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Abstrakt

Pyrenejské horotvorné pohyby sjednotily sedimentační prostory v severní části tethydní oblasti, která byla pod vlivem globální fáze chladného klimatu. Na území Českého masívu a Západních Karpat se v oligocénu neuplatnily regionální vlivy.

Nástup teplotního optima v mořském režimu, pozorovatelný od burdigalu do staršího serravallu ve světovém oceánu, můžeme korelovat s teplotním optimem eggenburg—střední baden v Záp. Karpatech. Regionální vliv sávských a štýrských horotvorných pohybů v alpsko-karpatské oblasti dokládá vztah velkých miocenních transgresí a jejich klimatických optim.

Na rozdíl od výrazného ochlazení světového oceánu v mladším serravallu, trvajícího do staršího tortonu, sledujeme v pánvích Západních Karpat od středního badenu do panonu jen postupné ochlazování, bez výrazných teplotních rozhraní.

Důsledkem horotvorných pohybů v Západních Karpatech byly: anoxický režim oligocenních pánví po doznění pyrenejských pohybů, brachyhalinní režim rzehakiového moře v ottnangu po doznění sávských horotvorných pohybů a nástup brachyhalinního režimu sarmatských sedimentačních prostorů po ukončení štýrských horotvorných pohybů.

V eggenburgu se ještě klimatický režim čela orogénu neliší od jeho týlových částí. S nástupem štýrských horotvorných pohybů v karpatu začíná S-J zonace, která je už v badenu velmi výrazná.

Zusammenfassung

Durch die pyrenäischen gebirgsbildenden Bewegungen wurden Sedimentationsräume im Nordteil der Tethys vereinigt, die von einer globalen kalten Klimaperiode beeinflußt wurden. Im Bereich der Böhmischen Masse und der Westkarpaten kamen im Oligozän keine regionalen Einflüsse zum Vorschein.

Der Beginn des Temperaturoptimums im marinen Regime, das vom Burdigal bis zum älteren Serravall im Weltozean zu beobachten ist, kann mit dem Temperaturoptimum vom Eggenburg bis zum mittleren Baden in den Westkarpaten korreliert werden. Der regionale Einfluß der savischen und steirischen gebirgsbildenden Bewegungen im Alpen-Karpaten-Bereich wird durch die Beziehung großer miozäner Transgressionen zu den Klimaoptima bezeugt.

Zum Unterschied von einer ausgeprägten Erkaltung des Weltozeans im jüngeren Serravall, die bis zum älteren Torton andauerte, ist in den westkarpatischen Becken vom mittleren Baden bis zum Pannon nur eine allmähliche Erkaltung, ohne einen ausgeprägten Temperaturwechsel, zu verzeichnen.

Die gebirgsbildenden Bewegungen in den Westkarpaten hatten ein sauerstoffarmes Regime in den Oligozänbecken nach dem Abklingen der pyrenäischen Bewegungen, ein brachyhalines Regime im Rzehakia-Meer im Ottnang nach dem Abklingen der savischen Bewegungen und den Beginn eines brachyhalinen Regimes in den sarmatischen Sedimentationsräumen nach dem Abschluß der steirischen Bewegungen zur Folge.

Im Eggenburg unterschied sich das Klimaregime der Orogenfront noch nicht von dem der Rückteile des Orogens. Mit dem Beginn der steirischen gebirgsbildenden Bewegungen im Karpat begann eine nördlich-südliche Zonenanordnung, die im Baden bereits sehr ausgeprägt war.

THE AUTOCHTHONOUS MESOZOIC ON THE EASTERN FLANK OF THE BOHEMIAN MASSIF — AN OBJECT OF MUTUAL GEOLOGICAL EFFORTS BETWEEN AUSTRIA AND ČSSR

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Introduction

The exploration of the Autochthonous Mesozoic along the Eastern flank of the Bohemian Massif led to contacts between ÖMV and ÚÚG Praha and later MND Hodonín as well as Geofyzika Brno in order to investigate the stratigraphy, paleogeography and structure of this geological unit, which was unknown until the early sixties.

It became evident soon, that the encountered Pretertiary deposits on both sides of the state boundaries belong to the same basin and form nearly the same vertical and horizontal sequences. The industrial results of the exploration in the basement of the foredeep and of the frontal part of the Alpine-Carpatian nappes are manifested by the discoveries of Dolní Dunajovice, Pottenhofen, Roseldorf, Höflein etc. Up to this activity only the outer, western part of an area prospective for hydrocarbons has been explored. There is to be expected, that in case of more apt economical situation for the future the exploration will advance into deeper positions, where larger accumulations of hydrocarbons may be possible because of more favourable maturity conditions of a very potential source rock.

