SEDIMENTS OF THE MIOCENE (MAINLY BADENIAN) IN THE MATZEN AREA IN AUSTRIA AND IN THE SOUTHERN PART OF THE VIENNA BASIN IN CZECHOSLOVAKIA

N. Kreutzer, ÖMV Aktiengesellschaft, Wien, Austria
V. Hlavatý, Moravské naftové doly, Hodonín, Czechoslovakia

Matzen area

Transgressive — Regressive facies — Cycle wedges

The 2000 — 2800 m Miocene basin fill of the Matzen field can be divided, on the basis of well data and some seismic data, into different geological units, bounded mostly by erosional and angular unconformities or at least some paleontological or lithological criteria (Fig. 1). These geological units mostly correspond to depositional sequences (R. M. MITCHUM et.al, 1977), in a lower scale, as well as to transgressive-regressive faciescycle wedges (Fig. 1,2,3) (D.A. WHITE, 1980), in a higher scale. In the following the latter model will be treated first. Although at places bounded by regional unconformities, the cycle wedges as fundamentally facies-defined bodies will be bounded by nonmarine tongues. The study of D. A. WHITE is based on stratigraphic cross-sections through the main producing areas of 80 basins of the western world (including Vienna basin, but without a published cross-section), as well as on WALTHER's law of facies (the vertical succession of facies commonly is the same as the lateral order of their depositional environments, shifted by transgression and regression of the coast). The ideal wedge represents a transgressive-regressive cycle of deposition including, from base to top, the vertical succession of facies from nonmarine to coarse- and fine- to coarse textured marine and back to nonmarine (Fig. 2).

The Miocene basinfill of the Vienna basin can be divided into a various number of sand-shale cycle wedges, depending on the occurrence of the pre-Karpatian sediments. In the Miocene basinfill of the Matzen field 4 sand-shale cycle wedges can be recognized more or less distinctly (Fig. 1). 1. Lower parts of a wedge base: The terrestrial-limnic and conglomeratic Gänserndorf beds, the fluviatile Aderklaa conglomerate, the deltaic conglomeratic Auersthal beds, the gravel beds at the Badenian — Sarmatian boundary. Upper parts of a wedge base: the transgressive sands of the Lower Bockfliess beds, the transgressive Matzen sand of the Lower Badenian, the upper part of the Lower Sarmatian (8th). 2. Wedge-middle: the sand-shale succession in the middle part of the brachyhaline Bockfliess beds, of the limnic Aderklaa beds, of the brachyhaline to marine Badenian, of the brachyhaline Sarmatian and of the brackish Lower to Middle Pannonian. 3. Wedgetop: the sand-rich beds of the uppermost Badenian (1st—4th) and the fresh water gravelbeds of the Pontian. Because of erosional and angular unconformities on the top of the Bockfliess beds (D2) and Aderklaa beds (D3), a wedge-top does not exist or is incomplete and will not be represented by the overlying Gänserndorf conglomerate (D2) or Aderklaa conglomerate (D3).

1. Cycle

In the mostly lenticular sands of the brachyhaline Bockfliess beds the oldest and first distinct trangressive-regressive sand-shale facies cycle wedge is developed. A thick transgressive wedge-base of coarse sandstones (B16) onlaps unconformably the flanks of the Spannberg Flysch ridge in the north, dolomite debris and conglomerates (complexes B11—B16) onlap the buried hills of the Calcareous Alps in the south, respectively. The transgressive-regressive wedge-middle comprises sandstones and thicker shale intervals and perhaps also overlying sand-rich beds (B9—B11 in the north, B9, B10 in the south), although truncated by a regional unconformity (D2) (Fig. 1).

2. Cycle

Therefore the overlying terrestrial limnic Gänserndorf beds (TL3, TL4) with a basal conglomerate correspond to the nonmarine part of the wedge-base of the second cycle and not of the wedge-top of the first cycle. The limnic Aderklaa beds (Marker M18—25) belong to the wedge-middle, although truncated on the top by the regional erosional and angular unconformity (D3 (Fig. 1). Both, the Gänserndorf-and the Aderklaa beds, consist also of mostly lenticular sands.

3. Cycle

The overlying Aderklaa conglomerate again probably corresponds to the nonmarine part of the wedge-base of the Badenian and not of the wedge-top of the second cycle. The Lower Lagenida zone (far in the south of the field), the Upper Lagenida zone (Auersthal beds) and the Matzen sand belong to the marine part of the wedge-base of the third cycle. The transgressive-regressive sand-shale facies-cycle wedge of the Badenian in the Matzen field is almost completely developed and is especially clear recognized (Fig. 1, compare Fig. 2 and Fig. 3) (N. KREUTZER, 1986).

The **Matzen sand** is a typical basal time transgressive sand of the Badenian, corresponding to the transgressive wedge-base of the third facies cycle. This sand onlaps, with increasing erosional and angular unconformity from south to north, various older beds, first the conglomeratic Auersthal beds of the Upper Lagenida zone, then the Aderklaa- and Gänserndorf beds of the Karpatian, the Bockfliess beds of the Ottnangian or Lower Karpatian and at last the Upper Cretaceous Flysch of the Spannberg ridge (Fig. 3). The within the field up to 80 m, outside up to 140 m thick diachronous Matzen sand is a high quality reservoir (average porosity 26%, average permeability 1000 md) with a cumulative oil production of about 34 million tons since 1949.

The facies change between the Matzen sand and the overlying marine shale wedge occurs progressively farther marginward toward the island of the Spannberg ridge (or the basin margin in the northwest, respectively) in successively younger strata, representing a transgressive or up-to-margin pattern (N. KREUTZER, 1986) (Fig. 1,3). The inner neritic Matzen sand (Chr. RUPP, 1986) (Fig. 5) fines upward, apart from the conglomeratic and deltaic Auersthal beds in channellike topographic lows at the base, from coarse sands into fine-grained clastics in response to a sea level rise and changes from a high to a low energy environment. The SP-log profil is typically cylinder-shaped in the lower and middle part and more bell-shaped in the upper part, as the sand grades into the overlying marine shales of the outer neritic environment (Chr. RUPP, 1986) (Fig. 5). The thickness of the basal transgressive sand is dependent on the gradient of the depositional surface (W. O. ABBOTT, 1985). Because of high sediment influx and the moderate to steep gradient of the flanks of the eroded Spannberg ridge (Fig. 3) the transgression was slow and unusually thick sands are deposited in the topographic lows, whereas over the topographic highs with a low to moderate surface gradient and a limited supply of source material, the transgression was relatively fast and thin sands are preserved, in some places only shales have been deposited. This situation of the Matzen sand agrees well with the many examples of basal transgressive sands from North-and South-America, Australia, described and illustrated by W. O. ABBOTT, 1985.

All the other sheetlike (and in some places lenticular) oil and gas sands in the Badenian (15th—5th) above the Matzen sand belong to the wedge-middle plays (Fig. 1,3). Numerous sand tongues, alternating with shale interbeds,

