale" are discussed below (chapter on organic matter). According to well site records, the Cenomanian uppermost part of the "Greensand" contains fosforite nodules. Such were not recorded in the cores available today, but seen in a museal sample of the SGU collections. The "Greensand" is in the Höllviken 2 core, as in the whole southwest Scania, followed by a thick sequence of fine-grained Turonian-Coniacian carbonates, i.e. mudstones and wackestones *sensu* Dunham (1962). The monotonous carbonate sequence comprises abundant bioturbation and slight variations in the contents of mud partings (see Fig. 21 for clay mineralogy) and flint concretions as well as few single glauconite grains.

Other cores of interest

Intervals of varying lengths from other boreholes were studied for lateral comparisons with the main boreholes (Svedala 1 and Höllviken 2). The borehole Höllviken 1 was drilled close to the well site of Höllviken-2 and will not be commented upon separately (see descriptions of Höllviken 2). In the boreholes Barsebäck 1 and Norrevång 1 parts of the the "Greensand" interval were studied and sampled. In both cases this interval appears more muddy than equivalent strata of other boreholes. Hence, it seems like the lithofacies of the glauconitic interval is variable as to mud content. However, the unit deserves to be classified as a wackestone rather than a sandstone (*sensu* Pettijohn et al. 1987).

STRUCTURAL GEOLOGY OF SW SCANIA

An important part of the present study deals with the structural conditions of SW Scania. The first deep wells drilled in SW Scania, i.e. Höllviken 1 and 2 meant that new possibilites arised to elaborate the structural conditions along the SW margin of the Fennoscandian Shield. Since the Höllviken wells, a vast material has accumulated as a result of additional deep drilling and geophysical surveys, the latter dominated by seismic profiling. These data have partly been utilized and presented as profiles, cross-sections and to some extent as structural and isopach maps (e.g. Norling & Skoglund 1977, Norling 1978, Bjelm *et al.* 1977, Norling 1981, Bergström *et al.* 1982, Larsson 1984, Norling & Bergström 1987, Norling *et al.* 1993). In a more regional context subsurface data from south-west Scania have been included, e.g. in Ziegler 1982, Pegrum 1984, Bergström 1985, Liboriussen *et al.* 1987, Kornfält & Larsson 1987, Bergström *et al.* 1990a,b). As a result of these and other papers, the main structural features of SW Scania and adjacent offshore areas as shown in Fig. 2 has been elaborated. The present study corroborates the present concept, but some important deviations in interpretation will also be submitted below.

Interpretation of seismic data

For the present study all seismic data derived from surveys conducted by SGU, OPAB and Swedegas during the last 30 years have been interpreted. As this seismic material derives from different generations of recording and processing techniques, variations in quality are common. This affects the mapping of some seismic markers, especially at deeper levels, i.e. in the lower Mesozoic and Palaeozoic sequences and the top of the crystalline basement. Undoubtedly, reprocessing of critical data will improve the mapping possibilities, but this has not been possible within the resources of the present investigation.

In this study, mapping of seismic markers are confined to levels associated to the studied Triassic - base Upper Cretaceous interval. Fortunately, the best developed and mappable marker coincide with the Lower - Upper Cretaceous transition (Blue Marker). In order to define the base of the Mesozoic sequence, a marker coinciding with top Palaeozoic - Triassic transition has been mapped (Green Marker). In areas with missing Palaeozoic sediments (Larsson 1984), a marker associated with top basement has been mapped (Red Marker). The designation of these seismic markers are the same as those used by OPAB in their various prospecting reports.

The geological representation of these seismic markers has been confirmed by the development of synthetic seismograms in wells with good vertical coverage of borehole logs, i.e. Sonic logs. In order to confirm the interpretation in different parts of the investigated area, synthetic seismograms were produced for Höllviksnäs 1, Håslöv 1, Mossheddinge 1 and Barsebäck 1 (Figs. 22-25). As a full sonic log was not available from Höllviksnäs 1, an additional seismogram is shown from Håslöv 1 in order to confirm the Green Marker (top Palaeozoic). As depth conditions changes markedly for some units towards the Tornquist Zone as do their sedimentological , e.g. a more argillaceous development of the Upper Cretaceous, as do the stratigraphical properties, synthetic seismograms for Mossheddinge 1 and Barsebäck 1 are shown.

Although a sufficient velocity control exists for several wells, no attempts have been made to convert the structural maps into metric units. The present distribution of deep wells is uneven in SW Scania (Fig. 1). On the Skurup Platform no wells have been drilled except along its western rim, i.e. Trelleborg 1, Svedala 1 and Mossheddinge 1. Well logs only exist from the latter well. The northern part of the investigated area also lacks wells for velocity control between Barsebäck 1 and Eskilstorp 1. Consequently, the two structural maps presented (Figs. 26-27) are expressed in two-way transit time (TWT) below mean sea level. This mode of presentation still fulfills the purpose of demonstrating structural trends, depth conditions and location of major faults.

Blue Marker

The marker designated "the Blue Marker" is the best developed seismic marker in the subsurface of SW Scania and, indeed, also in additional parts of the Danish Basin. This also means that major faults and/or structural changes are easily discernible. A general NE dipping trend of the marker can be observed, which means a depth of -800 ms TWT in the Falsterbo Peninsula region to a maximum depth of -1300 to -1350 ms TWT along the Romeleåsen FFZ. Along the latter fault zone well defined local areas of subsidence occur (Fig. 26), which coincides with accumulated piles of Campanian and Maastrichtian clastics (Erlström 1990; Larsson & Erlström in prep). Among major faults cutting this marker should be mentioned the Svedala and Carlsberg Faults, the Vellinge Fault, the Höllviken Fault and the Barsebäck Faults. Some of these faults, i.e. the Svedala, Carlsberg and Vellinge faults are associated with flexure zones along the fault lines.

On structural maps including SW Scania, the Svedala Fault is commonly marked to join the Tornquist Zone.It is difficult to find out how this misinterpretation of its extension originated, but the present study shows no evidences of a faulted Blue Marker in the area north of the depicted Svedala Fault (Fig. 26). As can be seen in this figure, contour lines are more densely packed along the strike of the Svedala Fault, but this has nothing to do with fault conditions. Instead it can be seen from the major seismic profiles in the area, i.e. lines L113 and L114, which run parallel to the Romeleåsen FFZ, that the Blue Marker is developed into a nortwesterly dipping flexure.

Another structural features commonly shown on structural maps of SW Scania are two fault lines running parallel to the Tornquist Zone. These faults are considered to define the Alnarp Valley, a major depression in the Danian bedrock surface. The present study cannot confirm the existance of these fault lines at any seismic level. This is especially clear from the most recent seismic survey run by Swedegas in the early 1980ies, when seismic profiling with good resolution down to 1000 ms TWT (approx. 1500 m depth) was performed.

From the synthetic seismograms it may be seen that the Blue Marker correlates with depths at -1190 m in Höllviksnäs 1, -1305 m in Håslöv 1, -1680 m in Mossheddinge 1 and -1725 m in Barsebäck 1 (all subsea depths), which correspond well with the Albian/Cenomanian Greensand - Turonian Limestone transition.

Green - Red Markers

The quality of the Green and Red markers are highly variable and consequently difficult to map in some areas. This is also true for areas, in which Palaeozoic deposits are missing or thin, i.e. within the Skurup Platform and along the Tornquist Zone. The deepest levels of the Green Marker occur along the down-faulted north-eastern side of the Carlsberg Fault (-1500 to -1700 ms TWT) and the down-faulted west side of the Svedala Fault (-1300 to -1400 ms TWT). The marker disappears towards the north and the east, which obviously is the result of outwedging Palaeozoic strata. This is also confirmed by the missing Palaeozoic sequence in Mossheddinge 1, Barsebäck 1 and Norrevång 1, and possible erosional rest of Lower Cambrian (?) in Svedala 1. The approximate limit for Palaeozoic sediments is marked in Fig. 27.

In areas outside this erosional boundary, the Red Marker representing top Basement has been mapped in order to obtain a fuller picture of the structural conditions at the base of the Mesozoic. This marker dips towards the Tornquist Zone on the Skurup Platform (- 1150 to -1200 ms TWT) and possibly also northwestwards along the Tornquist Zone (-1300 to -1400 ms TWT), Fig. 27.

The extension of the Svedala Fault northwards is rather obscure at this seismic level, but present data suggest a flexure in the basement as is also shown by the densely spaced contours within the area north of the presently depicted Svedala Fault (Fig. 27). The Svedala Fault as well as the Carlsberg Fault represent major structural changes at the Basement level and throws of 500 to 1000 m can be inferred.

Other faults are also well defined at this level, e.g. the Vellinge Fault and the Foteviken Fault. Another fault, commonly referred to as the Malmö Fault, is commonly included in structural maps (e.g. Norling 1978, Bjelm e*t al.* 1977, Norling & Bergström 1987). The existance of this fault cannot be verified in this study as no structural breaks occur at any level along the proposed extension between approx. Svedala and Malmö. Thus, the northernmost limit of the area with Palaeozoic sediments is not fault-controlled, but rather represent an denudation boundary resulting from a southwardly tilting of the Höllviken Graben in Late Palaeozoic - Early Mesozoic times.

Isopach Map

An isopach map was produced based on the interpretation of the previously discussed seismic markers (Fig. 28). As these markers coincide with the upper and lower limits of the Triassic - base Upper Cretaceous interval, this isopach map gives an overview of thickness variations of the interval. The down-faulted character of the Höllviken Graben can easily be seen and the thickest parts are found along the west side of this graben, i.e. along the Carlsberg Fault. Due to poor quality of the basement marker within the Skurup Platform and in the north-western part of the investigated area,i.e. the Landskrona-Barsebäck region, no complete coverage of thickness conditions could be obtained from the seismics. The thinner development of the investigated interval in these areas is clear,however, and is also confirmed by the wells penetrating the sequence, i.e. Svedala 1, Mossheddinge 1, Barsebäck 1 and Norrevång 1. The major part of the decreased thickness can be referred to the missing lower and middle parts of the Triassic.

Log correlation

Lack of biostratigraphically well-dated sequences in uncored wells from Scania has only permitted a rather coarse correlation of various stratigraphical levels. Some distinct lithostratigraphical units can be traced, however, and by using various well logs, this correlation has improved considerably. Cross-sections based on well records are important tools to demonstrate subsurface conditions and hence two major sections have been compiled for this report. Well-defined lithostratigraphical levels used are: top/base "Greensand", top/base Kågeröd Clay, top Triassic basal conglomerate, top Palaeozoic and top crystalline Basement. The choice of these levels demonstrate structural position, depth trends and thickness variations for the Upper Cretaceous, the "Greensand", the Lower Cretaceous-Rhaetic and the Triassic. One section is run from Falsterborev 1 to Mossheddinge 1 , Fig. 29, the other from Smygehuk 1 to Norrevång 1 (Fig. 30). For correlation purposes Self-potential (SP), Gamma Ray (GR), Resistivity and Sonic logs have been utilized. Many smaller intervals can easily be correlated with these logs, but for the present purpose the chosen levels are considered adequate. As can be seen from Figs. 29-30, these cross-sections conform well with the structural trends and basin configurations obtained from the seismic interpretation.

DEPOSITIONAL ENVIRONMENTS

Svedala 1

The Kågeröd Formation

As in northwestern Scania, the texturally and mineralogically immature red-beds of this formation, i.e. conglomerates, arkoses and arkosic wackestones clearly implies an arid or semiarid continental depositional environment. In Svedala 1, and other sections in the Kågeröd Formation, this impression is supported by the presence of smectite-bearing mudstones indicating alkaline soil conditions, eodiagenetic haematite-stainings of detrital grains, and a pronounced deficiency in organic matter. Core mapping revealed repeated fining-up sequences typical of alluvial deposits (Fig. 31). It is conceivable that deposition took place in a system of alluvial cones where erosional surfaces followed by orthoconglomerates and subsequent fining-up beds represent fluvial deposition in braided rivers. The recorded paraconglomerates, on the other hand, with "floating" boulders imply deposition by debris flow processes. The averagely large grain sizes involved reflects a considerable relief of the sediment source areas (i.e. the hinterland). Hence, the overall fining up trend that is notable in the Kågeröd Formation in the core Svedala 1 (and in the Kågeröd Formation in northwestern Scania, cf. Norin 1949) indicates the gradual wearing down of pre-existing topography created by tectonic movements along the Tornquist Zone.

The red-bed interval in Svedala 1 has neither yielded any determinable biogenic remains nor any distinct palaeosols. However, scattered carbonate cemented patches may be related to arid climate soil processes.

The Bjuv Member (Höganäs Formation)

This coal-bearing interval, corresponding to the Bjuv Member of northwestern Scania (cf. Troedsson 1951), exhibits texturally and mineralogically mature clastic strata. Hence the sedimentary record in Svedala 1 display significant and for the stratigraphic level typical petrographical evidences of a climatic shift from dry to humid conditions at the Norian(?)-Rhaetian transition (see above). The Rhaetian interval commences with several palaeosols with coal seams (1571-1575 m) indisputably indicating humid subaeril conditions. In the interval 1571-1543 m wave agitated heterolites indicate subaqueous depositional conditions (Fig. 31). Since the microflora denote calm fresh water deposition (see below), a lacustrine setting is inferred. The heterolites comprise sandstone sheets with foreset bedding surfaces, and scattered trace fossils (*Planolites* and *Lockeia*). Occasionally, clean sand sheets covered the bottom of the lake, possibly due to small scale turbidity currents. A gradual shallowing of the lake is recorded from strata at 1543 m (and upwards), where a single fossil rootlet bed leaves evidence for renewed subaerial exposure. In the depth-interval 1543-1527 m it is evident that palaeosols were formed as plants colonized sediment-filled peripheral areas of the lake repeatedly. Lacustrine delta progradation formed coarsening-up cycles with subaerial paleosol development on the tops of each cycle, and each progradation was more successful than the previous one. Hence, ephemeral palaeosols were followed by palaeosols reflecting more stable pedogenic conditions (see discussion below). The last true palaeosol was followed by a fining-up sandstone sequence (1525-1517 m) with allochthonous coal seams and a final *in situ* single rootlet prior to a vast hiatus and following open marine deposits.

No truly marine influence whatsoever were recorded in the investigated samples of the Bjuv Member. Counterwise, the presence of the colonial green alga *Botryococcus* indicates freshwater influence on the depositional environment for samples at 1516.55 m and 1535.83 m (Fig. 3). The qualitative and quantitative changes noted in the palynomorph content at sample 1535.8 m may reflect an environmental change. The total assemblage composition suggests deposition close to the point of dispersal from the parent plants from which they were derived. The excellent preservation also confirms that transport over any distance has not been involved, and presumably the deposition occurred under calm and undisturbed conditions.

Palaeosols of the Bjuv Member are primarily revealed by the occurrence of rootlet beds and by the pale colour of the beds penetrated by rootlets. Two palaeosol types are distinguishable (Figs. 33-35). Type 1, found at the -1571 m level, is dark to medium grey and commonly overlain by a coaly layer and rarely exceeding depths of 40 cm. The parent rock is typically a muddy siltstone to fine sandstone. Two soil horizons are discernible. Typically a 20-25 cm thick B horizon is superimposed by a H horizon of 10-15 cm. No other distinctive soil horizon is present. The roots reach depths of 25 cm and are occasionally impregnated by pyrite. The boundary to the underlying parent rock is lobate and sharp. Type 2 palaeosols are found in the upper part of the Bjuv Member, between depths of 1527-1539 m. They consist of drab-coloured (pale yellowish to yellowish grey) well sorted silts and sands with initially high permeability. This has caused extensive leaching of most constituents in the soil and created E and A horizons which typically are superimposed by an originally surficial Ah horizon. The horizon boundaries are diffuse and smooth. Heterolithic sedimentary structures have been obliterated in the upper parts of the soil profiles and are barely recognizable in their middle parts. Rootlets are preserved as sediment filled organic structures, reaching depths of 65-80 cm. The pattern of the root systems are fibrous, dominated by small elongated roots. X-ray diffractometry of oriented clay size fractions of palaeosols from Svedala-1 indicate that all palaeosols are dominated by kaolinite (strong 001-reflection at 7Å) and illite (strong 001-reflection with negative skewness at 10Å). The illite content increase towards the soil surface in type 2 soil profiles. These are typical patterns of many Rhaetian and Hettangian palaeosols in NW Scania and on the island of Bornholm (Ahlberg & Arndorff 1994; Arndorff 1993, 1994b). Minor amounts of chlorite are present in the type 1 palaeosols. The type 1 palaeosols are typically depleted in oxides (in particular Al, Mg and K oxides) towards the soil surface whereas the soil type 2 shows an opposite trend. TOC in the surficial horizon has been determined to 45 wt.% for a type soil 1 and 13-17 wt.% for type 2 soils. Corresponding values of sulphur content are 2.3 wt. % and 0.1 wt. %, respectively. Molecular ratios of $CaO+MgO+Na_2O$ to ZrO_2 (cf. Chittleborough 1991) and SiO_2 to $CaO+MgO$ (cf. Russel 1988, 858-859) was calculated to demonstrate weathering and leaching patterns of the palaeosols (Figs. 33-34). For the type 2 soils an increased downward rate of weathering is evident. This is not the case for type 1 palaeosols, probably due to cation accumulation in the H horizon

of a less well drained soil profile. Due to the more permeable and freely drained conditions of soil type 2, it yields higher SiO_2/CaO+MgO ratios and thus stronger leaching than palaeosol type 1. In conclusion, the two palaeosol types reflects the caternary relationships in the area at the time of their developement. The type 1 palaeosols well illustrate gleization and should accordingly be labeled Gleysols because of the following criteria:
(1) the presence of chlorite (indicating restricted weathering);
(2) the upward depletion of Al, Mg and K (movable elements in aerobic environments);
(3) drab-coloured mudstone and pyrite (indicating reducing conditions);
(4) accumulation of organic matter resulting in a thick H horizon;
(5) near-surface rooting systems.

Gleysols are today developed in depressions with water-saturated grounds subjected to reducing conditions, preferreably around lakes and restricted marine bays. The type 2 palaeosol represent Luvisols which typically are evolved on flat and gently sloping grounds with free drainage. Characteristic features are;
(1) illuvial accumulation of clays in the A horizon (see Fig. 34);
(2) evidence of extensive weathering (see Fig. 34);
(3) vertically elongated rootlets (striving for the ground water table);
(4) a fresh water microflora (see previous sub-chapter).

The "Greensand" (Lower Cretaceous)

Directly upon Rhaetian strata, glauconitic strata of Lower Cretaceous age follow. This interval is dominated by poorly stratified glaucony-bearing siliciclastic wackestones. Bioturbation is abundant, though very hard to distinguish due to lack of petrographical contrasts. At 1501-1502 m a sudden incursion of coarse grained glauconitic sandstone occur. A continuation of glauconitic strata has been reported from the interval 1487-1500 m (F. Brotzen 1949-51, unpublished well site diary). That core interval is unfortunately missing at the core storage of SGU. The texture of the Greensand implies that most of the glaucony is formed *in situ* (i.e. not recycled). The coarse grained and well sorted incursion at 1501-1502 m is possibly an exception to this. As glauconite formation is a marine very slow eodiagenetic to synsedimentary process, it is conclusive that deposition took place in an open marine environment with very slow sedimentation rates. The abundant bioturbation observed corresponds well to that interpretation. As K_2O probably is incorporated in glauconite directly from sea water at or slightly below the sediment-water interface, the potassium content of the glauconite grain can be referred to as a rough estimate of duration of glauconite formation, which indirectly is a measure of the total sedimentation rate (Odin & Fullagar 1988). In accordance with this model, the potassium content of the Svedala-1 glaucony is intermediate on a scale ranging between 1-8 wt.% K_2O and corresponds to 10^4-10^5 years of duration of glauconite formation. Element analyses (EDX-spot analysis) of single glauconite grains revealed K_2O contents of around 4 wt.%.

