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Some ammonites of the Klentnice Beds (Upper Tithonian) and remarks on correlation of the uppermost Jurassic

ABSTRACT: A review of published ammonites from the Klentnice Beds is given along with a description of some recently discovered new forms. The genus *Pseudovirgatites* is revised, and the species of the genera *Ilowaiskya, Isterites* and *Pavlovia* are described. The Upper Klentnice Beds correspond to the Upper Neuburg Beds and higher zones, as evidenced by the ammonites. Correlation with the zonal sequences from other Upper Jurassic provinces is presented and its problems are discussed.

INTRODUCTION

In 1972 Professor Dr. J. Kutek of the University of Warsaw and the author started an investigation of the famous ammonites fauna of Tomaszów Mazowiecki in Central Poland. It was shown that the oldest fauna from that locality comprises the representatives of the genera *Ilowaiskya, Pseudovirgatites* and *Isterites*. When working on the *Pseudovirgatites* it became necessary to undertake detailed research on the type material of this genus, which had been interpreted quite differently in the past. It was not possible to publish the results together with those of Tomaszów (Kutek & Zeiss 1974), so they were prepared as a separate publication. For this purpose the author studied the types available as well as additional material which belonged to *Pseudovirgatites* or to the other contemporaneous genera (that means specimens of the Upper Klentnice Beds). Therefore collections of the Geological and Paleontological Institutes of the University of Vienna were carefully examined for those specimens, as well as collections of the Museum of Natural History in Vienna, of the Krahuletz Museum at Eggenburg, of the Department of Paleontology of

the ČAV and of the ÚÚG in Prague and of the museums of Brno, Opava and Štramberk, Czechoslovakia. Because of bad outcrop conditions near Klentnice, a finding of new specimens in the type section of the Klentnice Beds was impossible.

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DESCRIPTION OF THE AMMONITES

In the descriptions the following abbreviations are used:

D diameter, *U* umbilical width, *H* whorl height, *W* whorl width, *IR* primary ribs (internal ribs), *ER* secondary ribs (external ribs); *Coll.* Collection; *N.Ö.* Nieder-Österreich (Lower Austria).

Subfamily **Pseudovirgatitinae** Spath, 1931

The material of the Klentnice Beds contains representatives of the tribes Pseudovirgatitini and Sublithacoceratini. Concerning the content and subdivision of the subfamily see Zeiss (1968) and Kutek & Zeiss (1974).

Tribus **Pseudovirgatitini** Spath, 1931

This tribus encloses genera of both the former tribus Ilowaiskyini and tribus Pseudovirgatitini s. str. As a result of the investigations carried out by Kutek & Zeiss (1974), the tribus Ilowaiskyini was united with Pseudovirgatitini because of their close phylogenetic relationships. It must be added that they are also related with the subfamily Virgatitinae *(Zaraiskites).* The latter, however, is characterized by the permanent appearance of real virgatotome ribs, thus distinguishing itself as an independent descendent development of the Pseudovirgatitini.

Genus *PSEUDOVIRGATITES* Vetters, 1905

The genus *Pseudovirgatites* has been carefully described when it was established by Vetters (1905). Schneid (1915a, b) considerably extended the ranges of this genus as well as that of *Virgatosphinctes* from their original substance by incorporation of the Lower and Middle Tithonian and even Upper Kimmeridgian ammonites of Southern Franconia. This broad interpretation of the genera *Pseudovirgatites* and *Virgatosphinctes* could not be maintained, as later investigations have shown. A revision of the genus *Virgatosphinctes* is urgently needed. The paper, in addition to former works, gives a revision of the characteristic material of *Pseudovirgatites;* moreover, it included some descriptions of recently collected material and of old specimens.

The collections of Bachmayer perhaps contained more material *(cf.* Bachmayer 1958). Despite great efforts, the specimens quoted in Czech publications

from Moravia (Matzka 1936; *fide* Hanzlikova 1965, p. 40—41) could not be found. It seems that all the material available at present has been studied. Professor Pokorný was kind enough to send the copies of illustrations and descriptions contained in the paper by K. Matzka. However, their reliable interpretation is rather difficult.

The examination of the Czechoslovakian collections from Stramberk yielded no additional specimens of this genus. Up to now this genus s. str. is known only from Austria, ČSSR, and Poland[1].

Generic diagnosis: Genus dimorphic. Inner whorls always decorated with dense, well contoured, fine ribs. Points of furcation usually low. The following stages generally have polygyrate or bidichotomous to fasciculate (rarely virgatotome) ribs, more loosely spaced and coarser. External whorls of macroconch forms with dichotomous to polygyrate ribs (*cf.* Kutek & Zeiss 1974, p. 502).

Pseudovirgatites scruposus (Oppel, 1865)
(Pl. 1, Figs 1—2 and Pl. 2, Fig. 7)

1865. *Ammonites scruposus* Oppel; A. Oppel, Tith. Et., p. 557.
1868. *Ammonites scruposus* Opp.; K. A. v. Zittel, Stramberg, p. 115, Pl. 24, Fig. 3a—b.
1905. *Perisphinctes (Pseudovirgatites* nov. subgen.) *scruposus* Oppel; H. Vetters, Juraklippen, p. 227, Pl. 21, Fig. 1; Pl. 22, Figs 1—4.
1974. *Pseudovirgatites scruposus* (Oppel); M. Książkiewicz, Tith. Woźniki, p. 449, Text-fig. 2; Pl. 1, Fig. 1.

Material: Originals of Zittel (1868) and Vetters (1905) as far as figured (Bayer. St. Slg. Paläont., München; Krahuletz Museum, Eggenburg; Geol. Inst. Univ. Wien).

Dimensions (in *cm*):

D	H	W	U	IR
51.8	10.9 (0.35)	7.3 (0.23)	13.8 (0.44)	18

Remarks on the type specimen: Oppel (1865, p. 557) studied only one specimen when establishing the species, which became a holotype due to monotypy (*IRZN, Art. 73a*). Zittel (1868) apparently illustrated this specimen and reported additional ones presumably derived from other localities. The holotype consisting only of a fragment of the external whorl with small remains of the whorl following inside (Pl. 2, Fig. 7) corresponds to the large Eggenburg specimens at $H = 7.5$ cm. For the understanding of this species, illustrations of other specimens by Vetters (1905) are important; especially the shape of a nearly complete specimen from the Eggenburg collection is useful for the specific diagnosis (see Pl. 1).

