

Ann. Naturhist. Mus. Wien	87	A	145–166	Wien, November 1985
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Ammonite Zonation of the Gosau Group (Upper Cretaceous, Austria)

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(With 4 tables, 1 textfigure)

Manuscript received 7 May 1985

Abstract

Seventeen ammonite assemblages can be distinguished in the Gosau Group, ranging from the top Turonian to the Upper Maastrichtian. Between the top Turonian/Lower Coniacian and the Upper Coniacian seven faunas can be separated. Four faunas are of Santonian age, three faunas are Campanian, two faunas are Lower Maastrichtian, one is Upper Maastrichtian. The general zonation is mainly based upon the framework provided by KENNEDY's (1984a) revision of the French Coniacian; the Santonian is well-documented following recent investigations by SUMMESBERGER 1979, 1980, KOLLMANN 1980, 1981 and KOLLMANN & SUMMESBERGER 1982. The Campanian is still insufficiently known and poorly documented. A recent study on the Lower Maastrichtian of Neuberg is in press (KENNEDY & SUMMESBERGER); a systematic revision of the ammonites of the Gosau Group as a whole is in preparation.

A "*Romaniceras*" fauna is from the Turonian/Coniacian boundary (Brandenberg I). *Barroisiceras haberfellneri* is probably of Lower Coniacian age. Possibly younger is a *Forresteria* fauna from Ischl. The Middle Coniacian is well represented by a peroniceratid fauna and by *Metatissotia*. The „Fauna von Glaneck“ previously thought to be the oldest ammonite fauna from the Gosau (BRINKMANN 1935), is from the Upper Coniacian and can be separated into two assemblages, one containing *Gauthiericeras margae* and a second with *Paratexanites serratomarginatus*.

The base of the Santonian is indicated by the appearance of *Texanites quinquenodosus*. *Hemitissotia randoi* appears abundantly as a local event in the Lower Santonian. The appearance of *Muniericeras gosauicum* is provisionally taken as the event indicating the base of the Upper Santonian. Abundant *Placenticeras polyopsis* characterizes the top Santonian.

The base of the Campanian is marked by the appearance of *Placenticeras* cf. *bidorsatum*. The most prominent ammonites from the Lower Maastrichtian are *Pachydiscus neubergicus* and *Pseudokossmaticeras brandtii*. The Upper Maastrichtian is marked by the appearance of *Pachydiscus gollevillensis*.

Zusammenfassung

In der Gosaugruppe können 17 Ammonitenfaunen unterschieden werden. 7 Faunen treten zwischen der Turon/Coniac Grenze und dem Oberconiac auf. 4 Faunen sind in das Santon zu stellen, 3 Faunen ins Campan und 3 ins Maastricht. Zufolge der komplizierten tektonischen Verhältnisse im Mittelabschnitt der Kalkalpen konnte bislang keine lithostratigraphische Folge für das Coniac erstellt

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werden. Die Korrelation der Coniacfaunen basiert daher in erster Linie auf der Revision des französischen Coniac durch KENNEDY (1984a). Das Santon ist durch Neuaufnahmen im Becken von Gosau gut dokumentiert (KOLLMANN, H. A., SUMMESBERGER, H., verschiedene Arbeiten seit 1979). Das Campan ist vielfach durch Tiefwasserablagerungen vertreten, die ganz allgemein wenig Ammoniten führen. Arbeiten über das Maastricht (Neuberg) und über die systematische Revision der österreichischen Gosauammoniten sind im Druck oder in Vorbereitung (KENNEDY & SUMMESBERGER).

Eine „*Romaniceras*“-Fauna (Brandenberg I) tritt an der Turon/Coniac Grenze auf. Diese wird als die älteste bekannte Ammonitenfauna der Gosaugruppe aufgefaßt. In stratigraphischer Reihenfolge folgt eine *Barroisiceras*-Fauna im Unterconiac (?). Das Mittelconiac ist durch eine Peroniceraten-Fauna vertreten. Die vermutlich ältere *Forresteria*-Fauna von Ischl wird ebenfalls dem Mittelconiac zugerechnet. Die „Fauna von Glaneck“, noch von BRINKMANN (1935) als älteste Ammonitenfauna der Gosauschichten aufgefaßt, enthält Vertreter der beiden obersten Ammonitenzonen des französischen Coniac (sensu KENNEDY 1984a, b), *Gauthiericeras margae* und *Paratexanites serratomarginatus*.

Das Auftreten des *Texanites quinquenodosus* markiert die Zeitenwende zum Santon. Ein Lokalereignis im Untersanton stellt das Auftreten von *Hemitissotia randoi* dar. *Muniericeras gosauicum* dient vorläufig dazu, die Untergrenze des Obersantons zu markieren. Das Obersanton ist durch die relative Häufigkeit des Zonenammoniten *Placenticeras polyopsis* gekennzeichnet. *Placenticeras* cf. *bidorsatum* tritt im Unter Campan auf. Bekanntester Vertreter des Untermaastricht ist *Pachydiscus neubergicus*. Etwa gleichalt ist die Untermaastrichtfauna aus Grünbach und der Neuen Welt. *Pachydiscus gollevillensis* von der Gahnsleiten (Niederösterreich) ist offenbar der einzige Vertreter des Obermaastricht in der Gosaugruppe.

