Field Trip B

TRIASSIC CONODONT LOCALITIES OF THE SALZKAMMERGUT REGION
(Northern Calcareous Alps)

By

L. KRYSTYN

with contributions from B. PLÖCHINGER & H. LOBITZER

16 figures and plates 11–14

A contribution to Project „Triassic of the Tethys Realm“

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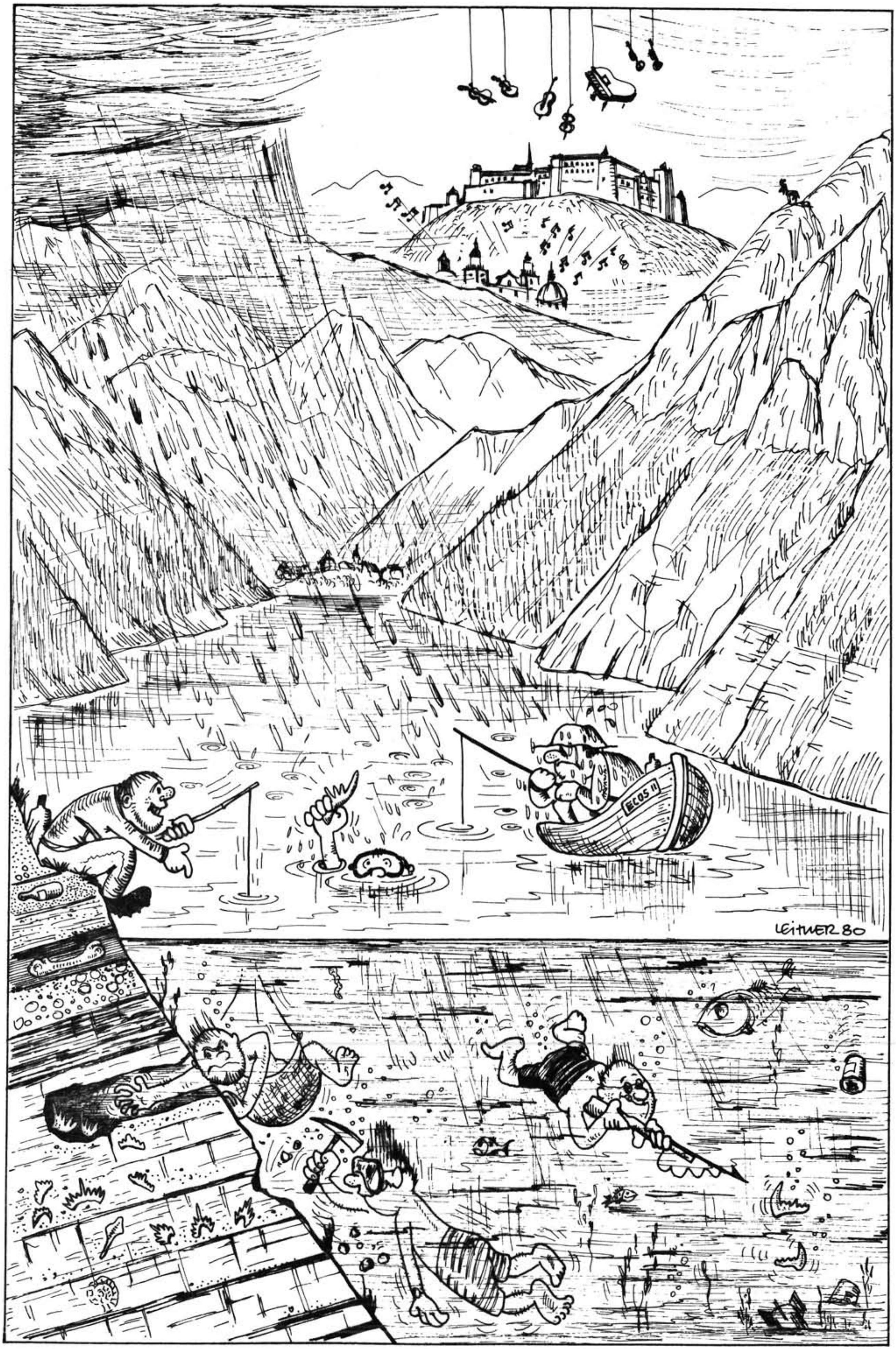
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The Salzkammergut and its geological setting within the Northern Calcareous Alps

By

B. PLÖCHINGER (Geological Survey of Austria)

A short introduction describes the geology of the Northern Calcareous Alps (N. C. A.) and the tectonic position of the Salzkammergut area situated in the central part (figs. 1, 2). Fig. 3 summarizes the stratigraphy of the N. C. A. with special reference to the Hallstatt facies development which will be shown during the excursion.

The Northern Calcareous Alps form a zone 500 km in length and 40–50 km wide, situated between the Central Alps and the Grauwacken Zone in the south and the Flysch and Molasse Zones in the north (fig. 1). The Permomesozoic series of the N. C. A. were deposited in an Austroalpine realm formerly si tuated south of the Penninic realm; rocks of the latter are now culminating in the Hohe Tauern mountain range. In the Cretaceous and early Tertiary the N. C. A. and the underlying Paleozoic Grauwacken Zone were sheared off from the crystalline basement and thrust towards north. Consequently, no basement rocks can be found underneath the Grauwacken Zone which in turn is only partly preserved along the southern margin of the N. C. A.

During the Triassic and Jurassic early crustal movements occurred. The movements of Jurassic (Younger Kimmeridge Phase) and Lower Cretaceous (pre-Austrian or Austroalpine Phase) may have increased submarine salt diapirism and with it the formation of submarine ridges with Hallstatt facies. These ridges are responsible for the formation of olisthostromes with components of Hallstatt facies and olistholites of Hallstatt facies.

Cenomanian sediments of the Northern Calcareous Limestone realm transgressed after intense folding and formation of slices during the pre-Cenomanian Austric Phase. The Gosau Formation disconformably overlies slices and nappes of pre-Coniacian age. During the Senonian and Lower Tertiary the nappe transport towards north continued. These movements reached a climax during the Lower Tertiary Illyric-Pyrenaic Phase or Pyrenaic-Savic Phase in an en bloc northerly thrust of the calcalpine nappe pile onto the Flysch and Helvetic Zones. An excellent example illustrates this situation in the tectonic Window of Lake Wolfgang (Province of Salzburg) where along thrust planes rocks of the basalmost Ultrahelveticum and those of the Flysch Zone are exposed within the Northern Calcareous Alps.

During the Upper Tertiary the old thrust planes were rejuvenated and formation of slices and folding reoccurred. This was the time when the present day exposed N. C. A. became a mountain chain.

The Salzkammergut of Salzburg, Upper Austria, and Styria, with its famous salt mines, is part of the central section of the N. C. A. There the nappes of the tectonically lower „Bajuvaricum" are reduced by the far to the north reaching „Tyrolicum", a higher tectonic unit („Tirolischer Vorstoß of Staufen-Höllengebirgsdecke").

Within the Tyrolicum, forming a huge synform, the „Lower Juvavicum" (Hallstatt zones and Hallstatt Deckschollen with their distinct facies), and the „Upper Juvavicum" (Berchtesgaden or Reiteralm nappe and Dachstein nappe, both supposed to be transported over long distances towards the north) are embedded.

According to J. NOWAK (1911), F. F. HAHN (1913) and E. SPENGLER (since 1914) the Hallstatt outliers originated south of the realm of the Dachstein Limestone, i. e., south of the higher Juvavic Dachstein massif. In contradiction, E. HAUG (1908) placed the roots of these outliers between the Toten Gebirge nappe and the Dachstein nappe. This idea was followed by L. KOBER (1927), W. MEDWENITSCH (since 1949), A. TOLLMANN (since 1960), L. KRYSTYN & W. SCHÖLLNBERGER (1972), U. PISTOTNIK (1975).

Following E. MOJSISOVICS (1903) modern geologists assume channel like Hallstatt throughs („Hallstätter Kanäle") which are located between the sedimentation areas of Hauptdolomite, Dachstein Lst. and Dachstein reef limestone, e. g., in the Zlambach-Grundlsee area of the Upper Austrian – Styrian Salzkammergut (Zlambach unit), in the zone of Torrener Joch–Lammer valley–Zwieselalm area (Lammer unit), on the southern side of the Dachstein massif, in the Mandling slice, and in the Blühnbach valley (H. ZANKL 1962, 1967; V. HÖCK & W. SCHLAGER 1964; W. SCHLAGER 1967, A. TOLLMANN 1976, R. LEIN 1976). The existence of the Sandling nappe of A. TOLLMANN, previously described as upper Hallstatt nappe and derived from the southern Hallstatt channel, however, is more and more doubted because of the interfingering of rocks of basinal and ridge facies (G. SCHÄFFER 1973, 1976, U. PISTOTNIK 1974). The mechanism of intra-Jurassic emplacement of the Lammer unit is still under discussion.

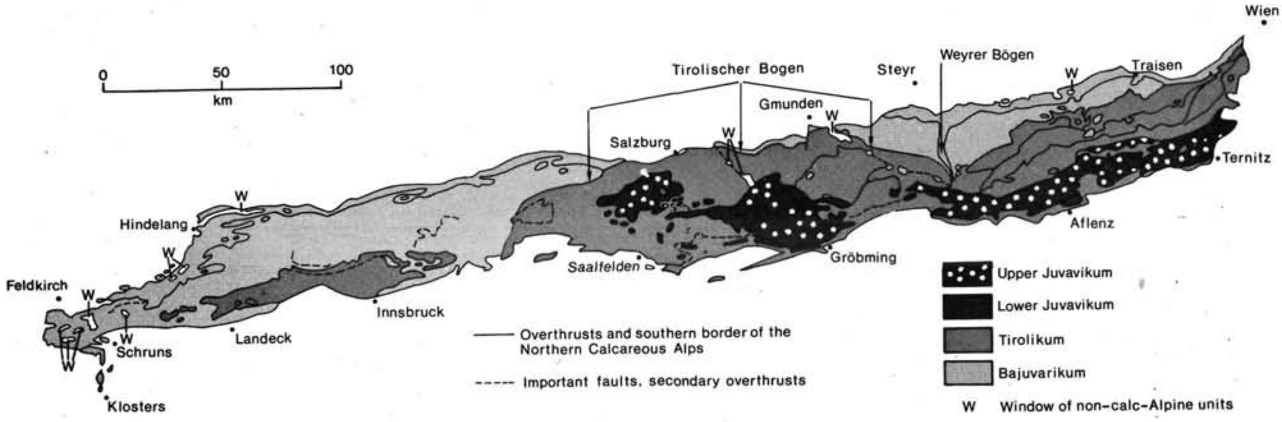

Fig. 1: Sketch of the main tectonic units of the Northern Calcareous Alps (after A. TOLLMANN, 1976, simplified; from W. JANOSCHEK & A. MATURA, 1980).

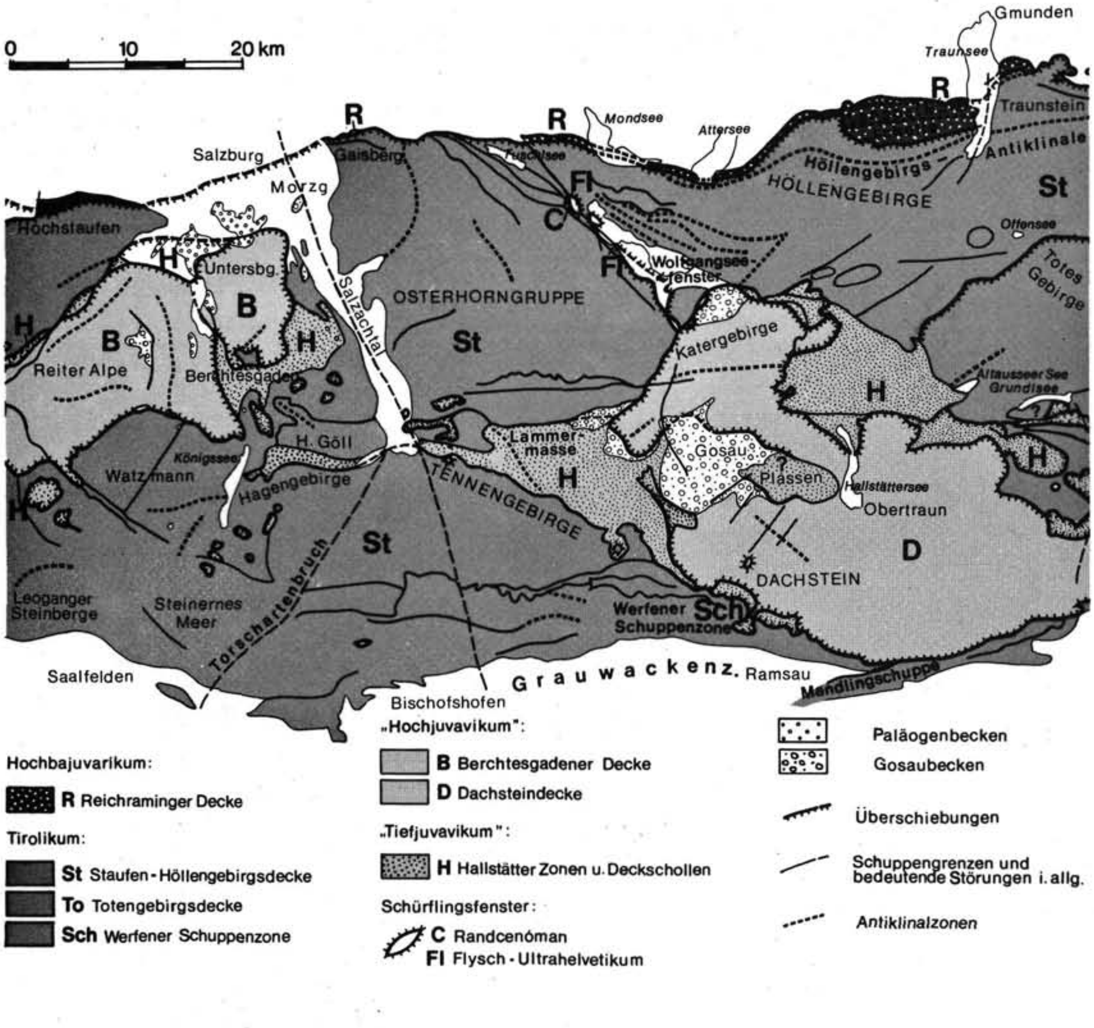

Fig. 2: Tectonic map of the Salzkammergut and surrounding regions (from B. PLÖCHINGER, 1980).

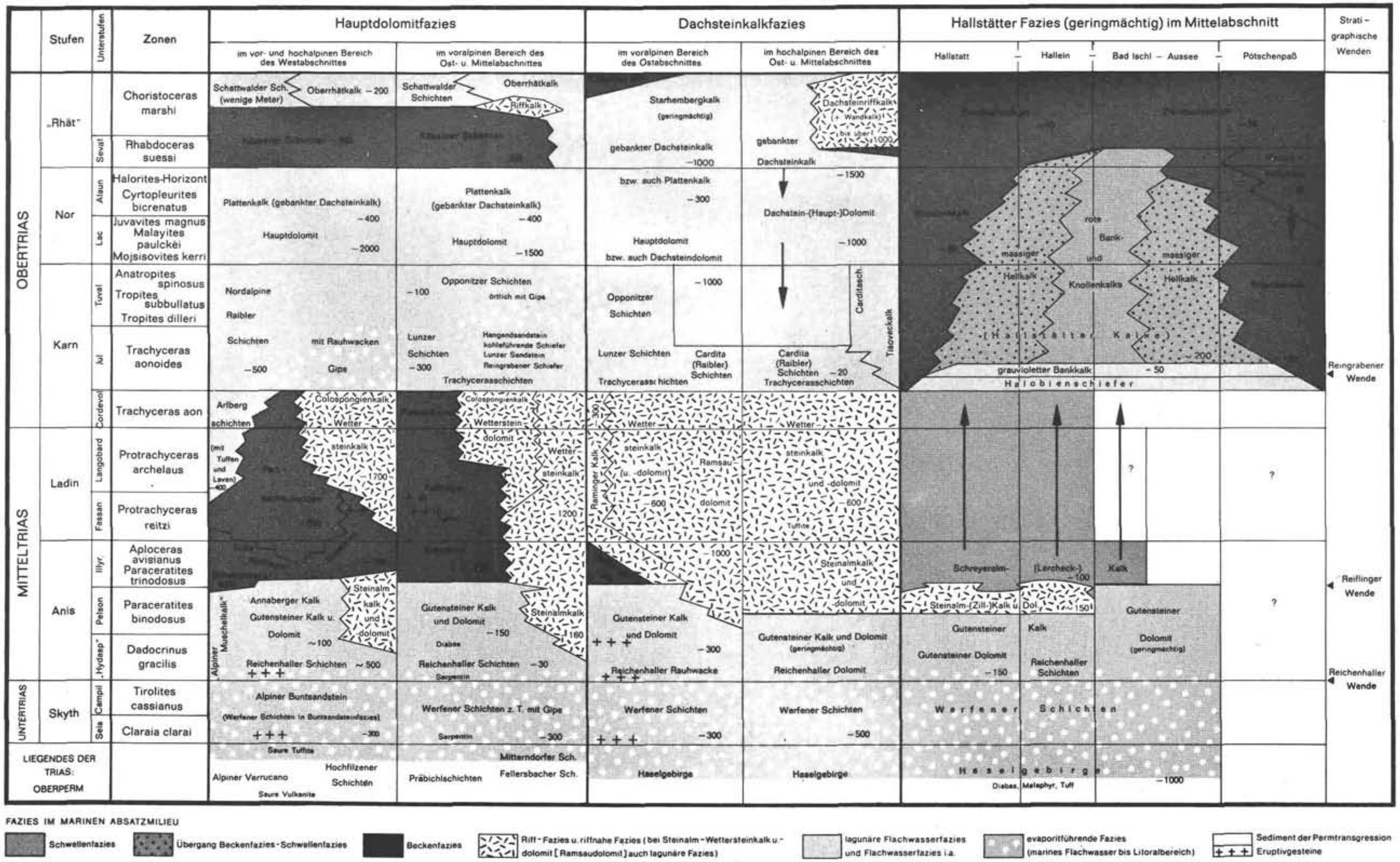

Fig. 3: Permo-Triassic stratigraphy of the Northern Calcareous Alps (from B. PLÖCHINGER, 1980).

According to G. SCHÄFFER (1976), E. HAUG and L. KOBER, the Plassen mountain next Hallstatt (considered by A. TOLLMANN 1976 as part of the Sandling nappe following E. SPENGLER's idea) forms a window of the Hallstatt zone of the Upper Austrian Salzkammergut. The overlying Dachstein nappe is disconformably plombed by a sedimentary breccia of middle Liassic age (G. SCHÄFFER 1976); hence, a pre-middle Liassic emplacement can be inferred. After G. SCHÄFFER the Dachstein Limestone shelf environment was situated north of the Hallstatt sedimentation area.

Almost unanimously accepted has been a long distance transport of the Hallstatt outliers in the area of Hallein-Lofer south and southwest of the city of Salzburg (O. AMPFERER 1936, W. E. PETRASCHECK 1947, B. PLÖCHINGER 1955, 1976, 1977, H. PICHLER 1963, W. DEL NEGRO 1970, 1977, 1979). Following new evidences two phenomena must be distinguished:

(1) Hallstatt outliers which glided into a basin as intra-Jurassic olistholits, e. g., the „Gleitscholle" at Guthratsberg south of St. Leonhard in the Salzach valley or the outlier east of the town Golling, and probably together with it the continuous Hallstatt zone of Hallein-Berchtesgaden (B. PLÖCHINGER 1976, 1977, 1979, 1980, p. 248, 260, prof. 7, 8; W. DEL NEGRO 1979, p. 22, 23, fig. 23);

(2) Outliers which were emplaced in the post-Neocomian, e. g., outliers in the Rossfeld and Lofer area or the outlier of Grubach-Grabenwald east of the village Kuchl in the Province of Salzburg.

Submarine salt diapirism may have been the main cause which led to the formation of submarine rises with Hallstatt sediments and gliding processes. This can be concluded from mudflow breccias in rocks of Tithonian to Berriasian age of the Hallein area rich in components of Hallstatt facies, particularly in Upper Permian „Haselgebirge".

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History of geologic research in the Salzkammergut

By
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The stratigraphy of the Alpine Triassic mainly is based on the publications by F. v. HAUER (1853) and subsequent papers by E. v. MOJSISOVICS (1873–1902): 1892: Hallstatt Zone. Presently a revision of stratigraphic type localities and ammonites is carried out by L. KRYSTYN and E. T. TOZER caused by the discovery of G. SCHÄFFER and W. SCHLAGER (e. g. 1969), that most of the fossil accumulations are either due to synsedimentary tectonic fissures or to faunal condensation, the latter caused by periods of minimum sedimentation. The tectonic fissures show evidence of repeated opening (W. SCHLAGER, 1969). Some of the fissures cut through the whole sequence of Hallstatt Limestone (e. g. fissures with Norian sediments in Anisian Hallstatt Limestone!).