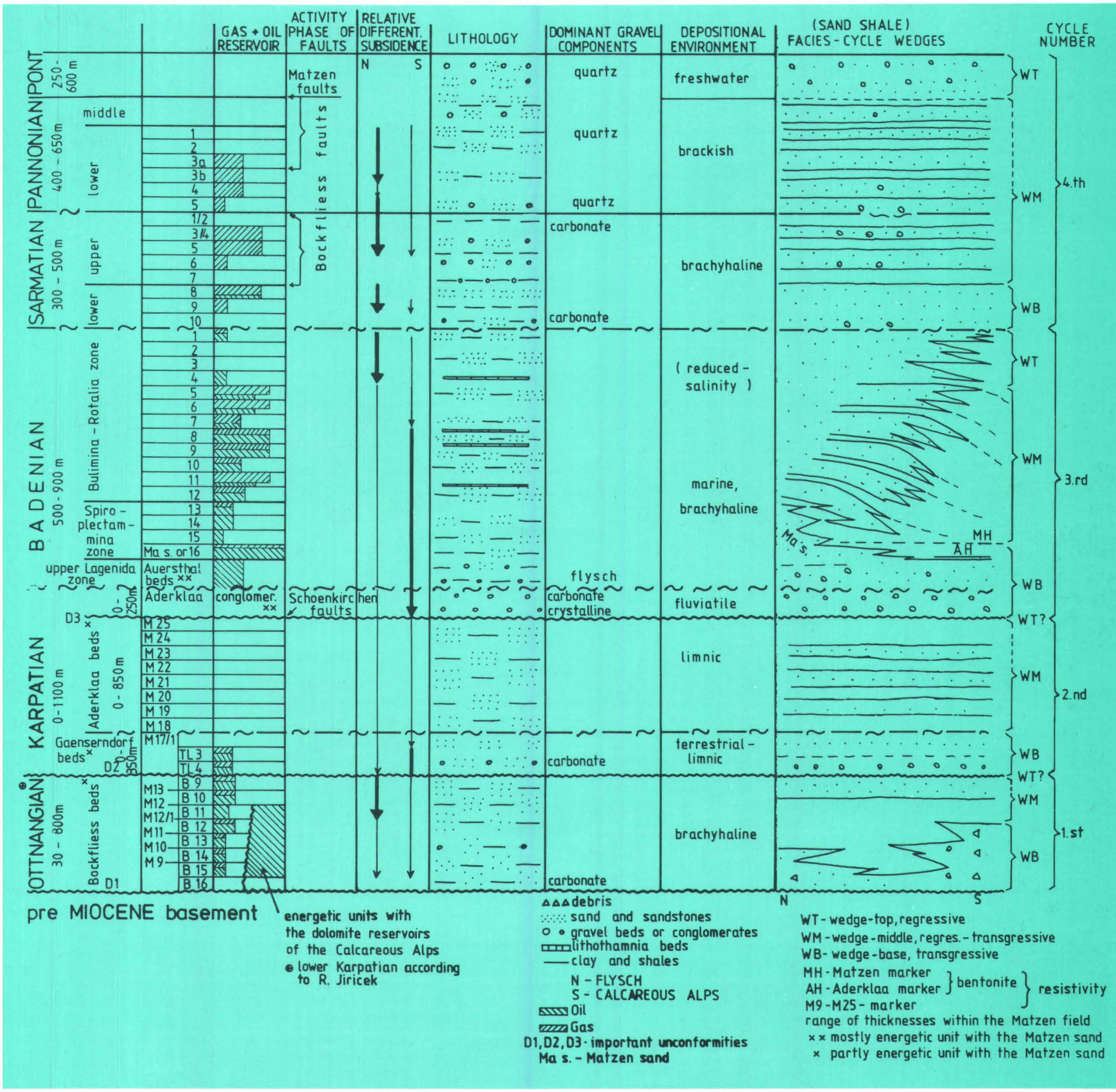


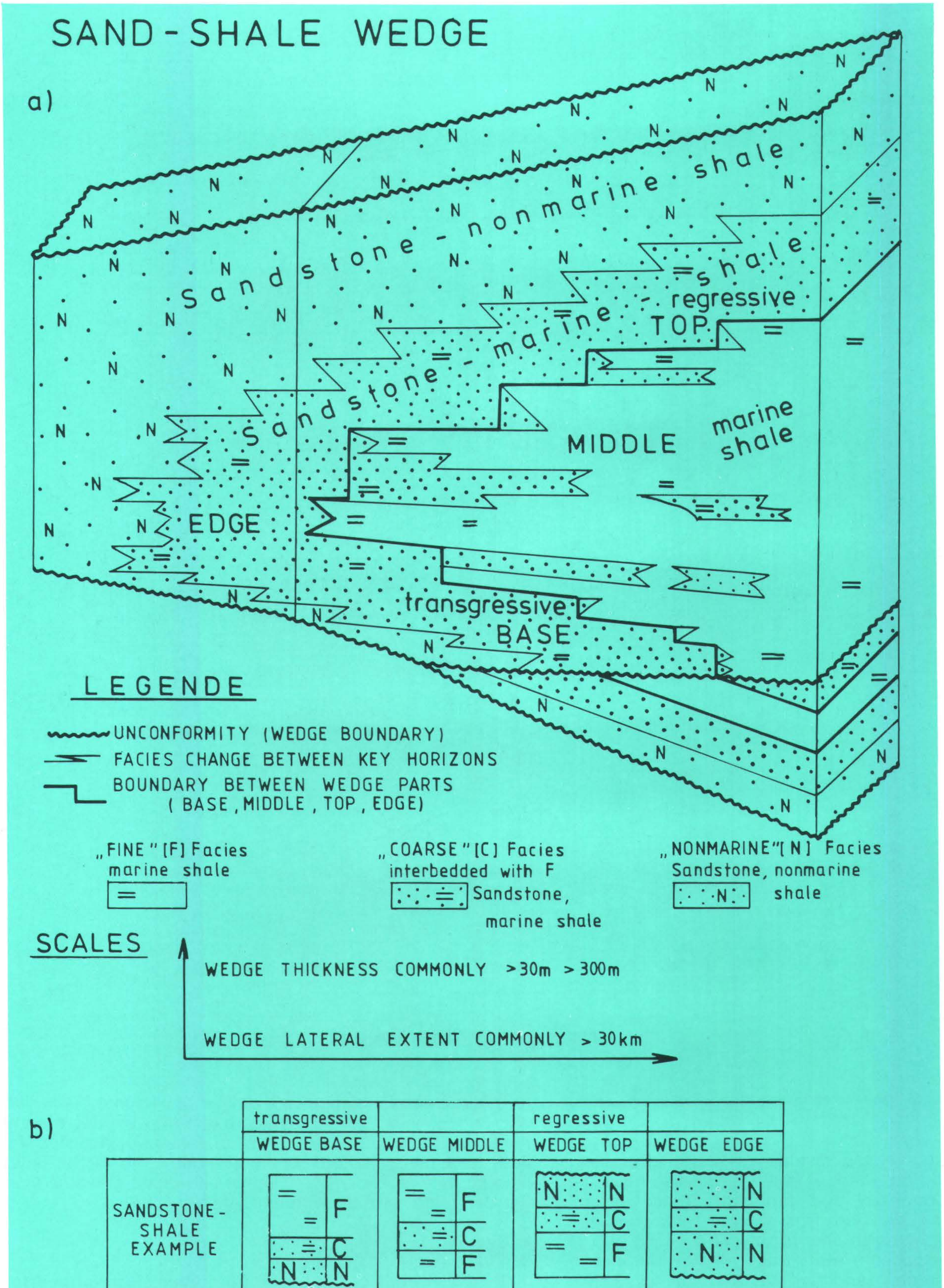
Fig. 1: Stratigraphy, tectonics, gas- and oil reservoirs of the Miocene basin fill in the Matzen field.

probably representing on the one side the transgressive fully marine parts, on the other side the regressive marine parts of deltas (deltafront and prodelta). These sand tongues extent, first (15th, 14th) from the northeast around and then also from the north and northwest over the subsided Spannberg ridge, into the wedge-middle part progressively farther south —and basinward in successively younger strata. The lower and upper segments of such tongues commonly have up-to-center (regressive) and up-to-margin (transgressive) facies patterns and funnel-shaped or bell-shaped SP-log patterns, respectively. The oil and gas reservoirs of the Badenian (15th — 5th) follow this trend, they occur in an up-to-center progression. The wedge-middle plays in the Matzen field are typically associated with marked depositional slopes and interval thickening (Fig. 1,3,4) (N. KREUTZER, 1986).

The regressive wedge-top of the uppermost Badenian (4th-1st) consists of sand- rich beds with a poor marine fauna and is truncated locally by an erosional unconformity in synsedimentary highs in the southern part of the field, marked by extraformational alpine carbonate gravelbeds at the Badenian-Sarmatian boundary (Fig. 1,3,4).

4. Cycle

Sand-rich beds of the Lower Sarmatian (10th-8th) correspond to a new transgressive wedge-base, transitional to an Upper Sarmatian thick shale interval (between 8th and 7th), followed again by sand-rich fining- or coarsening upward beds (7th-3rd/4th) including 3 channelized sharp-based sands with extraformational alpine carbonate gravels (3rd/4th, 6th and 7th Sarmatian) as well as several thicker shale intervals. It seems that the transgressive-regressive wedge-middle part comprises not only the lower thick shale interval but also the overlying sand (gravel) and shale



a) Facies-cycle wedge
b) Vertical facies successions

[modified fig. 1 and 2 by David A. White, 1980 Assessing Oil and Gas Plays in Facies-Cycle Wedges, AAPG-Bulletin, v. 64, No 8.]

Fig. 2: Sand-shale wedge (modified) (According to D. A. White, 1980).

beds of the deltaic Upper Sarmatian, together even with the brackish and deltaic Lower and Middle Pannonian sand, (gravel) and shale or clay succession (Fig. 1). The Lower Pannonian sands (1st-5th) are characterized by an upward-coarsening facies (L. KÖLBL, 1953, H. WIESENEDER, 1959, N. KREUTZER, 1974) with regressive Sp-log shapes, except in the cylinder-shaped channelized parts of very thick sand lobes. The wedge-top would be represented by the sands and gravelbeds of the fluviatile-lacustrine Pontian (Fig. 1).

The Miocene basin fill has been subdivided into three sedimentary cycles already by L. KÖLBL, 1953 (internal report), 1957, 1959. Because all his cycles begin with the thick shale intervals and end with the sand-rich beds, the wedge bases of the 4th and 3rd cycle still belong to his 2nd and 1st cycle, respectively. The 2nd and 1st cycle correspond to his 1st cycle, but the pre-Badenian sediments have been only little known at this time and therefore could have not been differentiated by L. KÖLBL.

The depositional sequences

The Miocene geological units of the Matzen field generally also correspond to despositional sequences (R. M. MITCHUM et al, 1977: „A depositional sequence is a stratigraphic unit composed of a relatively conformable succession of genetically related strata and bounded at its top and base by unconformities or their correlative conformities"). Because depositional sequences are recognized by the geometry of their bedding planes, it was necessary to divide the **Badenian** of the Central Vienna basin into two completely different geological units or depositional sequences, a lower transgressive unit or sequence of the Lower Badenian and an upper alternating regressive-transgressive unit or sequence of the Upper Badenian (Fig. 3,4) (N. KREUTZER, 1986).

The lower transgressive sequence of the Badenian in the Matzen field (Fig. 3), showing an increasing base discordant onlap and hiatus towards north, comprises the Matzen sand as well as the overlying parallel to slightly divergent bedded and rather homogeneous and bentonite bearing shales, which have a facies change with the sand and are increasing in thickness southward. This situation of the lower sequence indicates probably a deposition (sedimentation rate lower than subsidence rate) after a relative fall of sea level followed by a rise in sea level („lowstand deposits" of VAIL et al., 1977) (N. KREUTZER, 1986).