The pelagic limestone interval

Due to the monotonous lithology of this vast interval, probably, only representative cores (1 to 2 m of core was stored per 10-20 m coring) were preserved at the Svedala 1 well site. However, from studies of existing cores and well diaries it is clear that the limestone interval (see Fig. 31) comprises a thick sequence of fine grained limestone consisting mainly of coccoliths, planktic foraminifera and minor constituents of macrofauna and terrigeneous material. The grain sizes and fossil content reflect deposition in the pelagic marine realm, in deep shelf areas submerged by the high sea level stand prevalent at the time of deposition. As in younger parts, the lowermost cirka 100 m of this limestone interval is bioturbated, which implies well oxygenated fully marine bottom conditions. Some intervals contain scattered glauconite grains, which indicate that the rate of deposition, i.e. the production rate of organic carbonate, was not very high. Also, intervals with abundant flint concretions may reflect times of lesser carbonate production when pelagic siliceous organic ooze would be able to equal the carbonate production to some extent.

Höllviken 2

Pre-Rhaetian Middle to Upper Triassic

This 400 m thick sequence at the base of Höllviken 2 (cf. Fig. 32) is hitherto poorly dated. Typical for the interval are the immature mineralogy and sediment textures, the almost total deficiency in organic matter and the scarcity of signs of biota. In all, it is obvious that the strata are deposited in continental settings dominated by a dry climate. In order to reconstruct variations in the effects of the climatic regime during the deposition, Jacobsson (1993) divided the lowermost half of the pre-Rhaetian interval (1745-1924 m) into seven units, based on variations in maturity of the detrital mineralogy, clay mineralogy, sedimentary structures, texture, sediment colour, and organic contents. A humid-versus-arid climatic curve was constructed which indicates that the prevailing arid to semiarid climate was interrupted during a slightly more humid period corresponding to the 1765-1892.5 m interval (Fig. 36). Arndorff (1994a) has analyzed textures, petrography and chemistry of abundantly occuring authigenic calcite and dolomite concretions of the superimposed middle portion of the pre-Rhaetian Triassic sequence (1565-1710 m). He has assigned the unit to the Kågeröd Formation and classified the carbonate-rich intervals as laminar-, hardpan-, powder- and conglomeratic calcretes, which occasionally comprise calcified rootlets (Fig. 37). Their genesis were influenced by vadose waters giving rise to various geopetal fabrics. Except for the calcretes, which only have been found in the Höllviken 2 well, the red-beds (conglomerates, arkoses, arkosic wackes and smectite-bearing haematite-stained mudstones) of the upper part of the pre-Rhaetian show characteristics typical of the alluvial fan deposits of the Kågeröd Formation (see previous sub-chapter on the Kågeröd Formation of Svedala 1).

Rhaetian-Lower Cretaceous

The Rhaetian-Lower Cretaceous of Höllviken 2 contrasts the arid climate strata below in being mature (mineralogically and texturally) humid climate deposits rich in coalified plant remains. As almost all mudstones of Rhaetian-Jurassic age within the Tornquist Zone, those in Höllviken 2 are kaolinite-dominated and smectite-free. They were predominantly formed in soils subjected to raised acidity due to the abundance of partly decomposing organic sedimentary components, which raised the content of CO_2 (i.e. HCO^{3-}) and of humic acids of the sediments. The transition from arid climate red-beds is obscure due to reduced core recovery at that level. However, the Rhaetian-Lower Cretaceous interval also shows bedding features typical of other Rhaetian-Lower Cretaceous sequences of the Tornquist Zone. Strata such as autochthonous coal seams (former peat) and rootbioturbated palaeosols alternate with subaquatic heterolites with scattered trace fossils and sandstone sheets. These variations most probably reflect microtopographic changes on lacustrine floodplains or, in some cases, upper delta plains (cf. Ahlberg 1990; Ahlberg & Arndorff 1994).

Palaeosols are abundant in the Early Jurassic(?) 1305-1332 m interval (Figs. 33 and 38). They are typically drab-coloured (light olive grey to yellowish grey) and overlain by a dark coaly layer. The palaeosols are developed on sedimentary rocks with a silty and sandy texture and the distinctness and outline of the soil horizon boundaries are diffuse and smooth. Original sedimentary structures (lenticular bedding) are mostly destroyed by pedogenic processes, particularly in the upper parts of the soil columns. Roots are preserved as organic-mineral mixtures and the rooting structure is simple, that is the roots are small and elongated, but reaches depths of 50 to 60 cm. The boundary to the underlying parent rock is gradational and smooth. In many aspects (i.e. clay mineralogy, elemental distribution, weathering and leaching ratios), the features of the palaeosols are similar to features of Bjuv Member palaeosols of Svedala 1. However, the palaeosols in the Rhaetian-Lower Cretaceous of Höllviken 2 appears to be less mature than the Rhaetian palaeosols of Svedala 1, as a consequence of a shorter timespan of soil development in the former palaeosols.

The deposition of the interbedded monotonous mudstone interval at 1250-1292 m leaves few sedimentological or palaeontological clues to interpret the deposition. The transition to the superimposed marine part of the sedimentary column, i. e. from coal-bearing strata to the "Greensand" and the "Aptian Shale" is marked by a profound shift from solely lacustrine palynomorphs to a mixture of marine and lacustrine microfloristic elements (Fig. 7). Although not directly observed in the core, the coinciding abrupt sedimentary facies change and occurrence of reworked Late Palaeozoic palynomorphs at 1250.90 m may well mark an important disconformity.

Marine Lower Cretaceous -Upper Cretaceous

The "Greensand" interval of Höllviken 2 does not differ much from equivalent glauconitic deposits in SW Scania, in terms of detrital mineralogy and texture. Hence, the interval is dominated by marine glauconite-rich siliciclastic wackestones and quartz arenites (see Figs. 12 and 14). The most conspicious feature of the "Greensand" interval is the interbedded organic rich "Aptian Shale" (Fig. 32). The clay mineralogy of the shale does not differ much from underlying Jurassic alluvial mudstones, which implies that the clastic sediment components were derived more or less directly from adjacent alluvial and littoral areas. The impression of marine sedimentation with a marked continental influence is reinforced by the palyno-facies recorded from the "Greensand" and the "Aptian Shale". This sequence comprises distinctly marine elements (such as dinoflagellates) whereas reworked lacustrine algae *(Botryococcus)*, and pollen and spores still dominate quantitatively (Fig. 7). It is notable that this Early Cretaceous sedimentary sequence comprises reworked Palaeozoic and Jurassic microflora.

The subsequent basal portion of the pelagic limestone interval commences with a thin basal conglomerate comprising reworked greensand clasts. This interval is upwards dominated by fine carbonate material, i.e. coccoliths, foraminifera, unidentified micrite and minor constituents of macrofauna and terrigeneous material. The rock clearly reflect deposition in the open pelagic marine realm in submerged deep shelf areas, as a consequence of the high eustatic sea level stand of the Early Cretaceous. The strata are bioturbated, which implies that the sea bottom was oxygenated. Scattered glauconite grains occur, which may indicate a moderate to slow rate of deposition (if the glauconite grains are not reworked).The abundant flint concretions may reflect times of diminished carbonate production allowing pelagic siliceous organic ooze to equal the pelagic carbonate production.

ORGANIC MATTER IN MESOZOIC STRATA OF SVEDALA 1 AND HÖLLVIKEN 2

Data

Data from investigations of organic matter in the Svedala-1 and Höllviken-2 cores are presented in Fig. 40.

TOC

Svedala 1

The content of organic matter in the Mesozoic of Svedala 1 is low, even in the most promising beds (Fig. 41). From an economical perspective, TOC, S1 and S2 data indicate that most of the Mesozoic in Svedala 1 is poor in kerogen (*sensu* Peters 1986; Fig. 42 herein). The red-beds of the Kågeröd Formation is deficient in organic matter due to an oxidizing depositional environment. In the Rhaetian, abundant organic matter is found concentrated in thin coal seams, i.e. not dispersed in the strata. However, in the Lower Cretaceous "Greensand" interval a fair amount of dispersed organic matter is found. Those strata are followed by pelagic limestones with predominantly low TOC values.

Höllviken 2

Organic matter, as estimated from TOC, S1 and S2 data in the Middle to Upper Triassic red-beds of Höllviken 2 is very low as the preservation potential of organic matter was severely hampered by the oxidizing arid depositional environments (Fig. 43). The coal-bearing Rhaetian-Lower Cretaceous of Höllviken 2 is much richer in organic matter, at most 9%, due to stimulation of plant growth in the humid continental setting. As in the equivalent section of Svedala 1, organic matter is concentrated to coal seams in this interval. The Lower Cretaceous part of the Höllviken 2 is fairly rich in organic matter within the "Greensand" interval. Notably, the interbedded "Aptian Shale" yielded a TOC value of 3.6%. The pelagic limestone interval following the glauconitic interval in Höllviken 2 is again poor in organic matter, TOC of 0.2 to 0.3% appears normal. This is probably due to oxidizing sea bottom conditions during the deposition (as revealed by plentyful bioturbation in this interval).

Kerogen typing

Kerogen characterization can, despite pitfalls (mineral matrix effects, effects of low maturity etc.), be carried out using a crossplot of HI vs OI instead of using real H/O elemental ratios (Larter 1985, Peters 1986). HI and OI values in the Svedala 1 and Höllviken 2 samples are in general low. Only 13 acceptable pairs of HI/OI values were recorded (values below or near the detection limits were omitted). All HI/OI-pairs indicate that type III kerogen is dominating the organic matter (Figs. 44-45). Type III is gas prone and mainly derived from remnants of higher plants. Thus, a humid continental origin of most parts of the present organic matter is clearly implied. Hence, the obtained data were expected for samples of the coal-bearing Rhaetian-Lower Cretaceous strata, but surprising for some samples of the Lower Cretaceous glauconitic and pelagic marine carbonate facies. The marine realm obviously received notable amounts of organic matter from land, a fact which is confirmed by the palynofacies analysis.

Thermal maturation

Svedala 1

Thermal maturation of organic matter in the core Svedala 1 has been analyzed by means of Rm, Tmax, PI and Thermal Alteration Index (TAI) for palynomorphs. Vitrinite reflectance trends in sedimentary columns with a simple burial history are typically linear when Rm is plotted on a logaritmic scale (Dow 1977). In Svedala 1, such downhole increasing Rm values, from 0.3% to 0.6%, were observed in the interval 700-1575 m (Fig. 46). This implies a normal increasing thermal maturity merely reaching the roof of the oil generation window (the birthline; cf. Fig. 47). The two lowermost analyzed levels yielded anomalously high Rm; highly mature to post-mature kerogen. This may have been caused by local heatflows along the Svedala-fault which runs near Svedala 1 and possibly is inclined towards the borehole (cf. Dow 1977).

Being partly dependent on kerogen type and substrate, Tmax and PI are less reliable thermal maturity indicators than Rm. However, most type II & III kerogens enter the oil generative window at Tmax temperatures of 435-445°C and PI values around 0.1 and leaves it at Tmax temperatures about 470°C and PI values around 0.4 (Espitalie' 1986; Peters 1986; Fig. 47 herein). In Svedala 1, the downhole trend of the interval 700-1500 m roughly span an increase in Tmax from 430°C to 445°C (Fig. 46), i.e. approaching the roof of the oil generative window. Tmax data did not reveal the anomalously high thermal influence recorded from the deepest Rm observations. Production Index (PI) was not considered a reliable maturity tool in our investigation. It can be used as a measurement of thermal maturity provided that the composition of organic matter is consistent and the samples are constantly kept moist with formation water (Barker 1974). TAI observations scatter around 3 for palynomorphs in Rhaetian strata at 1520-1575 m. This supports the idea that the major part of sedimentary column barely has reached the roof of the oil generative window.

Conclusively, the Mesozoic sequence in the Svedala 1 borehole was subjected to a normal burial temperature increase from around 60°C to around 90°C, i.e. from immaturity to the the birthline of oil generation. In addition, local anomalously high thermal influence of 150-200°C was recorded, probably due to heatflow along permeable faults and fissures.

Höllviken 2

Vitrinite reflectance of Höllviken 2 samples (Fig. 48) show a downhole palaeothermal trend which ends at the onset of the oil generative window. Rm starts in the shallowest samples around 0.3-0.4 and in the deepest analyzed sample it ends up at 0.6%. This denotes burial temperatures which probably not are much higher than the present temperature of the borehole, max 50-70°C. Likewise, Tmax values rise downhole from 425 to 450 (Fig. 48), which is typical for strata which not yet have reached temperatures of the oil generative temperature interval.

DIAGENESIS

Diagenesis of strata in the Svedala 1 core

The Kågeröd Formation

The conglomerates, arkoses and wackestones of this interval are mostly poorly lithified, showing few diagenetic features. As in all known exposures of this formation, occasional eodiagenetic hematite rims around detrital grains occur. This is in concordance with the inferred semi-arid depositional environment of the Kågeröd Formation (see above). Hematite forms in the oxic diagenetic zone, i.e. the vadose zone of of dry climate red-beds deficient in organic matter. Patches of later porefilling and partly poikilotopic calcite cement occur . They are also known in the Kågeröd Formation of NW Scania (Ahlberg, unpublished data) and in equivalent strata of the borehole Höllviken 2 (Ahlberg, in prep.). The diagenetic components of the Svedala 1 Kågeröd Formation interval are slightly atypical in their relative scarsity of hematite and their higher $FeCO_3$ and $MnCO_3$ contents of calcite cements. Clay mineral suites with Illite/smectite mixed layering can probably be assigned to partial smectite collapses due to raised diagenetic temperatures.

The Bjuv Member (Höganäs Formation)

The mature arenites, kaolinitic muds and the coals of this formation exhibit diagenetic features clearly distinctive from those of the Kågeröd Formation and correlative to those of equivalent strata in NW and SW Scania. As with the Kågeröd Formation, the eodiagenesis of the Bjuv Member was influenced by processes active in the depositional environments of the formation. The introduction of organic matter (coal) in the Rhaetian radically raised the CO_2 content and thus the acidity of soils. Percolating acid ground water caused gravity-driven flushing of acid meteoric waters through permeable formations (i.e. arenites). This has clearly influenced the eodiagenetic processes, giving way to typical acid reactions such as interstitial feldspar dissolution, authigenic kaolinite growth and silica cementation (cf. Björlykke 1983; Ahlberg 1990). During subsequent burial diagenesis, patchily distributed poikilotopic ferroan calcite cements occur. EDX analysis and stable isotope composition of the carbonate cements show similary with equivalent Rhaethian-Hettangian strata of the Tornquist Zone (Ahlberg, in prep.).

The "Greensand" interval

In the glaucony interval the syndepositional to eodiagenetic glauconitization process is of leading interest. Glauconitization require marine conditions, neutral redox potential and slow sedimentation to maintain the two first conditions. It normally takes place in the uppermost few centimetres of marine substrates at a very slow rate. Diagenetic components other than glauconite are sparse in the Svedala-1 glaucony interval. Chlorite has substituted some of the glauconite. As in underlying formations, patchily distributed porefilling calcite cement may be found (we only found it in one covered thin section). A thin rim of quartz cement was observed around the detrital quartz grains in one sample.

The pelagic limestone interval

The monotonous pelagic limestone interval (Turonian - Coniacian) leave few diagenetic clues. An exception to that rule is the scattered presence of pyritizised internal parts of foraminifera and other shells. Pyrite was formed eodiagenetically in the sulphate reduction zone, which normally extends from the sediment surface, or a few cm down, down to 10 m below the sediment surface. Marine reducing pore waters are prerequisits for this process. On thin-section scale, such conditions are easily achieved at sites where aerobic bacterial decomposition of animal softparts has depleted marine pore water in oxygen.

Additionally, several cm- to dm-wide calcite vein-fillings of fractures where recorded in the pelagic limestone interval. The calcite veins are notably richer in $CaCO_3$ than other diagenetic calcites of the Mesozoic in Svedala 1. Fluid inclusion analysis of these phases are under preparation an will futher unravel the thermal and chemical history of these fracture filling mineralizations (Ahlberg, in prep.).

Diagenesis of strata in the Höllviken 2 core

The pre-Rhaetian Middle to Upper Triassic interval

Most of the texturally and mineralogically immature siliciclastic strata of these continental red-beds show discrete if any signs of diagenetic influences. Except for eodiagenetic calcrete formation (see above) and haematite rims, porefilling ferroan calcite cements are present in some arkosic beds which initially had a high permeability. However, most beds are poorly sorted and matrix-rich, leaving little opportunity to pore water circulation which in turn has hampered diagenetic processes.

The Rhaetian-Lower Jurassic(?) interval

The mature coal-bearing strata of this inetrval comprises, as contemporaneous strata within Scania, eodiagenetic siderite nodules within mudstones, and in the arenites early diagenetic features as quartz overgrowths (not in all samples), partly dissolved and kaolinized feldspars and authigenic kaolinite. During subsequent burial diagenesis porefilling ferroan calcite is present at some thin levels, however absent in most arenites. Additionally, disseminate siderite crystals occurs at some places. The high initial permeability of the arenites has enhanced pore water circulation and thereby the diagenetic precipitations and dissolutions mentioned.

The "Greensand" interval

In these strata, as in the contemporaneous interval in Svedala 1, the glauconitization process is of leading interest. Chlorite cement covers some of the authigenic glauconite grains, and disseminate siderite crystals are locally very abundant. As in underlying formations, pathchily distributed porefilling poikilotopic calcite cement may be found.

The pelagic limestone interval

As in Svedala 1, this interval leaves few diagenetic clues. Pyritization of animal softparts is abundant and concentrated to the internal parts of tests. Pyritization occurs within the sulphate reduction zone of the sedimentary column (normally within 10 m from the sea water-sediment interface), in marine settings supplying SO_4^{2-}. It is probable that the pore waters were depleted in oxygen at sites of intensive aerobic bacterial actitvity.

Calcite vein-fillings of fractures are late diagenetic features formed after the lithification of the strata, as revealed by the brittle fractures. It is likely that the veins were filled by minerals precipitated by upwards migrating compactional waters which could not pass through the narrow sediment pores of the micritic limestone. Tectonic deformation allowed waters escape along fissures, and as temperature and pressure diminished on the path upwards, the fluids became supersaturated with respect to calcite. The calcite veins are notably richer in $CaCO_3$ than other diagenetic calcites of the Mesozoic in Svedala 1. Fluid inclusion analysis of these phases are under preparation an will futher unravel the thermal and chemical history of these fracture filling mineralizations (Ahlberg, in prep.).

DISCUSSION AND CONCLUSIONS

Stratigraphy

The stratigraphical results in the present study show that striking biostratigraphical, petrographical and depositional similarities occur between strata of the Kågeröd Formation & Bjuv Member (Höganäs Formation) of NW Scania (cf. Sivhed 1984), and the intervals 1516 -1575 m & 1575-1612 m of the borehole Svedala 1, respectively. We therefore find it appropriate to extend the formal stratigraphy of NW Scania to Svedala 1 and related nearby proximal areas of the Danish Basin. Hence, we can now demonstrate the stratigraphical development of the pre-Santonian Mesozoic sequence within the Skurup Platform. A prominent result from this analysis is the complete lack of lower and middle Triassic strata, the missing Jurassic and most of the Lower

Cretaceous (Figs. 6,8-9). Additionally we have found that the early Turonian hiatus is slightly larger in Svedala 1 compared to the conditions in e.g. Höllviken 1 & 2.

There is still one part of the cored sequence in Svedala 1 which is stratigraphically undefined. The levels below 1612 m down to the crystalline basement is composed of quartzitic sandstones and conglomerates and these sediments have not yielded any stratigraphical evidences. It cannot be entirely excluded that this sequence represent an erosional remnant of an Early Palaeozoic sequence and could then possibly be compared to the Lower Cambrian quartzites and quartzitic sandstones which form the Early Cambrian within the Tornquist Zone. To some extent this hypothesis is corroborated by the mapping of the seismic marker elsewhere representing the top Palaeozoic (the Green Marker). This seismic marker can be traced across the Svedala Fault into the western part of the Skurup Platform and its disappearance eastwards can be traced reasonably well (Fig. 28). A Triassic age of this quartzitic interval may not be excluded either. In other wells within the Höllviken Graben the early Triassic clastics are always supported by a coarse, quartzitic conglomerate which rests directly on the Palaeozoic shales (Figs 29-30). All attempts have failed to date this conglomerate. Quartzitic coarse conglomerates also occur in the Barsebäck 1 and Norrevång 1 wells here forming the substratum of the Kågeröd Beds. A significant feature of these conglomerates is the thicker and more indurated character of the conglomerate in wells located close to major fault zones, e.g. in Eskilstorp 1 (cf. Fig. 30). This could infer more extensive flows of silica-rich fluids along these faults resulting in more extensive silica precipitation. This could be the mechanism behind the formation of the almost 30 m thick quartzitic sequence in Svedala 1 affecting an Mesozoic clastic sequence.

