Rapid sea-level change in the Late Guadalupian (Permian) on the Tethyan side of South China: litho- and biostratigraphy of the Chaotian section in Sichuan

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Abstract: The Capitanian (Late Guadalupian) Maokou Formation at Chaotian in northern Sichuan, South China, is composed mainly of shallow marine shelf carbonates deposited on the Tethyan side of South China. By detailed field mapping and scientific drilling, we newly found out unique fossil assemblages and a sharp lithologic change in the upper part of the Maokou Formation. The main part of the Maokou Formation (over 130 m thick) is composed of algal packstone with Wordian-Capitanian large-tested fusulines, rugose corals and other sessile benthos, whereas the Uppermost Member (13 m thick) is composed of black limy mudstone/chert with Capitanian offshore biota (ammonoids, radiolarians, and conodonts). The topmost Capitanian conodont zones are missing; however, the Maokou Formation is disconformably overlain by 260 ± 4 Ma volcanic ash (Wangpo bed) and the Early Lopingian Wujiaping Formation with plant-bearing coaly mudstone and shallow marine carbonates (packstone). The newly identified facies change indicates that northern Sichuan has experienced rapid sea-level changes in the late Guadalupian, i.e., first a transgression in the mid-Capitanian and then a regression across the Guadalupian-Lopingian boundary. As the end-Guadalupian is characterized by a global regression, such a volatile sea-level fluctuation, in particular the sea-level rise, is unique to the Tethyan side of South China. The newly recognized relatively deep-water late Guadalupian sequence adds new paleo-environmental information and further provides a paleotectonic interpretation of the low-latitude eastern Tethyan margin immediately before the end-Guadalupian mass extinction.

Keywords: Permian, South China, end-Guadalupian, mass extinction, transgression

Introduction

The so-called end-Permian mass extinction is characterized not only by the greatest magnitude in the Phanerozoic extinction events but also by its unique double-phased nature. Almost at the end of the ca. 300 million year-long Paleozoic era, two independent extinction events occurred in succession during a short time interval less than 10 m.y.; first at the Guadalupian-Lopingian (Middle-Late Permian) boundary (G-LB, ca. 260 Ma) and second at the Lopingian-Induan (Permo-Triassic) boundary (P-TB, ca. 252 Ma).[1] Although the first event at the G-LB has long been overlooked in the great shadow of large catastrophe at the P-TB, its significance probably needs more emphasis with respect to the equivalent large magnitude of extinction and to the chronological coincidence to the onset of superanoxia, another global event appeared in the Permian superocean Panthalassa.[2] The Late Permian to early Middle Triassic deep Panthalassa of a hemisphere-scale experienced an unusual condition of oxygen-depletion for up to 20 million years. Nonetheless, details of direct kill mechanism and actual features of environmental deterioration

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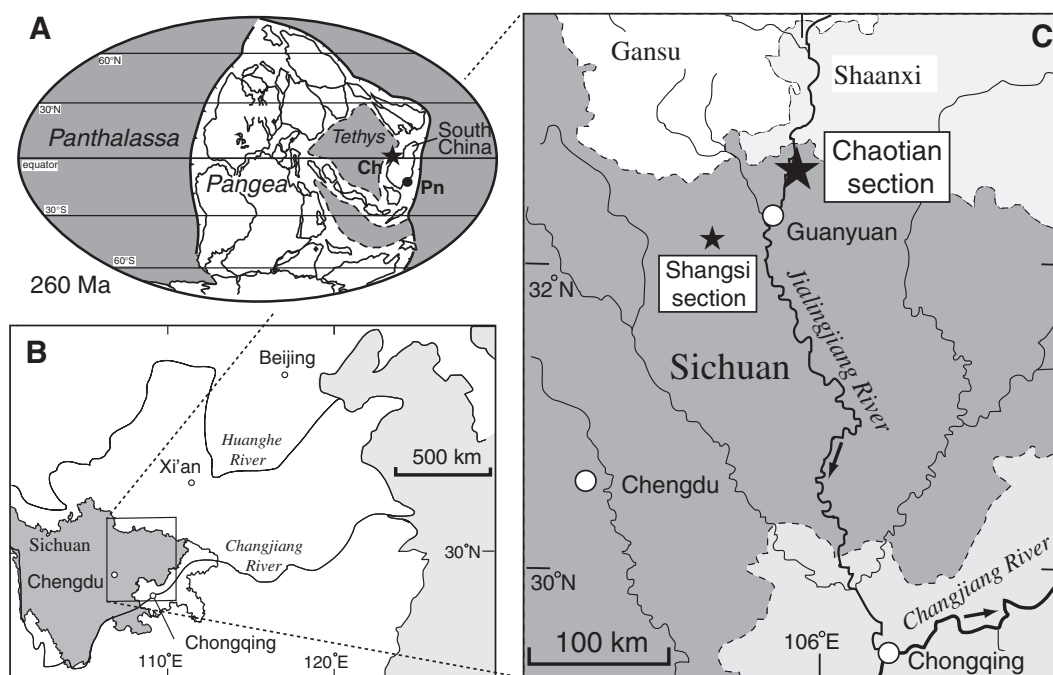
Fig. 1. Index map of the Chaotian section in northern Sichuan, South China.
A: Paleogeographic map of the 260 Ma world simplified from,[8] B,C: Location of the Chaotian and Shangsi sections in northern Sichuan.
Note the Chaotian and Shangsi sections (Ch in A) was located on the western continental shelf of Permian South China faced directly to the Paleo-Tethys to the west, whereas the GSSP of G-LB at Penglaitan in Guanxi (Pn) faced to Panthalassa to the east.

