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西藏南部岗巴地区白垩纪中期钙质超微化石带和 Cenomanian-Turonian 界线*

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提要　我国西藏南部海相白垩系含有较丰富的钙质超微化石。文中着重研究岗巴地区两个剖面(即剖面 A，B)Albian-Santonian 钙质超微化石的分布。根据标志种的存在，识别出 5 个初现面事件，相应地建立 6 个钙质超微化石带，自下至上是 *Prediscosphaera cretacea* 带，*Eiffellithus turriseiffeli* 带，*Lithraphidites acutum* 带，*Gartnerago obliquum* 带，*Quadrum gartneri* 带，*Lucianorhabdus cayeuxii* 带。同时，通过洲际对比，建议以 *G. obliquum* 初现面作为划分本区 Cenomanian 和 Turonian 界线的标志。此外，*Q. gartneri* 带和 *I. cayeuxii* 带之间缺失多个化石带，据此推测 Turonian 至 Santonian 期间本区可能存在沉积间断。

关键词　钙质超微化石　岗巴群　白垩纪中期　西藏南部

THE MIDDLE CRETACEOUS CALCAREOUS NANNOFOSSIL ZONES IN GAMBA AREA，SOUTHERN XIZANG (TIBET)，CHINA AND THE CENOMANIAN-TURONIAN BOUNDARY

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Abstract：This study deals with calcareous nannofossils of mid-Cretaceous at Gamba Area in Southern Xizang (Tibet)，China. The rock samples were collected from the Gamba Group of both Sections A and B. On the basis of the characteristic sediments，the Gamba Group can be divided into three stratigraphic units from bottom to top，namely the Gambadongshan，Chaqiela and Gambacunkou formations. Calcareous nannofossils mainly appeared from the uppermost Gambadongshan Formation to Gambacunkou Formation. The preliminary results enable us to propose a detailed nannofossil zonation for the middle Albian to the late Santonian. This zonation scheme consists of six zones and five addition biohorizons. The upper part of Gambacunkou Formation clearly exhibits a stratigraphic hiatus since the top of *Quadrum gartneri* zone (early Turonian) is immediately overlain by *Lucianorhabdus cayeuxii* zone (late Santonian). The Cenomanian-Turonian boundary is discussed in detail on the basis of calcareous nannofossil data. The first occurrence of *Gartnerago obliquum* rather closely corresponds with the first appearance datum of *Helvetoglobotruncana praehelvetica* (foraminifera)，thus that they are considered to be very useful to determine the boundary between Cenomanian and Turonian in Southern Xizang (Tibet).

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Key words: Calcareous nannofossil, Gamba Group, Mid-Cretaceous, Cenomanian-Turonian boundary, Southern Xizang

1 INTRODUCTION

Marine Cretaceous is well exposed in Gamba area, Southern Xizang. Since the first studied by Hayden (1907) the overall stratigraphic sequence has been divided into different lithostratigraphic units (Group, Formation) and subunits (Member) mainly based on lithofacies aspects. The various correlated schemes can be found in the literature of Willems and Zhang (1993), who adopted three lithostratigraphic units for the Cretaceous, namely the Gamba Group (subdivided into the Gambadongshan, Chaqiela and Gambacunkou formations), the Zongshan and Jidula formations from bottom to top. The present investigation indicates that calcareous nannofossils frequently occur in these units except for the Jidula Formation. So far, Cretaceous calcareous nannofossils from Gamba area have been reported by Xu Yu-lin and Mao Shao-zhi (1992) under the title: Cretareous-Early Tertiary calcareous nannofossils from Southern Xizang (Tibet) and their sedimentary environments. They proposed one zone, four combination zones and one assemblage for the Middle Aptian-Middle Maastrichtian. As a main purpose, this study will offer the scheme of calcareous nannofossil zones and discuss the boundary between Cenomanian and Turonian at Gamba area according to the first- or last-occurrence horizons of some index species comparable with the marker's ranges of the type localities of Cretaceous elsewhere.

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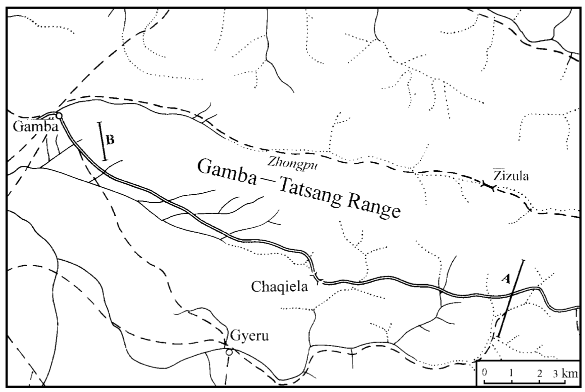
2 MATERIAL AND METHODS

