2.5. Geology of the central and eastern sector of the Northern Calcareous Alps (NCA)

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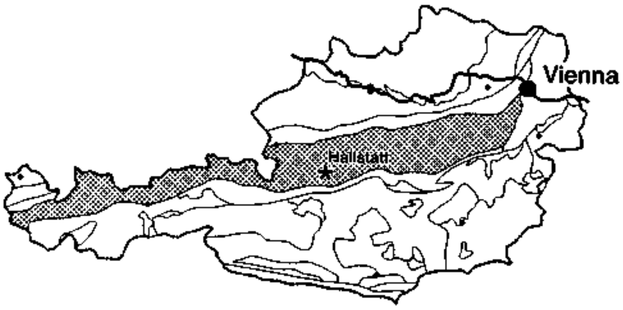

General features

One of the most prominent units of the Eastern Alps are the Northern Calcareous Alps, which extend for about 500 kilometers from the Rhine valley in the west to Vienna in the east, forming a 20 to 50 kilometer wide belt. The NCA consist of mountain ranges with considerable plateau mountains, the latter being a remnant of the late Lower Tertiary peneplain, faulted and uplifted since the Miocene. In the western and middle part the highest peaks reach altitudes of up to 3.000 meters and are locally glaciated (Dachstein area). In the eastern part elevations are up to 2.000 meters.

At their eastern end the NCA are bounded by the Vienna Basin, which subsided during Neogene times. In the basement of the Vienna Basin, however, the NCA continue in principle into equivalent units of the Western Carpathians even if the details are still in discussion. For example the uppermost tectonic unit of the NCA - the Juvavic Nappe System - ends in the Slovakian part of the Vienna Basin. Equivalent units occur again only far in the east of the Western Carpathians (Stratena-, Muran-, Silica-, Aggtelek- and Rudabanya-Mountains).

In the Northern Calcareous Alps Mesozoic carbonates are predominating, but also clastic sediments are frequent at several stratigraphic levels. The sequence begins in the Permian and extends locally into the Paleogene (Gosau Group), but the Triassic rocks are the most prevailing ones, details of stratigraphy and facies see below.

Principles of structural evolution

The sequence of Mesozoic sediments of the NCA has lost its former crustal basement during Alpidic Orogeny. During Upper Jurassic to Tertiary times several events of folding and thrusting have created a complex pile of nappes which rests with overthrust contact in the north on the Rhenodanubian Flysch Zone and in the south on the Greywacke Zone - see Fig. 2.

The following nappe scheme of the Northern Calcareous Alps can be given today (Fig. 2.5.1.): The northern (= frontal) part of the NCA is built by the Bajuvaric nappes, which one show narrow synclines and anticlines. They dip down toward the south below the overthrusted Tirolic nappe system. Due to their widespread dolomitic lithology the Tirolic nappes exhibit internal thrusting and faulting and only minor folding. The Greywacke Zone is thought to represent the Palaeozoic sedimentary substratum of the Tirolic nappes, remaining several kilometers in the south during the nappe movements. The Juvavic nappes represent the uppermost tectonic element, overlying the Tirolic Mesozoic in the north and the Greywacke Zone with its Tirolic transgressive Permoskythian (Werfen

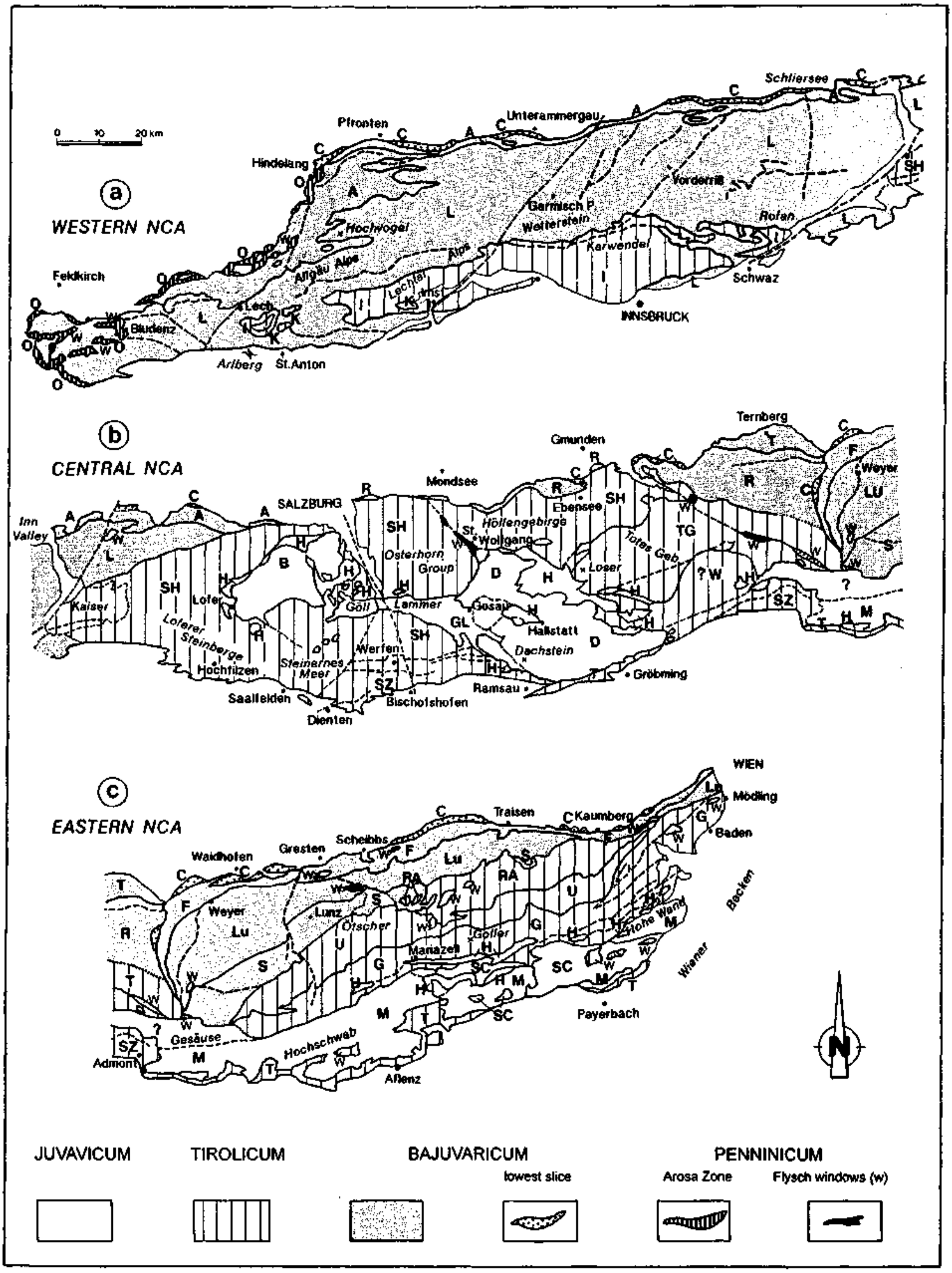

Fig. 2.5.1.: The Nappe System of the Northern Calcareous Alps; after PLÖCHINGER, 1995.

