JAHRBUCH DER GEOLOGISCHEN BUNDESANSTALT
Jb. Geol. B.-A. | ISSN 0016–7800 | Band **143** | Heft 4 | S. 543–566 | Wien, Dezember 2003

Some Field Observations and Remarks on the Gmünd Beds of the Northwestern Waldviertel Region (Lower Austria)

KARL HEINRICH HUBER*)

17 Text-Figures, 1 Table

Niederösterreich
Waldviertel
Südböhmisches Becken
Gmündner Schichten
Klikov-Formation
Oberkreide
Santon
Senon
Lithofazies
Palynologie

Österreichische Karte 1 : 50.000
Blätter 4–6, 18, 19

Inhalt

Einige Geländebeobachtungen und Bemerkungen zu den Gmünder Schichten des nordwestlichen Waldviertels (Niederösterreich)

Zusammenfassung

Der vorliegende Aufsatz versucht den gegenwärtigen Stand der geologischen und stratigraphischen Erforschung der Gmünder Schichten sowie der südböhmischen Sedimentformationen zu überblicken und stellt eine Auswahlbibliographie unveröffentlichter Archivmaterialen wie publizierter Fachliteratur zusammen. Einige Feldbeobachtungen an Gmünder Schichten werden dokumentiert, darunter ein im Jahre 1982 in der Baugrube des Allgemeinen Öffentlichen Krankenhauses Gmünd aufgeschlossenes Profil, worin sich ein geringmächtiges Kohlenflöz fand. Daraus wurde eine Kohlenprobe entnommen, die von Peter Andreas HOCHULI palynologisch und von Martin VINZENZ kohlenpetrographisch analysiert wurde. Die vorläufigen Ergebnisse deuteten darauf hin, dass die Gmünder Kohle stratigraphisch mit der oberkretazischen südböhmischen Klikov-Formation korreliert. Mit modernen mikroskopischen Untersuchungsmethoden konnte Reinhard ZETTER im Jahre 2002 die reiche Mikroflora beschreiben, sie dem Santon, d.h. laut GRADSTEIN et al. (1955: 106) einem Alter von ~85,8 bis ~83,5 Mio. Jahren, zuordnen und die Korrelation bestätigen. Weiters wird auf jüngere Schotter und Gerölle aus dem Raume Dietmanns bei Gmünd im Süden der Gmünder Bucht hingewiesen, die unidentifizierte Kieselhölzer enthalten.

*) KARL HEINRICH HUBER, Pfeilgasse 31/18, 1080 Vienna.

Abstract

The paper presented tries to give a short outline of the latest developments in the geological and stratigraphical research of the Gmünd Beds and of the South Bohemian sediment formations, as well as a selected bibliography of unpublished archive material and printed literature. Some field observations on Gmünd Beds are documented, among them a bed succession, opened in 1982 at the foundation pit of the Common Public Hospital in Gmünd. Here a thin coal seam was found, from which a coal sample has been taken. The brown coal's petrography was examined by Martin VINZENZ, and its palynology by Peter Andreas HOCHULI. The preliminary results indicated a stratigraphical correlation of the coal from Gmünd with the Upper Cretaceous South Bohemian Klikov Formation. In 2002, Reinhard ZETTER, using modern microscope technology, was able to describe the rich microflora, to assign it to the Santonian, i.e., following GRADSTEIN (1995: 106), to an age of ~85. 8 to ~83,5 million years, and to confirm the correlation. Furthermore, gravels and pebbles are discussed, bearing unidentified silicified woods and spreading around the village of Dietmanns near Gmünd, which is situated in the southern part of the Gmünd Bay.

1. Introduction

Near Gmünd, (a small town in the northwestern corner of Lower Austria, a region commonly known as the Waldviertel, and separated from its neighbouring municipality České Velenice by the border between Austria and the Czech Republic), thick sediment series, lowered into the crystalline of the southeastern Bohemian Massif, cross the Austrian boundary, running from the NW to the SE. These sediment series are mainly extended within the two South Bohemian Basins (Text-Fig. 1), in the České Budějovice Basin (Českobuděovická pánev/Budweiser Becken), and in the Třeboň Basin (Třeboňská pánev/Wittingauer Becken), which by some authors have been regarded as a singular entity, the South Bohemian Basin, occupying a total area of some 2.300 km^2.

Like a bay, their furthermost SE-end narrows into the northwestern Waldviertel region. This small Austrian part of the Třeboň Basin is mainly limited to the community district of Gmünd, and to its nearest environs. Leo WALDMANN (1936: 46; 1943: 6, 7; 1951: 15; 1952: 50, 51, 52, 53) named it "Gmünder Bucht" – a term already earlier used by Rudolf ROSENKRANZ (1925: 8) and by Franz KASMANHUBER (1931: 5) meaning Gmünd Bay – and its sediment-fillings, which continue into South Bohemia, he named "Gmünder Schichten" (WALDMANN, 1951: 16; 1958: 10), in Czech "Gmündské souvrství", or "serie gmündská", or "vrstvy gmündské", meaning Gmünd Beds.

Although the Gmünd Beds in Austria cover an area of only about 50 km^2 at a rough estimation, their stratigraphical correlation with the South Bohemian sediment series may be important for a future reconstruction of the earth's history of the previous sediment cover of the southeastern Bohemian Massif, which today is extensively eroded.

2. The Gmünd Bay

With regard to geomorphology, the Gmünd Bay represents a shallow depression with altitudes of 530–470 m a.s.l. (above sea level), embedded within a hummocky highland which slopes down from levels between 650 and 485 m a.s.l.

In general, the bay's interior topography is characterized by low relief energy ratios, and is modelled by evennesses or low, gently konvex hills. Pleistocene fluvial gravel-terraces (of detritus derived from the nearby crystalline surroundings of the bay [ROETZEL & KURZWEIL 1986: 211–212]), developed on Gmünd Beds, run along the river Lainsitz. This river meanders on a widening flood plain N of Gmünd through the Gmünd Bay and enters the Czech Republic some 5 km downstream of the town, changing its name to "Lužnice". The alluvial plain environment of this river with its meander loops, shallows, dead waters (oxbows), riverine valley ponds, wet meadows, etc., shows such really outstanding ecological variety that it has been protected both in Bohemia as the Protected Landscape Area Třeboňsko and in its Austrian part – which in the vernacular is called "Wasserfeld" or "Bachwiesen" – as the area "Lainsitzniederungen" by the Ramsar-Convention no. 1013 (1999), an international agreement on conservation and wise use of wetlands.

From a hydrographical point of view, the Gmünd Bay represents the biggest groundwater reservoir of northwestern Lower Austria (GROSSAUER, 1991a: 14). It is of vital importance for the water supply (BERGER, 1980: 25–38. 1989: 12–15; PAUKNER, 2003: 109) and for the economy of many thousands of people in the Waldviertel region and in southern Bohemia. The sediment fillings of the Gmünd Bay contain a system of irregularly distributed and subdivided aquifers (WOLFBAUER, 1993a: 9; KOROŠ, RAUCH & LARGE, 1996: 22) with complex groundwater streams (KRÁSNÝ, 1980, Fig. 41), which is sensitive to human interference (BERGER, 1977: 7–8; GROSSAUER, 1991a: 4) and which, between 1967 and 1990, was subjected to phreatic maximal fluctuations of between only a few meters and a remarkable <7 meters, documented at a sand pit at the village Breitensee (GROSSAUER 1991b: 16; ERHART-SCHIPPEK 1993a: 11; 1993b: 13. 1993c: 4th enclosure).

2.1. The Crystalline Surroundings of the Gmünd Bay

The Gmünd Bay (Text-Fig. 2), like the South Bohemian Basins, is at a distinctly lower ground level than the surrounding crystalline etchplain, where on the Czech side of the basin mostly gneisses and schists prevail.

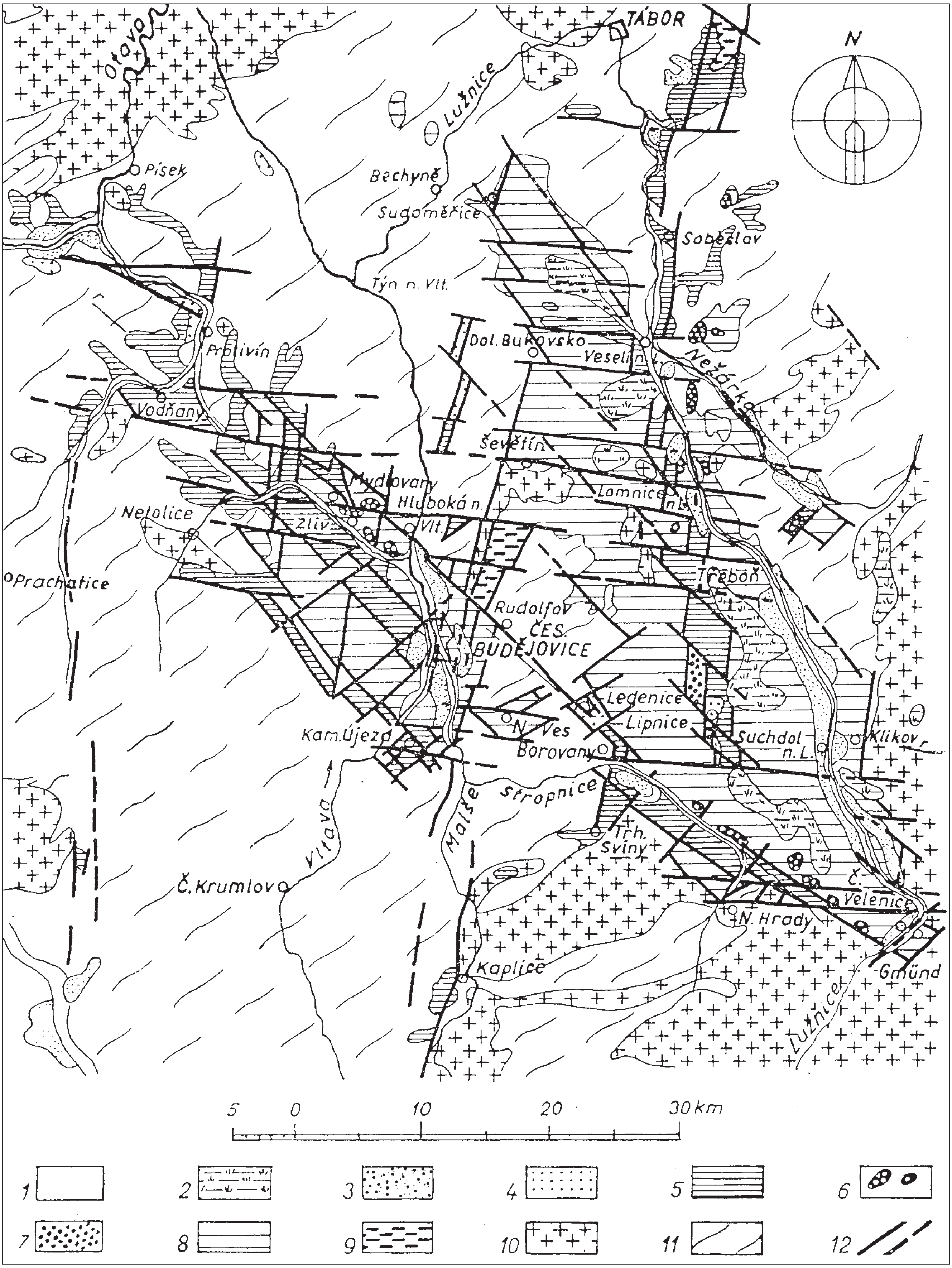
On the Austrian side of the basin mainly granitoids can be found: With regard to expanse, the first place is taken up by the coarse-grained, biotitic Weinsberg granodiorite-type with kalifeldspar megacrysts, and by the medium- to fine-grained two-mica Eisgarn granite type and its varieties. Less expanded are the fine grained biotitic Mauthausen granite type, younger dikites of these granitoids. greisens as well as quartzmonzodiorites and quartzmonzonites. All the above-mentioned magmatites together represent multiple Variscan intrusions, building up a complex batholith, referred to as South Bohemian Pluton by the Austrian, and as Central Massif of the Moldanubian Pluton by the Czech geologists. Residuals of the almost totally erosively destructed gneiss mantle of the pluton (biotite-plagioclase gneisses, cordierite gneisses of the Monotonous Series) are exposed locally.

Thus the unroofed, hilly etchplain-surface flanking the Gmünd Bay is shaped predominantly by granitoid landforms due to rock structure, weathering and erosion (HUBER, 1999), developed as a typical boulder-strewn, undulating peneplain, well preserved, for example, in the lovely nature park "Blockheide Eibenstein" near Gmünd (HUBER, 2000).

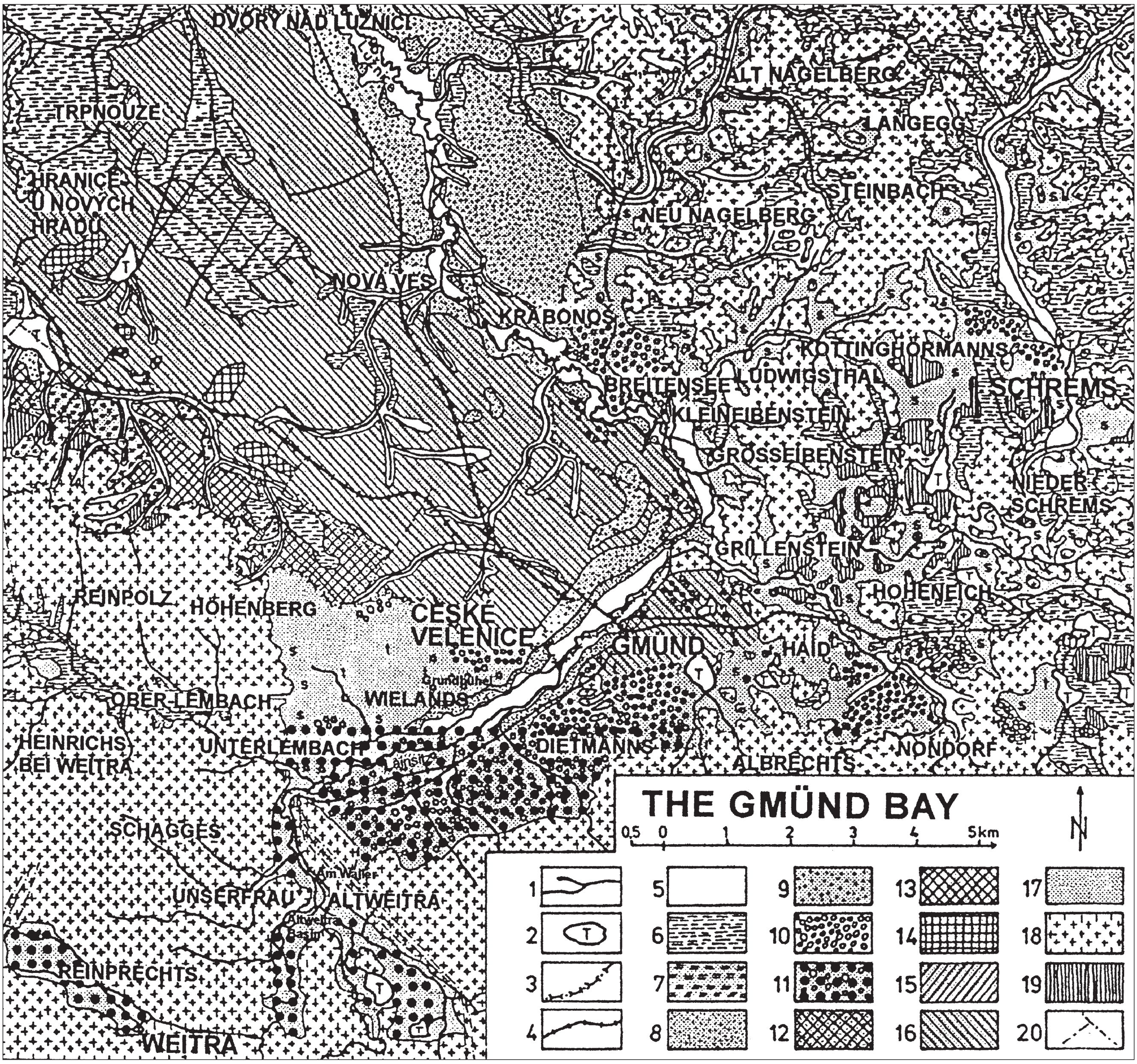
3. The Gmünd Beds

3.1. Tectonics and Spreading of the Gmünd Beds

Along wide stretches, tectonic lineaments or faults, running NW–SE and NNW–SSE, or at a right angle to these



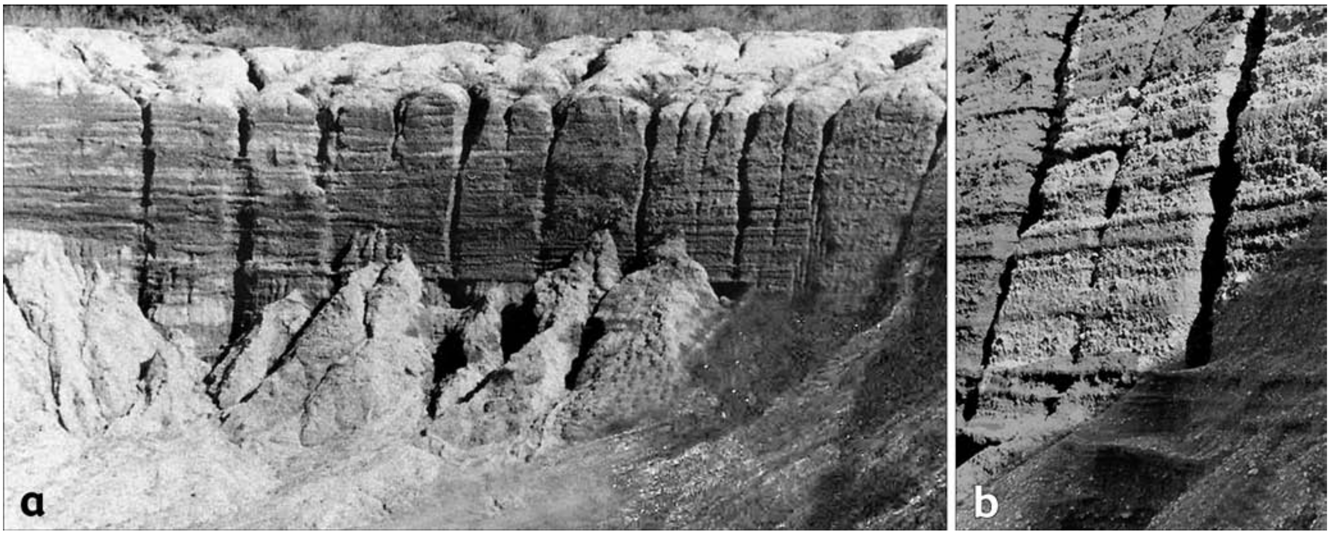
Text-Fig. 1.
Geological map of the South Bohemian Basins, compiled by MALECHA (1964, Fig. 73).
1 = Alluvium (Holocene); 2 = peat bog (Holocene); 3 = terrace gravel (Pleistocene); 4 = Ledenice Formation (Pliocene); 5 = Mydlovary Formation (Miocene); 6 = Zliv Formation (Miocene); 7 = Lipnice Formation (Oligocene); 8 = Klikov Formation (Senonian); 9 = Permo-Carboniferous; 10 = igneous rocks (granite, syenite); 11 = crystalline schists and other metamorphics (biotite paragneiss, migmatite, orthogneiss, and others); 12 = faults.



Text-Fig. 2.
Geological sketch of the Gmünd Bay, compiled by K.H. Huber.
This compilation effort is due to a very resolute generalization of the maps published by Waldmann (1950), Erich & Schwaighofer (1977; Austrian part) and by Malecha (1977; Czech part), although the maps are all very different in conception and scale. The representation of the sediments in the map by Slabý & Holásek (1992) is identical with Malecha (1977).
1 = watercourses; 2 = ponds; 3 = Austrian-Czech border; 4 = railways; 5 = alluvium and meadow loams (Holocene); 6 = peats (Holocene); 7 = solifluidal loam, degraded loessloam, in places flying sands (dunes) (Pleistocene); 8 = lower terraces (Pleistocene); 9 = Pre-Würm accumulations, mainly fluviatile (Pleistocene); 10 = quartz pebble occurrences of uncertain age (around Dietmanns containing silicified woods), belonging to the Gmünd Beds; their spreading out of the Gmünd Bay, still unmapped, is not on the sketch; 11 = sediments of uncertain age, after Waldmann (1951), representing the uppermost Gmünd Beds, after Erich & Schwaighofer (1977) Quaternary in general; 12 = upper unit of the Mydlovary Formation (Miocene); 13 = lower unit of the Mydlovary Formation (Miocene); 14 = Zliv Formation (Miocene); 15 = upper unit of the Klikov Formation (Upper Cretaceous); 16 = lower unit of the Klikov Formation (Upper Cretaceous), belonging to the Gmünd Beds; 17 = sediments of unknown age, belonging to the Gmünd Beds and showing a predominantly sandy (s) or a predominantly muddy (t) environment; 18 = plutonic rocks in general; 19 = gneiss in general; 20 = probable faults or lineaments. As a detailed reproduction of the complex pattern of photolineations in the Austrian part would make the little sketch illegible, cp. Buchroithner (1984).

directions, define the boundaries of the Gmünd Bay. Most evidently, the basin's margins are predetermined by fault structures along the following sections:

1) Some 6 km W of Gmünd the Austrian village Höhenberg (Text-Fig. 2) is situated on a hill called Lagerberg (650 m a.s.l.). Quite abruptly the northeastern Lagerberg slope falls some 150 m down to the edge of the Třeboň Basin, marking a graben, the Stropnice graben, which runs for more than 20 km from the NW to the SE in the direction of Gmünd, but before reaching the town, it ends abruptly still on the Czech territory E of Höhenberg, at a transversal threshold of the basin's bottom (Malecha, Staník et al., 1977: 25). Plumbed with Miocene deposits of the Mydlovary Formation (mentioned below) which vary in thickness between only a few and several tens of meters, these graben fillings are interpreted as a former episodical communication with the sea of the Alpine-Carpathian Foredeep, from where marine ingressions temporarily reached the South Bohemian Basins during the Miocene (ibidem: 9).