The sections A, B, C, D, E, which were measured by the China-Germany Specialist Group (1983), have essentially covered throughout the rock formations from Upper Aptian to Maastrichtian. All the samples studied were collected from sections A and B (Text-fig. 1) chosen for the sediments appear to be more suitable for preservation of calcareous nannofossils. The smear slides are directly prepared using standard methods from unprocessed samples and examined under a light-polarized microscope at a magnification of 1250X. More than 300 fields of view were detected for each slide. The relative abundance of calcareous nannofossil taxa was estimated using the criterion defined by Hay (1970). These criteria are as follows:



Text-fig. 1 The location of Sections

V = very abundant; >25 specimens per field of view

A = abundant; 6—10 specimens per field of view

C = common; 1—5 specimens per field of view

F = few; 1 specimen per 2—10 fields of view

R = rare; 1 specimen per 11—50 fields of view

Taxonomic reference for the species applied in this study can be found in Perch-Nielse (1985).

3 BIOHORIZON

At Gamba Area, the Cretaceous essentially containing an interval from Middle Aptian to Maastrichtian is divided into the Gamba Group, the Zongshan Formation and Jidula Formation (partly) mainly based on the lithological features of rocks from bottom to top. Among them the Gamba Group has been subdivided into the Gambadongshan, Chaqiela and Gambacunkou Formations. A more detailed and comprehensive discussion of these units, containing description of lithology and thickness of rock formation, is presented in Willems and Zhang (1993).

Between the sections investigated, the succession of section A with a total of 1 680 m thick comprises the Gambadongshan, Chaqiela and Gambacunkou formations. It is noteworthy that the stratigraphic sequence was disturbed by reverse faults and overthrusts which run parallel to the bedding planes, especially there is a tectonically duplicated zone in the lower part of the section (Willems and Zhang, 1993). The section B, a succesion of 640m thick, continuously exposed and contained the topmost part of the Gambadongshan Formation, the Chaqiela Formation and the Gambacunkou Formation is a more normal sequence as compared with that of section A. The study of calcareous nannofossils, therefore, has to focus the section B.

At Gamba Area, a large number of calcareous nannofossils are found in strata assigned to the Chaqiela Formation and Gambacunkou Formation. Tables Ⅰ and Ⅱ show the distribution and relative abundance of calcareous nannofossils on the sections A and B. The fossils are generally well-preserved, though the elements of some specimens are overgrown with secondary calcite or lightly destroyed by dissolution. The calcareous nannofossil assemblages are dominated by *Watznaueria barnasae*, *Prediscosphaera cretacea*, *Zygodiscus diplogrammus* and *Eiffellithus turriseiffelli* in quantity. Other taxa encountered more or less, such as *Eiffellithus turriseiffeli*, *Lithraphidites acutum*, *Gartnerago obliquum*, *Quadrum gartneri*, *Eiffellithus eximius* and *Lucianorhabdus cayeuxii*, are very useful in determination of age and zone. According to the ranges of these important species, therefore, can be recognized five biohorizons in the section B from bottom to top as follows (Text-fig.2).

1. The first occurrence of *Eiffellithus turriseiffelii* (Dflandre) Reinhardt in the middle part of Chaqiela Formation, Sample Bf-18.

2. The first occurrence of *Lithraphidites acutum* Verbeek and Manivit in the lower part of Gambacunkou Formation, Sample Bf-39.

3. The first occurrence of *Gartnerago obliquum* (Stradner) Thierstein in the middle part of Gambacunkou Formation, Sample Bf-47.

4. The first occurrence of *Quadrum gartneri* Prins and Perch-Nielsen in the upper part of Gambacunkou Formation, Sample Bf-53.

5. The first occurrence of *Lucianorhabdus cayeuxii* Deflandre or *Eiffellithus eximius* (Stover) Perch-Nielsen in the upper part of Gambacunkou Formation, Sampled Bf-59.

In addition, following five biohorizens can be also recognized in supplementary section A (Text-fig. 3):

1. The first occurrence of *Eiffellithus turriseiffelii* (Deflandre) Reinhardt in the upper part of Chaqiela Formation, Sample Af-80.

2. The first occurrence of *Lithraphidites acutum* Verbeek and Manivit in the middle-upper part of Gambacunkou Formation, Sample Af-97.

3. The first occurrence of *Gartnerago obliquum* (Stradner) Thierstein in the middle-upper part of Gambacunkou Formation, Samplie Af-112.

4. The first occurrence of *Quadrum gartneri* Prins and Perch-Nielsen in the upper part of Gambacunkou Formation, Sample Af-123.

5. The first occurrence of *Lucianorhabdus cayeuxii* Deflandre in the upper part of Gambacunkou Formation, Sample Af-125.

