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Abstrakt

Byly shrnuty poznatky o genezi kaolínových ložisek Českého masívu na území ČSSR a sousedních států. Ložiska jsou přiřazena k jednotlivým genetickým typům a vlastnosti jejich kaolínů stručně charakterizovány. Nově provedená mineralogická studia (SEM) potvrzují primární pozici kaolinitu ve většině hornin. U objemově i průmyslově velmi významných ložisek v s. části plzeňské pánve (Kaznějov, Horní Bříza) byl vedle in situ kaolinizovaných zrn živců potvrzen významný podíl sedimentovaného kaolinitu. Znamená to, že tato ložiska vznikla redepozicí již dříve kaolinizovaného materiálu z neznámé vzdálenosti; po usazení byla dodatečně kaolinizována dosud relativně čerstvá zrna živců. Ostatní ekonomicky významná ložiska kaolínů v Českém masívu jsou vesměs zvětrávacího původu a představují kaolinitická rezidua granitoidů, metamorfitů a živci bohatých sedimentů in situ.

Zusammenfassung

Die Entstehung der Kaolinlagerstätten der Böhmischen Masse in der ČSSR und ihren Nachbarstaaten wird zusammenfassend dargelegt. Die Vorkommen werden getrennt nach genetischen Typen beschrieben und kurz charakterisiert. Aufgrund neuer mineralogischer Untersuchungen (Röntgendiffraktometrie, Rasterelektronenmikroskopie) konnte die primäre Entstehung der meisten Lagerstätten bestätigt werden. Bezüglich der großen, wirtschaftlich bedeutenden Vorkommen im nördlichen Teil des Beckens von Plzeň (Kaznějov, Horní Bříza) konnte festgestellt werden, daß abgesehen von in situ kaolinisierten Feldspatkörnern hauptsächlich sedimentierte Kaolinite vorliegen. Diese Vorkommen entstanden durch Umlagerung. Anschließend wurden die relativ frischen Feldspatkörner kaolinisiert. Die übrigen wirtschaftlich bedeutenden Kaolintone sind Verwitterungslagerstätten und stellen Residualtone von Granitoiden, Metamorphiten und feldspatreichen Sedimenten dar.

MONITORING OF EXPLORATORY WELLS AND HIGH-PRESSURE DETECTION IN POLYGENETIC STRUCTURED AREAS

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1. Introduction

Registration and interpretation of well data have become increasingly important to ÖMV exploration.
During drilling it's necessary to collect all data available, which are useful to get information about porosities, porepressures and formations.

For these reasons every well drilled is connected to a data unit, to get all the information needed.

Which drilling parameters are being used and which geological conclusions may be drawn, will be presented and discussed based on selected examples.

The following data were registered during drilling:

Drilling parameters:
- Time (minutes)
- Depth (meters)
- Weight on hook (tons)
- Rate of penetration (meter/hour)
- Torque
- RPM — Rotary per minute
- Pumpstrokes (strokes/minute)

Mud parameters:
- Mud weight in/out
- Temperature in/out
- Flow
- Pit volume
- Gas readings

Several sensors which transfer the data directly to the data unit were mounted on the rig-site.
There these data were digitally registered and permanently transferred on to „strip charts". Furthermore, the P.C. stores and evaluates all data on a discette.

Therefore, the aim is the registration and interpretation of all drilling parameters.
The data can be used as a helpful tool for logging-DST and casing decisions before entering a high pressure environment.

2. Criteria to predict high pressure zones and some genetic aspects

To identify transition-zones, the following criteria are decisive:

I. D-exponent
II. Gas readings
III. Shape of cuttings

IV. Increase in hook load
V. Increase in torque

I. D-exponent

This is the main criterion where lithological influences are expecially strong. In general a relationship between penetration rate, weight on bit, rotary speed, bit diameter, matrix strenght constants and effective circulating density has to be assumed.

$$D = \frac{\mathrm{Log}\,(\frac{ROP}{RPM}\,.\,0.0547)}{\mathrm{Log}\,(\frac{BITWT}{BITDIAM}\,.\,0.672)}$$

$$Dcs = \frac{D\,.\,1.08}{ECD}$$

ROP = Rate Of Penetration (m/h)
RPM = Rotation Per Minute (U/min)
BITWT = Bit Weight (tons)
Bit Diameter (inch)
ECD = Equivalent Circulation Density (kg/l)

Some basic remarks on high pressure prediction:

In a normal case i.e. in a basin with increasing compaction, drillability decreases and D-exponent increases with depth. In shales and marls under which high pressure zones may be expected exactly the opposite is to be observed i.e. a very clear decrease of the Dcs.

As a classical example „Zistersdorf ÜT“ can be mentioned, where the „transition-zone“ was exceptionally thick, i.e. about 450 m (see fig. 2)

As genetic explanation „sedimentary loading“ must be assumed.

High rates of sedimentation in connection with rapid burial — the fluid within the pores could not escape and took over a supporting function within the sediment against the overburden pressure.

This results in an essential increase in the rate of penetration although WOB is reduced as soon as the transition-zone is reached.

Two reasons for this are to be mentioned:

1) Increase in porosity with increasing depth (overcompacted shale section).
2) Decrease in differential pressure. The fact of increase in ROP can technically be explained through the decrease in differential pressure between formation and mud column. Formation pressure may increase significantly in transition-zones — gradients from 1.80 bar/10 m have often been registered in the northern part of the Vienna basin.

   This example only demonstrates the simplest case in which, based on drilling parameters and under consideration of lithology, exceptional high formation pressures could be concluded.

Following advantages result from an analysis of Dcs:

1) High pressure zones can be identified before an eventual kick and mud weight may be increased during drilling in this zone.
2) Another advantage to be mentioned is the correlation of the Dcs with SP or a resistivity log. This fact provides optimum information about lithology, porosity and formation changes during drilling.

In the Neogene, especially in the northern part of the Vienna basin, in the area of Mühlberg, Rabensburg and Ringelsdorf, transition-zones could be predicted only based on anomalies in the Dcs and required measures, like setting of a casing, could be taken.

II. Gas Readings:

If a transition-zone is drilled into, there will be a very obvious increase in trip-, connection- and backgroundgas, caused by the fast increasing formation pressure.

