Age of Neuburg Formation (Bavaria, Federal Republic of Germany) and its correlation with the Subboreal Volgian and Mediterranean Tithonian

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with 2 figures

Abstract. Only the topmost Bed 238 of the Neuburg Formation is a lower Upper Tithonian deposit (middle and upper microcanthum Zone). The basal Upper Tithonian (Simplispinocerites Zone) is faulted out. The rest of the Oberhausen Member (Beds 117-237) is an upper Lower Tithonian deposit (fallauxi to ponti/Burckhardticeras Zones). The Unterhausen Member (i.e. the Pseudolissoceras bavaricum Zone), except for its basal Bed 22, is a middle Lower Tithonian (Fallauxi, = lower Middle Tithonian of some authors) deposit correlative with the semiforme/verruciferum Zone of the Mediterranean standard.

The Zaraiskites scythicus Zone of Central Poland and Central Russia is roughly equivalent to the Beds 102-112 of the Unterhausen Member bearing Zaraiskites-like ammonites. Therefore, it is a middle Lower Tithonian deposit correlative with the semiforme/verruciferum Zone. The next older Ilyoaiskhyia pseudoscythica Zone of these two Subboreal regions corresponds to the lower semiforme/verruciferum and upper darwinii/albertinum Zones of the Mediterranean Province as well as to the Bed 22 and the upper Rennersthofer Beds of the Franconian Basin. Therefore, the Central Russian Virgatites virgatus and Epivirgatites nikitini Zones correspond to the upper Lower Tithonian fallauxi to ponti/Burckhardticeras Zones of the Mediterranean standard. The entire Portlandian Stage of England is a Lower Tithonian deposit.

Isterites and Pseudovirgatites are exclusively mid to late Early Tithonian genera. The controversial Central European Pseudovirgatites scroopus Zone appears to be correlative with the upper semiforme/verruciferum and Zaraiskites scythicus Zones.

1. Introduction

There was a tight deadline for the submission of contributions to the Jurassic-Cretaceous Biochronology and Biogeography of North America volume. Furthermore, the length of my contribution to it (JELLETZKY, 1984) was severely restricted by the editor. The appended critical discussion of the paper by A. ZEISS and myself was a subject to an even tighter deadline and a greater restriction of the length. Therefore, I was unable to provide a detailed explanation and documentation of my opposition to KUTEK & ZEISS (1974, 1975) and ZEISS' (1968, 1977, 1979, 1983, and in JELLETZKY, 1984) claim that the Lower Volgian Zaraiskites-bearing beds of Central Poland are correlative with the basal Upper Tithonian Crassicollaria-bearing beds and the

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underlying *Isterites palmatus*-bearing beds of the Neuburg Formation, SW Germany. The refutation of this claim is most important as it forms the basis of the widespread, but in my opinion (JELETZKY, 1965, 1968, 1970, 1973, 1984) erroneous, idea that the Upper Tithonian Substage of the Tethyan Realm is largely or entirely correlative with the Upper Lower Volgian Stage (= Middle Volgian Substage of KUTEK & ZEISS, l.cit., ZEISS, l.cit. and other workers) of the Russian Platform and other regions of the Boreal Realm. Consequently, the adherents of this idea equate the next younger Upper Volgian Stage (or Substage) with the Lower Berriasian Stage of the Cretaceous System. This claim is based almost exclusively on the dating and correlation of the Neuburg Formation and the Brzostowka section of Volgian rocks in Central Poland by KUTEK & ZEISS (l.cit.) and ZEISS (l.cit.). My stated opposition to this claim (JELETZKY, 1984, p. 253) and allusions to the fact that it was already opposed, in part or entirely, by the majority of Soviet workers (most recently by MESSEZHNIKOV, in VAKHrameev et al., 1982, p. 131, 133, table 19) has failed to attract the attention of the readers. This was made obvious by oral discussion of the subject with Dr. A. ZEISS in Ottawa and western British Columbia in 1985 and written discussion with Dr. P. J. HOEDEMAEKER in 1986. This paper summarizes and documents my previously unpublished conclusions on the subject.

The manuscript was critically read by Dr. J. CALLOMON, University College, London, Great Britain who contributed materially to its improvement, particularly to the interpretation of the historical development of stratigraphic nomenclature of the Tithonian. However, a number of Dr. CALLOMON'S comments were unacceptable to the writer.

2. Age limits of the Neuburg Formation within the Tithonian Stage

The age limits of the Tithonian Neuburg Formation were in dispute ever since the original description of its ammonite fauna by SCHNEID (1915a, 1915b). However, the earlier stages of this controversy preceding the studies of BARTHEL (1962, 1964, 1969, 1975), BARTHEL & GEYSSANT (1973), ZEISS (1968, 1977, 1979, 1983, 1986, etc.) and KUTEK & ZEISS (1974, 1975) are of historical interest only. Furthermore, their results were already summarized and evaluated by BARTHEL (1962, p. 23, 24) and ZEISS (1968, p. 12–15). Therefore, these studies will not be further discussed and the reader is referred to these publications for further details.

Subsequent attempts to zone and to date the Neuburg Formation are marred by an extremely casual attitude of the workers concerned who mostly failed to define the proposed fossil beds and zones sufficiently for their effective use. No explanation at all was provided in many cases. Even the brief and scattered explanations provided occasionally are commonly obscure and contain errors about the time ranges of diagnostic ammonites or their taxonomy. The following historical comments shall stress those defects that affect materially the zonal subdivisions of the formation and its dating in terms of the standard Tithonian stages and zones.

2a. Older attempts at the zonation, dating and lithological subdivision

BARTHEL (1962, p. 24–27, table V) was the first to collect the ammonites of the Neuburg Formation bed by bed and to study their stratigraphic sequence in detail. Because of the
presence of *Pseudolissoceras* in the older and younger beds of the formation trenched at that time (i.e. Beds 1-180; see Barthel, 1962, p. 6-8, table IV) it was assigned a Middle Tithonian age. The stratigraphic ranges of *Pseudolissoceras* and other characteristic ammonites were not defined and it was not made clear (compare Barthel, 1962, p. 7) whether or not the Middle Tithonian dating applied to the so called “Duennkalk” that overlies the Bed 116. The Middle Tithonian was only defined by the time ranges of the genus *Pseudolissoceras* and the species *Semiformalceras semifomne* as they were interpreted then. Barthel (l.cit.) did not introduce a *Pseudolissoceras* Zone for the Neuburg Formation but one could argue that he did so implicitly. Neither the *Pseudolissoceras bavaricum* Zone nor the *bavaricum* Zone of the current usage are mentioned in the paper. Later Barthel stated (1964, p. 513, 514) that *P. bavaricum* ranges from the Bed 28 to the Bed 116 only and that its last examples occur in the higher part of the Bed 116 stratigraphically above the youngest listed *Zaraiskites*-like ammonites. A still later paper of Barthel (1969) deals almost exclusively with the previously neglected regressive shallow water phase of the formation overlying its Bed 116 (i.e. the Duennkalk). This phase (Beds 117-238) was designated the Oberhausen Beds while the open marine beds 22 to 116 inclusive were designated the Unterhausen Beds. Barthel (1969, p. 151) also proposes to subdivide the entire ammonite-bearing part of the Neuburg Formation (i.e. its Beds 22 to 200 inclusive) into beds with *Lemencia ciliata* below and those with *Isterites palmatus* above. Though neither formally designated as zones nor further defined, these beds may be interpreted as partly overlapping range zones of these species. Barthel (1969, p. 151) also notes the presence of the lower Upper Tithonian *Crassicollaria* sp. in the topmost Bed 238 of the formation and draws the Middle/Upper Tithonian boundary inside of its Oberhausen Beds (i.e. between the Beds 111 and 112). Neither *Pseudolissoceras bavaricum* Beds nor Zone are mentioned in this paper.

