6th International Cretaceous Symposium
August 27 to September 4, 2000
Vienna, Austria

Field trip C

Cretaceous of eastern Austria

Friday, September 1 to Monday, September 4, 2000

Guides: J. EGGER, H.A. KOLLMANN, D. SANDERS, H. SUMMESBERGER, M. WAGREICH

Lake Traunsee with Traunstein (NCA), Grünberg (Flysch) to the left and the soft morphology of the Gschliefgraben area (Ultrahelvetic) inbetween

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Cretaceous of eastern Austria

H.A. KOLLMANN, H. SUMMESBERGER, M. WAGREICH
With contributions of J. EGGER, H. LOBITZER, F. RÖGL, D. SANDERS, R BARON-SZABO

September 1st, 2000

Cretaceous of the Rhenodanubian Flysch Zone, the Ultrahelvetic Zone and Lower Cretaceous of the Northern Calcareous Alps in the vicinity of Salzburg

Route: Vienna - Vorchdorf - Gmunden - Salzburg - St. Leonhard

Stop 1.1. Hatschek-Quarry, Altlengbach Fm., Rhenodanubian Flysch Zone
Stop 1.2. Rehkogelgraben, "Buntmergelserie", Ultrahelveticum
Stop 1.3. Greisenbach, "Buntmergelserie", Ultrahelveticum
Stop 1.4. Leube Quarry, Gutrathsberg (Gartenau, S Salzburg), Lower Cretaceous, NCA

Overnight stop Leonharderhof, A-5083 St. Leonhard-Grödig, Mitterweg 14, tel. 06246-72640

September 2nd, 2000

Upper Cretaceous Gosau Group of the Northern Calcareous Alps in the Salzkammergut

Route: St. Leonhard - Fuschl - Strobl/Wolfgangsee - Abtenau - Rußbach - Gosau

Stop 2.1. Reef Theresienstein, Strobl, Gosau Group, NCA
Stop 2.2. Postalm road, Gosau Group, NCA
Stop 2.3. Randograben, Gosau Group, NCA
Stop 2.4. Parking area Rußbach, Grabenbach Fm., Gosau Group, NCA
Stop 2.5. Forest road Gosau-Zwieselalm, Gosau Group, NCA
Stop 2.6. Rote Wand, Gosausee, Gosau Group, NCA

Overnight stop: Brandwirt, A-4824 Gosau, Gosau 151, Tel.: 06136-8226

September 3rd, 2000

Cretaceous of the Northern Calcareous Alps in the Enns Valley

Route: Gosau - Hallstatt - Koppenpass - Bad Aussee - Liezen - Admont - Gesäuse - Hieflau - Gams - Großraming

Stop 3.1. Akogl road, Gams, Gosau Group, NCA
Stop 3.2. Noth gorge, Gams, Gosau Group, NCA
Stop 3.3. Radstatt road, Gams, Gosau Group, NCA
Stop 3.4. Hölleitengraben, Großraming, Tannheim Fm., NCA
Stop 3.5. Höllleitengraben, Losenstein Formation, NCA
Stop 3.6. Pechgraben, Buch-Memorial, Buntmergelserie, Großraming, Ultrahelveticum

Overnight stop: Ennstaler-Hof, A-4463 Großraming, Aschasiedlung 1, tel.: 07254-7615

September 4th, 2000

Cretaceous of the Northern Calcareous Alps near Vienna

Route: Großraming - Amstetten - Alland - Wöllersdorf - Piesting - Kaltenleutgeben - Vienna

Stop 4.1. Piesting sports area, Gosau Group, NCA
Stop 4.2. Quarry Kaltenleutgeben, Lower Cretaceous, NCA
Back to Vienna ca. 18.00

Overview of the Cretaceous of the Eastern Alps

The Eastern Alps represent a highly compressed segment of the Alpine mountain chain, located between the Rhine valley to the west and the Neogene Vienna Basin toward the east. The Eastern Alps comprise a thrust orogen which originated within the western Tethys paleogeographic domain due to repeated convergence between the European and the African plate. The orogenic evolution can be divided into several stages of deformation: a Jurassic and a Cretaceous, "**Eoalpine**" stage, followed by **Meso-** and **Neoalpine** deformational events during the Tertiary, from the Late Eocene onwards. Cretaceous geodynamics are strongly discussed because of polyphase Tertiary deformation overprinting Mesozoic structures, the incompleteness of the sedimentary record and the less constrained palaeogeographic and palaeotectonic positions of individual tectonic domains. These led to a variety of proposed models for the evolution of the Eastern Alps during the Cretaceous, differing especially in the inferred positions and timing of subduction zones, collisions and suturing (e.g. CHANNELL et al., 1992; FAUPL & WAGREICH, 1992a, 2000; NEUBAUER, 1994; VON EYNATTEN & GAUPP, 1999; WAGREICH & FAUPL, 1994; WINKLER, 1996).

Four major nappe complexes can be distinguished within the Eastern Alps (Fig. 1): (1) the **Helvetic zone**, (2) the **Penninic zone**, (3) the **Austroalpine zone** and (4) the **Southalpine zone**. The Austroalpine zone is subdivided into a Lower, Middle and Upper nappe complex. Within the Upper Austroalpine zone the **Northern Calcareous Alps** (NCA) represent a complicated pile of cover nappes including thick Mesozoic carbonate successions.

Alpine orogeny commenced with the closure of a **Triassic Tethys Gulf** (Hallstatt-Meliata Ocean) within the Austroalpine domain during the Jurassic. Contemporaneously, the **Penninic Ocean** opened by oblique rifting and spreading between the European plate and the **Austroalpine microplate**, connected to the opening of the Atlantic Ocean (FRISCH, 1979). Jurassic subduction processes in the Hallstatt-Meliata Ocean, resulted in an elevated suture zone towards the present south of the NCA. Then the Penninic Ocean changed from a transtensional into a transpressional regime and an accretionary structure developed to the north of the NCA. During the Albian - Turonian, the sedimentary cover of the NCA was sheared off from its basement and stacked into a complex nappe pile followed by deposition of the Gosau Group.

Alpine Foreland and Helvetic/Ultrahelvetic zones

The **Helvetic domain** comprises sedimentary strata deposited on the shelf and upper slope of the European plate in a passive margin setting during the Cretaceous (Fig.2). Lower Cretaceous shallow-water deposits of the Helvetic realm are exposed mainly in the western part of the Eastern Alps.
Autochthonous Mesozoic successions, overlying the Bohemian Massif and covered by sediments of the Molasse foreland basin (Fig.1) display a significant Cenomanian transgression onto the European foreland (KOLLMANN et al., 1977; FUCHS & WESSELY, 1996) followed by shale

sedimentation of Late Cretaceous age. Subsidence occurred contemporaneously with the Bohemian Cretaceous Basin, probably due to plate tectonic reorganization during Alpine convergence.
The Lower Cretaceous deposits of the **Ultrahelvetic zone** and the **Gresten Klippen zone** (Fig. 1) are characterized by deeper-water carbonate facies, followed by a variegated shale succession ("Buntmergelserie") from the Albian on (e.g. Rehkogelgraben section, Stop 2). In the Paleogene parts of the "Buntmergelserie" huge olistoliths are common (FAUPL, 1978), e.g. the granitic to granodioritic block of the Leopold von Buch-Memorial in Upper Austria (Stop 3.5; WIDDER, 1986).

Penninic zones

The Penninic zone is subdivided into the North, Middle and South Penninic zones, which developed due to extension and spreading between the European foreland/Helvetic zones and the Austroalpine microplate during Jurassic (South Penninic) and Cretaceous (North Penninic) times.

During Early Cretaceous time turbiditic sedimentation began within the North Penninic **Rhenodanubian Flysch Zone**. The succession started with carbonate-dominated flysch deposits, but passed into turbidites rich in siliciclastic material in the uppermost Early Cretaceous. The Upper Cretaceous turbidite successions are subdivided by several thin-bedded variegated pelitic intervals. Upper Cretaceous sandstones, especially siliciclastica-rich ones, contain garnet-rich heavy mineral assemblages (e. g. Altlengbach Formation; see Stop 1.1, Hatschek quarry).

In the South Penninic domain, the non-metamorphic Upper Jurassic - Lower Cretaceous succession of the **Ybbsitz Zone** and the Kahlenberg Nappe (DECKER, 1990; HOMAYOUN & FAUPL, 1992) comprises calpionellid limestones with thin turbiditic interbeds passing into carbonate-dominated flysch sediments and a siliciclastica-rich sandy interval. Turbidite deposits of the Ybbsitz zone commonly contain chrome spinel in the heavy mineral assemblages, a significant feature of Mid-Cretaceous flysch sediments of the South Penninic domain (e.g. POBER & FAUPL, 1988). Metamorphic **South Penninic** successions are known from the Tauern Window, including huge ophiolitic complexes and metamorphosed shales.

The opening of the North Penninic trough and the onset of turbiditic sedimentation appears to correlate with the beginning of subduction in the South Penninic ocean. In the Helvetic domain, the formation of a separate Ultrahelvetic zone as a mobile margin of the European plate can also be seen as a result of extension within the North Penninic trough.

Austroalpine zones

Based on palaeomagnetic data the Austroalpine domain is considered as a partly independent microplate at the northern margin of the Apulian plate (e.g. CHANNELL et al., 1992, HAUBOLD et al., 1999). The best documented sedimentary successions of the Austroalpine domain are preserved within the Northern Calcareous Alps (NCA, Fig.1). Based upon a restoration of late Tertiary fault tectonics (FRISCH et al. 1998), it is suggested, that the Eastern Alps had about half the length of the presentday mountain chain during the Late Cretaceous.

Within the **Northern Calcareous Alps** deep-water carbonate facies of the Lower Cretaceous, the **Schrambach Formation**, comprises Maiolica-type limestones at their base grading into a shale - limestone facies (Stop 1.4, Leube Quarry). Resedimented clasts of shallow-water Urgonian-type carbonates (e.g. SCHLAGINTWEIT, 1991) give evidence that platform carbonates were common during the Early Cretaceous, but were later completely eroded.
In northern nappe complexes of the NCA (southern parts of the Reichraming and Lunz nappe), deep-water limestones graded into synorogenic terrigenous facies of the **Rossfeld Formation** during Valanginian to Aptian time (FAUPL & TOLLMANN, 1979; DECKER et al., 1987; VASICEK &

FAUPL, 1996). This formation is composed of shales, turbiditic sandstones and locally of huge masses of deep-water conglomerates/breccias as well as slump deposits sedimented on an active north-facing slope. The sandstones contain considerable amounts of siliciclastic and ophiolitic detritus. The oldest turbiditic interbeds with significant ophiolitic detritus were observed in Upper Berriasian deposits (VASICEK & FAUPL, 1998).
With the termination of the Rossfeld sedimentation in the Aptian, the synorogenic facies shifted to tectonically lower (northern) zones of the NCA, the Frankenfels-Ternberg-Allgäu nappe system. There, the Schrambach Formation passed into an Aptian-Albian shale succession including black shales (**Tannheim Formation**, WAGREICH & SACHSENHOFER, 1999), followed by the **Losenstein Formation** (middle Albian - Lower Cenomanian; KOLLMANN, 1968), which is composed of silty shales, turbiditic sandstones and deep-water conglomerates. The terrigenous material of the Losenstein Formation gives evidence for a new source terrain located to the north of the NCA including ophiolitic detritus (POBER & FAUPL, 1988; VON EYNATTEN, 1996; VON EYNATTEN & GAUPP, 1999).

The onset of the deposition of the **Branderfleck Formation** (Cenomanian - Santonian) unconfomably upon external parts of the Lunz-Reichraming-Lechtal nappe system in the Cenomanian illustrates a further step in the synsedimentary deformational history of the NCA (GAUPP, 1982; WEIDICH, 1984; FAUPL & WAGREICH, 1992b). Basal breccias and sandstones containing orbitolinids pass into turbiditic successions.

In the Turonian, as a consequence of the Eoalpine orogeny, most of the deformed Austroalpine domain was lifted above sea level. In front of the Austroalpine microplate, an **accretionary wedge** existed which had been formed by subduction of the Penninic ocean under a dextral transpressional regime since the Mid Cretaceous. This wedge comprised tectonic slices of Austroalpine zones, including high-pressure series and obducted ophiolitic complexes. The NCA, which had already been sheared off from their crystalline basement, were situated directly behind this tectonically active continental margin. **Metamorphism** was widespread during the Early Cretaceous up to the Turonian within the Austroalpine zone (e.g. THÖNI, 1999).

In Late Turonian time, a new sedimentary cycle started with the deposition of the **Gosau Group**, which rests unconfomably upon the Eoalpine deformed pre-Gosau sediments and metamorphic zones south of the NCA. The Gosau Group of the NCA can be divided into two subgroups (WAGREICH & FAUPL, 1994). The **lower Gosau Subgroup** (Upper Turonian - Campanian; Maastrichtian only in the east) consists of terrestrial, mainly conglomeratic deposits at the base and passes gradationally into shallow-marine successions. At the base, karst bauxites are present. Sandstones and sandy limestones together with rudist-bearing limestones, storm-influenced inner and outer shelf facies and shelf/slope transitional facies are common (WAGREICH & FAUPL, 1994, SANDERS et al., 1997; SANDERS, 1998). Locally, high contents of ophiolitic detritus are a conspicous feature of sandstones of this subgroup (e.g. Gams; WAGREICH, 1993b). The lower Gosau Subgroup was probably deposited in small strike-slip basins (WAGREICH & DECKER, in press)

The **upper Gosau Subgroup** comprises deep-water deposits, such as a shaly slope facies with common slump deposits (Nierental Formation; e.g. KRENMAYR, 1999), and a broad variety of deep-water clastics, deposited above or below the local calcite compensation level of the basin. Facies distribution and palaeocurrent data of the upper Gosau Subgroup indicate a pronounced fault-controlled relief of a generally north-facing palaeoslope. In many Gosau localities of the NCA, a conspicuous angular unconformity separates the lower from the upper Subgroup (e.g. FAUPL, 1983), and parts of the lower Gosau Subgroup have been eroded at this unconformity. In contrast to the lower Subgroup, the terrigenous material of the deep-water successions comprises predominantly metamorphic detritus. Shallow-water components, such as corallinacea, orbitoid foraminifera, bryozoa etc., point to active shelf carbonate production in the south of the NCA (WAGREICH & FAUPL, 1994).

The shallow-water facies of the lower Gosau Subgroup to deep-water facies of the upper Gosau Subgroup migrated diachronously from the Santonian/ Campanian onwards from northwest towards the southeast of the NCA. The easternmost parts of the NCA were involved in Maastrichtian and Paleocene times. The strong subsidence of the NCA can be explained by subcrustal tectonic erosion, eliminating parts of the accretionary structure along the northern margin of the Austroalpine plate (WAGREICH, 1993a, 1995).

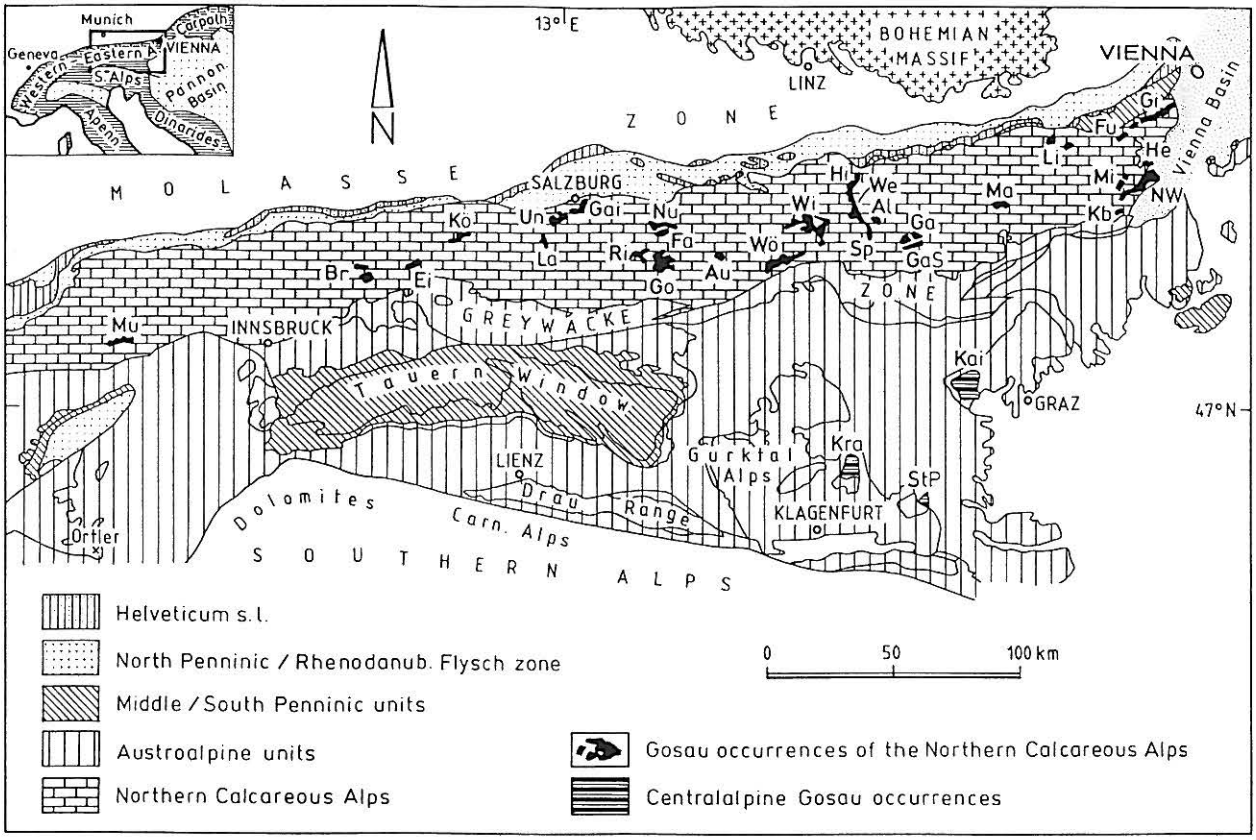


Fig.1. Tectonic sketch-map of the Eastern Alps indicating the major occurrences of the **Gosau-Group**. Al-Altenmarkt; Au-Bad Aussee, Br-Brandenberg, Ei-Eiberg, Fa-Fahrenberg, Fu-Furth, Ga-**Gams**, Gai-Gaisberg, GaS-Gams South, Gi-Gießhübl, Go-**Gosau**, He-Hernstein, Hi-Hieselberg, Kai-Kainach, Kö-Kössen, Kra-Krappfeld, La-Lattengebirge, Li-Lilienfeld, Ma-Mariazell, Mi-Miesenbach, Mu-Muttekopf, Ne-Neuberg, Nu-Nussensee, NW-**Neue Welt**, Ri-Rigaus, Sp-Spitzenbach, StP-St.Paul, Un-Untersberg, We-Weißwasser, Wi-Windischgarsten, Wö-Wörschach (after WAGREICH & FAUPL 1994).

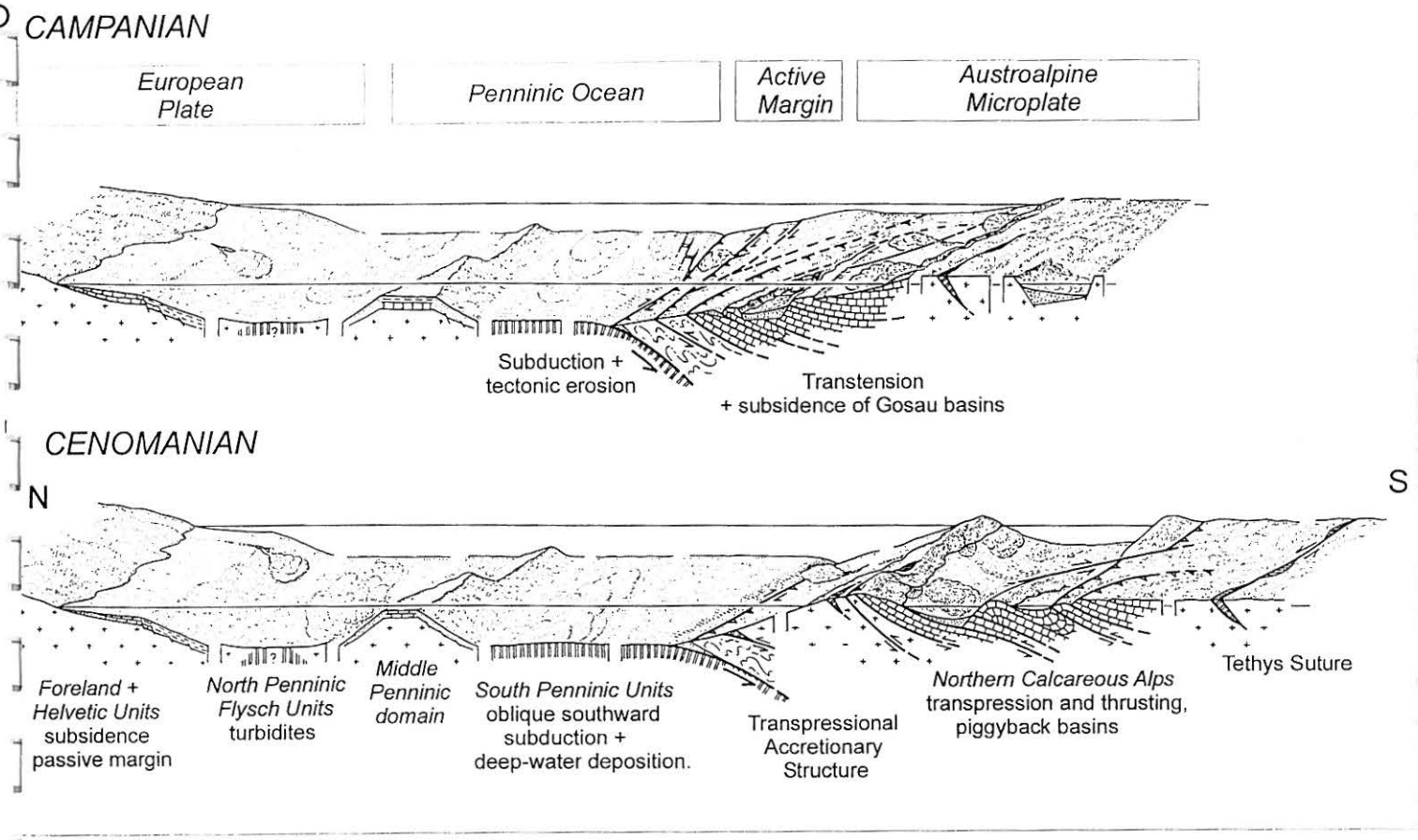


Fig.2. Palinspastic development of the Alpine orogeny during Late Cretaceous times (FAUPL & WAGREICH 2000)

STOP 1.1 Hatschek quarry (cement plant) near Gmunden

H. EGGER, with contributions of F. RÖGL

Topic: Turbidites of the Rhenodanubian Flysch Zone
Lithostratigraphic Unit: Ahornleiten Member, Altlengbach Formation
Age: Maastrichtian
Tectonic unit: Rhenodanubian Flysch Zone
Location: Upper part of Hatschek quarry, Pinsdorf 1 km E of Gmunden (Upper Austria)

Within the Altlengbach Formation (Maastrichtian - Late Paleocene), which can reach a thickness of approximately 1500 m, four members can be distinguished: the psammitic Roßgraben member at the base, the Ahornleiten member with a lot of calcareous shales, the psammitic Kotgraben member and the Acharting member, which is rich in clayey marls. These members represent different source areas of the turbiditic material. Generally the material of the psammitic members was delivered from the east whereas turbidity currents dominated by calcareous material came from the west.