Schuppen-Zone) in the south. An additional subdivision into a "Lower" and an "Upper" Juvavicum has been used in literature; these terms seem not to be useful anymore. They had a mixed facial and tectonic meaning: "Lower" means pelagic Hallstatt facies and a tectonic position below the "Upper"Juvavic carbonate platforms of Wetterstein-/Dachstein facies. Recent mapping has shown that also an opposite configuration is existing frequently.
Apart from slightly metamorphosed beds at the basal parts - mainly within the siliciclastic Permo-Skythian rocks - it was assumed that most parts of the NCA do not exhibit any metamorphic overprint - see KRALIK et al. (1987). Investigations of Conodont Color Alteration Index during the last years have revealed a considerable thermal event in parts of the Juvavic nappes, predating the oldest (Late Jurassic) overthrusts (GAWLICK et al.,, 1994, KOZUR & MOSTLER, 1992, MANDL, 1996).
Today there is a common agreement that the NCA depositional realm during the Permotriassic was a passive continental margin between Variscian (= Hercynian) consolidated Pangäa and the Tethys ocean, Fig. 2.5.2. That sector of the ocean that bordered the NCA and the Western Carpathians was also named "Hallstatt-Meliata-Ocean" by KOZUR, 1991 and it is thought to be closed by plate tectonics during Jurassic times. The position of this geosuture in the today visible nappe stack as well as the original arrangement of the tectonic mega-units to each other is still a matter of discussion and major disagreement (HAAS, KOVACS, KRYSTYN & LEIN, 1995, KOZUR, 1991, KOZUR & MOSTLER, 1992, SCHWEIGL & NEUBAUER, 1997, TOLLMANN, 1976, 1981).

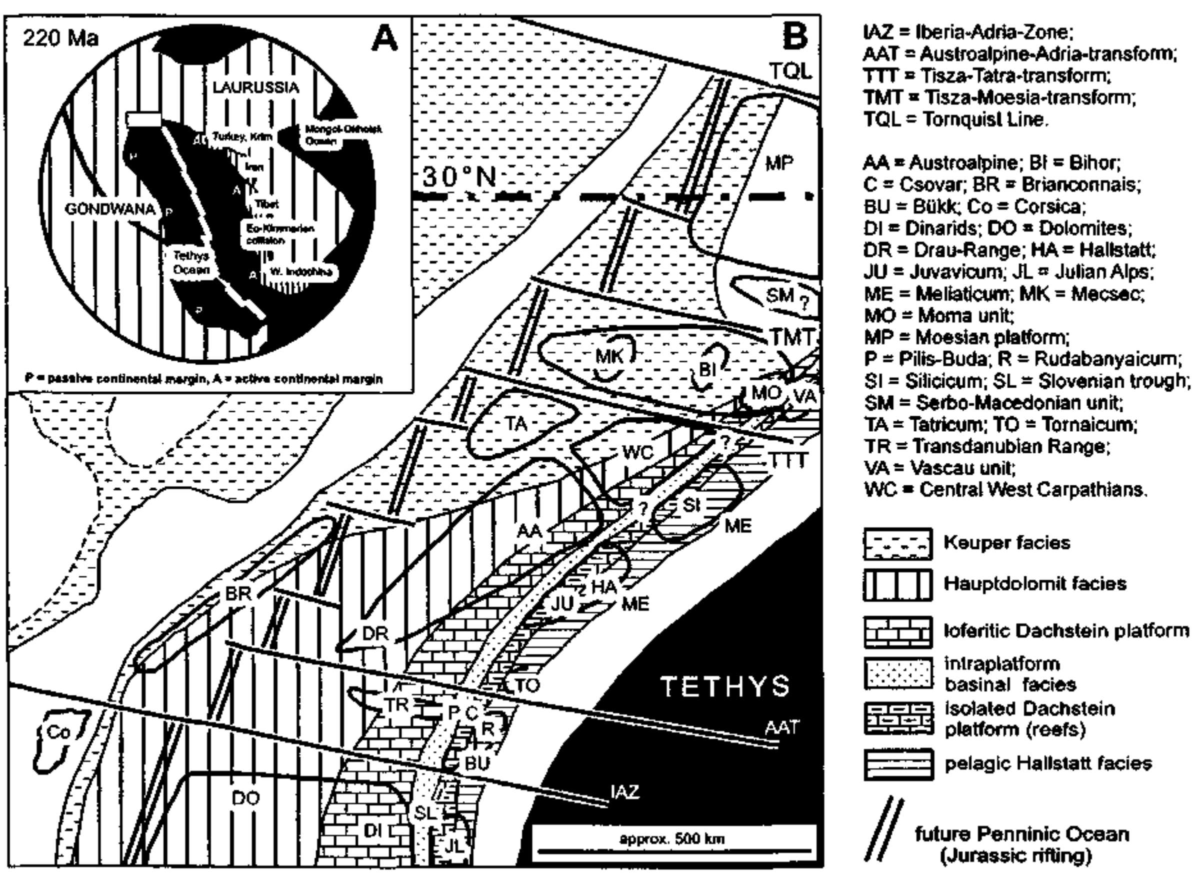

Fig. 2.5.2.: The Alpine-Carpathian sector of the Triassic Tethyan shelf.
After HAAS et al., 1995, modified.

Beginning in the Jurassic the Austroalpine realm (including the NCA) became separated from its European hinterland by the birth of the transtensional basin of the Penninic Ocean, which was linked by large transform faults with the opening of the Northern Atlantic Ocean. Contemporaneous compressional tectonics have affected the Tethyan ocean and the adjacent shelf of the Austroalpine realm, causing the first displacements of the Juvavic Nappe System.
Subduction processes at the southern margin of the Penninic Ocean have started in the Cretaceous, accompanied by heating and crustal shortening within the Austroalpine crystalline basement and by synorogenic clastics and nappe movements in its sedimentary cover (DECKER et al., 1987, FAUPL & TOLLMANN, 1979). For details of metamorphic evolution of the Eastern Alps and controversial discussions see FRANK (1987).
Upper Cretaceous clastic sediments of the Gosau-Group transgressed after a period of erosion over the NCA nappe stack. The sediments of the Gosau-Group show a facies change in time from shallow water clastics to flysch-like deep water sediments, WAGREICH & FAUPL, 1994. The latter ones are also typical for the adjacent Penninic trough, where beside other structural units (e.g. ophiolite-bearing metamorphic Bündner-schiefer-Group of the Tauern-Window) the Rhenodanubian Flysch Zone originates from.
Ongoing subduction of the Penninic realm toward the south below the Austroalpine units led to the closure of the Penninic Ocean. The sediments of the Rhenodanubian Flyschzone became deformed, lost their oceanic basement (only preserved in form of some Klippen) and became partly overthrusted by the nappes of the NCA, beginning in the late Eocene.
The remaining sea between the alpine orogenic front and the european foreland was during Oligocene and Miocene the depositional site of the Molasse Zone, which collected the erosional debris of the uplifting Alps. The southernmost part of the Molasse Zone became also incorporated into the alpine orogeny due to the youngest subduction pulses.
The large scale overthrusts of the NCA, Flysch- and Klippen Zone over the Molasse Zone and the European Foreland (crystalline basement of the Bohemian Massive with autochthonous sedimentary cover) is proven today by several drillings, which penetrated all units and reached the basement in depth of about 3.000 to 6.000 meters.
The uplift of the central part of the Eastern Alps in the Miocene was accompanied by large strike slip movements on its northern side (sinistral Salzach-Ennstal- and Mur-Mürz-fault systems; responsible also for the genesis of the Vienna Basin and also dissecting the NCA) and on its southern side (dextral Periadriatic faults) - see for example LINZER et al. (1995), DECKER et al. (1994).