4 BIOZONATION

On the basis of synthesized above biohorizons, a preliminary scheme of calcareous nannofossil zonation is proposed for sequence from the uppermost part of Gambadongshan Formation to the Gambacunkou Formation at Gamba Area (Text-figs. 2 and 3). The lowermost part of *Prediscosphaera cretacea* zone spans an interval from the uppermost part of Gambadongshan Formation to the lower part of Chaqiela Formation. The second *Eiffellithus turriseiffeli* zone appears in Chaqiela Formation and the lower part of Gambacunkou Formation. These two zones straddle the Middle Albian to Early Cenomanian in age. The next higher *Lithraphidites acutum* zone restricted within Middle Gambacunkou Formation belongs to Cenomanian. The following zones, *Gartnerago obliquum* zone and overlying *Quadrum gartneri* zone covering the Middle-Upper Gambacunkou Formation, are mostly Early Turonian in age. In the top part of Gambacunkou Formation, *Lucianorhabdus cayeuxii* zone is assigned to Late Santonian. It is thus obvious that there is a stratigraphic hiatus between *Q. gartneir* and *L. cayeuxii* zones. What led the

Table Ⅰ Distribution and relative abundance of calcareous nannofossils from Section B, Gamba area

Samples	*Cretarhabdus conicus*	*Prediscosphaera cretacea*	*Parhabdolithus angustus*	*Lithastrinus floris*	*Watznaueria barnesae*	*Zygodiscus diplogrammus*	*Chiastozygus litterarius*	*Biscutum blacki*	*Discorhabdus ignotus*	*Cribrosphaerella ehrenbergi*	*Cretarhabdus crenulatus*	*Scapholithus fossilis*	*Manivitella pemmatoidea*	*Rucinolithus irregularis*	*Braarudosphaera africana*	*Braarudosphaera bigelowii*	*Nannoconus tuitti*	*Nannoconus elongatus*	*Tranolithus orionatus*	*Vagalapila matalosa*	*Parhabdolithus asper*	*Parhabdolithus embergerii*	*Eiffellithus turriseiffeli*	*Eiffellithus trabeculatus*	*Zygodiscus elegans*	*Corollithion achylosum*	*Corollithion kennedyi*	*Lithraphidites acutum*	*Podorhabdus albianus*	*Microrhabdulus decoratus*	*Gartnerago obliquum*	*Corollithion exiguum*	*Lucianorhabdus cayeuxii*	*Eiffellithus eximius*	*Marthasterites furcatus*	*Quadrum gartneri*
Bf-73	F	F	R		C	F	F						R			F	R		R					R						R			R	R		
Bf-71	C	F		F	A		C	R	R	F						R			C			R	F	R	F					R	R		C	C		R
Bf-70	F	F	R	R	A	F		F	R	R	R		R										R							R			F	R		
Bf-59	C	C	F	F	A	C	R	F	R	R		F	R							R			F	F						R	R	R	C	C	R	C
Bf-56	F		R	F	F	F	R	F	R	R										R			R													
Bf-53	C	C	R	F	F	F	F	F	F	R			R						R	R			F	F	F	R				R	R	R			R	R
Bf-51	R	R	R	R				R	R															R												
Bf-49	C	A	C	A	A	C	R	C	C	F			R			F			R	R			F	F	F	R				F	F					
Bf-47	C	C	F	A	C	F	R	C	C													R	F	R		R	R	R			F					R
Bf-45	F	F	R	F	C	R	R	C	C	R	R					R				R			R													
Bf-42	A	A	C	C	A	C	F	C	C		F	F	F							R			C	F		F	F	F	R	R						R
Bf-39	A	A	F	C	A	A	C	F	F	R	F		R						R	F			C	F	F	C	R	F		R		R				R
Bf-35	C	C	F	F	C	C	F	F		F		R							R		R	F		F	F	R										
Bf-32	C	C	F	F	A	A	R	C	A	R			R							R			F	F	F	R	R					R				
Bf-25	F	F		R	C	C	R	A	A	R			F		R			R	R		C		F			R	R					R				
Bf-18	F	R	F		C	F	R	C	R					R									R		R											
Bf-6	C	C	C	A		C	F	A	C		F	F	F	R	A		F	F		R		R														

Table Ⅱ　Distribution and relative abundance of calcareous nannofossils from Section A, Gamba area

