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Liassic (Pliensbachian) Ammonites from the Lienz Dolomites (Eastern Tyrol, Austria)

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With 17 Text-Figures and 7 Plates

Tyrol
Eastern Alps
Upper Austroalpine
Lienz Dolomites
Jurassic
Lias
Pliensbachian
Austroalpine
Ammonites
Biostratigraphy
Paleogeography

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Contents

Liasammoniten (Pliensbach) aus den Lienzer Dolomiten (Osttirol, Österreich)

Zusammenfassung

Im Pliensbachium der Amlacher Wiesen-Mulde (N Lienzer Dolomiten, Osttirol, Österreich) wurden in Rotkalken drei Profile detailliert auf Ammoniten beprobt. Insgesamt konnten 11 „Lager" mit charakteristischer Faunenzusammensetzung unterschieden werden. Es gelang der Nachweis der Ibex- (mittleres Carixium), Margaritatus- und Spinatum-Zone (Domerium).

Die Fauna umfasst sowohl Formen der Tethys als auch des Euroboreals und erlaubt damit eine gute Korrelation mit bereits bekannten biostratigraphischen Daten dieser Faunenprovinzen.

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Abstract

In the Amlacher Wiesen Syncline (N Lienz Dolomites, East Tyrol, Austria) three sections of Pliensbachian red (nodular) limestone have been sampled in detail for ammonites. 11 horizons or levels yielding characteristic faunas could be distinguished. We have shown these belong to the the Ibex (Middle Carixian), Margaritatus, and Spinatum zones (Domerian).

The fauna comprises of Tethyan as well as Euroboreal elements and therefore allows a good correlation with known zonation schemes of both realms.

Ammonites liassiques (Pliensbachien) des Lienz Dolomites (Est Tyrol, Autriche)

Résumé

L'étude de trois profils dans des calcaires (nodulaires) rouges du Synclinal d'Amlacher Wiesen (N Lienz Dolomites, Est Tyrol, Autriche) a permis la récolte détaillée d'une importante faune d'ammonites. 11 horizons ou niveaux on pu être distingués et sont attribuables aux zones à Ibex (Carixien moyen), à Margaritatus et Spinatum (Domérien).

La faune, caractérisée par des ammonites d'affinités téthysienne et euroboréale, permet de bonnes corrélations avec les zonations proposées pour ces deux provinces paléogéographiques.

1. Introduction

The Lienz Dolomites represent the western part of the Drauzug, which is comprised of, from E to W, the North Karawanks, the Gailtal Alps, the Lienz Dolomites, the Winnebacher Kalkzug, and tectonic slices of Hauptdolomit to the W of the latter one. With the exception of the Gailtal Alps, the remaining parts of the Drauzug contain Liassic sediments. Tectonostratigraphically the Drauzug represents the S part (Licicum) of the Upper Austroalpine.

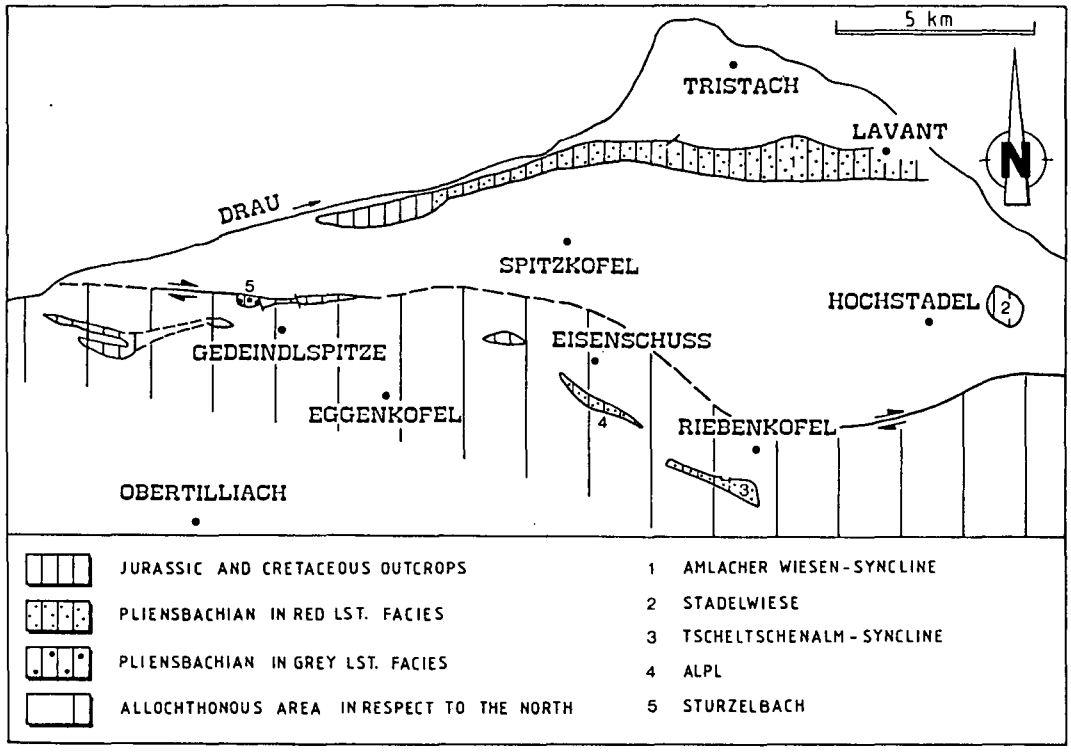
The Pliensbachian stage of the Liassic sequence of the Lienz Dolomites has been known to yield ammonites since the last century. EMMRICH (1855) was the first author to recognize the "red marble" ("rother Marmor") opposite the Lienzer Klause as Liassic (l.c.: 445) based on ammonite findings. D. STUR combined the Liasfleckenmergel and red (nodular) limestone facies as the "Adnether Schichten" in 1856. He also found ammonites in the above mentioned stratigraphy. Von HAUER (1855) included these ammonites in his study "Über die Cephalopoden aus dem Lias der nordöstlichen Kalkalpen". In 1868 BENECKE (l.c.: 103) described Arietits from the Galitzenbach ("Ausgang des Gallitzenbaches") and the species

Amaltheus margaritatus DE MONTFORT
Prodactylioceras davoei (SOWERBY)
Arieticeras algovianum (OPPEL)

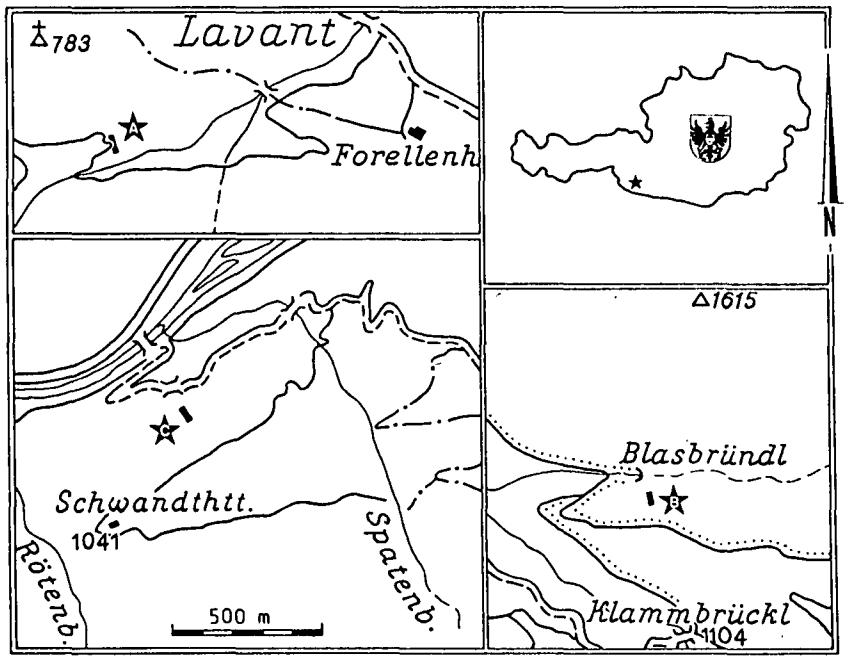
from the Klause (= Rötenbach area) (from "höherliegenden, rothen mehr mergeligen Kalken").

In 1903 GEYER reported the Pliensbachian species

Phylloceras sp. ind.
Androgynoceras capricornus (SCHLOTHEIM)
Paltarpites gr. *kurrianus* (OPPEL) near to *Protogrammoceras celebratum* (FUCINI)



Text-Fig. 1.
Jurassic and Cretaceous outcrops in the Lienz Dolomites.
All localities mentioned in the text are shown on the map.



Text-Fig. 2.
Locations of the investigated profiles in the Amlacher Wiesen Syncline.
2A: Profile Lavant, ÖK 1 : 25.000, Sheet 180 (Winklern).
2B: Profile Blasbründl, ÖK 1 : 25.000, Sheet 179 (Lienz). Note that the name "Blasbründl" is not in use on older maps.
2C: Profile Stadtweg, ÖK 1 : 25.000, Sheet 179 (Lienz).

Protogrammoceras gr. *normanianum* (D'ORBIGNY) near to *Protogrammoceras isseli* (FUCINI).

MARIOTTI (1972: 125) discovered

Harpoceras cf. *falciferoides* BUCKMAN
Dactylioceras cf. *braunianum* (D'ORBIGNY)
Pseudogrammoceras sp.

in the outcrops E of Franz-Lerch-Weg (Blasbründl area) and from the Stadtweg.

He was the first to show Toarcian in the red limestone facies of the Amlacher Wiesen Syncline. BLAU (1983) discovered new localities yielding ammonites of Pliensbachian age in the Amlacher Wiesen Syncline.

2. The Lias in the Lienz Dolomites

Outcrops of Liassic (in general connected with the whole Jurassic and Lower Cretaceous) sediments in the Lienz Dolomites are bound to a syncline N of the Central Anticline (Hauptantiklinale) and to a ±SE–NW striking zone of discrete occurences, S of the Central Anticline (Fig. 1).

The southern zone belongs to Permo-Mesozoic tectonic slices, which are exotic bodies with respect to the Central Anticline and the Amlacher Wiesen Syncline (see below). For this reason, they will be described separately.

2.1. The Amlacher Wiesen Syncline

The northern syncline is the Amlacher Wiesen Syncline, which has to be regarded in an evolutionary context together with the Stadelwiese Liassic. The Amlacher Wiesen Syncline shows a large heteropie in its facies developement (BLAU, 1987: Fig. 2; BLAU & SCHMIDT, 1988; BLAU, 1990), which is the result of synsedimentary tectonics. Two basinal regions separated by a swell (Lavant swell) can be distinguished in the N Lienz Dolomites.

To the E of this is the Stadelwiese area, which is interpreted as the autochthonous, drowned section of a tilted block (BLAU & SCHMIDT, 1988). This area accomodated a regular Liasfleckenmergel-sedimentation with intercalated megabreccias, derived from the bordering fault scarps. At the Stadelwiese no Pliensbachian is preserved.

According to BLAU & SCHMIDT (1988), the Amlacher Wiesen Syncline is the next block to the west. It was tilted to the west, causing a swell within the condensed Jurassic of the Lavant area and basinal facies towards the west.

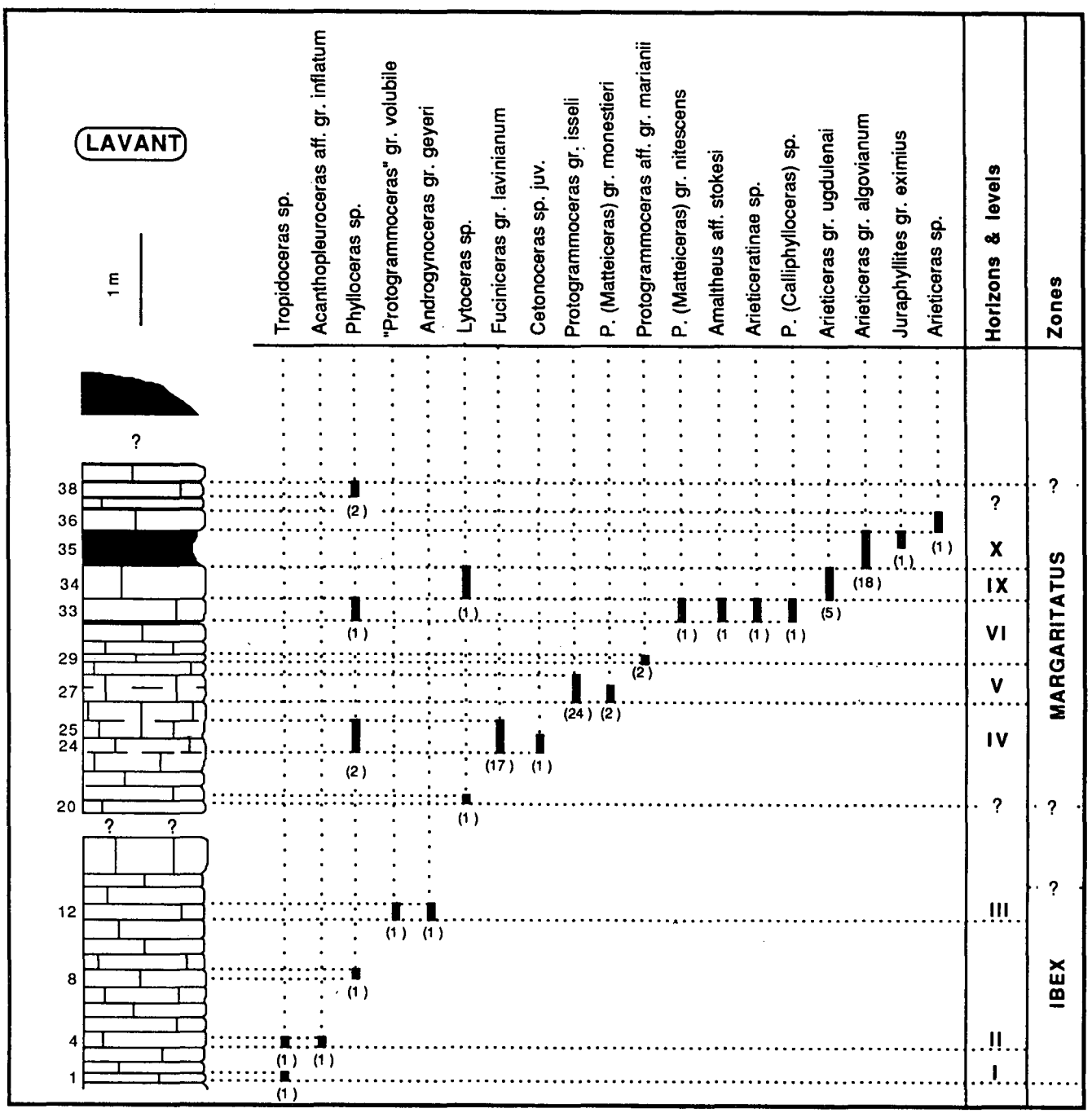
The "normal" (basinal) Liassic sequence in the Amlacher Wiesen Syncline starts with the Liasfleckenmergel (Hettangian–Sinemurian) which are overlain by red (nodular) limestones (Pliensbachian–Malm). At the swell area of the Amlacher Wiesen Syncline, the Liassic sequence starts with a multiphased breccia (Lavant Breccia). This breccia is overlain by red (nodular) limestones, Pliensbachian to Malm in age. Basin and swell are connected by a zone where the Lias starts with variegated limestones overlain by Liasfleckenmergel and Pliensbachian red (nodular) limestones.

