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The Correlation of the Zechstein with the Marine Standard*)

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Die Korrelation des Zechstein mit dem marinen Standard

Zusammenfassung

Der untere Z_1 kann mit Hilfe von Conodonten und Ostracoden gut mit dem Dzhulfian (nicht basales Dzhulfian) korreliert werden. Sporomorphen und die Lage der paläomagnetischen Illawarra-Umpolung weit unterhalb des Zechstein zeigen einen ähnlich späten Beginn des Zechstein an. Der oberste Zechstein, zeitlich äquivalent mit der unteren „Übergangs-Folge“ (unterer Bröckelschiefer) sensu SEIDEL (1965), hat eine Sporomorphen-Assoziation der *Triquitrites proratus* A.-Z. geliefert, die auch aus dem White Sandstone Member der obersten Chhidru-Formation (oberstes Dzhulfian oder basales Changxingian) der Salt Range bekannt ist. Das Einsetzen von *T. proratus* BALME und anderer für diese Zone charakteristischer Sporomorphen ist eine wichtige stratigraphische Marke für das oberste Dzhulfian in dem riesigen Gebiet von Australien über China, die Salt Range, den Irak bis zum Germanischen Becken. Sowohl in Südchina als auch in der Salt Range kann dieses wichtige palynostratigraphische Niveau mit marinen Faunen korreliert werden.

Die P/T-Grenze liegt nahe der Obergrenze des Tonigen Sandstein-Members der Nordhausen-Formation (siehe Fußnote 4) und in zeitlich äquivalenten Niveaus innerhalb des tieferen Teils des Unteren Buntsandsteins, und damit beträchtlich oberhalb der Zechstein/Buntsandstein-Grenze des Germanischen Beckens. Die *Lundbladispora obsoleta* – *Lunatisporites noviaulensis* A.-Z. kann von Thüringen (Toniges Sandstein-Member) bis Polen (*Otynisporites*-Schluffstein) nachgewiesen werden, und die gleiche Sporomorphen-Assoziation findet sich auch im unteren Tesero-Oolith der Profile Tesero und Sass de Putia in den Südalpen, wo diese Zone mit Hilfe von Conodonten, Foraminiferen, Ostracoden und Brachiopoden in das Obere Changxingian eingestuft werden kann. Eine ähnliche Assoziation („*Taeniaesporites*“-Assemblage sensu BALME, 1970) kann auch in der höheren *Otoceras boreale*-Zone von Grönland nachgewiesen werden.

Der Umfang der oberpermischen tethyalen Stufen in ihren Stratotypen, die Korrelation der tethyalen und borealen (Cis-Ural) oberpermischen Stufen und einige stratigraphische Probleme in jenen marinen Einheiten, die mit Teilen des Zechstein korreliert werden können, werden kurz diskutiert. Alle diese Probleme haben beträchtlichen Einfluß auf die Korrelation des Zechstein mit dem marinen Standard.

*) This paper was accepted in 1987 for publication in the Symposium Volume "Zechstein 1987" in the Zbl. Geol. Paläont, 1991(4). By a mistake of the editors SCHRÖDER et al. this paper was, however, not printed and the manuscript could not be found for longer time. In 1992 Prof. SCHRÖDER found the manuscript. Because in the 1987 version of the manuscript the largest part, in some areas the whole Bröckelschiefer was correlated with uppermost Zechstein in the central Basin (see also KOZUR, 1989), the lithostratigraphic subdivision and correlation in the Germanic Basin had not to be changed after the German Stratigraphic Subcommission Perm/Trias had placed the Bröckelschiefer in the Zechstein. Therefore only the new data of the marine scale (rejection of Abadehian as a junior synonym of the Capitanian) and some newer literature references have been added to the otherwise unchanged original manuscript.

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Abstract

The lower Z_1 can be well correlated by conodonts and ostracods with the Dzhulfian (not earliest Dzhulfian). Sporomorphs and the position of the paleomagnetic Illawarra Reversal well below the base of the Zechstein also indicate a late beginning of the Zechstein. The uppermost Zechstein, time-equivalent of the lower "Übergangs-Folge" (lower Bröckelschiefer) sensu SEIDEL (1965) has yielded the sporomorph association of the *Triquitrites proratus* A.Z., present also in the topmost Dzhulfian (or basal Changxingian) White Sandstone Member (uppermost Chhidru Formation) of the Salt Range. The first appearance of *T. proratus* BALME and other species of this Zone is an important marker for the uppermost Dzhulfian in the huge area from Australia through China, the Salt Range, Iraq to the Germanic Basin. Both in South China and in the Salt Range this important level in the sporomorph stratigraphy can be correlated with marine faunas.

The P/T boundary lies clearly above the Zechstein/Buntsandstein boundary, near the top of the Clayey Sandstone Member of the Nordhausen Formation (see footnote 4) within the lower part of the Lower Buntsandstein of the Germanic Basin. The *Lundbladispora obsoleta – Lunatisporites noviaulensis* A.Z., recognizable from Thuringia (Clayey Sandstone Member) to Poland (*Otynisporites* Siltstone), can be found with the same species composition in the lower Tesero Oolite of the Tesero and Sass de Putia sections in the Southern Alps together with conodonts, foraminifers, ostracods and brachiopods of Late Changxingian age. A very similar association (*"Taeniaesporites"* assemblage sensu BALME, 1970) can be found in the upper *Otoceras boreale* Zone of Greenland.

The extent of Late Permian Tethyan Stages in their stratotypes, their correlations as well as the correlation of the Cis-Uralian Late Permian Stages are briefly discussed. Some stratigraphic problems in those marine successions that can be correlated with parts of the Zechstein are discussed as well. These stratigraphic problems have considerable influence on the correlations of the Zechstein with the marine scale.

1. Introduction

The Zechstein is still today mostly correlated with the Kazanian s.l. (often including the Ufimian) and Tatarian, whereas the Rotliegend is regarded as Lower Permian (e.g. JORDAN & KERKMANN, 1970; HAUBOLD, 1973; HAUBOLD & KATZUNG, 1975; and many international time-stratigraphic correlation schemata). Partly the lower Zechstein was even included into the Kungurian.

Only VISSCHER (1971, 1974) and KOZUR (1974a, 1977, 1980a) placed the Zechstein into the Tatarian. In the direct correlation with the only reliable Upper Permian scale, the Tethyan scale[2]), even a still younger age, Dzhulfian and Lower Changxingian or maximally Upper Capitanian to Dorashamian (Changxingian) was determined for the Zechstein by KOZUR (1974a, 1977, 1980a, 1985). Already in KOZUR (1974a), where the Zechstein Limestone (Z_1) was still placed into the Upper Capitanian, a Lower Dzhulfian age was not excluded for this level. According to our present-day knowledge about the age of the Tatarian, this correlation by KOZUR (1974a and later papers) corresponds to an Upper Tatarian to post-Tatarian or even to a largely post-Tatarian age of the Zechstein (see below). However, this view about a biostratigraphically proven very short time-interval of the Zechstein (about Upper Permian of the three-fold subdivision) was largely rejected (DDR-Fachbereichsstandard, 1980).

The view about an Ufimian to Tatarian age of the Zechstein is regarding the Ufimian and Kazanian part unsubstantiated and only based on the traditional assignment: Rotliegend = Lower Permian and Zechstein = Upper Permian s.l. (two-fold subdivision = Ufimian to Tatarian). But as shown by KOZUR (e.g. 1980 a), the Rotliegend comprises the uppermost Carboniferous, Lower and Middle Permian, in some places (e.g. Richelsdorf Mts, eastern margin of Harz Mts, NW-German-Polish Basin) even the lower part of the Tethyan Late Permian. The uppermost Rotliegend *Chelichnus duncani* tetrapod footprint Zone belongs according to KOZUR (in press a) to the Late Permian s.str. (Tethyan Upper Permian in the three-fold subdivision of the Permian System). Therefore, the base of the Zechstein must be still younger.

[2]) The continental Tatarian is by far more difficult to correlate with the international marine scale than the Zechstein. Therefore the correlation of the Zechstein with the Cis-Uralian scale is useless for the age determination of the Zechstein and only interesting for the age determination of the Tatarian. For this reason the correlation of the Zechstein with the Cis-Uralian scale is mostly omitted in the papers by KOZUR.

The palynologically (VISSCHER, 1971) and paleontologically/palynologically (KOZUR, 1974a,b, 1977, 1980a, 1985, 1988a,b, 1989) documented view about the young age of the Zechstein within the Permian scale was later supported by magnetostratigraphic correlations (WIEGANK & MENNING, 1984; MENNING, 1986). These paleomagnetic data and the newest biostratigraphic data (KOZUR, 1985, 1988a,b and present paper) show that the Zechstein corresponds only to the uppermost Tatarian and to the gap between the Tatarian and Vetlugian in the Cis-Uralian/Russian Platform standard. In places, even the lowermost Vetlugian can be correlated with the Zechstein, e.g. the Lower Volcanic Beds and the Inter-volcanic Beds in the Ural, where TUZHIKOVA (1985) has found rich sporomorph associations with dominating *Lueckisporites virkkiae*, norm A in the lower part and with dominating *L. virkkiae*, norm B (= *L.* cf. *parvus*) and norm C (*Guttulapollenites* sp.) in the upper part of this interval. In the Tethyan scale the Zechstein corresponds to the Dzhulfian and Lower Changxingian (see tables 5, 6 and chapter IV).

The present paper is based on paleontological and palynological investigations by the author in the Zechstein of Middle Europe (in Poland together with the late Dr. FUGLEWICZ) and in the Permian of the Southern Alps, Sicily, Greece, Hungary, Transcaucasia, Central and NW Iran (together with Prof. MOSTLER, Innsbruck), Salt Range, South China (together with Prof. WANG, Cheng-Yuan, Nanjing), Cis-Ural/Russian Platform (together with Dr. E.V. MOVSHOVICH, Rostov), Texas, New Mexico, Arizona. This comprehensive work (many paleontological data have been already published) was necessary, because those sequences outside the Germanic Basin that can be well correlated with the Zechstein or a part of it, are themselves often disputed in their ages. Even in the case of correct correlations with these sequences "evidences" for all ages between the Ufimian (inclusively) and the top of the Permian could be found for the Zechstein.

2. Short Discussions of the Extent and Correlation of the Stages in the Upper Permian s.str. (Tethyan Scale) and Upper Permian s.l. (Cis-Uralian Scale)

The stratotype of the Dzhulfian Stage (SCHENCK et al., 1941) lies at the left bank of the Araks river in the section Dorasham II-1 near Dzhulfa (Transcaucasia). The lower boundary of the Dzhulfian lies there at the base of the *Araxilevis* Beds and coincides about with the base of the *Clarkina leveni* Zone (KOZUR, 1973, 1980). Later changes of this boundary to the top of the *Araxilevis* Beds (KOTLJAR et al., 1984) cannot be accepted, because the *Araxilevis* Beds have a typical Dzhulfian fauna and the absence of Dzhulfian ammonoids has facial reasons. Now also KOTLJAR et al (1989) placed the *Araxilevis* Beds again into the Dzhulfian. The top of the Dzhulfian is universally defined by the base of the *Phisonites triangulus* Zone (see table 1) that coincides with the appearance of *Clarkina subcarinata* (SWEET).

The stratotype of the Dorashamian (ROSTOVCEV & AZRERJAN, 1971, biostratigraphic extent see table 1) is the section Dorasham II-3, about 1.2 km SW of the Dzhulfian

Table 1.
Upper Permian ammonoid, conodont and fusulinid zonations.

