Mid-Oligocene Thomasl Formation (Waschberg Unit, Lower Austria) – micropaleontology and stratigraphic correlation

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Abstract: Oligocene Thomasl Formation was encountered in the seventies during hydrocarbon exploration in the Waschberg Unit of Austria, which is a tectonic unit of the external thrust rim of the Alpine-Carpathian system NW of the Vienna Basin. The original description of the "Thomasler Schichten" is re-studied and compared with sections at Ottenthal (Lower Austria) concerning micropaleontological evaluation (calcareous nannoplankton and foraminifera) as well as sedimentological, petrographical and heavy mineral analyses.

The sedimentary character of the Thomasl Formation argues for a rather deep marine depositional setting. Autochthonous foraminifera with common agglutinated deep-water forms indicate an upper to middle bathyal environment.

The Thomasl Formation corresponds to nannoplankton zones of uppermost NP 23 to lowermost NP 25 resp. to planktic foraminifera zones P 20 to P 22? (Late Kiscellian to Early Egerian). The upper part of the Ottenthal Beds is synonymous to the Thomasl Formation. Additional, the correlation with southern Moravia ("Sitborice beds") and the Austrian Molasse Basin is discussed.

Zusammenfassung: Die in den 70er Jahren durch die OMV-AG erbohrten "Thomasler Schichten" der Waschbergzone werden mit Obertageaufschlüssen in Ottenthal (Niederösterreich) sowie mit den "Sitborice Schichten" in Südmähren biostratigraphisch, sedimentologisch und petrographisch verglichen. Im österreichischen Molassebecken ist eine Korrelation mit der Eggerding-Formation möglich. Kernmateriel des Stratotypus der Thomasl-Formation aus der Bohrung Thomasl 1 sowie Kerne der Bohrung Poysdorf 2 (Referenzsektion) wurden neuuntersucht und erstmals sedimentpetrographisch dokumentiert.

Der sedimentologische Charakter der Thomasl-Formation entspricht einem tieferen marinen Milieu. Die autochthone Foraminiferenfauna enthält viele agglutinierende Tiefwasserformen (oberes bis mittleres Bathyal).

Die Foraminiferenfauna der Thomasl-Formation repräsentiert die Planktonzonen P 20 bis P 22?. Das kalkige Nannoplankton entspricht der obersten Nannoplanktonzone NP 23 bis zur

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unteren NP 25. Diese Zonen reichen vom Oberen Kiscellium bis zum Unteren Egerium. Der obere Teil der Ottenthaler Schichten ist mit der Thomasl-Formation ident.

Eine Korrelation mit Südmähren ("Sitborice Schichten") und der österreichischen Molasse wird diskutiert.

Keywords: Thomasl Formation, Waschberg Unit, Paratethys, Kiscellian-Egerian, Foraminifera, Nannoplankton

Contents

1. INTRODUCTION

The Waschberg Unit (compare GRILL, 1953) comprises a distinct tectonic unit in front of the Alpine-Carpathian nappes, overthrusted onto the Neogene sediments of the Molasse Basin. It extends from north of the Danube to northeast into southern Moravia, where it continues as the Zdanice Unit. This unit is strongly imbricated and tectonically disturbed. In a matrix of Neogene sediments, intercalated wedges and klippen of Upper Jurassic, Upper Cretaceous, and Paleogene limestones, sandstones, marls and shales occur. For the present investigation the Oligocene part of these tectonic slices is of interest.

A first short note of Oligocene sediments and microfauna was given by RZEHAK (1888) for the locality Niederhollabrunn from the southern part of the Waschberg Unit. Extensive mapping by JÜTTNER (1938, 1940) in southern Moravia included also the area of Ottenthal in the north of Austria. He compared the sediments with the "Pausramer Schiefer" and "Menilitschiefer". The Waschberg Unit was mapped by GRILL (1953, 1968) who considered a Late Eocene to earliest Oligocene age for those sediments. In the following years different investigations with main efforts on Ottenthal followed (e.g., SEIFERT, 1982; HERLICSKA, 1989; SEIFERT et al., 1991). The stratigraphic revision of the sequences has given an Oligocene age (Kiscellian to Early Egerian, nannoplankton zones

NP 21–24). In the meantime the drilling campaign of OMV-AG in the Waschberg Unit explored different tectonic slices containing microfaunas comparable to those of the Molasse Zone in the west (Papp et al., 1978; Fuchs et al., 1980). The corresponding unit with faunas of the Puchkirchen Formation but different lithology has been named "Thomasler Schichten", and was dated as Egerian.

Research at a new section in Ottenthal (Rögl et al., 1997) raised the problem to incorporate a distinct lithologic unit within the Ottenthal Formation of Seifert (1980). The dark brown to black and variegated shales compare very well with the Sitborice Member of the "Menilitic Series" in the Zdanice Unit in southern Moravia, and also to some extent to the description of the "Thomasler Schichten" of Papp et al. (1978). The stratigraphic extension of the Sitborice Member comprises nannoplankton zones upper NP 23 to NP 24 (e.g., Stranik et al., 1991). Therefore, it was necessary to re-study the type section and comparative sections of the "Thomasl beds" from a micropaleontological and sedimentological point of view and to evaluate them as a distinct lithological unit and formation.

2. TECTONICAL AND GEOLOGICAL SETTING

To date, the Thomasl Formation only could be found in a few drillings and outcrops within the Waschberg Unit (Waschbergzone in German = "Zdanice Unit" in Czech) (Fig.1). This tectonic unit is part of the external thrust rim of the Alpine system with extensively thrusted and imbricated subalpine and folded Molasse (= allochthonous Molasse in contrast to autochthonous Molasse in the west; comp. Steininger et al., 1986).

Deep drillings down to the crystalline basement of the Bohemian Massif encountered a sedimentary column of Paleozoic, Jurassic and Upper Cretaceous sediments, which are overlain by Eocene – Lower Oligocene, Egerian, Eggenburgian, and Ottnangian sediments building up a complex imbricated thrust system (e.g., well Klement 1 and well Thomasl 1) (Fig. 2). Early stage thrusts caused overthrusting of the Flysch and have been reactivated later as normal and strike slip faults with different directions of movements (e.g., Schrattenberg Fault and Thrust). The Schrattenberg Fault/Thrust was active during Eggenburgian and Ottnangian times as both a normal fault and as the frontier thrust-plane of the Flysch thrusts. Main thrusting was ongoing from the Late Ottnangian to the Karpatian becoming younger to the west.

The fault pattern gave rise to transgressive sedimentation on top of the tectonic units (Flysch in the Vienna Basin and Waschberg Unit) and led to thick asymmetrical piggy-back basins which were moved during sedimentation of the Early Miocene on the back of these tectonic units. There is a seismically significant unconformity at the base of the piggy-back basins starting with Eggenburgian sediments ("Proto Vienna Basin" according Hamilton et al., 2000). Since Badenian time thrusting ceased and subsidence of the basin took place in a stationary position ("Neo Vienna Basin").

The Thomasl Formation is well developed overlying Upper Cretaceous sediments with a thickness up to +100 meters as is seen in the structural cross section in Fig. 2.

The thickest accumulation of Molasse sediments in the Waschberg Unit is to be seen in the well Poysdorf 2 with 2900 m of repeated thrust sections of the socalled "Oncophora beds".

STRUCTURAL STYLE IN WASCHBERG UNIT / MISTELBACH BLOCK AREA

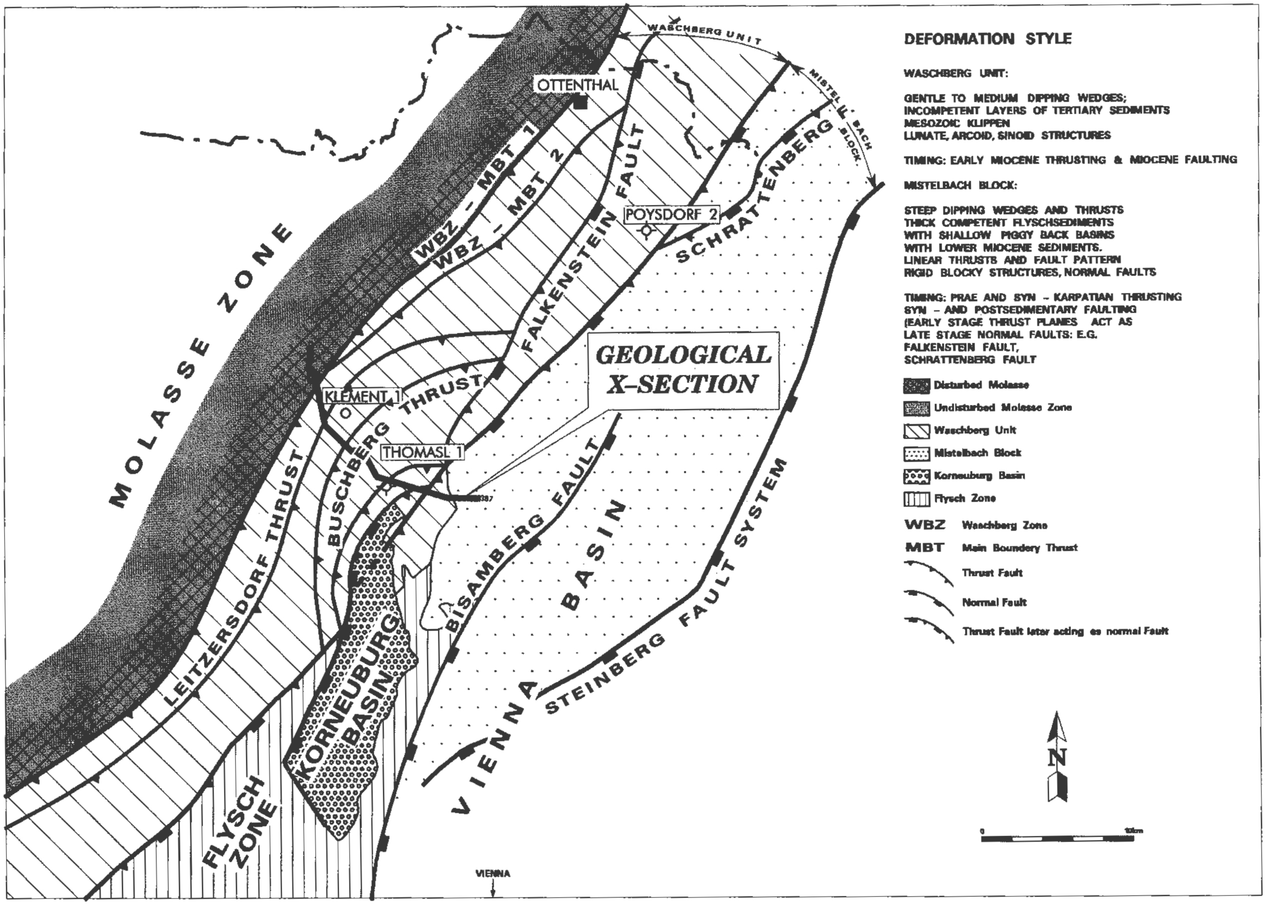


Fig. 1: Study area (Waschberg Unit) and structural style of the Waschberg Unit and the Mistelbach Block of the Vienna Basin.