No fossil zonation of any kind was proposed in Barthel's latest paper (1975, p. 233, text and correlation chart) which is very valuable because it lists for the first time the stratigraphic ranges of all diagnostic ammonites determined by him in the formation, including those used for its biochronologic subdivision. The entire Unterhausen Member (introduced herein) is assigned to the Middle Tithonian. The lower part of the Oberhausen Member (also introduced herein) ending with its Bed 111 is left unassigned while its upper part, including the topmost *Crassicollaria* sp.-bearing Bed 238, is assigned to the Upper Tithonian (Barthel, 1969, p. 335, table 2). Neither the Middle nor the Upper Tithonian were defined zonally in this paper.

Zeiss (1968, p. 137, 138, table 6) published a rather different sequence of ammonites for Southwestern Germany that is obviously based on that of the Neuburg Formation. This sequence, which appears to qualify as a zonal sequence in spite of the lack of any further definition, is as follows (downward sequence): *Zaraiskites* cf. *zarajskensis*, "A." *palatus*, *Pseudolissoceras bavaricum*, and *L. ciliata*. The only pointer about the stratigraphic ranges of these ammonites is the incorrect statement (compare Barthel, 1964, p. 514) that the last *Pseudolissoceras bavaricum* is replaced by *Zaraiskites* cf. *zarajskensis* near the boundary of the Lower and Middle Neuburg Beds. In Zeiss' (l.cit.) opinion this event defines the Middle/Upper Tithonian boundary.

Enay (1971; 1973, p. 298, table 1) was apparently the first to introduce formally the currently used *bavaricum* Zone (i.e. *Pseudolissoceras bavaricum* Zone) with the *ciliata* Sub-
zone below and the *palmatus* Subzone above. This zonal sequence was proposed for the entire SW Germany and erroneously credited to Zeiss. Like his predecessors, Enay (l.cit.) neither further defined these biochronological units nor provided any data about the stratigraphic ranges of their indices within the Neuburg Formation. The entire *bavaricum* Zone is assigned the Mid-Tithonian age but this substage is left undefined zonally in the Southwestern Europe and in the non-European regions. Enay’s (l.cit.) conclusion that *P. bavaricum* ranges through the entire thickness of the *palmatus* Subzone is erroneous (compare Barthel, 1964, p. 514).

Enay & Geysant (1975, p. 42, 52, fig. 2) erroneously attribute the erection of the *bavaricum* Zone and its *palmatus* and *ciliata* Subzones to Barthel (1962, 1964) and Zeiss (1968). Furthermore, they erroneously indicate in the Figure 3 that the Andalusian time range of *Pseudolissoceras* is almost entirely older than its range in the Neuburg Formation. Only its occurrence in the Bed 28 of the formation is shown to overlap the top part of its Andalusian range.

Enay & Geysant’s (1975, p. 42, 52, fig. 2) erroneous attribution of *P. bavaricum* ranges through the entire thickness of the *palmatus* Subzone is erroneous (compare Barthel, 1964, p. 514). Enay & Geysant’s (l.cit.) conclusion that *P. bavaricum* ranges through the entire thickness of the *palmatus* Subzone is erroneous (compare Barthel, 1964, p. 514).

Kutek & Zeiss (1974, p. 511, 512, table 1; 1975, p. 125, fig. 1) propose a zonal scheme for the Mid- and Late Tithonian of the Submediterranean Province that is based largely on the ammonite sequence of the Neuburg Formation but utilizes those of other Central European sections. Unlike those of all preceding zonal schemes, their zones are adequately defined. A new zone characterized by *Pseudovirgatites* and late representatives of *Isterites* is introduced for the lower part of the Oberhausen Member and its equivalents. *Pseudovirgatites* being known in the Klentnice Beds, their equivalents, and the Stramberg Limestone, its use as a provincial zonal fossil reflects the authors’ ideas about their equivalence to the exclusively *Isterites*-bearing Oberhausen Member. *Zaraiškites* cf. *zarajskensis* Zone of Zeiss (1968) is not used because this Neuburg ammonite is now considered to be an aberrant *Isterites* (Kutek & Zeiss 1974, p. 525). Finally, the Unterhausen Member is equated to a generalized *Pseudolissoceras* Zone, in which the genus is associated with the *Isterites* above and *Lemencia* below. Following Zeiss (1968, p. 132 and elsewhere), Kutek & Zeiss (l.cit.) emphasize the diagnostic value of *Pseudolissoceras* as an interregional Middle Tithonian index fossil. However, like all preceding workers, they treat the Mediterranean Middle Tithonian as a solitary *Pseudolissoceras* Zone. Following Zeiss (1986), but unlike Barthel (1969, 1975), Kutek & Zeiss (l.cit.) place the Middle/Upper Tithonian boundary at the top of their *Pseudolissoceras* Zone. Kutek & Zeiss’ (l.cit.) papers are the last ones to be composed prior to the appearance of Enay & Geysant (1975) paper.

### 2b. Recent zonal schemes and their correlation with the standard Mediterranean zones

All above discussed workers attempting to zone either the Neuburg Formation in particular or the Submediterranean Mid- to Late Tithonian in general only attempted to correlate their zones with the Mediterranean Tithonian substages because no detailed, demonstrably valid ammonite zonation of the Mediterranean Middle to Upper Tithonian rocks existed until Enay & Geysant (1975) have zoned their complete, richly fossiliferous Andalusian sections. The essential sequencial validity and provincial utility of this zonal sequence was confirmed by later workers (e.g. Olóriz, 1976; Olóriz & Távara, 1979, 1982) and its somewhat more refined and nomenclatorially altered variant is now generally accepted as a provincial zonal standard (e.g. Figs. 1, 2). This zonal sequence, which also considers the zonal sequence of
Fig. 1. Some recent zonal schemes for an interprovincial correlation of the Submediterranean Tithonian (part).
calpionellids, made it possible for the first time to recognize the correct stratigraphic positions and relative ages of various widely scattered and commonly disturbed partial sections of the Tithonian rocks of the Southwestern and Southern Europe and the Near East utilized by the earlier workers (e.g. Speth, 1950; Arkell, 1956; Enay, 1971, 1973; Enay et al., 1971) for the arrangement of the zonal sequence of the Tithonian Stage. This zonal sequence also made it possible, for the first time, to test the validity of earlier attempts of Barthel (1962, 1964, 1969, 1975), Zeiss (1968), Kutek & Zeiss (1974, 1975) and Enay (1973) to correlate the Tithonian zonal sequence of the Neuburg Formation with the Tithonian substages of the Mediterranean Province.