Diagnosis: A species of large size, inner whorls with very dense ribbing, dichotomous to bidichotomous, in part with low branching ribs; two outer whorls with more loosely spaced ribs furcating in the middle of the flanks into 2—4 branches (mainly polygyrate). Intercalated ribs frequent, cross-section trapezoidal, with flanks converging to a relatively small, arched external side. Ribs originate on the umbilical wall.

Remarks. — The species was carefully described by Vetters (1905), and additions are only necessary with respect to changes in the style of sculpture during the ontogeny. Since the opposite side of the Eggenburg specimen shows much better the form of the adult sculpture, it has been also illustrated (Pl. 1, Fig. 1).

On the inner whorls of the large specimen of the Eggenburg collection, points of furcation can be recognized at about 16—17 mm *UW*, slightly above the umbilical edge. Presumably they are also present on the innermost whorls in this position, however not clearly recognizable. The inner whorls have a very fine ribbing. From 53.3 mm *UW* points of furcation are also shifted upwards the

[1] The paper of Fülöp (1976) quoting *Pseudovirgatites scruposus* from Hungary was received after this study has been completed.

flanks. These are either primary points of furcation on approximately a third of the whorl height or secondary points of furcation in different whorl height. In the latter case we are concerned with polygyrate branching ribs of which the first branch splits up very deep while the second one ramifies at different whorl height. In some places the first branches seem to divide again in the middle of the whorl. At deeply branching ribs an obscure polypoke branching may occur in which case only the last and foremost rib branch is clearly recognizable, whereas the V-shaped field between them appears to be nearly smooth.

At 75 mm umbilical width 4—6 external ribs belong to one primary rib. Only from this point (corresponding to the first measurable value of the whorl 67.5 mm high) the external ribs can be clearly seen. With growing diameter polygyrate and bidichotomous ribs follow, rarely also with two intercalatories. On the last whorl there are dichotomous ribs, too.

The continuing fine ribbing reaches up to U = 35 mm, followed by a slightly dense ribbed stage up to U = 55 mm. After that there is an increase in spacing of ribs.

Remarks. — The differences to the species of *Pseudovirgatites*, recently described from Poland, have already been mentioned by Kutek & Zeiss (1974, p. 520), and those to *P. seorsus* (Oppel) indicated by Vetters (1905, p. 230).

Occurrence. — Stramberg Limestone, Klentnice Beds, Ernstbrunn Limestone (Upper Tithonian), Moravia (ČSSR) and northern part of Nieder-Österreich; also Southern Poland.

Pseudovirgatites sp. juv., aff. *scruposus* (Oppel, 1865)
(Pl. 2, Fig. 2a—2b)

Material: One specimen from Paläont. Inst. Univ. Wien (*coll.* Krystyn).
Dimensions (in *mm*):

D	H	W	U	IR	ER
46.1	21.20 (0.46)	13.2 (0.286)	1.07 (0.23)	22	64

Description. — Because the specimen has no trace line of a further whorl and its last half whorl is occupied by body chamber, it is assumed to be a juvenile form. The specimen has a narrow umbilicus, high whorls and a narrow trapezoidal cross-section. External side slightly convex; umbilical edge slightly rounded; umbilical wall steep. Ribs dividing at umbilical edge; further ramifications may follow in the mid-height. The secondaries curving forward to the external side, passing it with a convex bend. Simple ribs present. The sculpture elements are arranged in the same way as on inner whorls of larger specimens of *Pseudovirgatites*. However the shell dimensions differ it from the species already known, as *P. scruposus* and *P. seorsus* have a wider umbilicus at the same diameter. In addition, *P. seorsus* has an external furrow which is not developed on the specimen described here. Moreover, that has a larger value for the whorl-width. How far the specimen may belong to the variation of another species cannot be decided with the scarce material well preserved. Because a part of the last whorl is missing no statement can be made on the relationship of this specimen to *P. puschi*. Since those forms have not been known until now the specimen is illustrated here. In the author's opinion it is a juvenile specimen belonging to the stock of *P. scruposus* (Oppel). The specimen differs from the representatives of *Ilowaiskya tenuicostata* in better marked umbilical edge, deeper and stronger marked points of furcation as well as in dimensions.

Occurrence. — Klentnice Beds, way north of Niederleis to Buschberg/N.Ö.

Pseudovirgatites sorgenfreii sp. n.
(Pl. 2, Fig. 4)

Material: One specimen from Paläont. Inst. Univ. Wien (*Coll.* Krystyn).
Typical horizon and locality: Klentnice Beds, way north of Niederleis to Buschberg (N. Ö.).
Dimensions (in *mm*):

	D	H	W	U	IR	ER
(Holotype)	65.3	22.1 (0.32)	20.1 (0.31)	23.7 (0.36)	18	52
	55.9	21.2 (0.38)	19.2 (0.33)	20.1 (0.34)	19	65

Derivation of the name: In memory of the late Professor Dr. T. Sorgenfrei, an outstanding student of the Jurassic and Tertiary of Denmark.
Diagnosis: A species of the genus *Pseudovirgatites* characterized by its small size.

Description. — The shell characterized by wider umbilicus and lower whorls as compared with other species. The last three quarters of the outermost whorl are occupied by the body chamber. All these characteristics of the shell show that we are probably concerned with a microconch specimen. The sculpture exhibits a remarkable change: up to 11 mm *H* the ribs are very dense, often branching already at the umbilical edge. A further furcation takes place in the middle of the whorl height. Sometimes the second splitting is polygyrate. On the body chamber the primary ribs become more distant. No bidichotomous branching occurs there, but only the splitting up into three of four branches. The outermost parts of the ribs are curving forward to the periphery and crossing in a convex arch (similar as in *Kossmatia* and inner whorls of *Pseudovirgatites* sp. juv.). An external furrow not present. Four constrictions can be seen on the last whorls, connected with them irregularities appear in the arrangement of sculpture. Umbilical wall steep. Ribs sometimes thickened at the umbilical seam. Whorl-section almost rectangular.

Remarks. — Due to different dimensions of the shell the new form can easily be distinguished from the already described species.