System	Serie	Stage/ Substage	Ammonoid Zone boreal	Ammonoid Zone tethyal	Fusulinid A. Z.	Conodont Zone
Trias.	Scythian	Brahmanian	*Oph. commune*	*Ophiceras tibeticum*		*I. isarcica*
Perm.	Upper Permian	Changxingian / Gangetian	*Otoceras boreale*	*Hypophiceras changxingense*		*H. parvus*
				Rotodiscoceras asiaticum	*Palaeofusulina sinensis*	*Clarkina changxingensis Hindeodus latidentatus*
				Pleuronodoceras mapingense		
			Otoceras concavum	*Tapashanites chaotianensis*		
		Dorasham.	?	*Paratirolit. waageni*	*Palaeofusulina minima–Nankingella guizhouensis*	*Clarkina subcarinata–Hindeodus julfensis*
				Shevyrev. shevyrevi		
				Dzhulfites spinosus		
				I. transcaucasicus		
			?	*Phisonit. triangulus*		
		Dzhulfian	*Cyclolobus* genozone	*Vedioceras ventroplanum*	*Codonofusiella schubertelloides–Reichelina media*	*Clarkina orientalis* A.Z.
				Araxoceras latum		*C. leveni*
				Araxilevis[1] Beds		
			?		*Codonofusiella kwangsiana*	*Merrillina divergens–Clarkina liangshanensis* A.Z.
	Middle Permian	Capitanian		*Timorites* genozone	*Lepidolina kumaensis*	*Mesogondolella "babcockae"–Clarkina bitteri* A.Z.

1) Brachiopod

Vertical distances not time-related

stratotype. In general, it is regarded as a time-equivalent of the Changxingian. But the Chinese authors (e.g. ZHAO et al., 1981) correlated the Dorashamian only with the Lower Changxingian. Detailed investigations of conodonts both in South China (WANG & WANG, 1979; ZHAO et al., 1981; own unpublished material) and in Transcaucasia, NW and Central Iran (KOZUR, MOSTLER & RAHIMI-YAZD, 1975; KOZUR et al., 1978; and further rich own unpublished material) have shown that the view of the Chinese authors is correct. Therefore the Dorashamian can be preserved as independent Substage of the Changxingian (Tables 1, 7). Equivalents of the Upper Changxingian are present in the lowermost Karabagljar Formation of the whole Dorashamian type area (*Pleuronodoceras occidentale* Zone sensu ZACHAROV & PAVLOV, 1986). They contain the *Hindeodus latidentatus* conodont fauna that can be correlated with the upper Changxingian and at least with the lower Transitional Beds and with the lower *Otoceras woodwardi* Zone (see table 7). Because of the correct correlation of these beds with the *Otoceras woodwardi* Zone, they were placed mostly into the Triassic, despite of their exclusively Permian Upper Changxingian fauna. However, now also ZACHAROV & PAVLOV (1986) placed these beds with ammonoids into the Permian, as KOZUR (1972 and later papers) did by conodonts.

In South China, in the type area of the Changxingian Stage, the Dzhulfian is generally equated with the Wuchiaping Limestone below the Changxing Limestone (e.g. ZHAO et al., 1981). But on the base of the conodont fauna (compare conodont ranges in the Upper Maokou and Wuchiaping Formation, given by ZHANG et al., 1984 with the conodont data in Table 1 of the present paper) the lower 60 m of the Wuchiaping Limestone are older than the type Dzhulfian.

The overlying Changxing Limestone was regarded by FURNISH & GLENISTER (1970) as the type of the Changxingian (stratotype: Meishan section of Changxing county, here used biostratigraphic extent see in Table 1). The upper boundary of the Changxingian and therefore the P/T boundary is not yet definitely defined. ZHAO et al. (1978) included in their precise biostratigraphic original definition of the Changxingian an unnamed ammonoid Zone into the Changxingian. ZHAO et al. (1981) placed these beds into the basal Triassic on the base of some doubtful, badly preserved specimens of *Otoceras*? sp., despite the fact that the macro- and microfauna as a whole is typical Late Permian, e.g. with Permian brachiopods, last representatives of *Pseudotirolites* and *Pseudogastrioceras* (last goniatite) and the Permian *Hindeodus latidentatus* conodont fauna. Only in the uppermost Transitional Beds the *H. parvus* A.Z. may be present that has transitional character between Permian and Triassic conodont faunas.

SHENG et al. 1984) united the Transitional Beds with the immediately overlying beds of the *Claraia wangi* Zone to the Transitional Beds s.l. with mixed Permian-Triassic faunas. But the dominating Triassic elements of the "mixed" faunas, e.g. *Claraia wangi* (PATTE), *Ophiceras* spp., and *Isarcicella isarcica* (HUCKRIEDE) have been derived exclusively from the Triassic *Claraia wangi* Zone that was not included into the Transitional Beds by KOZUR (1980b), YIN (1985) and DAGIS & DAGIS (1987).

The Transitional Beds s.str. consist of "mixed" layers 1 and 2, without the *Claraia wangi*-bearing "mixed" layer 3. "Mixed" layer 1 has an undoubtedly Permian macro- and microfauna. Rather "mixed" layer 2 is disputed concerning its Permian or Triassic age. According to the occurrence of *Hypophiceras* in these beds, the *Hypophiceras changxingense* Zone is here discriminated for this assemblage (type locality: Meishan section, cephalopod fauna described by WANG, 1984 for the *Hypophiceras* fauna).

The only "Triassic" elements of the *H. changxingense* Zone are *Otoceras* and *Hypophiceras*. The latter one is a Permian xenodiscid, whereas *Otoceras* is the last representative of the Upper Permian Otoceratacea. Moreover, the determination of *Otoceras*? sp. is doubtful and DAGIS & DAGIS (1987) denied that *Otoceras* is present in the Transitional Beds s.str. They regarded the Transitional Beds s.str., like BANDO et al. (1980) and KOZUR (1980b) as topmost Changxingian in agreement with the original definition of this Stage by ZHAO et al. (1978, see above). However, DAGIS & DAGIS (1987) placed by this the Transitional Beds below the *Otoceras concavum* Zone, because they assumed a Triassic age for this Zone. But the upper Transitional Beds ("mixed" bed 2) contain according to ZHANG (1984, 1987) *Hindeodus parvus*. Despite the fact that the only figured specimen may be also a juvenile form of an advanced *H. latidentatus*, the presence of the *H. parvus* Zone is seemingly proven by this specimen, because also advanced specimens of *H. latidentatus* are restricted to the *H. parvus* A.Z. Therefore at least the upper part of "mixed" bed 2 cannot be older than upper *Otoceras woodwardi* Zone, where *H. parvus* and advanced *H. latidentatus* appeared. The *Otoceras woodwardi* Zone is, however, younger than the *O. concavum* Zone. The conodont fauna of the lower *O. woodwardi* Zone with *H. latidentatus* (without advanced forms) corresponds to the conodont fauna of the Upper Changxingian. Therefore the lower *O. woodwardi* Zone and the still older *O. concavum* Zone can be correlated with the Changxingian. This correlation is also supported by sporomorphs (see Chapter III: Southern Alps). Only the upper *Otoceras woodwardi* Zone, from where *Ophiceras* has been reported, may be somewhat younger than the "mixed" bed 2 of the Transitional Beds.

The Upper Permian s.l. (Ufimian, Kazanian, Tatarian) of the Cis-Uralian/Russian Platform standard has a totally different extent than the Tethyan Upper Permian s.str. This Upper Permian s.l. consists in the type areas of its Stages mostly of continental beds. Only in the Kazanian a widespread marine transgression came from the Boreal Permian sea. The correlation of this Upper Permian s.l. both with the marine Middle and Upper Permian s.str. of the Tethyan scale and with the Zechstein is therefore very difficult. Also the correlation with sporomorphs is difficult, because the Upper Permian s.l. even on the Russian Platform belongs to the margin of the Angaride floral province whereas the Zechstein belongs to the Euramerian floral province and the Permian of the Tethys belongs to the Cathaysian, Euramerian or northern margin of the Gondwanide floral provinces.

The Ufimian has marine equivalents in Novaja Zemlja, where the ammonoid genera *Daubichites*, *Sverdrupites* and *Altudoceras* have been found (STEPANOV, 1984). This ammonoid fauna can be correlated with the Roadian of the southwestern U.S.A. According to EFREMOV (1956) the vertebrates of the Ufimian indicate a correlation with the tetrapod faunas of the San Angelo and Flowerpot Formations of latest Leonardian age. The Ufimian sporomorphs with typical representatives of *Hamiapollenites* likewise indicate a correlation with the Flowerpot Formation. Therefore part of the Ufimian can be correlated with the Tethyan uppermost Early Permian (latest Leonardian s.str. = latest Chihsian s.l.) and part of the Ufimian corresponds to the basal Middle Permian (Roadian). In any case, the Ufimian is by far older than the Tethyan Upper Permian s.str. and the Zechstein.

Even the Tatarian belongs partly to the Middle Permian. The Illawarra Reversal lies about at the base of the Suchona Formation. In the other hand, it lies within the Capitanian of southwestern U.S.A. Therefore the lower Tatarian belongs to the Capitanian (Tethyan Middle Permian). This magnetostratigraphic correlation is supported by palynological data and the evaluation of the conchostracan faunas (KOZUR, 1988a,b, 1989). These data indicate that the Severodvina Formation (lower part of upper Tatarian) is pre-Dzhulfian. Equivalents of the Dzhulfian may be only present in the Vjatka Formation of the uppermost Tatarian. Only these beds or part of them may correspond to the lower Zechstein.

At the very base of the Vetluga Group (lowermost part of the Vochma Formation) in some places sporomorphs of the Upper Changxingian are known. The Lower Changxingian and at least parts of the Dzhulfian seem to be missing on the Russian Platform (gap between the Tatarian Vjatka Formation and the Vetluga Group). Where this gap is shorter or missing (in parts of the Ural) all post-Tatarian Permian beds have been placed erroneously into the Triassic (TUZHIKOVA, 1985, see chapter 1.).

3. Short Evaluation of the Stratigraphy in those Sequences Outside the Germanic Basin that Can Be Well Correlated with the Zechstein

In the eastern part of the Southern Alps the largest part of the Val Gardena Sandstone Formation belongs to the Middle Permian (KAHLER, 1974; KOZUR 1977; HOLUB & KOZUR, 1981), indicated by intercalations of fusulinid-bearing limestones of Roadian, Wordian and Capitanian ages. In the marginal parts of the basin[3]), to which belong also the Dolomites, the Val Gardena Sandstone Fm. replaces more and more the Bellerophon Limestone Formation and ranges therefore far into the Upper Permian. It begins there, in turn, later and later and it is represented mostly by continental beds with some marine intercalations (ASSERETO et al. in LOGAN & HILLS, 1973; KOZUR, 1977; HOLUB & KOZUR, 1981).

In contrast to this view about a Middle to Late Permian age of the Val Gardena Sandstone Fm., HAUBOLD (1973) and HAUBOLD & KATZUNG (1975) placed the Val Gardena Sandstone Fm. just in the marginal parts of the basin as a whole into the Lower Permian "Upper Autunian". The tetrapod footprints from the Bletterbach section, on which this age determination has been based, belong to the Upper Permian s.str. HAUBOLD's view about the correlation of the Bletterbach fauna with the Autunian was partly followed by CONTI et al. (1977). Only in CONTI et al. (1986) the Late Permian age of most of the Val Gardena Sandstone Fm. in the marginal part of the South Alpine Permian basin was again accepted, but now, in turn, too young ages were attributed to this sequence. The entire Val Gardena Sandstone Fm. of the Bletterbach-Butterloch section was placed into the Abadehian (in the sense of a post-Capitanian Stage, this Abadehian is in reality Lower Dzhulfian, whereas most of the type Abadehian is a time-equivalent of the Capitanian) and Dzhulfian. Only for the basal part of the Val Gardena Sandstone Fm. a latest Capitanian age was not excluded. This is not in agreement with the paleomagnetic and palynologic data.