General introduction

The Gosau group occurs in the Eastern Alps in a variety of different facies with basal transgressions of different age. Due to tectonic movements and subsequent erosion it appears today in isolated basins with sediment thicknesses that are in excess 2000 metres in some cases. Each basin is characterized by an independent clastic sequence. Ammonites were described by HAUER (1858, 1866), REDTENBACHER (1873), THIEDIG & WIEDMANN (1976), WIEDMANN (1978, 1979 in: HERM, KAUFFMAN & WIEDMANN), SUMMESBERGER (1979, 1980) and IMMEL, KLINGER & WIEDMANN



Textfigure 1: Sketch-map of the localities mentioned in the text.

(1982). Previous attempts to establish an assemblage fauna zonation on the basis of ammonites (BRINKMANN 1935, WIEDMANN 1979b) failed due to insufficient knowledge of lithostratigraphic sequences and inadequate collecting technique. Careful section measuring and bed-by-bed collecting as well as analysis of tectonic conditions by H. A. KOLLMANN and the author as well as a systematic revision of the ammonites by W. J. KENNEDY and the author (in preparation) are the basis for a renewed attempt to establish a reconstruction of the ammonite succession of the Gosau group. In the following account, roman numbers indicate different faunas occurring within a single area, fossil sites within a local sequence are marked by arabic numbers.

UPPER TURONIAN/LOWER CONIACIAN – UPPER CONIACIAN

The ammonite fauna Brandenburg I (Tyrol, Austria)

Introduction:

Two ammonite horizons are present in the Brandenburg sequence. The higher one (p. 155) is of Santonian age. The lower one, recently discovered (HERM, KAUFFMAN & WIEDMANN 1979), yielded a fauna described by WIEDMANN (in: l. c.). The age was determined as Middle Coniacian. KAUFFMAN (l. c., p. 76/77) identified and described the inoceramids. He suggested (l. c., p. 81) a Lower Coniacian age. This lower ammonite horizon Brandenburg I was apparently unknown to BRINKMANN. His "*Acanthoceras gentoni*" (l. c., p. 2) has not been traced in the collections of the Haus der Natur, Salzburg.

Ammonite fauna (after WIEDMANN, in: l. c.):

"*Solgerites*" cf. *brancoi* (SOLGER)

"*Romaniceras (Yubariceras)*" *gosauicum* (WIEDMANN)

Hemitissotia alpina WIEDMANN

Accompanying fauna – after KAUFFMAN, in: l. c.):

Table 1. Stratigraphic range of the inoceramids at Brandenburg 1.

TURONIAN		CONIACIAN	
M. T.	U. T.	L. C.	M. C.

Mytiloides africanus

Cremnoceramus w. hannovrensis

Inoceramus (I.) koegleri

Mytiloides lusatae brandenburgensis

Inoceramus (I.) inaequivalvis

Mytiloides striatoconcentricus troegeri

Age:

Upper Turonian/Lower Coniacian boundary according to the evidence of inoceramids.

Discussion:

After MATSUMOTO (1975, p. 131) *Yubariceras* is restricted to the Turonian. *Yubariceras otatumei* (MATSUMOTO, SAITO & FUKADA), the youngest representative, occurs near the top Turonian in the subzone of *Reesidites minimus*.

Following WRIGHT, CHANCELLOR & KENNEDY (1983) who regard "*Yubariceras*" *gosauicum* WIEDMANN as a member of the genus *Codazziceras* ETAYO-SERNA Lower Coniacian seems likely. No age indication is provided by *Hemitissotia alpina* WIEDMANN. *Hemitissotia* goes well up into the Santonian in the basin of Gosau (KOLLMANN & SUMMESBERGER 1982, p. 68/69). WIEDMANN's age determination of Middle Coniacian (1979 in HERM, KAUFFMAN & WIEDMANN) is based upon a single fragment of a corroded "*Solgerites*" (l. c.: p. 48; pl. 5, Fig. A, B). WIEDMANN's identification "*Solgerites*" sp. cf. *Solgerites brancoi* (SOLGER)" is doubtfully quoted by KENNEDY (in press b). According to KENNEDY (l. c.) *Solgerites* is a synonym of *Forresteria*. It appears in the Coniacian.

Better age indication is provided by the inoceramids. KAUFFMAN (1979 in: HERM, KAUFFMAN & WIEDMANN, p. 77) gives the following age determination: "The Inoceramidae of the northern Gosau facies are diverse cosmopolitan forms which mainly characterize the latest Turonian – Lower Coniacian boundary zone . . .". Additional support for KAUFFMAN's argumentation was given recently by U. KAPLAN (pers. comm. August 1985) who found *Cremnoceramus waltersdorfensis hannovrensis* (HEINZ) 15 metres below *Forresteria* (*Harleites*) *petrocoriensis* in the quarry N of Schlangen (Egge, Westphalia). In terms of ammonite stratigraphy proposed by KENNEDY (1984a, b) this means top Turonian.

Occurrence:

From only the northern facies of the Brandenburg Gosau (Brandenburg 1 = Zöttbachgraben).

The ammonite fauna Strobl I**Introduction:**

Ammonites haberfellneri was described originally by HAUER (1866, p. 2–4) from the Gams basin (Steiermark) and from the Ofenwand near Strobl (Weißbach valley). The latter locality is identical with Strobl I. REDTENBACHER (1873, p. 103) described *Ammonites paeon* from the same sites. Systematic revision (KENNEDY & SUMMESBERGER, in prep.) leads to the conclusion that both are conspecific. *Barroisiceras haberfellneri hemitissotiformis* from the same locality described by PLÖCHINGER (1955, p. 203–206, pl. 1) is an adult specimen of *B. haberfellneri* (KENNEDY & SUMMESBERGER, l. c.). The long lasting misidentification

of *Forresteria (Harleites) petrocoriensis* (COQUAND) as *Barroisiceras haberfellneri* was recently clarified by KENNEDY (1984a, p. 52, 1984b, p. 153). KENNEDY's work left open the question of the age of *B. haberfellneri*.