Maybe as a consequence of the beautiful countryside as well as of the most complicated geology of Salzkammergut area the „Hallstatt-Zone" became a „punching-ball" for generations of sediment geologists and of tectonic speculations. In the early phase of research (between approximately 1802 – marked by L. v. BUCH's monography – and 1903, the year of the IX. International Geological Congress in Vienna) stratigraphic problems of the Alpine Mesozoic were the main goal, but also considerations regarding the bathymetric conditions, the geometry of depositional environments and lithogenesis were made. In the years 1797–1799 L. v. BUCH travelled jointly with A. v. HUMBOLDT in the Salzkammergut area (L. v. BUCH, op. cit.). The first results of the investigations of the red colour of the limestones, of the age and environmental conditions of the salt deposits and of the origin of stratification were published. The unrivalled genius of the Austrian geologists E. SUESS (1888) gave already an explanation for the bedding resp. cyclicity of Dachstein Limestone, i. e. cycle emerging and subsequent weathering of the bedding planes – a simplified model for the „Lofer cyclothems" (A. G. FISCHER, 1964). A study by E. v. MOJSISOVICS (1874) represents an early attempt of facies zoning in Salzkammergut area. E. v. MOJSISOVICS (1903) in one of his last papers summarizes his ideas of the paleogeographic position of Hallstatt zone. He postulates an in situ position (sediments of Hallstatt type deposited in channels („Hallstätter Kanäle") cutting through the reefoid Dachstein Limestone barrier resp. platform). One year later the fateful paper by E. HAUG & M. LUGEON (1904) marks a fundamental break through in the history of geological research in Salzkammergut area: the concept of nappe-tectonics was established. In the sequel the „nappists" entered into competition with the „autochthonists". L. KOBER and his school (e. g. W. MEDWENITSCH, A. TOLLMANN up to a few years ago, and others) plead for an extreme nappism. On the other hand C. DIENER, K. LEUCHS, F. TRAUTH and in modern time H. ZANKL and especially W. SCHLAGER and his group followed the autochthonous concept of E. v. MOJSISOVICS (1903) in modified versions. The present author tends to accept this concept, too.

It would exceed the scope of this paper to enumerate all the famous people doing research in this area in the past century and the interested reader can refer to the book by A. TOLLMANN (1976) for this purpose or to the short review by W. JANOSCHEK & A. MATURA (1980) respectively.

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Stratigraphy of the Hallstatt region

By

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Introduction

Our excursion deals mainly with the Hallstatt Limestone development and its conodont fauna.

In the Hallstatt facies belt sedimentation started in the Upper Permian which is represented by clastic and evaporitic rocks known as „Haselgebirge". During the Lower and Middle Triassic shallow water limestones and dolomites dominated. Sandwiched between these carbonates of mainly Anisian age and clastic sediments of the Upper Norian/Rhaetian Zlambach Fm. the Hallstatt Lst. is placed. Stratigraphically the Hallstatt Lst. spans the time from Upper Anisian (Illyrian) to Upper Norian (Sevatian).

The Triassic of the Northern Calcareous Alps is characterized by several main facies zones which from N to S reflect an increasing open marine environment. The greater part of the Calcareous Alps comprises thick cyclic shallow water carbonates; in the Lower and uppermost Triassic they can be replaced laterally by pelitic basinal sediments. Particularly in the Upper Triassic the original transition from lagoonal deposits (so-called Hauptdolomit-Fazies) to normal saline intertidal Dachstein Lst. with large „barriere reefs" (Dachstein Reef Lst.) in the south can be traced although most of these blocks were strongly affected by Alpine nappe tectonics. In this paleogeographic restoration the pelagic fossiliferous Hallstatt Lst. presumably were located on the outer (?) shelf edge. However, they may have been deposited on an oceanic crust too as can be inferred from their connection with oceanic basement rocks (pillow lavas etc.) in the Eastern Tethys realm, e. g., in Greece and Turkey.

Although it has been known for more than a century that the Hallstatt Lst. ranges from the Anisian to the Norian the representation and extent of the individual stages has been a matter of a long discussion. For example, as concern the Ladinian Stage, a stratigraphic gap was assumed not only in the last century but also 10 years ago. The main reason for this conclusion was actually the poor representation of Ladinian faunas. Also, detailed sections were missing for comparison of the mostly isolated Hallstatt Limestone occurrences. The ammonite chronology of MOJSISOVICS was thus based more on phylogenetic considerations and less on biostratigraphic study of certain sections.

The zonal concept of MOJSISOVICS was widely used as a standard until recent times. On the other side it was very much disputed and even questioned very early (KITTL 1903, p. 16; ARTHABER 1906; SPENGLER 1919, p. 307). Finally, it was revised by TOZER 1965, 1967 and SILBERLING & TOZER 1968.

Biostratigraphy

The fauna of the Hallstatt Lst. consists of an abundant and diversified cephalopod fauna (orthoceratids, nautiloids, ammonoids), gastropods, bivalves (in particular of halobiids), brachiopods, crinoids, and even a few occurrences of corals. For detailed stratigraphic studies ammonoids, conodonts, and halobiids are most important. The microfauna includes conodonts, foraminiferas, sponge spicules, radiolaria, floating crinoids and holothurian sclerites.

The megafauna is concentrated in laterally limited thin layers („Lager"). Generally, the Hallstatt Lst. is more or less poor in fossils with the exception of conodonts which occur in almost every sample. The megafossil bearing „lenses" are either distinct beds or they are infillings of tectonic fissures which cut deep into the underlying limestone. According to WENDT 1971 cross cuttings and those which are parallel to bedding planes can be distinguished, the latter often hardly recognizably.

Individual zones established by MOJSISOVICS were founded on such fissure fillings and thus explain some of the mistakes of his zonal sequence.

The equivalent of the Anisian Stage is particularly fossiliferous in the surroundings of Hallstatt (Schreyeralm, Schiechlinghöhe). In that area the cephalopod fauna comprises some 20 genera (MOJSISOVICS 1882, DIENER 1901). Middle and Upper Anisian (Binodosus Zone, Trinodosus Zone) and probably also lowermost Ladinian (ASSERETO 1971) is indicated by representatives of the genera *Acrochordiceras, Paraceratites* and *Anolcites.* In other regions of the Salzkammergut proper megafossils of Anisian age have not been found at any other place yet.

As far as ammonoids are concerned the situation is comparable in the Ladinian. Due to the „Hornstein" limestone facies (Grauvioletter Bankkalk) megafossils are completely lacking in the Lower Ladinian. Upper Ladinian is represented by newly collected and undescribed *Protrachyceras pseudoar-*

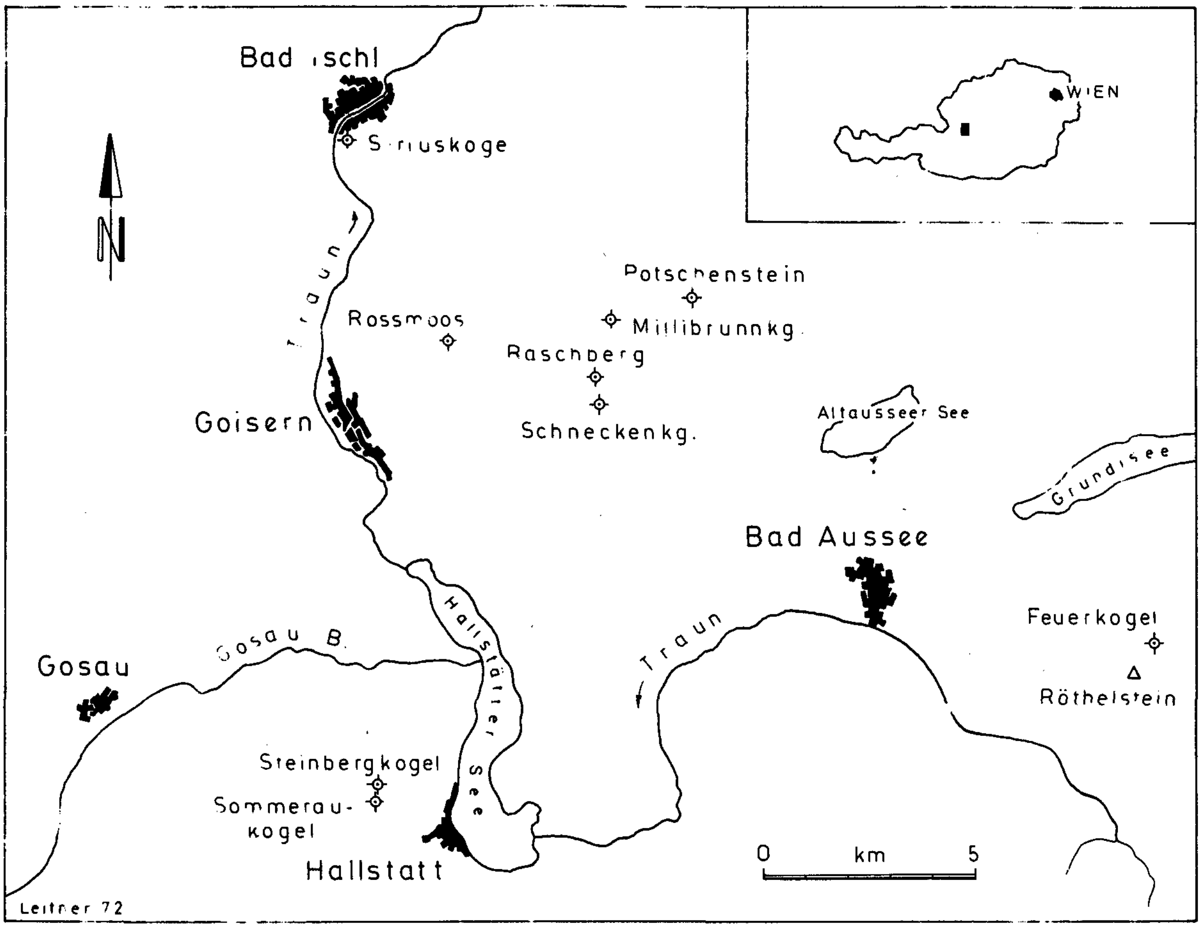

Fig. 4: Index map of Salzkammergut showing location of Hallstatt Limestone outcrops mentioned in text.

chelaus (BOECKH) and *Sturia sansovinii* MOJS. from Sommeraukogel resp. *Sturia* sp. and *Daonella lommeli* from Raschberg; some well known Ladinian genera (*Protrachyceras* s. str., *Sturia, Gymnites, Romanites* and *Daonella lommeli)* form part of the condensed „Ellipticus-Fauna“ at Feuerkogel (see KRYSTYN & GRUBER 1974).

The Upper Triassic Hallstatt Lst. yielded a well known association of megafossils, predominantly ammonoids referred to at least 50 genera (MOJSISOVICS 1873–1902). Pelagic bivalves (halobiids) are frequent (KITTL 1912); according to GRUBER (in press) they are of great stratigraphic significance. Brachiopods (BITTNER 1890) and gastropods (KOKEN 1897) are present and well known from various places (Feuerkogel, Sommeraukogel, Millibrunnkogel). According to TICHY (pers. comm.) in the Hallstatt Lst. the gastropods are of some ecological importance indicating deeper but distinct neritic environment (100 - 200 m).

Karnian ammonites form by most the widest distributed faunas of the Salzkammergut (Feuerkogel, Raschberg, Millibrunnkogel). The Lower Karnian *Trachyceras* fauna is also widely distributed outside the Hallstatt facies in the Northern and Southern Alpine Raibl Beds („*Trachyceras*-Schiefer“; see KRYSTYN 1978). Contrary, the Upper Karnian *Tropites* fauna is restricted to three localities in the Salzkammergut (Feuerkogel, Raschberg, Millibrunnkogel) of which the latter two form isolated fissure fillings in older rocks. Hence, their biostratigraphic significance is not unambiguous.

Lower and Middle Norian Hallstatt Lst. is poor in megafossils. Ammonoid faunas representing this time interval are only known at Feuerkogel and at Sommeraukogel. Although ammonites are lacking the Karnian/Norian boundary approximately can be drawn by the presence of a coquina bed composed of the pelagic bivalve *Perihalobia styriaca*, a species stratigraphically restricted to the lowermost Norian (GRUBER 1976).

The uppermost part of the Hallstatt Lst. representing the Upper Norian yielded a well known and wide occurring association of megafossils, the most conspicuous of which are leiostracous ammonites, e. g., *Pinacoceras metternichi, Cladiscites tornatus,* the bivalve *Monotis salinaria,* and the pelagic hydrozoan *Heterastridium*. More prominent fossil localities are Steinbergkogel near Hallstatt and Rossmoosalm near Bad Goisern (see fig. 1).

Lithostratigraphy

A comprehensive study on lithology, thickness and petrology of the Hallstatt Limestone of the Salzkammergut region was carried out by SCHLAGER 1969. According to him the Hallstatt sequence can be divided into five major parts each characterized by distinct lithologic features. All types of Hallstatt Lst. will be shown during the excursion to Feuerkogel and Sommeraukogel. The following summary mainly follows SCHLAGER 1969, p. 293, with amendments made by the author.

„Grauvioletter Bankkalk" (= greyish-violet bedded lst.):

Well bedded to nodular bedded, 10 to 20 cm thick microsparitic to pelsparitic, in part siliceous limestone beds. At its base chert nodules may frequently occur. Colour and the brittle fracture are distinct features of this type which hardly can be mixed with any other limestone type.

„Roter Knollenflaserkalk" (= red nodular Flaser-limestone):

Reddish and regularly bedded, nodular Flaser-limestone consisting of 10 to 30 cm thick beds separated by thin marly partings. In terms of microfacies this limestone is a biomicrite with bivalves and radiolarians as main constituents of the fauna. Formation of nodules and flaser structure is explained by pressure solution during an early diagenetic stage.

„Roter Bankkalk" (= red bedded limestone):

Reddish to pink coloured biomicritic limestone with strong bioturbation causing mottled and irregular structures. Beds are 20 to 50 cm thick and well bedded. Individual beds are mostly homogenous but locally interstratal reworking can be found. Particularly at Feuerkogel subsolution patterns with Fe-Mn crusts are frequently. In the upper part lateral changes may occur within short distances. The transition to the overlying massive „Hellkalk" is gradually; locally an alternation between both types occur.

„Massiger Hellkalk" (= massive light limestone):

Irregularly thick bedded to massive micritic limestone. Colour predominantly white or grey, yellowish or pink. Another characteristic feature is the great thickness. First reports on this rock were published by MOJSISOVICS 1905 from Raschberg („Wandkalk") and from Sommeraukogel.

„Hangendrotkalk" (= upper red limestone):

Platy to nodular bedded biomicritic limestone with mostly strong bioturbation pattern. Locally flaser-structure can be found but this feature is less dominating than in the „Knollenflaserkalk". Subsolution patterns occur frequently, in particular at Sommeraukogel (thinning of individual beds in the direction of a submarine ridge). The so-called „Hangendgraukalk" is regarded as a lateral equivalent of the „Hangendrotkalk"; apart from the colour, this type is also more argillaceous. It replaces the Upper Norian portion of the „Hangendrotkalk" at Steinbergkogel near Hallstatt.

Upper Triassic ammonoid and conodont time scales (fig. 5)

Ammonoid zonation (fig. 5)

Since publication of TOZER's ammonoid zonation in „Standard of Triassic Time" more than 10 years have gone and his zonal scheme which originally was established for North America has been successfully applied in various parts of the world. Different from North America in the meantime, however, new biostratigraphic studies have been carried out particularily in Europe and Asia (KRYSTYN 1978, TATZREITER 1978, KRYSTYN in press) which have provided more detailed data for a refinement of the ammonoid based subdivision of the Triassic system.

The major object of these studies is a subdivision of the currently used zonal concept into smaller intervals, for example, into subzones which are regarded as biozones. Such a biozone is defined by the total liefe span (= range zone) of a certain index species on a world wide scale. However, in many regions our present knowledge about distribution and ranges of Triassic ammonoids does not favour this theoretical consideration. Particularily in the Upper Karnian and Lower Norian no subdivision into subzones exists which is, for example, comparable to that of the Jurassic (see MOUTERDE 1971, URLICHS 1977). Hence, presently the corresponding index ammonoids are supposed to represent the best and most diagnostic species for Upper Karnian and Lower Norian times.

It is interesting to note that almost all of the new faunal subdivisions have been established in the Hallstatt Limestone of different regions in the Tethys realm (Alps, Greece, Turkey, Timor). The Hallstatt facies bears the richest ammonoid faunas of the Triassic but its successions normally are very re-

			ZONES	SUB-Z	CHARACTERISTIC SPECIES
NORIAN	RHAETIAN	2	*Choristoceras marshi*	II	*Choristoceras marshi*
				I	*Vandaites stuerzenbaumi*
	SEVATIAN	1	*Rhabdoceras suessi*	II	*Sagenites reticulatus*
				I	*Sagenites quinquepunctatus*
	ALAUNIAN	2	*Himavatites columbianus*	IV	"*catenate halorites*"
				III	*Amarassites s. semiplicatus*
				II	*Himavatites hogarti*
				I	*Himavatites watsoni*
		1	*Cyrtopleurites bicrenatus*		?
	LACIAN	3	*Juvavites magnus*		?
		2	*Malayites paulckei*	II	"*Miltites* beds"
				I	*Malayites paulckei*
		1	*Guembelites jandianus*	II	*Dimorphites selectus*
				I	*Dimorphites n. sp. 1*
KARNIAN	TUVALIAN	3	*Anatropites*-Bereich	II	*Gonionotites cf italicus*
				I	*Discotropites plinii*
		2	*Tropites subbullatus*	II	*Tropites subbullatus*
				I	*Projuvavites crassiplicatus*
		1	*Tropites dilleri*		?
	JULIAN	2	*Trachyceras austriacum*	II	"*Sirenites* subzone"
				I	*Trachyceras austriacum*
		1	*Trachyceras aonoides*	II	*Trachyceras aonoides*
				I	*Trachyceras aon*

Fig. 5: Tethyan Upper Triassic Ammonoid Time Scale (Zones and Subzones)

duced and therefore are supposed to represent no suitable lithologies for detailed zonations. It is hoped that further study in areas with any thicker successions (Himalayas, western North America) will contribute to the new concept, confirm it or even refine the present state. The general zonal scheme presented here follows wholly TOZER's work but uses pre-existing Tethyan indices.

In a series of papers KOZUR 1972, 1973, 1974 a, b, 1975 contributed to the Upper Triassic ammonoid time scale. However, most of the proposed modifications are either based on hypothetical considerations or are subject of unsatisfying changes in the content of the historical stages and substages. KOZUR's contradicting opinions have been treated elsewhere (TOZER 1974, KRYSTYN 1974 b, 1978, TATZREITER 1978).

Lower Karnian (= Julian)

The Lower Karnian has been subdivided by KRYSTYN 1978 into two zones (Aonoides and Austriacum Zone) each of it including two subzones (Aon and Aonoides Subzone, Austriacum and „*Sirenites*" Subzone respectively). The same sequence has newly been recognized in the Nepalese Himalayas (KRYSTYN in press) and thus suggests an adequate standard for expressing worldwide correlations within this interval of time (KRYSTYN 1978, p. 53).

Upper Karnian (= Tuvalian)

TOZER 1967 and SILBERLING & TOZER 1968 distinguish three Upper Karnian zones, i. e., the Dilleri, Welleri, and Macrolobatus Zones. According to KRYSTYN 1973 the Welleri Zone is a junior synonym of the Tethyan Subbullatus Zone.

The Dilleri Zone is one of the most poorly represented zones in the Tethyan Upper Triassic. Within the Salzkammergut it has been found only in quarry F 5 at Feuerkogel together with a distinct ammonoid fauna which is well comparable to that of the Californian type locality. The faunas of the two beds at Feuerkogel are identical, thus at the moment a subdivision of this zone is not possible.

The middle Tuvalian Subbullatus Zone is subdivided mainly on the base of the later appearance of *Tropites subbullatus* (HAUER) together with a large and distinct tropitid fauna. The lower subzone is characterized by *Projuvavites crasseplicatus* (MOJS.), its first appearance marks the base of the zone. This subzone also represents the typical level with *Discotropites sandlingensis* (HAUER). Concerning the results mentioned above contrary to the opinion of KOZUR 1973 a Dilleri portion within the Subbullatus faunas of the Raschberg and Millibrunnkogel must be surely excluded. Despite of the tropitids clear correlation of Subbullatus and Welleri Zones is indicated by the presence of *Projuvavites* species (*P. brockensis*) which are closely related to *Projuvavites crasseplicatus* in the stratotype of the Welleri Zone.

