Riv. It. Paleont. Strat.	v. 90	n. 4	pp. 515–544	tav. 62–65	Marzo 1985

REMARKS ON THE SCYTHIAN–ANISIAN BOUNDARY

WANG, YI–GANG

Key–words: Stratigraphy, Scythian–Anisian boundary, Boreal and Tethyan provinces, Ammonites.

Abstract. Different definitions of the Scythian–Anisian boundary are discussed. Based on taxa and sequence of *Keyserlingites* faunas at 19 Boreal localities and 6 Tethyan localities, *Keyserlingites* faunas are considered to be Late Spathian in the Boreal province and Early Anisian in the Tethyan province. *Keyserlingites* is not appropriate for cosmopolitan zoning. The base of *Lenotropites–Japonites* zone of Central Qinghai, China appears to indicate base Middle Triassic: it has abundant earliest Anisian ammonite faunas of mixed Boreal–Tethyan character (ecotone) providing direct correlation between these provinces.

Correlations of Early Anisian (Aegean), Spathian and the Anisian–Scythian boundary are made between different localities, particularly between the Tethyan and Boreal provinces and between basin and platform facies. *Olenikites* zone is coeval to *Subcolumbites* zone; *Lenotropites caurus* zone to *Lenotropites–Japonites* zone; *Columbites* zone to *Tirolites cassianus* zone; and *Subcolumbites* zone to *Tirolites carniolicus* zone.

Scythian–Anisian mixed faunas and stratigraphic condensation are also discussed.

The purpose of this paper is intended to deal with the marine Scythian – Anisian boundary, namely the Lower – Middle Triassic boundary. The proposals of Spath (1934) and Kummel (1957) concerning the boundary had been used by most of the authorities and led to no acute argument, before the sixties of this century. Since the last decade, it has become one of the most acutely debated problems in Triassic stratigraphic boundaries. Various divergences on the definition and division of the Scythian – Anisian boundary, have been raised. These divergences are mainly as follows: the problems of

(1) the geological age of *Keyserlingites* fauna;

(2) stratigraphic condensation leading to trouble on the division of the Scythian – Anisian boundary;

(3) the top of Scythian and the base of Anisian;

(4) the correlation of the Scythian – Anisian boundary between both biogeographic provinces of the Tethys and the Boreal.

– Nanjing Institute of Geology and Palaeontology, Academia Sinica.

The argument of the geological age of Keyserlingites fauna.

Before discussing this problem, the genus *Keyserlingites* has to be defined. The consideration of the present writer agrees with Dr. Tozer's opinion that *Robustites* Philippi, 1901; *Durgaites* Diener, 1905; and *Anastephanites* Spath, 1930, all of them, are synonyms of *Keyserlingites* Hyatt, 1900 (Type species: *Ceratites subrobustus* Mojsisovics).

The inner whorls of «*Durgaites*» *dieneri* from Central Qinghai province of China seem to be somewhat *Tirolites*–like (see Pl. 62, figs. 4, 5) just as those of «*Durgaites*» *dieneri* from Ellesmere Island and N. E. British Columbia, Canada (Tozer, 1965, p. 30). Thus, «*Durgaites*» *dieneri* should be referred to *Keyserlingites* of its more affinitive than *Keyserlingites middendorffi* of which, the inner whorls are *Olenikites*–like (Tozer, 1965, p. 30).

As regards *Robustites* and *Anastephanites*, the writer likes to assign them to *Keyserlingites* as Spath (1934), Kummel (1957) and Tozer did (1971, 1981). Besides, the writer recognizes «*Sibirites*» *prahlada* Diener (1897, p. 37, pl. 7, fig. 5a–d) to be a species of «*Anastephanites*». In our hands, there is a specimen identified as «*Sibirites*» *prahlada* (see Pl. 63, figs. 15–17), collected from central Qinghai of which, the whorls are quite like the inner whorls of *Keyserlingites dieneri* from the same level of the same locality, indicating *Tirolites*–like feature.

The writer agrees with Dr. Tozer that both species of «*K.*» *bearlakensis* Kummel and «*K.*» *bearriverensis* Kummel (Kummel, 1969) from the *Prohungarites* beds of Idaho might represent an undescribed genus (Tozer, 1971, p. 1016).

	(1) Tozer, 1965, 1967, 1971, 1974, 1981	(2) Assereto et al., 1980; Jacobshagen et al., 1981	(3) Spath, 1934; Zakharov, 1968; Kummel, 1969	(4) The present writer
Keyserlingites fauna	Late Spathian	Early Anisian	"*Durgaites*" Early Anisian	E. Anisian in the Tethyan province
			Keyserlingites Spathian	L. Spathian in the Boreal province

Table 1 – Schemes of the geological age of *Keyserlingites* fauna.

	Canada Tozer, 1965		Norway Tozer et al. 1968			V
	Ellesmere Island	N.E. British Columbia	Svalbard	I Verkhoyansk region		
	(1)	(2)	(3)	(4)	(5)	
Olenikites canadensis Tozer	●					
O. spiniplicatus (Mojsisovics)					●	
O. altus (Mojsisovics)						
O. glacialis (Mojsisovics)						
Svalbardiceras freboldi Tozer	●					
S. chowadei Tozer		●				
S. spitzbergense (Frebold)			●			
S. schmidti (Mojsisovics)						
S. dentosum (Mojsisovics)						
S. sibiricum (Mojsisovics)						
S. asiaticum Zakharov						
S. sp.						
Popovites borealis Tozer	●					
P. occidentalis Tozer		●●				
Monocanthites monoceras Tozer		●				
Arctomeekoceras rotundatum (Mojsisovics)						
Boreomeekoceras keyserlingi (Mojsisovics)						
B. sp.				●		
Arctotirolites menensis (Popow)						
Arctoprionites sp.						
Sibirites eichwaldi (Keyserling)					●	
S. pretiosus Mojsisovics						
S. subpretiosus Popow						
S. sp.				●		
Parasibirites grambergi (Popow)				●		
P. rariaculeatus Popow						
Zenoites arcticus Tozer	●					
Pseudosageceras bicarinatum Tozer		●				
P. multilobatum Noetling						
P. longilobatum Kiparisova						
P. boreale Zakharov						
P. sp.						
Procarnites modestus Tozer		●●				
Isculitoides minor Tozer		●				
Metadagnoceras pulcher Tozer		●				
Preflorianites multiplicatus (Mojsisovics)						
Proptychitoides kummeli (Popow)						
Prosphingites czekanowskii Mojsisovics						
P. insularis Kiparisova						
P. cf. *globosus* Kiparisova						
P. cf. *coombsi* Kummel						
P. sp.						
Nordophiceras pseudosimplex Kummel						
N. euomphalum (Keyserling)						
N. schmidti (Mojsisovics)						
N. alexeevae Popow						
N. ex gr. *karpinskii* (Mojsisovics)						
N. sp.					●	
Tirolites morpheos (Popow)						
Keyserlingites subrobustus (Mojsisovics)	●	●●	●			
K. middendorffi (Keyserling)				●	o	
K. nikitini (Mojsisovics)						
K. sp.				●		
Leiophyllites sp.		●				
Ussurites sp.						
Czekanowskites decipiens (Mojsisovics)						
Karangatites ? sp.						

Table 2 – Composition of *Keyserlingites* faunas in the Boreal province.

erkhoyansk-Kolyma regions, N.E. Sibiria, U.S.S.R.						
A. S. Dagys et al., 1979						Popow, 1961
II Lena-Anabar region			III Baky-Nelgehe region		IV Yana-Kolyma region	
(6)	(7)	(8)	(9)	(10)	(11)	
●	●	●	○	○	●	●
●				○		●
					●	●
						●
						●
●		●				●
	●○					
					●	
○						●
●○						●
	●					
						●
●						
●			●	●	● ex.gr.	●
				●○		●
						●
●		●	●	○	●	●
				●		
				○		
						●
	●					
●						
						●
						●
	●○	●				●
					○	
					●	
					●	
					●	
						●
●						
	●○	●○				
					●	
					●	
●	●	●				
					●	●
●		●				●
●	●	●○	●	○	●	●
						●
	●	●		●		
					●	
				●		
						●
				●		

○ = cf.

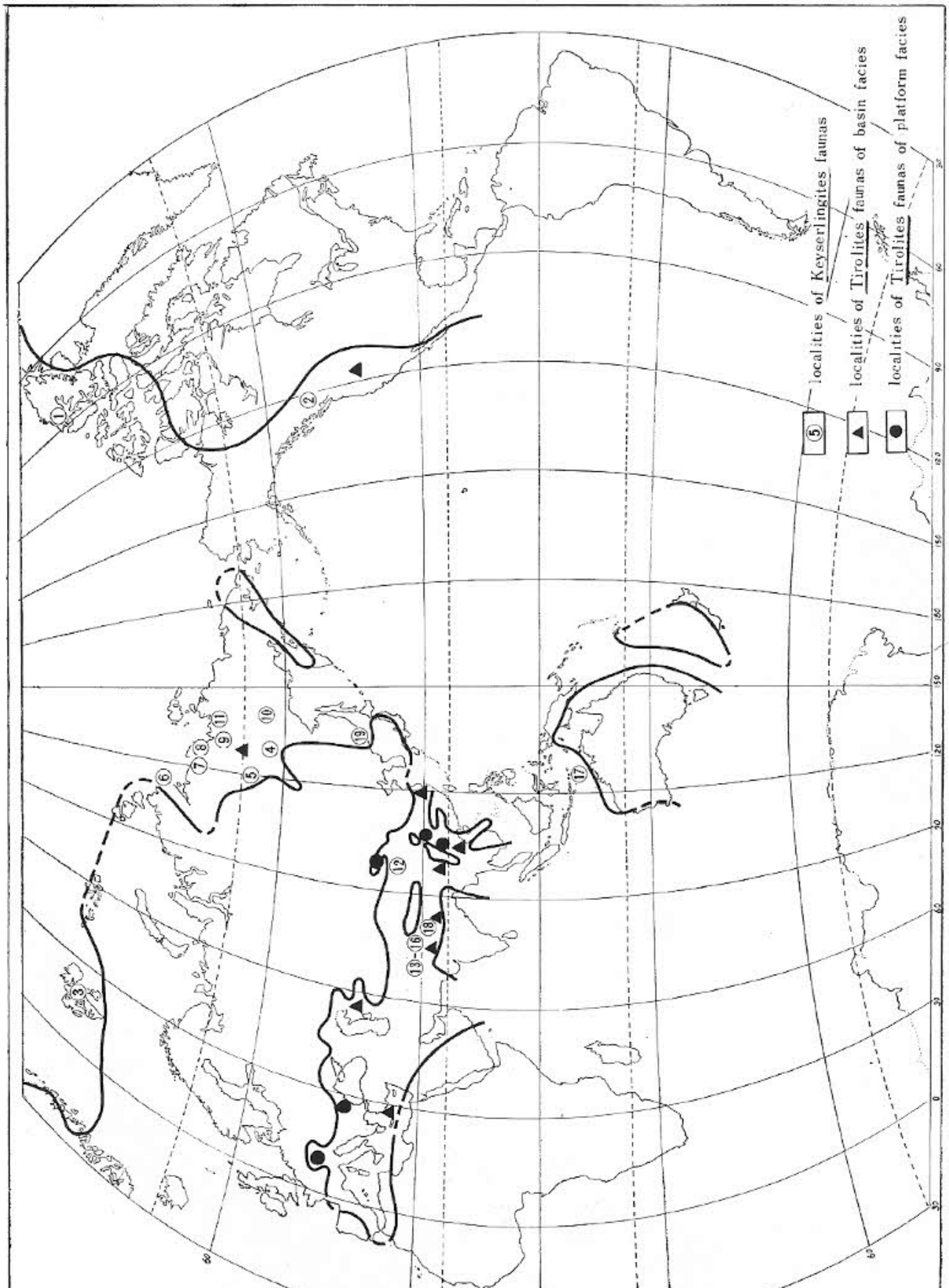
So that, the premise is essentially coincident with Dr. Tozer's, when we discuss the problem of the geological age of *Keyserlingites* fauna.