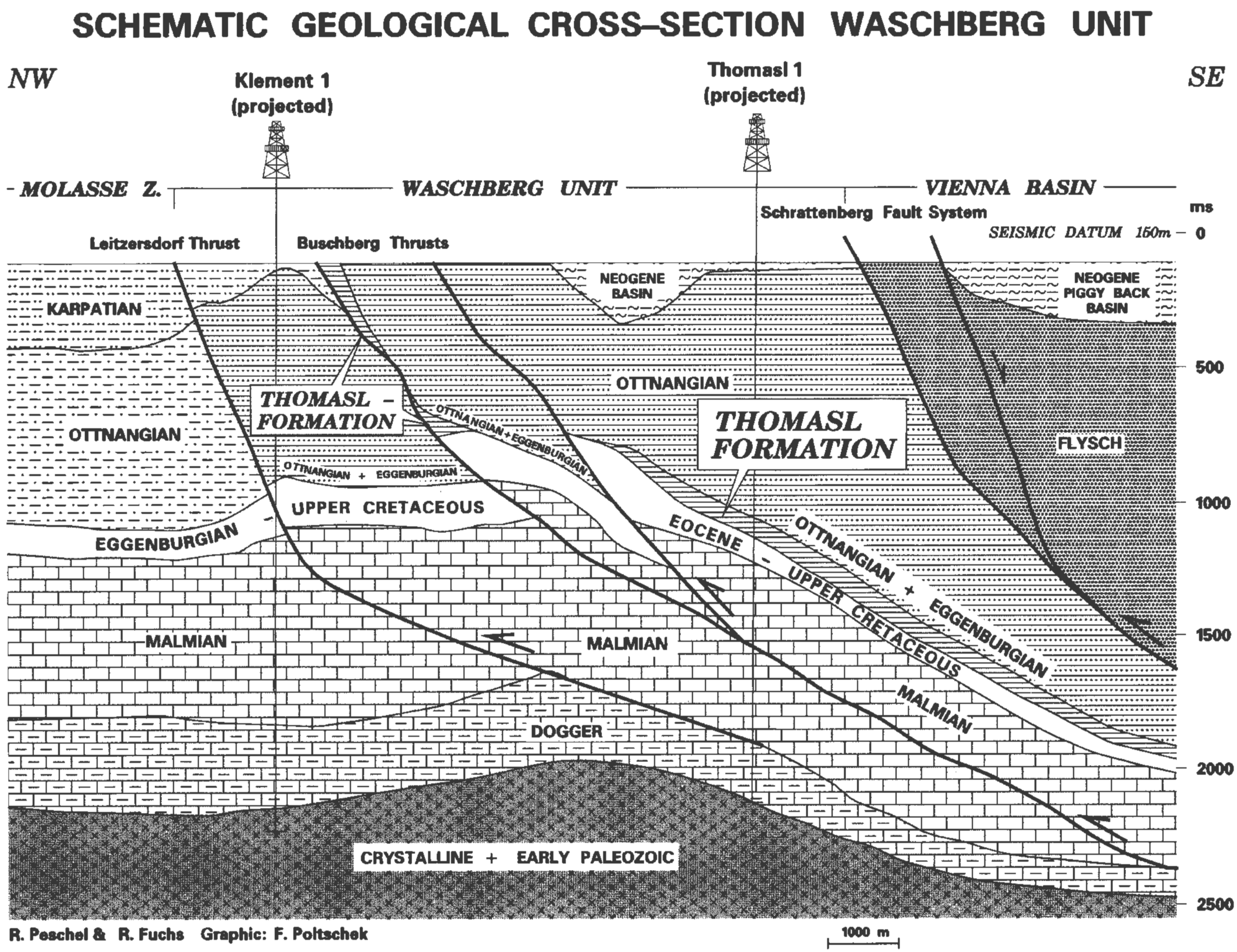


Fig. 2: Schematic geological cross-section of the Waschberg Unit based on drillings and 2-D seismic.

3. ORIGINAL DEFINITION OF THE THOMASL FORMATION

The lithological unit of the "Thomasler Schichten" originally has been described by PAPP et al. (1978) from drill sites with the stratotype in well Thomasl 1 (core # 3: 1760–1765 m): Sediments consist of brownish to greenishgrey, strongly tectonized calcareous shales including a fragment of granodiorite. The overall sequence of the Thomasl Formation comprises dark grey to brownish, commonly sandy, somewhat micaceous calcareous shales and black shales. Subordinate sandstone layers are intercalated. The sediment is tectonically disturbed and imbricated.

The foraminiferal fauna of the stratotype section according to PAPP et al. (1978) is assembled of *Globigerina praebulloides, G. ciperoensis, Catapsydrax unicavus, Globorotalia opima nana*, and of a benthic assemblage with a remarkable content of agglutinated forms. As indicative of an Oligocene/Egerian age are mentioned: *Trochamminoides irregularis, Bifarina reticulosa, Lenticulina inornata, Uvigerina farinosa, U. steyri steyri, Virgulina squamosa*; and from other bore holes (wells Klement 1, Falkenstein 2): *Cyclammina rotundidorsata, Vulvulina subflabelliformis, Textularia gramen, Semivulvulina pectinata*. Some Eocene reworking was observed. The occurrence of *Uvigerina steyri* was used for correlation with the Puchkirchen Formation (Egerian) in the Upper Austrian Molasse, as well as for a differentiation to the younger Michelstetten Formation. A deep water environment was proposed.

4. SEDIMENTOLOGICAL DESCRIPTION AND FACIES INTERPRETATION

For a revision of the Thomasl Formation the type section in the well Thomasl 1 was reevaluated. A comparison with core material from the well Poysdorf 2 was conducted.

Stratotype section: Well Thomasl 1: 16°24'15,94" E, 48°32'1,70" N

Thomasl Formation: 1636–1763 m

Plate 1

Core photograph of the well Thomasl 1, cored interval 1760–1765 m (stratotype of Thomasl Formation). Note the sharp tectonic (A) contact between slickensided brownishgrey slightly calcareous shale (Egerian) and greenishgrey calcareous shale and clay (Lower Eocene). Remarkable is the sharply bounded granodiorite fragment (B) interpreted as tectonical wedge. Scale bar at the left side: 1 m.


B
A

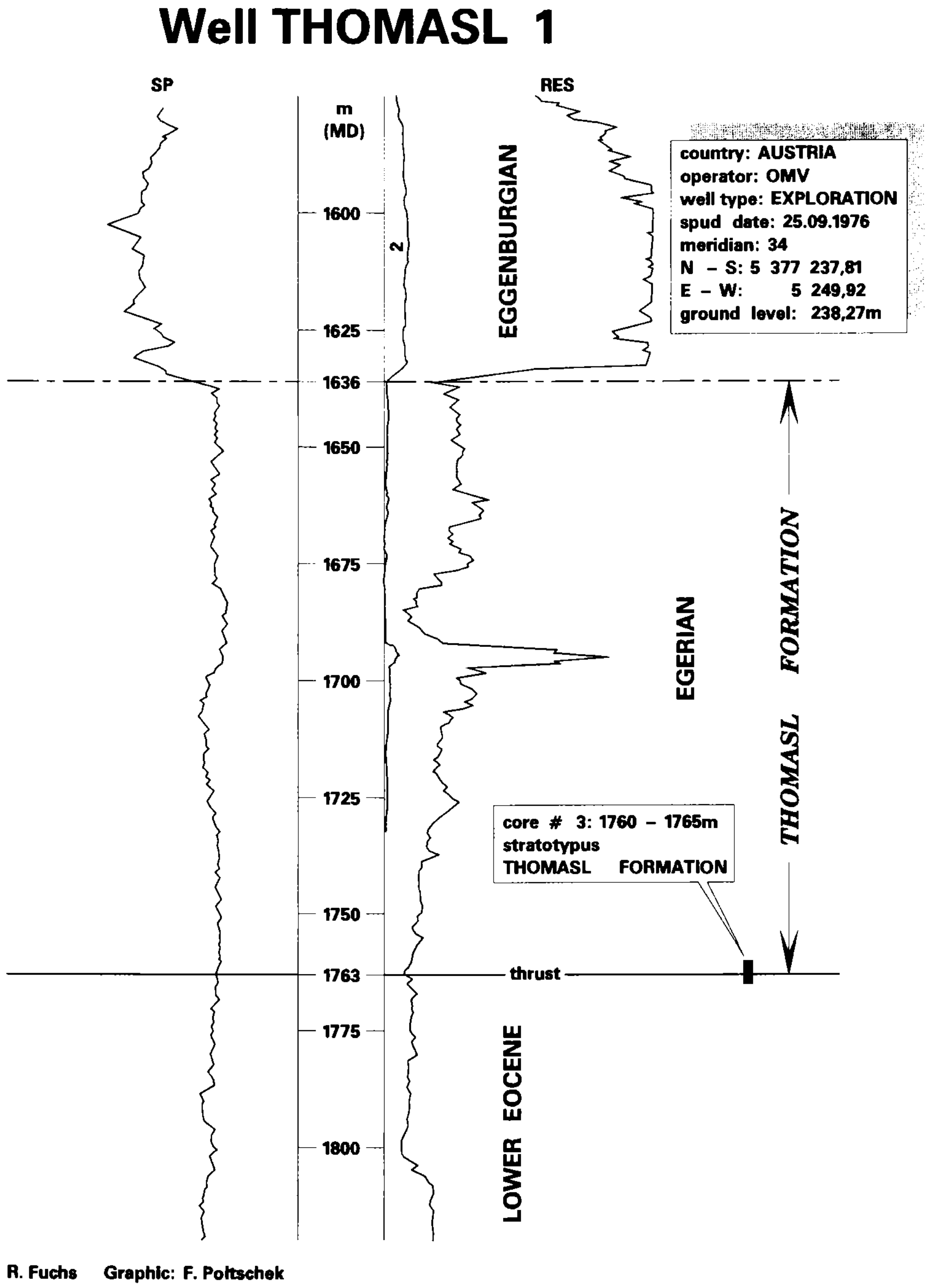


Fig. 3: Log diagram (SP and Resistivity) of the well Thomasl 1 with Thomasl Formation.

4.1. Well Thomasl 1: Core description (stratotype section)

The applied nomenclature of the studied sediments was used in accordance with the terminology for shales defined by POTTER et al. (1980). XRD-analyses were undertaken to determine the bulk mineralogy and carbonate content.