The publications of Zeiss (1977, 1979, 1983 and 1986), which utilize either the original zonal scheme of Enay & Geyssant (1975) or its modified version introduced by Tavera (1976) and employed by Oloriz & Tavera (1979, 1982), clarify for the first time his concepts of the Pseudolissoceras Zone and Pseudolissoceras bavaricum Zone in terms of the Mediterranean zonal standard (see Fig. 1). In the earlier of these papers Zeiss (1977, table 2; 1979, Corr. table) equates the Pseudolissoceras bavaricum Zone with Enay & Geyssant’s (1975) semiforme and fallauxi Zones of Southern Spain and the Pseudolissoceras zitteli Zone of other Tethyan regions. The bavaricum Zone and its subzones are only assigned to a substage in the 1979 paper where they all plus the next younger Mediterranean Zone of Micracanthoceras ponti and the allegedly correlative Submediterranean Zone of Pseudovirgatities puschi and Isterites are placed into the Middle Tithonian (Fig. 1). In the more recent of these papers, Zeiss (1983, table 1; 1986 Corr. table opp. p. 28) equates the Pseudolissoceras bavaricum Zone and its subzones with the approximately equivalent semiforme, fallauxi and amirandum Zones. The previously used zonal scope of the Middle Tithonian and the correlation and age of the zitteli Zone are maintained unchanged. The time range of the genus Pseudolissoceras is not discussed in any of the four papers (i.e. Zeiss, 1977, 1979, 1983, 1986) but their illustrations indicate that this genus continues to be considered as a reliable interregional index fossil of the bulk of the Middle Tithonian (i.e. except for its topmost Djurjuriceras ponti Zone).

Finally, Oloriz & Tavera (1979, fig. 2; 1982, Corr. table opp. p. 148) consider the bavaricum Zone to be correlative with their verruciferum, richteri, amirandum/biruncinatum and Burckhardticeras Zones which correspond to the semiforme-ponti zonal interval of Zeiss (1983, table 1). This upward extension of the Pseudolissoceras bavaricum (or bavaricum) Zone does not appear to be accepted by any other worker. The basal Upper Tithonian Zaraiskites Zone was reintroduced by Oloriz & Tavera (l.cit.) (compare Zeiss, 1986) between the scruposus and palmatus Zones (Fig. 1).

2c. Age and correlation of the Unterhausen Member

The age and interprovincial correlation of the Unterhausen Member must be reappraised because both of the correlations of the bavaricum Zone used since the publication of Enay & Geyssant’s (1975) paper and illustrated in the Figure 1 are untenable. Furthermore, the same is true of the interregional Middle Tithonian time range ascribed to the genus Pseudolissoceras by Barthel (1962), Zeiss (1968), Kutek & Zeiss (1974, 1975) and other workers and also pertinent to the problem. The reasons are:
1. In the southern Spain the genus *Pseudolissoceras* appears already in the basal Tithonian *hybonotum* Zone and ranges through the younger *darwinii* and *semiforme* Zones (Enay & Geysant, 1975, p. 43, 48, figs. 2, 3). However, it is not known to range above the middle part of the Middle Tithonian sensu Zeiss (1979, 1983, 1986) as its youngest known examples were found either in the *semiforme* Zone or in the basal *fallauxi* Zone (Enay & Geysant, l.cit.). This time range of *Pseudolissoceras* in Spain suggests that its reported association with *Hybonoticeras*, *Gravesia* and *Hildoglochiceras* in Madagascar (Collignon, 1960, table 161) is also of an early Early Tithonian age. In the Rogoznik sections *Pseudolissoceras* spp. were found only in the upper *semiforme* Zone and the lower *fallauxi* Zone exclusive of the topmost bed 7b (Kutek & Wierzbowski, 1979, p. 202, table 2; 1986, p. 311, 321, table II). Finally in the Neuburg Formation (as documented below; see p. 156), *Pseudolissoceras* is restricted to beds equivalent to the larger upper part of the *semiforme/verruciferum* Zone and does not appear to range either up into the equivalents of the *fallauxi* Zone (Fig. 2) or down into the *albertinum* Zone.

On the southern side of the Mediterranean Sea, in contrast, *Pseudolissoceras* ranges up way above either the equivalents of the *semiforme/verruciferum* Zone or basal *fallauxi* Zone. Already Spath (1950, p. 125, Pl. 6, figs. 8–10; Pl. 8, fig. 10) has described and figured typical representatives of the genus, including *P. zitteli*, from Kurdistan beds containing *Proniceras*. This is definitely a Late Tithonian fauna as *Proniceras* is not known to range down into the late Early Tithonian (= late Mid-Tithonian sensu Zeiss) anywhere in the world. Enay’s (1973, p. 300) suggestion that *Proniceras* appears exceptionally early in Kurdistan is untenable because of this lack of supporting evidence combined with Memmi’s (1967, p. 258) subsequent discovery of abundant *Pseudolissoceras* in the indubitably Late Tithonian beds of Algeria. There, *Pseudolissoceras*, including *P. zitteli*, is associated not only with *Proniceras* but also with other diagnostic Late Tithonian ammonites, including *Micracanthoceras*, *Berriasella*, *Spiticeras* and *Paraulacosphinctes*. This association indicates that in Algeria *Pseudolissoceras* ranges up right through the Upper Tithonian, including its uppermost *Berriasella jacobi*- and *Crassicollana*-bearing beds (compare Memmi & Salaj, 1975, tables 1, 3). These data indicate that Arkell’s (in Arkell et al., 1957, p. 273) citation of *Pseudolissoceras* from the Upper Tithonian is well founded. The same is also true of the astute remark of Imlay (1980, p. 32) that: “the association of *Pseudolissoceras* with typical Late Tithonian ammonite *Proniceras* in Kurdistan (Spath, 1950, p. 25) suggests that *Pseudolissoceras* may range higher than recorded in Europe.”

Thus the data available indicate that *Pseudolissoceras* is a long-ranging and temperature-dependent genus of a rather limited interregional biochronological value. As already noted by Enay & Geysant (1975, p. 51), it is an endemic Mediterranean genus. Its evolutionary center was apparently situated south of the Mediterranean Sea in the central part of this province where it has the longest upward time range (i.e. its zone approaches most closely its complete biozone). The upper part of this time range is reduced drastically to a Teilzone in the northern part of the province (i.e. southern Spain), presumably because of a gradual cooling of the Late Early Tithonian seas there. Judging by its already mentioned, still shorter Teilzones in the Rogoznik section and the Neuburg Formation, *Pseudolissoceras* penetrated only occasionally into the Mid-Early Tithonian Seas of Submediterranean Province (= Early Mid-Tithonian sensu Zeiss and other workers) during their temporary warming at the Franconian Basin.
these warming up phases were aptly designated the Tethydian peaks by BARTHEL & GEYSSANT (1973, p. 53; see Fig. 2 of this paper). The same considerations naturally apply to all other Mediterranean endemics occurring in the Franconian Basin and discussed below (e.g. Virgatosimoceras broilii and Sutneria asema).

This discreditation of Pseudolissoceras as a reliable interregional index fossil of the Middle Tithonian of authors is one of the reasons for the amalgamation of this substage with the Lower Tithonian Substage proposed by JELETZKY (1984, p. 177). Other, even more weighty reasons were provided by ENAY & GEYSSANT (1975, p. 53).

