Beitr. Paläont. Österreich 6:1–25, Wien, Juli 1979

Lower Albian Ammonites from the Tannheim Formation near Losenstein, Upper Austria.

Unter-Alb-Ammoniten aus der Tannheim-Formation bei Losenstein in Oberösterreich

by
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IGCP Project 73/I/58: Mid Cretaceous Events

KENNEDY, W. J. & KOLLMANN, H. A. 1979. Lower Albian Ammonites from the Tannheim Formation near Losenstein, Upper Austria. – Beitr. Paläont. Österr. 6:1–25, Wien.

A b s t r a c t – A limited thickness of shales in the Tannheim Formation in the Stiedelsbachgraben near Losenstein, Upper Austria has yielded thousands of ammonites, mainly as crushed moulds, referred to *Leymeriella (Leymeriella) tardefurcata* (d'ORBIGNY) and *Beudanticeras* sp. juv. Much rarer, and represented either by solitary individuals or a few specimens only, are *Phylloceras* ? sp., *Ptychoceras laeve hamaimense* PERVINQUIERE, *Metahamites* sp., *Protanisoceras (Protanisoceras)* sp., *Douvilleiceras* sp. (? *D. leightonense* CASEY), *Puzosia* sp. group of *P. quenstedti* (PARONA & BONARELLI), *Oxytropidoceras (Oxytropidoceras)* sp. and *Leymeriella (Leymeriella) pseudoregularis* SEITZ. The association is of *L. (Leymeriella) tardefurcata* Zone, *L. (L) regularis* Subzone age, and of typically Boreal aspect.
During the Cretaceous the North Alpine-Carpathian plate was only in the Lower Albian under Boreal influence. This suggests that its geographic latitude was 400 to 500 kilometers South of the continental margin of Mesoeurope. Later in the Albian and in the Upper Cretaceous, typical Boreal elements did not live South of the „Ultrapienidic Ridge" because of the warming of shelf waters be Tethyan currents.

Z u s a m m e n f a s s u n g Geringmächtige schwarze Tonmergel aus der Tannheim Formation des Stiedelsbachgrabens und des Dachsgrabens bei Losenstein, Oberösterreich, haben zahlreiche Ammoniten geliefert, die zumeist als zusammengepreßte Abdrücke erhalten sind. *Leymeriella (Leymeriella) tardefurcata* und *Beudanticeras* sp. juv. kommen am häufigsten vor. Seltener, und nur durch Einzelstücke oder wenige Exemplare vertreten, sind *Phylloceras*? sp., *Ptychoceras laeve hamaimense* PERVINQUIERE, *Metahamites* sp., *Protanisoceras (Protanisoceras)* sp., *Douvilleiceras* sp. (? *D. leightonense* CASEY), *Puzosia* sp., Gruppe der *Puzosia quenstedti* (PARONA & BONARELLI), *Oxytropidoceras (Oxytropidoceras)* sp. und *Leymeriella (Leymeriella) pseudoregularis* SEITZ. Die Fauna ist somit in die *Leymeriella regularis*-Subzone der *Leymeriella tardefurcata*-Zone des unteren Albiens einzustufen und von typisch borealem Charakter. Es ist dies die einzige boreale Periode der Nordalpin-Karpathischen Platte während der Kreidezeit. Daraus ist zu schließen, daß deren geographische Breite während des unteren Albiens 400–500 Kilometer südlich des Kontinentalrandes von Mesoeuropa lag. Da die Schelfmeere der Ostalpen und Karpathen im höheren Albien und in der Oberkreide durch die Entstehung eines Festlandgebietes (des „Ultrapienidischen Rückens") im Norden vollständig in den Einfluß der warmen tethyschen Strömungen kamen, wurden die borealen Faunenelemente wieder verdrängt.

INTRODUCTION

Albian ammonites were first decribed from the Losenstein area of the Eastern Alps by GEYER, 1909. In a paper on the stratigraphy and tectonics of this area he described black shales with ammo-

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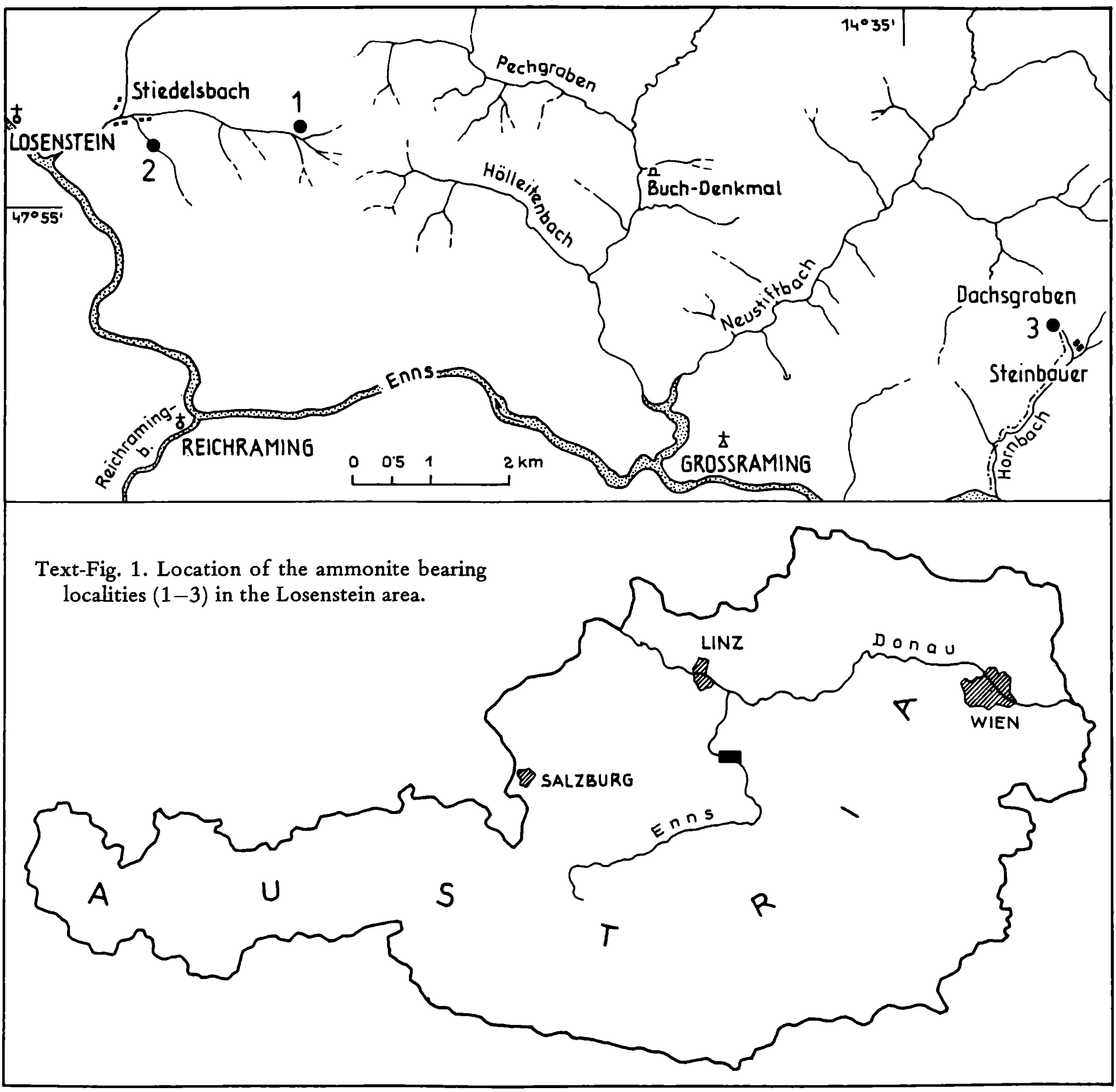
nites which had been determined by UHLIG as „*Hoplites tardefurcatus*". This remained the only record of the Albian stage in the Northern Calcareous Alps until micropalaeontological research started in the late fifties.