As far as known, there are several different proposals in determining the geological age of *Keyserlingites* fauna, which are indicated in Table 1. Table 1 shows that *Keyserlingites* fauna is (1) restricted to the beds of the Late Scythian wherever found (Tozer, 1965, 1967, 1971, 1974, 1981), (2) restricted at the base of Anisian wherever found (Assereto et al., 1980; Jacobshagen et al., 1981), (3) considered that *Keyserlingites* (s. s.) is limited to the beds of Late Scythian, and *«Durgaites»* appears in Anisian, and (4) the present writer has tried out some rules for the stratigraphic and geographic distribution of *Keyserlingites* fauna on the basis of their features and the levels yielded *Keyserlingites* faunas from 19 localities almost the world over (see Fig. 1). It seems to the writer that both biogeographic provinces of *Keyserlingites* fauna, viz. the Boreal and the Tethyan ones can be recognized.

The Boreal province (see Fig. 1 locs. 1–11 and Table 2).

The *Keyserlingites* fauna in this province is mainly found in the following localities: Ellesmere Is. (loc. 1) and N. E. British Columbia (loc. 2), Canada; Svalbard, Norway (loc. 3); and Verkhoyansk–Kolyma regions, N. E. Siberia, USSR (loc. 4–11).

The members of the faunas associated with *Keyserlingites* from 11 localities are listed in Table 2. There are totally 57 species belonging to 28 genera among which, there are 11 genera, restricted or being common in the Boreal province, including *Olenikites, Svalbardiceras, Sibirites, Parasibirites, Popovites, Monocanthites, Arctomeekoceras, Arctotirolites, Boreomeekoceras, Czekanowskites* and *Karangatites* ?. The rest are cosmopolitan genera, but the species are remarkably different from those of the Tethyan province, and also restricted in the Boreal province except two or three. Such being the case, the *Keyserlingites* faunas in this province show pronounced Boreal colour. From the analysis of another aspect, all of these genera and species (in Table 2) are uniformly common members of Late Scythian, except the last two genera. Facts of great significance are that owing to sufficient stratigraphic control, the accurate basis for determining the succession of *Keyserlingites* faunas are provided in this province, especially in N. E. Siberia, USSR, where the stratigraphic positions of the *Keyserlingites* fauna occupy the interval between the *Karangatites evolutus* Subzone, i.e. the Lower Subzone of *Grambergia taimyrensis* Zone representing Lower Anisian and the *Dieneroceras demokidovi* zone regarded as Lower Spathian (Dagys et al., 1979, pp. 39, 44). It is worthy to note that in the S. Primorye region, there are two levels of *Keyserlingites* faunas (see Fig. 1, loc. 19).


localities of Keyserlingites faunas
localities of Tirolites faunas of basin facies
localities of Tirolites faunas of platform facies

	Maduo. C. Qinghai (12) He, Wang & Chen (in press)			W. & M. Himalayas (13-16, 18) Diener, 1897, 1907, 1913					Timor (17) Welter, 1915			Chios Fantini Sestini 1981	Caucasus Shevyrev, 1968
	Naocangjianguo		W. Naocangjianguo										
	Zone I		Zone II	Lilang, Spiti (13)	Po, Spiti (14)	Shalshal cl. (15)	Bambanag cl. (16)	(18) Ex. block Chitichun	3	2	1		
	Subz. Ia	Subz. Ib											
Grambergia laevis Wang	●		●										
G.cf.olenekensis Popow		Δ											
G.tetsaensis Mclearn			●										
Lenotropites qinghaiensis Wang & Chen	●												
L.feeblis Wang	●												
L.sinensis Wang			●										
L.sp.		Δ											
Arctohungarites kharaulakhensis Popow	●												
A.cf.triformis (Mojsisovics)			●										
A.umbilicus Wang	●												
Groenlandites qinghaiensis Wang	●		●										
G.plicatus Wang	●		●										
Pearylandites(Tienjunites)spinosus Wu	●												
P.(T.)sp.		Δ											
Longobardites caucasius (Shevyrev)													●
Norites psilodiscus Arthaber	Δ												
Psilocladiscites qinghaiensis Chen			●										
Danubites sp.													●
Paradanubites kansa (Diener)		●	●					●					
P.robustus He		●	●										
P.tuosuohuensis He		●	●										
P.phyllus He		●	●										
P.compressus (Welter)										●			
P.alternecostatus (Welter)										●			
P.ambika (Diener)								●					
P.asseretoi Fantini Sestini												●	
P.depressus Fantini Sestini												●	
Parasageceras gracile Spath		●											
P.discoidale Welter											●		
Sageceras cf.welteri Mojsisovics		●											
Japonites kueichowensis Hsu		●	●										
J.meridianus Welter		●	●							●			
J.denticulatus He		●	●										
J.vastesellatus (Welter)											●		
J.amanubanensis (Welter)											●		
J.volzi (Welter)				●						●			
J.asseretoi Fantini Sestini		●								●		●	
J.sp.							●						
Aegeiceras ugra (Diener)				●				●		●		●	
Gymnites depauperatus Diener				●									
Gy. humboldti Mojsisovics											●		
Gy.meridianus Welter											●		
Psilosturia mongolica (Diener)		●	●					●		●			
P.strigatus Chen		●											
P.complex Chen		●											
Procladiscites brancoi Mojsisovics	Δ	●	●										
P.globosus Chen			●										
P.crassus Hauer			●										
P.qinghaiensis Chen			●										
P.yasoda Diener								●		●			
P.sp.												●	

Megaphyllites sandalinus Mojsisovics	Δ	●	●										
M.evolutus Welter		●	●							●			
M.maduoensis Chen			●										
M.chiosensis Fantini Sestini												●	
M.tenuis Chen		●											
*M.*sp.													●
Paracrochordiceras anodosum (Welter)											●		
P.pandya (Diener)								●				●	
P.asseretoi Fantini Sestini												●	
P.denseplicatum Fantini Sestini												●	
Laboceras cf. *gracile* Shevyrev													●
Romanites cf. *simionescui* Kittl											●		
Leiophyllites confucii (Diener)				●				●					
L.middlemissi (Diener)		●	●					●					
L.pradyumna (Diener)								●					
L.pseudopradyumna (Welter)											●	●	
L.pitamaha (Diener)	Δ		●					●				●	●
L.indoaustralicus (Welter)									●	●			
L.foliodenticulatus Wang & Chen		●											
L.laevis (Welter)										●			
L.asseretoi Fantini Sestini												●	
L.visendus Shevyrev													●
*L.*sp.							●						
Ussurites hara (Diener)		●	●	●		●	●	●	●	●			
U.kingi (Diener)				●			●	●				●	
U.yabei Diener			●										
U.robustus Wang		●	●										
U.rariplicatus Wang		●											
Keyserlingites dieneri Mojsisovics		●		●		●	●						
K.pahari Diener				●									
K.prahlada (Diener)			●	●									
K.pagoda Diener					●								
K.angustecostatus Welter									●				
K.qinghaiensis Wang		●	●										
K.sinensis Wang			●										
K.planus Wang			●										
*K.*sp.	Δ												
Ziyunites asseretoi Fantini Sestini												●	
Sturia sp.												●	
Stacheites ? *webbianus* Diener				●									
Dalmatites ropini Diener				●			●						
Prosphingites ? sp.													●

● abundant or common   Δ rare

Table 3 – Composition of Early Anisian ammonoid faunas in the Tethys province.

In the lower level, *Keyserlingites miroschnikovi, Olenikites sonticus* etc. are associated with abundant Tethyan forms such as *Prosphingites, Columbites, Subcolumbites, Prenkites, Paranannites, Hellenites, ?Eophyllites, Leiophyllites?, Preflorianites, Tirolites, ?Danubites* and some endemic genera *Procolumbites, Neocolumbites* and *?Subdoricranites* (Zakharov, 1978, pp. 12, 15, 22–26). Another *Keyserlingites* fauna occurs in the upper level, where an Anisian «*Durgaites*» aff. *dieneri* is associated with abundant Anisian Tethyan elements such as *Leiophyllites ?, Acrochordiceras, Hollandites, Balatonites, Arctohungarites, Phyllocladiscites, Japonites, Ussurites* and *Sturia*, etc. (Zakharov, 1978, pp. 22–26). The writer regards the faunas from S. Primorye as transitional ones between the Boreal and the Tethyan types. So, S. Primorye should be excluded from the Boreal province and regarded as a transitional area.

The Tethyan province (see Fig. 1, locs. 12–17, and Table 3).

As far as our information goes, the *Keyserlingites* fauna in this province has been known from Central Qinghai, China (loc. 12), the Himalayas (locs. 13–16) and Timor, Indonesia (loc. 17).

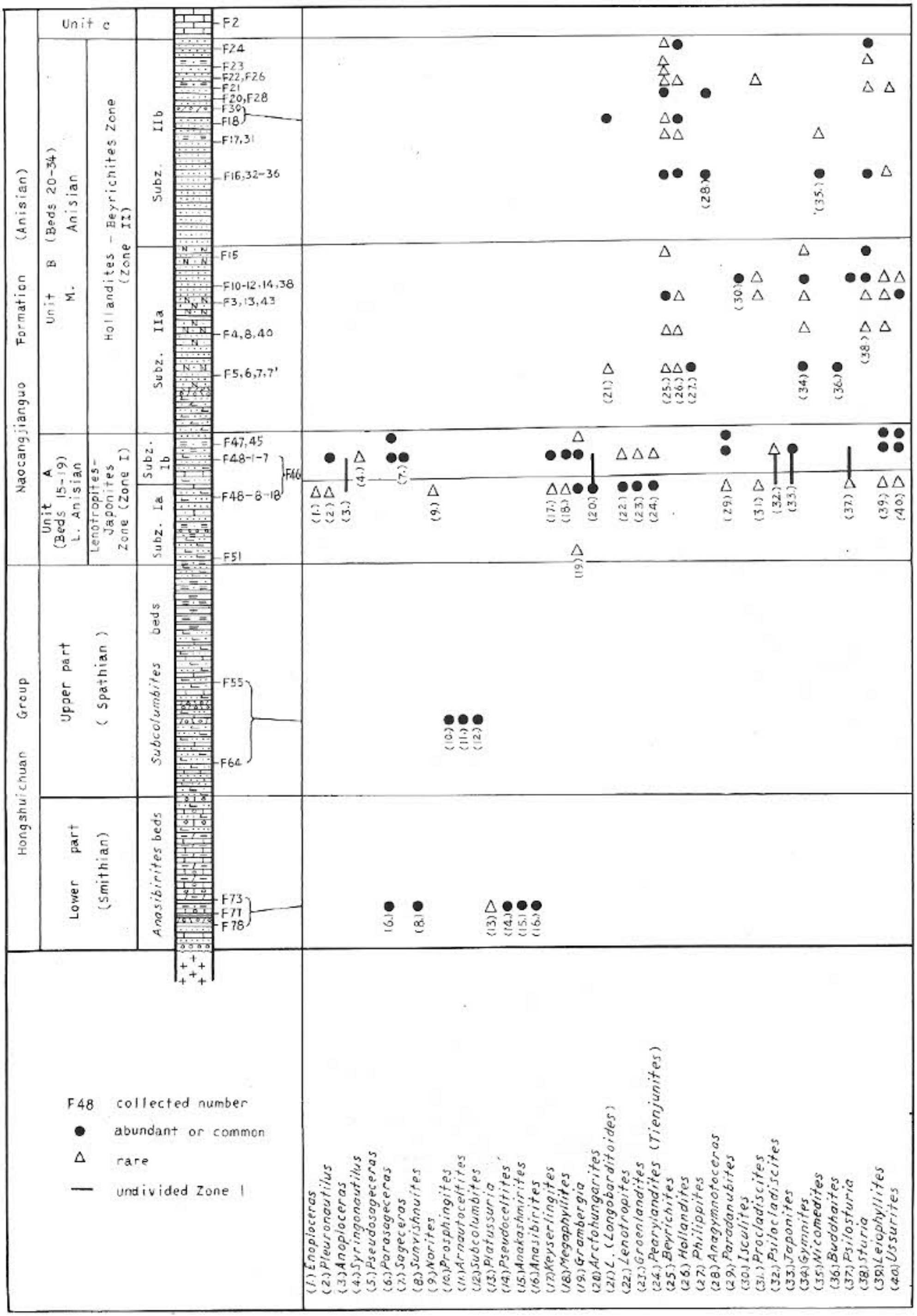
The characters of *Keyserlingites* faunas from the six localities of this province shown on Fig. 1, precisely form a sharp contrast to those of the Boreal province, and are all the Anisian common genera and species, except *?Stacheites* and *?Dalmatites* (see Table 3).