Pseudovirgatites seorsus (Oppel, 1865)
(Pl. 2, Fig. 6)

1865. *Ammonites seorsus* Opp.; A. Oppel, Tith. Et., pp. 536—537.
1868. *Ammonites seorsus* Opp.; K. A. v. Zittel, Stramberg, p. 114, Pl. 24, Figs 1—2.
Material: One specimen (holotype) from Bayer. St. Slg. Paläont. München.
Dimensions (in *mm*):

D	H	W	U	IR
10.0	0.35	0.30	0.39	26

Description. — Inner whorls with ribbing similar as in other Pseudovirgatites. Additionally the periphery has a furrow. There is a relative high value for the whorl width. This also applies to the preserved part of the outer whorl which at the beginning shows dichotomous and polygyrate ribs. The first point of furcation is placed on the middle of the flanks and the second one even higher. At the end of the last whorl three- to four-branched ribs of the fasciculate type are observed. The primary ribs are thickened. The point of furcation is obscure and situated on the inner third of the whorls. Intercalatories are present. The course of the ribs on the outer whorl is nearly recticostate. Constrictions are recognizable.

Remarks. — At the same diameter, *Pseudovirgatites seorsus* differs considerably from *P. scruposus*. The ribbing is more distant and reaches earlier the habitus of an adult one. The direction of the ribs is radial. The branching does

not occur near the umbilical seam. The final stage of sculpture is marked by relatively deep branching of fasciculate ribs. It is not certain whether a further stage with simple ribs, as in other (macroconch) *Pseudovirgatites*, followed. Further distinctions were given by Vetters (1905, p. 209).

Occurrence. — "Exotic blocks of Teschen, Bobrek and Chlebowitz" (Zittel 1868).

Genus *ILOWAISKYA* Vialov, 1940

Concerning the definition, justification, and delimination of the genus compare the data presented by Illovaisky & Florensky (1941), Zeiss (1968), and especially by Kutek & Zeiss (1974, p. 527 and 519).

Ilowaiskya tenuicostata occidentalis subsp. n.
(Pl. 3)

Material: One specimen (holotype) from Prir. Fak. Univ. Karl., Praha (*Coll.* Pokorný 1960).
Dimensions (in *mm*):

D	H	W	U	IR	ER
156.35	47.2 (0.31)	43.2 (0.28)	78.1 (0.50)	35	70
125.10	38.3 (0.31)	35 (0.28)	56.6 (0.46)	36	71

Derivation of the name: Latin *occidentalis* — western, after the westernmost occurrence of the species.
Type locality and horizon: Klentnice, football playground; Klentnice Beds. In the Klentnice area, these Beds are closely contacting the overlying Ernstbrunn limestone. At the type locality, however, the contact is tectonically disturbed (information by Dr. Houša). Thus no statement can be made in which part of the Upper Klentnice Beds the occurrence site is really situated.
Diagnosis: A subspecies of *Ilowaiskya tenuicostata* with the following peculiarities: at the same diameter the value of the umbilical width is much higher than that of the holotype of the species; direction of the ribs is ± recticostate.

Description. — Shell of middle size, incomplete; one quarter of the outer whorl is missing. Cross section high-rectangular; periphery arched upwards. Umbilical seam marked, umbilical wall steep. Inner whorls with relatively narrow, outer ones with relatively wide umbilicus; 6—7 constrictions per whorl. The sculpture is very distinct and sharp. On the inner whorl the ribs are dense and fine. The branching occurs already above the umbilical edge, in most cases bidichotomous. Rarely polygyrate, single, and intercalated ribs are recognizable. On the outer half of the penultimate whorl the ribs become more distant. The branching points above the umbilical seam are beginning to disappear. The ribs become more and more dichotomous (points of furcation slightly above the middle of the flanks). Sporadical deep-branching, bidichotomous or polygyrate ribs are observed. On the outer whorls these two kinds of ribs are limited to the neighborhood of constrictions. Apart from this the style of ribbing is dichotomous. Only on the outermost whorl single ribs occur.

Remarks. — Contrary to the Polish forms (Kutek & Zeiss 1974) it has to be mentioned that no flexuous direction of ribs can be recognized on the specimen studied. This means that the ribs have nearly a radial direction (recticostate). Only on the periphery a slight bending forward can be observed, which is especially remarkable on the inner whorls of the shell. Among the specimens of the Volga Province, two specimens illustrated by Michailov (1964, Pl. 10, Figs 1 and 3) are well comparable as far as the sculpture is concerned. However, these specimens have not such well defined transition fields between the densely ribbed inner whorls and the dichotomous outer whorls. The ribs, too, are not so sharply developed (?preservation). Kutek & Zeiss (1974, p. 519) have already reported

a large variability of the species. However, as compared with the holotype of the nominal subspecies, the present specimen shows, at the same diameter, a distinctly wider umbilicus. The same may also apply to the Polish specimens.

Tribus *Sublithacoceratini* Zeiss, 1968

When emending the subfamily Pseudovirgatitinae, the author (Zeiss 1968) intended to unite the descendents of Lithacoceratinae. Despite their separate provincial development, they show a number of common characteristics, which can be considered as a distinct grade in the development of Upper Jurassic Perisphinctidae. Thus a too large splitting up can be avoided as it would happen in a pure cladistic classification. This would lead to the necessity to introduce at least four subfamilies: Pectinatitinae, Pseudovirgatitinae, Sublithacoceratinae and Franconitinae. But as long as the relationship among these groups as well as their origin are not better explained, it seems more appropriate to unite the descendents in one subfamily only, i.e., not to revaluate taxonomically the tribus Sublithacoceratini.

Genus *ISTERITES* Barthel, 1975

Although it had been mentioned earlier in literature (Barthel 1969, p. 151; Kutek & Zeiss 1974, p. 524), the generic name Isterites has been validly introduced only recently (Barthel 1975, p. 426). With respect to the minor number of species mentioned by Barthel (1975), a wider interpretation is supported by Kutek & Zeiss (1974) including the earlier mentioned species.

Isterites austriacus Kutek & Zeiss, 1974
(Pl. 2, Fig. 5)

1905. *Perisphinctes* cfr. *Nikitini;* Vetters, Niederfellabrunn, p. 232—233, Pl. 22, Fig. 5 [*holotype*].
1974. *Isterites austriacus* nom. n.; Kutek & Zeiss, Tith.-Volg. Amm., p. 525.
Material: Geol. Inst. Univ. Wien (*1896 VIII.12*).
Dimensions (in *mm*):

D	H	W	U	IR	ER
107	36 (0.34)	28 (0.28)	40 (0.37)	15	42
80	27 (0.34)	25 (0.31)	32 (0.40)	14	45

Diagnosis: A species of the genus *Isterites* of middle size with relatively regular, three-to--four-branched ribs on the last whorl.