Permotriassic Stratigraphy and Facies of the NCA

Overviews as well as detailed data and further literature to this topic are given by TOLLMANN, 1976, LEIN, 1985, 1987, KRYSTYN & SCHÖLLNBERGER, 1972, MANDL, 1984, SCHLAGER & SCHÖLLNBERGER, 1975, ZANKL, 1971, FLÜGEL, 1981. A schematic representation of the Triassic sedimentary sequences is shown in Fig. 2.5.3.
The sedimentary sequence of the NCA starts in the Permian with continental red beds, conglomerates, sandstones and shales of the Prebichl Formation, transgressively overlaying the Lower Paleozoic rocks of the Greywacke Zone (Noric nappe). The Permian age is assumed due to local intercalations of acid tuffs and pebbles of quartzporphyr, which are widespread in the European Permian (Saalic tectonic phase). A marine facies of Permian sediments is the so called Haselgebirge, a sandstone-clay-evaporite association

containing gypsum and salt. This facies is frequent in the Juvavic units, exposed for example in the Hallstatt salt mine. The Upper Permian age is proved paleontologically by pollen/spores at several localities and confirmed by sulfur isotopes.
The Lower Triassic is characterized by uniform shallow shelf siliciclastics of the Werfen Formation, containing limestone beds in its uppermost part with a poor fauna including Scythian ammonoids.
In the Middle Triassic carbonate sedimentation became dominant. The dark Gutenstein Limestone and Dolomite is present in most of the NCA nappes. It can be laterally replaced in its upper part by light dasycladacean bearing carbonates, the Steinalm Limestone / Dolomite. During the Middle Anisian a rapid deepening and contemporary blockfaulting of the so called Reifling Event caused a sea floor relief, responsible for the following differentiation into shallow carbonate platforms (Wetterstein Formation and lateral slope sediments) and basinal areas. The basins can be distinguished into the Reifling/Partnach basins and the Hallstatt deeper shelf, the latter one was bordering the open Tethys. The transition from the Hallstatt depositional realm into oceanic conditions with radiolarites is not preserved in the NCA. We have hints on the existence of such an oceanic realm only in form of olistolites of Ladinian red radiolarite in the Meliata Klippen in the eastern Sector of NCA.
The Wetterstein platforms in general show a platform progradation over the adjacent basinal sediments until the Lowermost Carnian ("Cordevolian"). Then carbonate production decreased rapidly due to a sealevel lowstand. The platforms emerged, the remainig basins received siliciclastics from the European hinterland. The Reifling basin has been filled completely by marine black shales (Reingraben shale) and marine to ?brackish Lunz Sandstone, containing coal seams. Local intraplatform basins and the Hallstatt realm toward the south received also finegrained siliciclastics (Reingraben shale) interbedded with dark cherty limestones and local reef debris ("Leckkogel facies"), derived from small surviving reef mounds at the basin margins.
As sealevel started rising up again in the Upper Carnian, rather slowly in the beginning, carbonate production increased, locally filling a relief in the drowning platforms with lagoonal limestones (Waxeneck Limestone). The relief (several tens up to about 100 meters) may be caused by erosion during the lowstand time and/or by tectonic movements. More toward the north, in the Lunz - Reifling area, partly hypersalinar conditions led to the deposition of limestones and dolomites with evaporitic (gypsum) intercalations (Opponitz Formation).
A transgressive pulse just below the Carnian/Norian boundary caused an onlap of pelagic limestones over the shallow water carbonates and initiated the rapid growth of the Norian carbonate platform.
Due to local differences in platform growth conditions we can distinguish two different developments, see Fig. 2.5.4. In the central part of the NCA (Hochkönig, Tennengebirge, Dachstein area etc.) the pelagic onlap represents only a short time interval and became covered by the prograding Dachstein carbonate platform - see example of the type area below. In this areas the Upper Triassic reefs approximately are situated above the Middle Triassic ones.
An other situation characterizes the eastern sector of the NCA. There the Uppermost Carnian pelagic transgression continues until the Upper Norian and has been termed Mürztal Type of Hallstatt facies by LEIN (1982). Dachstein reefs are only known from the Upper Norian and this ones are situated above the former platform interior, several kilometers behind the former Wetterstein reef front. Such a configuration seems to be also typical for the Western Carpathians (Slovakian karst and the Aggtelek Mountains). This "backstepped" reefs show transitions into the basinal facies of the black Aflenz Limestone at the eastern Hochschwab / Aflenz area and at the Sauwand- and Tonion Mountains. The