The results of deep wells in the Carpathian frontal areas (for example Němčičky 1, Sedlec 1, Falkenstein 1) as well as in underground of the Vienna basin (Zistersdorf ÜT2, Maustrenk ÜT1, Aderklaa ÜT1) give evidence of the importance of a further cooperation.

1. History of exploration and investigation

Before the Autochthonous Mesozoic was explored by wells indications of a Jurassic-Cretaceous basin on the southeastern flank of the Bohemian Massif already existed in form of Jurassic carbonates in the vicinity of Brno (Eliáš 1962) and of klippen tectonically shorn off from this basin

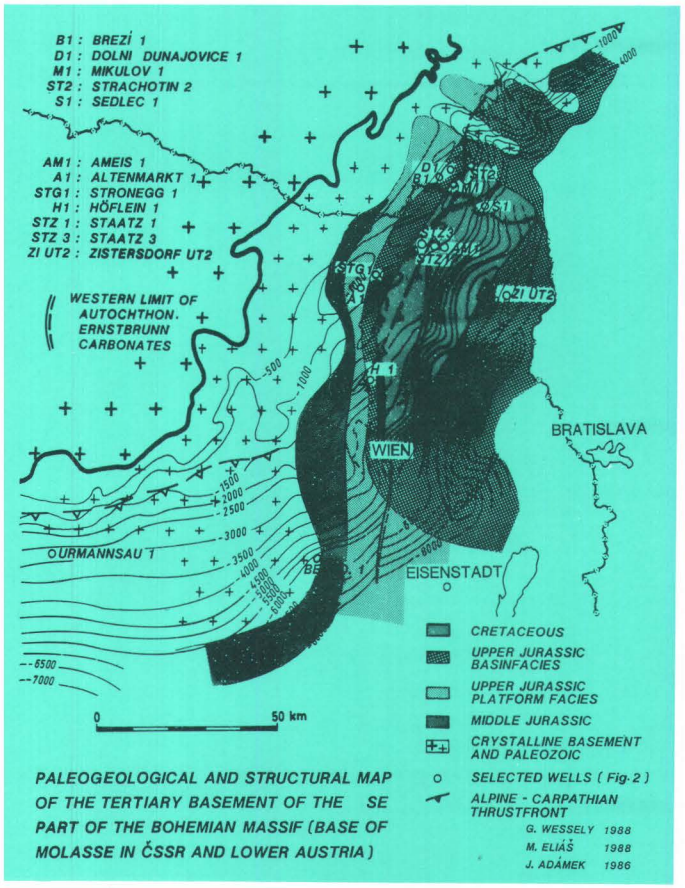


Fig. 1.

by the Carpathian external nappes. These klippen consist of Klentnitz beds (Abel 1899, Jüttner 1933), Ernstbrunn limestones (Boué 1829) and Klement beds (Glaessner 1931).

The carbonate platform of this basin was encountered in continuation of the Brno Jurassic in the fourties and early fifties (Pasohlávky 1, Novosedly 1, Hrušovany 1). But these wells documented only partial sections of the platform facies.

The first step of major importance for the knowledge of the Autochthonous Mesozoic sedimentary cover of the Bohemian Massif was made 1959 by the well Staatz 1, which exposed a continuous sequence of upper Cretaceous, Malmian in a thick mainly pelitic basin development and Dogger with its delta sediments (G. Wessely 1988). A whole series of wells in Austria and ČSSR were necessary until the extension, vertical sequences, facial distributions and thicknesses of this sedimentary basin could be established (fig.1,2).

A new dimension arose in exploring the Pretertiary basement of the Molasse below the Carpathian external zone and finally in the deepest underground section of the Vienna basin.

The step downwards into this deepest autochthonous etage of the Vienna basin was done by the wells Zistersdorf ÜT1a, ÜT2A, Maustrenk ÜT1a and Aderklaa ÜT1a in the period of 1977—1987. Depths from 6560—8553 m were reached (G. Wessely 1984, 1988).

The geological result of this deep exploration gave an important contribution to the reconstruction of the Western Carpathian-Eastern Alpine belt. The continuation and enlarging subsidence of these Mesozoic layers far towards the East were confirmed (fig.1). By following the Autochthonous Mesozoic towards the South under the Eastern Alps, the well Mauerbach 1 was drilled and finally the gas-condensate field Höflein was discovered.

In the ČSSR the exploration activity in Dolní Dunajovice, Nové Mlýny, Sedlec, Němčičky and Uhřice brought a substantial contribution to the knowledge of Autochthonous Mesozoic in northern and northeastern direction.