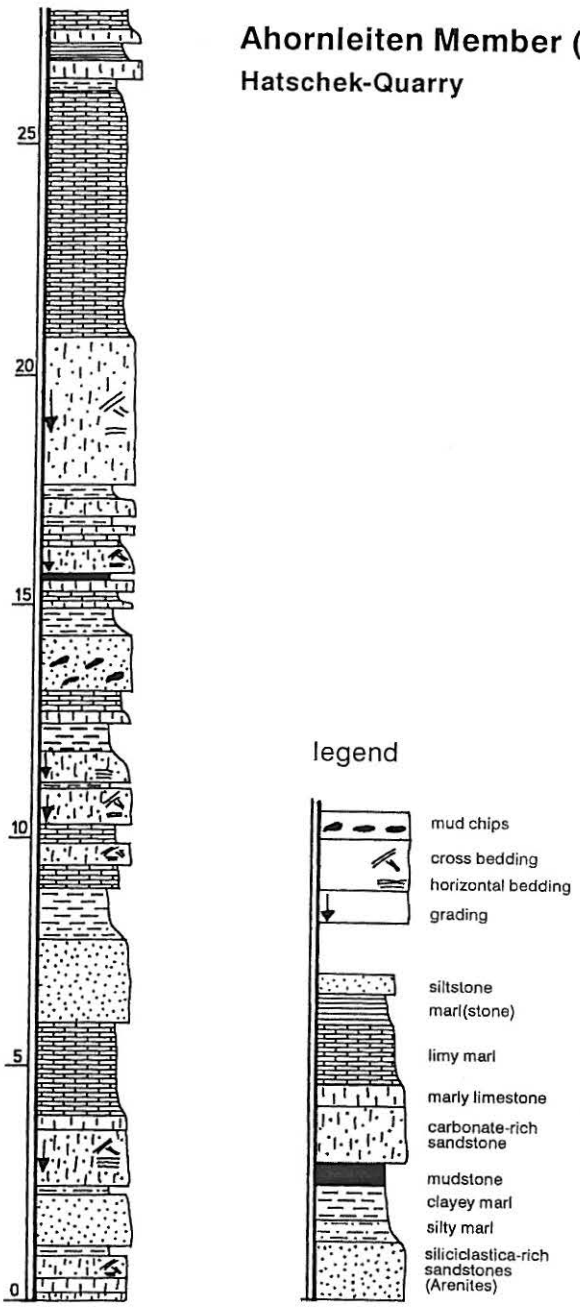


Fig.3. Lithostratigraphic section of the Ahornleiten member (Hatschek quarry, Pinsdorf, Upper Austria

Typical for the Ahornleiten member are grey calcareous shales which represent Bouma Td cycles. These layers can reach thicknesses up to 8m. Together with sandy to silty intervals at their base isolated complete turbidites are up to 10m thick. These are the thickest turbidites known from the Rhenodanubian Flysch. Beside of them very often incomplete (base missing) layers can be observed. The sand/shale ratio is generally low. According to MUTTI et al (1975) C2 and D2 are the dominating turbidite facies.

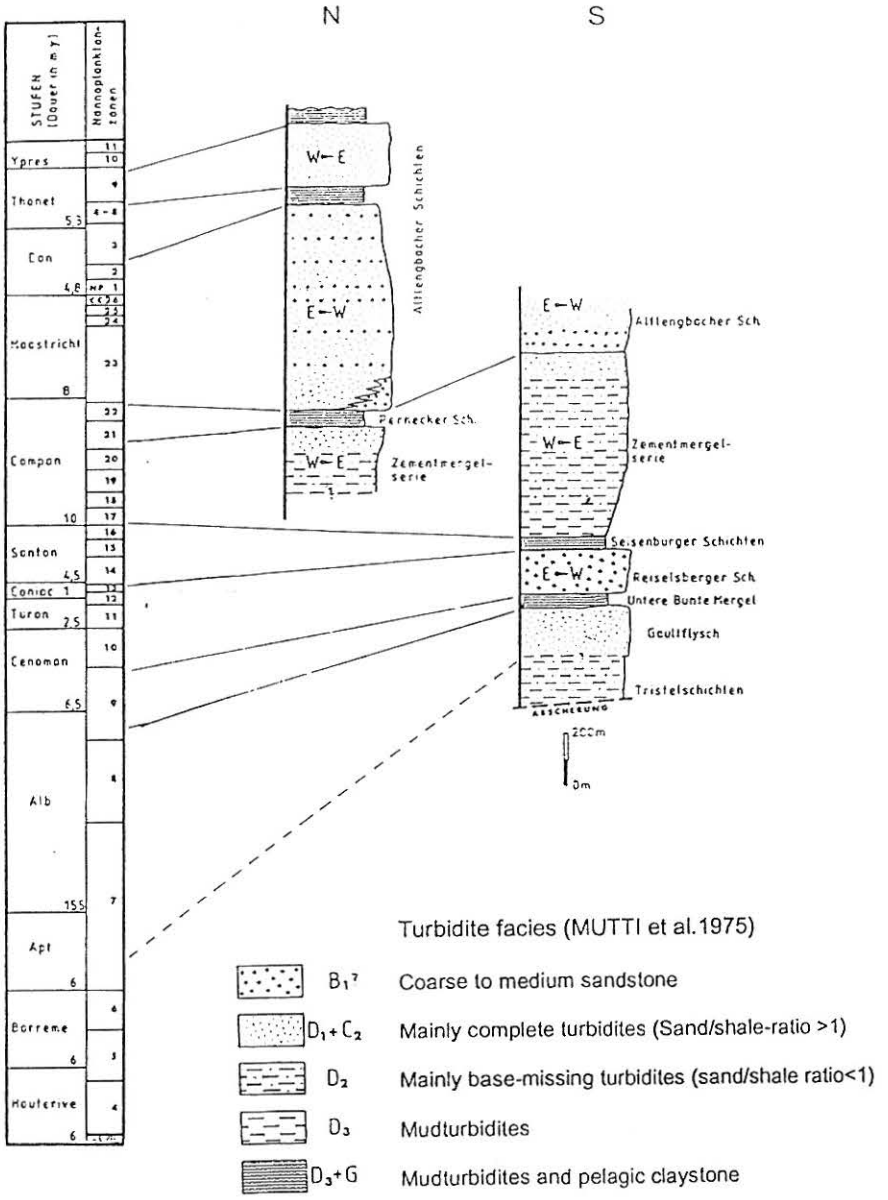


Fig. 4. Stratigraphy and facies of the Rhenodanubian Flysch (EGGER et al. 1997)

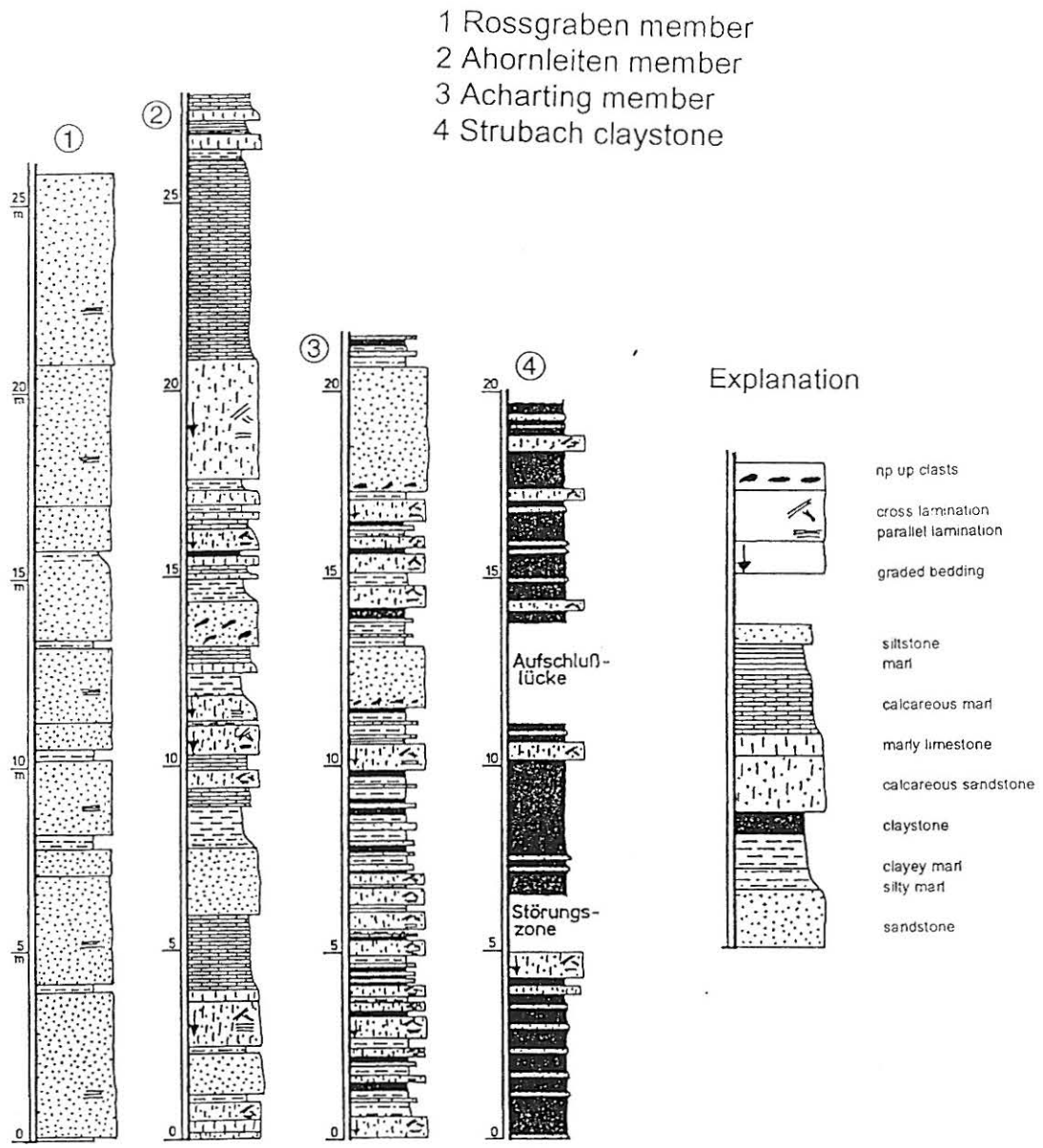


Fig. 5. Detailed sections from part of the members of the Altlengbach formation

Stop 1.2 Rehkogelgraben section

H. EGGER with contributions of F. RÖGL

Topic: Middle to Upper Cretaceous shales of the "Buntmergelserie" (Ultrahelvetic)
Lithostratigraphic Unit: "Buntmergelserie"
Age: Late Albian - Early Campanian
Tectonic unit: Ultrahelevtic zone, tectonic window within the Rhenodanubian Flysch zone
Location: Rehkogelgraben S of Hagenmühle; 8 km S of Vorchdorf (Upper Austria)

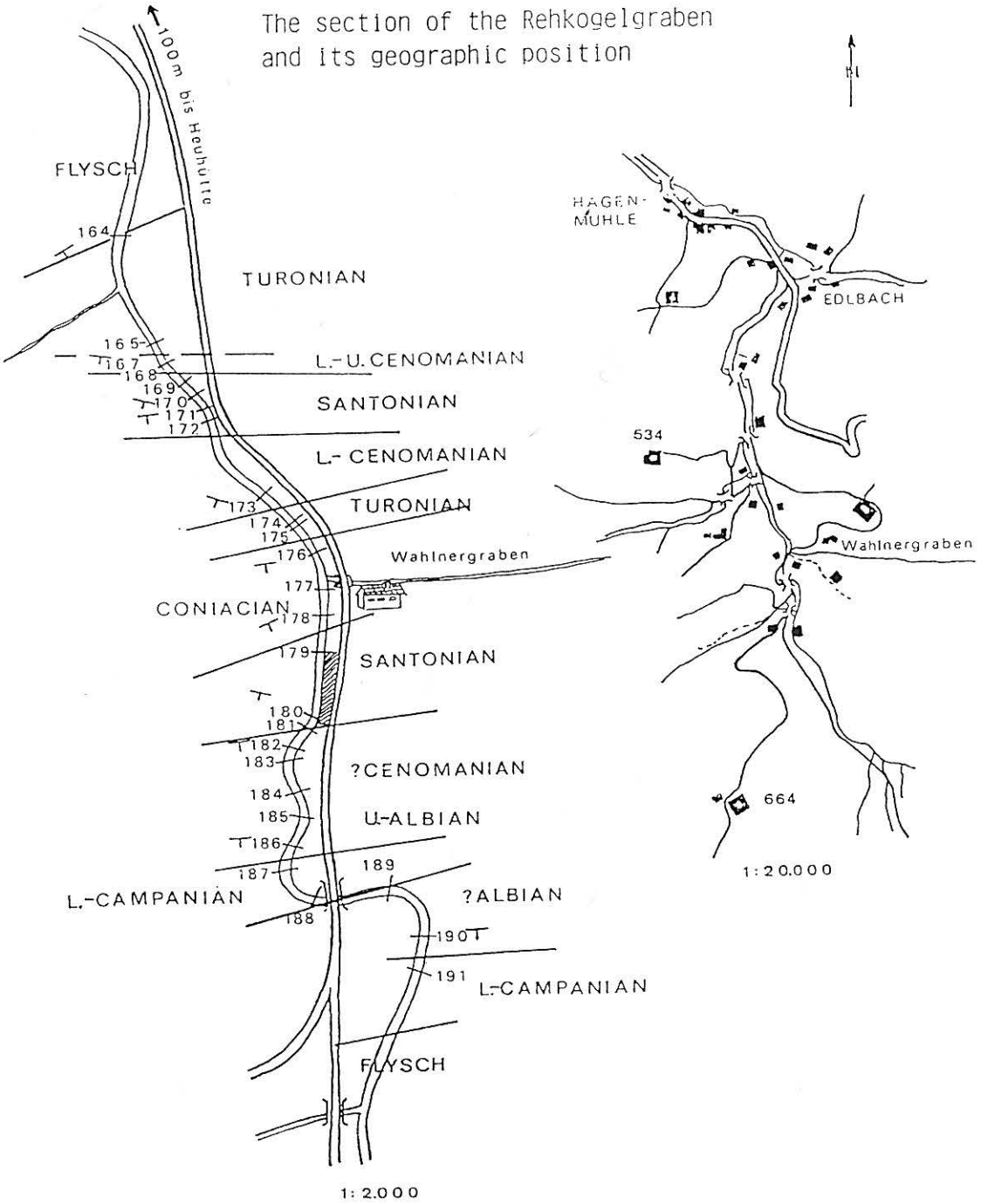


Fig. 6. Location of outcrops of the Rehkogelgraben section (from KOLLMANN & SUMMESBERGER, 1982)

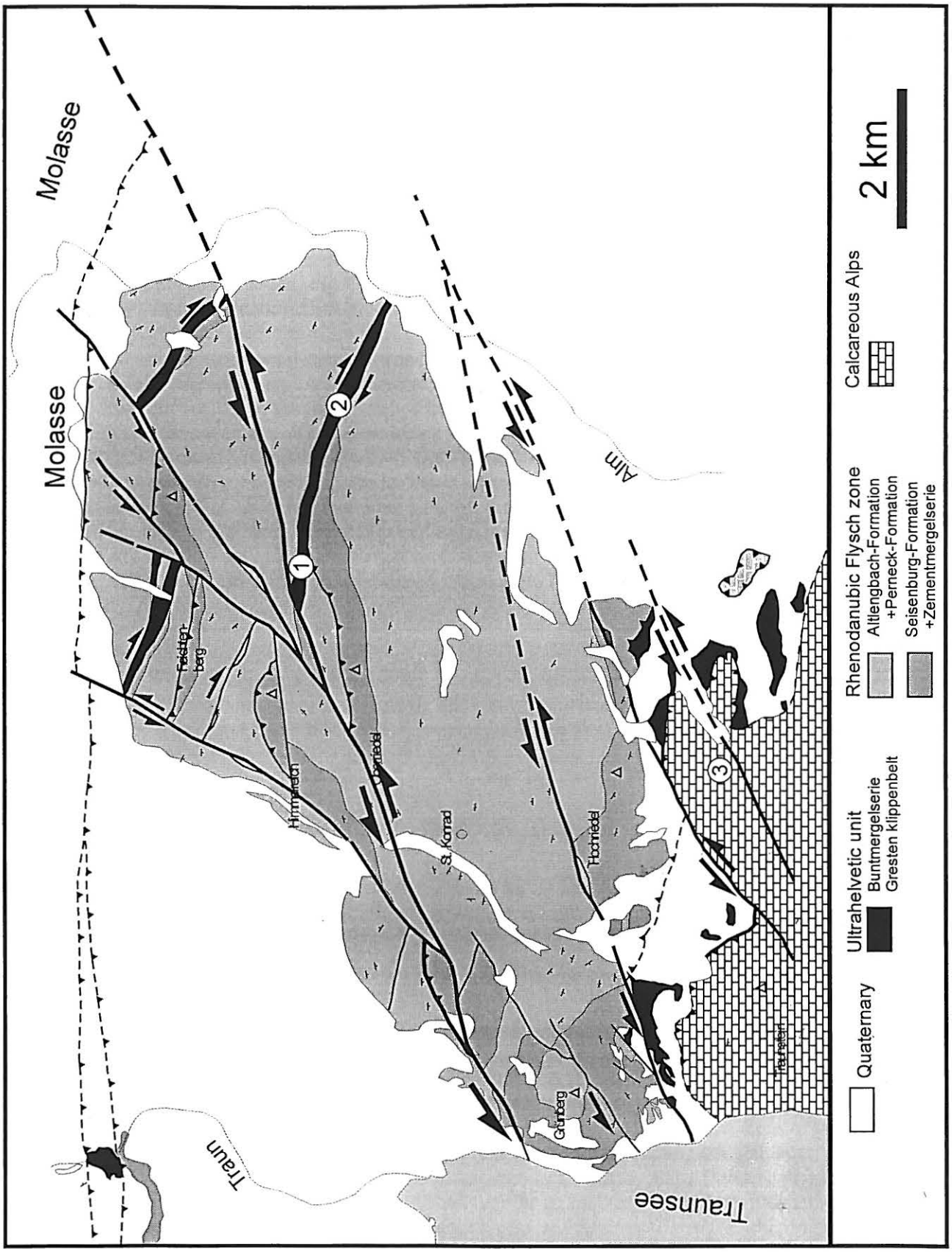


Fig. 7. Geological sketch map of the Flysch Zone and the Ultrahelvetic windows E of Lake Traun

PREY (1952) has introduced the name "Buntmergelserie" (variegated shales) for the pelitic rocks of the Ultrahelvetic zone. These rocks were deposited from the Albian to the Eocene. Due to increasing water depths to the south the shales were replaced by claystones and might interfinger with thinbedded turbidites and variegated shales of the Rhenodanubian flysch zone (EGGER, 1995). Within the Rhenodanubian flysch zone a number of tectonic windows with Ultrahelvetic rocks exist. Some of these structures are bound to internal overthrusts within the flysch nappe, the rest of them cuts diagonally the flysch zones. The Rehkogelgraben window (Fig.7, 8) belongs to this latter type of structures which were created along dextral strike-slip faults. The age of these faults is probably Oligocene. In the Miocene ENE-striking sinistral strike-slip faults cut the older NW-striking dextral strike-slip faults (Fig.7). These younger faults form eastern and western boundaries of the Rehkogelgraben window (EGGER et al., 1997).

A good view one can get from the narrow road beside the farmhouse (Fig. 6) to steeply south-dipping reddish shales and grey shaly limestones of Coniacian to Santonian age. The samples (180 and 181) from the outcrop at the outer bend of the small creek contained well preserved planktonic foraminifera of Santonian age. *Marginotruncana coronata* (BOLLI), *Marginotruncana sinuosa* PORTHAULT, *Marginotruncana marginata* (REUSS), *Marginotruncana paraconcavata* PORTHAULT and *Globotruncana lapparenti* BROTZEN are the most important species (RÖGL in KOLLMANN & SUMMESBERGER, 1982).There is a tectonic boundary between Santonian rocks, grey shales and highly bioturbated spotted shaly limestones of Cenomanian age. Sample 182 contained only badly preserved and small foraminifera: *Hedbergella* cf. *planispira* (TAPPAN), *Hedbergella* cf. *delrioensis* (CARSEY) and *Globigerinelloides* sp. . In sample 185 *Biticinella breggensis* (GANDOLFI), *Hedbergella planispira* (TAPPAN), *Clavihedbergella subcretacea* (TAPPAN) and *Globigerinelloides* sp. prove late Albian.

Just beside the small road bridge red shales are exposed along the creek. They are of early Campanian age (*Marginotruncana coronata* (BOLLI), *Marginotruncana marginata* (REUSS), *Globotruncana lapparenti* BROTZEN, *Globotruncana bulloides* VOGLER; *Globotruncanita elevata* (BROTZEN)).

STOP 1.3 Im Fleck - Greisenbach

Topic: Middle Cretaceous black shales
Lithostratigraphic Unit: "Buntmergelserie"
Age: Albian
Tectonic unit: Ultrahelevtic zone, tectonic window within the Rhenodanubian Flysch
Location: Greisenbach W Im Fleck; 8 km S of Vorchdorf (Upper Austria)

The outcrop is a continuation of the tectonic window of the Rehkogelgraben. Dark grey and black marlstones deposited at bathyal depths prevail in the basal part of the "Buntmergelserie". Samples yielded Albian microfaunas. Sample 1: *Rotalipora subticiensis* (GANDOLFI), *Ticinella primula* LUTERBACHER, *Globigerinelloides ferreolensis* (MOULLADE), *Hedbergella planispira* (TAPPAN) and H*edbergella* cf. *simplex* (MORROW). This indicates the *Rotalipora subticiensis* Zone of the middle Albian. Sample 2 yielded *Rotalipora subticiensis* (GANDOLFI), *Rotalipora ticiensis* (GANDOLFI), *Ticinella praeticiensis* SIGAL, *Ticinella primula* LUTERBACHER, *Ticinella raynaudi* SIGAL, *Hedbergella delrioensis* (CARSEY) and H*edbergella* cf. *simplex* (MORROW), indicating the *Rotalipora ticiensis* Zone of the lower Late Albian.

Due to lack of time and difficult terrain the famous Gschliefgraben window E of Lake Traunsee between Grünberg (Flysch) and Traunstein (NCA) cannot be visited. The Campanian mollusk faunas (ammonites, inoceramids), echinoids, crustaceans and nannofossils have been described recently by FRAAYE & SUMMESBERGER (1999), JAGT (1999), KENNEDY. & SUMMESBERGER

(1984, 1999, in press), TRÖGER, SUMMESBERGER. & SKOUMAL (1999). The complex geological setting was deciphered and mapped in detail by Siegmund PREY (1983)

STOP 1.4 Gutrathsberg Quarry of Leube Cement Company/Gartenau

Compiled by Harry LOBITZER

Topic: Continuous sequence from Late Tithonian to Early Cretaceous (Late Valanginian) pelagic limestones overlain of coarse clastic, respectively „Wildflysch" development.
Lithostratigraphic units: Schrambach Formation, Rossfeld Formation
Age: Berriasian - Late Valanginian, Hauterivian - ?Barremian
Tectonic unit: Schneiderwald-anticline, Staufen-Höllengebirge nappe, Tirolicum, NCA
Location: Gutrathsberg Quarry near St.Leonhard south of Salzburg

The quarry at Gutrathsberg (Gartenau, S Salzburg) exposes an almost 100m thick section of Late Tithonian to Late Valanginian pelagic "Aptychus Limestones" and various distal fan sediments of the late Early Cretaceous (Hauterivian-?Barremian). The sequence represents one limb of the Schneiderwald-anticline. Macrofossils (aptychi, belemnites, ammonites and trace fossils) are rather scarce. Microfossils, especially calpionellids, are abundant and relatively well preserved. Nannofossils and calpionellids are repeatedly redeposited. The geological setting was described by PLÖCHINGER (1974, 1976, 1977). Foraminifera were studied by WEIDICH (1990), BODROGI (in LOBITZER et al. 1994; BODROGI et al. 1999) and HRADECKA (in BÖHM et al. 1997). OŽVOLDOVÁ (in REHÁKOVÁ et al. 1996) documented the radiolarians. HOLZER (in PLÖCHINGER, 1976), KAISER-WEIDICH & SCHAIRER (1990), REHÁKOVÁ et al. (1996), FILACZ (in LOBITZER et al. 1994, BÖHM et al. 1997 and BODROGI et al. 1999) and BOOROVÁ et al. (1999) investigated the calpionellids. DRAXLER (in BODROGI et al., 1999) and SKUPIEN (in BOOROVÁ et al., 1999) documented a rich and well preserved assemblage of dinoflagellates, pollen and spores. The nannoplankton was studied by STRADNER (1961) and KNAUER, EGGER and STRADNER (in BODROGI et al., 1999).