Samples	*Watznaueria barnesae*	*zygadiscus diplogrommus*	*Prediscosphaera cretacea*	*Parhabdolithus angustus*	*Vagalapilla matalosa*	*Cretarhabdus conicus*	*Chiastozygus litterarius*	*Corollithion achylosum*	*Lithastrinus floralis*	*Parhabdolithus asper*	*Manivitella pemmatoindea*	*Cretarhabdus crenulatus*	*Rucinolithus irregularis*	*Discorhabdus ignotus*	*Biscutum blackii*	*Parhabdolithus embergerii*	*Nannoconus truitti*	*Nannoconus elongatus*	*Braarudosphaera africana*	*Braarudosphaera bigelowii*	*Scapholithus fossilis*	*Cribrosphaerella ehrenbergi*	*Tranolithus orionatus*	*Eiffellithus turreseiffeli*	*Eiffellithus trabeculatus*	*Lithraphidites acutum*	*Podorhabdus albianus*	*Zygodiscus elegans*	*Corollithion kennedyi*	*Corollithion exiguum*	*Corollithion signum*	*Gartnerago obliquum*	*Quadrum gartneri*	*Microorhabdulus decoratus*	*Lucianorhabdus cayeuxii*	*Eiffellithus eximius*	*Lithastrinus grilli*
Bf-138	A	F	C			C		R	F			R		R	F					F			F		F									R	F	F	
Bf-137	A	C	A		R	F		R	F					R	R								F		F							R	R		C		
Bf-134	A	C	A		F	F			F					R	R										F			R				R		R	C	R	
Bf-132	A	F	F	C	R	C	R		C			F		R	R							R		F	F			F			R	R	R	F	F		C
Bf-131	A	C	C	C	C	C		R	C					R	R									F	F								R	C			
Bf-130	C	F	F	F		F		R	C					R	R					R					R								R	R	R		
Bf-129	C	F	C	F	F	F	R		F					R	R							R		F	F			F		R		F		F			
Bf-128	A	C	C	F	F	C	F	F	F		R			R	R									R	R			C		R		R	R	R			
Bf-127	C		C	F		F	R		C			R		R	F										F							F		R			
Bf-126	A	F	A	F	R	C		R	F			R		R	R									F	R							F		R	R		
Bf-125	A	C	A	C		C	F	R	C		R			C	C									F	R						R	F		R			
Bf-124	A	C	A	C	R	C	R	F	C					F	C																	F	R	R			
Bf-123	A	C	A	F		F	R		C					F	C										F							R		R			
Bf-121	A	C	C	C	R	C	R		A					R	F									F	R					R		R		F			
Bf-120	F	R	F	R		R			R					R	C										R			F									
Bf-119	F	F	F	F		F			C		R			R	R									F	R					R							
Bf-118	C	F	F	F	R	F	R	R	C		R			R	F										R							R					
Bf-117	C	F	C	F	R	F	R	R	C					R	C									F	R			F		R		C	R	R			
Bf-116	C	C	C	F	R	F	R		C					R	C									F	R							R					
Bf-114	C	F	C	C	R		R	F	C					R	F							R		F	R							C	R	R			
Bf-113	F	F	A	C	R	C	R	R	C					C	R	R				F	F	R		C	R	R				F	R	C		R			
Bf-112	C	F	C	C	R	F	R	F	R					F	C									F	R							F		F			
Bf-111	C	C	A	C	R	F	R	R	C					F	A		R							C	R			C		F							
Bf-110	C	C	C		R	F	R		F		R	F		F	A									F	R		R	F									
Bf-108	C	C	C	C	F	C	R		C					C	A	R								F		R	R	F		R							
Bf-104	C	C	A	C	R	R		R	R		R	C	R	A	C				R				R	R			R										
Bf-103	C	A	C	A		A		R	F	R		R		C	A	R								F	R	R	R		F								
Bf-99	A		A	C	F	A	R	F	R	R				C	A							F		F	R		R										
Bf-97	A	A	A	A	F	C	R	R	R		R	R		F	C	R			R			R		F	F	R	R	F									
Bf-89	C	R	F			F			R		R	R		F	C								R														
Bf-88	A	C	C			F		R	R			R	R	F	F	R		R	R			F	F	F													
Bf-86	A	C	C	F	R	F	F		R	F	F	F	F	F	C	R	R	C	F		R	F	F														
Bf-84	A	A	C	F		F	R		R	F	R	F	F	F	C	R	R	C	F		R		F					R									
Bf-80	A	C	C	C	R	C	R	R	F	C	R	F	C	F	F		R		R	R				R													
Bf-79	A	F	F	C	R	F			F	R	R	F	F	F	C	R		R	F																		
Bf-78	A	C	C	C	R	F		R	R	F	R		C	R	A			R	F																		
Bf-77	A	C	C	F	F	F	R		F	R			F	F	C	F	F																				
Bf-76	A		C	F	R	R				F		R	R	R	F																						
Bf-75	A	F	C	F	F	R	R	R	F			R	R	R	F																						
Bf-74	C	F	C	F	F	F																															

existence of that hiatus deserves further study. Although the zonation described in the following (from low to above) possesses provincial and tentative natures, this zonation scheme enables us to make certain correlation with calcareous nannofossil zonation of Cretaceous from stratotype areas (Thiesrtein, 1974, 1976; Sissingh, 1977; Verbeek, 1977; Perch-Nielsen, 1979, 1985; etc.).

***Prediscosphaera cretacea* zone**

Definition: Interval from the first occurrence of *Prediscosphaera cretacea* (Arkhangelsky) Gartner to the first occurrence of *Eiffellithus turriseiffelii* (Deflandre) Reinhardt.

Author: Theirstien (1971).