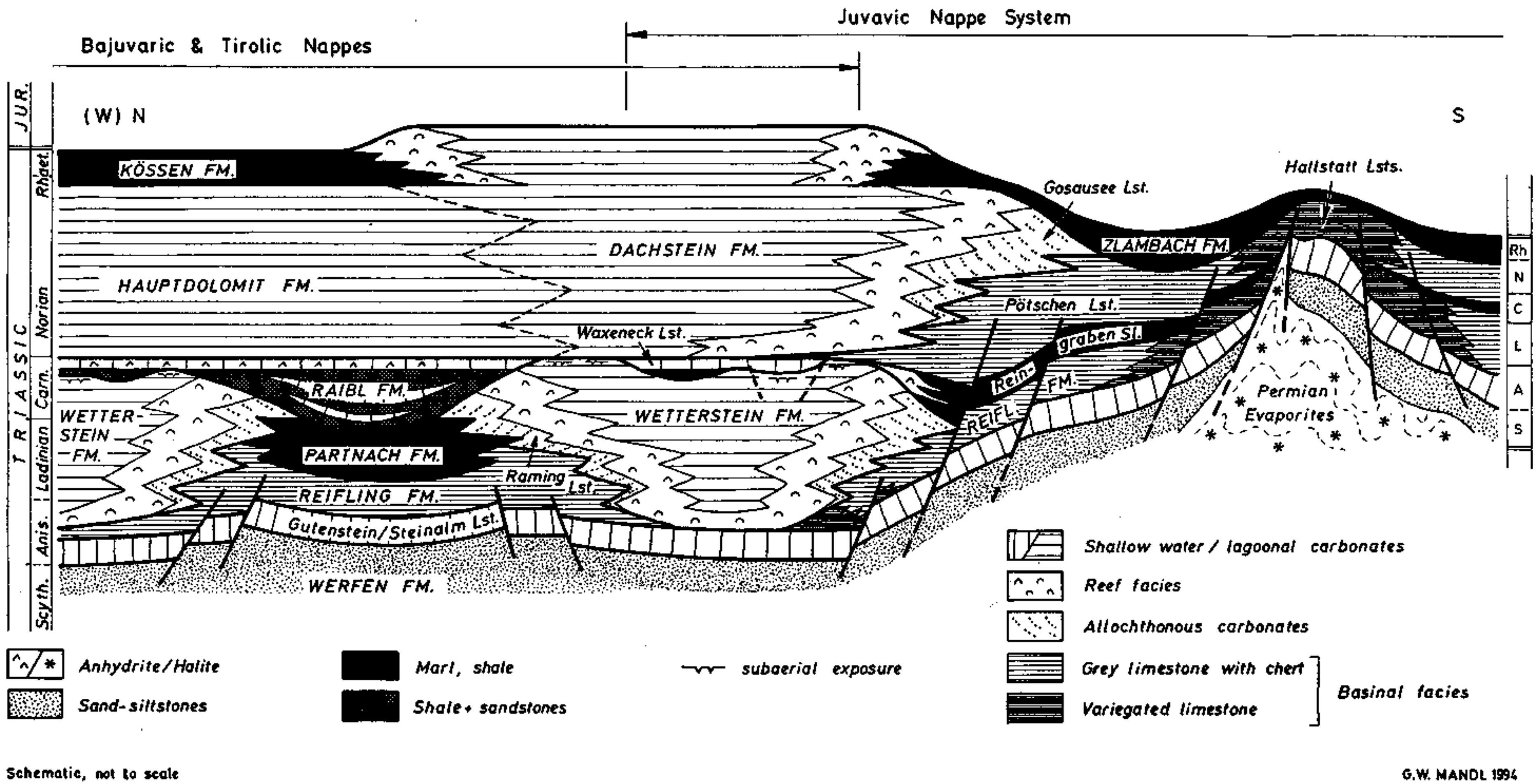

Fig. 2.5.3.: Triassic depositional realms of the middle part of the northern Calcareous Alps (Austria)

Fig. 2.5.4.: Triassic Depositional Realms of the Juvavic Domain (Northern Calcareous Alps, Austria).

„Middle Triassic“: Wetterstein Interval (Upper Pelson - Lower Julian); platform, margins, intraplatform basin

1 Wetterstein Facies; interior of carbonate platform, lagoonal subfacies.
2 Wetterstein Facies; carbonate platform, marginal reef subfacies.
3 „Northern“ slope facies; facing toward restricted intraplatform basin; reef debris.
4 Grafensteig Facies; restricted intraplatform basin; bedded black limestones, containing distal turbidites of platform origin; connecting seaways to open marine realm are not preserved; central parts of basin may persist into Upper Triassic (Carnian shales; Norian sediments are not preserved).
5 „Southern“ slope facies; reef debris interfingering with open marine pelagic carbonate mud facies.
6 Distal „southern“ slope facies; pelagic variegated carbonate mud facies mixed with finegrained platform derived debris.
7 Margin of basinal facies; grey limestones with chert nodules and intercalated carbonate turbidites.

Upper Triassic: Reingraben and Dachstein Interval (U. Julian to Rhaetian); platform, margins, drowned platform

Middle- and Upper Triassic carbonate platforms are separated by the Reingraben event (sealevel fall). Platforms emerged; locally bypassing siliciclastics (mainly shales) reached the remaining basinal areas, onlapping the former Wetterstein platform slopes. Sealevel rise during Upper Carnian initiated a next platform growth:

8 Dachstein Facies; carbonate platform, cyclic bedded lagoonal subfacies; toward north transition into intertidal Hauptdolomit.
9 Dachstein Facies; carbonate platform, marginal reef subfacies situated above Wetterstein reef, facing toward Hallstatt deeper shelf.
10 Mitteralm Facies; Dachstein carbonate platform, backstepped margin above drowned interior of Wetterstein platform, facing toward Aflenz intraplatform basin.
11 Tonion Facies; backstepped platform like 10, separeted from drowned Wetterstein platform by pelagic Mürztal facies; platform progradation during Upper Norian, older parts of platform are not preserved.
12 Hohe Wand Facies; backstepped platform, prograding during Upper Norian over red Hallstatt limestone facies and reaching again a reef position above Middle Triassic platform margin.
13 Gosausee Facies; (distal) slope toward Hallstatt deeper shelf; carbonate turbidites of platform origin interfingering with pelagic grey mud facies (Pötschen facies).
14 Aflenz Facies; intraplatform basin over drowned Wetterstein platform; connection into a persisting depression above Middle Triassic intraplatform Grafensteig Facies questionable (sediments eroded).
15 Mürztal Facies; variegated pelagic limestones on „pelagic plateau“ of drowned Wetterstein platform; transitions to Aflenz facies are not preserved (eroded).

Middle- and Upper Triassic (Upper Pelsonian to Rhaetian) in basinal facies, Hallstatt deeper shelf

16 Pötschen Facies; basinal realm of Hallstatt deep shelf; bedded grey limestones with chert.
17 Siriuskogel Facies; few occurrences of massive grey pelagic limestone, depositional site questionable.
18 Salzberg Facies; variegated Hallstatt limestones s. str.; intrabasinal rises due to synsedimentary diapirism of Permian evaporites and/or tectonics (mobile shelf margin) are the reason for reduced sedimentation, condensed sequences, block tilting and fissure fillings.

The Upper Triassic sedimentary history was terminated by increasing input of terrigenous material, in the Juvavic realm represented by the Zlambach Formation, covering the basinal areas as well as the platform slopes.