have not been fully clarified yet. Several causal mechanisms for the extinction and relevant global environmental changes were proposed, such as large-scale flood basalt or violent felsic alkaline volcanism generated by mantle plume activity.[3,4] With respect to the Pangean breakup, the significance of mantle plume (the largest convective flow of material and energy within the Earth's mantle) and of resultant formation of large igneous provinces (LIPs) on surface has been discussed by many researchers.

The world best exposure of the G-LB interval occurs at Penglaitan in Guanxi, South China, where the GSSP (Global Stratotype Section and Point) of the G-LB was ratified by virtue of its stratigraphic continuity and abundant fossils of shallow marine continental shelf sequence.[5] In addition to the turnover in fossil assemblages, a sharp negative shift in stable carbon isotope ratio was detected across the G-LB.[6] Lately an interval of exceptionally high positive C-isotope ratio was detected in the Capitanian (Upper Guadalupian) in Japan.[7]

These chemostratigraphic signatures suggest that a critical change in global carbon cycle have occurred during the Late Guadalupian-Early Lopingian transition.

The present study aims to analyze litho- and bio-stratigraphy of the Guadalupian sequence in northern Sichuan in order to clarify the pre-extinction environmental change. As northern Sichuan was once located on the northwestern corner of South China (Ch in Fig. 1A), the Permian rocks there provide new paleoenvironmental data of the Tethyan side of South China, that are likely distinct from those at Penglaitan in Guanxi that faced Panthalassa (Pn in Fig. 1A). In our project since 1998 on the G-LB stratigraphy at Chaotian in northern Sichuan (Fig. 1B, C), we conducted detailed surface mapping, 250 m-deep scientific drilling, and paleontological and geochemical analyses. This article reports preliminary results of our latest finding of unique fossil assemblages and facies change in the Capitanian rocks at Chaotian. Further detailed data will be published elsewhere.