Age: Early Albian to Middle Albian.

Remarks: The upper part of this zone involves Roth's (1978) *Axipodorhabdus albianus* zone. At Gamba area, *Podorhabdus albianus* Black (= *A. albianus* (Black) Wind *et* Wise) can not be used as zonation marker species, because its first appearance lies above *Eiffellithus turriseiffelii* zone. The base of *P. cretacea* zone in what datum level is now unknown for most calcareous nannofossils have not been discovered in the Gambadongshan Formation excepting its uppermost part. We infer that the sediments containing this assemblage may represent only Middle Albian in age.

Range: Section A, samples Af-74 to Af-79; Section B, samples Bf-6 to Bf-17; the uppermost part of Gambadongshan Formation.

***Eiffellithus turriseiffelii* zone**

Definition: Interval from the first occurrence of *Eiffellithus turriseiffeli* (Deflandre) Reinhardt to the first occurrence of *Lithraphidites acutum* Verbeek *et* Manivit.

Author: Verbeek (in Manivit *et al*., 1977).

Age: Late Albian to Middle Cenomanian.

Remarks: At present this zone does not correspond to Thierstein's (1971) *Eiffellithus turriseiffelii* zone, because the latter has the top limited by the entry of *Lithraphidites alatus* Thierstein which does not occur in our material studied. Verbeek (1977) pointed out that *L. alatus* could not be used to define the upper boundary of this zone, because it occurs below the first appearance of *E. turriseiffelii*, consequently he used *L. acutum* instead.

Range: Section A, samples Af-86 to Af-97; Section B, samples Bf-18 to Bf-35; from the Chaqiela Formation to the lower part of Gambacunkou Formation.

***Lithraphidites acutum* zone**

Definition: Interval from the first occurrence of *Lithraphidites acutum* Verbeek and Manivit to the first occurrence of *Gartnerago obliquum* (Stradner) Thierstein.

Author: Verbeek (1977).

Age: Middle Cenomanian to Late Cenomanian.

Remarks: The first appearance of *Microrhabdulus decoratus* Deflandre has been used by Sissingh (1977) to define the lower boundary of *M. decoratus* zone, i.e. the top of *Eiffellithus turriseiffelii* zone. Sissingh's definition can not be compared to the *L. acutum* zone at Gamba Area, as where the first occurrence of *M. decoratus* is within *Gartnerago obliquum* zone.

Range: Section A, samples Af-97 to Af-110; Section B, samples Bf-39 to Bf-45; the middle part of Gambacunkou Formation.

***Gartnerago obliquum* zone**

Definition: Interval from the first occurrence of *Gartnerago obliquum* (Stradner) Thierstein to the first occurrence of *Quadrum gartneri* Prins and Perch-Nielsen.

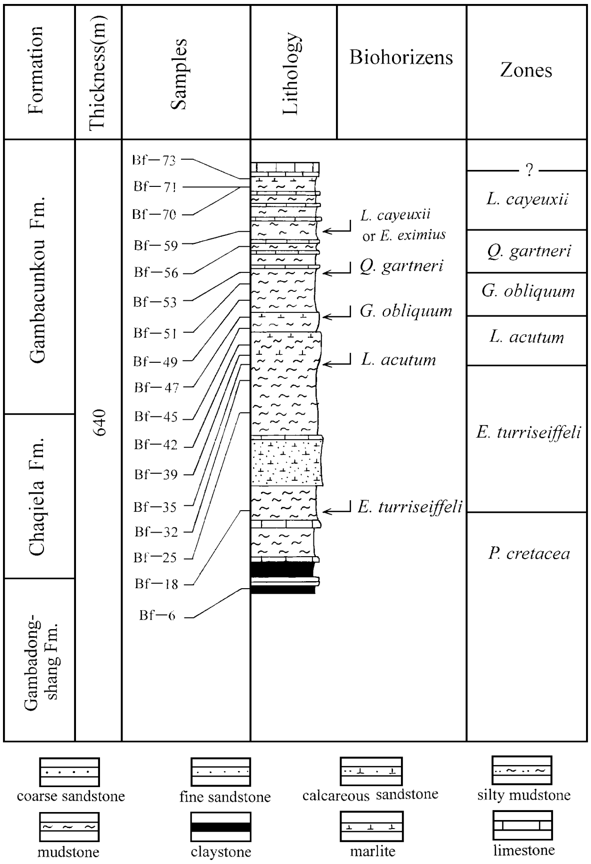
Author: Thierstein (1974).

Age: Early Turonian.

Remarks: The last occurrence of *Lithraphidites acutum* Verbeek and Manivit, which ranges upward to the lower *G. obliquum* zone, can not been used to define the zonal boundary. In addition, other species assigned to the genus *Gartnerago* have not been found underlying each and all zones. We agree with the view of Verbeek (1977) who emphasized the entry of *G. obliquum* to be used as a distinct biostratigraphic datum level in the upper Cretaceous.