Our analyses of the Höllviken 2 core corroborates the present stratigraphy of the Triassic portion, strengthening the hypothesis of a Ladinian-Carnian age of the Kågeröd Beds and submitting further palynological evidences for the presence of Rhaetian strata. The existance of Jurassic strata is still obscure, but some conclusions on the presence of Lower Jurassic strata can be made from the palynological analysis. Lower Cretaceous sediments are obviously present, but still no safe stage boundaries can be established. The hiata around the Lower-Upper Cretaceous boundary can be confirmed by palynological and foraminiferal evidences.

Due to the still vague stratigraphical evidences for the Jurassic-Lower Cretaceous interval in Höllviken 2, we refrain from introducing the formal stratigraphy introduced for NW and Central Scania (Sivhed 1984, Guy-Ohlson & Norling 1988 and Norling *et al.* 1993). However, it is clear from biostratigraphical analyses of some additional deep wells in SW Scania, that several of the established lithostratigraphical units are developed, although no safe boundaries can be established.

In the Jurassic, safe records of the Rydebäck and Fuglunda Members (Aalenian-Bajocian) can be established in Hammarlöv 1,and Fuglunda, Glass Sand (Bajocian-Bathonian), and Fortuna Marl (Callovian) in Kungstorp 1, Höllviksnäs 1, Håslöv 1 and Hammarlöv 1 (Fig. 8). Fyledal Clay (Oxfordian-Kimmeridgian) occurs in Höllviksnäs 1, Hammarlöv 1 and Barsebäck 1, and Nytorp Sand and Vitabäck Clays (Kimmeridgian-Tithonian) in Hammarlöv 1 and Barsebäck 1 (Fig. 8). These data show that at least Middle and Upper Jurassic strata occur in various parts of the Höllviken Graben and also north of it (Barsebäck 1).

Various stages of the Lower Cretaceous can also be recognized in different wells in SW Scania (Fig. 9). The presence of the earliest stages, Berriasian-Valanginian is uncertain, but possibly some levels in Barsebäck 1 can be referred to these stages. Hauterivian sediments occur in Hammarlöv 1, Barremian strata in Höllviksnäs 1, Hammarlöv 1 and Mossheddinge 1. The Aptian and Albian stages seem to have a wide extension within the area and are recorded in most wells (except in Svedala 1!). This obviously reflects transgressional events during the final stages of the Lower Cretaceous involving both anoxic conditions (the black Aptian shales) and more open marine conditions with glauconitic sand deposition in the Albian, continuing into the Cenomanian. Events of erosion obviously took place as indicated by several conglomeratic horizons within this interval. Hiata are also evident from the biostratigraphical analyses which show missing parts of early-middle Cenomanian strta and lower- middle Turonian.

Depositional environments of the Mesozoic:
-climatic changes and a transgression

The Mesozoic of SW Scania can roughly be divided into four main stratigraphical units, i.e.
A: the Lower to Upper Triassic interval dominated by continental red-beds;
B: the Rhaetian-Lower Cretaceous alluvial (to deltaic?) coal-bearing siliciclastic sequence;
C: the marine Lower Cretaceous glauconite-rich interval; and
D: the pelagic Upper Cretaceous limestone interval.

Lower-Middle Triassic strata are in Sweden exclusively found in the tectonic block penetrated by the Höllviken 2 well, i.e. the Höllviken Graben, whereas the superimposed Upper Triassic red-beds (Kågeröd Formation) are found in wider areas of western and southern Scania. The palaeopedology, low mineralogical and textural maturity, scarcity in organic remains, clay mineralogy and eodiagenetic features of this interval all clearly indicate that deposition took place in continental settings which most of the time were subjected to arid or semiarid conditions. Rainfalls were rare and sporadic, but violent and surface runoff was concentrated to incised channels of alluvial fans and ephemeral braided trunk streams. The aridity hampered the rate of chemical wheathering and favoured oxidizing eodiagenetic processes. However, new petrographical data (presented herein, and by Jacobsson 1993) show that in the lower portion of the Middle-Upper Triassic red-bed interval (Ladinian-Carnian) humid climatic excursions occurred. The introduction of humidity was most certainly connected to the breaking up of Pangea which opened seaways far into previously completely continental regions. In northern Europe, Middle to Late Triassic periods of raised humidity have been confirmed by floristic evidence (Van Buggenum 1985; Senkowicza & Szperko-Sliwczynska 1975). The upper part of the red-bed interval comprises few if any signs of humid influence. It is dominated by arkoses, arkosic wackes, haematite-stained smectite-bearing mudstones and carbonate hardpans (calcrete palaeosols with calcified rootlet mats and some dolomite). Variations in calcrete development reveal that the climate varied from arid to semi-arid (Arndorff 1994b). Grain-size trends reveal repeated fining-up cycles, from conglomeratic to arkosic to wackestones and mudstones, in the upper part of the red-bed intervals of Svedala 1 and Höllviken 2. This may be due to repeated progradation of coalescing alluvial fans, spreading out onto lower lying alluvial plains which hosted caliche or playa lake deposits. The Negev desert of southern Israel stand as an excellent recent environmental equivalent to Triassic arid climate environments of southern Sweden. In analogy with what we have shown for Triassic red-beds of Scania, the Red Sea-Negev region show local variations in humidity on the scale of a few kilometres which are controlled by ever-changing interacting factors such as climate, drainage patterns, topography, rift tectonics, and the extension of seaways into the Jordan and Red Sea Rift.

The Rhaetian-Lower Cretaceous coal bearing interval of SW Scania and adjacent areas sharply contrast the underlying continental red-beds. This is due to a regional climatic change towards humid conditions which favoured plant growth and significant accumulation of coalified plant litter and coal beds. The abundance of humic acids and CO_2 (HCO_3^-) in the sediments promoted acid soil processes. This and the constant wetting of the sediments clearly enhanced weathering of instable minerals in the sediments and their hinterlands. As a consequence of this, the Rhaetian-Jurassic strata are mature from a chemical-mineralogical point of view. They are also devoid of smectite (typical of alkaline arid soils) and rich in kaolinite (typical of acid humid soils). The strata are also more texturally mature than the underlying red-beds which probably has to do with the intensive sediment reworking caused by constantly flowing (i.e. not ephemeral) sediment-reworking rivers of the low gradient Rhaetian-Jurassic alluvial plains (cf. Ahlberg & Arndorff 1994). Vertic palaeosols described herein from the Rhaetian-Jurassic in SW Scania clearly verifies the inferred shift towards humid conditions (Arndorff 1994a). As in NW Scania, palaeosols developed in more marginal parts of the alluvial basins close to horsts (Svedala 1) are more mature, i.e. better developed than those formed more distally (Höllviken 2). The introduction of humid continental settings are also reflected by the abundance and state of preservation of palynomorphs which additionally have given much detailed information of the depositional environments (see above). The subaerially coal-bearing strata are typically interbedded by lacustrine heterolitic sand- and mudstones which comprise a scattered low-diversity ichnofauna and fresh-water palynofloras. As seen in several boreholes, the Rhaetian is in SW Scania terminated by a major hiatus which on some tectonic blocks spans the entire Jurassic and more.

The hiatus is followed by continental and deltaic argillaceous sandstones and shales and by glauconite-rich marine strata of Early Cretaceous age. Glauconitization is a very slow process going on at and slightly below the water-sediment interface. In the case of highly concentrated *in situ* (not redeposited) glauconite accumulations, as recorded in SW Scania, any significant input and overburden of other sedimentary constituents would have interupted the glauconite crystallization.The intermediate K_2O-contents of single glauconite grains in the "Greensand" corresponds to a duration of ionic exchange between potassium-yielding sea water and the growing mineral aggregate of approximately 10^4-10^5 years (Odin & Fullagar 1988). The clastic input was during most of the glauconitization event limited to a few percent of mature quartzose sand and kaolinitic-illitic mud which mineralogically resemble underlying Rhaetian-Lower Cretaceous strata. The clastic input certainly was hampered by the rising sea level during the Early Cretaceous, as land masses which supplied siliciclastic material to a large extent was covered by shallow epicontinental seas. In the Höllviken 2 core the lower part of the "Greensand" interval is interrupted by a few meters of organic rich marine shale, the "Aptian Shale", which may be related to a widespread regional anoxic event of restricted sea water circulation (cf. Jensen & Buchardt 1987,Thomsen *et al.* 1992). The clay mineralogy and palynology reveal continental influences of this black shale. However, a marine depositional setting is undisputed due to the *in situ* marine fauna and the hydrogen-rich kerogen observed. Within the glauconite-rich interval, carbonate debris is restricted to scattered foraminiferal tests (visible in thin sections). Carbonate accumulation (i.e. shell growth) may have been hampered by cold temperatures of the rising sea, which can have been strongly temperature stratified with warm surface waters supplying some pelagic carbonate producers and thereunder water too cold for effective carbonate shell growth. One should however stress that, except for during the anoxic event, the bottom sediments were penetrated by burrowing organisms, and hence oxygenated.

The "Greensand" interval is capped by a hiatus of variable timespan in different boreholes (see discussion above). We have hitherto not seen any signs of subaerial emergence or weathering, and it is possible that the hiatus has been caused by submarine erosion.The following pelagic carbonate sequence commences with a conglomerate with clasts from the underlying "Greensand" interval and further affinity between the two lithologies can be traced in the scattered glauconite grains seen in many thin sections of the limestone interval. We may interpret the glauconite content as evidence of intervals with somewhat limited carbonate production. This also goes for the parts of the pelagic limestone sequence which comprise flint intervals (siliceous pelagic microfauna). Low sea water temperatures may be the most obvious factor hampering carbonate production, but other factors may be involved. The clastic input in the sea from the Cenomanian and onwards was obviously restricted to far transported clay particles. During the slow process of mud settling, the clay mineralogy was affected by the alkaline marine waters. Therefore, muddy laminae within the pelagic interval comprise smectite (swelling clay minerals).

Diagenesis and hydrocarbon potential of the Mesozoic

The four main Mesozoic depositional units of SW Scania and the Tornquist Zone are all composed of different sedimentary constituents reflecting their depositional settings. However, they do have in common that their diagenetic features are dominated by signs of eodiagenetic activity, that is early diagenetic processes which were dependent on chemical, physical and biological factors of the depositional systems being active on the surface. The subsequent burial diagenesis has had less impact on the petrography, which may be regarded as a consequence of the limited burial depths and temperatures experienced by the sediments (see below). For, example, in the Middle to Upper Triassic red-bed sequence, formation of eodiagenetic caliche carbonates and haematite rims within the sediments were controlled by features of the dry continental setting. Likewise, Rhaetian-Lower Cretaceous humid climate alluvial strata caused gravitationally driven flushing of acid meteoric waters which promoted interstitial feldspar dissolution, kaolinite precipitation and quartz cement overgrowths, and siderite nodules were precipitated in anoxic fresh water soaked palaeosols. Further, in the "Greensand" interval the synsedimentary to eodiagenetic glauconitization is the main point of interest. A slow sedimentation rate, interstitial waters on the verge of anoxia, and ionic exchange with sea water are the most important prerequisits for this process. In the pelagic limestone interval, notable eodiagenetic features are restricted to pyritization of animal softparts within tests in the sulphate reduction zone of the sedimentary column. Burial diagenetic features, on the other hand, are dominated by porefilling ferroan poikilotopic calcite cements which are vertically limited. Within this investigation, calcite cements occur sporadically in all strata (i.e. arkoses, sandstones and glauconite sands) which had initial permeabilities high enough to allow the passing of large pore water volumes, which is necessary for the precipitation of notable amounts of cement. The problem of occurences of calcite cemented permeability barriers within potential siliciclastic reservoir rocks has been adressed by several authors. In some greensand samples, burial diagenetic disseminate siderite crystals were found. Probably, Fe^{2+} was abundant due to diagenetic changes of iron minerals (glauconite, chlorite) and was tied to HCO_3^{2-} released by bacterial decomposition of organic matter in the methanogenic diagenetic zone of the sedimentary column. In marine strata, this zone is normally found at levels between 10 and 1000 m below the seawater-sediment interface. No particular investigation has been performed in the case of burial diagenesis of the pelagic limestone interval. However, at two levels calcite healed tectonic fractures were found and will be investigated in the future.

As indicated by several independent downhole palaeothermometres of the wells Svedala 1 and Höllviken 2, Mesozoic subsurface strata of SW Scania rarely experienced temperatures higher than 60-70°C, i.e barely reaching the roof of the oil generative temperature interval (oil window). This temperature is comparable with the present-day maximum temperatures of the boreholes, and is in agreement with other observations from the Tornquist Zone of southern Scandinavia (Ahlberg, unpublished data; Thomsen 1980, unpublished thesis). At the base of Svedala 1, however, anomalously high heat influence was recorded. Possibly this is due to proximity to the Svedala Fault which may have been a conduit for hot mobile fluids during tectonic and volcanic events. Such events have been recorded from the Middle Jurassic and onwards, and has had a profound effect on the diagenesis of some Jurassic strata in Central Scania (Ahlberg & Goldstein, unpublished data). To sum up, burial temperatures were not adequate for hydrocarbon maturation within Mesozoic strata in SW Scania. Local heatflows along fractures triggered by volcanic and tectonic unrest stand out as the only plausible way towards thermal maturation of organic matter. In addition, most organic rich samples studied by us are too low in TOC and dominated by plant remains (gas-prone type III kerogen). The marine "Aptian Shale" of the Höllviken 2 borehole constitute the only plausible source rock of oil (type I kerogen), except for the lack of thermal maturity and the limited bulk volume of this rock unit).

Structural geology and basin analysis

As stated earlier the main structural conditions in SW Scania are well established and summerized in e.g. Norling & Bergström 1987. Two dominant structural features characterize the area, i.e. the Höllviken Graben defined by the Carlsberg and Svedala Faults, and the elevated Skurup Platform east of the Svedala Platform extending into the Baltic Sea. The northernmost part of SW Scania, i.e. the area north of an imaginary line between Malmö and Lund, is structurally less defined as basement data are missing or vague, especially in the the Öresund area. From a depositional point of view this area resembles the Skurup Platform with missing Palaeozoic and Lower-Middle Triassic deposits and a thick Upper Cretaceous sequence. Perhaps it should be referred to as a separate structural unit, e.g. the Landskrona Platform.

The Höllviken graben obviously started its subsidence already in Late Palaeozoic time as Cambrian-Silurian strata are well represented and exhibit a thick development, especially in the western part of the graben. The northern part of this graben structure shows evidences of less subsidence and in fact seems to have been subjected to uplift in the transitional area to the "Landskrona Platform" as evident from the gradually truncated Palaeozoic sequence and thinning Triassic towards the north. Structurally the Höllviken Graben should be defined as a half-graben. Its subsiding nature is reflected also in the thick deposition of Lower-Middle Triassic deposts amounting to 500-600 m in thickness. Crustal movements in adjacent areas provided coarse-clastics to the graben, today expressed as arcosic sandstones and conglomerates.

The absence of Lower-Middle Triassic deposits in the Skurup and "Landskrona" Platforms does not exclude that those areas received sediments during Early and Mid Triassic time, but no evidences can support such a scenario as the Upper Triassic Kågeröd Beds rest directly on the crystalline basement in these areas.

Crustal instability seems to characterize most of the Jurassic-Upper Cretaceous interval in SW Scania. This is evident from the incomplete development of the stratigraphical column and the presence of tilted Palaeozoic - Triassic strata (e.g. in the Höllviken wells). The main features of this development is summerized in Norling & Bergström 1987 and our study largely corroborates their account. The varying development of this interval in the different wells may reflect local crustal disturbences within the Höllviken Graben as well as in the platform areas. This is particularly well demonstrated in the Svedala 1 well with a completely missing Jurassic and most of the Lower Cretaceous, which suggest a structurally high position of parts of the Skurup Platform during this interval, while wells within the Höllviken Graben show evidence of deposition from late Middle Jurassic onwards, although with many depositional breaks. Late Lower Cretaceous transgressions overstepped the existing high areas, which means that a rather full record of the stratigraphical column exists from the Aptian onwards. Some crustal instability occurred, however, and stratigraphical breaks can be identified during the early phases of the Upper Cretaceous. The continued structural evolution of SW Scania is much more unifom than previously as the entire area subsided gradually as one structural unit towards the Tornquist Zone until the end of the Cretaceous. This resulted in thick accumulations of carbonates especially along the Tornquist Zone. Two events with clastic influx into the basin occurred in Campanian and Maastrichtian time. This uniform development of the area is especially obvious from the mapping of the base Upper Cretaceous seismic marker (Fig. 26). The only disturbances affecting this image were induced by minor structural shifts along the major fault zones.

Our study has shown no evidences for magmatic events in SW Scania during the Jurassic and Cretaceous, features which otherwise are characteristic for the Tornquist Zone during this time interval (cf. Norling & Bergström 1987).

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FIGURE CAPTIONS

Fig. 1: Geological map of Scania, showing the bedrock distribution of Mesozoic and Cainozoic rocks. Numbered wells refer to wells mentioned in the text.
1. Falsterborev 1; **2**. Smygehuk 1; **3**. Ljunghusen 1; **4**. Höllviken 2; **5**. Höllviksnäs 1; **6**. Höllviken 1; **7**. Granvik 1; **8**. Kungstorp 1; **9**. Håslöv 1; **10**. Eskilstorp 1; **11**. Maglarp 1; **12**. Hammarlöv 1; **13**. Trelleborg 1; **14**. Svedala 1; **15**. Mossheddinge 1; **16**. Barsebäck 1; **17**. Norrevång 1.

Fig. 2: Structural outline of Scania and adjacent areas. **AH**: Arkona High; **HG**: Höllviken Graben; **LP**: Landskrona Platform; **RFH**: Ringkøbing-Fyn High; **RG**: Rønne Graben; **SP**: Skurup Platform.

Fig. 3: Palynomorph content and palynofacies of Bjuv Member, Svedala 1.

Fig. 4: Occurrence and distribution of palynomorphs found during the light microscope analysis of the sample sequence at Svedala 1.

Fig. 5: Known published stratigraphical ranges of the palynomorphs found in the Svedala 1 borehole (Mainly after Schulz 1967; Lund 1977 and Morbey 1975).

Fig. 6: Stratigraphic chart showing divisions of the Triassic and Brotzen's (1950) division of the Höllviken 2 sequence. Stratigraphical divisions of the Höllviken 2 and Svedala 1 cores in this paper are shown as well as identified Uppper Triassic levels in Håslöv 1 (Håsl), Hammarlöv 1 (Hlöv) and Barsebäck 1 (Bars).

Fig. 7: Comments on palynomorph content and palynofacies of the Mesozoic in the Höllviken 2 core.

Fig. 8: Stratigraphic chart showing divisions of the Jurassic and Brotzen's (1945,1950) division of the Höllviken 2 sequence. Stratigraphical divisions of the Höllviken 2 and Svedala 1 cores in this paper are shown as well as identified Jurassic levels in other wells (Norling 1981) and this paper. Hnäs: Höllviksnäs 1; Håsl: Håslöv 1; Hlöv: Hammarlöv 1; Bars: Barsebäck 1.

Fig. 9: Stratigraphic chart showing divisions of the Cretaceous and Brotzen's (1945,1950) division of the Höllviken 2 sequence. Stratigraphical divisions of the Höllviken 2 and Svedala 1 cores in this paper are shown as well as identified levels in

other wells (Norling 1981) and this paper. Hlöv: Hammarlöv 1; Moss: Mossheddinge 1; Bars: Barsebäck 1; Norr: Norrevång 1.

Fig. 10: Known stratigraphical ranges of palynomorph taxa found in the of the "greensand" and lowermost "pelagic limestone" intervals of Höllviken 2 .