Text-Fig. 3.
Quarry on the right embankment of the rivulet Buschenbach, some 100 m S of the chapel in the village Ulrichs near Weitra (~2,5 km SW of Altweitra).
a) Sandstones and conglomerates in an 8 m high quarry face.
b) Detail from the same quarry face in Ulrichs near Weitra. The sandstones and conglomerates are intercalated by several loam-, iron-oxide- and coal seams. Today the former quarry is beveled and covered with vegetation.
Photos: B. SCHWAIGHOFER, September 1966.

2) The western and southwestern boundary of the Gmünd Bay corresponds with the eastern flank of the Lagerberg spurs and with the northeastern slope of the Eichberg ridge horst, N of the ancient village of Altweitra (Text-Fig. 2). This granite rift block, running NW–SE and reaching a height of 588 m a.s.l., separates the basin outliers named Altweitra Basin (HAUER, 1952: 31; see Text-Fig. 2), from the Gmünd Bay sensu strictu (HAUER, 1952: 34). These sediment outliers fork out into two branches, southwards upstream the river Lainsitz towards Weitra and southwestwards upstream the rivulet Buschenbach. This is also where
   " ... upstream of the village Wetzles ... "
   Rupert HAUER (1924: 15), parish priest of Dietmanns and author of excellent home-studies, had noted
   " ... the finding of osteocolla ... ",
   plant-pseudomorphisms and
   " ... tubelike limonite-precipitates, filling the place of rotted roots, having assumed their shape".
   At Ulrichs near Weitra SCHWAIGHOFER (1967: A44; 1978: 13) found planar gravel- and sandbeds, interlayered by several loam-, iron-oxide- and coal seams more than 20 m thick altogether – as they could be seen in an 8 m deep quarry app. 100 m S of the chapel (Text-Fig. 3a,b) together with some other smaller exposures. WALDMANN (1951: 16), obviously referring to KREBS (1929, Fig. 110), postulated a partially sediment-filled furrow, running from Altweitra via Ulrichs bei Weitra and Wetzles southeastwards across the Wörnharts saddle to Jagenbach, communicating with sediment deposits in the Zwettl and Kamp valleys – a hypothesis which was rejected by HAUER (1963: 68).
3) Considerable parts of the Gmünd Bay's southern boundaries undoubtedly are determined by tectonic lineaments, forming topographically significant, rectilinear slopes, e.g. S and SE of Dietmanns (a village 4 km WSW of Gmünd), and S of Gmünd (Text-Fig. 2).
4) In the same way, the NNW–SSE-running stretch of the eastern boundary of the Gmünd Bay between the villages of Grillenstein und Großeibenstein (Text-Fig. 2) is controlled by a block fault (the eastern master marginal fault of the Třeboň Basin – deduced by BERGER [1980: 42]). The marginal block is penetrated by a transverse valley section of the rivulet Braunau, thus forming a spectacular granite slope in Grillenstein, named "Grillensteiner Felswand" by DWIRKA (1911, no. 22), the Grillenstein rock wall.

3.2. Problematic Limits of the Gmünd Beds

But not on all sides the margin of the Gmünd Bay is contoured sharply in the terrain. In many places erosional remnants of Gmünd Beds overlap the crystalline framework of the basin.

The limits of the Gmünd Beds are the least clearly distinguishable against the local autochthonous crystalline saprolite within a zone eastwards of the stretch between Grillenstein and Asangteich, a local pond. From here eastwards, the expansion area of the deposits is perforated by residual boulders and little, barely emerging inselbergs, thus divided into numerous more or less small, mostly shallow sediment troughs, partly isolated from each other, partly communicating with others, forming sediment stains or islands, embedded along active or former valleys within the incompletely exhumed weathering front of the local etchplain. From this eastern periphery of the Gmünd Bay, sediments which are only partially identified cross in an ESE-ward direction the present European main watershed, which locally forms a valley floor divide, known as "Mulde von Gmünd-Vitis", the flat Gmünd-Vitis trough (GRUND, 1915: 180). They partly extend northwards along the upper Thaya valley, and partly ESE-wards along Schwarzenau and Allentsteig to Horn. The last-mentioned trough-fillings which have not been eroded have led SCHAFFER (1914: 81) to postulate a river, the braided "Horner Strom", the Horn stream, which he supposed to have flown across the Waldviertel region in an ESE direction. The stream accumulations, which STEININGER & ROETZEL (1991: 71 etc.) called St. Marein-Freischling Formation (see below), interlock with marine Eggenburgian sediments.

Isolated from the Gmünd Bay or from certain Gmünd Beds, the following stratigraphically undefined sediment occurrences are noteworthy among others:

1) A larger muddy area between the villages Gopprechts – Thaures near Eisgarn – Wielings, some 13 km NNW of Gmünd (WALDMANN, 1938a; STEININGER & ROETZEL, 1999: 73);

2) the Reinprechts Basin (HAUER, 1952: 31; see Text-Fig. 2) with brick pelites, and
3) the Ober-Lehmbach Basin (HAUER, 1952: 34. cf. Text-Fig. 2), running parallel to the above-mentioned Stropnice-graben from the village Ober-Lehmbach (8 km ESE of Gmünd) northwestwards to the frontier village Pyhrabruck on the flat Malše-Lainsitz divide. In 1973 at the northwesternmost end of Pyhrabruck a well was dug in muddy sediments, in which my friend Michael HERMANN, Vienna, who has an expert knowledge of the local geology, found a pelitic layer with hundreds of marcasite-rhizomorphs.

3.3. A Short Outline of the Research History and the Geological Character of the Gmünd Beds

Franz RIEPL (1822: 280) wrote of thin iron clay beds, exposed at the surface, extending from Gmünd to Veselí nad Lužnicí/Wesely, which can be found

"... within sand- and loam-filled synclines".

Paul Maria PARTSCH (1824: 16–17) noted down the sediment successions of ironstone mines near the villages Klikov/Klikau, Chlum u Třeboně/Chlumetz and Rapšach/Rothenschachen, 11–21 km NNW of Gmünd, mentioning clays bearing single wood trunks, of compact iron stone beds (limonite ore), occasionally with leaf impressions, and of sands, consisting of quartz and feldspar grains.

Franz Xaver ZIPPE (1841: X, XVIII) used the terms "Budweis Plain", "Wittingau Plain", sketched their sediments and outlined them as Tertiary formations.

During the first general mapping by the Kaiserlich-Königliche Geologische Reichsanstalt – i.e. the then Austrian geological survey – Constantin Freiherr VON ETTINGSHAUSEN (1852) recognized plant fossils in an iron clay that had been sampled near Třeboň by Ferdinand VON LIDL, and which later on were identified by August Emanuel Ritter VON REUSS (1854: 81) as

"... numerous leaf impressions of dicotyledons".

Marcus Vincenz LIPOLD (1852: 103) wrote that the "tertiary basin of Gmünd" is connected with the "tertiary basin of Wittingau [Třeboň]" and that it was possible to determine the age of the latter by plant remnants included in claystone beds and red ironstone beds.

Johann CŽJŽEK (1854) gave a precise description of the freshwater sediments of the South Bohemian Basins, mentioning, among other things, their lignite seams and, in places, their silicified wood. He subdivided the bed succession of the basins in a lower succession and in an upper section.

Underneath Gmünd, inexploitable coal seams were recorded at least as early as 1862 by Franz PATZNICK (1874: 18), then municipal secretary of Gmünd.

In 1902 Carl KORTE & Co. (1903) dug sixteen hydrogeological exploration wells at both Lainsitz embankments between Gmünd and the village of Breitensee (Text-Fig. 2) to a depth of max. 15.1 m below the surface, and an expert opinion by Prof. Arthur OELWEIN (1904) resulted in first insights in the succession of the sediment beds of the Gmünd surroundings.

The newspaper articles "Gmünd Bahnhof. Geologisches" (1905; "Gmünd railway-station. Geological remarks") and "Gmünd. Unser Tertiär" (1906; "Gmünd. Our Tertiary sediments"), misinterpreted coal seams, e.g. 1 m below the then railway station of Gmünd (today of České Velenice), as ash of burnt plants.

In 1908 the chaplain and catechist Friedrich DWIRKA (1911, no. 17), founder of the Town Museum Gmünd, tried to reconstruct from numerous waterpipe trenches dug in the old-town of Gmünd the following local ideal profile, which he took from the bottom upwards to be: granite, thin blue loam, up to 6 meters thick sand with

"... fine layers of sandgrains, most different in shape and colour". a *"thin layer of silvery shining, white to bright grey clay ... "*

and uppermost

"... 4 to 5 meters thick bluish grey loam."

Around 1910 the current knowledge of the South Bohemian basin sediments, for which KATZER (1904, 1905) used the term "Binnenlandtertiär" (i.e. Inland Tertiary), was extensively revised.

REININGER (1907; 1908: 488) compared the results of numerous borings in the České Budějovice Basin and consequently partly called the stratigraphical subdivision by CŽJŽEK (1854) and Franz Ritter VON HAUER (1869: 47–48) in question.

After Josef Emanuel HIBSCH (1913: 487–490, 499) had reviewed many plant fossils of South Bohemia, he related the sediments of the Třeboň Basin to the Oligocene. Except for Wilhelm Josef PETRASCHECK (1926–29: 465; 1929: 362), who judged their age as

"... not more than Tertiary",

HIBSCH's stratigraphical classification stayed undisputed for a long time.

In 1929 on the premises of the textile processing factory in Gmünd, Weitraer Straße 115, a boring was drilled through numerous variegated sand- and mudstones. At a depth of 24.25–24.50 m and 25.0–25.20 m it penetrated

"... black clay (shale) ... " (Lagerung der Bodenschichten etc., 1929)

most probably two coal layers. Richard ENGELMANN (1938: 95) documented a 5 m deep profile of

"... clayey, ferriferous, intensively consolidated, in parts significantly lamellar sand with quartz, mica and usually kaolinized feldspar",

exposed in a brick earth deposit (with beds, dipping to the W [Rupert HAUER, 1952b: 31]), exploited then, but abandoned and recultivated today, situated at about 454 m a.s.l., N of the pass Am Waller, by the western side of the road crossing the Eichberg-ridge-horst.

The former production of earthenware and stoneware of sediments from the Gmünd Bay and its surroundings has a long tradition: Already since late medieval resp. early modern times potters' guilds have existed in Weitra, Gmünd, Litschau, Heidenreichstein, and probably in Schrems (HAUER, 1951: 107–114).

In several places temporarily small quantities of bricks of inferior quality have been baked for the local needs, e.g. at Gmünd, Wielands, Reinprechts, Am Waller etc. (RAUSCHER, 1931: 115–116), Kleineibenstein and Gopprechts. Nevertheless, in this area all clay deposits explored in the recent past – "Tonfunde im Waldviertel" (1932), MAYRHOFER (1935: 82), LECHNER (1949, 1953), OSTADAL (1953), RIEDL (1959) – seemed to be unworkable resp. unprofitable for an exploitation by industrial ceramics for a prolonged period.

The first person to realise the Cretaceous age of sediments in Klikov – a village, some 17 km NNW of Gmünd - from *Aralia decurrens, Aralia formosa* and *Credneria laevis* impressed into greyish mudstones, was the Czech paleontologist František NĚMEJC (1938a; 1938b).

The petrographer Rudolf OSTADAL (1942), who later became custodian of the Town Museum Gmünd, a friend of WALDMANN, documented a 200 m long, 1–2 m deep exposure of Gmünd Beds, opened along the railway line for a short time, 200–400 m ESE of the present Austrian railway-station's waiting-hall at Gmünd. This cutting was dominated by a sandy, light grey to bluish grey, partially brownish clay, containing single quartz pebbles of varying grain sizes, with an average size of 8–10 cm in diameter. In places they were arranged in pebble-strings.

PETRASCHECK (1944, Fig. 26 and p. 101) reported sedimentary quartzites (Knollensteine)

" ... from the environs of Gmünd ... ",

without giving any particulars.

During many years the Austrian petrographer Leo WALDMANN (1930: 40–41; 1931: 31–32; 1932: 33–34; 1933: 28; 1934: 30; 1935: 26; 1936: 46–47; 1937a: 58–59;1937b: 145; 1938a, 1938b: 118;. 1943: 6–8; 1958, 1966, 1966/67, 1967) geologically mapped the northwestern Waldviertel and recorded its sediments. In the following statement (WALDMANN, 1951: 15–16) the Gmünd Beds represent

" ... flat-lying, multicoloured, alternating, mostly sandy clays to sands of various grain-sizes, here and there containing dispersed lines of quartz-pebbles. The sand- and clay-layers are not continuous ..., but are interlocked and often lenticulated. Locally, some sand beds are cemented by clay or brown haematite. Frequently the rock basement has been kaolinized, disintegrated into boulders and consolidated into boulder pavements. W of the Gmünd Bay, between Borovany and Ledenice, a diatomite-layer is included in the clays. There is a significant difference between these pelites together with their associated deposits and younger, cross-bedded, coarse and fine, quite thick sandbeds, now and then containing pebble strings. These younger sands overlay or lean against the furrowed Gmünd Beds, and where the Gmünd Beds have been removed from the basement erosively, these younger sands cover crystalline rocks or lean against them.

Borings within the basin W of Gmünd showed a thickness of more than 100 m. In the alluvial plain of the river Lainsitz near Klein-Eibenstein, the crystalline basement is situated ... [about 45 m below the terrain], *and near the Austrian railway station of Gmünd granite was cut ...* [at a level of up to 30 m below the surface]. *The old-town of Gmünd is located on a granite-island, an old cut-off, mantled by Gmünd Beds. ... Numerous eminences of the granite underground within the continental ... Gmünd* [Beds] *point to a well dissected granite landscape, buried by fresh-water deposits. ... Marine or brackish formations are completely lacking. ... Thus the hypothesis of a drainage from Bohemia is rather probable"*

During the turbulent times of the Second World War and of the years afterwards NĚMEJC's (1938a,b) really great discovery remained nearly unnoticed outside Czechoslovakia. Though most important for the stratigraphical knowledge of the South Bohemian Basins, it became internationally known only as late as during the fifties and sixties. For example, VETTERS (1947: 41–42), DORN (1951: 263–264) and HAUER (1952: 15–16) saw the sediments as Tertiary, and even PAPP & THENIUS (1962) wrote that the age of the Gmünd Beds was

" ... doubtful (?Miocene) ... ".

3.4. The South Bohemian Sediments

3.4.1. Trendsetting Czech Findings on the Geology of the South Bohemian Sediments

But in the meantime, many Czechoslovakian earth scientists had turned their attention towards the South Bohemian sediments. Intensive field-work was carried out and numerous, mainly paleontological articles on localities of the České Budějovice and Třeboň Basin, were published. As it is not possible here to mention all deserving Czech pioneers, cp. the extensive bibliography by CHÁBERA (1987, 1989). The multitude of new geological discoveries required a new terminology of the Mesozoic and Tertiary stratigraphical units of the South Bohemian Basins, which had been termed and characterized during a working conference, held at České Budějovice in 1960 (MALECHA & ŠPINAR, 1960), resulting in the following stratigraphical units separated by hiatuses: Klikov Formation, Lipnice Formation, Zliv Formation, Mydlovary Formation and Ledenice Formation (MALECHA & ŠPINAR, 1962). Later, MALECHA (1964: 423–424; 1966: 592) assumed that the Klikov Formation is an equivalent to the Gmünd Beds, and that it was probably deposited simultaneously with the Lower and Middle Gosau Beds in the Northern Calcareous Alps. In 1968, the uppermost part of the Mydlovary Formation was recognized through diatoms as an indvidual stratigraphical unit (ŘEHÁKOVÁ, 1969a, b, c) and was named Domanín Formation (Text-Fig. 1).

3.4.2. The Stratigraphy of the South Bohemian Basins

Thus the stratigraphy of the South Bohemian Basins can be differentiated into sediment series, specified below (see MALECHA, 1964, 1966; SLANSKÁ, 1974; MALECHA & SUK, 1985; CHÁBERA, 1998):

The up to 340 m thick Klikov Formation, which before 1960 was subsumed in the terms pestrá série (meaning variegated sequence or varicoloured series), or Zliv Series, or Zliv-Gmünd Series, overlays the deeply weathered crystalline basin floor, or buries – only locally within the České Budějovice Basin – Upper Paleozoic and Permo-Carboniferous graben fillings respectively, called Budějovice Formation or Českobudějovice Formation. It contains fluviolacustrine freshwater sediments and, according to paleontological and palynological research, belongs to the Upper Cretaceous.

After a hiatus of some 30 million years, the freshwater sedimentation of the 30 m thick Lipnice Formation set in, not earlier than towards the end of the Paleogene. Although unfossiliferous, it seems to be Oligocene, because of its petrology – basal unconsolidated sands and gravels or limonite-cemented conglomerates. Above them sandy kaolinic clays, which frequently show dark red and purple stains, superimposed by whitish grey to yellowish brown kaolinic sandstones and uppermost by a typical greyish yellow quartzite-layer – are very similar to Oligocene sediments of Northwest Bohemia.

The nearly 20 m thick (?Helvetian resp. ?Ottnangian–Carpathian) Zliv Formation as well as the max. 120 m thick (?Tortonian resp. ?Badenian) Mydlovary Formation contain diatomites, demonstrating their Lower to Middle Miocene age and in part their brackish origin, indicating repeated – at least four – short ingressions from the Alpine-Carpathian syncline. In biostratigraphical respect both formations are nearly analogous. However, they are interrupted by a diastem, and their lithology is different: While the Zliv Formation consists of basal greyish green sandy clays with sand lenses, gradually changing from bottom to top into strongly silicified sandstones and conglomerates (e. g. the "Zliv conglomerate", forming topographical elevations), the Mydlovary Formation bears basal greyish-green clayey sands or sandstones, changing as one moves upwards into olive-green clays, dark-grey coaly clays and xylites, uppermost buried by greenish diatomaceous clays.

The max. 30 m thick (?Sarmatian–?Pontian) Domanín Formation, characterized by grassgreen or greyish green sandy clays to clayish sands with thin coal inserts (ŘEHÁKOVÁ, 1991: 156), as well as the almost 20 m thick

Table 1.
Mineralogical, petrographical and geological features of the sediment formations of the South Bohemian Basins.
From SLANSKÁ (1974), slightly modified.