2. The bavaricum Zone of the Neuburg Formation contains several diagnostic species of the semiforme/verruciferum Zone of the Mediterranean standard and so cannot be younger than that zone. These species include numerous representatives of Virgatosimoceras broilii (Schneider) and Sutneria asema (Oppel) which range through its entire thickness (i.e. from the Bed 24 to the Bed 116 inclusive; BARTHEL, 1964, p. 513, 514; 1975, p. 334, table 1; BARTHEL & GEYSSANT, 1973, p. 27, 33, 34 and Fig. 2 of this paper). According to the most recent data available, V. broilii and all other representatives of Virgatosimoceras are restricted to beds not younger than the lower fallauxi Zone of the Mediterranean standard. In southern Spain the youngest representatives of Virgatosimoceras do not range above this part of the fallauxi Zone (ENAY & GEYSSANT, 1975, p. 42, fig. 2). Oloriz & Tavera (1979, p. 492, fig. 1) also record Virgatosimoceras spp. only from the albertinum Zone, verruciferum Zone, and the basal part of their richteri Zone (Fig. 1). This same range was re-confirmed by Oloriz & Tavera (1982, p. 149) who state that the youngest known typical Virgatosimoceras occur in the richteri Zone of their Subbetic sections.

According to the latest data available Sutneria asema is characteristic of the Rogozniki fauna where it ranges from the darwini to semiforme and questionably richteri Zone of the Mediterranean standard (e.g. Kutak & Wierzbowski, 1979, p. 200, 201, table 2; 1986, p. 311, 312, table II; Oloriz & Tavera, 1982, p. 149).

Simaspidoceras rafaeli occurring in the Bed 42 of the Unterhausen Member (Fig. 2) does not range above the semiforme/verruciferum Zone in southern Spain (ENAY & GEYSSANT, 1975, p. 43, 44, fig. 2; Oloriz & Tavera, 1982, p. 148).

Pseudolissoceras ex gr. bavaricum and P. bavaricum itself were only found in the semiforme Zone of Southern Spain by ENAY & GEYSSANT (1975, p. 43, 48, fig. 2). However P. bavaricum was only found in the next younger richteri Zone by Oloriz & Tavera (1979, p. 492, fig. 1). Furthermore, as mentioned earlier, the genus Pseudolissoceras, the zone of which coincides with the bavaricum Zone in the Neuburg Formation, is not known to range above the basal part of the richteri Zone in the southern Spain and the Rogozniki section.

Because of the time ranges of Virgatosimoceras ex gr. broilii, Sutneria asema, Simaspidoceras raphaeli, Pseudolissoceras bavaricum and the genus Pseudolissoceras outside of the Neuburg Formation, the Beds 24–116 of its Unterhausen Member are correlated with the greater upper part of the semiforme/verruciferum Zone of the Mediterranean standard (Fig. 2). In spite of their unsatisfactory preservation, the presence of Virgatosimoceras? broilii? and Sutneria cf. asema in the Bed 116 combined with the ascendance of P. bavaricum into that bed (BARTHEL & GEYSSANT, 1973) is deemed to be sufficient for its inclusion with the underlying beds of the Unterhausen Member containing these ammonites.
The occurrence of *Sutneria asema*, *S. cf. asema* and *Simaspidoceras rafaeli* is considered to be particularly diagnostic of the *seiforme/verruciferum* age of the Beds 24–116 of the Unterhausen Member. Furthermore, for reasons presented earlier in the discussion of *Pseudolissoceras* time ranges, it is considered improbable that its Franconian Teilzone and that of *Pseudolissoceras bavaricum* representing one of the two of its northernmost known occurrences would extend as high (i.e. into the lower *fallauxi* Zone) as does its Teilzone in the northern Mediterranean (southern Spain) province. It seems more probable that their Neuburg Teilzones do not reach even to the top of the *seiforme/verruciferum* Zone.

Finally, the zonal assignment of the Beds 24–116 proposed here and their proposed delimitation from the underlying zones of the Mediterranean standard (Fig. 2) is supported by the presence of *Virgatosimoceras cf. albertinum* in the next older fossiliferous (i.e. basal) Bed 22 of the Unterhausen Member (BARTHEL & GEYSSANT, 1973, p. 27, 33, figs. 1c, d, 4). This bed is accordingly assigned to the uppermost part of the next older *darwini/albertinum* Zone of the Mediterranean standard. The greater part of this Zone is represented by upper Rennertshofen Beds (i.e. by its Parapallasiceras palatinum Zone: see Fig. 2).

The presence of *Lemencia ciliata* (SCHNEID) and allied forms (i.e. *L. adepts*, *L. pergrata* and *L. patula*) in the Beds 42 to 60 of the Unterhausen Member is not believed to be indicative of their younger age than the *seiforme/verruciferum* Zone. According to ENAY & GEYSSANT (1975, p. 52, fig. 2), these typical *Lemencia* forms make their first appearance in the Spanish *fallauxi* Zone and reach their maximum frequency in the overlying *ponti* Zone. The Franconian *ciliata* Subzone was correlated accordingly with the upper part of the *fallauxi* Zone and part or all of the *ponti* Zone. However, the writer disagrees with this correlation and explains these discrepant time ranges of *Lemencia* by its being an endemic of Submediterranean Province that only belatedly migrated into the Mediterranean Province.

### 2d. Age and correlation of the Oberhausen Member

The above documented *seiforme/verruciferum* age of the entire Unterhausen Member (i.e. except for its basal Bed 22) combined with the presence of the basal Upper Tithonian *Crassicollaria* sp. in the uppermost Bed 238 of the conformably and apparently gradationally overlying Oberhausen Member reliably dates the latter. Though devoid of diagnostic zonal ammonites, this member must include considerably older Lower (= Middle of authors) Tithonian beds than it was hitherto believed. In fact it must include equivalents of the *fallauxi,* *amirandum/biruncinatum* and *ponti/Burckhardticeras* Zones of the Mediterranean standard (Fig. 2). The widely accepted suggestion of BARTHEL (1969, p. 150) to assign the Beds 237–191 of the Oberhausen Member to the basal Upper Tithonian (i.e. the lower part of the *micracanthum* Zone; see Fig. 2) is not followed here because these beds did not yield any *Crassicollaria* or *Chitinoidella* in spite of a comprehensive study of their microfauna by BARTHEL (l.cit.). In combination with the stratigraphically demonstrable presence of equivalents of the *fallauxi,* *amirandum/biruncinatum,* and *ponti/Burckhardticeras* Zones within the Oberhausen Member, a downward extension of the *palmatus* fauna into the *bavaricum* Zone (see below for further details), and the revision of the time range of *Isterites* in the section 5a, below this suggests strongly that the Beds 237–191 are entirely uppermost Lower Tithonian
(i.e. ponti/Burckhardticeras Zone) deposits. The writer assumes that the basal Upper Tithonian deposits are faulted out between the Beds 238 and 237 (Fig. 2).

The late Lower (= late Middle) Tithonian age of the Beds 200–117, including the Isterites palmatus fauna of the Beds 190 and 200, was already recognized by Barthel (1969, p. 141, 150, 151), Enay & Geysant (1975, p. 52, fig. 2), Zeiss (1977, table 2; 1979, p. 15, Corr. table; 1983; p. 431, Corr. table; 1986, p. 27, Corr. table opp. p. 27), Messeznhikow (in Vakhrameev et al., 1982, p. 136), and Oloriz & Tavera (1982, Corr. table). Most of these workers have correlated the palmatus fauna with the ponti/Burckhardticeras Zone of the Mediterranean standard. Messeznhikow (l.cit.) alone has assigned a fallauxi to ponti age to the Isterites Beds of the Oberhausen Member but the writer considers them to be still older. Isterites palmatus is closely related to /subpalmatus that characterizes the upper part of the bavaricum Zone (i.e. the upper part of the semiforme/verruciferum Zone) and these two species coexist in the Bed 102 of the Unterhausen Member (Barthel, 1964, p. 514). Therefore, the two faunas cannot differ much in age and the palmatus fauna of the Oberhausen Member appears to be mostly or (?) entirely of the fallauxi age. It is correlated here tentatively with the entire fallauxi Zone and the lower part of the next younger amirandum/biruncinatum Zone of the Mediterranean standard (Fig. 2). This correlation is also supported by the delimitation of the Lower and Upper Tithonian beds within the overlying upper part of the Oberhausen Member proposed earlier in this section.

