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Permian basinal ammonoid sequence in Nanpanjiang area of South China—possible overlap between basinal Guadalupian and platform-based Lopingian

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Abstract.—The Permian pandemic ammonoids in Nanpanjiang Basin (41 genera, including two new genera *Glenisteroceras* and *Fusicrimites*, and 56 species, including 21 new species) are systematically described and/or discussed. New species described in this paper are *Agathiceras sequaxilirae* n. sp., *Akmilleria parahuecoensis* n. sp., *Aristoceras liuzhaiense* n. sp., *Bamyaniceras nandanense* n. sp., *Bamyaniceras yangchangense* n. sp., *Bransonoceras longyinense* n. sp., *Difuntites furnishi* n. sp., *Emilites globosus* n. sp., *Eoaraxoceras spinosai* n. sp., *Eumedlicottia kabiensis* n. sp., *Fusicrimites nanpanjiangensis* n. gen. n. sp., *Glenisteroceras sidazhaiense* n. gen. n. sp., *Metaperrinites shaiwaensis* n. sp., *Miklukhoceras guizhouense* n. sp., *Neocrimites guizhouensis* n. sp., *Neopronorites leonovae* n. sp., *Popanoceras ziyunense* n. sp., *Properrinites gigantus* n. sp., *Stacheoceras shaiwaense* n. sp., *Svetlanoceras uraloceraformis* n. sp., and *Synartinskia meyaoense* n. sp. A relatively complete Permian basinal ammonoid sequence with six zones has been newly recognized in South China, in ascending order, *Properrinites gigantus-Svetlanoceras serpentinum*, *Svetlanoceras uraloceraformis-Prothalassoceras biforme*, *Popanoceras kueichowense-Medlicottia orbignyanus*, *Metaperrinites shaiwaensis-Popanoceras ziyunense*, *Waagenoceras* sp.-*Propinacoceras beyrichi*, and *Eoaraxoceras spinosai-Difuntites furnishi*. The upper three zones are close to being duplicated from the Permian of Las Delicias, Coahuila, Mexico and west Texas, USA; while the lower three zones compare well to those of the Lower Permian in South Urals. The *Eoaraxoceras-Difuntites* assemblage, as an index fauna of the upper Capitanian in Coahuila, has been found from the Claystone (3rd) Member of the Shaiwa Formation with the commonly accepted Lopingian stratigraphic age. The updated Permian ammonoid biostratigraphy in South China reveals a possible overlap between the basinal Guadalupian from North America and the platform-based Lopingian from South China.

Introduction

It has been well known since the 1920s that the Permian ammonoids found in South China display a glaringly endemic character and are difficult to compare with those found from the classic areas in the world (e.g., west Texas in USA, Urals in Russia and Kazakhstan, Timor in Indonesia, etc.) (Yabe, 1920, 1928; Chao, 1940, 1954, 1955, 1965; Zhao [formerly Chao] and Zheng, 1977; Zhao et al., 1978; Zhou et al., 2002; Zhou, 2007a, b). However, comparable pandemic ammonoid assemblages were successively discovered from the Nanpanjiang Basin in southwest Guizhou and northwest Guangxi in 1980s (Zhou, 1985–1986, 1987, 1988–1989) (Fig. 1.3.A–1.3.H). These discoveries demonstrated that the basinal solitary specimens of *Popanoceras kueichowense* (Zhao in Zhao and Liang, 1974) and *Neocrimites kuangsiensis*, Zhao and Liang, 1974 were not incidental, and verified the ecological control on the distribution of those so-called ‘pelagic’ organisms. Concomitant inspection of the geological background on the above-mentioned ‘unusual’ ammonoids resulted in the proposal of the concept of “ecological patterns” of the Permian ammonoids (Zhou, 1985–1986, Zhou et al., 1999, figs. 3, 4).

An analysis of the spatial distribution of Permian ammonoids in South China confirmed that the endemic ammonoid assemblages reported in previous studies consistantly occurred within the South China Platform, mainly in the marginal region of the epicontinental sea, and exclusively in relation to the coal-bearing detrital zone. Such ammonoids and their living environment were shielded from the open ocean, and migrated in the platform interior through the paralic areas (Figs. 1.1, 1.2, 2) with eustacy, and hence named the “restricted-sea ecological pattern.”

On the other hand, the pandemics in South China, systematically described herein for the first time, were basically affected by the various turbidity sequences, from the talus to various clastic limestones and siliciclastics in the open-marine basinal environment. This kind of ammonoids and deposits were chiefly distributed in front of the reef-/beach-characterized platform margin around the Nanpanjiang Basin, which was attached to the southwest margin of the South China Platform, therefore they are named with the “open-sea ecological pattern” (Figs. 1.3, 2, 3).

Taxonomically, the former from the restricted-sea is mainly featured by the tornoceratins (Paleozoic ammonoids with