The uppermost level in the southeast exposed allodapic coarse-grained **"Oberalm Basal Breccia"** with clast sizes up to 10cm is according to BOOROVÁ et al. (1999) of Upper Tithonian age (Crassicollaria zone, Intermedia Subzone).
The Late Tithonian - Early Berrasian **Oberalm Formation** is a deeper-water limestone sensu WILSON (1969) and GARRISON & FISCHER (1969): grey, cherty, dm-bedded micritic with comparatively few allodapic or clayey intercalations of Barmstein Limestone (STEIGER 1981). REHÁKOVÁ et al. (1996) proved the Kimmeridgian and Early Tithonian age of the Oberalm Formation. The microfauna of the Oberalm Formation itself is dominated by radiolarians and calpionellids. A poor foram-assemblage (*Lenticulina-Spirillina*-Zone sensu WEIDICH, 1990) is characteristic for the Oberalm- and Schrambach Formation as well. *Lamellaptychus beyrichi* (OPPEL) and *Punctaptycus punctatus* VOLZ indicate Tithonian-Early Berriasian age of the Oberalm Formation (VASICEK in BOOROVA et al., 1999).
The **Barmstein Limestone** intercalations within the Oberalm Formation contain a diverse fauna of foraminifera (det. BODROGI) with *Protopeneroplis trochangulata* SEPTFONTAINE, *Conicospirillina basiliensis* MOHLER, *Nautiloculina oolithica* MOHLER, *Pseudocyclammina lituus* YOKOYAMA, *Trocholina alpina* (LEUPOLD), *Nubecularia reicheli* RAT etc., which indicates Early Berriasian age. Calcareous algae (det. BODROGI), e.g. *Clypeina jurassica* FAVRE, *Salpingoporella annulata* CAROZZI, *Cayeuxia anae* DRAGASTAN and other biota, e.g. *Tubiphytes morronensis* CRESCENTI and *Bacinella irregularis* RADOICIC are characteristic for the allodapic Barmstein interlayers. According to LOBITZER (in BÖHM et al., 1997) the Plassen carbonate platform persisted from Upper Jurassic to the Early Cretaceous terminating earliest in the Early Berriasian. It is the source area of the material redeposited as Barmstein Limestone. SCHLAGINTWEIT & EBLI (1999) confirmed Early Cretaceous age for the analogous Plassen Limestone of the Trisselwand (Bad Aussee, Styria).

The Oberalm Formation grades into the Middle/Late Berriasian **Schrambach Formation** – as indicated by calpionellid assemblages. In the latter the chert content decreases, allodapic interlayers are absent while the number of marly/clayey intercalations increases. In the upper part of this sequence – below the Anzenbach Subformation – forams (det. BODROGI) indicate (Early) Valanginian age: *Dorothia* cf. *zedlerae* MOULLADE, *D.* cf. *trochus* (REUSS), *D.* cf. *kummi* (ZEDLER), *Spiroloculina* sp., *Lenticulina ouachensis ouachensis* SIGAL, *Pseudonodosaria* sp. According to FILACZ (in BODROGI et al. 1999) also calpionellids, e.g. *Cadosina* cf. *vogleri*, a.o., confirm the Early Valanginian age, while BOOROVÁ et al. (1999) and REHAKOVA et al. (1996) consider the Anzenbach Subformation still as Late Berriasian (Calpionellopsis Zone).
The **Anzenbach Subformation** grades into the **Lower Roßfeld Formation**. Tintinnid-Radiolarian-Foram assemblages with *Paalzowella feifeli* (PAALZOW), *Calpionellopsis* sp. and the aptychi point to Middle Valanginian age. The uppermost shaly limestones of the Lower Roßfeld Formation yielded *Lamellaptychus trauthi* RENZ & HABICHT and *L.* cf. *mendrisiensis* RENZ & HABICHT (VASICEK in BOOROVÁ et al., 1999) which indicate lower Late Valanginian.
The clastic **Upper Roßfeld Formation** comprises arenitic/fine-brecciated limestones with coarse-clastic "Wildflysch" intercalations. The nannoflora with *Cruciellipsis cuvillieri*, *Watznaueria barnesae*, cf. *Polycostella beckmanni*, *Parhabdolithus embergeri* and *Nannoconus steinmanni* (det. SVÁBENICKÁ) and a poor foram-assemblage dominated by agglutinated taxa, e.g. *Saccamina* sp., *Dorothia kummi* (ZEDLER); *Ammodiscus tenuissimus* GUEMBEL), *Psammosphaera* sp. and a few calcareous forams, as *Lenticulina nodosa* (REUSS), *L.* sp. and *Vaginulina arguta* REUSS suggest Late Valanginian/Hauterivian age (HRADECKÁ in BÖHM et al., 1997).
Further fossil content comprises rhodophyta (*Archaeolithothamnium* sp., *A.rude* LEMOINE, *Solenopora* sp.) and crinoids (BODROGI, 1999). Calpionellids (e.g. *Calpionellopsis nowaki*, *Calpionella alpina*, *Crassicollaria* sp., *Cadosina* sp.) indicate Hauterivian age. The age of the "Wildflysch" olistholites is inferred as Hauterivian-Barremian (WEIDICH, 1990; BODROGI et al., 1999). SKUPIEN (in BOOROVÁ et al., 1999) reports the dinocyst *Nexosispinum vetusculcum indicating* Hauterivian.

Fig. 8. The Leube quarry at Guthratsberg, St. Leonhard, Salzburg. Lower Cretaceous

Saturday, September 2nd

Upper Cretaceous Gosau Group of the Northern Calcareous Alps in the Salzkammergut

STOP 2.1. Coral reef Theresienstein /Strobl am Wolfgangsee

D. SANDERS & R. BARON-SZABO

Topic: Upper Cretaceous coral reef and associated shallow-water bioclastic limestones
Lithostratigraphic unit: "Theresienstein Formation", lower Gosau Subgroup
Age: Coniacian?
Tectonic unit: Sparber unit (Tirolicum), NCA
Location: Rock walls immediately below and southward of the viewpoint „Theresienstein" at right flank of the debouch of Strobler Weissenbachtal, village Weissenbach near Strobl am Wolfgangsee (Salzburg, Austria).

The coral reef at the Theresienstein probably was originally underlain by a poorly exposed ?Upper Turonian - Coniacian succession of neritic shales and sandstones. Up-section and separated by a gap in outcrop, the Theresienstein Formation is overlain by a succession of deep-water shales (Nierental Formation).

The Theresienstein Formation comprises the most spectacular Upper Cretaceous coral reef in the Eastern Alps. In its lower part, the Theresienstein Fm consists of poorly exposed shaly limestones rich in rudists (*Vaccinites* spp., radiolitids, *Plagioptychus*) and relatively small-sized scleractinians. Above the weathering surface, the major part of the formation consists nearly throughout of boundstone of lamellar-encrusting corals (up to more than a metre in size) and, subordinately, hemispherical corals and columnar corals. The corals are only scarcely encrusted and scarcely bored. Nearly all corals show thamnasterioid or plocoid arrangement of polyparia. Investigations under way indicate that, despite the extreme abundance and large size of the corals, the assemblage consists of only about 12 genera. Rudists are accessory, and occur as isolated specimens and clusters of hippuritids, a few *Plagioptychus* and radiolitids. No evidence for substantial marine cementation nor for steep clinoforms was found. In the topmost part of exposure, the coral limestone is overlain by an interval a few meters thick of shallow-water bioclastic limestone (mainly packstones to grainstones) with a few disoriented rudists.

The vertical succession from shaly, coarse bioclastic limestones at the base into an interval of pure coral boundstones and, at the top, to pure shallow-water bioclastic limestones indicates upward shoaling. The absence of clinoforms might suggest that the reef was of a relatively gentle syndepositional relief. Despite the abundance of well-preserved corals and the scarce and thin encrustations, the paucispecific composition of the coral fauna combined with the foliose-encrusting growth forms and the prevalence of thamnasterioid and plocoid arrangement of polyparia all suggest that the community grew under suboptimum ecological conditions. By the thickness of the coral reef, as well as by the extreme abundance and large size of the corals, the "Theresienstein reef" stands unique in the Eastern Alps.

The type locality of the Gosau Group, the Gosau Valley area

Upper Cretaceous deposits of the area of Gosau (Upper Austria), Rußbach, Abtenau (Salzburg) comprise the type locality of the Gosau Group. Historical descriptions include LILL von LILIENBACH 1830, SEDGWICK & MURCHISON 1832, REUSS 1854.

The basin fill comprises about 1000 m of Upper Turonian to lowermost Campanian terrestrial and shallow-water sediments of the lower Gosau Subgroup, which are unconformably overlain by more than 1200 m thick deep-water deposits of the upper Gosau Subgroup (Fig. 9). The upper Gosau Subgroup clearly seals Upper Turonian-Santonian basin bounding structures, as deep-water deposits of the UGS onlap the Triassic substrata (WAGREICH, 1988 b). A reconstruction of the basin geometry of the lower Gosau Subgroup results in an original basin about 8 to 10 km wide and 10 km long. If similar Cretaceous deposits in the area of Abtenau are included the composite Upper Cretaceous basin extended at least over 25 km.

The biostratigraphy, lithostratigraphy and sedimentology of the basin fill have been discussed in detail by HÖFLING (1985), TRÖGER & SUMMESBERGER (1994), SUMMESBERGER & KENNEDY (1996), WAGREICH (1988a,b, 1998) and SANDERS et al. (1997) based on WEIGEL (1937) and KOLLMANN (1982 a). At the base an up to 350 m thick interval of red alluvial conglomerates (**Kreuzgraben Fm.**) of probably Late Turonian age is overlain by a transgressive succession of shallow-marine shales and backstepping coarsening-upward paracycles of the Upper Turonian to Coniacian **Streiteck Fm.** Conglomerates of the Kreuzgraben Fm. were interpreted to record progradation and retrogradation of alluvial fans whereas parasequences of the Streiteck Fm. are the result of fan-delta progradation (WAGREICH 1988 b, 1998). Foraminiferal assemblages suggest water depths of about 150 to 300 m at maximum flooding in early Santonian time, at the base of **Grabenbach Fm**. Storm-influenced shelf and near-shore sediments of up to 500 m, including rudist bioherms (HÖFLING, 1985), fill the basin in Santonian to early Campanian times, but are interrupted by a short erosional phase in early Campanian time (Grabenbach, **Hochmoos** and **Bibereck Formations**). The overlying upper Gosau Subgroup starts with a sandstone-rich turbidite fan interval (**Ressen Fm.,** Lower Campanian), followed by (hemi)pelagic shales and marly limestones (**Nierental Fm.,** Upper Campanian - Maastrichtian) and a turbiditic interval (**Zwieselalm Fm.**, Upper Maastrichtian-Paleocene/Eocene).

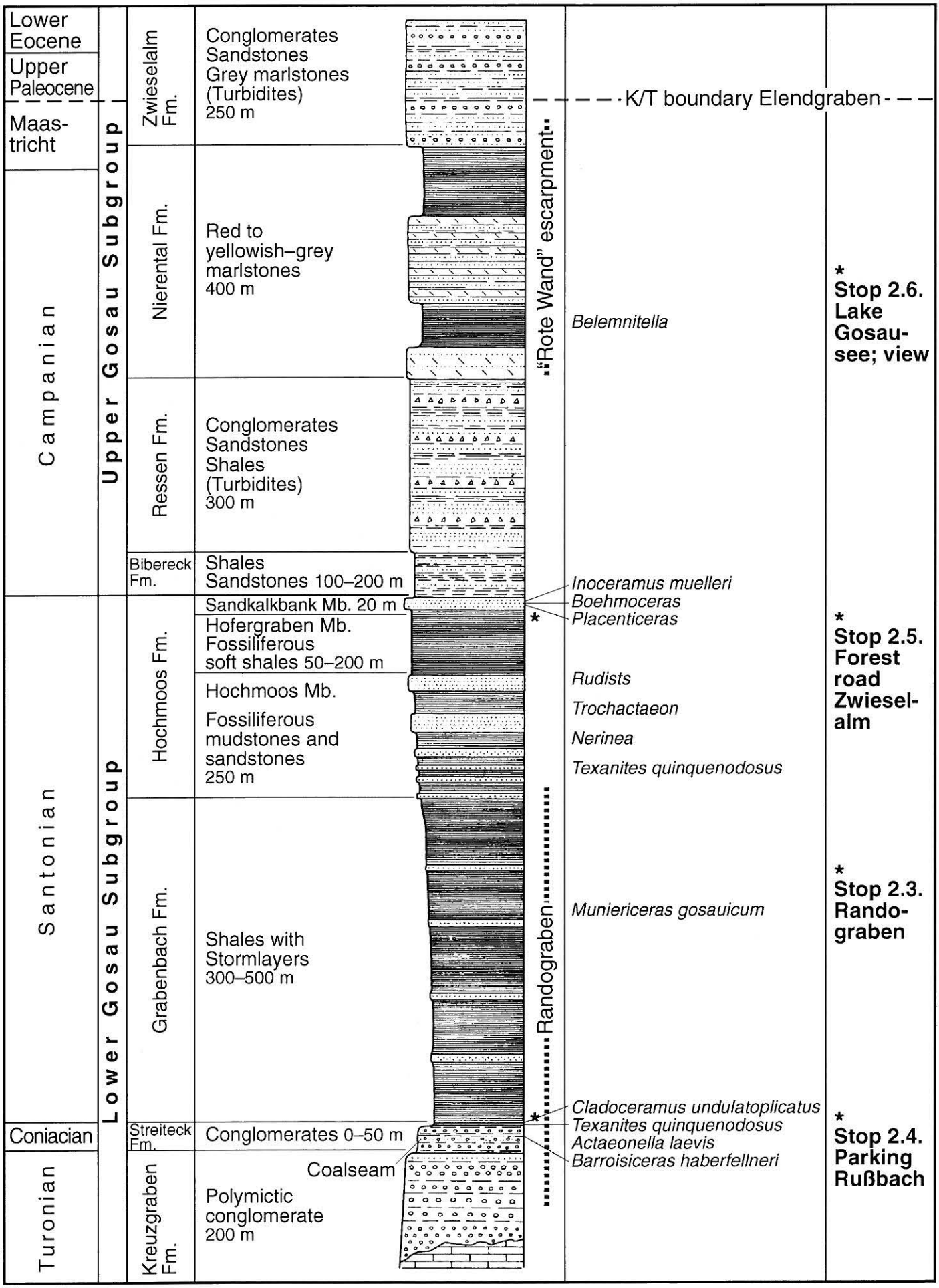


Fig. 9. Composite lithostratigraphic section of the Gosau Group of Gosau and Russbach including a selection of macrofossils; after Weigel (1937), Summesberger (1979), Kollmann (1980, 1982 a), Summesberger in: Matura & Summesberger (1980)

STOP 2.2 Postalm road, Rigaus-Abtenau, Gosau Group

Topic: section through the upper part of the Gosau Group; sequence boundary on top of Hochmoos Formation; red shaly limestones of Nierental Formation; Zwieselalm Formation.
Lithostratigraphic units: Gosau Group, Hochmoos Fm., Bibereck Formation, Nierental Formation
Age: Late Santonian - Campanian - Maastrichtian
Tectonic unit: Lammer unit (Juvavicum?, boundary to Tirolicum), NCA
Location: Postalm roadcut (Salzburg) near Rigaus, 7 km NNW of Abtenau (Salzburg)

The boundary between the lower Gosau Subgroup and the upper Gosau Subgroup is characterized by short-time uplift and erosion, followed by fast subsidence into bathyal depths. The section at the Postalm road starts within shallow marine sandstone and shales of the Hochmoos Formation (lower Gosau Subgroup). Fan-delta conglomerates dominate in the upper part of the Hochmoos Formation. On its top a distinct brownish Goethit-bearing layer indicates subaerial exposure. Based on strongly increasing amounts of planktonic foraminifera the following 3 m thick grey shales of the Bibereck Formation record rapid deepening. The Bibereck Formation shows onlap geometries from the basin center near Gosau to the basin margin at the Postalm road. Foraminifera indicate the *asymetrica-elevata* concurrent range zone assigned to the lower part of the early Campanian. Nannofossils indicate CC17b by the presence of *Calculites obscurus* and curved *Lucianorhabdus cayeuxii*. The Nierental Formation (upper Gosau Subgroup) is characterized by red shaly limestones grading into a limestone-turbidite interval. The red marly limestones (carbonate contents 67 - 80 %) are interpreted as (hemi)pelagites (KRENMAYR, 1996). Percentages of planktonic foraminifera of the total sediment are more than 10%. No grain size trends within the siliciclastic fraction was detectable. Sedimentation rates are about 25 mm/1000a. Fragments of inoceramids concentrated by bottom currents increase upsection. In the upper part of the section, mm-thick grey, fine sandstone to siltstone turbidite layers are intercalated. They represent distal turbidites of a small, but sandstone-rich deep-water fan of the Ressen Formation of the Gosau area. Biostratigraphic data are based on moderately preserved nannofossil assemblages, which indicate a complete Campanian section from CC18 (FO of *Broinsonia parca*) to CC23.

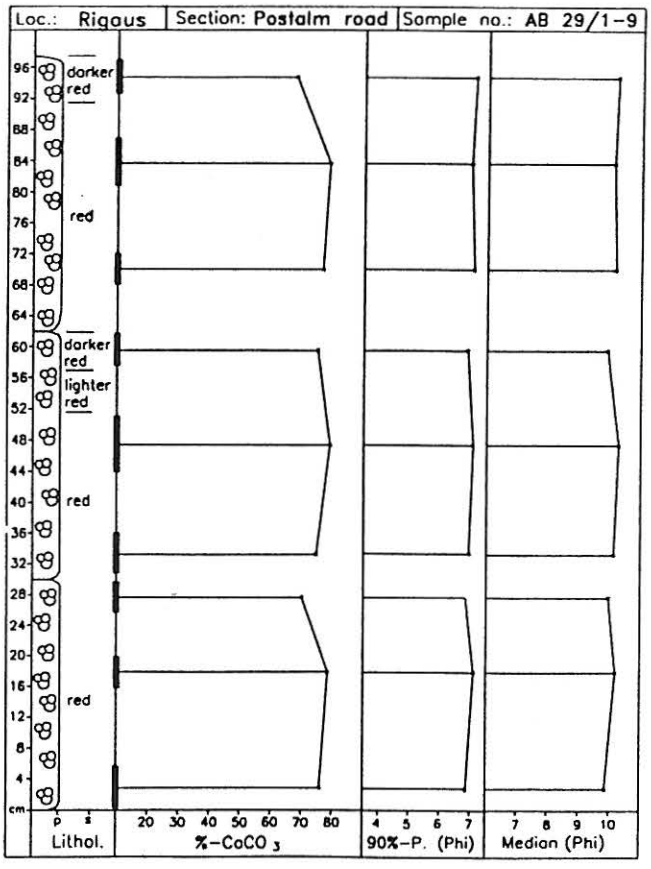


Fig. 10. Postalm road, red (hemi)pelagite facies of the Nierental Fm.; detailed sections including carbonate contents and grain size analysis. The lack of grading contradicts the interpretation as turbidites (KRENMAYR 1996).

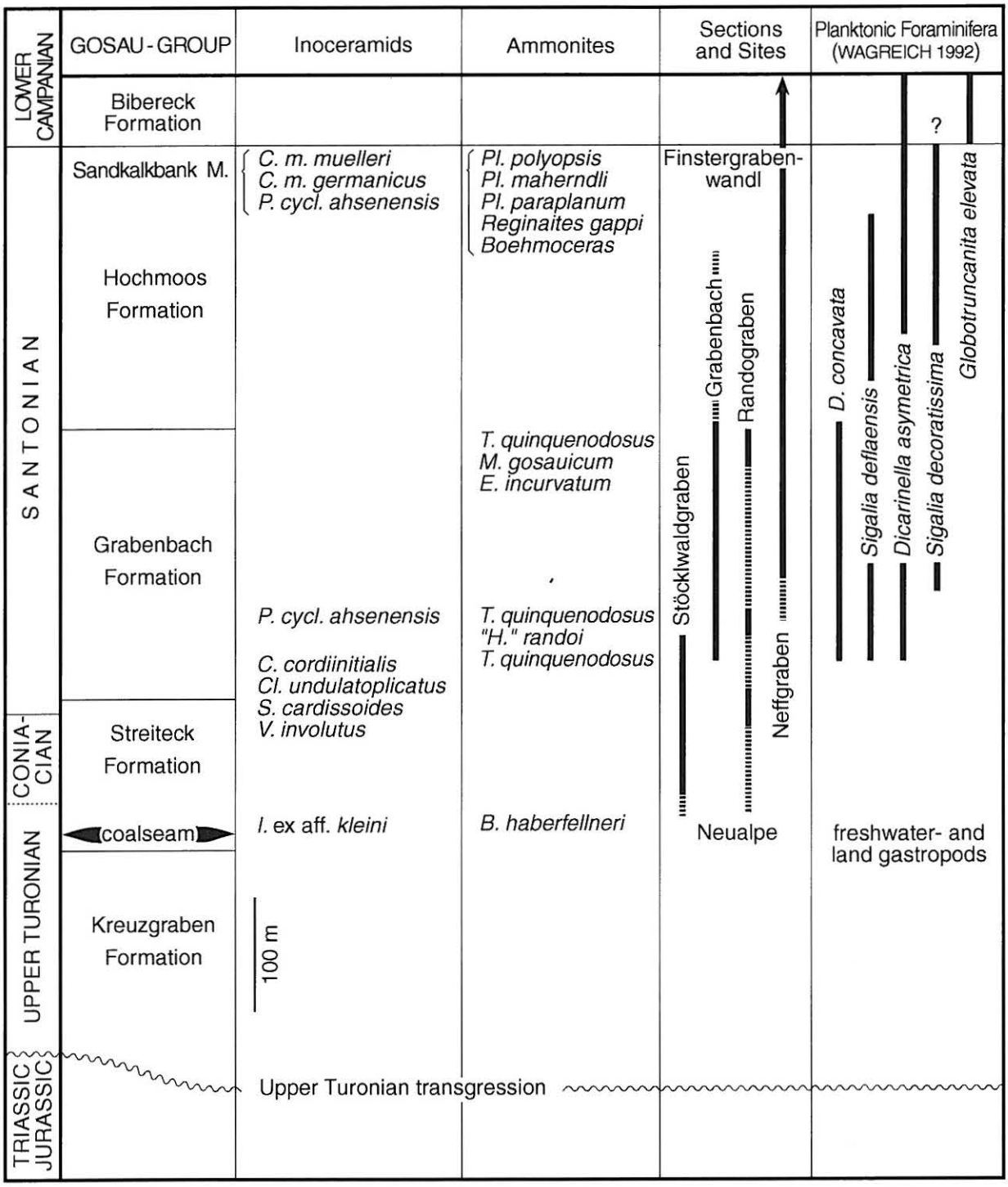


Fig. 11. The Upper Turonian transgression of the Lower Gosau Subgroup in the area of Gosau and Russbach; after Tröger & Summesberger (1994). Abbr.: C - *Cordiceramus*, Cl - *Cladoceramus*, S - *Sphenoceramus*, V - *Volviceramus*, I - *Inoceramus*; Pl - *Placenticeras*, T - *Texanites*, H - *"Hemitissotia"*, B - *Barroisiceras*, M - *Muniericeras*; D - *Dicarinella*.

STOP 2.3 Randograben NE Rußbach

Topic: Section within the lower Gosau Subgroup; red terrestrial conglomerates of alluvial fans, fan-delta sediments, shelf shales and tempestites, rudist bioherm
Lithostratigraphic units: Kreuzgraben Formation, Streiteck Formation, Grabenbach Formation, Hochmoos Formation (lower Gosau Subgroup)
Age: Late Turonian - Santonian
Tectonic Unit: Dachstein Nappe (Juvavicum), NCA
Location: section along the forest road Randobach, NW Rußbach (Salzburg)

Outcrops within the Randograben provide a complete section within the lower part of the lower Gosau Subgroup. Outcrops include fan-delta conglomerate cycles of the Streiteck Fm., shelf shales with a few siciliciclastic tempestites of the Grabenbach Fm. and fossiliferous marls and limestones of the Hochmoos Fm.

Walk downstream (stratigraphically upwards) from the forest road junction close to a rotten bridge which leads to the Stöcklwaldgraben (not visited).