Formation	ČESKO-BUDĚJOVICE FORMATION	KLIKOV FORMATION	LIPNICE FORMATION	ZLIV FORMATION	MYDLOVARY FORMATION	LEDENICE FORMATION
Age	Pre-Upper Cretaceous	Upper Cretaceous	Oligocene	Miocene(?Helvetian ?Carpathian)	Miocene (?Tortonian -?Pontian)	Pliocene
Main rock types	Conglomerates, sandstones, shales	Conglomerates, sandstones, mudstones, sandy and/or silty claystones	Gravels, sands, conglomerates (siliceous cement), sandstones, quartzite (quartz-limonite cement)	Conglomerates, sandstones (clayey quartz cement), sandy clays (silicified), volcanic conglomerate	Gravels, sands, sandstones, clays, claystones, diatomite, lignite, marl, tuffs, tuffites	Sands, sandy clays, diatomite
Cyclic sedimentation	Present	Pronounced	Absent	Absent	Absent	Absent
Main components of sand fractions	Quartz, orthoclase, plagioclase, muscovite, biotite, chlorite, calcite, plant fragments	Quartz, orthoclase, microcline, plagioclase, biotite, muscovite, chlorite, plant fragments	Quartz, minor feldspars (altered)	Quartz, pyroclastic material (volcanic glass), plant fragments, tests of diatoms	Quartz, feldspars, biotite, pyroclastic material	Quartz, tests of diatoms
Main components of clay	Mica, smectite, chlorite, kaolinite, limonite, silica	Kaolinite, illite, limonite, hematite, organic matter	Kaolinite, limonite, hematite, silica	Kaolinite, smectite, limonite, silica, organic matter	Kaolinite, smectite, illite, limonite, silica, calcite, organic matter	Kaolinite, illite, limonite
Siderite	-	Major amount	-	Accessory amount	Accessory am.	-
Calcite	Concretions, euhedral grains	-	-	-	Micrite (major amount in the Třeboň Basin)	-
Others	Anatase, biotite	Mineral of the crandallite group	-	-	Quartzine	-
Heavy minerals	Apatite, garnet, zircon, tourmaline, rutile	Zircon, tourmaline, rutile, kyanite, opaques, andalusite, staurolite, monazite, spinel. In places: corundum (VRÁNA,1991)	Zircon, tourmaline, rutile, kyanite, opaques, monazite, andalusite, staurolite, spinel	Zircon, tourmaline, rutile, kyanite, opaques, anatase, andalusite, garnet, clinozoisite, monazite, staurolite, sillimanite, spinel, sphene	Zircon, tourmaline, rutile, zoisite, kyanite, garnet, sillimanite, epidote, amphibole, etc.	-
Crystallinity of kaolinite	Poorly-ordered pseudomonoclinic	Well-orderded triclinic	Well-ordered triclinic to poorly-ordered pseudomonoclinic	Poorly-ordered pseudomonoclinic	Poorly-ordered pseudomonoclinic	Poorly-ordered pseudomonoclinic
Cement	Quartzose, carbonaceous	Ferrugineous (limonite, hematite, siderite), barite	Ferrugineous, quartzose	Ferrugineous, siliceous (opal), quartzose	Quartzose, ferrugineous, calcareous	Quartzose
Bedding type and other characteristic features	Cleavage, slickensided fractures, weak metamorphism	Massive, cross-bedding, graded bedding, horizontal	Horizontal	Undistinctive	Cross-bedding, horizontal	Horizontal
Environment and conditions of deposition	Lacustrine	Fluvial, lacustrine, alluvial fans, flood plains, river-channels, lakes	Lacustrine	Fluvio-lacustrine	Fluvio-lacustrine, river channels, overbank floods, backswamps, lakes	

Pliocene Ledenice Formation, with typical bluish grey sands and sandy kaolinic clays, locally including brown coaly clays, represent lacustrine environments. For more mineralogical, petrographical and geological details, cp. Table 1. Furthermore, moldavite-bearing sediments with a quite problematic Upper Miocene to Holocene stratigraphy (BOUŠKA, 1972; BOUŠKA & KONTA, 1986: 26–35) occur locally in both South Bohemian Basins.

During the Quaternary, relatively thin sediments, namely fluvial accumulations (especially river terraces), talus material, solifluidal sands, dune sands, weathering residuals, and peat bogs among others were deposited.

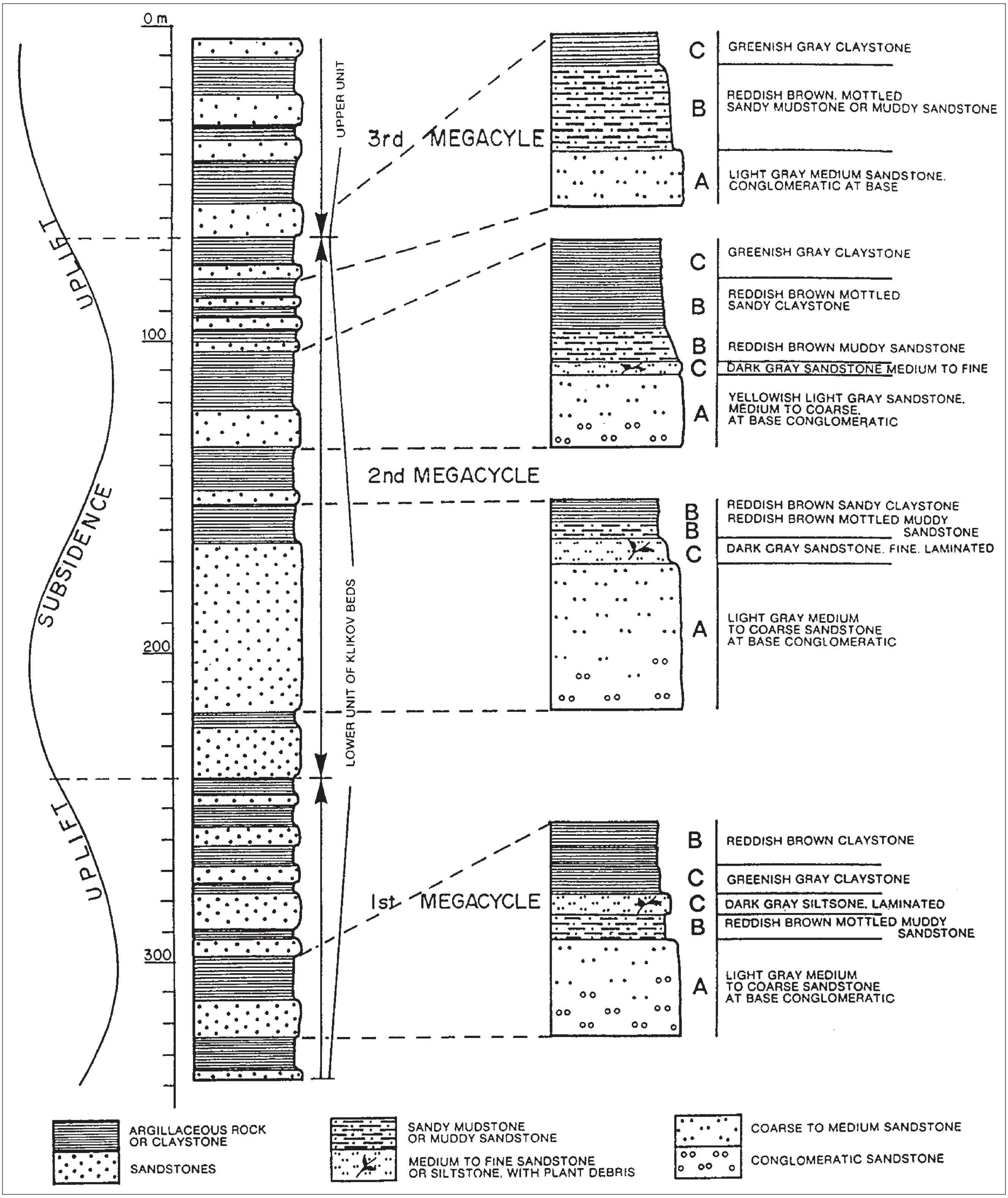
3.4.3. The Klikov Formation

3.4.3.1. Biostratigraphy

Among those who compiled remarkable outlines of the paleoflora of the Klikov Formation have been NĚMEJC (1961), NĚMEJC & KVAČEK (1975) and KNOBLOCH (1985).

The macroflora is characterized by fossil leafs, impressed into grey clays or reddish ferriferous sandstones (documented by NĚMEJC, 1955, 1968; KNOBLOCH, 1964. NĚMEJC & KVAČEK, 1975), e.g. of *Platanophyllum laeve* (VELENOVSKÝ) NĚMEJC, *Debeya haldemiana* (HOSIUS et VON DER MARK) DE SAPORTA et MARION, *D. insignis* (HOSIUS et VON DER MARK) KNOBLOCH, *Araliophyllum elongatum* NĚMEJC, *A. němejcii* KNOBLOCH, *Quercophyllum gracile* (DEBEY) NĚMEJC, *Q. pseudodrymejum* (VELENOVSKÝ) NĚMEJC, *Myricophyllum serratum* VELENOVSKÝ sp. (SOUKUP, 1968).

While the *Geinitzia – Dammarites – Credneria – Platanophyllum – Quercophyllum – Debeya* taphocenose allows no more exact stratigraphical classification than Upper Cretaceous, since 1956 extensive paleopalynological investigations by Ms. PACLTOVÁ (1958, 1959) have shown a characteristi assemblage of pollen grains and spores, especially various repre-



Text-Fig. 4.
Generalized section through the sediments of the Klikov Formation, and the most common types of cyclothems.
From SLANSKÁ (1976, Fig. 2).

sentatives of the family Abietineae, many types of the *Normapolles* group (PACLTOVÁ, 1981) and spores of Pteridophyta, which point to an early Coniacian (without provably excluding Turonian) to a middle Senonian at the utmost – thus as a whole predominantly Santonian – sedimentation of the Klikov Formation. These results have been re-examined and proved true by Ms. PACLTOVÁ herself (PACLTOVÁ, 1990), who in recent years has been emphasizing the partly marginal character of the sedimentation facies (PACLTOVÁ, 1996, friendly postal information).

Paleocarpological analyses (KNOBLOCH & MAI, 1986) of coalificated fruits and seeds have ascertained 92 different genus within the Klikov Formation, which prove its Upper Turonian up to Santonian age and its similarity to the Senonian floras of the Aachen – Limburg area (KNOBLOCH, 1997).

The paleofauna is represented by abundant shells of Conchostraca, for example by the genus *Lioestheria* DEPÉRET et MAZERAN and *Lioestheria blanensis* HOUŠA et ŠPINAR of insects by tube-cases of the caddishflies Trichoptera and elytrons of beetles of the families Cupedidae, Curculionidae and Carabidae (HOUŠA & ŠPINAR, 1960).

3.4.3.2. Lithostratigraphy

The Klikov Formation is a terrigenous freshwater series of clastic sediments, sometimes with varying degrees of consolidation within one and the same stratum. In some cases, therefore, one and the same arenitic sediment could be rightly classified either as sand or sandstone. To simplify matters, in this chapter only the terms conglomerates, sandstones, mudstones and claystones will be used, subsuming all degrees of consolidation, even those of rather moderate compactness.

The Klikov Formation represents a more or less regularly repeated red bed association with the following bed types (SLANSKÁ, 1976: 138):

A) Light grey or light yellow [to light brown] sandstones, with grains ranging from coarse to fine, occasionally (near the base) conglomeratic, rarely laminated, often with graded bedding, interpreted as fluvial fans or channel sediments.
B) Finer-grained red beds, i.e. brownish red or brown or dark red medium to fine-grained muddy sandstones, sandy mudstones or sandy claystones, usually poorly sorted. Their red pigment – iron oxides or hydroxides – probably deriving from red upland soils from their source area, deposited on a flood plain or less frequently in shallow lakes.
C) Grey beds, i.e. greenish grey or very dark grey coarse- to fine-grained sandstones, mudstones and claystones with varying amounts of carbonized plant debris and pigment (coloured according to the amount of organic matter they contain), partly laminated, most probably swamp or lake deposits, and better sorted than A and B.

Quite monotonously, the mineralogical composition of the sand fractions of the three types is dominated by quartz, feldspar, mica and partly by lithic fragments (derived from the crystalline rocks surrounding the basin). Within their clay fractions they mainly contain kaolinite. Red beds and grey beds are mostly greywackes, subgreywackes or arcosic classes (SLANSKÁ, 1974: 391). The degree of roundness, in most cases subangular to angular, indicates textural immaturity and short sediment transport distances of some kilometres to few tens of kilometres (DOMÁCÍ, 1979: 149, 158). The three types of sediment alternate in asymmetrical cycles (SLANSKÁ, 1974: 391). Their lithological sequence outlined above, is an idealized one. In fact, the red beds and grey beds have no definite position in respect to each other, taking alternatively the second or third place within a sequence, which can be one meter to tens of meters thick. Each member can replace the other one, but red beds are more frequent than grey beds. SLANSKÁ (1974: 393–394, 1976: 139–145) interpreted the sequences as numerous small-scale cyclothems, forming large-scale cyclothems (Text-Fig. 4). The large-scale cyclothems are influenced by the paleogeographic changes and the tectonic development of the South Bohemian Basins. Owing to the rapid vertical and lateral variations of their sedimentary lithology, their usually graded bedding, poor sorting and near lack of fossils, the deposits are similar to the

"... fluviatile facies of molasse, known as 'flysch in molasse' ..." (SLANSKÁ, 1976: 135).

This means that the beds of the Klikov Formation

" ... were deposited from fluctuating currents and periodically overloaded streams in an alluvial and/or lacustrine environment, continuously suffering from tectonic unrest, emanating from the Alpine-Carpathian geosyncline." (SLANSKÁ, 1976: 135, 160).

The lateral expansion of a cyclothem is not great. The attempt to correlate individual sections from different parts of both basins, based on a single cyclothem, was not successful. It seems more realistic to assume larger units, composed of several cyclothems. From this follows that the Klikov Formation consists of three megacycles (Text-Fig. 4). The first, predominantly muddy megacycle, containing units rich in vegetable fragments and pigment, comprises 6–10 cyclothems. The second one, comprising 9–12 cyclothems, covers the first one totally and spreads beyond its boundaries. Coarse sandstones mark the base of the second megacycle, overlain by fine, mainly red sediments. The first and second megacycles fill the České Budějovice Basin completely, but in the Třeboň Basin they are restricted to its central and southern parts. They correspond to the lower unit of the Klikov Formation (which stretches into the Gmünd Bay). The third megacycle, consisting mainly of coarse sandstones alternating with multicoloured sandy claystones without grey beds, represents the upper unit of the Klikov Formation and extends over the České Budějovice Basin as a whole and over the northern and central part of the Třeboň Basin (SLANSKÁ, 1976: 142–144).

3.5. Observing and Examining the Gmünd Beds Macroscopically

The opinion, that sediments of the Klikov Formation continue from České Velenice to Gmünd (MALECHA, 1964: 413. 1966: 584; SOUKUP, 1968: 165; THENIUS, 1974: 36; DEL-NEGRO, 1977: 18; FUCHS, 1977: 238, 1980: 164. MALECHA, & SUK 1985: 38; TOLLMANN, 1985: 676; CHÁBERA, 1999: 22), meets with unanimous approval. However, their exact limits within the Gmünd Bay are not clear in detail, because this terrain lacks exposures.

Several excavations, opened during the last two decades around the old and new town of Gmünd (Text-Fig. 2), showed parts of the sediment formation lying near the top of the soil. I have described the most revealing ones.

Of all excavations I have tried to take photographs, but unfortunately some important pictures turned out to be of no use. A sketch profile has been drawn of all the bed successions, projecting the measured bed-thickness geometrically onto a vertical plane (Text-Fig. 13). I wish to express my thanks to the construction company LEYRER & GRAF, Gmünd, and to the district surveyor's office Gmünd for assisting me with gaining altitude dates of some of the exposures.

In the text below the bed thickness is given as I have measured it on its inclined cross sections. The colours of the pit-moist sediments, seen under natural daylight, are defined in the terms used by OYAMA & TAKEHARA (1970). The grain sizes have been estimated (by moistening half a handful of every sediment-sample up to its flow-limit, while kneading and rolling it between clean fingers) according to the definition of ATTERBERG (1905), and the roundness-degrees according to POWERS (1953).

If not specified differently, the bed-boundaries are continuous and horizontal or subhorizontal, the roundness-degrees of the sand fractions subangular to subrounded, the main sand-components being quartz and feldspar. As far as I have been able to find out, the uppermost bed or beds of the sediment-successions examined seem to be scarcely or not at all influenced by Pleistocene cryoturbation processes.

The following is a selection of some of the lithostratigraphical profiles of Gmünd Beds that I have documented: the bed successions I, II, III, IV and V. (Text-Fig. 5 shows their location.)

I) Western longside of the basement excavation of the house Bahnhofstraße 20, Gmünd, at the crossing Bahnhofstraße – Schlossparkgasse
(Austrian federal referencing grid [Bundesmeldenetz] 6909: easting: 650950, northing: 404575)

In January 1984 a surface inclined at about 70° was opened up, dipping to the E, exhibiting the following Gmünd Beds below a ground level of ~490 m a.s.l. (Text-Figs. 5, 6 and 12):

(I- 1) 0.00–0.35 m: Dull yellowish brown (10YR 5/4) muddy sand, anthropogenic.

(I- 2) 0.35–0.55 m: Greyish yellow brown (10YR 4/2) fine-sandy mud. Rooting. Lower bed-boundary wavy.

(I- 3) 0.55–0.90 m: Dull yellow orange (10YR 6/4) sandy mudstone with sporadic, white, subrounded to rounded medium-gravel of quartz up to 13 cm in diameter. Lower bed-boundary indistinct.

(I- 4) and **(I-5)** 0.90–1.50 m: Bright brown (7,5YR 5/6) to dark reddish brown (5YR 3/6) sandy mudstone with bluish grey (5BG 6/1) spots, which includes lenses of dull-reddish brown (5YR 5/4) to dull yellow (2,5Y 6/4) angular sandstone. Lower bed-boundary curved and blurred.

(I- 6) 1.50–1.72 m: Dull brown (7,5YR 5/4) sandy mudstone with light grey (10Y 7/1) and reddish brown (5YR 4/6) spots. It breaks into angular clasts. Bed-sole very sharp.

(I- 7) 1.72–1.77 m: Dull yellow orange (10YR 7/3 to 10YR 6/4) fine- to medium-grained sandstone, poor in mud. Grading to

(I- 8) 1.77–2.20 m: Light grey (7,5Y 8/2) to light yellow (2,5Y 7/3) fine to medium-grained sandstone, without or nearly without mud, subhorizontally laminated. Grading to

(I- 9) 2.20–2.35 m: Light greenish grey (5GY 7/1) muddy sandstone, containing some light yellowish brown (10YR 6/6) streaks. It fills a 25 cm elongated, planar lens, which in parts is underlain by a 2–3 cm flat seam of light greenish grey (10GY 8/1) fine-grained sandstone.

(I-10) 2.35–3.05 m: Dull yellow orange (10YR 6/4) muddy sandstone with light brown (7,5YR 5/6) and light brownish grey (7,5Y 7/1) streaks. Lower bed-boundary indistinct.

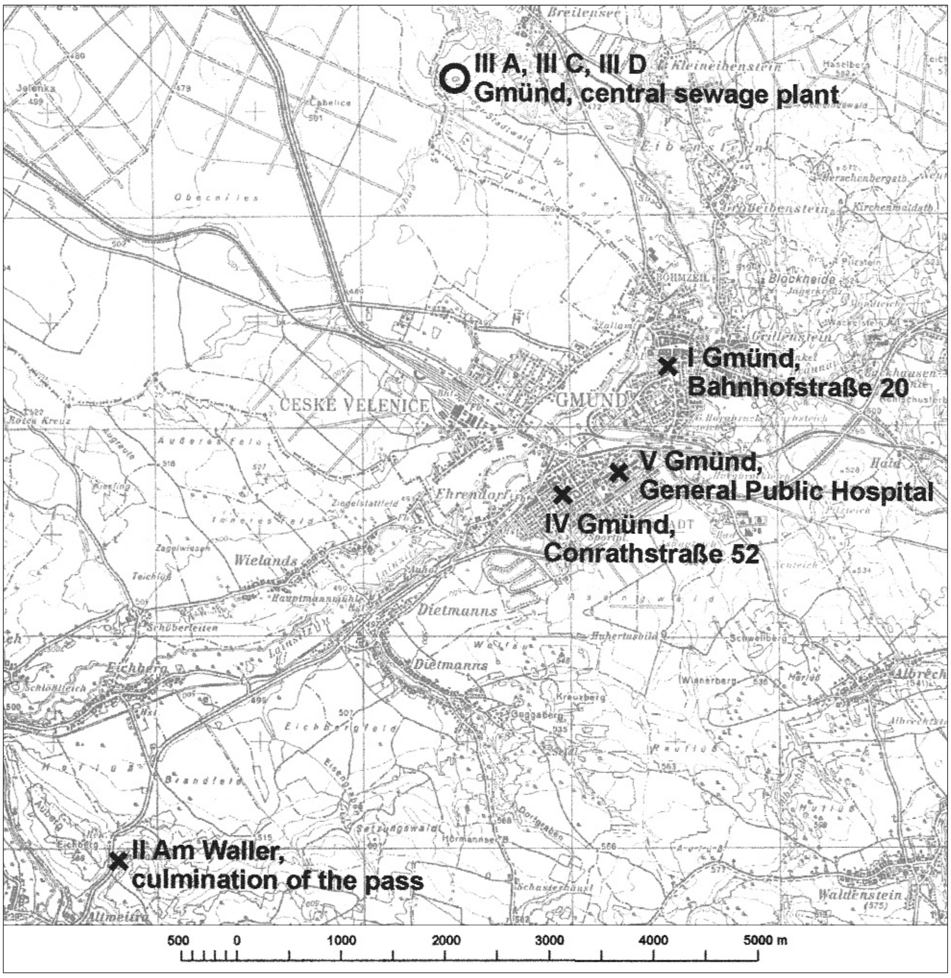
(I-11) 3.05–3.25 m: Grey (7,5Y 5/1) fine to medium-grained sandstone, including clasts of light grey (7,5Y 7/1) sandy mudstone and bluish black (10BG 2/1) coal fragments. Bed-sole, inclined ~25° and dipping to the S, is curved and sharp.