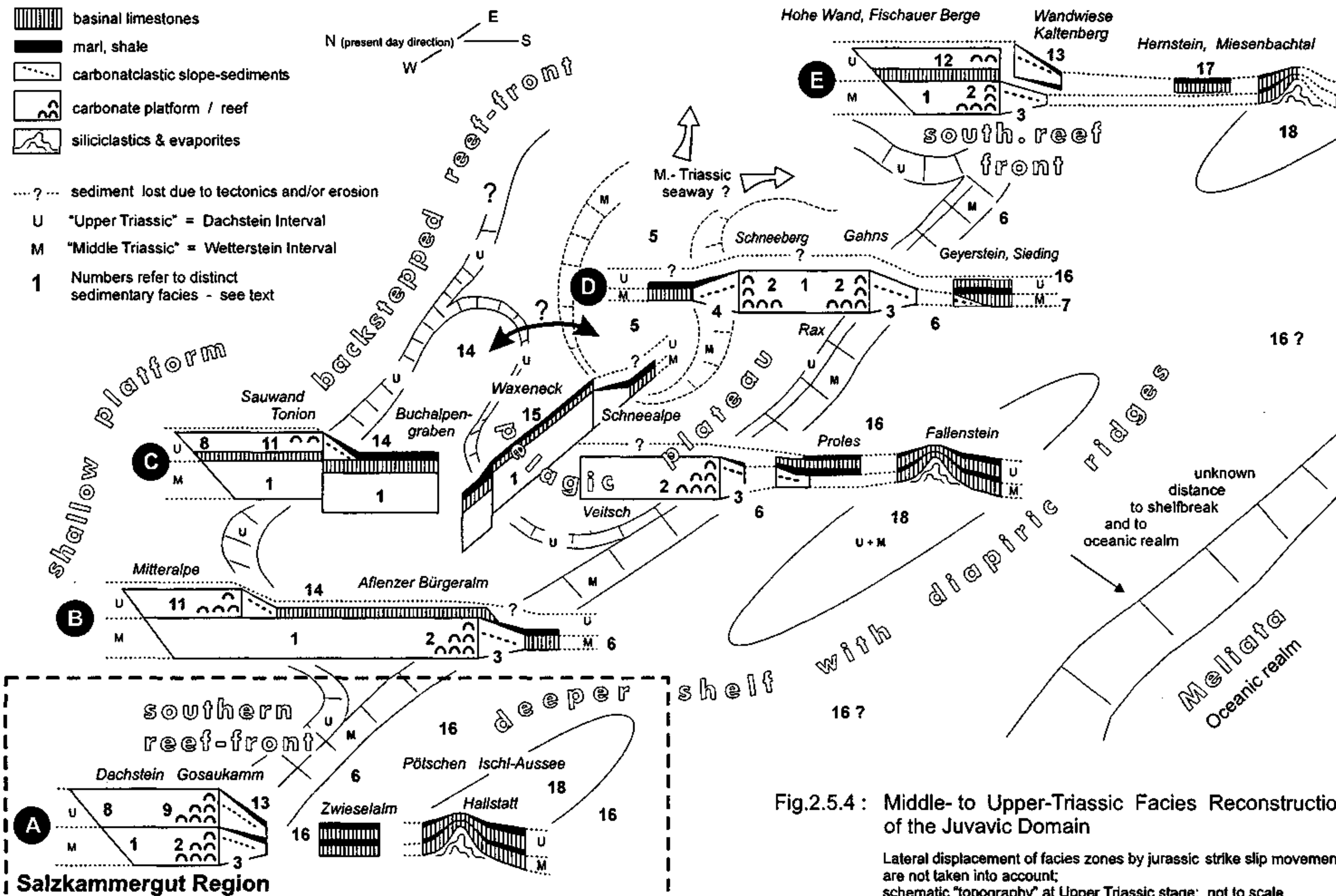

Fig.2.5.4 : Middle- to Upper-Triassic Facies Reconstruction of the Juvavic Domain

Lateral displacement of facies zones by jurassic strike slip movements are not taken into account;
schematic "topography" at Upper Triassic stage; not to scale

"Southern Marginal Reefs" of central NCA are connected by the allodapic Pedata Limestone to the Pötschen Limestone of the Hallstatt facies s.str.
The Hallstatt-Group shows a great variability of variegated limestones often with rapidly changing sedimentary features due to its mobile basement (diapirism) of Permian evaporites - details see below.
Behind the Dachstein reefs a large lagoonal environment extended all over the NCA with Dachstein bedded limestones near to the reefs and the intertidal Hauptdolomit in distal parts.
In the Uppermost Triassic ("Rhaetian") once again increasing terrigenous influx has reduced the carbonate platforms. The Hauptdolomit area and parts of the Dachstein lagoon became covered by the marly Kössen Formation, borderd by Rhaetian reefs.
In the Hallstatt realm as well as in the intraplatform basin of Aflenz Limestone the marly Zlambach Formation has been deposited onlapping and interfingering with the Dachstein platform slope.

Jurassic to Early Cretaceous sediments

At the beginning of Jurassic the Austroalpine shelf drowned completely, basinal conditions prevailed until the Lower Cretaceous with the only exception of local Plassen carbonate platforms (Late Malm - Earliest Berriasian) in southern parts of the NCA, especially in the realm of Juvavic nappes.

Irregular drowning and synsedimentary faulting caused a complex seafloor topography with reddish/grey crinoidal limestones (Hierlatz Lst.) and red ammonoid limestones (Adnet Lst., Klaus Lst.) mainly above former carbonate platforms and grey marly/cherty limestones (Allgäu Fm.) in the troughs between.
Parts of the Hettangian are often missing at the base of Hierlatz and Adnet Limestone - e.g. at the type locality. The reason - subaereal exposure or submarine non-deposition - is still in discussion. Neptunian sills and dykes filled with red or grey Liassic limestones are frequent, cutting down into the Norian shallow water carbonates up to more than 100 meters.
According to BÖHM (1992), BÖHM & BRACHERT (1993) Adnet and Klaus Limestones are bioclastic wackestones, mainly made of nannoplankton (*Schizosphaerella*, coccoliths) and very finegrained biodetritic material. After globigerinids had evolved in the Middle Jurassic, they also became a major component of these sediments along with the tiny shells ("filaments") of the probably planctonic juvenile forms of the bivalve *Bositra*. The macrofauna mainly consists of crinoids and in some places very abundant brachiopods and ammonites. Strong condensation, Fe/Mn stained hardgrounds and deep-water stromatolites are frequent.
The type locality of Klaus Limestone - also nearby Hallstatt - and its ammonites have been reviewed by KRYSTYN, 1971. According to him the Klaus Limestone unconformably covers the Upper Norian Dachstein Limestone and contains an ammonite fauna indicating Late Bajocian.

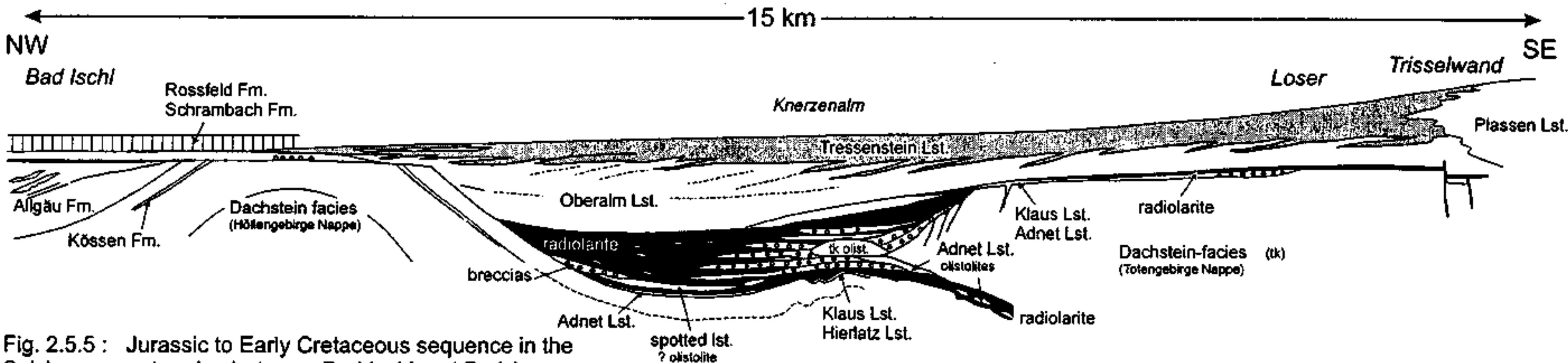

Fig. 2.5.5 : Jurassic to Early Cretaceous sequence in the Salzkammergut region between Bad Ischl and Bad Aussee, according to SCHÄFFER & STEIGER 1986.

