4.2. Geological overview of the "Juvavic" Realm

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The uppermost tectonical elements of the Northern Calcareous Alps are traditionally summarized under the term Juvavicum (Juvavum was the Latin name of Salzburg). From our recent point of view they represent those parts of the Austroalpine distal shelf area, which became firstly detached from its basement during the Upper Jurassic („Eohellenic“ phase of Alpine Orogeny), caused by the plate-tectonical closure of the westernmost part („Hallstatt-Meliata ocean“) of the Tethys ocean. Repeated compressional tectonics affected the NCA additionally between Upper Neocomian to Eocene, large strike slipe faults dissected the nappe pile during the Miocene.

Due to this deformation history a complex pattern of tectonical units has been created in the Juvavic realm. The dissection of the Triassic sediments mainly has followed facies boundaries, often resulting in „unifacial“ tectonic bodies. Therefore especially the original configuration of platforms and basinal areas has been a matter of long lasting and controversial discussion.

Careful mapping of facies distribution within distinct tectonic units, accompanied by biostratigraphic control, has revealed a lot of information about general facies trends and the relation between different facies types. This polarity of facies can be used as a tool for palinspastic reconstruction.

The orientation of platform to basin transitions within the larger Juvavic units provides a frame for palinspastic restoration of the Juvavic realm. As shown in Fig. 2.5.4. all transitions from platform to open marine conditions are oriented in a similar manner, facing toward the south. A „Dual Shelf Model“ - as it has been proposed recently by some authors (KOZUR & MOSTLER, 1992, SCHWEIGL & NEUBAUER, 1997) - is in contradiction to the visible facies patterns and has to be rejected. If the Juvavic units would originate from an opposite southern shelf, separated from the Tirolic shelf by an ocean (Meliata realm), the Juvavic units should exhibit facies gradients of also opposite orientation.

The NCA represent the carbonatic shallow shelf area and its transition into deeper pelagic conditions - see Fig. 4.2.1. The adjacent oceanic realm seems not to be preserved in Austria to a larger extent. Only a few small "exotic klippen" of such an origin have been discovered - MANDL & ONDREJICKOVA, 1991,1993, KOZUR & MOSTLER, 1992. But the Triassic deep-water sediment (red radiolarite) is preserved there only as olistolites in a Jurassic matrix of dark shales and greenish radiolarite. Representatives of the Triassic oceanic crust are not proven. Candidates for such an origin are the tholeiitic pillow basalts and serpentinite fragments within the melange of Permian evaporites along the basal thrust-planes of several Juvavic nappes. Unfortunately we have no clear evidence of their extrusion age until now.

Toward the north the carbonatic NCA shelf changes into a siliciclastic one ("Keuper facies") which is represented today by the cover of metasediments of the Austroalpine crystalline nappes.

The tectonical detachment of the Triassic to Jurassic shelf sediments from their basement has started about the end of the Middle Jurassic ("Eohellenic phase"). Jurassic syntectonic clastics as well as the "sandwich" of Juvavic units demonstrate a first displacement from Hallstatt deeper shelf (Pötschen- and Salzberg-Facies) and gravitative transport onto and across the drowned Triassic shallow shelf. Rocks derived from the Meliata oceanic realm should have been mobilized also before oder during this phase. With time the detachment encroached on the Triassic platform margins and at last on the platforms themselves - creating the large „Upper“ Juvavic nappes like Dachstein or Mürzalpen nappe. These large