Description. — On the last whorl there are regular three-branched ribs; the distances between them are considerably fluctuating. Besides regular ribs, constrictions and umbilical approaching of ribs, beginning with the last whorl, intercalations of external intercalatories and transitions to four-branched rib--units develop. The umbilical wall is vertical, the umbilical seam distinctly developed. The primaries are thickened in the region of the umbilical seam. The shell is moderately evolute. The elliptical cross-section is largest at the umbilical seam; with growing diameter the shell becomes trapezoidal with the external side slightly arched upward, and marginal edges rounded. The sculpture is somewhat similar to that of *Zaraiskites*. However, the normal (that means distant) ribbing of the inner whorls do not indicate a relation to this genus, of which the inner whorls are densely ribbed.

Remarks. — Without any doubt *Isterites austriacus* belongs to the group of *Isterites mazoviensis* Kutek & Zeiss. The latter has an arrangement of the sculpture more regular than all the other species of *Isterites*. The species *Isterites subpalmatus* appears to belong to the transition field between the older, irregularly ribbed forms and the group of *I. mazoviensis*.

A specimen described as *"Provirgatites pommerania"* by Arkell (1935, p. 340, Pl. 25, Fig. 1) corresponds rather well with *I. austriacus*. However, in that species the four-branched ribbing stage begins earlier, the branched bundles are more projected and regularly spaced. Furthermore, this species develops also constrictions and other irregularities, but not the thickening of ribs at the umbilical seam. The species *"Provirgatites" pommerania* has less densely ribbed inner whorls thus presumably it does not belong to *Zaraiskites* (*"Provirgatites"*), but rather represents a descendent species of *Isterites*, like *I. austriacus* and *I. mazoviensis*.

Probably the more than three-branched species of *Isterites* with regular ribbing style like *I. austriacus* and *I. pommerania* evolved from the three--branched *I. mazoviensis*. The species *I. mazoviensis* occurs in the lower scythicus zone, while *I. pommerania* and *I. austriacus* belong to the same zone, but may characterize younger horizons.

In earlier times the relatives of *Isterites* were regarded as species of the genus *Anavirgatites* Spath. Because there are only a few usable illustrations of this genus, a better preserved specimen of *A. divisiformis* Spath, from the British Museum (*No. C. 49 269*) is figured (Pl. 2, Fig. 3). The analogies with *Isterites* are insignificant. However, some specimens published by Verma & Westermann (1973, p. 211, Pl. 39, Fig. 5 and Pl. 40, Fig. 1) under the name *"Kossmatia alamitosensis (Aguilera)"* show similarities. Thus *Anarvirgatites* is supposed to be an extreme or special development of *Kossmatia*. Because the specimens from Mexico are of lower Upper Tithonian age, the related East-African forms presumably have a similar age.

Occurrence. — Klentnice Beds (Upper Tithonian), Grünstallwand near Niederfellabrunn/N.Ö.

Subfamily **Dorsoplanitinae** Arkell, 1950
Genus *PAVLOVIA* Ilovaisky, 1917
Pavlovia iatrensis Ilovaisky, 1917
(PL. 2, Fig. 1)

1905. *Perisphinctes* sp. ind.; Vetters, Juraklippen, p. 235.
1917. *Pavlovia iatrensis* var. *primaria*; Ilovaisky, Amm. Liapine, p. 93, Pl. 1, Fig. 1a—g; Pl. 23, Fig. 1a—b; Pl. 25, Fig. 1.
1917. *Pavlovia iatrensis* var. *micromphala;* Ilovaisky, Amm. Liapine, p. 106, Pl. 1, Fig. 3a—e.
1917. *Pavlovia iatrensis* var. *abscendens;* Ilovaisky, Amm. Liapine, p. 119, Pl. 2a—d; Pl. 23, Fig. 6.
1917. *Pavlovia iatrensis* var. *secundaria;* Ilovaisky, Amm. Liapine, p. 110, Pl. 1, Fig. 4a—c; Pl. 23, Fig. 4; Pl. 25, Fig. 17.
1917. *Pavlovia iatrensis* var. *ulterior;* Ilovaisky, Amm. Liapine, p. 113, Pl. 1, Fig. 5a—b; Pl. 4, Fig. 8a—b; Pl. 23, Fig. 5.
1917. *Pavlovia iatrensis* var. *neara;* Ilovaisky, Amm. Liapine, p. 141, Pl. 2, Fig. 1a—e; Pl. 23, Fig. 9.
1917. *Pavlovia iatrensis* var. *gracilis;* Ilovaisky, Amm. Liapine, p. 179, Pl. 4, Fig. 5a; Pl. 5, Fig. 1a—g; Pl. 29, Fig. 14a—c; Pl. 25, Figs 5 and 8.
1917. *Pavlovia iatrensis* var. *strongyla;* Ilovaisky, Amm. Liapine, p. 121 and 125, Pl. 2, Fig. 3a—d; Pl. 8, Fig. 2a—b.
1924. *Pavlovia iatrensis* Ilov.; Ilovaisky, Pavlovia, p. 337.
1966. *Pavlovia iatrensis* Ilovaisky, emed. Michailov; Michailov, Boreal Jur. Amm., p. 49, Text-figs 22—24; Pl. 9, Fig. 3; Pl. 15, Fig. 1.

Material: Geol. Inst. Univ. Wien (*1896 XVII.9*).

Dimensions (in *mm*):

D	H	W	U	IR	ER
34	12.8	—	12.8	14	28

Description. — Shell small, somewhat involute, becoming slightly eccentric towards the end, lateraly (?and trangentially) somewhat compressed, thus external ribs at the end of the last whorl are not really curved forward. Ribs rectiradiate and somewhat prorsiradiate. Point of furcation in the middle of the flanks. Dichotomous ribs alternating with single and polygyrate ribs, especially close to the constrictions.

Remarks. — A small form of the large number around *Pavlovia iatrensis* (cf. Ilovaisky 1917, p. 85). This species was revised and recently emended by Michailov (1966, p. 49). Considering the varieties gathered together under this name by Michailov (1966, p. 49) as definition for the content of the species good possibilities for comparisons are offered. But due to the lateral compression of the specimen investigated, the comparisons are limited. Especially similar are some illustrations presented by Ilovaisky (1917, Pl. 1, Fig. 1e, Pl. 2, Fig. 1c and 2 apart from the last half of the external whorl).

A comparison with a specimen of *Pavlovia iatrensis* of the Leningrad collection which Prof. Krimholz kindly supplied to the author, also yielded a good correspondence.

Occurrence. — Klentnice Beds, Niederfellabrunner Keller/N.Ö.