As shown above, the Pliensbachian red (nodular) limestone facies seals the previously highly heteropic lithologies (for details see BLAU & SCHMIDT, 1988; BLAU et al., 1989). Nevertheless, the swell acts as paleogeographic high which is documented by hardground(s) and omission in the swell area (BLAU, 1990) at least until the Aptian/Albian Amlacher Wiesen Schichten, which cover the whole area.

In the Amlacher Wiesen Syncline, we sampled three profiles bed by bed for ammonites.

The first profile ("Lavant", Figs. 2A,3) is located on the trail from the Forellenhof towards the Lavant Altalpl, at the road-section between the Himperlahner Bach and the Dorfbach. In this area, the Lavant Breccia is covered by a condensed series of red (nodular) limestones (BLAU, 1990). Our profile starts near the base of the series and spans a time interval from the Ibex- to the Margaritatus-zone.

The second profile ("Blasbründl", Figs. 2B, 4) can be reached following the Franz-Lerch-Weg to the Blasbründl and lies on the S flanc of the little creek at this locality. Paleogeographically this profile lies in the



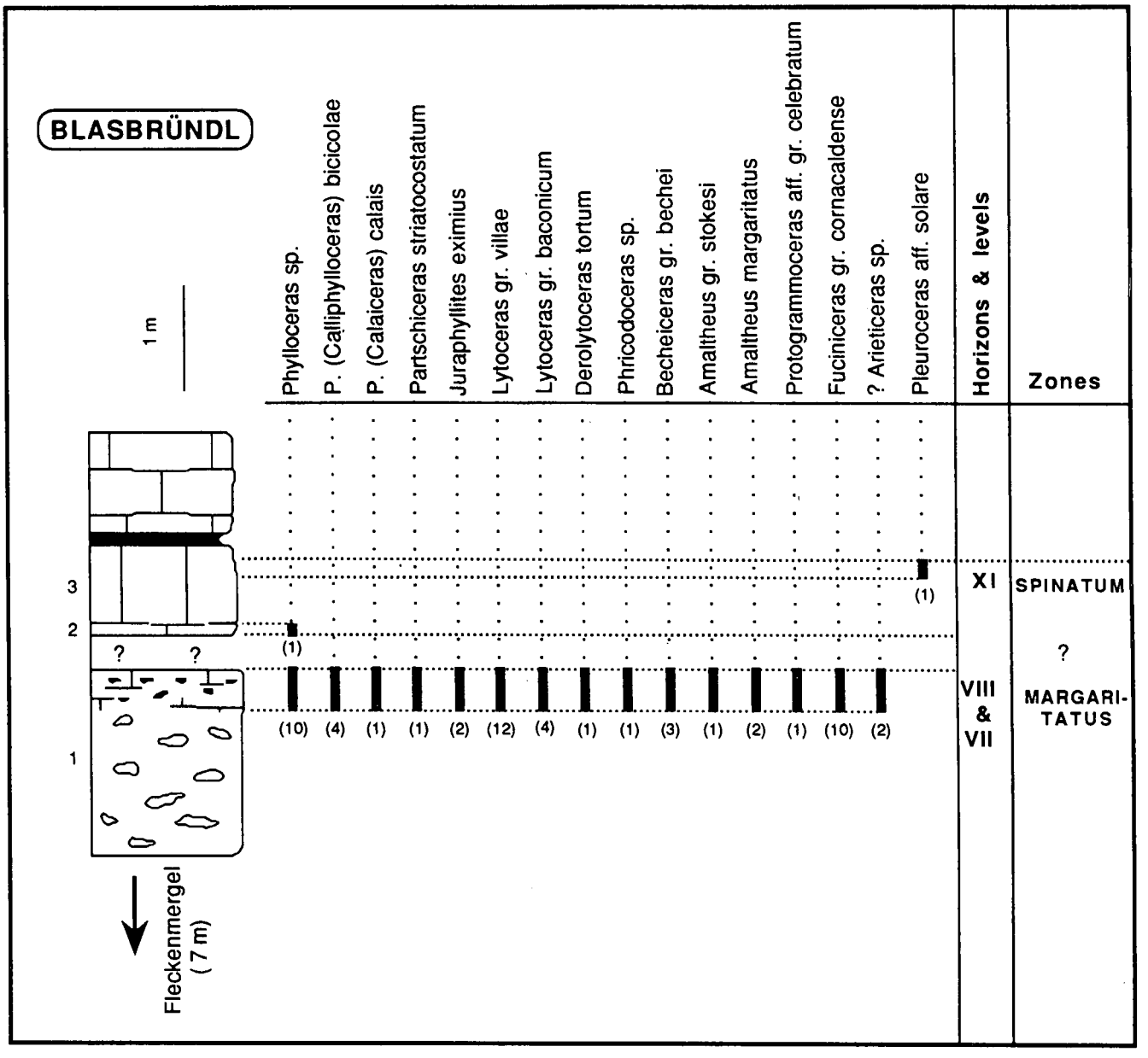
Text-Fig. 3.
Lavant lithological profile and ammonite ranges.

transitional area between the swell and the basin. The base of the Lias is marked by variegated limestones (Bunte Kalke) overlain by Liasfleckenmergel. The Liasfleckenmergel are covered with the red (nodular) limestone facies which shows a breccia with grey components at its base. Above this breccia a condensed layer spanning the Margaritatus- and Spinatum-zones can be observed. This layer seems to be a lens in the stratigraphic column, because it was not possible to recognize it in other outcrops. This profile yielded a strange fauna with partially large ammonites (Lytoceratides, one fragment of a Lytoceratid body chamber with about 50 cm in size, and Phylloceratides) and nautilides. Additionally we found one gastropode (Pl. 1, Fig. 3) and some Terebratulid brachiopods.

The third profile investigated is the "classical" profile in the old quarry at the Stadtweg (Figs. 2C,5). Paleogeographically this profile lies in the basin area of the Amlacher Wiesen Syncline. The base of the Lias are Liasfleckenmergel overlain by the red (nodular) limestone facies. The base of the red limestone facies is marked by a breccia, seen as a "Basisbreccie" by CORNELIUS-FURLANI (1953). This breccia was interpreted as a slump, containing components of Liasfleckenmergel by BLAU et al. (1989). The investigated part of the profile starts above this slump and spans the Margaritatus-zone.

2.2. The Southern Liassic Zone

The southern zone of Liassic outcrops consists of several distinct tectonic slices, starting in the E with



Text-Fig. 4.
Blasbründl lithological profile and ammonite ranges.

the Tscheltschenalm-Syncline (SCHLAGER, 1963). This syncline comprises a complete Jurassic sequence starting with Liasfleckenmergel (Hettangian–Sinemurian), covered by red (nodular) limestones (Pliensbachian, Toarcian, ?Dogger), Radiolarite (?Oxfordian), and Aptychenschichten (Malm–Berriasian/Valanginian).

The slices farther to the W comprise fragmented stratigraphic columns only. There are gaps and reductions of the thickness of the series due to tectonics.

The southern area is allochthonous to the northern Amlacher Wiesen Syncline. This was first recognized by TOLLMANN (1977: 629) who interpreted the Jurassic/Cretaceous slices W of the Tscheltschenalm-Syncline

" ... an WNW-Blattverschiebungen mit Rechtsseitensinn etappenweise ... gegen NW in das Innere des Gebirges versetzt ... "

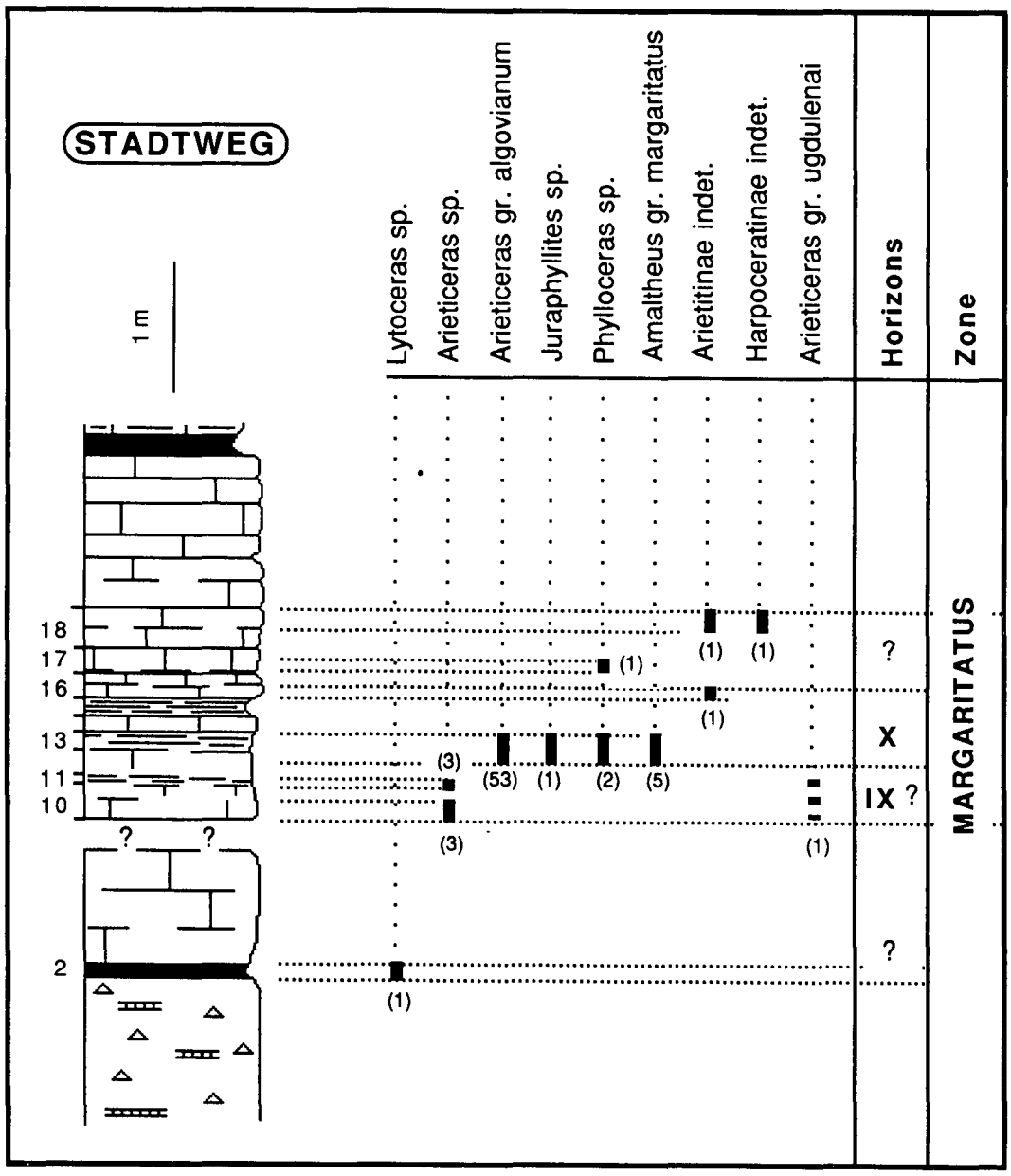
Based on facies comparisons, SPERLING (1990) estimated dextral movements of about 10 km for Triassic slices of the southern zone.

SCHMIDT et al. (in press) interpreted the southern Lienz Dolomites as a structure consisting of different tectonic slices juxtaposed by dextral strike slip faulting. This interpretation is based on facies comparisons of Triassic and Jurassic sediments.

Because ammonites are rare and often tectonically deformed or destroyed by pressure solution, detailed profiles in the southern Jurassic zone were not sampled. Nevertheless, Pliensbachian ammonites are known from two localities of the southern zone.

The first is the Alpl (see Fig. 1). The ammonite bearing beds are red nodular limestones (GRÜN, 1990) and the abundance of *Fuciniceras* gr. *lavinianum – portisi* indicates Upper Pliensbachian (Domerian) age.

The second locality yielding Pliensbachian ammonites are the Liasfleckenmergel at the western flanc of the Sturzelbach gorge (see Fig. 1) (GRÜN & SENFF, 1990). The Liasfleckenmergel in this area are thick bedded (>50 cm), light to yellowish grey, and very fine grained. Chert is rare. We found *Amaltheus margaritatus* "forme" *subnododus* (YOUNG & BIRD) (Pl. 5, Figs. 11,12), *Protogrammoceras aff.* gr. *celebratum* (FUCINI) (Pl. 5, Fig. 24), and fragments of *Protogrammoceras* sp. ind. This fauna documents Domerian (Margaritatus-zone) and is impor-



Text-Fig. 5.
Stadtweg lithological profile and ammonite ranges.

tant for paleogeographic reasons and for restoring the former positions of the different tectonic slices.

Paleogeographically, the red limestone facies in the Amlacher Wiesen Syncline is related to higher (slope) positions than the Liasfleckenmergel facies. This is shown by comparing different lithostratigraphic profiles of the Amlacher Wiesen Syncline (for detailed profiles see BLAU & SCHMIDT, 1988; BLAU, 1990).

In the southern Jurassic/Cretaceous zone, Pliensbachian red limestones are known from the Tscheltschenalm Syncline and the Alpl. The outcrops SSW of Spitzkofel and Sattele Sand/E-flanc Sturzelbach gorge produced no information until now, probably because of a tectonic reduction of the respective series.

We can assume a more basinal position of the Sturzelbach Pliensbachian and a more slope position of the Tscheltschenalm Syncline/Alpl Pliensbachian.

3. Sample Deposition

The ammonites figured in this paper belong to the collections of the authors. The collection of C. MEISTER is deposited at the Muséum d'Histoire naturelle, Département de géologie et de paléontologie des invertébrés, Genève. The collection of J. BLAU is kept at the Institut für Angewandte Geowissenschaften, Gießen. All ammonites are figured in natural size and have been coloured black by using graphite powder. Detailed information (collection, collection no.) on the figured specimens is given separately for each specimen with the explanation of the plates.

4. Systematic Paleontology

We will not repeat the descriptions or discussions presented previously in the following studies: BLAU (1983), DOMMERGUES et al. (1985, 1990), MEISTER (1986, 1988, 1989), DOMMERGUES & MEISTER (1986, 1989, 1990), MEISTER & LOUP (1989), MEISTER & BÖHM (in press). For certain taxa we only give short remarks and with few exceptions, the taxonomy is consistent with the studies cited above.

4.1. Suborder Phylloceratina ARKELL 1950

Superfamily: Phylloceratacea ZITTEL 1884
Family: Phylloceratidae ZITTEL 1884
Subfamily: Phylloceratinae ZITTEL 1884
Genus: *Phylloceras* SUESS 1865

Type species: *Ammonites heterophyllus* SOWERBY 1820.