Core # 3: 1760–1765 m [Recovery: 3.5 m (left: 2.0 m)]

Lithology: Core section 1760–1761.8 m (box 3 and 4): dark slightly brownishgrey and black, fissile shale and clay (2% $CaCO_3$), slightly calcareous shale and clay (7% $CaCO_3$) showing a single 3 cm-thick, lenticular-shaped, shaly, medium- to coarse-grained sandstone interlayer, in the uppermost part thinly laminated dark grey marl (41% $CaCO_3$), some thin calcareous mudstones intercalated; the lowermost part shows patchy greenish-brownish slickensided claystone; strongly slickensided, fissile, occasional glauconite. Core section 1761.8–1763.8 m (box 1 and 2): greenishgrey, strongly slickensided, fissile, calcareous shale and clay (11% $CaCO_3$); remarkable is the presence of a single granodiorite fragment (15 cm thick).

Further characteristics: The sediment appears strongly slickensided and drilled up. The cobble-sized granodiorite fragment is sharply bounded by steep slickensides (45°). Besides, occasional glauconite and isolated pyrite nodules are observed.

Facies Interpretation: The boundary between Egerian and Eocene, defined at 1763 m (relative depth according to CE-log), is confirmed by the occurrence of autochthonous Eocene and Paleocene fauna within the lower 2 meters of the core section. Also indicative is the abrupt colour transition ranging from dark brownishgrey and black to greenishgrey in the lowermost part of the core section (Pl. 1).

The **sedimentary character** of the Thomasl Formation argues for a deep marine depositional setting.

The SP-log response (interval between 1636–1763 m) shows a uniform pattern with slight coarsening upward tendencies. The marked RES-response at around 1695 m is interpreted to be due to an increasing content of siliceous microfossils (diatoms; see also petrographical description of cutting samples; Fig. 3).

4.2. Well Poysdorf 2: Core description (reference section)

Well Poysdorf 2: 16°38'17,62" E, 48°41'8,22" N; elevation: 235,01 m
Thomasl-Formation: 2801–2892 m

Core # 21: 2813–2817.5 m [Recovery: 4.0 m (left: 2.6 m)]

Lithology: Core section 2813–2814 m (box 4): dark greenishgrey, slickensided and sheared, claystone to mudstone (4% $CaCO_3$) and indurated calcareous shale, in the lowermost part almost black indurated calcareous shale (16% $CaCO_3$) showing rare mm-thin interlaminae of silt to fine-grained sandstone; frequent occurrence of fish scales, partly large coaly fragments.

Core section 2814–2815 m (box 3): dark brownishgrey calcareous mudstone (6–17% $CaCO_3$) (Pl. 2) showing some mm-thin, silt- to fine-grained sandstone layers and cm-thick, fish scale-bearing layers, single floating quartz pebble, frequent occurrence of floating coaly fragments, some glauconite, frequent calcite-filled healed fractures and

slickensides with striation pattern, common pyrite nodules; in the lowermost part greenishgrey claystone with a thin (<4 cm thick), coarse-grained sandstone interlayer containing some scattered granules.
Core section 2815–2816 m (box 2): dark slightly greenishgrey, thinly laminated, indurated slightly calcareous shale and claystone, thin (<3 cm thick) medium- to coarse-grained sandstone layer with isolated scattered granules, frequent fish remains, occasional glauconite and rare pyrite (Pl. 3).
Core section 2816–2817 m (box 1): dark brownishgrey, thinly laminated, slightly calcareous shale and dark greenishgrey to almost black slightly calcareous mudstone, frequent enrichments of coaly fragments, minor glauconite, occasional pyrite and fish remains.

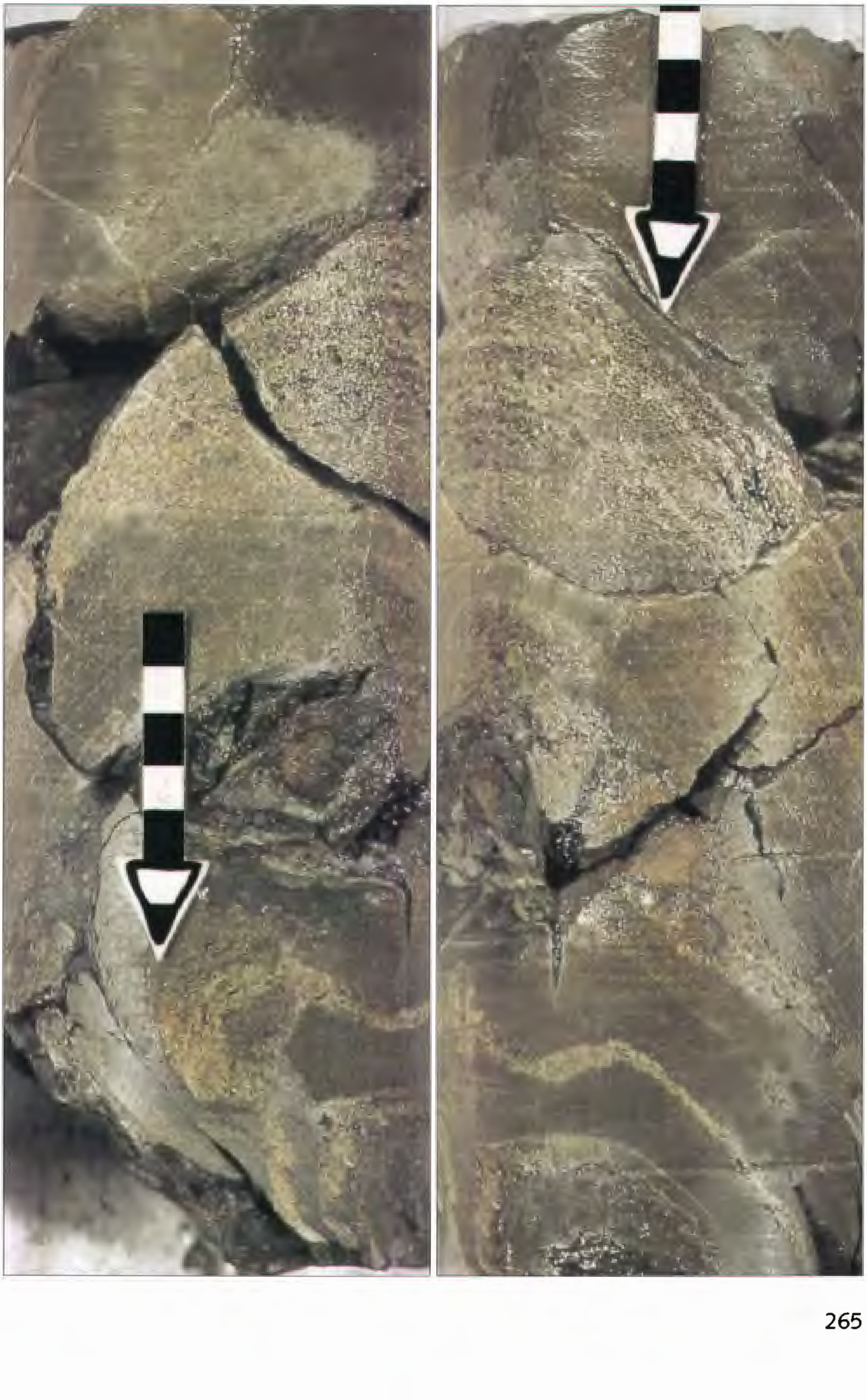
Sedimentary structures: The observed sedimentary structures include slump folds, very rare indistinctly graded layers and small ripples within the thin, silt- to fine-grained sandstone streaks.

Further characteristics: The core material appears partly intensely sheared and slickensided. Of particular interest is the abundant occurrence of fish remains (mainly layer-like enrichments). Slickensides with striation pattern and healed, calcite-filled fractures are quite common. Also shown are frequent carbonized plant debris (partly leaf fragments), occasional large coalified wood fragments, minor pyrite nodules within the coarse-grained sandstone streaks and glauconite.

Facies Interpretation: The recovered sediments contain clear indications which point to a deep water facies. The shales and mudstones are considered to represent hemipelagic deposits, whilst the thin, silt- to sandstone and fish scale-bearing layers are interpreted to have been formed by turbidity currents in a distal basinal setting. The observed slumping phenomena are generally known to dominate the slope and toe-of-slope settings. Occassionally observable high contents of pyrite nodules, poorly developed benthic fauna and lacking of biogenic activity provide evidence for an environment dominanted by anaerobic conditions.

Plate 2

Detailed core photographs of the well Poysdorf 2, core section 2814.5–2814.75 m, showing dark brownishgrey, calcareous mudstone with mm-thin, fine-grained turbiditic sandstone interlayers. Some of these layers contain considerable amounts of fish remains. Notable is the occurrence of prominent slump folds. Also shown are large coaly fragments.
(The arrows point from top to bottom of the core; they also may be used as scale bar: each rectangle, black or white, is 1 cm in size.)



The wireline log pattern of the interval between 2804–2892 m shows a general low gamma ray response with a slight coarsening upward tendency.

4.3. Ottenthal (reference section of the Thomasl Formation)

Co-ordinates: ÖK 1:50 000, sheet no.10, Wildendürnbach;
begin of section Ottenthal-Waldweg: 16°34'54" E, 48°45'35'" N
farmhouse L. Hauer, Ottenthal no. 138: 16°34'48" E, 48°45'31'" N

In the area of Ottenthal, in the northern part of the Waschberg Unit the most extended surface outcrops of Oligocene are observed (comp. Grill, 1968; Seifert, 1982). In recent investigations some sections at the eastern side of the Ottenthal village have been studied and their stratigraphic position revised (Herlicska, 1989; Seifert et al., 1991; Rögl et al., 1997). The stratigraphically younger part of these sections (included in the "Ottenthaler Schichten" of Seifert, 1982), comprising nannoplankton zones upper NP 23 to NP 24, is considered to be equivalent with the Thomasl Formation in the above cited drill sites (Fig 4).

The lithology of the Thomasl Formation of these sections is dominated by dark variegated shales, clays, claystones, and subordinate calcareous clays, with thin layers of silt and sand. Characteristic are yellow veins and cleavage surfaces of the iron sulfate Jarosite and layers of secondary gypsum. The shales are sometimes laminated and show rarely thin laminae and layers of calcareous nannoplankton blooms. According to Herlicska (1989) a distinct lithologic change in composition of heavy minerals is observed in the shales of the upper NP 23 zone with a dominance in garnet. Additionally, in this lower part of the Thomasl Formation, layers and lenses of silt, glauconitic sand and gravels occur, corresponding to the "Sitborice event" in the Zdanice Unit in southern Moravia (Krhovsky & Djurasinovic, 1993). An important outcrop with such sand lenses and gravels was found in the farmhouse L. Hauer, Ottenthal no. 138 (Herlicska, 1989, p. 91, section E). More extended outcrops of the Thomasl Formation are exposed east of Ottenthal village along the pathway to Klein Schweinbarth and along the sunken road in the brushwood (Seifert et al., 1991; Rögl et al., 1997, this volume).