The history of investigation may be divided in several phases. At the beginning ideas of the stratigraphic identifications and subdvisions were developed separately in Austria (J. Kapounek, A. Kröll, A. Papp, K. Turnovsky 1967) and ČSSR (Eliáš 1971).

An intensification of exchange of experiences began with a meeting of experts in May 1971 in Bratislava. For this meeting new stratigraphic concepts had been prepared on the base of cores, cutting strips and logs. An agreement was found concerning lithostratigraphy and diverging opinions of Austrian and ČSSR paleontologists about the age of the Malmian basin marls (the former was located by ÖMV into the Lower Cretaceous on the base of foraminifera).

A series of meetings of the competent specialists of ÖMV and ÚÚG-Praha brought a final correlation of all lithostratigraphic units. The paleontologic criteria were ammonites, defined by Z. Vašiček (ČSSR) and L. Krystyn (Austria). Beside these macrofossils, pollen and nannofossils brought a useful support for the correlation. Documentations of microfacies were completed especially by the ČSSR side and led to the establishment of a series of formations in the Dogger and Malmian (Eliáš 1977).

In order to keep open the possibility of differentiation and typifying facial variations in the stratigraphic sections a neutral lithological nomenclature was further used in Austria (G. Wessely in F. Brix et al. 1977). Classical terms were taken as comprehensive definitions.

A complete compilation and comparision of all terms, separated for all facial complexes was made by J. Adámek, 1986. Later the attention for further investigations in the autochthonous basement of the Molasse has been shifted to structural and paleogeographic questions in connection with the exploration for hydrocarbons and therefore the cooperation took place between ÖMV and MND Hodonín as well as Geofyzika Brno. Structural maps, seismic sections and well-logs were compared. New results as well as core material of deep wells were always exchanged and led to a uniform picture necessary as starting point for further exploration.

2. Recent stage of investigation in stratigraphy and facies

The data obtained by wells in both countries enabled to point out a general picture of the Autochthonous Mesozoic complex (figs. 2,3).

Upon the Hercynian basement (Devonian-Lower Carboniferous and partly Permo-Carboniferous sediments) rests unconformably a deltaic series of Dogger sediments, subsumed by the superior term „Gresten beds". The full facial variety in different tectonical settings influencing the thickness and lithology is clearly visible in the Austrian territory. Facies depends on the one hand on the position within the deltaic complex, on the other hand on the position within a synsedimentary tilted fault block system. In the subsided parts of the fault blocks large thicknesses (up to 1000 m) are observed in contrary to reduced thicknesses on elevated positions (about 100 m). The subdivisions of lithological groups, environments, directions of sedimentation etc. are object of a recent study. Until its result the term „Gresten group" should be used. The basal transgressive member „Untere Quarzarenitserie" consists of ?Aalenian arkoses, quartz-arenites containing intercalations of coaly shales and coals. Traces of roots point to a sedimentation in a continental part of the delta system. In prodeltaic positions and in areas of larger subsidence an intercalation of Bajocian dark shales appears („Untere Tonsteinserie"). It seperates the lower continental from a marine deltaic series of sandstones with shaly intercalations, the „Obere Quarzarenitserie" relating to the Upper Bajocian. The deltaic sequence is finally overlain by a further prodeltaic horizon of shales, the „Obere Tonsteinserie" of Bathonian age. In littoral positions the shales are replaced by glauconitic or