III. Shape of cuttings:

Due to higher formation pressure, which will come very close to mud pressure, or even supersede the later, the cuttings are much easier cut out of the formation by the bit.

This determines their shape. They are bigger, somewhat arched and of lengthy shape.

IV. Increase of hook load:

Because of pressure increase in the formation, marls grow into the bore hole and drag results. This, too, is an essential indicator that transition-zones are being drilled. As a logical consequence, considerable ream time could result.

V. Increase in torque:

Since size of cuttings is increasing and more material is chipped off at the bottom, an increase in torque may result.

There are sufficient criteria from a theoretical point of view for identification of high pressure zones on an early stage. The main problem is, however, that somewhat reliable predictions can only be made based on a combination of these parameters. In practice only some of the indicators mentioned will arise as soon as a transition-zone is being drilled into, and it depends on the state-of the art of the interpreter to interpret correctly even if only one or two of the criteria mentioned occur.

The following examples will clarify this point:

Exact knowledge about the formation and/or stratigraphical or tectonical information must exist. Only if one knows about the complexity of the matter it is possible to identify abnormal high pressures especially in the subcrops of the Alpine system buried and even then sources of errors cannot be completely eliminated.

3. High pressure prediction in ultra deep projects

Project „Zistersdorf Ultra Deep“

„Zistersdorf Ultra deep“ represented a model case in which — with the assistance of all drilling-parameters registered in the data-unit it was attempted to obtain as much information as possible, regarding rock-type, pressure conditions and content of drilled formation.

A geological cross section clearly shows the target, i.e. the Autochthonous Mesozoic in the area of the „Steinberg Fault“ in Zistersdorf.

In additon to the drilling parameters like weight on bit (WOB), rotation per minute (RPM) and rate of penetration (ROP) — the Pressure Control Analysis also contains the D-exponent and the sigma-plot (see fig. 2)

The sigma-plot, routinely being used during ultra deep drilling procedures is a further development of the Dcs by AGIP. Just as in the case of the Dcs it is based on the conformity or a number of basic formation-drilling relationships.

In addition, parameters covering the intensity of the compaction of a certain rock-type will be taken into consideration.

Thus, it represents an extension in the direction of geological — lithological criteria.

Which conclusion can be drawn from this pressure-profile?

First we see, as mentioned in the beginning and based on the crossection (fig. 1), down to 4.150 m a normal sequence in the Neogene, i.e. increasing compaction with depth. The line of the sigma-plot thus corresponds to a normal compaction trend line.

At 4.150 m the top of the transition-zone in the „Sandschaler Zone shows clearly (i.e. undercompacted shales). This, by the way, seems to be stratigraphically connected to this horizon.

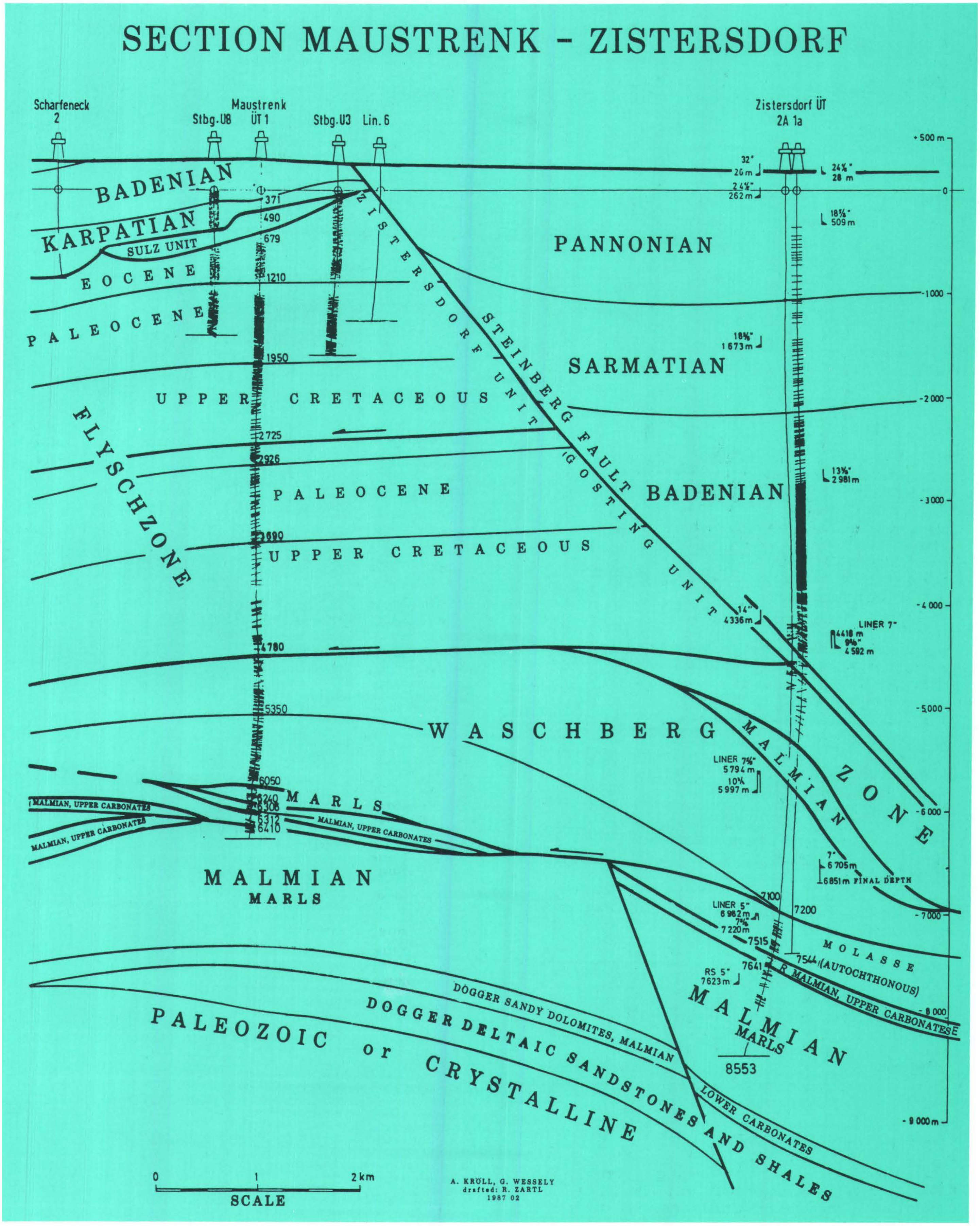


Fig. 1: Geological cross-section
Ultradeep projects "Zistersdorf ÜT 1, 1a, 2A" and "Maustrenk ÜT 1, 1a"
(G. Wessely, 1984).