It should be pointed out that the upper boundary of this zone is not easily to precisely define, because *Q. gartneri* is very poor in original appearance.

Range: Section A, samples Af-111 to Af-114a;



Text-fig. 2　Biohorizons and zones of calcareous nannofossils from Section B, Gamba area

Section B, samples Bf-47 to Bf-51; the middle part of Gambacunkou Fromation.

Quadrum gartneri zone

Definition: Interval from the first occurrence of *Quadrum gartneri* Prins and Perch-Nielsen to the first occurrence of *Eiffellithus eximius* (Stover) Perch-Nielsen or *Lucianorhabdus cayeuxii* Deflandre.

Authors: Cepek and Hay (1969), emended and nom. corr. by Manivit *et al*. (1977).

Age: Early Turonian.

Remarks: The lower boundary of this zone has been discussed under the *Gartnerago obliquum* zone. The first occurrence of *Lucianorhabdus cayeuxii* Deflandre (common) is at the same datum level with the first occurrence of *Eiffellithus eximius* (Stover) Perch-Nielsen at section B, even *L. cayeuxii* more lower at section A. Consequently, we surmised that the upper part of this zone is missing in our studied area.

Range: Section A, samples Af-114b to Af-124; Section B, samples Bf-53 to Bf-56; the upper part of Gambacunkou Formation.

Lucianorhabdus cayeuxii zone

Definition: Interval from the first occurrence of *Lucianorhabdus cayeuxii* Deflandre to the first occurrence of *Calculites obscurus* (Deflandre) Prins and Sissingh.

Author: Sissingh (1977).

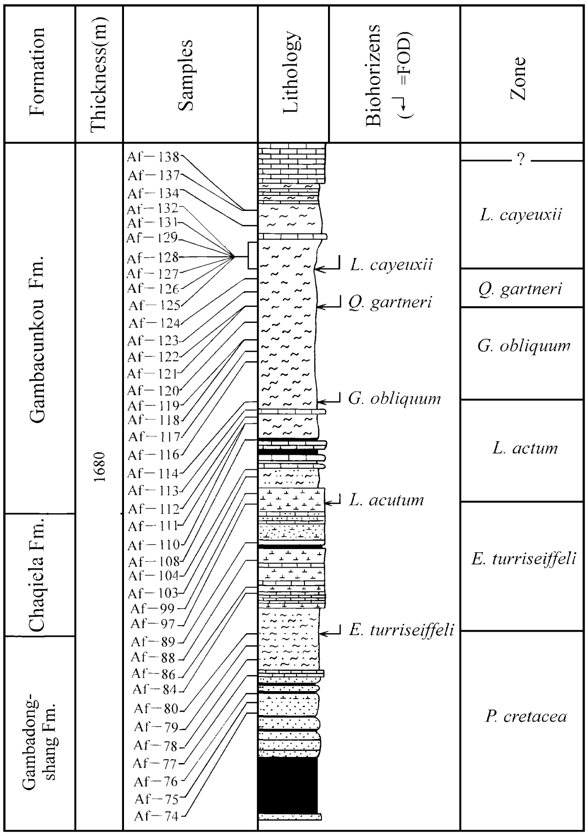
Age: Late Santonian.

Remarks: The upper limit of this zone can not be defined herein for the marker species *Calculites obscurus* has not been found in our studied samples.

Range: Section A, samples Af-125 to Af-138; Section B, samples Bf-57 to Bf-73; the upper part of Gambacunkou Formation.

Table Ⅲ　Calcareous nannofossils' zones of Mid-Cretaceous, Gamba area

Formation	Section A (Af-)	Section B (Bf-)	Zones	Age
Upper-Middle Gambacunkou Fm.	125-138	57-73	*L. cayeuxill*	L. Santornian
	114b-124	53-56	*Q. gartneri*	E. Turonian
	111-114a	47-51	*G. obliquum*	
	97-110	39-45	*L. acutum*	L. Cenomanian
Lower Gambacunkou Fm. | Chaqiela Fm.	86-97	18-35	*E. turriseiffeli*	M. Cenomania | L. Albian
Upper Gamba-Dongshan Fm.	74-79	6-17	*P. cretacea*	E.-M. Albian



Legend see figure 2

Text-fig. 3 Biohorizons and zones of calcareous nannofossils from Section A, Gamba area

5 CENOMANIAN-TURONIAN BOUNDARY

As the existence of a global anoxic event in the Mid-Cretaceous (Jenkyns, 1980; Bralower, 1988; Jarvis *et al*., 1988; Wan and Yin, 1996), the investigation on the boundary between Cenomanian and Turonian, consequently, has drew much attention than other stages of Cretaceous. However, how to define this boundary either based on macrofossils or on microfossils that can be used in international correlation, is still difficult and not unanimous. For example, based on calcareous nannofossil, at least the following four boundaries definitions have been proposed by some authors (Table Ⅳ):

1. On base of the first occurrence of *Gartnerago obliquum* (Stradner) Thierstein (Thierstein, 1976).

2. Below the first occurrence of *Quadrum gartneri* Prins and Perch-Nielsen (Sissingh, 1977; Manivit *et al*., 1977; Perch-Nielsen, 1979; Jafar, 1982; Doeven, 1983).