Plate 3

A.: Thin-section photomicrograph of the well Poysdorf 2 (sample 2815.4 m). Overview of calcite-cemented, lithic arenite. Visible are poorly sorted framework grains of quartz (1), crystalline rock fragments (2), and abundant phosphatic bioclasts (fish bones) (3).

B.: Thin-section photomicrograph of the well Thomasl 1 (sample 1761.3 m) showing calcite-cemented calcilithic arenite. The framework grains mainly consist of corallinaceans (1), polycrystalline quartz (2), crystalline rock fragments (3), and glauconite (4).


300 µm
1
2
3


300 µm
2
4
3
1

5. PETROGRAPHICAL AND HEAVY MINERAL ANALYSES

5.1. Cores

Typical samples of sandstone layers present in the cores of both wells Thomasl 1 and Poysdorf 2 have been analysed by means of thin-section and heavy mineral analyses.

Well Thomasl 1: 1761.3 m

The sample can be classified as a coarse-grained, calcite-cemented calcilithic arenite rich in reworked grains of corallinaceans, bioclasts and glauconite. The fabric is grain supported with prevailing long and concave-convex contacts (Pl. 3/B).

The framework grains are poorly sorted. The roundness of the siliciclastic grains range from subangular to subrounded.

Mineralogical-petrographical composition (estimated by point counting of 300 points): 6% monocrystalline quartz, 5% polycrystalline quartz, 1% feldspar (mainly plagioclase), 18% rock fragments (predominant crystalline), 8% glauconite grains, 37% grains of corallinaceans, 9% other bioclasts (echinoderms, mollusk fragments, bryozoans and foraminifers). 1% mica, traces of heavy minerals, 1% pyrite, 10% calcite cement, 1% iron dolomite cement (ankerite).

The crystalline rock fragments consist of partially altered (replaced by calcite cement) quartz-mica fragments and quartz-plagioclase/potassium feldspar-biotite aggregates. The crystalline fragments in the sample are mainly of granitic to granodioritic origin and are very similar in composition to the large granodiorite component found in the core at about 1762 m.

Subordinate glauconitic arenites and siltstone grains can also be observed.

The abundant corallinacean debris probably originates from reworked Paleocene or Eocene formations of the Waschberg Unit.

The heavy mineral assemblage is strongly contaminated by abundant pyrite.

The translucent heavy mineral composition is characterised by the dominance of garnet and titanite. Subordinately tourmaline, titanium oxides (rutile, brookite/anatase) and monazite are also present.

The high content of titanite is due to the abundance of titanite-bearing granodiorite debris.

Well Poysdorf 2: 2815.4 m

The sample can be classified as a coarse grained, calcite cemented lithic arenite. The fabric is grain supported with prevailing point, long and few concave-convex contacts (Pl. 3/B).

The framework grains are moderately sorted. The roundness of the siliciclastic grains range from subangular to subrounded.

Mineralogical-petrographical composition (estimated by point counting of 300 points): 4% monocrystalline quartz, 11% polycrystalline quartz, 1% chert, 2% feldspar (K-feldspar and plagioclase), 50% crystalline rock fragments (mainly quartz-plagioclase -K-feldspar-biotite and quartz-muscovite-K-feldspar grains), traces of calcite bioclasts (mainly foraminifers), 3% glauconite grains, 1% muscovite, 3% shale clasts, 2% phosphate bioclasts (mainly fish scales), 7% pyrite cement, 17% calcite cement.

The crystalline rock fragments are mainly of granitic and granodioritic origin. Especially

the granodiorite fragments are partially strongly altered (sericiticed feldspars, chloritised biotite, neoformation of titanium oxides, etc.). Occasionally, rock fragments are partially replaced by iron rich calcite.
The heavy mineral assemblage is strongly contaminated by abundant pyrite. Therefore it was not possible to get a statistically representative number of translucent grains (only about 50 grains have been counted).
The translucent heavy minerals are characterised by the dominance of garnet and titanium oxides (rutile and brookite/anatase). Subordinately zircon, tourmaline, titanite, and monazite are present. Most likely the heavy mineral composition is similar to the heavy mineral spectra found in the sandstone sample of well Thomasl 1.

Well Poysdorf 2: 2814.5 m, 2814.85 m

The samples are poorly sorted, iron dolomite (ankerite) cemented lithic arenites. The fabric is grain supported with prevailing point contacts.
The mineralogical-petrographical composition is similar to sample 2815.4 m.
The crystalline rock fragments are again characterised by the predominance of granitic and granodioritic particles. Additionally, fragments of coarse muscovite schist and fine-grained sericite-chlorite quartzite can be observed. Typical is also the abundance of phosphate fish scales. The constituents are partially replaced by iron dolomite cement.
The heavy mineral assemblage is completely represented by pyrite (sample 2814.85 m) or strongly contaminated by barite (2814,5 m). Therefore it was not possible to count a statistically representative number of translucent grains.

5.2. Petrographical description of cutting thin section samples

Well Thomasl 1

Samples 1670 m and 1680 m

<u>Predominant</u>: slightly calcareous, partially silty and laminated shale, rich in organic matter and finely dispersed pyrite, occasionally with inclusions of foraminifera, fish scales and glauconite
<u>Very rare:</u> chalky micrite and micaceous siltstone, granodiorite (only one grain!)

Samples 1690 m–1710 m

<u>Predominant</u>: mainly shale as described above, shale with an increasing content in siliceous microfossils (probably mainly recrystallised diatoms) and partially entirely silicified fragments with brownish laminae of diatomaceous chert ("menilite")
<u>Very rare:</u> chalky micrite, sparite and micaceous siltstone

Samples 1720 m, 1730 m, 1740 m, 1750 m, 1760 m

<u>Predominant</u>: mainly shale as described in samples 1670 m and 1680 m partially more silty, decreasing content in diatomaceous chert ("menilite") with brownish laminae .
<u>Very rare:</u> chalky micrite, siltstone, sandstone, sparite, traces of glauconite, chert, granodiorite

6. MICROPALEONTOLOGICAL RESULTS

6.1. Calcareous nannoplankton and Foraminifera

Samples from the drill sites Thomasl 1 and Poysdorf 2 were investigated for calcareous nannoplankton and foraminifera. Throughout the sections strong reworking of Cretaceous to Eocene sediments is observed. Especially for the agglutinated foraminifera it is difficult to distinguish between reworked Flysch type fauna and autochthonous elements in many cases. A larger part of the reworked assemblages can be traced to the autochthonous Paleocene-Eocene of the Vranovice and Nesvacilka Graben. Results of nannoplankton and foraminiferal determinations are listed in Tab. 1–4.

Well THOMASL 1 Calcareous Nannoplankton	core 3, 1761.15 m	core 3, 1762.10 m	core 3, 1762.30 m	core 3, 1762.60 m	core 3, 1763.25 m	core 3, 1763.60 m	core 3, 1764.20 m
	OLIGOCENE				**EOCENE**		
Coccolithus pelagicus	x		x	x	x	x	x
Dictyococcites bisectus	x			x		x	
Reticulofenestra lockerii	x						
Cyclicargolithus floridanus	x		x	x		x	x
Cyclicargolithus abisectus	x						
Pyrocyclus hermosus	x						
Transversopontis pulcher	x				x	x	x
Watznaueria barnesae		x	x				
Micula decussata		x					
Eiffellithus turriseiffelii		x					
Eiffelithus eximius		x					
Reinhardtites anthophorus		x					
Aspidolithus parcus expansus		x					
Lithraphidites praequadratus		x					
Kamptnerius magnificus		x					
Rhagodiscus angustus		x					
Arkhangelskiella specillata		x					
Stoverius achylosus		x					
Quadrum goticum		x					
Chiasmolithus bidens			x				
Placozygus sigmoides			x	x			

Tab. 1: Well Thomasl 1: Calcareous nannoplankton.

Well THOMASL 1 Calcareous Nannoplankton	core 3, 1761.15 m	core 3, 1762.10 m	core 3, 1762.30 m	core 3, 1762.60 m	core 3, 1763.25 m	core 3, 1763.60 m	core 3, 1764.20 m
	OLIGOCENE				**EOCENE**		
Ericsonia robusta			x				
Prinsius bisulcus			x	x		x	
Fasciculithus involutus			x				
Toweius tovae			x				
Chiasmolithus californicus			x	x			
Ellipsolithus macellus			x		x	x	x
Ericsonia subpertusa				x			
Toweius pertusus				x	x		
Chiasmolithus danicus				x			
Heliolithus cantabriae				x			
Heliolithus kleinpellii				x			
Sphenolithus radians					x	x	
Chiasmolithus eograndis					x	x	x
Neochiastozygus rosenkrantzii					x		
Tribrachiatus orthostylus					x	x	x
Discoaster lodoensis					x	x	
Chiasmolithus solitus					x	x	
Discoaster binodosus					x		
Lophodolithus nascens					x	x	
Discoaster barbadiensis					x	x	
Coccolithus formosus					x	x	
Toweius magnicrassus						x	x
Helicosphaera seminulum						x	
Discoaster gemmifer						x	
Discoaster kuepperii						x	x
Helicosphaera recta						cf.	
Pontosphaera cornifera						cf.	x
Triquetrorhabdulus carinatus						cf.	
Sphenolithus editus							x
Sphenolithus distentus							cf.
Zygodiscus adamas							x
Neochiastozygus junctus							x

Tab. 1: continued.