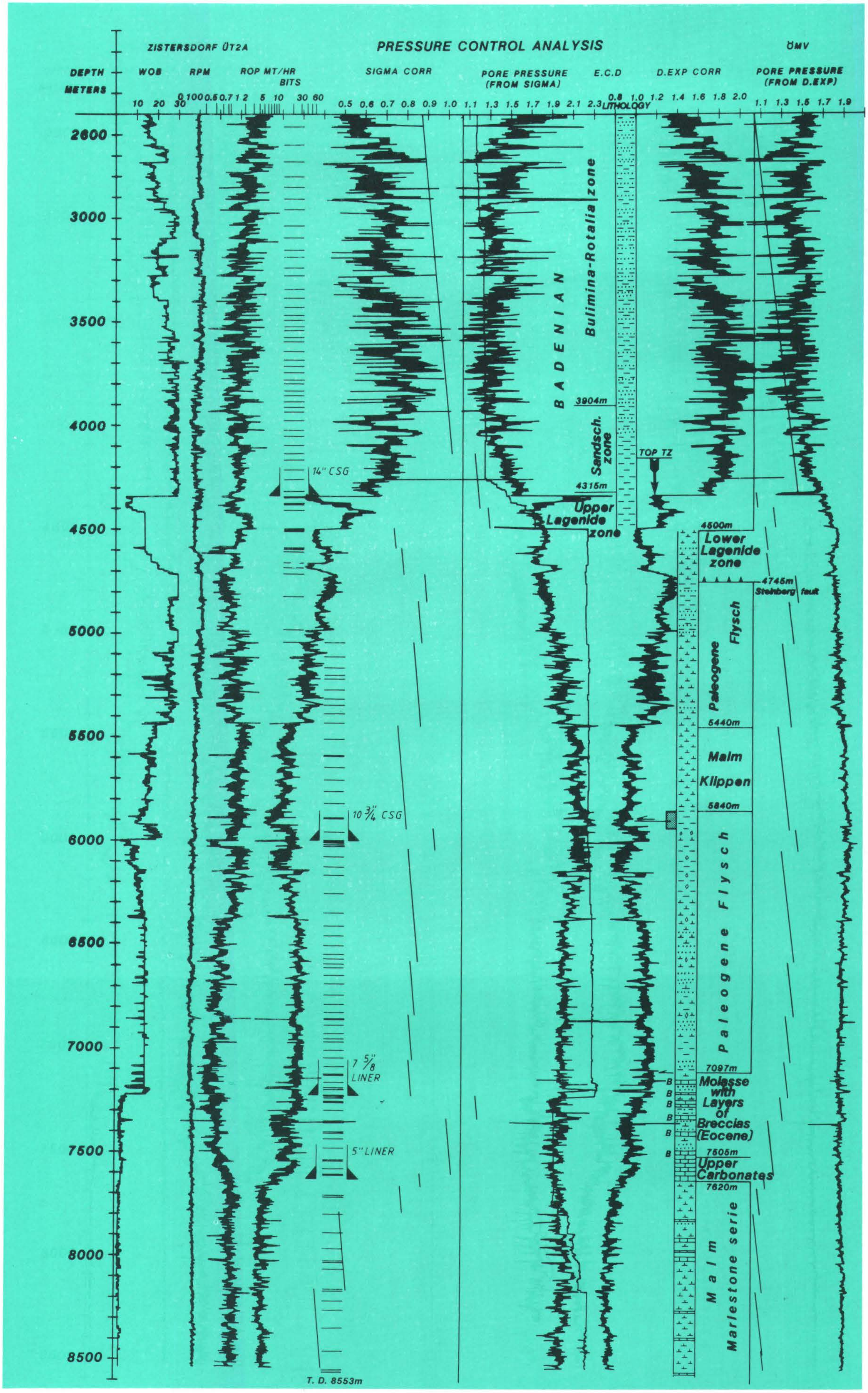


Fig. 2: Pressure Control Analysis, Project "Zistersdorf ÜT 2A" (W. Ringhofer 1986).

All projects drilled in the northern part of the Vienna basin have shown such anomalies in the „Sandschaler Zone".

The existence of transition-zone was also checked by logging methods as well as restivity and sonic-log.

1) Electric-log method:
   In normal pressured shales, there is an increase of resistivity with depth.
   In overpressured shales the resistivity curve shows a deviation from the normal trend, to lower than normal resistivities, indicating a higher water content and increasing porosity in the shales.
2) Acoustic log method:
   Plotting transit time against depth will give a normal compaction trend line.
   Pressure anomalies can be detected by an increase of transit time above the normal compaction trend (fig. 3).

Top of the transition-zone 4.150 m.

However, logging methods are „after the fact" techniques — after penetration of the bit. In the case of „Zistersdorf ÜT" only drilling parameters could help to detect „transition zones" immediately.

In accordance with pore pressure of the sigma-log, gradients of up to about 1,80 bar/10 m were detected in the Neogene.

The Paleogene flysch furthermore shows an increasing pressure up to approximately 2,0 bar/10 m.

From 5.840 m to 5.920 m the tectonically strongly influenced flysch, which was overthrusted by the „Malm-Klippe" has to be pointed out. It shows a significantly better drillability than the flysch sediments mentioned so far.

This tectonically severely disturbed area at the bottom of the „Malm-Klippe" also shows up very significantly in the sonic-plot (fig. 3).

The Molasse with its layers of breccias shows a very different course of the sigma-log, due to its differentiated lithology and is characterized by better drillability in connection with an increase of background gases in the calcareous breccial layers. Furthermore, the „Obere Karbonatserie" shows a better drillability which continues into the „Mergelsteinserie". Gradients of over 2,0 bar/10 m can be expected in these strata. The corresponding sonic-plot (fig. 3) substantiates the statement made with the assistance of the pressure control analysis also with regard to the top of the transition-zone at 4.150 m.