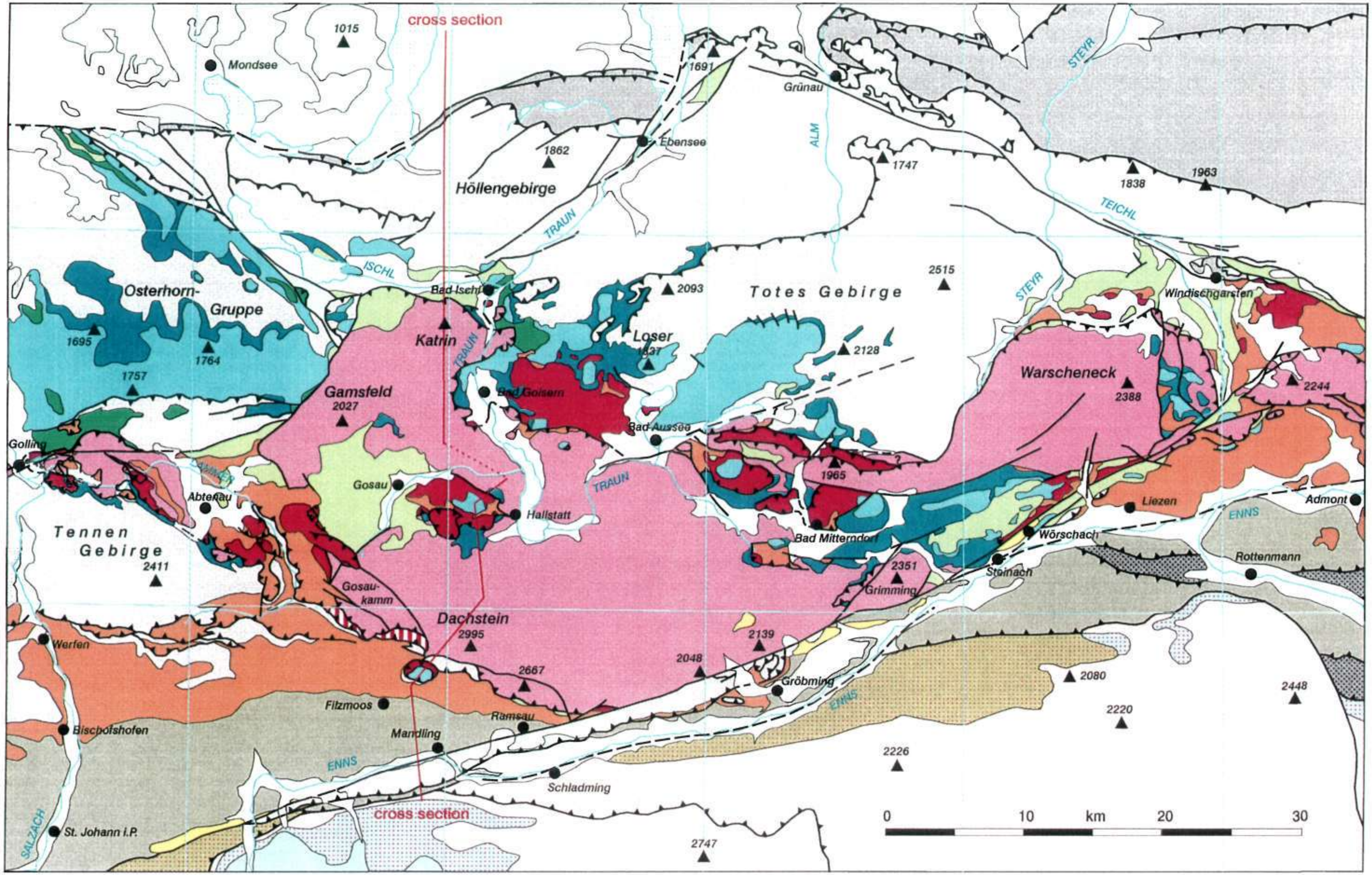

Fig. 4.2.1. : Geological map of the Salzkammergut Region.

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nappes carry tectonical outliers of Hallstatt facies on the one hand, on the other hand they have been transported onto similar Hallstatt outliers, resting in Jurassic basins of the future Tirolic nappes. Such a multiple stacking of triassic rocks of different depositional realms is a common feature of the Juvavicum, the time of stacking is restricted to the Ruhpolding Interval (Lowermost Upper Jurassic). After this first phase of intensive movements a period of tectonic quiescence lasted until Lower Cretaceous. The Juvavic units became covered by marine Upper Jurassic to Lower Cretaceous carbonate sediments of platform and basinal facies.
A next phase ("Austroalpine phase") of tectonics mobilized western parts of the Juvavicum again: the Dachstein nappe, the Reiteralm nappe and accompanied Hallstatt outliers have been transported onto the Upper Neocomian clastics of the Roßfeld trough, which contain also ophiolitic detritus (chromite). A subsequent uplift exposed large parts of the Eastern Alps to weathering and erosion before the Upper Cretaceous Gosau transgression. Intra- and Post-Gosau compressional tectonics and Miocene strike slip faults additionally affected the NCA nappe pile.