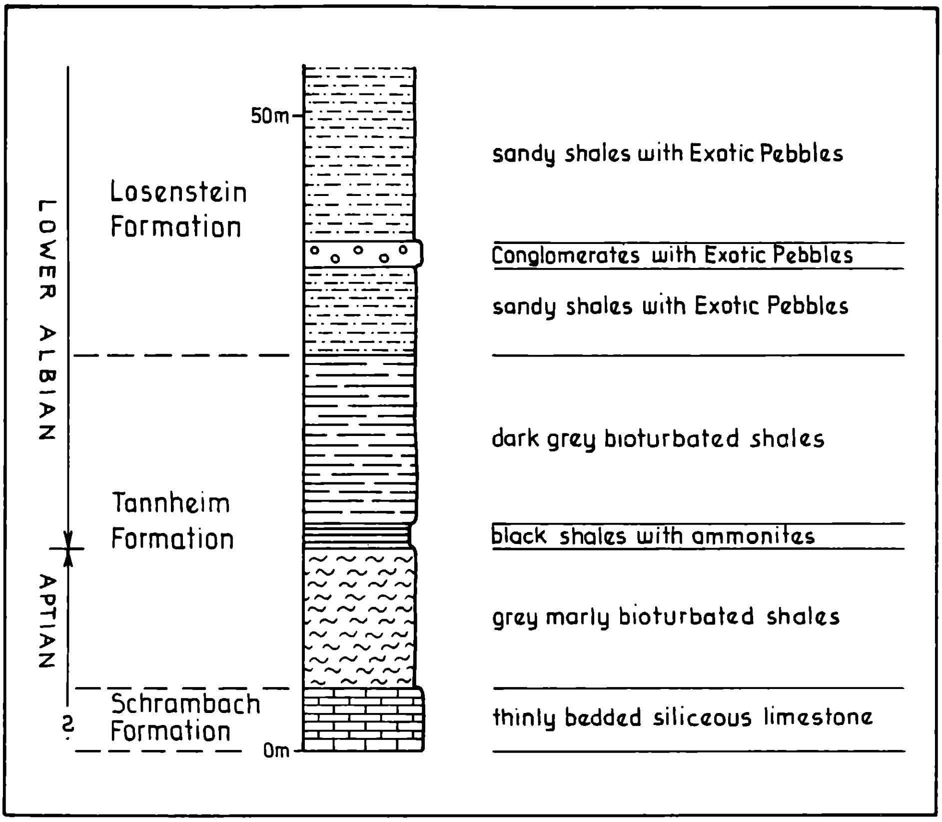
Palaeontologically, the ammonite fauna has not been described hitherto and also GEYER's exact locality was unknown since it had been exposed in a now overgrown landslide in the Stiedelsbach-graben near Losenstein. During field work in the area H. A. KOLLMANN found three localities which yielded larger numbers of ammonites within the Tannheim formation. This stratigraphic term had been established by ZACHER, 1966 for a shaly series of Upper Aptian and Lower Albian age with a type section in the Tannheim valley in Northern Tyrol. It was subsequently used by KOLLMANN, 1968 in the Eastern part of the Northern Calcareous Alps; further details on its distribution are given by TOLLMANN, 1976.

One of the ammonite bearing localities lies within the Stiedelsbach section described by KOLLMANN, 1968 (locality 1 on the map, section 1). Here, the Tannheim Formation is underlain by



Text-Fig. 1. Location of the ammonite bearing localities (1–3) in the Losenstein area.

thinly bedded siliceous limestones which are part of the widely distributed Schrambach Formation. At this locality only a large fragment of a *Phylloceras* was found. The Tannheim Formation begins with grey highly bioturbated marly shales with an Upper Aptian microfauna. These shales are overlain by 1.5 meters of thinly bedded black shales containing the crushed moulds of ammonites which are described in this paper. The Upper part of the Tannheim Formation consists of seven meters of dark grey, again highly bioturbated shales without any megafossils.



Text-Fig. 2. Stratigraphic column of the section at the locality 2 (Stiedelsbach valley)

The second locality is situated 650 meters up a subsidiary stream of the Stiedelsbach valley (locality 2 on the map). Here, the black shales with ammonites are underlain by dark grey shales. This section is incomplete as the Albian beds are in a tectonic contact with Upper Jurassic limestones which cause the small waterfall in the stream. Higher parts are not exposed.

The same sequence as in the Stiedelsbachgraben occurs in the section of the Dachsgraben (locality 3 on the map), but the shales containing ammonites are rather badly exposed there.

L o c a t i o n o f S p e c i m e n s The following abbreviations are used to indicate the repositories of the material studied

NHM Naturhistorisches Museum Wien, Geologisch-Paläontologische Abteilung.

OUM Oxford University Museum, Geological Collections.

All material indicated by NHM has been collected by H. A. KOLLMANN in locality 1 of the Stiedelsbach valley. The material deposited at the Oxford University Museum has been collected by W. J. KENNEDY and H. A. KOLLMANN in locality 2.

SYSTEMATIC DESCRIPTIONS

Phylum MOLLUSCA – Class CEPHALOPODA CUVIER, 1797
Subclass AMMONOIDEA ZITTEL, 1884
Order PHYLLOCERATIDA ZITTEL, 1884
Superfamily PHYLLOCERACEAE ZITTEL, 1884
Family PHYLLOCERATIDAE ZITTEL, 1884
Genus *PHYLLOCERAS* SUESS, 1865

Type Species. *Ammonites heterophyllus* J. SOWERBY, 1820.

'Phylloceras' sp. ind.

Plate 5, fig. 9.

Material One specimen only, NHM 1978/1952/1

Remarks. The specimen is a crushed mould with traces of partially exfoliated shell. The coiling is very involute, with a tiny umbilicus, and no obvious traces of ornament. The high degree of involution and lack of ornament, together with the estimated whorl proportions (Plate 5, fig. 9) are compatible with reference to the Phylloceratidae; lack of marked constrictions suggests *Phylloceras* sensu lato rather than one of the contricted genera such as *Ptychophylloceras* SPATH, 1927 or *Sowerbyceras* PARONA & BONARELLI, 1895. No more precise determination is possible.

Order LYTOCERATIDA HYATT, 1889
Suborder ANCYLOCERATINA WIEDMANN, 1966
Superfamily ANCYLOCERATACEAE MEEK, 1876
Family PTYCHOCERATIDAE MEEK, 1876
Genus *PTYCHOCERAS* d'ORBIGNY, 1842

Type Species *Ptychoceras emericianum* d'ORBIGNY, 1842.

Ptychoceras laeve hamaimense PERVINQUIERE

Plate 1, figs. 1, 4–13; Plate 3, fig. 8

1907 *Ptychoceras laeve* var. *hamaimensis* PERVINQUIERE: 90, pl. 4, figs. 5, 6; text-fig. 21.
1956 *Ptychoceras laeve* var. *hamaimensis* PERVINQUIERE; ALMELA & REVILA: 39, pl. 9, fig. 9
1962 *Ptychoceras laeve hamaimense* PERVINQUIERE; WIEDMANN: 94, pl. 4, fig. 3.

Material Over twenty specimens: OUM KZ 226, 228–332 a–b, 266–282.

Description Coiling ptychoceratid, with three closely adpressed parallel shafts in contact, the whorls slowly expanding, the largest specimen is 35 mm. in overall lenght (OUM KZ 332 a–b; Plate 1, figs. 10–13). All specimens are badly crushed, but the initial two shafts appear to have been smooth (Plate 1, figs. 4–8). On the final shaft, however, distinct ribs appear close to the aperture (Plate 1, figs. 10–13, especially fig. 11; Plate 3, figs. 8 a–b). These are narrow and very widely spaced, and most prominent on the venter and outer flank. The aperture bears a sharp rib associated with a constriction and trumpet-like flare (Plate 3, fig. 8).

Discussion *Ptychoceras* have a rather curious occurrence at Stiedelsbachgraben, apparently concentrated on only a few laminae, and occurring in profusion on a few specimens (e. g. OUM KZ 226, Plate 1, fig. 1). Both juvenile specimens with only two shafts (Plate 1, figs. 4–8) as well as adults are present.

Poor preservation makes confident determination of this material a little difficult. It is, however much smaller than the type species, *P. emericianum* d'ORBIGNY (1842, p. 555, pl. 137, figs. 1–4) from the Upper Aptian of southeastern France, which also has strong ribbing on much more of the shell.

P. puzosianum d'ORBIGNY (1842, p. 557, pl. 137, figs. 5–7) also an Aptian species is much larger, has fine, dense, prorsiradiate ribs on the penultimate shaft and broad scale like ribs on the final shaft.

P. adpressum (J. SOWERBY) (SPATH 1941, p. 657, text.-fig. 241) is a much smaller entirely smooth late Albian species.

P forbesianum STOLICZKA (1866, p. 195, pl. 90, fig. 10) is of similar size, but lacks all trace of ribbing, having only a constriction close to the aperture. The Aptian *P. laeve laeve* MATHERON (1842, p. 266, pl. 41, fig. 3; see WIEDMANN 1962, p. 90, pl. 1, fig. 1; text-figs. 31, 32) is also completely smooth but of similar size. The late Aptian and early Albian subspecies *hamainiensis*, which is smooth during early and middle growth but develops transverse ribs on the latter part of the final shaft thus seems the closest to our material, although the holotype (PERVINQUIERE 1907, pl. 4, figs. 5, 6a–b) is only a fragment of the final hook.

Occurrence. Late Aptian of Spain and Mallorca, early Albian of Tunisia and Austria.

Family ANISOCERATIDAE HYATT, 1900

Genus *METAHAMITES* SPATH, 1930

Type Species: *Hamites sablieri* d'ORBIGNY, 1842.

***Metahamites* sp. ind.**

Plate 2, figs. 1, 2, 4, 7.

Material. Five specimens: NHM 1978/1952/30, OUM KZ 233–235.

Description Early whorls coiled in an open spiral (Plate 2, fig. 4); because of crushing it is not possible to determine whether this was helicoid or is one plane only. Later whorls with at least one straight shaft (Pl. 2, figs. 1, 2). On the coiled portion, ornament consists of fine, dense, wire-like slightly flexuous rursiradiate ribs linked in groups to flat-topped ventral tubercles. On straight shafts the pattern of tuberculation is more readily discernible. There are from five to ten ribs linked by tubercles (Plate 2, figs. 1, 2). The two large specimens each show oblique prorsiradiate ribs and two clavate tubercles. Being crushed it is not possible to decide if these are a pair of ventral clavi or one ventral and one flank tubercle.