Project „Aderklaa Ultra Deep"

As previously discussed, it was the goal of this project, to prove the existence of Autochthonous Mesozoic below the flysch-nappes on the structural height in the Aderklaa area (fig. 4)

The sigma-plot shows normal pore pressures in the Neogene of the Vienna basin down to 3.160 m (fig. 5).

Starting at this depth the Calcareous Alpine Basin substratum was drilled, which made interpretation of pore pressure evaluation more difficult. The chart of the sigma-plot shows a drillability differing from the normal trend. This, however, cannot be interpreted as an increase in pore pressure, but has its reasons in the differentiated lithological composition of the Calcareous Alpine Basin substratum, consisting of limestones, dolomites and shales respectively. There were technical difficulties, when drilling through the shale layers embedded in between, as well as increase of torque and drag, indicating tectonically stressed zones, were registered. In this special case, the increase of background gas cannot be intepreted as an indicator for high pressure zones, since higher background gas levels may often be seen in overthrust areas.

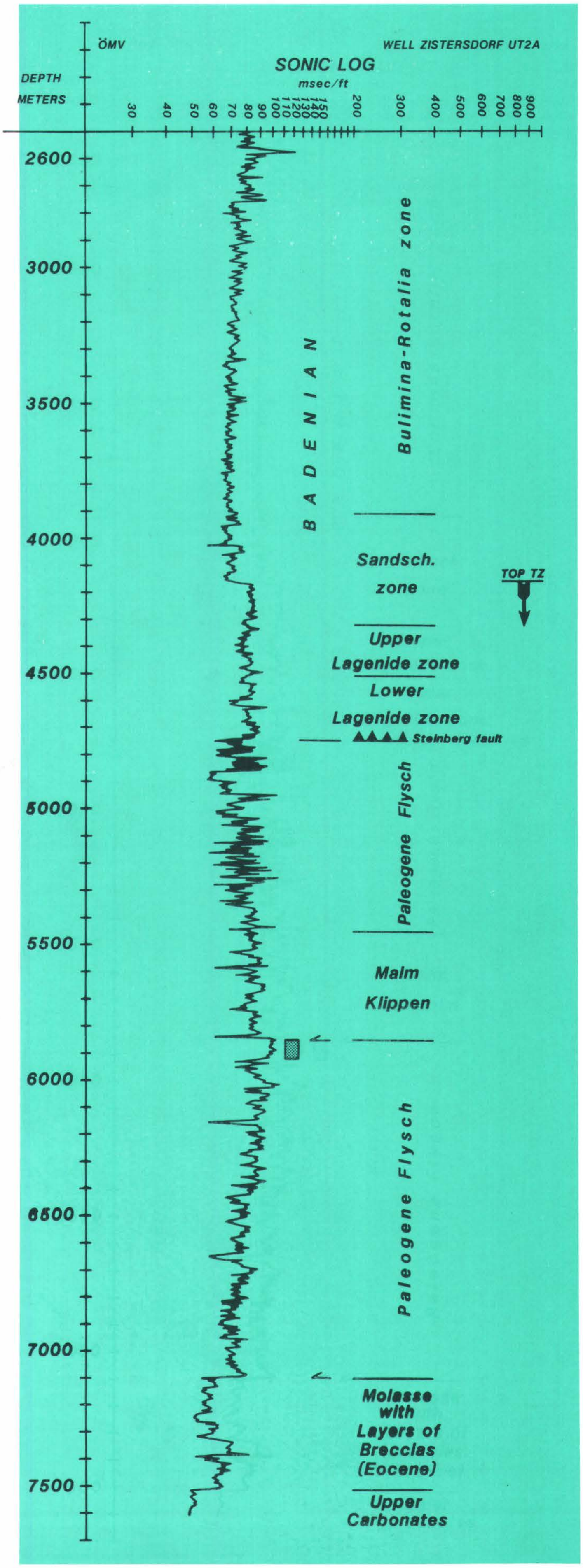


Fig. 3: Sonic-Plot of well "Zistersdorf ÜT 2A" (W. Ringhofer 1986). ►

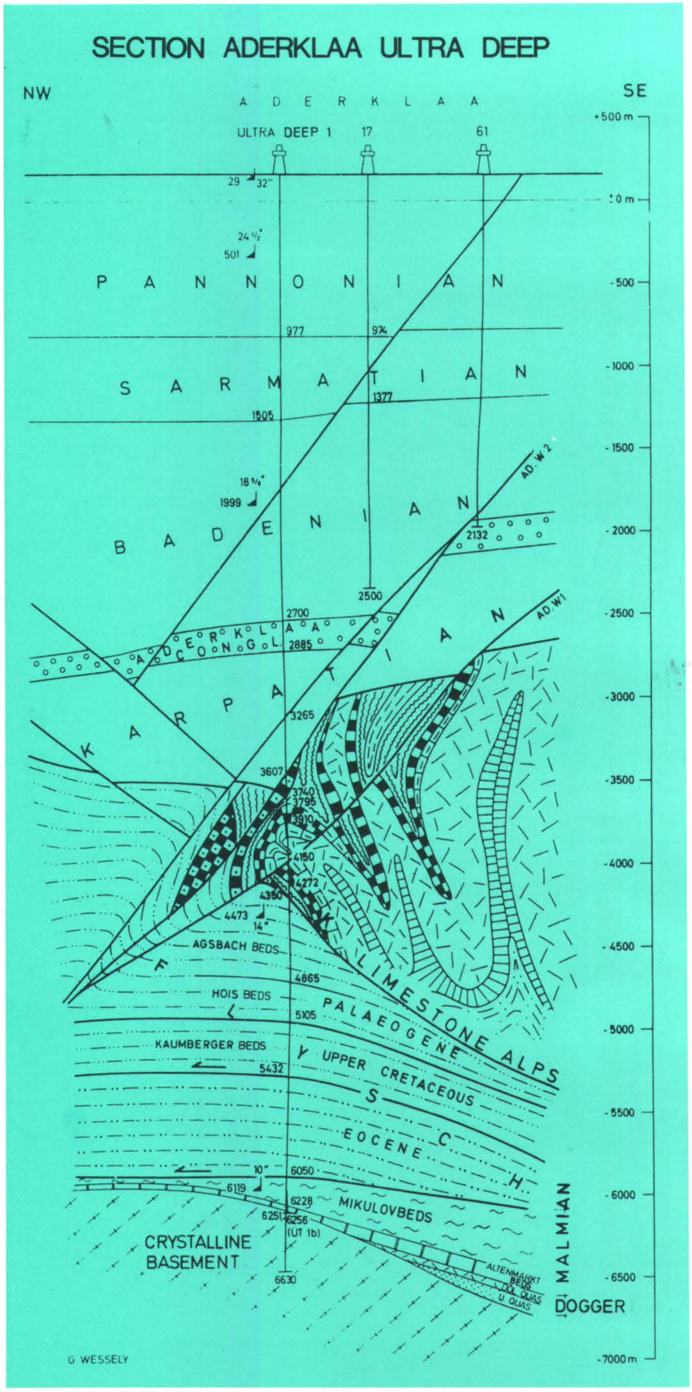