The Dachstein Nappe - an example for facies transitions from platform to basin in the Juvavic realm

The Dachstein Nappe represents a sector of the Triassic distal shallow shelf, bordering the open marine deeper Hallstatt shelf of the Tethys ocean. Along its southern rim transitions from platform to basin are preserved, which are used as connecting links in palinspastic models (SCHLAGER, 1967, LEIN, 1976, MANDL, 1984, 1987).
Anisian carbonates are followed after the Pelsonian drowning event by pelagic limestones (Reifling Lst., Hallstatt Lst.). The initial stage of Wetterstein carbonate platform growth is nowhere exposed, but progradation of the platform toward the basin during Ladinian to Lower Carnian is well preserved. Typical sedimentary features are reef breccias, platform derived massive to bedded allodapic limestones (Raming Limestone) and distal carbonate turbidites. Secundary dolomitization has affected large parts of the platform carbonates, especially the lagoonal interior.
During the Lower Carnian sea level drop the platform emerged. Framebuilding organisms (mainly calcisponges) became restricted to a narrow belt (Leckkogel Facies of the Reingraben Group) along the former platform slope, their detritus can be found within adjacent dark limestones and shales (FLÜGEL et al., 1978). As suggested by facies distribution and age data of superimposing strata the emerged platform has been exposed to a remarkable erosion, creating a relief of several 10 meters.
Sea level rise in the Upper Carnian led at first to lagoonal conditions (Waxeneck Lst.) mainly in local depressions of the eroded Wetterstein platform. Dolomites with relictic reef structures are thought to represent Waxeneck marginal reefs. Adjacent bedded dark dolomites with breccia layers and pelagic intercalations are interpreted as slope sediments of this interval. In the contemporaneous basin (Pötschen Limestone) breccias („Cidaris breccia“) of distal slope origin occur.
In the Uppermost Tuvalian a distinct transgressive pulse led to widespread pelagic conditions, covering the drowning platform. The prevailing relief caused a complex pattern of local reef patches, separated by depression, where massive micritic limestones have been deposited. They exhibit a mixture of components from the platform interior, of reef debris, crinoids and pelagic biogenes (ammonoids, conodonts, radiolarian, „filaments“). A

deeper depression (Plankenalm area) contains bedded allodapic limestones similar to Gosausee Limestone.
This initial stage of Dachstein platform growth has been rapidly terminated within the Middle Lacian by lagoonal limestones, the reefs became concentrated at the platform margin. The open platform situation changed into a rimmed platform configuration, characteristic for the Dachstein Facies:
The lagoonal platform interior exhibits cyclic bedded, inter- to subtidal „Lofer Facies“, which changes toward the north by an increase of intertidal dolomites into the Hauptdolomit Facies (FISCHER, 1964, ZANKL, 1971).
Back reef areas are showing massive to thick bedded limestones with ooids, oncoids and other coated grains, grapestones, algae and reef debris (sometimes black stained, „black pebbles“).
The massive reef limestone is composed of reef patches (frameworks built by calcisponges, corals, solenoporaceans and encrusting organisms) and bio-/lithoclastic debris. At the Gosaukamm reef breccias predominate (WURM, 1982).
Slope sediments are represented by the allodapic Gosausee Limestone (in literature mostly referred to as „Pedata Schichten“) which gradually passes into Pötschen Limestone of the basinal realm. Locally the terrigenous Rhaetian Zlambach Formation is preserved, onlapping and interfingering with the uppermost Dachstein Limestone.

The Central Salzkammergut Region - an example for facies diversity of the Hallstatt basinal realm.