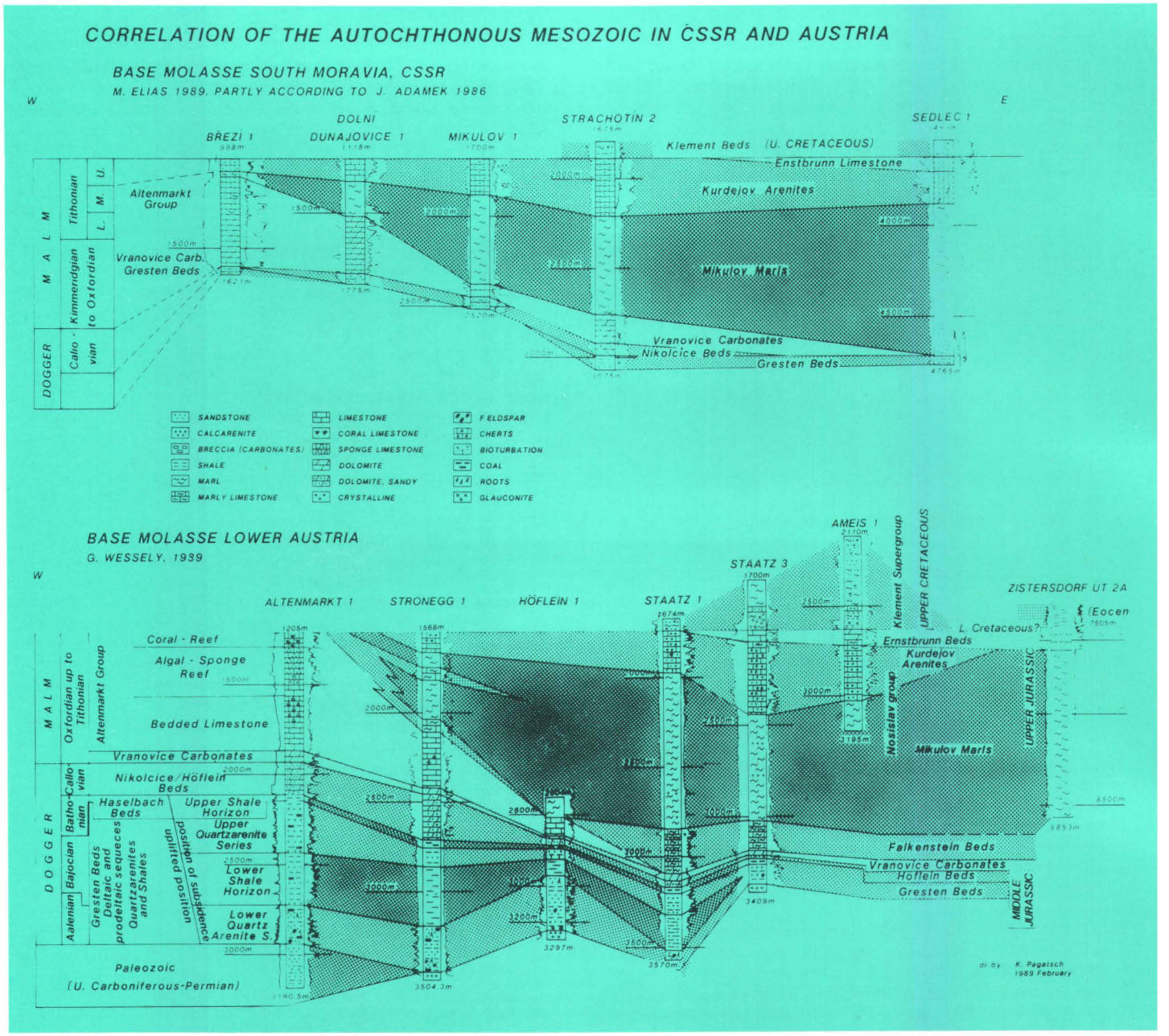


Fig. 2.

phosphorite bearing sandy beds (Haselbach, Höflein). These will find its nomenclatoric consequences in near future. A correlation to equivalent sediments in CSSR is to be found. In that context, after Adámek, 1986, the relevance of the term „Diváky beds" and „Bořetice beds" established 1971 by M. Eliáš, should be revised. Bořetice beds are proofed to be Lower Carboniferous according to the finds of trilobites.

In Callovian time starts a new and unique cycle (as a result of the global eustatic cycle). It is marked by unconformable superpositions on former tectonics and even sediments. The basal beds of this cycle are characterized by a beginning carbonatic influence of the extinguishing terrigenous sedimentation and are well defined by the term „Nikolčice beds" in ČSSR, in Austria represented by „Dolomitische Quarzarenitserie". Thickness range between 70—300 m. A facies differentiation of these deposits was described by Eliáš (1981). Obviously the specific development of Höflein (R. Sauer, 1984) requires an additional definition.

The Malmian complex of sedimentation is generally to be divided into an area of a throughgoing marginal carbonatic platform in the west and an area of mainly basinal development in the east, only near the bottom and on top replaced by platform carbonates and wedges of carbonate clastics.

Before the facial division takes place in Oxfordian time an overall carbonatic, mostly dolomitized member covers the Nikolčice beds in a restricted thickness towards east (some tens of meters). It is well defined with the term „Vranovice beds" corresponding to „Untere Karbonatserie" in Austria.

The starting carbonate platform on top of these lower carbonates in the western marginal area was first investigated and documented as a continuous series by W. Ladwein, 1976 („Altenmarkt beds"). The 750 m thick sequence begins with bedded limestones partly cherty, upwards grading into bioclastic limestones. These are overlain by algal-sponge-and finally coral patch-reefs. Laterally reef complexes may be replaced by oolitic-bioclastic series. The large facial variety within the platform complex may result in different local formations as „Pasohlávky limestones", „Novosedly" and „Hrušovany" limestones and dolomites, „Ivaň"-beds and presumable further more.