Tables 3 and 4 show that the *Keyserlingites* fauna from C. Qinghai is the most abundant one both in genera and species, totally being 47 species referred to 19 genera (see Tables 3, 4 and Plates) as comparing with those of other localities in the same province. However, the C. Qinghai fauna is of great significance in biostratigraphy, chronostratigraphy and biogeography.

Abundant specimens of *Keyserlingites* fauna of C. Qinghai were mainly collected from Subzone Ib (i. e. subz. *Japonites meridianus*) of Zone I (*Lenotropites–Japonites* zone), and only a few fragments of *Keyserlingites* were collected from Subzone Ia (i. e. subz. *Lenotropites qinghaiensis*) of Zone I (see Table 3, Fig. 2).

According to He, Wang and Chen's current studies, Subzone Ia of C. Qinghai is relatively more monotonous and characterized by the predominance of Longobarditidae containing *Grambergia, Arctohungarites, Lenotropites, Groenlandites, Pearylandites (Tienjunites)* which show obviously Early Anisian

Fig. 1 – Localities of *Keyserlingites* faunas and *Tirolites* faunas. 1) Ellesmere Is.; 2) N. E. British Columbia; 3) Svalbard; 4–5) Verkhoyansk region; 6–8) Lena–Anabar region; 9–10) Baky–Nelgehe region; 11) Yana–Kolyma region; 12) C. Qinghai; 13) Lilang; 14) Po; 15) Shalshal Cl.; 16) Bambanag; 17) Timor; 18) Exotic block no. 1 of Chitichun; 19) S. Primorye.


Naocangjiangou Formation (Anisian)
Hongshuichuan Group
Unit c
Unit B (Beds 20–34) M. Anisian
Hollandites – Beyrichites Zone (Zone II)
Subz. IIb
Subz. IIa
Unit A (Beds 15–19) L. Anisian
Lenotropites–Japonites Zone (Zone I)
Subz. Ib
Subz. Ia
Upper part (Spathian)
Subcolumbites beds
Lower part (Smithian)
Anasibirites beds
F48 collected number
● abundant or common
Δ rare
— undivided Zone I
(1) Enoploceras
(2) Pleuronautilus
(3) Anoploceras
(4) Syringonautilus
(5) Pseudosageceras
(6) Parasageceras
(7) Sageceras
(8) Sunvishnuites
(9) Norites
(10) Prosphingites
(11) Arnautoceltites
(12) Subcolumbites
(13) Piatussuria
(14) Pseudoceltites
(15) Anakashmirites
(16) Anasibirites
(17) Keyserlingites
(18) Megaphyllites
(19) Grambergia
(20) Arctohungarites
(21) L. (Longobarditoides)
(22) Lenotropites
(23) Groenlandites
(24) Pearylandites (Tienjunites)
(25) Beyrichites
(26) Hollandites
(27) Philippites
(28) Anagymnotoceras
(29) Paradanubites
(30) Isculites
(31) Procladiscites
(32) Psilocladiscites
(33) Japonites
(34) Gymnites
(35) Nicomedites
(36) Buddhaites
(37) Psilosturia
(38) Sturia
(39) Leiophyllites
(40) Ussurites

The Locality (see fig. 1)	(12) C.Qinghai	(13) Lilang	(14) Po	(15) Shalshal	(16) Bambanag	(18) Exotic block Chitichun	(13)–(16) (18)	(17) Timor	Chios	(1)(2) Canada
number of genera of the each region	18	7	1	2	5	7	11	9	8	13
abundance*	64.2%	25%	3.5%	7.1%	17.8%	25%	39.2%	32.1%	28.5%	
similarity rate**		57%	100%	100%	80%	85.7%	63.6%	77.7%	75%	53.8%

Table 4 – Comparison of Early Anisian ammonoid faunas.

$$* \text{ abundance} = \frac{\text{number of genera of each region in Table 3}}{\text{total number of genera in Table 3 (28 genera)}}$$

$$** \text{ similarity rate} = \frac{\text{number of common genera between those of C. Qinghai and other region}}{\text{number of genera of that region}}$$

aspect of the Boreal province, only a few specimens of *Paradanubites, Leiophyllites, Megaphyllites, Keyserlingites, Procladiscites* and *Norites* with some Tethyan features. In Subzone Ib of Zone I, Boreal forms of Longobarditidae remarkably fall into decline and finally disappear. On the other hand, the common elements with Tethyan feature mainly including *Japonites, Psilosturia, Paradanubites, Megaphyllites, Keyserlingites* and *Procladiscites* become rapidly abundant. Besides, there are also a few specimens of *Parasageceras, Sageceras* and *Psilocladiscites*. Table 4 shows that the similarity rate shows high as comparing the *Lenotropites–Japonites* zone of C. Qinghai both with those of correlatives in the Tethyan province and with Lower Anisian *Lenotropites caurus* zone in Boreal province. In this case, the *Lenotropites–Japonites* zone of C. Qinghai with *Keyserlingites* seems to be also a transitional fauna similar to the «*Durgaites*» fauna of the upper level of S. Primorye, S. E. USSR.

The stratigraphic relations of the *Lenotropites–Japonites* zone containing *Keyserlingites* are well displayed in C. Qinghai (see Fig. 2, *Lenotropites–Japonites* zone overlies *Subcolumbites* beds and underlies *Hollandites–Beyrichites* zone). So that, the *Keyserlingites* fauna of C. Qinghai should undoubtedly represent Early Anisian.

Fig. 2 – Naocangjianguo section, Maduo county, the southern slope of Mt. Burhan Budai, the eastern branch of Mts. Kunlun, Central Qinghai.

As concerning the *Keyserlingites* faunas of the Himalayas and Timor (see Table 3), the writer formerly tended to assign those forms associated with *Keyserlingites*, to *Stacheites, Dalmatites, «Sibirites», Japonites, Ussurites* and *Leiophyllites* and pointed out that they belonged to «non–typical Anisian forms», owing to the fact that the Ziyun fauna was regarded as a natural assemblage at that time (Wang, 1978).

The writer thanks to Prof. Jacobshagen who kindly wrote me to call attention that «would it be possible that your association is a result of stratigraphic condensation?» (Prof. Jacobshagen per. commun., 1978) (see next part of this paper about the discussions of stratigraphic condensation and Ziyun fauna).

Having compared the *Keyserlingites* faunas of the Himalayas and Timor with those of C. Qinghai (see Table 3), the writer considers that similarity rates between those faunas of C. Qinghai and the Himalayas or Timor are also comparatively high. And it has to be firstly considered that among the members of *Keyserlingites* faunas of the Himalayas and Timor, none typical Scythian elements are known, while the similarity rates of these *Keyserlingites* faunas are also comparatively high as comparing with those of classic L. Anisian ammonoid faunas without *Keyserlingites*, such as the faunas of Chios (Assereto, 1974; Fantini Sestini, 1981), the exotic block no. 1 of Middlemiss crag near Chitichun (Diener, 1897) and Caucasia, S. USSR (Shevyrev, 1968). However, the writer now tends to assign the *Keyserlingites* faunas of this province to Aegean in age as those of Chios and the exotic block no. 1 of Chitichun.

It is very interesting to note that the geological age provided by the brachiopod fauna associated with the *Keyserlingites* fauna in the Himalayas is not contrary to the geological age determined by the *Keyserlingites* fauna itself. The brachiopod faunas from the same level associated with *Keyserlingites* in the Himalayas contain «*Rhynchonella mutabilis* Stoliczka, *Rhynchonella griesbachi* Bittner, *Rhynchonella dieneri* Bittner, *Retzia himaica* Bittner, *Spirigera stoliczkai* Bittner, *Mentzelia koeveskalliensis* (Suess), *Spiriferina stracheyi* Salter and *Dielasma himalayensis* Bittner». Recently, a correlative brachiopod fauna has already been known from Laibuxi formation (Anisian) at Nyanang and Dingri counties, S. Tibet, China (Yin, Wang & Chang, 1974; Ching et al., 1976; Sun, 1980). The brachiopod fauna of S. Tibet contains *Nudirostralina griesbachi* (Bittner) (= «*Rhyn.*» *griesbachi*), *N. mutabilis* (Stoliczka) (= «*Rhyn.*» *mutabilis*), *Tulungospirifer stracheyi* (Salter) (= «*Spiriferina*» *stracheyi*), *Aequispiriferina koeveskalliensis* (Boeckh) (= «*Mentzelia*» *koeveskalliensis*). They are associated with typical Anisian ammonoids such as *Hollandites, Beyrichites, Leiophyllites* and *Paracrochordiceras* etc. The aspect of brachiopod fauna from S. Tibet is thus very similar to those from W. Himalayas. They are more monotonous and seem to correspond to the correlatives in the Lower Muschelkalk in Germany, Hungary, Yugoslavia, S. USSR and others. The appearance of *Tulungospirifer stracheyi*, which is a common element within both the Tethyan and Boreal provinces, is particularly significant. It was also found in the Middle Triassic of Spitsbergen Island (Kublov, 1965; Pchelina, 1965), N. E. Siberia (Dagys, 1965), N. E. Japan (Yabe & Shimizu, 1927; Westermann, 1962) and Rocky Mountains, Canada (Westermann, 1962).

Recently, H. Kozur considered that the holothurian fauna of the *Subrobustus* Zone is typical Aegean, the ostracode fauna of the *Subrobustus* Zone is not only universally the same in the whole Aegean but also similar to the Spathian assemblages, and the sporomorph assemblage has also Anisian character.

Based on the above discussion, the present writer favours to offer the following summary:

(1) In the Boreal province, the *Keyserlingites* faunas are restricted to Late Spathian, and in contrast, in the Tethyan province restricted to Early Anisian. Therefore, it is not so appropriate to regard the *Keyserlingites* faunas as a cosmopolitan typical zone, instead of a local zone.'

(2) From the stratigraphic and geological distributions of *Keyserlingites* faunas, a migratory rule of *Keyserlingites* in the relation between space and time could be ascertained that the Boreal province was the original region of *Keyserlingites* during Spathian stage, then they migrated southward through transitional region (S. Primorye, C. Qinghai) during Spathian to Early Anisian, and later moved further to the S. Tethyan province before Middle Anisian.

(3) The writer thus proposes that in the Boreal province, *Olenikites* zone represents Spathian more accurately than *Keyserlingites* zone.