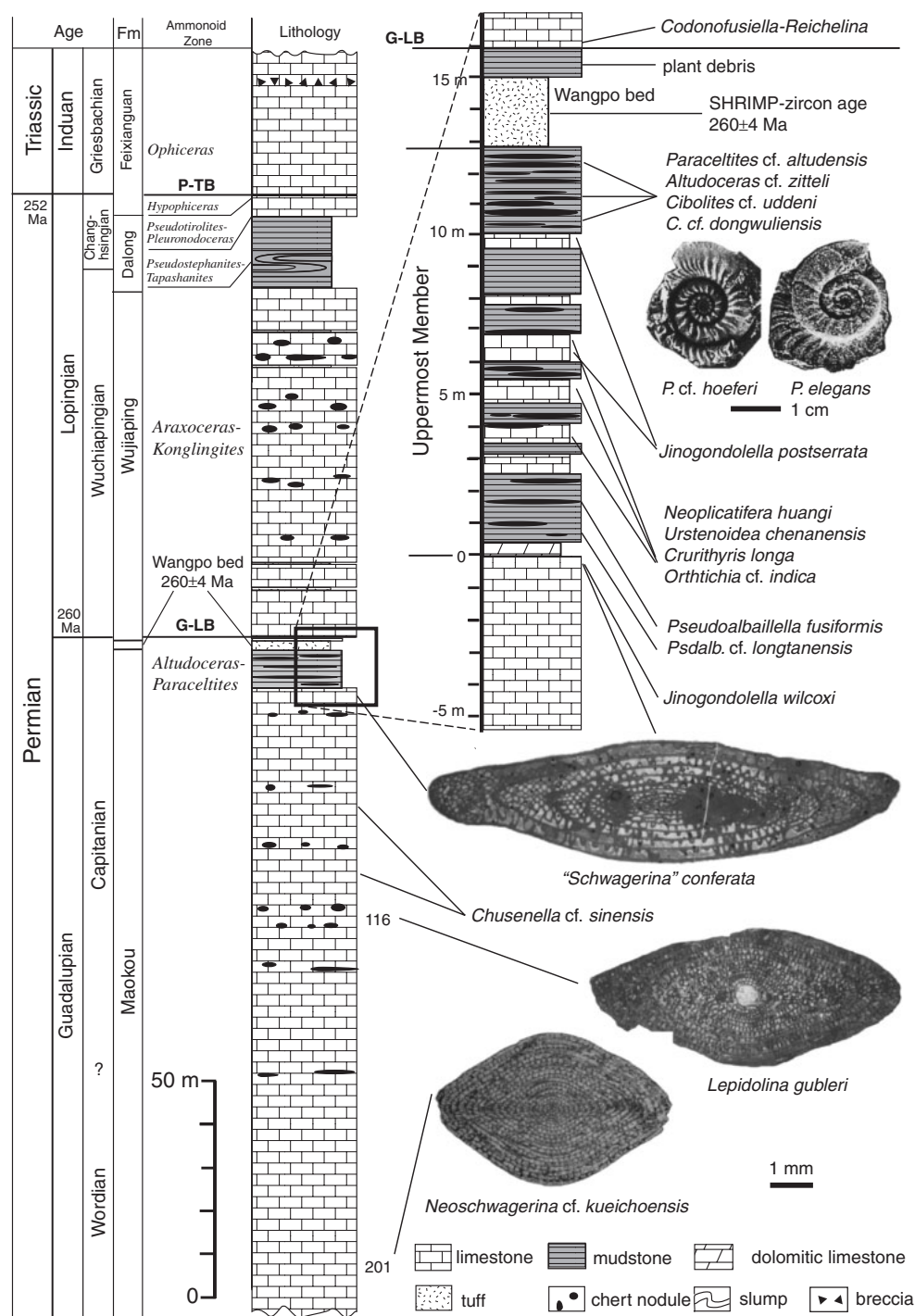
Fig. 2. Stratigraphic column of the Chaotian section with enlarged column of the G-LB interval.
      The occurrences of the mid-Capitanian *Jinogondolella postserrata* (conodont) and the Wuchiapingain *Codonofusiella-Reichelina* (fusuline) assemblage constrain the Guadalupian-Lopingian boundary (G-LB) horizon around the base of Wujiaping Formation, that is marked by the prominent volcanic tuff, the Wangpo bed with SHRIMP zircon age 260 ± 4 Ma.[16] The G-LB is tentatively placed at the base of the bedded limestone characterized by the first occurrence of the Wuchiapingian *Codonofusiella-Reichelina* assemblage. The occurrence of plant debris and radiolarians are from 11) and, 21) respectively. Note the sharp facies changes first from massive shallow marine carbonates to relatively deep-water limy mudstone/chert at the base of the Uppermost Member of the Maokou Formation, and then back to shallow marine coaly mudstone/carbonates of the basal Wujiaping Formation.
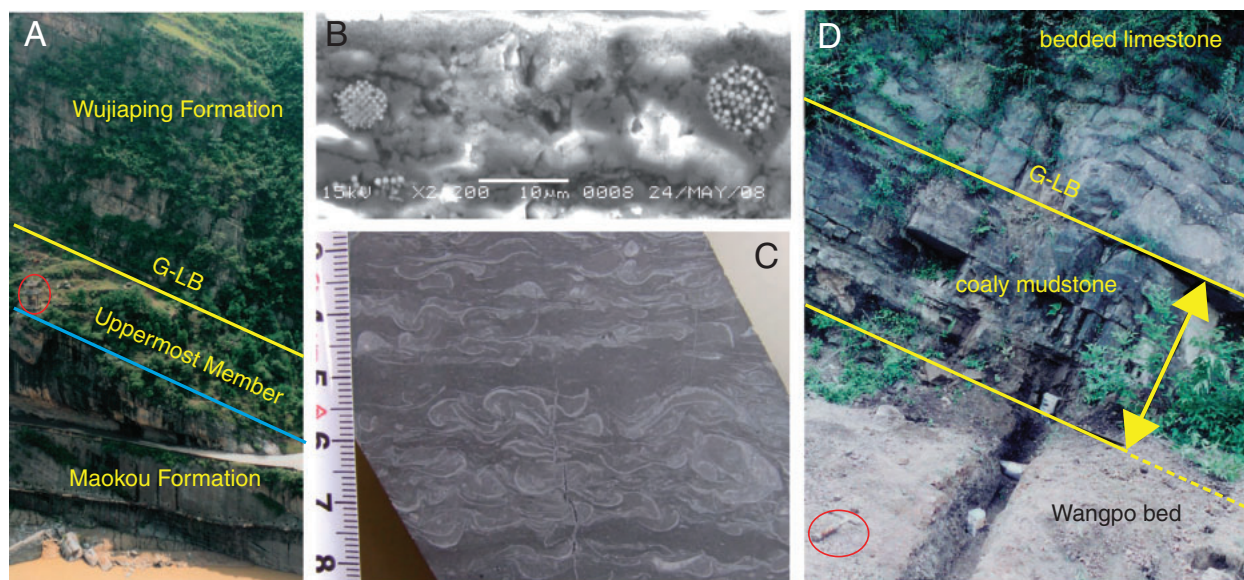
Fig. 3.   Field views and unique features of the Chaotian section.
   A: distant view of the studied section from the opposite (west) side of the Jialingjian river (a small hut ca. 4 m tall at the vista point for tourist in red circle), B, C: black mudstone of the Uppermost Member of the Maokou Formation (B: SEM photo of framboidal pyrite; C: abundant "Lilliput" brachiopods, scale in centimeter), D: top of the Wangpo bed (volcanic tuff weathered into soft clay) and the basal Wujiaping Formation composed of a 1 m-thick coaly mudstone and overlying bedded limestone. The G-LB is set at the base of the limestone with the Wuchiapingian fusulines. Hammer for scale in red circle.