Remarks. The fine, dense ribbing and looping of some ribs between tubercles show these specimens to be *Metahamites*, and the first material in which the coiled early whorls have been figured. Unfortunately, they do not permit resolution of the problem of planispiral or helicoid early parts in the genus (fide CASEY 1961 a, p. 99).

Being crushed, it is not possible to identify our material fully, and in consequence it is left in open nomenclature; one would, however, point to the similarities to a number of finely ribbed species known from India and Madagascar, in particular *Metahamites spathi* COLLIGNON (1949, p. 56, pl. 10, figs. 2–2b).

Genus *PROTANISOCERAS* SPATH, 1923

Type Species *Hamites raulinianus* d'ORBIGNY, 1842.

***Protanisoceras (Protanisoceras)* sp. ind.**

Plate 3, fig. 5.

Material Two specimens; NHM 1978/1952/28–29

Description NHM 1978/1952/28 is part of the hook of a heteromorph bearing strong, very to slightly rursiradiate ribs which are markedly weakened on the dorsum and strongly developed across the venter. These are closely spaced on the curved part of the shell, but become widely spaced on the straight shaft, resembling the ornament of some *Ptychoceras* species. NHM 1978/1952/29 consists of a crushed dorsum of the same species, and shows a somewhat later growth stage, with very distant ribs, the interspaces decorated by fine dense growth striae.

The hook on the smaller specimen before us bears traces of what appear to be small inner and outer ventrolateral tubercles on all ribs.

Remarks At first sight these specimens appear to be very early representatives of the genus *Hamites* PARKINSON, 1811 but the indications of ventral tubercles on the hook of the smaller fragment suggest them to represent some anisoceratid. The material is too poor to usefully compare with the numerous early Albian *Protanisoceras* described by CASEY (1961 a), although it is to this genus that it probably belongs.

Superfamily DOUVILLEICERATACEAE PARONA & BONARELLI, 1897
Family DOUVILLEICERATIDAE PARONA & BONARELLI, 1897
Subfamily DOUVILLEICERATINAE PARONA & BONARELLI, 1897
Genus *DOUVILLEICERAS* DE GROSSOUVRE, 1894

Type Species: *Douvilleiceras mammillatum* (SCHLOTHEIM)

Douvilleiceras sp. ind.
Plate 5, fig. 2

Material. One specimen only, NHM/1978/1952/2.
Description The specimen is a crushed composite mould of a nucleus 22 mm. in diameter and an outer whorl with a maximum whorl height of 26 mm. Coiling appears to have been moderately evolute. Ornament consists of strong, closely spaced straight radial ribs, narrow at the umbilicus and broadening towards the venter. All the ribs are long, and bear small pointed umbilical and inner lateral tubercles, and longer, blunter mid-lateral tubercles. Three rows of clavate tubercles are visible on what corresponded to the ventrolateral region of the shell prior to crushing, the innermost being the weakest. At the largest diameter visible, one rib shows a further, stronger clavate ventral tubercle.
Remarks Although only a fragment, the simple ribbing and numerous tubercles allow confident reference of this specimen to the genus *Douvilleiceras*. Beyond this, specific determination is scarcely practicable, but the fragment belongs to the *D. leightonense* – *D. mammilatum* group, with typically even ribs and tubercles. In all probability it is a *D. leightonense* CASEY (1962, p. 244, pl. 41, figs. 1 a–b, pl. 42, fig. 3, text.-figs. 96, 97, 102 i 103 e–h) which species is known from the *Leymeriella regularis* Zone of England and France.

Order AMMONITIDA HYATT, 1889
Superfamily DESMOCERATACEAE ZITTEL, 1895
Family DESMOCERATIDAE ZITTEL, 1895
Subfamily PUZOSIINAE SPATH, 1922
Genus *PUZOSIA* BAYLE, 1878

Type Species. *Puzosia planulata* BAYLE, 1878 (= *Ammonites subplanulatus* SCHLÜTER, 1871)

Puzosia sp., group of ***P. quenstedti*** (PARONA & BONARELLI)
Plate 1, figs. 2–3; Plate 4, figs. 1–5.

Material Seven specimens, NHM 1978/1952/23–25; OUM KZ 227a–b, OUM KZ 244a–b; and OUM KZ 284–5.
Description. Our specimens range from 30 to 100 mm. in diameter, most are crushed laterally, but one dorsal impression is preserved (Plate 4, fig. 4).
Coiling appears to have been moderately involute, with a medium-sized, probably fairly shallow umbilicus, rounded flanks and venter; the whorls may have been somewhat compressed.
There were approximately six prominent constrictions per whorl which arise at the umbilical seam. They are flexuous and prorsiradiate, flexing forwards and convex across the inner flank, back across the outer flank where they are concave, and sweeping forwards over the venter, where they are markedly convex (Plate 4, fig. 4). Each constriction is preceeded by a strong rounded primary rib, and followed by a further, rather variably developed rib. Between constrictions, the inner flank is virtually smooth but for fine flexuous growth striae, which parallel constrictions (Plate 4, fig. 5). These strengthen across the mid-flank, and on the outer flank, there are fine, dense, crowded concave ribs, which cross the venter with marked convexity.
There are twenty-six such ribs in our best preserved specimen (Plate 4, fig. 2).
Discussion. WIEDMANN & DIENI (1968) divided the mid Cretaceous *Puzosia* into two groups: 1, That of *P. quenstedti* (PARONA & BONARELLI), with an umbilicus comprising 25–33 % of diameter, flattened sides and a narrowly rounded venter, and 6–7 strong radial constrictions which form a strong ventral sinus, and: 2, That of *P. mayoriana* (d'ORBIGNY) with a wider umbilicus comprising 31–40 % of the diameter, with 4–6 deep sigmoidal constrictions per whorl, forming a distinctive ventral chevron.

Our specimens obviously belong to the first group, from the form and number of constrictions present, but determination beyond this is difficult because specific differentiation commonly depends on details of whorl section and relative proportions. In consequence they are simply referred to as *Puzosia* sp., group of *P. quenstedti*

Subfamily BEUDANTICERATINAE BREISTROFFER, 1953
Genus *BEUDANTICERAS* HITZEL, 1905

Type Species. *Ammonites beudanti* BRONGNIART, 1822.

Beudanticeras **sp. juv.**

Plate 3, figs. 1 a–h, 2 a–e, 3, 4, 6–7, 10; Plate 11, figs. 1, 11.

Material We have two pyritic specimens, NHM 1978/1952/26–27, and hundreds of crushed individuals, including OUM KZ 237–238, OUM KZ 240–241, OUM KZ 243, and OUM KZ 376–429.

Description. The two pyritic specimens which retain replaced shell material, show the coiling to be quite involute, with a small umbilicus (24–26 % of diameter). The dimensions are as follow:

	D	Wb	Wh	Wb:Wh	U
NHM 1978/1952/26	18.6(100)	6.8(37)	8.3(47)	0.82	4.8(26)
NHM 1978/1952/27	19.0(100)	6.7(35)	8.1(43)	0.83	4.6(24)

The umbilical wall is low, and the umbilical shoulder narrowly rounded. The inner flanks are swollen, the outer flanks convergent, with the greatest breadth just below mid-flank. The ventrolateral shoulders are broadly rounded, and the venter somewhat flattened. Ornament consists of fine, dense flexuous prorsiradiate striae (Plate 3, figs. 1a, 1c, 2c), which strengthen across the venter (Plate 3, figs. 1e, 2 d), where they are broadly convex. Occasional narrow, weak, flexuous constrictions are visible on both specimens, little more than accentuated interspaces between striae.

Discussion The overall form, presence and direction of constrictions and growth striae indicate these specimens to be juvenile *Beudanticeras*, although at the size of our material they are not specifically identifiable, although belonging to the feebly ornamented *B. newtoni* CASEY – *B. walleranti* (JACOB) group.

Superfamily ACANTHOCERATACEAE HYATT, 1900
Family BRANCOCERATIDAE SPATH, 1933
Subfamily MOJSISOVICZIINAE HYATT, 1903
Genus *OXYTROPIDOCERAS* STIELER, 1920

Type Species *Ammonites roissyanus* d'ORBIGNY, 1841.

Oxytropidoceras (Oxytropidoceras) **sp.**

Plate 5, figs. 1, 4.

Material One specimen and counterpart, OUM KZ 245a–b.

Description. The specimen is a fragment with a maximum whorl height of only 10 mm, ornamented by seven low, broad flattened concave ribs, effaced on the inner flank and strongest across the ventrolateral shoulder, terminating in a smooth band which is produced into a sharp, entire keel.