(4) It seems that the ammonoid faunas associated with *Keyserlingites* in the Tethyan province and its correlatives may represent Early Anisian (see Table 7). However, the *Lenotropites–Japonites* zone of C. Qinghai or *Aegeiceras ugra* horizon of Chios can be regarded as the representatives of the typical earliest Anisian ammonoid faunas in the Tethyan province, and especially the Qinghai fauna is more appropriate representative, because it is a direct link between the Tethyan province and the Boreal province, which leads better correlation of the Early Anisian between both provinces.

On the Scythian–Anisian «mixed ammonoid faunas» and stratigraphic condensation.

Since the last decade, more and more stratigraphers and palaeontologists have paid attention to the Scythian–Anisian «mixed ammonoid faunas». As it is well known that the *Neopopanoceras haugi* fauna of Nevada, USA was firstly known as a Scythian–Anisian mixed one (Smith, 1914; Silberling & Wallace, 1969). Subsequently, the present writer recorded two localities of the «mixed fauna», viz. Ziyun, Guizhou and Derong, Sichuang, China (Wang, 1978). Assereto et al., (1979) also reported another «mixed fauna» from E. Chios, Greece and pointed out that "this Chios assemblage is due to stratigraphic condensation" and in their opinion, however, "the possibility of stratigraphic condensation can not be excluded" for Ziyun fauna from Guizhou (Assereto et al., 1979, p. 728).

The present writer has already paid attention to the palaeogeographic position and environments of the mixed ammonoid fauna of Ziyun on the basis of two field observations in 1963 and 1978, and results of other Chinese collegues' studies (Ho et al., 1980) (see Fig. 3). According to sedimentary development, deposits in Guizhou can be divided into two lithological facies, viz. the basin facies and the platform facies along a «S–shaped» line drawn approximately from south of Xinyin, Ceheng counties in the south, through Zhengfeng, Anshun, Qingyan to Fuquan in the east. The area north and west of this line, U. Scythian – L. Anisian deposits are of platform facies, and south and east of this line, the deposits are of basin facies during Late Scythian to Early Anisian. Ziyun is just located right in the area of the least deposit thickness of basin facies of the S. Guizhou – N. Guangxi open sea basin during that time (see Fig. 3 and Fig. 4).

Besides, the conodont fauna from the bed yielding the Ziyun ammonoid fauna has been recently studied by Wang, Zhi–hao who is the writer's collegue (Wang, Zhi–hao, 1982). The conodont fauna is also very interesting, and contains *Neospathodus timorensis* (Nogami), *N. homeri* Bender, *Gladigondolella tethydis* (Huckriede), *Cypridodella muelleri* (Tatge), *C. unialata* Mosher, *Enantiognathus ziegleri* (Diebel), *Hindeodella multihamata* Huckriede, *H. suevica* (Tatge), *Ozarkodina tortilis* Tatge, *Diplododella* sp., *Hibbardella* sp., *Xaniognathus* sp., *Gondolella excelsa* (Mosher), *G. bidentata* (Wang, Zhi–hao,

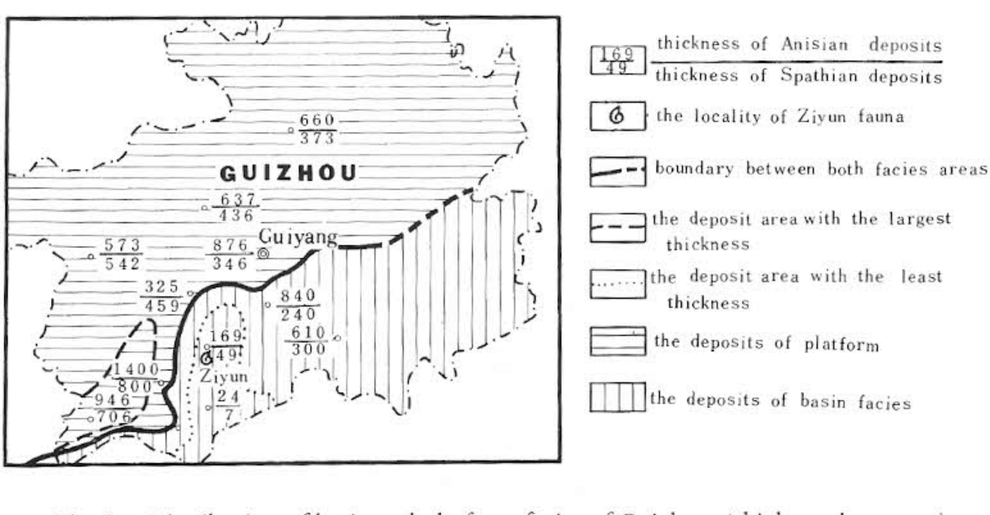


Fig. 3 – Distribution of basin and platform facies of Guizhou (thickness in metres).

1982) among them, most elements are typical forms of Early Triassic, however *Gladigondolella tethydis* and *Gondolella excelsa* hitherto are known from Middle Triassic. Seemingly, the fauna also appears to be a mixed assemblage.

Thus, a condition of starved sedimentation might be existent. Consequently, the writer also considers that it can not be excluded that the Ziyun fauna was possibly a result of stratigraphic condensation. However, when drawing the Scythian – Anisian boundary, the problem is how to treat those beds with mixed fauna, since stratigraphic condensation leads to some troubles for drawing the boundary. Assereto et al. (1979) expressed their opinion for solving the problem that "the Scythian–Anisian boundary is drawn at about 12.25m, within a thin layer of reduced sedimentation which yielded an ammonoid fauna of Scythian and L. Anisian types" (Assereto et al., 1979, pp. 715, 731–732). The present writer agrees with their opinion that the mixed fauna was a result of stratigraphic condensation, but dissents in drawing the Scythian–Anisian boundary. Having considered the fact that the starved sedimentation happened in a short span of time during the earliest Anisian, instead of during Spathian, the present writer thus prefers to draw the Scythian–Anisian boundary at the top of the thin layer containing a mixed ammonoid fauna of Scythian and Early Anisian types, instead of drawing it within the thin layer.

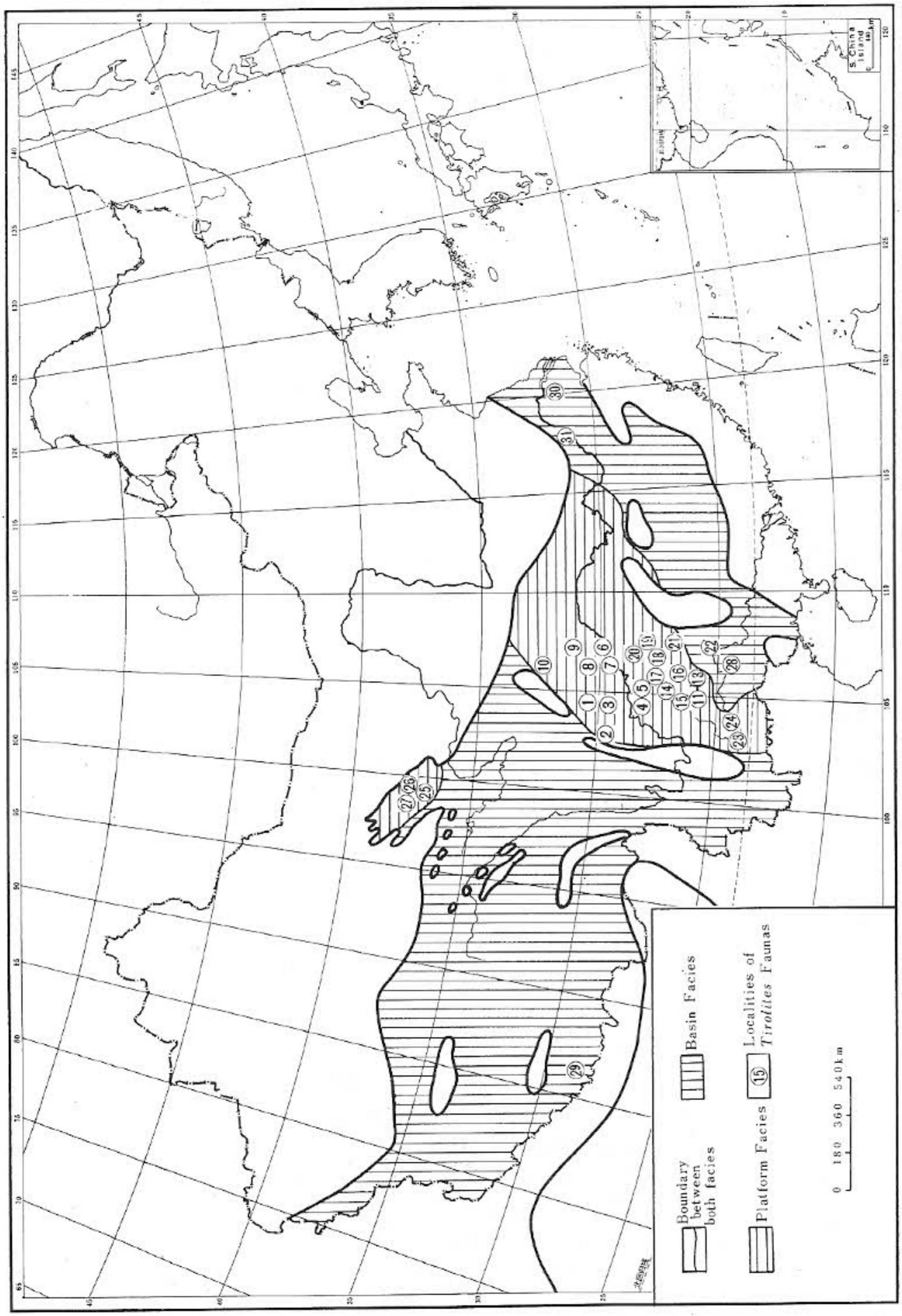
Correlation of the Scythian–Anisian boundary between basin facies and platform facies.

It is still a ticklish problem, how to correlate the Scythian–Anisian boundary between basin facies and platform facies.

In the area with the deposits of platform facies, the earliest Anisian ammonoid fauna is not clearly known and the latest Spathian ammonoid fauna is more monotonous and characterized by predominance of Dinaritidae, mainly including *Tirolites, Dinarites, Dalmatites, Hololobus, Stacheites* and *Doricranites* etc. As far as our information goes, the most abundant fauna is well known from the Campil Member of the Werfen Formation in Central Europe (Kittl, 1903). The Campil beds in Bulgaria contain *Lanceolites, Balkanites, Tirolites, Dinarites* etc. (Ganev, 1966; Kummel, 1969).

The *Tirolites* faunas of platform facies in China are also widespread in vast areas, covering most part of Sichuan, N. and W. Guizhou, E. Yunnan and N. Qinghai (see Fig. 4), mainly including *Dinarites, Tirolites, Doricranites, Dalmatites* and *Hololobus* etc. The *Tirolites* faunas from different localities in China are given herein Table 5, which shows as follows:

(1) The most predominant members of *Tirolites* faunas in China are *Tirolites* and *Dinarites. Tirolites* generally occurs in the upper part of Lower Spathian (Unit B of Kialingkiang Group or Yongningchen formation), a few forms even range upward to the lower part of Upper Spathian (Unit C of Kialingkiang Group or Yongningchen formation) at a few localities (Wang et al., 1981).


Boundary between both facies
Basin Facies
Platform Facies
Localities of Tirolites Faunas
0 180 360 540 km
S. China Island

Generally speaking, the levels of *Dinarites* are higher than those of *Tirolites*, usually situated from Unit C to Unit D of Kialingkiang group or Yongningchen formation corresponding Upper Spathian. *Dinarites*, however, more frequently occurs in Unit D.

In addition, only a few specimens of *Doricranites*, *Dalmatites* and *Hololobus* are found in China.