3. Correlation with the Volgian Stages

3a. The age of Zaraiskites scythicus Zone in Central Poland and Central Russia

Zeiss (1968, 1977, 1979, 1986, and in Jeletzky, 1984, p. 251, fig. 1) and Kutek & Zeiss (1974, 1975) maintain steadfastly that the Zaraiskites scythicus Zone in Central Poland and Central Russia is a lower Upper Tithonian deposit. This conclusion is based on the observations made in the Neuburg section. As stated by Zeiss (1968, p. 138, 139; writer's translation from German): "With the extinction of Pseudolissoceras ends the Middle Tithonian. Therefore, in the present state of our knowledge, the Upper Tithonian begins with the Zaraiskites cf. zarajskensis, which is soon followed in the profile by such other important diagnostic fossils as Pseudovirgatites scruposus and Paraulacosphinctes senex." This conclusion appears to be based on Zeiss' (1968, p. 138; writer's translation from German) belief that: "The last Pseudolissoceras bavaricum is replaced by Zaraiskites cf. zarajskensis near the upper limit of the boundary bed between the lower and middle Neuburg Beds." However, all these ideas are outdated. According to the painstaking work of Barthel (1975, Table 1; see Figure 2 of this paper), all Zaraiskites-like ammonites of the Neuburg Formation are restricted to the Beds 102–112 of the Unterhausen Member which is entirely (i.e. including its topmost Bed 116) of the semiforme/verruciferum age (see 2c, above). Therefore, these approximate equivalents of the Zaraiskites scythicus Zone are of the upper semiforme/verruciferum age in terms of the Mediterranean standard (Fig. 2). The claimed close superposition of Pseudovirgatites scruposus and Paraulacosphinctes senex on the Zaraiskites cf. zarajskensis-bearing beds is only an inference based on a hypothetical combination of a least two Submediterranean profiles. Neither of
these species was ever found in the Neuburg profile. Furthermore, *P. scruposus* is a late Early Tithonian species about contemporary with the *Zaraiskites scythicus* in the writer's opinion (see 5b below).

It must be stressed in this connection that, like Messezhnikov (in Vakhrameev et al., 1982, p. 131), the writer disagrees with Kutek & Zeiss' (1974, p. 525; 1975, p. 127) tentative re-assignment of the Neuburg ammonite previously determined as *Zaraiskites* cf. *zarajskensis* by Zeiss (1968, p. 591, Pl. 26, fig. 7) to *Isterites*. According to an express statement of Kutek & Zeiss (1974, p. 525), this re-assignment was suggested merely because of the stratigraphic position of this specimen which did not agree with their ideas about the correlation of the Brzostowka and Neuburg sections. In the writer's opinion, this re-assignment is opposed by a typical *Zaraiskites*-like morphology of this specimen while the correlation of the Brzostowka and Neuburg sections proposed by Kutek & Zeiss (l.cit.) is unacceptable to the writer. Barthel's (1969, p. 150) opinion that these ammonites cannot be identified with the genus *Zaraiskites* is also unacceptable to the writer on the basis of the specimen figured by Zeiss (l.cit.).

The here proposed correlation of the *Zaraiskites scythicus* Zone of the Brzostowka section with the Beds 102–112 of the Neuburg Formation bearing *Zaraiskites* cf. *zarajskensis* and other *Zaraiskites*-like ammonites is confirmed by the presence of *Isterites subpalmatus* (Schneid) in the Beds a-1 and a-2 of the Brzostowka section (Kutek & Zeiss, 1974, p. 507). These beds of the *Pseudovirgatites puschi* Subzone of the *Ilowaiskya pseudoscythica* Zone (Fig. 2) underlie immediately and conformably the *Zaraiskites zarajskensis* Subzone in this profile. As pointed out by Zeiss (1968, p. 139), "*Anavirgatites* subpalmatus" (Schneid) of the Neuburg Formation also occurs stratigraphically below its Beds 102–112, to which all *Zaraiskites*-like ammonites are confined. The two only coexist in the Bed 102 (Barthel, 1964, p. 514). Therefore, this correlation does not depend on *Z. zarajskensis* alone. Finally, the presence of *Isterites spurius* (Schneid) in the Beds a-1 and a-2 (Kutek & Zeiss, l.cit.) points out in the same direction. The stratigraphic range of this species within the Neuburg Formation was never exactly defined. However, it should be confined to the Beds 60 to 116 of the Unterhausen Member as only *Isterites palmatus* was recorded from the overlying Oberhausen Member (see under 2d for further details).

Because of the morphological intergradation of *Zaraiskites* with the next older *Pseudovirgatites* ex gr. *puschi-passendorfferi* in the Brzostowka section (Kutek & Zeiss, 1974, p. 510, 537) combined with an apparent absence of an intergradation between *Zaraiskites* and next older *Ilowaiskya* in Central Russia, the writer accepts Kutek & Zeiss', (1974, p. 534–537, fig. 3) conclusion that *Pseudovirgatites* evolved into *Zaraiskites* in the Central Polish basin. If so, the Subboreal *Zaraiskites* migrated eastward (mainly) as well as southward and westward (a short term invasion only) from that evolutionary center. This southward and westward migration of *Zaraiskites* is recorded by its occurrence in Bavaria, southern Poland (Ksiazkiewicz, 1963), Pomerania (Schmidt, 1905, p. 70, 71), and Lower Austria (Bachmayer, 1958, p. 660). As noted by Messezhnikov (in Vakhrameev et al. 1982, p. 131), the Franco- nian partial zone (= Teilzone) of *Zaraiskites* probably does not coincide entirely with its biozone in the Brzostowka section. However, this does not preclude their approximate correlation as any partial zone is bound to be confined within the biozone of the species concerned. These postulated relationships are reflected in Figure 2.
3b. The age of *Ilowaiskya pseudoscythica* Zone in Central Poland

The *Ilowaiskya pseudoscythica* Zone of Central Poland, including the *Pseudovirgatites puschi* Subzone, underlies the *Zaraiskites scythicus* Zone conformably and apparently gradationally. Therefore, and contrary to Kutek & Zeiss (1974, p. 512, table 1; 1975, p. 125, figure 1) and Zeiss (1977, p. 379, 382, tables 1, 2; 1979, p. 15, Corr. table; 1983, table 1; 1986, p. 27, table opp. p. 28), this subzone includes only the older part of the *semiforme/verruciferum* Zone (Fig. 2). The *Ilowaiskya pseudoscythica* Zone itself must correspond to part or all of the next older *darwini/albertinum* Zone because of the presence of *Virgatosimoceras cf. albertinum* in the basal bed 22 of the Unterhausen Member combined with the occurrence of *Ilowaiskya cf. pseudoscythica* in the *palatinum* Zone of the upper Rennertshofen Beds (Zeiss, 1968, p. 117; fig. 2). As already noted by Messezhnikov (in Vakhrameev et al., 1982, p. 135, table 19), further confirmation is provided by the discovery of *Franconites vimineus* (see Mikhailov, 1964, p. 58, Pl. XI, fig. 1) in the next older *Ilowaiskya sokolovi* Zone of the Russian Platform.