(I-12) 3.25-3.40 m: White to light grey (5Y 5/2) China clay, within its lowermost parts including chips of smoky quartz with elongations up to 6 cm. Lower bed-boundary blurred, grading to

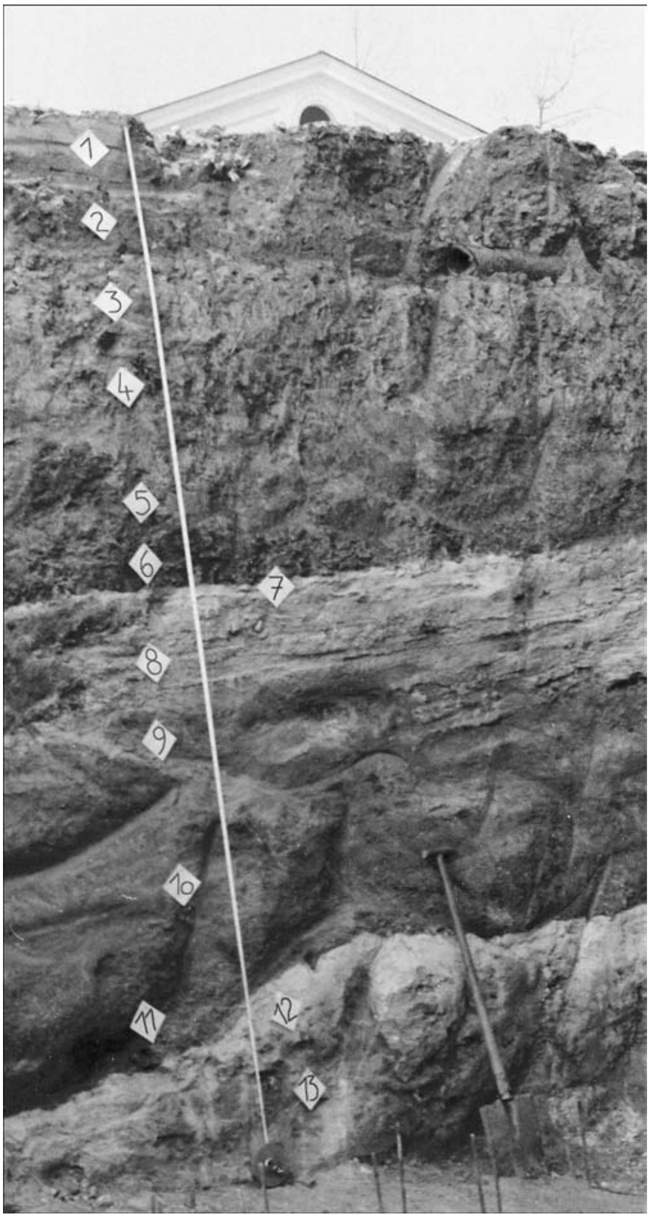
(I-13) 3.40–3.80 m: Red (10R 4/8) mudstone, interveined by pale yellow (5Y 8/4) to light grey (5Y 8/2) mudcracks. In places interspersed with very fine-fragmented coalified plant-remains, and white-dotted by intensively kaolinized feldspars. 7.5 m E of the bottom of this exposure, the underlying beds have been opened (Text-Fig. 8). The top of their surface, inclined ~70° and dipping to the N, corresponds in altitude with the bottom-level of the exposure described above:

(I-14) 3.80–4.15 m: Brown (10YR 4/6) mudstone, in places including light yellowish brown (10YR 6/6) streaks. Crossed by a 3–12 cm thin black coal seam. Lower bed-boundary of (I-14) is inclined ~12°, dips to the W, is sharp, wavy and curved.

(I-15) 4.15–4.40 m: Pale yellow (2,5Y 8/4) to greyish yellow (2,5Y 7/2) sandstone with intensively mouldered granitoid fragments (saprolite clasts) with diameters up to 9 cm, the feldspar of which totally has been altered to kaolinite. In places the sand is bright reddish brown (5YR 5/6) mottled. Grading to



Text-Fig. 5.
Topographical position of the openings of Gmünd Beds, which are documented here.



Text-Fig. 6.
Succession of Gmünd Beds (I) at the basement excavation of the house Bahnhofstraße 20, Gmünd.
Uppermost beds: (I-1) to the red bed (I-13).
Photo: K.H. HUBER, January 1984.

(I-16) 4.40–4.90 m: Light grey (10Y 7/1 to 10Y 8/1) kaolinic mudstone, in places showing dull yellow orange stains. Bed-sole underneath the groundwater table.

II) Slope cutting near the highest point of the road at the pass Am Waller across the Eichberg-ridge horst between Dietmanns and Altweitra

(Austrian federal referencing grid [Bundesmeldenetz] 6913: easting: 645590. northing: 399895)

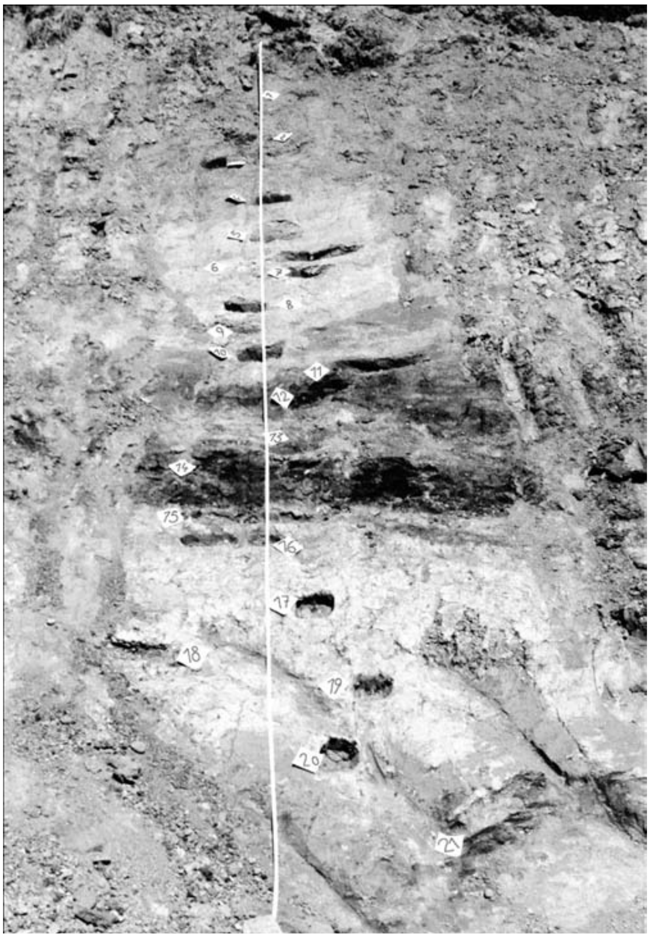
In July 1984 the eastern slope of the road-trench opposite the junction of the signposted road way Güterweg Altweitra and the main road was opened (Text-Fig. 5). It was inclined about 40°, dipped to the W and showed the following succession of Gmünd Beds below a ground level of ~565 m a.s.l. (Text-Figs. 8 and 12):

(II-1) and **(II-2)** 0.00–1.40 m: Greyish yellow brown (10YR 4/2) sandy mudstone, humous, crumbly, loose, with rooting.

(II-3) 1.40–2.10 m: Brown (10YR 4/4) to dull yellowish brown (10YR 5/3) sandy mudstone, poorly sorted. Grading to

Succession of Gmünd Beds (I) at the basement excavation of the house Bahnhofstraße 20, Gmünd.
Lowermost beds: (I-14), with a thin coal seam, to (1-16).
Photo: K.H. HUBER, January 1984.

(II-4) 2.10–2.50 m: Yellowish brown (10YR 5/8) fine-sandy mudstone, non-laminated, including in places small, up to 4 cm elongated, single lenses of rust-brown coarse-grained sandstone. Wavy lower bed-boundary.



Text-Fig. 8.
Gmünd Beds at the highest point of the pass Am Waller (II), exposing two coaly mudstone beds (II-12) and (II-14), which seem to be unsuitable for palynological investigation, and the grey beds (II-17) to (II-20).
Photo: K.H. HUBER, July 1984.

(II- 5) 2.50–2.90 m: Yellowish brown (10YR 5/8) fine-sandy mudstone with an irregular, nonparallel fissible bedding or up to 3 mm thin lamination.

(II- 6) 2.90–3.10 m: Light grey (5Y 7/2) to greyish olive (5Y 6/2) mudstone, non-laminated, with dull yellow orange (10YR 6/4) streaks. Grading to

(II- 7) 3.10–3.45 m: Greyish olive (7,5Y 6/2) to brown (10YR 4/6), fine or medium-grained sandy mudstone. Bed-sole indistinct.

(II- 8) 3.45–3.80 m: Nearly identical with (II-6), but with a higher sand-content.

(II- 9) 3.80–3.90 m: Dull yellow orange (10YR 7/4) to yellowish brown (10YR 5/8) sandy mudstone, representing a single flat lens of a lenticular bed with lens-elongations of about 15 cm on average. Grading to

(II-10) 3.90–4.30 m: Dull yellow orange (10YR 6/4) sandy mudstone, with discontinuous, wavy, nonparallel lamination.

(II-11) 4.30–4.47 m: Dull yellowish brown (10YR 5/4) to greyish yellow brown (10YR 4/2) sandy mudstone, with bright yellowish brown (10YR 6/8) streaks, with brownish black (10YR 3/2) mottles and with single, continuous, 1–2 mm thin planar laminations of dull yellow orange (10YR 7/3) sand. Lower bed-boundary well defined.

(II-12) 4.47–4.65 m: Brownish black (10YR 2/2) coaly mudstone, including brown (10YR 4/6) to bright yellowish brown (10YR 6/6) angular gravelly grains of sand. Within their coaly mudstone matrix the gravel individuals have no preferred orientation. In places, the coaly mudstone-matrix includes up to 20 cm elongated and up to 8 cm thick flat lenses of sandstone, which is very poor in mud. Gradual transition to

(II-13) 4.65–5.00 m: Yellowish brown (10YR 5/6) sandy-gravelly mudstone with dark greyish (2,5Y 4/2) and brownish black (2,5Y 3/1) mottles. Compact and hard. Includes single, up to 1 cm elongated coaly-clay clasts. Irregularly wavy, but sharp lower boundary.

(II-14) 5.00–5.40 m: Black (7,5Y 2/1), with a greasy lustre, coaly claystone to coaly mudstone with a high water-content. When drying, contracting fast and breaking into lumpy clasts. A sample of (II-14), macerated by the palynologist Reinhard ZETTER, Vienna, has proved the material to be unsuitable for further paleopalynological investigation. Lower boundary indistinct, wavy.

(II-15) 5.40–5.60 m: Greyish olive (7,5Y 6/2) mudstone with single bright yellowish brown (10YR 6/6) stains. Includes finest brownish black coalified plant-fragments. Compact and very hard. Continuous transition to

(II-16) 5.60–5.80 m: Bright yellowish brown (10YR 6/8) sandy-gravelly mudstone with light grey (7,5Y 7/2) mottles, with white dots of kaolinized feldspar grains, and black dots of coal-fragments. Continuously grading to

(II-17) 5.80–6.46 m: Greyish olive (7,5Y 6/2) mudstone, and with brownish black (2,5Y 3/1) streaks of coalified plant detritus. (II-18) 6.46–6.54 m: Light grey (5Y 7/1) to grey (5Y 4/1) sandy mudstone, bearing fine sand within a muddy matrix. Filling a single flat lens of a lenticular bedding with an average lens-elongation of about 25 cm and a lens-thickness up to 8 cm. The mud-matrix is perforated by fine cracks, filled with finest detrital coaly substance.

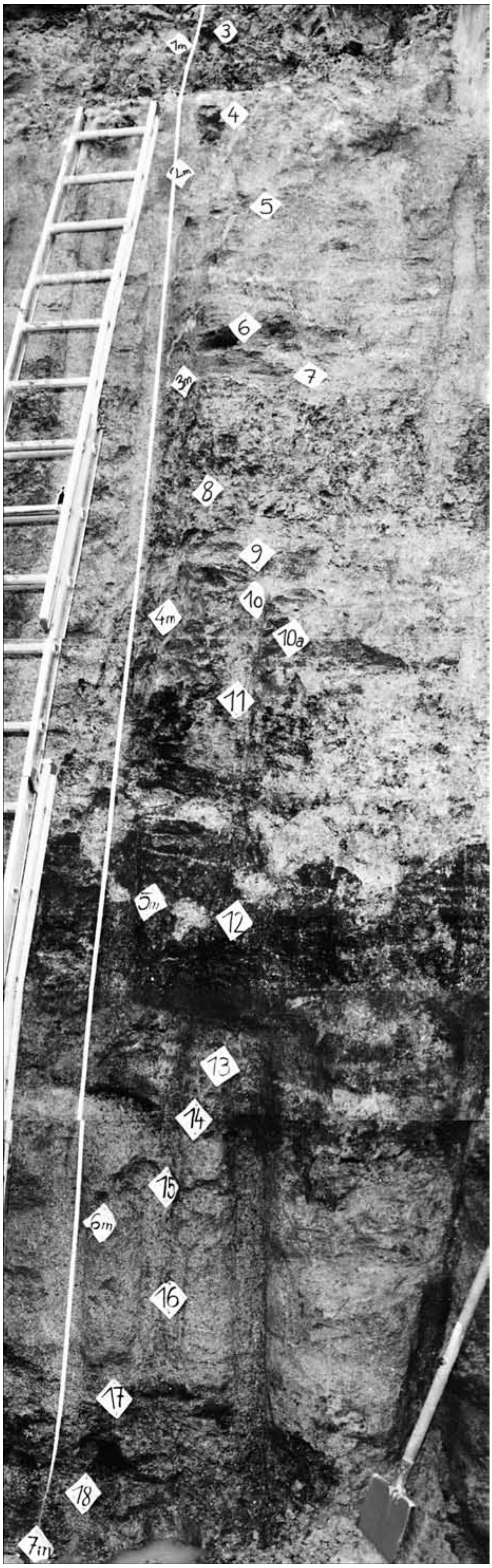
(II-18) is included within **(II-17)**.

(II-19) (II-20) 6.54–7.35 m: Identical with **(II-17)**. Lower bed-boundary curved, in parts indistinct. (II-21) 7.35–7.90 m: Yellow orange (10YR 7/6) sandy mudstone with bright brown (7,5YR 5/6) streaks. It contains single subangular fine-gravel grains of quartz and lithic fragments. The sediment is lamellated by 2–3 mm thin sandy and muddy laminae.

III) Foundation pit of the central sewage plant of the waste water association (Abwasserverband) Lainsitz, Fischbachweg 1. Gmünd, on the left Lainsitz embankment opposite the village Breitensee, within the Gmünder Stadtwald (town forest), adjacent to the Austrian/Czech border

(Austrian federal referencing grid [Bundesmeldenetz] 6909: 4806 – 1c, 2d; see Text-Fig. 6)

In November 1996 I was able to document three profiles of Gmünd Beds there, lying one below the other – III-D was the



Text-Fig. 9.
Opening (III-D) of Gmünd Beds, i.e. the uppermost bed succession at the foundation pit of the central sewage plant Gmünd with the red beds (III-D8) to (III-D14). Photo: K.H. HUBER, November 1996.

uppermost, III-C the middle, and III-A the lowermost cutting – the three of them together continuously exposing the nearly 13.5 meters of the local Gmünd Beds' succession between ~479,3 m and ~466 m a.s.l. As the pit's surface has been changed by human influence considerably since 1996, some more detailed topographical data are given here:

Bed succession III-D was excavated in the southernmost slope of the sewage plant area, and had been situated in the westernmost corner of the pit, behind the little transformer house of the sewage farm. The outcrop surface of D was exposed to the N. In 1996 the upper 1.65 meters of the 7 m long outcrop fall line were inclined 40°, the lower part 70°. The outcrop's top was at ~479,3 m a.s.l., the outcrop's bottom, then at a height of 472,9 m a.s.l., today is covered by aggradation. The following Gmünd beds could be seen (Text-Figs. 9 and 12):

(III-D 1) 0.00–0.15 m: Brown (7,5YR 4/4) fine-sandy mud. Humous. Dense rooting. Grading to

(III-D 2) 0.15–0.65 m: Orange (7,5YR 6/6) mudstone with light olive grey (5GY 7/1) mottles. Greasy. Moderate rooting. Indistinct, irregularly waved lower bed-boundary.

(III-D 3) 0.65–1.65 m: Light bluish grey (10BG 7/1) sandy mudstone with dull orange (2,5YR 6/6) mottles. Penetrated by a netted texture of fine polygonal mud cracks, distanced 3–30 mm from one another. Breaking into lumps. After drying, colours changed to light olive grey (5GY 7/1) sandy mud with orange (7,5YR 6/6) mottles.

(III-D 4) 1.65–1.90 m: Orange (7,5YR 6/6) and light olive grey (2,5GY 7/1) fine-sandy mudstone, including some up to 25 x 25 cm large clasts of a greyish red (2,5YR 6/2) sandy mudstone, which contains single coarse-sand grains of quartz and feldspar.

(III-D 5) 1.90–2.65 m: Orange (7,5YR 6/6) to reddish brown (5YR 4/8) muddy sandstone with tiny black (7,5YR 2/1) dots. Includes angular to subrounded coarse-grained sand to fine-gravel grains of quartz and feldspar. Hard. A thin, bright, fine-grained sand-vein, dipping down slanting from the upper bed-boundary, penetrates the bed. No distinct lower bed-boundary. Step by step grading to

(III-D 6) 2.65–2.95 m: Yellowish grey (2,5Y 6/1) to bright brown (7,5YR 5/8) fine to medium-grained sandstone, poor in mud, with black streaks. Indistinct bed-sole.

(III-D 7) 2.95–3.05 m: Dull yellow orange (10YR 6/4) muddy coarse-grained sandstone. Lower bed boundary wavy, subhorizontal and sharp.

(III-D 8) 3.05–3.70 m: Dusky red (7,5R 4/4) mudstone with grey (N 6/6) and bright yellowish brown (2,5Y 6/6) mottles. Soft, but not greasy. Breaking into 2–3 cm-elongated angular lumps. Lower bed boundary well recognizable.

(III-D 9) 3.70–3.85 m: Reddish brown (2,5YR 4/6) muddy sandstone with olive grey (5GY 6/1) streaks. Grains of the coarse-sand content are angular. Indistinct lower bed-boundary.

(III-D10) 3.85–3.95 m: Dull reddish brown (5YR 4/4) muddy fine-grained sandstone or fine-sandy mudstone with dark reddish brown (2,5YR 3/6), brownish grey (7,5YR 6/1) and olive (5Y 5/4) mottles and streaks, breaking into lumps. Without significant lower bed boundary grading to **(III-D10a)** 3.95–4.15 m: Dull reddish brown (5YR 4/4) mudstone with (5Y 5/4) olive mottles and streaks, breaking into lumps. Lower margin indistinct.

(III-D11) 4.15–4.60 m: Greyish red (7,5R 4/2) mudstone with bright yellowish brown (2,5Y 6/6) to yellow (5Y 7/6) streaks and mottles, hard, breaking into lumps. Lower bed boundary quite significant, very intensively waved, in respect to colour partly recognizable, partly blurred by greenish grey (10GY 8/1) streaks.

(III-D12) 4.60–5.32 m: Reddish brown (10R 4/6) fine to coarse-grained sandstone, including light greenish grey (10GY 8/1) lenses and streaks. It contains angular medium-gravel grains of quartz and shows white dots from angular kaolinized medium-gravel grains up to 1 cm in diameter. Sharp bed-sole.

(III-D13) 5.32–5.58 m: Greyish red (10R 5/2) muddy medium to coarse-grained sandstone with light greenish grey (7,5GY 7/1) mottles and red (10R 4/6) streaks. It contains single angular white and yellow fine-gravel grains of feldspar up to 3 mm in diameter. Lower bed boundary well defined.

(III-D14) 5.58–5.68 m: Greyish red (7,5R 4/2) mudstone, very hard. Includes black, thin, curved, discontinuous black strings. Without significant bed-sole grading to

(III-D15) 5.68–6.05 m: Light grey (10Y 7/2) siltic sandstone or sandy siltstone with bright yellowish brown (2,5Y 7/6) streaks. Continuously grading to

(III-D16) 6.05–6.45 m: Light grey (7,5Y 7/2) fine to coarse-grained sandstone, poor in mud. Loose. Indistinct lower bed boundary. Grading to

(III-D17) 6.45–6.65 m: Greenish grey (7,5GY 6/1) muddy coarse-grained sandstone with dull yellow (2,5Y 6/4) mottles and streaks. Contains single angular grains of feldspar, up to 5 mm in diameter. Sharp, wavy lower bed boundary.

(III-D18) 6.65–7.00 m: Greyish red (2,5YR 5/2) mudstone with grey (7,5Y 6/1) mottles. Downward continuously grading to grey (7,5Y 6/1) sand, which near the sole includes more than 10 cm elongated clasts of dark red (7,5R 3/6) fine to coarse-grained sandstone. Fissured, penetrated by a net of fine cracks, filled with orange (7,5YR 6/8) mudstone.

Bed succession III-C was situated at a distance of 80 meters and a direction of 77° from D, today covered by the centre of the southern front of the present preliminary-clarification basin. The outcrop-surface of C was exposed to the N. On the average, its 4 m long outcrop fall line was inclined 65°, its top at 472,80 m a.s.l., its bottom at

Text-Fig. 10.
Opening (III-C) of Gmünd Beds, i.e. – with respect to altitude – the middle bed succession at the foundation pit of the central sewage plant Gmünd.
The grey beds (III-C12) and (III-C14) contain fine bluish-black coal particles. (III-C13) and (III-C-15) are red beds.
Photo: K.H. HUBER, November 1996.

469.10 m a.s.l. The following lithostratigraphy was found here (Text-Figs. 10 and 12):

(III-C1) 0.00–0.40 m: Light greenish grey (7,5Y 7/1) mudstone with bright yellowish brown (10YR 6/6) mottles. Rooting. Lower bed boundary partially vague, partly intensively curved (Pleistocene cryoturbation?).