Discussion The oxycone fragment is referred to *Oxytropidoceras* on the basis of both ribbing style and inferred whorl section. The only other early to mid Cretaceous group it might be compared to is the Aconeceratidae, in particular *Sanmartinoceras* BONARELLI, 1921. All subgenera of this genus show falcoid, narrow ribs (see illustrations in CASEY, 1961), and have a distinctively (if minutely) serrated keel, both of which features are absent in our specimen. Lack of umbilical and ventrolateral tubercles precludes reference of the specimen to the subgenus *O. (Adkinsites)* SPATH, 1931 and lack of umbilical tubercles precludes *O. (Androiavites)* COLLIGNON, 1936. *O. (Venetzoliceras)* SPATH, 1925 is also tuberculate, as are *O. (Laraiceras)* RENZ, 1968 and *O. (Tarfayites)* COLLIGNON, 1963.

Of the remaining subgenera, *O. (Manuaniceras)* is typified by rather inflated inner whorls, and ribs which tend to branch, a feature not shown by our fragment, so that reference to the nominotypical subgenus is suggested.

Although specifically indeterminate, the record is of great interest, representing the earliest known member of the genus, not previously recorded from below the *Douvilleiceras mammilatum* Zone.

Family LYELLICERATIDAE SPATH, 1921
Subfamily LEYMERIELLINAE BREISTROFFER, 1951
Genus *LEYMERIELLA* JACOB, 1907

Type Species. *Ammonites regularis* BRUGIERE, 1780.

Leymeriella (Leymeriella) pseudoregularis **SEITZ.**
Plate 3, fig. 8; Plate 5, figs. 3, 5–8, 10–11.

1930 *Leymeriella pseudoregularis* SEITZ, p. 24, pl. 5, fig. 3.
1957 *Leymeriella pseudoregularis* SEITZ; CASEY, p. 52, pl. 10, fig. 1 (with synonymy).

Material Seven specimens NHM 1978/1952/3–4; OUM KZ 246, 247 a–b, 248, 249.

Description The coiling is moderately evolute, with slowly expanding whorls. The shell is smooth up to a diameter of approximately 12 mm. (Plate 3, fig. 9; Plate 5, fig. 8), followed by the appearance of strong, distant feebly flexed prorsiradiate ribs, approximately twenty per whorl. The ribs are weak at the umbilical seam, but develop into distinct bullae on the umbilical wall (Plate 5, fig. 11). Our best specimen, NHM 1978/1952/3 (Plate 5, fig. 3) shows a later growth stage, with sharp, strong distant ribs which are more obviously flexed, and are thickened at the ventral periphery into strong clavi (see also Plate 5, fig. 5).

Discussion The coarse ribbing and prominent clavi of these specimens is very similar to that of the holotype of *L. (L.) pseudoregularis* figured by SEITZ (1930, pl. 5, figs. 4–4 c) as well as other specimens referred or compared to the species by him (loc. cit., pl. 5, figs. 1 a–b, 3, 5 a–b – 8). Of other coarsely ornamented *Leymeriella*, *L. (L.) renascens* SEITZ (loc. cit., pl. 5, figs. 9 a–c) shows an initial and final finely ribbed stage not seen in our specimens, *L. (L.) regularis* (e. g. CASEY 1957, p. 49, pl. 8, figs. 5–5 b, 9–9 a; pl. 9, fig. 2; pl. 10, fig. 7) has finer-ribbed inner whorls, less pronounced tubercles, and flattened or grooved ribs at the diameter of our larger specimens.

L. (L.) consueta CASEY (1957, p. 53, pl. 9, figs. 8–8 a; Plate 10, figs. 5 5 b, 13; text-fig. 1 a–h) is more coarsely ribbed and tuberculate than our material and has ventral spines rather than clavi; *L. diabolus* CASEY (1957, p. 56, pl. 9, fig. 6) and *L. rudis* CASEY (1957, p. 54, pl. 7, fig. 10, pl. 8, figs. 6 -6 b) are also more strongly ribbed and tuberculate.

Occurrence *L. (Leymeriella) pseudoregularis* is confined to the *L. (L.) regularis* Subzone of the *L. (L.) tardefurcata* Zone. Its geographic distribution extends from England north to Jutland (in Drift boulders), south to the Alpes Maritimes and east to the Rhaetic Alps and the present records from Losenstein; related species extend to Iran.

Leymeriella (Leymeriella) tardefurcata (d'ORBIGNY)
Plate 2, figs. 3, 5, 6, 8; Plate 4, fig. 4; Plate 6, figs. 1–11; Plate 7, figs. 1 10.

1841 *Ammonites tardefurcatus* LEYMERIE; d'ORBIGNY, p. 248, pl. 71, figs. 4–5.
1957 *Leymeriella (Leymeriella) tardefurcata* (LEYMERIE m. s.) d'ORBIGNY sp.; CASEY p. 45, pl. 7, fig. 9; pl. 8, figs. 1–3, 8–8 a; pl. 9, fig. 1; pl. 10, figs. 10–11 (with synonymy).
1957 *Leymeriella (Leymeriella) tardefurcata* var. *densicostata* SPATH; CASEY, p. 47, pl. 9, figs. 7–7 a; pl. 10, figs. 9–9 a, 12 (with synonymy).
1957 *Leymeriella (Leymeriella) tardefurcata* var. *intermedia* SPATH; CASEY, p. 48, pl. 10, figs. 2, 6, 8–8a (with synonymy).

Material We have several hundred specimens, many slabs covered with individuals at all growth stages, including NHM 1978/1952/5–22 and OUM KZ 236, 251–265, 286–375.

Description The material before us includes juveniles showing the earliest stages of development (e. g. Plate 6, figs. 2, 7, 8) up to adults 60 mm. in diameter (e. g. Plate 7, fig. 3). Most specimens are crushed laterally, but a few crushed ventral areas are also present, revealing details of tuberculation and sulcus (Plate 2, fig. 3; Plate 4, fig. 4).

Coiling is quite evolute, and the whorl section appears to have been compressed and rectangular. Up to 5–6 mm. diameter (rarely a little larger) the shell is smooth (Plate 6, figs. 2, 7, 8, 10): beyond this ribbing develops. The number of ribs varies widely from individual to individual; at the one extreme are fine ribbed forms corresponding to SPATH's variety *densicostata* with over fifty ribs per whorl (e. g. Plate 7, fig. 2); at the other, coarse ribbed forms with as few as thirty ribs (e. g. Plate 6. figs. 5, 10; Plate 7, figs. 4–6), although the number of ribs increases slightly with increasing diameter.

The ribs arise at the umbilical seam, where they are narrow, crowded and markedly prorsiradiate. In some individuals they flex forwards, and are convex across the inner to mid-flank, flex backwards and are concave on the outer flank, and sweep forwards to terminate in the ventral clavi (e. g. Plate 7, figs. 1, 2, 5); in others they are almost straight across most of the flank (e. g. Plate 6, fig. 3), and in yet others they are predominantly concave (Plate 6, fig. 6). From umbilical seam to a point just below mid-flank, the ribs are narrow and rounded. Beyond this, they flatten and broaden into wedge-shaped elevations with a distinctive sulcus, which in some specimens gives a distinct impression of complete splitting of the rib (e. g. Plate 6, fig. 9), although they terminate in a single, oblique placed ventral clavus (Plate 2, fig. 3; Plate 4, fig. 4) on either side of a smooth siphonal area. In a few individuals, the inner parts of the ribs are strengthened into the merest suggestion of an umbilical bulla, resembling SPATH's variety *intermedia* (e. g. Plate 6, fig. 3).

D i s c u s s i o n The illustrations of selected examples from the hundreds of specimens available to us demonstrate the range of variation seen in the species far better than descriptions. Rib strength, density, flexure, degree of sulcation, and development of ventral clavi are all variable. and specimens resembling the varieties *densicostata* and *intermedia* are both present, if rather scarce in comparison with the typical form.

Specimens of *L. (L.) tardefurcata* are easily separable from the much more coarsely ribbed *L. (L.) pseudoregularis* present in our collections, for not only are these more robustly ribbed and tuberculate, but they do not show such striking sulcation of the ribs. Of other species, that most open to confusion is *L. renascens* SEITZ (1930, pp. 29–30, pl. 5, figs. 9 a, b) which has, however, finely ribbed inner whorls followed by coarsely ribbed middle growth stages, and shows a return to fine ribbing at maturity.

O c c u r r e n c e *L. (L.) tardefurcata* is confined to the *L. (L.) regularis* Subzone, and is known from England north to Germany, south to the Alpes Maritimes and east to Transcaspia and Iran.

Discussion

The faunas from the two localities in the Stiedelsbachgraben near Losenstein, although crushed in shales, include thousands of determinable specimens of *Beudanticeras* sp. juv. and *Leymeriella (Leymeriella) tardefurcata*. Much rarer, and represented by only a few specimens are *Phylloceras*? sp. ind., *Ptychoceras laeve hamaimense, Metahamites* sp. ind., *Protanisoceras (Protanisoceras)* sp. ind., *Douvilleiceras* sp. ind. (? *D. leightonense* CASEY), *Puzosia* sp. group of *D. quenstedti, Oxytropidoceras (Oxytropidoceras)* sp. and *Leymeriella (Leymeriella) pseudoregularis*. This association can be precisely referred to the highest, *L. (L.) regularis* Subzone of the *L. (L.) tardefurcata* Zone as used by CASEY (1957, 1961 b, etc.). Furthermore, the dominance of *L. (Leymeriella)* is a feature of Boreal Lower Albian faunas, for the genus is restricted to OWEN's (1971) hoplitinid faunal province. The only Tethyan element of the fauna is the dubious *Phylloceras* ? sp., one specimen amongst thousands. Of additional interest is the abundance of *Beudanticeras*, a phenomenon better known in the succeeding *Douvilleiceras mammilatum* Zone, where the genus is equally common, although before and after this, Desmoceratidae form only a minor element of Boreal ammonite assemblages.