The carbonate facies is fringed basinward by 150 m, max.

400 m thick marly limestones („Mergelkalkserie") with an upwards rising marly content and with intercalated slope clastics. The age of this member is running through the whole Malmian stages according to its updip replacement of successive older and younger sediments. According to lithology and logshape it is clear to be identified and it is proposed to separate it from the proper basin facies by a new formation name — „Falkenstein formation".

The basinal development of the Malm is represented by dark marls, which laterally replace the platform facies respectively its slope deposits. The age of these marls is Kimmeridge (in ČSSR Oxford) to lower Tithonian. The member in Austria called „Mergelsteinserie" is well defined by the formation term „Mikulov marls". Their thickness, often tectonically enlarged by duplications ranges at 500 m and exceeds in some cases 1000 m.

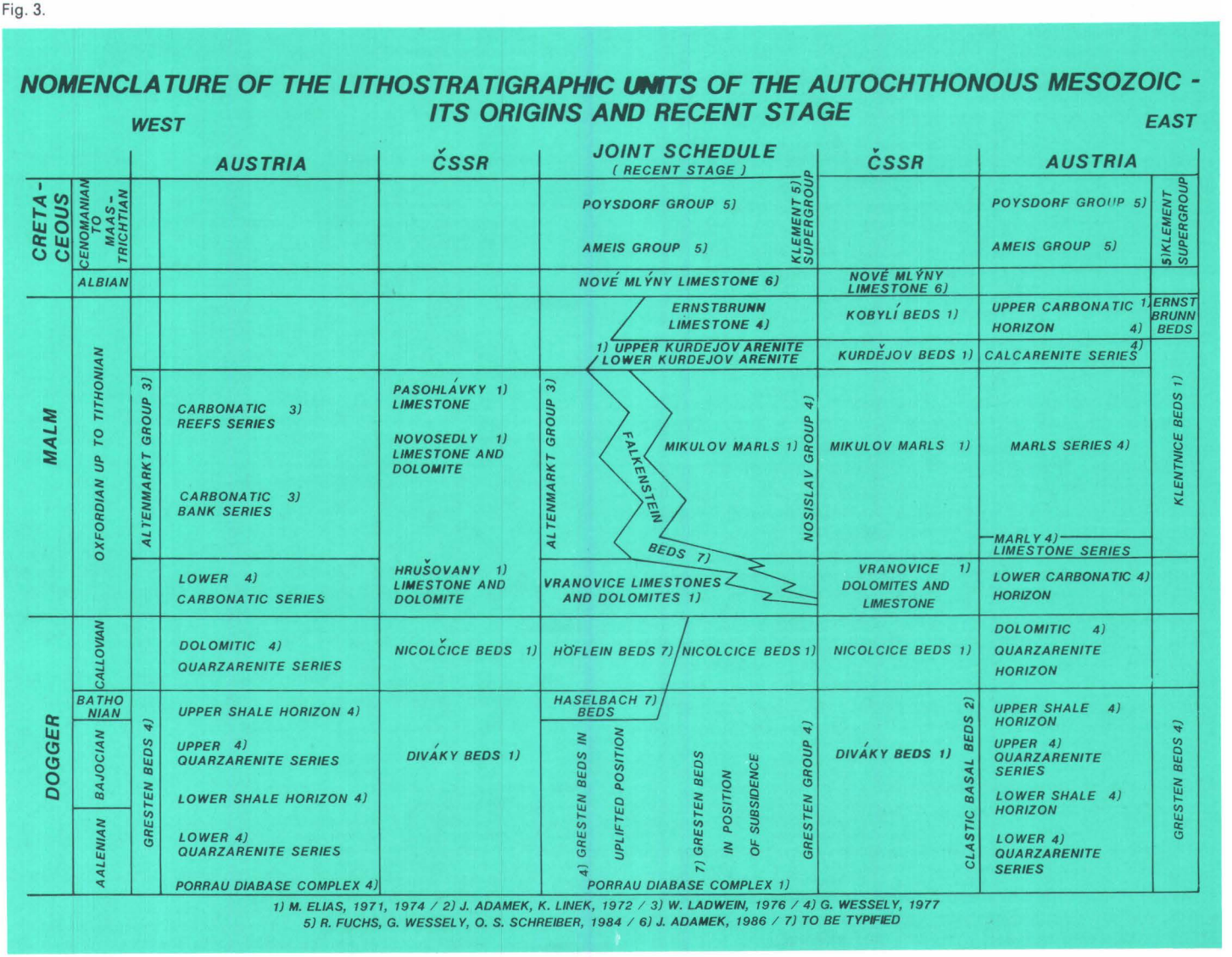
During the Upper Tithonian the basin got shallower again manifested by a basinward progradation of upward coarsening terrigenous and bioclastic carbonates. These up to 400 m thick, generally dark deposits developed by an upward transition from the Mikulov marls and show in some portions further marly influence. According to its detrital character these sediments were defined as „Kalkarenitserie" in Austria. The formation name is „Kurdějov limestone", after Eliáš, 1971. There can be distinguished a lower part with fine-grained carbonatic quartz sandstones from an upper part with upwards coarsening carbonate detritus. It is therefore proposed to change the term „Kurdějov limestones" into „Kurdějov arenites" and to divide these into „Lower" and „Upper Kurdějov arenites". The bulk of basin facies formations may be subsumed under the term „Nosislav group".