(2) The arranged sequences of stratigraphy which provide *Dinarites* bed as the upper horizon, and *Tirolites* bed as the lower horizon are well displayed in those sections of Gong Xian, Chongqing and Guangan counties in Sichuan.

In Zhijin section nearly over 100 km west of Guiyang, the beds yielding *Tirolites* faunas were overlain by *Procarnites* bed containing *Procarnites* and *Dagnoceras*. There is a specimen identified as *Leiophyllites* cf. *pitamaha*, which is associated with *Dinarites* from a bed of Unit D of Kialingkiang Group at Chongqing.

Based on these facts mentioned above (see Table 5 and Table 6), the writer thus distinguishes two ammonoid zones, viz. *Tirolites* zone at below and *Dinarites* zone at above for platform facies (Wang & He, 1980; Wang et al., 1981). Further more based on the synthetical analysis of the horizons of *Tirolites* faunas (s.l.) from different localities in the platform facies as well as in the basin facies, where they are associated with other Spathian ammonoid faunas all over the world, the writer tabulates the following table concerning their appearance, vicissitude and disappearance of some main genera in *Tirolites* faunas (s.l.) (see Table 5 and Table 6). Therefore, in China both ammonoid zones of platform facies probably correlate with the *Columbites* zone and the *Procarnites–Subcolumbites* zone of basin facies respectively. While they also may correspond to the *Tirolites cassianus* zone and *T. carniolicus* zone of platform facies in C. and E. Europe, established by L. Krystyn (1974) separately.

The link between Early and Middle Triassic ammonoids.

The writer remarked this problem in 1978. Progress in recent years promotes the knowledge of this problem. In order to further recognize the Lower–Middle Triassic boundary, it is necessary to discuss the present problem.

According to the writer's present knowledge, there are about 9 or more linking genera between Scythian and Anisian, such as *Leiophyllites, Japonites,*

Fig. 4 – Localities of *Tirolites* faunas in China. 1) Leshan; 2) Ebian; 3) Weiyuan; 4) Gao Xian; 5) Gong Xian; 6) Chongqing; 7) Jiangjin; 8) Hechuan; 9) Guong'an; 10) Wangcang; 11) Qinglong; 12) Langdai; 13) Guanling; 14) Pu'an; 15) Shuicheng; 16) Zhijin; 17) Dafang; 18) Bijie; 19) Zunyi; 20) Renhuai; 21) Duyun; 22) Luodian; 23) Kaiyuan; 24) Qiubei; 25) Ulan; 26) Gangca; 27) Tianjun; 28) Fengshan; 29) Nyanang; 30) Nanjing; 31) Chao Xian.

Dalmatites Hololobus	*Doricranites*	*Tirolites*	*Dinarites*		
		Tb		(1) Leshan	Sichuan
			Td	(2) Ebian	
	Tc		Tc	(3) Weiyuan	
		Tb Tc		(4) Gao Xian	
	Tc	Tb Tc	Tc	(5) Gong Xian	
		Tb	Td	(6) Chongqing	
		Tb		(7) Jiangjin	
		Tb		(8) Hechuan	
		Tb	Td	(9) Guong'an	
		Tb		(10) Wangcang	
		Tb		(11) Qinglong	Guizhou
Tb(*Dalm.*)		Tb		(12) Langdai	
		Tb		(13) Guanling	
			Tc-d	(14) Pu'an	
		Tb		(15) Shuicheng	
		Tb		(16) Zhijin	
		Tb		(17) Dafang	
		Tb		(18) Bijie	
		Tb		(19) Zunyi	
		Tb		(20) Renhuai	
		Tb		(21) Duyun	
		Tb		(22) Luodian	
		Tb	Tc?	(23) Kaiyuan	Yunnan
		Tb		(24) Qiubei	
(*Holol.*) T_1^2				(25) Ulan	Qinghai
		T_1^2	T_1^2	(26) Gangca	
	T_1^2	T_1^2		(27) Tianjun	

Lower Triassic				M. Tri.	
Kialingkiang Group					Sichuan
Unit A (Ta)	Unit B (Tb)	Unit C (Tc)	Unit D (Td)	Unit E (Te)	
Yongningchen formation					Guizhou and Yunnan
L. Mem.		U. Mem.			
L. Pt. (Ta)	U. Pt. (Tb)	L. Pt. (Tc)	U. Pt. (Td)		

T_1^2 = Spathian

Table 5 — Localities and horizons of *Tirolites* faunas of platform facies in China.

Upper Scythian					
Smithian		Spathian			
Eufleming-ites romunderi zone	Wasatch-ites tardus zone	Kazakhstan-ites pilaticus zone	Keyserling-ites subrobustus z	Boreal Province	Basin facies
Owenites zone	Anasibir-ites zone	Columbites zone	Prohungar-ites Subcolumbites	Tethyan Province	
		Tirolites cassianus zone	Tirolites carniolicus zone	M. & E. Europe	Platform facies
Meekoceras		Tirolites zone	Dinarites zone	S. China	
		Tirolites		Guangxi Zhao, 1959	China
		Tirolites ?		S. Tibet Wang et He, 1976	
		Tirolites		S. Jiangsu and Anhui Guo et al,1980	
		Tirolites		Idaho Smith, 1932	U. S. A.
			Tirolites	Utah Kummel, 1969	
Tirolites				W. Himalayas Krafft and Diener, 1909	
			Tirolites	Albania Arthaber, 1911	
		Tirolites		N.E. Siberia Popov, 1961	U. S. S. R.
		Tirolites		S. USSR Astachova	
		Tirolites		S. Primorye Zakharov,1968	
		Tirolites			
			Dinarites		
		Doricranites			
			Stacheites		

Table 6 – Horizons of *Tirolites* faunas of basin facies and geological range of main genera in *Tirolites* faunas.

Procladiscites, Beyrichites, Ussurites, Keyserlingites, Ziyunites, Beneckeia, Czekanowskites, and *?Karangatites, ?Hungarites, ?Stacheites* and *?Dalmatites.* Among them, *Leiophyllites* is the common element in both the Tethyan and Boreal provinces found from Lower and Middle Triassic, *Ussurites* is more common from Middle Triassic than from Lower Triassic and their species from Middle Triassic are quite different from those of Lower Triassic.

Originally, *«Acrochordiceras»* was listed as one of the linking genera by the writer in 1978 on the basis of *Neopopanoceras haugi* fauna of USA. Currently during visiting Geological Survey of Canada in Ottawa, the writer examined the casts of *Neopopanoceras haugi* fauna, and therefore considers the so–called *«Acrochordiceras»* is a inner whorls of *Keyserlingites.*

Beneckeia is both from Lower Triassic and from Middle Triassic of platform facies.

As discussed above, the geological range of *Keyserlingites* is also from Late Spathian to Early Anisian, however it is restricted to Spathian in the Boreal province, and limited to Early Anisian in the Tethyan province, except that from S. Primorye, USSR.

Japonites, Procladiscites, Beyrichites and *Czekanowskites* were all formerly known only from Middle Triassic, however recently, a few species of these genera with simpler characters and quite different from those of the Middle Triassic are also found in the Lower Triassic.

As regards *?Hungarites, ?Karangatites, ?Stacheites* and *?Dalmatites*, it is not completely clear that whether or not they can be really referred to these genera separately.

It was pointed out as early as 1978 that some Late Scythian ammonoid forms were closely related to their corresponding Anisian genera.

Scythian form	Anisian form
Pseudosageceras	*Parasageceras*
Procarnites	*Megaphyllites*
Albanites	*Norites*
Eodanubites	*Paradanubites*
Eoacrochordiceras	*Paracrochordiceras*
Eosturia	*Sturia*

Conclusion.

(1) In order to draw a relatively complete and realizable definition of the Scythian–Anisian boundary, it is very important to determine that what is the base of Anisian or Middle Triassic and what is the top of the Spathian or Scythian or Lower Triassic, and how to correlate the boundary between basin and platform facies.

(2) The present writer prefers to use the top of *Prohungarites* zone or

Scythian	Anisian			
Spathian	Aegean	Bithynian		
Subcolumbites zone	**Aegeiceras ugra horizon** / **Paracroch-Japonites bed**		Chios, Greece	Tethyan Province
Procarnites bed — Albanites bed	Ussurites bed / Procladiscites bed	Leiophyllites bed / Anagymnotoceras ismidicus bed	C. Iran Tozer, 1972	Tethyan Province
Stacheites beds	"Prosphingites" beds ? / ? Lower part of Megaphyllites prometheus beds	Lower part of Megaphyllites prometheus beds	S. USSR	Tethyan Province
Prohungarites middlemissi bed	"Keyserlingites beds"	Lower part of Ptychites rugifer beds	West Himalayas	Tethyan Province
	Paracrochordiceras — Japonites block		Chitichun exotic block	Tethyan Province
Upper part of Procarnites — Anasibirites beds	Japonites magnus zone	Japonites magnus zone / L. part of Anacrochordiceras nodosum zone	Nyanang S. Tibet China	Tethyan Province
Procarnites — Subcolumbites zone	?	? Parapopanoceras nanum zone	Guizhou and Guangxi China	Tethyan Province
Procarnites — Subcolumbites zone	bed 3 "Keyserlingites bed" / bed 2 Japonites meridianus bed	bed 1 Gymnites bed	Timor Indonesia	Tethyan Province
Subcolumbites zone (Columbites subzone / Subcolumbites subzone) / Arnautoceltites zone	Leiophyllites zone	? Lower part of Hollandites zone	Japan	Tethyan Province
Subcolumbites multiformis bed with Keyserlingites	Leiophyllites pradyumna zone	Lower part of Phyllocladiscites basarginensis zone	South Primorye USSR	Transitional region
Subcolumbites beds	Lenotropites–Japonites zone: Lenotropites qinghaiensis subzone / Japonites meridianus subzone	Beyrichites–Hollandites zone: Gymnites subzone / Nicomedites — Anagymnotoceras subzone	C. Qinghai China	Transitional region
Subcolumbites — Prohungarites bed / Neopopa. haugi zone	Lenotropites caurus zone	Acrochordiceras hyatti zone	Nevada USA	Transitional region
Olenikites spiniplicatus zone	Grambergia taimyrensis zone / Lenotropites tardus zone	L. part of Malletoptychites kotschetkovi zone / Czekanowskites decipiens subzone	N. E. Siberia USSR	Boreal Province
"Keyserlingites subrobustus beds"	Lenotropites caurus	With Anagymnotoceras, Hollandites etc.	Svalbard Norway	Boreal Province
"Keyserlingites subrobustus zone"	Lenotropites caurus zone	Lower part of Anagymnotoceras varium zone	Canada	Boreal Province
	Groenlandites beds		Greenland Denmark	Boreal Province

Table 7 – Correlation of Spathian and Aegean between Tethys and Boreal provinces.

Subcolumbites zone (including *Neopopanoceras haugi* zone regarded as the upper part of *Subcolumbites* zone) in the Tethyan province and the top of *Olenikites* zone in the Boreal province as the top of Scythian or Spathian or Lower Triassic rather than the *Keyserlingites subrobustus* zone in the Boreal province since the latter is not appropriate for a cosmopolitan zone. On the other hand, the top of the Scythian of platform facies may be well represented by the top of the *Tirolites carniolicus* zone or *Dinarites* zone.

As regards the base of Anisian, generally speaking, the base of *Lenotropites caurus* zone of Canada is justified as the representative of the base of Anisian in the Boreal province, and the base of the *Aegeiceras ugra* bed of Chios may represent the base of Anisian in the Tethyan province, however the present writer prefers to offer the base of *Lenotropites–Japonites* zone of C. Qinghai, China as the base of Anisian or Middle Triassic, not only because it contains the most abundant earliest Anisian ammonoids, but also it lies in a region of a «linking bridge» providing the possibility of directe correlation between the Tethyan and the Boreal provinces.