3c. The *Virgatites virgatus* and *Epivirgatites nikitini* Zones are upper Lower Tithonian deposits

The above documented approximate correspondence of the Central Polish *Zaraiskites scythicus* Zone with the upper part of the Mediterranean *semiforme/verruciferum* Zone (Fig. 2) indicates that, contrary to the opinion of Kutek & Zeiss (1974, 1975) and Zeiss (1968, 1977, 1979, 1983, 1986, and in Jeletzky, 1984, p. 251, fig. 1), the *Zaraiskites scythicus* Zone of the Russian Platform is of about the same mid-lower Tithonian age. This indicates, in turn, that the allegedly younger Upper Tithonian (e.g. Kutek & Zeiss, l.cit.; Zeiss l.cit.) *Virgatites virgatus* and *Epivirgatites nikitini* Zones of the Russian Platform are considerably older. Because of their stratigraphic position, they must be roughly equivalent to the younger to youngest Lower Tithonian (= Late Middle Tithonian of authors) *fallauxi, amirandum/biruncinatum,* and *ponti/Burckhardticeras* Zones combined. The presence of a significant time gap between the *Zaraiskites scythicus* Zone and the younger Lower Volgian (= late Middle Volgian of Gerassimov & Mikhailov, 1966 and later workers) zones of the Russian Platform can be ruled out. The ammonite faunas of all these zones are very closely allied and overlap stratigraphically (e.g. Casey & Messezhnikov, 1986, p. 73). Therefore, in spit of the presence of numerous erosional disconformities and local time gaps of a short duration, the *Virgatites virgatus* and *Epivirgatites nikitini* Zones do follow the *Zaraiskites scythicus* Zone immediately and are only insignificantly younger than the latter. Therefore, there is every reason to correlate the Subboreal *Virgatites virgatus* Zone with the *fallauxi* and *amirandum/biruncinatum* Zones on the stratigraphy alone. The next younger *Epivirgatites nikitini* Zone should then correspond roughly to most or all of the *ponti/Burckhardticeras* Zone (Fig. 2). As already pointed out by Messezhnikov (in Vakhrameev et al., 1982, p. 131), this stratigraphically-based zonal correlation of the post-*Zaraiskites*-bearing Volgian beds with the post-*Zaraiskites*-bearing Tithonian beds of Submediterranean Province lacks any direct paleontological support in Europe. However, its validity is attested to by the persistence of the demonstrably late Early Tithonian *Buchia* faunas of western North America (particularly of the *Buchia russiensis* fauna) into the upper Lower Volgian rocks of the Central Russian Basin.
JELETZKY, 1984, p. 185–188, 253, fig. 10). In this basin the Circum-Boreal *Buchia mosquensis* s. str. fauna characterizes the *scythicus* and *virgatus* zones while the directly descendant Circum-Boreal *Buchia russiensis* fauna characterizes the *nikitini* Zone. The essential restriction of the *Buchia russiensis* fauna to the *nikitini* Zone and its high Boreal equivalents indicates, in particular, an approximate correspondence of the upper boundary of this zone with that of the ponti/Burckhardticeras Zone. It should be noted in this connection that the only locally present *Paracrasededites* ex gr. *oppressus*-bearing beds of the Russian Platform (e.g. CASEY & Messezhnikov, 1986, p. 71, 73, 75) are treated tentatively as the uppermost part (?a subzone) of the *nikitini* Zone because of the presence of *Epivirgatites? bippicatus* and *E. nikitini* in them. Because of this inferred approximate correspondence of the Lower/Upper Volgian boundary with the Lower/Upper Tithonian boundary, the basal Upper Volgian *Kachpurites fulgens* Zone and its high Boreal equivalents are equated approximately with the *Micracanthoceras micracanthum* Zone of the Mediterranean standard (Fig. 2). The correlation of younger Upper Volgian zones with the younger Upper Tithonian zones was already comprehensively discussed by JELETZKY (1984) and does not require any additional comments.

It should be noted in this connection, that Messezhnikov's (in Vakhrameev et al., 1982, p. 136, table 19) correlation of the uppermost Middle Volgian substage with the *Paraulacosphinctes transitorius* Zone is a lapsus calami. As he states in the text (Messezhnikov, ibid., p. 135; writer's translation from Russian): “the *bavaricum* Zone apparently corresponds to the *semiforme* Zone, that is to the lower part of the Middle Tithonian. The rest of the Middle Tithonian (i.e. *fallauxi* and *ponti* Zones) would evidently be represented by the *Isterites* Beds (Bartel & Geysant, 1973) and the ammoniteless beds 177–237 underlying the calpionellid Zone A.” Therefore, Messezhnikov's (ibid.) correlation of the Oberhausen Member is essentially the same as that proposed in this paper (see Fig. 2), except that he does not concern himself with the *Chitinoidella*-bearing Beds or *Simplispinctes* Subzone forming part of the *micracanthum* Zone.

4. The age of the Portlandian Stage

The latest Lower Tithonian age of the *Virgatites virgatus* and *Epivirgatites nikitini* Zones of Central Russia documented in the preceding section invalidates the widespread idea (i.e. Enay, 1971, 1973; Casey, 1973; Zeiss, 1968, 1977, 1979, 1983, 1986, and in JELETZKY, 1984, p. 251, fig. 1; Kutek & Zeiss 1974, 1975) that all of the marine Portlandian deposits in England are Upper Tithonian. The original claim of the Late Tithonian age of these Subboreal beds was advanced by Zeiss (1968, p. 138, 139; writer's translation from German) on the following grounds: “the base of the Upper Tithonian corresponds approximately with the lower boundary of the Portlandian in England (Zone of *Zaraiskites albani*). This is also indicated by the most recent study of the ostracods of the layered limestones of Neuburg, which have indicated a Portlandian age for the beds with *Z. cf. zarajskensis* (H. Oertli, 1965).” While it is still true that the *Zaraiskites scythicus* Zone of Central Poland and Central Russia, and hence the *Zaraiskites cf. zarajskensis*-bearing beds of the Neuburg Formation, are correlative with the lower Portlandian beds (see Casey & Messezhnikov, 1986, p. 76, Corr. table for further details), neither of these rock units is younger than the middle Lower
Tithonian (= lower Middle Tithonian sensu Zeiss l.cit.) *semiforme/verruciferum* Zone (see 3a above and Figure 2 for further details). Furthermore, the *Epivirgatites nikitini* Zone of Central Russia (including its *Paracraspedites* ex gr. *oppressus*-bearing uppermost beds) is an uppermost Lower Tithonian deposit because of its stratigraphic position and *Buchia* fauna (see preceding section for further details). Therefore, the correlative Portlandian zones of England, including the uppermost *Paracraspedites oppressus* Zone, are Lower Tithonian deposits also.