The regression within the Uppermost Tithonian resulted in a development of a new Upper Tithonian carbonatic platform perhaps covering the whole basin but preserved only in more eastern parts of it. The carbonate platform consists of many types of carbonatic environments, which as in the klippen of the external Carpathian nappes we subsumed as „Ernstbrunn beds". Similarities in lithofacies and in basal development of this member in boreholes and on surface suggest to use a uniform term for the carbonates in the autochthonous and allochthonous position. The names „Obere Karbonatserie" and „Kobyly limestones and dolomites" are therefore not necessary.

Lower Cretaceous seemed for a long time to be missing, until Upper Albian was reported at first by Krystek, I., Samuel, O., 1978 and than from the well Nove Mlýny 2 by Řehánek 1983, 1984. These „Oncoidic limestones" were defined as „Nové Mlýny limestones" by J. Adámek 1985 (published 1986). Possibly the whole part of the carbonatic section in Zistersdorf ÜT2A does not belong to the Ernstbrunn beds, the higher part shows boulders of mixed carbonates of the Ernstbrunn type in a carbonatic matrix. But no relevant indications for Cretaceous were found.

The Upper Cretaceous has been encountered by a large number of wells. But there are especially two of them, Ameis 1 and Poysdorf 2 which allow to establish a combined section from Cenomanian to Maastrichtian. It con-

Fig. 3.



tains marine glauconitic marls, sandy marls and at the Turonian/Coniacian boundary zone a horizon of sandy limestones. The whole section is subsumed under the term „Klement super group" and is to be divided into an Ameis group (Cenomanian to Santonian) and a Poysdorf group (Campanian to Maastrichtian) (R. Fuchs and G. Wessely 1977).

The unique situation of an existing Mesozoic basin crossing the Austrian — Czechoslovakian border requires a common nomenclature which stands for stratigraphic units well defined by a representative occurrence on surface or in boreholes and by representative paleontologic, micro- and macrofacial, bio-and lithostratigraphic characteristics. The structure of nomenclature should be open for further infillings or additions if future investigations lead to the necessity for that. A summary of the existing terms and their validity is presented by J. Adámek 1986. In the following there is shown a compilation of the different terms to one at that time valid joint schedule (fig.3).

3. Paleogeographic and structural results

Wells and seismic data brought a general view of the distribution of the different members and facial complexes of the Autochthonous Mesozoic.

The arrangement of the formations under Molasse along the southern flank of the Bohemian Massif (fig.1) is different in ČSSR and in Austria.

In Austria a uniform succession from W to E is to be seen with a rim of Dogger deltaic sediments, followed by platform carbonates and finally basin development of the Malm. The western limit of the latest carbonatic development (Ernstbrunn beds) can be traced only along a short extension. A not everywhere preserved Upper Cretaceous cover is restricted to the more eastern area of the Jurassic complex and rests unconformably over its substratum.

In the northernmost part of Lower Austria the Malmian western platform zone seems to cover the margin of the Dogger and to rest directly upon the basement. The arrangement of the sediments in Czechoslovakia in the border zone with Austria is similar, but towards the north it is stronger influenced by tectonical and erosional affects especially in the area of the „Vranovice" and „Nesvačilka" graben (Adámek 1965, plate 8). The Upper Cretaceous is restricted to the southern part of Czechoslovakia. The less importance of the areal extent of the Dogger in comparison to Austria is due to a more expressed and thicker development of a deltaic system in Austria.