Geologic setting

In the Late Permian and Early Triassic, the South China existed in a low-latitude area around the paleo-equator, plugging the eastern opening of the Pangean embayment (Paleo-Tethys) to isolate from Panthalassa (Fig. 1A).[8] Shallow marine carbonate platform developed extensively over South China to form the Yangtze carbonate platform.[9] The Middle-Upper Guadalupian carbonates, with abundant shallow marine fossils of the Tethyan affinity, have been totally called the Maokou Formation.

The Chaotian section is located nearly 20 km to the north of Guangyuan city, northern Sichuan (Fig. 1B,C). Extensive exposures of Middle Permian to Lower Triassic rocks are observed along the southbound Jialingjiang River that forms a narrow gorge called Mingyuexia (Fig. 2 of ref. 10)). The studied section, on the eastern side of the river and on the southern limb of an anticline, is composed of the Guadalupian Maokou Formation ($>$ 150 m), Lopingian Wujiaping and Dalong formations (68 m, 26 m), and Induan (lower Triassic) Feixianguan Formation ($>$ 30 m), in ascending order

(Fig. 2). The occurrence of various Middle-Upper Permian-lowermost Triassic ammonoids and conodonts were previously reported,[11]–[13] and detailed litho- and biostratigraphy was recently clarified for the P-TB interval.[14] Nonetheless, high resolution stratigraphy of the Maokou Formation and of the G-LB interval at Chaotian has not yet been documented. The G-LB occurred between the Maokou and the overlying Wujiaping formations as marked by a prominent felsic ash bed called the Wangpo bed,[4],[10),[15] which was recently dated 260 ± 4 Ma by SHRIMP zircon method.[16] Details of litho-and bio-stratigraphy are described below on the basis of observations of field outcrop, polished rock slabs, and thin sections of both the outcrop and drilled core samples. As to the uppermost part of the Maokou Formation, drilled core samples (between 157–174 m-deep levels) are particularly informative because surface outcrops are strongly weathered and not continuously exposed. Full description of the drilled core samples will be reported in a separate article.

Lithostratigraphy

The Maokou Formation at the Chaotian sec-

tion is over 150 m thick; the stratigraphic bottom was not confirmed, whereas its top is clearly capped by the Wangpo bed (2 m-thick felsic tuff) that uniquely marks the G-L boundary horizon in northern South China (Fig. 2).[4),15)] The main part of the formation is composed of thickly bedded to massive, dark gray bioclastic limestone (Fig. 3A). Microscopic observation confirmed that these carbonates are mostly algal packstone with minor amount of wackestone that contain abundant shallow marine fossils and their fragments, such as calcareous algae (e.g., *Permocalculus*), fusulines (e.g., Verbeekinidae, Schwagerinidae, Schubertellidae), smaller foraminifers, rugose corals, bryozoans, crinoids, brachiopods, and gastropods.