5. Ages and time ranges of Central European genera *Isterites* BARTHEL 1975 and *Pseudovirgatites* VETTERS 1905

The revision of age of *Pseudolissoceras bavaricum* and *Zaraiskites scythicus* Zones documented in the preceding sections necessitates a far-reaching re-appraisal of currently accepted ideas about the age and time ranges of the endemic Central European genera *Isterites* BARTHEL 1975 and *Pseudovirgatites* VETTERS 1905, including those of some of their zonal species.

5a. Time range of *Isterites* and some of its species

The data presented in the section 3a indicate that the more primitive *Isterites subpalmatus* (SCHNEID) and *I. spurius* (SCHNEID) occurring in the *puschi* Subzone of the *Ilowaiskya pseudoscythica* Zone in the Brzostowka profile (KUTEK & ZEISS 1974, p. 507, fig. 1) are neither the earliest Late Tithonian nor the latest Lower (= latest Middle) Tithonian forms. They definitely occur in the Subboreal equivalents of the mid-Lower Tithonian rocks corresponding to the *semiforme/verruciferum* Zone. The same is true of the more advanced *Isterites mazoviensis* restricted to the Layer a-3 of this profile representing the basal part of the *Zaraiskites scythicus* Zone (KUTEK & ZEISS, 1974, pp. 508, fig. 1). Instead of being a basal Upper Tithonian form, *I. mazoviensis* is a mid-Lower Tithonian form that occurs in the Subboreal equivalents of the upper part of the *semiforme/verruciferum* Zone (Fig. 2).

The still more advanced *Isterites palmatus* was so far only definitively recorded from the Bed 102 of the Neuburg profile (BARTHEL, 1964, p. 514). However, because of Zeiss's (1968, p. 137, table 6) and BARTHEL's (1969, p. 151, Corr. Table) indications that the Zone of *Isterites palmatus* spans the Neuburg beds overlying those with *Pseudolissoceras bavaricum* and extending through the lower third of the Oberhausen Member, this species is inferred to range up into the Bed 200 where the last representatives of *Isterites* were found (BARTHEL, 1969, p. 141). Therefore, *Isterites palmatus* is inferred to appear in the uppermost part of the *semiforme/verruciferum* Zone that corresponds to some middle part of the *Zaraiskites scythicus* Biozone of the Brzostowka section (Fig. 2). This first appearance is younger than the Bed a-3 of Brzostowka section containing *Isterites mazoviensis* in association with the oldest *Zaraiskites* spp. (KUTEK & ZEISS, 1974, p. 508, fig. 1). According to the age limits of the Beds 117–200 of the Oberhausen Member proposed in this paper (see in 2d above and Figure 2), this principal part of the *Isterites palmatus* Zone corresponds to the entire *fallauxi* Zone and the lower part of the *amirandum/biruncinatum* Zone.

The *Isterites australicus* KUTEK & ZEISS and other closely related *Isterites* forms described by Zeiss (1977) from the upper Klentnice Beds of Lower Austria are very closely related to
Isterites mazoviensis. According to Zeiss (1977, p.375): "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." Because of these affinities, I. austriacus and all other Isterites forms of the Klentnice Beds are believed to be approximately contemporary with I. mazoviensis and I. subpalmatus. Their mid-Lower Tithonian age is supported by the recorded presence of "Provirgatites" scythicus in the Klentnice Beds (BACHMAYER, 1958, p. 660) and other evidence presented below in the section dealing with the Pseudovirgatites scapus Zone.

On the above basis, the upper limit of the Isterites palmatus Zone in the Neuburg profile coincides with the upper limit of the known time range of Isterites. However, the true biozone of the genus and its youngest known species I. palmatus remain unknown because the highest Isterites-bearing beds and all overlying Oberhausen beds exhibit clear signs of shallowing and freshening and so are an unsuitable habitat for ammonites (BARTHEL, 1969, p. 141).

KUTEK & ZEISS' (1974, p.511) generalized conclusion that: "Isterites is an earlier genus than Zaraiskites, and its stratigraphical range but slightly overlaps that of Zaraiskites" is untenable in the light of the above presented data. This conclusion is valid for the Brzostowka section alone, though the evidence is inconclusive even there because of the absence there of beds younger than those of the Zaraiskites scythicus Zone. However, it definitely is not applicable to the Neuburg section where Isterites appears appreciably later than in the Brzostowka section (i.e. in the upper part of the semiforme/verruciferum Zone; see above), ranges right through the Zaraiskites-bearing beds and persists through the lower third of the Oberhausen Member which corresponds to the entire fallauxi Zone and the lower amirandum/biruncinatum Zone of the Mediterranean standard. Judging by its known time range in the Neuburg Formation, Isterites ranges well below as well as well above the mid-Lower Tithonian beds (i.e. upper semiforme/verruciferum Zone) containing Zaraiskites spp. in the Brzostowka section and Zaraiskites cf. zarajskensis, etc. in the Neuburg section. Its much more restricted local time range in the Brzostowka section may either reflect its shorter term, temporary penetration into the Subboreal basin of Central Poland, or be simulated by the absence of the post-Zaraiskites marine beds in that basin. Interestingly, KUTEK & ZEISS (1974, p.511) were already aware of the possibility of these time ranges; they state: "the possibility cannot be ruled out, however, that the stratigraphic range of Pseudovirgatites and that of Isterites are not the same in the Submediterranean province and in Central Poland."

In spite of its considerably more extensive time range in the Neuburg Formation, Isterites remains an exclusively mid- to late (but not the latest) Lower Tithonian genus. Its youngest known species – I. palmatus of the lower Oberhausen Member – occurs in beds that could hardly be younger than the lower part of the amirandum/biruncinatum Zone of the Mediterranean standard (see sections 2d and 3b, above and Figure 2).

5b. Time range of Pseudovirgatites and the age of Pseudovirgatites scapus Zone

The assignment of the Zaraiskites scythicus Zone to the upper part of the semiforme/verruciferum Zone invalidates KUTEK & ZEISS' (1974, p.512) claim that: "At present the available
data strongly suggest that the *Pseudovirgatites* occurs above the upper boundary of the Middle Tithonian as defined by the extinction of *Pseudolissoceras*.

In central Poland *Pseudovirgatites puschi* KUTEK & ZEISS and *P. passendorfferi* KUTEK & ZEISS occur in the upper part (i.e. the regional *puschi* Subzone) of the *Ilowaiskya pseudoscythica* zone which corresponds to the lower part of *Pseudolissoceras bavaricum* Zone of the Franconian Basin and approximately to the lower part of the *semiforme/verruciferum* Zone of the Mediterranean standard. Therefore, these two *Pseudovirgatites* species characterize mid-Lower Tithonian (= lower Middle Tithonian) beds (see section 3b and Figure 2).

The rather controversial (e.g. KUTEK & ZEISS, 1974, p.511; Oloriz & Tavera, 1982a,p.43) *Pseudovirgatites scruposus* Zone was nevertheless assigned to the lowermost to lower Upper Tithonian by KUTEK & ZEISS (1974, 1975) and ZEISS (1968, 1977, 1979, 1983, 1986, and in Jeletzky, 1984, p.251, Figure 1) and this assignment is generally accepted by the modern workers (e.g. Enay, 1971, 1973; Enay & Geysant, 1975; Oloriz & Tavera, 1982, Corr. Chart; compare Figure 1 of this paper). ZEISS (1986, p.27) provides the following reasons for this assignment: "In Poland, below the beds with *Zaraiskites scythicus* there exists a layer containing an assemblage of late *Isterites* and early *Pseudovirgatites* which mark the uppermost Middle Tithonian (ZEISS, 1977). In southern Central Europe above this bed there are layers with assemblages of late *Pseudovirgatites* (scruposus group) and hitherto unknown pre-*Paraulacosphinctes* ammonite fauna (at present under study by the author). Within this interval no calpionellids have been discovered, and thus it corresponds well to the basal *Micracanthoceras* Zone (Simr'isphinctes Subzone) of southern Spain (Oloriz-Tavera, 1979)."