Fig. 11: Occurrence of palynomorphs in the "greensand" and lowermost "pelagic limestone" intervals of Höllviken 2 .

Fig. 12: Point counting data of arenites in the Mesozoic in the cores Svedala 1 and Höllviken 2.

Fig. 13: XRD-patterns of clay mineral fractions of the redbed interval (Kågeröd Formation) in Svedala 1.

Fig. 14: Quartz-Feldspar-Lithic fragment (QFL) triangle diagrams of Upper Triassic to Lower Cretaceous detrital sand compositions in the cores Svedala 1 and Höllviken 2.

Fig. 15: XRD-patterns of clay mineral fractions of the coal-bearing interval (Bjuv Member, Höganäs Formation) in Svedala 1.

Fig. 16: XRD-patterns of clay mineral fractions of the Glaucony interval in Svedala 1.

Fig. 17: XRD patterns of clay mineral fractions of the Turonian-Coniacian pelagic limestone interval.

Fig. 18: XRD-patterns of clay mineral fractions of the Middle to Upper Triassic red-bed interval in the Höllviken 2 core.

Fig. 19: XRD patterns of clay mineral fractions of the Rhaetian-Jurassic coal-bearing interval of Höllviken 2.

Fig. 20: XRD-patterns of clay mineral fractions of the Glaucony interval in Höllviken 2.

Fig. 21: XRD-pattern of clay mineral fractions of the pelagic limestone interval in the Höllviken 2 core.

Fig. 22: Synthetic seismogram for Höllviksnäs 1.

Fig. 23: Synthetic seismogram for Håslöv 1.

Fig. 24: Synthetic seismogram for Mossheddinge 1.

Fig. 25: Synthetic seismogram for Barsebäck 1.

Fig. 26: Structural map showing the "Blue" seismic marker (approx. base Upper Cretaceous). Hatched area: The Romeleåsen Fault and Flexure Zone.

Fig. 27: Structural map showing the "Green" and "Red" seismic markers (top Palaeozoic and top Basement). Wide hatched area: Palaeozoic forming the bedrock surface; Narrow hatched area: Romeleåsen Fault and Flexure Zone. Erosional limit of Palaeozoic dashed. Major faults: **C**: Carlsberg Fault; **F**: Foteviken Fault; **H**: Höllviken Fault; **S**: Svedala Fault; **V**: Vellinge Fault.

Fig. 28: Isopach map showing thickness of strata (in ms TWT) between the Blue and Green/Red seismic markers , i.e. approx. base Upper Cretaceous to top Palaeozoic/Basement. Hatched area: Romeleåsen Fault and Flexure Zone.

Fig. 29: West-East cross-section showing selected correlated levels in wells from SW Scania. For position of section, see Fig. 1.

Fig. 30: South-North cross-section showing selected correlated levels in wells from SW Scania. For position of section, see Fig. 1.

Fig. 31: Sedimentary log of the Svedala-1 borehole.

Fig. 32: Sedimentary log of the Höllviken 2 borehole.

Fig. 33: Data from palaeopedologic investigations in the Bjuv Mb of the borehole Svedala 1 and of the Rhaetian-Jurassic strata of the Höllviken 2 borehole.

Fig. 34: Palaeopedological trends in the coal-bearing interval of the Svedala 1 borehole.

Fig. 35: Typical palaeosol of the Bjuv Mb, Svedala 1.

Fig. 36: Subfacies division (A-G) of the lowermost portion of the Höllviken 2 core, based on various parametres (1-7) such as clay mineralogy, presence of organic matter, presence of calcrete carbonates, colour, texture, lithology, grain roundness and sorting. A climatic curve, shown at the far right of the table, was constructed on the basis of the primary data (after Jacobsson 1993).

Fig. 37: Typical calcrete profile from the Höllviken 2 core.

Fig. 38: Palaeopedological trends in the coal-bearing interval of the Höllviken 2 borehole.

Fig. 39: Rock-Eval principles.

Fig. 40: Data from investigations of organic matter in Svedala 1 and Höllviken 2.

Fig. 41: TOC, S1 and S2 of the Mesozoic interval in Svedala 1.

Fig. 42: Interpretations of TOC (after Peters 1986).

Fig. 43: TOC, S1 and S2 of the Mesozoic interval in Höllviken 2.

Fig. 44: Hydrogen Index vs Oxygen Index of organic matter in Svedala 1.

Fig. 45: Hydrogen Index vs Oxygen Index of organic matter in Höllviken 2.

Fig. 46: Downhole vitrinite reflectance and Rock-Eval Tmax trends of bh Svedala 1.

Fig.47: Thermal maturity levels (after Peters 1986).

Fig. 48: Downhole vitrinite reflectance and Rock-Eval Tmax trend of the borehole Höllviken 2.

APPENDIX

Appendix 1: Alphabetical list of palynomorph species found at Svedala 1.

Appendix 2: Alfabetical list of palynomorphs in the Greensand and lowermost pelagic limestone intervals of borehole Höllviken 2.

SERIES	STAGES	FORMATION	MEMBER	Brotzen 1950	This paper: Höllviken 2	Svedala 1	Håsl	Hlöv	Bars
KEUPER	Rhaetian	HÖGANÄS	Bjuv	1445-1487	1445-1487	1516-1577	1563-1569	1428-1431	
KEUPER	Rhaetian	HÖGANÄS	Vallåkra	1487-1496	1487-1496	?			
KEUPER	Norian	KÅGERÖD		1496-1604	1496-1712	1577-1612	1578-	1451-	1982-2180
KEUPER	Carnian	KÅGERÖD		1604-1755					
MUSCHELKALK	Ladinian	Not designated yet		1755-1862	1712- (1807)		Present but not divided	Present but not divided	
MUSCHELKALK	Anisian								
BUNTER	Scythian			1862-1924 (TD)					

Fig 6

Preliminary biostratigraphical results from the Höllviken-2 core, palynomorphs

Sample section (depth in metres)	***Biostratigraphical datings based on presence of index or diagnostic palynomorphs***	***Additional comments***
1179.18 and 1186.00	----	barren samples.
1190.60	----	poorly preserved dinoflagellates and bisaccate pollen.
1191.00	**Cenomanian**	Abundant dinoflagellates, few pollen, triporate pollen indicative of age.
1224.00	----	Abundant pollen and spores, few dinoflagellates. Well preserved palynoflora, long stratigraphic ranges.
1229.00	----	Poorly preserved palynomorphs, mostly bisaccate pollen. Long stratigraphic ranges.
1240.15	**Apt-Alb**	Very well preserved palynomorphs, mostly pollen and spores.
1244.00	**Late Apt-Alb**	Very well preserved palynomorphs, mostly pollen and spores.
1245.83 to 1289.00	**Hauterivian-Early Apt and "Jurassic-Cretaceous transition"**	Dinoflagellates give a Hauterivian-Barremian up to Early Aptian age. Palynofacies change at 1249.60m. Reworked palynomorphs of Late Palaeozoic age at 1250.90m. Palynoflora characteristic of the Jurassic-Cretaceous transition at 1287.00m.
1291.40 to 1443.40	----	Fresh water algal mat deposits at 1291.40m. Preservation state of Bottryococcus indicate reducing depositional conditions. Alternating barren and productive samples with long range taxa only, but an Early Jurassic character of the palynoflora.
1466.75 to 1477.95	**Rhaetian**	Presence of several index palynomorph species permits correlation with Assemblage No. 5 of the Gassum-1 core of the Danish Sub-basin (cf. Vasard Nielsen1988).
1548.00 to 1477.95	----	A majority of samples in this interval are barren and contain very few stratigraphically non-diagnostic palynomorphs.
1807.00 to 1919m	**Landinian-Carnian**	A majority of samples are barren except for some amorphous plant remains. At 1807.00m a few identifiable palynomorphs with index species permit this sample to be correlated with Assemblage No. 1 of the Gassum-1 core (see above).

Fig 7

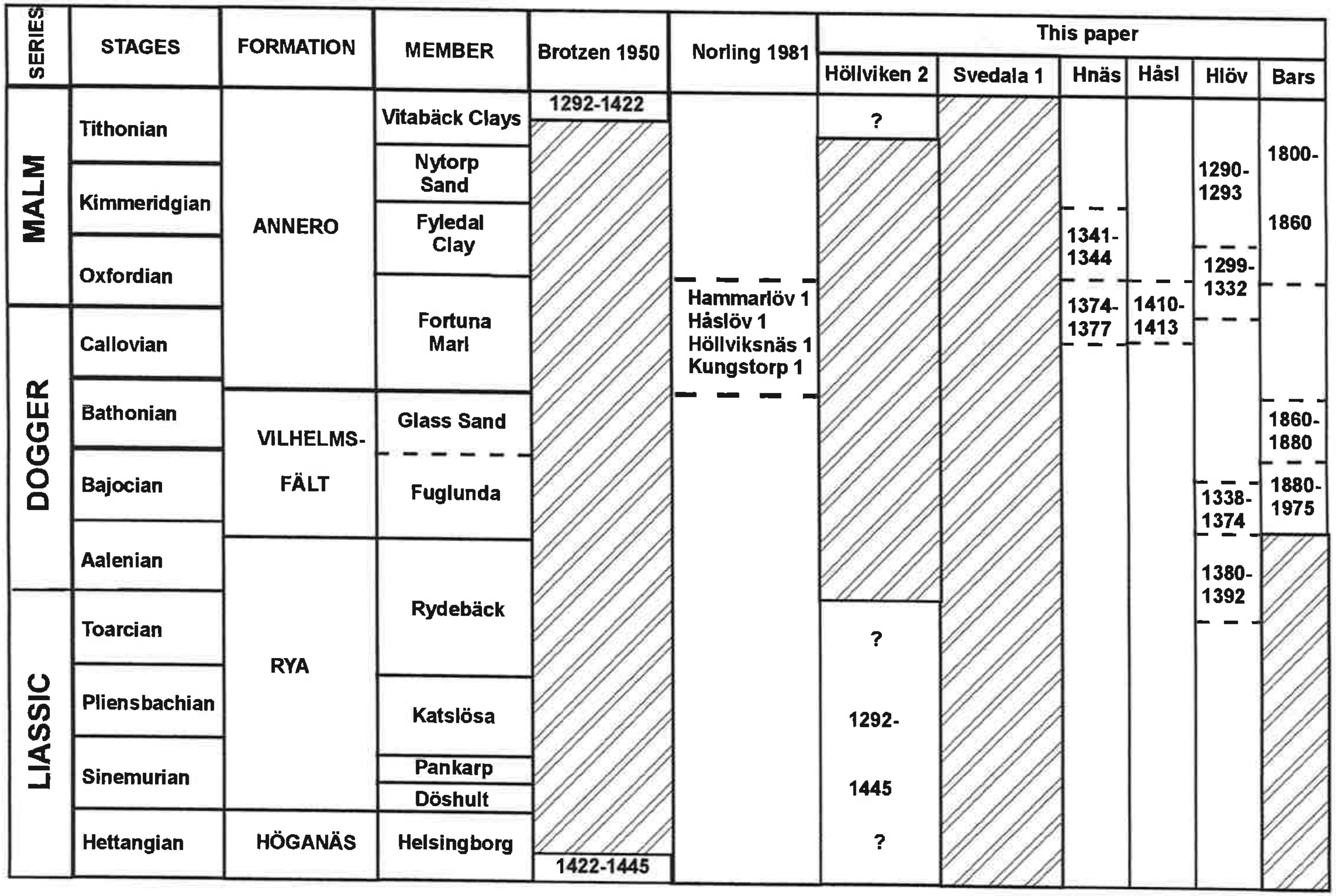

SERIES
STAGES
FORMATION
MEMBER
Brotzen 1950
Norling 1981
This paper
Höllviken 2
Svedala 1
Hnäs
Håsl
Hlöv
Bars
MALM
DOGGER
LIASSIC
Tithonian
Kimmeridgian
Oxfordian
Callovian
Bathonian
Bajocian
Aalenian
Toarcian
Pliensbachian
Sinemurian
Hettangian
ANNERO
VILHELMS-
FÄLT
RYA
HÖGANÄS
Vitabäck Clays
Nytorp Sand
Fyledal Clay
Fortuna Marl
Glass Sand
Fuglunda
Rydebäck
Katslösa
Pankarp
Döshult
Helsingborg
1292-1422
1422-1445
Hammarlöv 1
Håslöv 1
Höllviksnäs 1
Kungstorp 1
?
?
1292-
1445
?
1341-
1344
1374-
1377
1410-
1413
1290-
1293
1299-
1332
1338-
1374
1380-
1392
1800-
1860
1860-
1880
1880-
1975

Fig 8

SERIES	STAGES	FORMATION	MEMBER	Brotzen 1945,1950 (Höllviken 2)	Norling 1981	This paper: Höllviken 2	This paper: Svedala 1	This paper: Hlöv	This paper: Moss	This paper: Bars	This paper: Norr
UPPER	Maastrichtian			46-530							
	Campanian	Lund Sandstone		530-800							
	Santonian	Not designated yet		800-1075							
	Coniacian			1075-1136							
	Turonian			1136-1187		1136-1190	-1488				
	Cenomanian			1187-1191	Höllviksnäs 1 (1200-1250) Håslöv 1 (1328-1360) Svedala 1 (1490-1542/L.C.)	1190-1191	1490- 1514 ?	1251- 1254 1260			
LOWER	Albian			1191-1245		1191-1245		1269-	1671-	1734-	
	Aptian			1245-1250	Eskilstorp 1 Höllviken 1 Höllviken 2 Höllviksnäs 1 Håslöv 1	1245-1250		1272	1695	1764	1835
	Barremian			1250-1274		?		1278- 1281	1704- 1730		
	Hauterivian			?	Hammarlöv 1	1250-				1764-	
	Valanginian			1274-1292		1292				1800	
	Berriasian	ANNERO	Vitabäck Clay			?		1290			

Fig 9

BORE HÖLLVIKEN -II	STRATIGRAPHICAL RANGE									
	Lower cretaceous				Upper cretaceous					
LIST OF PALYNOMORPHS	Neocomian	Barremian	Aptian	Albian	Cenomanian	Turonian	Coniacian	Santonian	Campanian	Maastrichtian
Cerebropollenites thiergarthi										
Clavifera triplex			—	—	—	—	—	—	—	—
Cyathidites australis	—	—	—	—	—	—	—	—	—	—
Cyathidites minor	—	—	—	—	—	—				
Gleicheniidites apilobatus			—	—						
Gleicheniidites bulbosus			—	—						
Gleicheniidites senonicus	—	—	—	—	—	—	—	—	—	—
Lycopodiumsporites clavatoides	—	—	—	—						
Perinopollenites elatoides	—	—	—	—						
Spheripollenites psilatus	—	—	—	—						
Spheripollenites subgranulatus	—	—	—	—	—	—				
Sestrosporites pseudoaveolatus	—	—	—	—						
Taxodiaceaepollenites hiatus	—	—	—	—	—	—	—	—	—	—
Triporopollenites sp.					—	—	—	—	—	—
Vitreisporites pallidus	—	—	—	—						
Alisporites sp.										
Baculatisporites sp										
Cicatricosisporites sp										
Cingutriletes sp A										
Crybelisporites sp.										
Densoisporites sp.										
Lycopodiumsporites sp.										
Podocarpidites sp.										

Fig 11

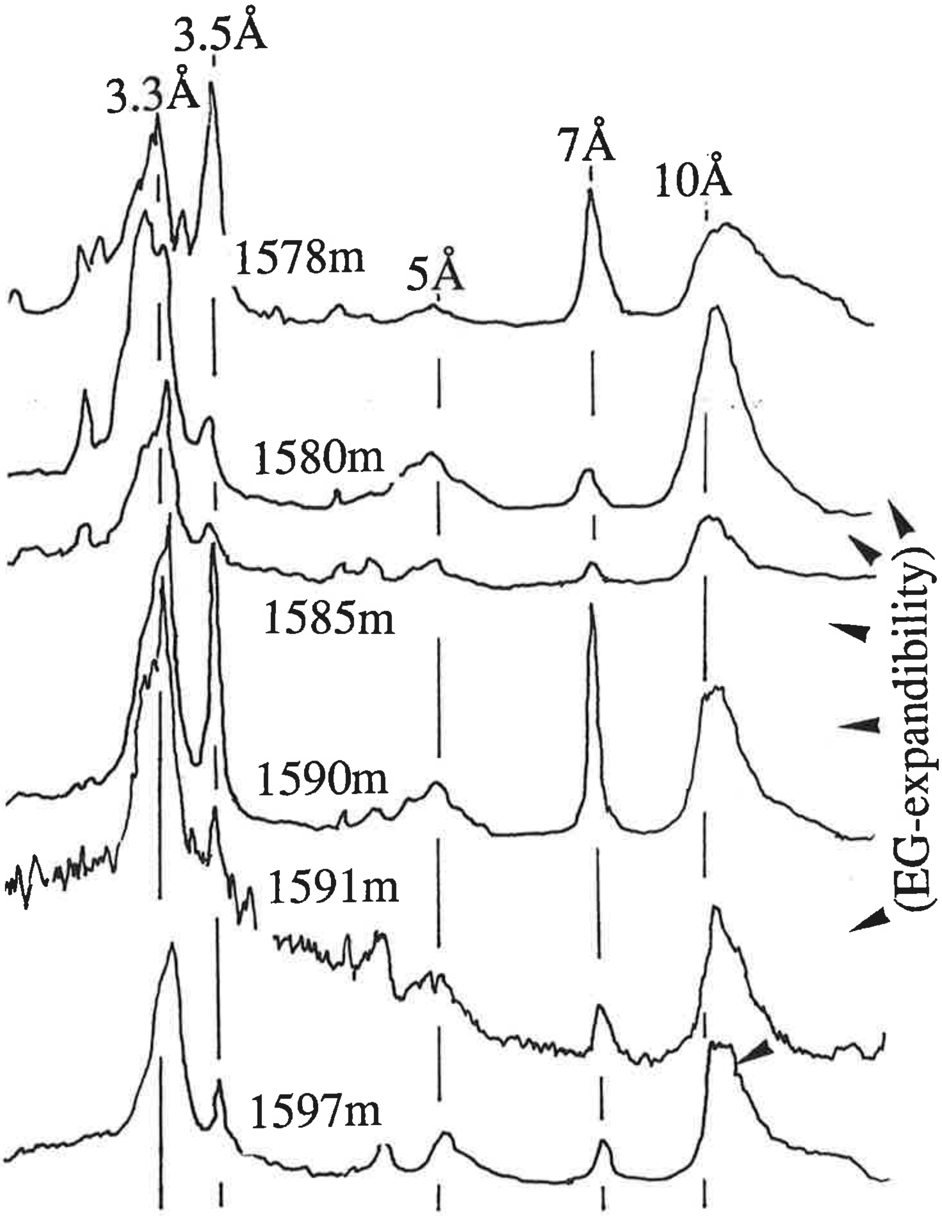
HÖLLVIKEN- II	PRESENCE OF PALYNOMORPHS IN SAMPLE INDICATED BY "+"					
PALYNOMORPH CONTENT						
Depth m.	1244.00	1240.15	1229.00	1224.50	1191.00	1190.60
Alisporites sp.	+	+			+	+
Baculatisporites sp.	+	+				
Cerebropollenites thiergarthi	+			+		
Cicatricosisporites sp.	+					
Cingutriletes sp.A	+	+				
Clavifera triplex	+	+				
Crybelisporites sp.	+					
Cyathidites australis	+			+		
Cyathidites minor	+	+		+		
Densoisporites sp.	+					
Gleicheniidites apilobatus	+	+				
Gleicheniidites bulbosus	+					
Gleicheniidites senonicus	+	+	+	+	+	+
Lycopodiumsporites sp	+			+		+
Lycopodiumsporites clavatoides	+	+				
Perinopollenites elatoides	+	+				
Podocarpidites sp.	+	+				+
Spheripollenites psilatus	+					
Spheripollenites subgranulatus	+					
Sestrosporites pseudoaveolatus	+					
Taxodiaceaepollenites hiatus	+	+		+		
Triporopollenites sp.					+	
Vitreisporites pallidus		+				