The same Boreal infuence in the Lower Albian may be observed in the Carpathians, where ANDRUSOV, 1965 figured *Leymeriella tardefurcata* from the Pienidic Klippen belt near Tvorodsin. At the same locality he also records *Douvilleiceras mammillatum* (SCHLOTHEIM) so that both Lower Albian ammonite zones are present. As in the Eastern Alps, however, all other Cretaceous faunas of the

Carpathians are Tethyan. These observations suggest that during the Lower Albian the North Alpine-Carpathian plate (this is a term we prefer over the geographically erroneous „Carnic plate" of DEWEY & others, 1973), the northernmost microplate of the Alpine belt in Central Europe, was under Boreal influences. Otherwise, the boundary between the Boreal and the Tethyan realm lies within the Mesoeuropean plate as in the Cenomanian (VOIGT, 1964, KOLLMANN, 1978) or at its southern margin as in the Middle to Upper Albian (OWEN, 1971, KENNEDY & COBBAN, 1976) and in the Maastrichtian (KEGEL-CHRISTENSEN, 1976).

The Boreal episode represented in the early Albian of the Northern Calcareous Alps and the Carpathians certainly cannot be seen as a short fluctuation of isotherms due to climatic changes: we have to assume that the North Alpine-Carpathian plate was separated from Mesoeurope by an ocean. Its oceanic crust, together with the overlying sediments, is now mostly subduced below the plate margins and only fragmentarily preserved in the Penninic zone of the Alps (DIETRICH, 1976). The occurrence of a Boreal fauna together with Tethyan elements in the Northern part of the Alpine belt certainly gives some hints on the width of the ocean in the Lower Albian: KENNEDY & COBBAN, 1976 have shown that a transition between Boreal and Tethyan faunas occurs in Southern France. Here a rich hoplitinid fauna extends down the Rhône valley as far South as the region around Escragnolles and Goudron in the Alpes Maritimes. Moving southward, Tethyan elements become more diverse. Following WIEDMANN & DIENI, 1968 Boreal influences on the Sardinian Cretaceous are rather strong due to the more northerly position of this island together with Corsica in the Cretaceous. As we find both Boreal and Tethyan elements in the Tannheim formation and its Carpathian equivalent, we have to assume that an open communication existed from the North Alpine sea to both realms. We therefore conclude that the composition of the fauna is primarily due to the geographic latitude of the shelf within which these sedimentary areas were situated in the Lower Albian. In other words, the North Alpine sedimentary area was at about the same latitude as Southern France in the Albian. To the East the Moesian platform with its rich Boreal fauna occupied a similar latitude. We therefore believe that, in the Lower Albian, the Alpine front was about 400 to 500 kilometers South of the continental margin of Mesoeurope which (after the geophysical section through the Eastern Alps given by ANGENHEISTER & others, 1972) is now concealed below the Penninic zone of the Alps.

Later in the Albian, the Tethyan influence became dominant. This is probably due to the build up of a land area in the northern part of the North Alpine-Carpathian plate which acted as a barrier to migration and Tethyan currents. This land area is the „Ultrapienidic Ridge" of TRAUTH, 1937 and was the source area of clastic sediments in the Northern Calcareous Alps. Since the sedimentation of these clastic sediments began in the upper part of the Lower Albian with a distinct break in lithology it had been suggested by DIETRICH, 1976 to mark the beginning of subduction along the continental margin of the North Alpine-Carpathian plate. The land area in the North was certainly of great importance in its influence on the composition of marine faunas. Although it did not wholly interrupt communication with the Boreal realm, as the occurrence of forms common to both provinces shows, typical Boreal elements did not live South of the land area because of the warming of shelf waters by Tethyan currents.

Acknowledgements

We are grateful to Dr. M. K. HOWARTH and Mr. D. PHILLIPS (British Museum (Natural History), London) Mr. C. W. WRIGHT (London) and Mr. C. J. WOOD (Geological Museum, London) for their advice and for allowing us to study material in their collections, the British Council for financing a visit to Austria by one of us (W. J. K.) and the staff of the Geological Collections at the Oxford University Museum for their help in many ways.

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Revidiertes Manuskript von der Schriftleitung angenommen am 7. 6. 1978
Begutachter: Dr. L. Krystyn

Explanation of Plates

Plate 1

Figs. 1, 4–13 *Ptychoceras laeve hamaimense* PERVINQUIERE. 1 is OUM KZ 226; 4 is OUM KZ 228; 5 & 7 (reversed) OUM KZ 229; 6 (reversed) and 8 are OUM KZ 230; 9 is OUM KZ 231; 10–12 OUM KZ 232 a; 13 OUM KZ 232 b.

Figs. 2–3 *Puzosia* sp. group of *quenstedti* (PARONA & BONARELLI) – OUM KZ 227 a–b.

All specimens are figured X 2

Plate 2

Figs. 1, 2, 4, 7 *Metahamites* sp. ind. 1 is NHM 1978/1952/30; 2 is OUM KZ 233; 4 is OUM KZ 234; 7 is OUM KZ 235;

Figs. 3, 5, 6, 8 *Leymeriella (Leymeriella) tardefurcata* (d'ORBIGNY). 3 is NHM 1978/1952/11; 5 is NHM 1978/1952/13; 8 is OUM KZ 236.

All specimens are figured X 1

Plate 3

Figs. 1 a–h, 2 a–e, 3, 4, 6, 10 *Beudanticeras* sp. juv. 1 a–h is NHM 1978/1952/26; 2 a–e is NHM 1978/1852/27; 3 is OUM KZ 237; 4 is OUM KZ 238; 6 is OUM KZ 240; 10 is OUM KZ 243;

Fig. 5 *Protanisoceras (Protanisoceras)* species undetermined. – NHM 1978/1952/28

Fig. 7 *Beudanticeras* and *Leymeriella (Leymeriella)* spp. – OUM KZ 241 (reversed)

Figs. 8 a–b *Ptychoceras laeve hamaimense* PERVINQUIERE. – OUM KZ 282.

Fig. 9 *Leymeriella (Leymeriella)* cf. *pseudoregularis* SEITZ. – OUM KZ 242.

Figs. 1 a–g, 2 a–d, 3, 4, 6, 8, 9 and 10 are figured X 2. The remainder are figured X 1.

Plate 4

Figs. 1–5 *Puzosia* sp. group of *P. quenstedti* (PARONA & BONARELLI). 1,2 are OUM KZ 244 a–b; 2 is NHM 1978/1952/23; 4 is 1978/1952/24; 4 is NHM 1978/1952/25.

All specimens are figured X 1

Plate 5

Figs. 1, 4 *Oxytropidoceras (Oxytropidoceras)* sp. ind. – OUM KZ 245 a.

Fig. 2 *Douvilleiceras* sp. ind. – NHM 1978/1952/2

Fig. 3, 5–8, 10–11 *Leymeriella pseudoregularis* SEITZ. 3 is NHM 1978/1952/3; 5 is OUM KZ 246; 6 is OUM KZ 247 a; 7 is OUM KZ 248; 8 is OUM KZ 249; 10 is OUM KZ 247 b; 11 is NHM 1978/1952/4.