Phylloceras sp.

Some badly preserved fragments of typical *Phylloceras* occur in the profile Lavant. Probably they can be included to *Phylloceras hebertinum* s.l. because of the absence of constrictions.

Local range: Ibex zone to Apyrenum subzone (*solare* horizon).

Subgenus: *Calliphylloceras* SPATH 1927

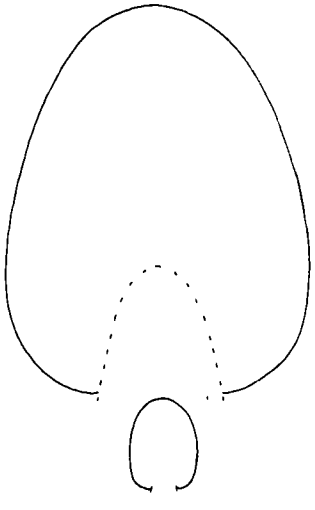
Type species: *Phylloceras disputabile* ZITTEL 1869.

Phylloceras (Calliphylloceras) bicicolae (MENEGHINI 1874)

(Pl. 1, Figs. 6–9; Pl. 2, Fig. 1; Fig. 6)

*1874 *Phylloceras Bicicolae* MENEGHINI, p. 106.
1989 *Calliphylloceras bicicolae* (MENEGHINI). – MEISTER, Pl. 2, Fig. 3, 4; with synonymy.

Several specimens bearing numereous constrictions can be attributed to *Phylloceras (Calliphylloceras) bicicolae*. The presence of constrictions is the only feature which distinguishes the subgenus *Calliphylloceras* from *Phylloceras*.



Text-Fig. 6.
Phylloceras (Calliphylloceras) bicicolae (MENEGHINI) whorl sections.

Local range: Stokesi subzone (*marianii* horizon) to ?Subnodosus subzone (*cornacaldense* level).

Subgenus: *Calaiceras* KOWACS 1939

Synonyme: *Hantkeniceras* KOWACS 1939.

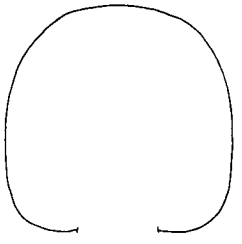
Type species: *Phylloceras calais* MENEGHINI 1874 (see BRAGA & RIVAS 1987).

Phylloceras (Calaiceras) calais (MENEGHINI 1874)

(Pl. 1, Figs. 1,2; Fig. 7)

*1874 *Phylloceras Calais* MENEGHINI, p. 106.
1977 *Calaiceras calais* (MENEGHINI). – WIEDENMAYER, Pl. 1, Figs. 1,8; Pl. 8, Figs. 2,3; with synonymy.
?1981 *Hantkeniceras* cf. *hantkeni* (SCHLOENBACH). – WANG & HE, Pl. 1, Figs. 13–15.
1987 *Calaiceras calais* (MENEGHINI). – BRAGA & RIVAS, Pl. 2, Fig. 1.
?1987 *Calaiceras* cf. *hantkeni* (SCHLOENBACH). – BRAGA & RIVAS, Figs. 4f,5g.

Only one *Phylloceras*, found in the slightly condensed level of Blasbründl, is characterized by a broad and subsquare whorl section and can be attributed to KOWACS' subgenus.



Text-Fig. 7.
Phylloceras (Calaiceras) calais (MENEGHINI) whorl section.

Local range: ?Stokesi subzone (*celebratum* level) – ?Subnodosus subzone (*cornacaldense* level).

Genus: *Partschiceras* FUCINI 1923

Type species: *Ammonites Partschi* STUR 1851.

Partschiceras striatocostatum (MENEGHINI 1853)

(Pl. 2, Figs. 2,3)

1851 *Ammonites Partschi* STUR, p. 26 (nom. nudum).
*1853 *Ammonites striatocostatus* MENEGHINI, p. 28.
1868 *Ammonites Sturi* REYNÈS, Pl. 3, Fig. 1.
1913 *Phylloceras anonymum* HAAS, Pl. 1, Fig. 5.
1977 *Partschiceras sturi* (REYNÈS). – WIEDENMAYER, Pl. 2, Figs. 6,7; Pl. 5, Figs. 1–4; with synonymy.
1977 *Partschiceras striatocostatum* (MENEGHINI). – WIEDENMAYER, Pl. 4, Figs. 5–8; with synonymy.
1986 *Partschiceras anonymum* (HAAS). – GAKOVIC, Pl. 1, Fig. 3.
1987 *Partschiceras striatocostatum* (MENEGHINI). – BRAGA & RIVAS, Pl. 1, Figs. 5–8.
1989 *Partschiceras striatocostatum* (MENEGHINI). – MEISTER, Pl. 2, Fig. 6.

In *Partschiceras striatocostatum* (MENEGHINI) we regroup all compressed Phylloceratidae which are characterized by high whorls and bear quite rectiradiate, blunt ribs associated with fine striae on the outer half of the whorl flancs as well as on the venter.

Local range: ?Stokesi subzone (*celebratum* level) – ?Subnodosus subzone (*cornacaldense* level).

Family: Juraphyllitidae ARKELL 1950
Genus: *Juraphyllites* MÜLLER 1939

Type species: *Phylloceras diopsis* GEMMELLARO 1884.

Subgenus: *Harpophylloceras* SPATH 1927

Type species: *Ammonites eximius* HAUER 1854.

Juraphyllites (Harpophylloceras) eximius (HAUER 1854)

(Pl. 1, Figs. 4,5)

*1854 *Ammonites eximius* HAUER, p. 18, Pl. 2, Figs. 1–4.
1989 *J. (Harpophylloceras) eximius* (HAUER). – MEISTER, Pl. 3, Figs. 1–3; with synonymy.

Two *Juraphyllites* from Blasbründel and Lavant bear a ventral keel. This feature is diagnostic for SPATH's subgenus which is monospecific.

Local range: Stokesi subzone (*celebratum* level) – Subnodosus subzone (*cornacaldense* level) to Gibbosus subzone (*algovianum* horizon).

4.2. Suborder Lytoceratina HYATT 1889

Superfamily: Lytocerataceae NEUMAYR 1875
Family: Lytoceratidae NEUMAYR 1875
Genus: *Lytoceras* SUESS 1865

Type species: *Ammonites fimbriatus* SOWERBY 1817.

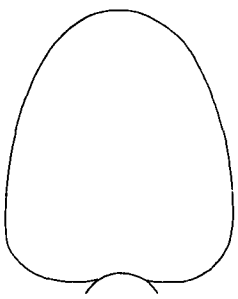
Lytoceras gr. *villae* MENEGHINI 1874

(Pl. 2, Figs. 4,5; Pl. 3, Figs. 1,2; Pl. 4, Fig. 4; Fig. 8)

1874 *Lytoceras Villae* MENEGHINI, p. 107.
1987 *Lytoceras villae* (MENEGHINI). – BRAGA, JIMENEZ & RIVAS, Pl. 1, Fig. 6; Pl. 2, Figs. 1–4; with synonymy.
1989 *Lytoceras villae* (MENEGHINI). – MEISTER, Pl. 1, Figs. 1,3,6,7.

Most of our specimens belong to the group of *Lytoceras villae* as defined by BRAGA et al. (1987). Our specimens show

1) a quite fine subdivided ribbing on the side and
2) a suboval whorl section. They can be distinguished essentially from the group of *Lytoceras fimbriatum* (SOWERBY) by the presence of these two features.



Text-Fig. 8.
Lytoceras gr. *villae* MENEGHINI whorl section.

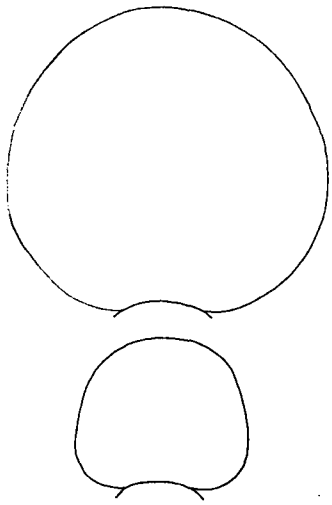
Local range: ?Stokesi subzone (*celebratum* level) – ?Subnodosus subzone (*cornacaldense* level).

Lytoceras gr. *baconicum* VADASZ 1910

(Pl. 1, Figs. 10,11; Pl. 4, Fig. 1; Fig. 9)

*1910 *Lytoceras baconicum* VADASZ, p. 75, Abb. 24,25.
1977 *Kallilytoceras baconicum* (VADASZ). – WIEDENMAYER, Pl. 11, Figs. 6,7; with synonymy.

Among the Lytoceratina of Lienz two specimens show a subdivided, but more sinuous ribbing than *Lytoceras* gr. *villae*. The whorl section is subrounded (quite more broad than high) and somewhat flattened. These features characterize the group of *Lytoceras baconicum* including associated species as *Lytoceras mariae* MAUGERI. In *Lytoceras furcicrenatum* BUCKMAN the whorl section is well rounded and the ribbing is subdivided on the ventral part only. Moreover, BUCKMAN's species seems to be restricted to the Euroboreal realm.



Text-Fig. 9.
Lytoceras gr. *baconicum* VADASZ whorl sections.

Local range: ?Stokesi subzone (*celebratum* level) – ?Subnodosus subzone (*cornacaldense* level).

Genus: *Derolytoceras* ROSENBERG 1909

Type species: *Ammonites lineatus tortus* QUENSTEDT 1885.

Derolytoceras tortum (QUENSTEDT 1885)

*1885 *Ammonites lineatus tortus* QUENSTEDT, Pl. 39, Figs. 12,13.
1989 *Derolytoceras tortum* (QUENSTEDT). – MEISTER & LOUP, Pl. 6, Fig. 7.
1990 *Derolytoceras tortum* (QUENSTEDT). – DOMMERGUES, MEISTER & METTRAUX, Pl. 6, Figs. 8,9; with synonymy.
1990 *Derolytoceras tortum* (QUENSTEDT). – DOMMERGUES & MEISTER, Figs. 3 (13,14); Fig. 5 (23).

Besides the previous two lytoceratid macroconch species, we only have found one microconch form (see MEISTER, 1986) which belongs to *Derolytoceras tortum* (QUENSTEDT).

Local range: ?Stokesi subzone (*celebratum* level) – ?Subnodosus subzone (*cornacaldense* level).

4.3. Suborder Ammonitina HYATT 1889

Superfamily: Eoderocerataceae SPATH 1929
Family: Phricodoceratidae SPATH 1938
Genus: *Phricodoceras* HYATT 1900

Type species: *Ammonites Taylori* SOWERBY1826.

Phricodoceras sp.

One fragment of a Domerian *Phricodoceras* (not figured here) is characterized by a close and fine ribbing. Only the two rows of ventral tubercles are obvious; they are poorly developed.

Local range: ?Stokesi subzone (*celebratum* level) – ?Subnodosus subzone (*cornacaldense* level).

Family: Acanthopleuroceratidae ARKELL 1950
Genus: *Tropidoceras* HYATT 1867

Type species: *Ammonites masseanum* D'ORBIGNY1844.

Tropidoceras sp.

(Pl. 4, Figs. 2,3)

Only 2 fragments of *Tropidoceras* have been found in Lavant. The first one (Pl. 4, Figs. 2,3) shows the inner whorls with strong broadly spaced ribs as in *Tropidoceras calliplocum* (GEMMELLARO). The second one, which is not figured here, is a body chamber of a large specimen which shows morphological similarities to *Tropidoceras flandrini* (DUMORTIER) or perhaps *Tropidoceras masseanum* (D'ORBIGNY).

Local range: Masseanum subzone (*Tropidoceras* level) to Valdani subzone (*inflatum* level).

Genus: *Acanthopleuroceras* HYATT 1900

Type species: *Ammonites valdani* D'ORBIGNY 1844.

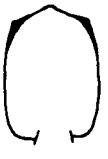
Acanthopleuroceras gr. *inflatum* (QUENSTEDT 1885)

(Pl. 5, Figs. 1,2; Fig. 10)

*1885 *Ammonites Maugenestii inflatus* QUENSTEDT, Pl. 35, Fig. 17.
1986 *Acanthopleuroceras* aff. *inflatum* (QUENSTEDT). – MEISTER, Pl. 9, Fig. 8; with synonymy.

This *Acanthopleuroceras* is characterized by coarse, spaced ribs with a large blunt of outer tubercles and a less developed inner one. The venter is fastigate, quite flattened as in QUENSTEDT's species. This specimen also represents an intermediate morphology between *Acanthopleuroceras maugenesti* (D'ORBIGNY) and *Acanthopleuroceras valdani* (D'ORBIGNY).

Local range: Valdani subzone (*inflatum* level).



Text-Fig. 10.
Acanthopleuroceras gr. *inflatum* (QUENSTEDT) whorl section.

Family: Liparoceratidae HYATT 1867
Genus: *Becheiceras* TRUEMAN 1918

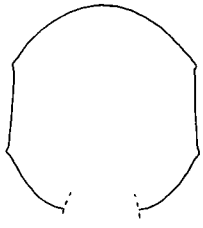
Type species: *Ammonites bechei* SOWERBY, 1821 (see DONOVAN & FORSEY 1973, p. 13).

Becheiceras gr. *bechei* (SOWERBY 1821)

(Pl. 4, Fig. 5; Fig. 11)

*1821 *Ammonites bechei* SOWERBY, p. 143, Pl. 280.
1986 *Liparoceras (Becheiceras) bechei* (SOW.). – MEISTER, Pl. 13, Fig. 4; with synonymy.

This typical *Becheiceras* (globose form with fine *Liparoceras* ornamentation) shows an intermediate morphology between the coarser ribbed *Becheiceras gallicum* (SPATH 1938) and the fine ribbed *Becheiceras bechei* (SOWERBY). In our specimen the lyrae ornamentation is very well developed.



Text-Fig. 11.
Becheiceras gr. *bechei* (SOWERBY) whorl section.

Local range: ?Stokesi subzone (*celebratum* level) – ?Subnodosus subzone (*cornacaldense* level).

Genus: *Androgynoceras* HYATT 1867

Type species: *Ammonites hybrida* D'ORBIGNY 1844.

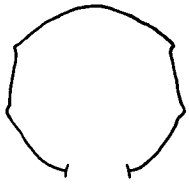
Remark: In this genus we include ammonites characterized by a "capricorne" and "liparoceratid" ontogeny. This androgyne morphology is interpreted either in terms of sexual dimorphism (MEISTER, 1986) or in terms of *Aegoceras* variability where they represent the peramorphic pole (DOMMERGUES, 1987; DOMMERGUES et al., 1986). These two models are compatible.

Androgynoceras gr. *geyeri* (SPATH 1938)

(Pl. 5, Fig. 3,4,5; Fig. 12)

*1938 *Liparoceras geyeri* SPATH, Pl. 4, Figs. 4,6; Pl. 6, Fig. 2; Pl. 10, Figs. 3.4; Pl. 18, Fig. 11.
1990 *"Androgynoceras" geyeri* (SPATH). – DOMMERGUES, MEISTER & METTRAUX, Pl. 5, Fig. 12; with synonymy.