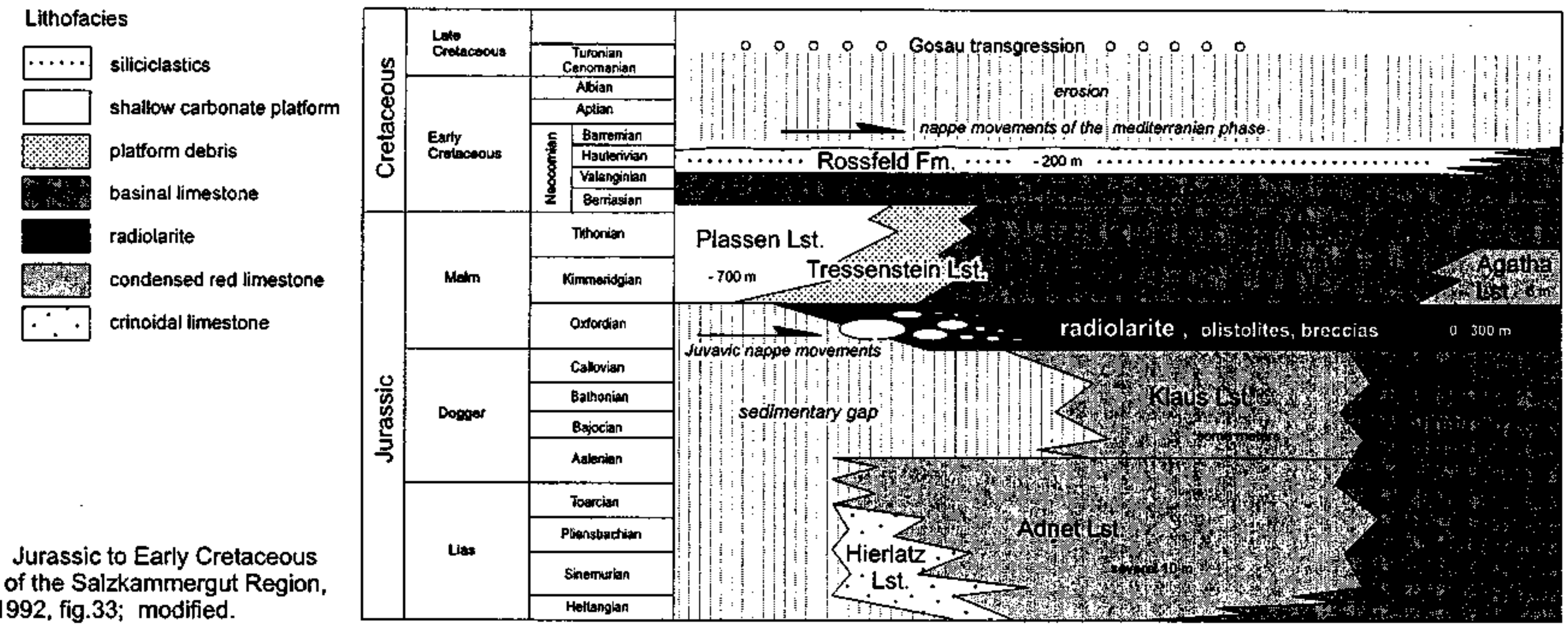

Fig. 2.5.6 : Jurassic to Early Cretaceous stratigraphy of the Salzkammergut Region, after BÖHM 1992, fig.33; modified.

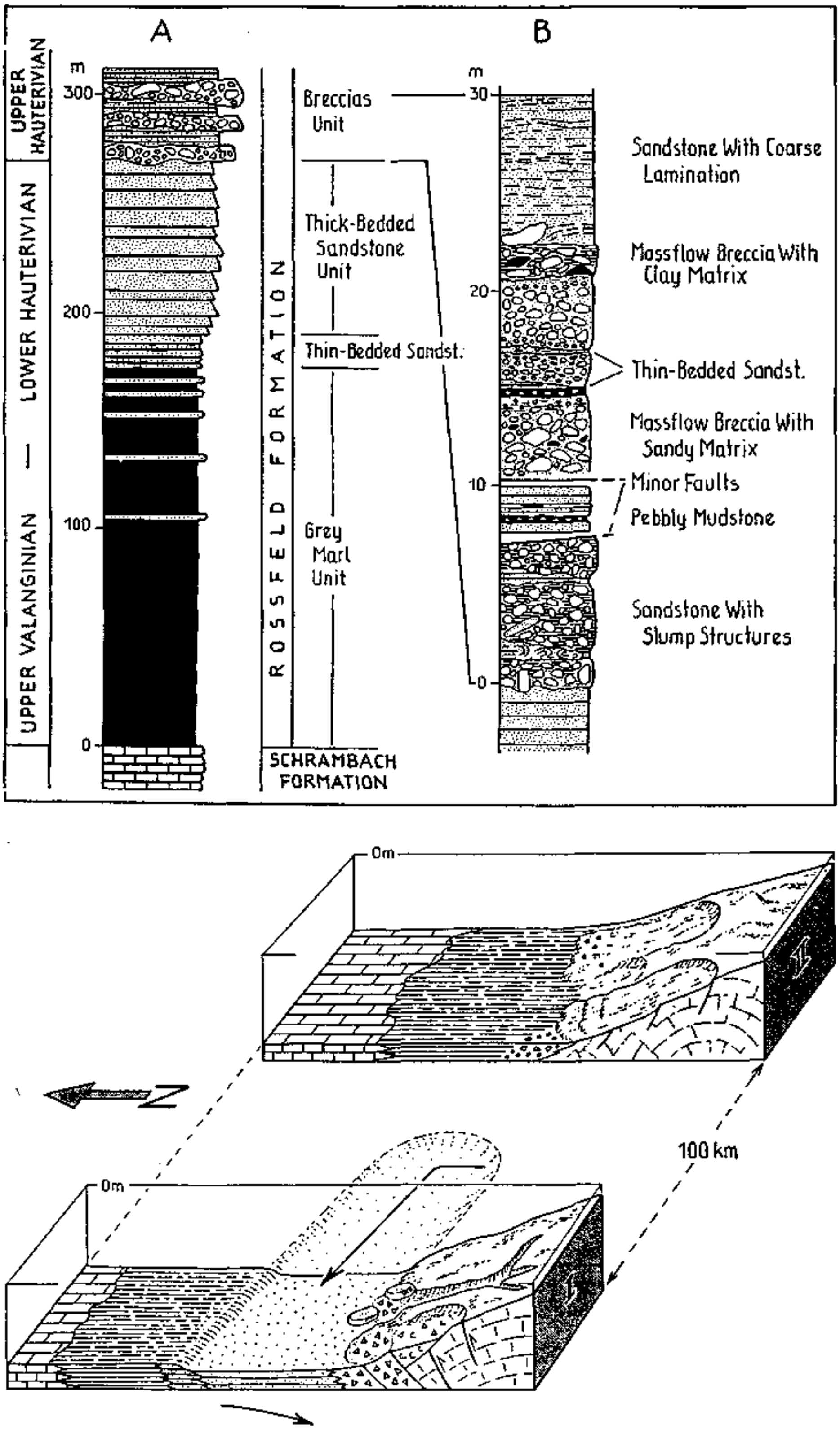

Fig. 2.5.7.: Lithology and depositional model of the Rossfeld Fm.
After DECKER, FAUPL & MÜLLER (1987).
A: Schematic profile at the Rossfeld area. Coarsening upward trend in front of advancing Juvavic nappes; B: Detailed section of the breccias unit.
Block diagramm of sedimentary environments (out of scale):
I: Locality Rossfeld area (west); II: Locality Reichraming area (east)

The greatest water depth has been reached in Oxfordian, characterized by widespread radiolarite deposits, the Ruhpolding Formation and equivalents (DIERSCHE, 1980). Contemporaneously breccias, olistolites and large sliding blocks occur as a consequence of the Juvavic gravitational nappe movements. This first pulse of alpine orogeny caused a new seafloor topography in the Late Jurassic. Especially above large Juvavic "sliding units" shallow water conditions led to the deposition of platform carbonates (Plassen Lst., Tressenstein Lst.) whereas pelagic limestones (Oberalm Lst.) have filled the basins in between (FENNINGER & HOLZER, 1972, STEIGER & WURM, 1980).
As indicated by microfossils, the facies of Late Jurassic carbonates persists into the Early Cretaceous. Deepening and increasing terrigenous input caused a gradual transition into the marly aptychus limestones of the Schrambach Formation. The terrigenous facies of the Rossfeld Formation replaced the deep water carbonates since the Late Valanginian (DECKER et al., 1987). The Rossfeld Fm. consists of grey marls, turbiditic sandstones and breccias partly associated with huge slide blocks. In the central NCA a coarsening and thickening-upward sequence is developed, while toward the northeast a transition into contemporaneous deep water limestones is preserved. At the Rossfeld area the synorogenic clastics filled a trench-like structure in front of the advancing nappes - see FAUPL & TOLLMANN (1979).
The deposition of the Rossfeld Fm. took place during the crustal shortening within the Austroalpine basement. This tectonic process caused an uplift of southern parts of the NCA, overthrusting of Juvavic Nappes and metamorphism in the Austroalpine crystalline nappes below. The clastic material of the Rossfeld Fm. is a mixture of two different kinds of components. The coarse grained material mainly consists of carbonates, derived from uplifting parts of the NCA (e.g. Hallstatt limestones from the south). In contrast to this locally derived material the sand sized components contain siliciclastics, including quartz, feldspar, chlorite and heavy mineral spectra with "exotics" as actinolitic amphibols, rare kaersutite and dominating chrome spinel. These constituents are derived from an ophiolitic belt situated south of the NCA, which is interpreted as the suture zone of the Late Jurassic orogenic front.