BIOCHRONOLOGY

THE AGE OF THE KLENTNICE BEDS

Pokorný (1973) has recently presented a detail discussion of the age of the Klentnice Beds. Due to investigations of the foraminiferal faunas, Hanzlikova (1965) had assumed an age between the Upper Oxfordian and Upper Portlandian, while researches on ostracodes by Pokorný (1973) suggest a Tithonian to Berriasian age. In turn, Vašiček (1971) dated the Klentnice Beds down to the Lower Oxfordian on the basis of ammonites and aptychi found in core material from drillings.

The statements of Spath and Arkell (1956) concerning the problem of age of the Klentnice Beds can be regarded as outdated with regard to the interpretation of ammonites, described by Vetters (1905).

Far more important are the explanations of Bachmayer (1958), on the age relation between the Stramberg Limestone, the Ernbrunn Limestone and the Klentnice Beds. Due to a comparison of ammonites the Stramberg and Ernstbrunn limestones are assumed to be of the same age. Only in parts this comes true for the Klentnice Beds: on one hand they interfinger with the Ernstbrunn Limestone (same age) and on the other they are underlying it (older age). Concerning the exact age of the Ernstbrunn Limestone, Bachmayer refers to the Upper Tithonian species like "*Virgatosphinctes transitorius*" and the Lower Tithonian like "*Subplanites contiguus*". With respect to the latter species, its typical specimens were derived from the uppermost Lower Tithonian, but similar forms are also known from higher beds, as for example certain species of *Pseudosubplanites* and *Parapallasiceras* (cf. Hégarat 1973). Confusion is possible among such microconch genera,

especially when the material is badly preserved. Perhaps the *contiguus*--group reaches the younger horizons than those known till now. On the other hand, the Stramberg Limestone may correspond to different zones (Fallauxi to Jacobi zones) as it is suggested by the faunas listed by Houša (1975). Whether this is also true in the case of the Ernstbrunn Limestone can only be concluded after the final study of the ammonites found there is made.

Ammonites are very important for dating the Klentnice Beds. The ammonites so far described from the Upper Klentnice Beds allow to draw the following conclusions:

(i): Pseudovirgatites scruposus

According to Bachmayer (1958) this species occurs in the Klentnice Beds, which partly are of the same age and partly somewhat older than the Ernstbrunn Limestone. Regarding its phylogenetic development within the genus *Pseudovirgatites* this species comprises progressive forms which, therefore, must be younger than the Polish group clustered around *Pseudovirgatites puschi*. Especially much larger size of the shell with its long lasting pseudovirgatite sculpture indicates a better developed form as opposed to the *puschi* group (*cf.* Kutek & Zeiss 1974). Thus, it is not wrong (Bachmayer 1958) to regard the *puschi* group as a direct ancestor of *P. scruposus* which is occurring together with *Z. scythicus*.

(ii): *Pseudovirgatites* sp. juv. and *Pseudovirgatites sorgenfreii*

Both new forms are not known from older beds. They also differ from *P. puschi* and related forms and may be indicative of a somewhat younger horizon, like *P. scruposus*.

(iii): Isterites austriacus

This species is also a late phylogenetic form of the genus and a further development of *Isterites mazoviensis*, thus indicating a younger age of this species, that is, corresponding to upper scythicus zone.

(iv): Pavlovia iatrensis

This species is indicative of an equivalent of the scythicus (iatrensis) zone in Poland and Russia.

(v): Ilowaiskya tenuicostata occidentalis

This species suggests an equivalent of the *P. puschi* Zone of Poland. Thus in the Moravian part of the Waschberg zone (Ždanice unit) somewhat older parts of the Klentnice Beds are identified by ammonites. However the difference in age is not great.

Other, less satisfactorily preserved ammonites of the Klentnice Beds figured by Matzka (1936, Pls 16—17) are extremely difficult to determine. The illustration of a *"Haploceras"* might also well be an *Aspidoceras* or *Semiformiceras*; the *Oppelia* may either belong to *Neochetoceras* or *Uhligites*, and *"P. scruposus"* resembles rather a *P. transitorius*.

To the forms here dealt with we have to add those figured by Vetters (1905) such as *Substreblites* sp. sp. (Vetters, Pl. 17, Fig. 8—9), *Spiticeras? reniforme* (Vetters, Pl. 17, Fig. 6a—b), *Pseudosubplanites* sp.

sp. (Vetters, Pl. 16, Fig. 3, Pl. 18, Fig. 7). All these forms are characteristic of the Lower Upper Tithonian.

Finally Bachmayer (1958) mentioned the following species:

„Calliphylloceras ptychoicum (Oppel)
Thysanolytoceras liebigi strambergensis (Zittel)
Hemilytoceras montanum (Oppel)
Provirgatites scythicus (Vischniakoff)
Subplanites cf. *contiguus* (Cat.)
Pseudovirgatites scruposus (Oppel)".

This fauna can be regarded as of Upper Tithonian age, with the exception of *S.* cf. *contiguus.*

A review of age-relations of the Klentnice Beds to contemporaneous beds in Poland, S-Germany and N-Austria is given in Table 1.

Table 1
Stratigraphic position of the Klentnice Beds and their correlation

Subboreal zones in Poland see: Kutek & Zeiss (1974)	Tomaszów Maz., Central Poland	Moravia (ČSSR)		Lower Austria (N-Österreich)	Southern Frankenalb		Submediterranean zones (Middle Europe)	
Zaraiskites zarajskensis	Limestones with serpulids, Limestones and Marls	Stramberg Limestones s. l. "Hauptfauna" "ältere Fauna"	Ernstbrunn Limestones	Ernstbrunn Limestones			Paraulacosphinctes transitorius, Crassicollaria	A
Zaraiskites scythious (Isterites pomerania)	Marls $a_3 - b_2$		Upper Klentnice Beds	Klentnice Beds	Neuburg Formation	238 Upper Oberhausen Member 190–237	Pseudovirgatites scruposus (Isterites austriacus, Pavlovia iatrensis)	
Ilowaiskya tenuicostata	Marls $a_1 - a_2$			?		190–237 Lower Oberhausen Member 117–190	Pseudovirgatites puschi (Isterites subpalmatus, Ilowaiskya tenuicostata occidentalis)	
Ilowaiskya pseudoscythica	Marls and Clays					117–190 Upper Unterhausen Member 61–116	Pseudolissoceras bavaricum (Isterites palmatus, Semiformiceras fallauxi)	

THE PRESENT-DAY CORRELATION OF THE UPPERMOST JURASSIC

Difficulties with obtaining a satisfying correlation of the uppermost Jurassic layers are well known. In certain regions occurred strong regressions toward the end of the Late Jurassic time, beginning with shallowing of sea-level and separation of the marginal parts of the basins. Thus, distinct faunal provinces developed. Only in a few places we know of faunal overlapping. This concerns partly the deposition of the Berriasian, which is moreover regarded as the basal stage of the Cretaceous.