This typical "dimorph" specimen sketches a *Beaniceras (Beaniceras luridum* (SIMPSON)) capricorne morphology. The "capricorne" stage is rather short and allows to distinguish our specimen from *Androgynoceras hybrida*



Text-Fig. 12.
Androgynoceras gr. *geyeri* (SPATH) whorl section.

(D'ORBIGNY) and *Androgynoceras subhybrida* (SPATH) with longer ontogenetic capricorne stages.

Local range: Luridum subzone (*geyeri* level).

Family: Amaltheidae HYATT 1867
Genus: *Amaltheus* DE MONTFORT 1808

Type species: *Amaltheus margaritatus* DE MONTFORT, 1808.

Amaltheus stokesi (SOWERBY 1818)

(Pl. 5, Fig. 9)

*1818 *Ammonites Stokesi* SOWERBY, Pl. 190.
1958 *Amaltheus stokesi* (SOWERBY). – HOWARTH, Pl. 1, Figs. 5,7,12-14; Pl. 2, Figs. 1,3,10; Text-Figs. 4,5; with synonymy.
1986 *Amaltheus stokesi* (Sowerby). – Meister, Pl. 19, Fig. 2; Pl. 20, Figs. 1,8; with synonymy.
1986 *Amaltheus stokesi* (SOWERBY). – SMITH & TIPPER, Fig. 2 (1,2).
1988 *Amaltheus stokesi* (SOWERBY). – MEISTER, Pl. 1, Fig. 1.
1988 *Amaltheus stokesi* (SOWERBY). – SMITH, TIPPER, TAYLOR & GUEX, Pl. 4, Fig. 15–16.
1988 *Amaltheus (Amaltheus) stokesi* (SOWERBY). – KRIMHOLTS, Pl. 2, Fig. 1.
1990 *Amaltheus stokesi* (SOWERBY). – DOMMERGUES, MEISTER & METTRAUX, Pl. 6, Figs. 4–6.
1990 *Amaltheus stokesi* (SOWERBY). – DOMMERGUES & MEISTER, Text-Fig. 3 (5,6,9,10); Text-Fig. 5 (12–14).

Our *Amaltheus* fragment is characterized by a ribbing and a crenulated keel which are still connected. In the Amaltheidae found in overlying beds (*Amaltheus margaritatus* DE MONTFORT and *Amaltheus margaritatus* "forme" *subnodosus* (YOUNG & BIRD)) this feature disappears indeed, the ribs and the keel become clearly disjoined.

Local range: Stokesi subzone (*marianii* horizon to *celebratum* level).

Amaltheus margaritatus DE MONTFORT 1808

(Pl. 5, Fig. 10)

*1808 *Amaltheus margaritatus* DE MONTFORT, p. 91, Fig. 90.
1958 *Amaltheus margaritatus* DE MONTFORT. – HOWARTH, Pl. 3, Figs. 4–6; Text-Figs. 8,9; with synonymy.
1986 *Amaltheus margaritatus* DE MONTFORT. – MEISTER, Pl. 20, Fig. 9; Pl. 22, Fig. 1; Pl. 23, Fig. 6; with synonymy.
1988 *Amaltheus margaritatus* DE MONTFORT. – MEISTER, Pl. 1, Figs. 2–4; Pl. 2, Figs. 1–3,5; Pl. 3, Figs. 3–5,10; Pl. 4, Figs. 1,3,4.

This species is rather well represented in the studied area, the specimens are mainly from Lavant and Blasbründl.

Local range: Subnodosus subzone (*cornacaldense* level) to Gibbosus subzone (*algovianum* horizon).

Amaltheus margaritatus "forme" *subnodosus* (YOUNG & BIRD 1828)

(Pl. 5, Figs. 11,12)

*1828 *Ammonites subnodosus* YOUNG & BIRD, Pl. 13, Fig. 3.
1958 *Amaltheus subnodosus* (Y. & B.). – HOWARTH, Pl. 2, Figs. 11–18; Text-Fig. 6; with synonymy.
1986 *Amaltheus subnodosus* (Y. & B.). – MEISTER, Pl. 20, Fig. 5; with synonymy.
1988 *Amaltheus margaritatus* forme *subnodosus* (Y. & B.). – MEISTER, Pl. 1, Figs. 5,6.

The only *Amaltheus* from the Sturzelbach is characterized by strong, spaced, rectiradiate ribs and by fine ventro-lateral tubercles in the juvenile stage. In the adult stage the tubercles tend to disappear and the ribbing is becoming more sinuous (for more explanations see MEISTER, 1988: 769).

Local range: Subnodosus subzone.

Genus: *Pleuroceras* HYATT, 1867

Type species: *Ammonites spinatus* BRUGUIÈRE 1789.

Pleuroceras aff. *solare* (PHILLIPS 1829)

(Pl. 5, Figs. 6,7,8)

*1829 *Ammonites solaris* PHILLIPS, Pl. 4, Fig. 29.
1958 *Pleuroceras solare* (PHILLIPS). – HOWARTH, Pl. 4, Figs. 1–7; Text-Figs. 15–17; with synonymy.
1960 *Pleuroceras solare* (PHILLIPS). – JORDAN, Pl. 4, Figs. 6–7.
1961 *Pleuroceras solare* (PHILLIPS). – TINTANT, GAUTHIER & LACROIX, Pl. 1, Fig. 5.
1969 *Pleuroceras solare* (PHILLIPS). – POPA, Pl. 1, Figs. 1–4.
1976 *Pleuroceras solare* (PHILLIPS). – SCHLEGELMILCH, Pl. 36, Fig. 2.
1980 *Pleuroceras solare* (PHILLIPS). – WIEDENMAYER, Pl. 3, Figs. 8–13.
1980 *Pleuroceras solare* (PHILLIPS) var. *trapezoidiforme* (MAUBEUGE). – WIEDENMAYER, Pl. 3, Figs. 22,23.
1980 *Pleuroceras solare* (PHILLIPS) var. *leve* WIEDENMAYER, Pl. 3, Figs. 14–19.
1982 *Pleuroceras solare* (PHILLIPS). – BRAGA, COMAS RENGIFO, GOY & RIVAS, Pl. 3, Fig. 8.
1983 *Pleuroceras solare* (PHILLIPS). – BRAGA, Pl. 15, Figs. 14–16.
1984 *Pleuroceras solare* (PHILLIPS). – CUBAYNES, BOUTET, DELFAUD & FAURÉ, Pl. 3, Fig. 20.
1985 *Pleuroceras solare* (PHILLIPS). – COMAS RENGIFO, Pl. 10, Figs. 5–9; Pl. 11, Fig. 4.
1988 *Pleuroceras solare* (PHILLIPS). – MEISTER, Pl. 6, Figs. 6,7,9–11; Pl. 7, Figs. 1–3.

This evolute representative of the Amaltheidae is rather abundant in the Upper Austroalpine and posesses a wide geographical distribution throughout the western Tethys.

Local range: Apyrenum subzone (*solare* horizon).

Family: Dactylioceratidae HYATT 1867
Subfamily: Reynesocoeloceratinae DOMMERGUES 1986
Genus: *Cetonoceras* WIEDENMAYER 1977

Type species: *Cetonoceras psiloceroides* FUCINI, 1905.

Cetonoceras juv. sp.

(Pl. 5, Figs. 13,14)

These very evolute Dactylioceratidae are characterized by a quadrate to rounded whorl-section, by primary lateral (rigid) radiate ribs with an outer row of marginal tubercles and by closer and more delicate secondary ventral ribs. Our specimen is comparable

with juvenile growth stages of the group of *Cetonoceras psiloceroides* (FUCINI).

This Domerian group is known from the Tethyan realm (FUCINI, 1905; GÉCZY 1976; BRAGA 1983) and from the southern euroboreal seas: Portugal, Provence (DOMMERGUES et al., 1983) and Subbriançonnais (DOMMERGUES & MEISTER, 1990).

Local range: Stokesi subzone (*lavinianum* horizon).

Superfamily: Hildocerataceae HYATT 1867
Family: Hildoceratidae HYATT 1867
Subfamily: Harpoceratinae NEUMAYR 1875

Remark: In this paper we use *Protogrammoceras* in a wide sense. Only unambiguous forms with typically sigmoidal rursiradiate ribs (angulirursiradiate sensu SPATH) and which are characterized by a tricarenate flat venter during the whole ontogeny are placed in *Fuciniceras*. The ambiguous forms are placed in *"Protogrammoceras"*.

Genus: *Protogrammoceras* SPATH 1913

Types species: *Grammoceras bassanii* FUCINI, 1900.

"Protogrammoceras" gr. *volubile* (FUCINI 1900)

(Pl.6, Figs. 1,2; Fig. 13)

*1900 *Harpoceras ? volubile* FUCINI, Pl. 7, Fig. 3.
1900 *Grammoceras varicostatum* FUCINI, Pl. 8, Fig. 6.
1900 *Harpoceras ? pantanelli* FUCINI, Pl. 7, Fig. 7.
?1905 *Hildoceras bastianii* FUCINI, Pl. 44, Fig. 14.
?1905 *Hildoceras bastianii* var. *perplicata* FUCINI, Pl. 43, Fig. 1; Pl. 44, Fig. 1.
1976 *Fuciniceras pantanelli serratum* (FUCINI). – GÉCZY, Pl. 35, Figs. 6–7; Pl. 36, Figs. 1–5.
1977 *Protogrammoceras ? volubile* (FUCINI). – WIEDENMAYER, Pl. 19, Fig. 16.
1983 *Protogrammoceras* gr. *volubile* (FUCINI) - *pantanelli* (FUCINI). – DOMMERGUES, FERRETTI, GÉCZY & MOUTERDE, Pl. 5, Figs. 1–17.

This fragment of a *"Protogrammoceras"* is characterized by weakly sinuous and rursiradiate ribs and by a narrow and flat ventral part. These morphological features show good affinities with the Carixian species *"Protogrammomoceras"* volubile (FUCINI) and *"Protogrammoceras" costicillatum* (FUCINI). Between them there are transitional forms and often the determination of fragments is difficult. The systematic position is still in discussion. For example FERRETTI (1990) considers *"Protogrammoceras" costicillatum* (FUCINI) as a synonyme of *"Protogrammoceras" volubile* (FUCINI). Here we follow the systematic point of view of DOMMERGUES et al. (1983) and attribute this specimen to *"Protogrammoceras" volubile* (FUCINI). Its association with *Androgynoceras* gr. *geyeri* corroborates this taxonomic position (see DOMMERGUES 1987).

Text-Fig. 13.
"Protogrammoceras" gr. *volubile* (FUCINI) whorl section.

Local range: Luridum subzone (*geyeri* level).

Protogrammoceras gr. *isseli* (FUCINI 1900)

(Pl.5, Figs. 15–22)

*1900 *Grammoceras isseli* FUCINI, Pl. 9, Figs. 6–8.
1983 *Fuciniceras isseli* (FUCINI). – BRAGA, Pl. 2, Fig. 10; Pl. 3, Figs. 1–5.
1983 *Protogrammoceras isseli* (FUCINI). – DOMMERGUES, FERRETTI, GÉCZY & MOUTERDE, Pl. 4, Figs. 1–12.

In the *Protogrammoceras* found overlying the beds with *Fuciniceras lavinianum*, the rib-sketching is more falciform with a forward rib projection on the external part. The ventral sulci tend to dissappear and the whorl section appears more acute.

Local range: Stokesi subzone (*isseli* horizon).

Protogrammoceras aff. gr. *marianii* (FUCINI 1904)

(Pl. 5, Figs. 26,27)

*1904 *Harpoceras marianii* FUCINI, Pl. 41, Figs. 1–3.
1972 *Protogrammoceras marianii* (Fucini). – FERRETTI, Pl. 13, Fig. 6.
1977 *Protogrammoceras marianii* (FUCINI). – WIEDENMAYER, Pl. 19, Figs. 7,8; with synonymy.
1989 *Protogrammoceras (Protogrammoceras)* aff. gr. *marianii* (FUCINI). – MEISTER, Pl. 3, Fig. 11.

Protogrammoceras marianii (FUCINI) presents more falciform ribs and an even more acute external part than *P. isseli*. This tendency is already initiated in *Protogrammoceras isseli* (FUCINI) and is more expressed in *Protogrammoceras marianii* (FUCINI).

In Lavant the *Protogrammoceras* from bed 29 are badly preserved with a quite coarse ribbing. They probably belong to *Protogrammoceras marianii* (FUCINI).

Local range: Stokesi subzone (*marianii* horizon).

Protogrammoceras aff. gr. *celebratum* (FUCINI, 1900)

(Pl. 5, Figs. 24,25)

*1900 *Grammoceras celebratum* FUCINI, Pl. 10, Figs. 1,2.
?non 1986 *Protogrammoceras (Protogrammoceras) celebratum* (FUCINI). – GAKOVIC, Pl. 13, Figs. 1.
1989 *(Protogrammoceras) celebratum* (FUCINI). – MEISTER, Pl. 3, Figs. 14,15; Pl. 4, Fig. 1; with synonymy.

In *Protogrammoceras celebratum* (FUCINI) the falciform sketch of the ribs is even more pronounced and the ventral part more acute than in *P. marianii*. From *P. isseli* – > *P. marianii* – > *P. celebratum*, it is possible to recognize a general tendency to develop a progressively more falcate ribbing and a more acute ventral part by peramorphosis (acceleration in terms of heterochrony) (GOULD, 1977; ALBERCH et al., 1976; MAC NAMARA, 1982; DOMMERGUES et al., 1986).

Local range: Stokesi subzone (*celebratum* level).

Subgenus: *Matteiceras* WIEDENMAYER 1980

Type species: *Ammonites nitescens* YOUNG & BIRD 1828.

Protogrammoceras (Matteiceras) gr. *monestieri* (FISCHER 1975)

(Pl. 6, Figs. 3,4)

partim 1934 *Harpoceras falciplicatum* (FUCINI). – MONESTIER, Pl. 1, Figs. 3,13,32,33,36,37; non Pl. 10, Figs. 40,41.
*1975 *Protogrammoceras monestieri* FISCHER, Pl. 1, Figs. 13–17; Abb. 10,14, Figs. 4–7; Abb. 15, Fig. 5.
1986 *P. (Matteiceras) monestieri* (FISCHER). – MEISTER, Pl. 21, Figs. 3,4,8,9.
1989 *P. (Matteiceras) monestieri* (FISCHER). – MEISTER, p. 38; with synonymy.
1990 *P. (Matteiceras) monestieri* (FISCHER). – DOMMERGUES & MEISTER, Fig. 5 (20).

Local range: Stokesi subzone (*isseli* horizon).

Protogrammoceras (Matteiceras) gr. *nitescens* (YOUNG & BIRD 1828)

***1828** *Ammonites nitescens* YOUNG & BIRD, p. 257.
1985 *Protogrammoceras nitescens* (Y. & B.). – COMAS RENGIFO, Pl. 14, Figs. 5–6; with synonymy.
1989 *P. (Matteiceras) nitescens* (Y. & B.). – MEISTER, Pl. 3, Figs. 10,12.
1990 *P. (Matteiceras) nitescens* (Y. & B.). – DOMMERGUES & MEISTER, Fig. 3 (11,12); Fig. 5 (21).