(3) Finally, the correlations of Aegean or early Anisian and Spathian or Upper Scythian and the Scythian–Anisian boundary are given in Table 7.

Acknowledgements.

The writer owe sincere gratitude to Dr. E. T. Tozer for his great assistance and a promise of examining the concerned specimens and casts which are deposited in Geological Survey of Canada in Ottawa, when the writer visited there, and to Dr. N. Fantini Sestini (University of Milano, Italy) for reading the manuscript and her kind advice.

The writer is also deeply indebted to Dr. G.E.G. Westermann (McMaster University, Hamilton, Canada) and Dr. M. Gaetani (University of Milano, Italy) for their valuable assistance.

This paper was revised and completed in Department of Geology, McMaster University, Hamilton, Canada, when the writer visited there.

REFERENCES

Arthaber G. v. (1911) - Die Trias von Albanien. *Beitr. Paläont. Geol. Ost.–Ung. Orients*, v. 24, pp. 169–247, 8 pls., Wien.

Assereto R. (1974) - Aegean and Bithynian: proposals for two new Anisian substages. *Schriftenr. Erdwiss. Komm. Österr. Akad. Wiss.*, v. 2, pp. 23–39, 8 figs., Wien.

Assereto R., Jacobshagen V., Kauffmann G. & Nicora A. (1980) - The Scythian/Anisian boundary in Chios, Greece. *Riv. Ital. Paleont. Strat.*, v. 85 (1979), n. 3–4, pp. 715–736, 6 figs., Milano.

Astachova T. V. (1960) - New species of fossil plants and invertebrates of the USSR, pt. II, New Lower Triassic ammonites of Mangyshlak. *All Union Sci. Res. Geol. Inst.*, pp. 139–159, 4 pls., Leningrad.

Bando Y. (1967) - Study on the Triassic ammonoids and stratigraphy of Japan. Pt. 2. Middle Triassic. *Jour. Geol. Soc. Japan*, v. 73, pp. 151–162, 1 pl., Tokyo, (in Japanese).

Bando Y. & Shimoyama S. (1974) - Late Scythian ammonoids from Kitakami Massif. *Tran. Proc. Palaeont. Soc. Japan*, n. s., n. 94, pp. 293–312, 3 pls., Tokyo.

Bittner A. (1899) - Trias Brachiopoda and Lamellibranchiata. *Palaeont. Indica*, ser. 15, v. 3, pt. 2, Calcutta.

Ching Y. K., Sun D. L. & Rong J. Y. (1976) - Mesozoic and Cenozoic Brachiopoda from the Mount Jolmo Lungma Region. *A Report of Scientific Expedition in the Mount Jolmo Lungma Region 1966–1968, Palaeontology*, fasc. 2, pp. 271–356, 10 pls., Science Press, Peking, (in Chinese).

Dagys A.S. (1965) - Triasovye brakhiopody Sibiri. 186 pp., 26 pls., Nauka, Moskva.

Dagys A. S., Arkhipov Yu. V. & Bytschkov Yu.M. (1979) - Stratigraphy of the Triassic system of the North–Eastern Asia. *Acad. Sci. USSR, Siberian Branch, Transactions of the Institute of Geology and Geophysics*, No. 447, 228 pp., 16 pls., Novosibirsk, (in Russian).

Diener C. (1897) - The Cephalopoda of the Triassic Limestone–crags of Chitichun. *Palaeont. Indica*, ser. 15, v. 2, pt. 3, pp. 101–118, 3 pls., Calcutta.

Diener C. (1907) - The fauna of the Himalayan Muschelkalk. *Palaeont. Indica*, ser. 15, v. 5, pt. 2, pp. 1–140, 17 pls., Calcutta.

Diener C. (1912) - The Trias of the Himalayas. *Geol. Surv. India Mem.*, v. 36, n. 3, pp. 1–159, Calcutta.

Diener C. (1913) - Triassic fauna of Kashmir. *Palaeont. Indica*, n. s., v. 5, n. 1, pp. 1–133, 13 pls., Calcutta.

Fantini Sestini N. (1981) - Lower Anisian (Aegean) ammonites from Chios Island (Greece). *Riv. Ital. Paleont. Strat.*, v. 87, n. 1, pp. 41–66, 3 pls., Milano.

Ganev M. (1966) - Untertriassische Ammoniten aus dem Ostbalkan. *Bulgarian Acad. Sci. Geol. Inst.*, Works on Geology of Bulgaria, s. Paleont., v. 8, pp. 21–28, Sofia, (in Bulgarian).

Guo P. X. & Xu J. C. (1980) - New ideas on the age of the Qinglung group in Chaoxian, Anhui. *Jour. Stratigraphy*, v. 4, n. 4, pp. 310–315, 1 pl., Peking, (in Chinese).

He G. X., Wang Y. G. & Chen G. L. (in press) - Early Middle and late Early Triassic Cephalopods of Mt. Burhan Budai, Central Qinghai. (In Chinese with English abstract).

Ho Z. A., Yang H. & Zhou J. C. (1980) - The Middle Triassic reef in Guizhou province. *Scientia Geologica Sinica*, n. 3, pp. 264–277, 1 pl., Beijing, (in Chinese with English abstract).

Hsu T. Y. & Tseng T. C. (1942) - An interesting Anisic fauna of Machangping, Pingyueh, Kueichou. *Bull. Geol. Soc. China*, v. 22, n. 3–4, pp. 205–209, Peking, (in English).

Intern. Subcom. Strat. Clas. Report 6 (1971) - Preliminary report on Chronostratigraphic units. *24th Intern. Geol. Cong.*, Montreal.

Jacobshagen V. & Nicora A. (1981) - The Lower/Middle Triassic boundary - a proposal, submitted to the session of IUGS Subcommission on Triassic Stratigraphy in Sarajevo, on Oct., 1981.

Kittl E. (1903) - Die Cephalopoden der oberen Werfener Schichten von Muc in Dalmatien sowie von anderen dalmatinischen, bosnischherzegowinischen und alpinen Lokälitaten. *Abh. K. K. Geol. R.–A.*, v. 20, pp. 1–77, 11 pls., Wien.

Kozur H. (1980) - The main events in the Upper Permian and Triassic conodont evolution and its bearing to the Upper Permian and Triassic stratigraphy. *Riv. Ital. Paleont. Strat.*, v. 85 (1979), n. 3–4, pp. 741–766, Milano.

Krafft A. V. & Diener C. (1909) - Lower Triassic Cephalopoda from Spiti, Malla Johar, and Byans. *Palaeont. Indica*, ser. 15, v. 6, n. 1, pp. 1–186, 31 pls., Calcutta.

Krystyn L. von (1974) - Die *Tirolites* – Fauna (Ammonoidea) der untertriassischen Werfener Schichten Europas und ihre stratigraphische Bedeutung. *Österreich Akad. Wiss. Math. Naturw. Kl. Sitzungsber.*, Abt. 1, v. 183, n. 1–3, pp. 30–50, 5 fig., Wien.

Kublov B. A. (1965) - Triasovye i Jurskie otlozhenija ostrova Vilgelma. In: Materialy po geologii Spitzbergena, Moskva.

Kummel B. (1953) - Middle Triassic ammonites from Peary Land. *Medd. Gronland*, v. 127, n. 1, pp. 61–106, 1 pl., København.

Kummel B. (1957) - In: Treatise on Invertebrate Paleontology, Part L, Mollusca 4, Cephalopoda, Ammonoidea. *Geol. Soc. America, Univ. Kansas Press.*, pp. 130–187, Lawrence.

Kummel B. (1969) - Ammonoids of the Late Scythian (Lower Triassic). *Bull. Mus. Compar. Zool.*, v. 137, n. 3, pp. 483–509, 71 pls., Cambridge, Mass.

Pchelina T. M. (1965) - Mesozojskie otlozhenija rajona Van Kejlonforda (Zap. Spitzbergen). In: Materialy po geologii Spitzbergena, Moskva.

Popov Yu. N. (1961) - Triassic ammonoids of northeast USSR. Trans. NIIGA (Leningrad), v. 79, pp. 1–124, 25 pls., Leningrad, (in Russian).

Shevyrev A. A. (1968) - Triassic ammonoids in South USSR. Akad. Nauk USSR, Trudy Pal. Inst., v. 119, Moscow, (in Russian).

Silberling N. J. & Tozer E. T. (1968) - Biostratigraphic classification of the marine Triassic in North America. *Geol. Soc. America*, Spec. Paper 110, 63 pp., Boulder.

Silberling N. J. & Wallace R. E. (1969) - Stratigraphy of the Star Peak Group (Triassic) and overlying Lower Mesozoic rocks Humboldt Range, Nevada. *U.S. Geol. Surv. Prof. Paper*, n. 592, pp. 1–50, Washington.

Smith J. P. (1914) - The Middle Triassic marine invertebrate faunas of North America. *U.S. Geol. Surv. Prof. Paper*, n. 83, pp. 1–254, 99 pls., Washington.

Smith J. P. (1932) - Lower Triassic ammonoids of North America. *U. S. Geol. Surv. Prof. Paper*, n. 167, 199 pp., 81 pls., Washington.

Spath L. F. (1934) - Catalogue of the fossil Cephalopoda in the British Museum (Natural History). Part IV. The Ammonoidea of the Trias, pp. 1–521, London.

Sun D. L. (1980) - Triassic Brachiopoda of China. *Riv. Ital. Paleont. Strat.*, v. 85 (1979), n. 3–4, pp. 1175–1188, 1 fig., Milano.

Tozer E. T. (1965) - Latest Lower Triassic ammonoids from Ellesmere Island and Northeastern British Columbia. *Geol. Surv. Canada Bull.*, n. 123, pp. 1–45, 8 pls., Ottawa.

Tozer E. T. (1967) - A standard for Triassic time. *Geol. Surv. Canada Bull.*, n. 156, pp. 1–103, 10 pls., Ottawa.

Tozer E. T. (1971) - Triassic time and ammonoids: Problems and proposals. *Can. Jour. Earth Sci.*, v. 8, n. 8, pp. 989–1031, Ottawa.

Tozer E.T. (1974) - Definitions and limits of Triassic stages and sustages: suggestions prompted by comparisons between North America and the Alpine–Mediterranean region. *Österr. Akad. Wiss., Schriftenr. Erdwiss. Komm.*, v. 2, pp. 195–206, Wien.

Tozer E. T. (1981) - Triassic Ammonoidea: Classification, evolution and relationship with Permian and Jurassic forms. Geographic and stratigraphic distribution. *Systematics Assoc.*, Spec. Vol. n. 18, «The Ammonoidea», pp. 66–100, pp. 394–431, Academic Press, London, New York.

Wang Y. G. (1964) - Middle Triassic Ammonoids from Southern and Southwestern Guizhou (unpublished report).

Wang Y. G. (1978) - Latest Early Triassic ammonoids of Ziyun, Guizhou– with notes on the relationship between Early and Middle Triassic ammonoids. *Acta Palaeont. Sinica*, v. 17, n. 2, pp. 151–179, 3 pls., 12 figs., Peking, (in Chinese with English summary).

Wang Y. G. & He G. X. (1976) - Triassic ammonoids from the Mount Jolmo Lungma Region.

In: *A Report of Scientific Expedition in the Mount Jolmo Lungma Region 1966–1968, Palaeontology*, fasc. 3, pp. 223–438, 48 pls., Science Press, Peking, (in Chinese).

Wang Y. G. & He G. X. (1980) - Triassic ammonoid sequence of China. *Riv. Ital. Paleont. Strat.*, v. 85 (1979), n. 3–4, pp. 1207–1220, Milano.