As the ammonites were developing a more or less stronger provincialism in latest Jurassic time it is often necessary to refer for the purpose of correlation to other animal groups like tintinnids,

ostracodes, aptychi, etc. All the difficulties connected therewith are well known and need not be discussed here again (*cf.* Casey & Rawson 1973). By the use of such fossil groups it was possible in the last few years to correlate the Upper Jurassic zonal sequences over far distances and from different faunal provinces. Thus in the western part of North America the correlation between the Boreal Upper Volgian and the Andine circumpacific Tithonian could be better established by Imlay & Jones (1970) who discovered layers which had yielded Boreal as well as Tithonian ammonites. This very important region of interfingering guide fossils of both provinces made it possible to connect the subdivisions of *Buchia*-bearing beds of Southern Canada and the sequences with Boreal ammonites in Northern Canada (*cf.* Jeletzky 1965, 1966, 1973; Frebold 1957, 1961; Frebold & Tipper 1970). On the other hand correlation was possible with the circumpacific Upper Jurassic classification, as e.g. established by Verma & Westermann (1973) in Mexico. Beside of some smaller alternations this classification can be followed down to Southern America (Leanza 1945, Arkell 1956).

Nowadays it is to some extent possible to trace connections from the Andine Upper Jurassic to the European Mediterranean area via Japan, the Himalaya, Asia Minor as well as northern and eastern Africa. However, in detail there are many questions open, because we have no sufficient knowledge about the exact distributions and ranges of many Middle and Upper Tithonian ammonite genera and species, or only conflicting data about it exist. Thus it is very difficult to establish an exact zonation based on index species (chronozones); often the zonation is only possible by "assemblages".

In Europe, the correlation of the Upper Jurassic zonal sequences between the Mediterranean and Submediterranean area has been put forward in southern Spain by Enay & Geyssant (1973). On the basis of new collections of ammonites they proposed a new zonal subdivision for the Tithonian stage in Southern Spain[2]. By this the comparison between the Mediterranean and Submediterranean areas, which have been investigated by Donze & Enay (1961), Barthel (1962, 1969, 1975), and Zeiss (1968, 1975), has been facilitated and completed. Subsequently, Hégarat & Remane (1968) and Hégarat (1973) added considerable facts by using calpionellids and ammonites for the zonal subdivisions simultaneously (see also Allemann & al. 1975). Memmi & Salai (1975) contributed a very detailed faunal analysis and subdivision of the Mediterranean area of Tunisia.

Concerning the Submediterranean and Subboreal Upper Jurassic beds of Central Europe, Kutek & Zeiss (1974, 1975) succeeded in

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[2] This has been changed and supplemented in a very recent Thesis of F. Oloritz (1976), which is still in course of publication and therefore has not been included in Table 2.

correlating them. With respect to zonal subdivision of the southern USSR, the range of species as well as the correlation of Upper Jurassic and lowermost Cretaceous beds in the area of interfingering of Mediterranean and Subboreal faunal elements (north-eastern Caucasus, Mangyschlak) the following papers are important: Sakharov (1975), Schulgina (1975), Luppov & al. (1975), Gerasimov & al. (1975), Yegoyan (1975) and Druschits (1975).

In detail the zonal correlation is to some degree still problematical, especially for the Upper Tithonian. Complete descriptions of ammonite faunas of this important region are urgently needed. In contrast, the correlation of the Boreal Upper Jurassic of Sibiria (Michailov 1964, 1966, Shulgina 1967, Zakharov & Mesezhnikov 1974), with the Subboreal Upper Jurassic of the Russian Platform has been well established.

The correlation with the English Upper Jurassic is posing more problems. But when the current researches in England are finished (*cf.* Cope 1973) a much clearer picture about the possibilities of correlation is supposed to be available. The problems especially concerned are the detailed chronostratigraphic position of the "Purbeck"-beds as well as the correlation of the sequence P. albani — T. giganteus Zone, and that of the basal and uppermost Pavlovia zones with the sequences of the Russian Platform and the Submediterranean area. The correlation with the English Upper Jurassic is more difficult than it was believed earlier (*cf.* Zeiss 1968), since new results of the Submediterranean and Subboreal areas, and even of England have been published by Cope & Wimbledon (1973), Casey (1973), and Kutek & Zeiss (1974). One conclusion from these results follows already now: as, according to the present interpretation, the English Pavlovia pallasioides-rotunda zones are corresponding to the Russian Zaraiskites zones, the Lower Neuburg Beds (Unterhausen member) must be somewhat older than supposed hitherto (see Table 1).

For the Purbeck beds a certain limitation of the age boundaries has resulted from the work of Dembowska & Marek (1974):

> In Central Poland the Purbeck beds lie between the Virgatites and rjasenensis zones. They correspond, according to Anderson (1973), in larger part with the English Lower Purbeck beds and according to Bischoff & Wolburg (1963) to the Münder marls and the Serpulite of NW Germany. They also should correspond to the Purbeck of the Jura Mountains in Switzerland and France. If the correlations of Imlay & Jones (1970) and of Jeletzky (1973) are valid, the upper boundary of the Volgian and Tithonian are obviously the same. In such case the placing of the upper boundary of these stages by Casey (1973) needs revision. This author considered the Lower Purbeck beds and the Cinder bed as Upper Volgian; if so they would after Imlay & Jones (1970) and Jeletzky (1973) also correspond to the Upper Tithonian. This means that the ostracode zones of *Fabanella ansata*, *Cypridea dunkeri* and *C. granulosa* would belong to the Upper Jurassic as indicated by Dembowska (1973, Table 26) and by Anderson (1973, Table 1). These zones are

contained in divisions *B*—*F* of the Polish section; division *A* may represent the equivalents of the Grandis and Occitanica zones which underly the Malbosieras paramimoumum Zone (*cf.* Hégarat 1973) where the first *Riasanites* appear in the USSR (Sakharov 1975, Luppov & al. 1975). Or, if division *A* is equivalent to the Cinder Bed (Anderson 1973), there are no equivalents of the Grandis and Occitanica zones represented in the Purbeck beds, which seems rather improbable. Thus, it should be kept in mind that the Cinder Bed might not be situated at the upper boundary of the Volgian but somewhat higher. In such a case the Serpulite of NW Germany (C. granulosa Zone and its equivalents: upper part of the English Lower Purbeck Beds, *B*—*C* of Poland, see Anderson 1973) probably represent the Grandis and Occitanica zones, while the Münder marls (Dunkeri and Ansata zones) and their correspondents (lower part of the English Lower Purbeck Beds, *D*—*F* of Poland) belong to the uppermost Jurassic. This distribution is also indicated by a figure of Dembowska & Marek (1974, Table 1), but in the text (p. 112) they propose different ages.