At present faunas of the Upper Tuvalian „*Anatropites*-Bereich" are by far the best known. The division into two subzones has been proposed by KRYSTYN as early as 1974 a and has been confirmed in all sequences studied from Europe (Alps, Sicily) to the Far East (Himalayas, Timor). The lower subzone is characterized at its base by the appearance of *Discotropites plinii* (MOJSISOVICS) but the main feature of this subzone is the abundance of *Jovites* and *Hoplotropites*. The upper subzone apparently corresponds to the main layer of *Anatropites*, though the genus extends as far as the base of the zone. Other genera characterizing the upper subzone are *Microtropites*, *Euisculites* and *Thisbites*, the latter ranging to the lowermost Norian. *Gonionotites* cf. *italicus* GEMMELLARO has been designated as index because it is fairly abundant and yet the only species which spans the whole subzone.

By comparison with the North American Macrolobatus Zone some problems arise. At its type-locality the lower Macrolobatus Zone is represented by a rich *Tropites* fauna (SILBERLING 1959). In the Tethys realm, however, *Tropites* s. str. ends at the upper boundary of the Subbullatus Zone. Hence, we assume that the lower part of the Macrolobatus Zone is coeval with the upper part of the Subbullatus or Welleri Zone, respectively. Good correlation exists between the *Anatropites* level of the upper Macrolobatus Zone described at its type-locality and faunas of the upper subzone of the *Anatropites*-Bereich elsewhere. *Discotropites plinii* and *G.* cf. *italicus* are both found in Canada (Mc LEARN 1960, TOZER pers. comm.)

Lower Norian (= Lacian)

The name of the lowermost Lacian zone has been changed by KRYSTYN (in press) to *Guembelites jandianus* Zone. The advantage of this species is its worldwide distribution and its well known stratigraphic range. The zone is divided into two subzones based on a phyletic line between *Dimorphites* n. sp. 1 and *Dimorphites selectus* MOJSISOVICS; both species have been known from Feuerkogel.

The characteristic ammonoid faunas of the subzones have been stressed by KRYSTYN 1974 a. Therefore only additional remarks will be presented here. The lower subzone is characterized at its base by the appearance of *Griesbachites* and *Dimorphites*. The upper subzone is the main and exclusive layer of the genus *Guembelites*. From this viewpoint it can be stated that the North American Kerri Zone only comprises the upper subzone of the Jandianus Zone as defined by KRYSTYN (in press); it does not represent the entire base of the Norian.

With the beginning of the Paulckei Zone faunal records become poor especially in the Salzkammergut area. At Feuerkogel the lower part of this zone is highly fossiliferous but grades upwards into beds without any ammonoids. The proposed subdivision of the zone is very preliminary and based on investigations in the Nepalese Himalayas (KRYSTYN in press). In this region a sequence of typical Paulckei beds is overlain by rocks containing an ammonite fauna dominated by the genus *Miltites* (e. g. *Miltites rastli* MOJS.) together with *Malayites*. At present nothing comparable has been described elsewhere.

Within the Salzkammergut diagnostic ammonoids of the uppermost Lower Norian Magnus Zone have only been found at Sommeraukogel. Recognition of subzones has not been achieved at this locality.

Middle Norian (= Alaunian)

The two zones attributed to the Alaunian have been in poor state of knowledge until recently. Though geographically widely distributed studies within the lower zone or Bicrenatus Zone have revealed no significant faunal changes. It must be noted, however, that *Cyrtopleurites bicrenatus* (HAUER) occurs as far as Canada where it is associated with *Drepanites rutherfordi* (E. T. TOZER pers. comm.).

Based on the studies of TATZREITER (1978 and unpubl.) the upper Middle Norian Columbianus Zone has become well known in different parts of the Tethys region. His careful stratigraphic survey of the famous Hallstatt Limestone of Timor has led to the discovery of four distinct subzones which are in succeeding order the Watsoni, Hogarti, Semiplicatus Subzones, and the yet unnamed „No. IV" Subzone. Subzone IV correlates with the so-called *Halorites* Beds widely distributed throughout the Tethys region. The rich ammonite fauna previously described by MOJSISOVICS (1893) from Sommeraukogel includes all four subzones. However, at present only the *Halorites* Beds (= Subzone IV) can be assigned to certain beds at Sommeraukogel.

Upper Norian (= Sevatian)/Rhaetian

During the last few years many papers have dealt with the stratigraphic subdivision of the uppermost Triassic (for reference see FABRICIUS 1974, TOLLMANN 1978, WIEDMANN et al. 1979). As a result of these discussions some proposals have been submitted to the meeting of the „Subcommission on Triassic Stratigraphy" held in Munich from July 3–4, 1978. During the session it was proposed to combine the Upper Norian with the Rhaetian Stage and to treat the expanded Rhaetian as uppermost stage of the Triassic. Consequently, the Middle Norian would have changed to Upper Norian and the original Upper Norian would be named Lower Rhaetian. It is outside of the scope of this introduction to a conodont guide to contribute to this merely academic discussion. However, to avoid any errors which may arise by comparing data presented here and those from previously published literature it seems more reasonable to keep on with the old nomenclature.

The terminological problem arose from the necessary change of names between the historical Metternichi Zone and the zone of *Rhabdoceras suessi* as proposed by TOZER 1967. In the meantime this generally accepted change of names turned out to bear problems. As has been earlier suggested by KOZUR 1973 and has been confined indepentently by WIEDMANN et al. 1979 in Europe as well as by E. TOZER 1979 in Canada, *Rhabdoceras suessi* extends somewhere above the typical Sevatian *Pinacoceras metternichi* Zone of MOJSISOVICS. Moreover, based on a detailed biostratigraphic survey of the Alpine Koessen Beds WIEDMANN et al. 1979 have found that *Choristoceras marshi* begins much lower than had been suggested previously; also, it is associated with *Rhabdoceras suessi* during a longer period than formerly thought. To resolve the problem some differing zonations have been published recently (KOZUR 1973, 1975; GAZDZICKI & al. 1979; TOZER 1979, WIEDMANN et al. 1979).

Further use of Suessi and Marshi Zones is favoured by the author because it needs no nomenclatural changes. In the new context it also agrees with the current use of the two zones. What is needed is a new definition of the two zones in question to become the status of „overlap range zones" (see JOHNSON 1979).

The proposed Sevatian subzonal indices are widely distributed (*Sagenites quinquepunctatus* as far as South America, *S. reticulatus* at least as far as Timor). They have been proved to form a distinct faunal sequence. *Sagenites giebeli* originally introduced by MOJSICOVICS 1893 as a Lower Norian zonal guide most probably reflects the same age as *S. quinquepunctatus*. It is, however, only known from two localities (Taubenstein, Leislingwand near Raschberg) both forming stratigraphically isolated fissure deposits. *Choristoceras haueri* is a long ranging species and occurs both in the Upper Norian and in the Rhaetian. Therefore it serves no place in a standard zonation. The Reticulatus Subzone correlates with the *Cochloceras* Subzone of TOZER 1967 and the *Cochloceras suessi* Zone of KOZUR, respectively.

At the top of the so defined Suessi Zone the major part of Triassic ammonites belonging to subordo Trachyceratina disappears and only some Ceratitinas *(Cycloceltites, Rhabdoceras, Choristoceras, Vandaites)* and the long ranging leiostracean genera *Arcestes, Placites, Cladiscites, Rhacophyllites* and *Megaphyllites* survive into the lower Rhaetian.

For the Rhaetian Marshi Zone a two fold division has been proposed by WIEDMANN & KRYSTYN (in WIEDMANN et al. 1979, p. 145). The base of the newly defined Marshi Zone is marked by the appearance of *Vandaites stuerzenbaumi* (BOECKH), simplified described as a „helicoid choristoceras". Another distinct ammonite species of the lower subzone is *Eopsiloceras planorboides* (GUEMBEL). At the end of the subzone some more ammonoid genera disappear. Thus the impure fauna of the topmost Triassic Marshi Subzone consists of not more than the four genera *Choristoceras, Arcestes, Rhacophyllites* and *Megaphyllites.* The two subzones have been found in a vertical sequence within different sections of the Alpine Koessen Beds.

A revised North American biochronological scale for the interval between the Middle Norian and the Jurassic has been provided by E. T. TOZER 1979. This new division comprises three zones which are in ascending order the Cordilleranus, Amoenum and Crickmayi Zones. They can be exactly correlated with the Alpine Quinquepunctatus, Reticulatus and Stuerzenbaumi Subzones. A remarkable fact at present, however, is the missing of an equivalent of the topmost Triassic in North America.

Conodont zonation

General remarks

This section treats with some 10 species of platform conodonts assigned to the form genera *Gladigondolella, Gondolella, Metapolygnathus* and *Epigondolella,* their phylogenetic relationships are outlined in fig. 6. In addition two species of the „neospathodid" genus *Misikella* KOZUR & MOCK are discussed. Most of these species have been described during the past 10 years, either based on too few specimens or with unprecise and even wrong stratigraphic ranges (HAYASHI 1968, KOZUR 1972). Due to the fact that the ontogenetic evolution of many species has not been treated to such an extent as is needed specific identification of Upper Triassic platform conodonts is highly problematic at present. Hence, the author has followed no other currently applied concepts than the one suggested by MOSHER 1968. Several taxa can be revised on the basis of our collections available and notes on these species are given in the following paragraphs. However, this paper is intended to provide a summary of stratigraphy and thus, systematic treatment of the categories are not included here.

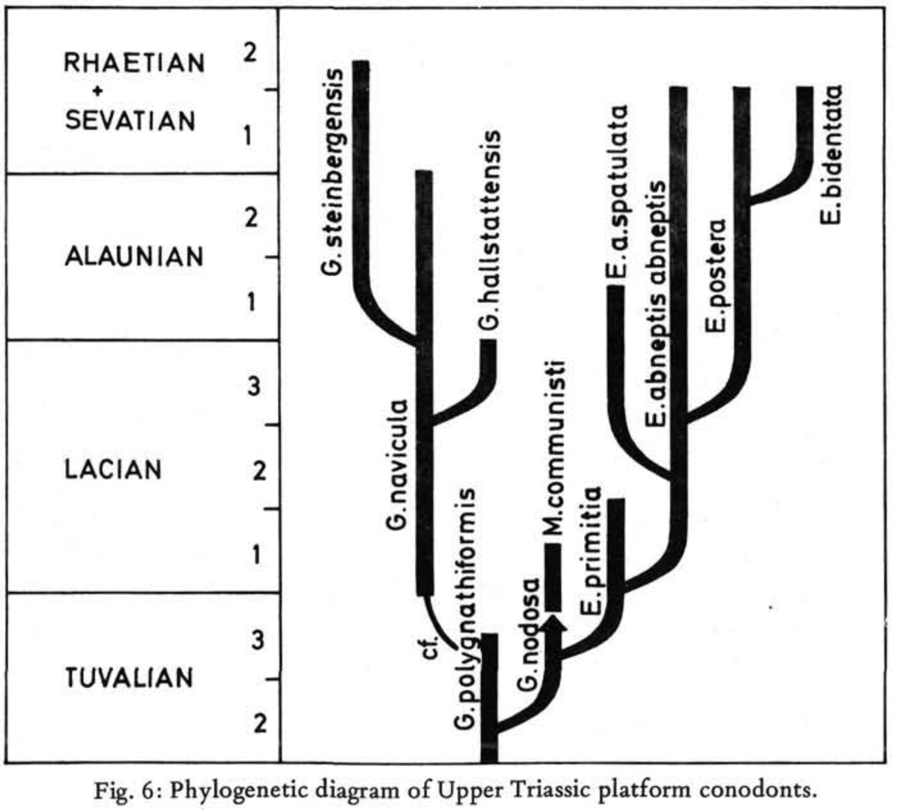

Fig. 6: Phylogenetic diagram of Upper Triassic platform conodonts.

Contrary to the view of KOZUR 1972 (and later) the author has continued to discriminate the two genera *Metapolygnathus* and *Epigondolella*. The main reason is the outline of the denticles on the margin of the platform which clearly demonstrates a distinct and definite separation of the two genera: Within *Metapolygnathus* they are either missing or form weak and rounded nodes; *Epigondolella* on the other side is characterized by spinelike nodes on the platform margin.

Gondolella navicula HUCKRIEDE, 1958: This well known species has been misinterpreted both phylogenetically and stratigraphically by all previous workers. Based on our studies in various regions of the Tethys realm (Alps, Yugoslavia, Greece, Timor) it can be demonstrated that the first appearance of *G. navicula* is at the base of the Norian Stage; its ancestor is *G. polygnathiformis*. Transitional forms occurring in the uppermost Upper Karnian are very rare, their similarity with *G. reversa* (MOSHER, 1973) is considerable. It is supposed that all earlier reports of the species from Anisian, Ladinian and Karnian strata were based on *navicula*-type variants of different species of *Gondolella*.

Gondolella hallstattensis MOSHER, 1968, and *G. steinbergensis* MOSHER, 1968: Both species were described thoroughly by MOSHER 1968 and his definitions have been followed in this study. The only difference is the treatment as independent species.

Metapolygnathus communisti HAYASHI, 1968: Due to the badly figured holotype this unusual named species has been misinterpreted by several authors for a longer period (KOZUR 1972, KRYSTYN 1973, MOSHER 1973). KOZUR 1972 who gave an adequate description of the adult growth stage figured under the same name a clearly different species referred by MOCK 1979 to *G. carpathica*, a species treated herewith as junior synonym of *G. nodosa*. MOSHER 1973 and KRYSTYN 1973 independently concluded that *M. communisti* represents a junior synonym of *G. polygnathiformis*. Based on REM-fotos of the holotype at hand (provided by S. HAYASHI and kindly forwarded to the author by S. KOVACS, Budapest) and on new material obtained from Timor as well as from Feuerkogel a revised description of the species can be given. Study of subsequent growth stages within one sample revealed that the two species *Gladigondolella abneptis echinatus* HAYASHI, 1968 and *Metapolygnathus parvus* KOZUR, 1972 must be regarded as juvenile representatives of *M. communisti*. Moreover, the study of fairly large collections of *M. communisti* suggests identity of *Metapolygnathus linguiformis* HAYASHI, 1968 with the former species. *M. angustus* KOZUR, 1972 shows a considerable similarity with *M. communisti* although only one specimen has been figured yet. According to KOZUR 1972, however, it occurs below the first known occurrence of *M. communisti*.

Metapolygnathus communisti can be shortly defined as a mixture of (highly evolved) *G. polygnathiformis* and *G. nodosa* with a basal pit migrated towards the center of the platform. The common occurrences of specimens of *M. communisti* with smooth crenulated and platform margins suggest that *G. nodosa* and *G. polygnathiformis* biologically form a single species.

Within the uppermost Karnian a rapid transition links *G. nodosa* with *M. communisti* the latter replacing the former. In samples collected from the lowermost Norian section B at Feuerkogel two distinct morphotypes named *M. communisti* morphotype A and morphotype B have been found which exclude each other by their stratigraphic ranges (see fig. 11). Interestingly, *M. communisti* morphotype B shows a re-appearance of such features which already had characterized *G. polygnathiformis*.

Gondolella nodosa (HAYASHI, 1968): Different from KRYSTYN 1973 *G. nodosa* and *Epigondolella primitia* are regarded as two separate species which, however, are closely related. *G. nodosa* is closely similar to *G. polygnathiformis*, the only difference being the formation of nodes on the platform margins. In phylogenetically early representatives of *G. nodosa* growth of nodes begins at the anterior end of the platform; highly evolved specimens on the other side show the extent of nodes towards the lateral margins of the platform. This type is represented by the holotype. Since the early morphotype has also been found together with late ones of the species, *G. carpathica* MOCK, 1979 (primitive type) can not be accepted as independent species.

Epigondolella primitia MOSHER, 1970: This species evolved from *G. nodosa*. It forms the initial stage of the *E. abneptis* lineage. The species was described and discussed thoroughly by MOSHER 1970; his concept has been followed in this study. *Metapolygnathus spatulatus pseudodiebeli* KOZUR, 1972 may be a junior synonym of the species.

Epigondolella abneptis (HUCKRIEDE, 1958): Reference collections in hand confirm MOSHER's treatment of the species (1968, 1973). Additional study of material available has proved *E. permica* (HAYASHI) to represent a juvenile stage of this species rather than an independent taxon as had been treated by KRYSTYN 1973. This is also suggested for *Metapolygnathus slovakensis* KOZUR, 1972.

In accordance with KOZUR 1972 two subspecies can be distinguished which morphologically are similar but have different ranges (fig. 8). In *E. a. spatulata* the outline of the platform is posteriorly expanded to form a triangular shape. A similar feature, however, may also be observed in some adult representatives of the nominate subspecies. Hence, discrimination of the two subspecies seems only possible in early ontogenetic stages during which the outline of the platform either forms a square (= *E. abneptis* s. str.) or a triangle (= *E. a. spatulata). Ancyrogondolella triangularis* BUDUROV, 1972 is considered as junior synonym of *E. a. spatulata* . According to the author's opinion *Tardogondolella postera hayashii* KOZUR & MOSTLER, 1972 represents a juvenile growth stage of *E. abneptis* s. str.

Epigondolella postera KOZUR & MOSTLER, 1971: The current concept about this species is the same as in 1973. *Epigondolella zapfei* KOZUR & MOSTLER is thus regarded as an adult growth stage of *E. postera.* The species is a morphologic link between *E. abneptis* and *E. bidentata* as has already been demonstrated by KOZUR & MOSTLER 1971.

Epigondolella bidentata MOSHER, 1968: This well established species was thoroughly re-discussed by MOSHER 1973. His arguments to include *E. mosheri* KOZUR & MOSTLER, 1971 as junior synonym are fully accepted. Another probable synonym may be *E. misiki* KOZUR & MOCK, 1973.

From the uppermost Norian KOZUR & MOCK 1972 described the evolution of *E. bidentata* to such forms in which platforms are completely lacking; they were named *Parvigondolella andrusovi.* With material at hand it can be demonstrated that all *bidentata* faunas from the early beginning of the species in the upper Middle Norian in a certain number include even large „*Parvigondolella andrusovi*". Furthermore, a distinct *andrusovi*-horizon as described by MOSTLER et al. 1978 has not been confirmed in the Hallstatt Lst. of the Salzkammergut yet. Hence, at present this separation is not followed by the author.

Conodont zonation (figs. 7 and 8)

Within this paper a sequence of 16 faunal assemblages is described most of them being recognized in the Karnian and Norian Hallstatt Lst. of the Salzkammergut area. In the Rhaetian Stage no Hallstatt Lst. occurs. Therefore the topmost Triassic representing two zones were investigated outside the Salzkammergut in the Koessen Beds of the Provinces of Salzburg and Tyrol.

Many of these assemblages are very widespread and it is supposed that they may provide a tool for at least Tethys-wide correlations of Upper Triassic rocks. Of the various zonal indices only a few are short ranging taxa restricted to specific conodont zones. Most of the taxa discussed range through several zones. Therefore, the zonation scheme presented here (fig. 7, 8) is based on the overlap of ranges of taxa and within subzonal units also on the relative abundance of important taxa.

Almost all of the zonal indices have been in use by KOZUR since 1972. However, age assignment varies slightly in his many publications. This fact has caused serious troubles and errors during the past 10 years and even raised some doubts about utility of conodonts in the Upper Triassic. Actually, the zonal assignements of KOZUR are either based on historical Alpine ammonite material from different museum collections or on samples from sections which are lacking megafossils (e. g., Siliza Brezova, cf. KOZUR 1972, KOZUR & MOCK 1974 a). By means of conodonts in a further step these sections were correlated with certain ammonite zones. However, his errors are less burdening as compared with his outstanding contributions to the stratigraphy of the Tethys realm deduced from his restricted environment in East Germany.

K a r n i a n

1. *Carinella diebeli*-Assemblage Zone

Carinella diebeli is not restricted to this zone but it is a characteristic species of it. The base of the zone is defined by the appearence of *G. polygnathiformis* which was found in the ammonite bearing sequence at Epidaurus (Greece) to extend to the upper part of the *Frankites ? regoledanum*-Zone (= Tethyan counterpart of the Sutherlandi Zone). The base of the zone therefore encompasses the Ladinian/Karnian boundary.

2. *Gladigondolella tethydis*-Assemblage Zone

The base of the zone is defined – mainly negatively – by the disappearance of species of the *mungoensis*-group. In terms of ammonoid stratigraphy it corresponds to the upper Aonoides Zone (Julian 1/II) and the lower Austriacum Zone (Julian 2/I). The platform conodont fauna comprises *Gladigondolella tethydis* and *Gondolella polygnathiformis,* both, however, are not restricted to the zone.