On the contrary, the upper sequence of the Badenian in the Matzen field above the regional Matzen bentonite marker, overlying the lower sequence with increasing apparent base-discordant downlap and apparent hiatus towards south, (Fig. 3,4), is characterized by cyclic beds of lower regressive (coarsening-upward) and upper transgressive (fining-upward) sands and rather heterogeneous clays and shales. The upper and middle sands are thicker and laterally more extensive than the lower sands. Up to 1 m thick calcareous sandstones with a marine macrofauna are frequent on the top of such sandcomplexes and are, together with the overlying shales, marine transgressive sediments. These shales, 5—20 m thick and repeatedly intercalated, separate the sandcomplexes and reservoirs. Slightly increasing SP- and resistivity values as well as silt-or sand-content of the shales indicate marine prodelta sediments, transitional to the marine deltafront sands of such sandcomplexes. The upper sequence (Fig. 3) exhibits a sigmoid to oblique progradation or offlap with a paleo-topographical differentiation into a northern upper platform (topset) zone with gently dipping and rather parallel bedded segments of a sand-rich facies, a middle (foreset) zone with thicker more steeply dipping (up to 6°) segments locally

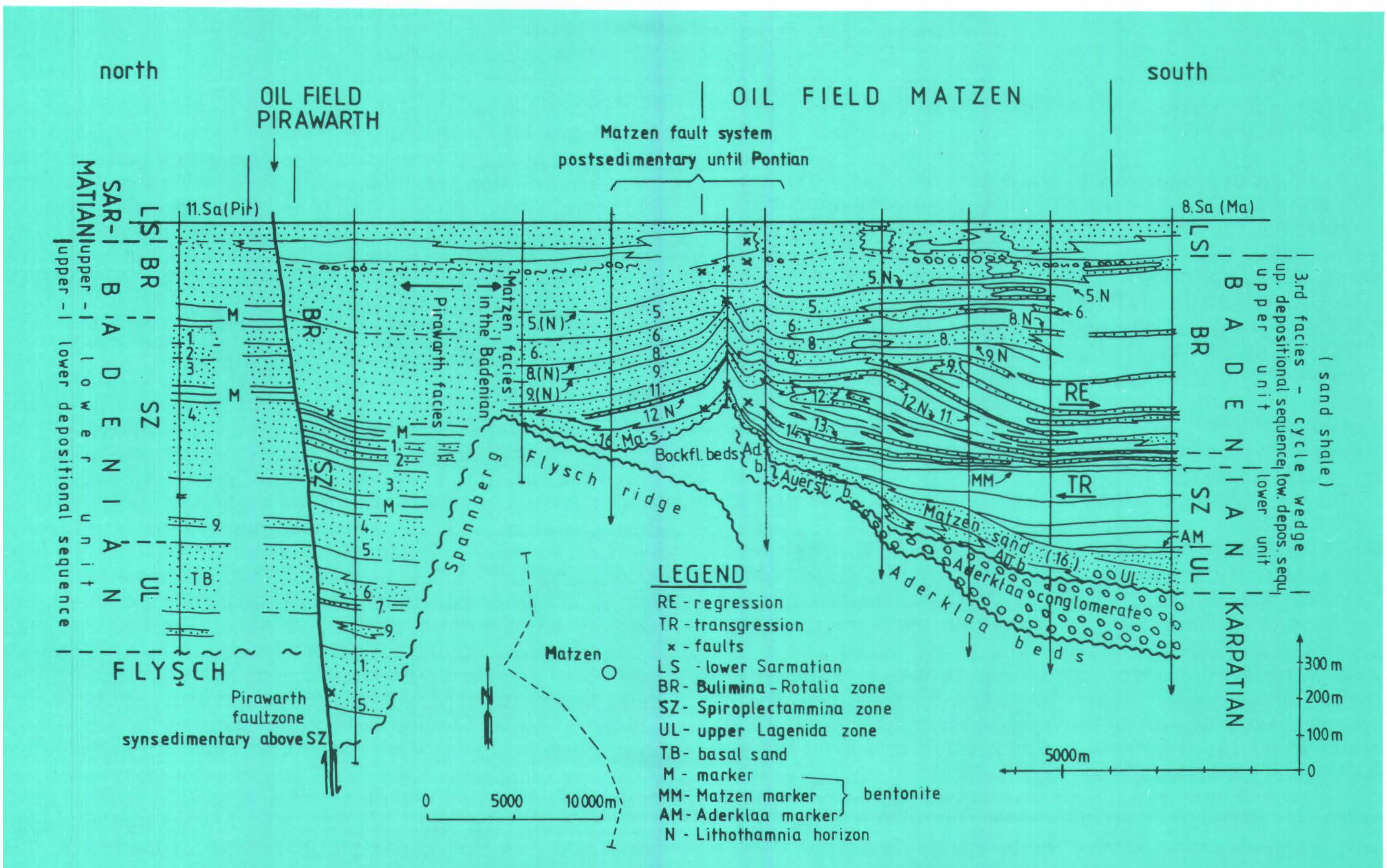


Fig. 3: Stratigraphic cross-section of the Badenian in the Matzen field with a facies-cycle wedge (south of the Spannberg ridge) and depositional sequences (according to N. Kreutzer, 1986, modified).

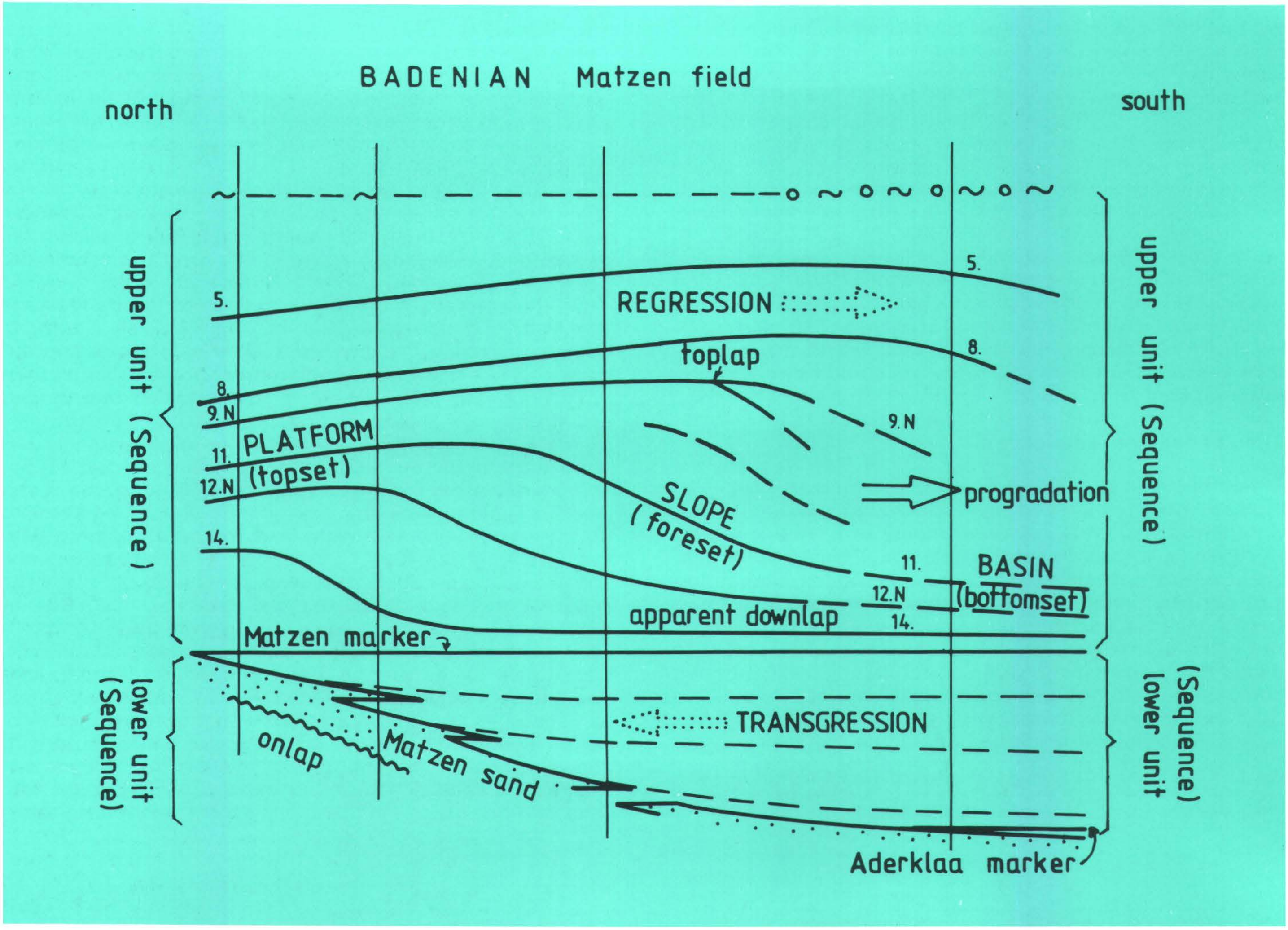


Fig. 4: Schematic cross-section of the depositional units or sequences of the Badenian in the Matzen field.

terminating updip by toplap, and a southern lower (bottomset) zone again with gently dipping segments of a shale-rich facies, terminating downdip by apparent downlap on an apparent „nondepositional unconformity". The depositional environments generally have been shifted by regression southwards, therefore the platform facies of the beds, containing large oil and gas reservoirs, is overlying the basin facies of the older beds („Walther's law of facies") (Fig. 3). The strata of the upper sequence (sedimentation rate higher than subsidence rate) indicate probably a relative rise of sea level, leading to the complete inundation of the Spannberg ridge („highstand deposits" of VAIL et al., 1977) (N. KREUTZER, 1986).

Several lines of evidence point to a subaqueous part of an ancient Danube delta of the upper sequence of the Badenian in the Matzen field (N. KREUTZER, 1986): The cyclic succession, the geometrical configuration of the strata and the investigations by Ch. RUPP, 1986, (Fig. 5) resulting in alternated shale intervals of fully marine „deeper water" foraminifera and sandcomplexes of dominant hyposaline shallow water foraminifera, indicating proximity to a river mouth system (for instance Textularia earlandi, the recent species of it is typical for the Mississippi mouth facies). The sediments consist generally of unbedded or evenly (parallel) to wavy bedded (flaser and lenticular bedding) sometimes bioturbated sands and shales with common lignitic and plant debris. In the „deeper water" fully marine intervals frequent up to several meters thick layers of Lithothamnia nodules, embedded in a matrix of calcareous clays and micritic limestone, are repeatedly intercalated from the 5th to the 14th Badenian. Although the occurrence of the red algae indicates episodes of very shallow marine water over a submarine swell (50 — 150 m water depth), the composition of the matrix points to a low-energy environment. The extent of these Lithothamnia beds and the distribution of their thicknesses is for the most part influenced by the synsedimentary structures (L. KÖLBL, 1953, H. WIESENEDER, 1956, 1964, N. KREUTZER, 1978).