According to DACHROTH (1976) the lower part of the Val Gardena Sandstone Fm. in the Dolomites belongs to the inversely magnetized Kiaman Interval. This part must be therefore older than Late Capitanian. This is in good agreement with the sporomorph association with *Corisaccites* sp. ex gr. *alutas* VENKATACHALA & KAR from the basal Val Gardena Sandstone Fm. in the Bletterbach/Butterloch section, because this sporomorph group is unknown above the Wordian to lower Capitanian. A Late Dzhulfian age of the upper Val Gardena Sandstone Fm. of this section (*P. crenulata* – *P. microcorpus* association sensu CONTI et al. (1986) cannot be confirmed. This association that is characterized by the joint occurrence of *L. virkkiae* POTONIÉ & KLAUS and many other Late Permian species with the Middle Permian *Gigantosporites* spp. is surely older than the basal Zechstein, were *Gigantosporites* is already missing. However, the Zechstein begins somewhat above the base of the Dzhulfian. *Gigantosporites* is also missing in the middle *Parvikirkbya transita* ostracod A.Z. that contains in the Bükk Mountains *Araxilevis intermedia* (ABICH) = *Pustula ? buekkensis* SCHRÉTER, a guide form of the Lower Dzhulfian *Araxilevis* Beds of the Dzhulfian type area. Thus, the *P. crenulata* – *P. microcorpus* association of the upper Val Gardena Sandstone Fm. of the Bletterbach-Butterloch section is either basal Dzhulfian or uppermost Capitanian.

Also the Late Dzhulfian to Changxingian age of the lower Bellerophon Limestone Formation and the (Late) Changxingian age of the upper Bellerophon Limestone Fm. in the Bletterbach-Butterloch section cannot be confirmed. Even the evidences for a Changxingian age of the uppermost Bellerophon Limestone Fm. in this section (CONTI et al., 1986) are very weak. The small foraminifer genus *Robuloides* is not restricted to the Changxingian, but it occurs even in the pre-Dzhulfian Hachik Beds in the Transcaucasian Dzhulfian type area. *Palaeofusulina sinensis* SHENG, which would indicate Late Changxingian age was not figured and even the generic assignment was doubtful (CONTI et al., 1986). *Palaeofusulina* was also reported from other sections in the Bellerophon Fm., but never figured. The only figured specimen has been derived from the overlying Tesero Oolite (PASINI, 1984). Even this species is a very doubtful *Palaeofusulina*. It is so small that it could belong only to the "*Palaeofusulina*" simplex group that begins in the Dzhulfian upper Wuchiaping Limestone of South China below the type Changxingian. This species was also reported from the uppermost Bellerophon Limestone Fm. of the Sass de Putia section. It does not belong to *Palaeofusulina*, but to *Nanlingella* and it is a long-ranging species (Dzhulfian to Lower Changxingian). Even real *Palaeofusulina* are already present in undoubtedly Dzhulfian beds (e.g. Hydra, Greece, together with Dzhulfian conodont index species, NESTELL & WARDLAW, 1987).

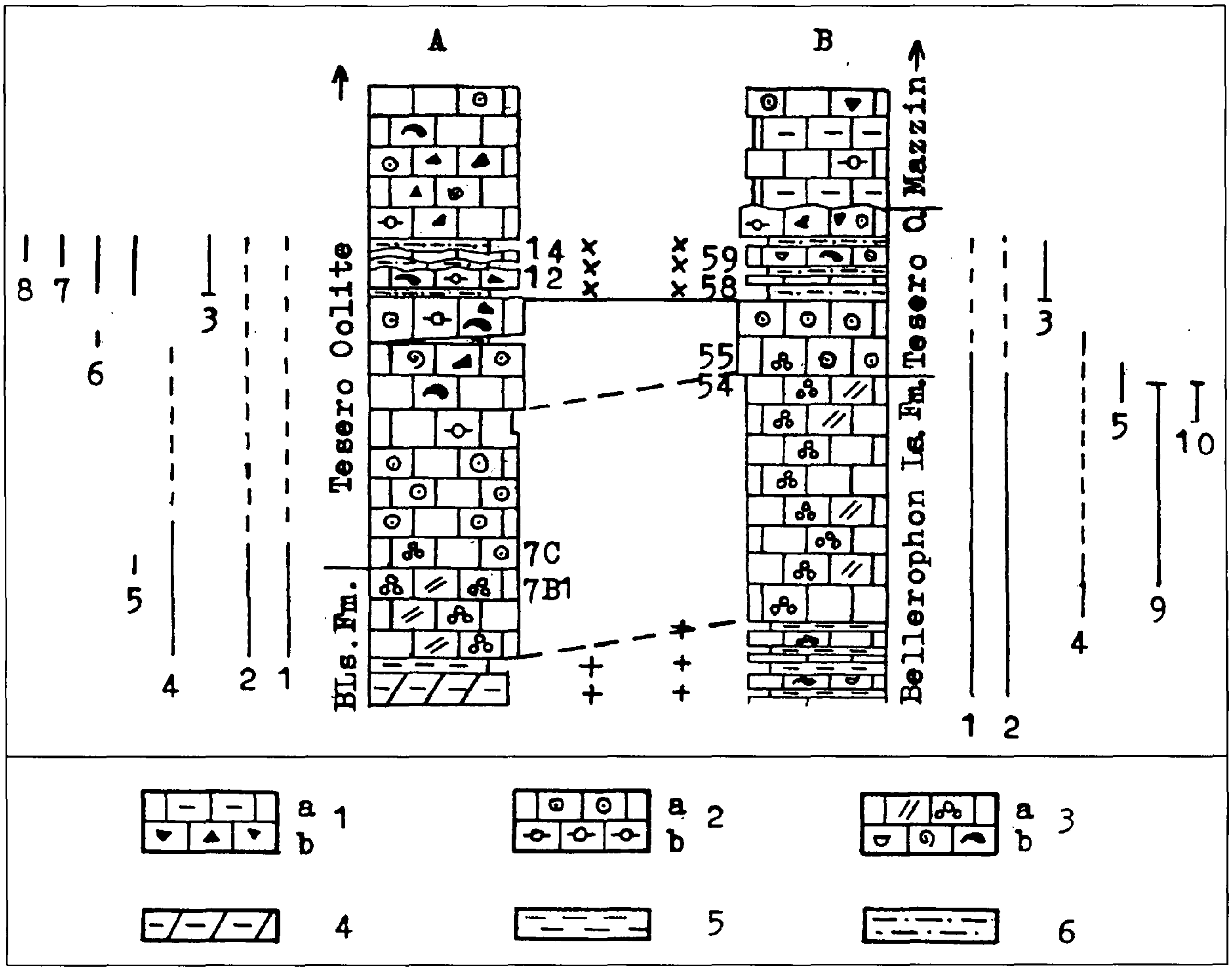
In the Dolomites, the fusulinid genus *Nankingella* is dominating in the uppermost Bellerophon Limestone Fm., mostly represented by *N.* cf. *quasihuanensis* SHENG that is restricted to the Dzhulfian in South China (RUI, 1979; YAO et al., 1980). Also *Codonofusiella, Nanlingella simplex* (SHENG & CHANG), *Reichelina* and *Staffella* are present, but rare. In the more basinal facies (Carnian Alps, Italy and Bükk Mts, Hungary) *Codonofusiella* and *Staffella* are common in the upper Bellerophon Limestone Fm. These genera are com-

[3]) What is here named as basin, is in reality the southern shelf of the Dinaric branch of the Permian Southern Tethys that reached until the eastern Southern Alps. Remnants of the marginal parts of this pelagic Southern Tethys are known in Slovenia ("clastic Trogkofel beds", olistostrome units with the pelagic Lower Permian *"Gondolella" slovenica* fauna, see RAMOVŠ, 1982).

Table 2.
Range chart of ostracods, conodonts, holothurian sclerites and conchostracans in the Zechstein and lower part of Buntsandstein.
The used lithostratigraphic subdivision of the Zechstein in the NW German – Polish Basin and for the Z1–Z4 also in the Thuringian Basin are primarily based on RICHTER-BERNBURG (1955), REICHENBACH (1970) and KÄDING (1978a,b).
OS = *Otynosporites* Siltstone; LO B = Lower Oolitic Beds; CS M = Clayey Sandstone Member; LW M = Lower "Wechsellagerung" Member; Trans. Mbt. = Transitional Member; B.F. = Bernburg Formation; Z.-L. = Zechsteinletten.

mon in the Dzhulfian, but absent or very rare in the Changxingian of the Asiatic Tethys.

Only the uppermost 1.5 m of the Bellerophon Limestone Fm. in the Sass de Putia section could belong to the basal Changxingian. These beds contain *Comelicania* that was for a long time regarded as brachiopod index genus for the *Phisonites triangulus* Zone of the basal Changxingian, where it has really its main occurrence. But in the Bükk Mts *Comelicania* is present already in the *Parvikirkbya fueloepi* ostracod Zone that can be well correlated with the Upper Dzhulfian (KOZUR, 1985). On the other hand, this genus was never reported from beds younger than the lowermost Changxingian. Therefore the *Comelicania* beds of Sass de Putia should not be younger than earliest Changxingian, but a



Text-Figure 1.
Diachronous boundary between the Bellerophon Limestone Formation and the basal Werfen Group (Tesero Oolite) in the Southern Alps.
Lithostratigraphic subdivision and range of brachiopods after NERI, PASINI & POSENATO (1986) for the Tesero section (A) and after BROGLIO LORIGA et al. (1986) for the Sass de Putia section (B). Range of the other fossils after the present author.
Lithology: 1 = a) marly, b) intraclastic limestone; 2 = a) oolitic, b) peloid limestone; 3 = bioclastic limestone, a) with algae, foraminifers, b) with ostracods, microgastropods, bivalves; 4 = marly dolomite; 5 = marl; 6 = silty marl.
Range of fossils (fossil distribution above beds A 14 and B 59 not shown): 1 = Permian foraminifers; 2 = Permian algae; 3 = *Hindeodus latidentatus* (KOZUR, MOSTLER & RAHIMI-YAZD); 4 = *Theelia dzhulfaensis* MOSTLER & RAHIMI-YAZD; 5 = *Ombonia*; 6 = *Crurithyris*; 7 = *Spinomarginifera*; 8 = *Araxathyris*; 9 = *Comelicania*; 10 = *Janiceps*.
xxx = Upper Changxingian sporomorph association (*L. obsoleta – L. noviaulensis* A.Z.), dominated by spores of marine fungi. Among the land-derived sporomorphs the following species are characteristic = *"Anaplanisporites" stipulatus* JANS., *Apiculatisporites lanjouwii* JANS., *Kraeuselisporites apiculatus* JANS., *Lundbladispora obsoleta* BALME, partly still attached to each other in tetrahedral tetrads, *Klausipollenites schaubergeri* (POT. & KLAUS) JANS., *Lunatisporites noviaulensis* (LESCHIK) SCHEUR., *Protohaploxypinus samoilovichii* (JNS.) HART, *Striatoabieites richteri* (KLAUS) WILSON, *Tessellaesphaera tessellata* FOSTER etc., megaspores = *Otynisporites eotriassicus* FUGL.
+++ = Upper Dzhulfian sporomorph association. Beside rare spores of marine fungi the following species are characteristic = *Nuskoisporites dulhuntyi* POT. & KLAUS, *Alisporites* spp., *Falcisporites zapfei* (POT. & KLAUS) LESCHIK, *Klausipollenites schaubergeri* (POT. & KLAUS) JANS., *Lueckisporites virkkiae* POT. & KLAUS, rare, *Lunatisporites noviaulensis* (LESCHIK) SCHEUR.
Scale: 1 cm = 0.5 m.