Well THOMASL 1 Foraminifera	cuttings 1750 m	cuttings 1760 m	core 3, 1761.25 m	core 3, 1762.40 m	core 3, 1762.60 m	core 3, 1763.20 m	core 3, 1763.70 m	core 3, 1764.20 m	cuttings 1770 m	**stratigraphic distribution**	**agglutinated Flysch type fauna**
	OLIGOCENE					**EOCENE**					
agglutinated foraminifera:											
Bathysiphon taurinensis	x	x			x		x	x			
Cyclammina sp.	x				x						
Dorothia fallax	x				x	x		x	x	E-M	
Haplophragmoides horridus	x	x		x	x				x	C-E	x
Haplophragmoides spp.	x	x		x	x	x			x		
Karreriella subglabra	x							x		E-M	
Psammosiphonella cylindrica	x	x		x	x	x		x	x	E-O	
Hyperammina rugosa	x	x		x		x	x	x		O-M	
Recurvoides cf. *gerochi*	x				x	x				P-E	x
Repmanina charoides	x			x	x	x	x	x	x		
Reticulophragmium amplectens	x	x								E-O	
Silicobathysiphon sp.	x	x		x	x		x				
Tritaxia alpina	x	x	x		x		x	x	x	E-O	
Adercotryma glomeratum		x									x
Alveolophragmium sp.		x									
Gerochammina conversa		x		x	x		x		x	C-E	x
Gerochammina tenuis		x						x		C-E	x
Haplophragmoides carinatus		x								O-M	
Haplophragmoides suborbicularis		x		x	x	x	x			C-M	x
Hyperammina nuda		x									x
Kalamopsis sp. / *grzybowskii*		x	x	x		x	x				x
Karrerulina coniformis		x		x		x		x	x	P-E	x
Miliammina sp.		x									
Recurvoides immane		x		x	x	x		x		P-E?	x
Tritaxilina pupa		x	x	x					x	E	
Trochammina globigeriniformis		x			x	x					
Vulvulina haeringensis		x		x	x					E-O	
Ammodiscus cf. *glabratus*			x	x		x		x	x	C-E	
Saccorhiza ramosa			x	x		x		x	x		
Recurvoides spp.			x	x	x	x		x	x		x
Spiroplectinella navarroana			x	x		x	x	x		C-E	
Eggerella? irregularis			x							E-M	
Plectina dalmatina			x							E-O	
Tritaxia szaboi			x						x	E-O	
Ammodiscus cf. *planus*				x			x			C-E	

Tab. 2: Well Thomasl 1: Foraminifera;
C= Cretaceous, E= Eocene, M= Miocene, O= Oligocene,
P= Paleocene; Zones acc. to BERGGREN et al., 1995.

Well THOMASL 1 Foraminifera	cuttings 1750 m	cuttings 1760 m	core 3, 1761.25 m	core 3, 1762.40 m	core 3, 1762.60 m	core 3, 1763.20 m	core 3, 1763.70 m	core 3, 1764.20 m	cuttings 1770 m	**stratigraphic distribution**	**agglutinated Flysch type fauna**
	OLIGOCENE					**EOCENE**					
Ammodiscus cretaceus				x		x		x		C-M	
Ammodiscus tenuissimus				x		x	x	x		C?-M	
Buzasina sp.				x		x		x			
Eggerella sp.				x							
Gaudryina expansa				x						E	
Glomospira? irregularis				x			x	x		C?-E	x
Glomospira gordialis				x			x	x			
Glomospirella gibbosa				x	x					O-M	
Glomospirella grzybowskii				x		x		x		C-E	x
Haplophragmoides walteri				x		x		x	x	P-O	x
Hyperammina dilatata				x							x
Karrerulina horrida				x		x		x		P-E	x
Plectorecurvoides alternans				x						C	x
Reophax nodulosus				x							
Reophax pilulifer				x							
Spiroplectammina cf. *dentata*				x						C-P	
Trochamminoides folius				x	x	x		x	x	C-E	x
Trochamminoides subcoronatus				x		x				C-E	x
Vulvulina spinosa				x					cf.	O-M	
Remesella varians					x					C-E	x
Trochamminoides dubius					x					C-E	x
Trochamminoides variolarius					x	x				C-E	x
Caudammina ovulum					x		x		x	C-E	x
Dorothia cf. *germanica*							x			O-M?	
Karreriella seigliei							x			E-O	
Karreriella siphonella							x			O-M	
Paratrochamminoides contortus							x			C-E	x
Recurvoides walteri							x			C-E	x
Thalmannammina gerochi							x			C-E?	x
Ammolagena clavata									x		
Paratrochamminoides irregularis									x	C-E	x
calcareous benthics:											
Abyssamina poagi	x	x								P-E	
Bulimina alsatica	x			x						E-M?	
Caucasina schischkinskayae	x									E-M	
Hoeglundina elegans	x	x	x						x	E-M	

Tab. 2: continued.

Well THOMASL 1 Foraminifera	cuttings 1750 m	cuttings 1760 m	core 3, 1761.25 m	core 3, 1762.40 m	core 3, 1762.60 m	core 3, 1763.20 m	core 3, 1763.70 m	core 3, 1764.20 m	cuttings 1770 m	**stratigraphic distribution**	**agglutinated Flysch type fauna**
	OLIGOCENE					**EOCENE**					
Korobkovella sp.	x	x									
Laevidentalina elegans	x										
Oridorsalis umbonatus	x								x	E-M	
Praeglobobulimina bathyalis	x	x								O	
Praeglobobulimina primitiva	x									E-O	
Robertina declivis	x	x								E-O	
Siphonodosaria spp.	x	x		x		x	x	x	x		
Stilostomella spp.	x	x		x		x	x	x	x		
Uvigerina rustica	x									O-M	
Valvulineria palmarealensis	x		x							E-O	
Chilostomella ovoidea		x	x							E-M	
Cibicidoides mexicanus		x						x		E-M	
Cibicidoides tenellus		x							x	O-M	
Grigelis sp.		x									
Gyroidinoides girardanus		x	x					x		E-O	
Gyroidinoides parvus		x								O-M	
Lenticulina spp.		x	x	x	x	x	x	x	x		
Neugeborina sp.		x						x			
Praeglobobulimina pupoides		x								E-M	
Pullenia bulloides/quinqueloba		x							x		
Quadrimorphina petrolei		x								E-O	
Valvulineria wittpuyti		x							x	E-O	
Dentalina sp.			x								
Alabamina wolterstorffi			x	cf.						O	
Cribroparella pteromphalia			x	x					x	E-O	
Pseudonodosaria inflata			x				x			E-O	
Uvigerina multistriata			x							O	
Anomalinoides affinis				x			x	x	x	E-O	
Anomalinoides capitatus				cf.	x		x	x		E-O	
Bolivina crenulata				x						O	
Bulimina semicostata				x		x			x	E	
Bulimina subtruncana				x						E	
Bulimina tuxpamensis				x		x		x		P-E	
Cibicides amphysiliensis				x		x		x		E-O	
Cibicidoides cf. *pachyderma*				x				x		O-M	
Cibicidoides ungerianus				x						E-M	

Tab. 2: continued.

Well THOMASL 1 Foraminifera	cuttings 1750 m	cuttings 1760 m	core 3, 1761.25 m	core 3, 1762.40 m	core 3, 1762.60 m	core 3, 1763.20 m	core 3, 1763.70 m	core 3, 1764.20 m	cuttings 1770 m	**stratigraphic distribution**	**agglutinated Flysch type fauna**
	OLIGOCENE					**EOCENE**					
Eponides sp.				x							
Marginulina behmi				x						E-M	
Melonis affinis				x					x	(O-M)	
Nuttallides truempyi				x		x		x		C-E	
Oridorsalis subumbonatus				x				x		E-M	
Pleurostomella acuta				x						E-O	
Linaresia semicribrata					x		x	x		P-E	
Alabamina abstrusa							x		x	E-O	
Anomalinoides granosus							x		x	E-O	
Anomalinoides sublobatulus							x			E	
Cibicidoides dalmatinus							x	x		E-O	
Cibicidoides lopjanicus							x			O-M	
Epistomina sp.							x				
Gavelinella cenomanica							x			C	
Guttulina sp.							x				
Hanzawaia ammophila							x			E	
Kolesnikovella tubulifera							x			E-M?	
Pyramidulina sp.						x	x	x	x		
Stensioeina beccariiformis							cf.			C-P	
Svratkina sp.							x				
Fursenkoina mustoni						x				O-M	
Asterigerina bartoniana								x	x	E	
Cancris subconicus									x	E-O	
Nonionella spissa									cf.		
Quadrimorphina allomorphinoides									x	E-O	
Nummulites sp.								x			
planktic foraminifera:										**ZONES**	
Acarinina subsphaerica	x			x			x			P4-5	
Catapsydrax dissimilis	x									P11-M3	
Catapsydrax primitivus	x	x	x						x	P14-20	
Catapsydrax unicavus	x	x	x		x	x				P20-M3	
Globigerina wagneri	x									P20-21	
Globigerina ? euapertura	x	x								P19-M1	
Globigerinatheka mexicana	x								x	P11-15	
Globoquadrina globularis	x	x							x	P20-21	
Globorotaloides sp. - suteri	x	x	x				x			(P13-M5)	
Paragloborotalia opima opima	x									P21	
Subbotina cf. *tripartita*	x									P18-M1	

Tab. 2: continued.

Well THOMASL 1 Foraminifera	cuttings 1750 m	cuttings 1760 m	core 3, 1761.25 m	core 3, 1762.40 m	core 3, 1762.60 m	core 3, 1763.20 m	core 3, 1763.70 m	core 3, 1764.20 m	cuttings 1770 m	**stratigraphic distribution**	**agglutinated Flysch type fauna**
	OLIGOCENE					**EOCENE**					
Catapsydrax pera		x								P14-22	
Globigerina praebulloides		x								P16-M13	
Globigerinatheka index		x							x	P12-17	
Subbotina cf. *angiporoides minima*		x								P11-15	
Subbotina cryptomphala		x	x						cf.	P13-21	
Subbotina praeturritilina		x	x							P15-21	
Subbotina utilisindex		cf.							x	P15-21	
Turborotalia cerroazulensis		x								P14-17	
Turborotalia increbescens		x								P16-19	
Acarinina matthewsae			x			x	x			P9-12	
Morozovella subbotinae			x					x		P6-8	
Pseudohastigerina wilcoxensis			x							P6-11	
Subbotina linaperta			x	x				x	x	P5-20	
Subbotina triangularis			x	x	x	x	x	x		P3-6	
Subbotina velascoensis			x	x		x		x	x	P3b-6	
Subbotina gortanii			x							P16-21	
Subbotina pseudovenezuelana			x							P14-20	
Acarinina appressocamerata				x				x		P8-9	
Acarinina nitida				x		x	x		x	P4	
Globanomalina compressa				x						P6-10	
Morozovella aragonensis				x					x	P7-11	
Paragloborotalia? pseudocontinuosa				x						P21-M6	
Parasubbotina varianta				x					x	P1-5	
Acarinina primitiva						x		x		P4-12	
Acarinina pseudotopilensis						x	x	x	x	P6-10	
Acarinina spinuloinflata							x			P9-14	
Chiloguembelina sp.							x				
Globanomalina pseudomenardii							x			P4	
Morozovella apanthesma							x			P3-4	
Morozovella praeangulata							x			P2-3	
Subbotina cancellata							x			P2-4	
Acarinina broedermanni								x		P8-12	
Acarinina mckannai						x		x		P4	
Globanomalina chapmani									x	P3-5	
Igorina tadjikistanensis									x	P3-6	
Subbotina angiporoides									x	P14-20	
Subbotina eocaena									x	P10-17	
Subbotina hagni									x	P10-16	

Tab. 2: continued.