The seismic facies

The seismic facies in the marginal parts of the Matzen field and in the surrounding area is variable, depending on lithologies and stratal configurations. In the bedded sand-shale successions of the Pannonian Sarmatian and Upper Badenian the principal stratal configuration is parallel to subparallel or slightly divergent, sometimes hummocky, with continuous to discontinuous reflections and weak to strong amplitudes. The prograding and predominantly shaly part of the Upper Badenian is almost reflection-free, but sometimes distinct sigmoid and oblique clinoforms with apparent downlap and toplap are recognizable. In the shale wedge of the lower Badenian, also nearly reflection-free (seismically „transparent"), however, an although weak developed parallel to slightly divergent seismic facies is indicated and onlapping reflections upon the strong reflective Aderklaa conglomerate exist. The lenticular and on the top truncated Aderklaa beds are characterized by rather indistinct and discontinuous reflections with weak amplitudes or reflection-free zones. The conglomeratic Gänserndorf beds and the Bockfliess beds indicate sometimes stronger ref-

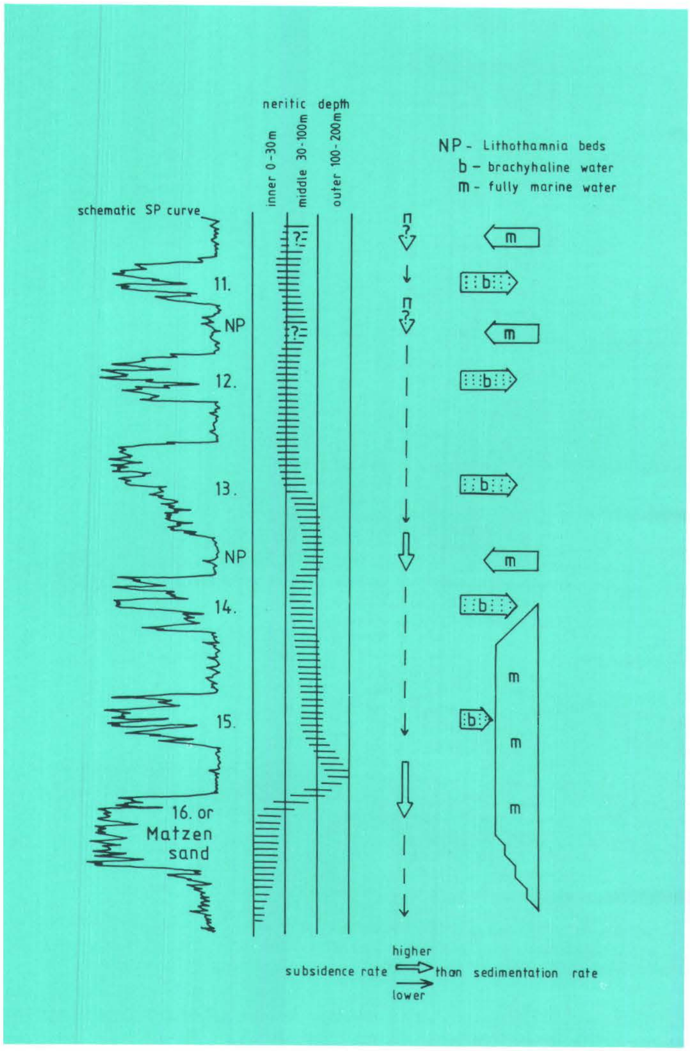


Fig. 5: Paleoenvironment and foraminiferal paleoecology between the Matzen sand and the 11^{th} Badenian, by Chr. Rupp, 1986 (modified). Foraminiferal groupings in the sand complexes are made up of hyposaline shallow water foraminifera, in the shale intervals of fully marine "deeper water" foraminifera.

lections, those of the latter beds onlapping the older sedimentary basement.

The Gänserndorf beds probably represent delta plain sediments, equivalent beds in Czechoslovakia, as shown by R. JIŘIČEK, indicate delta front and prodelta sediments, which distinctly prograde and updip to east in the seismic sections.

Structural development and faults

The structural development in the Miocene basin fill of the Matzen field predominantly is governed by the differential subsidence of the sedimentary basement, that is the generally SW-NE striking Spannberg Flysch ridge in the north and the N-S striking ridge of the Calcareous Alps in the south (Fig. 1). This development, by use of isopach maps, has been investigated in the Pannonian, Sarmatian and Badenian by N. KREUTZER, 1971, in the Aderklaa, Gänserndorf, Bockfliess beds by S. KÖVES, 1971 and HLADEČEK et al., 1971. A southward convergence of E-log markers suggests a less subsidence of the Calcareous Alps during the sedimentation of the upper Bockfließ beds (B 11—9) as well as of the upper Badenian (above 5th), Sarmatian and Pannonian (a short interruption of this tendency in the lowest Pannonian is caused apparently by the rapid deposition of some delta lobes). A northward convergence suggests a less subsidence of the flysch ridge generally during the sedimentation of the Gänserndorf beds, the Aderklaa conglomerate and until upper Badenian (8th). The rather parallel markers of the intervening intervals point to a balanced subsidence in the lower Bockfliess beds (B16-12), the Aderklaa beds and the upper Badenian (between 8th and 5th) (Fig. 1).

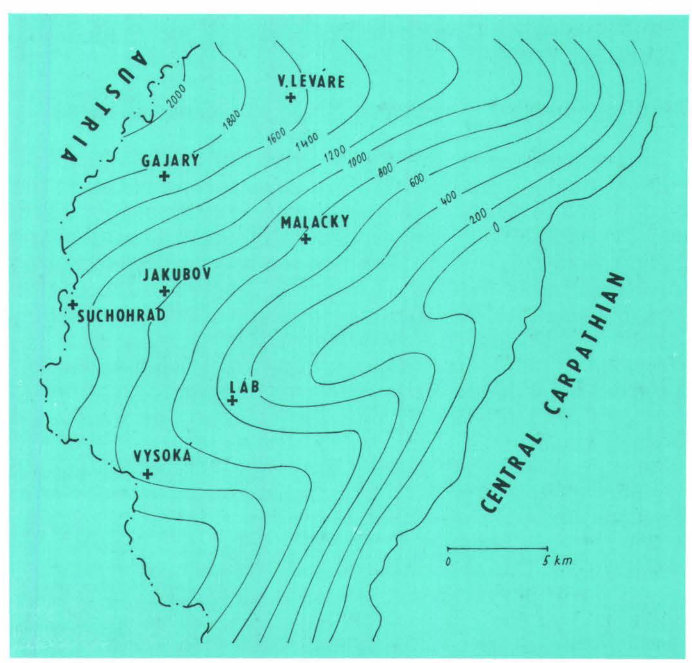
The structural development in the upper regressive-transgressive depositional sequence of the Badenian is influenced not only by the differential subsidence but also by the progradation of the strata. The more steeply dipping segments of the individual foreset zones (5th — 15th Badenian) establish sedimentary structural flanks shifting laterally to southwest, south and southeast from the older to younger beds (Fig. 3 and 4).

A final important change occurs in the Pontian owing to the origin of a new (postsedimentary) structure in the northern part of Matzen field, together with the Matzen fault system. Numerous old synsedimentary structure elements are preserved, however.

In the Matzen field three genetically unrelated fault systems can be recognized in the Miocene basin fill (Fig. 1).

1) the oldest is the north to south striking postsedimentary Schönkirchen fault system above the ridge of the Calcareous Alps in the southern part of the field. Its activity began after the sedimentation of the Aderklaa beds and ended pre-Badenian, the vertical throw is up to about 50 m (S. KÖVES, 1971, K. HLADECEK et al., 1971) (Fig. 1).
2) The north — south striking and west dipping synsedimentary Bockfliess fault system, consisting of en echelon fault segments, on the western field margin with a vertical throw of up to 400 m. Upthrown and downthrown blocks are directly connected by steeply dipping narrow strips between two faults. A large difference in the thickness of the Miocene sediments of the upthrown and downthrown blocks and increase in thickness within the narrow strips accentuate the synsedimentary character (G. WESSELY, 1988). There are two activity phases, the one from the 7th Badenian up to the top of Sarmatian, the other from the 3rd Lower Pannonian up to the top of Middle Pannonian, repectively (N. KREUTZER, 1971) (Fig. 1).
3) the southwest to northeast striking postsedimentary Matzen fault system in the northern part of the field, consisting of northwest and southeast- dipping rotational

Fig. 6: Map of total thicknesses of the Badenian in the southern part of the Vienna Basin. After D. Jiráček 1969.