Perhaps a revision of the ammonites found in the Purbeck Beds of the Jura Mountains, which Arkell (1956) regarded as Upper Tithonian, Donze (1958) however as Berriasian, could perhaps lead to a clarification; one should not omit the arguments of Persoz & Remane (1976), suggesting rather an Upper Tithonian age of the Purbeck Beds in the Jura Mountains.

The author has tried to summarize the more recent results

Table 2

Tentative correlation of the Upper Jurassic zonal sequences of different faunal provinces

Boreal (Siberia)	Subboreal: England	Subboreal: East European Platform, Poland		Submediterranean (Middle Europe)	Mediterranean (S Europe, N Africa)		Circumpacific-indic (America, Asia, Africa)
Ch. chetae, Cr. singularis	Suboraspedites lamplughi	Craspedites nodiger	C. dunkeri	Berriasella oppeli	Berriasella jacobi	B	Substeuroceras koeneni (Spiticeras, Berriasella, Paradontoceras, Aulacosphinctes, Pronicoras, Dalmasiceras, Blanfordiceras)
Cr. taimyrensis	S. preplicomphalus						
Cr. originalis Cr. okensis	S. primitivus	Cr. subditus					
V. exoticus		K. fulgens	P. ansata,				
Epilaugeites vogulicus	Paracraspedites oppressus	Epivirgatites nikitini		Paraulacosphinctes transitorius	Durangites	A	Corongoceras alternans (Durangites, Kossmatia, Amavirgatites, Micracanthoceras, Virgatosphinctes, Aulacosphinctes, Hildoglochiceras)
Laugeites greenlandicus	Titanites giganteus						
Crendonites sp., Dorsoplanites saohsi	Kerberites, Crendonites, Glaucolithites gorei, Epivirgatites, Progalbanites albani, Pavlovia? (n.gen.)	V. rosanovi			Micracanthoceras micracanthum		
Dorsoplanites maximus		V. virgatus					
Dorsoplanites ilovaiskyi Pavlovia iatrensis	Pavlovia rotunda Pavlovia pallasioides	Z. zarajskensis Z. scythicus		Pseudovirgatites scruposus			
Pectinatites lideri	Pavlovia sp.	I. tenuicostata		P. puschi	M. ponti		W. internispinosum
		Ilowaiskya pseudoscythica		Pseudolissoceras bavaricum	S. fallauxi		Pseudolissoceras zitteli
					S. semiforme		
	Pectinatites pectinatus			D. palatinus	Neochetoceras darwini		Virgatosphinctes mendozanus
				Franconites vimineus			Mazapilites Uhligites
Subdichotomoceras subcrassum	Arkellites hudlestoni Virgatosphinctes wheatleyensis	Ilowaiskya sokolovi		Neochetoceras mucronatum			
Eosphinctoceras magnum	V. scitulus, V. elegans	I. klimovi		H. hybonotum	H. hybonotum		H. hybonotum

(Table 2), but insecurities had to be taken into consideration when correlating the sequences of zones. It is much to be hoped that further detailed work will help to clarify these problems.