Fig. 4: Geological cross-section — Ultra deep project "Aderklaa UT 1, T 1a" (G. Wessely 1984).

Summarizing we found hydrostatic pressure conditions prevailing in this area with a few tectonic stress zones. Concerning this area it is important to point out that due to different WOB, the sigma-curve follows drilling rather than lithological criteria, i.e. is very much influenced by different drilling parameters.

This fact in addition renders the interpretation of the Calcareous Alpine Basin substratum more difficult. However, a partial loading of the limestone-alps within the contact-region to the Agsbach-nappes under highpressure conditions cannot be precluded completely.

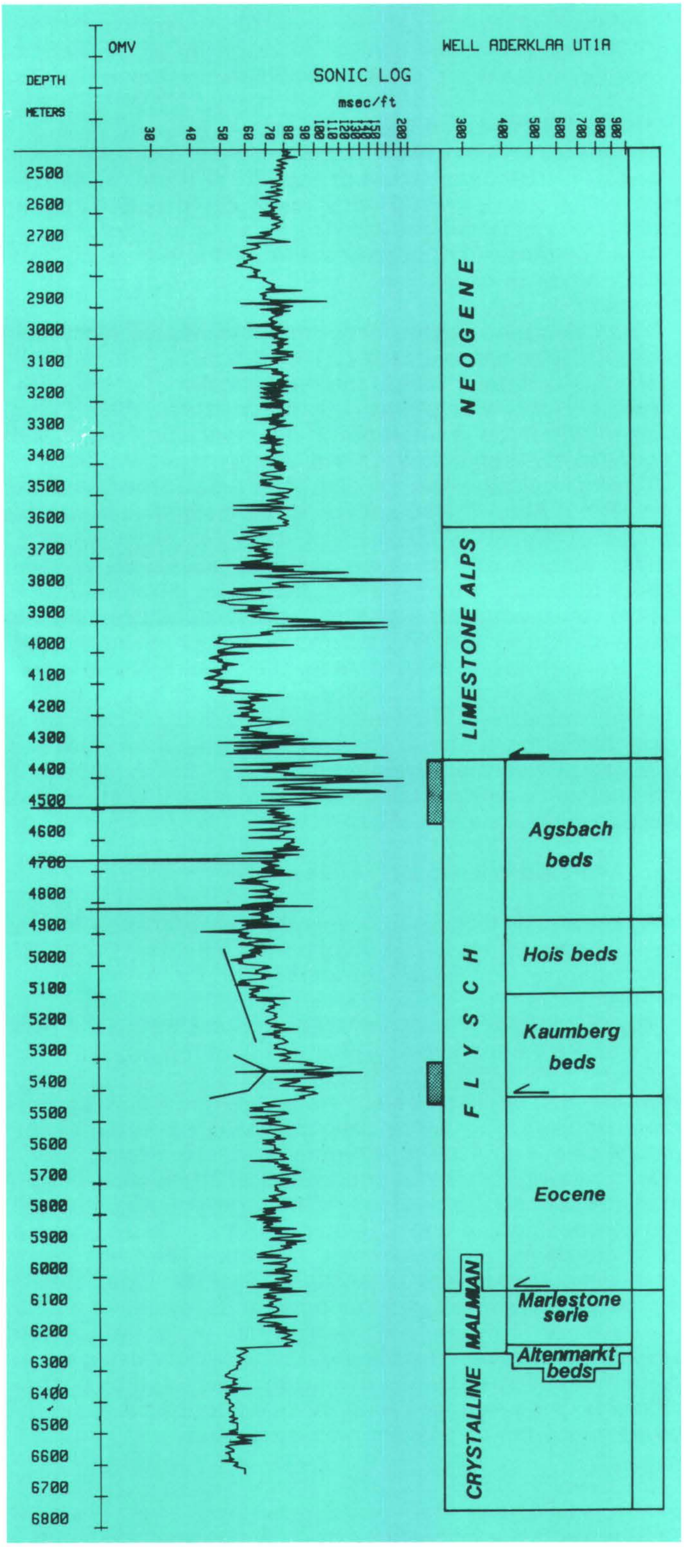
Especially prominent is the overthrust zone „Calcareous Alps over flysch sediment" (interval 4.350 — 4.550 m).

Because of varying velocities in this interval, the sonic-plot confirms statements made during drilling procedure.

The caliper log shows considerable cavings. This also points to tectonically stressed zones. Subsequently a 14" casing was run in. The first significant indication in the sigmalog showing the presence of a transition-zone, was detected about 4.550 m in the Agsbach-nappes, a dominately shaly-marly distal flysch environment. Based on their genesis, the Agsbach-nappes therefore have to be considered as a „seal".