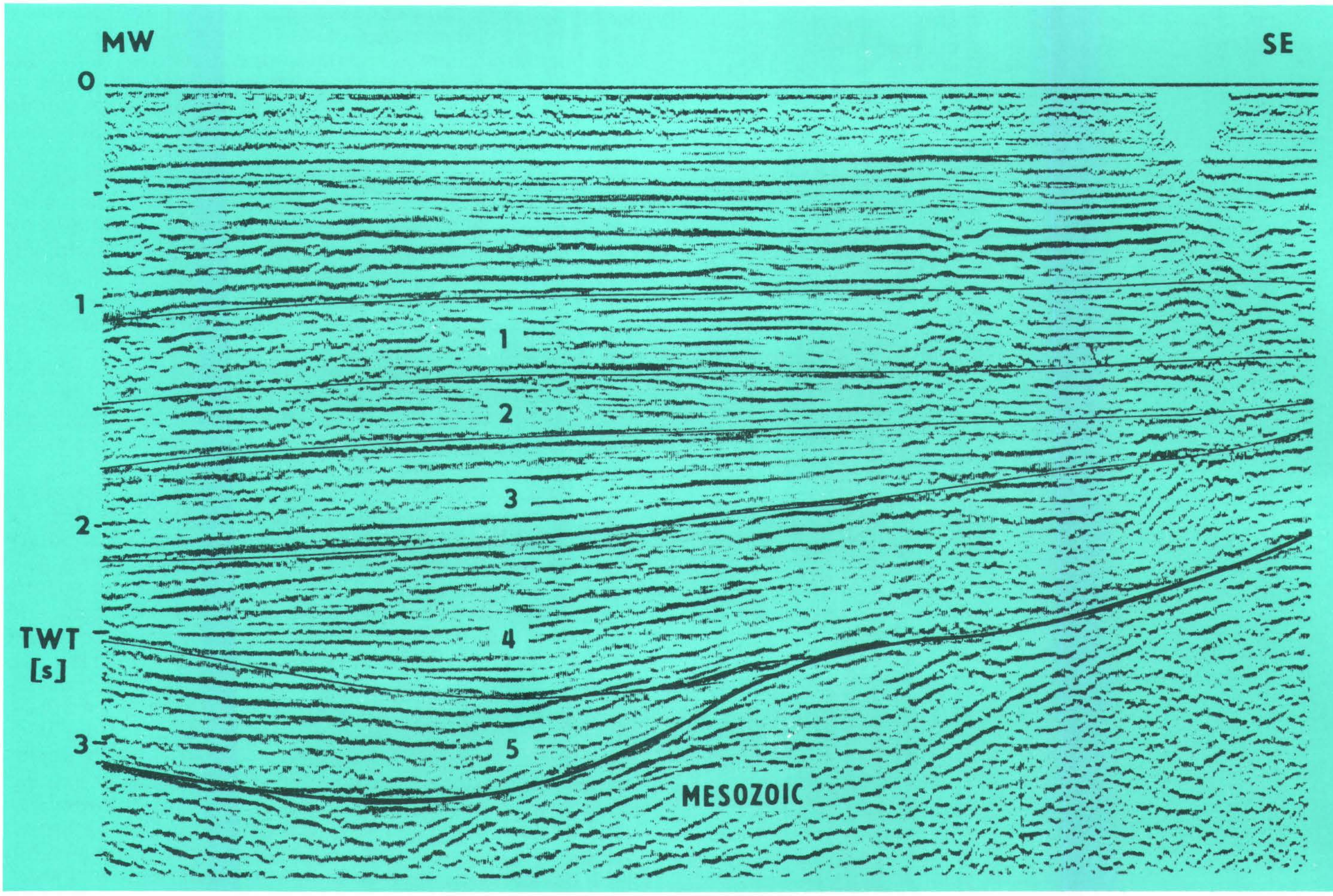


Fig. 7: Seismic line No. 651/84
1 — UB; 2 — MB; 3 — LB; 4 — Aderklaa + Láb Ostracoda Beds; 5 — Gänserndorf + Bockfliesser Beds.

faults (Fig. 1.). It is post-Pannonian in age (N. KREUTZER, 1971), the faults show a maximum vertical throw of 80 m and may be explained by tension above an updoming of the deeper however still undrilled autochthonous basement, which causes the Matzen-Spannberg elevation (G. WESSELY, 1988). By displacing southeast dipping faults the northwest dipping faults prove to be younger (G. WESSELY, 1988).

Southern part of the Vienna Basin in Czechoslovakia

In Czechoslovakia, the southern part of the Vienna Basin comprises the area between the Leváre depression on the north and the Czechoslovak/Austrian frontier on the south (fig. 6). Geologically it is related to the central part of the basin situated in Austria. The two regions developed during the Neogene as two opposite flanks dipping to the central Gajary deep and the Suchohrad depression. Minor differences in the development of the individual sequences recognized in the course of exploration work are the result of different subsidence rates. However, the most pronounced changes occurred during the development of the Lower Miocene sediments. The results of exploratory drilling and seismic profiles have shown that, for the Bockfliess and Gänserndorf Beds which form the basic part of the Lower Miocene, the centre of basinal sedimentation was situated within the Austrian part of the Vienna Basin. On Czechoslovak territory, the sedimentation of these sequences appears to have extended into the area of the Suchohrad depression and the Gajary deep only, or to the lower-lying parts of the Láb and Malacky elevations. They could not be identified by drilling in the higher levels of the slopes of the elevations mentioned above. After the deposition of the Bockfliess and the Gänserndorf Beds, the whole western flank was uplifted and the centre of sedimentation shifted eastwards to the bases of the slopes of the Láb and Malacky elevations. (fig. 7—10). The Láb Beds with ostracodes (Aderklaa Schichten) were deposited in this new area of sedimentation and overlain by a sand-and- clay complex —the so-called Upper Karpatian Variegated Beds — on the northeastern margin. These beds are the terminal part of the Lower Miocene.

Cycle 1

The comparison of the above data with the division into cycles according to N. Kreutzer has shown that, in the Czechoslovak southern part of the Vienna Basin, cycle 1 can be present only with its top part (the top of the Bockfliess Beds) which is spatially related to the depression zones along the western margin of the region under study (figs. 7,8,10). By their bedding, the sediments onlap the relief of the underlying beds in the Suchohrad depression.

Cycle 2

The bedding of the transgressive part of cycle 2 — the Gänserndorf Beds — appears to be nearly conformable with the Bockfliess Beds as apparent along the western margin of the Czechoslovak part of the basin. by contrast, a marked unconformity can be recognized between the Gänserndorf Beds and the overlying limnic Láb Beds with ostracodes (Aderklaa Schichten) that form the wedge middle. The wedge base onlaps the lower-lying slopes of the elevation zones. The wedge top is missing in the western part, because it was eroded away by the transgressive part

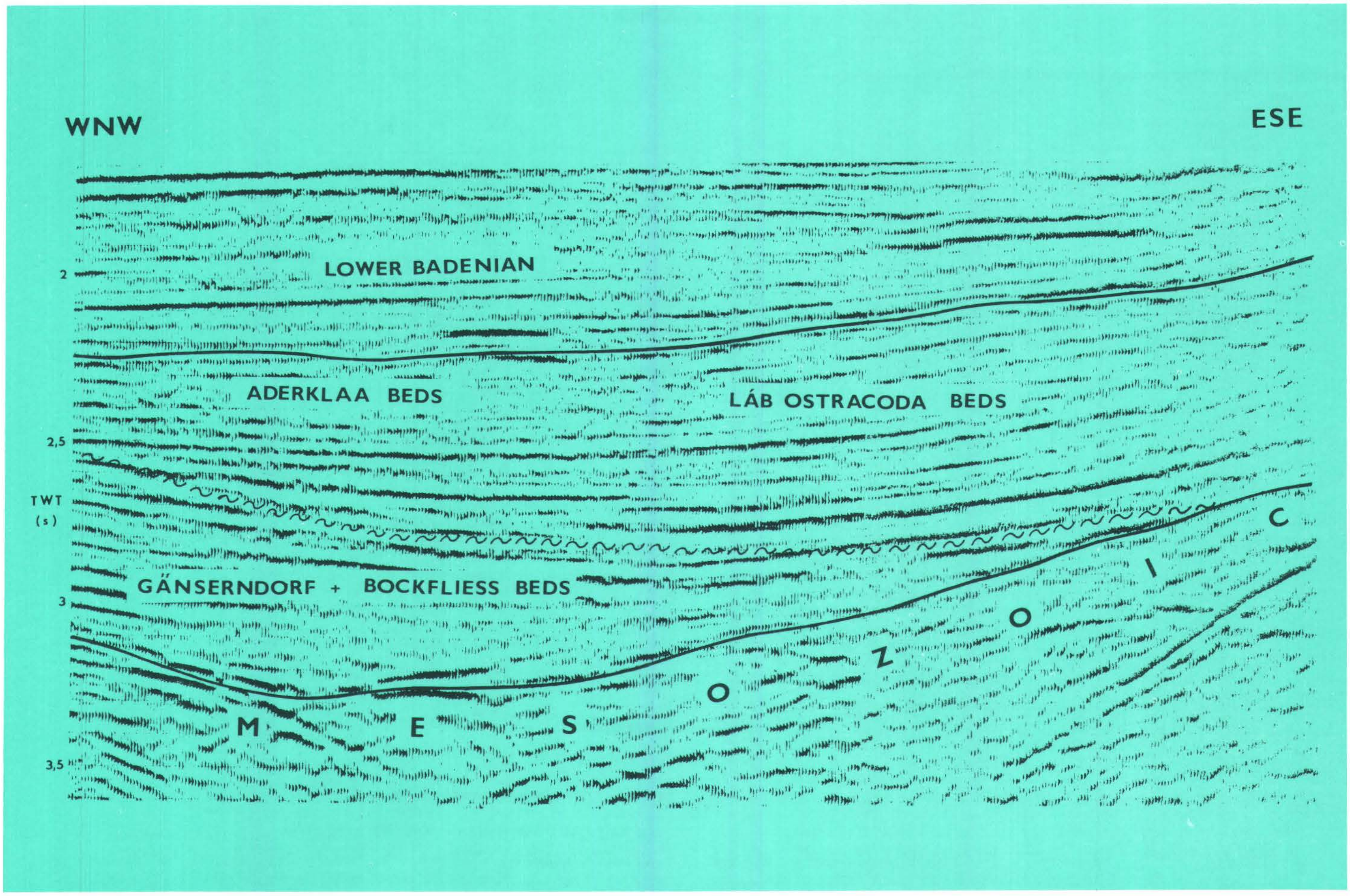


Fig. 8: A section of the seismic line No. 539/81 showing the discordant contact of the Aderklaa + Láb Ostracoda beds with Gänserndorf beds. Wave line = unconformity.

of cycle 3, but it is present in the higher-lying slopes and elevation tops with a 300 m thick sand-and-clay complex comprising the Upper Karpatian Variegated Beds.

Cycle 3

This cycle corresponds to cycle 1 which is completely and clearly developed throughout the region investigated. The transgressive wedge base consists of fluvial conglomerates equivalent to the Aderklaa conglomerate from the Austrian part of the Vienna Basin. They are overlain by thick layers of sandy sediments of deltaic origin that can also be attributed to the wedge base. In the Láb and Malacky elevation zones, the wedge base is reduced to the presence of transgressive marine sand termed the Láb horizon. In all of the region the wedge middle consists of marine pelites of the Agglutinantia zone, an equivalent to the Sandschaler ozone in the Austrian portion of the basin. The regressive top is composed of sand layers of the Upper Badenian Rotalia zone.

The development of the Upper Miocene can be considered to constitute a separate cycle (cycle 4 of N. Kreutzer), or this sequence can be regarded as the upper regressive part of a multiple wedge (D. A. White, 1980) whose transgressive part is formed by the sedimentation of cycle 3. One of the reasons supporting this view is the fact that, beginning with the terminal part of the Upper Badenian, the flattening and freshening of the sea continued until its complete regression.