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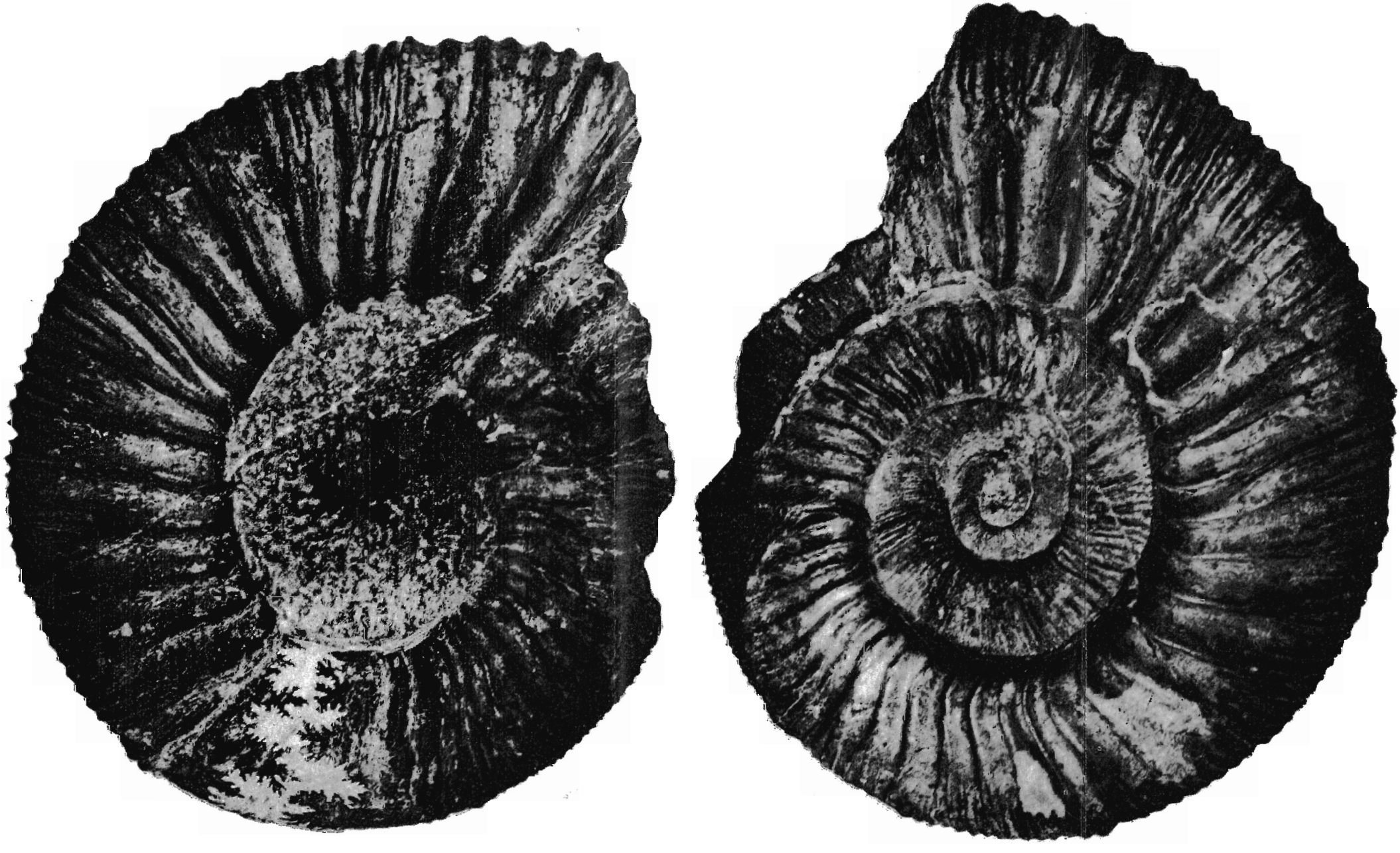
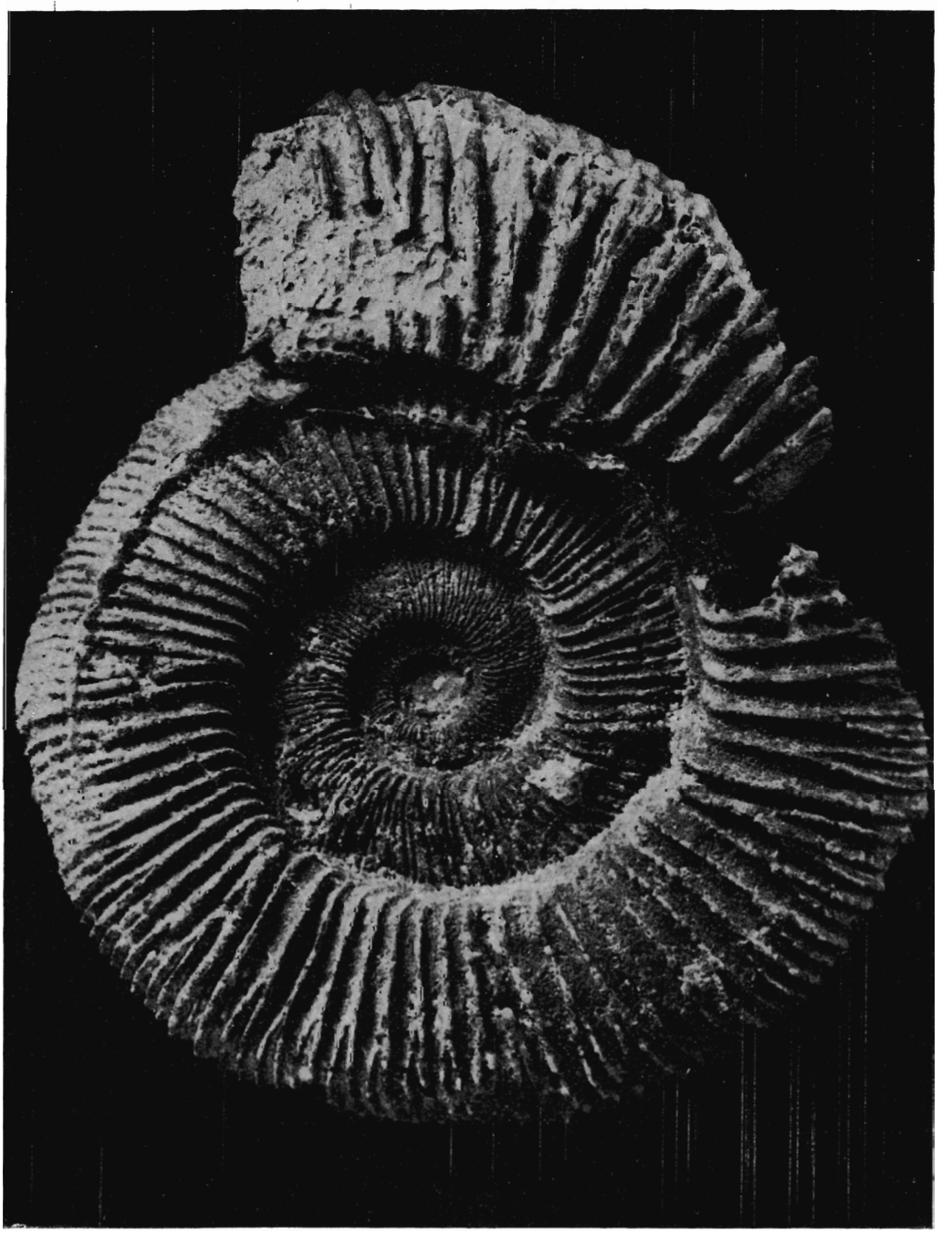


1--2 *Pseudovirgatites scruposus* (Oppel); Krahuletz Museum Eggenburg; × 0.5, taken from both sides; Klentnice Beds, Niederfellabrunn/N.Ö., Austria

1 *Pavlovia iatrensis* Ilovaisky; Geol. Inst. Univ. Wien; nat. size; Klentnice Beds, Niederfellabrunn/N.Ö., Austria
2a, b *Pseudovirgatites* sp. juv., aff. *scruposus* (Oppel); Paläont. Inst. Univ. Wien: nat. size; Klentnice Beds, N Niederleis/N.Ö., Austria
3 *Anavirgatites divisiformis* Spath; Brit. Mus. (Nat. Hist.) London; cast in nat. size; Upper Tithonian, Bihendala, Somalia
4 *Pseudovirgatites sorgenfreii* sp. n.; holotype kept at Paläont. Inst. Univ. Wien; nat. size; Klentnice Beds, N Niederleis/N.Ö., Austria
5 *Isterites austriacus* Kutek & Zeiss; holotype kept at Geol. Inst. Univ. Wien; nat. size; Klentnice Beds, Grünstallwand/N.Ö., Austria
6 *Pseudovirgatites seorsus* (Oppel); holotype kept at Bayer. St. Slg. Paläont. München; nat. size; exotic block, Tešin [= *Teschen* of Zeittel (1868)], Czechoslovakia
7 *Pseudovirgatites scruposus* (Oppel); holotype kept at Bayer. St. Slg. Paläont. München; nat. size; Stramberg Limestone, Ignaziberg, Czechoslovakia



Ilowaiskya tenuicostata occidentalis subsp. n.; holotype kept at Prir. Fak. Univ. Karl. Praha; nat. size; Klentnice Beds, Klentnice, Czechoslovakia