Ammonite fauna:

Barroisiceras haberfellneri (HAUER)

Gaudryceras glaneggense (REDTENBACHER)

possibly: the holotype of *Gaudryceras mite* (HAUER)

Accompanying fauna:

A diverse fauna of gastropods, bivalves and solitary corals. Stratigraphically interesting is the appearance of *Didymotis* sp.

Age: Lower Coniacian; zone of *F. (H.) petrocoriensis*.

Discussion:

The appearance of *Didymotis* suggests a lower Coniacian age (HERM, KAUFFMAN & WIEDMANN, l. c., p. 80). WOOD, ERNST & RASEMANN (1984) record it from the top Turonian/basal Coniacian of Lower Saxony. They suggest that their *Didymotis* ecoevent II indicates the base of the Coniacian because of the contemporaneous appearance of *Cremnoceramus ? waltersdorfensis hannovrensis* (HEINZ) and *Forresteria (H.) petrocoriensis*. Following WOOD, ERNST & RASEMANN, Strobl I would be placed into the top Turonian/basal Coniacian. That would be approximately the same stratigraphic position as Brandenburg I. Direct correlation with Brandenburg is impossible. With respect to the absence of *Didymotis* in the Middle Coniacian faunas Strobl II and III, Strobl I is thought to be older than Middle Coniacian.

Comparable faunas containing *Barroisiceras* and/or *Didymotis* are generally of Lower Coniacian age. *Barroisiceras onilahyense* BASSE, a close ally of *B. haberfellneri* (HAUER), occurs in Madagascar in the Zone of *Kossmaticeras theobaldianum* (STOLICZKA) and *B. onilahyense* (COLLIGNON 1965, p. 68). This is Coniacian I (sensu KENNEDY & KLINGER 1975, p. 278) and lowest Coniacian after KENNEDY (1976, p. 5). In Japan *B. onilahyense* occurs in the lower zone (Zone of *Inoceramus uwajimensis* YEHARA) of the Lower Urakawan (MATSUMOTO 1981, p. 68 in: MATSUMOTO, MURAMOTO, HIRANO & TAKAHASHI) together with *Didymotis akamatsui* (YEHARA) (MATSUMOTO, HIRANO & TAKAHASHI in: l. c., p. 62) and *Kossmaticeras theobaldianum* (MATSUMOTO 1981, p. 68 in: l. c.). MATSUMOTO (l. c., p. 69) correlates the Zone of *I. uwajimensis* with the Lower and Middle Coniacian of Madagascar, apparently following COLLIGNON (l. c.) who put the Zone of *K. theobaldianum* and *B. onilahyense* into Middle Coniacian position. However I am following in this paper the stratigraphic conclusions of KENNEDY & KLINGER (l. c.), KENNEDY (l. c.) and the early informations of BASSE (1947, p. 109), BESAIRIE (1936) and HOURCO (1936). Further investigations should prove this.

Occurrence: Strobl 1 (= locality Ofenwand near Strobl-Weißenbachtal); Gams.

The ammonite fauna Ischl N

Introduction:

The fauna from the highway tunnel N of Bad Ischl (Oberösterreich) was discovered and collected recently by W. P. MAHERNDL (Bad Ischl). Due to the techniques of the tunnel construction, bed-by-bed collection was impossible. The sequence is several hundred metres thick and yielded ammonites of Coniacian to Santonian age. The occurrence of *Forresteria* (*F.*) *alluaudi* is regarded as a distinct horizon within the sequence. Only this fauna is discussed below. *Peroniceras* and *Texanites*, also present in the collection, are thought to be from higher levels.

Ammonite fauna:

Forresteria (*Forresteria*) *alluaudi* (BOULE, LEMOINE & THEVENIN)

Accompanying fauna:

Diverse gastropod and bivalve faunas are hardly to be separated by age indication. Association with the *Forresteria* fauna is doubtful.

Age: Middle Coniacian (*Tridorsatum* – zone).

Discussion:

Ammonites indicate the tunnel section to be a sequence ranging from Coniacian to Santonian. The relative abundance of *Forresteria* (*F.*) *alluaudi* suggests a low Middle Coniacian Horizon. Correlation with neighbouring localities (Strobl I–III) is impossible due to tectonic complexities. Neither of these faunas nor Brandenburg I yielded *Forresteria*. In Zululand *F.* (*F.*) *alluaudi* is restricted to the Middle Coniacian *Peroniceras* (*P.*) *tridorsatum* Zone (= Coniacian II, KENNEDY & KLINGER 1975, p. 278). A single specimen has been recorded from France by KENNEDY (1984a). It also occurs with species typical for the *Tridorsatum* zone.

The ammonite fauna Strobl II

Introduction:

The classical area of the Schmolnauer Alpe comprises several sites scattered over an area of about 1 km². They represent approximately the same stratigraphic level and are discussed here under the name Strobl II. The fauna of Strobl III, probably also lumped with this assemblage is treated separately below.

Ammonite fauna (after KENNEDY & SUMMESBERGER, in prep.):

Anagaudryceras sp.