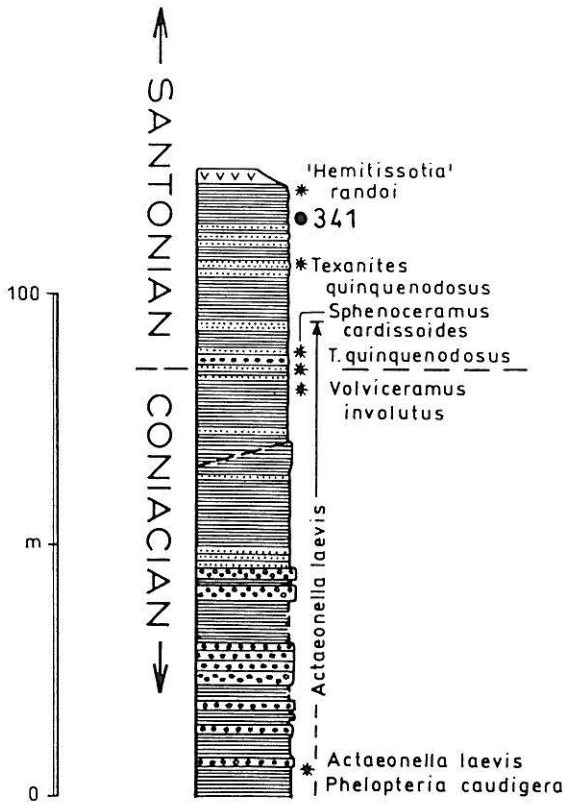


Fig. 12. The Coniacian/Santonian boundary in the Stöcklwaldgraben, a subsidiary of the Randograben. Top Coniacian is proved by the occurence of *Volviceramus involutus*, basal Santonian by the co-occurrence of *Texanites quinquenodosus, Sphenoceramus cardissoides* and *Cladoceramus undulatoplicatus; ‚Hemitissotia' randoi* is a useful local marker of the Lower Santonian. After TRÖGER & SUMMESBERGER (1994). 341: sample number of WAGREICH (1992, p.509, fig. 3)

Itinerary:

1. Overgrown exposure in Streiteck formation with fine conglomerates and clayey intercalations with coal seams (Coniacian).
2. Roadside exposure in basal Grabenbach formation possibly of top Coniacian age with abundant *Acteonella laevis*
3. Exposures in the streambed, visit depending on water conditions: relatively fossiliferous Grabenbach Formation

Fossil list (after TRÖGER & SUMMESBERGER 1994):

Inoceramids:
Cladoceramus undulatoplicatus (ROEMER)
Platyceramus cycloides cycloides (WEGNER)
Sphenoceramus cardissoides (GOLDFUSS)

Ammonites
Parapuzosia daubreéi (GROSSOUVRE)
'Hemitissotia' randoi GERTH
Texanites quinquenodosus (REDTENBACHER)

All fossils are indicative of Lower Santonian.

4. Below the 2nd bridge an 80 m coarsening upward cycle within the Hochmoos Fm. grades from silty shales to sandstones and ends with fine conglomerates. The sandstones are strongly bioturbated, including *Ophiomorpha*- and *Thalassinoides*-burrows and show shell-layers at their bases and hummocky cross-stratification. The microfauna is predominated by miliolids and ostracods. Nannofossil data indicate CC16 to CC17 by the presence of *Lucianorhabdus cayeuxii* and rare *Calculites obscurus*. Bivalves (*Pinna*, Pholadidae) in life position.

5. 70 m upstream from the first bridge over the Randobach creek.
Hard sandstone on the left side of the riverbed containing:

Muniericeras gosauicum (HAUER)
Texanites quinquenodosus (REDTENBACHER)
Baculites sp.

Fossils are typical of Santonian (possibly middle Santonian) age.

STOP 2.4 Parking area Rußbach

Topic: Tempestites and shales of the Grabenbach Formation; transgression onto Triassic limestones
Lithostratigraphic unit: Grabenbach Formation
Age: Early Santonian
Tectonic Unit: Dachstein Nappe (Juvavicum)
Location: parking area of cable car to Horneck, SW Rußbach (Salzburg)

At the parking area of the cable car Rußbach/Horneck a reduced succession of the lower Gosau Subgroup is exposed. A thin interval of conglomerates and coals is followed by shales and fine grained sandstones of the Grabenbach Formation. Inoceramids prove an early Santonian age. Planktonic foraminifera give evidence for the *Dicarinella concavata*-Zone, nannofossils indicate standard zone CC14/15 (e.g. *Marthasterites furcatus*, *Micula decussata*). Sandstones of the

Grabenbach Formation show features of tempestites (e.g. small-scaled hummocky cross stratification, wave ripples, flute casts). Provisional fossil list: cf. *Cladoceramus undulatoplicatus* (ROEMER), cf. *Platyceramus cycloides cycloides* (WEGNER), *Gaudryceras* sp., *Eupachydiscus* sp.

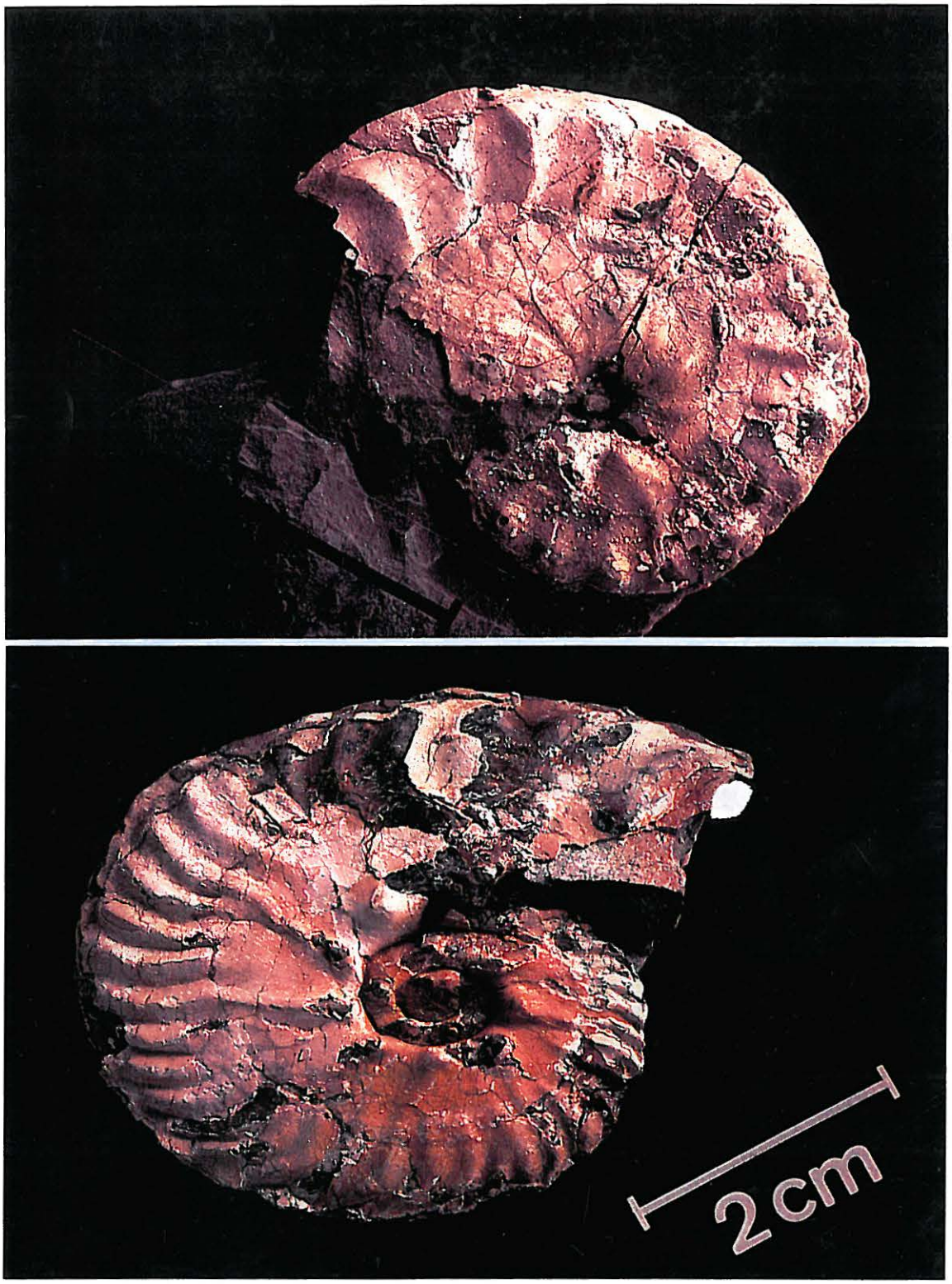


Fig. 13. Ammonites of the Lower Gosau Subgroup of the Randograben. 1. *„Hemitissotia" randoi* GERTH, Randograben, Lower Santonian 2. *Muniericeras gosauicum* (HAUER), Randograben, Russbach; middle Santonian.

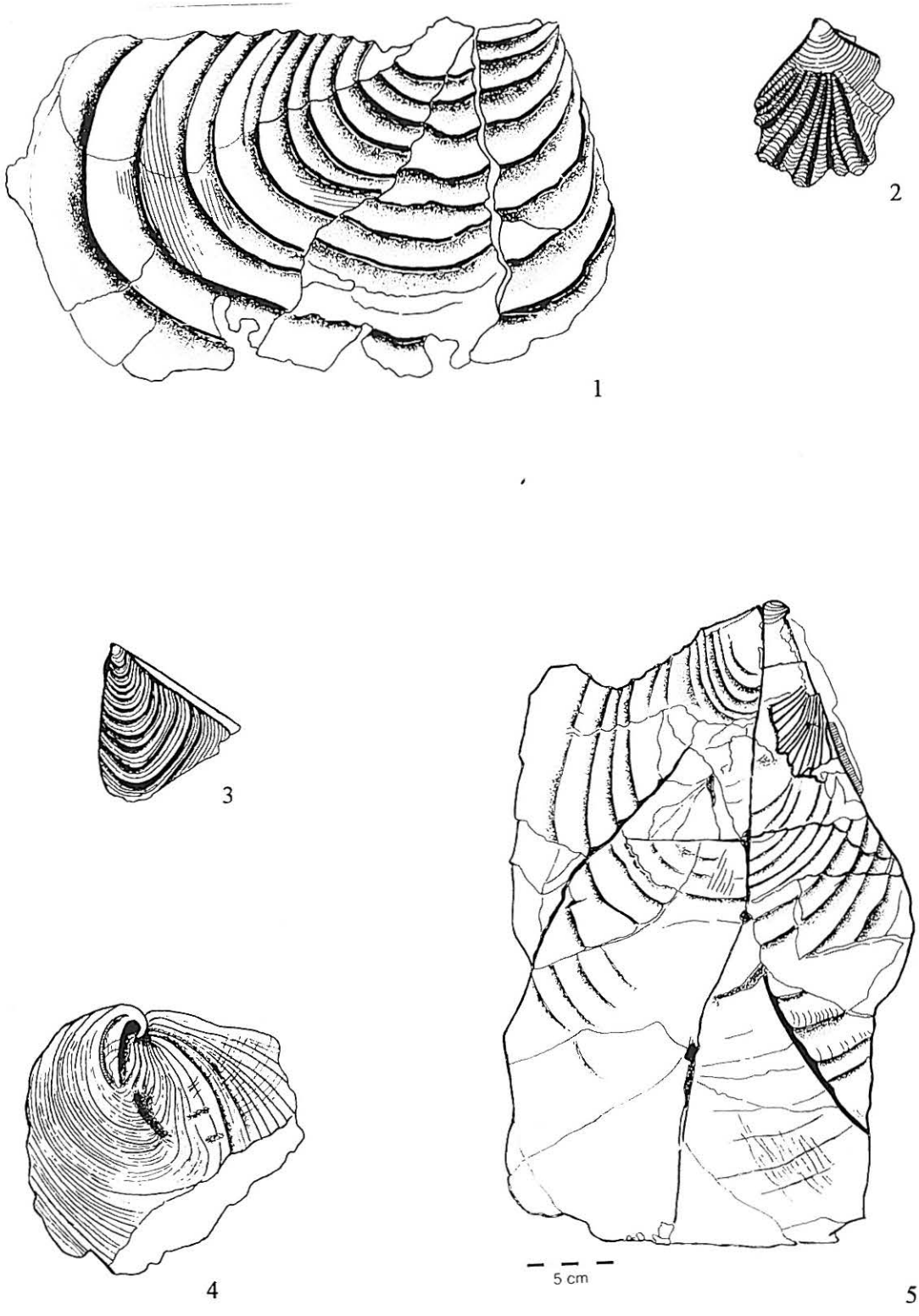


Fig. 14. Inoceramids from the Lower Gosau Subgroup 1. *Cordiceramus muelleri muelleri* (PETRASCHECK) . 2. *Cladoceramus undulatoplicatus* (ROEMER). 3. *Sphenoceramus cardissoides* (GOLDFUSS). 4. *Volviceramus involutus* (SOWERBY). 5. *Platyceramus cycloides ahsenensis* (SEITZ)

Fig. 15. Russbach, parking area at the cable car station (Hornspitzbahn). Basal Grabenbach Fm. With ammonites and inoceramids, resting upon layers of shales with pebbles, coalseam, corals, gastropods (possibly equivalent to Streiteck Fm.).Transgression upon Triassic rocks (right side), overlain on top by Pleistocene moraine with „scratched boulders".

STOP 2.5 Forest road into the Finstergraben N of the village Gosau

Topic: sandy to silty shales with macrofauna
Lithostratigraphic unit: Hochmoos Formation
Age: Late Santonian
Tectonic Unit: Dachstein Nappe (Juvavicum)
Location: Forest road into the Finstergraben N of village Gosau (UpperAustria)

Outcrops along a forest road into the Finstergraben show conglomerates and silty to sandy shales of the Hochmoos Formation. The marls are fossiliferous. The marls of the Hochmoos Formation are interpreted as shallow marine pelitic deposits of the transition zone between the nearshore and the offshore area. Sandstones of the Hochmoos Formation include nearshore/shoreface sediments, often burrowed by *Ophiomorpha*-type burrows. Immediately above the silty shales the sandstone of the about 20 m thick Sandkalkbank Member is visible. It yielded an abundant mollusk fauna. with 23 gastropod taxa (KOLLMANN 1980), 50 bivalve taxa (DHONDT 1984) and 22 ammonite taxa (SUMMESBERGER, 1979, 1980, 1992 a; WIEDMANN 1978). *Pinna* in life position and the articulated infauna of bivalves indicates a soft substratum and a low water energy level together with a fast sedimentation rate. Inner shelf conditions were concluded. Long transport can be excluded as ammonites are preserved in general with the bodychambers. The stratigraphic position at the top of the Late Santonian is based upon correlation of the heteromorph ammonite *Boehmoceras* with the Münster basin (Germany) endorsed by micropalaeontological data (WEISS,1975; see WAGREICH 1988 a). Palaeobiogeographical connections to the Münster basin, North America (Gulf coast, Western Interior), Japan and Madagascar indicate a worldwide system of open waterways in Late

Santonian times. Subtropical to tropical climate can be concluded from the occurrence of hermatypic corals and rudists in the Hochmoos Formation. The gastropod *Pleurotomaria* indicates the presence of cooler water temperatures at slightly greater depths; scaphitids and belemnites are absent. Biostratigraphically the Sandkalkbank Member of the Hochmoos Formation belongs to the recently established Upper Santonian *Boehmoceras arculus* zone (KAPLAN & KENNEDY 2000). The occurrence of *Boehmoceras arculus* (MORTON) allows precise correlation to the Münster basin (Germany) and to the Tombigbee Sand of Mississippi and Alabama (USA; KENNEDY & COBBAN 1991). Sponges, corals, brachiopods, nautiloids, crustaceans are presently undescribed

Gaudryceras mite (HAUER)
Pseudophyllites latus (MARSHALL)
Damesites compactus (VAN HOEPEN)
? *Parapuzosia* cf. *seppenradensis* (LANDOIS)
Kitchinites stenomphalus SUMMESBERGER
Hauericeras (G.) gardeni (BAILY)
Eupachydiscus isculensis (REDTENBACHER)
Nowakites draschei (REDTENBACHER)
Eulophoceras austriacum (SUMMESBERGER)
Placenticeras polyopsis (DUJARDIN)
Placenticeras maherndli SUMMESBERGER
Placenticeras paraplanum (WIEDMANN)
Reginaites gappi WIEDMANN
Hyphantoceras (?) amapondense (VAN HOEPEN)
Nostoceratide gen. et sp. indet. (? *Jouaniceras*)
Glyptoxoceras cf. *rugatum* (FORBES)
Glyptoxoceras cf. *tenuisulcatum* (FORBES)
Baculites fuchsi REDTENBACHER
Baculites tanakai MATSUMOTO & OBATA
Baculites sp.
Boehmoceras arculus (MORTON)
Boehmoceras krekeleri (WEGNER)

Tab.1. Ammonites of the Sandkalkbank Member (SUMMESBERGER 1979, 1980, 1992 a; WIEDMANN 1978; with alterations)

Pleurotomaria sp.
Bathrotomaria subgigantea (D'ORBIGNY)
Keilostoma tabulata (ZEKELI)
Climacopoma quadrata (SOWERBY)
Torquesia rigida (SOWERBY)
Exechocirsus reticosus (SOWERBY)
Quadrinervus subtilis (ZEKELI)
Cyphosolenus sp.
Helicaulax gibbosus (ZEKELI)
Xenophora plicata (ZEKELI)
Pseudamaura sp.
Lunatia semiglobosa (ZEKELI)
Mesorhytis cancellata (SOWERBY)
?Palaeopsephaea sp.
Fusinus reussi (ZEKELI)
Fusinus subabbreviatus (ZEKELI)
Woodsella turbinata (ZEKELI)
Fuside indet.
Tudicla indet.
Volutide indet.

Gosavia squamosa (ZEKELI)
Licoarenus sp.
Acteonella elongata KOLLMANN

Tab.2. Gastropods of the Sandkalkbank Member (KOLLMANN 1980)

Nucula concinna SOWERBY
Nucula redempta ZITTEL
Nucula cf. *N. stachei* ZITTEL
Arca aquisgranensis J. MUELLER
Barbatia? Inaequidentata (ZITTEL)
Cucullaea cf. *matheroniana* (D'ORBIGNY)
Limopsis calva SOWERBY
Glycymeris marrotianus (D'ORBIGNY)
Glycymeris noricus (ZITTEL)
Inoperna flagellifera (FORBES)
Modiolus typicus (FORBES)
Modiolus capitatus (ZITTEL)
Modiolus cf. *siliquus* (MATHÉRON)
Pinna cf. *cretacea* (SCHLOTHEIM)
Gervillia solenoides DEFRANCE
Gervbillaria neptuni (GOLDFUSS)
Pseudoptera raricosta (REUSS)
Aguileria ? falcata (ZITTEL)
Cordiceramus muelleri (PETRASCHECK)
Sphenoceramus angustus (BEYENBURG)
Platyceramus cycloides ahsenensis (SEITZ)
Camptonectes virgatus (NILSSON)
Merklinia septemplicata (NILSSON)
Neithea coquandi (PÉRON)
Spondylus coquandianus D'ORBIGNY
Spondylus requienianus MATHÉRON
Plagiostoma cretaceoum (WOODS)
Pycnodonte vesiculare (LAMARCK)
Ceratostreon pliciferum (DUJARDIN)
Mutiella ? coarctata (ZITTEL)
Astarte similis (MUENSTER in GOLDFUSS)
Crassatella macrodonta (J. SOWERBY)
Granocardium productum (J. SOWERBY)
Linearia costulata (GOLDFUSS)
Icanotia impar (ZITTEL)
Proveniella testacea (ZITTEL)
Ambocardia planidorsata (ZITTEL)
Pitar s.l. *matheroni ?* (ZITTEL)
Cytherea cf. *polymorpha* (ZITTEL)
Cyprimeria ? discus (MATHÉRON)
Legumen martinianus (MATHÉRON)
Cyclorisma ? dubiosa (ZITTEL)
Corbula ? angustata J. SOWERBY
Pholadomya nodulifera ? MUENSTER in GOLDFUSS
Cercomya ? producta (ZITTEL)
Poromya frequens (ZITTEL)

Tab.3. Bivalves of the Sandkalkbank Member (DHONDT 1984)

Fig. 16. Ammonites of the Late Santonian Sandkalkbank Mb., Hochmoos Fm, 1. *Placenticeras polyopsis* (DUJARDIN), 2. *Placenticeras maherndli* (SUMMESBERGER), 3. *Boehmoceras arculus* (MORTON)

Fig. 17. *Eupachydiscus isculensis* (REDTENBACHER), holotype of the type genus, Santonian, Bad Ischl, Upper Austria; under care of Oberösterreichisches Landesmuseum, Linz; photo: W. J. KENNEDY, 1986.

STOP 2.6 Lake Gosausee in the Gosau valley.

Topic: Dachstein scenery; Triassic of the NCA; Nierental Formation of the Rote Wand section
Lithostratigraphic unit: Nierental Formation
Age: Campanian - Maastrichtian
Tectonic Unit: Dachstein Nappe (Juvavicum), NCA
Location: parking area of Gosausee cable car near Gosausee (UpperAustria)
View and photo stop

The scenery of the lake Gosausee and the Hohe Dachstein (3004/2996 m) is one of the most spectacular views of the Salzkammergut. The Triassic carbonates sourrounding the lake comprise reef limestones of the Dachsteinkalk at the Gosaukamm, bedded Dachstein limestone of the Dachstein itself and transitional basinal limestones (Pötschenkalk).
The not so famous view from the Gosausee to the north shows the "Rote Wand": interbedded hemipelagic and turbiditic red and grey shaly limestones of the Nierental Formation (Late Campanian-Maastrichtian-Danian), including a complete KT-boundary section. Nannofossil biostratigraphy (WAGREICH & KRENMAYR, 1993) prove significant diachroneity of red, (hemi)pelagite rich intervals even in nearby sections, thus indicating the predominance of local factors (tectonics, sediment supply) in the control of pelagic intervals rather than eustatic sea-level changes.

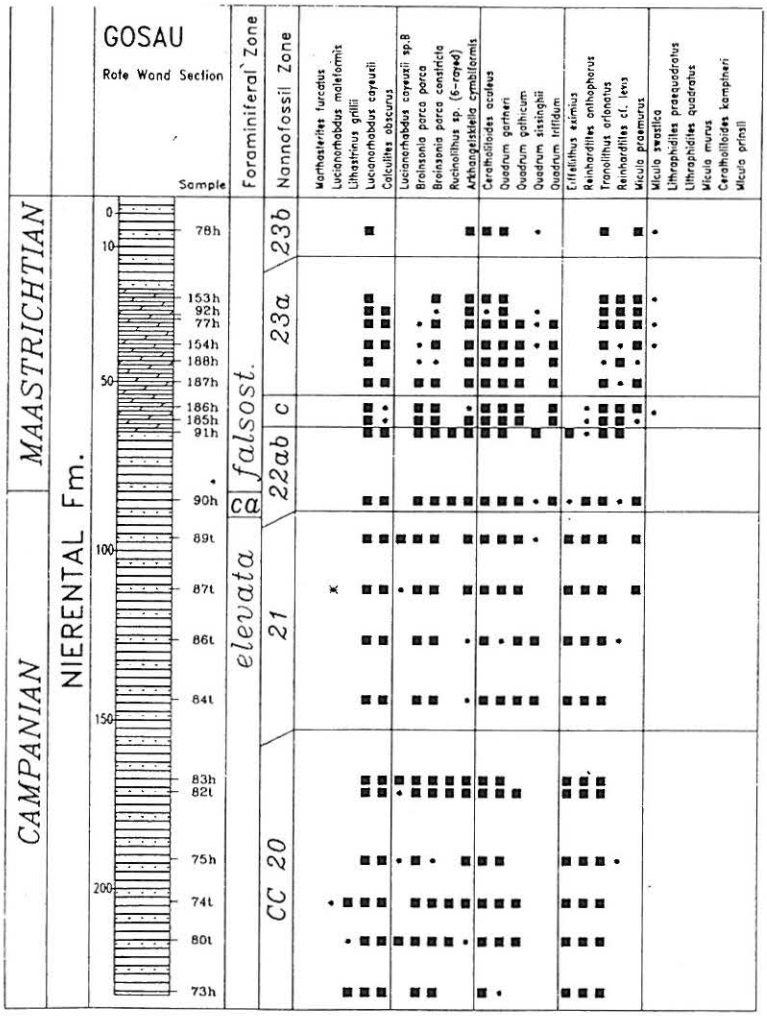


Fig. 18. Nannofossil biostratigraphy of the Rote Wand section (WAGREICH & KRENMAYR, 1993)

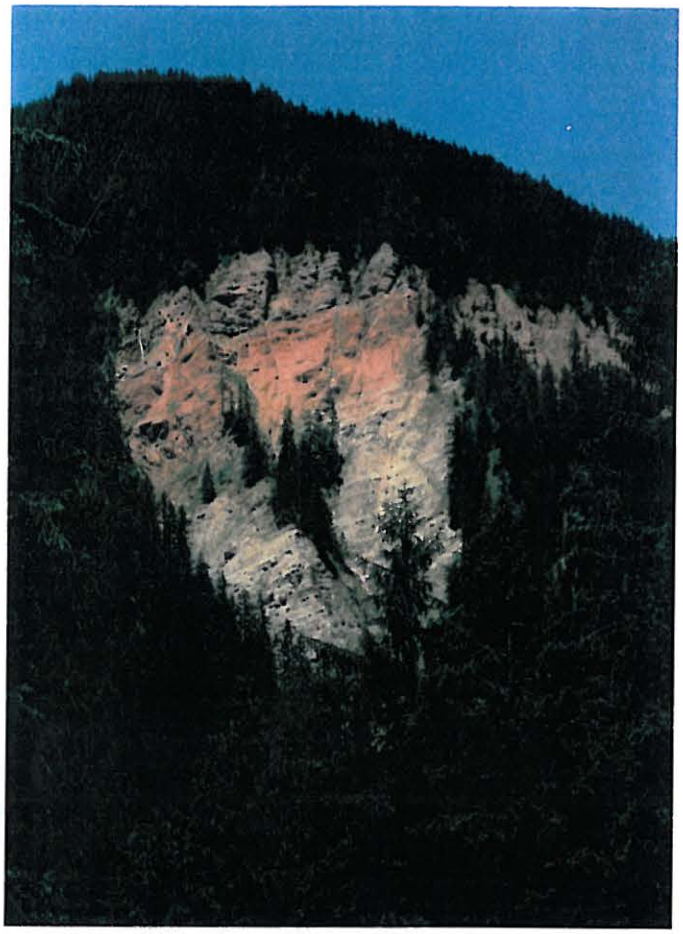


Fig. 19. "Rote Wand", escarpment of Nierental Formation. From the viewpoint at Lake Gosausee.