Fig 12

Level (m)	stratigraphic interval	Qz grain	Kfsp grain	Plag grain	Rock fragm	Calcite clasts	Heavy miner.	Glau-cony	Mtrx (unid.)	Mica	Chlo-rite	Fe-ox.	Org mtr	Quartz-cement	Calcite cement	Siderite cement	empty pores
		vol.-%	vol.-%	vol.-%	vol.-%	vol.-%	vol.-%	vol.-%	vol.-%	vol.-%	vol.-%	vol.-%	vol.-%	vol.-%	vol.-%	vol.-%	vol.-%
1498.3	glaucony	48.8	1.6	0.0	0.4	0.0	0.0	8.8	4.4	0.4	11.6	0.0	2.0	0.0	18.0	0.0	4.0
1500.1	glaucony	43.2	1.6	0.0	1.6	0.0	0.0	9.6	30.0	2.8	5.6	0.0	4.4	0.0	0.0	0.0	1.2
1506.2	glaucony	55.2	4.8	0.8	4.0	0.0	0.0	2.4	18.4	1.6	3.2	0.0	2.4	0.8	0.0	0.0	6.4
1506.9	glaucony	51.6	5.6	0.0	4.4	0.0	0.0	8.0	14.0	0.8	0.0	0.0	3.2	1.2	0.0	0.0	11.2
1508.6	glaucony	40.8	0.8	0.0	1.2	0.0	0.0	4.4	25.6	0.0	16.4	0.0	6.8	0.8	0.0	0.0	1.6
1510.9	glaucony	48.4	0.8	0.4	2.8	0.0	0.8	7.2	8.0	0.0	0.8	0.0	27.6	0.0	0.0	0.0	2.8
1550.6	Bjuv Mb	59.6	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	27.2	0.0	0.0
1551.4	Bjuv Mb	57.6	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	41.2	0.0	0.0
1548.5	Bjuv Mb	64.0	2.0	0.0	0.8	0.0	4.0	0.0	2.4	0.0	0.0	0.0	2.0	0.4	1.2	0.0	23.2
1557.1	Bjuv Mb	65.2	1.6	0.0	1.6	0.0	0.8	0.0	2.4	0.0	0.0	0.0	0.8	0.8	0.4	0.0	26.4
1560.4	Bjuv Mb	62.4	1.6	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.4	1.2	0.0	0.0	32.8
1560.6	Bjuv Mb	60.8	1.6	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	3.6	0.0	0.0	0.0	32.8
1568.2	Bjuv Mb	65.2	0.8	0.0	0.4	0.0	0.4	0.0	0.0	0.0	0.0	0.0	1.2	2.4	0.0	0.0	29.6
1578.2	Bjuv Mb	60.1	0.4	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.4	25.2	0.0	0.0
1595.8	Kågeröd Mb	37.2	16.8	2.8	16.4	0.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0	2.4	5.6	0.0	0.0
1596.5	Kågeröd Mb	46.0	11.6	1.6	13.3	0.0	0.4	0.0	3.2	0.0	0.0	0.0	0.0	0.4	14.8	0.0	0.4
1189.8	glaucony	36.0	2.4	0.0	0.4	9.2	0.0	5.2	0.0	0.0	0.0	0.0	0.0	0.0	9.2	0.0	0.0
1220.0	glaucony	46.4	2.8	0.0	0.8	0.0	0.0	27.2	0.0	0.8	1.6	0.0	1.2	0.0	18.4	0.0	0.8
1220.3	glaucony	45.2	0.4	0.0	1.2	0.0	0.0	30.4	0.0	0.4	1.6	0.0	0.0	0.4	19.6	0.0	0.0
1233.0	glaucony	58.8	0.8	0.0	0.8	0.0	0.0	6.4	0.0	0.0	2.8	0.0	0.0	0.0	29.6	0.0	0.0
1236.0	glaucony	42.0	3.6	0.0	0.4	0.0	0.0	7.2	0.0	0.0	2.4	0.0	0.4	0.0	0.0	43.8	0.0
1243.3	glaucony	48.8	2.8	0.0	0.8	0.0	0.0	14.0	27.6	0.4	3.2	0.0	0.8	0.0	0.0	0.0	1.6
1282.5	glaucony	56.0	1.6	0.0	3.6	0.0	0.0	13.6	0.0	0.0	5.6	0.0	0.0	0.0	0.0	16.4	3.2
1309.2	"Jurassic"	69.2	2.4	0.0	0.0	0.0	0.0	0.0	1.6	0.4	0.0	0.0	4.8	1.6	0.0	0.0	20.0
1365.3	"Jurassic"	49.2	0.4	0.0	0.4	0.0	0.0	0.0	0.4	0.0	0.0	0.0	3.2	0.0	46.4	0.0	0.0
1380.3	"Jurassic"	48.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	48.0	0.0	0.0
1380.4	"Jurassic"	60.0	1.6	0.0	0.4	0.0	0.0	0.0	0.0	0.4	0.0	0.0	6.4	0.0	0.0	0.0	29.2
1395.8	"Jurassic"	63.6	2.4	0.0	0.4	0.0	0.0	0.0	0.0	0.8	0.0	0.4	4.4	1.6	0.0	0.0	26.4
1410.0	"Jurassic"	52.8	4.0	0.0	4.8	0.0	0.0	0.0	7.2	2.8	0.0	9.2	1.2	2.0	0.0	0.0	16.0
1430.7	"Jurassic"	45.6	4.0	0.0	0.8	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.4	0.0	48.8	0.0	0.0
1541.0	"Triassic"	30.4	14.4	1.6	4.0	2.0	0.0	0.0	0.0	0.0	0.0	6.0	0.4	0.0	41.2	0.0	0.0
1548.0	"Triassic"	6.0	3.2	0.4	2.4	44.8	0.0	0.0	0.0	0.0	0.0	4.4	0.0	0.0	28.0	0.0	0.0
	"Triassic"	17.6	12.4	0.3	23.6	7.2	0.4	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	37.2	0.0
	"Triassic"	9.2	9.6	0.4	54.1	0.0	0.4	0.0	0.0	0.0	0.0	2.8	0.0	0.0	20.8	0.0	0.0
1606.5	"Triassic"	11.6	6.0	0.0	46.4	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.0	33.2	0.0	0.0
1640.0	"Triassic"	20.0	6.4	2.0	27.2	0.0	0.4	0.0	0.0	0.0	0.0	5.2	0.0	0.0	38.8	0.0	0.0
1647.0	"Triassic"	20.0	10.0	2.4	13.2	4.0	0.0	0.0	0.0	0.0	0.0	9.6	0.0	0.0	28.0	0.0	0.0
1678.3	"Triassic"	41.2	5.2	0.4	0.4	0.0	0.4	0.0	35.6	0.0	0.0	16.8	0.0	0.0	0.0	0.0	0.0
1680.0	"Triassic"	15.2	3.2	0.0	2.4	10.0	0.0	0.0	2.4	0.0	0.0	16.4	0.0	0.0	50.4	0.0	0.0
	"Triassic"	44.8	6.8	0.0	1.2	4.4	0.4	0.0	6.4	0.0	0.0	14.4	0.0	3.2	7.2	0.0	11.2

250 points per thin section

Fig 13



Clay minerals of the Kågeröd FM

Fig 14

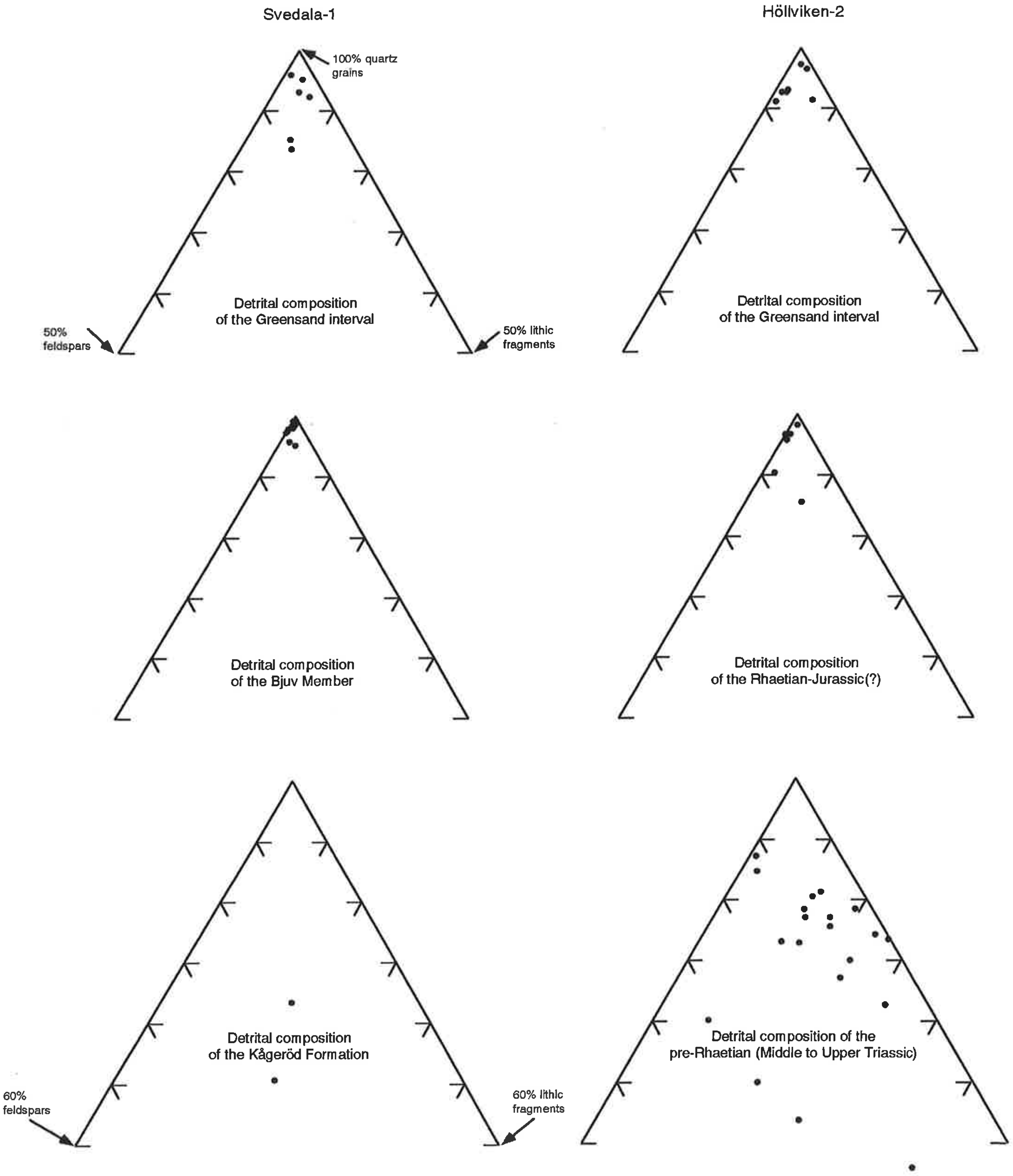
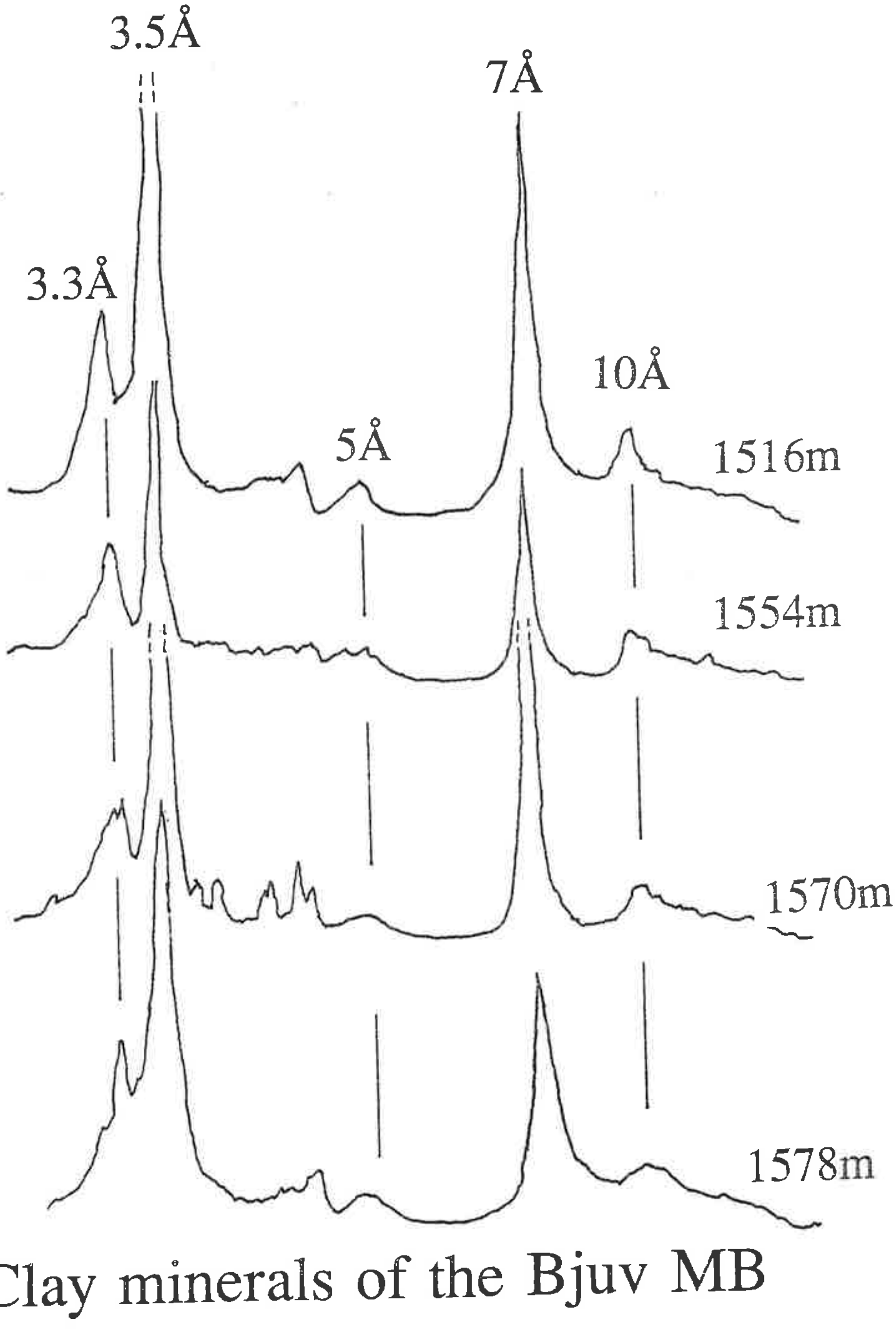
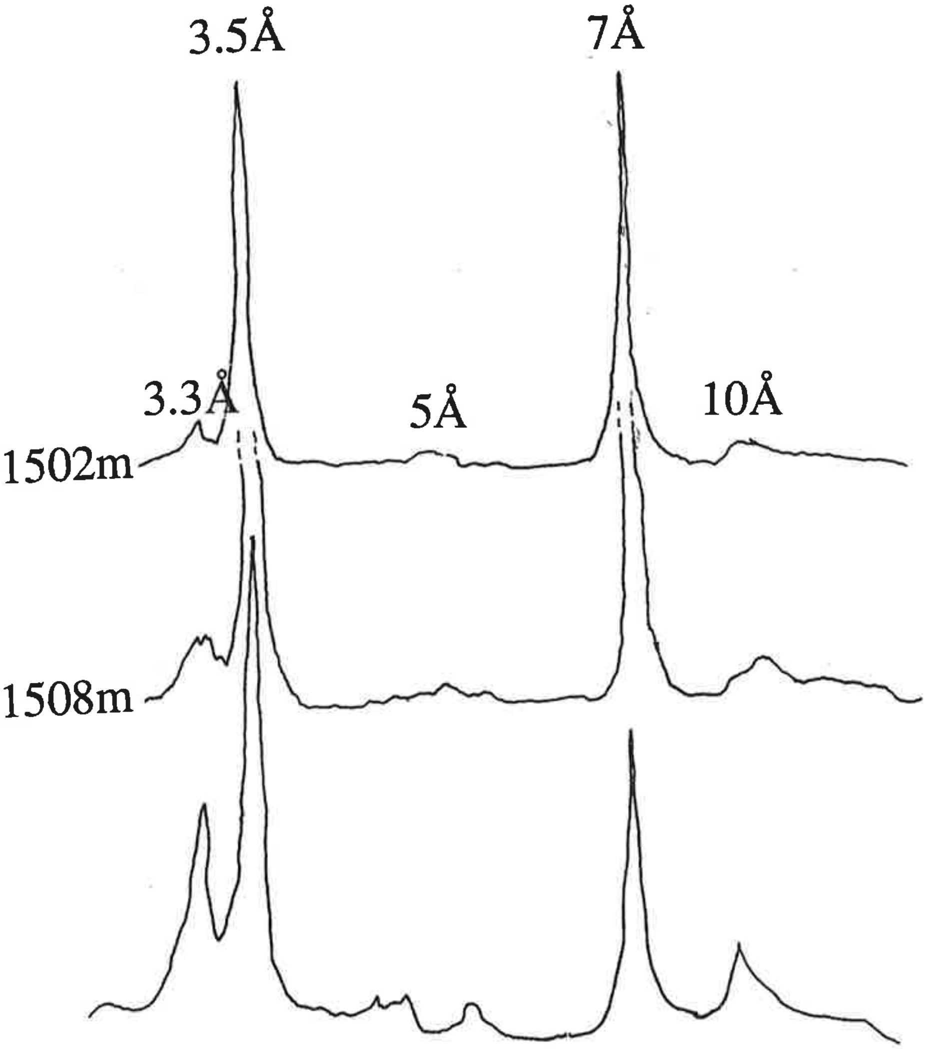

Svedala-1
Höllviken-2
100% quartz grains
50% feldspars
50% lithic fragments
Detrital composition of the Greensand interval
Detrital composition of the Greensand interval
Detrital composition of the Bjuv Member
Detrital composition of the Rhaetian-Jurassic(?)
Detrital composition of the Kågeröd Formation
Detrital composition of the pre-Rhaetian (Middle to Upper Triassic)
60% feldspars
60% lithic fragments