Zechstein-Buntsandstein boundary (generally)	Zechstein / Buntsandstein →
NW German-Polish Basin (WAGNER, 1987, FUGL., 1980)	Z1 · Z2 · Z3 · Z4 · Z5 · Z6 · Z7 · Suboolitic Beds (OS) · LO B →
Thuringian Basin (SEIDEL, 1956)	Z1 · Z2 · Z3 · Z4 · Uppermost Z.-L. · Lower Trans. Mbr. · Upper Trans. Mbr. · CS M · SC M (Nordhausen Formation) · LW M B. F. →

No.	Taxon	Range
1	*Acratia ? acuata* (JONES)	5**
2	*Bairdia lebae* KRÖMMELBEIN	6**
3	*Bairdia plebeia* REUSS	7** *
4	*Bairdia pommeriana* KRÖMMELBEIN	8··
5	*Bairdiacypris jonesiana* (KIRKBY)	9**
6	*"Basslerella" suavis* IVANOV	10**
7	*Callicythere mazurensis* (STYK)	11****
8	*Callicythere* n. sp. aff. *mazurensis* (STYK)	12++
9	*Cavellina subelongata* (GEINITZ)	13** * ++
10	*Cooperuna* aff. *rostrataformis* (SHEVZOV)	14**
11	*Cryptobairdia ampla* (REUSS)	15** *
12	*Cryptobairdia hisingeri* (MÜNSTER)	16** *
13	*Cryptobairdia knüpferi* (IVANOV)	17**
14	*Cryptobairdia mucronata* (REUSS)	18** *
15	*Dorsoobliquella pulchra* KNÜPFER	19** * ++
16	*Europermiana longissima* (KRÖMMELBEIN)	20**
17	*Europermiana wiekensis* KNÜPFER	21**
18	*Fabalicypris parva* (KOTCHETKOVA)	22**
19	*Haworthina ? patria* IVANOV	23++
20	*Haworthina ? regularis* (RICHTER)	24**
21	*Healdia dahlgrueni* KRÖMMELBEIN	25**
22	*Healdia incisurelloides* KNÜPFER	26++
23	*Heladianella ? richteriana* (JONES & KIRKBY)	27**
24	*Hungarella ogmoconchelloides* (KNÜPFER)	28**
25	*"Kellettella" kotschetkovae* IVANOV	29++
26	*Kirkbya permiana* JONES	30**
27	*Microcheilinella nuciformis* (JONES)	31**
28	*Microcheilinella pusilla* (KRÖMMELBEIN)	32**
29	*Monoceratina ? parvula* KOTCHETKOVA	33++
30	*Nemoceratina suprapermiana* (JORDAN)	34**
31	*Paraberounella* sp.	35**
32	*Polycope* sp.	36**
33	*Roundyella lebaensis* KRÖMMELBEIN	37**
34	*Triassocypris* cf. *prisca* KOZUR	38++
35	*Vallumoceratina permiana* (KRÖMMELBEIN)	39**
36	*Vallumoceratina rugensis* KNÜPFER	40++
37	*Waylandella seitzi* KRÖMMELBEIN	41++
38	*Clarkina bitteri* (KOZUR)	1··
39	*Clarkina rosenkrantzi* (BENDER & STOPPEL)	2··
40	*Merrillina divergens* (BENDER & STOPPEL)	3**
41	*Stepanovites inflatus* (BENDER & STOPPEL)	4**
42	*Achistrum* sp.	42**
43	*Eocaudina* sp.	43**
44	*Theelia dzhulfaensis* MOSTLER & RAHIMI-YAZD	44**
45	*Arabellites ? capricornu* (SEIDEL)	45··
46	*Arabellites eudoxus* (SZANIAWSKI)	46++
47	*Delosites falcatus* (SEIDEL)	47** +
48	*Eunicites biconvexus* (SEIDEL)	48** *
49	*Eunicites magnidentatus* (SEIDEL)	49** *
50	*Eunicites spinosus* (SEIDEL)	50** *
51	*Staurocephalites compressus* (SZANIAWSKI)	51** *
52	*Palaeolimnadia* sp. aff. *cishycranica* NOVOZHILOV	52***
53	*Falsisca eotriassica eotriassica* KOZUR & SEIDEL	53*****
54	*Euestheria gutta gutta* LJUTKEVICH	54************ *****++++
55	*Falsisca eotriassica postera* KOZUR & SEIDEL	55++****
56	*Euestheria jakutica* (NOVOZHILOV)	56·····
57	*Euestheria gutta oertlii* KOZUR	57········ *********
58	*Falsisca* n. sp. aff. *verchojanica* (MOLIN)	58+**
59	*Molinestheria seideli* KOZUR	59*********
60	*Vertexia tauricornis tauricornis* LJUTKEVICH	60****+++++
61	*Vertexia tauricornis transita* KOZUR & SEIDEL	61··++***
62	*Liograpta (Magniesth.) ? malangensis* (MARLIÈRE)	62·······
63	*Liograpta (Magniestheria) ? lerichi* (MARLIÈRE)	63 ······
64	*Cornia germari* (BEYRICH)	64+****
65	*Polygrapta rybinskensis* (NOVOZHILOV)	65**

Table 3.
Range chart of sporomorphs in the Zechstein and lower part of Buntsandstein.

... sporadic occurrence	*** common to dominant	ooo <10 %	xxx 30 - 50 %
+++ rare		øøø 10 - 50 %	■■■ >50 %

Abbreviations see Table 2.

late Dzhulfian age cannot be excluded. Sporomorphs from the immediately underlying marly layer indicate a Dzhulfian age (Text-Fig. 1).

The boundary between the Bellerophon Limestone Fm. and the basal Werfen Group (Tesero Oolite horizon) is clearly diachronous (see Text-Fig. 1). Toward the deeper part of the basin the lowermost Tesero Oolite Horizon is replaced by the facies of the Bellerophon Limestone, whereas its upper part is replaced by the fine-bedded or laminated marls of the Mazzin Member, so that the Mazzin Member finally rests directly on the Bellerophon Limestone Fm. in the deeper parts of the basin, e.g., in San Antonio (BRANDNER et al., 1986). Therefore the top of the Bellerophon Limestone Fm. cannot be regarded anymore as synchronous level and as P/T boundary, as already pointed out by KOZUR (1972, 1974 a, 1989), who placed the P/T boundary within the lowermost Werfen beds (first appearance of the genus *Isarcicella*), a view that was for the first time also taken into consideration by other authors during the Brescia Symposium (1986).

The lateral replacement of the Tesero Oolite by the Bellerophon Limestone Fm. (below) and by the Mazzin Member (above) is shown in Text-Fig. 1. About 1.7 m above the top of the Bellerophon Limestone Fm. in the Tesero section and 0.5 m above the top of this Formation in the Sass de Putia section a rich conodont fauna with *H. latidentatus* and *Stepanovites* begins that indicates Late Changxingian age (below the Transitional Beds, see chapter 2 and Table 1). In the Tesero section the Late Changxingian age of this horizon is additionally supported by Changxingian brachiopods (see Text-Fig. 1). In both sections the Upper Changxingian fauna is accompanied by a rich sporomorph association of the *Lundbladispora obsoleta – Lunatisporites noviaulensis* A.Z. (see also explanation to Text-Fig. 1) that can be well correlated by numerous common species with the *Taeniaesporites* association (BALME, 1970) of the upper *Otoceras* beds of Eastern Greenland. Like there, spores of marine fungi are very common also in the Southern Alps beside the land-derived sporomorphs. Even the fungi themselves have been found in the Sass de Putia section. *Lundbladispora obsoleta*, often still attached in tetrahedrons, and other spores of lycopodid origin are most frequent among the land-derived sporomorphs.

In the Salt Range, the Chhidru Formation was named by FURNISH & GLENISTER (1970) Chhidruan Stage and it was regarded to be younger than the Araksian (Dzhulfian) and older than the Changxingian. On the other hand, many other authors (e.g. WATERHOUSE, 1972, 1976; LEVEN, 1975; KOTLJAR et al., 1984) regarded the whole Chhidru Fm. as older than Dzhulfian. KOZUR (1978) placed the Chhidru Fm. into the uppermost Abadehian. This part of the Abadehian corresponds to the Lower Dzhulfian according to the newer data about the age of the Abadehian (GLENISTER et al., 1992; KOZUR, 1992a,b,c, 1993) and Dzhulfian; the largest part of the Abadehian corresponds to the Capitanian. The PAKISTANI-JAPANESE RESEARCH GROUP (1985) regarded the Chhidru Fm. as Dzhulfian as well. The majority of the Titular Members of the SCPS places the Chhidruan into the "Midian" (stratigraphic extent see Table 7) and lowermost Dzhulfian (DICKINS, in Permophiles, **12**, 1987) or into the uppermost "Midian" and lower Dzhulfian (JAPANESE WORKING GROUP in Permophiles, **12**, 1987). Conodont studies by the present author and the evaluation of the distribution of the other faunal elements published by the PAKISTANI-JAPANESE RESEARCH GROUP (1985) indicate a Dzhulfian age for the Chhidru Fm., but its uppermost part (White Sandstone Member) could reach up to the basal Changxingian (see Table 7).

The overlying Kathwai Member of the Mianwali Formation was for a long time regarded as Lower Triassic, because its ammonoid fauna was correlated with the *Ophiceras* faunas. WATERHOUSE (1972, 1976), in turn, placed the entire Kathwai Member into the Late Permian. GRANT (1970) and GRANT & COOPER (in LOGAN & HILLS, 1973) placed the lower part of the Dolomite Unit (lower Kathwai Member) on the basis of brachiopods into the Late Permian, in the latter paper into the Changxingian. KOZUR (1972, 1974b, 1978) placed the Lower Dolomite Unit into the latest Permian, because the conodont fauna indicates for this part a correlation with the *Otoceras woodwardi* zone, placed into the Permian by KOZUR (1972 and later papers). The careful investigations of the PAKISTANI-JAPANESE RESEARCH GROUP (1985) have shown that even fusulinids (*Reichelina* sp.) are present in the lower Dolomite Unit. In the basal beds of the Dolomite Unit *Comelicania* was found (DICKINS, Permophiles, 1987). These beds cannot be younger than basal Changxingian.

In Greenland the Foldvik Creek Group was placed in the last years into the Kungurian-Ufimian (WATERHOUSE, 1972, 1976), into the Guadalupian (Wordian-Capitanian, e.g. SWEET, 1976) or into the Dzhulfian (NASSICHUK et al., 1965). The age of the rich brachiopod fauna is disputed, but the ammonoid and conodont faunas yielded important data for the correlation. *Godthaabites kullingi* FREBOLD from the upper Foldvik Creek Group indicates an Early Dzhulfian age for this part of the Formation, because the only occurrence of the genus *Godthaabites* outside Greenland is in the Lower Dzhulfian of Transcaucasia and Iran (ZACHAROV, 1983). *Clarkina rosenkrantzi* (BENDER & STOPPEL) s.str., present in the entire Foldvik Creek Group with exception of its uppermost part, indicates a Dzhulfian age. An earliest Changxingian age for the uppermost Földvik Creek Group above the occurrence of C. rosenkrantzi cannot be excluded.