Tetragonites cf. *epigonus* (KOSSMAT)

Hauericeras lagarum (REDTENBACHER)

Hauericeras schlueteri (REDTENBACHER)
Peroniceras (P.) *tridorsatum* (SCHLÜTER)
Peroniceras (Zuluiceras) *czoernigi* (REDTENBACHER)
Peroniceras (Z.) *bajuvaricum* (REDTENBACHER)
Peroniceras (Z.) *propoetidum* (REDTENBACHER)
Tissotoides haplophyllus (REDTENBACHER)
Metatissotia robini (THIOLLIÈRE)
Neocrioceras (*Schlueterella*) sp.
Baculites sp.
Scaphites meslei ssp. nov.
Otoscaphtes sp. nov.

Accompanying fauna: Diverse bivalve fauna with inoceramids.

Age: Middle Coniacian; *Peroniceras* (P.) *tridorsatum* – zone.

Discussion:

Peroniceratids are the commonest ammonites in this fauna. The correlation with the French *Tridorsatum*-zone is obvious (KENNEDY 1984a, p. 26). Several elements of the fauna agree even at the species level. On the other hand it also can be correlated with the South African Coniacian II, where *P.* (P.) *tridorsatum* and *P.* (Z.) *bajuvaricum* are also common. BRINKMANN (l. c., p. 7/8) confused the fauna from the Schmolnauer Alpe with Lower Coniacian, Santonian and even Campanian elements (“Fauna von Gams”).

Occurrence:

Besides the classical sites around the Schmolnauer Alpe (= Strobl II) and Nussenseebach 1, peroniceratids of Middle Coniacian age are present at Aussee (Weißenbachtal), at the Breitenau near Kiefersfelden and at the Bad Ischl tunnel section.

The ammonite fauna Strobl III

Introduction:

REDTENBACHER (1873, p. 99) mentioned 54 specimens of *Ammonites* cfr. *Ewaldi* BUCH from this locality. The discovery of the Strobl III fauna by the Viennese collector family SKOUMAL leads to the supposition that the site, 1 km N of the Schmolnauer Alpe is REDTENBACHER's original locality.

Ammonite fauna:

Metatissotia robini (THIOLLIÈRE)

Accompanying fauna:

Inoceramids and other bivalves.

Discussion:

The dominating *Metatissotia* in the new collections suggested a separation of this fauna from that of Strobl II. The sites of Strobl II and III are all situated within a fault zone. Correlation is impossible, but Strobl III is probably younger than Strobl II where *Metatissotia* is also present as at the Nussenseebach site.

Age: Middle Coniacian.

Occurrence:

As a distinct fauna only at the locality N of Strobl II on the Fahrenberg forest road.

The ammonite fauna Glanegg I**Introduction:**

The "Fauna von Glaneck" was regarded by BRINKMANN (l. c., p. 7) as the oldest ammonite fauna from the Gosau ("Tiefster Unteremscher, Margae – Zone"). KENNEDY (1984 a, p. 27; b, p. 153/154) introduced *Gauthiericeras margae* and *Paratexanites serratomarginatus* as index fossils for two ammonite zones of the French Upper Coniacian; these species do not occur together in France. *Ammonites Margae* has been recorded from Glanegg by REDTENBACHER (l. c., p. 109; pl. 25, fig. 1). KENNEDY (1984a, text-fig. 31) recently figured one of the best Glanegg specimens. *Ammonites serrato-marginatus* REDTENBACHER, also occurring at Glanegg, appears to be from a higher horizon.

Ammonite fauna:

Gaudryceras glaneggense (REDTENBACHER)

Tetragonites sp.

Hauericeras lagarum (REDTENBACHER)

Peroniceras (Zuluiceras) aberlei (REDTENBACHER)

Gauthiericeras margae (SCHLÜTER)

Baculites fuchsi REDTENBACHER

Otoscaphtes cf. *arnaudi* (GROSSOUVRE)

Accompanying fauna:

A list of molluscs given by FUGGER (1907) comes from both ammonite zones and has not been revised since that time.

Age: Upper Coniacian; zone of *Gauthiericeras margae*.

Discussion:

Recent collections from Glanriedel close to Glanegg yielded *P. serratomarginatus* and *Scaphites* but no *G. margae*. This, together with KENNEDY's revision of the French Coniacian (l. c.), leads to the conclusion that early collections from Glanegg could be from two different levels, the older assemblage characterized by *G. margae*, the younger one by *P. serratomarginatus*. This idea is supported by REDTENBACHER's (l. c., p. 111) note that all his *serratomarginatus* specimens came from a separate locality named by him as "Mergelwand". The "Mergelwand" could well be the Glanriedel, a locality only a few hundred metres away from the small quarry behind the chapel of the Glanegg castle, where the early material was collected (teste BRINKMANN, l. c., p. 2). Recently collected *P. serratomarginatus* all come from Glanriedel.

Occurrence:

The Glanegg I fauna occurs at Glanegg only. *G. margae* was found also at the Fahrenberg forest road coming from sediments overlying the site of Strobl II.

The ammonite fauna Glanegg II

Introduction:

This fauna was linked with that of Glanegg I by BRINKMANN (l. c.). As mentioned above *Paratexanites serratomarginatus* appears above *G. margae* and is the index fossil of the top zone of the French Coniacian. *Ammonites serratomarginatus* has been described by REDTENBACHER (l. c., p. 110) together with other ammonites from Glanegg. It has been revised recently by KENNEDY, KLINGER & SUMMESBERGER (1981, p. 117).