Wang Y. G., Chen C. C., He G. X. & Chen J. H. (1981) - An Outline of the marine Triassic in China. *Intern. Union Geol. Sci.*, Publ. n. 7, 21 pp., 1 map, 2 tabs., Haarlem.

Wang Y. G., Zheng Z. G. & Chen G. L. (1979) - Atlas of Palaeontology of Qinghai - Cephalopods. Vol. of 59 pp., 17 pls., Geological Publishing House, Beijing, (in Chinese).

Wang Z. H. (1982) - Discovery of Early Triassic *Neospathodus timorensis* fauna in Ziyun of Guizhou. *Acta Palaeont. Sinica*, v. 21, n. 5, pp. 584–587, 1 pl., Peking, (in Chinese with English abstract).

Welter O. (1915) - Die Ammoniten und Nautiliden der ladinischen und anisischen Trias von Timor. *Paläont. Timor*, v. 5, pp. 71–136, 13 pls., Stuttgart.

Westermann G. (1962) - The Mid–Triassic brachiopod «*Spiriferina*» *stracheyi* (Salter) from the Canadian Rocky Mountains. *Jour. Alberta Soc. Petrol. Geol.*, v. 10, n. 11, Calgary.

Yabe H. & Shimizu S. (1927) - The Triassic fauna of Rifu, near Sendai. *Sci. Rept. Tohoku Imp. Univ.*, sect. 2, v. 11, n. 2, Tokyo.

Zacharov Yi. D. (1978) - Lower Triassic Ammonoids of East USSR. *Nauka*, pp. 1–224, Moscow, (in Russian).

Zhao J. K. (=Chao K. K.) (1959) - Lower Triassic ammonoids from western Kwangsi, China. *Palaeont. Sinica*, n. 154 (n. s. B, n. 9), pp. 1–355, 45 pls., Peking, (in Chinese and English).

PLATE 62

Fig. 1 - 8 – *Keyserlingites dieneri* Mojsisovics. 1–3) Ventral, anterior and side views (cat. no. 69206). Ib subzone, L. Anisian; x 1/2. 4, 5) Side and ventral views (inner whorls of the specimen cat. no. 69206). Ib subzone, L. Anisian; x 1. 6–8) Ventral, side and anterior views (cat. no. 69205). Ib subzone, L. Anisian; x 1.

All of figured specimens in Plate 62, 63 and 64 were collected from Naocangjianguo, Maduo, Qinghai province, except cat. no. 69276, 69292 (i. e. the specimens of Pl. 64, figs. 3, 4, 20–22) from Golmud, Qinghai province.

All of figured specimens are deposited in Nanjing Institute of Geology and Palaeontology, Academia Sinica.

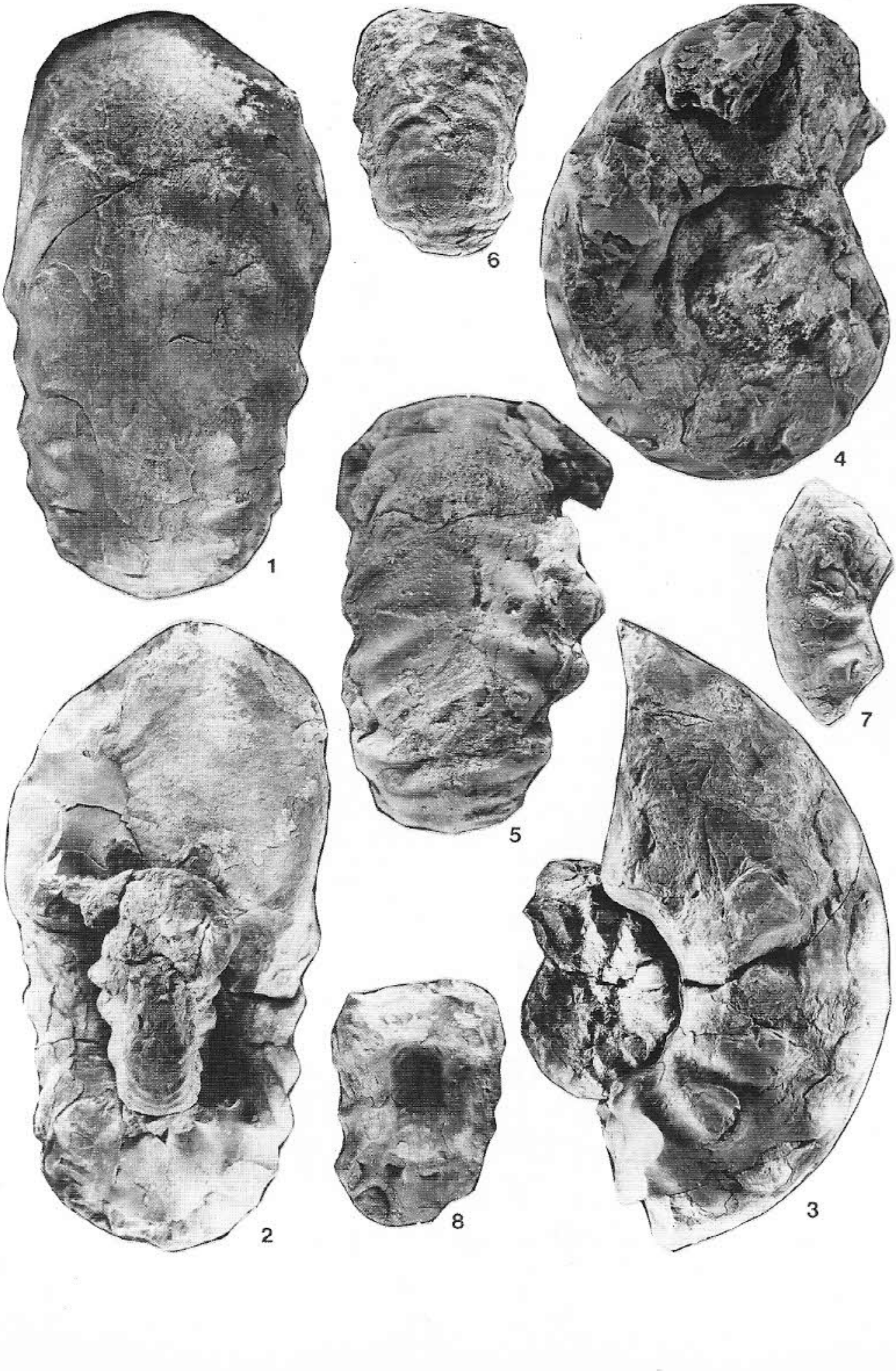

6
4
1
5
7
2
8
3

PLATE 63

Fig. 1, 2 – *Parasageceras gracile* Spath. Side and ventral views (cat. no. 69181). Ib subzone, L. Anisian.

Fig. 3, 4 – *Norites psilodiscus* Arthaber. Side and ventral views (cat. no. 69190). Ib subzone, L. Anisian.

Fig. 5, 6 – *Psilosturia complex* Chen (in He, Wang & Chen). Ventral and side views (cat. no. 69409). I zone, L. Anisian.

Fig. 7, 8, 22, 23, 25–27 – *Keyserlingites qinghaiensis* Wang (in He, Wang & Chen). 7, 8) Side and anterior views (cat. no. 69217). I zone, L. Anisian. 22, 23) Side and ventral views (cat. no. 69212). I zone, L. Anisian. 25–27) Anterior, ventral and side views (cat. no. 69211). Holotype. I zone, L. Anisian.

Fig. 9 - 11 – *Nicomedites barbarossae* (Toula). Anterior, side and ventral views (cat. no. 69325). IIb subzone, M. Anisian.

Fig. 12 - 14 – *Procladiscites brancoi* Mojsisovics. Ventral anterior and side views (cat. no. 69373). Ia subzone, L. Anisian.

Fig. 15 - 17 – *Keyserlingites prahlada* (Diener). Ventral, anterior and side views (cat. no. 69210). I zone, L. Anisian.

Fig. 18 - 20 – *Keyserlingites sinensis* Wang (in He, Wang & Chen). Anterior, side and ventral views (cat. no. 69207). Holotype. I zone, L. Anisian.

Fig. 21 – *Japonites asseretoi* Fantini Sestini. Side (cat. no. 69391). Ib subzone, L. Anisian.

Fig. 24 – *Keyserlingites dieneri* Mojsisovics. Anterior view (cat. no. 69206). Ib subzone, L. Anisian.

All figures natural size.

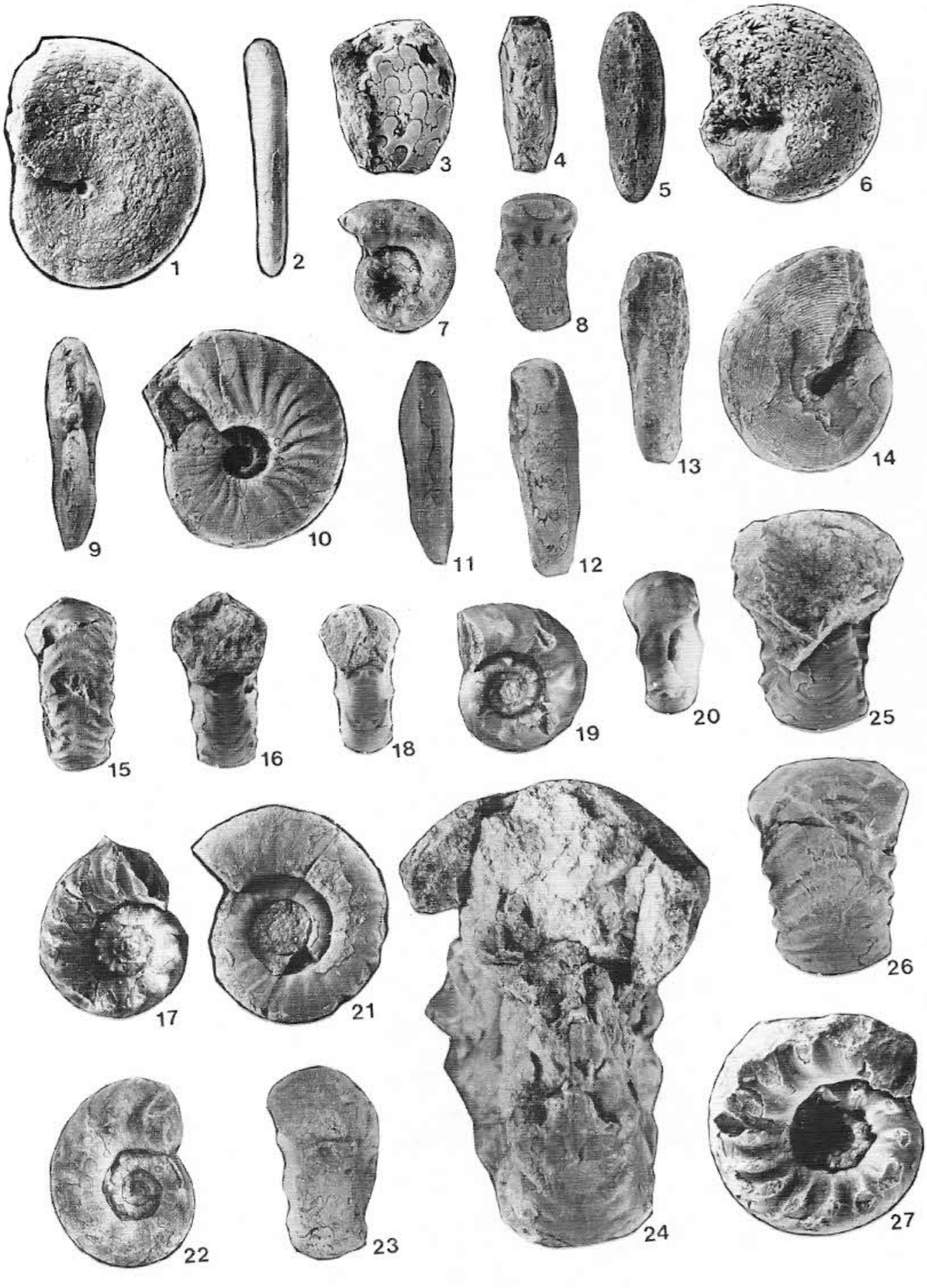

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27

PLATE 64

Fig. 1, 2 – *Ussurites hara* (Diener). Side and anterior views (cat. no. 69433). I zone, L. Anisian.