Late Cretaceous to Eocene sediments of the Gosau Group

Palaeogeographically the NCA were situated during Upper Cretaceous at the northern margin of the Apulian microplate within the western Tethys realm, facing toward the Penninic oceanic realm in the northwest.
During the Cretaceous orogeny the sedimentary succession of the Northern Calcareous Alps and their Palaeozoic substratum (Greywacke Zone) had been sheared off from their crystalline basement. North-verging folds, thrusts and nappe structures developed. The unconformable deposition of the Gosau-Group began after this tectonic event, sealing folds and thrust structures. A second phase of compressive deformation affected the NCA during the end of Eocene, terminating the sedimentation. Finally in Miocene large scale strike-slip movements dissected the whole nappe stack.
Today only relatively small remnants of the formerly widespread Late Cretaceous to Eocene sedimentary cover of the NCA are still preserved. As a consequence of the complex deformation history the paleogeographic relationships between individual Gosau occurrences are often obscured.
The Gosau-Group can be divided into two subgroups (WAGREICH & FAUPL, 1994): The Lower Gosau Subgroup comprises alluvial fan deposits passing into a shallow-marine

succession. Reviews of lithofacies and sedimentary environment are given by HERM (1977), BUTT (1981), POBER (1984), HÖFLING (1985), GRUBER (1987), WAGREICH (1988, 1989a,b), FAUPL et al. (1987) and LEISS (1988, 1990).
The Upper Gosau Subgroup is characterized by deep-water deposits. Descriptions of these sediments are given by HESSE & BUTT (1976), BUTT (1981), FAUPL (1983), ORTNER (1992), LAHODYNSKY (1992) and KRENMAYR (1999).
The thickness of the whole succession reaches up to 2500 m at the type locality, the area around the village of Gosau in the middle part of the NCA.
Despite the very early knowledge of rich macrofaunas in the sediments of the Gosau-Group the biostratigraphic framework for modern investigation is mainly based on planktonic foraminifera - e.g. HERM (1962), OBERHAUSER (1963), KOLLMANN (1964), WILLE-JANOSCHEK (1966), Butt (1981), WAGREICH (1988, 1992), - and calcareous nannoplankton - e.g. WAGREICH (1988, 1992), WAGREICH & KRENMAYR (1993).
In the Lower Gosau Subgroup, a zonal refinement has been attained by ammonite and inoceramid stratigraphy - e.g. SUMMESBERGER (1985), IMMEL (1987), TRÖGER & SUMMESBERGER (1994), SUMMESBERGER & KENNEDY (1996).
A comprehensive description of stratigraphy and facies was recently given by FAUPL, POBER & WAGREICH (1987), WAGREICH & FAUPL (1994), FAUPL & WAGREICH (1996), also including paleogeographic maps and geodynamic/palaeotectonic conclusions.
After a period of non deposition or erosion sedimentation has started diachronously from the Late Turonian onwards, see Figs. 2.5.8. and 2.5.9.
The Lower Gosau-Subgroup can be subdivided into 5 formations (WAGREICH, 1988):
The basal Kreuzgraben Formation consists of reddish conglomerates and subordinate sandstones and pelitic sediments. An alluvial fan environment can be reconstructed with debris flow and braided stream sedimentation. Within the lower part of the overlying Streiteck Formation several coarsening upward marl-sandstone-conglomerate cycles of a fan-delta facies are preserved. The cycles are interpreted as progradational sequences of a fan into a shallow marine environment to the south. The upper part of the Streiteck Formation indicates a deepening with sedimentation of marls with sandstones and fossiliferous beds. The Grabenbach Formation consists of marls of the middle to outer shelf with storm layers of sandstone. Within the following Hochmoos Formation a regressive tendency is observed, resulting in local fan-delta sedimentation. The sediments of the Bibereck Formation mark a renewed subsidence from the shelf to bathyal depth with turbiditic influence.
Heavy mineral studies indicate both local sources of detritus with apatite-turmalin-garnet and "exotic" source areas with chromian spinels.
During the Campanian, tectonic activities caused a considerable facies change. In some places striking unconformities can be observed. Simultaneously with this facies change a new spectrum of clastic material arrived, dominated by metamorphics. The source area was situated south of the NCA. K-Ar dating give evidence of its affection by early Alpine metamorphism. The Upper Gosau-Subgroup comprises deep-sea fan sequences - Ressen Formation, Zwieselalm Formation - deposited partly below the CCD, as well as a marl-dominated slope facies - Nierental Formation. South of the northward dipping slope - mainly outside of the NCA nappe-stack - a carbonatic shallow-marine shelf facies was developed, serving as a source of bio- and lithoclasts during Maastrichtian to Paleocene.
A special highlight in the investigation of the Gosau Group was the discovery of an undisturbed and complete sedimentary sequence of the Cretaceous/Tertiary boundary at the locality „Elendgraben" (PREISINGER et al., 1986). The outcrop in a steep creek exposes a more than 30 m thick sequence of flyschoid sediments of the Zwieselalm Formation. The sequence across the boundary consists of marly limestone and silty marl and is not disturbed by turbidites. The 2 mm thick boundary clay differs from the