3. Above the first occurrence of *Q. gartneri* (Verbeek, 1977; Birkelund *et al*., 1984; Burnetl, 1996).

4. Equal to the first occurrence of *Microstaurus chiastius* (Worsley) Grün (Bralower, 1988).

The reasons led to the above diverse views, besides incomplete exposition of the stage in some stratotype sections and different taxonomic criteria for marker's species used by some authors (Jafar, 1982), may be due more directly to the changing range of certain important species along with the divergence of depositional environments and geographic locations.

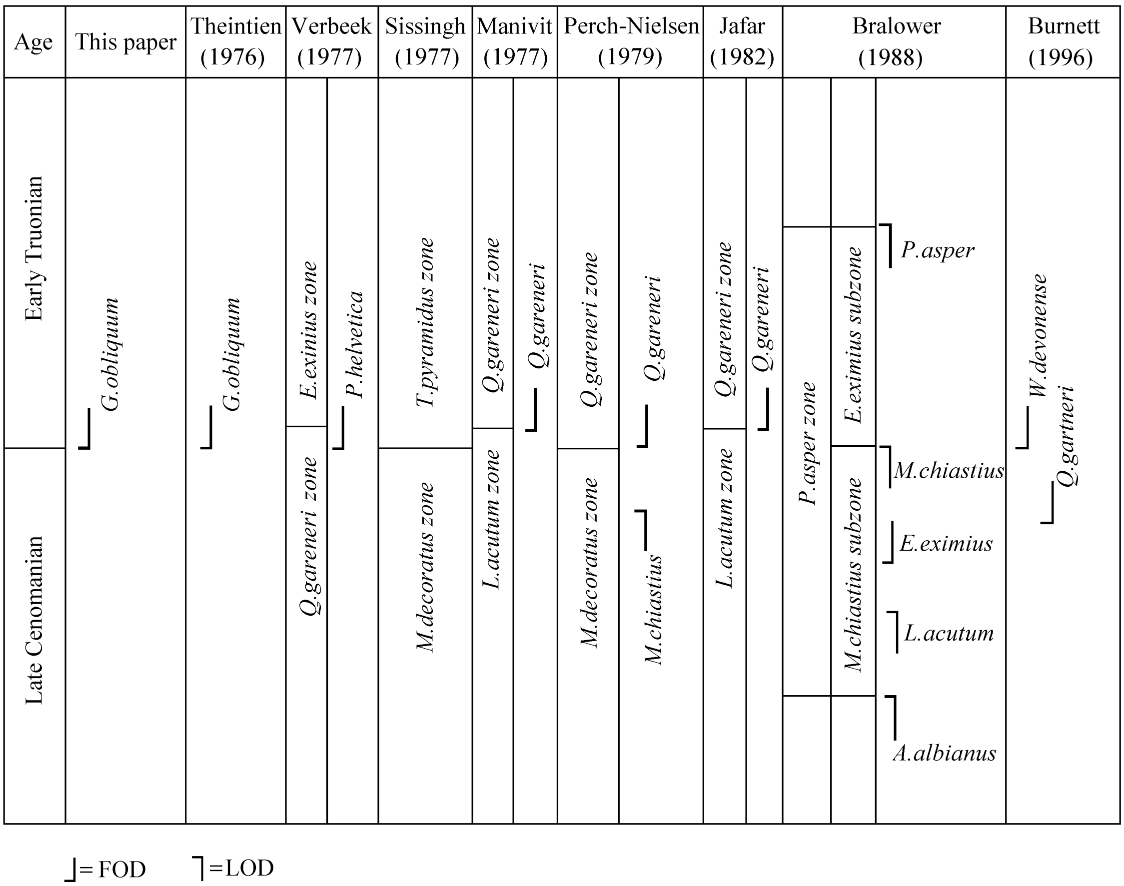
The results of this study indicate that calcareous nannofossil *Quadrum gartneri* is rather low in abundance and *Microstuarus chiastius* has not been found herein. On the contrary, *Gartnerago obliquum* is not only in higher frequency but better preserved in the sections A and B. A boundary between stages should be a reflection of events of organisms' evolution. The marker species representing these events, should have a higher abundance and fixed range in stratigraphy. For this reason we suggest that the Cenomanian-Turonian boundary can be marked by the first occurrence of *Gartnerago obliquum* at Gamba Area.