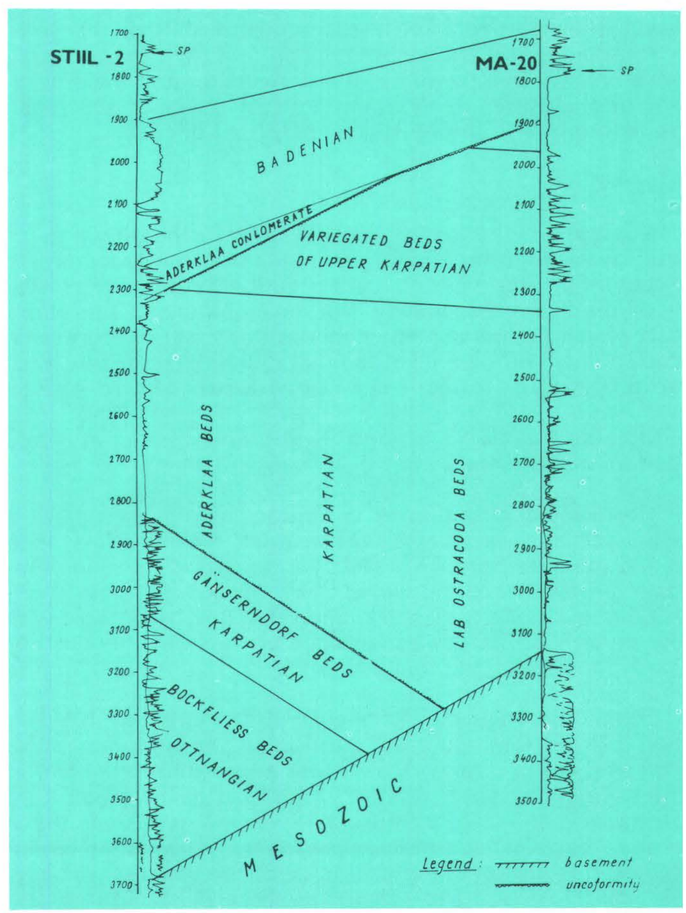


Fig. 9: Correlation profile of the boreholes Malacky-20 and Stillfried-2. ▶

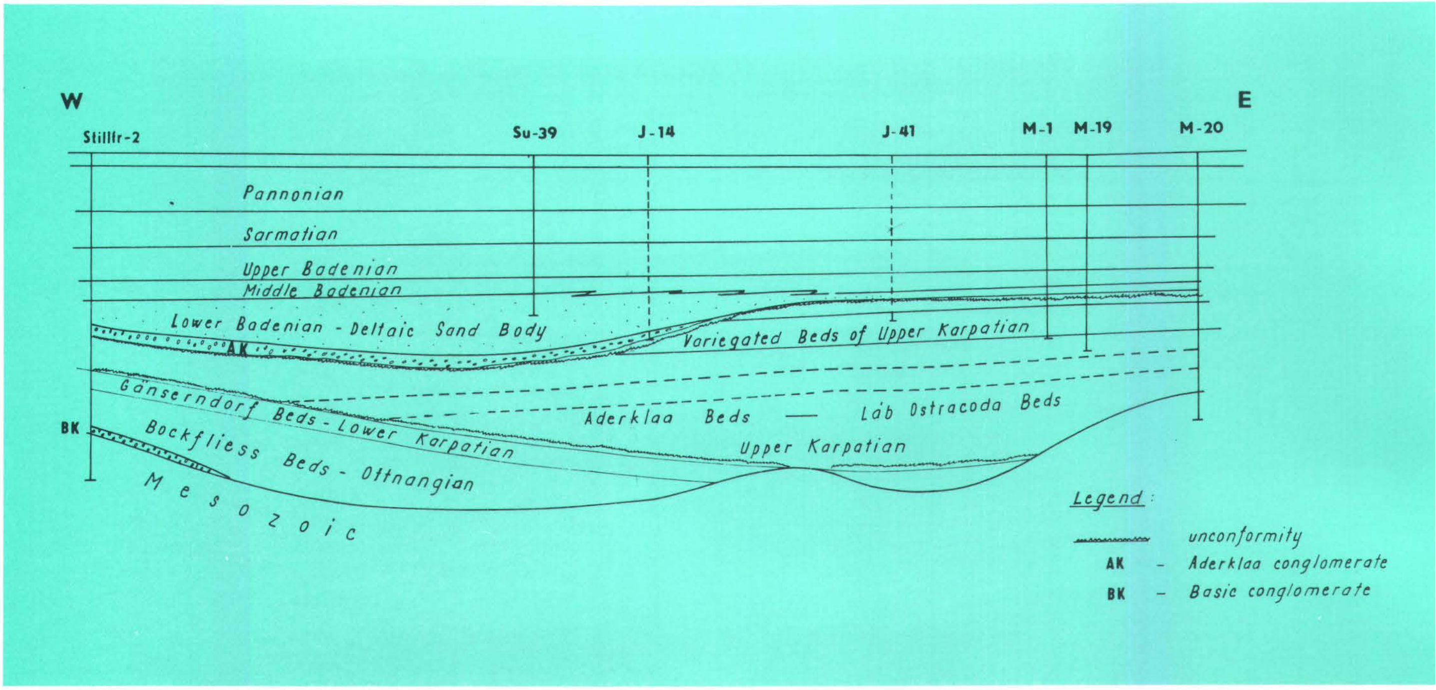


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Fig. 10: Geological profile between the boreholes Malacky-20 and Stillfried-2

In consequence, the development of the Vienna Basin as a whole can be characterized by the following three evolutional stages:

Stage 1

This stage includes the Lower Miocene, i. e. cycles 1 and 2 in the sense of the division by N. Kreutzer. This period is characterized by dynamic basin development and continuous changes in the shape and extent of the sedimentary basin. Basin growth and the southward shift of the sedimentation centre are accompanying features. This stage of development culminated in a full inversion and the formation of a new area of sedimentation the shape of which can be recognized in the Middle and Upper Miocene.

Stage 2

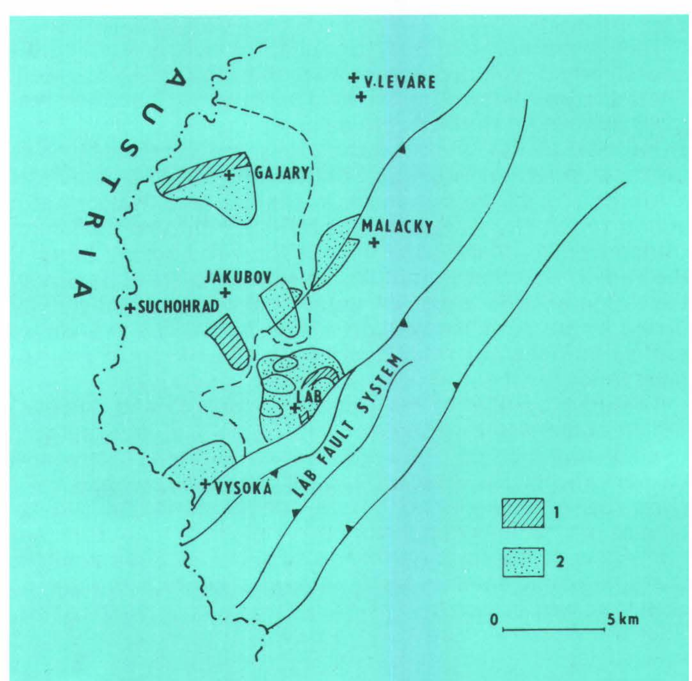
A Badenian sequence (cycle 3) covered the new area of sedimentation after a long-lasting hiatus. The Badenian sedimentation was a certain consolidation period in the history of the basin. Essentially, the development of the upper part of this Badenian sequence was the onset of regression that, jointly with sea level fluctuations, characterized **stage 3 until the complete regression of the sea.**

Lithologic Development and Stratigraphic Division of the Badenian Sequence

The Badenian sequence is composed of a complex of sand and clay sediments whose total thickness has been found to range from 400—600 m in the elevation zones. Seismic profiles have suggested this thickness to attain about 2,000 m in the Gajary central deep (fig. 6). The contact with the underlying Karpatian is unconformable; in the Suchohrad depression this unconformity is of erosional nature (fig. 10).

Three lithologic units identical with the stratigraphic division can be distinguished throughout the sequence. The first of them is a sandy facies with a conglomerate layer at the base. Its extent is related to the lows of the Suchohrad depression and Gajary central deep to their flanks. In these zones, the thickness may exceed 600 m. Abundant Cibicides faunas were identified in clay bands in the drill cores (R. Jiříček, 1979). The whole complex is thought to be a product of deltaic sedimentation. On the basis of his sedimentological studies, N. Kreutzer has reached the same conclusion. The unit has stratigraphically been classed as Lower Badenian with the exception of the terminal part which can be placed into the Middle Badenian. The entire sequence is associated with an erosion valley by the major part of its thickness (fig. 10).