Fig 15

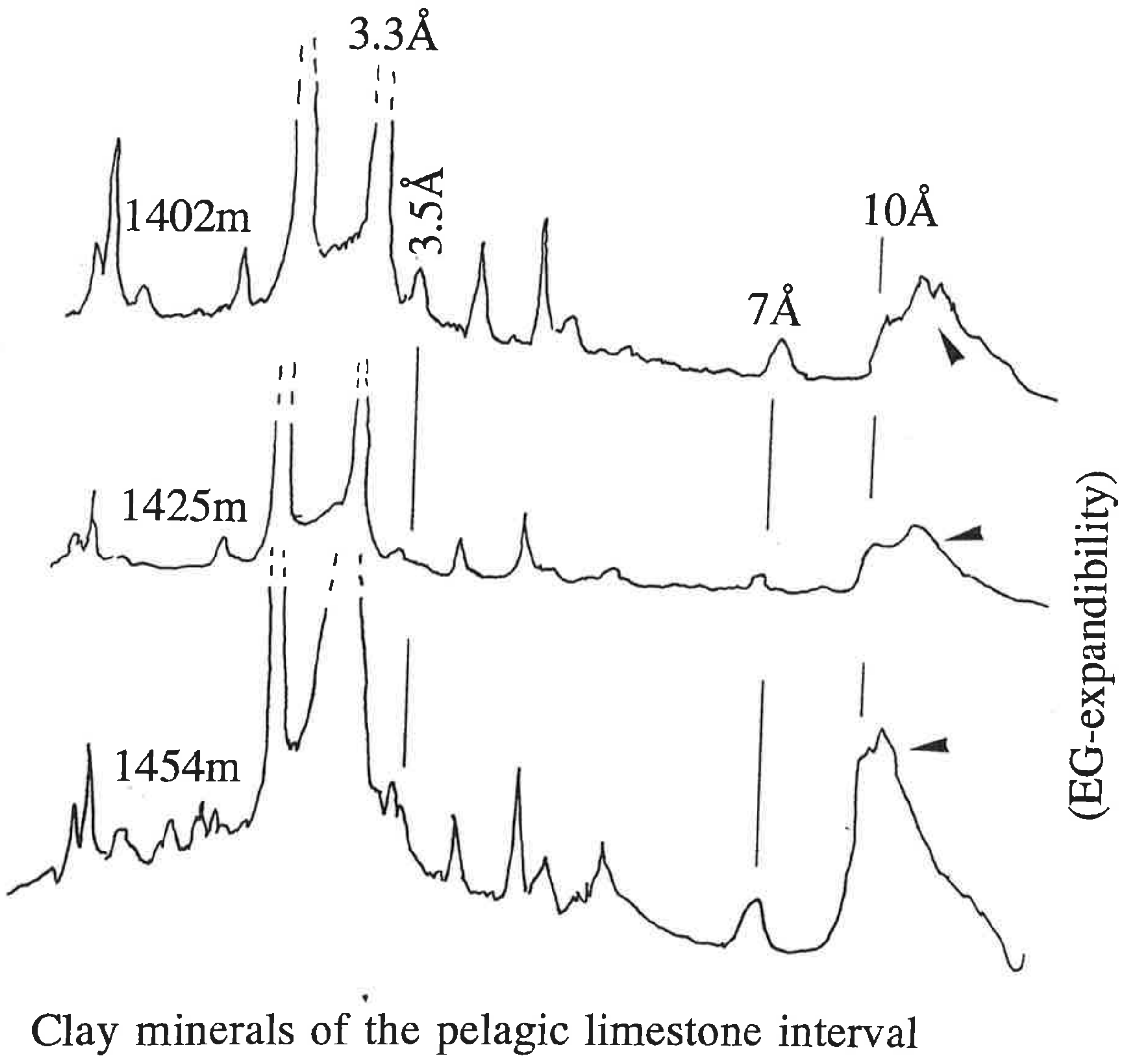


Clay minerals of the Bjuv MB



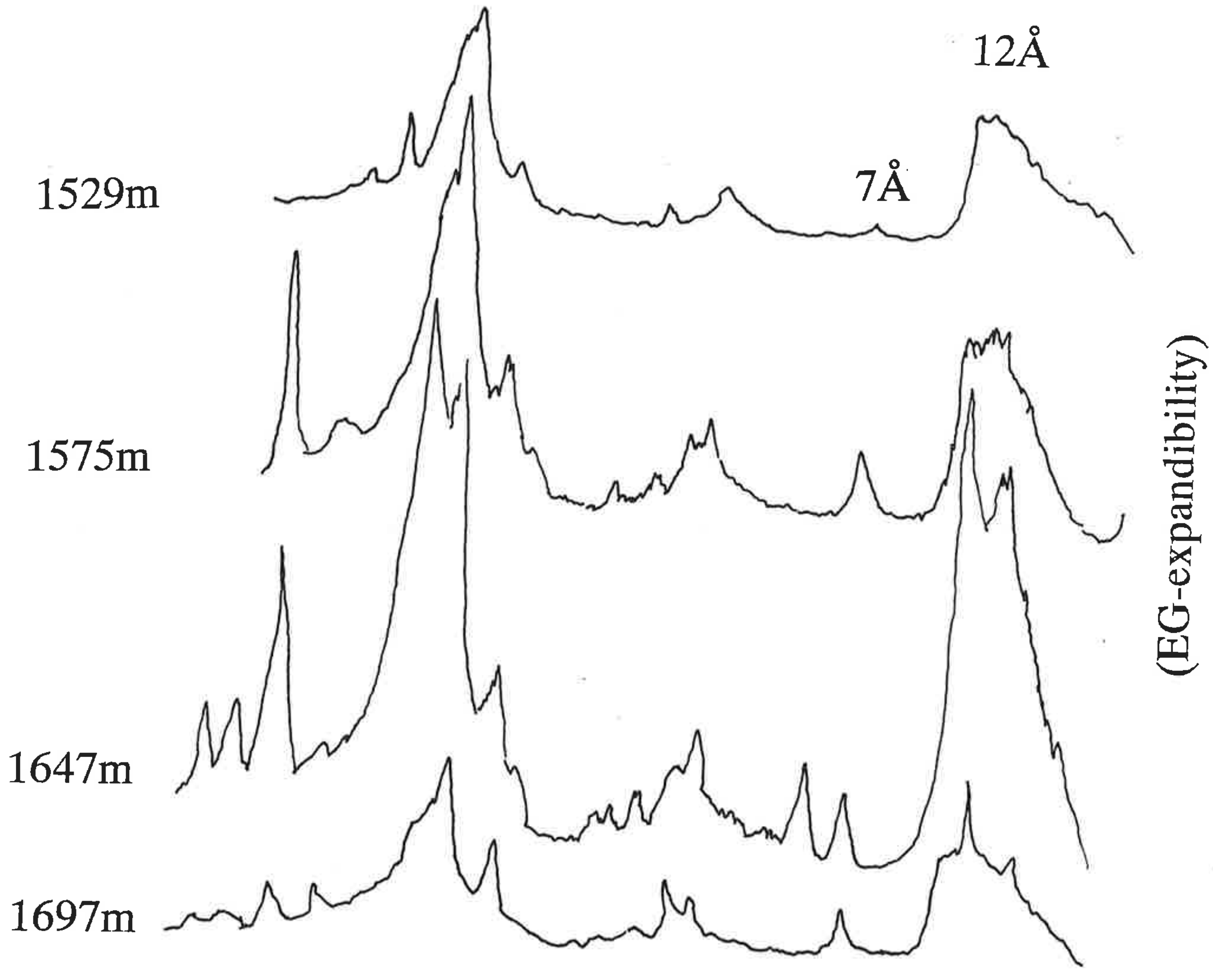
Clay minerals of the greensand interval

Fig 17

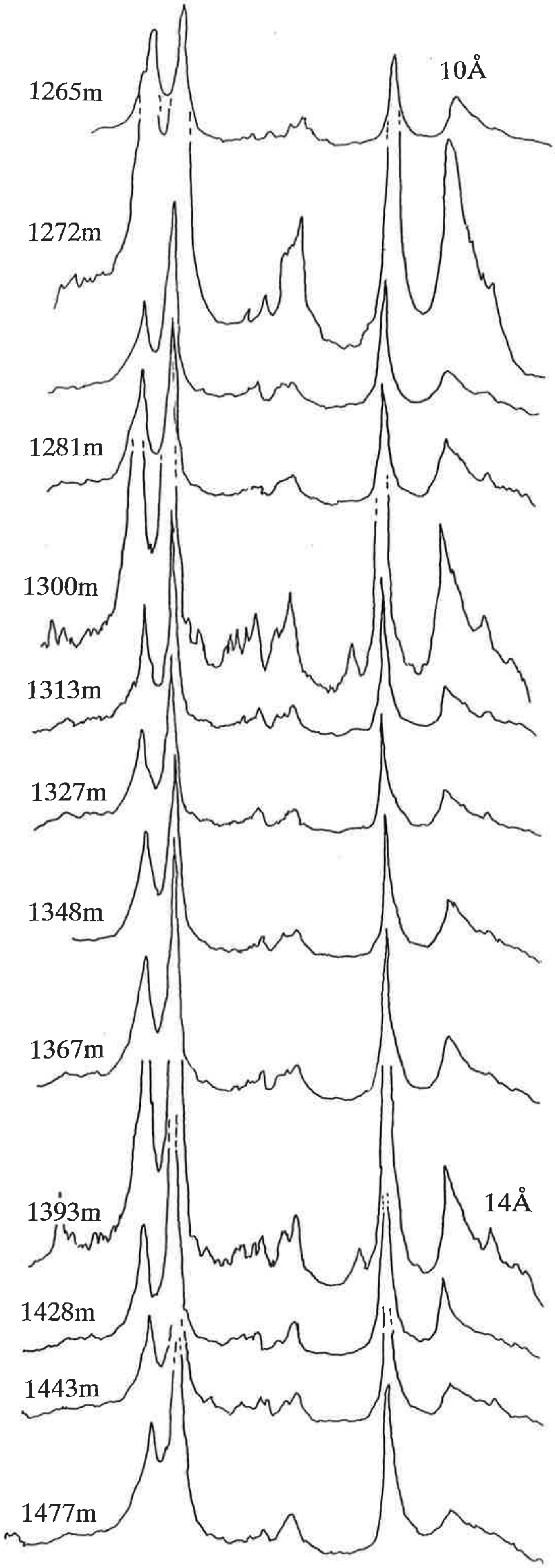


Clay minerals of the pelagic limestone interval

Fig 18

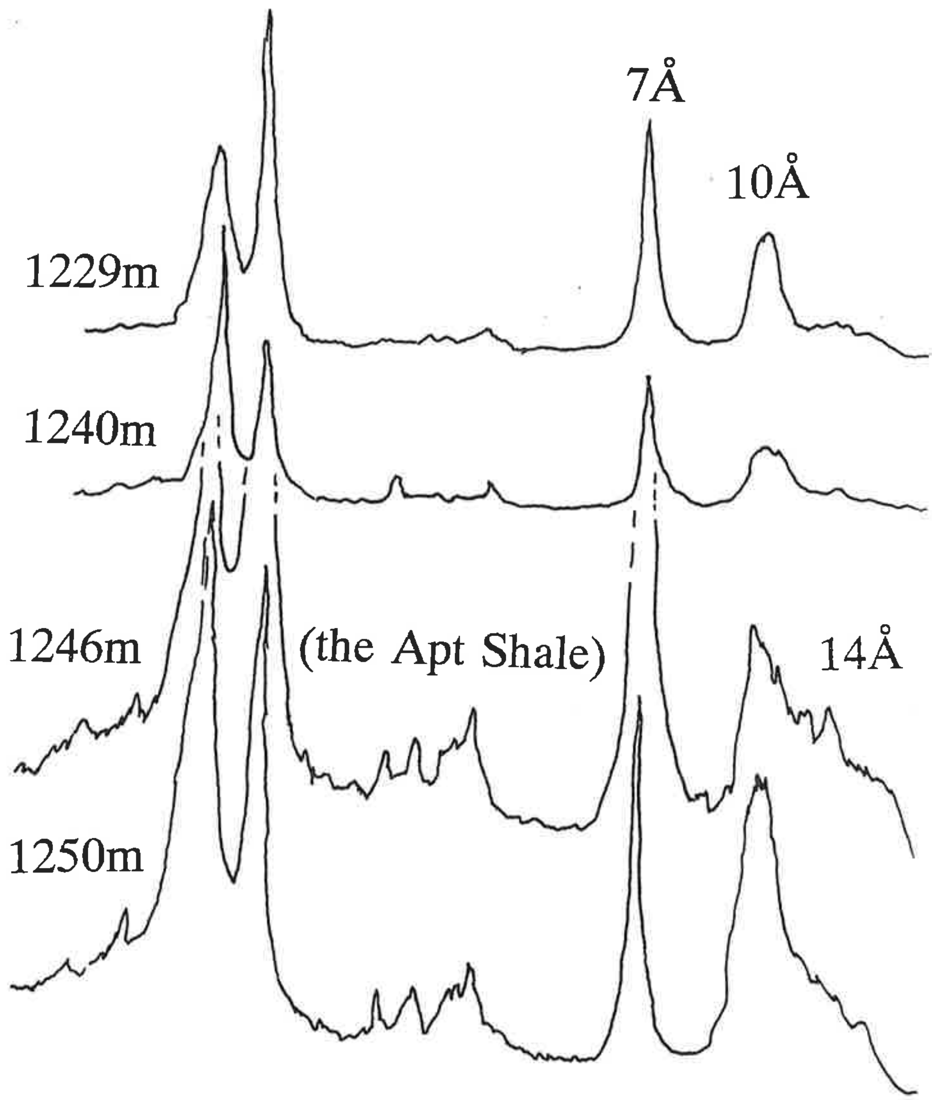


Clay minerals of the pre-Rhaetian (Middle and Upper Triassic)

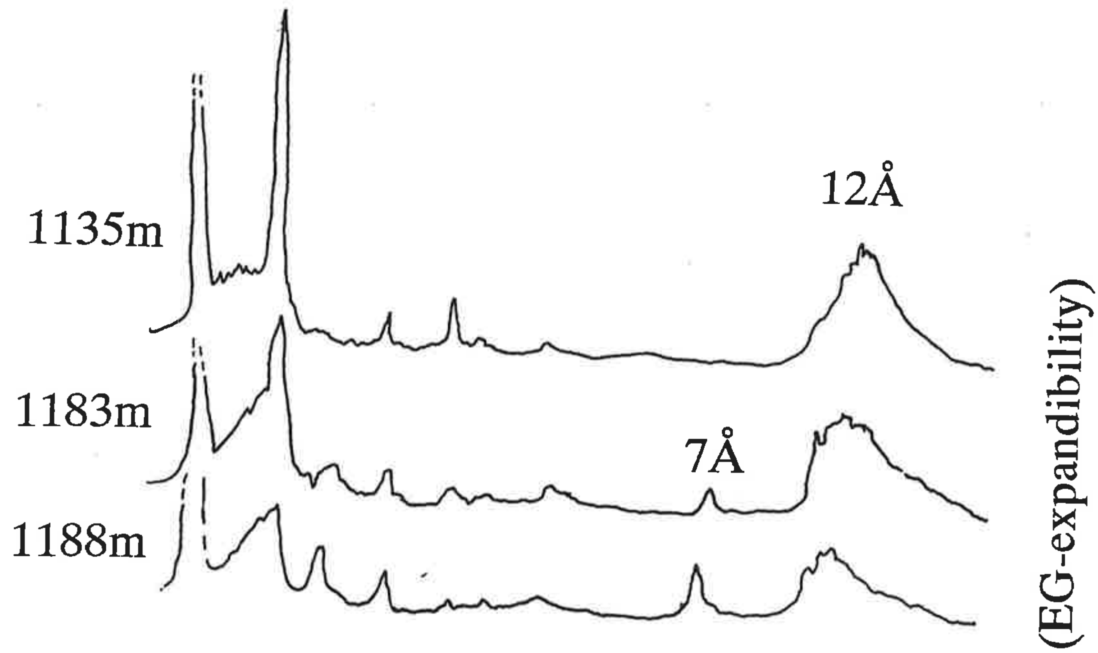


Clay minerals of the Rhaetian-Jurassic(?)

Fig 20

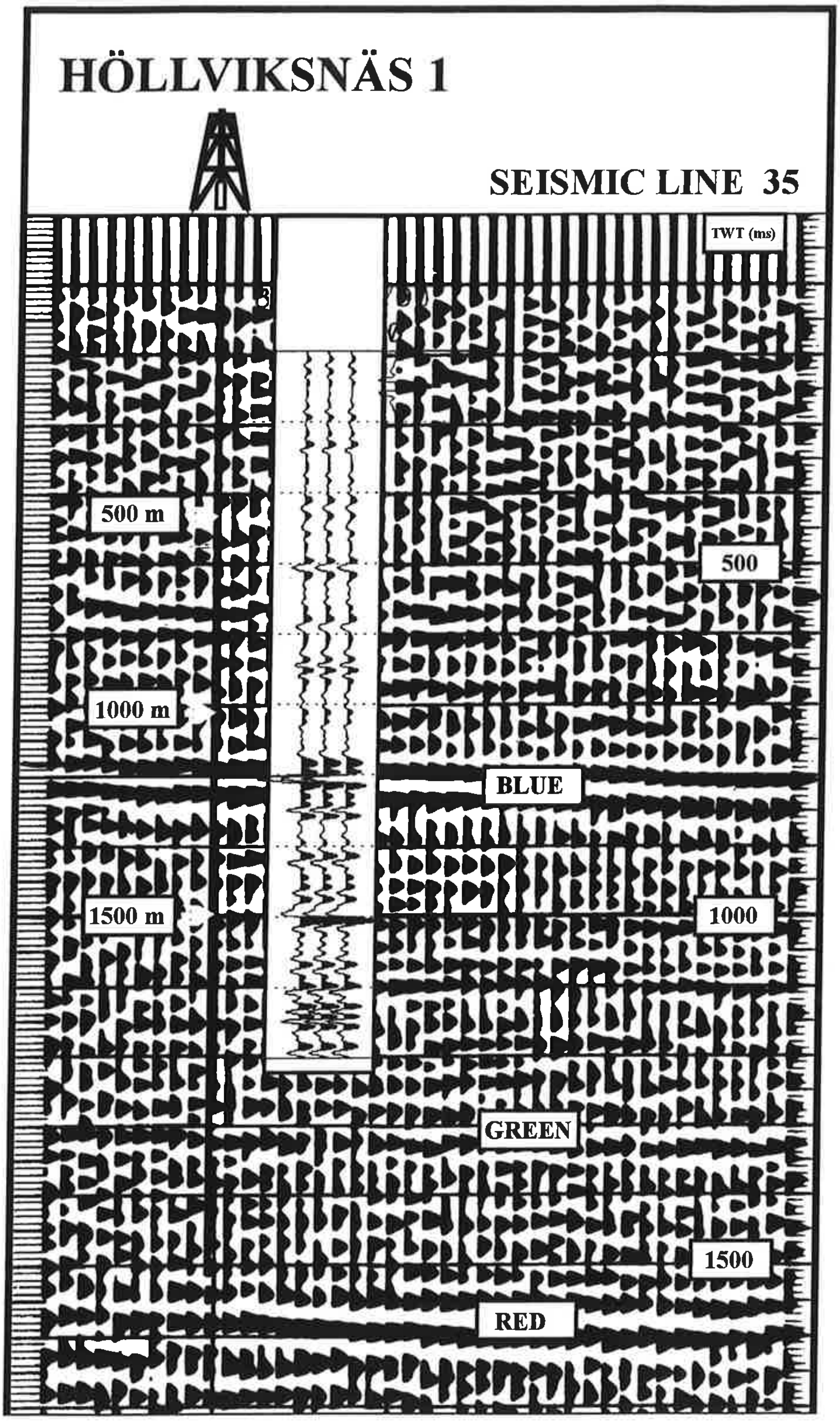


Clay minerals of the greensand interval



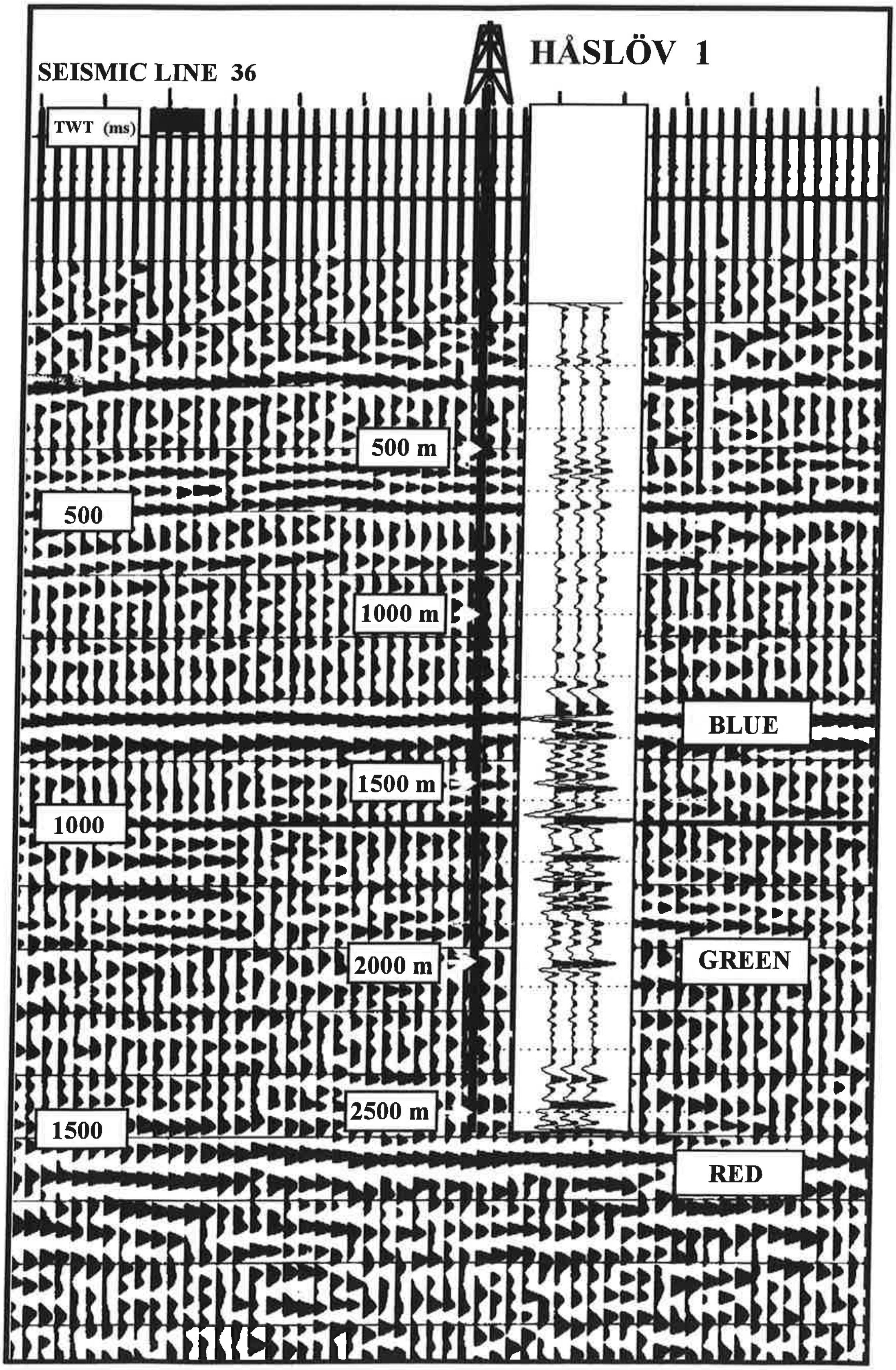
Clay minerals of the pelagic limestone interval