Sunday, September 3rd

Cretaceous of the Northern Calcareous Alps in the Enns Valley

The journey from Gosau to Gams pas through the Salzkammergut, a both historically and geologically famous area between Upper Austria, Salzburg and Styria. Classical Triassic geological sites include the type locality of the Hallstatt limestones (Cultural World Heritage of the UNESCO), the Pötschenpass and the Bad Aussee area. Within the Enns valley we approach the Paleozoic basement (Greywacke Zone) and metamorphic units at the southern margin of the NCA. The Enns valley follows a prominent Neogene sinistral E-W- strike slip fault (Salzach-Ennstal-Gesäuse-Fault or SEMP) in connection with lateral extrusion of the central part of the Eastern Alps. Afterwards the Enns valley enters again the NCA in the Gesäuse gorge between Admont and Hieflau and turns northward to Mooslandl/Gams.

The Gosau Group of Gams

The Gosau Group of Gams consists of a terrestrial to shallow-marine part of Late Turonian to Early Campanian age (lower Gosau Subgroup) and deep-marine Campanian to Lower Eocene deposits (KOLLMANN, 1963, 1964; upper Gosau Subgroup). Outcrops of the lower Gosau Subgroup are more or less restricted to the western part of the E-W-elongated outcrop belt ("western basin" of KOLLMANN, 1964; KOLLMANN & SUMMESBERGER, 1982). The following lithostratigraphic units could be distinguished based on KOLLMANN (1964):

(1) A basal unit of red alluvial conglomerates up to 70 m thick (Kreuzgraben Formation).

(2) A succession of shales and clays with rarely intercalated sandstones, and coaly clays, containing marine fossilscoaland jet. (Schönleiten Fm.; KOLLMANN & SACHSENHOFER, 1998).
(3) A succession up to 400 m thick of grey shales containing coal seams, sandstone with serpentinite sands, *Trochacteon* and rudist limestones ("Noth Formation"; Upper Turonian; SIEGL-FARKAS & WAGREICH 1997).
(3) Several hundred meters of grey silty shales with rare sandstone tempestites (Grabenbach Formation; Upper Turonian - Santonian).
(4) A transgressive series of conglomerates and sandstones and grey shales (Krimpenbach Formation, Late Santonian - Late Campanian age, SUMMESBERGER et al., 1999).
(5) Deep-water shales and turbidites of the Nierental Formation and Zwieselalm Formation, including olisthostromes (Late Campanian – Early Eocene).

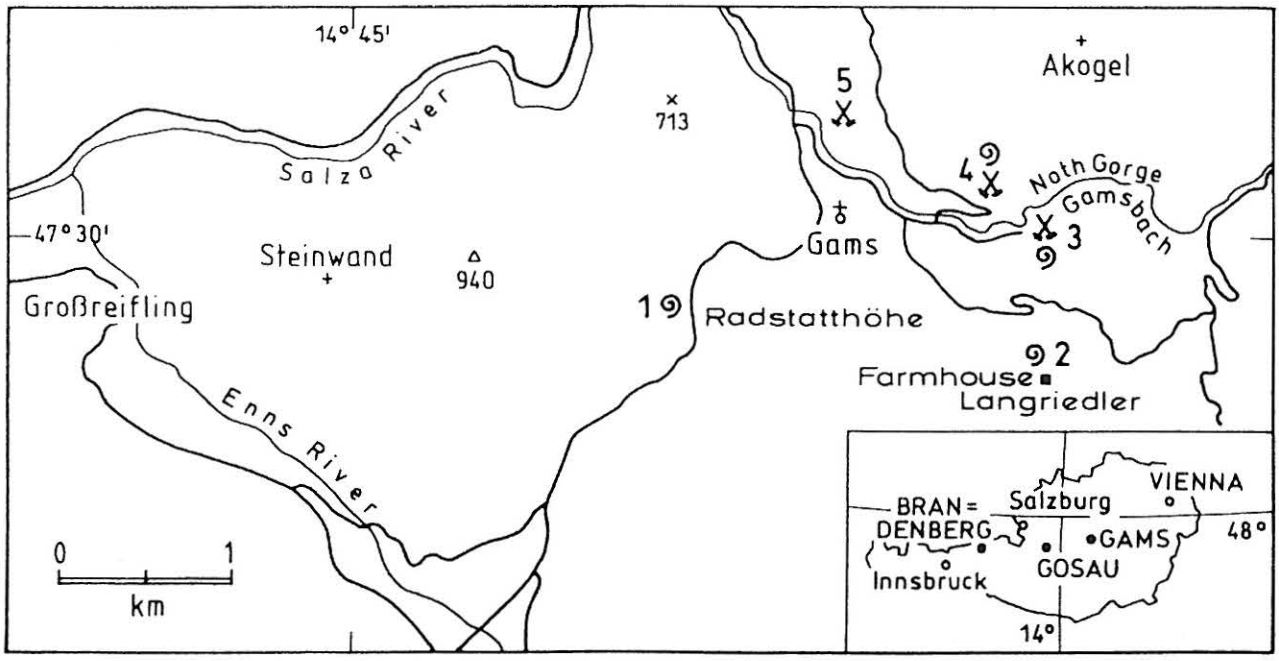


Fig. 20. Sketch map of sites in the Gams basin (after SUMMESBERGER & KENNEDY, 1996). 1. Radstatt (site of *B. haberfellneri, Didymotis*; stop 3.3). 2. Langriedler farmhouse. 3. Site with *Trochactaeon lamarcki* and rudist biostrome next to abandoned coal mine (stop 3.2). 4. Marine transgressive series with molluscs; abandoned coalmine (stop 3.1). 5. Section at the abandoned jet mines (optional stop).

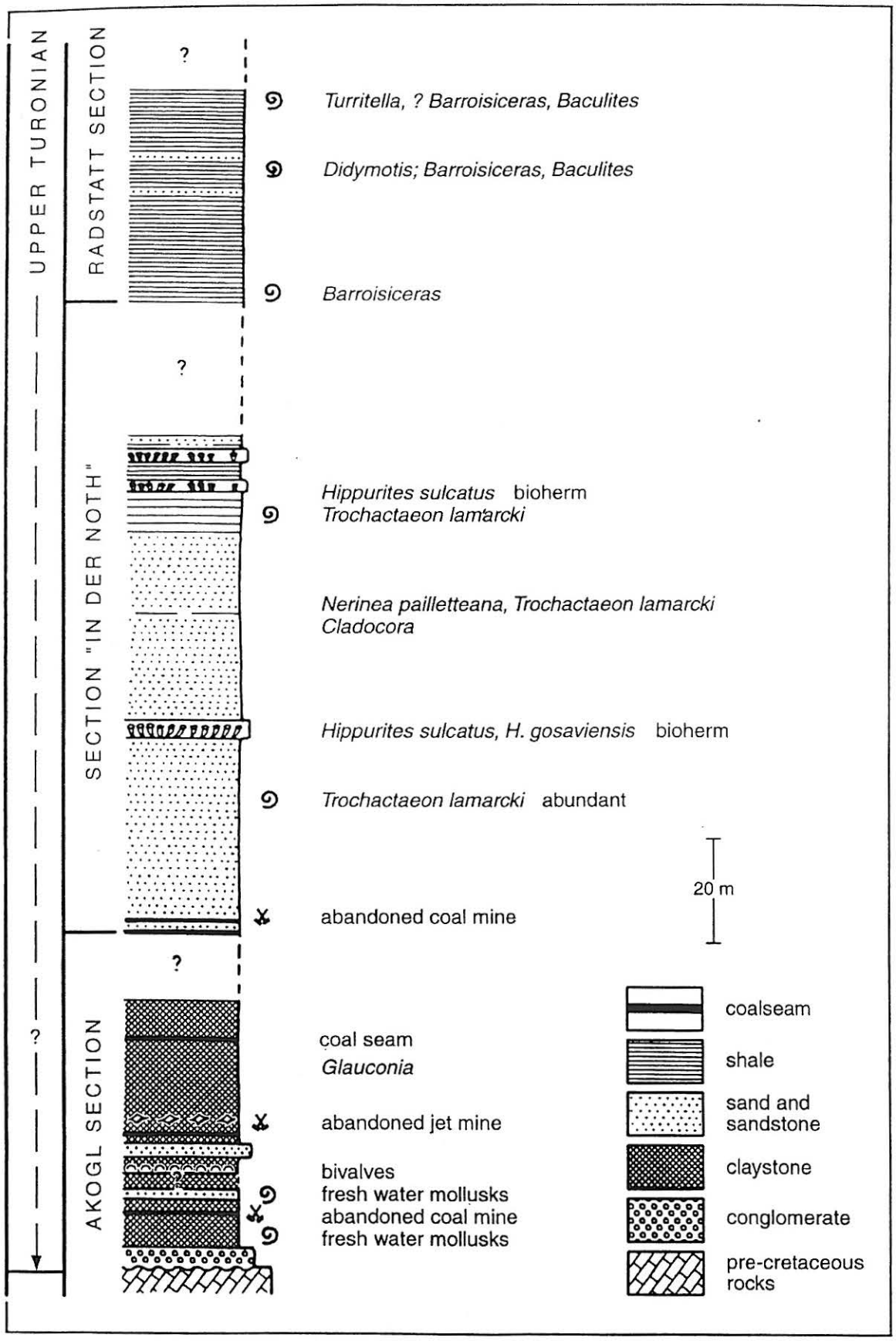
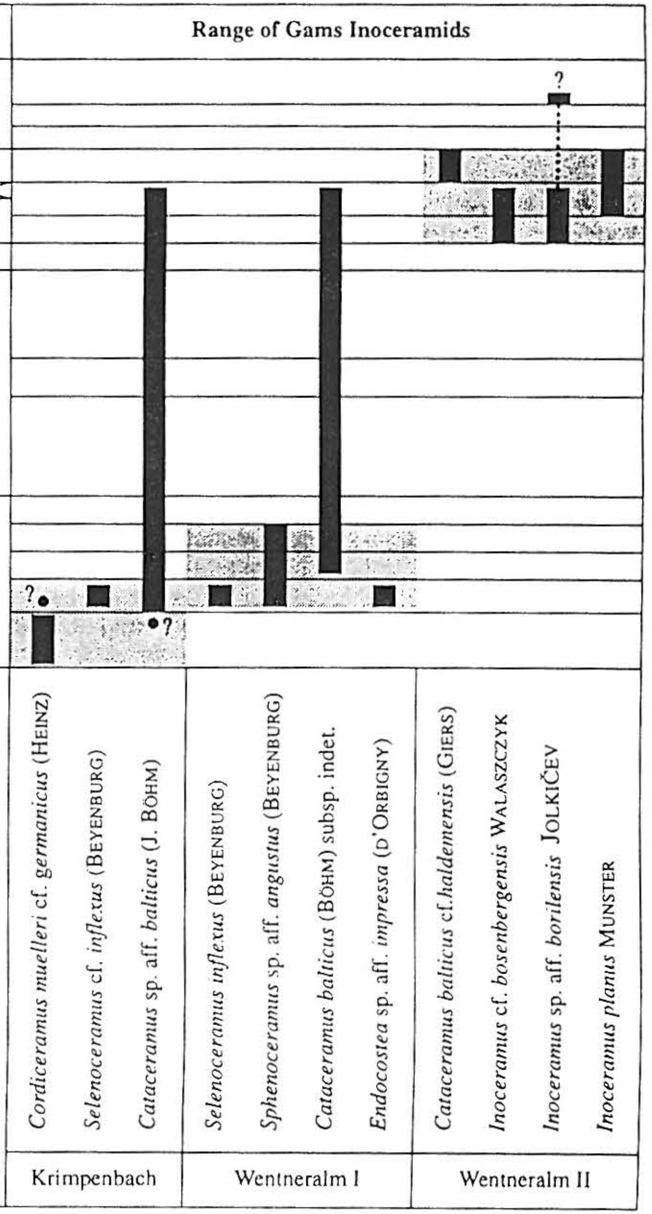


Fig. 21. Lithostratigraphical section (not to scale) of the trangressive Gosau Group (Turonian) in the western part of the Gams area (after SUMMESBERGER & KENNEDY, 1996).

Chronostratigraphy	Biostratigraphy NW Germany	Inoceramid assemblage zones	IZ
EARLY MAASTRICHTIAN	*Lanceolata* Zone		
LATE CAMPANIAN	*Grimmensis/Granulosus* Zone		
	Langei Zone		
	Polyplocum Zone	*Cat. haldemensis* Zone	33
	Vulgaris Zone	Unnamed Zone	
	Basiplana/Spiniger Zone	*Cat. vorhelmensis* Z. - *Inoc. agdjakendsis* Z.	32
	Conica/Mucronata Zone	*Cat. beckumensis* Zone	31
EARLY CAMPANIAN	*Gracilis/Mucronata* Zone	*Sph. sarumensis* Zone - *Cat. dariensis* Zone	30
	Conica/Gracilis Zone		
	Papillosa Zone		
	Senonensis Zone		
	Pilula/Senonensis Zone	*Sphe. patootensiformis* Zone	29
	Pilula Zone		
	Lingua/Quadrata Zone		
	Granulataquadrata Zone		
LATE SANTONIAN	*Marsupites/Granulata* Zone		



Biostratigraphical range of the sites Krimpenbach, Wentneralm I and Wentneralm II on the NW German biostratigraphical zonal scheme including the Subhercynian Cretaceous and the Münsterland Basin according to CHRISTENSEN (1988, 1997), ERNST (1964, 1970 b, 1972, 1974), PETRASCHECK (1906), RIEDEL (1931), SCHULZ & SCHMID (1983), SCHULZ (1979), ULBRICH (1971) and unpublished data.

Sphe - *Sphenoceramus*
Sph. - *Sphaeroceramus*
Cat. - *Cataceramus*

Inoceramid zones after WALASZCZYK (1997), IZ Inoceramid zones after TRÖGER (1989), TRÖGER et al. (this volume).

Fig. 22. Biostratigraphical range (Santonian/Campanian) of the Krimpenbach Formation in the Eastern part of the Gams area (Wenteneralm I, II and Krimpenbach) based on inoceramids (after TRÖGER, in: SUMMESBERGER et al. 1999).

STOP 3.1 Lower Gosau Subgroup along the Akogl forest road

Topic: Basal sediments of the Gosau Group of the Gams area, red conglomerates and coal-bearing clay and shales, marine mollusks, jet.
Lithostratigraphic unit: Kreuzgraben Formation, Schönleiten Fm. (lower Gosau Subgroup)
Age: Late Turonian
Tectonic unit: Untersberg nappe / Göller nappe (Tirolicum), NCA
Location: first bend of forest road to Akogl E of Gams (Styria)

Along the Akogl forest road several outcrops are situated within the basal strata of the Gosau Group of Gams. At the first bend, along a young strike-slip fault, red conglomerates of the Kreuzgraben Formation are overlain by a coal-bearing succession of clay and sandstone (Schönleiten Fm.). Nannofossils from the clays are moderately rich. The nannofossil marker *Marthasterites furcatus*, whose first occurrence marks the base of zone CC13, is present in every samples taken so far from the base of the Gams section. The first occurrence of *M. furcatus* in low latitude sections defines a level in or below the uppermost standard ammonite zone of the Late Turonian (*neptuni*-Zone). Therefore a middle? to late Late Turonian age is suggested for the base of the marine transgression in the Gams area. The Lower Gosau Group of Gams was extensively mined in the past for coal (19th cent.) and jet (15th – 16th cent.).

Solitary corals

Otostoma sp.
Neritoptyx goldfussi (MUENSTER)
Turritella rigida (SOWERBY)
Cassiope suffarcinata (MUENSTER)
Gymnentome giebeli (ZEKELI)
Megalonoda reussi (HOERNES)
Pirenella muensteri (KEFERSTEIN)
Echinobathra cf. *debile* (ZEKELI)
Echinobathra gosauense (STOLICZKA)
Potamides sp.
Pseudamaura brevissima (REUSS)
Pictavia acuminata (REUSS)
Fasciolariide
Mitride

Brachidontes sp.
Phelopteria sp.
Pseudamussium exilis (REUSS)
Cardium sp.
"Astarte " sp.
Ostreid, indet.

Fish:
Coelodus plethodon ARAMBOURG & JOLEAUD

Tab. 4. Mollusk fauna of the Schönleiten Fm. (after KOLLMANN; In: KOLLMANN & SACHSENHOFER 1998; the fish after SCHULZ & PAUNOVIC, 1997)

Remark: There will be the possibility for visiting the new Geological Museum of the area (GeoZentrum Gams) during the lunch break.

Optional stop.

Depending on time and weather conditions a prepared collecting site (FRITZ & KOLLMANN 2000) higher up the forest road will be visited. The fauna is dominated by gastropods and pectinaceans.

STOP 3.2 W of the Noth gorge

Topic: rudist reef, serpentinitic sandstones, *Trochacteon* sandstones
Lithostratigraphic unit: "Noth Formation" (lower Gosau Subgroup)
Age: Late Turonian
Tectonic unit: Untersberg nappe /Göller nappe (Tirolicum), NCA
Location: roadside and riverbed outcrops W of the Noth gorge E of Gams (Styria); protected site!

Serpentinitic sandstones are a conspicous feature of this outcrop. Modal analysis indicates that serpentinitic grains make up more than 50 percent of particles. Chrome spinel is the predominating heavy mineral. Although no present-day local source for the serpentinitic grains is known, serpentinized ophiolitic bodies, which were interpreted as remnants of a Tethys (Hallstatt-Meliata) suture, must have been present within the NCA during the Cretaceous (e.g. WAGREICH, 1993b; POBER & FAUPL, 1988).

The Pitzengraben outcrop shows the development of rudist formations on a wave-dominated, mixed siliciclastic-carbonate shelf. The basal part of the section which is not shown in the sections consists of arenites with layers of paralic coal. One of these layers is exposed at the mouth of an abandoned coal mine.

The section A which begins above the coal. Hybrid arenites with small benthic foraminifers and accumulations of *Trochacateon lamarcki* (SOWERBY) are sharply overlain by a biostrome. In its lower part it is composed of densely packed hippuritids (*Vaccinites* cf. *sulcatus*). The upper part consists of an open to packed parautochthonous fabric of radiolotids and subordinate hippuritids. Lenses of floatstone composed of fragments from the radial funnel plates of radiolitids recognizable by their zig-zag pattern are intercalated. In the topmost part of the biostrome, the wackestone- to floatstone-matrix contains a few percent of siliciclastic sand and is mottled with burrows that are filled with sandstone. The biostrome is overlain by sandstone.
The higher part of the section (B) shows a monospecific thicket of *Hippurites requieni* MATHERON in hybrid arenites with abundant *Quinqueloculina* and *Cuneolina*. The thicket is overlain by burrow-mottled sandy limestone with toppled *H. requieni* and *Radiolites*. Above follows a bioturbated, open parautochthonous biostrome of radiolitids. At the top, the biostrome grades into an interval of organic-rich, marly wackestones with miliolids, *Cuneolina*, ostracods and coalified plant fragments.
To save this outcrop it is protected by nature conservation law since 1998. Any kind of alteration is prohibited.

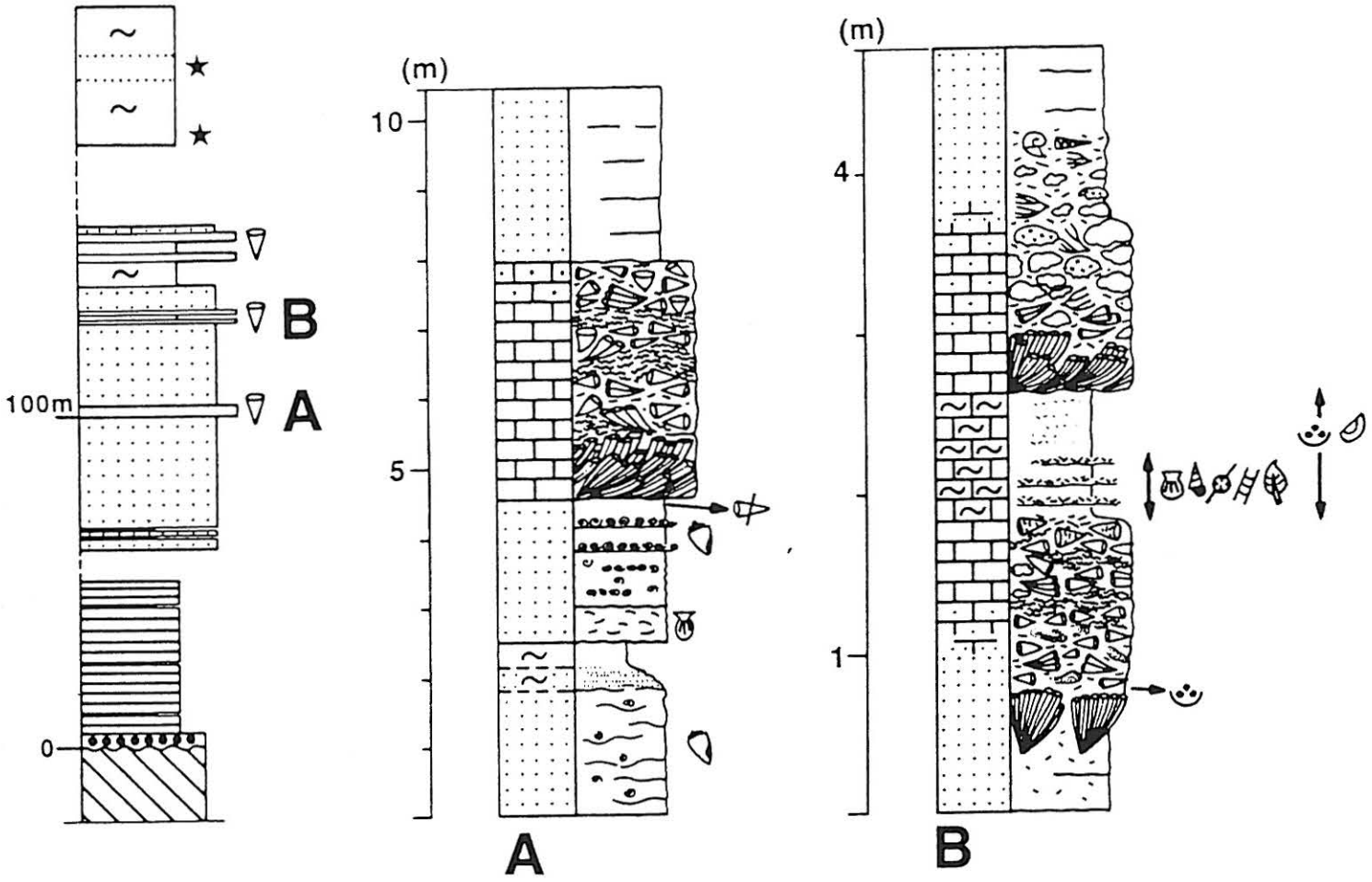


Fig. 23: Rudist formations in mixed siliciclastic-carbonate environments, Pitzengraben, Gams (SANDERS & PONS 1999).