The uppermost ca. 13 m-thick part of the formation (Uppermost Member) is distinct from the main part in rock type, bedding style, and fossil contents (Fig. 2). It is composed of thinly bedded black limy mudstone with frequent intercalations of black chert beds/lenses. Planer bedding surface of these beds shows clear contrast to the wavy bedding planes of the main part of the formation. The abundant occurrence of framboidal pyrite (less than 10 μm in diameter) is recognized throughout the Uppermost Member (as shown in a SEM image of Fig. 3B). This member yields radiolarians, ammonoids and numerous small brachiopods (Fig. 3C) but no shallow marine benthos, such as calcareous algae, fusulines, rugose corals, crinoids etc. Although minor in amount, thin beds of fine-grained limestone with smaller foraminifers are sporadically intercalated.

The transition from the main limestone to the Uppermost Member is sharp; a remarkable surface develops at the bottom of a unique 0.3 m-thick unfossiliferous dolomitic limestone interbedded into the overlying limy mudstone and chert, suggesting a rapid facies change (Fig. 2). In turn at the top of the member, the black mudstone/chert is covered sharply by a 2 m-thick, yellowish to reddish brown tuff called the Wangpo bed that is strongly weathered into soft clay (Fig. 3D) with abundant euhedral volcanic phenocrysts of zircon, apatite, and beta-quartz.[10)] In drilled cores, abundant pyrite nodules were observed in the basal Wangpo bed.

The Wangpo tuff is covered by the Wujiaping Formation, of which the basal 1 m interval consists of coaly mudstone with plant debris (Fig. 3D),[11)] indicating deposition in near-shore environment.

The coaly mudstone changes upward into thinly bedded light gray limestone (mostly packstone) that yields various shallow marine fossils, such as fusulines, smaller foraminifers, calcareous algae (*Gymnocodium* etc.), brachiopods, bivalves, sponge spicules, and gastropods.

Biostratigraphy

Table 1 lists informative fossils for dating/correlation, i.e., fusulines, ammonoids, conodonts, brachiopods, rugose corals, and radiolarians, from the Maokou and lower Wujiaping formations of the Chaotian section. Most of them are typical elements of the warm-water Tethyan fauna.

Fusulines: The Maokou Formation at Chaotian yields various large-tested fusulines; in particular, large-tested ones of Verbeekinidae and Schwagerinidae are important, e.g. *Neoschwagerina multicircumvoluta* Deprat, *Lepidolina gubleri* (Kanmera), *Pseudodoliolina ozawai* Yabe & Hanzawa, *Verbeekina furnishi* Skinner & Wilde, *Chusenella conicocylindrica* Chen, and *"Schwagerina" conferata* (Ding).[13)] These were commonly described from the Maokou Formation at many localities in South China.[13),17)]

We newly collected fusulines from 5 horizons, and two assemblages are biostratigraphically informative (Fig. 2, Table 1); Sample 201 (138 m below the top of the Maokou Formation) with *Neoschwagerina* cf. *kueichoensis* Sheng and *Verbeekina* sp. and Sample 116 (58 m below the Maokou's top) with *Lepidolina gubleri* (Kanmera), *Pseudodoliolina pseudolepida* (Deprat), *Codonofusiella* sp., and *Nankinella* sp.

Neoschwagerina predominantly occurs throughout the Tethyan domains including the Maokou Formation in South China and the Murgabian in Transcaucasia that is correlated with the Wordian in west Texas. *N.* cf. *kueichoensis* is a primitive form of neoschwagerinid that resembles *N. craticulifera* in wall structure, whereas *L. gubleri* represents an advanced form of Verbeekinidae with more complicated structure than *Neoschwagerina*. *Lepidolina* as well as *Yabeina* is a representative genus of the Midian in Transcaucasia that is correlated with the Capitanian in west Texas.[18),19)] These stratigraphical correlations suggest that the Wordian/Capitanian boundary is set somewhere between Samples 201 and 116, about 100 m below the top of the Maokou Formation.