Attention has been drawn to the variegated limestones of Hallstatt since the beginning of the research in the Northern Calcareous Alps (NCA) in the 19th century due to its local richness in cephalopodes; about 500 species have been firstly described from these strata. MOJSISOVICS´s ammonite chronology (Monographs 1873 to 1902) based on this fauna was widely used as a standard for Triassic time.
Despite this importance of Hallstatt limestones no general lithostratigraphy existed until SCHLAGER (1969). He established firstly a subdivision of the Hallstatt sequence based on distinct lithological features. Additionally work like reinvestigation of classical ammonite sites (KRYSTYN, SCHÄFFER & SCHLAGER, 1971), correlation of lithostratigraphy and conodont zonation (e.g. KRYSTYN, 1980) and studies on the lithological variability of Hallstatt sequences (e.g. MANDL, 1984) led to a picture shown (with some improvements) in Fig. 4.2.5.
It became also clearly visible, that the two subfacies types as there are Pötschen Facies (grey cherty limestones, marls, shales) and Salzberg Facies (variegated Hallstatt limestones) do not belong to two different nappes as suggeested in previous works. Lateral transitions between these subfacies can be demonstrated nearly at each stratigraphic level. Syndepositional blockfaulting and local uplift due to salt diapirism of the Permian evaporites are thought to be the reason for the differentiation into basinal areas and intrabasinal ridges with reduced sedimentation. Syndepositional faulting is well documented (SCHLAGER, 1969) by numerous sedimentfilled fissures at several stratigraphic levels at a scale of millimeters to some meters in width and up to 80 meters in depth, cutting down at a maximum from Sevatian red limestone into Anisian dolomites. Faulting is sometimes accompanied by block tilting and rotation, causing remarkable differences in sediment thickness of nearby sequences. Additionally the normal sequence can be superimposed by sedimentary gaps and discontinuities with breccias.

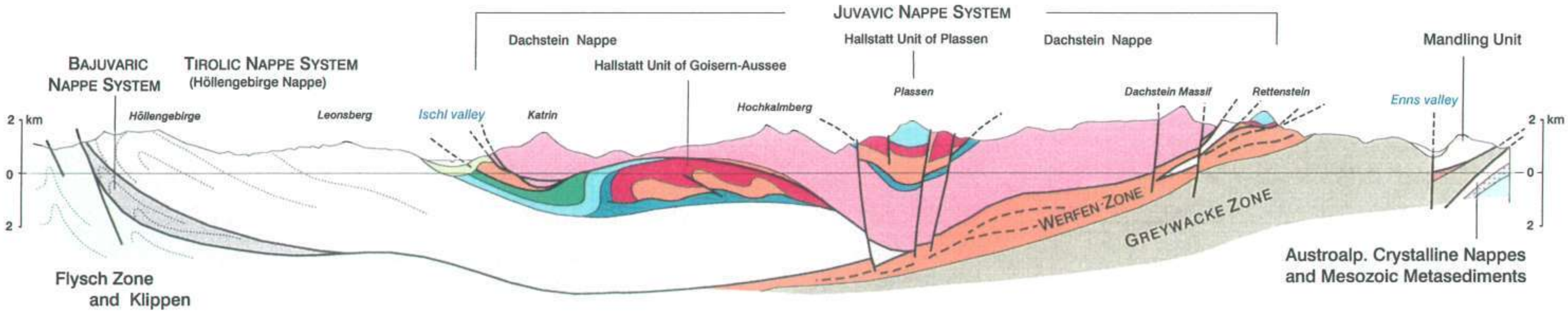

Fig. 4.2.2.: Cross Section of the Nappe System of the Northern Calcareous Alps in the Salzkammergut Region.