STOP 3.3 Outcrops at the northern Radstatt road

Topic: *Didymotis*, Turonian-Coniacian boundary section
Lithostratigraphic unit: Grabenbach Formation (lower Gosau Subgroup)
Age: Turonian-Coniacian boundary
Tectonic unit: Untersberg nappe / Göller nappe (Tirolicum), NCA
Location: Outcrops at a local road near Radstatt SW of Gams (Styria)

The Radstatt section within the lower part of the Grabenbach Formation yielded a macrofauna characteristic of the Turonian-Coniacian boundary interval (KOLLMANN & SUMMESBERGER, 1982; SUMMESBERGER, 1985; SUMMESBERGER & KENNEDY, 1996). The bivalve *Didymotis costata* was found together with the ammonite *Barroisiceras haberfellneri*. The occurrence of *Didymotis* is regarded as a marker for the base of the Early Coniacian in accordance with the definition of the Coniacian at the *Didymotis* event II in European key sections of Germany (e.g. WOOD et al., 1984) and Bohemia (CECH, 1989).

Gaudryceras sp. indet., group of *mite* (HAUER)
Pseudophyllites postremus (REDTENBACHER)
Tetragonitidae gen. et sp. indet.
Lewesiceras cf. *mantelli* WRIGHT & WRIGHT
Barroisiceras haberfellneri (HAUER)
Reesidites minimus (HAYASAKA & FUKUDA)
Tridenticeras binodosum (HAUER)
Neocrioceras (Schlueterella) sp.
? Nostoceratidae gen. et sp. indet.
Baculites cf. *undulatus* D'ORBIGNY
Baculites sp. indet.
Scaphites sp. indet.

Bivalve:Didymotis costata (FRIC)

Tab. 5. Ammonite fauna from the Radstatt site, type locality of *Pseudophyllites postremus* (REDTENBACHER), *Barroisiceras haberfellneri* (HAUER) and *Tridenticeras binodosum* (HAUER) (after SUMMESBERGER & KENNEDY, 1996).

Co-occurrence of *Barroisiceras haberfellneri* (HAUER) and *Reesidites minimus* (HAYASAKA & FUKUDA) endorses the stratigraphic position in the highset Turonian as *Reesidites minimus* indicates the highest Turonian zone in Japan.

Microfauna:

The lower part of the section is characterized by the presence of Marginotruncana taxa of the *coronota-pseudolinneiana*-group, the *sigali-renzi*-group, rare *Marginotruncana schneegansi* and the absence of both *Helvetoglobotruncana helvetica* and *Dicarinella primitiva*. This indicates the *Marginotruncana sigali*-zone of the zonation by CARON (1985) and the *Marginotruncana schneegansi*-zone of WEIDICH (1984), which covers the Late Turonian.

The *Didymotis*-bearing horizon at the Radstatt section (section C) is within zone CC13 (*Marthasterites furcatus*-zone). Up to this level *M. furcatus* is accompanied by common *Quadrum gartneri*, thus dividing zone CC13 into a lower part with frequent *Qu. gartneri* and a higher part without this species. This corroborates the results from the Gosau section of Strobl/Weißenbach, where *Qu. gartneri* becomes also very rare to absent in the Early Coniacian (WAGREICH, 1992). In the middle part of the Grabenbach Formation *Micula* cf. *decussata* occurs. Generally, the first occurrence of *Micula decussata* is reported worldwide from the "middle" Coniacian (e.g. SISSINGH, 1977; PERCH-NIELSEN, 1985; BURNETT, 1998).

From Gams we turn back to the Enns valley, following the valley to the north through the NCA up to Großraming.

STOP 3.4 Pechgraben, Höllleiten Graben

Topic: mid-Cretaceous black shales with *Leymeriella tardefurcata*
Lithostratigraphic unit: Tannheim Formation
Age: Early Albian
Tectonic unit: Losenstein syncline of the Ternberg nappe (Lower Bajuvaricum), NCA
Location: Pechgraben near Großraming, Höllleitengraben, first bend of the forest road above the Lehner Alm

During the Cretaceous, piggyback basins evolved in front of north to northwestward propagating thrusts of the NCA, such as the Tannheim-Losenstein basin during Late Aptian to Early Cenomanian times. Deposits of the Tannheim-Losenstein basin are confined to the northernmost tectonic units of the NCA, the Frankenfels-Ternberg-Allgäu nappe system (Fig. 1 and 2), now forming faulted and partly overturned, narrow synclines (see EGGER, 1988, ZIMMER & WESSELY, 1996). Within these units Lower Cretaceous limestones of the Schrambach Formation ("Aptychus limestones") and shales are overlain by 10 to 30 meters of marlstones and calcareous shales of the Tannheim Formation (ZACHER 1966, GAUPP 1982) followed by a 100 - 350 m thick coarsening-upward cycle of the Losenstein Formation (KOLLMANN, 1968, KENNEDY & KOLLMANN, 1979, IMMEL, 1987; WEIDICH 1990).

In the Losenstein syncline (EGGER 1988) a dark gray to black shaly interval of about 2 m in thickness occurs within the Tannheim Fm., 8 m above the transition from mottled limestones of the Schrambach Formation to marlstones of the Tannheim Formation. Ammonites indicate an Early Albian age for the dark gray marlstones. The association of the index species *Leymeriella tardefurcata*, *Leymeriella pseudoregularis* and *Beudanticeras* sp. can be referred to the highest *L. regularis* Subzone of the Lower Albian *L. tardefurcata* Zone (KENNEDY & KOLLMANN, 1979; IMMEL, 1987). Early Albian age (*Hedbergella planispira*-Zone) is corroborated by planktonic foraminifera (WEIDICH 1990).

The fabric of the dark grey shales is laminated, partly destroyed by bioturbation (mostly small *Chondrites*-type burrows, rare *Planolites*-tubes). Pyrite is present finely disseminated throughout beds. The calcium carbonate content varies between 17 and 49 % (Fig. 3). Grain size analyses indicate fine silt- to mudstones. The average TOC-content of the marlstones of the Tannheim Formation is about 0.5 %. If calculated on a carbonate free base, TOC values are between 0.4 and 3.7 % (Fig. 4). Petrological investigations show that the organic matter is dominated by vitrinite and inertinite. Recycled vitrinite occurs frequently. Lamalginite dominates among the liptinite macerals. The content in vitrinite and inertinite are uniformly distributed, whereas the content of marine lamalginit varies significantly and is strongly correlated with increased TOC-values. RockEval analysis indicates increasing Hydrogen Index (HI) values with increasing contents in organic matter and indicate kerogen type II and III (Figs. 3 and 5). Mean random vitrinite reflectance Rr ranges from 0.5 to 0.7 % Rr. RockEval parameter Tmax values (418 - 432°C; Fig. 5) and production index values below 0.1 indicate maturation levels below the oil-window.

The marlstones and calcareous shales of the Tannheim Formation can be classified as hemipelagites, being a mixture of an autochthonous biogenic carbonate fraction, mainly planktonic foraminifera and calcareous nannoplankton, a terrigenous siliciclastic fine silt and clay fraction, and organic carbon. Bathyal depositional depth of at least a few hundred meters can be estimated (WEIDICH, 1990) based on the high content of planktonic foraminifera and the lack of shallow water foraminifera. The oxygen biofacies can be classified as mainly dysaerobic based on the presence of significant bioturbation and foraminiferal assemblages containing benthic groups. Lower Albian shales show an increase in the TOC-content compared to the underlying limestones of the Schrambach Formation and the overlying silty marlstones of the Losenstein Formation. This increase in organic carbon seems to be related to a global event (OAE 1b). Detrital input of organic matter (vitrinite, inertinite) seems to be largely constant throughout the investigated section, whereas the marine production (lamalginite) varies cyclically, resulting in organic carbon-peaks above an elevated TOC background. A weak positive correlation of TOC-values and carbonate contents suggests that the production and preservation of organic matter was at least partly coupled with the production of planktonic carbonate [after WAGREICH & SACHSENHOFER, 1999]

STOP 3.5 Höllleitengraben, Losenstein Formation

Topic: synorogenic sandstones of the Losenstein Fm.
Lithostratigraphic unit: Losenstein Formation
Age: Late Albian/Early Cenomanian
Tectonic unit: Losenstein syncline of the Ternberg nappe (Lower Bajuvaricum), NCA
Location: Pechgraben near Großraming, Höllleitengraben at Lehner Alm

The Tannheim Fm. is overlain by a 100 to 350 m thick coarsening-upward megacycle of the Losenstein Formation (Lower/Middle Albian - lowermost Cenomanian. KOLLMANN, 1968; WEIDICH, 1990), comprising turbidites, deep-water conglomerates and slump horizons. In the lower part of the Losenstein Formation, thin sandy turbidites and laminated siltstone-shale intervals prevail. Sandstone beds are up to 30 cm thick and show grading and both complete and partly incomplete Bouma-cycles. The amount of conglomeratic layers increases upsection. Both normal and inversly graded clast-supported conglomerates and matrix-supported pebbly mudstones and pebbly sandstone are found in 5 to 15 m thick intervals without any coarsening or fining upward trends within the sandstones. Overall, the thickness of pebbly mudstones and slump intervals increases in the upper part of the Losenstein Formation. Slump intervals comprise folded beds of laminated siltstone-shale intervals with only minor sandstone intercalations. The uppermost preserved facies type includes thick slump intervals and a 7 m thick conglomerate with boulders up to 1.20 m in diameter.

KOLLMANN, 1976, 1978, 1979, 1982 b, has described a gastropod fauna of 93 taxa from the Losenstein formation, the majority of them from the visited outcrop. It contains acteonids, ringiculids, acteonellids, nerineaceans, turritellids, fusinids, cancellariids, turritellids, cerithiids, aporrhaids and diverse archaeogastropods. Orbitolinids, Serpulids and Bivalves (*Glycimerites, Idonearca*) are abundant but have not yet been described. Hermatypic corals are rare.

An ammonite fragment from the same locality has been determined as *Puzosia* cf. *lata* SEITZ by KENNEDY, COOPER & KOLLMANN, 1977 and suggests Upper Albian.

STOP 3.6 Leopold von Buch Memorial

Topic 1: large granitic to granodioritic block within marly matrix
Depositional Age: Paleogene

Topic 2: red shales
Lithostratigraphic unit: Campanian; "Buntmergelserie"
Tectonic Unit: Ultraheleveticum of the Gresten Klippen belt;

A small outcrop at the parking area shows red shales of the "Buntmergelserie", containing globotruncanids (e.g. rare *Globotruncanita elevata*) and a poor nannoflora consisting primarely of solution-resistantant taxa (e.g. *Micula decussata, Lucianorhabdus cayeuxii*).

The Leopold von Buch - Memorial comprises a large granitic to granodioritic block within Paleogene variegated shales ("Buntmergelserie") of the Gresten Klippen Belt (Ultrahelveticum). It is interpreted (WIDDER 1986) as a submarine block slide - canyon fill of Eocene age.

We follow the Ybbs valley to the highway A1 to Vienna and turn southward along the eastern margin of the Eastern Alps to highway A21 and A2 up to Wöllersdorf/Piesting.

Monday, September 4th

Cretaceous of the Northern Calcareous Alps near Vienna

STOP 4.1 Piesting sports area (Sportplatz)

The Gosau Group of the Grünbach - Neue Welt - Piesting area forms a continous Upper Cretaceous - Paleogene belt south of Vienna. Whereas the existence of an overturned syncline is clear in the western part of the area (Grünbach) the structure in the eastern part (Piesting) is more complicated and hardly resolved due to poor outcrop conditions. Strike-slip faulting, e.g. along the E-W trending Piesting valley may have contributed to the complex structural situation.
At the southern flank of the Piesting valley, a section can be reconstructed, beginning with brachiopod and rudist limestones (probably Upper Santonian according to Sr86/Sr87 data), transgressively resting upon triasic Dachsteinkalk Fm. It is overlain by the the coal-bearing "Grünbach Fm." (Lower Campanian). The Upper Campanian - Maastrichtian sandy/silty shales of the "Piesting Formation" ("Inoceramenschichten" of authors) are exposed along the roadside.

The outcrop at the Piesting sports area provides the best exposure of the formation. The environment of deposition is interpreted as the distal part of a submarine fan with the proximal part and a presumed delta area probably situated in the southwest. The sequence of thin-bedded sand/siltsones is throughout bioturbated by an unknown creator grazing on the sea-bottom. Macrofossils are generally rare with the exception of inoceramids and trace fossils. The inoceramid fauna is rich in individuals, most of them broken and hardly to be collected. The Lower Maastrichtian age is endorsed by a few specimens of the Lower to Middle Maastrichtian ammonite *Pachydiscus (P.) neubergicus* (HAUER).

Trochoceramus cf. *dobrovi* PAVLOVA
Trochoceramus cf. *tenuiplicatus* (TZANKOV)
Trochoceramus cf. *monticuli* (FUGGER & KASTNER)
Trochoceramus sp. aff. *zitteli* (KOCJUBINSKY non PETRASCHECK)
Spyridoceramus cf. *tegulatus* JOLKICEV
Inoceramus salisburgensis (FUGGER & KASTNER)
Inoceramus borilensis JOLKICEV

Tab. 6. Incoceramids of the sports area of Piesting, Lower Austria (K.-A. TRÖGER, unpublished):

The nannofossils assemblages from the sports area of Piesting show poor preservation and low abundances. Marker species include *Lucianorhabdus cayeuxii, Micula decussata, Arkhangelskiella cymbiformis, Ceratolithoides aculeus, Lithraphidites* cf. *praequadratus, Quadrum* sp. This indicates most probably standard zone CC24 within the Early Maastrichtian.

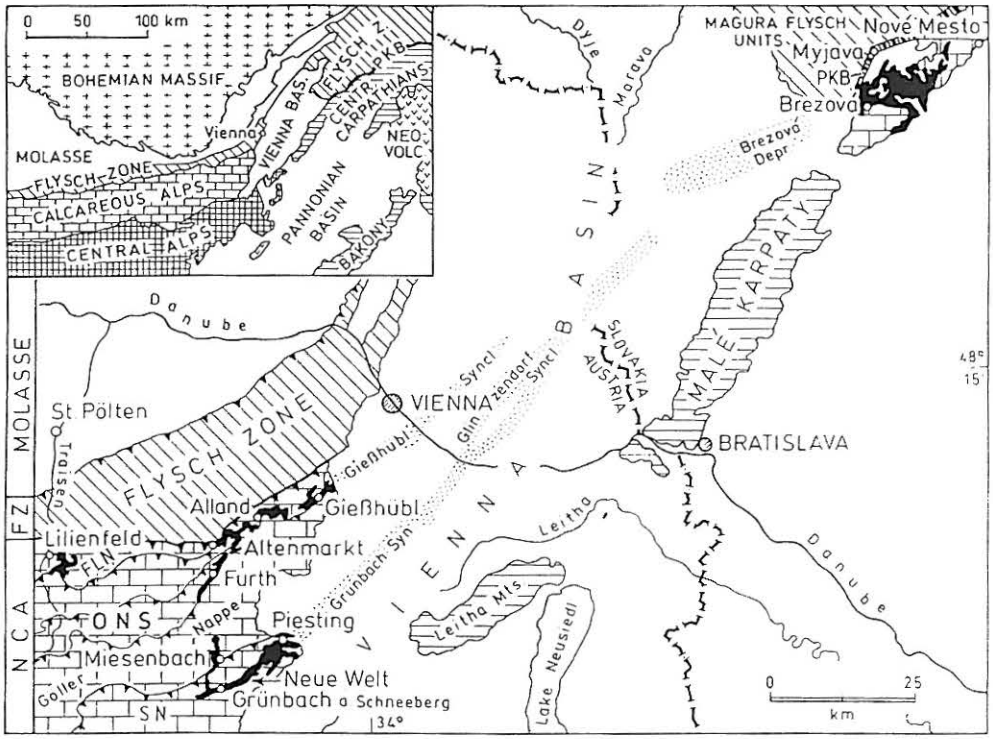


Fig.23. Extension of the Grünbach Neue Welt basin across the Neogene Vienna basin (After WAGREICH & MARSCHALKO 1995).

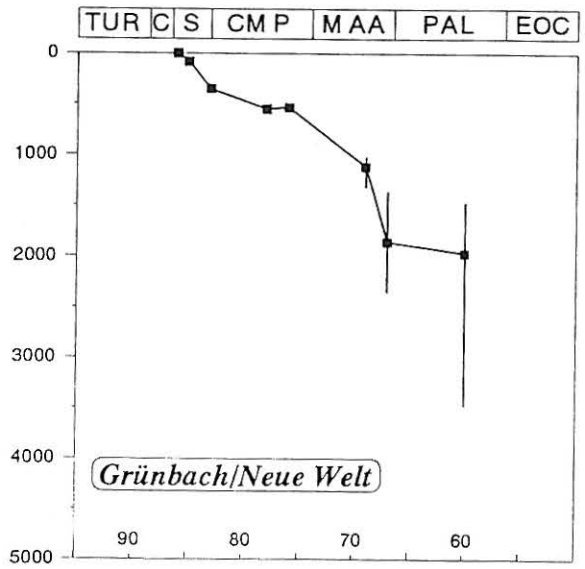


Fig.24. Acceleration of the subsidence rates in the Late Cretaceous (After WAGREICH & MARSCHALKO, 1995)

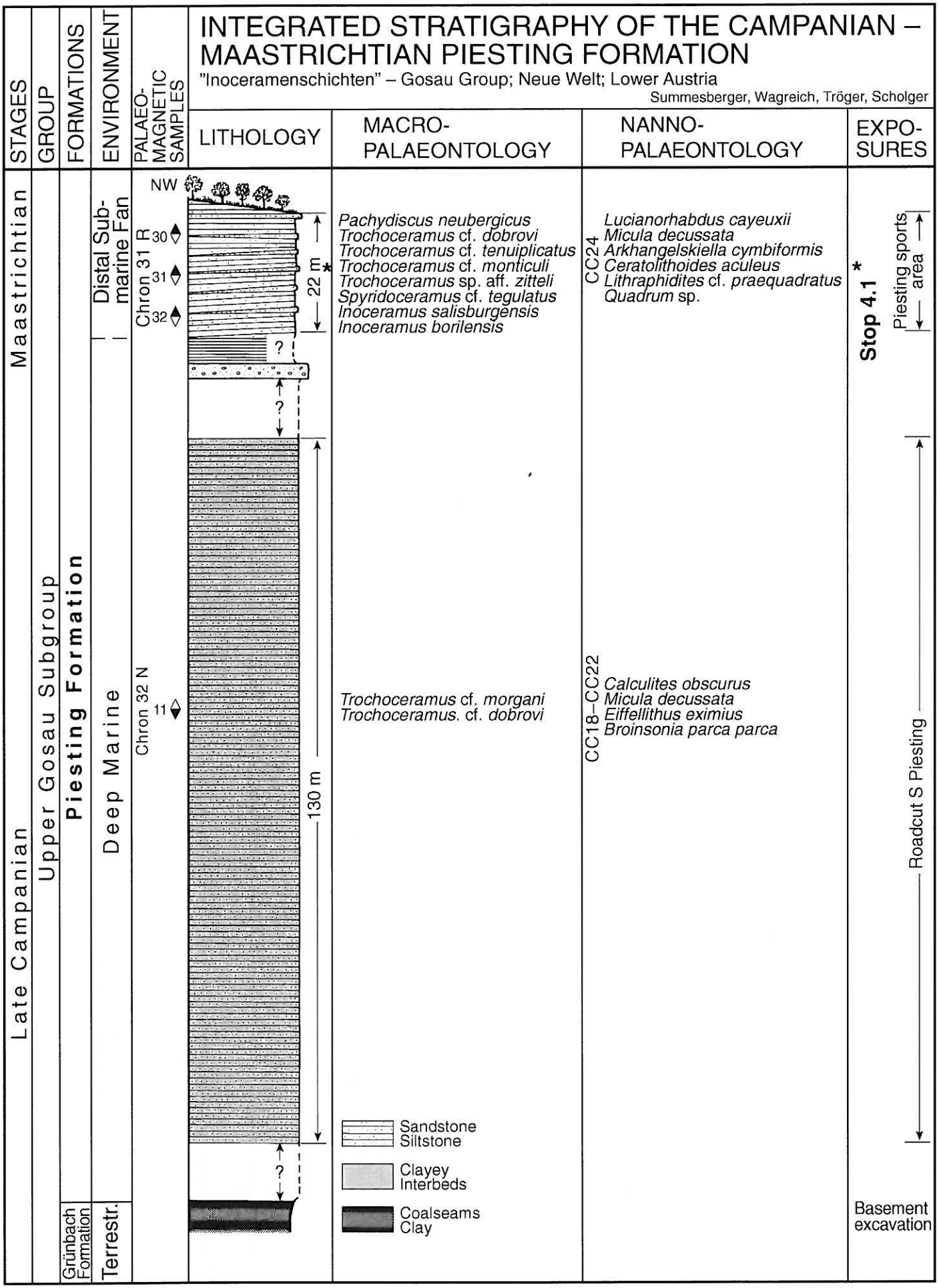


Fig. 25. Compiled measured sections (Summesberger) of the "Piesting Formation" ("Inoceramenschichten", "Inoceramus beds" of authors) of the Neue Welt basin, sports area, roadcut Piesting, basement excavations; Piesting, Lower Austria)

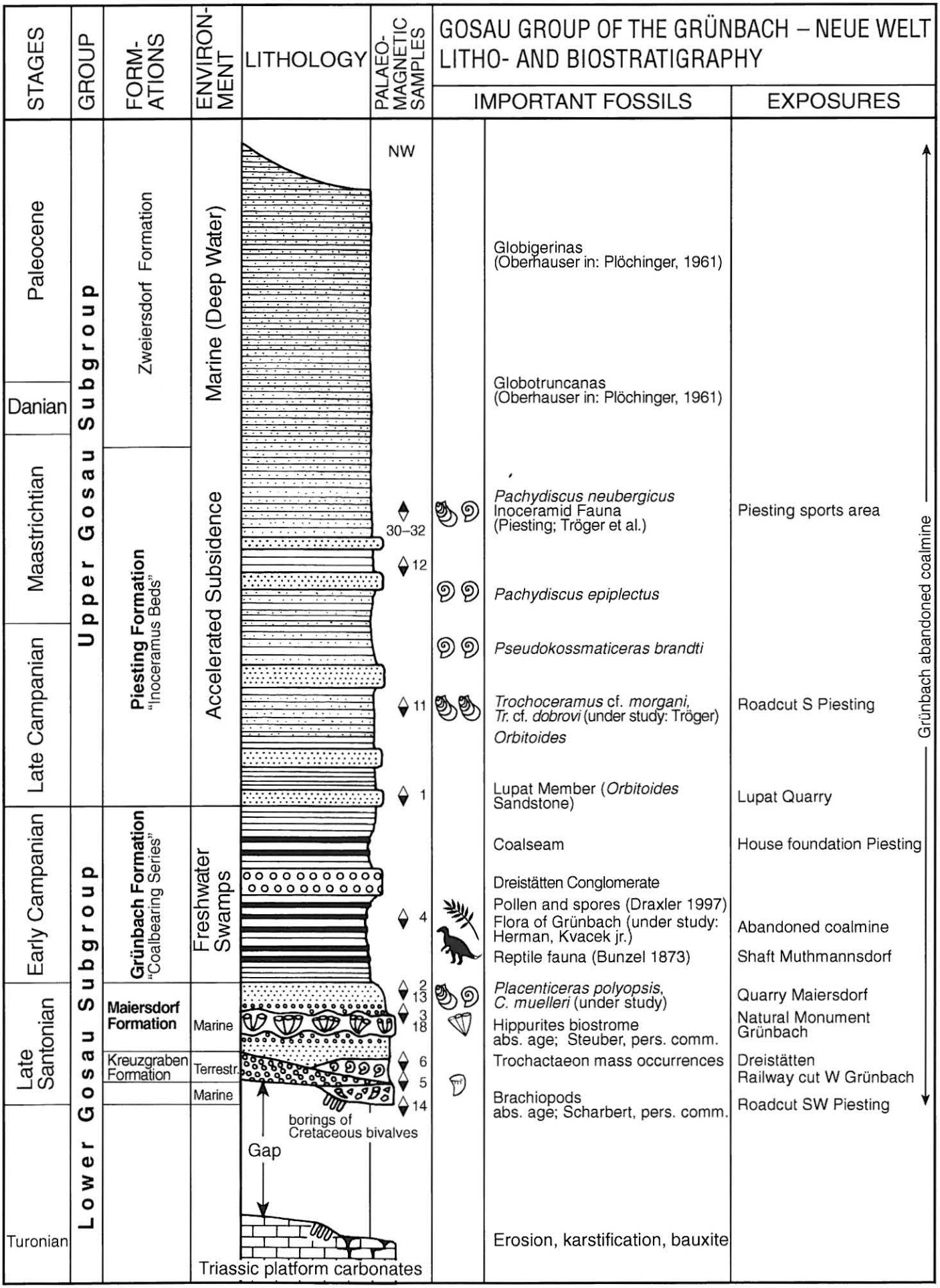


Fig. 26. Section of the Gosau Group in the Grünbach – Neue Welt basin tentatively compiled (with alterations after Summesberger, in Piller et al.(1997)