3. *Gondolella polygnathiformis*-Assemblage Zone

The zone is defined by the exclusive presence of *G. polygnathiformis* and at its base by the disappea-

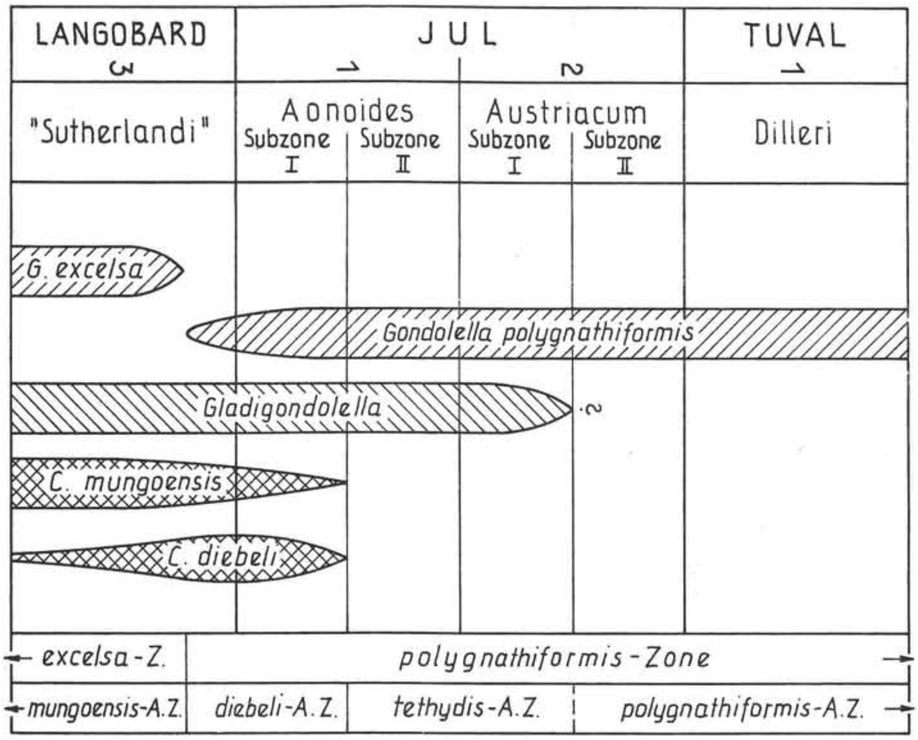

Fig. 7: Lower Upper Triassic platform conodont zonation and its correlation with the ammonoid time scale. From KRYSTYN 1978.

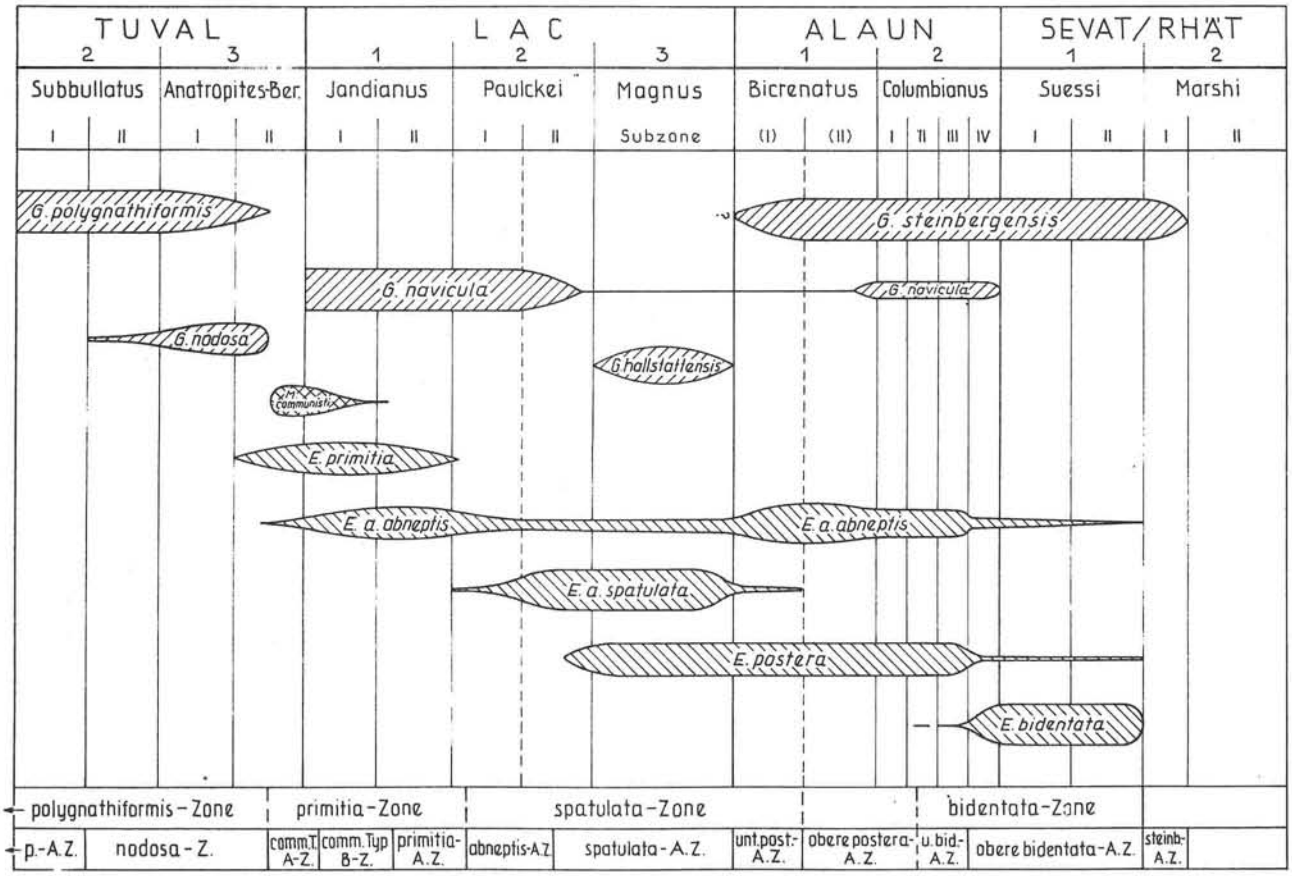

Fig. 8: Upper Karnian and Norian revised platform conodont zonation and its correlation with the ammonoid time scale. Stratigraphic distribution and relative abundance of zonal guides are shown.

rance of *Gladigondolella tethydis.* It is a long ranging zone corresponding to the upper Austriacum Zone (Julian 2/II), the Dilleri and the lower Subbullatus Zones (Tuvalian 2/I) in terms of ammonoid zonation.

***Gondolella nodosa*-Zone**

The range of *Gondolella nodosa* defines this zone which can be divided by the latter appearance of *Epigondolella primitia.*

4. Lower Nodosa-Assemblage Zone:

This time marked by the presence of abundant *G. polygnathiformis* and rare *G. nodosa* is a correlative of the upper Subbullatus Zone (Tuvalian 2/II) and the lower *Anatropites*-Bereich (Tuvalian 3/I). Samples from the Hallstatt Lst. generally rich in platform conodonts allow a more precise correlation with the ammonoid stratigraphy by changing frequency rates of the two conodont species: In the Tuvalian 2/II the ratio between *G. polygnathiformis* and *G. nodosa* is approx. 10:1, in the Tuvalian 3/I it is 3–5:1.

5. Upper Nodosa-Assemblage Zone:

This subzone is defined by the appearance of *E. primitia* and further occurrences of *G. nodosa* and rare *G. polygnathiformis.* The upper subzone is a short ranging correlative of the upper *Anatropites*-Bereich (lower Tuvalian 3/II).

6. *Metapolygnathus communisti* morphotype A-Zone

This zone correlates to the range of the index species which is most frequent in all samples studied. Other platform conodonts are *Epigondolella primitia* and rare *Epigondolella abneptis.* So far this short time interval is known at Feuerkogel, Slovakia, Yugoslavia (Sarajevo) and Timor. At both, Feuerkogel and Timor the zone correlates to the upper part of the upper *Anatropites*-Bereich (upper Tuvalian 3/II) and basalmost Norian. The short Norian portion has been easily recognized in all sections studied by the sudden und rich appearance of *Gondolella navicula* which evidently indicates the base of the Norian Stage.

Norian

7. *Metapolygnathus communisti* morphotype B-Zone

This species is an index to the lowermost Norian and corresponds well to the Lacian 1/I ammonoid zone. Associated with the name bearer are *Epigondolella primitia, E. abneptis* and frequent *Gondolella navicula.* At yet this zone has only been recognized at Feuerkogel where it has been found at different places.

8. *Epigondolella primitia*-Assemblage Zone

The base of this zone is defined by the disappearance of *Metapolygnathus communisti* morphotype B which, by comparison with the ammonoid stratigraphy, shortly extends into the upper Jandianus Zone (Lacian 1/II). The platform conodont fauna is composed of *E. primitia, E. abneptis* s. str. and *Gondolella navicula;* the latter may also be missing sometimes. This zone seems of worldwide utility because the index species is distributed as far as Canada and Western North America (MOSHER 1973).

9. *Epigondolella a. abneptis*-Assemblage Zone

This zone is marked at its base by the disappearance of *Epigondolella primitia* and contemporaneously, by the beginning of *Epigondolella abneptis spatulata.* The base of the zone is not correlative to the base of the Paulckei Zone directly, but somewhat younger. Though no further distinct separation is possible a more detailed correlation with the two ammonoid levels of the Paulkei Zone is suggested by different ratios of the two subspecies: In the Lacian 2/I subzone *E. a. abneptis* is frequent and *E. a. spatulata* rare whereas the Lacian 2/II subzone contains reverse frequency ratios.

10. *Epigondolella a. spatulata*-Assemblage Zone

The base of this zone is defined by the appearance of *Epigondolella postera* and by abundant representatives of *E. a. spatulata.* Furthermore, this zone is the exclusive level for *Gondolella hallstattensis.* In terms of ammonoid stratigraphy it corresponds to the uppermost Paulckei and the Magnus Zones.

***Epigondolella postera*-Assemblage Zone**

This zone is subdivided into two faunal units, the lower and upper Postera Assemblage Zones.

11. Lower Postera Assemblage Zone

The subzone is marked at its base by the appearance of *Gondolella steinbergensis* and by a change in the relative abundance ratios of the two subspecies of *E. abneptis: E. a. abneptis* becomes frequent as compared with *E. a. spatulata* which is represented rarely. Another common species is *Epigondolella postera.* Fauna representing this interval were found in ammonite bearing rocks to be restricted to the lower part of the Bicrenatus Zone.

12. Upper Postera-Assemblage Zone

Platform conodonts of this unit comprise *E. abneptis* s. str., *Epigondolella postera* and *G. steinbergensis; E. a. spatulata* has already disappeared at the base of the subzone which is an equivalent of the upper Bicrenatus and the lower Columbianus ammonoid Zones.

***Epigondolella bidentata*-Zone**

The base of this zone is marked by the appearance of *Epigondolella bidentata* approximately in the middle part of the Columbianus Zone. At present the lower limit has not been dated precisely. MOSTLER 1977 reported *E. bidentata* from the type locality of the Pötschen Lst. which according to TATZREITER 1978 corresponds to the lower Columbianus Subzone II. In the ammonoid controlled conodont sequence of the Hallstatt Lst. of Timor the first occurrence of *E. bidentata* was found in subzone III and more abundantly in subzone IV. This discrepancy may be explained by that juvenile specimens of *E. postera* resemble *E. bidentata* and thus may have been misidentified in the past. Based on the relative abundance ratios of different species of *Epigondolella* two subzones are discriminated. *Gondolella steinbergensis* ranges through both subzones.

13. Lower Bidentata-Assemblage Zone

This subzone is marked by rare occurrences of *E. bidentata* together with abundant representatives of *E. abneptis* and *E. postera.* It is equivalent to the Columbianus Subzone III and perhaps to Subzone II.

14. Upper Bidentata-Assemblage Zone

In this faunal unit *Epigondolella bidentata* ist most common and is associated with *Gondolella steinbergensis* together with rare occurrences of *E. abneptis* as well as *E. postera.* In terms of ammonoid zonation this subzone correlates to the uppermost Culumbianus Zone (Subzone IV) and to the Suessi Zone as defined in this paper. Moreover, it is a close correlative of the *bidentata*-Zone introduced by SWEET et al. 1971.

15. *Gondolella steinbergensis*-Assemblage Zone

This zone includes the youngest platform conodonts of the Triassic and is represented in the Salzkammergut in the transitional beds from the Hallstatt Lst. to the marls of the Zlambach Fm. At its base the zone is marked by the complete disappearance of all species of *Epigondolella* and at its upper limit by the disappearance of *Gondolella steinbergensis.* In accordance with the ammonoid record it is dated as lowermost Rhaetian.

16. *Misikella rhaetica* and *Misikella posthernsteini*-Zones

Both zones were recognized by MOSTLER et al. 1978 in the Koessen Beds of the Weißloferbach section close to the village Koessen in Tyrol. They contain various conodonts but lacking are any platform type conodonts. According to MOSTLER 1978 and personal observations *Grodella delicatula* (MOSHER), *Neohindeodella triassica* (MÜLLER) *Hibbardella magnidentata* (TATGE), *Hindeodella suevica* (TATGE) and *Prioniodina muelleri* TATGE were found. *Misikella rhaetica* MOSTLER, 1978 is the successor of *Misikella hernsteini* (MOSTLER, 1967), a species widespread in the Upper Norian Hallstatt Lst. but also represented in the Lower Rhaetian (Stuerzenbaumi Subzone) Zlambach marls of the Salzkammergut and in the lowermost Koessen facies of the Osterhorn syncline.

The *Rhaetica*-Zone as defined by MOSTLER 1978 may be correlated to the lower part of the Marshi Zone, i. e., to the upper part of the Stuerzenbaumi Subzone and to the lower Marshi Subzone as newly defined.

The *Posthernsteini*-Assemblage Zone represents the youngest conodont fauna of the Triassic. It was found in the Kendlbach and the Fonsjoch section to range as high as 7 m below the base of the Jurassic. This zone is marked by the presence of the long ranging species *Misikella posthernsteini* KOZUR & MOCK, 1974 and at its base by the disappearance of *M. rhaetica.* So far it is only known from the Upper Zlambach and Koessen Beds corresponding there approximately to the topmost Triassic Marshi Subzone.

The Ecxursion

DAY 1

Feuerkogel near Bad Aussee, Middle and Upper Triassic Hallstatt Limestone
(Stratotype of the Tuvalian Substage; Anisian to Lower Norian conodonts).

Access of the locality from Hallstatt is along the river Traun via Bad Aussee to Mitterndorf. Leaving Hallstatt on the roadside mainly Dachstein Lst. is exposed representing a cyclic lagoonal type sediment of the so-called „Loferer type" (A. G. FISCHER 1964). Upon Bad Aussee the valley opens and forms a wide depression filled with fluviatil Quarternary deposits. From Mitterndorf the route runs through the Salza valley to Kochalm and further westward on a forrest road to Teltschenalm. Starting at an altitude of approx. 1350 m we will arrive at Feuerkogel (1625 m) after one hour walk. On the official topographic map (sheet 97, Mitterndorf) Feuerkogel is indicated as an unnamed elevation on the east side of Mount Röthelstein.

The mountain Feuerkogel (fig. 9) is one of the numerous tectonic blocks developed in Hallstatt facies which in the surroundings of Mitterndorf tectonically overlay the Dachstein nappe (cf. TOLLMANN 1960). Feuerkogel consists of some 50 m of moderately north dipping Hallstatt Lst.

The complete section is exposed at the southern side beginning in the Middle Anisian with Reifling Lst. (Kockeli-Zone). They are followed by dark marls presumably of Upper Anisian age, forming a small depression. On the ascent to the peak the following members of Hallstatt Lst. will be passed:

1) Lower Ladinian „Grauvioletter Bankkalk" (grey violet bedded lst.), poor in conodonts;
2) Ladinian „Roter Knollenflaserkalk" (red nodular flaser-lst.), poor in conodonts;
3) Upper Ladinian to lowermost Norian „Roter Bankkalk" (red bedded lst.) with abundant conodonts but in part condensed faunas;
4) Lower Norian „Massiger Hellkalk" (massive light lst.) rich in conodonts, forming the peak.

Compared with earlier reports (KRYSTYN 1973) the age of the „Roter Knollenflaserkalk" and of „Roter Bankkalk" has been slightly changed depending on new conodont evidence. The classic ammonite localities described at Feuerkogel occur in the „Roter Bankkalk" and in part also in the overlying „Hellkalk". Their maximum age range from the Upper Ladinian to the Lower Norian; faunas from two fissures even indicate Middle and Upper Norian. During the excursion three fossil localities (quarries) will be visited (F1, F4, F5). Two others, still existing, are due to their sedimentary structures too complicated and therefore not suited for detailed biostratigraphic studies.

„The Feuerkogel is probably one of the most famous cephalopod collecting sites in the world. The rocks exposed near its peak have yielded thousands of specimens of ammonoids, nautiloids, pelecypods and other invertebrate fossils. During the last century a rather sizable industry was developed through wich an extraordinary number of cephalopods were quarried out of these rocks and sold to museums, collectors, and tourists. MOJSISOVICS in the last half of the last century described 444 cephalopod species from these strata" (MOSHER 1968, p. 903); DIENER added some 20 more.

Conodont research

The Feuerkogel represents one of the most important Triassic conodont localities of the world, both for stratigraphic reasons and concerning abundance of conodonts. The locality is closely related to the study of Triassic conodonts. It is the type locality of three diagnostic platform conodonts of the Triassic, namely, *Gladigondolella tethydis* (HUCKRIEDE 1958, p. 157), *Gondolella navicula* (HUCKRIEDE 1958, p. 147), and *Gondolella excelsa* (MOSHER 1968, p. 158). Furthermore, a certain number of Triassic ramiform elements were first described at Feuerkogel.

Following HUCKRIEDE 1958, MOSHER 1968, p. 915 carried out an excellent study of the conodont fauna. He also drew attention to the discrepancies between the ranges of several index species (quarry F1) and concluded stratigraphic condensation. Some years later KRYSTYN 1972, 1973 presented a detailed stratigraphic synthesis of the Feuerkogel and its main fossil sites including a correlation of ammonoid and conodont biostratigraphy. KRYSTYN's results were questioned and critizised in a quite unusual way by KOZUR 1973 who – unfortunately – never was able to visit parts of the section at Feuerkogel. His samples were collected by another person and sent to him. Though KOZUR had no real stratigraphic control of his samples he tentatively assigned them to certain beds of the section. This, in fact, may explain his misinterpretations.