Like in other Upper Austroalpine regions (e.g. Rötelstein: MEISTER & BÖHM in press), the two typical coarse ribbed Euroboreal forms (DOMMERGUES et al., 1985; DOMMERGUES & MEISTER, 1989) *Protogrammoceras (Matteiceras) nitescens* and *monestieri* coexist with Tethyan *Protogrammoceras* and allow a good correlation between these two realms.

Local range: Stokesi subzone (*marianii* horizon).

Genus: *Fuciniceras* HAAS 1913

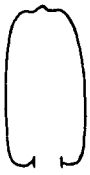
Type species: *Hildoceras lavinianum* MENEGHINI in FUCINI 1900.

Fuciniceras gr. *lavinianum* (FUCINI, 1900)

(Pl. 5, Fig. 23; Pl.6, Figs. 5–11; Fig. 14)

*1900 *Hildoceras Lavinianum* MENEGHINI in FUCINI, Pl. 11, Figs. 6,7.
1900 *Hildoceras Lavinianum* var. *brevispirata* FUCINI, Pl. 8, Fig. 6.
1900 *Grammoceras Portisi* FUCINI, Pl. 9, Figs. 1–3.
1983 *Fuciniceras lavinianum* (FUCINI). – BRAGA, Pl. 1, Figs. 6–8; Pl. 2, Figs. 1–3; with synonymy.
partim 1983 *Fuciniceras brevispiratum* (FUCINI). – BRAGA, Pl. 2, Figs. 4–9; with partim synonymy; not *Protogrammoceras pantanelli* (FUCINI).
1983 *Fuciniceras portisi* (FUCINI) – *lavinianum* (FUCINI). – DOMMERGUES, FERRETTI, GÉCZY & MOUTERDE, Pl. 6, Figs. 9–10.

Following DOMMERGUES et al. (1985), DOMMERGUES (1987) and MEISTER & BÖHM (in press) we consider *Fuciniceras lavinianum* (FUCINI) and *Fuciniceras portisi* (FUCINI) as synonyme: *Fuciniceras lavinianum* (FUCINI) represents



Text-Fig. 14.
Fuciniceras gr. *cornacaldense* (TAUSCH) whorl section.

the coarse and spaced ribbed morphology and *Fuciniceras portisi* (FUCINI) the fine and close ribbed pole. The specimens from the Lienz Dolomites show an angulirursiradiate sketching (sensu SPATH 1913) and are closer to the morphology of *Fuciniceras portisi* (FUCINI). In *"Protogrammoceras" costicillatum* (FUCINI) from the Upper Carixian the *Fuciniceras features* (tricarinate venter and sigmoidale rursiradiate ribs) are still not well expressed during the whole ontogeny. However, they are well developed in the Lower Domerian *Fuciniceras lavinianum* (FUCINI).

Local range: Stokesi subzone (*lavinianum* horizon).

Fuciniceras gr. *cornacaldense* (TAUSCH 1890)

(Pl. 6, Figs. 12–17)

*1890 *Harpoceras cornacaldense* TAUSCH, Pl. 1, Fig. 1.
1895 *Harpoceras ? cornacaldense* TAUSCH var. *Bicicolae* BONRELLI, p. 339.
1983 *Fuciniceras cornacaldense* (TAUSCH). – BRAGA, Pl. 3, Fig. 6–8; Pl. 4, Fig. 1; with synonymy.

Our fragments show typical *Fuciniceras* ribs, often fasciculated on the lower half of the sides. Their rib-density is quite important and the venter is tricarinate and flat.

In *Fuciniceras cornacaldense* (TAUSCH) we regroup *Fuciniceras bicicolae* (BONARELLI) which is considered by BONRELLI as a variety of TAUSCH's species only.

Two other species are very close to *Fuciniceras cornacaldense* (TAUSCH). The first is *Fuciniceras boscense* (REYNÈS) which is perhaps a coarser ribbed form and the second is *Fuciniceras pectinatum* (MENEGHINI) characterized by a more sinuous and prorsiradiate ribbing. These 3 "species" are subcontemporaneous but the phylogenetic connections between them are still not well understood and our badly preserved material does not allow us to discuss these relationships.

Local range: Subnodosus subzone (*cornacaldense* level).

Subfamily: Arieticeratinae HOWARTH 1955
Genus: *Arieticeras* SEGUENZA 1885

Type species: *Ammonites algovianus* OPPEL 1862.

Arieticeras gr. *ugdulenai* (GEMMELLARO 1885)

(Pl. 6, Figs. 19–22)

*1885 *Arieticeras (Grammoceras) ugdulenai* GEMMELLARO, p. 6.
1929/30 *Seguentia ugdulenai* (GEM.). – FUCINI, Pl. 15, Figs. 1–7.
1929/30 *Seguentia ugdulenai* (GEM.) *rareplicata*. – FUCINI, Pl. 15, Figs. 10-13.
1929/30 *Seguentia ugdulenai* (GEM.) *denseplicata* . – FUCINI, Pl. 15, Figs. 8,9.

*1934 *Arieticeras lozeriense* MONESTIER, Pl. 9, Figs. 8–11,14–17, ?18; Pl. 11, Fig. 4.
*1983 *Arieticeras ugdulenai* (GEM.). – BRAGA, Pl. 11, Figs. 8–15; with synonymy.
*1986 *Ugdulenia ugdulenai* (GEM.). – GAKOVIC, Pl. 8, Fig. 3.
*1989 *Arieticeras ugdulenai* (GEM.) – MEISTER, Pl. 6, Figs. 15,17.

These quite involute *Arieticeras* with rigid radiate, sometimes weakly sigmoidal ribs, high and compressed whorl section, and an acute keel belong to *Arieticeras ugdulenai* (GEMMELARO). Some specimens are coarsely ribbed and close to FUCINI's variety *rareplicata*.

The inner whorls are characterized by a quite irregular and more sinuous rib-pattern with two or three ribs being connected near the periumbilical part (fasciculate look). In the adult stage, the ribbing is more regular and disappears near the ventral part. Some specimens bear little ventrolateral tubercles as shown in FUCINI's illustration (1931: Pl. 13, Figs. 1,6).

The juvenile ribbing also resembles FUCINI's genus *Trinacrioceras* with a still more irregular ribbing and a more evolute conch (ibidem: Pl. 20,21).

Local range: Gibbosus subzone (*ugdulenai* horizon).

Arieticeras gr. *algovianum* (OPPEL 1862)

Pl. 6, Fig. 23; Pl. 7, Figs. 1–18)

*1862 *Ammonites Algovianus* OPPEL, p. 137.
1987 *Arieticeras* cf. *algovianum* (OPPEL). – SMITH, TIPPER, TAYLOR & GUEX, Pl. 4, Figs. 10,11.
1989 *Arieticeras* gr. *algovianum* (OPPEL). – MEISTER, Pl. 7, Fig. 10–12; with synonymy.

Our specimens immediately overly *Arieticeras ugdulenai* and are characterized by a wider umbilicus and more prominent sigmoidal ribs. They belong to *Arieticeras algovianum* (OPPEL) which shows a large range of variability (see MEISTER, 1989: 48).

Local range: Gibbosus subzone (*algovianum* horizon).

gen. et sp. ind. ex Arieticeratinae

Some fragments are attributed tentatively to the subfamily Arieticeratinae because of their weakly sinuous and tight ribs. They are neither *Protogrammoceras* nor true *Arieticeras*, perhaps they are closer to *Leptaleoceras*. The bad preservation of our samples does not allow a precise determination.

Local range: Stokesi subzone (*marianii* horizon).

5. Biostratigraphy

The 11 faunal horizons or levels which we recognized in the Lienz Dolomites sequences (Fig. 15) allow correlations with the two standard zonations presented for NW Europe (DEAN et al., 1961) and for the Tethyan realm (FERRETTI, 1990).

Remark

The term "horizon" is reserved for one or several beds containing a rich ammonite fauna. We use "level" for condensed beds or beds with a poor fauna which might be regrouped with more data support.

5.1. Pliensbachian Stage

5.1.1. Carixian substage

Ibex zone

Until now the early Carixian has not been recognized in the studied area. In the middle Carixian, the ammonites are very rare. Nevertheless we can distinguish 3 levels in this period:

(I) ***Tropidoceras* level**
Only characterized by *Tropidoceras*.

(II) ***inflatum* level**
Characterized by the association *Acanthopleuroceras* and *Tropidoceras*.

(III) ***geyeri* level**
In this level, the index species co-occurs with *Protogrammoceras* gr. *volubile*.

We were not able to prove the existence of late Carixian in the Lienz Dolomites. Nevertheless, GEYER (1903) reported *Androgynoceras capricornus* (SCHLOTHEIM) from the Amlacher Wiesen Syncline (Rötenbach area). Possibly this horizon is not developed in the investigated sections.

5.1.2. Domerian substage

The family Amaltheidae is rather well represented in the faunas of the Lienz Dolomites and is quite diversified with *Amaltheus stokesi, Amaltheus margaritatus, Amaltheus margaritarus* "forme" *subnodosus* and *Pleuroceras*.

Margaritatus zone

The Margaritatus zone sensu DEAN et al. (1961) is equivalent with the Stokesi and Margaritatus zones in FERRETTI (1990).

Stokesi subzone

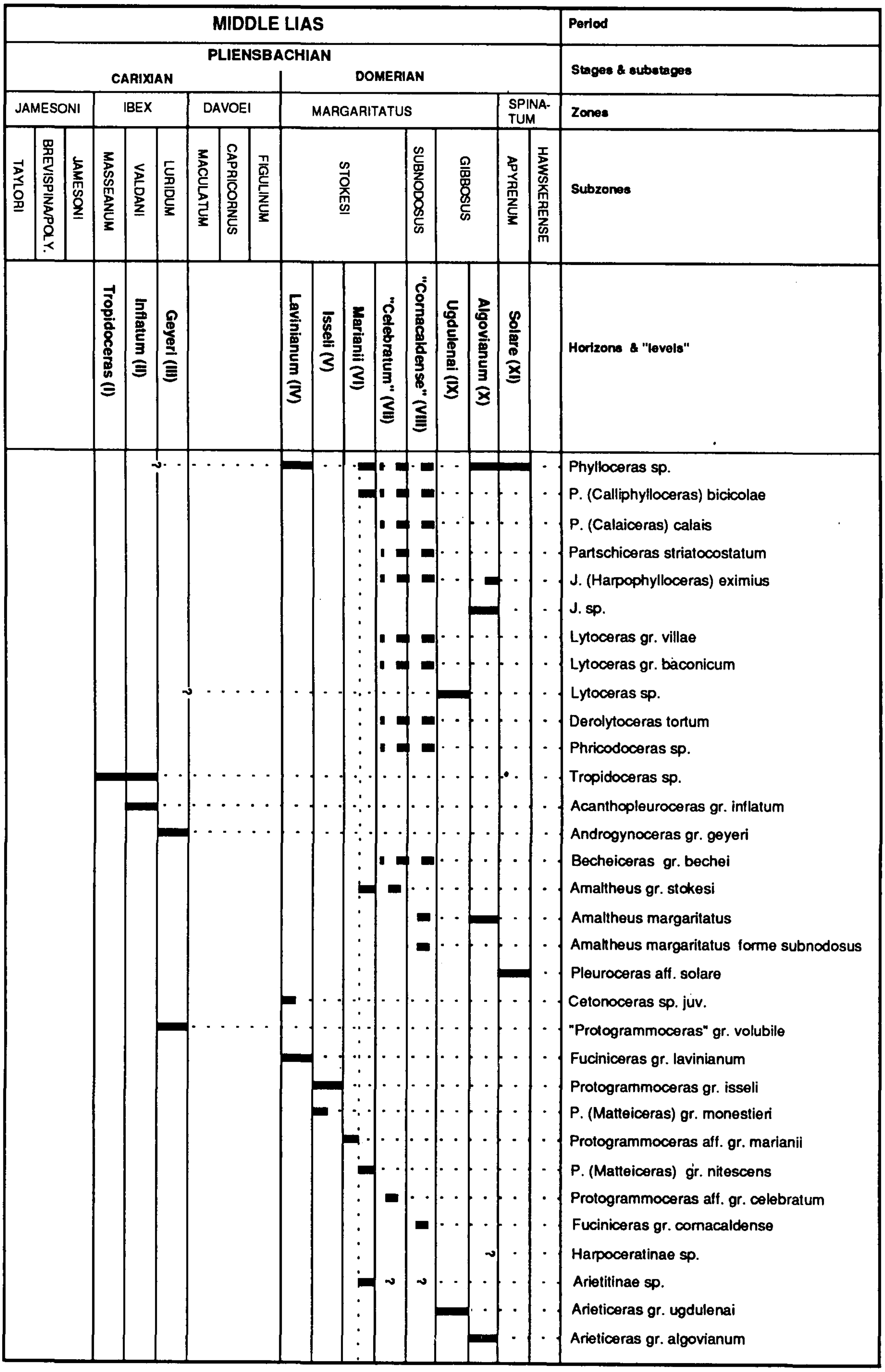
At the present time the correlations between the Euroboreal and Tethyan realms appear to be good for the Stokesi subzone, especially between the Apennines and the Burgundy – Causses basin.

(IV) ***lavinianum* horizon**
This horizon classically characterizes the base of the Domerian in the Tethyan realm. In our region *Fuciniceras* gr. *lavinianum, Cetonoceras* sp. and *Phylloceras* co-occur in this stratigraphical unit.