Fig. 9 *Phylloceras* ? sp. ind. – NHM 1978/1952/1

Figs. 1, 4, 6, 8 and 10 are figured X 2; the remainder X 1

Plate 6

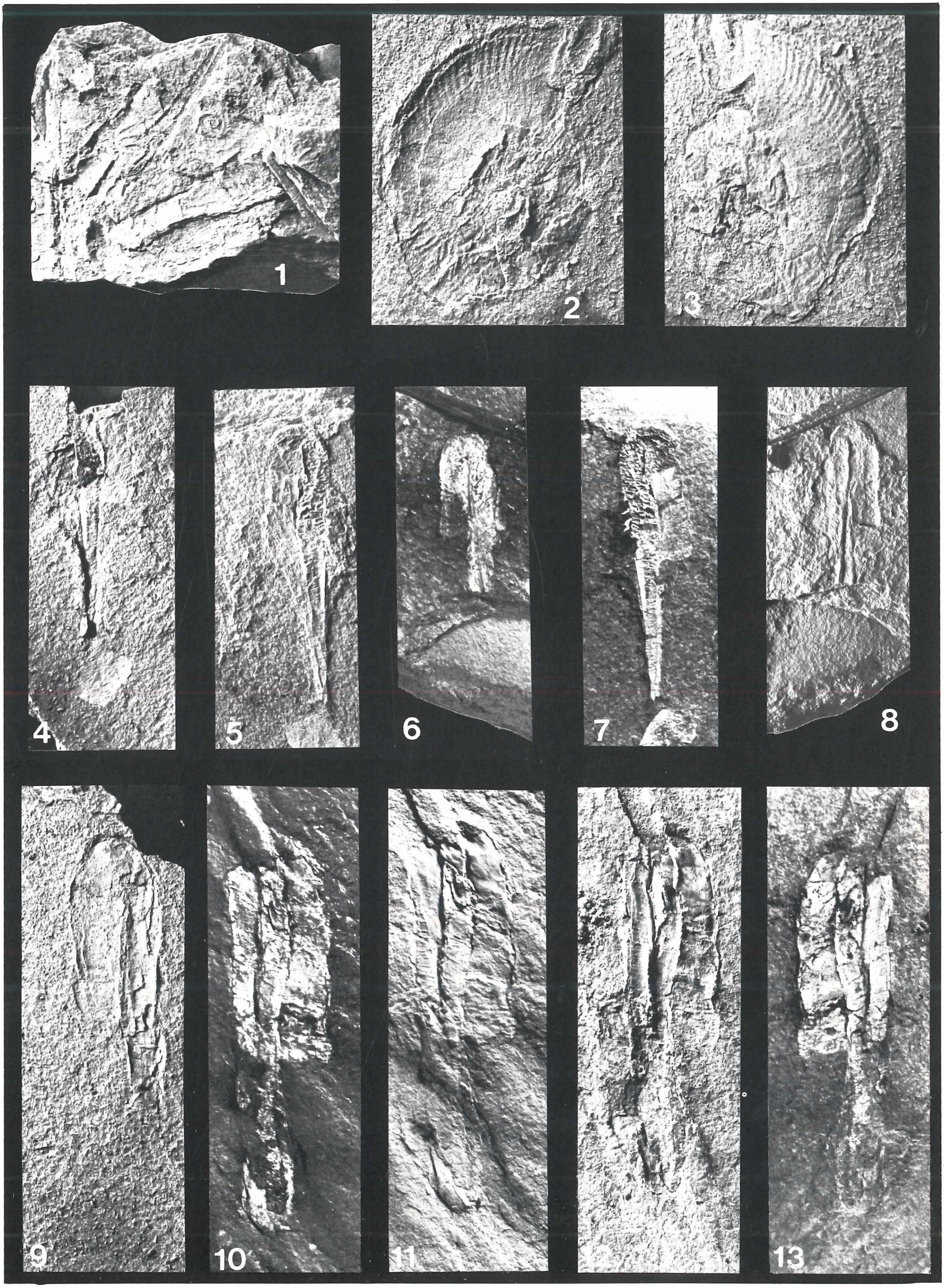
Figs. 1–11 *Leymeriella (Leymeriella) tardefurcata* (d'ORBIGNY). 1 is OUM KZ 250; 2 is OUM KZ 251; 3 is OUM KZ 252; 5 is OUM KZ 254; 6 is OUM KZ 255; 7 is OUM KZ 256; 8 is OUM KZ 257; 9 is OUM KZ 258; 10 is OUM KZ 259; 11 is OUM KZ 260.

All figures X 2.

Plate 7

Figs. 1–10 *Leymeriella (Leymeriella) tardefurcata* (d'ORBIGNY). 1 is OUM KZ 261; 2 is OUM KZ 262; 3 is NHM 1978/1952/22; 4 is OUM KZ 263; 5 is OUM KZ 264; 6 is OUM KZ 265; 7 a–b is no. 17949, 8 a–b no. 13603 and 10 a–b no. 19703 in C. W. WRIGHT's Collection, all from the *L. regularis* subzone nodule beds at the top of the Lower Greensand at Leighton Buzzard, England, figured for comparison with the Austrian material. Figures 1 and 2 are X 2; the remainder X 1.