So far, Feuerkogel has been the only place in the Tethys realm where it is possible to correlate precisely the ammonite and conodont chronologies in the Upper Karnian and Lower Norian. Beside this

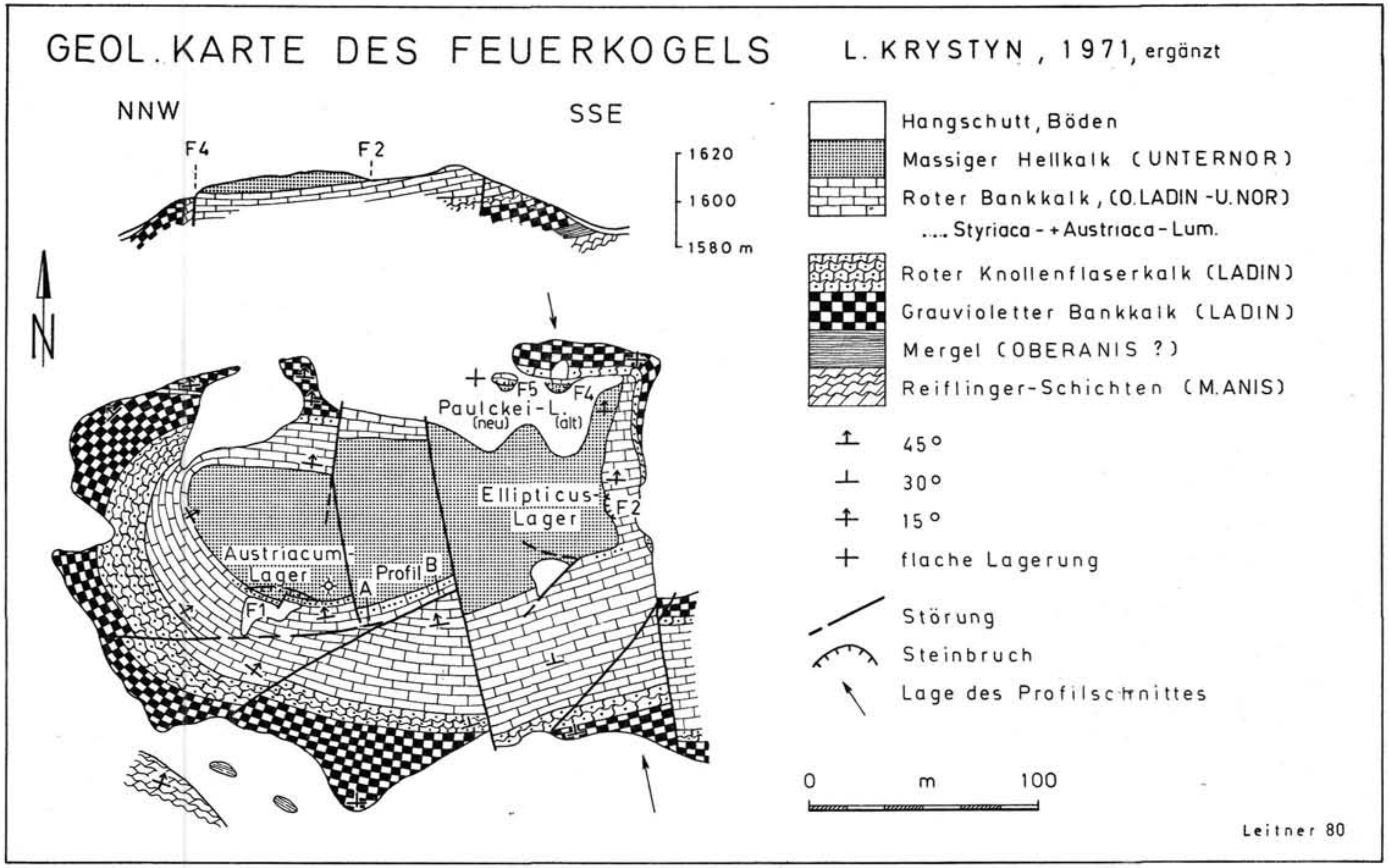

Fig. 9: Geological map of Feuerkogel with Ladinian through Norian Hallstatt Limestone. F1, F4 und F5 indicate position of fossil localities described in text. Slightly modified from KRYSTYN 1973.

the section at Feuerkogel apparently is one of the most important Triassic conodont occurrence in the world. The following platform conodont species can be found in considerable numbers: *Gl. tethydis*, *G. excelsa*, *G. polygnathiformis*, *G. nodosa*, *G. navicula*, *M. communisti* (morphotype A + B), *E. primita* and *E. abneptis* s. str.

Due to the results from many detailed and short ranging sections and numerous stratigraphic data the conodont faunas will not be dealt separately but will be included in the description of the following sections.

Austriacum-Lager (F 1, figs. 10 and 11)

This fossil site is located on the southern slope close to the peak of Feuerkogel. It is characterized by a bif scree coming from a 30 m long and 2 m high quarry which resulted from many years of collecting cephalopods. Up to 1970 in the outcrop only Lower Norian „Hellkalk" and the *Halobia styriaca*-lumachelle were exposed; by that time the „Rotkalke" with its famous fossil layers were buried under meters of rock debris. This explains why MOSHER 1968 failed to find any traces of the *Trachyceras* beds in the outcrop. All samples collected by him were derived from Lower Norian beds only exposed. During the years 1971, 1976 and 1977 systematic ditches were made to enlarge the quarry and to expose its base.

The section (fig. 10) starts with unfossiliferous „Rotkalke" which yielded Ladinian conodonts such as *G. excelsa*, *G. trammeri* and *Carinella hungarica*. These limestones are followed by an extraordinary rich fossil bed (76/2 in fig. 10) containing a condensed ammonite fauna of Upper Ladinian and lowermost Karnian age (Julian 1 according to KRYSTYN 1978); also, conodonts reflect condensation. In the western part of the quarry (section described by KRYSTYN 1973, fig. 3) the same bed embraces upper Lower Karnian (Austriacum Zone).

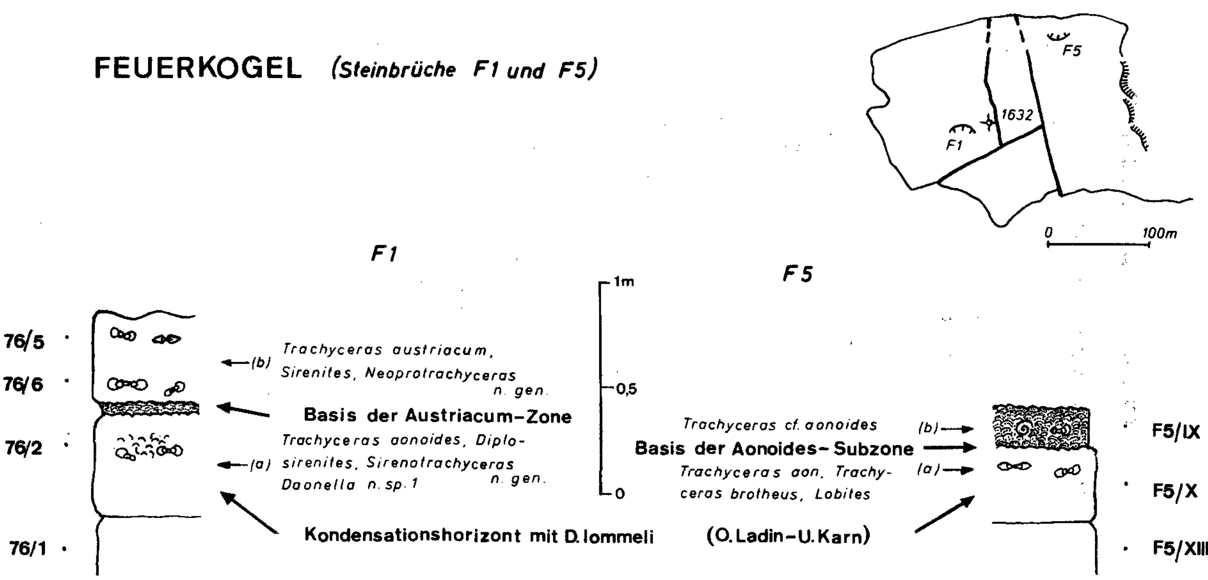

Fig. 10: Upper Ladinian to Lower Karnian sequence at the quarries F1 and F5 of Feuerkogel showing vertical distribution of conodont samples. Correlation of beds based on ammonoid evidence. From KRYSTYN 1978.

In the middle part the above mentioned bed is succeeded by a thin „Black horizon" which has been known from all fossil sites at Feuerkogel and thus represents a marker-bed. According to the ammonites it is assigned to the upper Julian 1 (Aonoides Subzone). The layer contains rare and fragmentary specimens of *Gladigondolella tethydis* and *Gondolella polygnathiformis*.

The next bed is composed of a light red to yellowish red limestone showing lense-like shape. It begins in the eastern part of F1-W with a thickness of 20 cm (fig. 10, section F 1), reaches its maximum thickness in section F1-E with 60 cm and thins towards the east after 5 m. It was designated as type-horizon of the Austriacum Zone as defined by KRYSTYN 1978 and contains a rich invertebrate fauna. The ammonite fauna comprises the following genera: *Trachyceras (Austrotrachyceras)*, *Sirenites*, *Neoprotrachyceras*, *Joannites*, *Proarcestes*, *Monophyllites*, and *Pompeckjites* (a pinacoceratid). A more detailed list can be found in KRYSTYN 1978, p. 58 (for detailed description see MOJSISOVICS 1893). The rich platform conodont fauna (samples 76/6 and 77/40) is composed exclusively of *Gladigondo-*

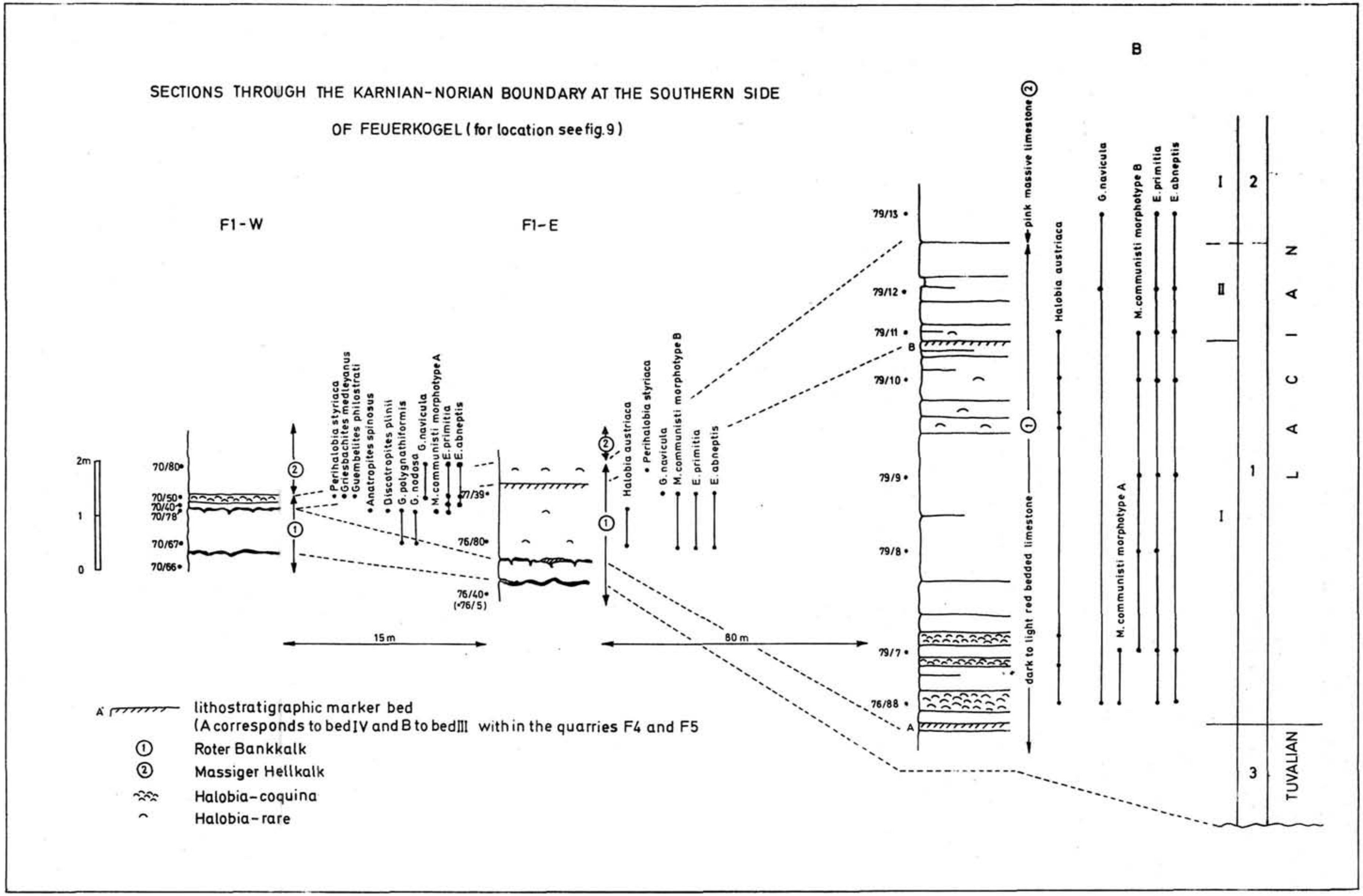

Fig. 11: Correlation of sections F 1-W, F 1-E and B on the basis of lithostratigraphic marker beds and the faunal evidence.

ella tethydis and *Gondolella polygnathiformis.*

With a distinct change in facies the fore-mentioned fossil bed is overlain by a bed of „Rotkalk" with varying thickness (between 20 cm and maximally 80 cm) which can be traced in the whole quarry. The surface of this bed is characterized by a several cm high small-scaled relief plombed by small lenses of „Rotkalk" and iron-manganese crusts. From here a rich ammonite fauna is recorded indicating the uppermost Tuvalian *Anatropites*-Bereich (e. g., *Anatropites spinosus, Discotropites plinii, Thisbites;* for reference see KRYSTYN 1973, p. 117). Since this fauna indicates the presence of both subzones some condensation must be assumed.

From this bed two conodont samples were collected, the first close to the base and the second from the top. The lower one (70/67) contains rare *G. polygnathiformis* and *G. nodosa* in an almost equal ratio and clearly points to the Tuvalian 3. In the upper sample (70/78) a rich fauna was found composed of *G. polygnathiformis, G. nodosa, M. communisti* and *E. primitia.* This fauna represents a mixture of otherwise two distinct conodont assemblages (see fig. 9). The unusual composition must be due to condensation as is suggested by the ammonite fauna too. From level 70/78 the holotype of „*Metapolygnathus spatulatus pseudodiebeli*" (KOZUR 1972, pl. 4, fig. 5) is derived.

During the lowermost Norian the western part of the quarry supposedly was located at the summit of a small submarine ridge. Some 100 m to the east in section B (fig. 11) the „Rotkalke" of the Jandianus Zone reach a thickness of 8 m; in section F1-E the thickness decreases to 2 m and in section F1-W to less than 50 cm! Lowermost Norian strata (Lacian 1/I) are completely missing in F1-W whereas in section F1-E they are represented by a 1,60 m thick limestone bed with *Halobia austriaca.* Two conodont samples from the base and from near the top produced the following taxa:

76/80: *M. communisti* morphotype A (3 x), *M. communisti* morphotype B (53 x), *E. abneptis* (7 x).
77/39: *M. communisti* morphotype B (3 x), *E. primitia* (25 x), *E. abneptis* (7 x), *G. navicula* (2 x).

In section F1-W the upper Lacian 1 is represented by the „Rotkalk"-bed 70/40 and the overlying lumachelle bed with *Halobia styriaca* (70/50). Within the lumachelle bed a shallow fissure filling of „Rotkalk" occurs which contains a rich but tiny ammonite and gastropod fauna (70/51). In addition to the fauna listed in KRYSTYN 1973, p. 118 *Guembelites philostrati* DIENER and *Griesbachites medleyanus* (STOLIZKA), two index species of the Lacian 1/II-Subzone were found. The latter also occurs in the lumachelle bed proper. The conodont fauna of both beds is identical and comprises *E. primitia, E. abneptis* and *G. navicula.*

Above the Styriaca-lumachelle lithology changes to a more fine grained, light to pink coloured, irregularly thick bedded limestone, the so-called „Massiger Hellkalk". Yet, no fossils have been found at this place. However, this facies change also occurs in the quarries F4 and F5 where it is proved by ammonites to take place at the boundary from the Jandianus to the Paulckei Zones. In quarry F1-W the sample 70/80 yielded *E. primitia* (2 x), *E. abneptis* (4 x) and a large number of *G. navicula* (60 x). This bed most probably is the stratum typicum of *G. navicula* as described by HUCKRIEDE 1958, p. 114 (sample 49 c).

Section B (see fig. 11) offers the possibility to collect reference material from the lowermost Norian and the uppermost Tuvalian, depending that the latter will be exposed during the excursion. The two marker horizons A and B indicate the Tuvalian/Lacian boundary and the boundary between Lacian 1/I and 1/II respectively. Except the rich occurrence of *Halobia austriaca* in many beds megafossils are lacking in this part of the section. The rich conodont fauna exhibits a distinct vertical sequence from *M. communisti* morphotype A to *M. communisti* morphotype B; this transition has been traced shortly above the Karnian/Norian boundary.

Quarries F 4 and F 5 (Subbullatus and Paulckei-Lager)

The two quarries F 4 and F 5 are located on the north side of Feuerkogel at an altitude of approx. 1590 m hidden by dwarf-pines. Previously, quarry F 4 was described by KRYSTYN & SCHLAGER 1971 and KRYSTYN 1973. Quarry F 5 has been open since 1973; it is situated about 30 m to the west of F 4. This quarry was made to improve fossil collecting and also, to examine the complicated sequence exposed in quarry F 4. Subsequent study of this quarry in 1973 and 1977 provided more detailed information about the sequence (see KRYSTYN 1974 a).

Correlation between both quarries has been achieved on a bed by bed study. The two fossil sites accumulated in a graben-like structure which had formed from the Upper Karnian to the Lower Norian. The extension of the graben is at least 4 x 50 m. Faster subsidence of the northern edge resulted in differentially north dipping sediments whereas in the southern part a thinning of individual beds can be observed. The dip angle depends on the age of the beds (see fig. 12 a) in such a way that the base of the stratigraphic oldest bed VII is almost vertical and its upper bedding plane has an inclination of some 50°. The angle decreased to about 20° in the Lower Norian (bed II). Finally, bed I overlies this structure with a dip angle of approx. 15°. Subsequent tectonic movements were responsible for the opening of fissures which in quarry F 4 were infilled by Upper Norian „Rotkalk" (bed B 3) and in quarry F 5 by Middle Norian „Rotkalk" (bed F 5/B).

Within Upper Karnian time the Feuerkogel represented an area of non-deposition presumably caused by a local submarine ridge and by currents. During that time the depression of the graben in the quarries F 4 and F 5 acted as an ideal fossil and sediment trap. The infilling of cephalopod shells was accompanied by continuous sedimentation and thus condensation did not occur. Detailed study led to the recognition of 7 distinct beds which are described in the following paragraphs. Lithologically, beds VII to II consist of „Roter Bankkalk", the uppermost bed (I) consists of „Massiger Hellkalk" and gradually passes into non-fossiliferous beds (1 + 2).

Quarry F 4 was designated as stratotype of the Tuvalian Stage by KRYSTYN & SCHLAGER 1969. This procedure has been supported by recently achieved results of ongoing studies. For example, in the basal part of bed VII (quarry F 5) a distinct and large ammonoid fauna of the lowermost Tuvalian Dilleri Zone has been found; or a continuous faunal record has been recognized which enabled a precise determination of the Karnian/Norian boundary between beds IV and III.

Fig. 12 b demonstrates the generalized bed sequence of quarries F 4 and F 5. Correlation is based on a distinct lithology (e. g., marker beds IV and III) as well as on faunal evidence. The basal bed VII is not included in the figure because it is fully represented only in quarry F 5 (fig. 12 a); also, for the study of faunistic changes at the assumed Karnian/Norian boundary it is not so important. In fig. 12 b stratigraphically more important ammonoids, halobiids and conodonts are summarized (we refer to this chart; for additional reference see KRYSTYN 1974 a). All beds contain a fairly rich conodont fauna dominated by platform conodonts in a frequency between 50 and 200 specimens per sample (1 kg).

B e d V I I : This bed was subdivided by partings into 4 levels, the lower two containing a distinct ammonoid fauna assigned to the Dilleri Zone (Tuvalian 1): *Tropites* cf. *dilleri* SMITH, *Gymnotropites dinaricus* (DIENER), *G. sulcatus* (CALCARA teste GEMMELARO), *Discotropites* sp., *Sirenites betulinus* (DITTMAR), *Spirogmoceras* cf. *lecontei* (SMITH), cf. *Neoprotrachyceras* n. sp., *Trachysagenites glamocensis* DIENER, *Traskites* sp. and *Halobia superba* MOJS. (VII/3). The only platform conodont found is *G. polygnathiformis.*

The upper two horizons in both quarries contain a typical Tuvalian 2 ammonite fauna as described in earlier reports (KRYSTYN & SCHLAGER 1971, KRYSTYN 1973). Additionally can be stated that *Tropites subbullatus* (HAUER) has been found to be restricted to the uppermost level of the bed thus representing the Tuvalian 2/II-subzone. The conodont fauna of level VII/1 is marked by the appearance of rare *Gondolella nodosa.*

B e d V I a n d V / 2 (F 4) : They are the main layers of the ammonoid genera *Hoplotropites* and *Jovites;* a further distinct species is *Eusagenites tschermaki* (MOJS.) referred to *Malayites* sp. by KRYSTYN 1973, p. 120. The platform conodont fauna comprises *G. polygnathiformis* and *G. nodosa* in a relative abundance ratio of 3–5: 1. Age: Tuvalian 3/I.

B e d V r e s p . V / I (F 4) : The ammonite fauna is dominated by juvavitids *(Projuvavites, Gonionotites)* and scarce tropitids *(Anatropites, Hoplotropites). G. polygnathiformis* and *G. nodosa* are found in an almost equal ratio, together with first representatives of *Epigondolella primitia.* Age: Lower Tuvalian 3/II.

B e d I V : The ammonite fauna is dominated by juvavitids and the stratigraphically more important genera *Anatropites, Microtropites* and *Thisbites.* Concerning platform conodonts a remarkable faunal break occurs between bed V and IV: *G. polygnathiformis* and *G. nodosa* disappeared and are replaced by abundant representatives of *Metapolygnathus communisti* morphotype A associated with *E. primitia* and rare *E. abneptis*. Age: Upper Tuvalian 3/II.