The internal geometry of the Autochthonous Mesozoic mantle is devided into a Precallovian and a Postcallovian part formed within two different cycles. The first one is characterized by a stronge differentiation in sedimentation, thickness of deposits, mainly caused by synsedimentary tectonics. In Austria halfgrabens probably caused by inner Alpine-Carpathian rifting events contain a thick sedimentary infill in their subsided positions and a thin developed one on their uplifted parts. The Callovian seals this tectonic sedimentary conditions and initiate a second cycle with tectonically more uniform sucessions where the main dominant feature is the boundary of the marginal carbonatic platform to the eastward thickening basin facies in the Malm. The different, mainly postmesozoic tectonics are object of specific regional geological and geophysical investigations in combination with the search for trapping positions of hydrocarbons.

4. Aspects of investigations for the exploration of hydrocarbons

The exploration of hydrocarbons has to be based on a broad spectrum of knowledge about reservoir rocks, source rocks, maturity of sediments, structural possibilities for trapping. The ambiguous exchange of information enables both sides to get a maximum of information to diminish risks and costs especially with respect to very deep targets.

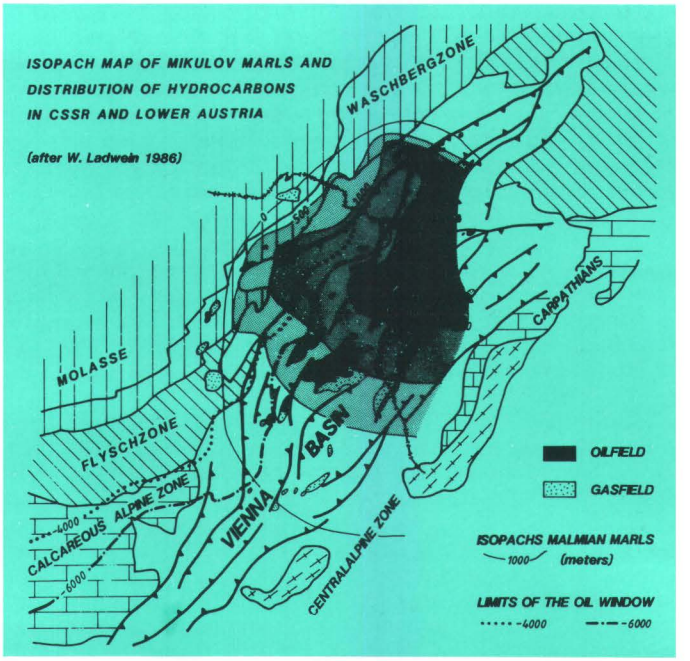


Fig. 4

Reservoir rocks are to be found in deltaic sequences of the Dogger (Klement, Höflein), in sandy dolomites with cherts in the uppermost Dogger (Höflein), in carbonates of the platform facies (Roseldorf) and in calcarenites, partly dolomitized of the Kurdějov beds (D. Dunajovice, Pottenhofen). Possibly Mikulov marls can have reservoir properties if they are fractured by effects associated with hydrocarbon genesis causing high pressure (W. Ladwein). A large thickness of the layer would be necessary in this case (Zistersdorf ÜT2a).

The information on rock thicknesses in both countries led to a construction of an isopach map of the Mikulov marls, the most important source rock of the Autochthonous Mesozoic mantle because of its high content in organic matter (Ladwein, 1988) and its large volume. The thickness exceeds in the deepest parts 1000 m (fig. 4). The history of subsidence and the thermal history of the Jurassic basin lead to the conclusion, that a large amount of hydrocarbons must have been generated. Even if the amount of hydrocarbons, migrated and accumulated in the Vienna basin, is substracted from this volume, large possibilities remain in the lowermost section of the Vienna basin and underneath the external zones of the Alpine-Carpathian nappes. Additionally prodeltaic shales of the Dogger may act as source rocks.

Experiences in structural possibilities for trapping are important for exploring the Autochthonous Mesozoic plays: updoming, blockfaulting, upthrusting, onlapping, pinchout, facial changing in carbonate complexes (reefs, dolomitisations, karstifications) and possibly thick fractured complexes of marls.

All these features have been realized already in this tectonic—sedimentary environment and give chance for future exploration.

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Abstrakt

Ropařské vrty provedené v Rakousku a v ČSSR v oblastech karpatské a alpské předhlubně (molasy), flyšového pásma a vídeňské pánve přinesly důkazy, že krystalinikum a paleozoikum na jv. svazích Českého masívu pokrývají uloženiny mezozoika. Výskyty téměř identických litologických a stratigrafických jednotek v Rakousku a Československu po obou stranách státní hranice podmínily stálou spolupráci při jejich výzkumu. Společný výzkum se soustředil na definování a doložení nejdůležitějších litostratigrafických jednotek. Přiložené tabulky dokumentují současný stav výzkumů. Podáváme přehled paleogeografických a strukturních poměrů. Uvádíme dosavadní výsledky detekce uhlovodíků a možné aspekty jejich vyhledávání ve vztahu ke kolektorským, zdrojovým a strukturním podmínkám.