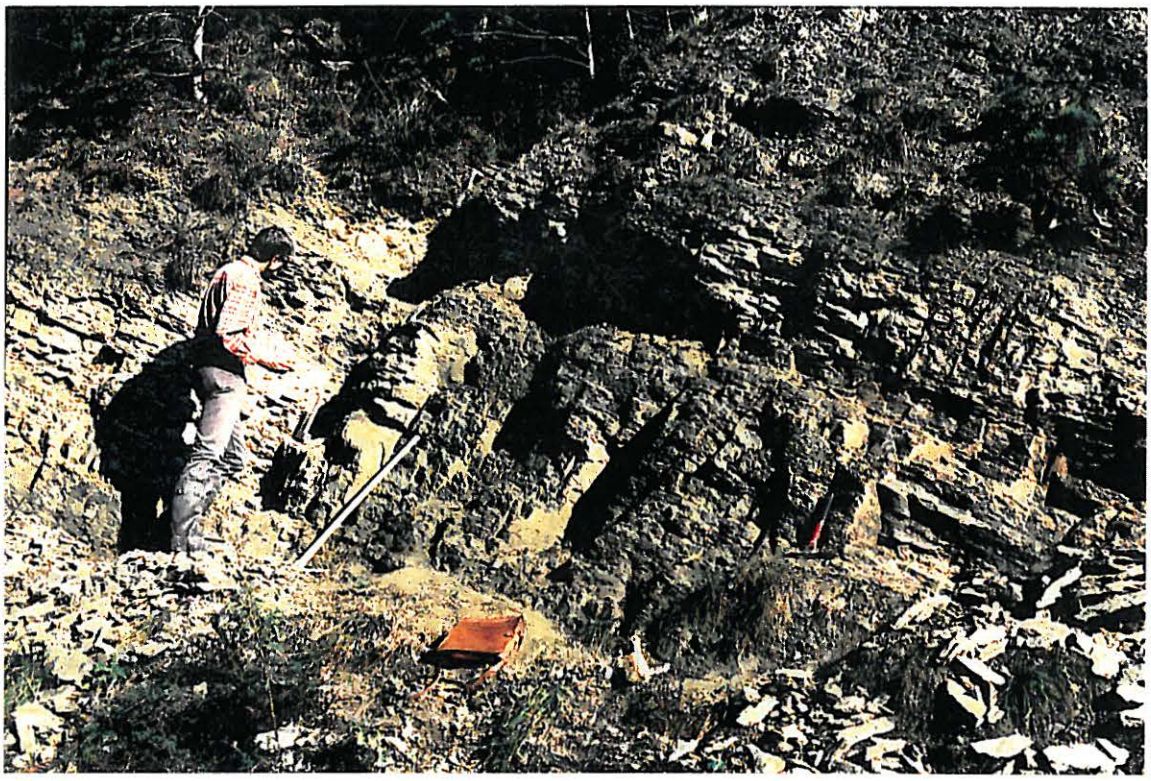


Fig. 27. Exposure of the Maastrichtian part of the "Piesting Formation" (Gosau Group, formerly („Inoceramenschichten") at the the sports area of Piesting (Lower Austria)

STOP 4.2 Quarry "Flösselberg", Kaltenleutgeben

Alexander Lukeneder

Topic: Lower Cretaceous ammonites
Lithostratigraphic unit: Schrambach Formation, Rossfeld Formation
Age: Late Valanginian - Late Hauterivian
Tectonic unit: Flössel syncline, Lunz Nappe, NCA
Location: abandoned quarry "Flösselberg" at Kaltenleutgeben in the Wienerwald W of Vienna

The excursion site is an abandoned quarry at the Flösselberg near Kaltenleutgeben. It is situated in the Lunz Nappe, one of the northern tectonic units of the Northern Calcareous Alps (NCA). The general tectonic style is that of steep synclines and anticlines (e.g. Höllenstein anticline, Flössel syncline). The Flössel syncline is formed of Late Triassic dolomite, followed by a reduced jurassic sequence. The core of the Flössel syncline consists of the Early Cretaceous Schrambach Formation (U.-Valanginian - Barremian) which was deposited in a passive margin setting.

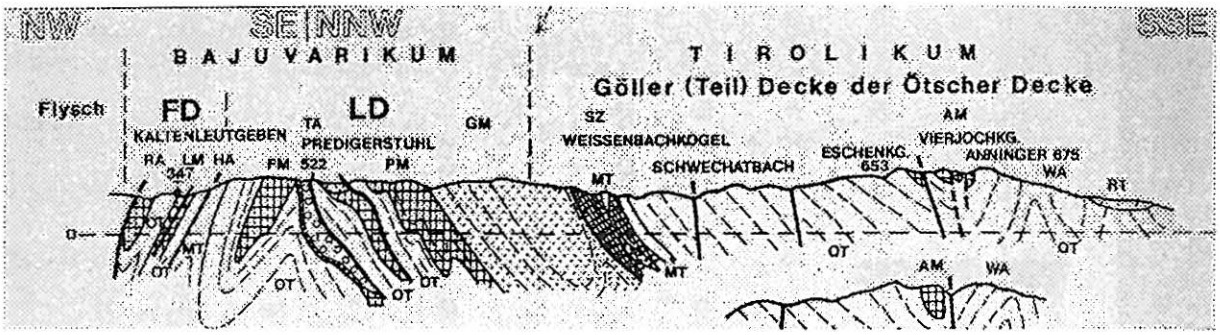


Fig.28. Cross section through the northern units of the Northern Calcareous Alps near Vienna (PLÖCHINGER 1991)
FD= Frankenfels Nappe, LD= Lunz Nappe, FM= Flössel Syncline

The Lower Cretaceous Schrambach Formation is a sequence of deepwater limestones and marls with intercalations of thin turbiditic sandstone layers. Dark marls and grey spotted limestones can be classifiedas highly bioturbated biomicritic mudstones to wackestones. Occurrence of chrome spinel supports the correlation with the turbiditic intercálations in the Schrambach Formation of the Reichraming Nappe (Upper Austria), a western equivalent of the Lunz Nappe.

The Schrambach Formation has been exploited extensively for many years for cement production. Therefore the name "Zementmergel" which has now been abandoned was used in the older literature for the Schrambach Fm. The basal part of the sequence differs by more numerous sandy intercalations and has now been differentiated as Rossfeld Fm (Geol. Map 1: 50.000, sheet 58 Baden). A part information about the ammonite fauna of the Flösselberg exposures goes back to SCHWINGHAMMER's (1975) attempt of bed by bed collecting.

Ammonite fauna

The ammonite fauna of the Flösselberg quarry comprises 21 taxa exclusively representatives of the Mediterranean province. The preservation of the ammonites without a calcareous shell indicates deposition below the aragonite compensation depth.

Partschiceras winkleri (D`ORBIGNY)
Partschiceras infundibulum (D`ORBIGNY)
Oosterella ex gr. *Gaudryi* (NICKLES)
Oosterella kittli (RICHARZ)
Haploceras sp.
Olcostephanus (Olcostephanus) astierianus (D`ORBIGNY)
Olcostephanus (Olcostephanus) sayni (KILIAN)
Olcostephanus (Jeannoticeras) jeannoti (D`ORBIGNY)
Olcostephanus sp.
Spitidiscus cf. *meneghinii* (ZIGNOIN & RODIGHIERO)
Neocomites (Teschenites) neocomiensiformis (HOHENEGGER)
Neocomites (Teschenites) sp.
Phylloceras (Hypophylloceras) sp.
Phylloceras sp.
Himantoceras trinodosum (THIEULOY)
Himantoceras sp.
Crioceratites (Crioceratites) cf. *quenstedti* (OOSTER)
Crioceratites (Crioceratites) majoricensis (NOLAN)
Crioceratites (Pseudothurmania) mortilleti (PICTET & LORIOL)

Bochianites neocomiensis (D`ORBIGNY)
Bochianites oosteri (SARASIN & SCHÖNDLMAYR)

Lamellaptychus seranonis seranonis (COQUAND)

Trace Fossils:

Zoophycos
Chondrites

Microfossils (after VASICEK et al., 1994):

Cadosina semiradiata olzae (NOWAK)
Cadosina semiradiata semiradiata (WANNER)
Cadosina semiradiata cieszynica (NOWAK)
Cadosina fusca fusca (WANNER)
Cadosinopsis nowaki (BORZA)
Amphorellina sp.
Didemnoides moreti (DURAND & DELGA)
Colomisphaera vogleri (BORZA)
Carpistomiosphaera valanginiana (BORZA)
Stomiosphaera echinata (NOWAK)
Stomiosphaera wanneri (BORZA)
Tintinnopsella carpathica (MURGEANU & FILIPESCU)
Nannoconus sp.

Tab.7. Faunal list compiled from SCHWINGHAMMER (1975), IMMEL (1987), VASICEK et al. (1994) and the author's recent collections.

Himantoceras trinodosum refers to the Upper Valanginian, *-trinodosum* zone, *Olcosteophanus (O.) astierianus* and *Olcostephanus (O.) sayni* are mainly Upper Valanginian forms.
Spitidiscus meneghinii and *Olcostephanus (J.) jeannoti* are representatives of the Hauterivian. The latter is the index fossil of the higher Lower Hauterivian, *-jeannoti* zone.
SCHWINGHAMMER (1975) and IMMEL (1987) still considered the Lower Cretaceous of the Flössel syncline to range from the Upper Valanginian to the Lower Barremian. This conclusion required *Crioceratites (P.) mortilleti* to be a representative of the Lower Barremian. More recently HOEDEMAEKER, COMPANY et al. (1993), regarded *Crioceratites (P.) mortilleti* as an Upper Hauterivian species (see VASICEK et al. 1994). The fossil list presented above, yields a stratigraphic framework of the excursion site from the Upper Valanginian up to the Upper Hauterivian. Ammonites limited to the Barremian are absent although some of the species mentioned by SCHWINGHAMMER (1975) occur also in the Barremian (VASICEK et al., 1994).

Fig. 29. Stratigraphical range of the Schrambach Formation in the Flössel syncline after GRÜN & BLAU (1997; with alterations).

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References

BODROGI, I., DRAXLER, I. FOGARASI, A., FILACZ, E., KNAUER, J. & LOBITZER, H., with contributions by STRADNER, H., EGGER, H., SURENIAN, R., SACHSENHOFER, R. F. & KLEIN, P. (1999): Die Mikrofauna und –

flora ausgewählter (hemi)pelagischer Oberjura/Unterkreide-Schichtfolgen der Salzburger Kalkalpen sowie ein Vergleich mit der Unterkreide des Gerecse-Gebirges in Ungarn. – Unpublished manuscript, 40 p.

BÖHM, F., EBLI, O. & LOBITZER, H., with contributions by BODROGI, I., DRAXLER, I., FILACZ, E., HRADECKÁ L. & VAŠIČEK, Z. (1997): Jurassic and Cretaceous of the Northern Calcareous Alps south of Salzburg. – In: EGGER, H., LOBITZER, H., POLESNY, H. & WAGNER, L. R.: Cross Section through the Oil and Gas-Bearing Molasse Basin into the Alpine Units in the Area of Salzburg, Austria-Bavaria. – AAPG Internat. Conf. & Exhibition, Sept. 7-10, 1997, 5-67.

BOOROVÁ, D., LOBITZER, H., SKUPIEN, P. & VAŠIČEK, Z. (1999): Biostratigraphy and Facies of Upper Jurassic-Lower Cretaceous pelagic carbonate sediments (Oberalm-, Schrambach- and Roßfeld-Formation) in the Northern Calcareous Alps, South of Salzburg. – Abh. Geol. Bundesanst., 56/2, 273-318.

BRIX, F. & PLÖCHINGER, B. (1988): Erläuterungen zu Blatt 76 Wiener Neustadt. - 85 p. (Geol. Bundesanst.).

BURNETT, J. (1998): Upper Cretaceous. - In: BOWN, P.R. (Ed.): Calcareous Nannofossil Biostratigraphy, 132-199, Cambridge (Chapman & Hall).

CARON, M. (1985): Cretaceous planktic Foraminifera. - In: BOLLI, H.M., SAUNDERS, J.B. & PERCH-NIELSEN, K. (Hrsg.): Plankton Stratigraphy, 329-426, Cambridge (Cambridge Univ. Press).

CECH, S. (1989): Upper Cretaceous *Didymotis* events from Bohemia. - In: WIEDMANN, J. (ed.): Cretaceous of the Western Tethys, pp. 657-76 (Proceedings of the 3rd International Cretaceous Symposium Tübingen.)

CHANNELL, J. E. T., BRANDNER, R., SPIELER, A., STONER, J. (1992): Paleomagnetism and paleogeography of the Northern Calcareous Alps (Austria). - Tectonics, 11: 792-810.

CHANNELL, J. E. T, & KOZUR, H. W. (1997): How many oceans? Meliata, Vardar, and Pindos oceans in the Mesozoic Alpine palaeogeography. – Geology, 25: 183-186.

DECKER, K. (1990): Plate tectonics and pelagic facies: Late Jurassic to Early Cretaceous deep-sea sediments of the Ybbsitz ophiolite unit (Eastern Alps, Austria). - Sediment. Geol., 67: 85-99.

DECKER K., FAUPL P. & MÜLLER A. (1987): Synorogenic sedimentation on the Northern Calcareous Alps during the Early Cretaceous. - In: FLÜGEL, H.W. & FAUPL, P. (eds.): Geodynamics of the Eastern Alps, 126-141; Wien (Deuticke).

DECKER, K. & JARNIK, M. (1993): Structural analysis of the Late Cretaceous Gosau Group of Rigaus, Fahrenberg and Nussensee (Northern Calcareous Alps, Salzburg - Upper Austria): Tertiary deformation during lateral extrusion illustrated. - Mitt. Ges. Geol. Bergbaustud. Österr., 38: 93-106.

DECKER, K. & PERESSON, H. (1996): Tertiary kinematics in the Alpine-Carpathian-Pannonian system: links between thrusting, transform faulting and crustal extension. - In: WESSELY, G. & LIEBL, W. (eds.): Oil and gas in Alpidic thrustbelts and basins of central and eastern Europe. EAGE Special Publ. 5: 69-77; Geol. Soc. London.

DECKER, K., PERESSON, H. & FAUPL, P. (1994): Die miozäne Tektonik der Östlichen Kalkalpen: Kinematik, Paläospannungen und Deformationsaufteilung während der „lateralen Extrusion" der Zentralalpen. - Jahrb. geol. Bundesanst., 137: 5-18.

DHONDT, A. (1984): Bivalves from the Hochmoos Formation (Gosau-Group), Oberösterreich, Austria) - Ann. Naturhist. Mus Wien, Ser. A, **88**: 41-102. – Wien.

DRAXLER, I. (1997): Palynological contribution on the Coal-bearing Series of Grünbach. In: PILLER, W.E., SUMMESBERGER, H., DRAXLER, I., HARZHAUSER, M. & MANDIC, O.: Meso- to Cenozoic tropical/subtropical climates – Selected examples from the northern Calcareous Alps. - Second European Palaeontological Congress – Climates: Past, Present and Future – Vienna, 111 pp. - Wien; Excursion guides 1997)

EGGER, H. (1988): Zur Geologie der Kalkvoralpen im östlichen Oberösterreich. - Jahrb. geol. Bundesanst., 131: 245-254.

EGGER, H. (1995): Die Lithostratigraphie der Altlengbach-Formation und der Anthering-Formation im Rhenodanubischen Flysch (Ostalpen, Penninikum). - N. Jb. Geol. Paläont. Abh. 196: 69-91.

EGGER, H., BICHLER, M., DRAXLER, I., HOMAYOUN, M., HUBER, H.-J., KIRCHNER E. CHR., KLEIN, P. & SURENIAN, R. (1997): Mudturbidites, black shales and bentonites from the Paleocene/Eocene boundary: the Anthering Formation of the Rhenodanubian Flysch (Austria). – Jb. Geol. B.-A., 140, 29-45, Wien.

EGGER, H. POLESNY, H. & WAGNER, L.R. (1997). Cretaceous of the Rhenodanubian Flysch and Ultrahelveticum. Core storage display of rocks from the Molasse basement and the Molasse. – IN: Field Trip Notes Vienna '97, AAPG International Conference and Exhibition: 86-104. – Vienna.

EISBACHER, G. & BRANDNER, R. (1995): Role of high-angle faults during heteroaxial contraction, Inntal Thrust Sheet, Northern Calcareous Alps, western Austria. - Geol. Paläont. Mitt. Innsbruck, 20: 389-406.

FAUPL, P. (1978): Faziestypen der paläogenen Buntmergelserie der östlichen Ostalpen. – Mitt. Österr. Geol. Ges., 68: 13-38.

FAUPL, P. (1983): Die Flyschfazies in der Gosau der Weyerer Bögen (Oberkreide, Nördliche Kalkalpen, Osterreich). - Jahrb. geol. Bundesanst., 126: 219-244.

FAUPL, P., CSÁSZÁR, G. & MIŠÍK, M. (1997): Cretaceous and Palaeogene sedimentary evolution in the Eastern Alps, Western Carapathians and the North Pannonian region: An overview. - Acta. Geol. Hung., 40: 273-305.

FAUPL, P. & TOLLMANN, A. (1979): Die Roßfeldschichten: Ein Beispiel für Sedimentation im Bereich einer tektonisch aktiven Tiefseerinne aus der kalkalpinen Unterkreide. – Geol. Rundsch., 68: 93-120.

FAUPL, P. & WAGREICH, M. (1992a): Cretaceous flysch and pelagic sequences of the Eastern Alps: Correlations, heavy minerals, and palaeogeographic implications. - Cret. Research., 13: 387-403.

FAUPL, P. & WAGREICH, M. (1992b). Transgressive Gosau (Coniac) auf Branderfleckschichten (Turon) in den Weyerer Bögen (Nördliche Kalkalpen, Oberösterreich). - Jahrb. geol. Bundesanst., 135: 481-491.

FAUPL, P. & WAGREICH, M. (2000): Late Jurassic to Eocene palaeogeography and geodynamic evolution of the Eastern Alps. - Mitt. Österr. Geol. Ges., 92: 79-94.

FELIX, J. (1908): Studien über die Schichten der oberen Kreideformation in den Alpen und den Mediterrangebieten. II. Teil: Die Kreideschichten von Gosau. Palaeontographica, 54: 251 - 344, 5 textfig., pl. 25-26. Stuttgart

FRAAYE, R.H.B. & SUMMESBERGER, H. (1999): New crustacean records from the Late Campanian of Austria. - Beitr. Paläont. **24**:1-6. - Wien.

FRISCH, W. (1979): Tectonic progradation and plate tectonic evolution of the Alps. - Tectonophysics, 60, 121-139.

FRISCH; W., KUHLEMANN, J., DUNKL, I. & BRÜGEL, A. (1998): Palinspastic reconstruction and topographic evolution of the Eastern Alps during late Tertiary tectonic extrusion. – Tectonophysics, 297: 1-15.

FRITZ, I. & KOLLMANN, H.A. (2000): Fossiliengrabung in Gams bei Hieflau (Obersteiermark), 15. bis 19. Mai 2000. Projektmappe für Schulen. 40 pp.. Graz

FUCHS, R., & WESSELY, G. (1996): The autochthonous Cretaceous at the southern edge of the Bohemian Massif (Austria). - In: WESSELY, G. & LIEBL, W. (eds.): Oil and Gas in Alpidic Thrustbelts and Basins of Central and Eastern Europe, EAGE Spec. Publ., 5: 249-253.

GARRISON, R. & FISCHER, A. G. (1969): Deep-water limestones and radiolarites of the Alpine Jurassic. – In: FRIEDMANN, G. M. (Ed.): Depositional Environments in Carbonate Rocks. A Symposium. – Soc. Econ. Paleont. Mineral. Spec. Publ., 14: 20-56.

GAUPP, R. (1982): Sedimentationsgeschichte und Paläotektonik der kalkalpinen Mittelkreide (Allgäu, Tirol, Vorarlberg). - Zitteliana, 8: 33-72.

GRÜN, B. & BLAU, J. (1997): New aspects of calpionellid biochronology: proposal for a revised calpionellid zonal and subzonal division. - Rev. Paleobiol., 16/1: 197-214.

GÜNTHER, W. (1988): 150 Jahre Leube 1838-1988.- Firma Gebr. Leube, Gartenau, 98p.

HAUBOLD, H., SCHOLGER, R., FRISCH, W., SUMMESBERGER, H & MAURITSCH, H.J. (1999): Reconstruction of the geodynamic evolution of the Northern Calcareous Alps by means of paleomagnetism. - Phys. Chem. Earth (A), 24: 697-703.

HOEDEMAEKER, P. J., COMPANY, M. (Ed.) at al. (1993): Ammonite zonation for the Lower Cretaceous of the Mediterranean region; basis for the stratigraphic correlation within IGCP Project 262. - Rev. Esp. Paleont., 8: 117-120.

HÖFLING, R. (1985): Faziesverteilung und Fossilvergesellschaftungen im karbonatischen Flachwasser-Milieu der alpinen Oberkreide (Gosau-Formation). - Münchner Geowiss. Abh., A 3: 1-206.

HOMAYOUN, M. & FAUPL, P. (1992): Unter- und Mittelkreideflysch der Ybbsitzer Klippenzone (Niederösterreich). – Mitt. Ges. Geol. Bergbaustud. Österr., 38: 1-20.

IMMEL, H: (1987): Die Kreideammoniten der Nördlichen Kalkalpen. - Zitteliana, 15: 3-163.

JAGT, J.W.M. (1999): Late Campanian echinoids and crinoids from the Gschliefgraben (Ultrahelvetic, Austria). - Beitr. Paläont. **24**:7-22. - Wien.

JARNIK, M. (1994): Zur Sedimentologie, Stratigraphie und Tektonik der Gosau von Rigaus/Abtenau (Salzburg/Österreich). - Unpubl. Master Thesis. Univ. Wien, 178 p.

KAISER-WEIDICH, B. & SCHAIRER, G. (1990): Stratigraphische Korrelation von Ammoniten, Calpionellen und Nannoconiden aus Oberjura und Unterkreide der Nördlichen Kalkalpen. – Eclogae Geol. Helv., 83/2: 353-387.

KAPLAN, U. & KENNEDY, W.J. 2000. Santonian ammonite stratigraphy of the Münster basin, NW Germany. – Acta Geol. Polonica, **50**/1: 99-117. – Warszawa. E.

KENNEDY, W.J. (1984): Ammonite faunas and the "standard zones" of the Cenomanian to Maastrichtian stages in their type areas, with some proposals for the definition of the stage boundaries by ammonites. - Bulletin geological Society Denmark, 33: 147-161.

KENNEDY, W.J. (1986): Campanian and Maastrichtian ammonites from the northern Aquitaine, France. – Spec. Pap. Palaeont. 36145 pp. – London

KENNEDY, W.J. & COBBAN, W.A. (1991). Upper Cretaceous (upper Santonian) Boehmoceras fauna from the Gulf Coast region of the United States. - Geol. Mag. **128**/2:167-189, 12 figs. - London.