Fig 22



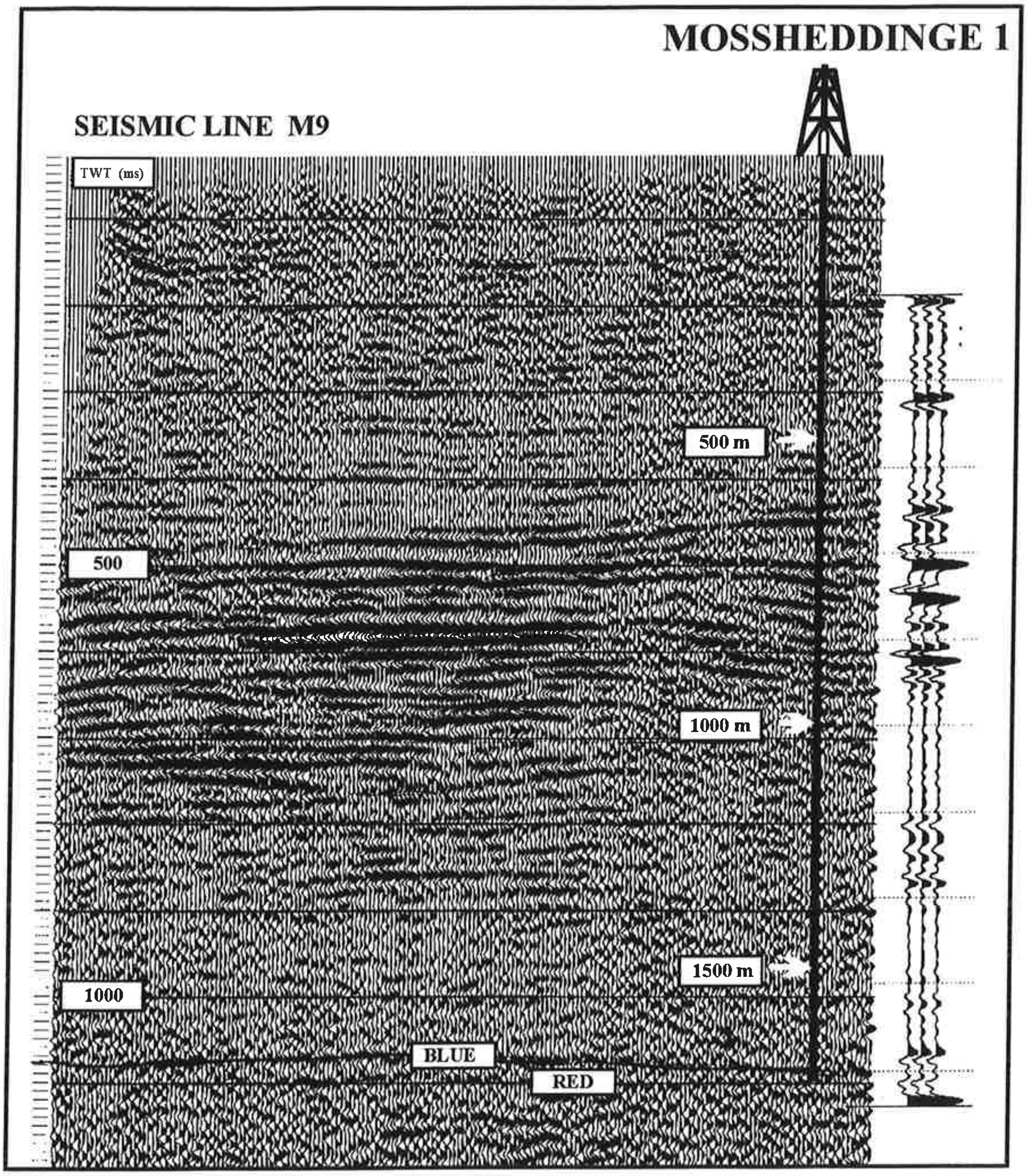
HÖLLVIKSNÄS 1
SEISMIC LINE 35
TWT (ms)
500 m
500
1000 m
BLUE
1500 m
1000
GREEN
1500
RED

Fig 23



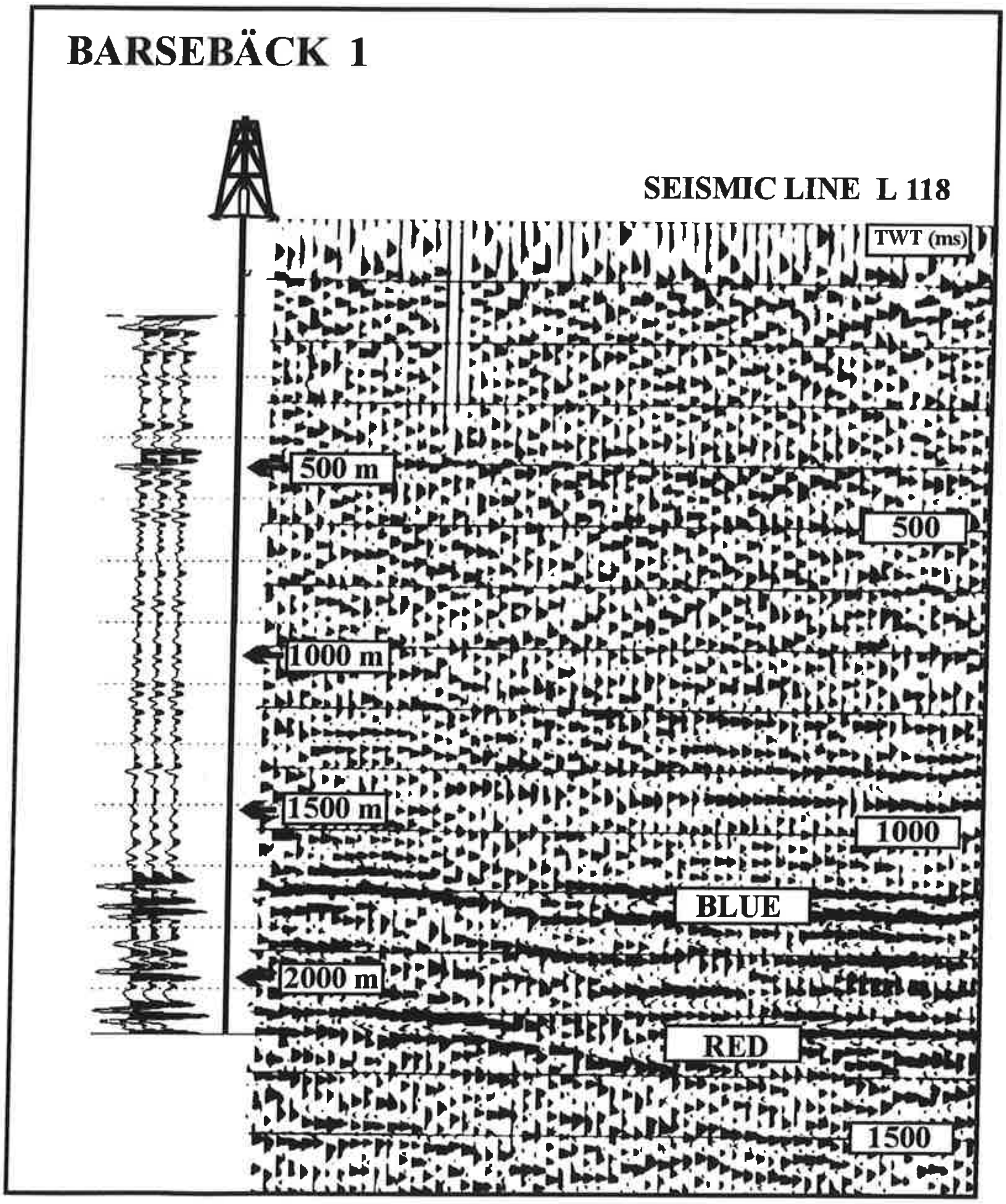
HÅSLÖV 1
SEISMIC LINE 36
TWT (ms)
500 m
500
1000 m
BLUE
1500 m
1000
2000 m
GREEN
2500 m
1500
RED

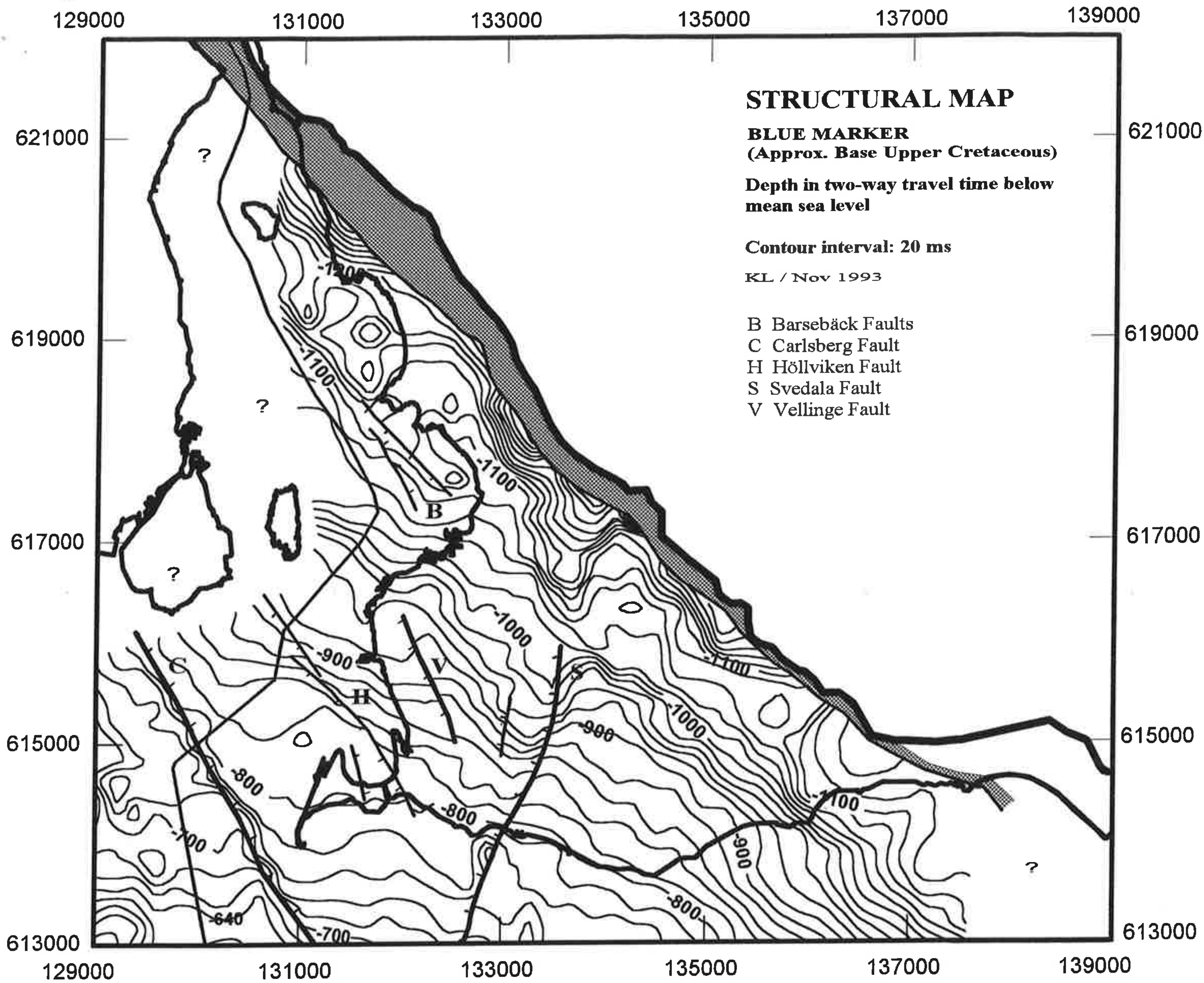
Fig 24



MOSSHEDDINGE 1
SEISMIC LINE M9
TWT (ms)
500
1000
500 m
1000 m
1500 m
BLUE
RED

Fig 25


BARSEBÄCK 1
SEISMIC LINE L 118
TWT (ms)
500 m
500
1000 m
1500 m
1000
BLUE
2000 m
RED
1500


STRUCTURAL MAP
BLUE MARKER
(Approx. Base Upper Cretaceous)
Depth in two-way travel time below mean sea level
Contour interval: 20 ms
KL / Nov 1993
B Barsebäck Faults
C Carlsberg Fault
H Höllviken Fault
S Svedala Fault
V Vellinge Fault
129000
131000
133000
135000
137000
139000
621000
619000
617000
615000
613000
-1200
-1100
-1000
-900
-800
-700
-640
?

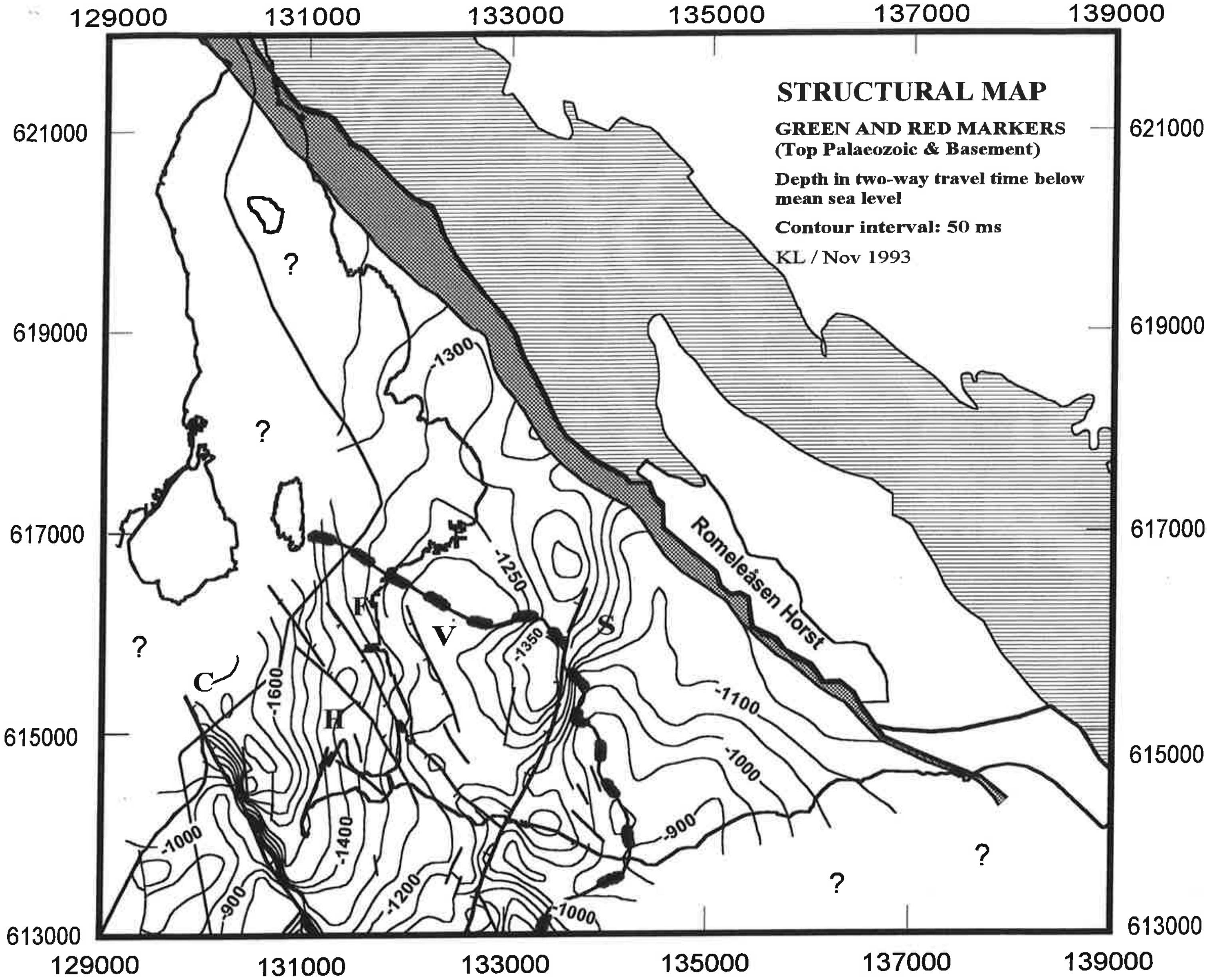

STRUCTURAL MAP
GREEN AND RED MARKERS
(Top Palaeozoic & Basement)
Depth in two-way travel time below mean sea level
Contour interval: 50 ms
KL / Nov 1993
Romeleåsen Horst
129000
131000
133000
135000
137000
139000
621000
619000
617000
615000
613000
-1300
-1250
-1350
-1100
-1000
-900
-1600
-1400
-1200
F
V
S
C
H
?