Zusammenfassung

Bohrungen für Kohlenwasserstofferkundung in Österreich und der ČSSR haben den Nachweis eines autochthonen mesozoischen Sedimentmantels an der Ostflanke des Kristallin-Paläozoikumspornes der Böhmischen Masse unter Molasse, unter der alpin-karpatischen Externzone und unter dem Wiener Becken erbracht. Die nahezu identischen stratigraphisch-faziellen Einheiten beiderseits der Grenze bedingten eine kontinuierliche Kooperation beider Länder. Es wurden die wichtigsten dieser Einheiten stratigraphisch definiert und dokumentiert. Der neueste Stand dieser Gliederung wurde in einem gemeinsamen Schema dargestellt.

Ebenso werden die paläogeographischen und strukturellen Ergebnisse übersichtsmäßig wiedergegeben. Die Ergebnisse der Kohlenwasserstofferkundung und die künftigen Aspekte werden im Zusammenhang mit Speicher- und Muttergesteinsfragen sowie den strukturellen Gegebenheiten erörtert.

PALEOGEOGRAPHY AND STRATIGRAPHY OF THE AUTOCHTHONOUS PALEOGENE ON THE SOUTHEASTERN FLANK OF THE BOHEMIAN MASSIF

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The Nesvačilka and Vranovice canyons, filled with autochthonous Paleogene sediments, were discovered in the south Moravian part of the Bohemian Massif in the late sixties. Natural gas was found in Paleogene sandstones in the early eighties, which put this formation into the centre of attention of the Moravian Oil company. In this region, the author (R. Jiříček, 1981, 1986) studied the stratigraphic and facies division of sediments in relation to gradually transgression and troughs evolution. Autochtonous Paleogene rocks were identified in 42 boreholes from which 233 cores and some cuttings correlated by means of electric logging (Table 1) were recovered for lithological and micropaleontological purposes. Seismic sections were used not until in the paper presented that gives more precission to previous results. For some of the boreholes, the presumed autochthonous Paleogene rocks were placed into the autochthonous Eggenburgian or into the overthrusted Nikolčice Unit of the parautochthone.

1. The age of the autochthonous Paleogene is seen individually. Originally, the Paleogene sediments of Arta-H2 borehole were classified as Aquitanian to Burdigalian (K. Friedl, 1937). Later they were assigned, together with the equal layers of the adjoining Brno-1 borehole, to the Lower Oligocene (M. Dlabač, 1946,; R. Grill, 1947). In accordance with the bethos foraminifers present, they were determine as ranging from the Upper Eocene to the Lower Oligocene or Rupelian in Nesvačilka-1 borehole (M. Holzknecht, in V. Homola et al., 1961). The occurence of Nummulites and Discocyclines at Uhřice placed them into the Middle Eocene (E. Benešová, 1969). J. Krhovský (1988) basing on a revision of the benthos forams, concluded, after all, that age was Paleocene to Oligocene.

According to the author (R. Jiříček, 1986), the problem of disagreement consist in the fact that the abundant benthos fauna is of deepwater nature similar to that of the Upper Eocene to Lower Oligocene faunas of eastern Europe reported by M. Holzknecht (1961), but that is also resembles Paleocene faunas of western Europe, described under other species names, by J. Krhovský (1988). The occurrence of Eocene age, indicates the possible survival of a large part of the faunas from the Paleocene to the Eocene. Typical faunas including Bulimina parisiensis („B. trigonalis") extend from Lower Eocene into Paleocene pelites. In addition, a number of mollusc faunas are present there that resemble those in the Lower Oligocene Pouzdřany Unit not altered throughout the Paleogene. For this reason, the upper part of the Paleogene seems to be composed of Upper Eocene perhaps to Lower Oligocene sediments linking up with the primary molasse extending from the Perialpine region into southern Moravia (R. Jiříček, 1981). The lower part of the Paleogene is regarded as Middle and Lower Eocene and Paleocene (M. Holzknecht—J. Krhovský, 1988; B. Hamršmíd, 1988).

2. The determination of the internal stratigraphy of the autochthonous Paleogene was equally difficult as that of the age of the sediments. On the basis of well cores, V. Homola et all. (1961) identified several horizont; a few of them could be correlated with the aid of electric logs to the closest proximity of the Nesvačilka boreholes (F. Němec, 1973), but not to regions more distant. Presently the clastic Těšany formation, westwards replaced by dark-grey claystones of the Lower Nesvačilka Member, can be