Figures 1 and 2 are X 2; the remainder X 1.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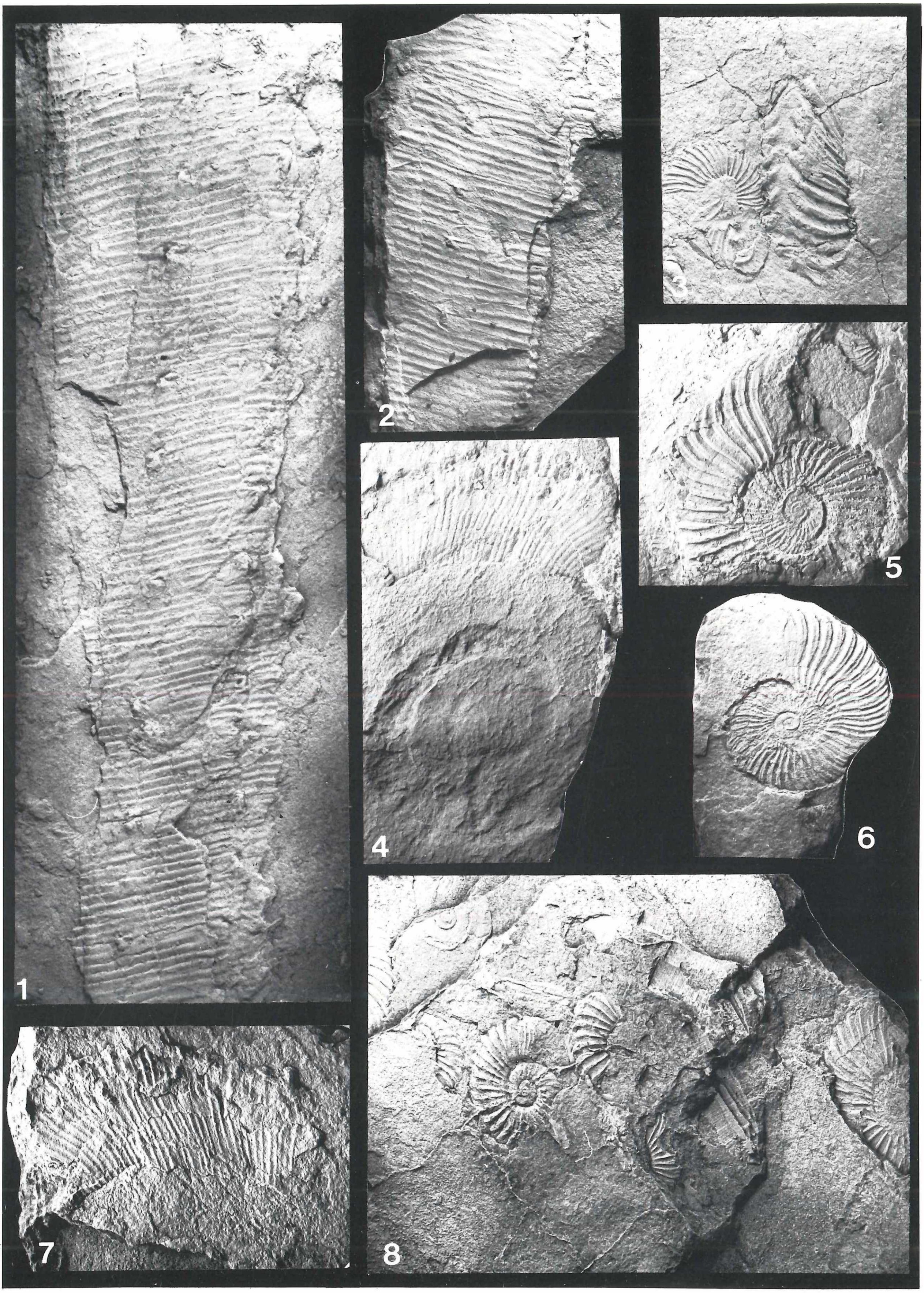
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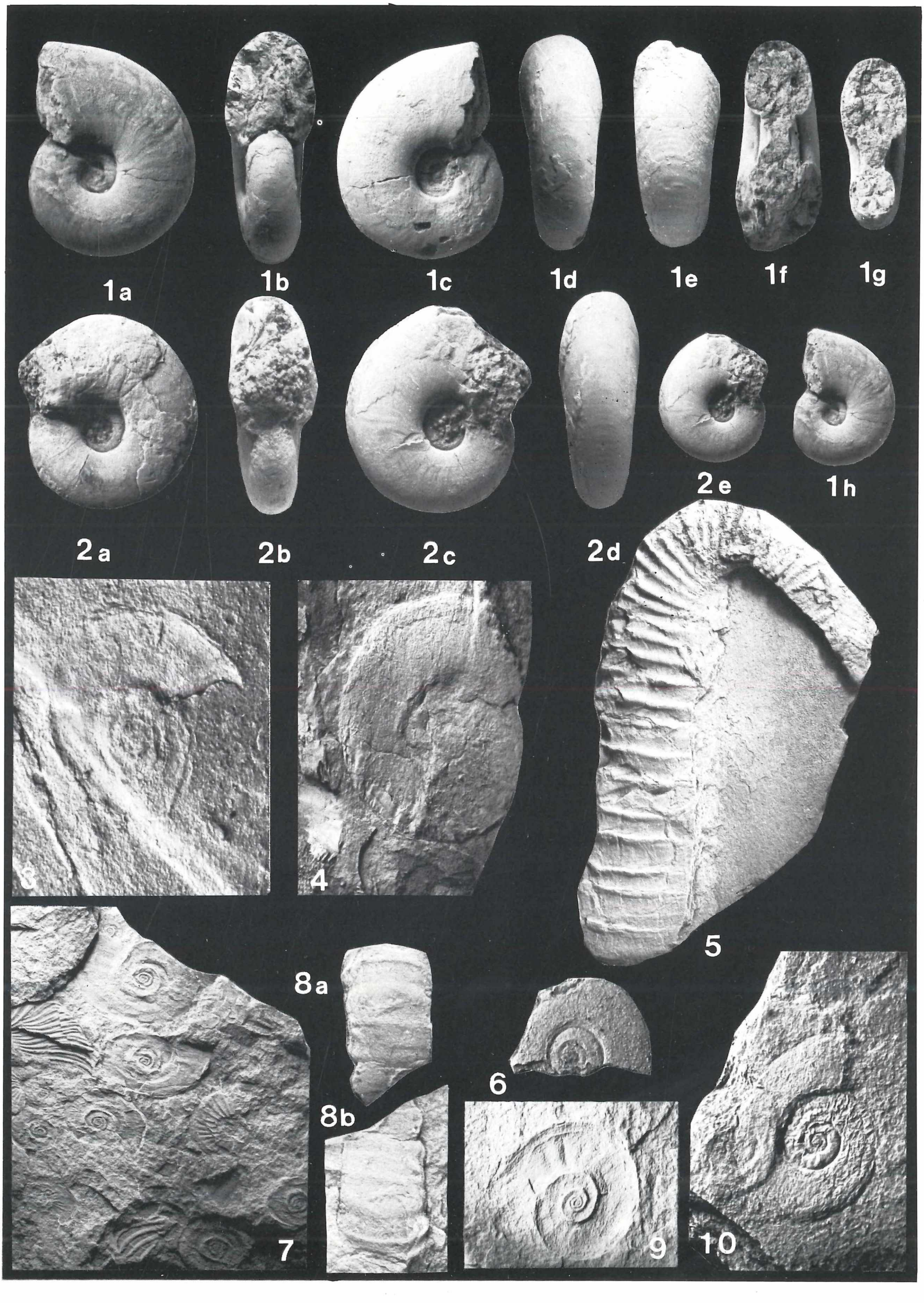
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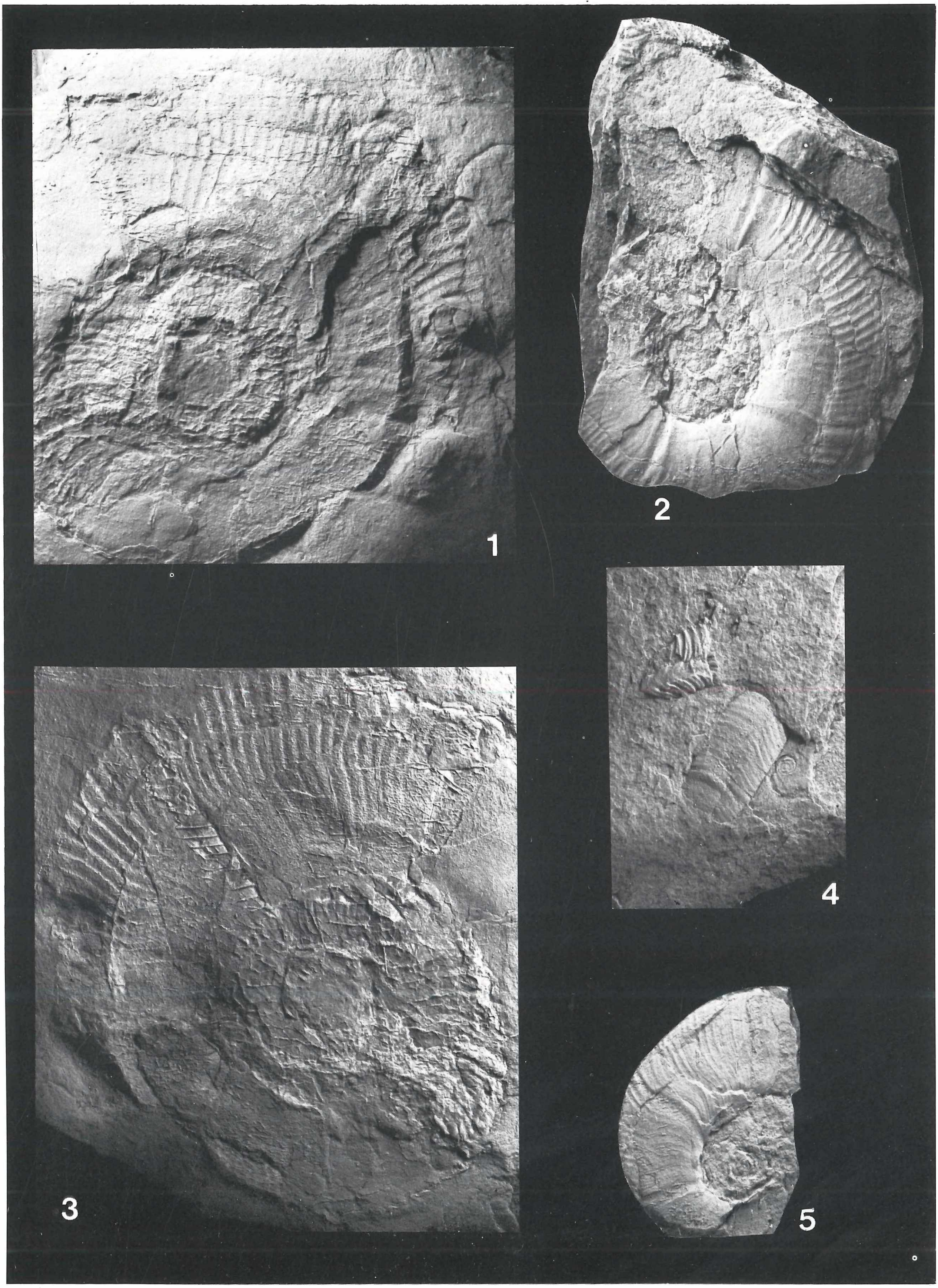
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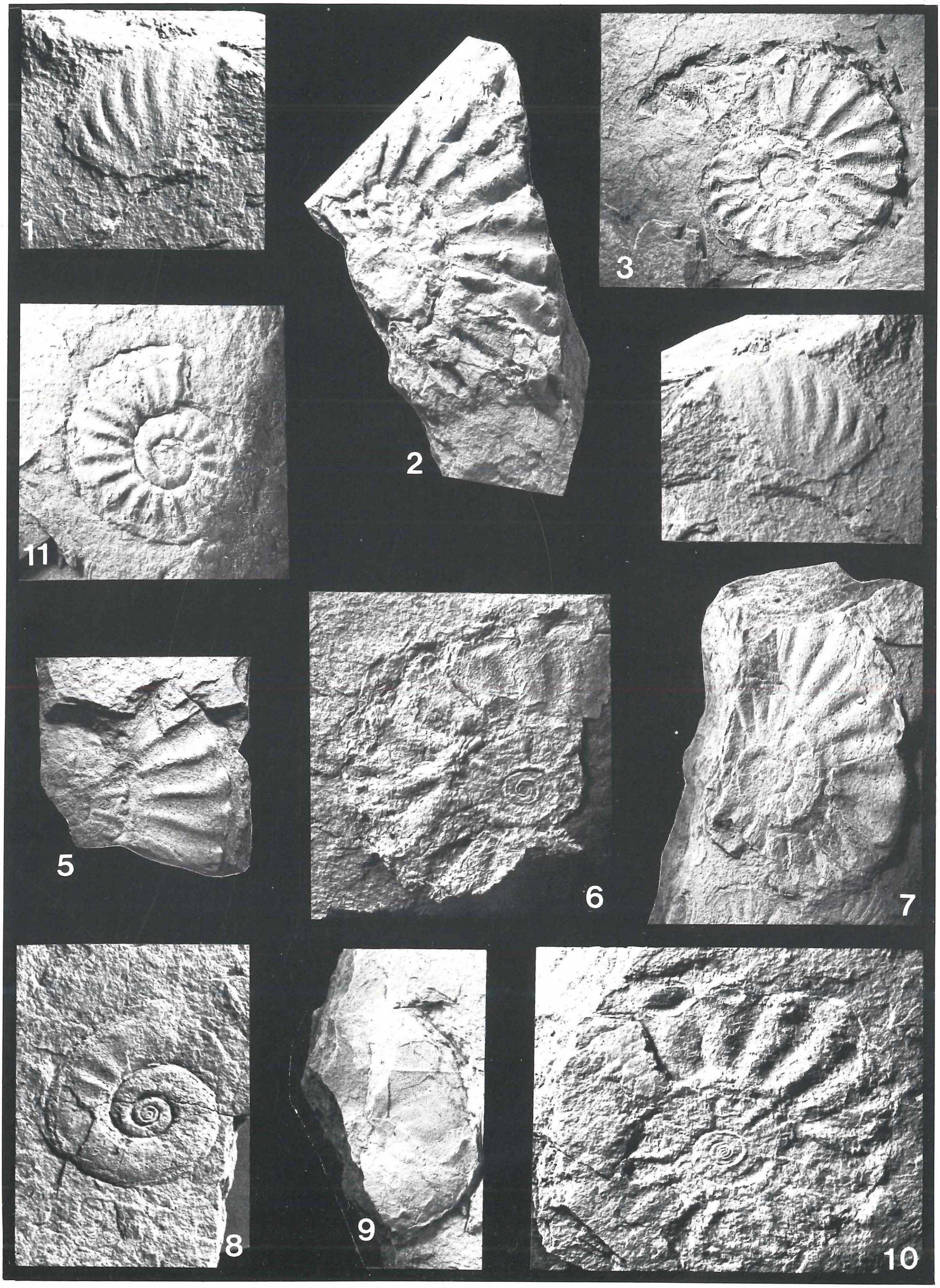