Ammonite fauna:

Paratexanites serratomarginatus (REDTENBACHER)
Scaphites sp.

Accompanying fauna:

The other molluscs, especially bivalves have not been revised recently. The fauna is listed by FUGGER (1907, p. 512ff.).

Age: Upper Coniacian; zone of *P. serratomarginatus*

Discussion:

Evidence for the age determination is given by the index species. As discussed above, separation of the Glanegg II fauna from the Glanegg I fauna is suggested by appearance of two index species indicating different ammonite zones.

Occurrence:

Paratexanites serratmarginatus appears at the Glanriedel next to Glanegg. It is also recorded by BRINKMANN (l. c., p. 2, 3) from the localities Breitenau (next Kiefersfelden) and Morzg (close to Glanegg). Both specimens are apparently lost. The occurrence at Brandenburg 2 is discussed below (p. 155). *Protexanites bourgeoisi* (d'ORB.) possibly also indicating the *Serratmarginatus* zone (KENNEDY 1984 a, p. 112) appears at Gams (teste BRINKMANN, l. c., p. 5) and Wörschach/Styria (JANOSCHEK 1968, p. 140).

Table 2

Ammonite Zonation of the Gosau Group (Upper Turonian/Coniacian)					
Fauna	Localities	Charact. Ammonites	Acc. Fossils	Age	
Glanegg II	Glanriedel	<i>Paratexanites serratmarginatus</i> , <i>Scaphites</i>	Bivalves	Upper Coniacian	Serrato-marg.-z.
Glanegg I	Glanegg, Fahrenberg	<i>Gauthiericeras margae</i> , <i>Scaphites</i> , <i>Otoscapites</i>	Bivalves Diverse fauna		Margae-z.
Strobl III	Schmolnauer Alpe 2	<i>Metatissotia robini</i>	Inoceramids	Middle Coniacian Tridorsatum-z.	
Strobl II	Schmolnauer A. 1, Nussenseebach 1, Aussee (Weißbachtal)	<i>Peroniceras tridorsatum</i> , <i>Tissotioides haplophyllus</i>	Inoceramids Diverse fauna		
Ischl N	Bad Ischl (tunnelsection)	<i>Forresteria alluaudi</i>			
Strobl I	Strobl 1/ Ofenwand, Gams	<i>Barroisiceras haberfellneri</i>	„Didymotis”	Lower Coniacian Petrocoriensis-z.	
Brandenberg I	Brandenberg 1/ Zöttbachgraben	“ <i>Romaniceras</i> (Y.)” <i>gosaicum</i> , <i>Hemitissotia alpina</i>	<i>Cremnoceramus w. hannovrensis</i>	Upper Turonian	

SANTONIAN

The ammonite fauna Gosau I

Introduction:

The basal fauna of the Santonian with the characterizing fossil *Texanites quinquenodosus* (REDTENBACHER) appears at many localities in the Gosau group. The index fossil has been revised recently by KENNEDY, KLINGER & SUMMESBERGER (1981, p. 126, figs. 8–16). This fauna is identical with the “Fauna von Eiberg” of BRINKMANN (1935, p. 8). He compared the fauna with the German “Mittelemscher mit *Inoc. undulato-plicatus* and *Act. westfalicus* + Oberemscher mit *Inoc. cordiformis* und *Act. westfalicus-granulatus*”. A description of the most diverse fauna from Mühlbach (= Brandenburg 2) was recently given by WIEDMANN (1979, in: HERM, KAUFFMAN & WIEDMANN) and by IMMEL, KLINGER & WIEDMANN (1982). Co-occurrence of *Cladoceramus undulatoplicatus* and *T. quinquenodosus* permits precise correlation with northwestern European sequences. Unfortunately Brandenburg 2 is the only well authenticated locality for *C. undulatoplicatus* in the Gosau.

Ammonite fauna:

The most recent list of ammonites occurring at Brandenburg 2 (= Mühlbach) was given by IMMEL, KLINGER & WIEDMANN (l. c., p. 29). A number of their generic and specific identifications are, however, questionable. In addition *Tissotia* sp. and “*Muramotoceras*” sp. nov. (KOLLMANN & SUMMESBERGER 1982, p. 58) appear in the basin of Gosau.

Accompanying fauna:

Inoceramids (after: HERM, KAUFFMAN & WIEDMANN, l. c., p. 39):

Cladoceramus undulatoplicatus (ROEMER)

Platyceramus cycloides (WEGNER)

Magadiceramus subquadratus (SCHLÜTER)

Sphenoceramus sp.

Foraminifera (basin of Gosau): a list was given by WEISS (1975), vide KOLLMANN & SUMMESBERGER (l. c., p. 56)

Other molluscs: The diverse fauna accompanying *T. quinquenodosus* at Gosau (Rußbach, Stöcklwaldgraben) was mentioned by KOLLMANN & SUMMESBERGER, l. c., p. 69).

Age: Lower Santonian.

Discussion:

The appearance of the genus *Texanites* is taken as the base of the Santonian (KENNEDY 1984b, p. 155). BAILEY & al. (1984, p. 35) suggest the entry of *Platyceramus siccensis* and/or *Cladoceramus undulatoplicatus* and/or *Texanites oliveti* for the definition of the base of the Santonian, emphasizing the co-occurrence of *Texanites*

and *C. undulatoplicatus*. Coincidence is also documented at Brandenburg 2, making this site to an important locality for the stratigraphy of the Gosau group. *Paratexanites serratomarginatus*, also recorded from Brandenburg 2 by IMMEL, KLINGER & WIEDMANN (l. c., p. 23), has been discussed by KENNEDY (1984b, p. 155). He doubts all records from the French Santonian. Its occurrence in the Gosau I fauna at Brandenburg 2 could be explained if it actually came from a lower horizon than the rest of the fauna (vide: IMMEL, KLINGER & WIEDMANN, l. c., p. 6).