The overlying *Otoceras* beds are mostly placed into the Triassic. According to DAGIS & DAGIS (1987) equivalents of the *O. concavum* Zone are missing in Greenland (gap) and only the *O. boreale* Zone is present. The sporomorph association of the upper *O. boreale* Zone of Greenland belongs to the *L. obsoleta – L. noviaulensis* A.Z. (= *"Taeniaesporites"* association sensu BALME, 1979) that is also present in the lower Tesero Horizon of the Southern Alps, where it can be dated by conodonts, ostracods and brachiopods as Late Changxingian (see above). Also in Greenland this Upper Changxingian conodont fauna is present (SWEET, 1976). In the lower *O. boreale* Zone the *Protohaploxypinus* association sensu BALME (1979) is present that is according to BALME (1979) nearer related to Zechstein sporomorph associations than to any Lower Triassic sporomorph association all over the world. This view is confirmed by the discovery of the sporomorphs association of the *T. proratus* A.Z., in the

Zechstein-Buntsandstein boundary (generally)	Zechstein ⁄ Buntsandstein →		
NW German-Polish Basin (WAGNER, 1987, FUGL., 1980)	Z1 Z2 Z3 Z4 Z5 Z6 Z7	Suboolitic Beds (OS)	LO B →
Thuringian Basin (SEIDEL, 1956)	Z1 Z2 Z3 Z4 Uppermost Z.-L.	Lower Trans. / Upper Mbr. / CS M / SC M — Nordhausen Formation	LW M B. F. →
Spores (total)	ooooooooooøøøøøøøøxxxxxxxxx	▪x▪x	xxxxxxx
Monosaccate pollen (total)	ooooooooooooooooøøøøøøxøxøxø	oooo	ooooooo
Bisaccate pollen (total)	▪▪▪▪▪▪▪▪▪▪▪▪▪▪▪▪▪▪▪▪▪▪xxxxx	x▪x▪	xxxxxxx
1 *Lunatisporites labdacus* (KLAUS) CONTI et al.	1+++···		
2 *Perisaccus granulatus* KLAUS	2·········		
3 *Potonieisporites novicus* BHARADWAJ	3·········		
4 *Crustaesporites globosus* LESCHIK	4·········		
5 *Labiisporites granulatus* LESCHIK	5+++++++++		
6 *Striatoabieites microcorpus* (SCHAAR.) n. comb.	6·········		
7 *Vittatina costabilis* WILSON	7·············		
8 *Vittatina hiltonensis* CHALONER & CLARKE	8·············		
9 *Nuskoisporites dulhuntyi* POTONIÉ & KLAUS	9··················		
10 *Vestigisporites minutus* CLARKE	10+++++++++·········		
11 *Lueckisporites* cf. *parvus* KLAUS (= norm Bc)	11·······+**********		
12 *Florinites* sp.	12························		
13 *Limitisporites delasaucei* (POT. & KLAUS) SCH.	13+++++++++++++++··········		
14 *"Limitisporites" moersensis* (GREBE) KLAUS	14·······++**·············		
15 *Lueckisporites virkkiae* POTONIÉ & KLAUS	15************+++++········		
16 *Protohaploxypinus chaloneri* CLARKE	16························		
17 *Guttulapollenites* sp.	17···················+++++++++		
18 *Paravesicaspora splendens* (LESCHIK) KLAUS	18·······+++++············		
19 *Punctatisporites* spp.	19············++++++*********	++++	·······
20 *Falcisporites zapfei* (POTONIÉ & KLAUS) LESCHIK	20++++++++++++++++·········	···	
21 *Klausipollenites schaubergeri* (POT. & K.) JANS.	21***************************	···	
22 *Lunatisporites noviaulensis* (LESCHIK) SCHEUR.	22··········+++++++**********	****	*******
23 *Platysaccus papilionis* POTONIÉ & KLAUS	23+++++++++++++++++*********	****	+++····
24 *Protohaploxypinus samoilovichii* (JANS.) HART	24·············++++*********	****	++++···
25 *Strotersporites richteri* (KLAUS) WILSON	25++++++++++***************	****	·······
26 *Cycadopites follicularis* WILSON & WEBSTER	26···········+++************	****	*******
27 *Vitreisporites* sp.	27······+++++++++	++++	+++++++
28 *Iraqispora labrata* SINGH	28·····		
29 *Kraeuselisporites* sp.	29··+++		
30 *Cordaitina* sp.	30+++++		
31 *Playfordiaspora* sp.	31+++++		
32 *Potonieisporites* sp.	32+++++		
33 *Vestigisporites* sp.	33+++++		
34 *Circumstriatites brevitaeniatus* van der LAAR	34·····		
35 *Protohaploxypinus jacobii* (JANSONIUS) HART	35+++++		
36 *Gnetaceaepollenites* sp.	36+++++		
37 *Triquitrites proratus* BALME	37+++++	··	
38 *Deltoidospora nigrans* (NAUMOVA) n. comb.	38+++++	****	
39 *Brevitriletes* cf. *hennellyi* FOSTER	39+++++	++++	
40 *Rewanispora minuta (SINGH)* n. comb.	40·····	****	
41 *Nuskoisporites minutus* n. sp.	41+++++	++++	
42 *Lunat.* cf. *transversundatus* (JAN.) CONTI et al.	42+++++	****	
43 *Lunat.* sp. aff. *pellucidus* (GOUBIN) HELBY	43·····	****	
44 *Densoisporites playfordi* (BALME) DETTMANN	44·····	++++	+++****
45 *"Anaplanisporites" stipulatus* JANSONIUS		45****	
46 *Araucariacites* sp.		46····	+++++++
47 *Concavissimisporites grumulus* FOSTER		47····	
48 *Densoisporites* sp. aff. *nejburgii* (SCHULZ) BALME		48····	
49 *Endosporites* cf. *papillatus* JANSONIUS		49····	
50 *Endosporites* sp. sensu BALME, 1979		50++++	
51 *Lundbladispora* sp. aff. *brevicula* BALME		51++++	
52 *Crustaesporites jansonii* n. sp.		52****	
53 *Falcisporites stabilis* BALME		53····	
54 *Striatoabieites duiveni* (JANSONIUS) HART		54····	
55 *Striatopodocarpites rugosus* (JANSONIUS) HART		55++++	
56 *Kraeuselisporites apiculatus* JANSONIUS		56****	*******
57 *Lundbladispora obsoleta* BALME		57****	*******
58 *Lunatisporites pellucidus* (GOUBIN) HENELLY		58·	*******
59 *Osmundiacites* sp.			59·······
60 *Densoisporites nejburgii* (SCHULZ) BALME			60·······
61 *Endosporites papillatus* JANSONIUS			61++*****
62 *Kraeuselisporites punctatus* JANSONIUS			62·······
63 *Lundbladispora brevicula* BALME			63+++++++
64 *Lundbladispora willmotti* BALME			64*******
65 *Lunatisporites hexagonalis* (JANSONIUS) n. comb.			65+++++++
66 *Echitriletes* sp.	66+++++		
67 *Otynisporites* sp.	67+++++		
68 *Hughesisporites simplex* FUGLEWICZ		68****	
69 *Triangulatisporites reticulatus* FUGLEWICZ		69····	
70 *Otynisporites eotriassicus* FUGLEWICZ		70****	*******
71 *Otynisporites tuberculatus* FUGLEWICZ		71****	*******
72 *Trileites vulgaris* FUGLEWICZ		72****	*******
73 *Talchirella permotriassica* (FUGLEWICZ) n. comb.			73+++++++

uppermost Zechstein that is very similar to the *Protohaploxypinus* association of the lower *Otoceras* beds of Greenland.

4. Correlation of the Zechstein

The lower boundary of the Zechstein is placed at the base of the first marine bed in the basinal facies. The lower part of the Zechstein Conglomerate is often non-marine, because fluviatile conglomerates have been often united with the marine clastic basal sediments of the Zechstein.

The lithostratigraphic subdivision and correlation of the Z_1–Z_4 are since RICHTER-BERNBURG (1955) well established. Problems still exist with the subdivision of the Z_5–Z_7 and with the Zechstein-Buntsandstein boundary. This boundary is in its present (1987) use diachronous between the central parts of the basin and the more marginal parts[4]). The subdivision and correlation from the Z_5 to the basal Buntsandstein is shown in table 4.

The Z_5 (REICHENBACH, 1963, 1970) was later subdivided by KÄDING (1978 a,b) into the Z_5 (Ohre Formation) and Z_6, but the upper boundary of the Z_6 was not used uniformly in these two papers. KÄDING (1978a) placed the top of the Z_6 below the Lower Bröckelschiefer, KÄDING (1978 b) placed it below the Basis Sandstone of the Upper Bröckelschiefer. BRÜNING (1986) followed KÄDING (1978a) and he regarded all beds below the Gray-green Boundary Bank (sensu SEIDEL, 1965) and above the Z_4 as $Z_5 + Z_6$. But between the top of the Z_4 and the base of the Gray-green Boundary Bank only one cycle can be observed. This can be proven in the Calvörde Block, where the Gray-green Boundary Bank (0.5 m brown and gray siltstones and anhydrite) can be recognized just above the Ohre (Z_5) Halite. Therefore the Gray-green Boundary Bank is not situated above the Z_6, but it corresponds to the base of the Z_6 (or perhaps even partly to the recessive top of the Z_5). In Thuringia beside the Gray-green Boundary Bank seemingly the lower part of the cycle 1 of the basal Bröckelschiefer (sensu SEIDEL, 1969) belongs to the Z_6. These beds are characterized by the occurrence of dolomite nodules. But no clear separation from the Z_7 is possible in Thuringia so that there the uppermost Zechstein beds should be rather designated as $Z_6/7$. According to BEST (in KLARE & SCHRÖDER, 1987) the Z_6 is named as Friesland Formation ("Serie"), the Z_7 as Mölln Fm. Above the latter Formation still a further Zechstein cycle is present (unnamed). In the Polish subdivision the Z_5 corresponds to the P Z_4b, the Z_6 to the P Z_4c, the Z_7 to the P Z_4d, the unnamed uppermost cycle corresponds to the P Z_4e and an also there unnamed interval (see table 4).

In the Calvörde Block the Z_6 anhydrite is still well developed just below the anhydrite-bearing Bröckelschiefer. The lower part of this Bröckelschiefer that begins in the upper part of the cycle 1 sensu SEIDEL (1969) should correspond to the Z_7 (see Table 4). This cycle clearly ends at the base of the Basis Sandstone of the upper Bröckelschiefer sensu BRÜNING (1986). But we should notice here that SEIDEL (1965) placed these beds into the upper 5–6 m of the "undeutlich geflaserte Folge" of the lower Bröckelschiefer. These beds correspond to the lower part of cycle 2 sensu SEIDEL (1969). In the upper meter of these beds the 0.1 – 0.2 m thick gray-green Bröckelschieferbank sensu SEIDEL (1965) can be recognized in large parts of Germany (SEIDEL, 1965; BRÜNING, 1986). Until this horizon the sabkha conditions continued in the more basinal parts of the basin. Perhaps this horizon corresponds to the last saline cycle in the very centre of the basin (P Z_4 e) in the Zuber facies of Poland, still above equivalents of the Z_7 (= P Z_4d, see WAGNER, 1987).

At the base of the upper Bröckelschiefer sensu SEIDEL (1965) that corresponds to the base of the upper part of cycle 2 sensu SEIDEL (1969) a very characteristic horizon can be traced in the entire Germanic Basin (with exception of the coarse-clastic marginal parts). This horizon is characterized by a mm-fine, very dense flaser-bedding that indicates the end of the sabkha conditions also in the central parts of the Germanic Basin, because there the first fresh-water sediments begin that are unknown in the Upper Zechstein (including the lower Bröckelschiefer sensu SEIDEL, 1965). Immediately above these beds the first conchostracans have been found (KOZUR & SEIDEL, 1983 a,b) that can only exist under fresh-water or slightly brackish conditions. This very densely flaser-bedded horizon marks the base of the Buntsandstein (Baltic Formation) in western Poland (WAGNER, 1987) and this Zechstein/Buntsandstein boundary is here accepted as a natural and seemingly in the whole basin (with exception of the coarse clastic marginal parts) synchronous boundary (Table 4).