Within the assemblages of calcareous nannoplankton the following species are considered as autochthonous:

Coccolithus pelagicus (Wallich) Schiller
Dictyococcites bisectus (Hay, Mohler & Wade) Bukry & Percival
Reticulofenestra lockerii (Müller)
Cyclicargolithus floridanus (Roth & Hay) Bukry
Cyclicargolithus abisectus (Müller) Wise
Pyrocyclus hermosus Roth & Hay
Helicosphaera cf. *recta* Haq
Sphenolithus cf. *distentus* (Martini) Bramlette & Wilcoxon
Pontosphaera latelliptica (Baldi-Beke & Baldi) Perch-Nielsen
Pontosphaera cornifera Lehotayova
Transversopontis pulcher (Deflandre in Deflandre &Fert) Perch-Nielsen
Triquetrorhabdulus carinatus Martini

Some of the above mentioned species were used as index fossils in Martini's zonation and/or their FO or LO (first/last occurrence) was used for definition of the Late Oligocene – Early Miocene biozonal boundaries (Martini, 1971). New studies showed a broader stratigraphical range for some of these species (*Helicosphaera recta* has been reported from NP 21–NP 22, *Cyclicargolithus abisectus* and *Triquetrorhabdulus carinatus* from NP 23 Zones (Aubry, 1995; de Kaenel & Villa, 1996). The only reliable nannofossil datum is the LO of *Sphenolithus*

Well POYSDORF 2 Calcareous Nannoplankton	core 21, 2814.60 m	core 21, 2815.10 m	core 21, 2816.30 m	core 21, 2817.05 m	core 21, 2817.40 m
Coccolithus pelagicus	x	x		x	
Cyclicargolithus floridanus	x	x		x	
Dictyococcites bisectus	x	x		x	
Reticulofenestra lockerii	x				
Pontosphaera cornifera	x			x	
Pontosphaera latelliptica	x	x		x	
Triquetrorhabdulus carinatus	cf.				
Arkhangelskiella cymbiformis		x		x	BARREN
Aspidolithus parcus		x			
Dictyococcites filewiczii		x			
Eiffelithus turriseiffelii		x			
Reinhardtites anthophorus		x			
Transversopontis zigzag		x			
Discoaster binodosus				x	
Watznaueria barnesae				x	
Zygrhablithus bijugatus				x	

Tab. 3: Well Poysdorf 2: Calcareous nannoplankton.

Well POYSDORF 2 Foraminifera	**core 21**	2814.45 m	2816.15m	2817.22 m	2817.45 m	**cuttings**	2770 m	2780 m	2790 m	2800 m	2810 m	2830 m	2840 m	2850 m	2860 m	2870 m
agglutinated foraminifera:																
Hyperammina rugosa		x	x		x											
Bogdanowiczia sp.		x	x	x	x											
Saccorhiza ramosa		x	x	x	x			x					x			
Subreophax sp.		x	x		x											
Repmanina charoides		x		x							x					x
Karreriella chilostoma		x														
Psammosiphonella cylindrica			x		x		x	x	x			x	x	x	x	x
Silicobathysiphon sp.			x												x	x
Ammodiscus cretaceus			cf.	x										x		
Ammodscus tenuissimus					x											
Haplophragmoides horridus							x	x			x		x	x	x	
Spiroplectammina spectabilis							x									
Bathysiphon / Rhizammina								x	x		x	x	x	x	x	x
Tritaxia szaboi								x								
Eggerella irregularis								x					x			
Recurvoides spp.								x	x				x	x	x	x
Karreriella subglabra									x						x	
Haplophragmoides spp.											x					
Vulvulina haeringensis													x		x	x
Karrerulina coniformis													x	x		
Miliammina cf. *paleocenica*													x			x
Reticulophragmium amplectens														x		
calcareous benthics:																
Lenticulina spp.		x		x	x			x					x		x	x
Uvigerina vicksburgensis		r					x									
Virgulinella chalkophila		x		x												
Buliminella acicula		cf.														
Bulimina elongata		cf.														
Chilostomella ovoidea		x		x							x					x
Oridorsalis umbonatus		x					x			x	x		x			
Nummulites sp.		r														
Asterigerina sp.		r			r											
Pararotalia lithothamnica		r												x		
Uvigerina acutocostata					x											
Stilostomella spp.					x		x		x				x	x	x	x
Cibicidoides borislavensis					x								x	x		
Cibicides amphysiliensis					x											

Tab. 4: Well Poysdorf 2: Foraminifera; r= reworked.

Well POYSDORF 2 Foraminifera	**core 21**	2814.45 m	2816.15m	2817.22 m	2817.45 m	**cuttings**	2770 m	2780 m	2790 m	2800 m	2810 m	2830 m	2840 m	2850 m	2860 m	2870 m
Gyroidinoides girardanus							x	x					x	x	x	x
Gavelinella acuta							x						x			
Chrysalogonium elongatum							x	x							x	
Neugeborina sp.								x								
Nodosariella tuberosa								x								
Pullenia bulloides/quinqueloba								x					x		x	x
Cibicidoides cf. *pachyderma*								x						x		
Charltonina budensis									x							
Dentalina acuticosta									x					x		x
Melonis pompilioides									x							x
Asterigernata sp.										x			x	x		x
Globocassidulina subglobosa											x					
Uvigerinella majcopica											x					
Heterolepa eaocaena													x		x	x
Globocassidulina globosa													x	x		x
Lobatula sp.													x			
Valvulineria wittpuyti													x			x
Alabamina abstrusa													x			
Cassidulina alabamensis													x	x	x	
Anomalinoides affinis													x			
Anomalinoides granosus														x		
Alabamina wolterstorffi														x		
Uvigerina hantkeni														x		
Cancris subconicus														x		
Bulimina arndti															x	x
Bulimina alsatica																x
Uvigerina tenuistriata																x
planktic foraminifera:																
Globigerina labiacrassata		cf.		x												
Globigerina officinalis		x		x	x		x	x	x	x	x	x		x	x	x
Globigerina ouachitaensis		x		x	x			x	x	x	x	x			x	
Globigerina praebulloides		x		x	x		x	x	x	x	x	x			x	
Globigerina wagneri		x							x							
Subbotina praeturritilina		cf.		cf.												
Paragloborotalia? inaequiconica		x														
Globigerina brevis				x	x		x		x		x	x				
Globigerina ciperoensis					x											
Globigerinella obesa					x											
Subbotina linaperta					r									x	x	

Tab. 4: continued.

Well POYSDORF 2 Foraminifera	**core 21**	2814.45 m	2816.15m	2817.22 m	2817.45 m	**cuttings**	2770 m	2780 m	2790 m	2800 m	2810 m	2830 m	2840 m	2850 m	2860 m	2870 m
Subbotina cryptomphala					r					x			x			
Subbotina hagni							x									
Subbotina utilisindex							x		x			x	x	x	x	
Catapsydrax unicavus							x	x	x		x	x	x		x	x
Paragloborotalia?																
pseudocontinuosa							x				x				x	
Paragloborotalia opima nana								x	x					x	x	
Paragloborotalia opima opima								x	x							
Globigerina angulioffcinalis									x	x	x	x		x		
Globigerina gnaucki									x		x					
Globigerina krosniensis									x	x	x	x	x	x	x	
Subbotina angiporoides									x						cf.	
Subbotina gortanii										x		x	x			
Globorotaloides suteri										x	x		x		x	
Catapsydrax primitivus										x	x			x	x	x
Tenuitellinata angustiumbilicata											x					
Globigerina? ampliapertura													x	x		x
Subbotina galavisi													x	x	x	x
Subbotina prasaepis													x		x	x
Subbotina tripartita														x	x	
Catapsydrax dissimilis															x	
Globigerina? euapertura															x	

Tab. 4: continued.

distentus indicating the top of NP 24 biozone. *Pontosphaera cornifera* was described from Upper Oligocene – Lower Miocene sediments of the Central Paratethys.

Most planktic foraminifera in Thomasl 1 are reworked from Eocene and Paleocene, whereas in Poysdorf 2 in the cuttings a strong downhole contamination of Lower Oligocene marls with rich plankton masks the autochthonous elements. A greater part of the agglutinated foraminifera fauna is indicative of abyssal deposition depth (flysch type agglutinated fauna of Gradstein & Berggren, 1981) and is reworked from Upper Cretaceous to Paleocene. According to preservation, stratigraphic range and paleoecological indications, the reworked or contaminated species have been sorted out. The remaining assemblage may correspond to the original composition of the fauna of the Thomasl Formation. To verify the autochthonous foraminifera assemblages, samples from the Thomasl Formation in the Ottenthal reference sections with only occasional reworking have been studied.

The following planktic species are characteristic of the middle part of the Oligocene in the Central Paratethys and the Thomasl Formation (Cicha et al., 1998):

Beella rohiensis (POPESCU & BROTEA)
Catapsydrax primitivus (BLOW & BANNER)
Globigerina ampliapertura (BOLLI)
Globigerina anguliofficinalis BLOW
Globigerina ciperoensis BOLLI
Globigerina? euapertura JENKINS
Globigerina officinalis SUBBOTINA
Globigerina ouachitaensis HOWE & WALLACE
Globigerina wagneri RÖGL
Globigerinella megaperta RÖGL
Globigerinita juvenilis (BOLLI)
Globoquadrina globularis BERMUDEZ
Globoquadrina winkleri (BERMUDEZ)
Globorotaloides suteri BOLLI
Paragloborotalia opima nana (BOLLI)
Paragloborotalia opima opima (BOLLI)
Paragloborotalia? pseudocontinuosa (JENKINS)
Subbotina gortanii (BORSETTI) ?
Subbotina praeturritilina (BLOW & BANNER)
Tenuitella munda (JENKINS)