Fig. 3, 4 – *Lenotropites* cf. *tardus* Mclearn. Side and anterior views (cat. no. 69276). I zone, L. Anisian.

Fig. 5, 6 – *Arctohungarites umbilicus* Wang (in He. Wang & Chen). Ventral and side views (cat. no. 69270). Ia subzone, L. Anisian.

Fig. 7, 8 – *Arctohungarites kharaulakhensis* Popow. Side and anterior views (cat. no. 69261). I zone, L. Anisian.

Fig. 9, 10 – *Grambergia tetsaensis* Mclearn. Side and ventral views (cat. no. 69243). I zone, L. Anisian.

Fig. 11 - 14 – *Pearylandites (Tienjunites) spinosus* Wu (nom. nud.). 11) Side (cat. no. 69310). Ia subzone, L. Anisian. 12–14) Side, anterior and ventral views (cat. no. 69313). I zone, L. Anisian.

Fig. 15, 16 – *Grambergia laevis* Wang (in He, Wang & Chen). Ventral and side views (cat. no. 69247). I zone, L. Anisian.

Fig. 17 - 19 – *Lenotropites qinghaiensis* Wang & Chen. Anterior, ventral and side views (cat. no. 69277). Ia subzone, L. Anisian.

Fig. 20 - 22 – *Lenotropites sinensis* Wang (in He, Wang & Chen). Side, ventral and anterior views (cat. no. 69292). Holotype. I zone, L. Anisian.

Fig. 23 - 25 – *Groenlandites qinghaiensis* Wang (in He, Wang & Chen). Ventral, side and anterior views (cat. no. 69296). Holotype. I zone, L. Anisian.

Fig. 26 - 28 – *Nicomedites osmani* Toula. Anterior, ventral and side views (cat. no. 69324). IIb subzone, M. Anisian.

Fig. 29, 30 – *Paradanubites kansa* (Diener). Side and ventral views (cat. no. 69340). I zone, L. Anisian.

Fig. 31, 32 – *Japonites meridianus* Welter. Anterior and side views (cat. no. 69383). Ib subzone, L. Anisian.

All figures natural size.

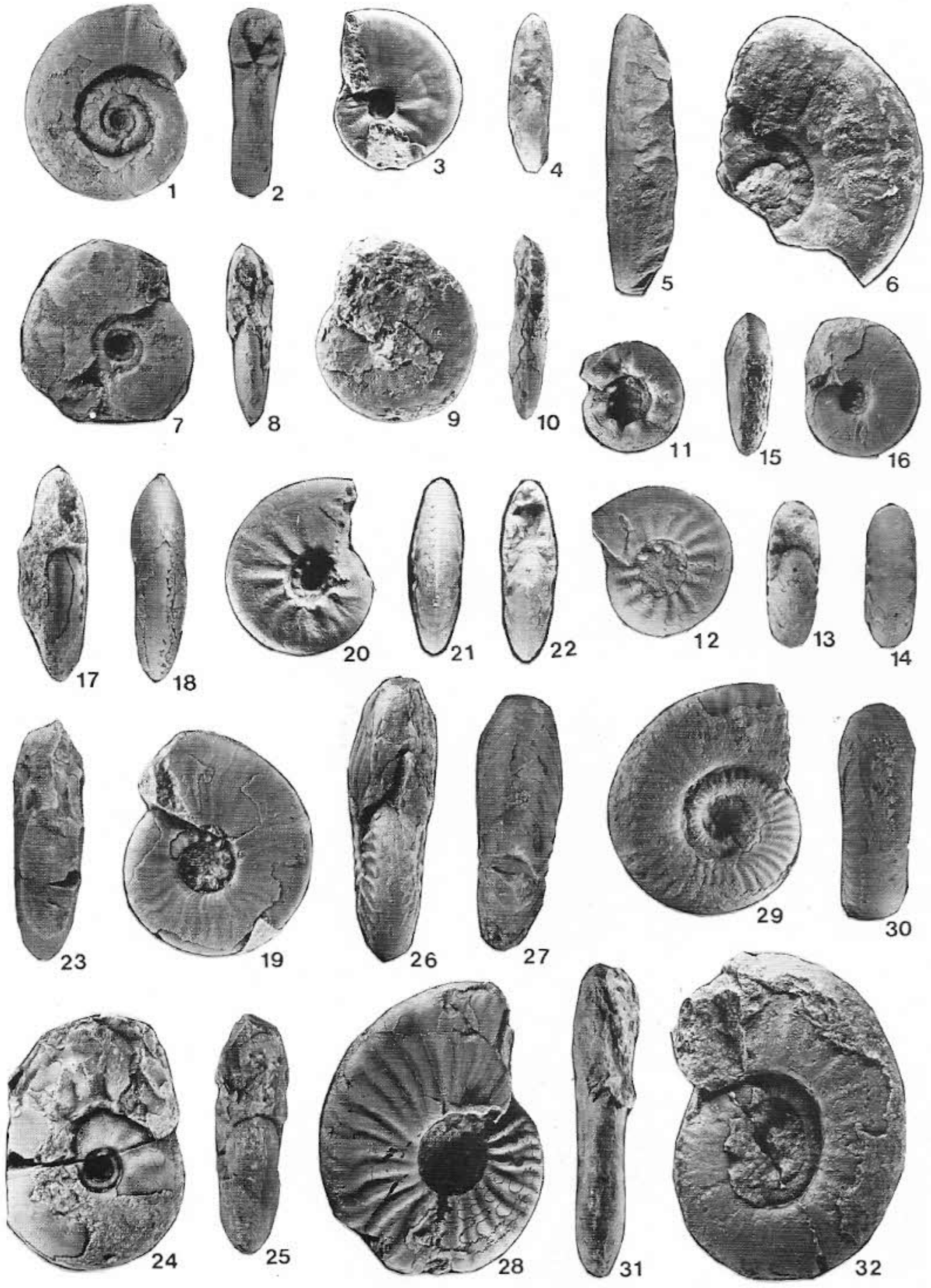


PLATE 65

Fig. 1 – *Tirolites cassianus* (Quenstedt). Side (cat. no. 33971, collected from Tianjun, Qinghai province). Spathian.

Fig. 2 - 4 – *Anagymnotoceras* cf. *helle* (Mclearn). Ventral, side and anterior views (cat. no. 69337, collected from Maduo, Qinghai province). IIb subzone, M. Anisian.

Fig. 5, 6 – *Dalmatites* cf. *morlaccus* Kittl. Ventral and side views (cat. no. 84782, collected from Langdai, Guizhou province). Spathian.

Fig. 7, 8 – *Hololobus evolutus* Wang & Chen. Ventral and side views (cat. no. 33973, collected from Ulan, Qinghai province). Spathian.

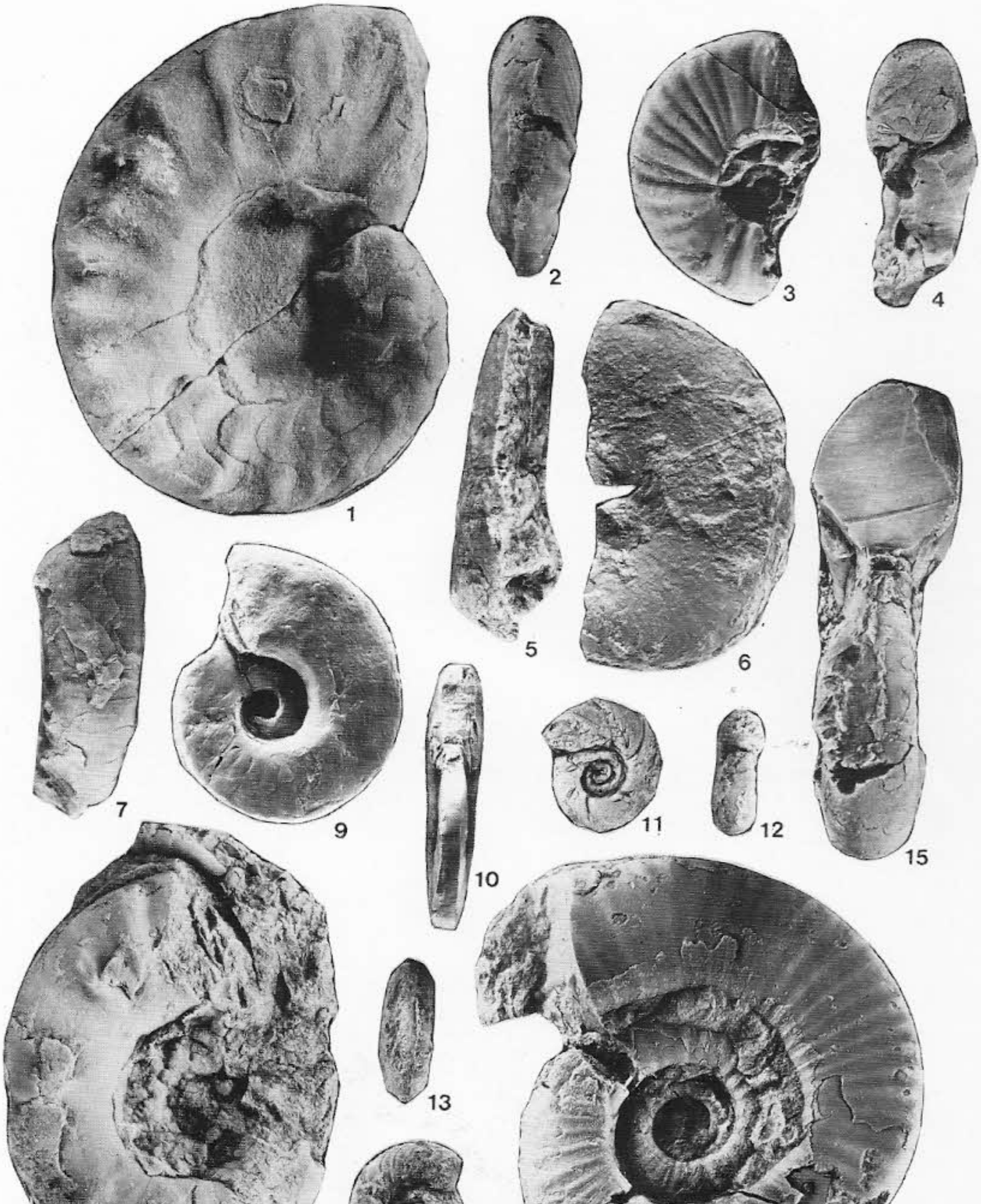
Fig. 9, 10 – *Dinarites puanensis* Zhao & Wang. Side and anterior views (cat. no.22032, collected from Pu'an, Guizhou province). Spathian.

Fig. 11, 12 – *Arnautoceltites* cf. *arnauticus* (Arthaber). Side and anterior views (cat. no. 69197, collected from Maduo, Qinghai province). *Subcolumbites* zone, Spathian.

Fig. 13, 14 – *Subcolumbites* sp. Ventral and side views (cat. no. 69194, collected from Maduo, Qinghai province). *Subcolumbites* zone, Spathian.

Fig. 15, 16 – *Ussurites yabei* Diener. Anterior and side views (cat. no. 69438, collected from Maduo, Qinghai province). Ib subzone, L. Anisian.

All figures natural size.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16