The Zechstein can be well correlated by conodonts, ostracods and sporomorphs with several marine and partly also with continental sequences in many areas outside the Germanic Basin, e.g. in the Southern Alps, Hungary, Transcaucasia, NW- and Central Iran, in the Salt Range and in Greenland. But as mentioned in chapter 1, the stratigraphic subdivision and above all the correlation with the Late Permian stages are in these areas often disputed. Therefore the stratigraphic problems of these areas as well as the biostratigraphic extent of the Late Permian Stages have been discussed in chapters 2 and 3. The biostratigraphic extent of the Late Permian Stages as used in the present paper is shown in Table 1. In Tables 6 and 7 the most important European and Asiatic Middle and Upper Permian sequences, including the stratotypes of the Late Permian Stages are correlated with each other and with the Tethyan, Cis-Uralian/Russian Platform and world standards.

Without these stratigraphic investigations outside the Germanic Basin even correct correlations of certain stratigraphic units of these areas with the Zechstein could lead to quite contrary chronostratigraphic datings of the Zechstein. The stratigraphic correlation of the uppermost Zechstein, for instance, is in the moment decisively influenced by the stratigraphic position of the White Sandstone Member of the uppermost Chhidru Formation (see chapter 3) that belongs to the same sporomorph zone as

[4]) Meanwhile also the German Stratigraphic Subcommission Perm/Trias has decided (1. 5. 1992 in Aschersleben, written remarks Prof. ROSENFELD, Münster) that the Bröckelschiefer as time-equivalent of the Zechstein in the central part of the Germanic Basin must be placed into the Zechstein. However, as pointed out by KOZUR (1989) only in some areas the whole Bröckelschiefer belongs to the Zechstein. In other areas, e.g. in Thuringia, the upper Bröckelschiefer, consisting mainly of fresh-water lake and fluviatile deposits, is younger than the Zechstein in the central Basin (see Table 4). A similar view was expressed by BEST (in KLARE & SCHRÖDER, 1987). Because the Bröckelschiefer is not more placed into the Nordhausen Formation, this term was abandoned and replaced by the Calvörde Fm. However, in the type section of the Nordhausen Fm. in Nordhausen, the beds placed into the Bröckelschiefer are according to their conchostracan fauna with many spined vertexiids in reality the upper red part of the Sandy Claystone Member of the Nordhausen Fm. that are only facially similar to the Bröckelschiefer. Therefore it was not necessary to replace the term Nordhausen Fm.

Table 4.
Correlation of the lithostratigraphic units near the Zechstein/Buntsandstein Boundary from the Thuringian Basin until western Poland.
Vertical distances are not time- or thickness-related, gaps not indicated.
N.F. = Nordhausen Formation; upper Z.L. = uppermost Zechsteinletten.

			Thuringian Basin (SEIDEL, 1965, 1969), KOZUR & SEIDEL, 1983 c)			SE margin of Harz Mts. (RADZINSKI, 1967)			Subhercyne Basin/Calvörde Basin (SCHULZE, 1969, REICHENBACH, 1963, 1970)			Polish Basin (WAGNER, 1987, FUGL., 1980)		present paper
			Sandy Claystone Mbr. (N. F.)			45-55 m Lower Sandstone-Claystone Interbedding with oolitic beds			Lower Claystone Zone oo β2 oo β1		Baltic	Sub-Oolitic Beds		Nordhausen Fm.
			20-43 m Clayey Sandstone Member (Nordhausen Formation)				BUNTSANDSTEIN		15-20 m Graubank Zone with oolite horizon oo α	BUNTSANDSTEIN		Otyniepor. Siltstone, oolites	BUNTSANDSTEIN	
BUNTSANDSTEIN	Bröckelschiefer	cyc. 3	9-14 m reddish-brown claystone/siltstone, sandstone flaser; first conchostracan-bearing fresh-water deposits			18 m upper part (siltstone with sandstone flaser, in the lower part			35-40 m Sandstone-Claystone Zone		Formation	Sub-Oolitic Beds		
		cyc1	5-10 m reddish-brown claystone/siltstone, mm-dense sdst. flaser	BUNTSANDSTEIN	Bröckelschiefer	horizon with very dense flaser-bedding)			horizon with very dense flaser-bedding					
		se2	5-6 m reddish-brown siltstone, medium- to coarse-grained sdst.			5 m middle part (siltstone, partly coarse sdst.)			10 m Bröckelschiefer			PZ4e		
		cyl	3-7 m reddish-brown clayst. with anhydrite			10 m lower part					Rewal	PZ4d		Z 7
		se1	2-5 m red siltstone, with sandstone flaser, dolomite nodules			(predominantly			0.25-0.5 m anhydrite	ZECHSTEIN	Fm	PZ4c	ZECHSTEIN	Z 6/7
							ZECHSTEIN		2 m brown siltstone					Z 6
ZECHSTEIN	Zechstein 4	upp	0.1-0.5 m Gray-green Boundary Bank			Gray-green Boundary Bank		Zechst. 5	0.5 m brown and gray siltstone and anhydrite					
		upper Z.L.	5-8 m reddish-brown, basal reddish-green siltstones, anhydrite/gypsum nodules, partly sandstone flaser			claystone)			0.3-3 m pink halite; 0.3 m anhydr., siltst.; 5 m siltstone, partly with sandstone flaser			PZ4b		Z 5
	4		Aller Salinar	Z	Z4	Aller Salinar		Z4	Aller Halite			PZ4a		Z4

the uppermost Zechstein. The present day opinions about the age of this lithostratigraphic unit vary among the Titular Members of the Subcommission on Permian Stratigraphy between pre-Dzhulfian Late Permian (e.g. KOTLJAR), basal Dzhulfian (e.g. DICKINS), Early Dzhulfian (e.g. KATO) and uppermost Dzhulfian or basal Changxingian (KOZUR).

In the following, only the chronostratigraphic correlation of the basal and uppermost Zechstein will be discussed to show the stratigraphic range of this lithostratigraphic unit. The more detailed correlation of the lithostratigraphic units within the Zechstein with the sporomorph zonation and the marine standard is shown in Table 5. The range of the sporomorph zones within the lithostratigraphic units of the Zechstein is rather well established.

The only larger discrepancy exists regarding the base of the *Lueckisporites* cf. *parvus* A.Z. (= sporomorph association with dominating norm Bc among the *Lueckisporites* palynodemes). In the Plattendolomite quarry Oberrhon (southern Thuringia) this zone is well documented in the claystones immediately above the Plattendolomite. VISSCHER (in KOZUR, 1978) recognized dominating *L. virkkiae*, norm B among the *Lueckisporites* palynodemes. Later investigations of further samples from this level in the locality Oberrohn by the present author confirmed these data. DYBOVA-JACHOWICZ et al. (1984), in turn, stated that still in the P Z_4 a (= Z_4) *L. virkkiae*, norm Ac prevails and only in the P Z_4 b to P Z_4 d (Z_5 to Z_7) *L. virkkiae*, norm Bc dominates. WAGNER (1987) stated that no sporomorphs are known from the

P Z_4 d. May be that the data presented by DYBOVA-JACHOWICZ et al. (1984) have to be generally lowered one cycle. In this case, also in Poland the *L.* cf. *parvus* A.Z.. would be present already in the Z_4 that is not far away from the data by VISSCHER and the present author.

The correlation of the *L.* cf. *parvus* A.Z. with the marine standard is not yet well established, but because the overlying *T. proratus* A.Z. begins in the uppermost Dzhulfian, an Late Dzhulfian age for the *L.* cf. *parvus* A.Z. is probable.

The lower Z_1 can be well correlated with the standard scale by conodonts, ostracods and sporomorphs. *Merrillina divergens* (BENDER & STOPPEL), the most characteristic conodont species of the Zechstein Limestone, is known from unit 5 (*Codonofusiella kwangsiana* Zone) and the *Araxilevis* Beds (basal unit 6) of Central Iran (both lower Dzhulfian) as well as from the upper Hachik Formation (*Codonofusiella* Zone) and the overlying *Araxilevis* Beds of NW Iran and Transcaucasia (Lower Dzhulfian in the type area; KOZUR, MOSTLER & RAHIMI-YAZD, 1975; KOZUR, 1978; KOZUR et al., 1978; IRANIAN-JAPANESE RESEARCH GROUP, 1981). From the Cordilleran miogeosyncline of western North America WARDLAW & COLLISON (1986) reported the joint occurrence of *M. divergens* and *"Neogondolella" bitteri* (KOZUR) in their zone 7 that they placed near the Wordian-Capitanian boundary. CLARK & BEHNKEN (1979), in turn, regarded even beds with *Clarkina ? wilcoxi* (CLARK & BEHNKEN) (and *M. praedivergens* KOZUR & MOSTLER) below zone 7 of WARDLAW & COLLISON (1986) as post-Capitanian. With regard to the ammonoid- and fusulinid controlled Upper Permian conodont ranges of the Asiatic Tethys, the *M. divergens* – *C. bitteri* fauna of western North America belongs probably also to the Lower Dzhulfian.

The other conodont species of the Z_1 (listed in Table 2) have a longer range (mostly Upper Capitanian to Middle Dzhulfian). *Clarkina bitteri* (KOZUR) was determined as *Neogondolella* aff. *idahoensis* by SWIFT & ALDRIDGE (1986). As a whole, the conodonts indicate a Dzhulfian age for the Z_1 (see Tables 1 and 2).

The conodont correlation of the Zechstein Limestone is confirmed by other fossils. The sporomorph association of the Z_1 to lower Z_3 (see Table 3) can be well correlated with the association II_3 by BARABÁS-STUHL (1981) of the Mecsek Mountains (southern Hungary) and with the *L. noviaulensis* – *P. splendens* and *Sch. maximus* – *P. splendens* associations sensu CONTI et al. (1986) from the upper Bellerophon Limestone of the Southern Alps. Most characteristic for these typical Upper Permian sporomorph associations with rich occurrence of *L. virkkiae* POTONIÉ & KLAUS is the absence of *Gigantosporites* spp., still common in the Upper Capitanian[5]).

Direct correlation of the ostracod faunas (see Table 2) are rather difficult, because only very few species of the Zechstein Limestone can be found in the Tethyan Late Permian that belong even partly to other subspecies. According to KOZUR (1985) *Bairdia plebeia* REUSS occurs from the middle *P. transita* A.Z. to the lower *P. fueloepi* Zone (Dzhulfian). *Hungarella* aff. *ogmoconchelloides* (KNÜPFER) occurs in the upper *P. transita* A.Z. (Dzhulfian). *Roundyella lebaensis* KRÖMMELBEIN occurs in the Late Dzhulfian *P. fuelopi* Zone, but with a different subspecies. As a whole, the ostracods indicate a Dzhulfian, but not earliest Dzhulfian age for the basal Zechstein.

With regard to the Cis-Uralian standard, the magnetostratigraphic data indicate that the base of the Zechstein cannot be older than the upper part of Late Tatarian, because the Illawarra Reversal lies on one side considerably below the base of the Zechstein (DACHROTH, 1976; WIEGANK & MENNING, 1984; MENNING, 1986), on the other side it is situated about at the base of the Suchona Formation near the Early/Late Tatarian boundary (STROK et al., 1984). The same results yielded paleontological/palynological correlations. The Severodvina Formation of the lower Late Tatarian can be well correlated by conchostracans with the lower Kővágószőllős Formation of the Mecsek Mountains (KOZUR, 1985, 1988a,b) that has, in turn, a sporomorph association with *Gigantosporites*. This association is a little older than the basal Zechstein (already without *Gigantosporites*, but see footnote 5). The sporomorph association of the Zechstein without *Gigantosporites* follows in the Mecsek Mountains immediately above this association. The base of the Zechstein must be therefore younger than the Severodvina Formation. It can be only situated within the uppermost Tatarian Vjatka Formation, if the Zechstein is not as a whole post-Tatarian, what cannot be quite excluded (KOZUR, 1985).