The supposedly autochthonous benthic foraminifera faunas (partly unpublished material of PAPP et al., 1978) consist of:

agglutinated species:
Ammodiscus cretaceus (REUSS)
Ammodiscus tenuissimus GRZYBOWSKI
Bathysiphon taurinensis SACCO
Bogdanowiczia sp.
Cribrostomoides subglobosus (CUSHMAN)
Dorothia cf. *germanica* CUSHMAN
Eggerella? irregularis (HANTKEN)
Glomospira gordialis (JONES & PARKER)
Glomospirella gibbosa SUBBOTINA
Haplophragmoides carinatus CUSHMAN & RENZ
Hyperammina rugosa VERDENIUS & VAN HINTE
Karreriella siphonella (REUSS)
Miliammina paleocenica KIESEL
Plectina dalmatina (SCHUBERT)
Psammosiphonella cylindrica (GLAESSNER)
Reophax pilulifer BRADY
Repmanina charoides (JONES & PARKER)
Reticulophragmium amplectens (GRZYBOWSKI)
Rhabdammina sp.
Rhizammina algaeformis BRADY
Saccorhiza ramosa (BRADY)
Silicobathysiphon sp.
Tritaxia szaboi (HANTKEN)
Tritaxilina pupa (GÜMBEL)
Vulvulina haeringensis(GÜMBEL)
Vulvulina spinosa CUSHMAN

calcareous benthics:
Alabamina wolterstorffi (FRANKE)
Anomalinoides affinis (HANTKEN)
Anomalinoides capitatus (GÜMBEL)
Anomalinoides granosus (HANTKEN)
Bolivina crenulata CUSHMAN
Bulimina alsatica CUSHMAN & PARKER
Bulimina arndti HAGN
Cassidulina alabamensis BANDY
Caucasina schischkinskayae SAMOYLOVA
Charltonina budensis (HANTKEN)
Chilostomella ovoidea REUSS
Cibicides amphisyliensis (ANDREAE)
Cibicicoides borislavensis AISENSTAT
Cibicidoides dalmatinus (VAN BELLEN)
Cibicidoides filicosta (HAGN)
Cibicidoides lopjanicus (MYATLIUK)
Cibicidoides mexicanus (NUTTALL)
Cibicidoides cf. *pachyderma* (RZEHAK)
Cibicidoides tenellus (REUSS)
Cibicidoides ungerianus (d'ORB.)
Globocassidulina globosa (HANTKEN)
Gyroidinoides altiformis (R.E.& K.C. STEWART)
Gyroidinoides girardanus (REUSS)
Gyroidinoides parvus (CUSHMAN & RENZ)
Hemirobulina hantkeni (BANDY)
Hoeglundina elegans (d'ORBIGNY)
Kolesnikovella tubulifera (KAASCHIETER)
Lenticulina spp.
Marginulina behmi (REUSS)

Melonis affinis (Reuss)
Melonis pompilioides (Fichtel & Moll)
Oridorsalis umbonatus (Reuss)
Pleurostomella acuta Hantken
Praeglobobulimina bathyalis (Reiser)
Praeglobobulimina primitiva (Todd)
Praeglobobulimina pupoides (d'Orb.)
Pseudonodosaria inflata (Bornemann)
Pullenia bulloides (d'Orb.)
Pullenia quinqueloba (Reuss)
Quadrimorphina petrolei (Andreae)
Robertina declivis (Reuss)
Svratkina perlata (Andreae)
Uvigerina hantkeni Cushman & Edwards
Uvigerina multistriata Hantken
Uvigerina rustica Cushman & Edwards
Uvigerina steyri Papp
Uvigerina tenuistriata Reuss
Uvigerinella majcopica Krajeva
Valvulineria palmarealensis (Nuttall)
Valvulineria wittpuyti Van Bellen
Virgulinella chalkophila (Hagn)

From the original material, described by Papp et al. (1978) a slide with figured foraminifera and a Plummer slide with specimens from Thomasl 1 (core 1760–1765 m) have been re-studied.

Papp et al., 1978:		this revision:
pl. 1, fig. 1:	*Uvigerina steyri steyri* Papp	*Uvigerina multistriata* Hantken
pl. 1, fig. 2:	*Uvigerina steyri steyri* Papp	*Uvigerina steyri* Papp
pl. 1, fig. 3:	*Uvigerina steyri steyri* Papp	*Uvigerina multistriata* Hantken
pl. 1, fig. 5–7:	*Uvigerina steyri steyri* Papp	*Uvigerina steyri* Papp
pl. 1, fig. 8–10:	*Uvigerina gallowayi* Cushman	*Uvigerina popescui* Rögl
pl. 2, fig. 1:	*Cyclammina acutidorsata* (Hantken)	*Reticulophragmium amplectens* (Grzybowski)
pl. 2, fig. 2:	*Ammodiscus incertus* (d'Orbigny)	*Ammodiscus pennyi* (Cushman & Jarvis)
pl. 2, fig. 3:	*Anomalinoides grosse rugosus* (Gümbel)	*Anomalinoides granosus* (Hantken)
pl. 2, fig. 4–5:	*Glomospira charoides charoides* (Jon. & Park.)	*Repmanina charoides* (Jones & Parker)
pl. 2, fig. 6:	*Glomospira charoides corona* (Cushm. & Jarv.)	*Repmanina charoides* (Jones & Parker)
pl. 2, fig. 7:	*Glomospira gordialis* (Jon. & Park.)	*Glomospira gordialis* (Jones & Parker)
pl. 2, fig. 8:	?*Glomospirella* sp.	*Ammodiscus glabratus* Cushman & Jarvis
pl. 2, fig. 9:	?*Glomospirella* sp.	*Glomospirella* sp. or *Ammodiscus* sp.

6.2. Depositional environment

Autochthonous foraminifera with common agglutinated deep-water forms, e.g., *Repmanina, Glomospira, Glomospirella, Psammosiphonella,* and *Reticulophragmium amplectens* point to a rather deep (bathyal) deposition depth. Calcareous benthics, e.g. *Alabamina abstrusa, Anomalinoides capitatus, Bulimina subtruncana, Cassidulina alabamensis, Charltonina budensis, Cibicidoides dalmatinus, Cribroparella pteromphalia, Pleurostomella acuta, Uvigerina rustica, U. steyri* indicate an upper to middle bathyal environment.

7. BIOSTRATIGRAPHIC RESULTS

The stratigraphic range of the Thomasl Formation is based primarily on calcareous nannoplankton in combination with planktic foraminifera, and for regional stratigraphy and correlation on some selected species of benthic foraminifera. This age determination follows the chronostratigraphic subdivision of Berggren et al. (1995) and the regional correlation system of Rögl (1998) and Rögl et al. (1998).

Nannofossil assemblages present in the studied samples are mostly dominated by reworked Late Cretaceous, Paleocene, Early Eocene and Middle Eocene species (Tabs. 1,3). Some samples (Thomasl 1, core 3, 1762.3m) contain pure Late Cretaceous assemblages without any younger species and it was difficult to decide whether these assemblages were autochthonous or not. Sample Thomasl 1, core 3, 1763.25m contained a genuine Early Eocene (NP 12) assemblage. In other samples (except of Thomasl 1, core 3, 1761.15m and Poysdorf 2) the Oligocene species are rare or occur only sporadically. *Reticulofenestra lockerii, Cyclicargolithus abisectus, Helicosphaera* cf. *recta, Pontosphaera cornifera, Sphenolithus* cf. *distentus, Triquetrorhabdulus* cf. *carinatus* were found in the samples. As discussed above, these species have been reported to have a slightly broader stratigraphical range than originally mentioned. Common occurrences of *Cyclicargolithus abisectus* (NP 23–NN 1), *Triquetrorhabdulus* cf. *carinatus* (NP 23-NN 3), *Helicosphara* cf. *recta* (NP 22-NN 2), and *Sphenolithus* cf. *distentus* (NP 23–NP 24) lead to the conclusion that the studied samples from Thomasl 1 well were of Early Oligocene (upper part of NP 23) to Late Oligocene (NP 24) age. As *Sphenolithus distentus* was not present in Poysdorf 2 samples, these could be of Late Oligocene (NP 25) age.

The foraminifera assemblage, which is considered as autochthonous, corresponds to the middle part of the Oligocene in the Central Paratethys (comp. Cicha et al., 1998; Olszewska, 1985; Olszewska in Malinowska & Piwocki, 1996; Rusu et al., 1996). The stratigraphically most important planktic species is *Paragloborotalia opima opima*. The total range of it defines the "*Globorotalia*" *opima opima* zone of Bolli (1957), Bolli & Saunders (1985) and by the LAD (last appearance datum) marks the top of zone P 21, the *Globigerina angulisuturalis/Paragloborotalia opima opima* concurrent range zone of Blow (1969) and Berggren et al. (1995). This LAD falls within the lowermost nannoplankton zone NP 25. Early Oligocene markers are subbotinids with *Subbotina gortanii* and *S. praeturritilina*, and a restricted occurrence is also reported for *Tenuitella munda* from the "*Globigerina*" *angiporoides* and *Globigerina euapertura* zones (about P 19/20–21) in New Zealand (Hornibrook et al., 1989), and from P 20–21 in Trinidad and the

Gulf Coast (Li Qianyu, 1987). Of more regional importance are *Beella rohiensis, Globigerina wagneri* and *Globigerinella megaperta* with a range from the upper part of Kiscellian to Early Egerian (Cicha et al., 1998).

To define the lower boundary of the Thomasl Formation the occurrence of planktic foraminifera and calcareous nannoplankton has been checked. The LAD of *Globigerina? ampliapertura* marks the base of zone P 20 within the upper nannoplankton zone NP 23 (Berggren et al., 1995). This species was found in the lower part of the reference section of the Thomasl Formation in the Ottenthal outcrop of the farmhouse L. Hauer.

In the comparative sections at Ottenthal another stratigraphically important species, *Chiloguembelina gracillima,* has been found in shales of the Thomasl Formation in zone NP 24 (Rögl et al., 1997). The occurrence of the related *Chiloguembelina cubensis* (Palmer) defines the upper boundary of planktic foraminifera subzone P 21a within nannoplankton zone NP 24. By the range of *P. opima opima* and *T. munda* the upper part of the Thomasl Formation at Ottenthal approximates the P21/P22 boundary.

Some of the occurring benthic species are important for regional correlation. An ecostratigraphic marker for the Lower Puchkirchen Formation in the Molasse Basin is *Psammosiphonella cylindrica* (Glaessner), which was determined formerly as *"Rhabdammina linearis"*. This species is common in the Thomasl Formation, especially in drill site Poysdorf 2. Another agglutinated species is *Reticulophragmium amplectens* (Grzybowski), with a range from the Eocene to the Early Egerian on the top of the Lower Puchkirchen Formation. A correlation between the Egerian of the Puchkirchen Formation in the Molasse Basin and the Thomasl Formation in the Waschberg Unit was given by Papp et al. (1978) with *Uvigerina steyri* Papp. A differentiation between Upper and Lower Puchkirchen Formation by means of an evolutionary lineage of this species as proposed by Papp (1975) cannot be followed.

The Thomasl Formation biostratigraphically corresponds to nannoplankton zones of uppermost NP 23 to lower NP 25 (?) or to planktic foraminifera zones P 20 to 22 (?). In the regional stage system this formation extends from the Late Kiscellian to the Early Egerian.

8. REVISED DEFINITION OF THE THOMASL FORMATION

Type area: Waschberg Unit (Lower Austria)
Type Section: Well Thomasl 1, 1636–1763 m
Co-ordinates: 16°24'15,94" E, 48°32'1,70' N
Reference Sections: Well Poysdorf 2 and surface outcrops in the Ottenthal area (Waschberg Unit, Lower Austria)
Synonyms: Bunte Tone, Pausramer Schiefer and Menilithschiefer (Jüttner, 1938); Niemtschitzer Schichten, upper part (Grill, 1953); Ottenthaler Schichten, upper part (Seifert, 1982).
Lithology: Dark brownishgrey to patchy greenishgrey, partly black, strongly slickensided, fissile, slightly calcareous shale and clay showing sporadically thin, medium- to coarse-grained sandstone interlayers and thin intercalations of dark grey marl and calcareous mudstone. The sediment contains commonly glauconite, occasionally considerable amounts of diatoms, fish scales and isolated pyrite nodules.