B e d I I I : The ammonite fauna is marked by the appearance of distinct Norian genera such as *Dimorphites* and *Griesbachites*; other common genera are *Gonionotites, Thisbites* and *Styrites.* The platform conodont fauna is composed of abundant *M. communisti* morphotype B together with *E. primitia, E. abneptis* and *Gondolella navicula.* Age: Lacian 1/I.

B e d I I : It is divided by a thin bedding plane which represents the boundary between the Jandianus and the Paulckei Zones.

B e d I I / 2 : It yields an ammonite fauna dominated by the genus *Guembelites;* otherwise it re-

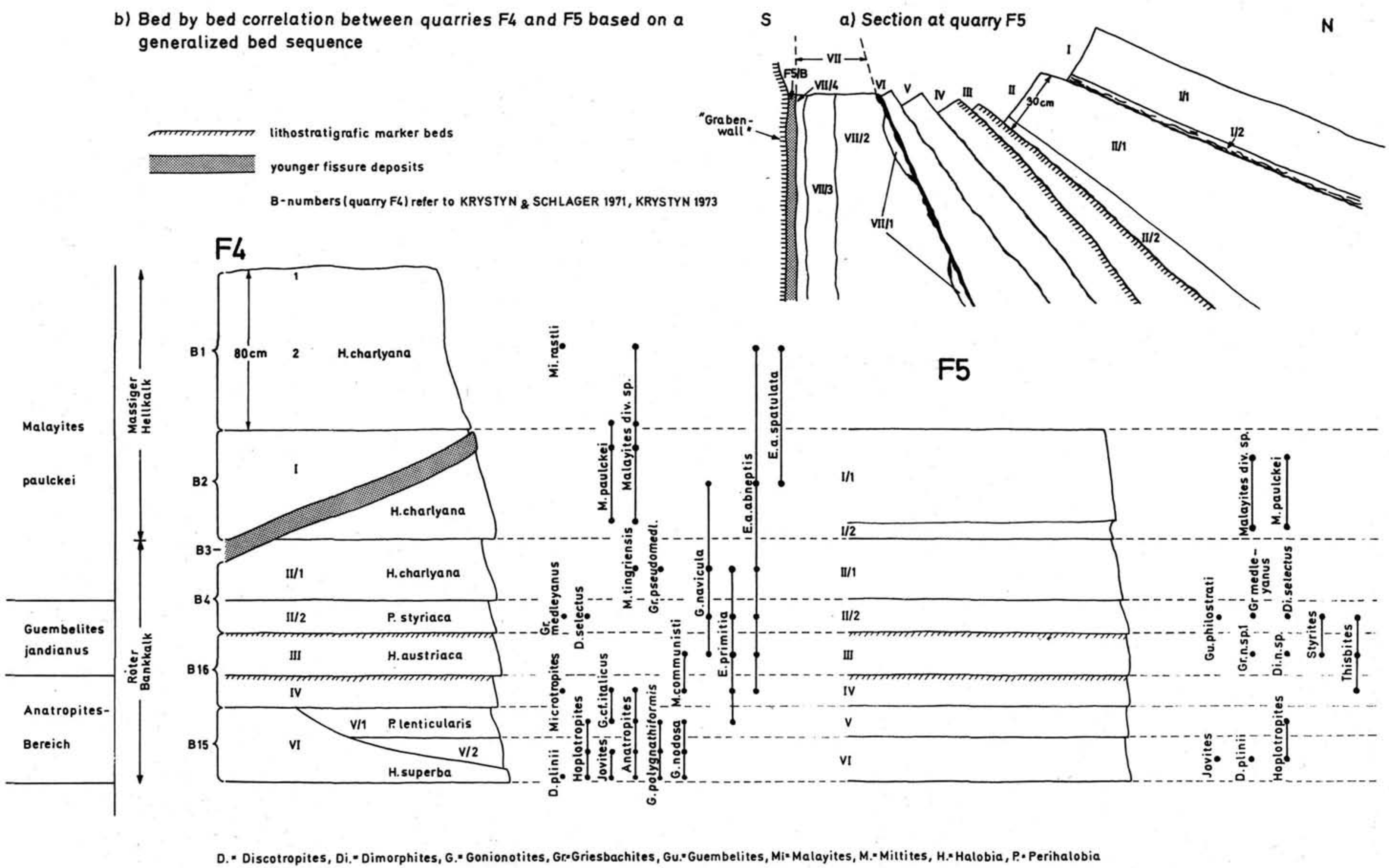

Fig. 12: Bed by bed correlation of sections F 4 and F 5 on the basis of lithologies and faunal evidence as shown by the ranges of diagnostic ammonite and conodont species.

sembles bed III. Also, the conodont fauna is comparable to bed III with the exception that in this bed *M. communisti* disappears. Age: Lacian 1/II.

B e d II / 1 : This bed is characterized by a remarkable change of the ammonite fauna. At least four important genera have disappeared (i. e., *Projuvavites, Guembelites, Styrites, Thisbites);* they are replaced by a rich and diversified *Malayites* fauna. No change affects the conodont fauna. Age: Lower Lacian 2/I.

B e d I : This bed is regarded as typical for the genus *Malayites* at Feuerkogel; moreover, it is the stratum typicum for *Malayites paulckei* (DIENER). The bed may be further subdivided by internal partings which at present, however, do not represent any faunistic changes. The platform conodonts comprise *E. abneptis* and *G. navicula.* Age: Lacian 2/I.

B e d 2 (only in quarry F 4): It represents the horizon with the highest ammonite fauna of the continuous sequence. Yet, our study has not been finished and the fauna collected is not very rich. Different from bed I the genus *Miltites* occurs frequently. A comparable change has been found in the conodont fauna exhibiting frequently *E. abneptis* s. str., rare occurrences of *E. a. spatulata* and questionable representatives of *G. hallstattensis* (broken specimens).

Two isolated fissure deposits filled with „Hangendrotkalk" represent considerable younger faunas. Within quarry F 5 it is bed F 5/B which contains a rich ammonite fauna (see KRYSTYN 1973, p. 130) attributed to the Middle Norian Bicrenatus Zone. The associated platform conodonts are: *E. a. abneptis, E. a. spatulata, E. postera,* and *G. steinbergensis.*

Within quarry F 4 it is bed B 3 originally not recognized as fissure deposit by KRYSTYN & SCHLAGER 1971. It lacks megafossils but contains conodonts such as *Misikella hernsteini* and *G. steinbergensis* indicating an Upper Norian age.

DAY 2

Sommeraukogel, Upper Triassic Hallstatt Limestone
(Stratotype of the Norian Stage; Norian conodonts).

Access from Hallstatt is by a small forest road which runs through the Echern valley to „Hallstatt Salzberg". The two fossil localities Sommeraukogel and Steinbergkogel at Salzberg have been famous for more than 100 years. Although both sites are separated by younger strata of Rhaetian and even Liassic age they have been regarded as part of a continuous sequence (MOJSISOVICS 1905, SPENGLER 1919, see also MOSHER 1968, p. 904). According to SCHÄFFER 1971, however, also at Steinbergkogel a complete Norian section is exposed. Hence, most probably the section at Steinbergkogel represents the original continuation of Sommeraukogel now separated from the latter by a fault.

At Sommeraukogel (= western continuation of Solingerkogel, 1144 m) the most complete Triassic section of the Hallstatt zone is exposed forming an anticlinal structure (cf. KRYSTYN et al. 1971 b). The sequence starts with the Scythian Werfen Fm. which is succeeded by 300 m thick Gutenstein Beds and Steinalm Lst. (light algal lst.), both of Lower to Middle Anisian age. The upper Middle Anisian and lower Upper Anisian is represented by thin bedded dark, nodular „Graukalk" (= grey limestones), a non-typical Reifling Lst.-type. It is regarded as lateral equivalent of the Schreyeralm Lst. which is widely occurring at Hallstatt Salzberg. The Graukalk is separated from the overlying Hallstatt Lst. by several meters of marls.

In 1968, p. 903, MOSHER described a Ladinian (?) conodont fauna with „*Neospathodus microdus*" which was derived from the so-called „Reef Lst." at the east side of Sommeraukogel. Subsequent studies have shown that these strata correspond to the Reifling Lst. and directly overlie the Steinalm Lst. suggesting a Middle Anisian age (*kockeli*-Zone).

At Sommeraukogel the Hallstatt Lst. Group begins above the forementioned marl horizon. Ladinian to Norian equivalents of the Hallstatt Lst. are represented by various lithologic types (compare fig. 13 and KRYSTYN et al. 1971, pp. 614 respectively); the equivalents of the Rhaetian Stage are developed as Zlambach Fm. In this connection it should be noted that the Ladinian Stage has been proved for the first time by megafossils within the Hallstatt facies of the N.C. A. occuring in the greyish-yellowish „Bankkalk" (= bedded limestone) at Sommeraukogel.

During the excursion main emphasis will be drawn to the Norian „Hangendrotkalk" with its classical ammonite and conodont localities. The Ladinian and Karnian Hallstatt Lst. will be shown much easier at locality Feuerkogel; its access at Sommeraukogel on the steep forest seems too strenuous for this party.

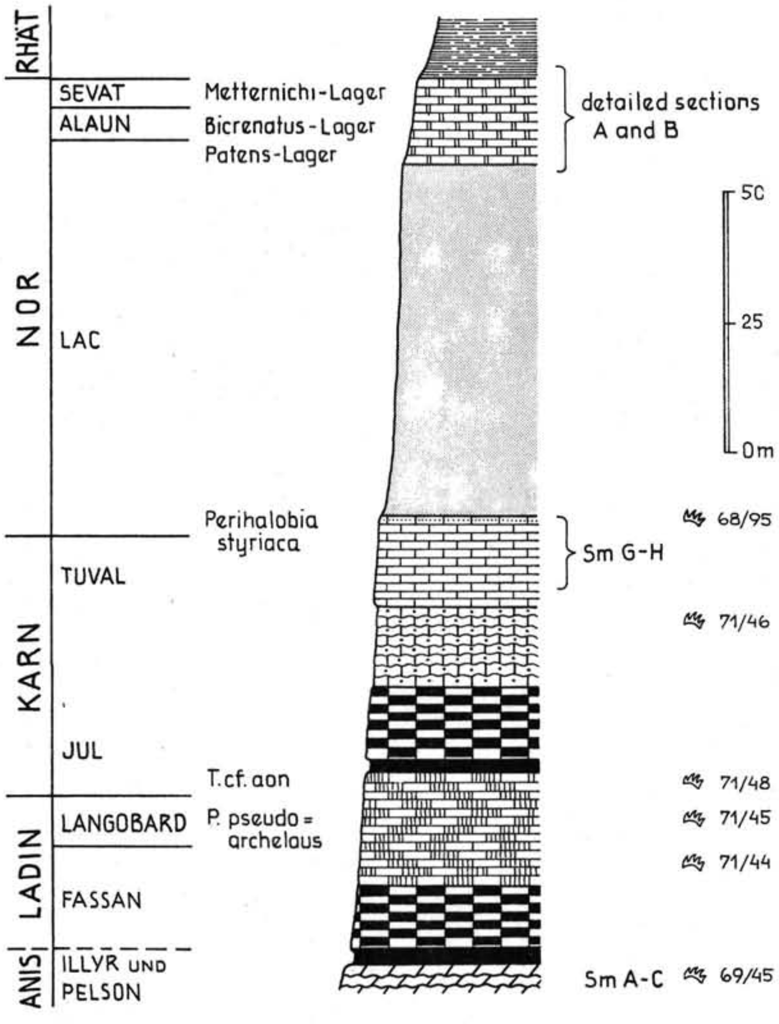

Fig. 13: Composite stratigraphic column of the Hallstatt limestone at Sommeraukogel with vertical distribution of conodont samples mentioned in text. Lithology as in fig. 9, Sm – Numbers refer to MOSHER 1973; for detailed sections A and B see fig. 15. Modified from KRYSTYN & SCHÖLLNBERGER 1972.

Access to the Norian fossil localities in the upper part of the sequence, an E–W striking wall at an altitude of 1050 m is through the graben „Zwischen den Kögeln". The well bedded steeply dipping Rotkalk was quarried in the last century to armour the gallery of the salt mine. Together with coeval limestone at Steinbergkogel they represent the type locality of the Hallstatt Lst. (HAUER 1846, p. 45–46).

Due to the fact that the rich ammonite faunas provided the base to establish the Norian Stage (MOJSISOVICS 1869) Sommeraukogel was chosen and proposed as stratotype for the Norian by KRYSTYN et al. 1971 b. All classical fossil horizons are embedded in a Fe–oxid rich subsolution facies of the Hangendrotkalk, the thickness of which is thinning in the direction of a submarine ridge. Hence, the extension and thickness of the cephalopod bearing horizons („Lager") presumably depends on the relief of the sea bottom. According to figs. 14 and 15 individual fossil localities are separated both geographically and stratigraphically: Nearest to the ridge beds with the Lower Norian Patens-Fauna („Linse mit *Discophyllites patens*" by MOJSISOVICS 1873–1902) are developed; some 30 m further to the west the Bicrenatus-Lager („Linse mit *Cyrtopleurites bicrenatus* s. MOJSISOVICS) follows (in previous times a 4 to 5 m thick ammonite bearing bed of red limestone was exposed the exact place of which can be located by some drilling holes). The third fossil layer is some 150 m to the west and 2 m above the Bicrenatus-Lager in the upper clayey part of the Rotkalk; this bed has been known as „Metternichi-Lager" due to abundant occurrences of Upper Norian ammonites and heterastridians.

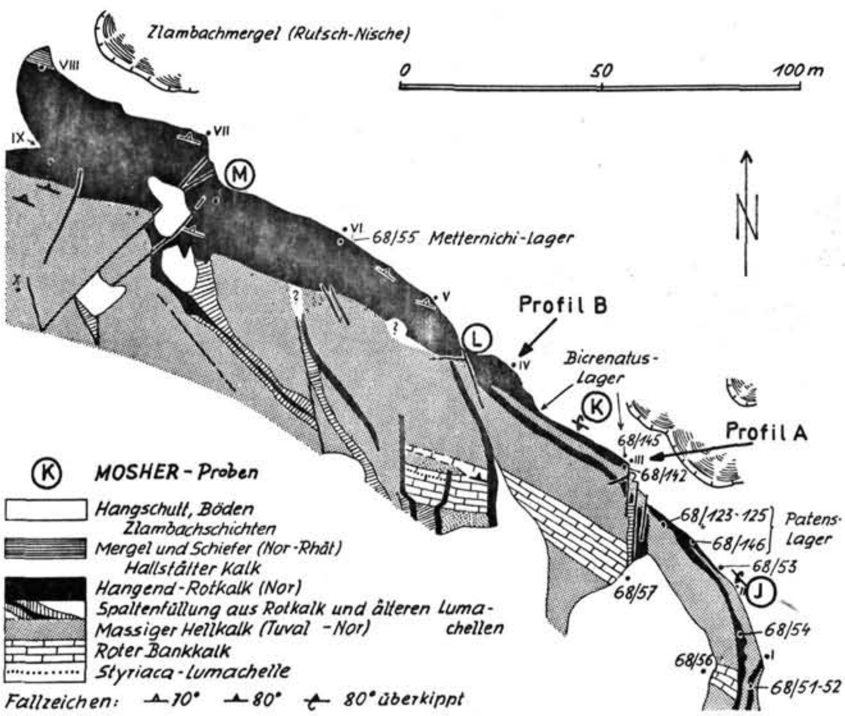

Fig. 14: Geological map of northern slope of Sommeraukogel. Strongly northwards dipping beds of Massiger Hellkalk (dotted) followed by Hangendrotkalk (black). Arrows indicate location of conodont sections A and B. Roman figures: topographic measure points. Modified from KRYSTYN, SCHÄFFER & SCHLAGER 1971 a.

In the upper part the Hangendrotkalk passes into the Zlambach Fm.; the transitional beds with a thickness of a few meters yielded conodonts, e. g., *Gondolella steinbergensis* MOSHER and *Misikella hernsteini* (MOSTLER).

According to MOJSISOVICS 1902 the fauna of the Patens-Lager represents his Patens-Zone and defines Lower Norian. In the zonal scheme of TOZER 1967 it corresponds to the Magnus Zone. From the typical beds 68/123–125 a large number of ammonoids was collected dominated by species of the genus *Juvavites* (for description of the species we refer to MOJSISOVICS 1873–1902); two specifically undeterminable *Juvavites* have also been found in the uppermost bed of the „Massiger Hellkalk" and in the overlying basal bed of the Hangendrotkalk of conodont section A (see pt. III, fig. 15).

The upper part of section A is equivalent to the Bicrenatus-Lager of MOJSISOVICS (identical with his „Bicrenatus-Zone"). The extremely rich ammonoid fauna described by him between 1873 and 1902 originated from a several meter thick horizon including also some beds of the underlying Patens-Fauna. Based on a re-study two levels can be distinguished, i. e., a lower one with the Bicrenatus-Fauna proper (Bicrenatus Zone) and an upper one which is characterized by ammonites of the genus *Halorites* (fig. 15, beds 68/102, 68/146 and section B, bed 4). The latter horizon which is widely distributed at Sommeraukogel has been named *Halorites* Beds by KRYSTYN 1973. Subsequent studies by TATZREITER 1978 on the Middle Norian ammonoid fauna of the Hallstatt Lst. of Timor has proved this genus to be diagnostic of the upper half of the Columbianus Zone throughout the Tethys realm. However, the main layer of *Halorites* can be attributed to subzone IV of TATZREITER, i. e., the highest level of the zone (TATZREITER 1978, p. 113). Hence, in section B the Middle/Upper Norian boundary may be drawn near or at the top of bed 4 (see fig. 15).

The placement of the Lower to Middle Norian boundary causes more problems: Specimens of the genus *Juvavites* from the basal beds 75/11 and 75/12 of section A are clearly attributed to the uppermost Lower Norian Magnus Zone. Above, i. e., within the lower division of the Bicrenatus-Lager ammonites are exceedingly rare. Since no stratigraphically diagnostic species have been found in bed 75/13 or above the Lower to Middle Norian boundary can not be drawn precisely. Perhaps it corresponds to the base of bed 75/13 as is indicated by the conodont fauna (see below). Moreover, in both sections a zonal subdivision of the Bicrenatus-Lager is still lacking and probably will not be possible in the future too due to the present rare occurrences of megafossils.

The Upper Norian Metternichi-Lager (fossil locality 68/55) was newly described by KRYSTYN et al. 1971; it represents the Suessi Zone in terms of ammonoid biostratigraphy. The ammonoid fauna consists of large specimens of *Pinacoceras metternichi* (HAUER) and some other leiostracean forms (see KRYSTYN & SCHÖLLNBERGER 1972, p. 96). Furthermore, the uppermost bed of the Hallstatt

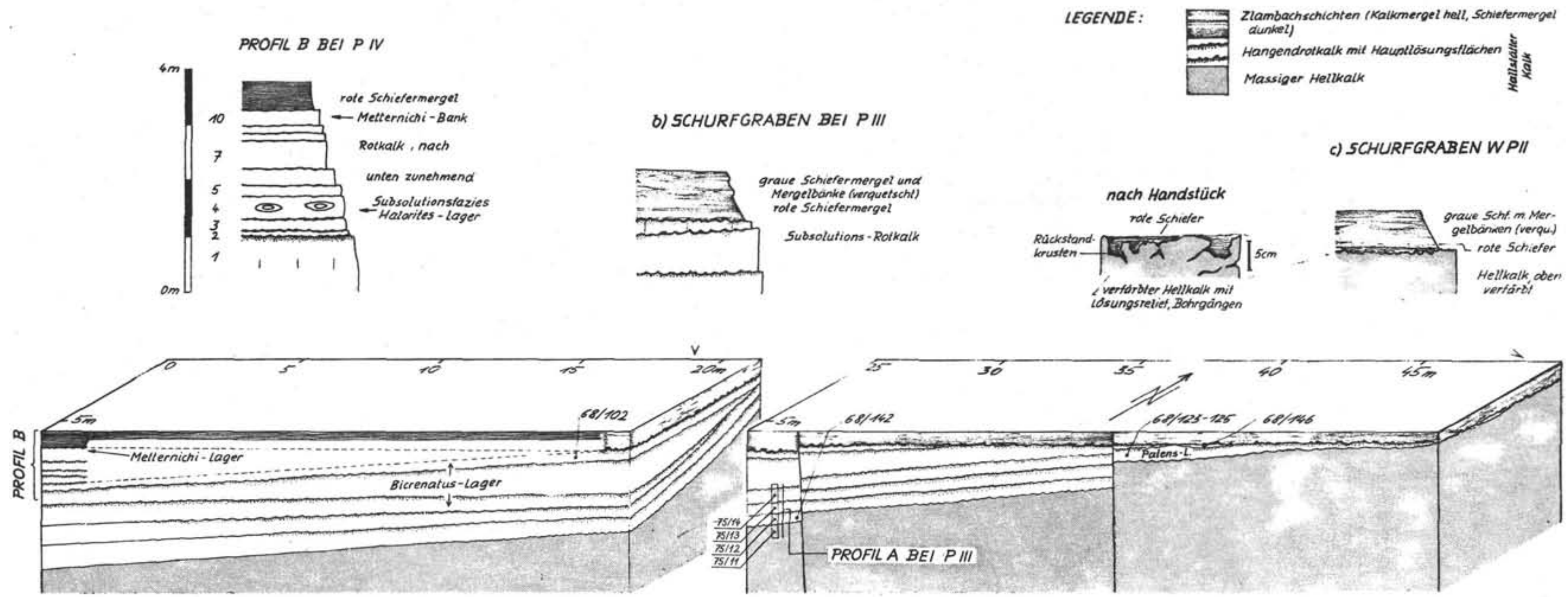

Fig. 15: Diagrammatic section of Sommeraukogel near Hallstatt showing position of classical Norian ammonite beds and conodont sections A and B. Note lack of sedimentation on the top of this submarine ridge (right part of fig.). Modified from KRYSTYN, SCHÄFFER & SCHLAGER 1971 a.