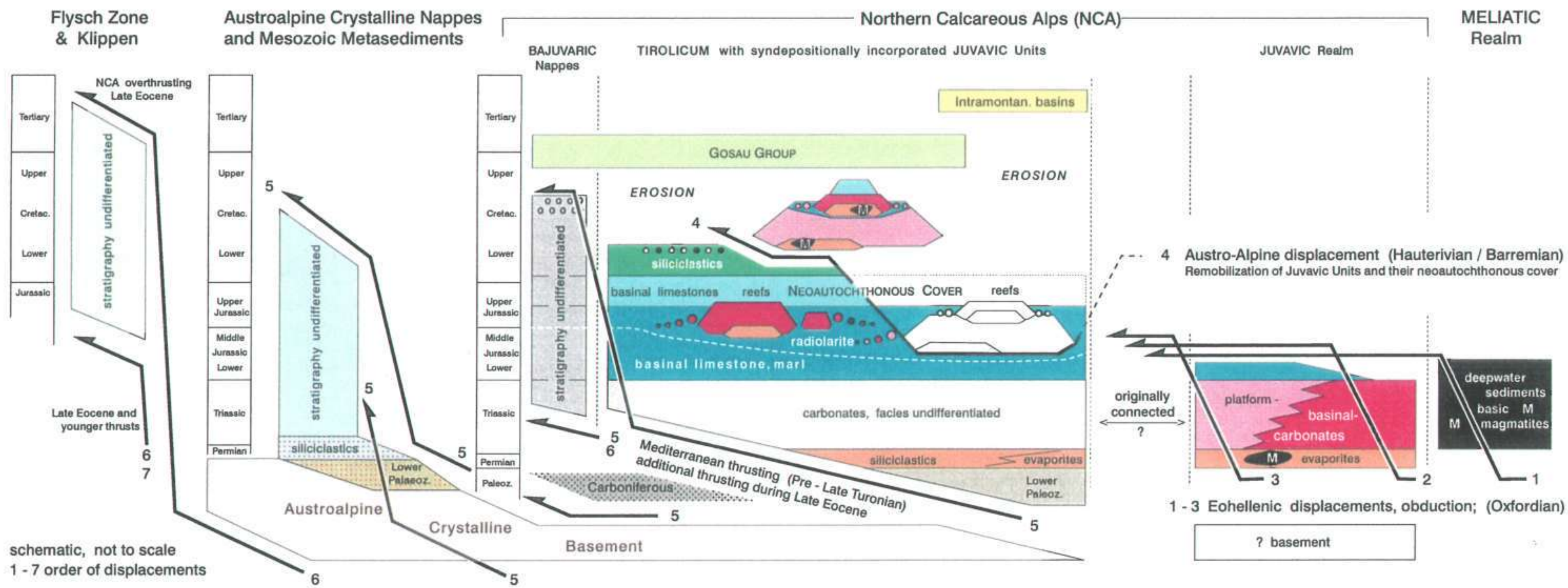

Fig. 4.2.3.: Interaction of sedimentation and tectonical displacements in the Middle Sector of the Northern Calcareous Alps.