The "late *Isterites* and early *Pseudovirgatites*" fauna of this quotation is the already discussed *Pseudovirgatites puschi* fauna which was shown to be correlative with the mid-Lower Tithonian (= early Middle Tithonian sensu ZEISS) lower *semiforme/verruciferum* Zone. Furthermore, the next younger *Zaraiskites scythicus* Zone of this quotation was shown to be correlative with the upper part of the *semiforme/verruciferum* Zone (see 3a above and Figure 2). These data contradict the earliest Late Tithonian age of the overlying *Pseudovirgatites* ex gr. *scruposus* fauna of southern Central Europe proposed by ZEISS. Already because of its stratigraphic position, this zone is more likely to represent the *fallauxi* to *amirandum/biruncinatum* Zones instead of the basal *microcanthum* Zone. The complete absence of calpionellids in this fauna and in the overlying "pre-*Paraulacosphinctes*" fauna strongly supports this interpretation.

This re-appraisal of the stratigraphic position and age of the *Pseudovirgatites* ex gr. *scruposus* fauna of Central Europe is further supported by the unfortunately scanty and generalized data available about the age and stratigraphic position of *P. scruposus* in the Stramberg, Ernstbrunn, Wozniki, and Klennice Beds.

Contrary to ZEISS (1977, p. 337, 338, tables 1, 2, etc.), the occurrence of *P. scruposus* in the Stramberg Limestone does not indicate its earliest Late Tithonian age. Oloriz & Tavera (1982a, p. 44, fig.1) have demonstrated convincingly that the Stramberg Beds also include deposits of the Lower Tithonian upper *semiforme/verruciferum* Zone as well as the *richteri* and *amirandum/biruncinatum* Zones. Therefore, and as the stratigraphic position and faunal association of all older Stramberg representatives of *P. scruposus* are unknown, they could have been derived from one of these Lower Tithonian zones. This interpretation is supported
by the fact that HOUSE, SCHREIBNER and STRANIK (1964, p. 9) cite *Pseudovirgatites scruposus* from the basal Stramberg Beds associated with other “antique” ammonites. Now, after the *Pseudovirgatites*-bearing *puschi* Subzone and the *Zaraiskites scythicus* Zone of Central Poland have been shown to be *semiforme/verruciferum* deposits (see 3a and Figure 2), there is the best of reasons to treat all Stramberg specimens of *P. scruposus* as part of its “ancient fauna” and to assign either an upper *semiforme/verruciferum* or a *richteri* age to them. Interestingly, ZEISS (1977, p. 378) also cites the possible presence of the “fallauxi to jacobi zones” in the Stramberg Limestone when trying to explain the “unnatural” association of *Virgatosphinctes* *transitorius* with *Subplanites contiguus* in the apparently equivalent Ernstbrunn Limestone. However, he does not mention this possibility where *P. scruposus* is concerned.

The faunal list of Ernstbrunn Limestone provided by BACHMAYER (1958, p. 659) includes *Pseudovirgatites scruposus* together with such characteristic Late Tithonian species as “*Sub-lithacoceras* senex”, “*Virgatosphinctes* *transitorius* and *Berriasella callisto*, and such characteristic Lower Tithonian forms as *Subplanites contiguus*. BACHMAYER (1958, p. 660) does not say whether or not all these species occur together. However, he points out that “*Virgatosphinctes* *transitorius* indicates a Late Tithonian age while *Subplanites contiguus* indicates an Early Tithonian to Late Kimmeridgian age. Therefore, and because of the above discussed re-evaluation of the *Pseudovirgatites puschi* and *Zaraiskites scythicus* Zones, it is inferred that *Pseudovirgatites scruposus* and *Subplanites contiguus* do not occur together with “*Virgatosphinctes* *transitorius*” and other above listed Late Tithonian ammonites. Contrary to ZEISS (1977, p. 377, 378, table 1), the Ernstbrunn Limestone is inferred to include the middle to upper Lower Tithonian rocks in addition to the Upper Tithonian ones. This interpretation is also supported by a reported (BACHMAYER, 1958, p. 659) partial interfingering of the Ernstbrunn Limestone with the Klentnice Beds which appear to be a middle to upper Lower (i.e. Middle) Tithonian deposit in their entirety for reasons presented below.

The ammonite fauna of Klentnice Beds listed by BACHMAYER (1958, p. 660) includes numerous *Pseudovirgatites scruposus*, “*Provirgatites* *scythicus* and *Subplanites* cf. *contiguus*. Furthermore, ZEISS (1977, p. 370–377, Pls. 1–3) has described and figured the following ammonites from these beds: *Pseudovirgatites scruposus* (OPPEL), *P. sorgenfreii* n. sp., *Pseudovirgatites* sp. juv. aff. *scruposus* (OPPEL), *Isterites austriacus* KUTEK & ZEISS, *Pavlovia iatriensis* ILOVAJSKY, and *Ilowaiskya tenuicostata* (MIKHAILOV) subsp. *occidentalis* subsp. nov. None of the above listed characteristic Late Tithonian ammonites of the Ernstbrunn Limestone were recorded from the Klentnice Beds. These data, the presence of *S. contiguus*, and that of such characteristic species of the *puschi* and *scythicus* Zones of Central Poland as *Z. scythicus* and *I. tenuicostata* indicate that the presently known Klentnice ammonites were derived exclusively from the middle to upper Lower Tithonian (= Middle Tithonian) beds equivalent to the two above mentioned Central Polish zones and the middle to upper Lower Tithonian fauna(s) of the Ernstbrunn Limestone. The localities of most of the species described by ZEISS (1977) differ and *I. tenuicostata* is an older species than *Z. scythicus* and *P. iatriensis*. Therefore, at least two late Early Tithonian faunas must be represented by these ammonites. Because *P. scruposus* was recorded in association with *Z. scythicus* (BACHMAYER, 1958, p. 660) it should characterize the younger fauna that corresponds to the *scythicus* Zone of Central Poland and the upper part of the *semiforme/verruciferum* Zone of the South Spain. The evolutionarily advanced *Isterites austriacus* probably forms part of this fauna also because it is
very closely related to *I. mazoviensis* KUTEK & ZEISS from the basal part of the Central Polish *scythicus* Zone (ZEISS, 1977, p. 375, 376). *Ilowaiskya tenuicostata occidentalis* is inferred to represent the *puschi* Subzone of the *Ilowaiskya occidentalis* Zone of Central Poland as already proposed by ZEISS (1977, p. 378). However, this zone is considerably older than it was believed by KUTEK & ZEISS (1974, 1975) and ZEISS (1977, 1979, 1983, 1985 and in JELETZKY, 1984, p. 251, fig. 1).

Finally, *Pseudovirgatites scruposus* was found in association with *Zaraiskites cf. zarajskensis* at Wozniki in southern Poland (KSIAZKIEWICZ, 1963) which confirms once more the upper *semiforme/verruciferum* age of its zone.

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