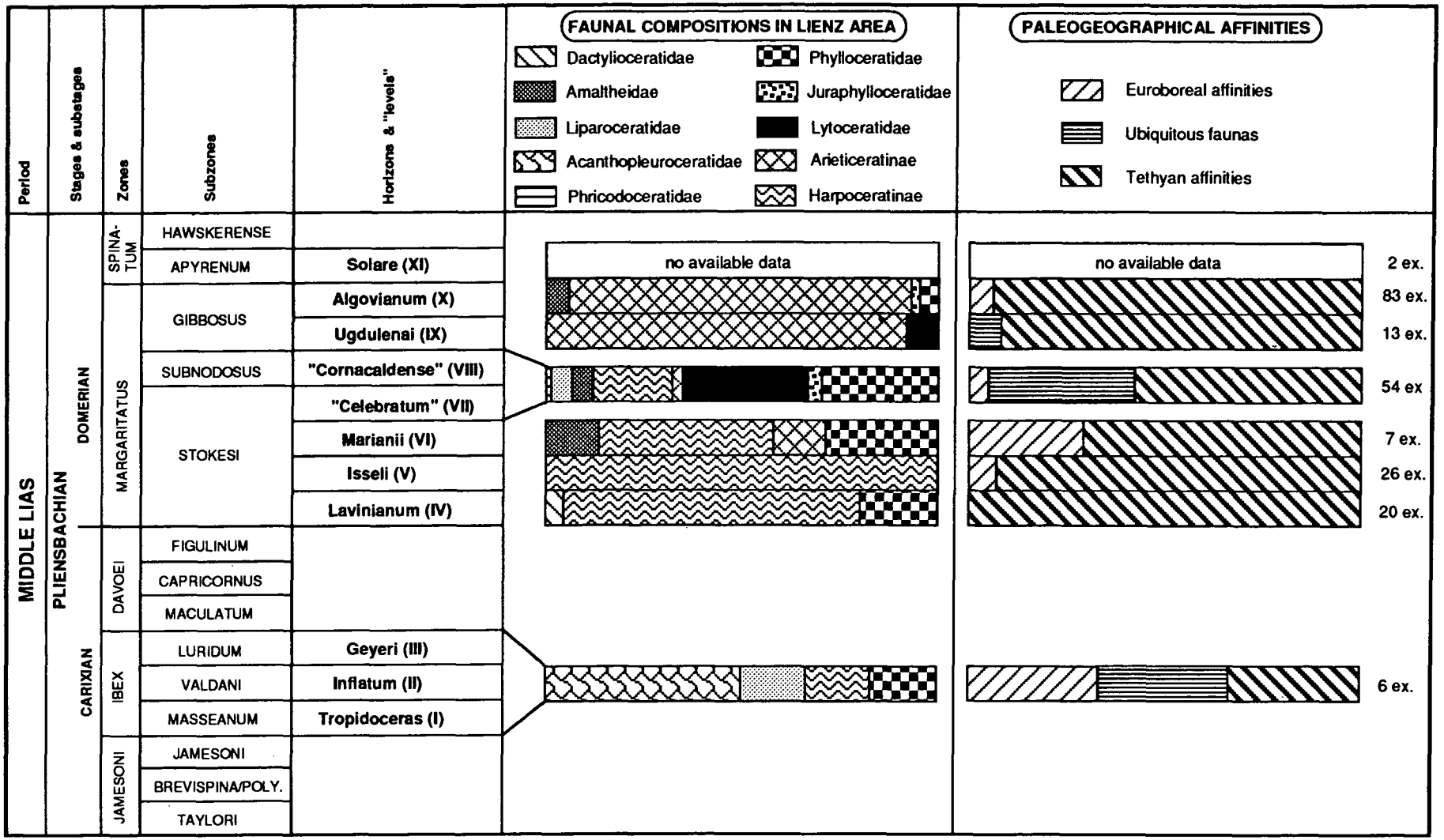
(V) ***isseli* horizon**
Besides the index species, we find an Euroboreal group: *Protogrammoceras (Matteiceras) monestieri*. This species allows us a good correlation, particularly with the Causses basin (MEISTER, 1986) and Burgundy (DOMMERGUES 1987). Consequently the "Euroboreal" *monestieri* horizon appears to be equivalent to the "Tethyan" *isseli* horizon.

(VI) ***marianii* horizon**
After comparison with the marianii horizon from the Rotkögel (Upper Austroalpine, Salzburg area, MEISTER & BÖHM in press), we regroup here *Protogrammoceras* aff. gr. *marianii* (Lavant bed: 29) with *Protogrammoceras (Matteiceras) nitescens* and *Amaltheus* aff. *stokesi* (Lavant bed: 33) to only one horizon. In this case, the *marianii* horizon appears to be the equivalent to the "Euroboreal" *nitescens* horizon.

(VII) ***celebratum* and (VIII) *cornacaldense* levels**
The condensed bed at Blasbründl can be attributed to two stratigraphical units by comparison



Text-Fig. 15.
Biostratigraphical framework of the Lienz region.



Text-Fig. 16.
Faunal composition and paleogeographical affinities in the Lienz area.

with the continuous biostratigraphical sequence of the Causses Basin (MEISTER, 1989).

Protogrammoceras aff. gr. *celebratum* and *Amaltheus stokesi* belong without doubt to the *celebratum* level. Likewise *Fuciniceras* gr. *cornacaldense* and *Amaltheus margaritatus* (with *Amaltheus margaritatus* "forme" *subnodosus*) belong to the *cornacaldense* level. On the contrary, it is impossible to attribute the longer ranging taxa of the condensed bed (Phylloceratina, Lytoceratina, *Phricodoceras* sp., *Becheiceras* gr. *bechei* and ?Arieticeratina sp.) to one of these two stratigraphic units.

Subnodosus subzone

In the Tethyan realm and in the Causses basin, the first level (*celebratum* level) still belongs to the Stokesi subzone and the *cornacaldense* level already to the Subnodosus subzone. Therefore, the boundary between the Stokesi subzone and the Subnodosus subzone lies between the *celebratum* and *cornacaldense* levels.

Gibbosus subzone

(IX) *ugdulenai* horizon

This horizon is charaterized by the index species and some *Lytoceras* sp.

(X) *algovianum* horizon

Like in the Apennines or in the Causses Basin, we find *Arieticeras* gr. *algovianum* immediately overlying the *ugdulenai* horizon. *Arieticeras* gr. *algovianum* is associated with *Amaltheus margaritatus* and Juraphyllitidae and Phylloceratidae.

Spinatum zone

Apyrenum subzone

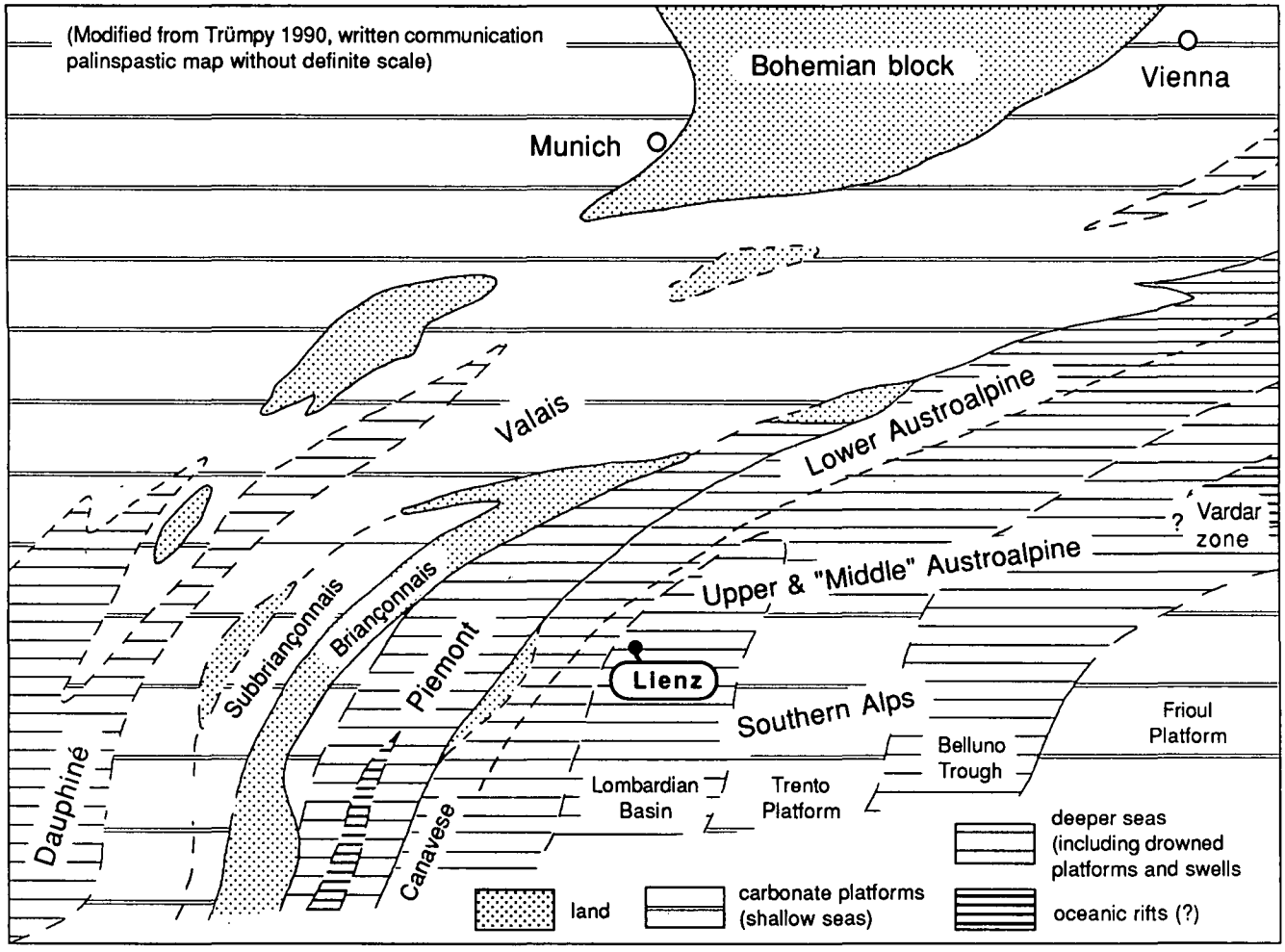
(XI) *solare* horizon

This horizon with *Pleuroceras* aff. *solare* and *Phylloceras* is well known throughout the Euroboreal and the western Tethyan realms (FERRETTI & MEISTER, in press).

6. Faunal Composition

The faunal composition (Fig. 16) shows well the Tethyan affinities of the Lienz Upper Austroalpine. However, this typical Tethyan fauna with Phylloceratidae, Juraphyllitidae, Dactylioceratidae (here *Cetonoceras*), Harpoceratinae (*Protogrammoceras* and *Fuciniceras*) and Arietitceratinae is mixed with classical Euroboreal ammonites as *Acanthopleuroceras, Androgynoceras, Protogrammoceras (Matteiceras)* and Amaltheidae (*Amaltheus* and *Pleuroceras*).

The Euroboreal influence appears nearly continuous during the Pliensbachian in this region. This observation becomes evident when we compare the proportion of Tethyan and Euroboreal ammonites (Fig. 16).



Text-Fig. 17.
Paleogeographical reconstruction of the Lias of the Alpine Range.
Modified after TRÜMPY (1990: written comm.) and SCHMIDT et al. (in press).

Tropidoceras, *Becheiceras*, and the Lytoceratina are considered to occure in both realms.

Some events like the acme of Lytoceratina at the boundary between the Stokesi and Subnodosus subzones can be observed more globally. The abundance of Lytoceratina corresponds to an obliteration of the Harpoceratinae and to the development of the Arieticeratinae. FERRETTI & MEISTER (in press) have shown that the Lytoceratina seem to have acme-episodes during periods of instability of the Ammonitina.

In the Lienz Dolomites, the Phylloceratina are always present but do not dominate the fauna as in true "ammonitico rosso" areas.

7. Conclusions

The Upper Austroalpine occupies a key position for palinspastic reconstructions (Fig. 17) and particularly for biochronological correlations between the Euroboreal and Tethyan realms. This tectonic unit represents without doubt a Tethyan region and has been under the permanent influence of the Euroboreal in the Pliensbachian. This could be demonstrated in the Lienz Dolomites, based on the presence of *Acanthopleuroceras* gr. *inflatum* and *Androgynoceras* gr. *geyeri* for the Middle Carixian and to Amaltheidae (*Amaltheus* and *Pleuroceras*) and *P. (Matteiceras)* for the Domerian period.

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Plate 1

Figs. 1, 2: ***Phylloceras (Calaiceras) calais*** **(MENEGHINI 1874).**
Coll. MEISTER, no. 55501, sect. Blasbründl, bed 1, Margaritatus zone.

Fig. 3: **Gastropode, gen. et sp. ind.**
Coll. MEISTER, no. 55502, sect. Blasbründl, bed 1, Margaritatus zone.

Figs. 4, 5: ***Juraphyllites (Harpophylloceras) eximius*** **(HAUER 1854).**
Coll. MEISTER, no. 55503, sect. Blasbründl, bed 1, Margaritatus zone.

Figs. 6, 7: ***Phylloceras (Calliphylloceras) bicicolae*** **(MENEGHINI 1874).**
Coll. MEISTER, no. 55504, sect. Blasbründl, bed 1, Margaritatus zone.

Figs. 8, 9: ***Phylloceras (Calliphylloceras) bicicolae*** **(MENEGHINI 1874).**
Coll. BLAU, no. H 8320, sect. Lavant, bed 33, Margaritatus zone.

Figs. 10,11: ***Lytoceras*** **gr.** ***baconicum*** **VADASZ 1910.**
Coll. MEISTER, no. 55505, sect. Blasbründl, bed 1, Margaritatus zone.

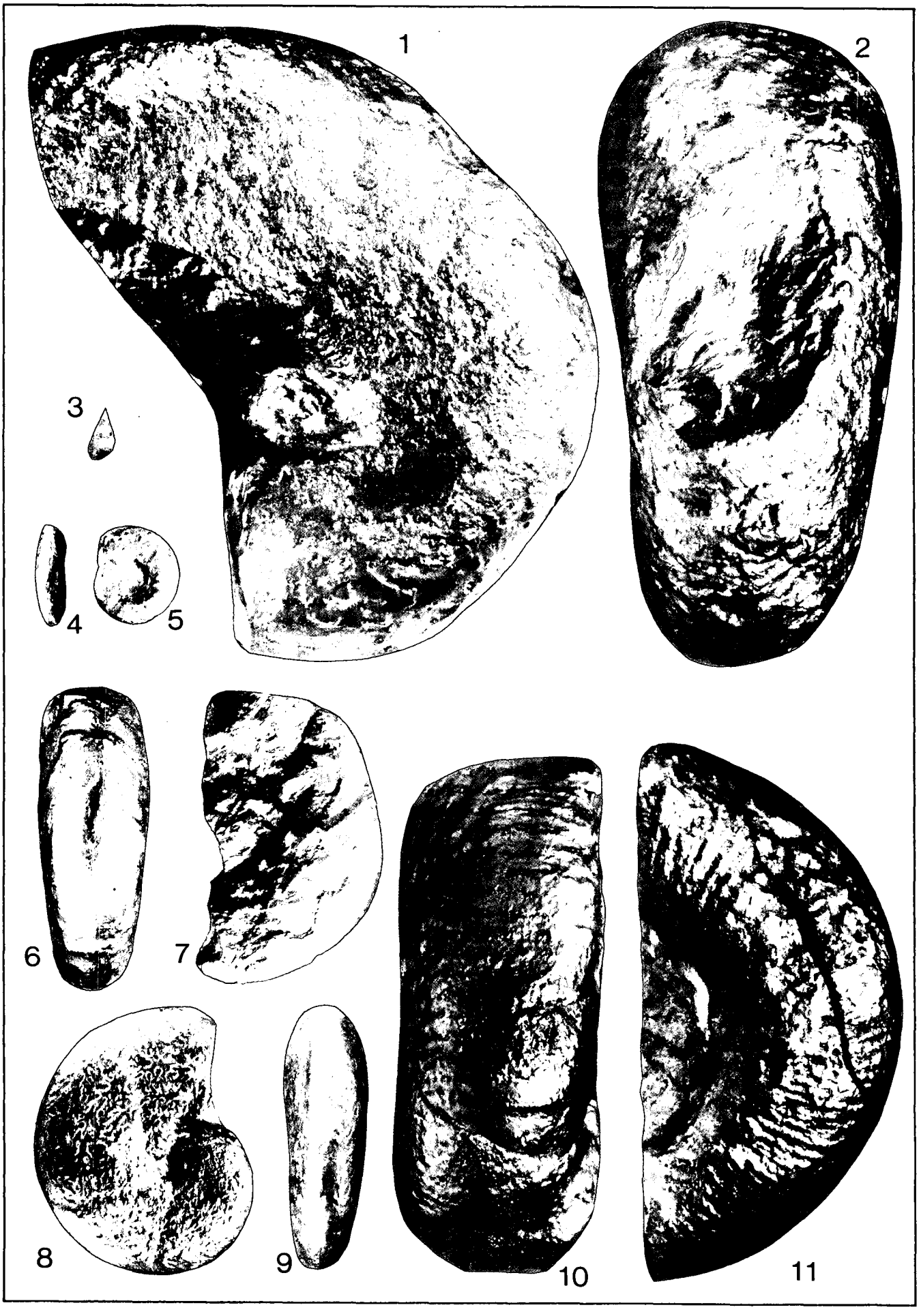


Plate 2

Fig. 1: ***Phylloceras (Calliphylloceras) bicicolae*** **(MENEGHINI 1874).**
Coll. MEISTER, no. 55506, sect. Blasbründl, bed 1, Margaritatus zone.