Fig 28

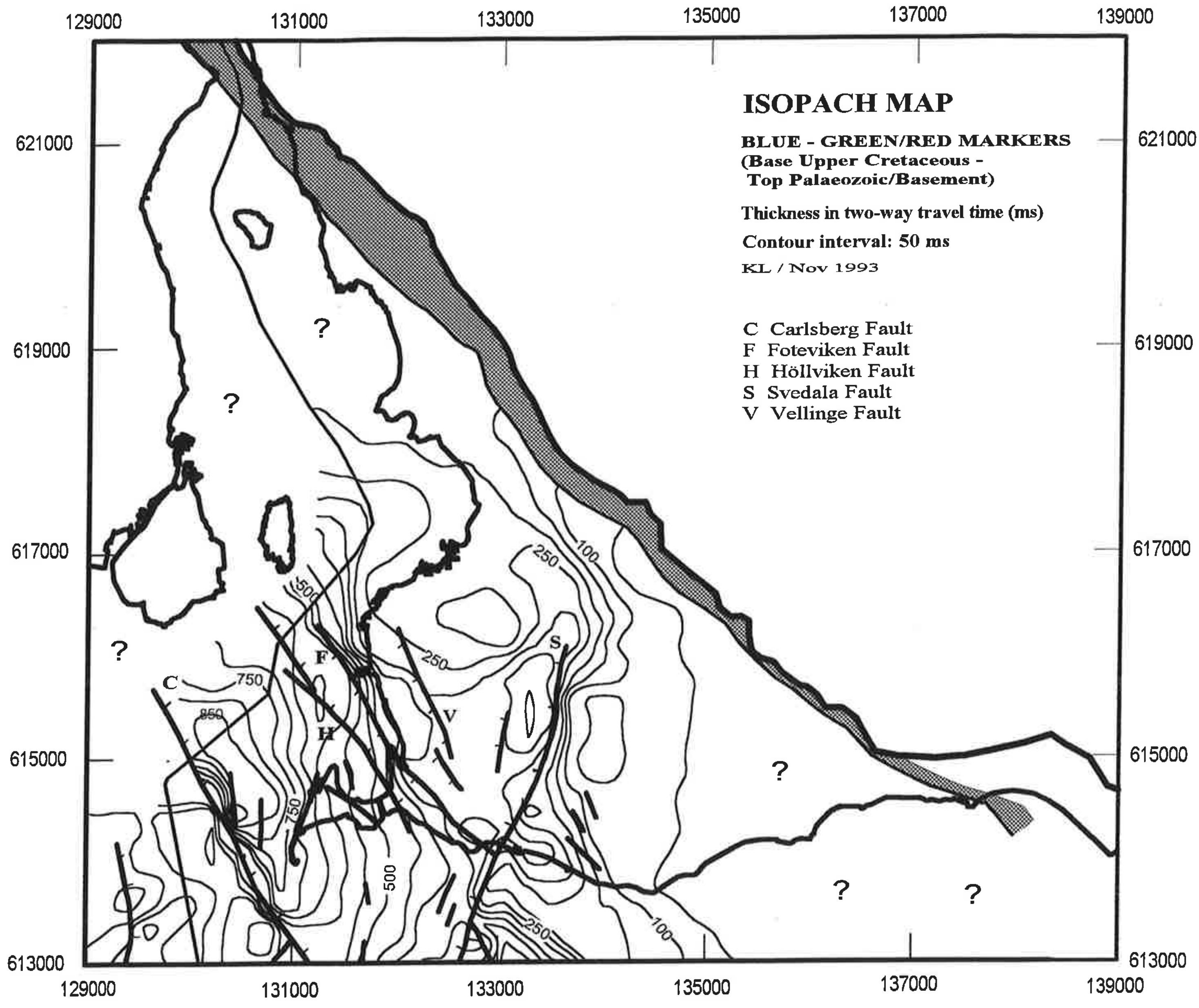

ISOPACH MAP
BLUE - GREEN/RED MARKERS
(Base Upper Cretaceous -
Top Palaeozoic/Basement)
Thickness in two-way travel time (ms)
Contour interval: 50 ms
KL / Nov 1993
C Carlsberg Fault
F Foteviken Fault
H Höllviken Fault
S Svedala Fault
V Vellinge Fault
129000
131000
133000
135000
137000
139000
621000
619000
617000
615000
613000
750
850
500
250
100
C
F
H
V
S
?

Fig 36

Meter	Fig.	xld	Ts	Il	Cli	Sm	Ka	Div	Org	Mk	Dol	Col	Tex	Sst	Sil	Mst	wA	A	sA	sR	R	wR	wW	W	M	P	wP	<— HUMID ARID —>
1745	17	X	T					D				RG	L	Sa				X								X		
1747.5								D				RG	L	Sa				X								X		
1750								D				RG	L	Sa				X								X		
1752.5								D				Gg	L	Sa				X								X		
1755								D				Gg	L	Sa				X								X		
1757.5											N	g		Sa				X								X		
1760										M		g	L		Sl			X								X		
1762.5		X						C,D	O		N	R			Sl			X								X		
1765												gR	L		Sl							X	X					
1767.5												gR			Sl							X	X					
1770			T						O	M	N	g	RD	Sa							X			X				
1772.5	16		T						O	M	N	g	L		Sl						X			X				
1775			T						O		N	g	L	Sa		Mu					X			X				
1777.5											N	g	L			Mu					X			X				
1780		X	T			S	(K)				N	g	L		Sl						X			X				
1782.5												Rg			Sl						X			X				
1785										M		Rg			Sl													
1787.5									O	M		Rg				Mu												
1790									O	M		g				Mu		X								X		
1792.5									O			R		Sa				X								X		
1795									O			R		Sa				X								X		
1797.5		X			(C)	S				M		R		Sa				X								X		
1800		X	T		C	S				M		R		Sa				X								X		
1802.5		X	T						O	M		Gg		Sa				X								X		
1805		X	T		C	S			O	M	N	Gg		Sa							X			X				
1807.5		X	T		C				O	M	N	Gg	L		Sl						X			X				
1810			T						O			g		Sa							X		X					
1812.5			T						O			g		Sa								X	X					
1815									O			g		Sa								X	X					
1817.5									O			g		Sa								X	X					
1820									O			g		Sa								X	X					
1822.5									O		N	g		Sa								X	X					
1825								Py	O		N	R	L	Sa								X	X					
1827.5	16		T					C	O		N	R		Sa						X				X				
1830		X				S			O			g	L	Sa						X				X				
1835.5		X				S			O			g	L	Sa						X				X				
1835		X				S			O			g	L	Sa							X			X				
1837.5		X		(I)		S	(K)		O			g	L	Sa							X			X				
1840		X				S						RG				Mu					X			X				
1842.5		X				S						g	L			Mu					X			X				
1845		X		I	(C)	S	(K)					g	L			Mu					X			X				
1847.5		X		I		S						g	L			Mu					X			X				
1850		X		I		S						g	L			Mu					X			X				
1852.5		X	T	I		S						g	L			Mu					X			X				
1855	13	X	T	I		S						g	L			Mu					X			X				
1857.5		X	T	I		S			O			g	L			Mu					X			X				
1860		X	T	I		S			O			RG		Sa							X			X				
1862.5		X		I	(C)	S		C	O			RG		Sa							X			X				
1865			T					D	O			RG		Sa							X			X				
1867.5			T					C				RG				Mu		X							X			
1870		X		I	(C)		K					RG				Mu				X				X				
1872.5		X		I	(C)		K					RG				Mu				X				X				
1875	12	X	T	I	(C)	(S)	K	D				RG			Sl					X				X				
1877.5		X		I	(C)	(S)	K					RG				Mu				X				X				
1880		X		I	(C)	(S)	K		O			R		Sa					X							X		
1882.5		X	T	I		S	K	D	O			R		Sa				X								X		
1885	10	X	T	I		S	K	D	O			RG		Sa						X			X					
1887.5		X	T	I		S	K	D	O			RG		Sa							X		X					
1890								D			N	RG		Sa						X						X		
1892.5											N	R		Sa				X								X		
1895	8		T	I	C			D			N	R		Sa					X							X		
1897.5								D			N	RGg		Sa					X							X		
1900			T					D			N	RGg		Sa					X							X		
1902.5												G		Sa					X							X		
1905												RGg		Sa					X							X		
1907.5	7		T									RGg		Sa					X							X		
1910			T					D			N	RGg		Sa					X							X		
1912.5				I	C						N	R		Sa					X							X		
1915				I	C						N	R		Sa					X							X		
1917.5			T	I	C						N	R		Sa					X							X		
1920												RG		Sa					X							X		
1922.5												RG		Sa					X							X		

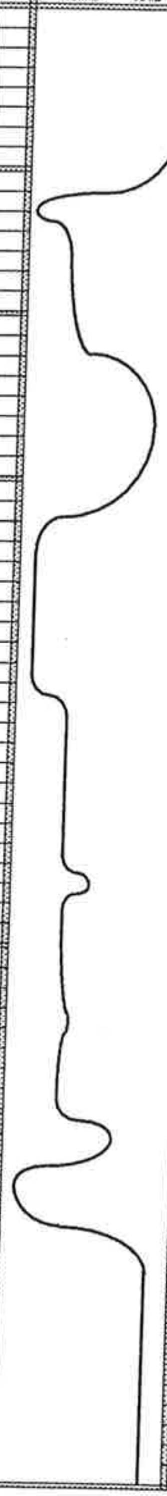
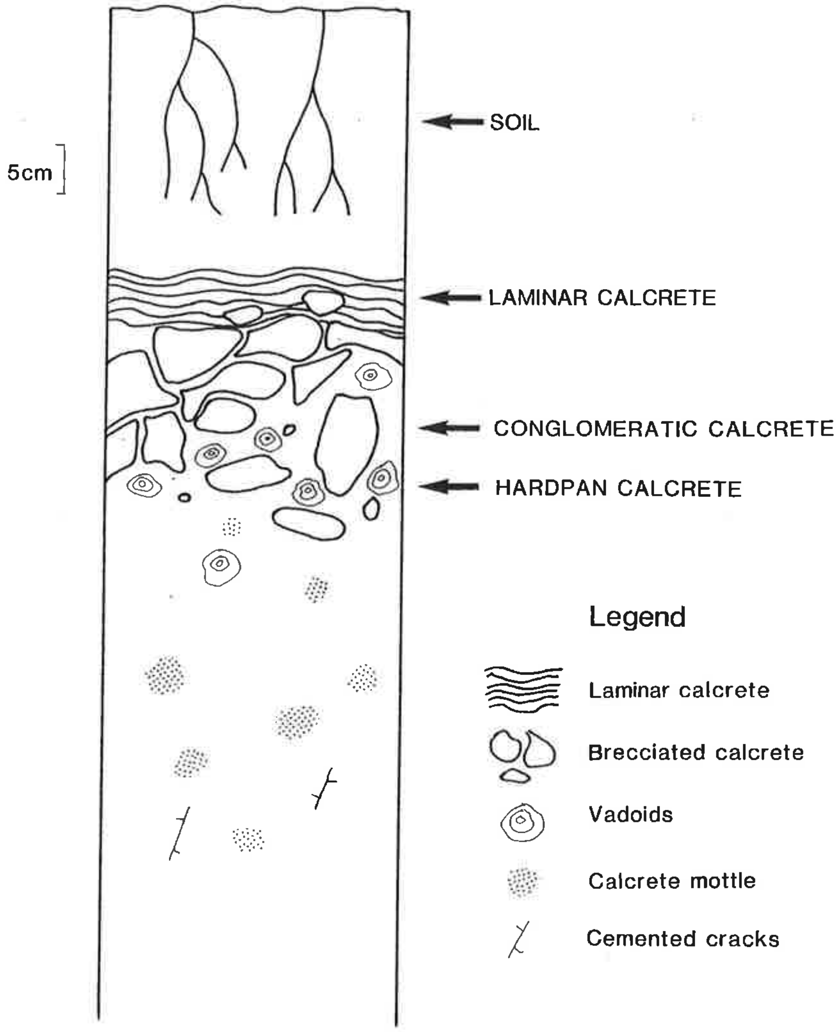
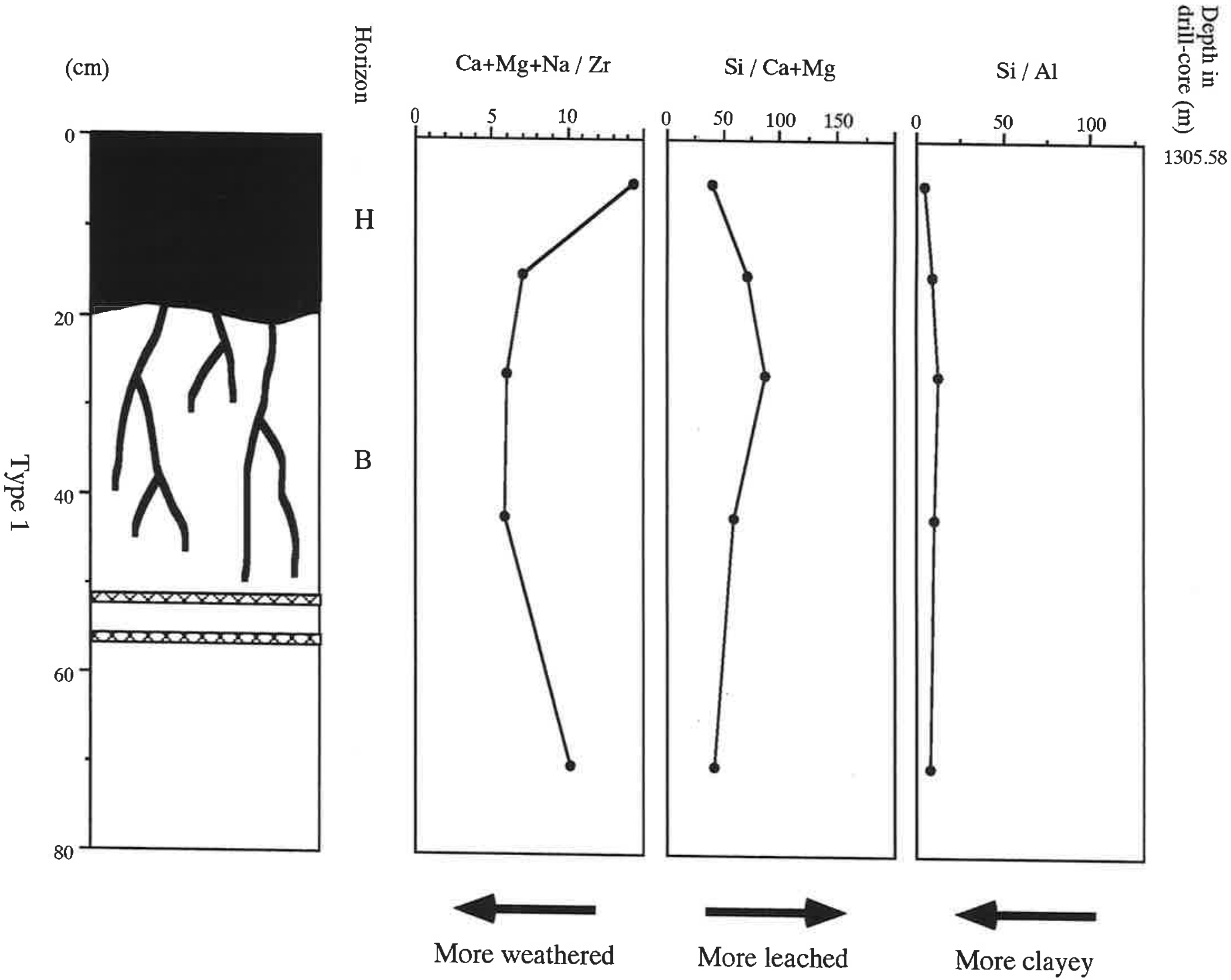


Fig 37

SCHEMATIC CALCRETE PROFILE FROM THE HÖLLVIKEN 2 BOREHOLE





(cm)
0
20
40
60
80
Type 1
Horizon
H
B
Ca+Mg+Na / Zr
0
5
10
Si / Ca+Mg
0
50
100
150
Si / Al
0
50
100
Depth in drill-core (m)
1305.58
More weathered
More leached
More clayey

Fig 38

Rock-Eval pyrolysis; principles

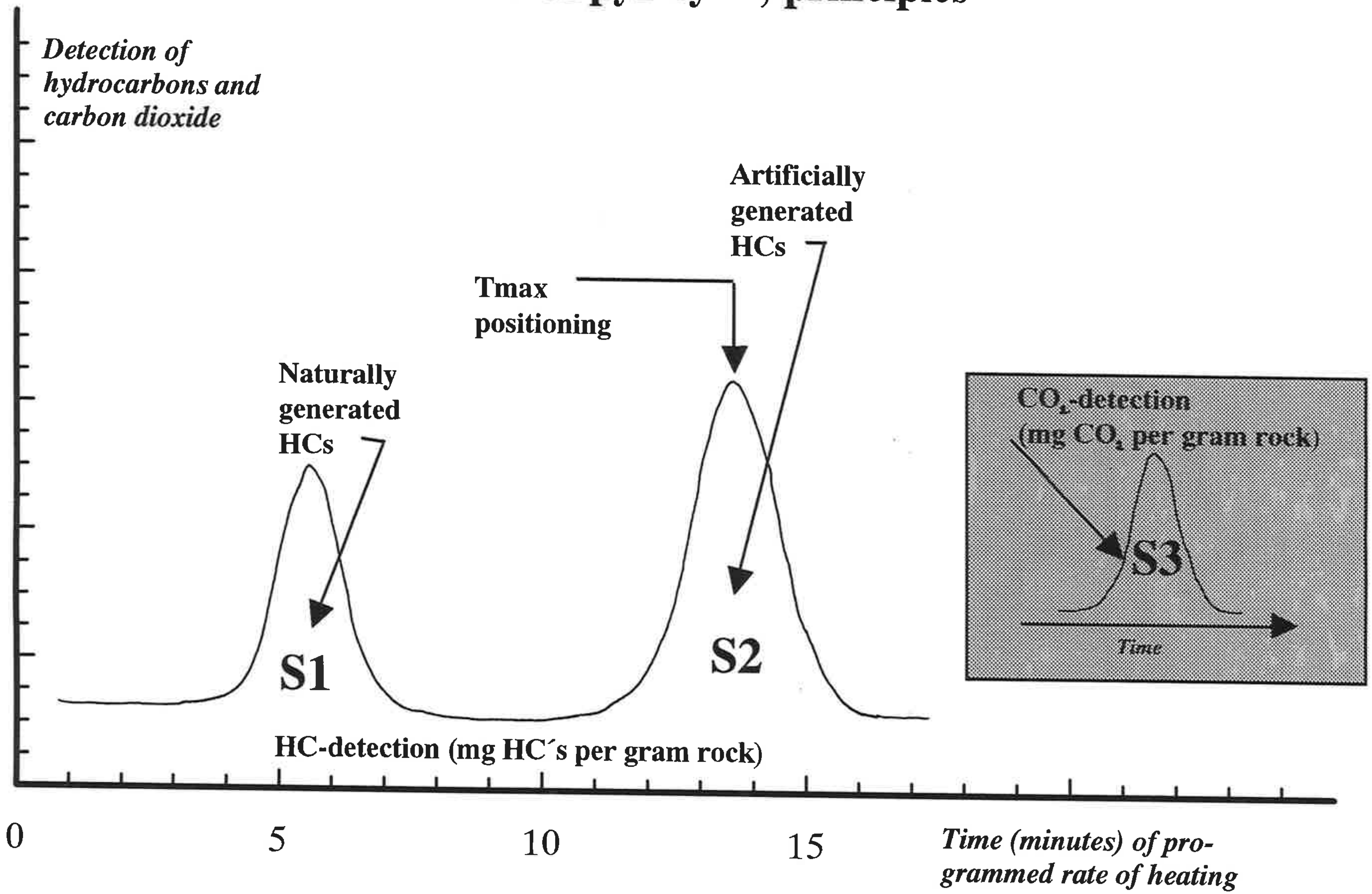


Fig 39

Parameters describing source rock generative potential

Quantity	TOC	S1	S2
poor	<0.5	<0.5	<2.5
fair	0.5-1.0	0.5-1.0	2.5-5.0
good	1.0-2.0	1.0-2.0	5.0-10.0
very good	>2.0	>2.0	>10.0
	(wt.%)	(mg HC per gram rock)	

Parameters describing level of thermal maturation

Maturation:	Rm (%)	Tmax (°C)	PI
Top of oil window (i.e. birthline)	0.6	435-445	0.1
Bottom of oil window (i.e. deadline)	1.4	-470	0.4

(after Peters 1986)

HÖLLVIKEN BORE No-II : LIST OF PALYNOMORPHS PRESENT

Alisporites sp.
Baculatisporites sp.
Cerebropollenites thiergarthii SCHULZ 1967
Cicatricosisporites sp.
Cingutriletes sp.
Clavifera triplex BOLCHOVITINA 1953
Crybelosporites sp.
Cyathidites australis COUPER 1953
Cyathitides minor COUPER 1953
Densoisporites sp.
Gleicheniidites cf. apilobatus BRENNER 1963
Gleicheniidites bulbosus KEMP 1970
Gleiicheniidites senonicus ROSS 1949
Lycopodiumsporites sp.
Lycopodiumsporites clavatoides COUPER 1958
Perinopollenites elatoides COUPER 1958
Podocarpidites sp.
Sestrosporites pseudoaveolatus COUPER 1958
Spheripollenites psilatus COUPER 1958
Spheripollenites subgranulatus COUPER 1958
Taxodiaceapollenites hiatus (POTONIÈ) KREMP 1949
Triporopollenites sp.
Vitreisporites pallidus (REISSINGER) NILSSON 1958