In addition, Wan and Yin (1996) have studied the foraminifera from the Zongshan Section of Gamba and have determined the Cenomanian-Turonian boundary by the first occurrence of *Helvetoglobotruncana praehelvetica* within *Whiteiella archaeocretacea* zone. They pointed out: "The scenery is completely different during the *W. archaeocretacea* zone. As all species of the genus *Rotalipora* became extinguished and other species temporally disappeared, both diversity and abundance are very low in these samples. This bioevent is well marked by the keeled/non-keeled planktonic foraminifera ratio. It falls from 100% to merely 2%, and then increases towards the top of this zone. Benthic foraminifera are scarce and small, mainly in the lower part of the *W. archaeocretacea* zone. The genus *Ammodiscus* and other agglutinate foraminifera species are the dominant specimens; this is probably caused by the bottom waters with very low oxygen."

The sampled Af-111/Af-112 in Section A and

Bf-47/Bf48 in Section B are the first occurrence datum of *H. praehelvetica* respectively (deter. Weidich, K. F.), it is surprising which coincide with the first occurrence of *G. obliquum* (Text-figs. 2 and 3). Therefore, the calcareous nannofossil *G. obliquum* and foraminifera *H. praehelvetica* are great advantage for recognizing the Cenomanian-Turonian boundary in the Southern Xizang (Tibet), which was epicontinental sea situated in East Tethys during the Late Cretaceous period.

Table Ⅳ　The various schemes on Cenomanian-Turonian boundary by calcareous nannofossils



6 CONCLUSIONS

1. At Gamba area, the Gamba Group is divided into three stratigraphic units from bottom to top, namely the Gambadongshan, Chaqiela and Gambacunkou formations and has been assigned to Middle Albian to Late Santonian in age. But there is a distinct hiatus between the lower Turonian and upper Santonian localized in the upper part of Gambacunkou Formation

2. The detail zonation of calcareous nannofossils from the uppermost Gambadongshan Formation to Gambacunkou Formation is proposed. This scheme consists of six zones and additional five biohorizons, which can be roughly correlated with nannofossil zones of synchronous deposits elsewhere.

3. The first occurrences of *Gartnerago obliquum* and foraminifera *Helvetoglobotruncana praehelvetica* are nearly at the same level, thus the two species are considered to be rather useful as markers to recognize the Cenomanian-Turonian boundary in the Southern Xizang (Tibet).

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EXPLANATION OF PLATES

All specimens studied are deposited in Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing, China. All light micrographs approximate ×3000.

Plate Ⅰ

1—4. *Arkhangelskiella cymbiformis* Vekshina
Lf-92; 2, 4. Cross-nicols X0°; specimen from Section L in Tingri area situated northwest of Gamba city, also found in Sections A, B in Gamba area.

5, 6. *Braarudosphaera africana* Stradner
Af-84, 5. Cross-nicols X0°.

7, 8. *Corollithion kennedyi* Crux
Bf-36, Cross-nicols X0°.

9, 10. *Corollithion signum* Stradner
Af-113, 10. Cross-nicols X0°.

11, 12. *Cribrosphaerella ehrenbergii* (Arkhangelsky) Deflandre
Lf-102, 12. Cross-nicols X0°; specimens from Section L in Tingri area situated northwest of Gamba city, also found in Sections A, B in Gamba area.

13, 14. *Eiffellithus eximius* (Stover) Perch-Nielsen
Bf-63, 14. Cross-nicols X0°.

15, 16. *Eiffellithus trabeculatus* (Gorka) Reinhardt and Gorka
Bf-42, 16. Cross-nicols X0°.

17—20. *Eiffellithus turriseiffelii* (Deflandre) Reinhardt
Af-137; 18, 20. Cross-nicols X0°.

Plate Ⅱ

1—3. *Gartnerago obliquum* (Stradner) Thierstein
Af-111, 2. Cross-nicols X0°, 3. Cross-nicols X45°.

4, 5. *Lithastrinus floralis* Stradner
Af-132, 5. Cross-nicols X0°.

6. *Lithastrinus grillii* Stradner
Af-132.

7, 8. *Lithraphidites acutum* Verbeek and Manivit
Bf-42, 8. Cross-nicols X0°.

9,10. *Lucianorhabdus cayeuxii* Deflandre
Bf-63, 9. Cross-nicols X0°, 10. Cross-nicols X45°.

11—13. *Manivitella pemmatoidea* (Manivat) Thierstein
Bf-42, 12. Cross-nicols X0°, 13. Cross-nicols X45°.

14. *Marthasterites furcatus* (Deflandre) Deflandre
Bf-63.

15,16. *Microrhabdulus decoratus* Deflandre
Af-113, 15. Cross-nicols X0°, 16. Cross-nicols X45°.

17,18. *Prediscosphaera cretacea* (Arkhangelsky) Gartner
Bf-36, 18. Cross-nicols X0°.

19,20. *Quadrum gartneri* Prins and Perch-Nielsen
Bf-63, 20. Cross-nicols X0°.

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