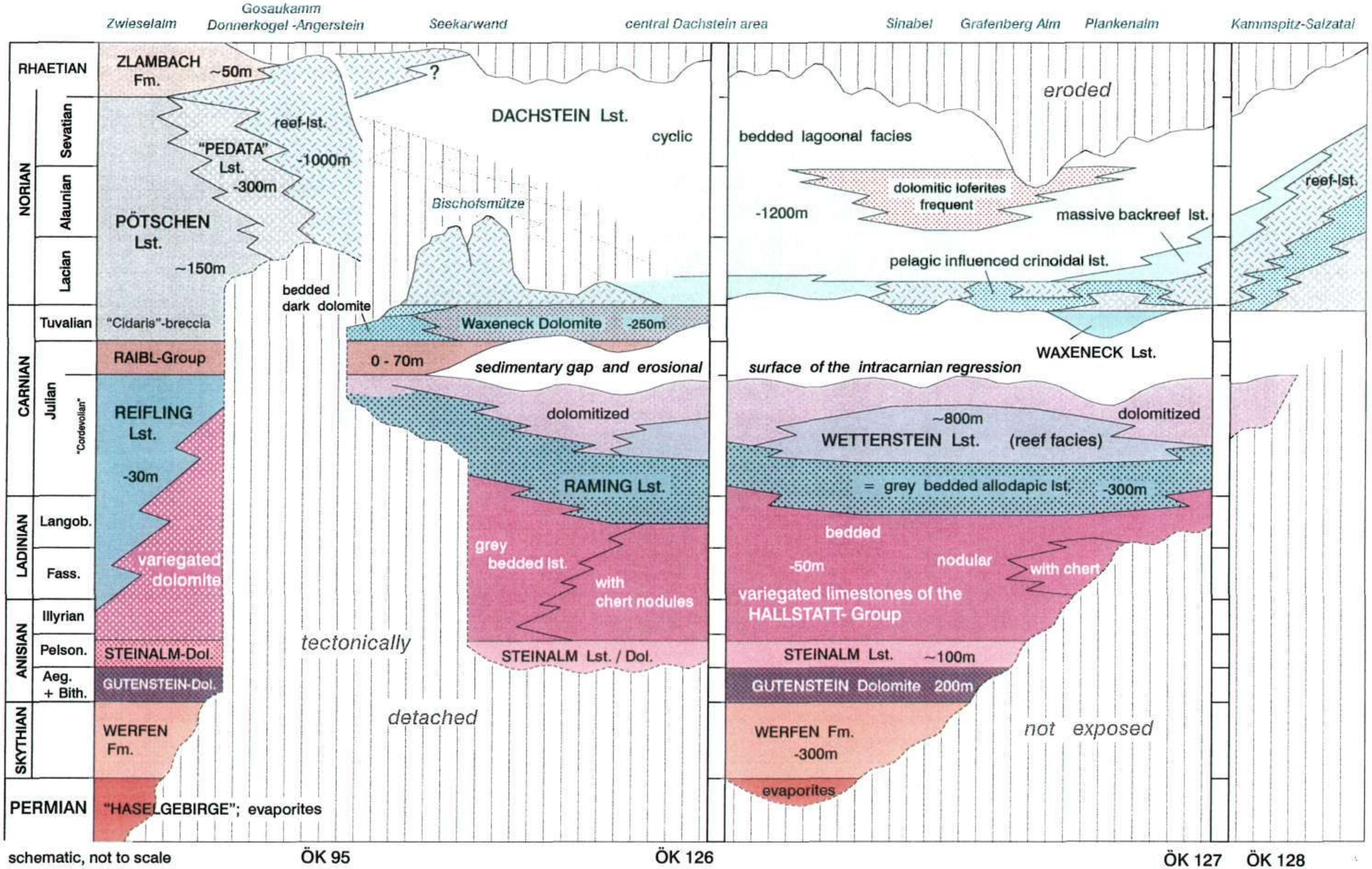

Fig. 4.2.4.:
Stratigraphy and Facies of the Dachstein Nappe (Triassic Carbonate Platform; Juvavic Nappe System)

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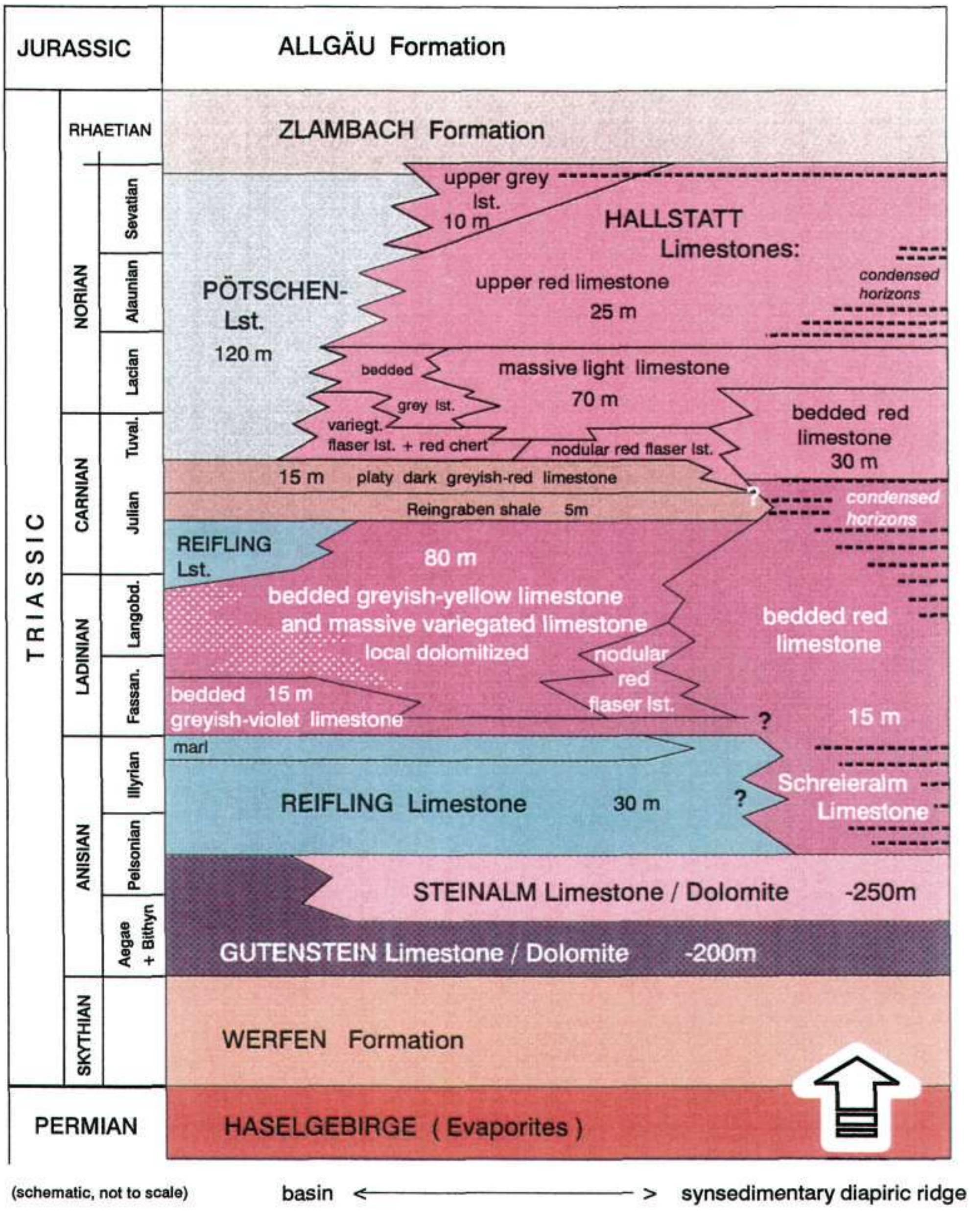