Lst. is rich in large representatives of *Heterastridium* which supposedly belongs to planctonic hydrozoans.

The transition from the Hallstatt limestone to the Zlambach Fm. is characterized by distinct disappearances of many faunal groups. Based on the discovery of *Vandaites stuerzenbaumi* (BOECKH) in a comparable position in the Lauterbachgraben west of Sommeraukogel (by A. TOLLMANN) the Lower Rhaetian age for the transitional beds has been confirmed.

Conodont research

Based on the studies of HUCKRIEDE 1958 and MOSHER 1968 the Sommeraukogel has become most important for conodont research in the Norian Stage. It is the type locality of *Epigondolella abneptis* (HUCKRIEDE 1958, p. 156) and „*Paragondolella navicula hallstattensis*" (MOSHER 1968, p. 939) as well as of the *E. abneptis* Assemblage Zone of MOSHER. The same author also recognized in samples collected from the Hallstatt Lst. at Sommeraukogel the transition from *G. polygnathiformis* to *E. abneptis*. Some of his „intermediate forms" are now treated as independent species. Furthermore. MOSHER 1968 was the first to proof the presence of Upper Norian strata at Sommeraukogel by means of conodonts. Additional data concerning conodont biostratigraphy at Sommeraukogel were provided by KRYSTYN & SCHÖLLNBERGER 1972 and MOSTLER et al. 1978.

In the following chapter a few diagnostic samples are listed from the lower part of the sequence (Anisian to Karnian). The exact stratigraphic position is indicated in fig. 13. As already has been said these sampling sites will not be visited because access is too difficult. Main attention should be drawn to sample 69/45 which, apart from others yielded *Gladigondolella tethydis* reported for the first time in the Middle Anisian of the „Austroalpine conodont province" of KOZUR.

sample 69/45: Middle Anisian (= Pelsonian)
Gondolella bulgarica BUDUROV & STEFANOV, *Gondolella excelsa* MOSHER, *Gladigondolella tethydis* HUCKRIEDE, *Nicoraella kockeli* (TATGE), *Cornudina triquetra* (TATGE), *Enantiognathus petraevirdis* (HUCKRIEDE), *Hibardella magnidentata* (TATGE), *H. pectiniformis* (HUCKRIEDE), *H. suevica* TATGE, *H. aequiramosa* KOZUR & MOSTLER, *Prioniodina muelleri* TATGE.

sample 71/44: Lower Ladinian? (= Fassanian)
Gondolella excelsa (MOSHER), *G.* cf. *longa* BUDUROV & STEFANOV, *Gladigondolella tethydis* (HUCKRIEDE), *Enantiognathus ziegleri* (DIEBEL), *E. petraeviridis* (HUCKR.) *Didymodella alternata* (MOSHER), *Hibardella magnidentata, Hindeodella (M.) pectiniformis* (HUCKR.), *Neohindeodella triassica* (MÜLLER), *Ozarkodina saginata* (HUCKR.), *Pioniodina pectiniformis* (HUCKR.).

sample 71/45: Upper Ladinian (= Longobardian)
Gondolella excelsa (MOSHER), *G. excentrica* BUDUROV & STEFANOV, *G. trammeri* KOZUR, *Gladigondolella tethydis,* ramiform elements as in sample 71/44.

sample 71/48: Lower Karnian (= Julian 1/I); corresponding to sample 68/58 of KRYSTYN et al. 1971 b).
G. polygnathiformis BUDUROV & STEFANOV, *Carinella mungoensis* (DIEBEL) – see KRYSTYN 1973, pl. 1, fig. 1, 3; ramiform elements as in sample 71/44.

sample 71/46: Upper Karnian (= Tuvalian 3)
G. polygnathiformis (BUD. & STEF.), *G. nodosa* (HAYASHI).

sample 68/95: Lower Norian (= Lacian 1/II)
Epigondolella primitia MOSHER, *E. abneptis* (HUCKRIEDE), *G. navicula* HUCKRIEDE, *E. ziegleri* (DIEBEL), *H. suevica* (TATGE), *Neohindeodella triassica* (MÜLLER).

During the excursion the Norian part of the sequence can be studied and sampled in detail. Two sections both rich in conodonts will be demonstrated: Section A comprises the interval from the uppermost Lower Norian to the Middle Norian (Magnus to Columbianus Zones), section B exposes rocks from the uppermost Middle Norian to the top of the Norian (Suessi Zone). Both sections are very short (approx. 3 m) but apparently they are not condensed. Depending on the quality of the exposures the transition from the Hallstatt Lst. to the overlying Zlambach Fm. can be sampled too; from here the youngest platform conodonts of Triassic age may be expected. Dipping of the beds is almost vertical, in parts the layers are even upside down.

Section A located at the eastern end of the Bicrenatus-Lager (pt. III in fig. 15, identical with MOSHER's sample locality Sm-K) consists of a 3 m thick sequence of thick bedded red limestones (Hangendrotkalk) underlain by the topmost bed of the Massiger Hellkalk. The boundary between the two rocks is markedly sharp. The irregular and nodular bedding planes of the Hangendrotkalk are covered by thin iron-hydroxide crusts (subsolution pattern, see KRYSTYN et al. 1971 a). Samples so far collected have yielded platform conodonts the frequence of which varies from 50 to 100 specimens per kg.

The fauna of the two lowermost samples 75/11 and 75/12 is dominated by specimens of *E. abneptis spatulata* against rare occurrences of *E. abneptis abneptis*, further *E. postera*, and *Gondolella hallstattensis*. The age of this assemblage is precisely determinable by the accompanying ammonites indicative of uppermost Lower Norian (Magnus Zone). The succeeding sample 75/13 contains the same platform conodonts except *G. hallstattensis* which is replaced by *G. steinbergensis*. This species has been found elsewhere, e. g., at Feuerkogel and in Timor, to range not lower than the base of the Bicrenatus Zone. Therefore a Middle Norian age is concluded for this fauna but this is not proved implicitly. The uppermost collected sample 75/14 contains a great number of *E. a. abneptis* together with rare *E. a. spatulata*, *E. postera* and *G. steinbergensis*. Based on these conodonts the sample clearly can be assigned to the basal Middle Norian Bicrenatus Zone (lower *postera*-A. Z.).

Section B is located at the western end of the Bicrenatus-Lager (p. IV in fig. 15). It is also composed of a 3 m thick sequence of Hangendrotkalk; 10 exposed beds have been sampled. Conodont abundance varies considerably: Generally, the abundance is lower than in section A. Bed nos. 2, 3, 4 and 10 are rich in platform conodonts. Bed no. 1 forms a prominent and steep rock structure near p. IV with a small north directed base on which the section is located.

Bed nos. 1 to 10 contain the following platform conodonts:

age		
Columb.-Z.	III	bed 1: *E. abneptis* 1 x, *E. postera* 2 x, *E. bidentata* 4 x, *G. steinbergensis* 4 x.
		bed 2: *E. abneptis* 19 x, *E. postera* 19 x, *E. cf. bidentata* 1 x, *G. steinbergensis* 45 x.
	IV	bed 3: *E. abneptis* 4 x, *E. postera* 6 x, *G. steinbergensis* 27 x.
		bed 4: *E. postera* 1 x, *E. bidentata* 3 x, *G. steinbergensis* 18 x.
Suessi Z.		bed 7: *G. steinbergensis* 6 x.
		bed 10: *E. abneptis* 1 x, *E. postera* 2 x, *E. bidentata* 4 x, *G. steinbergensis* 4 x.

Due to rich presence of the ammonoid genus *Halorites* in bed no. 4 samples 1 to 4 are tentatively dated as uppermost Middle Norian. The high content of *E. abneptis* and *E. postera* in sample no. 2 allows a more precise age determination of the two basal beds based on conodont evidence (see above). In the Upper Norian portion of section B (bed nos. 5–8) megafossils are extremely rare; the only exception is the occurrence of the hydrozoan genus *Heterastridium*. One specimen of *Paracladiscites multilobatus* (BRONN) was found in bed no. 8, also one questionable representative of the genus *Rhabdoceras* (a cross section). Bed no. 10 may be traced laterally over some 40 m representing there the typical Metternichi-Lager (locality 68/55). At Sommeraukogel it contains a rich Upper Norian ammonoid and conodont fauna (*E. postera* 10 x, *E. bidentata* 95 x, *G. steinbergensis* 18 x).

The last stop at Sommeraukogel is dedicated to the transition beds between the Hallstatt Lst. and the Zlambach Fm. (between p. VI and p. VII, see fig. 14). The transitional beds consist of two meters of red to greyish thin bedded nodular limestones with red marl intercalations. The following ramiform conodonts were found: *Misikella hernsteini* (MOSTLER), *Oncodella paucidentata* (MOSTLER), *Hindeodella suevica* (TATGE), *Neohindeodella triassica* (MÜLLER), *Hibardella magnidentata* (TATGE), *Prioniodina muelleri* (TATGE). According to MOSTLER et al. 1978 also *G. steinbergensis* is represented but yet no other platform conodonts have been found. In terms of ammonoid stratigraphy these beds indicate a lowermost Rhaetian age (Stuerzenbaumi Subzone).

DAY 3

Koessen Beds of the Osterhorn mountains (Adnet region)
(Rhaetian conodonts)

The excursion will leave Hallstatt in northward direction via Trauntal to Bad Ischl and then turn westward to Salzburg. Close to the village Strobl at Lake Wolfgang the Zinkenbach will be crossed. One of the branches of Zinkenbach is Kendlbachgraben where Koessen Beds are well exposed along a forest track. This classical locality, however, seems unsuitable to obtain good reference material of Rhaetian conodonts due to its dominance of marls. Hence, another locality will be visited in the surroundings of Adnet near the small village of Gaissau, south of the city of Salzburg. The Gaissau section is situated about 10 km from Kendlbachgraben (fig. 16). The Koessen Beds exposed at either locality are lateral equivalents and part of the same tectonic unit. Both sections are easily comparable by their distinct li-

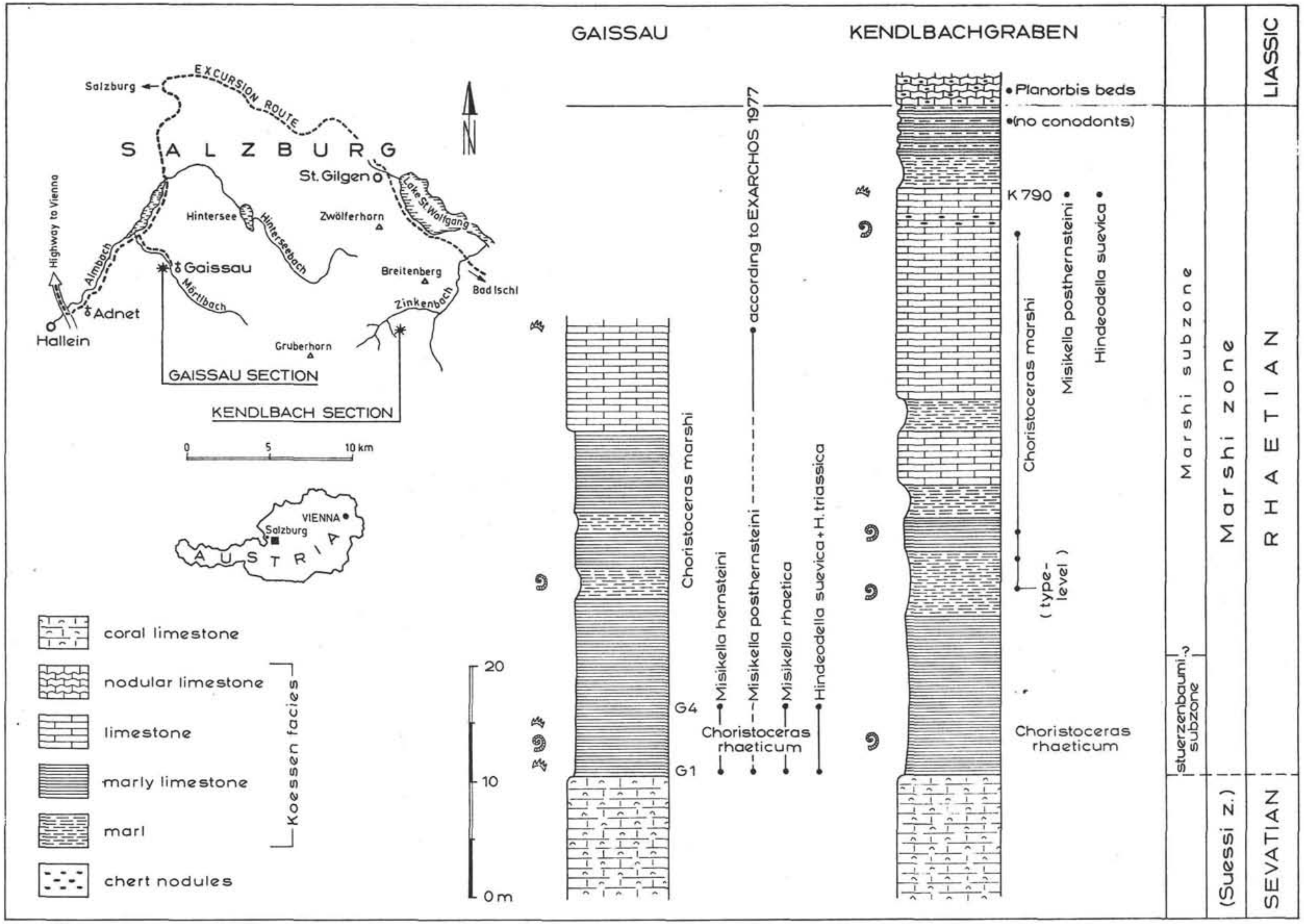

Fig. 16: Stratigraphic sections of Upper Koessen Beds (Koessen facies), Osterhorn syncline near lake St. Wolfgang showing vertical distribution of ammonites and conodonts. Correlation of sections is based on lithology as well as faunal evidence.

thology as well as by the main *Choristoceras marshi*-layer.

The Koessen Beds are widely distributed in the northern part of the Calcareous Alps forming a sequence of thin to medium bedded dark limestones alternating with black to greenish marls and siltstones with a total thickness of 200 to 300 m. They contain a rich megafauna mainly composed of bivalves and brachiopods the latter being recently revised by PEARSON 1977. Stratigraphically the Koessen Beds occupy a position between the Norian Hauptdolomit and various Liassic sediments (e. g., Adnet Limestone, Lias Fleckenmergel), thus ending at the top of the Triassic. By the pioneer study of SUESS & MOJSISOVICS 1868 four main facies have been recognized in the Osterhorn syncline near St. Wolfgang. In ascending order they are:

1) Swabian facies, predominantly composed of thin layered shell beds containing shallow water bivalves such as *Rhaetavicula, Gervilleia* and *Modiolus*.
2) Karpathian facies, mostly nodular limestones and marls with a mixed bivalve and brachiopod fauna the latter dominated by the genus *Rhaetina.*
3) Koessen facies, forming a sequence of well bedded micritic limestones (locally with cherts) and marl intercalations. The fauna is composed of brachiopods dominated by the genus *Oxycolpella* (an unusual large spiriferid), ammonites (abundant *Choristoceras, Eopsiloceras)* and rare bivalves.
4) Salzburg facies, composed of dark soft shales containing pyritized ammonites restricted to the genus *Choristoceras* (stratum typicum of *Choristoceras marshi).*

Based on the study of the famous section Weißloferbach (stratotype of Koessen Beds) URLICHS 1973 presented arguments to consider the Salzburg facies only as a thick marls intercalation of the Koessen facies, a procedure followed by the author. Concerning thickness the Koessen facies corresponds to the upper third of the total Koessen Beds. Only this part contains an abundant pelagic fauna composed of ammonoids and conodonts indicating a deeper environment of approximately 100 m (OHLEN 1959); benthonic organisms are less frequent, in particular bivalves (no *Rhaetavicula).*

At Gaissau section some 100 m of Koessen Beds are exposed the lower 30 m being mainly composed of black shales with nodular limestone intercalations (= Swabian + Karpathian facies). This basal part is succeeded by a 12 m thick layer of massive corallinacean limestone *(Thecosmilia* Lst.) which also occurs at section Kendlbachgraben. The upper part of the section (fig. 16) – corresponding to the Koessen facies – is represented by well bedded grey, partly marly limestones with two dark marls intercalations of which the lower one contains *Choristoceras marshi.* Compared with section Kendlbach some 10 to 20 m of the uppermost Koessen Beds are missing and hence, the Rhaetian/Liassic boundary is not exposed.

Conodont research

Conodonts from the Rhaetian Koessen Beds were first described by MOSHER 1968. Later on KOZUR 1971 and KOZUR & MOSTLER 1973 questioned these founds but changed their mind by subsequent studies (KOZUR & MOCK 1974 b). Finally, MOSTLER (in MOSTLER et al. 1978) published a large and distinct conodont fauna from the above mentioned section Weißloferbach. He attributed the fauna to two zones which were named in ascending order the *rhaetica* and *posthernsteini*-Zones. Almost all species described are represented in the Gaissau section too.

The Gaissau section was studied in detail by EXARCHOS 1977 (unpubl. phil. thesis, Innsbruck University; forewarded to the author by the courtesy of H. MOSTLER). According to EXARCHOS *M. hernsteini* is restricted to the lowermost few meters of the sequence; *M. rhaetica* ranges a little higher up; and *M. posthernsteini* together with rare ramiform elements characterizes the upper part of the section thus confirming the zonation established by MOSTLER at Weißloferbach.

Two samples collected by the author from the base of the Koessen facies yielded a rich fauna which is dominated by species of the conodont genus *Misikella:*

G 1: *Misikella hernsteini* (15 x), *M. rhaetica* (5 x), *M. posthernsteini* (3 x), *Neohindeodella triassica* (1 x).

G 4: *Misikella hernsteini* (1 x), *Misikella rhaetica* (2 x), *Neohindeodella triassica* (1 x).

At section Kendlbach (fig. 16) the uppermost conodonts occur 7 m below the base of the Liassic series. Sample K 790 contains *M. posthernsteini* and *Hindeodella suevica.* The argillaceous limestones (in part sandy lst.) immediately underlying the Planorbis beds and conventionally placed within the topmost Triassic yielded no conodonts.

Acknowledgements

The data presented in this study have resulted from intensive field work carried out in the Upper Triassic Hallstatt Limestone of different parts of the Tethys realm (Salzkammergut, Southern Europe, Timor) in the past ten years. The study is part of a major research program leaded by Prof. Dr. H. ZAPFE on the stratigraphy and invertebrate faunas of the Alpine Mediterranean Triassic at the Paleontological Institute of Vienna University. Field and laboratory work has been supported by the Fonds zur Förderung der wissenschaftlichen Forschung in Österreich (project nos. 2695 and 3726) and by the Austrian Ministry of Science and Scientific Research as a contribution to the International Geological Correlation Programme proj. 4 entitled „Triassic of the Tethys Realm".

Special problems have been discussed with several persons: concerning the ammonoid faunas with Dr. E. T. TOZER, Ottawa; concerning conodonts with Dr. S. HAYASHI, Omama Machi, Prof. Dr. T. KOIKE, Yokohama, and Dr. S. KOVACS, Budapest. Prof. Dr. H. MOSTLER kindly provided additional information on Rhaetian conodonts and made available to the author the unpublished study of A. EXARCHOS, Innsbruck University, on conodonts from the Koessen beds near Adnet. Dr. F. TATZREITER, Vienna, assisted in the field work at Sommeraukogel section B and in the preparation of conodont samples collected there.