(III-C2) 0.40–0.55 m: Bright reddish brown (5YR 5/6) sandstone, filling a subhorizontal single flat lens with indistinct margins, an elongation of 20 cm and a max. thickness of 7 cm. It is included in

(III-C3) 0.40–1.22 m: Light grey (10Y 7/2) coarse-grained sandstone to fine-grained conglomerate with very thin brownish black streaks and fine cracks. Sole indistinct, curved.

(III-C4) 1.22–1.48 m: Light greenish grey (10GY 8/1) muddy medium-grained sandstone without sharp bed-margins. (III-C4) is part of a discontinuous and fragmentary net of slanting, irregularly curved, garland-like streaks, penetrating nearly the whole bed-succession. Probably the net represents seams of (former) paths of kaolinite suspension-bearing groundwater, infiltrating the sediment beds.

(III-C 5) 1.48–1.64 m: Greyish yellow (2,5Y 6/2) muddy sandstone, filling a single flat lens (max. 13 cm thick, subhorizontal and slightly curved) without clearly defined margins.

(III-C 6) 1.64–1.79 m: Reddish brown (5YR 4/6), continuously grading to brown (7,5YR 4/6) and to light greenish grey (10GY 8/1) fine-sand streaks without sharp boundaries.

(III-C 7) 1.79–2.30 m: Olive grey (5GY 6/1) coarse-grained sandstone to fine-grained conglomerate, very densely dotted with fine orange (7,5YR 6/6) spots. Distinct, wavy bed-sole.

(III-C 8) 2.30–2.45 m: Dull reddish brown (5YR 5/3) and light greenish grey (5G 7/1) mudstone with dull orange (7,5YR 6/4) mottles, lamellated by laminae, thinner than 1 mm. Its upper bed boundary is seamed dark red (7,5R 3/6), its well defined lower one dull orange (2,5YR 6/4).

(III-C 9) 2.45–2.60 m: Light greenish grey (7,5GY 7/1) muddy fine-grained sandstone with dull yellow orange (10YR 6/4) mottles. Hard. Lower bed boundary partly wavy, partly indistinct.

(III-C10) 2.60–3.05 m: Dull yellow orange (10YR 6/3) muddy fine-grained sandstone, spotted densely with dull brown (7,5YR 5/4) dots and single, angular, up to 5 mm elongated fine-gravel-grains of kaolinized feldspar. Bed-sole wavy and indistinct.

(III-C11) 2.80–2.90 m. Light grey (5GY 7/1) fine-grained sandstone, filling a single flat lens that is elongated 20 cm horizontally and max 10 cm thick. The lens is included in (IIIC-10) and has blurred margins.

(III-C12) 3.05–3.40 m: Light grey (10Y 7/1) to grey (10Y 6/1) muddy coarse-grained sandstone with yellowish brown (10YR 5/6) dots and bluish black (5PB 2/1), more or less sporadic coal detritus. Coal particle size up to few millimeters. Bed-sole undefinable, wavy.

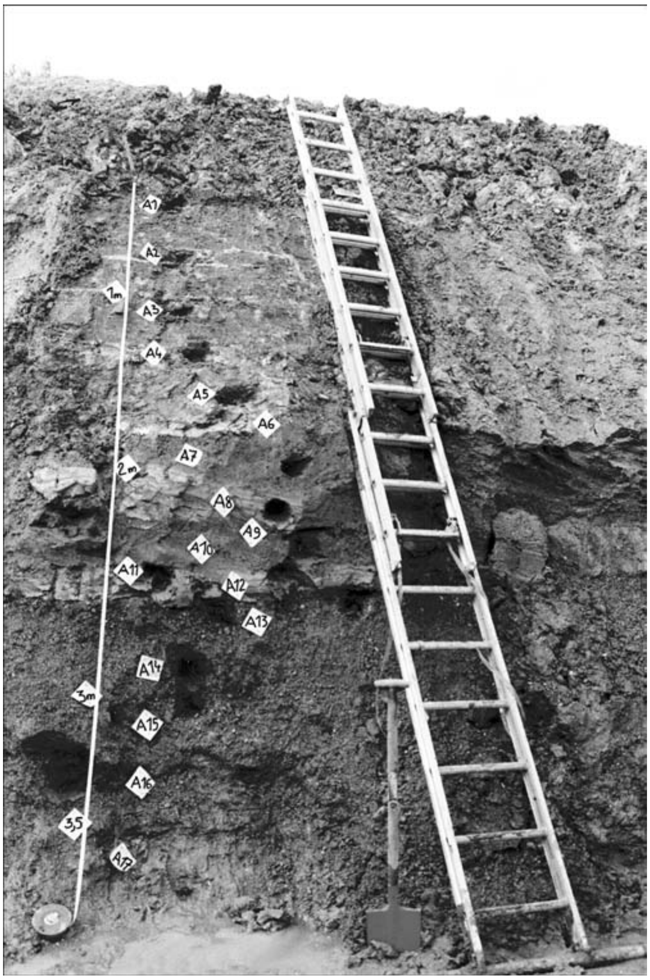
(III-C13) 3.40–3.65 m: Dull reddish brown (7,5R 5/3) to yellowish brown (10YR 5/6) mudstone with orange (2,5YR 7/6), light bluish grey (5B 7/1) and bright yellowish brown (2,5Y 6/6) mottles. Lower bed boundary indistinct and blurred.

(III-C14) 3.65–3.85 m: Greyish yellow (2,5Y 6/2) fine to coarse-grained, very compact sandstone with dull reddish brown (2,5YR 5/3) and light bluish grey (5B 7/1) streaks and bluish black (5PB 2/1) coal detritus similar to **(III-C12)**. Without clear sole, grading to

(III-C15) 3.85–3.90 m: Dull reddish brown (2,5YR 4/4) coarse-grained sandstone with light yellow (2,5Y 7/4) and light bluish grey (5B 7/1) mottles. Continuously grading to

(III-C16) 3.90–4.00: Olive yellow (5Y 6/3) sandstone to conglomerate, poor in mud. Seems to be included within **(III-C15)**.

Bed succession III-A (Text-Figs. 11 and 12), at a distance of 85 meters and a direction of 21° from the bottom of III-D, today is covered by the SW-side of the present quadrangular activated-sludge-tank, and located some 4 meters SE of the tank's westernmost corner. The outcrop-surface, with its top at 469,20 m and its bottom at 466,10 m a.s.l., was dipping app. to the NE. The upper



Text-Fig. 11.
Opening (III-A) of Gmünd Beds, i.e. the lowermost bed succession at the foundation pit of the central sewage plant Gmünd with the grey beds (III-A11) to (III-A16).
Photo: K.H. HUBER, November 1996.

1.75 meters of the 3.90 m long outcrop-fall-line were inclined ~35°, the lower part 70°. The former terrain surface today is buried by anthropogenic aggradation.

(III-A1) + (III-A2) + (III-A3) 0.00–1.35 m: Bright brown (7,5YR 5/6) muddy sandstone, including single lenses or interrupted strings of light greenish grey (10GY 8/1) mud, which are laminated horizontally or vertically by up to 2 cm thin microbeds, and also including up to fist-size, rounded clasts of light greenish grey (10GY 7/1) muddy sandstone, rich in white mica. Grading to

(III-A4) + (III-A5) 1.35–1.75 m: Bright brown (7,5YR 5/6) sandy mudstone with light olive grey (5GY 7/1) clayish mottles and streaks. Lower bed boundary indistinct.

(III-A 6) 1.75–1.85 m: Light grey (7,5YR 8/1) claystone with dull yellow orange (10YR 7/3) streaks, greasy, lamellated by laminae, thinner than 1 mm. Some 2 meters NE of the outcrop the same bed is structured by concave-curved, slanting microbeds, dipping to the NE (foresetbeds?). Bed sole sharp, curved.

(III-A 7) 1.85–1.95 m: Yellowish brown (10YR 5/6) coarse-grained sandstone, poor in mud. Lower bed boundary distinct, curved.

(III-A 8) 1.95–2.20 m: Light grey (10YR 7/1) claystone with dull yellow orange (10YR 6/3) streaks. Laminated. Lower bed boundary sharp, moderately curved.

(III-A 9) 2.20–2.27 m: Bright yellowish brown (10YR 6/8) coarse-grained sandstone, poor in mud. Continuously grading to

(III-A10) 2.27–2.40 m: Bright yellowish brown (10YR 6/6) coarse-grained sandstone, poor in mud. Lower bed boundary distinct, moderately curved.

(III-A11) 2.40–2.45 m: Light greenish grey (7,5GY 7/1) mudstone with orange (7,5YR 6/6) mottles. It bears black, pinhead- to half-fingernail-size as well as very fine particles of coalified plant-detritus and white mica. Grading to

(III-A12) 2.45–2.60 m: Light greenish grey (7,5GY 7/1) claystone, lamellated with laminae thinner than 1 mm. Bearing finest detritus of coalified plants. Lower bed boundary sharp.

(III-A13) 2.60–2.75 m: Greenish grey (7,5GY 6/1) fine-gravelly sandstone with single angular to subangular medium-gravel individuals of grey quartz, milky quartz and lithic fragments. Gravel-elongations irregularly orientated. Very moist. Grading to

(III-A14) 2.75–3.05 m: Greyish yellow (2,5Y 7/2) gravelly sandstone with bright yellowish brown (10YR 6/6) streaks, including thumb to fist-size clasts of light grey (10Y 7/1) muddy sandstone with indistinct margins. The gravel-content consists of angular to subangular fine and medium-grained individuals up to 8 cm in diameter of the following petrographical components: milky quartz and most intensively weathered dull brown (7,5YR 5/4) quartz, grey quartz and lithic fragments. Indistinct lower bed boundary.

(III-A15) 3.05–3.20 m: Light grey (7,5Y 7/2) to light greenish grey (7,5GY 7/1) muddy-gravelly sandstone with dull yellow orange (10YR 6/4) and dull reddish brown (2,5YR 4/4) streaks. It includes single subangular to angular fine and medium-gravel grains of milky quartz, up to 6 cm in diameter, and fist-size rounded clasts of dull brown (7,5YR 5/4) sand. Continuously grading to

(III-A16) 3.20–3.55 m: Light bluish grey (10BG 7/1) sandy mudstone with reddish brown (10R 4/4) and dull yellow (2,5Y 6/4) mottles and streaks. Hard. Bed-sole indistinct, curved.

(III-A17) 3.55–3.90 m: Light greenish grey (7,5GY 6/1) muddy fine-grained sandstone, nearly equigranular. Rich in white mica. Bed-sole below the groundwater level.

IV) Foundation pit of the house in Conrathstraße 52 in Gmünd (Text-Fig. 5), a housing-area at the crossroad Conrathstraße-Stiftergasse

(Austrian federal referencing grid [Bundesmeldenetz] 6909: easting: 649950; northing: 403375; see Text-Fig. 6)

In November 1989 at the centre of its southeastern long-side, below a terrain level of 496 m a.s.l., the following succession of Gmünd Beds was opened in a surface that dipped to the NW and was inclined ~70° (Text-Fig. 13):

(IV-1) 0.00–0.25 m: Brownish grey (10YR 4/1) to brownish black (10YR 3/1) muddy humous. Moderate rooting. Lower bed boundary sharp.

(IV-2) 0.25–0.37 m: Yellowish brown (10YR 5/6) to bright brown (7,5YR 5/8) fine-sandy mud with single angular medium to coarse sand-grains of quartz, feldspar and granitoid fragments. Horizontal and parallel lamination. Continuously grading to

(IV-3) 0.37–0.70 m: Bright brown (7,5R 5/6) fine-sandy mudstone with light grey (5Y 7/1) and brownish grey (10YR 5/1) streaks and mottles. Very softly curved, parallel lamination. Bed-sole horizontal on the whole, wavy in places, marked by a noticeable, discontinuous sharp black seam, a few millimetres thin, enriched with finest coal detritus.

(IV-4) 0.70–0.97 m: Dull yellow orange (10YR 6/4) fine to medium-grained sandstone, poor in mud. Horizontal to very softly curved and subparallel lamination. The fine and medium-sand amount of **(IV-4)** consists of angular quartz, angular feldspar, biotite, much white mica and single well-rounded, transparent reddish andalusites. With a relatively small amount of coarse-sand. Furthermore, single fine-gravel individuals of rounded feldspar and lithic fragments are elongated up to 1.5 cm. Lower bed boundary distinct, marked by a thin dark seam, presumably enriched with finest coal detritus.

(IV-5) 0.97–01.10 m: Dull brown (7,5YR 5/4) muddy gravelly sandstone, angular to subangular. The fine-grained gravel content is composed of subrounded grey and white quartz. Subhorizontal, subparallel lamination. Bed-sole indistinct.

(IV-6) 0.10–1.50 m: Greyish yellow brown (10YR 6/2) moderately muddy sandstone, bearing biotite. Coarse-sand content of grey and milky quartz, of very friable feldspar and of granitoid-fragments. Single rounded to well rounded gravels and pebbles of white, brown and reddish quartz. Subhorizontal and subparallel lamination. Lower bed boundary curved and wavy.

Manual digging next to the southernmost corner of the pit opened two additional beds below **(IV-6)**:

(IV-7) (1.50–~1.70 m) Dark reddish brown (2,5YR 3/4) muddy, quite well sorted fine-grained sandstone with a inconsiderable middle-sand content. The sand contains quartz, biotite and opaque grains.

(IV-8) (~1.70 m–?) Light olive grey (2,5GY 7/1) sandy mudstone with brown (10YR 4/6) mottles, very sporadically including fine-gravel grains. Its coarse-sand content is composed of partly angular, partly subrounded quartz, feldspar and single andalusite grains.

V) Some 10 m SW of the western corner of the foundation pit of the main building of the General Public Hospital Gmünd, Conrathstraße 17

(Austrian federal referencing grid [Bundesmeldenetz] 6909: easting: 650300; northing: 403505; see Text-Fig. 6)

Here, in May 1982, a surface of Gmünd Beds, NW-exposed and inclined about 65°, was opened below a ground level of ~500.0 m a.s.l.

The grain size mixtures specified below are named in the manner of a ternary graph, designed by FÜCHTBAUER & MÜLLER (in FÜCHTBAUER, 1959, Fig. 5). Its corners have been marked as silt – sand – gravel, because all samples contained more sand + gravel than clay + silt. As the sand and gravel were classified by dry sieving (using a screen set according to DIN 4022), the resulting contents of the mud fractions (i.e. of the silt and clay-fractions) quantified by repeated pipetting of 20 ml from the continuously sedimentating mud/aqua dest. suspension (analysis procedure proposed by KUBIENA [1929], making use of a modified pipette apparatus after KÖHN [1928]), may be a little under-represented. Thus the grain size concentrations, determined at the Physiogeographical Laboratory of the Vienna University, should be considered as hypothetical approximations only. The following beds have occurred (Text-Fig. 12):

(V- 1) 0.00–0.95 m: Yellow Eisgarn granite rubble, anthropogenic aggradation. Lower bed boundary sharp.

(V- 2) 0.95–1.35 m: Dull brown, sandy-clayish similigley, containing single well-rounded quartz pebbles. Grading to

(V- 3) 1.35–1.95 m: Light yellow (2,5YR 7/4), silty-gravelly sandstone.

(V- 4) 1.95–2.15 m: Greyish yellow brown (10YR 6/2) silty-gravelly sandstone.

(V- 5) 2.15–2.5 m: Red (10R 5/8) silty-gravelly sandstone, interspersed with red and dark greyish yellow streaks of the same material. Grading to

(V- 6) 2.50–2.90 m: Greyish olive (2,5Y 6/2) silty-gravelly sandstone without streaks.

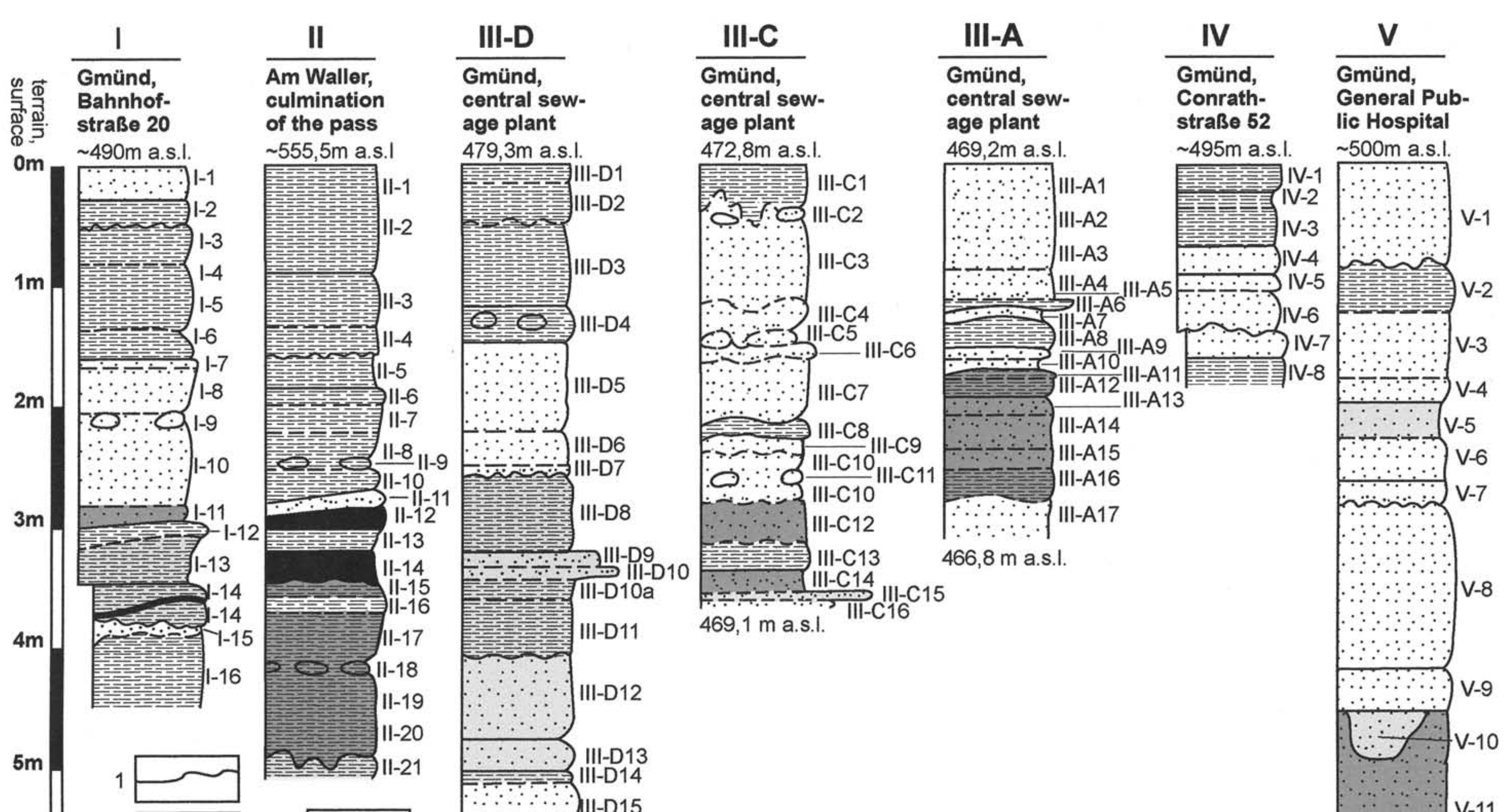
(V- 7) 2.90–3.10 m: Light grey (5Y 7/1) clayey sandstone with subhorizontal and subparallel laminations, a few millimetres thin.

(V- 8) 3.10–4.60 m: Greyish olive (5Y 6/2) silty-gravelly sandstone.

(V- 9) 4.60–5.0 m: Dull yellow orange (10YR 6/3) silty-gravelly sandstone, bearing much water. The base of this bed cuts **(V-10)** and **(V-11)**.

(V-10) 5.00–5.45 m: Red (10R 4/6) clayey-silty sandstone with greyish white streaks, plastic. When drying, breaking into clasts. It fills a shallow trough within the uppermost part of **(V-11)**.

(V-11) 5.00–6.90 m: Grey (7,5Y 4/1) clayey-silty sandstone, quite greasy. At a depth of 6.50 m below the ground level it is passed through by a black coal-seam which, on average, is 5 cm thick, containing at places bluish black to black lustering concretions, which are platy and very compact, shattering like extremely hard glass when hit hard with a hammer.



Text-Fig. 12.
Documented successions of Gmünd Beds.
Projected onto a normal plane and classified in terms of the Klikov Formation's bed-typology after SLANSKÁ (1976: 138). More detailed explanations in the text.
1 = sharp, distinct bed-boundaries; 2 = indistinct or blurred bed-boundaries, or continuous gradations; 3 = clasts or lenses (lenticular bedding); 4 = claystones and mudstones; 5 = sandstones and conglomeratic sandstones; 6 = coal-seams; 7 = light-grey or yellowish-grey or light brown beds, or others than 8 and 9, comparable to SLANSKÁ's bed type A; 8 = red to reddish brown to intensively brown beds, comparable to SLANSKÁ's bed type B; 9 = grey beds with varying amounts of carbonized plant debris and pigment, comparable to SLANSKÁ 's bed type C.