Fossils: Autochthonous, stratigraphically important calcareous nannoplankton species are *Cyclicargolithus abisectus, Helicosphaera* cf. *recta, Reticulofenestra lockerii, Pontosphaera cornifera, Sphenolithus* cf. *distentus, Triquetrorhabdulus* cf. *carinatus.*
Stratigraphically useful planktic foraminifera of the Thomasl Formation are *Paragloborotalia opima opima, Globoquadrina globularis, Globigerina? ampliapertura, Globigerina ciperoensis, Gg. officinalis, Gg. wagneri, Globigerinella megaperta, Tenuitella munda, Chiloguembelina gracillima.* The first or last appearances of following benthic foraminifera are used for regional correlation: *Bolivina crenulata, Charltonina budensis, Psammosiphonella cylindrica, Reticulophragmium amplectens, Tritaxia szaboi, Uvigerina multistriata, U. steyri.*
Facies: The benthic foraminifera assemblages indicate a deeper environment from an outer shelf to upper bathyal in well Poysdorf 2 and the Ottenthal area, whereas in the well Thomasl 1 an increased number of Flysch-type agglutinated foraminifera points to an upper to middle bathyal deposition depth. Alternations of non-calcareous, barren dark shales and calcareous shales with benthic faunas are interpreted as depending on changing dysaerobic or oxygenated bottom conditons.
Chronostratigraphic age: Oligocene, Late Kiscellian to Early Egerian
Biostratigraphy: Calcareous nannoplankton zones upper NP 23 to lower NP 25 (?); planktic foraminifera zones P 20 to lower P 22 (?).
Thickness: At least 127 m (drilled section = measured section) in well Thomasl 1 (base is cut off by thrust), in well Poysdorf 2 the Thomasl Formation reaches a tectonically reduced thickness of 91 m (measured section). In adjacent seismic x-sections thickness is expected of about +/– 100 m.

Base Unit: Well Thomasl 1: tectonic position of Lower Eocene of the Waschberg Unit;
Well Poysdorf 2: tectonic position of Klement Formation (Upper Cretaceous)
Ottenthal area: Ottenthal Formation

Superimposed Unit: Well Thomasl 1: Eggenburgian sediments
Well Poysdorf 2: Ottnangian/Eggenburgian sediments ("Fischfazies")
Ottenthal area: erosive contact with Pleistocene gravel

Comments: Reference material (cores, cuttings; microfauna) is archieved in OMV Vienna, Laboratory for Exploration and Production (LEP), core magazine. Additional samples (foraminifera and calcareous nannoplankton) are stored in the Museum of Natural History, Vienna.

9. LITHOSTRATIGRAPHIC AND BIOSTRATIGRAPHIC CORRELATIONS WITH SOUTHERN MORAVIA AND THE AUSTRIAN MOLASSE BASIN

Southern Moravia

The Thomasl Formation is expected to continue towards the north-east into Southern Moravia into the Zdanice Unit (Fig. 4). Similar sediments are described as the Sitborice Beds or as the Sitborice Member (Stranik et al., 1974; Stranik, 1981). These beds comprise the upper part of the "Menilitic Fm.". The sequence is composed of dark

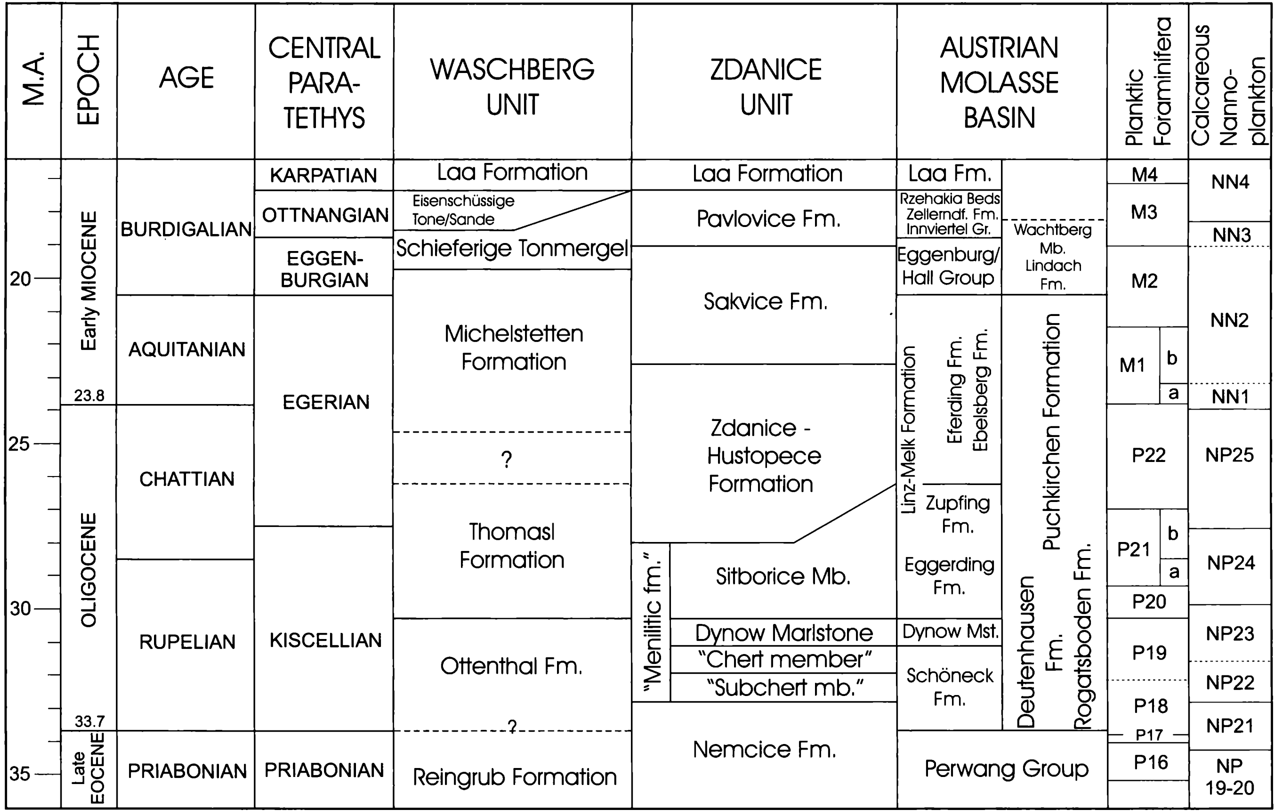


Fig. 4: Stratigraphic correlation of Waschberg Unit, Zdanice Unit and Austrian Molasse Basin.
[biostratigraphic correlation acc. Berggren et al. (1995); Paratethys stage correlation acc. to Rögl (1998); Waschberg and Zdanice Units acc. Krhovsky et al. (this volume); Molasse Basin acc. Wagner (1996, 1998)].

brown, grey and greenish shales and claystones, occasionally with a violet and yellowish tint. The claystones are slightly calcareous or non-calcareous with a variable content of silts and sands. Frequent laminae and bands of jarosite, rusty Fe and black-grey Mn oxides, as well as white sand layers occur in the claystones. Bands of the brownish-grey silicified shales and cherts can be observed in the lower part of the section. Slump bodies of paraconglomerates occur in the lower part and intercalations of sideritic dolomitized limestones in the upper part.

The pelagic Sitborice Mb. rests unconformably upon the Dynow Marlstone and gradually pass to the overlying Zdanice-Hustopece-Formation. The boundary between the Sitborice and Zdanice-Hustopece Formation corresponds to the bottom of the first sandstone layer. The basal intercalation of slumps and pebbles is considered to be the combined result of eustatic sea level fall and tectonic activity, and is named the basal "Sitborice Event" (KRHOVSKY & DJURASINOVIC 1993). The Sitborice Member accompasses nannoplankton zones NP 23 and NP 24 with possible inclusion of NP 25 (JURASOVA, 1987; BUBIK, 1987, 1993; KRHOVKY & DJURASINOVIC, 1993). The Sitborice Member of the Zdanice and Subsilesian Flysch units can be correlated with variegated clays of the Uhercice Formation in the Pouzdrany Unit. Their time equivalents, supposed to be in an autochthonous position, have also been described by HAMRSMID et al. (1990) from the Nesvacilka Graben (wells Uhrice 1, Uhrice 2, Uhrice 10) and from the Nikolcice – Kurdejov Ridge (well Nemcicky 1).

The Thomasl Formation and the Sitborice Member are partly identical as indicated by lithology and microfossil content (upper NP 23 to NP 24/25[?]). An outer shelf to upper bathyal deposition depth in well Poysdorf 2 and in the Ottenthal sections is indicated by the foraminiferal assemblages. These are similar to the Sitborice Member, dominated by calcareous benthics in distinct layers (comp. JURASOVA, 1987). In the Thomasl 1 section the benthic faunas are dominated by strong reworking, but also show a higher content of deep water agglutinated species, indicating a deeper, upper to middle bathyal environment. The presence of low diversity nannoplankton blooms in thin layers, together with silicified layers in the studied sections compares well with sections in the Zdanice Unit.

Austrian Molasse Basin

Correlation of the Thomasl Formation with the Austrian Molasse Basin sediments and Waschberg Unit shows significant differences. A sequence of dark shales rest unconformably above the Dynow Marlstone ("Heller Mergelkalk") in the Waschberg Unit, but has a conformable relationship within the Molasse Basin. These so-called "Bändermergel", banded marls comprising the Eggerding Formation (WAGNER, 1998) are a sequence of laminated, non-calcareous to slightly calcareous silty shales with thin laminae of calcareous nannoplankton. In the Thomasl-Formation however such nannoplankton laminae are more scarce and ,additionally, silicified diatomaceous layers occur. However, assemblages of nannoplankton are similar with blooms of one or a few species. In the Eggerding Formation bioturbation and benthic foraminifera generally are absent. On the other hand in the Thomasl Formation variable foraminifera assemblages are present in a few thicker bioturbated layers.

In the younger Molasse sequences, sedimentation differs from the Waschberg Unit. Here the stratigraphic equivalent of the upper Thomasl Formation comprises the socalled "Rupel-Tonmergel", Rupel-shales of the Zupfing Formation (WAGNER, 1996, 1998). This formation is characterized by increasing clastic input with dark grey calcareous pelites and distal turbidites, deposited under condition of improved bottom circulation as indicated by bioturbation and rich benthic foraminifera assemblages. Large planktic foraminifera are similar to the Thomasl Formation. The nannoplankton assemblages of the Zupfing Formation are diversified, dating the formation as zone NP 24 to NP 25 (?).

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