Figs. 2,3: ***Partschiceras striatocostatum*** **(MENEGHINI 1853).**
Coll. MEISTER, no. 55507, sect. Blasbründl, bed 1, Margaritatus zone.

Figs. 4,5: ***Lytoceras*** **gr.** ***villae*** **MENEGHINI 1874.**
Coll. BLAU, no. L-X, S Kreithof, Margaritatus zone.

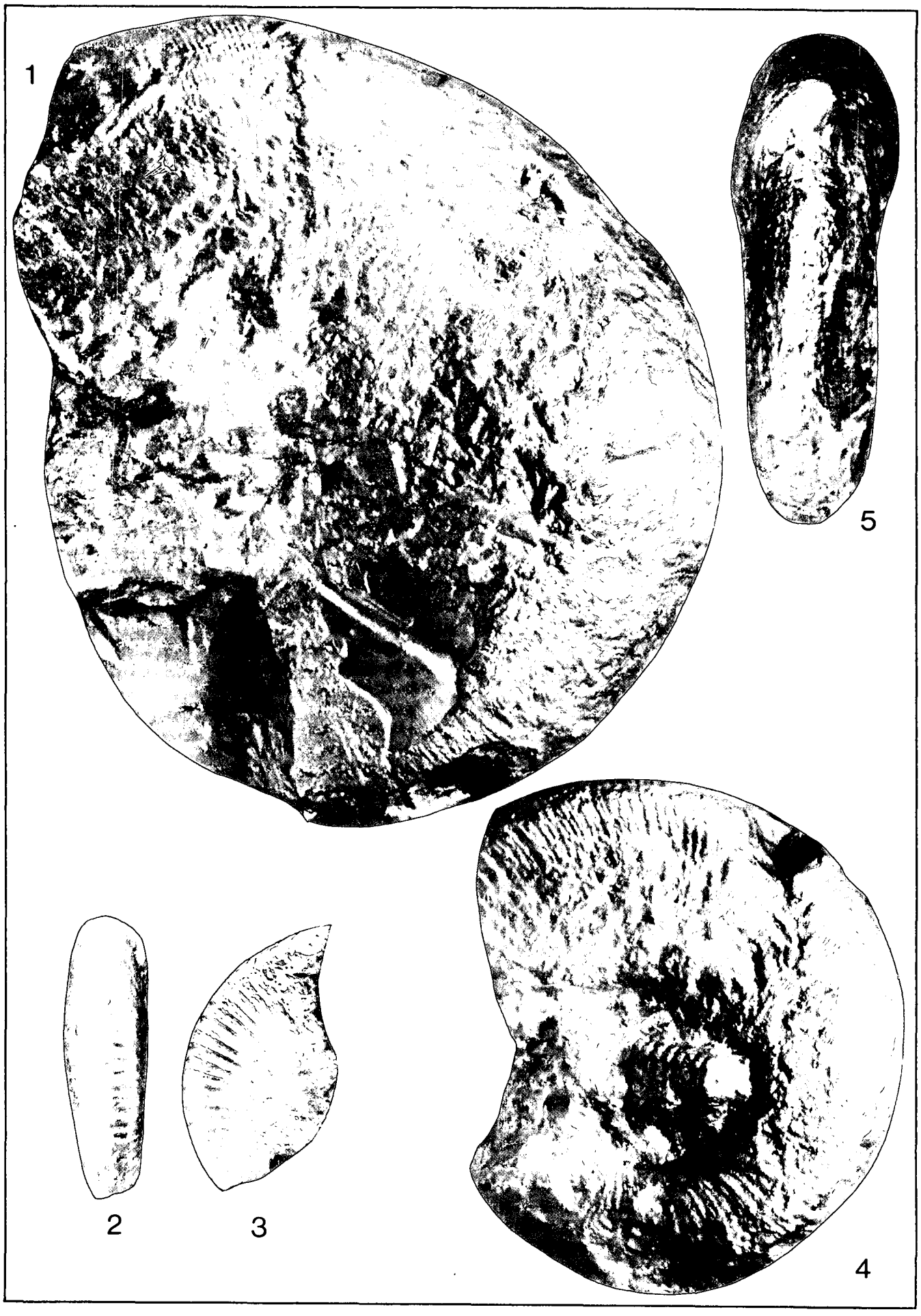


Plate 3

Figs. 1,2: ***Lytoceras* gr. *villae* MENEGHINI 1874.**
Coll. MEISTER, no. 55508, sect. Blasbründl, bed 1, Margaritatus zone.

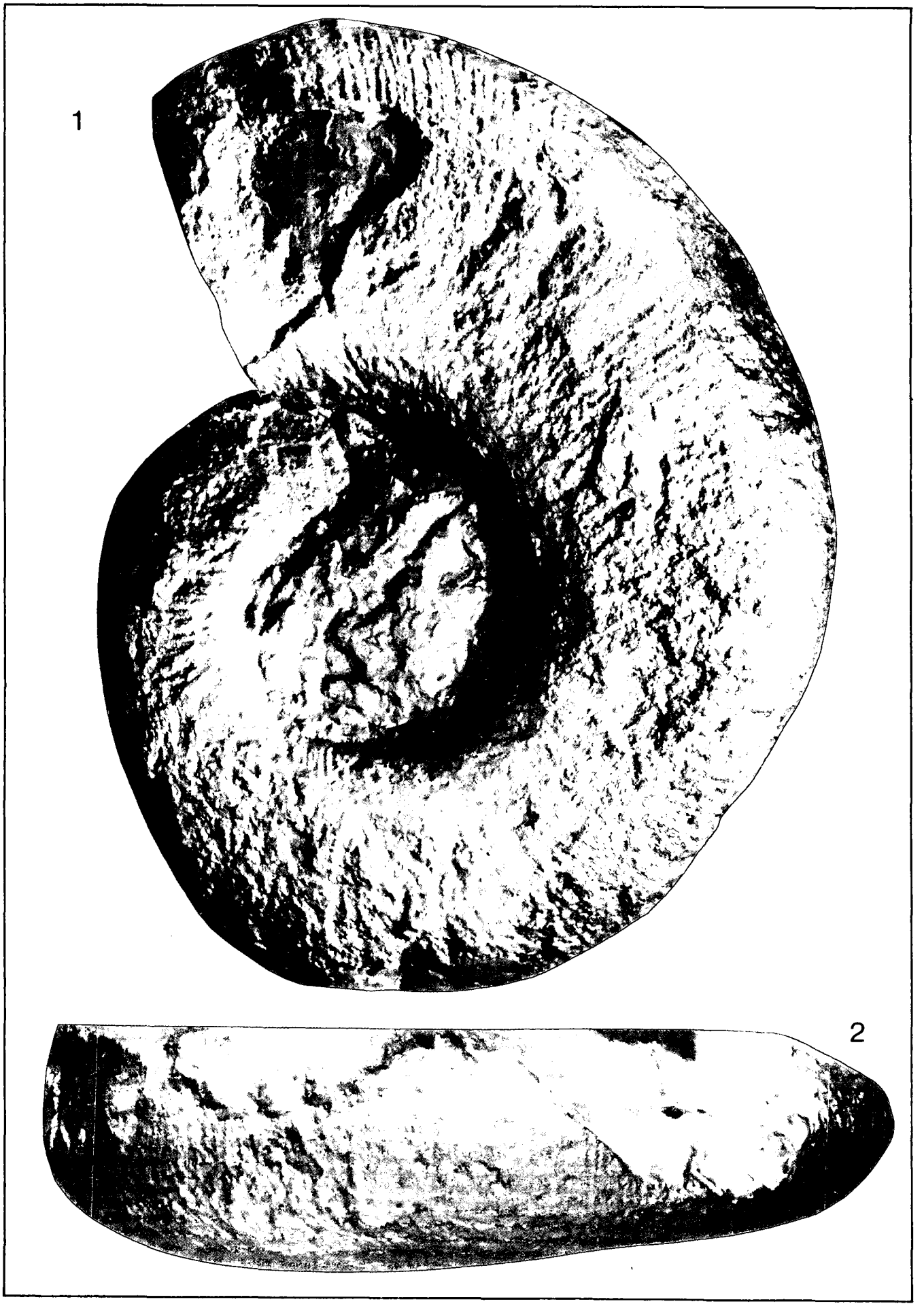


Plate 4

Fig. 1: ***Lytoceras* gr. *baconicum* VADASZ 1910.**
Coll. MEISTER, no. 55509, sect. Blasbründl, bed 1, Margaritatus zone.

Figs. 2,3: ***Tropidoceras* sp.**
Coll. MEISTER, no. 55510, sect. Lavant, bed 1, Ibex zone.

Fig. 4: ***Lytoceras* gr. *villae* MENEGHINI 1874.**
Coll. MEISTER, no. 55511, sect. Blasbründl, bed 1, Margaritatus zone.

Fig. 5: ***Becheiceras* gr. *bechei* (SOWERBY 1821).**
Coll. MEISTER, no. 55512, sect. Blasbründl, bed 1, Margaritatus zone.

Plate 5

Figs. 1,2: ***Acanthopleuroceras* gr. *inflatum* (QUENSTEDT 1885).**
Coll. MEISTER, no. 55513, sect. Lavant, bed 4, Ibex zone.

Figs. 3,4,5: ***Androgynoceras* gr. *geyeri* (SPATH 1938).**
Coll. MEISTER, no. 55514, sect. Lavant, bed 12, Ibex zone.

Figs. 6,7,8: ***Pleuroceras* aff. *solare* (PHILLIPS 1829).**
Specimen to Figs. 7,8: coll. BLAU, no. 83152, sect. Lavant.
Specimen to Fig. 6: coll. MEISTER, sect. Blasbründl, bed 3, Spinatum zone.

Fig. 9: ***Amaltheus stokesi* (SOWERBY 1818).**
Coll. MEISTER, no. 55515, sect. Blasbründl, bed 1, Margaritatus zone.

Fig. 10: ***Amaltheus margaritatus* DE MONTFORT 1808.**
Coll. MEISTER, no. 55516, sect. Stadtweg, bed 13, Margaritatus zone.

Figs. 11,12: ***Amaltheus margaritatus* "forme" *subnodosus* (YOUNG & BIRD 1828).**
Coll. BLAU, Sturzelbach, Margaritatus zone.

Figs. 13,14: ***Cetonoceras* juv. sp..**
Coll. MEISTER, no. 55517, sect. Lavant, bed 24, Margaritatus zone.

Fig. 15: ***Protogrammoceras* gr. *isseli* (FUCINI 1900).**
Coll. BLAU, no. H 8315, sect. Lavant, bed 27, Margaritatus zone.

Figs. 16,17: ***Protogrammoceras* gr. *isseli* (FUCINI1900).**
Coll. BLAU, no. H 7, sect. Lavant, bed 27, Margaritatus zone.

Fig. 18: ***Protogrammoceras* gr. *isseli* (FUCINI 1900).**
Coll. MEISTER, no. 55518, sect. Lavant, bed 27, Margaritatus zone.

Fig. 19: ***Protogrammoceras* gr. *isseli* (FUCINI 1900).**
Coll. MEISTER, no. 55519, sect. Lavant, bed 27, Margaritatus zone.

Fig. 20: ***Protogrammoceras* gr. *isseli* (FUCINI 1900).**
Coll. BLAU, no. 84–314, sect. Lavant, bed 27, Margaritatus zone.

Fig. 21: ***Protogrammoceras* gr. *isseli* (FUCINI 1900).**
Coll. MEISTER, no. 55520, sect. Lavant, bed 27, Margaritatus zone.

Fig. 22: ***Protogrammoceras* gr. *isseli* (FUCINI 1900).**
Coll. MEISTER, no. 55521, sect. Lavant, bed 27, Margaritatus zone.

Fig. 23: ***Fuciniceras* aff. gr. *lavinianum* (FUCINI 1900).**
Coll. BLAU, no. 84–309, sect. Lavant, bed 24–25, Margaritatus zone.

Fig. 24: ***Protogrammoceras* aff. gr. *celebratum* (FUCINI 1900).**
Coll. BLAU, no. 1697, Sturzelbach, Margaritatus zone.

Fig. 25: ***Protogrammoceras* aff. gr. *celebratum* (FUCINI 1900).**
Coll. MEISTER, no. 55522, sect. Blasbründl, bed 1, Margaritatus zone.

Figs. 26,27: ***Protogrammoceras* aff. gr. *marianii* (FUCINI 1904).**
Coll. MEISTER, no. 55523, sect. Lavant, bed 29, Margaritatus zone.