Fig. 11: Location of the Badenian oil and gas deposits in the southern part of the Vienna Basin.
1 — oil deposits; 2 — gas deposits.
▼



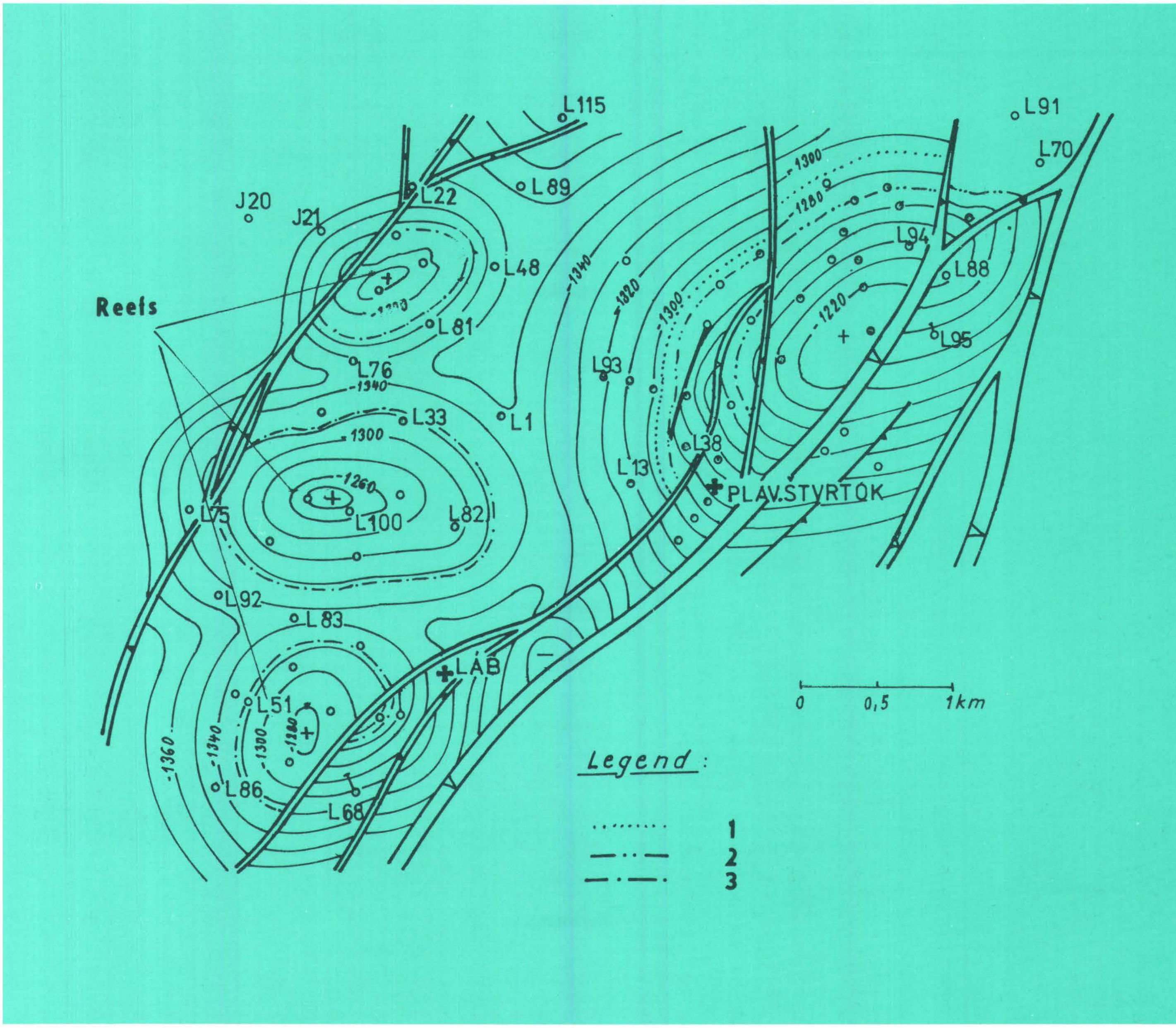


Fig. 12: Oil and gas-bearing deposits Láb. A map reflecting the geological structure of the Láb horizon (eastern part) and the surface of the lithothamnion rifts (western part).
1 — contact of oil and water; 2 — contact of oil and gas; 3 — contact of gas and water (after Bílek and Hlavatý).

The second lithologic unit consists of a pelitic zone replacing marine sedimentation characterized by deep-sea faunas — Cyclamina pleschakovi and Bathysiphon filiformis (R. Jiříček 1979). The beds have been known as the „Agglutinantia zone", they are distributed throughout the basin maintaning their constant thickness which varies in the range from 220—240 m in the southern part of the basin. This sequence was the sealing element during the formatin of oil and gas traps. Associated with this zone are three domal bioherms developed in the beds overlying the transgressive Láb horizon on the western slope of the Láb elevation (fig. 11,12).

The third unit is composed of a sand and clay sequence of a relatively constant thickness of 350—380 m. With regard to the faunas present and lithological differences, this sequence can be divided into a loweer level with pelites predominating over sands (Bolivina-Bulimina zone) and an upper level with prevailing sands. The latter level is characterized by Rotalia faunas and combines with deltaic sedimentation in the western part. The distribution and the shapes of some horizons display the properties of channel fill in delta systems.

Tectonic setting

From the viewpoint of fault tectonics, the southern part of the basin can be divided into a tectonized eastern section represented by the Láb and Malacky elevations and a tectonically undisturbed western section comprising mainly the depression zones and the lower-lying parts of the slopes of the elevations mentioned above. The principal tectonic feature of the whole region is represented by the Láb fault system that disturbs the eastern slopes of the Láb and Malacky elevations (fig. 11,12). It consists of two main faults with vertical throws of 200 and 100 m, respectively. These principal fault lines are related to a greater number of disturbances with which several deposits on the above elevations are associated.

This fault system is striking from the northeast to the southwest in parallel to the Lesser Carpathians. Together with the Litava reverse marginal fault it forms a distinct tectonic graben system — the Zohor-Plavec graben. The faults are of Upper Miocene age.

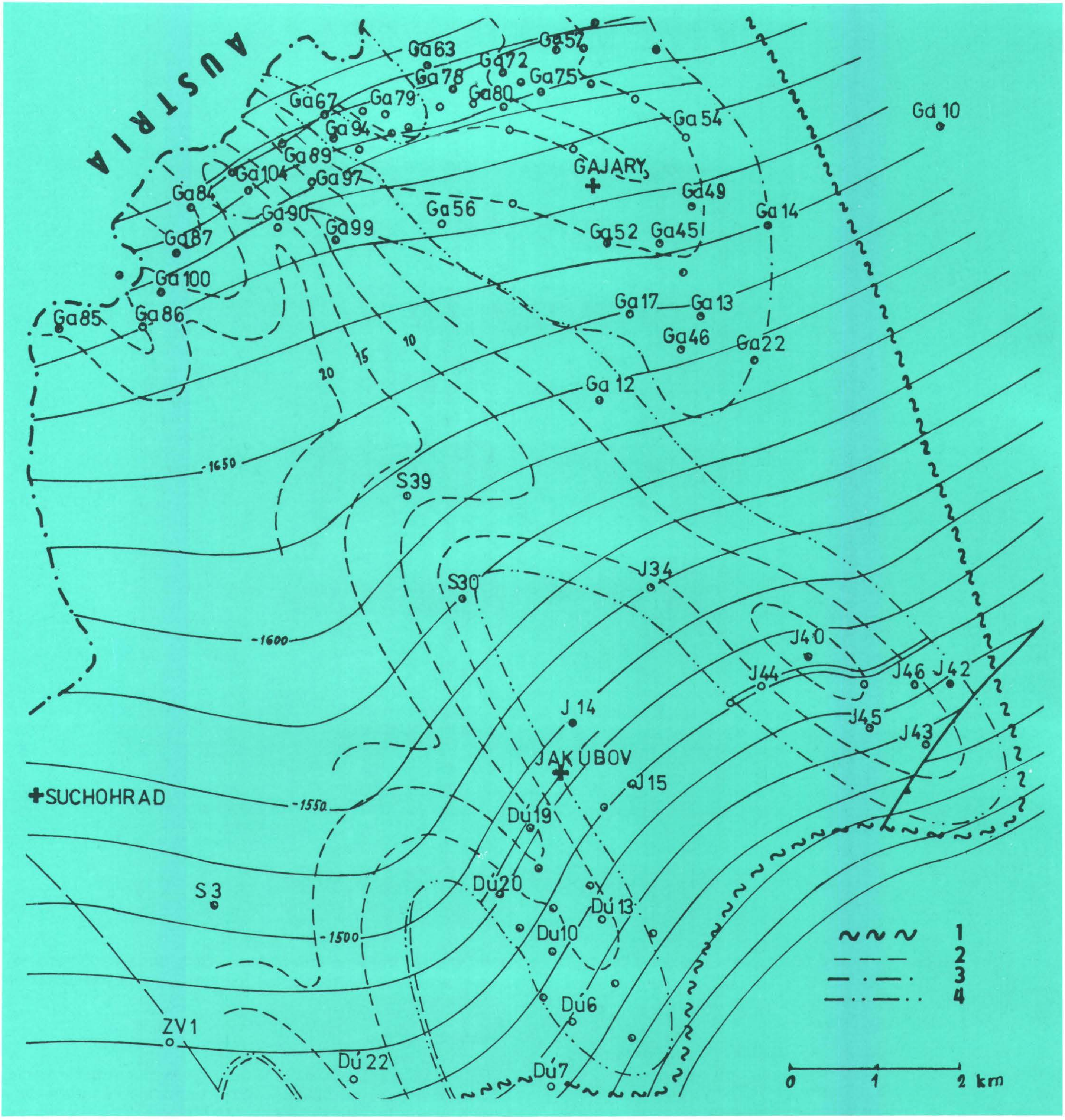


Fig. 13: Oil and gas deposits connected with terminal part of the deltaic sand body (after Hlavatý, Ralbovský, Šalyová).
1 — boundary of deltaic body; 2 — isolines of thickness; 3 — boundary of extension of the first sand; 4 — boundary of extension of the second sand.

Types of oil and gas traps in the Badenian sequence

The unconformable contact with the underlying Lower Miocene and the regional distribution of the sand base of the Badenian sequence provided advantageous conditions allowing the basal part of the sequence to act as a reservoir rock sequence. Another favourable element is the pelitic „Agglutinantia zone" that overlies the basal sand beds. By its regional extent, this zone acts as a seal for the whole basin. The terminal parts of the deltaic sandy body, developed as delta fronts to prodelta, played an essential role in the formation of Badenian oil and gas deposits.

In the course of exploration drilling several types of deposits were discovered in the southern part of the Vienna Basin.

The following deposits are considered to be of particular interest:

Láb and Malacky deposits:

Both deposits are associated with high-lying levels of the Láb and Malacky elevations. The individual reservoir sands are sealed by the faults of the Láb fault system (fig. 12).