The pressure curve of the sigma-plot in the Agsbach-nappes increased continuously. The transition from Ags-

Fig. 5: Pressure Control Analysis — Project "Aderklaa Ultra T 1, T 1a" (W. Ringhofer 1986). ▶



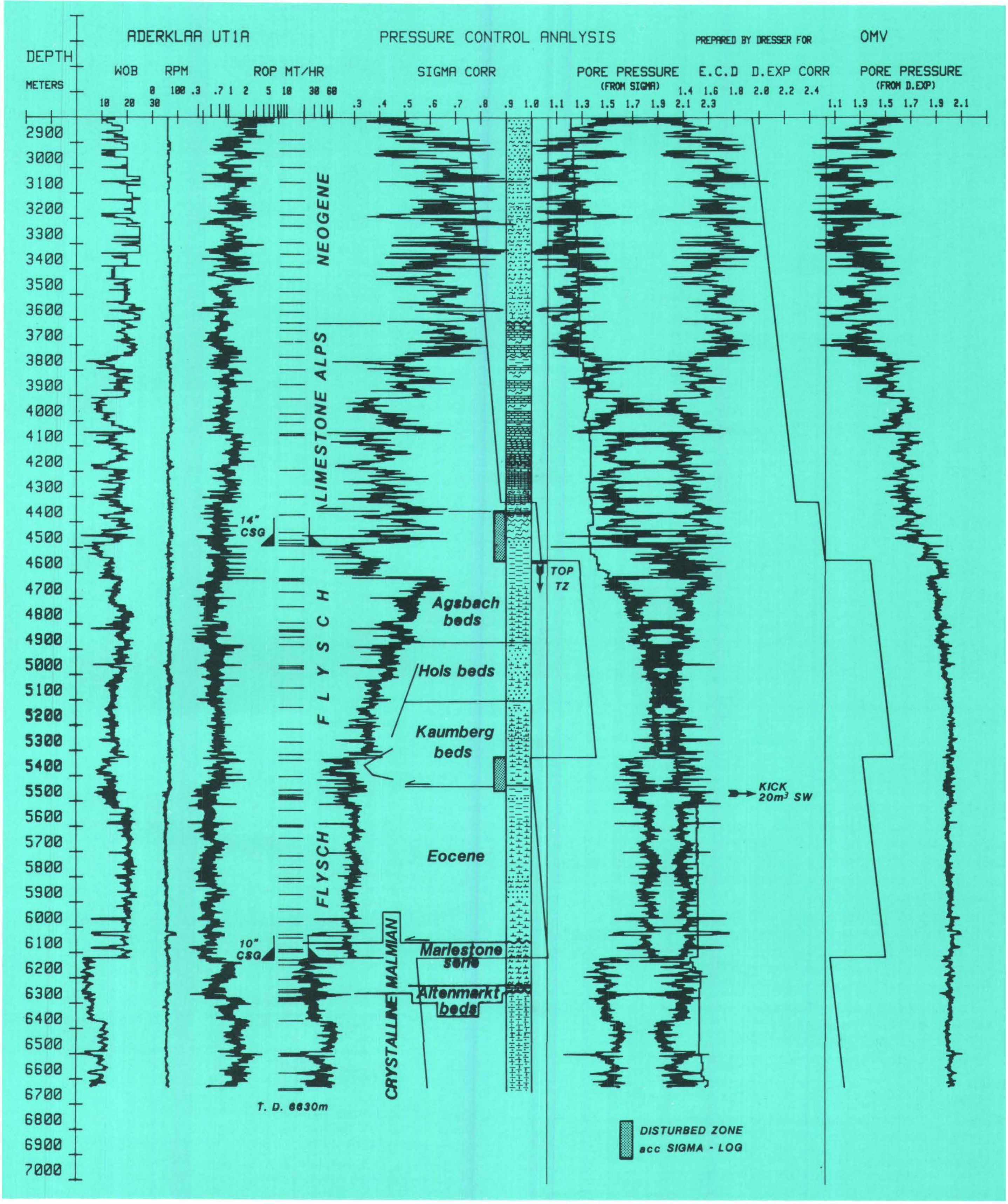


Fig. 6: Sonic-plot of well "Aderklaa UT 1a" (W. Ringhofer 1986).
◄

bach to Hoisnappes is of sedimentary origin. Therefore, no trend-anomalies show up in the sigma-log. The Kaumberg-nappes are the oldest formations in the normal sequence of this southern flysch environment. Down to 5.330 m, the sigma-log shows continuously increasing pressure conditions with gradients of about 1,90 bar/10 m. The interval from 5.330 to 5.460 m represents an area which even at first glance looks like a strongly disturbed zone.