With regard to the North American standard, the conodont fauna of the Zechstein Limestone (Table 2) is younger than the conodont fauna of the uppermost Capitanian in its Western Texas type area, where still the *Mesogondolella postserrata* group is dominating. Because the uppermost Lamar Limestone of the type Capitanian belongs already to the basal Dzhulfian (KOZUR, 1992a,b,c, 1993) the base of the Zechstein must be somewhat younger than the base of the Dzhulfian s.l..

The richest sporomorph association from the uppermost Zechstein was found by FUGLEWICZ & KOZUR (in prep.) in the borehole Otyn IG-1 (western Poland) in 2 horizons 8 m and 21.5 m below the base of the Baltic Formation (base of Buntsandstein). This association (present species see Table 3 under Z_7) is clearly younger than the sporomorph association of the P Z_4 c that contains according to DYBOVA-JACHOWICZ et al. (1984) still the association with dominating *L. virkkiae*, norm Bc (= *L.* cf. *parvus*), missing in the uppermost Zechstein sporomorph association of the borehole Otyn IG-1. The former view of DYBOVA-JACHOWICZ et al. (1984) that the association with dominating *L. virkkiae*, norm Bc ranges up to the P Z_4 d was corrected by WAGNER (1987), who pointed out that no sporomorphs were known so far from the P Z_4 d and P Z_4 e. Just from this interval the sporomorph association of the Otyn IG-1 borehole has been derived. For the lower horizon, 21.5. m below the top of the Zechstein, cannot be excluded that it corresponds to the upper P Z_4 c (upper Z_6); the upper horizon 8 m below the top of the Zechstein belongs to the Z_7.

As shown in Table 4, the interval from the P Z_4 d to the top of the Zechstein in western Poland can be correlated with the Bröckelschiefer on the Calvörde Block and with the lower (but not lowest) Bröckelschiefer sensu SEIDEL (1965) in Thuringia.

The sporomorph association in the uppermost Zechstein of the borehole Otyn IG-1 is placed into the *T. proratus*

[5]) However, it has been taken into consideration that both in the Southern Alps and in the Mecsek Mts the Upper Permian sporomorph associations contain up to 10 % Gondwanide elements. May be that also *Gigantosporites* is a southern element, missing in the Germanic Basin. In this case, the associations with dominating *L. virkkiae* norm Ab and *Gigantosporites* of the Southern Alps and the Mecsek Mts could have the same age as the association with dominating *L. virkkiae* norm Ab, but without *Gigantosporites* in the Germanic Basin. However, in the Mecsek Mts the latter association lies above the *Gigantosporites*-bearing association.

Table 5.
Correlation of the Middle European Rotliegend to basal Buntsandstein lithostratigràphic units with the Permian time-scale, the Euramerian Permian sporomorph zonation and the Cis-Uralian Standard.

	Used time-scale (proposed standard)	Sporomorph Assemblage Zones	Germanic Basin	Cis-Ural/ Russ. Platf.
Upper Permian	Changxingian, upper	*Lundbladispora obsoleta - Lunatisporites noviaulensis*	Clayey Sandstone Member and time-equivalents	basal Vetluga Group
	Changxingian		Upper Bröckel= schiefer and time-eqivalents	
	Changxingian, lower	*Triquitrites proratus*	------ Z 7; Lower Bröckel= schiefer	
	Dzhulfian	II4 *Lueckisporites* cf. *parvus*	Z 6; Z 5 (Lower Bröckelschiefer s.l.); Z 4	
		II3 *Lueckisporites virkkiae*	Z 3; Z 2; Z 1	
		II2 *L. virkkiae-Gigantosporites hallstattensis*	Rotliegend	Upper Tatarian
Middle	Capitanian	II1 *L. virkkiae-Corisaccites*		Lower Tatarian
	Wordian			Kazanian
	Roadian	*L. virkkiae-Corisaccites Crucisaccites*		
Lower Perm.	Leonardian s.str.	*L. virkkiae-Corisaccites-Crucisaccites-Hamiapollen.*		Ufimian
				Kungurian
	Artinskian			Artinskian
	Sakmarian			Sakmarian
	Asselian s.str. / s.l.			Asselian
C.	Gzhelian			Gzhelian

A.Z. (see Table 5). As shown in Table 3, it is distinguished from the underlying sporomorph association of the Zechstein (*L.* cf. *parvus* A.Z. and *L. virkkiae* A.Z., see Table 5) e.g. by the first appearance of *T. proratus* BALME and *I. labrata* SINGH as well as by the considerably higher percentages of spores and monosaccate pollen. But almost all guide-forms of the Late Permian pollen are still present, even if some of these forms are very rare. The overlying sporomorph association of the *L. obsoleta – L. noviaulensis* A.Z. is distinguished by the common to dominant occurrence of *Lundbladispora obsoleta* and other cavate trilete spores of lycopodid origin (see Table 3).

The *T. proratus* A.Z. of the uppermost Zechstein can be well correlated with the *T. proratus* A.Z. of the White Sandstone Member (uppermost Chhidru Formation) of the Salt Range (BALME, 1970) and even with the *Playfordiaspora crenulata* Zone of eastern Australia (FOSTER, 1982), where likewise *T. proratus* appears. This species has a huge regional distribution from South China to Australia and across the Salt Range to Middle Europe. *T. proratus* has evolved in the Cathaysian floral province, where the genus *Triquitrites* is present in the entire Permian and the immediate forerunner of *T. proratus* is known. *T. proratus* begins in South China in well dated marine sequences in the Upper Dzhulfian, has it main occurrence in the Changxingian and reaches upward with a few specimens into the basal Lower Triassic (OUYANG, 1986). The White Sandstone Member is latest Dzhulfian or earliest Changxingian in age (see chapter 3). The same age can be assumed for the *T. proratus* A.Z. of the Germanic Basin.

It is interesting that the association of the *T. proratus* A.Z. (and the contemporaneous *P. crenulata* Zone of Australia) is known in the huge area from Australia to the Germanic Basin always from beds that lie below a sharp, climatically controlled lithologic change. More precisely, this change lies in the upper part of the very short time-interval of the *T. proratus* A.Z. This sporomorph zone is always situated in the uppermost part of sediments of "Permian type", already somewhat transitional to sediments of "Lower Triassic type" and in the basal part of sediments of "Lower Triassic type", still somewhat transitional to sediments of "Permian type", if in the latter sediments any sporomorphs are present: Bowen Basin (Australia): Uppermost part of Baralaba Coal Measures and lowermost part of Rewan Formation; Salt Range: Uppermost part of Chhidru Formation (the basal part of the Kathwai Member has not yet yielded sporomorphs); Germanic Basin: Uppermost part of the Zechstein (just those parts of the Zechstein in the central basin that are placed into the basal Buntsandstein – lower Bröckelschiefer – in the marginal parts of the basin), the upper Bröckelschiefer has not yet yielded sporomorphs; Ural/Russian Platform: in places in the basal Vetluga Group above a gap; Greenland: In the lower *Otoceras*-bearing beds above a gap.

The *T. proratus* A.Z. and time equivalents (*P. crenulata* Zone of FOSTER, 1982, upper *P. meishanensis* – *M. gigantea* and *Y. radiata* – *Gardenasporites* spp. assemblage of OUYANG, 1986) lies always somewhat before an important break in the flora and fauna. Moreover, during the *T. proratus* A.Z. and the following *L. obsoleta* – *L. noviaulensis* A.Z. shallow-marine deposits are world-wide marked by mass occurrences of marine fungi and their spores that are in this time generally by far more frequent than land-derived sporomorphs. These mass occurrences of marine fungi and their spores indicate most probably a time of reduced influx of sunlight on the earth surface because of the presence of aerosols. Such aerosols could originate both from a cosmic impact or an extraordinary strong volcanism. The latter cause is more probable, because the time interval of mass occurrences of marine fungi and their spores in shallow-marine deposits corresponds to the uppermost Dzhulfian and Changxingian, a time interval of at least several 100.000 years that requires the repeated origination of rather dense aerosols during this time interval. The maximum activity of the Siberian trap volcanism coincides with this time interval (KOZUR, 1989).

The above mentioned strong world-wide climatic changes during the Changxingian are clearly related to the rather long-lasting event that created the aerosols (higher albedo, self-strengthening effects). World-wide (but over very large distances different) and sharp climatic changes in a short interval that have also caused sharp lithofacial changes in continental and shallow-marine sediments, reduced input of sun-light, mass occurrences of marine fungi in shallow-marine environments could finally lead to a collapse of the shallow marine and continental ecosystems that may be finally triggered or strengthened in its effects by any high energy event (peak in the volcanic activity, impact of a cosmic body) or by an anoxic event (HALLAM, pers. comm.) in the basal Triassic. The interaction of these conditions during the Changxingian is seemingly the cause for the big turnover in the fauna in the time-interval from the uppermost Dzhulfian to basal Triassic.

The species composition of the *T. proratus* A.Z. indicates the beginning of a world-wide more uniform flora after the strong Permian floral provincialism. Just in this time the first floral immigrants from formerly sharply separated floral provinces reached the central parts of other floral provinces (e.g. the Euramerian *Playfordiaspora crenulata* reached Australia, whereas before this species penetrated the Gondwanide province not further south than to its northern margin, e.g. in the Salt Range and North Africa; the Gondwanide *Iraquispora labrata* reached the whole Euramerian and Cathaysian floral provinces; the Cathaysian *Triquitrites proratus* reached Australia, the Salt Range and the Germanic Basin).

In this connection is interesting that all over the world the *T. proratus* A.Z. and its time-equivalents (see above) are overlain by beds with predominant cavate trilete spores of lycopodid origin (*L. obsoleta* – *L. noviaulensis* A.Z.), quite independent from the Permian floral provinces. This Upper Changxingian sporomorph association was found by the present author in the Clayey Sandstone Member of Thuringia, in the lower Claystone-Sandstone Interbedding up to the ooß1 on the SE margin of Harz Mts, in the "Graubank Zone" of the Subhercyne Basin and by FUGLEWICZ & KOZUR (in prep.) in the *Otynisporites* Siltstone of the boreholes Otyn IG-1 and Gorzów-Wielkopolski IG-1.

Only above this association sporomorphs appear that are restricted to the (Early) Triassic, like *Lundbladispora wilmotti* BALME and *Lunatisporites pellucidus* (GOUBIN) HELBY s.str. (see Table 3).

The Late Changxingian age of the *L. obsoleta* – *L. noviaulensis* A.Z. can be well proven in the Southern Alps, where this association (with the same species as in the Germanic Basin) occurs together with the Upper Changxingian conodont *H. latidentatus* (*H. parvus* is not yet present there !) and Changxingian brachiopods, ostracods (see Text-Fig. 1). The same sporomorph association occurs also in the upper *O. boreale* Zone of Greenland, thus indicating a Late Changxingian age of the *O. boreale* Zone that is also shown by the conodont fauna of the *O. boreale* Zone in Greenland (SWEET, 1986) and in the lower half of the Perigondwanian *O. woodwardi* Zone (KOZUR, 1980c; BANDO et al., 1980; BHATT & ARORA, 1984).