(V-12) 6.90–7.90 m: Light olive grey (2,5GY 7/1) sandstone with intensively kaolinized feldspars, which can be rubbed between the fingers.

It was not possible to correlate this bed-succession with that of the building-ground exploration-drilling Nr. 6, carried out in immediate vicinity of (V) in 1978 (in MÜLLER [1979]: enclosures 2/4, 4/2).

The coal-specialist VINZENZ (1983) described the coal of bed (V-11) as

"... a dull lignite without any internal texture or any heterogeneous structure, tending to disintegrate in sharp-edged cubes and to go bright brown and blue when exposed to the air for some days. Three microscopically examined polished sections of the sample showed that the coal completely consists of humocollinite, showing several cell-lumina filled with resinites. Thus this coal belongs to the maceral type 'telocollinite' and has developed from a homogenous initial material. Reflectorymetry came to R_{mo} = 0.28–0.40 %. Fluorescence observations confirmed that all other dark cell fillings are resinites (resin). Macerals and mineral components (such as pyrite, clay minerals,...) are missing completely. The petrographical structure does not permit a clear definition of the degree of coal maturity, but usually the occurrence of the maceral telocollinite is limited to well mature dull brown coal and to bright brown coal. It is not clear whether the coal is auto- or allochthonous, whether it has developed in a former peat, or whether it is the rest of a floated tree [driftwood]."

HOCHULI (1983) analyzed the coal of bed (V-11) palynologically:

"In this sample pollen grains and spores are well preserved. The organic remain is composed chiefly of fusinite and epidermis-fragments. The pollen spectrum is dominated by spores of the genus Dictyophyllidites, Cicatricosisporites *and* Polypodiaceoisporites. *Coarsely reticulated forms of the genus* Schizosporis *occur quite frequently. Up to now this genus is known above all from the Neocomian to the Turonian. Among the Gymnospermae pollen* Araucariacidites *are predominant.* Classopollis *could not be shown as yet. Air pocket pollen are quite rare. In respect to quantity Angiospermae pollen also are of secondary importance. On the one hand they represent little tricolporate forms, on the other hand members of the* Normapolles *group [*Complexiopollis *(occurrence: Upper Cenomanian to Lower Campanian) and* Plicapollis *(Turonian to Oligocene)].- The pollen spectrum can be assigned to the deep Upper Cretaceous (probably Turonian). There was no evidence of any marine forms whatsoever."*

Latest paleopalynological investigations by Reinhard ZETTER demonstrate the Santonian microflora of sample (V-11) to be a highly diversified spore and pollenflora of the Normapolles province, consisting of ~30 % moss and pteridophyte spores, ~10 % gymnosperm and ~60 % angiosperm pollen grains. Among others, characteristic features of (V-11) are: the remarkable frequency (~16 %) of *Aachenipoliis aachenensis*, a tetrad type, within the angiosperm pollen spectrum (ZETTER, HESSE & HUBER, 2002: 225) and the newly discovered pollen form (hexaaperturate) *Gmuendipoliis teppneri* gen. et spec. nov. (ibidem: 227 and plate 7/13. 7/14). The palynological results indicate humid subtropical resp. warm-temperate climatic conditions (ibidem: 227).

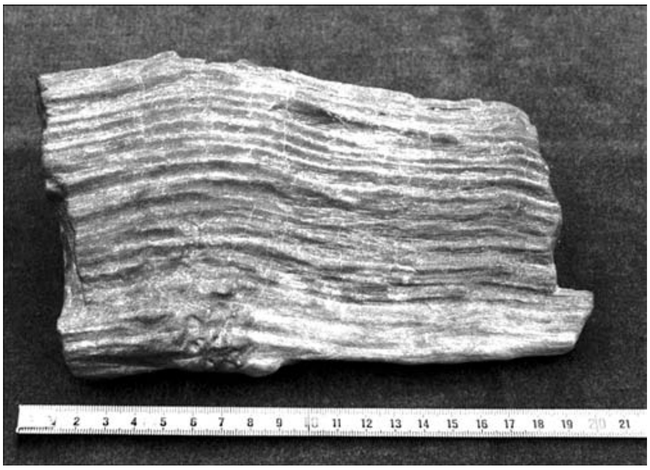
3.6. Quartz Pebbles and Silicified Woods around Dietmanns

In the western part of the Gmünd Bay – in the surroundings of Dietmanns (Text-Fig. 2) – evidences of Gmünd Beds have been found in Wielands, a village on the northern Lainsitz embankment, where a boring at a depth of more than 85 m beneath the earth's surface entered the base of the Gmünd Beds, which rest upon an highly decayed crystalline basement. North of Wielands confirmed Gmünd Beds are superimposed by pelitic and arenitic beds, which stratigraphically are still unidentified. Their main petrological environment has been differentiated macroscopically by Reinhard ROETZEL (carefully mapped, unpublished sheets 1 : 10.000, greatly generalized in SCHNABEL, 2002). Here, directly on the border between Austria and the Czech Republic, a flat hill, named Grundbühel (Text-Fig. 2), gently emerges, made up of muddy sediments (STINI, 1944: 2), and partly by laminated sands and gravels (HAUER, 1924: 16; 1951: 8; 1952b: 32). The Grundbühel as well as the fields W of it are scattered with up to double-fist-size subrounded to rounded quartz pebbles.

Also the fields 1–1.5 km S of the river Lainsitz, around Dietmanns, are strewn with subrounded to well rounded, thumb- to head-size (HAUER, 1928: 2-3) white, yellow, brownish, black and even reddish brown quartz fragments, which – like pebbles in other sectors in the W and S of the basin's periphery (SUESS, 1903: 104) – cross the southern limits of the western Gmünd Bay. They enter its crystalline outside, where they cover remarkable expanses more or less sporadically. Numerous pebbles turned out to be silicified wood.

It is predominantly the Dietmanns wood fossils – dimensioned like the common plutonic quartz-pebbles, in isolated

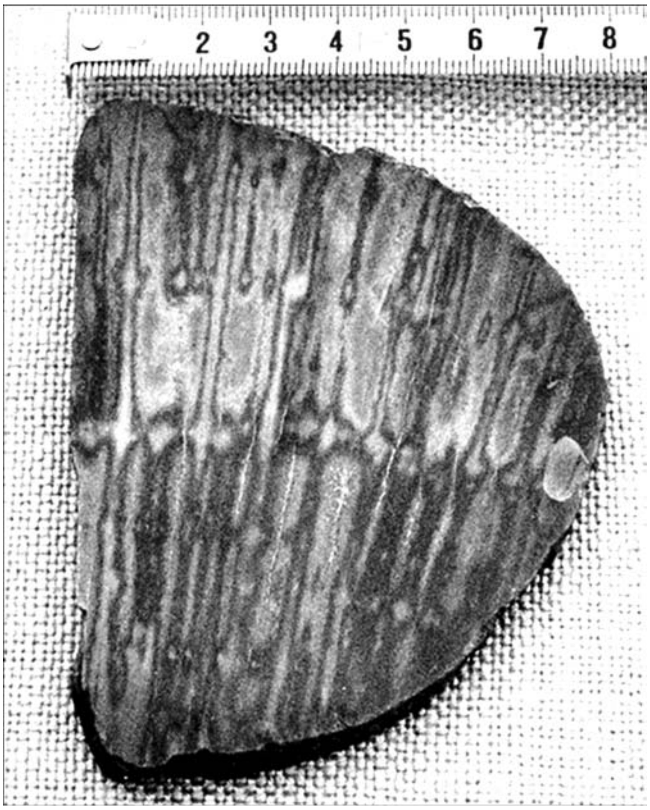
Text-Fig. 13.
Silicified wood from the immediate surroundings of the village Dietmanns near Gmünd, showing a knot-hole.
Found by F. ZIMMEL, Dietmanns, and part of his private collection.
Photo: K.H. HUBER, November 2001.



Text-Fig. 14.
Silicified wood from the immediate surroundings of the village Dietmanns near Gmünd, showing wood grain and wood fissures.
Found by F. ZIMMEL, Dietmanns, and part of his private collection.
Photo: K.H. HUBER, November 2001.

Text-Fig. 15.
Silicified wood from the immediate surroundings of the village Dietmanns near Gmünd, showing wood grain and wood fissures.
Found by F. ZIMMEL, Dietmanns, and part of his private collection.
Photo: K.H. HUBER, November 2001.

cases with max. diameters up to >75 cm – which tend to compact, or elongated, or bladed sphericity (SNEED & FOLK, 1958). Most of them are compact and generally showing rounded surfaces. If, as is normally the case, rounded Dietmanns woodstone surfaces are brownish and smooth, it is difficult to distinguish them from the common plutonic quartz pebbles on the ground. Macroscopically more significant are elongated or bladed woodstones, with subrounded, subangular and angular contours, where the plant-anatomical features like knot-holes (Text-Fig. 13), wood-grain, wood-marking and wood-fissures (Text-Figs. 14 and 15) are more easily recognizable. Bichromatical ones prevail among the Dietmanns wood petrifications. Brown and yellowish, respectively brown and whitish colour-associations dominate, while grey and white, or black and greyish white colour-pairs are subordinated. Mostly the colour-pair occurring on the outside and inside



Text-Fig. 16.
Cross-sections of silicified wood from a field near Dietmanns, demonstrating clear medullary rays and wood-vessels.
Found and polished by F. ZIMMEL, Dietmanns; part of his private collection.
Photo: K.H. HUBER, November 2001.

Text-Fig. 17.
Cross-section of silicified wood from a field near Dietmanns.
Found and polished by F. ZIMMEL, Dietmanns; part of his private collection.
Photo: K.H. HUBER, November 2001.

of a silificated wood is identical. Only rarely are the centres of Dietmanns wood petrifications coloured differently than their periphery. For example, the black "core" (heartwood?) of a woodstone cross-section is seamed by a thin greyish ring (sapwood?), bordering on the section's circumference. In one single case a cross section, polished by the pebble-grinder Franz ZIMMEL, Dietmanns, is polychromatical: A yellowish brown, dark brown and violet fossil-„core", garish-red-streaked, is seamed by a bluish black outer margin. Some polished cross-sections show medullary rays (Text-Fig. 16), wood-vessels (Text-Figs. 16 and 17) and suggest growth rings, some are perforated by numerous, irregularly distributed, tiny holes, similar to pin or knitting-needle sticks. Rarely, the tangential boundaries of woodstones are sculptured by phenomena, not unlike densely arranged wood-worm holes and tunnels.

In spite of the macroscopically often very well recognizable woodlike appearance of these petrifications, they seem to be microscopically unidentifyable (based on oral information from the paleobotanist and xylotomist Otto CICHOCKI, Vienna, who had polished a thin section from a sample, which turned out to be extremely hard).

In 1889, the elementary school teacher of Dietmanns, Josef SCHNEID, for the first time stumbled here on a "wood opal" (DWIRKA, 1911, no. 20). Later, fossil woods

> *"... with distinct annual rings, knots and pitch, belonging to ... different wood-types ..."*

and an undefined lithificated plant fragment, in the opinion of DWIRKA (1911, no. 20) a

> *" ... petrified fern, the cellular tissue of which has been interspersed with circular to oval vascular bundles ... "*

were found and integrated into the former collections of the Town Museum Gmünd (DWIRKA, 1913a: [6]; 1913b, no. 28; 1913c: 10; 1926: 1, TRAUTMANN, 1949: 9; "Das schönste Stück", 1952). OSTADAL observed the silicious woods of the Gmünd Bay to be not autochthonous, but included within layers of sand and gravel (WALDMANN, 1951: 16).

Since the beginning of the 19th century over and over again fossil woods have been discovered in many localities of the South Bohemian Basins (e.g. FRIČ, 873a,b; KUŠTA, 1873, 1879; KATZER, 1892: 1181). The places where they were found are specified in the regional bibliography of PRAKASH, BŘEZINOVÁ & AWASHTI (1974: 109–110), who identified *Cupressinoxylon* sp. cf. *diskoense* WALTON, *Canarium*

(*Canarioxylon českobudějovicense* sp. nov., *Canarioxylon* sp.), *Mimusops (Manilkaroxylon bohemicum* sp. nov.), an unknown member of Sapotaceae (*Sapotoxylon pacltovae* sp. nov.), as well as a member of Lauraceae (*Laurinoxylon oligocenium* sp. nov.). In his concise but informative synopsis, Vaclav NOVÁK (1997) supported the view, that the fragments of the silicified woody plants , which occur in the Czech part of the south Bohemian Basins, most probably derive from the Oligocene Lipnice Formation.

Compared to this, the palynologically (by HOCHULI) confirmed Kiscellian, Egerian and Eggenburgian St. Marein-Freischling Formation (STEININGER & ROETZEL, 1991: 66–85, 1994: 113–114; ROETZEL, MANDIC & STEININGER, 1999: 38, 45) comprises not only poorly sorted sands and gravels, containing clayey inclusions, a pollen flora within thin lignite-seams and leaf-impressions (of *Sequoia abietina, Taxodium dubium, Populus hornensis, Zelkova zelkovaefolia, Acer* aff. *haselbachense* and *acer* sp. – KNOBLOCH, 1981), but also silicified woods. As this Upper Oligocene to Lower Miocene formation ends with its westernmost sediment remainders near Gmünd (STEININGER & ROETZEL, 1999: 76) and as the Freistadt Tertiary, which ROETZEL (1999: 31) likewise assigned to the Oligocene bears petrified woods too (CHÁBERA & HUBER, 2000: 352–353), it is not improbable that the fossil woods, finally redeposited around Dietmanns, were subjected to silicification during the Oligocene.

Rupert HAUER spared no effort to judge the age of the latest deposition of the Dietmanns pebbles stratigraphically (as well as all other pebbles of the Waldviertel region) by correlating the altitudes of their deposits with the altitudes of analogous, stratigraphically defined accumulations E of the Waldviertel region (HAUER, 1952a, 1952b: 176). His interpretation of nearly all pebble occurrences as alluvial cones, indicating the shoreline of a freshwater lake that slowly withdrew across the Waldviertel region into the Gmünd Basin during the Tertiary, has been criticized. HAUER felt justified to assume a Middle Helvetian (Ottnangian/Carpathian) (re)sedimentation of the Dietmanns pebbles during the Lower Miocene.

In contrast to this, they are noted as "Quaternary in general" by ERICH & SCHWAIGHOFER (1977), and in Text-Fig. 2 as "quartz-pebble occurrences of uncertain age". I agree with ROETZEL (unpublished mapping sheets 1 : 10.000, inserted into SCHNABEL, 2002), that they most probably belong to the Gmünd Beds, because some years ago a foundation pit near the northwestern foot of the hill Guggaberg – in the southernmost part of the village Dietmanns – has cut into a coal seam below the pebbles (friendly oral information by Mr. ZIMMEL).

Acknowledgements

I am indebted to Peter Andreas HOCHULI, Zürich, to Martin VINZENZ, Leoben/Bad Ischl and to Fritz STEININGER, Eggenburg/Frankfurt am Main, who established the necessary contacts. Ms. Blanka PACLTOVÁ, Prague, spent a whole day answering my questions when I visited her at the Charles University. Stanislav CHÁBERA†, České Budějovice, introduced me to sediment localities in South Bohemia and provided me with some Czech literature. Otto CICHOCKI, Hans FISCHER, Hubert NAGL, Reinhard ROETZEL, all from Vienna, and Spyridon VERGINIS†, Vienna/Lefkas, accompanied and instructed me during terrain-excursions in Austria. Bernd SCHWAIGHOFER, Vienna, made two of his photos available. Reinhard ZETTER, Vienna, agreed to study a pollen sample from the Gmünd Beds. Christian SCHRENK, Neu-Nagelberg, assisted me with exploratory work. Franz ZIMMEL, Dietmanns near Gmünd, showed his unique collection of silicified woods to me. Ms. Christa GALL, Franz GROSSAUER, Erich SADILEK, all Gmünd, and Franz HAUER, Harald STEININGER, St. Pölten, made unpublished documents accessible to me. Ms. Irene STEINER, Vienna, prepared the reproduction of the Text-Figures. Last but not least, Walter REIHSNER and Karl Heinz RIBISCH, both Vienna, helped me with my English. To all of them I express my heartfelt gratitude.

References

ATTERBERG, A., 1905: Die rationelle Klassifikation der Sande und Kiese. – Chemiker-Zeitung. Central-Organ f. Chemiker, Techniker, Fabrikanten, Ingenieure, **29**/15, 195–198, Cöthen (Anhalt).

BERGER, E., 1977: Hydrologie des Raumes Breitensee/Gmünd. – Unpubl. typoscr., 8 leafs, Wien, Amt der Nö. Landesregierung, Abt. B/3-D Hydrologie; Archives of the engineering office of Arch. Dipl.-Ing. Erich SADILEK (Gmünd, NÖ).

BERGER , E., 1980: Hydrologie und Hydrogeographie des nordwestlichen Waldviertels. Ein wasserwirtschaftliches Regionalkonzept. – Doctoral thesis, 276 pp., ill., appendix with enclosures (22 folded tabs.), Wien.

BERGER , E., 1989: Hydrologie Gmünder Bucht. – Unpubl. typoscr., 17 leafs, maps, Amt der Nö. Landesregierung, Abt. B/3-D (Hydrologie) und B/9 (Wasserwirtschaft); Archives of the engineering office of Arch. Dipl.-Ing. Erich SADILEK (Gmünd, NÖ).

BOUŠKA, V., 1972: Geology of the moldavite-bearing sediments and the distribution of moldavites. – Acta Universitatis Carolinae Geologica **1972**/1, 1–29, ill., Praha.

BOUŠKA, V. & KONTA, J., 1986: Moldavites. Vltavíny. – Second International Conference on Natural Glasses, Prague 1987, Acta Universitatis Carolinae Geologica, **1986**/1, 128 pp., ill., Praha.

BUCHROITHNER, M.F., 1984: Karte der Landsat-Bildlineamente von Österreich 1 : 500.000. – 1 sheet, 123.0 x 83.7 cm, Wien (Geol. B.-A.).

CHÁBERA, S., 1987: Mineralogicko-geologická bibliografie Jihočeského kraje 1783–1985 [I. díl.]. Mineralogisch-geologische Bibliographie des Südböhmischen Kreises 1783–1985 [I. Teil.]. – Jihočeské muzeum v Českých Budějovicích, Přírodní vědy, České Budějovice, 144 pp.

CHÁBERA, S., 1989: Mineralogicko-geologická bibliografie Jihočeského kraje 1783–1985 [II. díl.]. Mineralogisch-geologische Bibliographie des Südböhmischen Kreises 1783–1985 [I. Teil]. – Jihočeské muzeum v Českých Budějovicích, Přírodní vědy, České Budějovice, 83 pp.

CHÁBERA, S., 1998: Fyzický zeměpisjižních Čech. Přehled geologie, geomorfologie, horopisu a vodopisu [= Physical geography of South Bohemia. An outline of geology, geomorphology, orography and hydrography]. – Jihočeská univerzita, Pedagogická fakulta, oddělení geografie, 140pp., ill., České Budějovice.

CHÁBERA, S. & HUBER, K.H., 2000: Ein Beitrag zur Frage der oberen Moldau im Tertiär. – Jb. Oberösterr. Musealverein, **145**/1, 339–367, ill., Linz (Gesellschaft für Landeskunde).

CŽJŽEK, J., 1854: Die geol. Beschaffenheit des Tertiärbeckens von Budweis in Böhmen. – Jb. Geol. R.-A., **5**/1, 215–216, Wien.

DEL-NEGRO, W., 1977: Abriß der Geologie von Österreich. – Bundesländerserie, 139 pp., ill., 4 pls., Wien (Geol. B.-A.).

DOMÁCÍ, L., 1979: Některé aspekty sedimentace klikovského souvrství. Some aspects of sedimentation of the Klikov complex. – Acta Universitatis Carolinae Geologica, **1979**/3–4, 149–166, ill., Praha.

DORN, P., 1951: Geologie von Mitteleuropa. – XII + 474 pp., ill., Stuttgart (E. Schweizerbart'sche Verlagsbuchhandlung Erwin Nägele).

DWIRKA, F., 1911: Fossiles aus Gmünd in NÖ (Waldviertel). – Kremser Zeitung. Volksblatt für Stadt und Land in NÖ., **42**/Nr. 16–18 and 20–22, Krems.

DWIRKA , F., 1913a: Aus Gmünds Frühgeschichte [etc.]. – In: Festschrift d. Niederösterr. Landes-Lehrertages in Gmünd, 15., 16. und 17. Juli 1913.

DWIRKA , F., 1913b: Das städtische Museum in Gmünd [etc.]. – Kremser Zeitung. Volksblatt für Stadt und Land in NÖ, **44**/Nr. 27–28, Krems.

DWIRKA , F., 1913c: Das städtische Museum in Gmünd [etc.]. – Druck von J. Kehl in Krems, 12 pp., ill., Gmünd.

DWIRKA , F., 1926: Die Stadt Gmünd im Wandel der Zeit. Kurzgefaßter Führer durch Gmünd und Umgebung [etc.]. – 16 pp., ill., Gmünd.

ENGELMANN, R., 1938: Der Elbedurchbruch. Geomorphologische Untersuchungen im oberen Elbegebiete. – Abh. Geogr. Ges. Wien, **13**/2, 138 pp., ill., Wien.