Fig. 4.2.5.:
Lithological diversity of the Hallstatt Limestone sequence,
according to MANDL 1984, modified. Numbers refer to maximal reported thicknesses.

The pelagic sedimentation of the Hallstatt Facies has started with the drowning of the Steinalm shallow platform (dasycladaceean limestone) during Pelsonian. This stratigraphic event is widespread also in other parts of the NCA. Grey cherty limestone (Reifling Lst.) represents the deeper basin, whereas red Schreieralm Lst. covers shallower horst structures; transitional types are not known yet. In Upper Anisian a marl horizon of a few meters in thickness is frequent in the basin.
Beginning with the Ladinian a characteristic lithological succession has developed which is repeated in a similar manner after the terrigenous Reingraben event also in the Upper Triassic: Within the basin the deposition of grey cherty limestones has continued (Reifling Lst. Pötschen Lst.); toward the ridges they pass laterally either via variegated cherty limestones into bedded red limestones or via bedded grey transitional types into light colored massive limestones. The red Hallstatt limestones, covering the top of the diapiric ridges, frequently show subsolution horizons and condensation. For example the thickness of the upper red limestone can be reduced within a lateral distance of 200 meters from about 25 meters to zero (KRYSTYN, SCHÄFFER & SCHLAGER, 1971).
The Lower Carnian Reingraben shales and accompanied platy limestones are missing in some profiles of red limestone. They are replaced there by thick ferromanganese crusts, containing condensed cephalopod faunas.
Most of the classical ammonite sites are situated in red limestones within layers with reduced sedimentation and subsolution. Beside the cephalopods certain lumachelle layers („styriaca beds", „monotis beds") can be used as lithostratigraphic as well as chronostratigraphic marker beds in the Lowermost and the Uppermost Norian.
The Hallstatt limestone sequence is terminated by increasing terrigenous input in the Uppermost Norian and Rhaetian (Zlambach marl). Lower to Middle Jurassic sediments (spotted marls of the Allgäu Formation) are preserved only at a few localities. Upper Jurassic radiolarite and limestones, resting on Hallstatt sequences, do not belong to the sequence in a strict sense, because they represent a matrix and a sealing „neoautochthonous" cover during and after displacement and gravitational transport of Hallstatt units during the Eohellenic (Oxfordian) tectonic event.

References

FISCHER, A.G.: The Lofer Cyclothems of the Alpine Triassic - Bull. geol. Surv. Kansas, 169, 107-149, 38 Abb., Lawrence 1964.