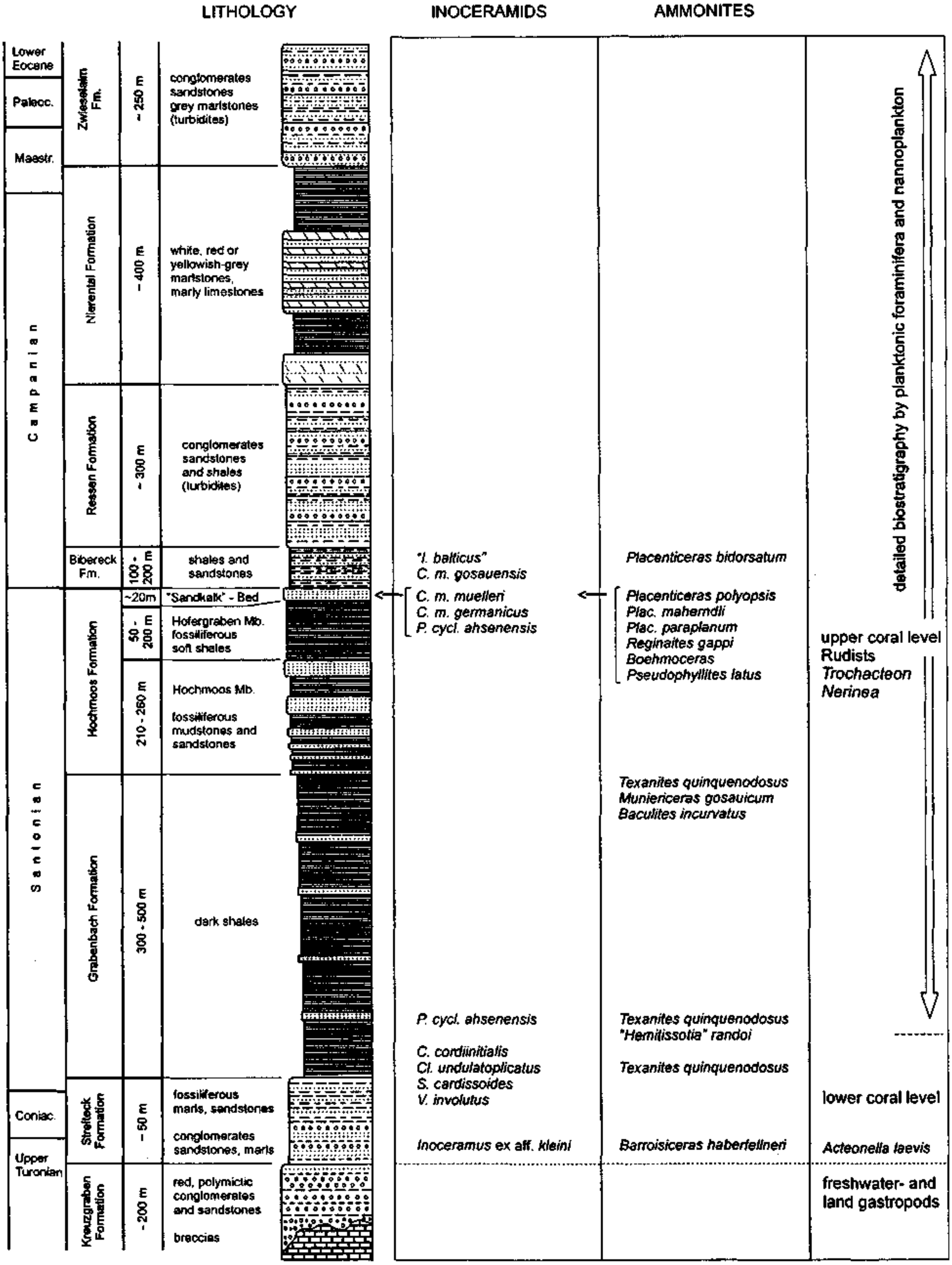

Fig. 2.5.8.: Idealized lithostratigraphic sequence of the Gosau-Group in the Gosau Basin according to KOLLMANN (1980). Fauna after SUMMESBERGER (1992), TRÖGER & SUMMESBERGER (1994) and SUMMESBERGER & KENNEDY (1996)

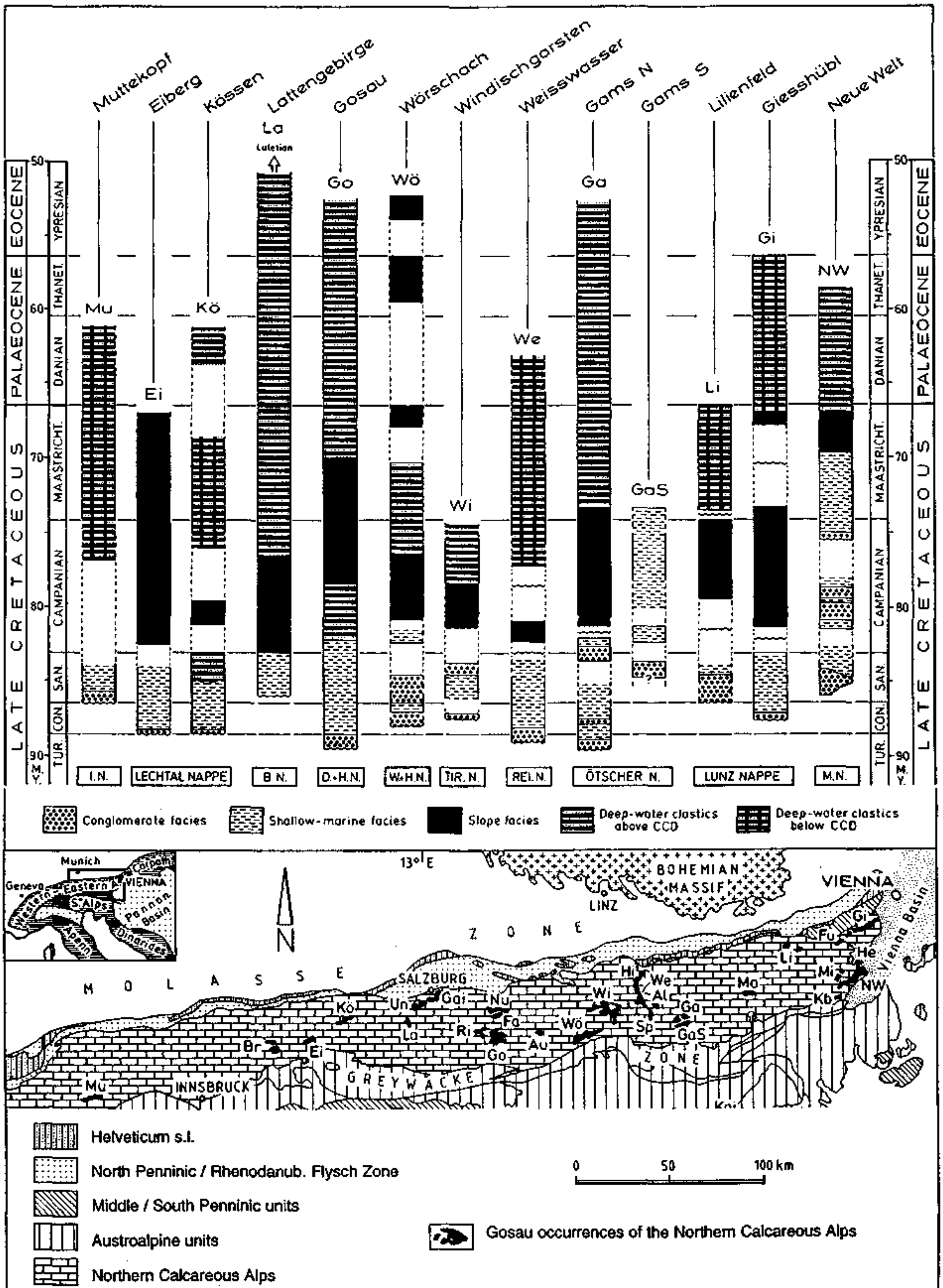

Fig. 2.5.9.: Selected lithological sections of the Gosau Group of the NCA (after FAUPL & WAGREICH, 1996)

surrounding sediment in having significant light-brown colour, no biogenic calcite, an enrichment of Ir, Cr, Co and Ni and a different content of rare-earth and siderophile elements, carbon and magnetic minerals. The clay also contains shocked quartz and plagioclase grains as well as glass particles. Micropalaeontological investigations have shown mass extinction of foraminifera and nannoplankton. All data fit to the impact-hypothesis of ALVAREZ et al. (1980).

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