Occurrence:

Gosau (Stöcklwaldgraben, Zimmergraben, Edlbachgraben, Grabenbach), Brandenburg 2, Eiberg, Nussenseebach 2, Bad Ischl, Breitenau and various other points in the Eastern Alps.

The ammonite fauna Gosau II

Introduction:

The fauna introduced here appears not much higher in the sequence than the *Texanites* fauna from the basal Santonian. It can be recognized by the occurrence of abundant *Hemitissotia*. The type locality of *H. randoi* GERTH (1961, p. 131) is the "mittlerer Randograben" (GERTH's exposure 15 b). This site corresponds to stop 26 of KOLLMANN & SUMMESBERGER (1982, p. 72) and is here named Randograben 1.

Ammonite fauna:

Hemitissotia randoi GERTH
Parapuzosia daubréei (DE GROSSOUVRE)
Placenticerias sp.
Baculites sp.

Accompanying fauna:

"*Inoceramus*" sp.
Cerithium sp.
Calliomphalus sp.

Age: Lower Santonian.

Discussion:

Hemitissotia randoi appears in considerable numbers and is valuable for local correlation within the Gosau basin. Wider correlation is based on the occurrence of *Parapuzosia daubréei* keeping in mind its entry earlier in the Santonian (e. g.: Brandenburg 2).

Occurrence:

Only two localities on the Salzburg side of the basin of Gosau (Rußbach): stops 21 and 26 of KOLLMANN & SUMMESBERGER, l. c., pp. 42, 68, 72). Large fragments of *P. daubréei* also occur at the junction of the Grabenbach and the Tauerngraben (basin of Gosau) indicating approximately the same horizon.

The ammonite fauna Gosau III

Introduction:

The assemblage fauna introduced here is characterized by *Muniericeras gosauicum*. The locality Randograben 2 seems to be the type locality of HAUER's (1858, p. 13, pl. 2, figs. 7–9) *Ammonites gosauicus*.

Ammonite fauna:

Muniericeras gosauicum (HAUER)
Placenticeras sp.
Texanites quinquenodosus (REDTENBACHER)
Baculites incurvatus DUJARDIN

Accompanying fauna: Bivalves, gastropods.

Age: (?) Basal Upper Santonian.

Discussion:

French species of the genus *Muniericeras* are restricted to the Santonian, possibly Lower Santonian (BILLOTTE & COLLIGNON 1981, erratum to pp. 179, 183). Madagascan species on the other hand occur only in the Upper Santonian (COLLIGNON 1966: "Zone à *Pseudoschloenbachia umbulazi*"). The level of the Randobach 2 site is provisionally taken as the base of the Upper Santonian in Austria.

Occurrence:

Gosau (Randobach 2, Grabenbach); Gams; St. Wolfgang (parking area 3).

The ammonite fauna Gosau IV

Introduction:

This diverse ammonite fauna was discovered and collected from 1971 to 1979 and described in three papers: WIEDMANN 1978b; SUMMESBERGER 1979, 1980. Some elements of the fauna have already been tested in the "Fauna des Hofergrabens" by BRINKMANN (l. c., p. 8).

Ammonite fauna:

21 taxa (list in SUMMESBERGER 1980, p. 281) with abundant
Placenticerias polyopsis (DUJARDIN)

Accompanying fauna:

Gastropods (KOLLMANN 1980): 23 taxa; bivalves (DHONDT, in prep.): approx.
50 taxa; corals, brachiopods, crustaceans.

Age: Upper Santonian; zone of *Placenticerias polyopsis*.

Discussion:

The term *Polyopsis* – zone has been erected recently by KENNEDY & WRIGHT (1983) in their revision of *Ammonites polyopsis* DUJARDIN. As a consequence of the revision they suggested that the old term *syrtale* – zone should be abandoned. Because *P. polyopsis* ranges throughout the entire Santonian in France the new term is not equivalent to the old *syrtale* – zone (KENNEDY & WRIGHT (l. c., p. 866/867). However good evidence of Upper Santonian age for Gosau IV is given by the appearance of *Boehmoceras* which is also useful for correlation with the German

Table 3

Ammonite Zonation of the Gosau Group (Santonian)				
Fauna	Localities	Charact. Ammonites	Acc. Fossils	Age
Gosau IV	Gosau/ Bibereck	<i>Placenticerias polyopsis</i> , <i>Boehmoceras</i>	<i>C. muelleri</i>	Upper Santonian
Gosau III	Gosau/ Randobach 2, Nefgraben, St. Wolfgang	<i>Muniericeras gosauicum</i> , <i>Texanites</i> , <i>Baculites incurvatus</i>	Gastropods Bivalves	
Gosau II	Gosau/ Randobach 1 Stöcklwaldgr. 2	<i>Hemitissotia randoi</i> , <i>Parapuzosia daubréei</i>	Gastropods	Lower Santonian
Gosau I	Gosau/ Stöcklwaldgr. 1, Zimmergraben, Edlbachgraben, Nussenseebach 2, Brandenberg 2	<i>Texanites quinquenodosus</i> , <i>Eupachydiscus</i> , <i>Nowakites</i>	Inoceramids Gastropods Bivalves <i>C. undulato- plicatus</i>	

Upper Santonian (SUMMESBERGER 1979, p. 122). In the basin of Gosau *P. polyopsis* appears first at a level somewhat higher than *Muniericeras* possibly together with *Baculites incurvatus* DUJARDIN.