This can be explained through the overthrust of Upper

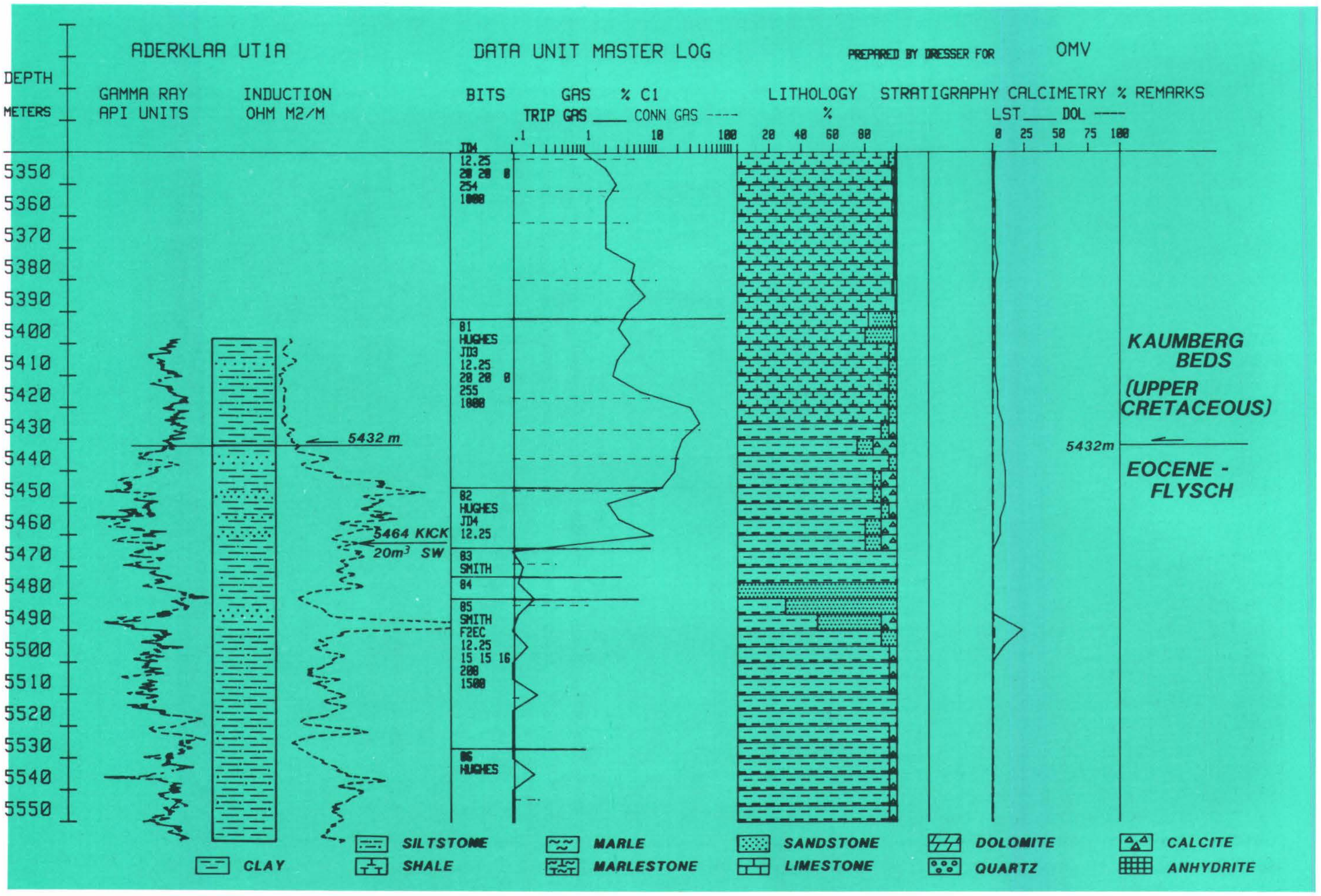


Fig. 7: DATA UNIT Master-Log of well "Aderklaa UT 1a" (W. Ringhofer 1986).

Cretaceous flysch-units onto younger Eocene-flysch.

At a depth of 5.464 m a kick occurred — about 20 m³ saltwater entered the bore hole. A pressure gradient of 2.2 was calculated. This pressure environment in general remained constant for the whole drilling process.

Now to the analysis of the kick at 5.464 m, at which about 20 m³ saltwater entered the bore hole (fig. 7)

The kick has occurred in the area Kaumberg-nappes (Upper Cretaceous) — Eocene flysch. The high drillability was documented by the sigma-log (see fig. 5).

Furthermore there occurred:

1. Extremely high gas readings were caused by connection gases (up to 40 %).
2. The background gas-level didn't decrease any longer, but remained at about the same amount as the connection gas did.
3. The massive presence of calcite also characterized this disturbed zone.

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Abstrakt

V souvislosti s intenzívní prospekcí autochtonního mezozoika se zvýšilo využívání vrtných parametrů, podle nichž lze usuzovat o geologicky významných horninových vlastnostech jednotlivých souvrství, jako např. o jejich pórovitosti, pórových tlacích atd.

Zvláštní význam se přikládá rozboru údajů o postupu vrtání a z něho vyplývajících údajů Dcs nebo Sigma-log vzhledem k jejich přímému vztahu k litologii. Dále se přistupuje k detailnímu včasnému zjišťování vysokých tlaků, jak je patrno z příkladů aplikace této metody např. na vrtech Zistersdorf ÜT 1a a Aderklaa Ultra T 1, 1a.

V kombinaci s údaji Sigmalog a s ohledem na geologická kritéria bylo tak možno rozpoznat „přechodné zóny" jak v neogénu, tak i v pánevním podloží, jež lze interpretovat značně obtížněji. D-exponent, resp. Sigma-log, se tak osvědčily jako mimořádně vhodné prostředky nejen ke včasnému zjišťování vysokých tlaků, nýbrž i k získání podrobných litologických informací v průběhu vrtání.

Zusammenfassung

In Zusammenhang mit einer intensivierten Prospektionstätigkeit auf das autochthone Mesozoikum hat sich die Auswertung von Bohrparametern, die für die Geologie wichtige Rückschlüsse auf Formationen, Porositäten, Porendrücke etc. ermöglichen, verstärkt.

Der Analyse des Bohrfortschritts, daraus resultierend des Dcs bzw. des Sigma-Logs, wird aufgrund ihrer direkten Beziehung zur Lithologie besondere Bedeutung beigemessen. Weiterhin wird eingehend auf die Hochdruckfrüherkennung anhand von angewandten Beispielen wie Zistersdorf ÜT 1a und Aderklaa Ultra T 1, 1a eingegangen.

Unter Berücksichtigung geologischer Kriterien, in Kombination mit dem Sigma-Log, ist es dadurch möglich geworden, „Transitionszonen" sowohl im Neogen als auch im wesentlich schwieriger interpretierbaren Beckenuntergrund anzusprechen. Der D-Exponent bzw. das Sigma-Log haben sich als äußerst probates Mittel, nicht nur für die Hochdruckfrüherkennung, sondern auch für detaillierte lithologische Informatio-

V této souvislosti je třeba zvláště zdůraznit možnosti korelace údajů odporového Dcs, resp. Sonic-log, se Sigma-log.

Navíc jsou uvedené metody, umožňující včasné rozpoznání kritických situací, důležitým příspěvkem nejen k hospodárnému, nýbrž především rovněž k bezpečnému hloubení vrtů.

nen während des Bohrvorganges erwiesen.

Besonders ist in diesem Zusammenhang die Korrelationsmöglichkeit Widerstand-Dcs bzw. Sonic-Log — Sigma-Log hervorzuheben.

Darüber hinaus wird durch das frühzeitige Erkennen von kritischen Situationen ein wichtiger Beitrag nicht nur zum wirtschaftlichen, sondern vor allem auch zum sicheren Niederbringen einer Bohrung geleistet.