KENNEDY, W.J. & HENDERSON, R.A. 1992 Heteromorph ammonites from the Upper Maastrichtian of Pondicherry, south India. - Palaeontology, **35**/3:693-731, 10 pls., 6 textfigs. - London.

KENNEDY, W. J. & KOLLMANN, H. A. (1979): Lower Albian ammonites from the Tannheim Formation near Losenstein, Upper Austria. - Beitr. Paläont. Österr., 6: 1-25.

KENNEDY, W. J. & SUMMESBERGER, H. (1984): Upper Campanian ammonites from the Gschliefgraben (Ultrahelvetic, Upper Austria). Beitr. Paläont. Oest. **11**:149-206, pls. 1-14. - Wien.

KENNEDY, W.J. & SUMMESBERGER, H. (1986): Lower Maastrichtian ammonites from Neuberg, Steiermark, Austria. - Beitr. Paläont. Österr., 12: 181-242.

KENNEDY, W. J. & SUMMESBERGER, H. 1999. New Upper Campanian Ammonites from the Gschliefgraben near Gmunden (Ultrahelvetic, Austria) - Beitr.Paläont. **24**:23-39. - Wien.

KENNEDY, W. J. & SUMMESBERGER, H. (in press) . Additional ammonites from the Upper Campanian (Upper Cretaceous) of the Gschliefgraben (Ultrahelvetic; Austria). - Ann. Naturhist. Mus. Wien

KOLLMANN, H.A. (1963): Zur stratigraphischen Gliederung der Gosauschichten von Gams.- Mitt. Ges. Geol. Bergb. Stud., 13: 189 - 212, 1 pl. Wien

KOLLMANN, H.A. (1964): Stratigraphie und Tektonik des Gosaubeckens von Gams (Steiermark, Österreich). - Jahrb. Geol. Bundesanst., 107: 71-159.

KOLLMANN, H. A. (1968): Zur Gliederung der Kreideablagerungen der Weyerer Bögen (O.-Ö.). - Verh. Geol. Bundesanst., 1968: 126-137.

KOLLMANN, H.A. (1976): Gastropoden aus den Losensteiner Schichten der Umgebung von Losenstein (Oberösterreich). 1. Teil: Euthyneura und Prosobranchia 1 (Neogastropoda). - Ann. Naturhistor. Mus. Wien 80: 163 - 206, 7 pl. Wien

KOLLMANN, H.A., et al. (1977): Beiträge zur Stratigraphie und Sedimentation der Oberkreide des Festlandssockels im nördlichen Niederösterreich. - Jahrb. geol. Bundesanst., 120: 401-447.

KOLLMANN, H. A. (1978): Gastropoden aus den Losensteiner Schichten der Umgebung von Losenstein (Oberösterreich). 2. Teil: Naticidae, Colombellinidae, Aporrhaidae, Ceritellidae, Epitoniidae (Mesogastropoda).- Ann. Naturhistor. Mus. Wien 81: 173 - 201, 5 pl. Wien

KOLLMANN, H.A. (1979): Gastropoden aus den Losensteiner Schichten der Umgebung von Losenstein (Oberösterreich). 3. Teil: Cerithiacea (Mesogastropoda). - Ann. Naturhistor. Mus. Wien 82: 11 - 51, 6 pl., 2 Textfig. Wien

KOLLMANN, H.A. (1980): Gastropoden aus der Sandkalkbank (Hochmoosschichten, Obersanton) des Beckens von Gosau, (OÖ) - Annalen Naturhistorisches Museum Wien, **83**: 197-213. - Wien.

KOLLMANN, H. A. (1982 a): Gosauablagerungen im Becken von Gosau. - (In:) PLÖCHINGER, B.: Erläuterungen zu Blatt 95 St. Wolfgang im Salzkammergut: 30-34; Wien (Geol. Bundesanst.).

KOLLMANN, H.A. (1982 b): Gastropoden aus den Losensteiner Schichten der Umgebung von Losenstein (Oberösterreich). 4. Teil: Archaeogastropoda und allgemeine Bemerkungen zur Fauna.- Ann. Naturhistor.Mus.Wien 84/A: 13 - 56, 7 pl. Wien

KOLLMANN, H.A. & SACHSENHOFER, R. (1998): Zur Genese des Gagats von Gams bei Hieflau (Oberkreide, Steiermark). – Mitt. Ref. Geol. Paläont. Landesmuseum Joanneum; SH2: 223-238. - Graz.

KOLLMANN, H.A. & SUMMESBERGER, H. (1982): Excursions to Coniacian – Maastrichtian in the Austrian Alps. – WGCM, – 4th Meeting – Gosau Basins in Austria. – Wien.

KRENMAYR, H.G. (1996): Hemipelagic and turbiditic mudstone facies associations in the Upper Cretaceous Gosau Grou p of the Northern Calcareous Alps (Austria). - Sediment. Geol., 101: 149-172.

KRENMAYR, H.-G. (1999): Sedimentologie der Nierental-Formation (Gosau Gruppe, Nördliche Kalkalpen). – Unpub. Ph. D. Thesis, Univ. Wien.

LILL VON LILIENBACH (1830): Ein Durchschnitt aus den Alpen mit Hindeutungen auf die Karpathen.. - Leonhard und Bronns Jb., Heidelberg.

LINZER, H.-G., RATSCHBACHER, L. & FRISCH, W. (1995): Transpressional collision structures in the upper crust: the fold-thrust belt of the Northern Calcareous Alps. - Tectonophysics, 242: 41-61.

LOBITZER, H., with contributions by BODROGI, I., FILACZ, E., HLADIKOVÁ, J., KRISTAN-TOLLMANN, E., PIROS, O., RAKÚS, M., RONIEWICZ, E., SIBLIK, M., SZABO, J. & VÖRÖS, A. (1994): Mesozoic of Northern

Calcareous Alps of Salzburg and Salzkammergut area, Austria. – In: Shallow Tethys 4 – Pre-Symposium Excursion 1, 44 p.

MATURA, A. & SUMMESBERGER, H. (1980) Geology of the Eastern Alps (Excursion guide) – Exc.

MUTTI, E. et RICCI LUCCI, F. (1975): Turbidite facies ansd facies associations. - IX. Int. Congr. Sedimentology, Guide to field trip A-11: 21-36. – Nizza.

NEUBAUER, F. (1994): Kontinentkollision in den Ostalpen. – Geowissenschaften, 12: 136-140.

PERCH-NIELSEN, K. (1985): Mesozoic calcareous nannofossils. - In: BOLLI, H.M., SAUNDERS, J.B. & PERCH-NIELSEN, K. (eds.). Plankton Stratigraphy, 329-426, Cambridge (Cambridge Univ. Press).

PILLER, W.E., SUMMESBERGER , H. DRAXLER, I., HARZHAUSER, M. & MANDIC, O. 1997. Meso- to Cenozoic tropical/subtropical climates – Selected examples from the northern Calcareous Alps. – In: KOLLMANN, H.S. & HUBMANN, B. (eds.): Second European Palaeontological Congress – Climates: Past, Present and Future – Vienna, 111 pp. - Wien; Excursion guides 1997)

PLÖCHINGER, B. (1961): Die Gosaumulde von Grünbach und der Neuen Welt (N.Ö.). - Jb. Geol. Bundesanst., 104:359-441.

PLÖCHINGER, B. (1973): Erläuterungen zur Geologischen Karte des Wolfgangseegebietes 1:25.000. - 91 S., Wien (Geol. Bundesanst.).

PLÖCHINGER, B. (1974): Gravitativ transportiertes permisches Haselgebirge in den Oberalmer Schichten (Tithonium, Salzburg). – Verh. Geol. Bundesanst., 71-88.

PLÖCHINGER, B. (1976): Die Oberalmer Schichten und die Platznahme der Hallstätter Masse in der Zone Hallein-Berchtesgaden. – N. Jb. Geol. Paläont. Abh., 151: 304-324.

PLÖCHINGER, B. (1977): Die Untersuchungsbohrung Gutrathsberg BI südlich St. Leonhard im Salzachtal (Salzburg). – Verh. Geol. Bundesanst., 1977: 3-11.

PLÖCHINGER, B. (1982): Erläuterungen zu Blatt 95 Sankt Wolfgang im Salzkammergut. - 74 S., Wien (Geol. Bundesanst.).

PLÖCHINGER, B. (1983): Salzburger Kalkalpen.- Samml. geol. Führer, 73, 144 p., Berlin (Bornträger).

PLÖCHINGER, B. & PREY, S. (1993): Der Wienerwald. - Samml. geol. Führer, 59, 2. Aufl., 168 S., Berlin (Bornträger).

POBER, E.& FAUPL, P. (1988): The chemistry of detrital chromian spinels and its implications for the geodynamic evolution of the Eastern Alps. - Geol. Rdsch., 77: 641-670.

PREY, S. (1952): Helvetikum in der oberösterreichischen Flyschzone. - Verh. Geol. Bundesanst., 1952: 301-343.

PREY, S. (1983): Das Ultrahelvetikum-Fenster des Gschliefgrabens südsüdöstlich von Gmunden (Oberösterreich). - Jb. Geol. B.A. **126**/1: 95-127, 4 Text-figs., 1 geol. map. - Wien.

RATSCHBACHER, L., FRISCH, W., NEUBAUER, F., SCHMID, S.M. & NEUGEBAUER, J. (1989): Extension in compressional orogenic belts: The eastern Alps. - Geology, 17: 404-407.

REHÁKOVÁ, D., MICHALIK, J. & OŽVOLDOVÁ, L. (1996): New microbiostratigraphical data from several Lower Cretaceous pelagic sequences of the Northern Calcareous Alps, Austria (preliminary results). – Geol. Paläont. Mitt. Innsbruck, Spec. Vol., 4: 57-71.

REUSS, A.E. (1854): Beiträge zur Charakterisitk der Kreideschichten der Ostalpen, besonders im Gosauthale und am Wolfgangsee. - Denkschr. Österr. Akad. Wiss., math.-naturwiss. Kl.: 7, 156 S.

SANDERS, D. (1998): Tectonically controlled Late Cretaceous terrestrial to neritic deposition (Northern Calcareous Alps, Tyrol, Austria). - Facies, 39: 139-178.

SANDERS, D., KOLLMANN, H. & WAGREICH, M. (1997): Sequence development and biotic assemblages on an active continental margin: the Turonian-Campanian of the northern Calcareous Alps, Austria. – Bull. Soc. géol. France, 168: 351-372.

SANDERS, D. & PONS, J.M. (1999): Rudist formations in mixed siliciclastic-carbonate depositional environments, Upper Cretaceous, Austria: stratigraphy, sedimentology, and models of development.- Paleogeography, Paleoclimatology, Paleoecology, 148: 249-284

SCHLAGINTWEIT, F. (1991): Allochthone Urgonkalke in mittleren Abschnitt der Nördlichen Kalkalpen: Fazies, Paläontologie und Paläogeographie. - Münchner geowiss. Abh., Reihe A, Geologie und Paläontologie, 20: 119 pp.

SCHLAGINTWEIT, F. & EBLI, O. (1999): New Results on Microfacies, Biostratigraphy and Sedimentology of Late Jurassic – Early Cretaceous platform carbonates of the Northern Calcareous Alps. Part I: Tressenstein Limestone, Plassen Formation. – Abh. Geol. Bundesanst., 56/2: 379-418.

SCHNABEL, W. (1992): New data on the Flysch Zone of the Eastern Alps in the Austrian sector and new aspects concerning the transition to the Flysch Zone of the Carpathians. – Cretaceous Res., 13: 405-419.

SCHULTZ, O. & PAUNOVIC, M. (1997): Der Nachweis von *Coelodus* (Osteichthyes, Pycnodontidae) im Turonien (Oberkreide) von Gams, Steiermark, Österreich und aus der Oberkreide von Kroatien und Italien with a contribution of H. SUMMESBERGER on the stratigraphy of the Gams basin. - Ann. Naturhist. Mus.Wien, **98** A:73-141. - Wien

SCHWINGHAMMER, R. (1975): Stratigraphie und Fauna des Neokoms von Kaltenleutgeben, NÖ. - Sitzber. Österr. Akad. Wiss., math.-naturw. Kl, Abt 1, 183: 149-158, Wien.

SEDGWICK, A. & MURCHISON, R. (1832): A sketch of the structure of the Eastern Alps. - Geol. Soc. London, Transactions, Ser. 23/2: 301-420.

SIEGL-FARKAS, A. & WAGREICH, M. (1997): Correlation of palyno- (spores, pollen, dinoflagellates) and calcareous nannofossil zones in the Late Cretaceous of the Northern Calcareous Alps (Austria) and Transdanubian Central Range (Hungary). - Advances in Austrian-Hungarian Joint Geological Research: 127-135. - Budapest.

SISSINGH, W. (1977): Biostratigraphy of Cretaceous calcareous nannoplankton. - Geol. Mijnbouw, 56: 37-56, Amsterdam.

STEIGER, T. (1981): Kalkturbidite im Oberjura der Nördlichen Kalkalpen (Barmsteinkalke, Salzburg, Österreich). – Facies, 4: 215-348.

STRADNER, H. (1961): Vorkommen von Nannofossilien im Mesozoikum und Alttertiär.- Erdoel Z., 77: 77-88.

SUMMESBERGER, H. (1979). Eine obersantone Ammonitenfauna aus dem Becken von Gosau (Oberösterreich). - Ann. Naturhistor. Mus. Wien 82:109-176, 15 pls., 48 text-figs., 4 tab.- Wien.

SUMMESBERGER, H. (1980). Neue Ammoniten aus der Sandkalkbank der Hochmoosschichten (Obersanton; Gosau, Österreich) - Ann. Naturhistor. Mus. Wien 83:275-283, 3 pls., 6 text-figs., 1 tab. - Wien.

SUMMESBERGER, H. (1985). Ammonite zonation of the Gosau Group (Upper Cretaceous, Austria). - Annalen Naturhistorisches Museum Wien, 87: 145-166.

SUMMESBERGER, H. (1992). Ammoniten aus dem Turon (Oberkreide) der Nördlichen Kalkalpen (Österreich). - Ann. Naturhist. Mus. Wien, 94: 103-133.

SUMMESBERGER, H. (1992 a): *Pseudophyllites latus* (MARSHAL), Ammonoidea, aus der Sandkalkbank der Hochmoosschichten (Obersanton; Gosau, Österreich). - Ann. Naturhistor. Mus. Wien 94 A:97-101.- Wien.

SUMMESBERGER, H., H. (1997). The Cretaceous of the Grünbach – Neue Welt Basin in: PILLER, W.E., SUMMESBERGER, H., DRAXLER, I., HARZHAUSER, M. & MANDIC, O.: Meso- to Cenozoic tropical/subtropical climates – Selected examples from the northern Calcareous Alps. - Second European Palaeontological Congress – Climates: Past, Present and Future – Vienna, 111 pp. - Wien; Excursion guides 1997)

SUMMESBERGER, H. & KENNEDY, W.J. (1996): Turonian Ammonites from the Gosau Group (Upper Cretaceous; Northern Calcareous Alps; Austria) with a revision of *Barroisiceras haberfellneri* (HAUER 1866). - Beitr. Paläont. Österr., 21: 1-75.

SUMMESBERGER, H., SANDERS, D. & KOLLMANN, H. A. (2000): Deciphering the Gosau Group - a Challenge for Cretaceous Palaeontology. In: PILLER, et al. Palaeontological Highlights of Austria– Mitt. Österr. Geol. Ges., 92 (1999):209-213. - Wien

SUMMESBERGER, H, WAGREICH, M, TRÖGER, K.-A. & JAGT, J.W.M. (1999).-Integrated biostratigraphy of the Santonian/Campanian Gosau Group of the Gams Area (Late Cretaceous; Styria, Austria) - Beitr. Paläont. Österr., 24: 155-205. – Wien.

THÖNI, M. (1999): A review of geochronological data from the Eastern Alps. - Schweiz. Mineral. Petrogr. Mitt., 79: 209-230.

TOLLMANN, A. (1976): Analyse des klassischen nordalpinen Mesozoikums. Stratigraphie, Fauna und Fazies der Nördlichen Kalkalpen. – XV+580 p. (Deuticke).

TRÖGER, K.-A. & SUMMESBERGER, H. (1994): Coniacian and Santonian inoceramid bivalves from the Gosau-Group (Cretaceous, Austria) and their biostratigraphic and paleobiogeographic significance. - Ann. Naturhist. Museum Wien, 96 A: 161-197.

TRÖGER, K.-A., SUMMESBERGER, H. & SKOUMAL, P. 1999. Inoceramidae from the Campanian (Upper Cretaceous) of the Gschliefgraben (Ultrahelvetic; Austria). - Beitr. Paläont., 24:155-205. - Wien

VASICEK et al. 1994 (p.26)

VASICEK, Z. & FAUPL, P. (1996): Die Cephalopoden aus den Rossfeldschichten der Reichraminger Decke (Obervalanginium; oberösterreichische Kalkalpen). - Jahrb. geol. Bundesanst., 139: 101-125.

VASICEK, Z. & FAUPL, P. (1998): Late Valanginian cephalopods in relation to the palaeogeographic position of the Rossfeld and Schrambach Formation of the Reichraming Nappe (Northern Calcareous Alps, Upper Austria). – Zbl. Geol. Paläont. Teil I, 1996, 1421-1432.

VASICEK, Z. & FAUPL, P. (2000): Zur Biostratigraphie der Schrambachschichten in der Reichraminger Decke (Unterkreide, oberösterreichische Kalkalpen). - Abh. geol. Bundesanst., (in press).

VASICEK, Z., MICHALIK, J., REHAKOVA, D. & FAUPL, P. (1994): Stratigraphische Daten zur Unterkreide der Lunzer- und Reichraminger Decke (Östliche Kalkalpen, Ober- und Niederösterreich). – Jb. Geol. B. A 137/2:407-412.

VASICEK, Z., REHAKOVA, D. & FAUPL, P. (2000): Zur Biostratigraphie der Schrambachschichten der Oisbergmulde bei Hollenstein a. d. Ybbs (Lunzer Decke, Kalkalpen, Niederösterreich). - Abh. geol. Bundesanst., 56, (in press).

VON EYNATTEN, H. (1996): Provenanzanalyse kretazischer Siliziklastika aus den Nördlichen Kalkalpen. - Diss. Univ. Mainz, 145 pp., Mainz.

VON EYNATTEN, H. & GAUPP, R. (1999): Provenance of Cretaceous synorogenic sandstones in the Eastern Alps: constraints from framework petrography, heavy mineral analysis and mineral chemistry. - Sediment. Geol., 124: 81-111.

WAGREICH, M. (1988a): Nannoplankton- und Foraminiferen-Feinstratigraphie des Santon-Untercampans der Gosauschichtgruppe von Gosau-Rußbach (Oberösterr.-Salzburg). - Mitt. Ges. Geol. Bergbaustud. Österr., 34/35: 279-294.

WAGREICH, M. (1988b): Sedimentologie und Beckenentwicklung des tieferen Abschnittes (Santon-Untercampan) der Gosauschichtgruppe von Gosau und Rußbach (Oberösterreich-Salzburg). - Jahrb. geol. Bundesanst., 131: 663-685.

WAGREICH, M. (1992): Correlation of Late Cretaceous calcareous nannofossil zones with ammonite zones and planktonic foraminifera: the Austrian Gosau sections. - Cret. Research., 13, 505-516.

WAGREICH, M. (1993a): Subcrustal tectonic erosion in orogenic belts - A model for the Late Cretaceous subsidence of the Northern Calcareous Alps (Austria). - Geology, 21, 941-944.

WAGREICH, M. (1993b): Serpentinitreiche Sandsteine als Anzeiger verschwundener Suturzonen am Beispiel der Oberkreide der Nördlichen Kalkalpen (Gosau Gruppe, Österreich). - Zbl. Geol. Paläont. Teil I, 1992, 663-673.

WAGREICH, M. (1995): Subduction tectonic erosion and Late Cretaceous subsidence along the northern Austroalpine margin (Eastern Alps, Austria). - Tectonophysics, 242: 63-78.

WAGREICH, M. (1998): Lithostratigraphie, Fazies und Sequenzstratigraphie der Gosau Gruppe von Bad Ischl und Strobl am Wolfgangsee (Oberturon – Maastricht, Nördliche kqlkalpen, Österreich). – Jahrb. Geol. B.A., 141:209-234.

WAGREICH, M. 1999. Calcareous nannofossil assemblages from the Gschliefgraben near Gmunden Ultrahelvetic, Austria). - Beitr. Paläont., **24**:41-61. - Wien.

WAGREICH, M. & FAUPL, P.(1994): Palaeogeography and geodynamic evolution of the Gosau Group of the Northern Calcareous Alps (Late Cretaceous, Eastern Alps, Austria). - Palaeogeogr., Palaeoclimatol., Palaeoecol., 110: 235-254.

WAGREICH, M. & KRENMAYR, H.-G. (1993): Nannofossil biostratigraphy of the Late Cretaceous Nierental Formation, Northern Calcareous Alps (Bavaria, Austria). - Zitteliana, 20, 67-77.

WAGREICH, M. & MARSCHALKO, R. (1995): Late Cretaceous to Early Tertiary palaeogeography of the Western Carpathians (Slovakia) and the Eastern Alps (Austria): implications from heavy mineral data. - Geol. Rundsch., 84: 187-199.

WAGREICH, M. & SACHSENHOFER, R. F. (1999): Organic carbon-rich calcareous shales in the Lower Albian of the Northern Calcareous Alps (Austria). - Zbl. Geol. Paläont. Teil I, 1997: 951-962.

WEIDICH K.F. (1984): Über die Beziehungen des "Cenoman" zur Gosau in den Nördlichen Kalkalpen und ihre Auswirkungen auf die paläogeographischen und tektonischen Vorstellungen. - Geol. Rundsch., 73: 517-566.

WEIDICH, K. F. (1990): Die kalkalpine Unterkreide und ihre Foraminiferenfauna. - Zitteliana, 17: 1-187; München.

WEIGEL, O. (1937): Stratigraphie und Tektonik des Beckens von Gosau. - Jahrb. geol. Bundesanst., 87: 11-40.

WEISS W. (1975): Mikropaläontologische Gliederung der Unteren Gosauschichten im N-Teil des Beckens von Gosau (Oberösterreich). – Dipl. Arb. München, 73 pp.

WIEDMANN, J. 1978. Eine paläogeographisch interessante Ammonitenfaunula aus der alpinen Gosau. – Ecl. geol. Helv. 71/3:663-675. – Basel.

WIDDER, R. (1986): Neuinterpretation des Buchdenkmalgranites. – Mitt. Ges. Geol. Bergbaustud. Österr., 33: 287-307.

WILSON, J.L. (1969): Microfacies and sedimentary structures in "deeper water" lime mudstones.- Soc. Econ. Paleont. Mineralogists Spec. Publ., 14, 4-19.

WINKLER, W. (1996): The tectono-metamorphic evolution of the Cretaceous northern Adriatic margin as recorded by sedimentary series (western part of the Eastern Alps). - Eclogae geol. Helv., 89: 527-551; Basel.

WOOD , C.J., ERNST, G. & RASEMANN, G. 1984. The Turonian-Coniacian stage boundary in Lower Saxony (Germany) and adjacent areas: the Salzgitter-Salder Quarry as a proposed international standard section.

ZACHER, W. (1966): Die kalkalpinen Kreideablagerungen in der Umgebung des Tannheimer Tales (Nordtirol). - Mitt. Bayer. Staatssamml. Paläont. Hist. Geol., 6: 213-228; München.

ZIMMER, W. & WESSELY, G. (1996): Exploration results in thrusts and subthrust complexes in the Alps and below the Vienna Basin in Austria. - In: WESSELY, G. & LIEBL, W. (eds.): Oil and gas in Alpidic thrustbelts and basins of central and eastern Europe. EAGE Special Publ. 5: 81-107, Geol. Soc. London.

Author`s addresses

jegger@cc.geolba.ac.at
Geologische Bundesanstalt
A-1031 Wien
Rasumofskygasse 23
Austria

heinz.kollmann@ nhm-wien.ac.at
Naturhistorisches Museum
A-1014, Wien, Burgring 7
Austria

herbert.summesberger@nhm-wien.ac.at
Naturhistorisches Museum
A-1014, Wien, Burgring 7
Austria

michael.wagreich@univie.ac.at
Institute of Palaeontology, Geozentrum
Althanstrasse 14, A-1090 Vienna
Tel: 01/31336/9730
e-mail: a9004013@unet.univie.ac.at
Austria