Occurrence:

Gosau ("Sandkalkbank" member; Bibereck, Hofergraben); (?) Piesting (Scharrergraben).

CAMPANIAN

Due to general subsidence and deepwater sedimentation, ammonites are rare in the Campanian part of the Gosau sequence. Three faunas mentioned subsequently are thought to be of Lower Campanian age, although their correlation with other ones presents difficulties.

The ammonite fauna Gosau V

Introduction:

The fossil bearing site "Schattau", the only locality where the fauna Gosau V is well represented, has been known since the last century. Lithostratigraphically it is situated at the base of the Bibereck formation (WEISS 1975, 1977; KOLLMANN & SUMMESBERGER 1982, p. 37, 40), only a few metres above the "Sandkalkbank" of the Hochmoos formation which bears the fauna Gosau IV.

Ammonite fauna (after KENNEDY & SUMMESBERGER, in prep.):

Eupachydiscus isculensis (REDTENBACHER)

Placentoceras cf. *bidorsatum* (ROEMER)

Eubostrioceras sp.

Diplomoceras ? sp.

Glyptoceras sp.

Polyptychoceras (?) sp.

Accompanying fauna:

The rich microfauna was studied by WEISS (1975, p. 61/62). *Globotruncana elevata* BROTZEN appears together with the fauna. Molluscs: Inoceramids, *Gervillia solenoides* (DEFrance). The echinoid fauna has been described by LAMBERT (1907) and KÜHN (1925).

Age: Lower Campanian; zone of *Placentoceras bidorsatum*.

Discussion:

Cooccurrence of *P. cf. bidorsatum* and *G. elevata* make the Gosau V fauna important for wider correlation. On the other hand correlation to the Lower Campanian faunas Gosau VI and Kainach is problematic.

Occurrence: Basin of Gosau only (Schattau).

The ammonite fauna Gosau VI**Introduction:**

This fauna of small heteromorph ammonites was discovered by H. A. KOLLMANN but it is not yet described. From lithostratigraphic considerations it must be younger than the above-mentioned Gosau V fauna and older than the stratigraphically following Ressen formation. The flysch sediments of the Ressen formation are barren of megafossils. Rare Globotruncanidae indicate a Lower Campanian age (WILLE-JANOSCHEK 1966; WEISS 1975). Consequently the fauna must be of Lower Campanian age. Further investigation should substantiate this.

Occurrence: Basin of Gosau (Gosauschmied only).

The ammonite fauna Kainach I**Introduction:**

The basin of Kainach (Styria) has yielded a considerable number of ammonites from different sites (BRINKMANN 1935, p. 6). HAUER's (1866) type series of *Ammonites milleri* survived in the collections of the Austrian Geological Survey. The other collections studied by BRINKMANN could not be traced. Stratigraphic conditions and correlation between the local sites are still insufficiently investigated and therefore omitted here. Only the type locality of *Ammonites milleri*, the quarry Hemmerberg between Kainach and Bärnbach, is treated here.

Ammonite fauna: *Placenticeras milleri* (HAUER)

Age: Lower Campanian

Discussion:

Historic information on stratigraphy is contradictory due to misidentifications, use of different fossil groups and lack of measured lithostratigraphic sequences. The type locality Hemmerberg is situated within the lithostratigraphic unit "Hauptbecken – Folge" which is thought to be of Lower Campanian age. The overlying "Zementmergel – Folge von St. Bartholomä" yielded an Upper Campanian microfauna (KAUMANN 1962, p. 294; OBERHAUSER 1963, p. 61; GRÄF 1975,

p. 95). Data from rudists, inoceramids, ammonites need revision. "*Scaphites hippocrepis* DE KAY var. *tenuis* REES." (teste BRINKMANN, p. 6) could not be traced at the present time.

MAASTRICHTIAN

Two Gosau faunas are of Lower Maastrichtian age; the Upper Maastrichtian is represented by one ammonite fauna.

The ammonite fauna of Neuberg, Styria

Introduction:

The ammonite fauna of Neuberg (Styria) has been revised recently by KENNEDY & SUMMESBERGER (in press). Early investigations were made by HAUER (1858) and REDTENBACHER (1873). The little quarry W of Neuberg is the type locality of *Ammonites neubergicus* HAUER and *Ammonites epiplectus* REDTENBACHER. BRINKMANN (1935, p. 5) recorded 14 ammonite species.

Ammonite fauna (after KENNEDY & SUMMESBERGER, in press):

- Partschiceras forbesianum* (d'ORBIGNY)
- Anagaudryceras lueneburgense* (SCHLÜTER)
- Saghalinites wrighti* BIRKELUND
- Pseudophyllites* cf. *indra* (FORBES)
- Pachydiscus* (*Pachydiscus*) *neubergicus* (HAUER)
- Pachydiscus* (*Pachydiscus*) *epiplectus* (REDTENBACHER)
- Menuites* sp. nov.
- Diplomoceras cylindraceum* (DEFrance)
- Eubaculites lyelli* (d'ORBIGNY)
- Hoploscaphites constrictus* (J. SOWERBY)

Age:

Lower Maastrichtian; boundary of *B. lanceolata*/*B. occidentalis* – zones (KENNEDY & SUMMESBERGER, in press).