Table 1. List of fossils from the Maokou Formation and the lowermost Wujiaping Formation at Chaotian in northern Sichuan, South China

Unit		fusuline	ammonoid	conodont/radiolaria	others
Wujiaping Fm	limestone	*Codonofusiella* spp. *Reichelina* spp.			algae (*Gymnocodium* etc.) brachiopods gen. et sp. indet.
	coaly mudstone				plant fragment*

Maokou Fm	Uppermost Mb		*Paraceltites elegans*
			P. cf. *hoeferi*
			P. cf. *altudensis*
			Cibolites cf. *uddeni*
			C. cf. *dongwuliensis*
			Altudoceras cf. *zitteli*
				conodont
				  Jinogondolella postserrata
				radiolaria**
				  Copicyntra? sp.
				  Copiellintra? sp.
				  Pseudoalbaillella fusiformis
				  Psdalb. cf. *longtanensis*
					brachiopod
					  Neoplicatifera huangi
					  Urstenoidea chenanensis
					  Crurithyris longa
					  Orthotichia cf. *indica*

	Main limestone	*"Schwagerina" conferata*
		Lepidolina gubleri
		Pseudodoliolina pseudolepida
		Chusenella cf. *sinensis, Ch.* sp.
		Codonofusiella sp.
		Nankinella sp.
			ammonoid gen. et sp. idet.	conodont
				  Jinogondolella wilcoxi
				  J. postserrata
					algae (*Permocalculus* etc.)
					gen. et sp. indet.
					  rugose coral, crinoid
					  brachiopod, bryozoa
					  bivalve, gastropod
					  smaller foraminifer

		Neoschwagerina cf. *kueichoensis* *Verbeekina* sp.			brachiopods gen. et sp. indet.

All fossils were found in the present study except for those with * and ** after 11) and, 21) respectively. Note the contrasting faunal assemblages between the limestone and mudstone/chert (shaded) facies.

The Wujiaping Formation at Chaotian, in particular, its basal part yields abundant small-sized fusulines of schubertellids, staffellids, and ozawainellids, such as genera *Codonofusiella* and *Reichelina*, but no large-tested verbeekinids and schwagerinids.[12]

Ammonoids: The black mudstone/chert of the Uppermost Member yields a unique fossil assemblage composed of ammonoids, radiolarians, conodonts, and tiny brachiopods but no shallow marine taxa such as fusulines, calcareous algae, rugose corals, etc. Although no ammonoids were previously reported from the Maokou Formation at Chaotian, we newly collected Guadalupian ammonoid assemblage dominated by *Paraceltites* with minor amount of *Cibolites* and *Altudoceras* from the cherty mudstone at 3 horizons (Table 1, Fig. 2). Genus *Paraceltites* ranges from the Roadian (Early Guadalupian) to Wuchiapingian, whereas *Cibolites* and *Altudoceras* from the Wordian to Wuchiapingian.[20]

Conodonts and radiolarians: The Uppermost Member yielded abundant conodonts dominated by early-middle Capitanian *Jinogondolella* from 3 horizons (Table 1, Fig. 2) but the upper Capitanian conodont zones (e.g., *J. altudoensis* to *J. granti* zones) were not confirmed from the topmost 3 m-thick interval above the topmost conodont horizon. In addition, radiolarians *Pseudoalbaillella fusiformis* (Holdsworth & Jones) and *Psdalb.* cf. *longtanensis* Sheng & Wang were recently found from the lower part of the Uppermost Member.[21] These radiolarians occur from the Upper Guadalupian cherts in Japan and South China that are roughly correlated with the Capitanian.

Brachiopods: Small brachiopod assemblage composed of *Neoplicatifera, Urstenoidea, Crurithyris*, and *Orthotichia* occurs abundantly and monotonously from the lower half of the Uppermost member (Fig. 3C). These genera commonly occur from the Guadalupian. Larger forms from the main part of the Maokou Formation and Wujiaping Formation are not yet identified.

Age: These fossil data indicate that the Maokou Formation at Chaotian ranges from the Wordian to Capitanian, and particularly its upper 90–100 m interval belongs to the Capitanian, whereas the Wujiaping Formation is correlated with the Wuchiapingian at its stratotype in SW Shaanxi,

ca, 100 km ENE from Chaotian. Judging from the undetected conodont zones above the *J. postserrata* Zone, the uppermost Capitanian interval is likely missing at Chaotian. Nonetheless the SHRIMP zircon age of the Wangpo tuff bed is 260 Ma,[16] although with a rather broad error range of 4 million years, by and large fits into the above-mentioned biostratigraphical framework and regional stratigraphic correlation.[10],[15] The age of the coaly mudstone of the basal Wujiaping Formation is unknown; however, on the basis of the first occurrence of the *bona fide* Wuchiapingian *Codonofusiella-Reichelina* assemblage, the G-LB horizon at Chaotian is tentatively placed at the base of the bedded limestone of the Wujiaping Formation (Fig. 2).