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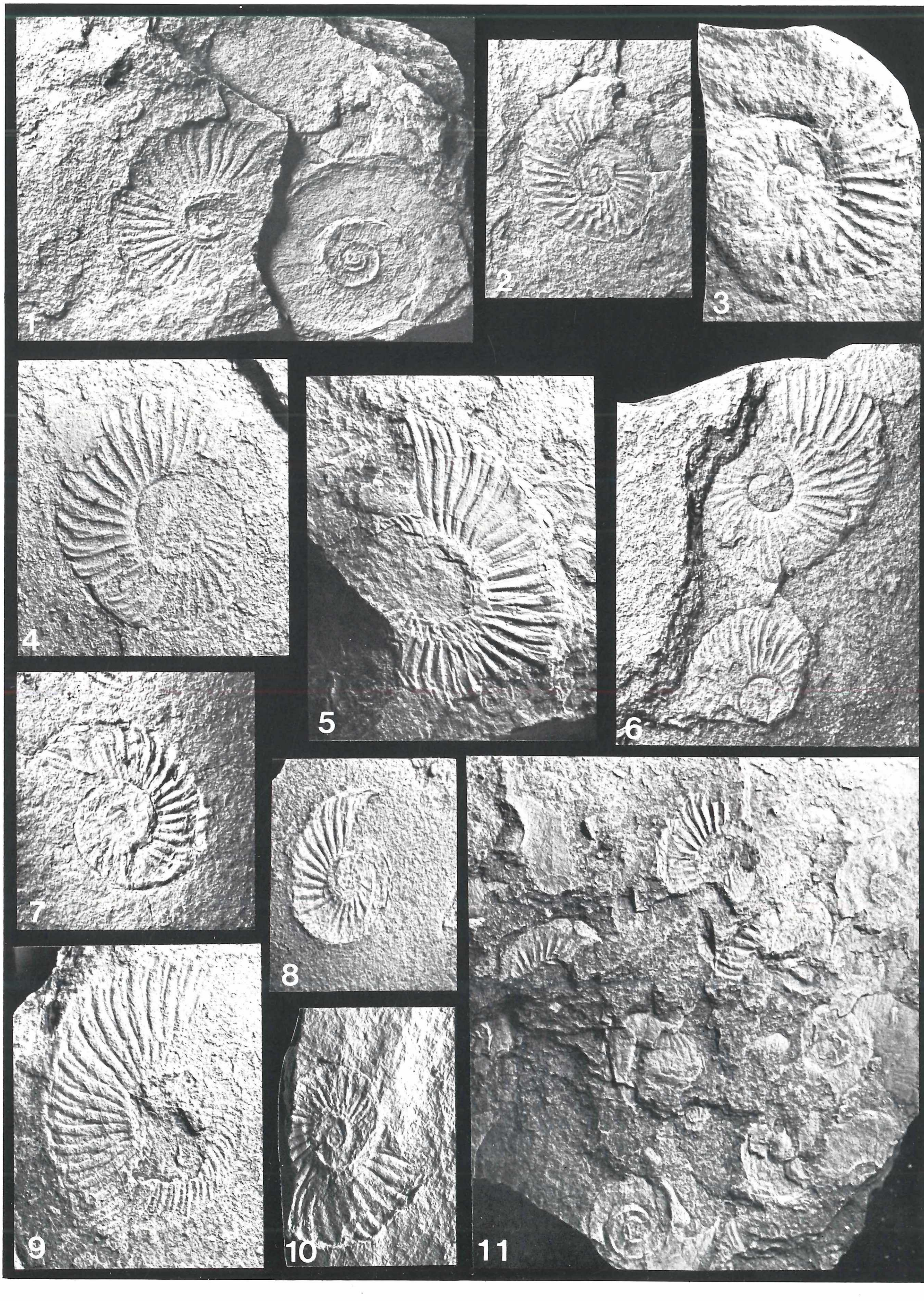
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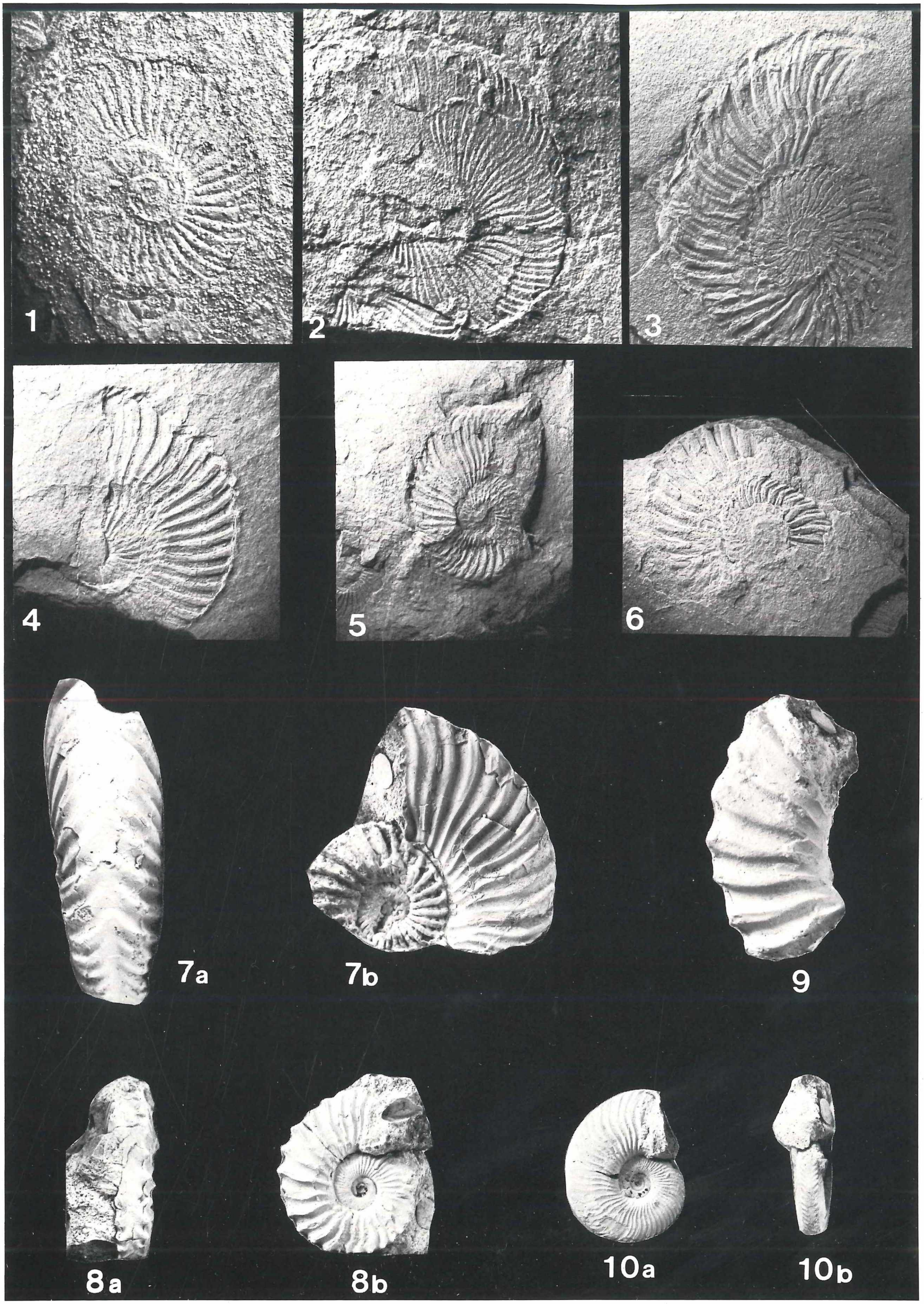
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Zeitschrift/Journal: Beiträge zur Paläontologie

Jahr/Year: 1979

Band/Volume: 6

Autor(en)/Author(s): Kennedy William James, Kollmann Heinz Albert

Artikel/Article: Lower Albian Ammonites from the Tannheim Formation near Losenstein, Upper Austria. 1-25