Dr. J. HOHENEGGER of Vienna University produced the SEM micrographs, L. LEITNER and N. FROTZLER drafted the figures, and Ch. REICHEL prepared the photographs.

Last but not least the writer wishes to thank his friend W. MAHERNDL, Bad Ischl for his help during fieldwork as well as the enjoyable time spending together in Salzkammergut during past years.

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Plate 11

Magnification 100 x

Fig. 1: *Gladigondolella tethydis* (HUCKRIEDE). Lateral view; Sommeraukogel, sample no. 69/45 (Pelsonian).

Fig. 2: *Gondolella* cf. *excentrica* (BUDUROV & STEFANOV). Lateral view; Sommeraukogel, sample no. 71/45 (Langobardian).

Fig. 3: *Gondolella trammeri* KOZUR. Lateral view; Feuerkogel quarry F1, sample no. 79/2 (Langobardian).

Fig. 4: *Gondolella excelsa* (MOSHER). Lateral view; Feuerkogel base of quarry F1; sample no. 79/1 (Ladinian).

Fig. 5: *Carinella mungoensis* (DIEBEL). Lateral view; Raschberg (Karlgraben), sample no. 77/6 (Langobardian).

Fig. 6: *Carinella diebeli* (KOZUR & MOSTLER). Lateral view; Raschberg (Karlgraben) sample no. 77/8 (uppermost Langobardian).

Fig. 7: *Gondolella polygnathiformis* BUDUROV & STEFANOV. Lateral view; Feuerkogel quarry F1, sample no. 76/2 (condensed upper Ladinian to Lowermost Karnian).

Figs. 8–9: *Gondolella* cf. *navicula* (HUCKRIEDE). Lateral and upper views; Feuerkogel quarry F4, bed no. V/1 (lower Tuvalian 3/II).

Figs. 10–11: *Gondolella navicula* (HUCKRIEDE). Lateral and upper views; Feuerkogel quarry F1, sample no. 70/80 (Lacian 2).

Fig. 12: *Gondolella hallstattensis* (MOSHER). Lateral view; Timor (Indonesia), sample no. F8 (Lacian 3).

Figs. 13–15: *Gondolella steinbergensis* (MOSHER). Lateral and upper views; Sommeraukogel section B, sample no. 2 (Alaunian 2/III).

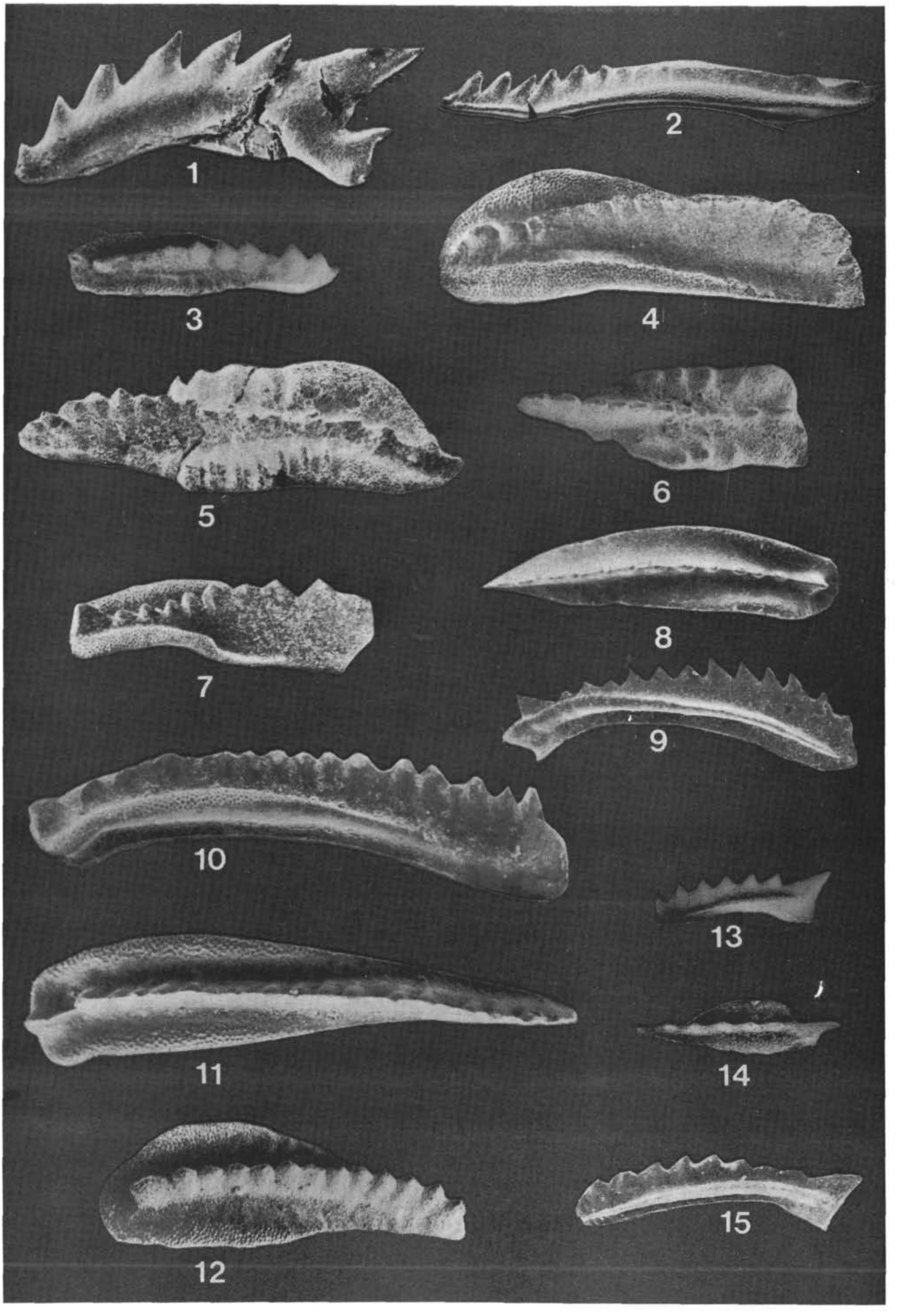
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Plate 12

Magnification 100 x

Feuerkogel, Uppermost Karnian to Lowermost Norian

Figs. 1–7: *Gondolella nodosa* (HAYASHI). Lateral, upper and lower views.
Figs. 1–6: quarry F5, bed no. VII/1 (Tuvalian 2/II), fig. 7: quarry F4, bed V/1 (lower Tuvalian 3/II).

Figs. 8–14: *Metapolygnathus communisti* HAYASHI morphotype A. Lateral, upper and lower views.
Figs. 8–9: section B, sample no. 76/88 (Lacian 1/I), figs. 10–14: quarry F4, bed no. IV (upper Tuvalian 3/II).

Figs. 15–19: *Metapolygnathus communisti* HAYASHI morphotype B. Lateral, upper and lower views; section B, sample no. 79/9 (Lacian 1/I).

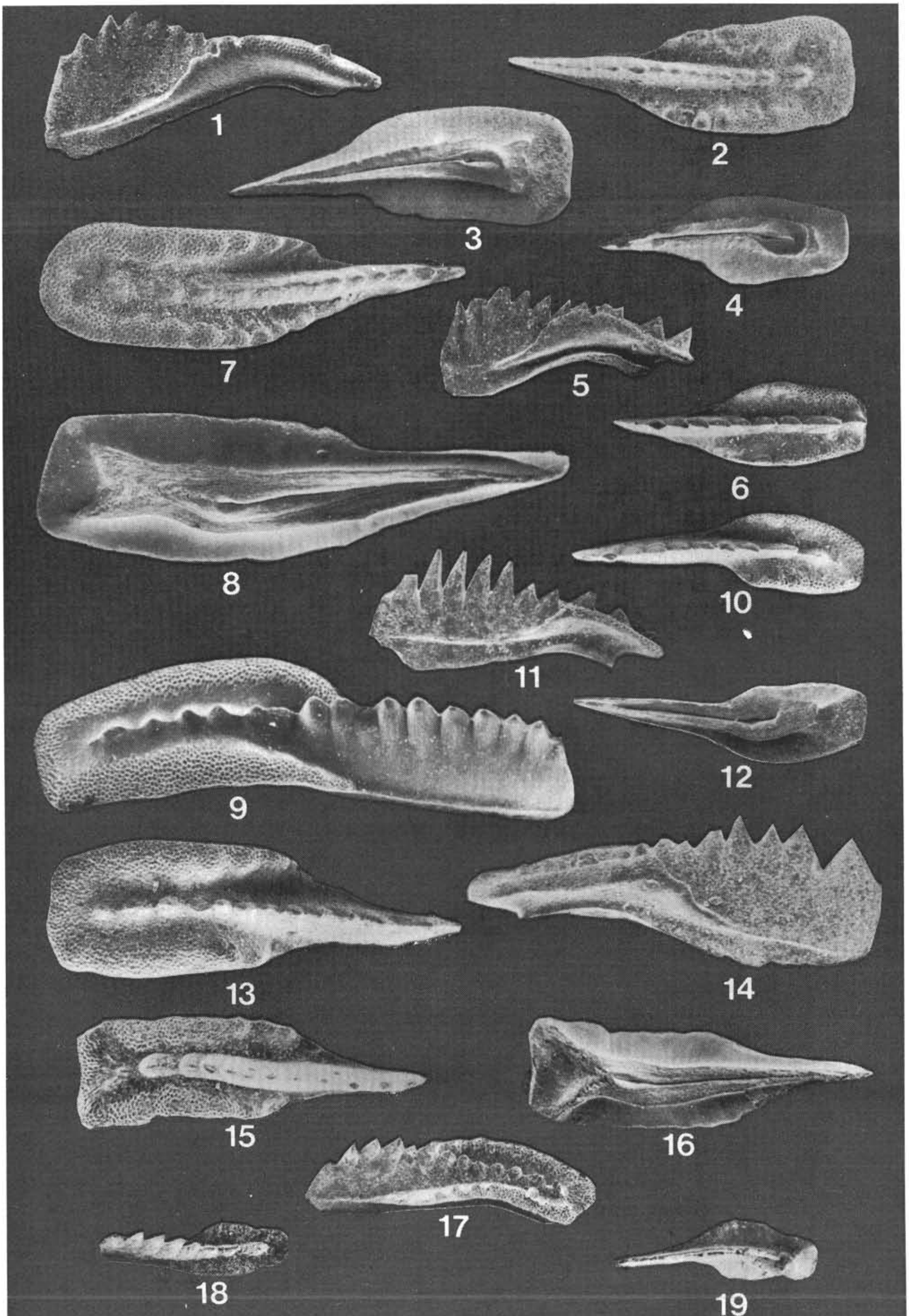
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Plate 13

Magnification 100 x

Feuerkogel and Sommeraukogel, Norian

Figs. 1–7: *Epigondolella primitia* MOSHER. Lateral, upper and lower views.
Figs.1–3: Feuerkogel quarry F4, bed no. IV (upper Tuvalian 3/II), figs. 4–5: same, bed no. V/1 (lower Tuvalian 3/II), figs. 6–7: Feuerkogel section B, sample no. 79/8 (Lacian 1/I).

Figs. 8–11: *Epigondolella abneptis abneptis* (HUCKRIEDE). Lateral and upper views.
Fig. 8: Feuerkogel quarry F4, bed no. IV (upper Tuvalian 3/II), fig. 9: Feuerkogel quarry F5, bed no. I/1 (Lacian 2/I). figs. 10–11: Sommeraukogel section B, bed no. 2 (Alaunian 2/III).

Figs. 12–14: *Epigondolella abneptis spatulata* (HAYASHI). Lateral and upper views.
Fig. 12: Feuerkogel quarry F5, bed no. I/1 (Lacian 2/I), figs. 13–14: Sommeraukogel section A, sample no. 75/12 (Lacian 3).

Figs. 15–18: *Epigondolella postera* KOZUR & MOSTLER. Lateral, upper and lower views.
Figs. 15–16: juv. specimen resembling *E. bidentata*, Timor, sample F 11 (Alaunian 1); figs. 17–18: Sommeraukogel „Metternichi-Lager", sample 68/55 (Sevatian).

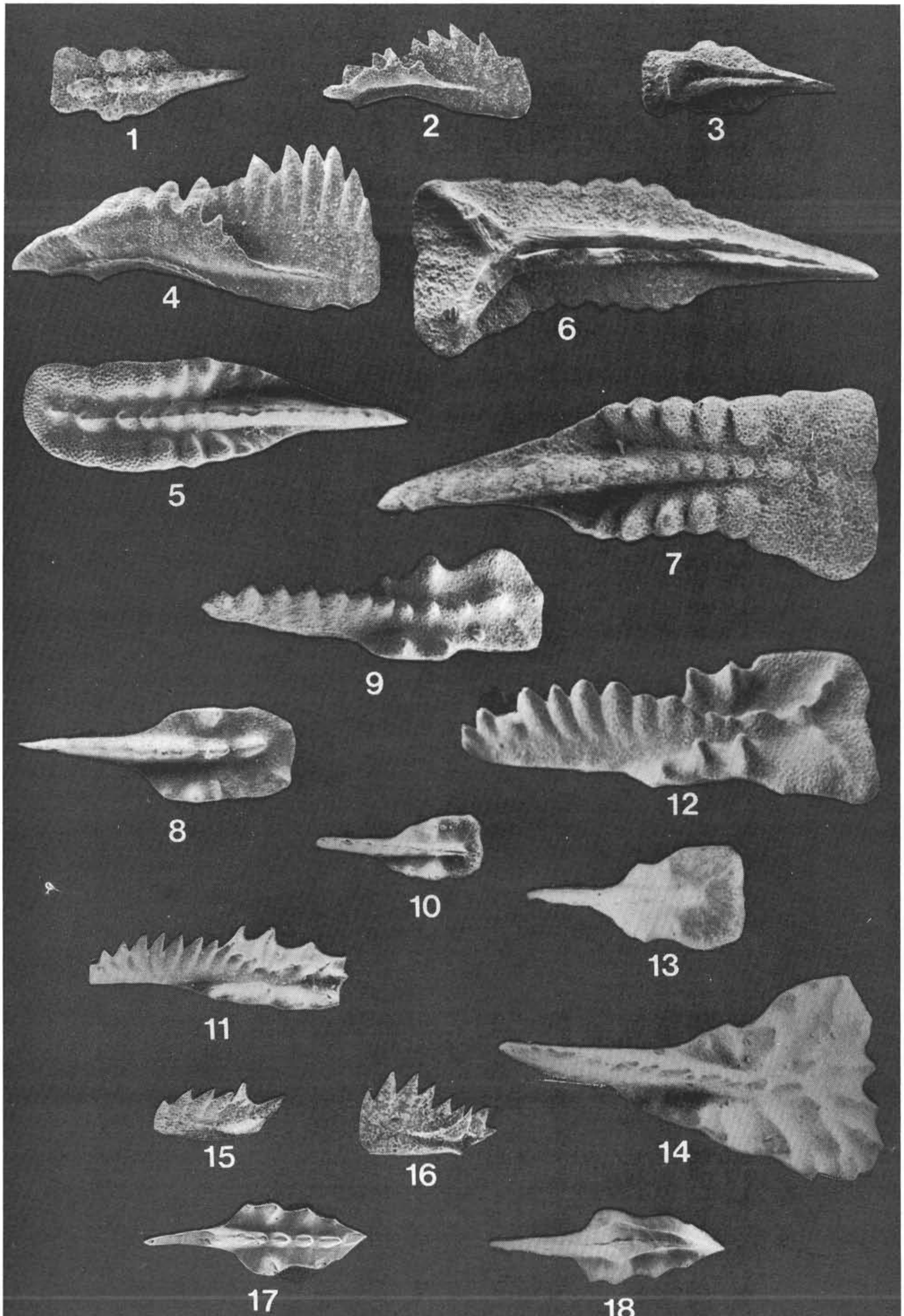
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Plate 14

Magnification 100 x (fig. 1–6)

Feuerkogel and Timor, Upper Norian

Magnification 200 x (fig. 7–14)

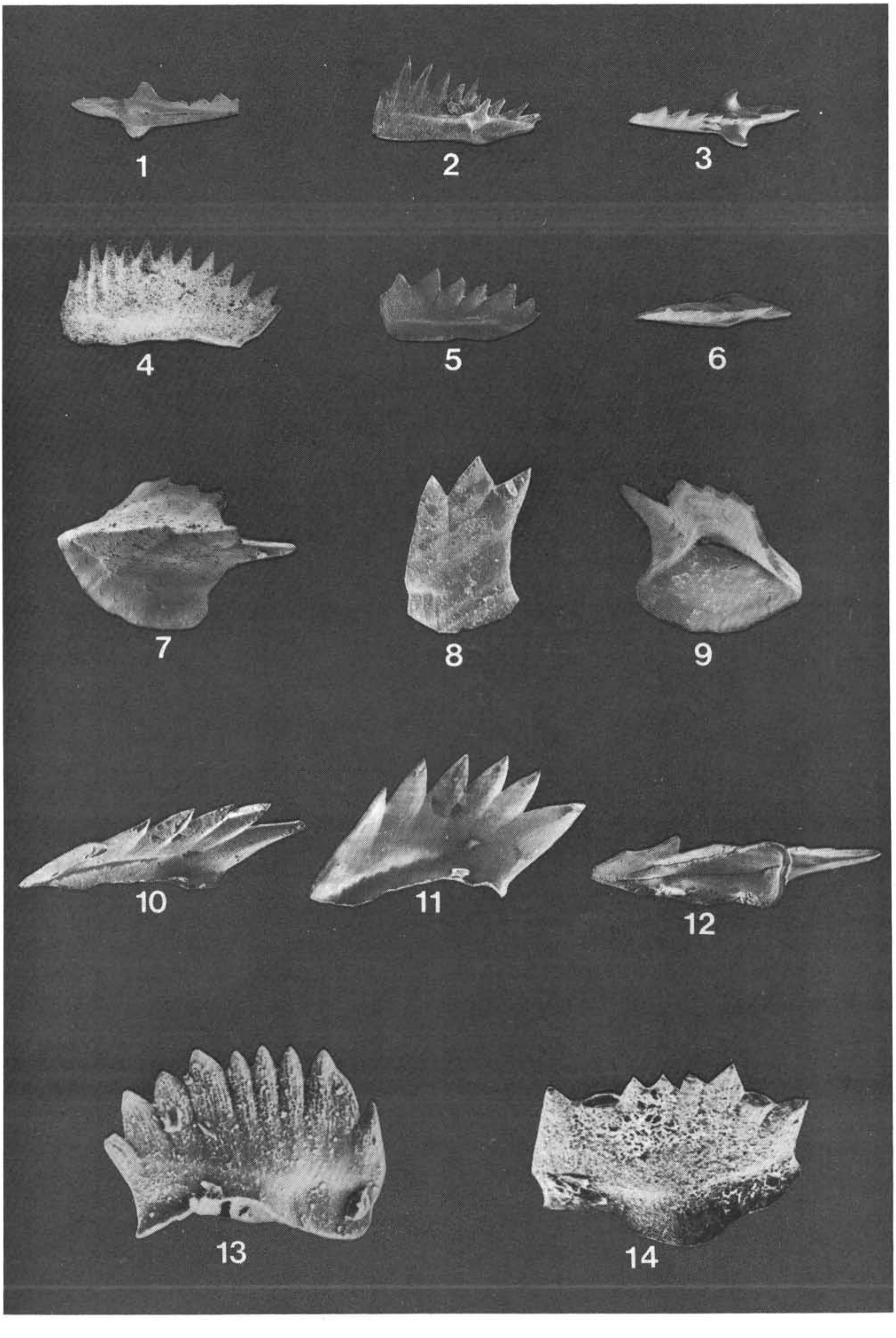
Gaissau section, Rhaetian

Figs. 1–6: *Epigondolella bidentata* MOSHER. Lateral, upper and lower views.
Figs. 1–3: Sommeraukogel, Metternichi-Lager, sample 68/55 (Sevatian), figs. 4–6: *andrusovi*-stage; fig. 4: Timor, sample no. F 18 (Alaunian 2/IV), figs. 5–6: Sommeraukogel, sample 68/55 (Sevatian).

Figs. 7–9: *Misikella posthernsteini* KOZUR & MOCK. Lateral, upper and lower views; Gaissau section, sample no. G 1 (Rhaetian).

Figs. 10–12: *Misikella hernsteini* (MOSTLER). Lateral, upper and lower views; Gaissau section, sample no. G 1 (Rhaetian).

Figs. 13–14: *Misikella rhaetica* MOSTLER. Lateral views.
Fig. 13: Weißloferbach section (from MOSTLER 1978, plate 1, fig. 1), fig. 14: Gaissau section, sample no. G 1 (Rhaetian).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