Discussion

Mid-Capitanian sea-level rise: The present study clarified that the sedimentary facies of the Maokou Formation at Chaotian had changed drastically during the Capitanian, from a carbonate-dominant facies to mudstone-dominant one (Fig. 2). The packstone-dominated carbonate fabrics of the main part of the Maokou Formation indicate their deposition in a relatively shallow marine environment. In particular, the abundant occurrence of calcareous algae, associated with large-tested fusulines and other shallow marine benthos, suggests that the limestone was deposited at least within the photic zone. In contrast, the black limy mudstone and chert of the Uppermost Member lacks shallow marine calcareous debris, instead contain ammonoids and radiolarians that normally flourished in relatively off-shore, deeper-water environments. The radiolarians of the genus *Pseudoalbaillella* commonly occurred in relatively off-shore deeper environments, as first described in the basinal Lamar limestone in west Texas[22] and also from mid-oceanic deep-sea chert.[23] The abundant occurrence of tiny equal-sized brachiopods (less than 1 cm in diameter; Fig. 3C) suggests the Lilliput-style adaptation under unfavorable conditions (*r*-strategy), showing a remarkable contrast with brachiopods from the main part of the Maokou Formation that are much larger in size, usually over 3 cm up to 10 cm in diameter.

Black colors of the rocks suggest high TOC (total organic carbon) likely derived from less ventilated conditions of bottom water and/or from

high productivity. The ubiquitous occurrence of framboidal pyrite (Fig. 3B) also supports an oxygen-depleted condition. These lines of evidence indicate that the Uppermost Member was deposited in relatively deeper-water slope to basinal settings below the photic zone, probably under anoxic condition or within the oxygen minimum zone. Thin intercalation of limestone with smaller foraminifers may represent distal tongues of calcareous turbidites from shallower shelf/slope.

The transition from shallow marine carbonates to deep-water mudstone occurs at the base of the Uppermost Member, particularly at the base of a 30 cm-thick, impure, unfossiliferous dolomitic limestone (Fig. 2). This transitional bed does not show any sharp erosional feature at its base, and is interbedded with overlying black limy mudstone/chert. The upward deepening trend first appeared in the top 5 m interval of the main limestone, as predominant packstone gradually becomes finer-grained upsection (Fig. 2). We confirmed the similar trend in lithologic change also at the Shangsi section in northern Sichuan,[24] ca. 60 km to the WSW from Chaotian (Fig. 1C).

Although the magnitude and rate are unknown owing to insufficient chronostratigraphic resolution, the apparent sea-level rise in the Capitanian is particularly noteworthy because non-such transgression has been previously reported in the Capitanian from anywhere in the world except the Iwaizaki limestone in Japan.[25] Instead, the end-Guadalupian in general has been regarded as a time of major regression when the growth of reef complex in Texas was terminated, and a remarkable unconformity formed in many areas in the world. Thus the global sea-level likely reached the lowest level of the Phanerozoic at the end of Guadalupian.[26],[27] In addition, a cold snap named "Kamura cooling event" in the Capitanian and subsequent gradual warming across the G-LB was recently detected in mid-oceanic paleo-atoll limestone in low-latitude Panthalassa.[7] This event accompanied extinction of unique tropical fauna composed of aberrant bivalve Alatoconchidae, all large-tested fusulines, and a large variety of rugose corals, probably owing to the cooling in low latitudes.[28] Thus the mid-Capitanian transgression in northern Sichuan documented in this study apparently contradicts with the general eustatic trend in the Permian including the Kamura cooling event, suggesting
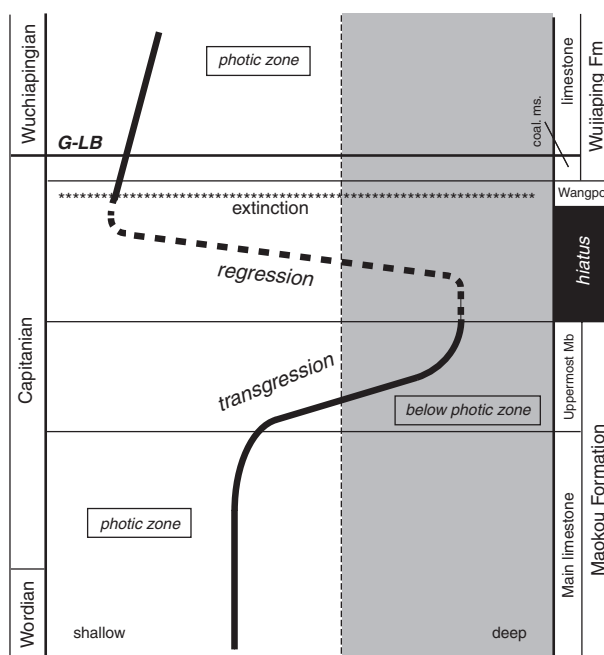