The Late Changxingian age of the *L. obsoleta* – *L. noviaulensis* A.Z. indicates that the P/T boundary lies well above the Zechstein/Buntsandstein boundary near the top of the Clayey Sandstone Member of Thuringia (KOZUR, 1984, lecture to the 27th Intern. Geol. Congr.; KOZUR, 1986, 1987, and in KLARE & SCHRÖDER, 1987). But it must be pointed out that this P/T boundary corresponds to the P/T boundary at the top of the Changxingian (including the Transitional Beds s.str. = *H. changxingense* Zone, see chapter 2) and not at the time-diachronic base of the *Otoceras* faunas that lies within the Changxingian. ECKE (in KLARE & SCHRÖDER, 1987) came to an almost identical P/T boundary in the Germanic Basin at the top of the "Graubankbereich", but it is not clear, which P/T boundary he used and what is the base of his correlations. Compared with the Cis-Uralian standard, ECKE placed the top of the "Graubankbereich" at the top of the Tatarian,

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Table 6.
Middle Permian to Middle Scythian (Lower Olenkian) in Europe.
Vertical distances are not time- or thickness-related

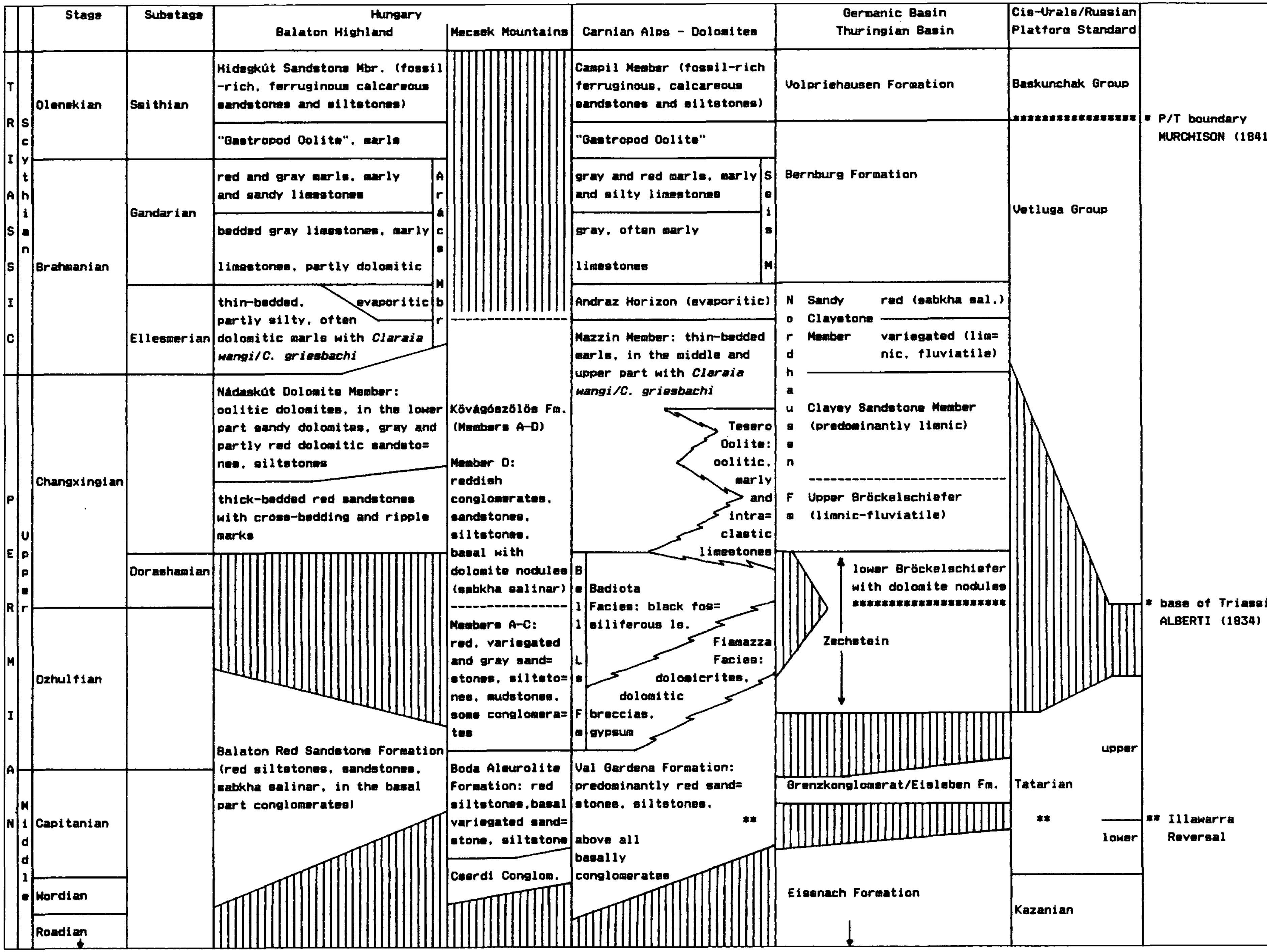
Stage
Substage
Hungary
Balaton Highland
Mecsek Mountains
Carnian Alps - Dolomites
Germanic Basin
Thuringian Basin
Cis-Urals/Russian
Platform Standard
TRIASSIC
Scythian
Olenskian
Smithian
Hidegkút Sandstone Mbr. (fossil-rich, ferruginous calcareous sandstones and siltstones)
Campil Member (fossil-rich ferruginous, calcareous sandstones and siltstones)
Volpriehausen Formation
Baskunchak Group
* P/T boundary MURCHISON (1841)
"Gastropod Oolite", marls
"Gastropod Oolite"
Brahmanian
Gandarian
red and gray marls, marly and sandy limestones
Arács Mbr
bedded gray limestones, marly
limestones, partly dolomitic
gray and red marls, marly and silty limestones
Seis M
gray, often marly
limestones
Bernburg Formation
Vetluga Group
Ellesmerian
thin-bedded, partly silty, often dolomitic marls with Claraia wangi/C. griesbachi
evaporitic
Andraz Horizon (evaporitic)
Mazzin Member: thin-bedded marls, in the middle and upper part with Claraia wangi/C. griesbachi
Nordhausen Fm
Sandy Claystone Member
red (sabkha sal.)
variegated (limnic, fluviatile)
Clayey Sandstone Member (predominantly limnic)
Upper Bröckelschiefer (limnic-fluviatile)
PERMIAN
Upper
Changxingian
Nádaskút Dolomite Member: oolitic dolomites, in the lower part sandy dolomites, gray and partly red dolomitic sandstones, siltstones
thick-bedded red sandstones with cross-bedding and ripple marks
Kővágószőlős Fm. (Members A-D)
Member D: reddish conglomerates, sandstones, siltstones, basal with dolomite nodules (sabkha salinar)
Tesero Oolite: oolitic, marly and intraclastic limestones
Dorashamian
Bellerophon Fm
Badiota Facies: black fossiliferous ls.
Fiamazza Facies: dolomicrites, dolomitic breccias, gypsum
lower Bröckelschiefer with dolomite nodules
Zechstein
* base of Triassic ALBERTI (1834)
Dzhulfian
Members A-C: red, variegated and gray sandstones, siltstones, mudstones, some conglomerates
Balaton Red Sandstone Formation (red siltstones, sandstones, sabkha salinar, in the basal part conglomerates)
Boda Aleurolite Formation: red siltstones, basal variegated sandstone, siltstone
Val Gardena Formation: predominantly red sandstones, siltstones, above all basally conglomerates
**
Grenzkonglomerat/Eisleben Fm.
Tatarian
upper
lower
** Illawarra Reversal
Middle
Capitanian
Wordian
Roadian
Cserdi Conglom.
Eisenach Formation
Kazanian

Table 7.
Perigondwanian and Central Tethyan Upper Permian (vertical distances are not time- or thickness-related).

		Standard Stage	Cis-Uralian Scale	Tethyan Scale	South China	Kashmir	Salt Range	Zentraliran Abadeh	Transcaucasia
TRIAS	Scyth	lowermost Brahmanian	Vetlugian	lowermost Brahmanian	yellow-gray mudstones, marls with *C. wangi*, *Ophiceras*, *I. isarcica*, basal only *H. parvus*	Khunamuh Fm.: lower Unit E3 with *Ophiceras*, *I. isarcica*; *H. parvus*	Dolomite Unit of Kathwai Mbr.	Hambast Fm.: Bedded marly limestones with *Isarcicella isarcica*, basal with stromatolites and *Hindeodus parvus*	Karabaglyar: Yellowish, gray, greenish-gray marly limestones, marls with *Isarcicella isarcica*, basal with stromatolites and *Hindeodus parvus*
PERMIAN	Upper	Changxingian		Changxingian	*********************** Transitional Beds *********************** Changxing Limestone or siliceous ******* shales and limestones / marine and continental beds	Khunamuh Fm.: Unit E2: *H. latidentatus*, *C. changxingensis*; Unit E1: *C. subcarinata*		Hambast Fm.: 0,1–0,3 m greenish, yellowish and pinkish-gray shales, in the upper part rarely stromatolites. *H. latidentatus*, *C. subcarinata*, *C. changxingensis*	Karabaglyar: 0,3–2 m reddish shales, marls, few limestones or ls. nodules, in the uppermost part only red shales. *H. latidentatus*, *C. subcarinata*, *P. occidentale*
						Zewan Fm.: Unit D: *Clarkina subcarinata*		Abadeh Fm.: Unit 7	Achurin Formation
		Dzhulfian		Dzhulfian	Wuchiaping Fm.: shales, limestones / Loping Fm.: sandstones, shales	Zewan Fm.: Units A–C	Chhidru Form.	Abadeh Fm.: Unit 6	Achurin Formation
								Abadeh Fm.: Unit 5	
	Middle	Capitanian	Tatarian	Abadehian (Midian)	Maokou Limestone or Mingshan Fm. (siliceous shales) / Tingchiashan Fm.		Wargal Formation; Kalabagh Member	Abadeh Fm.: Unit 4	Hachik Formation
								Abadeh Fm.: Unit 3	Arpin Formation
	↓	Wordian ↓	Kazanian ↓	Murghabian ↓	↓ ↓			uppermost Unit 2	

*** = Layers of tuffitic origin

but the uppermost Tatarian is not younger than Early Dzhulfian (see chapter 2). The Lower and Middle Dzhulfian Araksian, in turn, he placed below the Zechstein. The "*Taeniaesporites* association" (BALME, 1979) of Greenland, well correlable with the sporomorphs of the "Graubankbereich", he placed into the upper part of the Lower Buntsandstein in his *nejburgii-fimbriatus* phase. This sporomorph association, in turn, is well correlable with the basal Olenekian sporomorph associations in many parts of the world and also the Conchostracans of this stratigraphic interval indicate a correlation with the basal Olenekian (= Lower Jakutian) as pointed out by KOZUR & SEIDEL (1983 b). This level is 6 ammonoid zones younger than the *O. boreale* zone, from where the "*Taeniaesporites* association" of Greenland has been derived (see BALME, 1979). The top of the Chhidruan is placed by ECKE in the middle part of the Zechstein, despite of the fact that the topmost Chhidru Formation (*T. proratus* A.Z., even with *Lundbladispora obsoleta* BALME) can be only correlated with the uppermost Zechstein sporomorph association.

Seemingly ECKE has recognized the Permian character of the sporomorph association of the "Graubankbereich", in this we are in full agreement. The indicated "correlations" by ECKE seem to show only an arrangement of the Upper Permian (or assumed Upper Permian – large parts of the Tatarian are Middle Permian) stages of the Cis-Uralian and world standard beside the Zechstein and lower part of Lower Buntsandstein, but not a fossil-proven correlation.

The correlation of the Zechstein and lowermost Buntsandstein with the marine scale shows that the Zechstein was deposited in a very short time interval (Dzhulfian, above the basal Dzhulfian to basal Changxingian). Its duration was therefore not longer than one Tethyan Stage, a time-interval of 3 ammonoid and conodont zones and of one fusulinid zone (see Table 1). This could correspond to a time-interval of about 1 my as estimated by RICHTER-BERNBURG (in KLARE & SCHRÖDER, 1987), at least the Zechstein was not longer than 3 my.

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