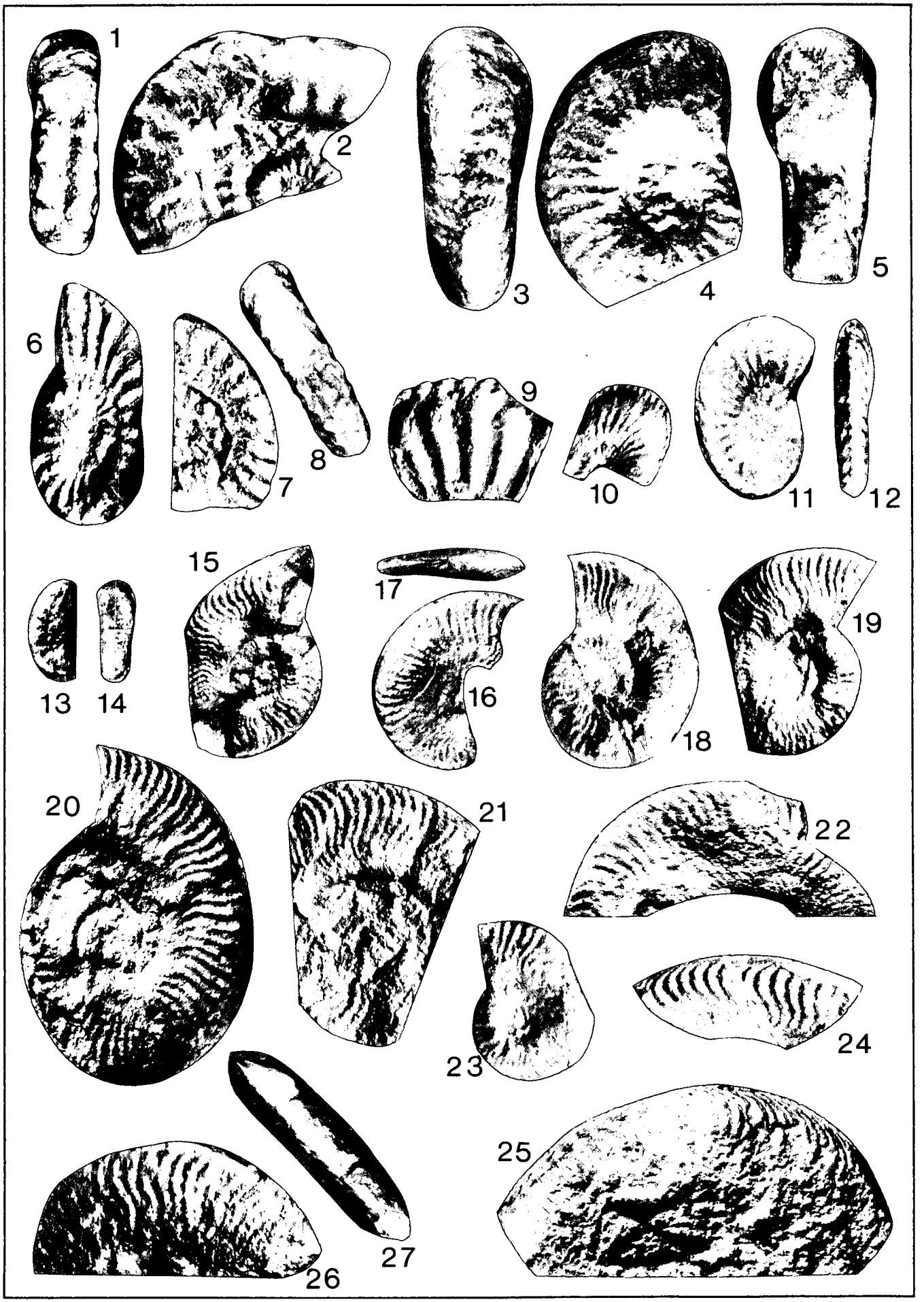


Plate 6

Figs. 1,2: ***Protogrammoceras* gr. *volubile* (Fucini 1900).**
Coll. Meister, no. 55524, sect. Lavant, bed 12, Ibex zone.

Fig. 3: ***Protogrammoceras (Matteiceras)* gr. *monestieri* (Fischer 1975).**
Coll. Meister, no. 55525, sect. Lavant, bed 27, Margaritatus zone.

Fig. 4: ***Protogrammoceras (Matteiceras)* gr. *monestieri* (Fischer 1975).**
Coll. Blau, no. H-8331 (123), sect. Lavant, bed 27, Margaritatus zone.

Figs. 5,6: ***Fuciniceras* gr. *lavinianum* (Fucini 1900).**
Coll. Meister, no. 55526, sect. Lavant, bed 24–25, Margaritatus zone.

Figs. 7,8: ***Fuciniceras* gr. *lavinianum* (Fucini 1900).**
Coll. Meister, no. 55527, sect. Lavant, bed 24–25, Margaritatus zone.

Fig. 9: ***Fuciniceras* gr. *lavinianum* (Fucini 1900).**
Coll. Meister, no. 55528, sect. Lavant, bed 24–25, Margaritatus zone.

Figs. 10,11: ***Fuciniceras* gr. *lavinianum* (Fucini 1900).**
Coll. Meister, no. 55529, sect. Lavant, bed 24–25, Margaritatus zone.

Figs. 12,13: ***Fuciniceras* gr. *cornacaldense* (Tausch 1890).**
Coll. Meister, no. 55530, sect. Blasbründl, bed 1, Margaritatus zone.

Fig. 14: ***Fuciniceras* gr. *cornacaldense* (Tausch 1890).**
Coll. Meister, no. 55531, sect. Blasbründl, bed 1, Margaritatus zone.

Figs. 15,16: ***Fuciniceras* gr. *cornacaldense* (Tausch 1890).**
Coll. Meister, no. 55532, sect. Blasbründl, bed 1, Margaritatus zone.

Fig. 17: ***Fuciniceras* gr. *cornacaldense* (Tausch 1890).**
Coll. Meister, no. 55533, sect. Blasbründl, bed 1, Margaritatus zone.

Fig. 18: **gen. et sp. ind. ?*Fuciniceras*.**
Coll. Blau, no. H-8328, sect. Lavant, Margaritatus zone.

Fig. 19: ***Arieticeras* gr. *ugdulenai* (Gemmelaro 1885).**
Coll. Meister, no. 55534, sect. Lavant, bed 34, Margaritatus zone.

Fig. 20: ***Arieticeras* gr. *ugdulenai* (Gemmelaro 1885).**
Coll. Meister, no. 55535, sect. Lavant, bed 34, Margaritatus zone.

Figs. 21,22: ***Arieticeras* gr. *ugdulenai* (Gemmelaro 1885).**
Coll. Meister, no. 55536, sect. Lavant, bed 34, Margaritatus zone.

Fig. 23: ***Arieticeras* gr. *algovianum* (Oppel 1862).**
Coll. Meister, no. 55537, sect. Stadtweg, bed 13, Margaritatus zone.

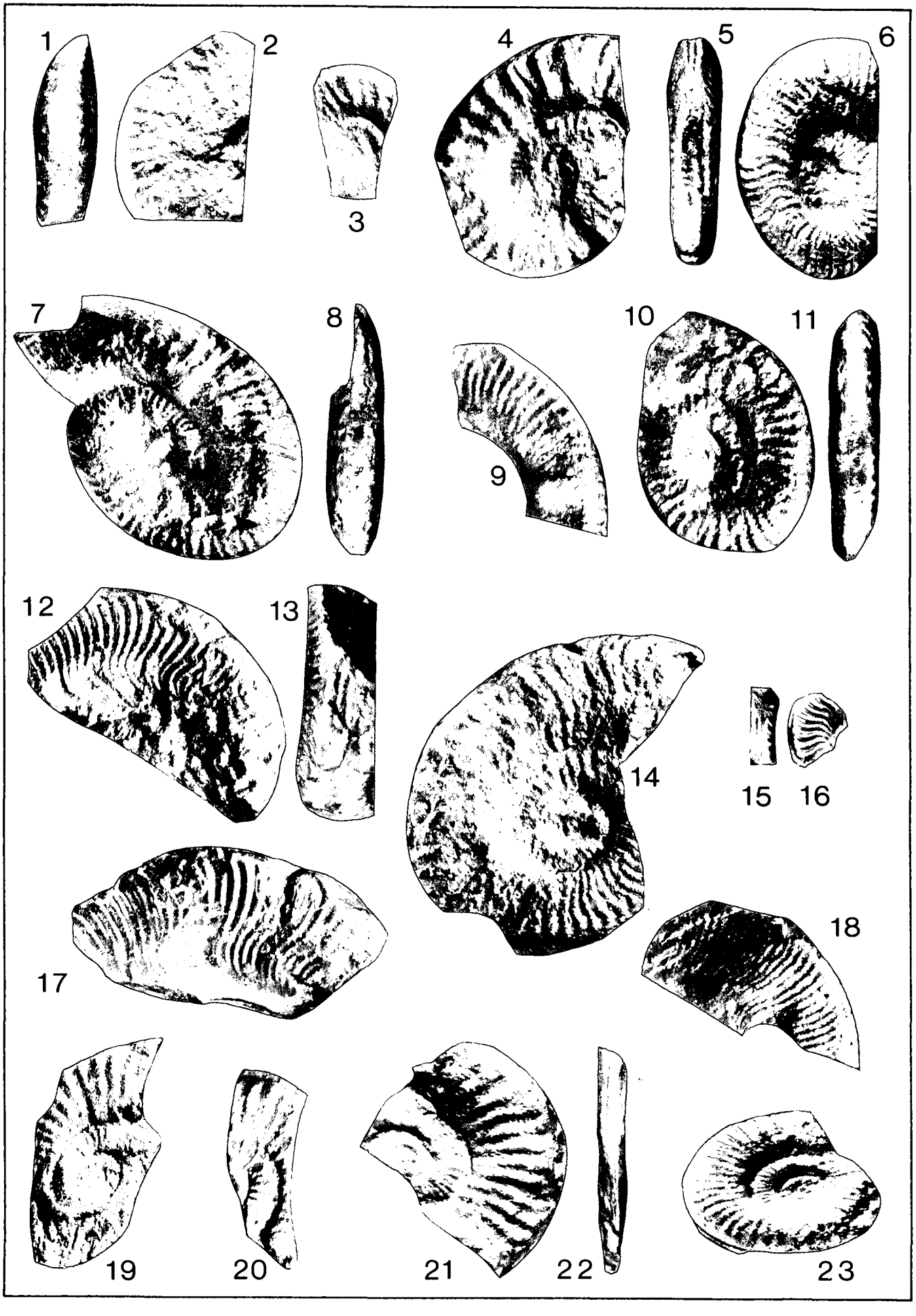


Plate 7

Figs. 1,2,3: ***Arieticeras* gr. *algovianum* (OPPEL 1862).**
Coll. BLAU, no. H-833, sect. Lavant, bed 35, Margaritatus zone.

Figs. 4,5: ***Arieticeras* gr. *algovianum* (OPPEL 1862).**
Coll. BLAU, no. H-834, sect. Lavant, bed 35, Margaritatus zone.

Figs. 6,7: ***Arieticeras* gr. *algovianum* (OPPEL 1862).**
Coll. BLAU, no. H-8317, sect. Lavant, bed 35, Margaritatus zone.

Fig. 8: ***Arieticeras* gr. *algovianum* (OPPEL 1862).**
Coll. MEISTER, no. 55538, sect. Stadtweg, bed 13, Margaritatus zone.

Fig. 9: ***Arieticeras* gr. *algovianum* (OPPEL 1862).**
Coll. BLAU, no. 84–576, sect. Stadtweg, bed 13, Margaritatus zone.

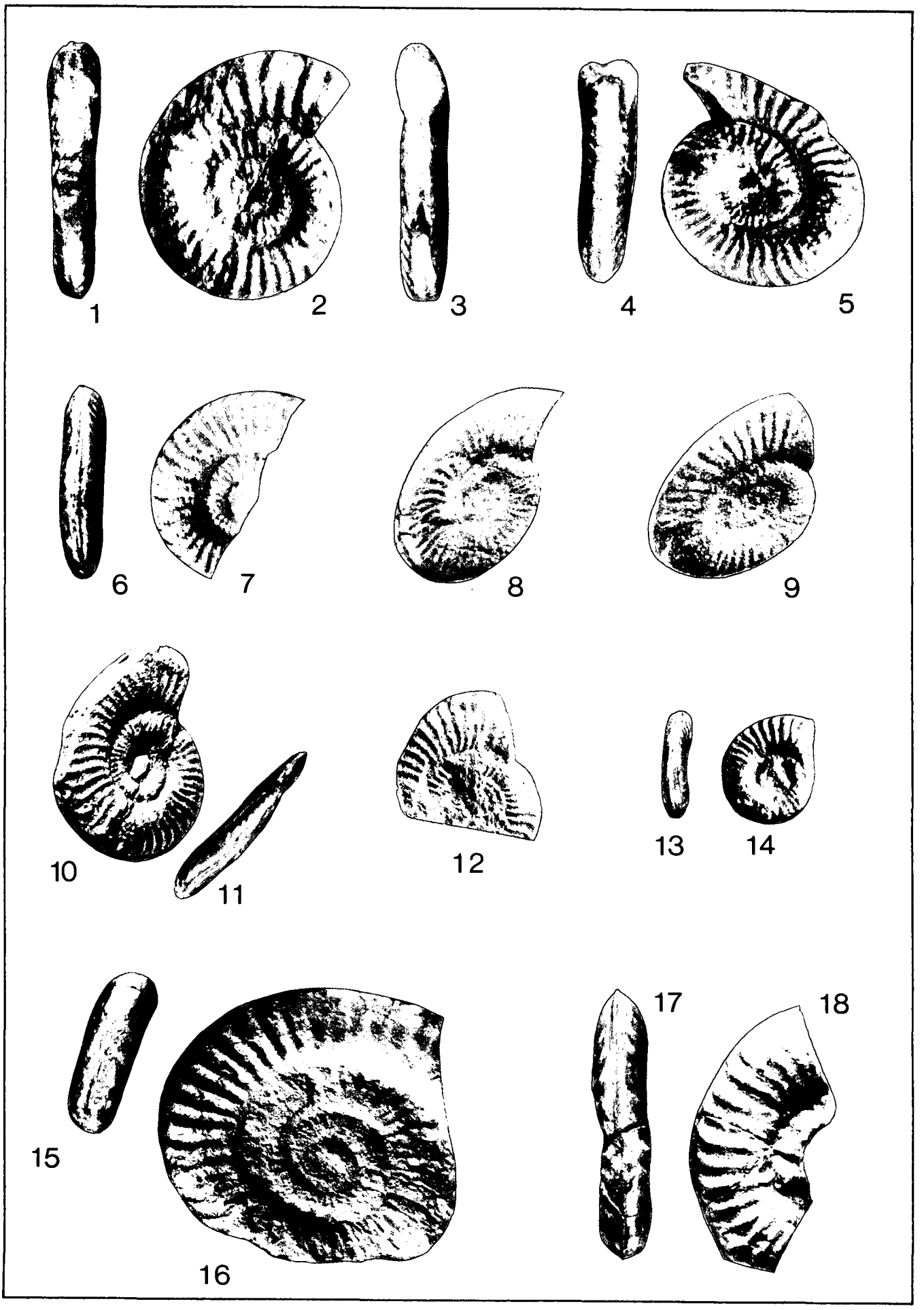
Figs. 10,11: ***Arieticeras* gr. *algovianum* (OPPEL 1862).**
Coll. MEISTER, no. 55539, sect. Lavant, bed 35, Margaritatus zone.

Fig. 12: ***Arieticeras* gr. *algovianum* (OPPEL 1862).**
Coll. MEISTER, no. 55540, sect. Lavant, bed 35, Margaritatus zone.

Figs. 13,14: ***Arieticeras* gr. *algovianum* (OPPEL 1862).**
Coll. BLAU, no. H-835, sect. Lavant, bed 35, Margaritatus zone.

Figs. 15,16: ***Arieticeras* gr. *algovianum* (OPPEL 1862).**
Coll. BLAU, sect. Lavant, bed 35, Margaritatus zone.

Figs. 17,18: ***Arieticeras* gr. *algovianum* (OPPEL 1862).**
Coll. MEISTER, no. 55541, sect. Lavant, bed 35, Margaritatus zone.



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