FLÜGEL, E., LEIN, R. & SENOWBARI-DARYAN, B.: Kalkschwämme, Hydrozoen, Algen und Mikroproblematica aus den Cidarisschichten (Karn, Obertrias) der Mürztaler Alpen (Steiermark) und des Gosaukammes (Oberösterreich). Mitt. Ges. Geol. Bergbaustud. Österr., 25, 153-195, 5 Abb., 1 Tab., 6 Taf, Wien 1978.

KOZUR, H. & MOSTLER, H.: Erster paläontologischer Nachweis von Meliaticum und Südrudabanyaicum in den Nördlichen Kalkalpen (Österreich) und ihre Beziehungen zu den Abfolgen in den Westkarpaten. - Geol. Paläont. Mitt. Innbruck, 18 (1991/92), 87-129, 1992.

KRYSTYN, L.: *Triassic conodont localities of the Salzkammergut Region*. - Abh. Geol. B.-A., 35, 61-98, Wien (Geol. B.-A), 1980.

KRYSTYN, L., SCHÄFFER, G. & SCHLAGER, W.: Über die Fossil-Lagerstätten in den triadischen Hallstätter Kalken der Ostalpen. - N. Jb. Geol. Paläont. Abh., 137/2, 284-304, Stuttgart, 1971.

LEIN, R.: Neue Ergebnisse über die Stellung und Stratigraphie der Hallstätter Zone südlich der Dachsteindecke. - Sitzber. österr. Akad. Wiss., math.-natw. Kl, Abt. I, 184 (1975), 197-235, 6 Abb., Wien 1976.

MANDL, G.W.: Zur Trias des Hallstätter Faziesraumes - ein Modell am Beispiel Salzkammergut (Nördliche Kalkalpen, Österreich). - Mitt. Ges. Geol. Bergbaustud. Österr., 30/31, 133-176, 5 Abb., 5 Taf., 8 Beil., Wien 1984.

MANDL, G.W.: Zur Tektonik der westlichen Dachsteindecke und ihres Hallstätter Rahmens (Nördliche Kalkalpen, Österreich). - Mitt. österr. geol. Ges., 77 (1984), 1-31, 7 Abb., 1 Taf., Wien 1984.

MANDL, G.W., HOLZER, H.L., LOBITZER, H. & PIROS, O.: Das kalkalpine Stockwerk der Dachstein-Region. - [In:] MATURA, A.: Arbeitstagung der Geologischen Bundesanstalt 1987, Blatt 127 Schladming, 168 S., 57 Abb., Wien (Geol.B.-A.) 1987.

MANDL, G. & ONDREJICKOVA, A.: Über eine triadische Tiefwasserfazies (Radiolarite, Tonschiefer) in den Nördlichen Kalkalpen - ein Vorbericht. - Jb. Geol. B.-A., 143/2, 309-318, Wien 1991.

MANDL, G. & ONDREJICKOVA, A.: Radiolarien und Conodonten aus dem Meliatikum im Ostabschnitt der Nördlichen Kalkalpen (Österreich). - Jb. Geol. B.-A., 136/4, 841-871, Wien 1993.

SCHLAGER, W.: Fazies und Tektonik am Westrand der Dachsteinmasse (Österreich) II. - Mitt. Ges. Geol. Bergbaustud. Wien, 17 (1966), 205-282, 8 Abb., 3 Taf., Wien 1967.

SCHLAGER, W.: Das Zusammenwirken von Sedimentation und Bruchtektonik in den triadischen Hallstätterkalken der Ostalpen. - Geol. Rdsch., 59/1, 289-308, Stuttgart 1969.

SCHWEIGL, J. & NEUBAUER, F.: Structural evolution of the Northern Calcareous Alps: Significance for the Jurassic to Tertiary geodynamics. - Eclogae geol. Helv., 90(1997), 303-323, Basel 1997.

WURM, D.: Mikrofazies, Paläontologie und Palökologie der Dachsteinriffkalke (Nor) des Gosau-kammes, Österreich. - Facies, 6, 203-296, Taf. 27-41, 32 Abb., Erlangen 1982.

ZANKL, H.: Upper Triassic Carbonate Facies in the Northern Limestone Alps. (In:) Müller, G. (ed.): Sedimentology of Parts of Central Europe, Guidebook, 147-185, 20 Abb., 1 Tab., Frankfurt 1971.