Accompanying fauna:

Small gastropod fauna (vide: H. A. KOLLMANN in: KENNEDY & SUMMESBERGER, l. c.).

Discussion:

Due to the lack of a well-documented lithostratigraphic sequence in the area and the scarcity of microfossils, correlation to the neighbouring Gosau basin of Grünbach and the Neue Welt is based on the occurrence of *P. (P.) epiplectus* in

both areas. The age is confirmed by comparison with ammonite-bearing sequences in the white chalk facies of NW Europe (KENNEDY & SUMMESBERGER, l. c.).

Occurrence:

Quarry of Neuberg (= Krampen/Neuberg); *P. (P.) neubergicus* appears also in the basin of Puchberg, at the railway cutting between Grünbach and Puchberg and possibly in the Krappfeld-Gosau (Kärnten).

The ammonite fauna from Grünbach and the Neue Welt basin

Introduction:

The ammonite fauna from the Grünbach and Neue Welt basin was described first by REDTENBACHER (1873). He erected three species, two from Muthmannsdorf in the Neue Welt: *Ammonites epiplectus* and ? *Scaphites Sturi*, one from Grünbach: *Ammonites Brandti*. A short synopsis of the history of investigation is given by KOLLMANN & SUMMESBERGER (1982, p. 89).

Ammonite fauna (after KENNEDY & SUMMESBERGER, in prep.):

Pseudokossmaticeras brandti (REDTENBACHER)

Pseudokossmaticeras muratovi MICHAILOV

Pachydiscus (P.) epiplectus (REDTENBACHER)

Menuites sturi (REDTENBACHER)

Urakawites sp. nov.

Hoploscaphites constrictus (J. SOWERBY)

Accompanying fauna:

Molluscs described from Grünbach and the Neue Welt come from different levels and sites. They should not be summarized until a revision has been carried out. Foraminifera have been studied by OBERHAUSER & PAPP (in: PLÖCHINGER 1961).

Age: Lower Maastrichtian.

Discussion:

Age determination is based upon *Pachydiscus (P.) epiplectus*. This ammonite and *Hoploscaphites constrictus* also appear at Neuberg, indicating comparable age. It remains unclear if the age is slightly different or not. Curiously, at Neuberg no *Pseudokossmaticeras* occurs whereas all records of *P. (P.) neubergicus* from the Grünbach/Neue Welt seem to be traceable to misidentifications. *P. (P.) neubergicus* is represented by a single specimen from the railway cutting between Grünbach and Puchberg.

Occurrence:

The fauna from Grünbach and the Neue Welt with the characteristic fossil *Pseudokossmaticeras brandti* appears outside of the basin also at Puchberg and in the Krappfeld Gosau (THIEDIG & WIEDMANN 1976).

The ammonite fauna from the Gahnsleiten, Lower Austria**Discussion:**

Pachydiscus gollevillensis (D'ORBIGNY) has been mentioned already by BRINKMANN (l. c., p. 5). In the type area (Cotentin peninsula, France) the species is recorded from the Upper Maastrichtian (KENNEDY, in press). This leads to the conclusion that the sequence of the Gahnsleiten is the only Upper Maastrichtian Gosau occurrence, where the age is indicated by an ammonite species.

Age: Upper Maastrichtian

Table 4

Ammonite Zonation of the Gosau Group (Campanian/Maastrichtian)				
Fauna	Localities	Charact. Ammonites	Acc. Fossils	Age
Gahnsleiten	Gahnsleiten	<i>P. gollevillensis</i>		Upper Maastrichtian
Grünbach/ Neue Welt	Grünbach, Muthmannsdorf	<i>Pseudokossmaticeras brandti</i>	Inoceramids	
Neuberg	Neuberg	<i>P. neubergicus</i> , <i>Sc. constrictus</i>		
Gosau VI	Gosau/Gosau- schmied	Heteromorphs		Lower Campanian Bidorsatum-z.
Kainach	Kainach	<i>Placenticerias milleri</i>		
Gosau V	Gosau/ Schattau	<i>Placenticerias cf. bidorsatum</i>	<i>Gl. elevata</i> „ <i>I. balticum</i> ”	

Acknowledgments: I am deeply indebted for personal communication and discussion to: Dr. A. V. DHONDT (Brussels), Prof. Dr. D. HERM (Munich), Dr. H. IMMEL (Munich), Prof. W. K. KENNEDY, Ph. D. (OXFORD); Dr. H. A. KOLLMANN (Vienna), Prof. Dr. T. MATSUMOTO (Fukuoka), Prof. Dr. J. WIEDMANN (Tübingen), and Mr. C. J. WOOD (London). I am especially grateful to all curators of paleontological collections who generously made available specimens under their care. I am equally grateful to Austrian private collectors for access to their collections. Financial support was given by the

Royal Society (London), the I.G.C.P. Program "Mid Cretaceous Events" and the Austrian Bundesministerium für Wissenschaft und Forschung.

Thanks are due to Drs. W. J. KENNEDY and H. A. KOLLMANN for careful reading of the manuscript and many suggestions during the preparation of the paper.

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Zeitschrift/Journal: [Annalen des Naturhistorischen Museums in Wien](#)

Jahr/Year: 1985

Band/Volume: [87A](#)

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Artikel/Article: [Ammonite Zonation of the Gosau Group \(Upper Cretaceous, Austria\) 145-166](#)