Bioherms of the Láb deposit:

They have formed on the western slope of the Láb elevation, in a plece where the Láb horizon forms a relatively wide platform. They constitute three plug domes the largest of which is 3 km long in its axis. Superelevation attains 100 m. The plugs consist of Lithothamnia limestones with favourable physical properties and with gas accumulated in them. They are hydrodynamically realted to the Láb horizon (fig. 12).

Gajary, Jakubov, Dúbrava deposits:

The three deposits are associated with wedging-out sandy tongues of the deltaic sedimentary body. The sand tongues are considered to be the channel fill of the channel system in the delta. The Gajary deposit is a gas-capped oil deposit, Jakubov is a natural gas deposit and oil has accumulated in the Dúbrava deposit (fig. 13).

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Abstrakt

Na podklade hojných údajov vrtného prieskumu, doplnených seizmickými profilmi, je možné v miocénnej výplni viedenskej panvy v oblasti Matzen rozlíšiť 4 transgresívno-regresívne faciálne cykly. S určitými odchýlkami v spodnom miocéne možno toto členenie uplatniť i v južnej časti panvy na čs. území, ktorá tvorí protiľahlý svah rakúskej strednej časti panvy. Rozdiely oboch svahov v úložných pomeroch a litologickom členení jednotlivých súvrství boli spôsobené rôznymi hodnotami subsidencie a vlivom deltovej sedimentácie. Hlavné tektonické línie porušujú oba svahy len vo vyšších polohách.

Súvrstvie bádenu je v oboch častiach panvy najbohatšie na akumulácie ropy a zemného plynu.

Zusammenfassung

Die miozäne Beckenfüllung kann im Feld Matzen in verschiedene geologische Einheiten gegliedert werden, die meist Ablagerungssequenzen sowie transgressiv-regressiven Fazies-Zyklus-Keilen entsprechen. Ein solcher Keil stellt im Idealfall einen transgressiv-regressiven Ablagerungszyklus dar, der von unten nach oben eine vertikale Faziesfolge von grobkörnigen kontinentalen über grob-, fein- und wieder grobkörnige marine zu erneut kontinentalen Schichten umfaßt. Im Feld Matzen können vier Sand-Ton-Zyklus-Keile erkannt werden: 1. Zyklus — Bockfließer Schichten, 2. Zyklus — Gänserndorfer und Aderklaaer Schichten, 3. Zyklus — Badener Serie (einschließlich Aderklaaer Konglomerat), 4. Zyklus — Sarmat, Pannon und Pont.

Da sich Ablagerungssequenzen durch die Geometrie ihrer Schichtflächen unterscheiden, mußte die Badener Serie des zentralen Wiener Beckens in zwei völlig verschiedene geologische Einheiten oder Ablagerungssequenzen unterteilt werden, eine untere, transgressive Einheit oder Sequenz des unteren Badens und eine obere, abwechselnd regressiv-transgressive Einheit oder Sequenz des oberen Badens.

Die strukturelle Entwicklung der miozänen Beckenfüllung des Feldes Matzen wird vorherrschend durch die differenzierte Absenkung des Beckenuntergrundes, des Spannberger Flyschrückens im Norden und des kalkalpinen Rückens im Süden, bestimmt. Die S-Konvergenz von Leithorizonten in den oberen Bockfließer Schichten, im oberen Baden, Sarmat und Pannon läßt auf eine geringere Absenkungstendenz der Kalkalpen, die N-Konvergenz innerhalb der Gänserndorfer Schichten, des Aderklaaer Konglomerates und bis ins obere Baden auf eine geringere Absenkung des Flyschrükkens schließen. Die ziemlich konkordanten Leithorizonte der dazwischen liegenden Intervalle weisen auf eine gleichmäßige Absenkung in den unteren Bockfließer Schichten, den Aderklaaer Schichten und dem oberen Baden hin.

Im Feld Matzen sind drei genetisch unabhängige Bruchsysteme in der miozänen Beckenfüllung erkennbar:

1) Das N-S-streichende postsedimentäre Schönkirchner Bruchsystem im Süden des Feldes, nach der Sedimentation der Aderklaaer Schichten

und vor jener des Badens wirksam.
2) Das N-S-streichende und W-fallende synsedimentäre Bockfließer Bruchsystem am W-Rand des Feldes mit zwei Aktivitätsphasen.
3) Das SW—NO streichende postsedimentäre Matzner Bruchsystem im N des Feldes, aus NW- und SO-fallenden Brüchen bestehend, nach dem Pannon entstanden.

ADDITION TO STRATIGRAPHY OF BORINKA LIMESTONE IN THE HAINBURG MOUNTAINS

Anna Kullmanová, Geologický ústav Dionýza Štúra, Bratislava, Czechoslovakia

The Borinka limestone is considered as a lithostratigraphic unit characteristic of the Malé Karpaty Mts. with stratigraphic assignment to the Liassic.

It is found in the SW and S part of the Malé Karpaty Mts. where it represents the Tatric unit. The most extensive occurrence of the Borinka limestone is observed in the area of the village Borinka (Propadlé valley) and continues in SW direction to the southernmost spur of the Malé Karpaty Mts. The Hainburg Mts. on Austrian territory are prevailingly built up of carbonates of Middle Triassic age. The lithological character of Middle Triassic carbonates occurring here is identical with carbonates found in the area of the villages Devín and Borinka in the underlier of the Borinka limestone. The carbonates found here have stratigraphic assignment to the Triassic.

The rock filling and stratigraphic assignment of the Borinka limestone changed in the course of several decades. Under the term Borinka limestone various lithological types of limestones were included (grey limestones, dolomitic limestones, laminated limestones of brecciated texture, organodetrical limestones) with assignment to Triassic — Liassic age. The works of M. Maheľ (1986), D. Plašienka (1987), M. Mišík (1986) and A. Kullmanová (1971, 1988) have contributed to solution of the problem of age of the Borinka limestone. D. Plašienka (1987) designates with the name Borinka unit the complex of Mesozoic sedimentary rocks of the Tatric unit in the Malé Karpaty Mts. According to this author the term Borinka unit represents a lithostratigraphic as well as tectonic unit. On the contrary, A. Kullmanová (1988) redefines the lithostratigraphic unit with the name Borinka limestone. On the basis of the results of lithological investigation the Borinka limestone contains thick-layered clastic, mostly organoclastic limestones with the stratigraphic range Lotharingian — Carixian. The macrofauna (lamellibranchs, brachiopods and belemnites) was studied at the locality Borinka (road cut of the Propadlé valley) and at the locality in the village Devín (castle rock and SW slope of elev. p. Devínska Kobyla).

The superposition relations of the Borinka limestone to the underlier and overlier were pursued in surficial outcrops and boreholes. In the underlier of the Borinka limestone dark — grey compact limestones, dolomitic limestones often with quartz spherolithes — Gutenstein limestones, grey dolomites and dolomitic limestones of brecciated texture are found. Stratigraphic assignment of the mentioned carbonates to the Middle Triassic is proved by algae (outcrop S slope of Devínska Kobyla) and foraminifers (Propadlé valley, outcrop 70 A).

At the outcrop in the Propadlé valley in the overlier of the Borinka limestone grey marly shales, sandstones — the Korenec formation (D. Plašienka, 1987) or Somár breccias are found. In the area of the village Devín, in the overlier of the Borinka limestone, grey marly shales with belemnites are found (railway cut Devínska Nová Ves).

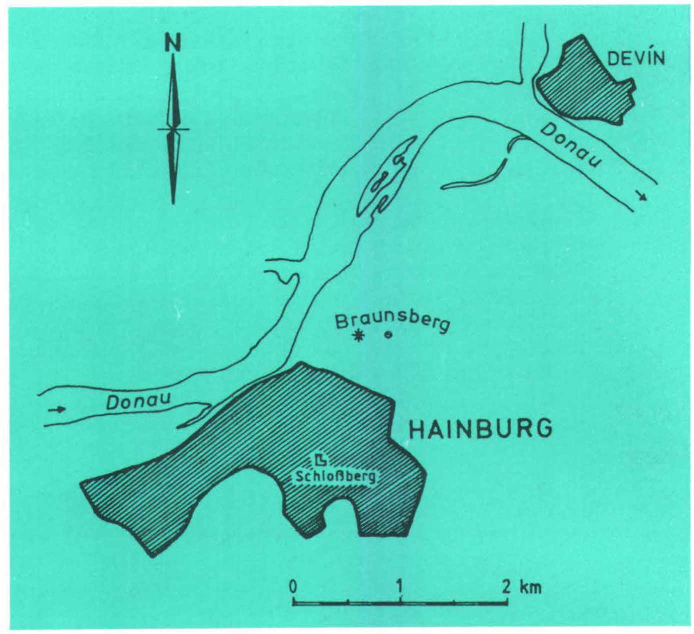

Fig. 1: Schematic situation of occurrence of belemnites at the locality of Braunsberg.

* Belemnite occurrences.

The Hainburg Mts. on Austrian territory are prevailingly built up of dark-grey micrite limestones, dolomitic limestones of brecciated texture and grey fine-grained organodetrical limestones. The Austrian geologists designate the above mentioned lithofacies with the term Borinka limestone. The organoclasts present in limestones in the Hainburg Mts. are represented by determinable crinoids, which enable to stratify the investigated rocks into the Middle Triassic, Anisian (Kristan-Tollmann-Spendlingwimmer, 1987). On our territory we observe identical rocks in the Propadlé valley (borehole 70 A) rock below castle ruins). The rocks studied at the mentioned locallity are of Middle Triassic age. In micrite matter Trochammina almtalensis Koehn-Zaninetti; Diplotremmina sp., Glomospira sp., Agathammina austroalpina Kristan-Tollmann, Meandrospira sp. are present. Similarly the southern and southwestern slope of Devínska Kobyla is bult up of the mentioned lithofacies. The present Dasycladacea sp. and Physoporella disita (Gümbel) enable to stratify the investigated carbonates as Anisisan (M. Mišík 1986).

Fig. 2: Belemnites from joint filling, western slope of Braunsberg.