Erhart-Schippek, W., 1993a: Bericht betreffend hydrogeologische Grundlagenerhebung Gmündner Bucht. – In: Hydrogeologische Grundlagenerhebung Gmündner Bucht, GZ 92/178, unpubl. typoscr., Amt der Nö. Landesregierung, Abt. B/9-Wasserwirtschaft, St. Pölten.

Erhart-Schippek, W., 1993b: Bericht betreffend hydrogeologische Grundlagenerhebung Gmünder Bucht. – Detailuntersuchungen zur Ermittlung der Grundwasserschwankungen im Bereich der Sandabbaue südlich des Gelsenberges, GZ 92/178a, unpubl. typoscr., 23 leafs, 6 figs., Amt der Nö. Landesregierung, Abt. B/9-Wasserwirtschaft, St. Pölten.

Erhart-Schippek, W., 1993c: Anhang betreffend hydrogeologische Grundlagenerhebung Gmünder Bucht. – Detailuntersuchungen zur Ermittlung der Grundwasserschwankungen im Bereich der Sandabbaue südlich des Gelsenberges, GZ 92/178a, unpubl. typoscr., Amt der Nö. Landesregierung, Abt. B/9-Wasserwirtschaft, St. Pölten.

Erich, A. & Schwaighofer, B. 1977: Geol. Karte der Republik Österr. 1 : 50.000, [Bl.] 18 Weitra. – 1 sheet, 72,0 x 54,0 cm, Wien (Geol. B.-A.).

Ettingshausen, C. v., 1852: Ein interessantes Vorkommen von fossilen Pflanzen bei Wittingau in Böhmen. – Jb. Geol. R.-A., **3**/4, 144, Wien.

Frič, A., 1873a: O zkřemenělých kmenech v okolí Třeboně a Hluboké [= On silicified woods in the surroundings of Třeboň and Hluboká]. – Vesmír, časopis pro šíření vědy přírodní, země- a národopísné, **2**/18, 232–233, Praha.

Frič, A., 1873b: Über fossile Baumstämme in der Umgebung von Wittingau und Frauenberg. – Sitzber. königl. böhm. Gesellschaft d. Wissenschaften in Prag, **1873**/3, 109–111, Prag 1874.

Fuchs, W., 1977: Einige Beiträge zur Tertiär- und Quartärstratigraphie Ober- und Niederösterreichs. – Verh. Geol. B.-A., **1977**/3, 231-241, Wien.

Fuchs, W., 1980: Die Molasse und ihr nichthelvetischer Vorlandanteil am Untergrund einschließlich der Sedimente der Böhmischen Masse. – In: Oberhauser, R. (Red.:) Der geologische Aufbau Österreichs, 144–176, ill., Wien – New York (Springer-Verlag).

Füchtbauer, H., 1959: Zur Nomenklatur der Sedimentgesteine. – Erdöl und Kohle. Organ der Deutschen Gesellschaft f. Mineralölwissenschaft und Kohlechemie, **12**/8, 605–613, Hamburg.

Gmünd Bahnhof (Geologisches), 1905. – Der Waldviertler Bote. Beilage zur Kremser Zeitung. Volksblatt für Stadt und Land in NÖ, **36**/17, 5, Krems a. d. Donau.

Gmünd (Unser Tertiär), 1906. – Der Waldviertler Bote. Beilage zur Kremser Zeitung. Volksblatt für Stadt und Land in NÖ, **37**/35, 4, Krems a. d. Donau.

Gradstein, F.M., Agterberg, F.P., Ogg, J.G., Hardenbol, J., van Veen, P., Thierry, J. & Huang, Z.: A Triassic, Jurassic and Cretaceous Time Scale. – In: Bergen, W.A., Kent, D.V., Aubry, M.-P. & Hardenbol, J. (eds.): Geochronology, Time Scales and Global Stratigraphic Correlation, Society for Sedimantary Geology, Special Publication, **54**, 95-126, Tulsa/Oklahoma.

Grossauer, F., 1991a: Sandleitplan Breitensee. Ber. Stand: Jänner 1991. – Unpubl. typoscr., 37 leafs with 2 figs. and 4 tabs. in the text; Archives of the landscape planning office of Dipl.-Ing. Franz Grossauer, Gmünd, NÖ.

Grossauer , F., 1991b: Sandleitplan Breitensee. – Raumordnung aktuell. Vierteljahresschrift f. Raumplanung, Raumforschung und Umweltschutz des Landes NÖ, **1991**/2, 16–17, Wien.

Grund, A., 1915: Die Pfingstexkursion der Prager Geographen ins nö. Waldviertel (10.–13. Mai 1913). – Geograph. Jahresber. aus Österr., **11**, 166–181, Wien.

Hackl, O., 1915: Ton von Brühl bei Weitra, N.-Ö. etc . – In: Eichleiter, C.F. & Hackl, O.: Arbeiten aus dem chemischen Laboratorium der Geologischen Reichsanstalt in den Jahren 1910–1912. – Jb. Geol. R.-A., **64**/3–4, 366, Wien.

Hauer, F.v., 1869: I. Geol. Uebersichtskarte der österr. Monarchie. Nach den Aufnahmen der GRA [etc.] Bl. I. und II. Böhmen. – Jb. Geol. R.-A., **19**/1, 1–58, Wien.

Hauer, R., 1924: Heimatkunde des Bezirkes Gmünd. – VII + 309 pp., ill., Zwettl (Kommissions-Verlag Buchhandlung O. Neugebauer).

Hauer, R., 1928: Dietmanns. Die Geschichte eines Dorfes. – Unpubl. typoscr., I + 51 leafs, Dietmanns bei Gmünd; Wiss. Bibliothek und Dokumentationszentrum f. das obere Waldviertel in Gmünd, NÖ, shelf-mark 1186.

Hauer, R., 1951: Heimatkunde des Bezirkes Gmünd. – 2., erweiterte Auflage, VII + 436 pp., ill., Gmünd (Verlag der Stadtgemeinde).

Hauer, R., 1952a: Die Erdgeschichte des Waldviertels. – Aus Welt und Heimat. Familienbeilage der nö. Wochenblätter, **1952**/12, 1–2, Beilage zur Volks-Presse. Wochenblatt für das Viertel unter dem Manhartsberg, **7**/12, Wr Neustadt.

Hauer, R., 1952b: Die Flußsysteme des n.-ö. Waldviertels. Beitrag zu ihrer Entwicklungsgeschichte. – 193.pp., ill., Gmünd (Verlag der Stadtgemeinde).

Hauer. R., 1963: Die europäische Hauptwasserscheide im nordwestlichen Waldviertel. – Das Waldviertel. Z. f. Heimatkunde und Heimatpflege, N.F. **12**/5–6, 65–75, Krems.

Hibsch, J.E., 1913: Die Verbreitung der oligocänen Ablagerungen und die voroligocäne Landoberfläche in Böhmen. – Sitzber. k. Akad. Wiss., mathem.-naturwiss. Klasse, **122**/4, 485–500, 1 pl., Wien.

Hochuli, P.A., 1983: S 82/71 Gmünd, NÖ. – In: Ber. Biostratigraphie und Palökologie palynologischer Proben aus dem Tertiär Österreichs, in Zusammenhang mit der Untersuchung von kohlehöffiger Fazies in NÖ, unpubl. typoscr., 2 leafs, Zürich (Geol. Inst. ETH); private archives of Karl H. Huber, Wien.

Houša, V. & Špinar, Z.V., 1960: Senonian Conchostracans (Conchostraca) from South Bohemia. – Sborník Ústředního geologického ústavu, oddíl paleontologický, **27**, 7–30, pl. I–XIII, Praha 1962.

Huber, K.H., 1999: Zum Formenschatz der Granitverwitterung und -abtragung im nordwestlichen Waldviertel. – In: Steininger, F.F. (ed.): Erdgeschichte des Waldviertels. Zweite, erweiterte Auflage, Schriftenreihe des Waldviertler Heimatbundes, **38**, 113–132, ill,. Horn – Waidhofen/Thaya.

Huber, K.H., 2000: Die Granitformen der Blockheidelandschaft. – In: Blockheide Gmünd-Eibenstein, ein besonders reizvoller Naturpark, p. 17, Gmünd (Naturpark Blockheide Gmünd-Eibenstein).

Kasmanhuber, F., 1931: Die Landwirtschaft im oberen Waldviertel – In: L. Babitsch (Red.): Amtliche Festschrift zur Waldviertel-Ausstellung und 850-Jahrfeier der Stadt Weitra, 19. bis 21. September 1931, 5–6, Weitra (Verlag der Ausstellungsleitung).

Katzer, F., 1892: Geologie von Böhmen. Der geognostische Aufbau und die geol. Entwickelung des Landes [etc.]. – XXII + 1606 pp., ill., Prag (Verlag I. Taussig).

Katzer, F., 1904: Notizen zur Geologie von Böhmen. IX. Zur näheren Kenntnis des Budweiser Binnenlandtertiärs. – Verh. Geol. R.-A., **1904**/14, 311–317, Wien.

Katzer, F., 1905: Zur näheren Kenntnis des Budweiser Binnenlandtertiärs. – Ungarische Montan-Industrie- und Handelszeitung. Fachorgan f. Berg-, Hütten- und Salinenwesen [etc.], **XI**/7, 1–3, Budapest.

Knobloch, E., 1964: Neue Pflanzenfunde aus dem südböhmischen Senon. – Jb. Staatl. Mus. f. Mineralogie und Geologie zu Dresden, **1964**, 133–201, ill., 8 pls., Dresden.

Knobloch, E., 1981: Pflanzenreste aus dem Tertiär von Horn. – Verh. Geol. B.-A., **1981**/2, 59–71, 4 pl., Wien.

Knobloch, E., 1985: Paläobotanisch-biostratigraphische Charakteristik der Klikov-Schichtenfolge (Oberturon–Santon) in Südböhmen. Paleobotanicko-biostratigrafická charakteristika klikovského souvrství (svrchní turon-santon) v jižních Čechách. – Sborník geologických věd. Geologie, **40**, 101–145, 3 pls., Praha.

Knobloch, E., 1997: Similarities between the Upper Cretaceous (Senonian) floras from Bohemia and the Aachen-Limburg area. – In: Herngreen, G.F.W. (ed.): Proceedings of the 4th European Paleobotanical and Palynological Conference [4. 1997, Kerkrade]. (= Mededelingen/Nederlands Instituut voor Toegepaste Geowetenschappen, TNR. 58), 115–119, Haarlem.

Knobloch, E. & Mai, H.D., 1986: Monographie der Früchte und Samen in der Kreide Mitteleuropas. Monografie plodů a semen zřidy střední Evropy. A monograph on fruits and seeds from the Central European Cretaceous. – Rozpravy Ústředního ústavu geologického, **47**, 220 pp., ill., 56 pls., Praha.

Köhn, M., 1928: Bemerkungen zur mechanischen Bodenanalyse III. Ein neuer Pipettapparat. – Z. f. Pflanzenernährung, Düngung und Bodenkunde. A. Wiss. Teil 11, 50–54, ill., Berlin.

Koroš, I., Rauch, O. & Jeník, J., 1996: Geology, geomorphology and soils [of the Lužnice floodplain]. – In: Prach, K., Jeník, J. & Large, A.A.G. (eds.): Floodplain Ecology and Management. The Lužnice River in the Třeboň Biosphere Reserve, Central Europe, 19–26, Amsterdam (SBP Academic Publishing).

KORTE, C. & Comp., 1903: Wasserversorgung der Stadt Gmünd, NÖ. – File, containing 29 numbered and some unnumbered unpubl. documents. K.k. Bezirkshauptmannschaft Gmünd, 2. Aug. 1904; Wissenschaftliche Bibliothek in Gmünd, shelf mark A24.

KRASNÝ, J., 1980: Hydrogeologie jihočeských pánví. L'hydrogéologie des bassins de la Bohême du Sud. – Sborník geologických v ěd. Hydrogeologie, inženýrská geologie, **14**, 7–81., ill., Praha.

KREBS, N., 1929: Die Ostalpen und das heutige Österr. Eine Länderkunde. – Zweite, wesentlich erweiterte Auflage [etc.], 2. Bd., Regionaler Teil, X + 496 pp., ill., Stuttgart (J. Engelhorns Nachf).

KUBIENA, W., 1929: Verfahren zur abgekürzten mechanischen Bodenanalyse mit einfachen Behelfen. – Fortschritte der Landwirtschaft. Z. u. Zentralbl. f. die gesamte Landwirtschaft, **4**/10, 313–316, Berlin und Wien.

KUŠTA, J., 1873: Geologické poznámky o Třeboňské a Budějovické Třeboň and Budějovice Plain]. – Vesmír, časopis pro šíšení vědy přírodní, země- a národopísné, **2**/18, 233, Praha.

KUŠTA, J., 1879: Verkieseltes Holz in der Wittingauer Tertiärebene. – Verh. Geol. R.-A., **1879**/15, 337–338, Wien.

Lagerung der Bodenschichten bei Bohrloch II nach Wasser bei der Firma Arthur Heinisch in Gmünd II. (E. Lötsch. 19. Nov. 1929.). Well section of a 34.7 m deep exploration drilling Gmünd II. – 1 leaf, Wasserbohrarchiv der Fachabteilung Hydrogeologie der Geol. B.-A., Wien, old shelf-mark 4454/4; private archives of Karl H. HUBER, Wien.

LECHNER, K., 1949: Bericht über einige Tonvorkommen im nordwestlichen Waldviertel – Unpubl. typoscr., 3pp., 1 sketch map, Wien. 1. Juni 1949; Lagerstättenarchiv der Geol. B.-A., Wien.

LECHNER, K., 1953: Tonvorkommen in der Umgebung von Gmünd, N.-Öst. Nach einer persönlichen Mitteilung von R. OSTADAL [etc.]. – Unpubl. typoscr. [Sine loco], 1p.; Lagerstättenarchiv der Geol. B.-A., Wien.

LIPOLD, M.V., 1852: Bericht über die Arbeiten der Section III [etc.], mitgetheilt in der Sitzung der Geol. R.-A. am 11. November 1851. – Jb. Geol. R.-A., **3**/1, 101–110. Wien.

MALECHA, A., 1964: Jihočeské pánve [= The basins of Southern Bohemia]. – In: SVOBODA, J. (s kolektivem autorů): Regionální geologie ČSSR. [= Regional geology of Czechoslovakia]. – Díl I. Česk? masív. Svazek 2. Algonkium – kvartér, 408–428, ill., Praha (Vydal Ústřední ústav geologický v Nakladatelství České akademie věd).

MALECHA, A., 1966: The basins of Southern Bohemia. – In: SVOBODA, J. et al.: Regional Geology of Czechoslovakia, Part I, The Bohemian Massif, 581–595, ill., Prague (Publishing House of the Czechoslovak Academy of Sciences.).

MALECHA, A., 1977 (red.): Základní geologická mapa ČSSR 1 : 25.000, List 33–132, 33–134 České Velenice [= Geological Basic Map of the Czechoslovakian Socialistic Republic 1 : 25.000, Sheet 33–132, 33–134 České Velenice]. – Vydal Ústřední ústav geologický ve spolupráci s. n. p. Kartografie, 1 sheet 89,8 x 63.4 cm, Praha. .

MALECHA, A. & ŠPINAR, Z. [V.] za spolupráce N. BOŘKOVÉ-GABRIELOVÉ, F., NĚMEJCE, B. PACLTOVÉ, Z. ŘEHAKOVÉ a J. SLÁNSKÉ, 1960: Úprava názvosloví a charakteristika mesozoických a terciérních stratigrafických jednotek jihočeských pánví [= Determination of the terminology and characterization of the Mesozoic and Tertiary stratigraphical units of the South Bohemian Basins]. – In: Pracovní konference Československé společnosti pro mineralogii a geologii pří ČSAV v Českých Budějovicích ve dnech 19. až 22. září 1960 o sedimentech jihočeských pánví a vývoji sedimentačního prostoru. [Cover-title:] Pracovní konference v Č. Budějovicích pořádaná v rámci 15tiletého osvobození ČSSR Čsl. společností pro mineralogii a geologii pří ČSAV za spolupráce Přírodovědecké fakulty U.K. a Ústředního ústavu geologického v Praze. – 25–39, Praha (Katedra paleontologie Přírodovědecké fakulty univerzity Karlovy, Ústřední ústav geologický).

MALECHA, A. & ŠPINAR, Z. [V.] za spolupráce N. BOŘKOVÉ-GABRIELOVÉ, F. NĚMEJCE, B. PACLTOVÉ, Z. ŘEHAKOVÉ a J. SLÁNSKÉ, 1962: Nové dělení a označení stratigrafických jednotek jihočeských pánví [= New subdivision and terminology of the stratigraphical units of the South Bohemian Basins]. – Věstník Ústředního ústavu geologického, **37**/3, 161–170, Praha.

MALECHA, A., STANÍK, E., SUK, M., ŠALANSKÝ, K. & ŽEBERA, K., 1977: Vysvětlivky k základní geologické mapě ČSSR 1 : 25000, 33–132 a 33–134 České Velenice [= Explanatory notes on the Geological Basic Map of the Czechoslovakian Socialistic Republic 1 : 25 000. 33–132 and 33–134 České Velenice]. – 36 pp., ill., Praha (Vydal Ústřední ústav geologický).

MALECHA, A. & SUK, M., 1985: Geologie jižních Čech. Die Geologie Südböhmens [= Geology of South Bohemia]. – In: CHÁBERA, S. (ed.): Jihočeská vlastivěda. Řada A. Neživá příroda [= South Bohemian local studies. Series A. Inanimated nature]. – Jihočeské nakladatelství, 36–63, 262–263, České Budějovice.

MAYRHOFER, R., 1935: Zur Mineralogie NÖs. – Unsere Heimat. Monatsbl. Ver. f. Landeskunde und Heimatschutz von NÖ und Wien, N.F. **8**/3, 75–83. Wien.

MÜLLER, W., 1979: Begutachtung des Baugrundes f. den Neubau des a[llgemeinen] ö[ffentlichen] Krankenhauses Gmünd. – Unpubl. typoscr., 6 leafs, 5 enclosures, Höhere Technische Bundeslehranstalt Krems, Höhere Abteilungen f. Hoch- und Tiefbau, Baufachschule [etc.]; private archives of Karl H. HUBER, Wien.

NĚMEJC, F., 1938a: První nález křídové květeny v jihočeské pánvi [= First finding of a Cretaceous flora in the South Bohemian Basin]. – Časopis Národního musea, **112**/2, 167–168, V Praze.

NĚMEJC, F., 1938b: Nález křídového útvaru v oblasti jihočeské třetihorní pánve. (Předběžná zpráva) [= Finding a Cretaceous formation in the region of the South Bohemian Tertiary basins. (Preliminary report)]. – Věda přírodní. Měsižník pro přstování a šíření věd přírodních, **19**/5, 153–154, Praha.

NĚMEJC, F., 1955: Paleobotanická studie k otázce stratigrafie uloženin jihočeské pánve. A Paleobotanical Study of the Question of the Stratigraphy of the Deposits of the South Bohemian Basin. – Sborník Ústředního geologického ústavu, oddíl paleontologický, **22**, 335–377, Praha 1956.

NĚMEJC, F., 1961: Fossil plants from Klikov in S[outh] Bohemia (Senonian). – Rozpravy Československé akademie věd. Řada matematických a přírodních věd, **71**/1, 48pp., ill., 7 pls., Praha.

NĚMEJC, F., 1968: Paleofloristické studie v křídových a třetíhorních uloženinách jihočeských pánví a pánve Plzeňské. Paleofloristical studies in the Cretaceous and Tertiary of the basins of Southern Bohemia and in the region of Plzeň. – Sborník Národního musea v Praze, Řada B, přírodní vědy, **24**/1, 7–34, Praha.

NĚMEJC, F. & KVAČEK, Z., 1975: Senonian plant macrofossils from the region of Zliv and Hluboká (near České Budějovice) in South Bohemia. – 83 pp, ill., 24 pls., Praha (Universita Karlova).

Novák, V.: Zkřemeněla dřeva jihočeských pánvi [Silicified Woods of the South Bohemian Basins]. – Minerál. Svět nérostů a drahych kamenů, **5**/3, 166–167, Brno.

OELWEIN, A., 1904: Gutachten über das von der Firma C. Korte & Komp. verfasste Projekt der Wasserversorgung von Gmünd in N. Oe. – Unpubl. typoscr., 13 leafs, Wiss. Bibliothek und Dokumentationszentrum für das obere Waldviertel in Gmünd, NÖ, file no. A 24.

OSTADAL, R., 1942: Bericht [über eine Böschungsabgrabung längs der Bahnstrecke, 200 m OSO vom Bahnhofsgebäude Gmünd]. – Unpubl. typoscr., photocop. 1 leaf, Geol. Melde- und Beobachtungsdienst, Arbeitszelle Heimatmuseum Gmünd, N.-D. 3. Oktober 1942; private archives of Karl H. HUBER, Wien.

OSTADAL, R., 1953: Tonvorkommen in der Umgebung von Gmünd. – Letter, addressed to K. LECHNER, Wien, unpubl. typoscr., Gmünd. 18. März 1953, 2 pp.; Lagerstättenarchiv der Geol. B.-A., Wien.

OYAMA, M. & TAKEHARA, H., 1970: Revised Standard Soil Color Charts. – 2nd edition, 14 pp., [7] tab., [8]; 14. 14pp., 13 leafs, Tokyo.