Fig. 4. Schematic diagram showing the rapid sea-level changes on the Tethyan side of the Capitanian South China.
Note that the sharp sea-level changes, both deepening and shallowing, within the Capitanian clarified in northwestern South China on the Paleo-Tethys side (Fig. 1A). The Capitanian is generally characterized by the global regression that marked the Phanerozoic lowest in sea-level.

a sea-level change by regional tectonics on the Tethyan side of South China, as will be discussed below.

Regression around the G-LB: The Maokou Formation is overlain by the Wangpo bed and then by Wujiaping Formation with *Codonofusiella-Reichelina* (fusuline) assemblage that characterizes the Wuchiapingian, the Lower Lopingian. The Wango bed is distributed extensively throughout the northern half of South China, as already confirmed at Chaotian, Shangsi, Emeishan, Ebien, and Huayin in Sichuan, Zhonghuopu in Hunan, and Lianshan in Shaanxi.[10],[15],[29] It is noteworthy that the Wangpo bed always occurs above the last occurrence horizon of all Guadalupian fossils in the above-mentioned areas. The SHRIMP zircon age of 260 ± 4 Ma by and large agrees with the assumed age for G-LB in the latest geologic timescale,[30] thus, supports the utility of the Wangpo bed as the key bed for the G-LB extinction horizon.[10]

The Wango bed at Chaotian contains a certain

amount of terrigenous clastics in its upper part. The overlying 1 m-thick coaly mudstone of the basal Wujiaping Formation contains plant debris.[11] These indicate that the Chaotian area experienced a remarkable regression around the G-LB clearly after the Capitanian transgression mentioned above. The absence of some late Capitanian conodont zones in the Chaotian section also supports the development of a stratigraphic gap, probably a disconformity at the base of the Wangpo bed. The transition from the coaly mudstone to shallow marine limestone with abundant calcareous algae and foraminifers indicates slow recovery of sea-level during the early Wuchiapingian.

Rapid sea-level change: The present study first clarified an apparent transgression in the mid-Capitanian and in turn a rapid regression across the G-LB in northern Sichuan on the Tethyan side of South China (Fig. 4). Such a volatile fluctuation in sea-level may have been caused by the combination of global eustacy and regional tectonics in South China. For the former, the onset and retreat of the Kamura cooling event in the Capitanian[7] may have been related, whereas for the latter, basin subsidence/uplift may have been driven by unique tectonic regime of northwestern South China. As to the end-Guadalupian, South China was considerably affected by mantle plume activity, in particular, the impingement of a mantle plume head beneath the southwestern part of South China may have drastically modified the pattern of sedimentation on surface.[31] The Emeishan Traps (continental flood basalt) represents the most well-known plume-related LIP formed around the G-LB. The formation of the LIP has led regional uplift and also relevant erosion to form regional-scale G-LB unconformity. We speculate further here that the plume-related rifting may have caused tectonic subsidence with apparent sea-level rise, thus triggered the quick drowning of carbonate platform in the mid-Capitanian, prior to the regional uplift across the G-LB. Such an impact of regional tectonic to the Capitanian sedimentation in South China needs further study that can give a conformable explanation also to the end-Guadalupian extinction and relevant environmental changes in South China.

Regardless of the cause of the sea-level change, it is emphasized here that the Capitanian strata in northern Sichuan provide a unique set of information on relatively deep slope/basin environments along the eastern Tethys even in the same South China, in contrast to those from the relatively shallow-water sequence of the GSSP of G-LB at Penglaitan in Guanxi.

Summary

The litho- and biostratigraphical research of the Upper Guadalupian to Lower Wuchiapingian rocks at Chaotian in northern Sichuan, South China, clarified the following preliminary results.
1. The uppermost 13 m-thick interval of the Guadalupian Maokou Formation in northern Sichuan recorded a remarkable facies change from shallow marine carbonates to relatively deep-water mudstone/chert.
2. In contrast to the abundant shallow-water fossils (algae, fusulines, corals etc.) from the main limestone, the uppermost mudstone/chert yielded a unique offshore-type fauna of ammonoids, conodonts, and radiolarians for the first time in South China.
3. A rapid sea-level rise was recognized in the mid-Capitanian for the first time in the world.
4. There was a remarkable sea-level drop across the G-LB in northern Sichuan in accordance with the global sea-level change.

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