PROBLEMS RELATED TO THE ORIGIN OF HYDROCARBONS IN THE VIENNA BASIN

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Although questions concerning the genesis of oil and natural gas in the Vienna Basin have received much attention, the problem has again come into prominence lately, when production from deposits located in sequences underlying the Tertiary basin fill was started. Intense studies on oil genesis in the Vienna Basin have been conducted, above all, by Austrian geologists and geochemists. The investigations made by D.H. Welte, H. Kratochvil et al. (1982), H. Kratochwil, H.D. Ladwein (1984) eliminate the generation of oil hydrocarbons in the Tertiary sediments of the basin. Basing on the results of Rock-Eval pyrolysis, microphotometry and chromatographic analyses of the hydrocarbon fraction of oils and rock (bitumen) extracts, they place the "oil window" to a depth of 4 to 6 km. They regard the organic matter of Tertiary rocks as of genetic type III, and that of the underlying sequences of the autochthonous Malm and Lias-Dogger as of genetic types II to III. These authors place the oils of the basin filling, the flysch basement and the basement of the Limestone Alps into a single genetic group. Most of the oils show features of biodegradation resulting in the complete absence of alkanes. The authors relate the variable oil composition (Klement boreholes) to a terrigenous organic parent matter. In their opinion, the source rocks of the hydrocarbons of the Vienna Basin are sediments of the autochthonous Malm (downdip blocks associated with the Steinberg fault system in the southwestern part of the basin); to some extent, also coal series of the autochthonous Lias-Dogger are thought to supply some hydrocarbons, mainly gaseous ones, at depths exceeding 4 km. The geological conditions of the basin apparently favour vertical migration. Recently, the Czechoslovak authors F. Chmelík and P. Müller (1987) have advanced their views on oil genesis in the Czechoslovak part of the Vienna Basin. They investigated the thermocatalytic alteration of dispersed organic matter (kerogen) that had not been examined by previous research (V. Šimánek, 1976). In their studies, they based upon the common parameters of thermocatalytic metamorphism of kerogen (maximum pyrolysis temperature T_{max}) and the S_1, S_2 indices derived, hydrogen and oxygen indices, production index, the reflectance of vitrinoid dispersinites, etc. They based their modelling of generative hydrocarbon zoning upon the summary temperature pulse method (L. A. Polster, 1984). This approach takes account of the principles of reaction kinetics and the dependence of the conversion of kerogen to oil hydrocarbons on the time and temperature of kerogen exposure during the geological history of the basin. The model development of the zonal generation of hydrocarbons in the Hrušky-Týnec area, illustrated in Fig. 1, can be extrapolated to the whole Moravian part of the Vienna Basin with regard to the geological setting of the region. The principal zones of possible oil-hydrocarbon genesis — "oil windows" — of mesokatagenesis 1 to 3 are situated at a depth of 2.7 to 6 km in this part of the basin. In accordance with paleotemperature history, indicated by the parameters of the pyrolysis temperature maximum T_{max} and reflectance R_o (Fig. 2) the kerogen of most of the rocks investigated was found to be „immature", even at depth intervals about 4 km. The reflectance of vitrinoid dispersinites assigns about half of the rocks examined to the lower part of the oil window and the other half to the protokatagenesis zone (PK_2-PK_3), that means to the zone, where early katagenic gas and incipient oil were formed. The results can be summarized as follows: as regards the level of katagenic kerogen conversion in the Moravian part of the Vienna Basin, kerogen can be assumed to convert to oil hydrocarbons at a depth of some 3 km and deeper. Katagenic hydrocarbon generation from kerogen in the Slovak part of the Vienna Basin is demonstrated in Fig. 3. During the most rapid subsidence in Sarmatian and Badenian time, Neogene sediments along the Kúty-Leváre-Suchohrad line lowered down as deep as 5 km in the early Badenian. At this depth, they were given the temperature pulse required for the conversion of kerogen to oil hydrocarbons. In this region, thermokatagenic kerogen metamorphism corresponding to the "oil window" starts in the late Sarmatian. In accordance with the summary-temperature-pulse theory, the top of the oil window, corresponding to protokatagenesis 3 to mesokatagenesis 1 zones in the Slovak part of the basin, is localized in Badenian sediments, whereas the bottom of the oil window, corresponding to mesokatagenesis 3 to mesokatagenesis 4 zones lies at about 6 km depth in the basement of the Neogene sediments. The katagenic metamorphism of the kerogen present in Neogene sediments in this part of the basin, established at a depth of about 4 km (Závod deposit), corresponds to the oil window bottom. The results of labørataory measurements and analyses are listed in Table 1 for the Moravian and for the Slovak part of the Vienna Basin.

The results obtained by the research on thermocatalytic metamorphism of dispersed organic matter in the rocks of the Czechoslovak part of the Vienna Basin have confirmed that kerogen conversion proceeds in rocks exhibiting favourable oil-generating properties at depths of about 3 to 6 km, as indicated by the level of thermocatalytic alteration and the summary temperature pulse. In the Czechoslovak part of the Vienna Basin, favourable geochemical properties and an adequate level of thermocatalytic alteration were established for the sediments of the autochthonous Mesozoic in the Mikulov marlstone facies and the autochthonous Paleogene, and, as far as gas genesis is concerned, probably also for Paleozoic sediments. The level of thermocatalytic metamorphism does not eliminate geochemically favourably developed Tertiary sediments deposited at adequate depth from the possible generation of oil hydrocarbons in the Vienna Basin* (p. 244).

Oils of rather varying physical and chemical composition have been recovered from deposits of the Tertiary fill of the Vienna Basin: very light paraffinic oils of a specific density less than 0.870 g/cm³ at 20 °C, light to heavy oils of paraffinic-naphthenic and/or naphthenic-paraffinic type, density 0.870 to 0.940 g/cm³, and rather heavy naphthenic oils of a density exceeding 0.940 g/cm³ at 20 °C. The distribution of these oil types is differentiated horizontally and in the vertical section through the basin: very light oils of the paraffinic or paraffinic-naphthenic type are associated with the (Lower, Middle, Upper) Badenian and the Paleogene of the Magura flysch; very heavy naphthenic oils are related to the Sarmatian, and light to heavy oils of mixed paraffinic-naphthenic and naphthenic-paraffinic types to the Karpatian and Eggenburgian-Ottnangian (Table 2). The individual sequences exhibit a distinct dependence of the chemical oil composition on the tectonic framework of the reservoir rocks. Deposits associated with the Steinberg fault system and the Moravian central depression contain oils