PACLTOVÁ, B., 1958: Palynologický výzkum křídových, třetíhorních a kvartérních hornin v jihočeských pánvích v roce 1956. Palynological investigation of the Cretaceous, Tertiary and Quaternary deposits in the South Bohemian Basins during the year 1956. – Věstník Ústředního ústavu geologického, **33**/5, 330–339, ill., Praha.

PACLTOVÁ, B., 1959: Některé rostlinné mikrofosilie ze sladkovodních uloženin svrchní křídy (senon) v jihočeských pánvích. Část 1. On some Plant Microfossils from Fresh-Water Sediments of the Upper Cretaceous (Senonian) in the South-Bohemian Basins. Part 1. – Sborník Ústředního ústavu geologického, oddíl paleontologický, **26**, 47–102, 24 tabs., Praha 1961.

PACLTOVÁ, B., 1981: The evolution and distribution of Normapolles pollen during the Cenophytic. – Review of Paleobotany and Palynology, **35**, 175–208, ill., 20 pl., Amsterdam.

PACLTOVÁ, B., 1990: Marginal facies of the Bohemian Upper Cretaceous. (Palynological Study). – Proceedings of the Symposium "Paleofloristic and paleoclimatic changes in the Cretaceous and Tertiary", 1989, Prague, 47–53, 1 pl., Prague.

PAPP, A. & THENIUS, E., 1962: Gmünder Schichten. – Lexique stratigraphique international. [Vol. 1.] Europe. Fascicule 8. Autriche. Par le Professeur O. KUEHN, 160, Paris.

PARTSCH, P.M., 1824: Geognostische Reise-Relation des Herrn Partsch. Bericht über die im Auftrag der löblichen n.ö. Herren Stände im Jahre 1824 unternommenen geognostischen Reisen [Teil II.]. – Unpubl. typoscr., 50 leafs, transcription by L. WALDMANN; Wiss. Archiv der Geol. B.-A., Wien, Leo-Waldmann-heritage, shelf-mark: A 10054–R.2, Wien; PARTSCHS codex is kept in the Nö. Landesarchiv, Ständisches Archiv, St. Pölten, shelf-mark: HS 119/1–4.

PATZNICK, F., 1874: Die Stadt Gmünd in Nieder-Oesterreich. Eine Darstellung derselben in topografischer, statistischer und historischer Beziehung. – 112 [+1] pp., Gmünd (Selbstverlag des Verfassers).

PAUKNER, M, 2003: Die hydrologischen und geologischen Verhältnisse im politischen Bezirk Gmünd westlich der mitteleuropäischen Hauptwasserscheide. Perspektiven für die Hochwasserprävention unter dem Blickwinkel der landschaftswirksamen Pflegemaßnahmen im Naturschutzgebiet „Lainsitzniederung". – Diss. Univ. Wien, V + 211 Blatt, ill., CD-ROM, Wien.

PETRASCHECK, W.[J.], 1922–29: Kohlengeologie der Österr. Teilstaaten [in 2 Teilen]. I. 1922/24. II. 1926/29. – Revidierter und ergänzter Sonderdruck aus der Zeitschrift des Oberschlesischen Berg- und Hüttenmännischen Vereins zu Katowice, 489 pp., ill., Katowice.

PETRASCHECK, W.[J.], 1929: Die Braunkohlenlager von Böhmen und Kleinpolen (Fortsetzung). – Z. Oberschlesis. Berg- u. Hüttenmänn. Ver. zu Katowice, **68**/7, 352–362, Katowice.

PETRASCHECK, W.[J.], 1944: Die Sudetenländer. Unter Mitarbeit von L. WALDMANN und A. LIEBUS. – In: O. WILCKENS (Hrsg.): Handbuch der Regionalen Geologie , 1. Bd., 5. Abteilung, 30. Heft, 295 pp., ill., 5 Taf., Heidelberg (Universitätsverlag C. Winter.)

POWERS, M.C., 1953: A new roundness scale for sedimentary particles. – Sedimentary Petrology, **23**/2, 17–119. Tulsa/Oklahoma.

PRAKASH, U., BŘEZINOVÁ, D. & AWASHTI, N., 1974: Fossil woods from the Tertiary of South Bohemia. – In: Paleontographica. Beiträge zur Naturgeschichte der Vorzeit. Abteilung B. Paläophytologie, **147**/4–6, 107–123, ill., pl. 48–57, Stuttgart.

RAMSAR-Convention no. 1013 from Dec. 22nd, 1999. –, 4 pp., ill. http://www.ramsar.org/w.n.austria_lainsitz.htm.

RAUSCHER, H., 1931: Die Industrie des Waldviertels. – In: STEPAN, E. (ed.): Das Waldviertel [Ein Heimatbuch. Sammelwerk der Ztschr. „Deutsches Vaterland", in 7 Bdn., 1925–37]. 6. Bd. Schrifttum, Schulwesen, Münzkundliches, Industrie, 86–185, ill., 1 map, Wien (Verlag Dr. E. Stepan).

ŘEHÁKOVÁ, Z., 1969a: Beitrag zur stratigraphischen Gliederung des Neogens der südböhmischen Becken. – Věstník Ústředního ústavu geologického, **44**/5, 307–309, Praha.

ŘEHÁKOVÁ, Z., 1969b: Entwicklung der Diatomeensedimentation im Neogen der südböhmischen Becken. – Mitt. Intern. Ver. f. Limnologie, **17**, 256–261, Stuttgart.

ŘEHÁKOVÁ, Z., 1969c: Příspěvek ke stratigrafii jihočeského terciéru [= A contribution to the stratigraphy of the South Bohemian Tertiary]. – Zprávy o geologických výzkumech v roce, **1968**, 186–188, Praha.

ŘEHÁKOVÁ, Z., 1991: Vývoj mydlovarského a domanínského souvrství v okolí Třeboň [= The development of the Mydlovary and Domanín Formations in the surroundings of Třeboň]. – Zprávy o geologických výzkumech v roce, **1989**, 154–157, Praha.

REININGER, H., 1907: Geologisch-tektonische Untersuchungen im Budweiser Tertiärbecken. Vorläufiger Ber. – Lotos, N.F., **1**/2, 22–25, Prag.

REININGER, H., 1908: Das Tertiärbecken von Budweis. – Jb. Geol. R.-A., **58**/3, 469–526, ill., Wien.

REUSS, A.E. [v.], 1854: Kurze Uebersicht der geognostischen Verhältnisse Böhmens. Fünf Vorträge, gehalten im naturwiss. Vereine Lotos im Jahre 1853. – 10 pp., 3 Karten, Prag (Verlag der J.G. Calve'schen Buchhandlung. F. Tempsky).

RIEDL, J., 1959: Bericht über die Untersuchungsbohrungen 1959. Gmünd – Altpölla – bis Grenze, Waldviertel, N.Ö. – Ber. der „KAMIG", Österr. Kaolin-Montan-Industrie-AG, unpubl. typoscr., 288 pp., Kriechbaum; Lagerstättenarchiv der Geol. B.-A., Wien, Inv.Nr. 202/60/Geol. B.-A..

RIEPL, F., 1822: Darstellung der Eisenerz-Gebilde in den Gebirgen der österr. Monarchie, welche im Norden der Donau liegen. – Jb. k.-k. Polytechn. Inst. Wien, **3**, 237–309, Wien.

ROETZEL, R., 1999: Die „Gmünder Bucht". – In: WANDALLER, E. & MANHART, D.: Universum vor der Haustür. Die außergewöhnlichen Naturschätze des Raumes Gmünd. The universe at the front door. The extraordinary environs of the town Gmünd, 28–33, St. Pölten – Linz – Wien (Landesverlag).

ROETZEL, R. & KURZWEIL, H. 1986: Die Schwerminerale in nö. Quarzsanden und ihre wirtschaftliche Bedeutung. – Arch. f. Lagerst.forsch. Geol. B.-A., **7**, 199–216, ill., Wien.

ROETZEL, R., MANDIC, O. & STEININGER, F.F., 1999: Lithostratigraphie und Chronostratigraphie der tertiären Sedimente im westlichen Weinviertel und angrenzenden Waldviertel – In: ROETZEL, R. (ed.): Geol. Karten ÖK 9 Retz und ÖK 22 Hollabrunn. Geogenes Naturraumpotential der Bezirke Horn und Hollabrunn, Arbeitstagung Geol. B.-A., 1999, 38–54, ill., Wien.

ROSENKRANZ, R., 1925: Bodenbeschreibung [des Waldviertels]. – In: STEPAN, E. (ed.): Das Waldviertel Ein Heimatbuch. Sammelwerk der Zeitschrift „Deutsches Vaterland" [in 7 Bdn. 1925–37], 1. Bd. Naturwiss., 5–46, ill., 1 map, Wien (Verlag Dr. E. Stepan).

SCHAFFER, F.X., 1914: Das Miocän von Eggenburg [etc.]. II. Stratigraphie. – Abh. Geol. R.-A., **22**/4, VIII + 124 pp, ill., X pl., Wien.

SCHNABEL, W. (Red.), 2002: Geol. Karte von Niederösterrreich 1 : 200.000. – 2 sheets (NÖ Nord, NÖ Süd) 113.3 x 70.3 cm, Wien (Geol. B.-A.).

Das schönste Stück im Heimatmuseum: Das Rippenbruchstück einer Seekuh, 1952. – Waldviertler Wegweiser. Waldviertler Wochenzeitung. Offizielles Mitteilungsorgan des Nö. Fußballverbandes, Hauptgruppe Nord-West, **1952**/27, 5, Wien.

SCHWAIGHOFER, B., 1967: Bericht 1966 über Aufnahmen auf Bl. Weitra (18), N-Hälfte. – Verh. Geol. B.-A., **1967**/3, A43–A44, Wien.

SCHWAIGHOFER, B., 1978: Geologische Karte der Republik Österreich 1 : 50.000. Erläuterungen zu Bl. 18 Weitra. – 18 pp., Wien (Geol. B.-A.).

SLABÝ, J. & HOLÁSEK, O. (Red.), 1992: Geologická mapa ČR 1 : 50.000, List 33–13 České Velenice [= Geological map of the Czech Republic 1 : 50.000, Sheet 33–13 České Velenice]. – 1 sheet, 68.6 x 46.8 cm, Praha (Český geologický ústav).

SLANSKÁ, J., 1974: Continental Cretaceous and Tertiary Sedimentation in the South Bohemian Basins, Czechoslovakia. – N. Jb. Geol. u. Paläont., Abh., **146**/3, 385–406, ill., Stuttgart.

SLANSKÁ, J., 1976: A red bed formation in the South Bohemian Basins, Czechoslovakia. – Sedimentary Geology, **15**/2, 135–164, ill., Amsterdam.

SNEED, E.D. & FOLK, R.L., 1958: Pebbles in the Lower Colorado River, Texas: A Study in Particle Morphogenesis. – The Journal of Geology, **66**/2, 114–150, Chicago/Illinois.

SOUKUP, J., 1968: Klikov Formation (Klikovské souvrství). – Lexique stratigraphique international [Vol. 1.], Europe, Seconde édition, Fascicule 6 b, Czechoslovakia, Part 6 bI, Bohemian Massif, 164–166, Paris.

STEININGER, F.F. & ROETZEL, R., 1991: Die tertiären Molassesedimente am Ostrand der Böhmischen Masse. – In: ROETZEL, R. & NAGEL, D. (eds.): Exkursionen im Tertiär Österreichs [etc.], 59–141, ill., Wien (Österreichische Paläontologische Gesellschaft).

STEININGER, F.F. & ROETZEL, R., 1994: Beiträge zu einer präquartären Landschaftsgeschichte des Waldviertels und des Kamptales. – In: DICK, G. (ed.): Das Waldviertel als Natur- und Kulturraum. Festschrift aus Anlaß des 10-jährigen Bestandsjubiläums des Instituts f. angewandte Öko-Ethologie in Rosenburg, Beiträge zur Waldviertel-Forschung, **1994**, 111–118, Wien.

STEININGER, F.F. & ROETZEL, R., 1999: Älteres Tertiär [im Waldviertel]. – In: STEININGER, F. F. (ed.): Erdgeschichte des Waldviertels, Schriftenreihe des Waldviertler Heimatbundes, **38**, 75–78, ill., Horn – Waidhofen/Thaya.

STINI, J., 1944: Geologisches Gutachten, betreffend die geplante Luftschutzanlage für das Reichsbahnausbesserungsamt Gmünd, N.D., 1944–12–28. – Unpubl. typoscr., 5 leafs, 2 enclosurses; Archive des Geologischen Dienstes, Amt der Nö. Landesregierung, Baudirektion, Abteilung Allgemeiner Baudienst, St. Pölten, shelf-mark: Nr. 662.

SUESS, F.E., 1903: Bau und Bild der böhmischen Masse. – In: DIENER, C.. HOERNES, R., SUESS, F.E. & UHLIG, V.: Bau und Bild Österreichs, 1–322, ill., Wien (F. Tempsky) – Leipzig (G. Freytag).

THENIUS, E., 1974: Niederösterreich. – Geologie der österreichischen Bundesländer in kurzgefaßten Einzeldarstellungen, 2. erw. Aufl., Verh. Geol. B.-A., Bundesländerserie, 280 pp., ill., Wien (Geol. B.-A.).

TOLLMANN, A., 1985: Geologie von Österr. [in 3 Bdn. 1977–86]. II. Außerzentralalpiner Anteil. – XV + 710 pp., ill., Wien (F. Deuticke).

Tonfunde im Waldviertel, 1932. – Österr. Hafner-Zeitung, Wirtschaftliche und technische Rundschau der Hafner, Ofensetzer und sämtlicher Tonwaren-Interessenten, **8**/11, 7, Wien.

TRAUTMANN, W., 1949: Heimatmuseum der Stadt Gmünd, N.-Ö. Ein übersichtlicher Führer durch die Sammlungen. – 17 pp., Gmünd (Verlag des Museums).

VETTERS, H., 1947: Erläuterungen zur Geol. Karte von Österr. und seinen Nachbargebieten [etc.]. – X + 343 pp., Wien (Geol. B.-A.).

VINZENZ, M., 1983: Untersuchung Kohlenprobe Gmünd, NÖ. 19. 1. 1983. – Unpubl. typoscr., 1 leaf, Leoben; private archives of Karl H. HUBER, Wien.

VRÁNA, S., 1991: Corundum in the Upper Cretaceous sandstone in southern Bohemia, its composition, provenance and dissolution. – Časopis pro mineralogii a geologii, Journal of Mineralogy and Geology, **36**/4, 237–242, 2 pls., Praha.

WALDMANN, L., 1930: Aufnahmsbericht von Privatdozent Dr. Leo Waldmann über das Blatt Gmünd-Litschau (4454). – Verh. Geol. B.-A., 1930/1, 38-41, Wien.

WALDMANN, L., 1931: Bericht des Privatdozenten Dr. Leo Waldmann über die Aufnahme des Blattes Gmünd-Litschau (4454) und Bereisung des Blattes Drosendorf (4445). – Verh. Geol. B.-A., **1931**/1, 31–34, Wien.

WALDMANN, L., 1932: Aufnahmsbericht des Privatdozenten Dr. Leo Waldmann über das Blatt Gmünd-Litschau (4454). – Verh. Geol. B.-A., **1932**/1–2, 32–34, Wien.

WALDMANN, L., 1933: Aufnahmsbericht des Privatdozenten Dr. Leo Waldmann: I. Über das Blatt Gmünd-Litschau (4454). – Verh. Geol. B.-A., **1933**/1–2, 28, Wien.

WALDMANN, L., 1934: Aufnahmsbericht des Privatdozenten Dr. Leo Waldmann über das Blatt Gmünd-Litschau (4454). – Verh. Geol. B.-A., **1934**/1–3, 28–30, Wien.

WALDMANN, L., 1935: Aufnahmsbericht des Privatdozenten Dr. Leo Waldmann über das Blatt Gmünd-Litschau (4454). – Verh. Geol. B.-A., **1935**/1–3, 25–26, Wien.

WALDMANN, L., 1936: Bericht des Privatdozenten Dr. Leo Waldmann über die Aufnahme des Blattes Gmünd-Litschau (4454). – Verh. Geol. B.-A., **1936**/1–2, 45–47, Wien.

WALDMANN, L., 1937a: Ber. des Privatdozenten Dr. Leo Waldmann über die Aufnahme des Blattes Gmünd-Litschau (4454). – Verh. Geol. B.-A., **1937**/1–2, 55–59, Wien.

WALDMANN, L., 1937b: Über Begehungen im Raume der Blätter Freistadt, Zwettl und Ottenschlag. – Verh. Geol. B.-A., **1937**/5–6, 143–146, Wien.

WALDMANN, L., 1938a: Tonvorkommen in den Gauen Nieder- und Oberdonau (nördlich der Donau). 19. 2. 1938. – Unpubl. typoscr., 1p, Wien; Lagerstättenarchiv der Geol. B.-A., Wien.

WALDMANN, L., 1938b: Über weitere Begehungen im Raume der Kartenblätter Zwettl-Weitra, Ottenschlag und Ybbs. – Verh. Geol. B.-A., **1938**/3–4, 115–119, Wien.

WALDMANN, L., 1943: Das außeralpine Grundgebirge der Ostmark. – In: SCHAFFER, F.X. (ed.): Geologie der Ostmark. – Wien (F. Deuticke), 4–44, 1 map.

WALDMANN, L., 1950 (red.): Geologische Spezialkarte der Republik Österreich 1 : 75.000, Nr. 4454. Litschau und Gmünd mit den angrenzenden Teilen der Blätter Neuhaus und Budweis – Gratzen [etc.] neu aufgenommen von Leo Waldmann ... mit Benützung ... [v.] einem Übersichtskärtchen der Umgebung von Hoheneich von R. Ostadal [etc.]. – 1 sheet, 67.8 x 56.6 cm, Wien (Geol. B.-A.).

WALDMANN, L., 1951: Das außeralpine Grundgebirge Österreichs. – In: SCHAFFER, F.X. (ed.): Geologie von Österreich, 10–104, 1 Karte, Wien (F. Deuticke)

WALDMANN, L., 1952: Studien über ältere Eisensteinbaue im nördlichen Waldviertel – In: KÜPPER, H. & WALDMANN, L. (eds.): Wiederaufbau- und Hundertjahrfeier der Geologischen Bundesanstalt, 12. Juni 1951, Verh. Geol. B.-A., Sonderheft C, 49–55, Wien.

WALDMANN, L., 1958: Führer zu geologischen Exkursionen im Waldviertel. – Verh. Geol. B.-A., Sonderheft E, 26 pp., 1 map, Wien.

WALDMANN, L., 1966: Übersicht der von mir begangenen vorquartären Absätze im N.-Ö. Waldviertel (Blatt 1 : 75.000 Krems, Ottenschlag, Horn und Zwettl-Weitra). 6. Mai 1966. – Unpubl. typoscr., 2 leafs. – Wiss. Archiv der Geol. B.-A., Wien, shelf mark: A-10005–R.

WALDMANN, L., 1966/67: Verbreitung der Schotter, Wind- (Drei-)kanter und Kieselsandsteine außerhalb des Thayatales im Bereiche des Bl. Gmünd-Litschau (österr. Teil). – Unpubl. typoscr., 3pp., enclosed to 4 maps entitled „Vorquartäre Absätze im Waldviertel“, Wien; Wiss. Archiv der Geol. B.-A., Wien, shelf-mark: A-10005–R.

WALDMANN, L., 1967: Verbreitung der Schotter, Wind (Drei-)kanter und Kieselsandsteine außerhalb des Thayatales im Bereiche des Blattes Gmünd-Litscha, zusammengestellt von Leo Waldmann. 27. 6. 1967. – Unpubl. typoscr.,4 leafs; Wiss. Archiv der Geol. B.-A., Wien, shelf-mark: A-10005–R.

WOLFBAUER, J., 1993: Systemstudie geogener und hydrologischer Umweltparameter für das südliche Wittingauer Becken / Gmünder Bucht. Forschungsprojekt in kooperativer Durchführung mit Wissenschaftlern der ČSFR im Auftrag des Bundesministeriums für Wissenschaft und Forschung (GZ 45.194/2–27b/91). Endbericht. – Unpubl. typoscr., V + 78 leafs, 15 tabs., 43 figs., 3 maps 1 : 25.000 and 7 appendices, Leoben – Prag, Amtsbibliothek des Bundesministeriums f. Bildung, Wiss. und Kultur, Wien, shelf-mark: II.98.473.EB.

ZETTER, R., HESSE, M. & HUBER, K.H., 2002: Combined LM, SEM and TEM studies of Late Cretaceous Pollen and Spores from Gmünd, Lower Austria. – Stapfia, **80**, 201–230, 9 pls., Linz.

ZIPPE, F.X.M., 1841: Allgemeine Uebersicht der physikalischen und statistischen Verhältnisse des Budweiser Kreises. – In: SOMMER, J.G. [= VOLTE, J.G.]: Das Königreich Böhmen, statistisch-topographisch dargestellt [in 16 Bdn. 1833–49], 9. Bd., Budweiser Kreis, I–XXXV, Prag (Verlag F. Ehrlich).

Manuskript bei der Schriftleitung eingelangt am 16. März 2003