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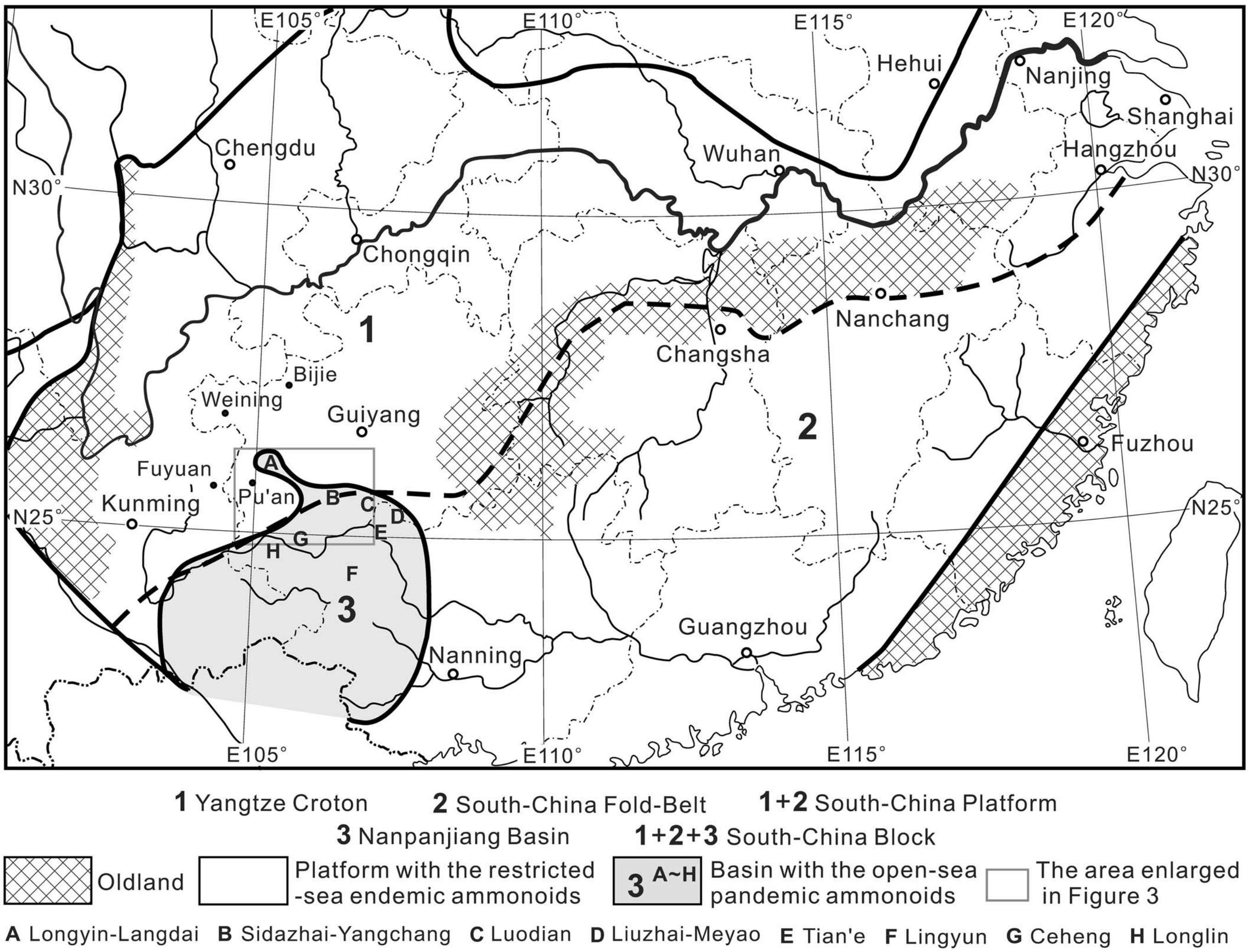

Figure 1. Permian tectonic subdivisions, platform, and basin in South China, and the open-sea pandemic ammonoid faunas in Nanpanjiang Basin (tectonics modified from Lehrmann et al., 2005, and partially referred to Zhou, 1985–1986).

siphuncle-heterotopia ontogenetically), the Paleozoic primitive ceratitids, and some eurytopic or specialized goniatitids; whereas the latter, from the open sea, is normally characterized by the representatives with the ventral-located siphuncle, namely, the order Prolecanititida, and the great majority of the order Goniatitida (Zhou, 1985–1986).

The regional geological survey carried out by the Geological Bureaus of Guizhou and Guangxi Provinces since the late 1970s has confirmed that the Nanpanjiang area is a reliable basin with some micro-intra-basinal carbonate platforms, characterized by almost complete marine depositional history from the late Proterozoic through the Late Triassic. In Permian, the Nanpanjiang Basin formed a relatively deep-marine embayment by the southwest margin of the South China Platform. A successive facies series from basin, through platform-margin, platform-interior, paralic, finally to the terrestrial could be traced in the northwest profiles in both southwest Guizhou and northwest Guangxi up to west Yunnan (Figs. 1, 2).

All the geological knowledge, known so far, indicates that the Nanpanjiang Basin is certainly not a Triassic allochthonous terrane as first thought by Hsü et al. (1990).

Investigation of the Permian pandemic ammonoids within Nanpanjiang area has discovered 41 genera and 56 species in total; besides the monotypic *Popanoceras kueichowense* (Zhao in Zhao and Liang, 1974) and *Neocrimites kuangsiensis* Zhao and Liang, 1974, the additional taxa were sampled by the present author in a series of field works during 1982–1996. All these open-sea materials (including two new genera, *Glenisteroceras* and *Fusicrimites*, and 21 new species) are formally described and/or discussed. They might be grouped into six ammonoid zones with fairly good comparability to those in the major classic areas, North America, Pamirs, and South-Urals.

Discovery of the pandemic ammonoid sequence in the Nanpanjiang Basin, especially, the *Eoaraxoceras spinosai* n. sp.-*Difuntites furnishi* n. sp. Zone, the *Waagenoceras* sp.-*Propinacoceras beyrichi* Zone, and the *Metaperrinites shaiwaensis* n. sp.-*Popanoceras ziyunense* n. sp. Zone, from the basinal Shaiwa-Sidazhai general section (Sec. IV-IV") (Figs. 4–6, 9) indicates identity with equivalents from the Permian section of Las Delicias, Coahuila, Mexico (Miller, 1944; Wardlaw et al., 2000). Direct correlation through the zonation of

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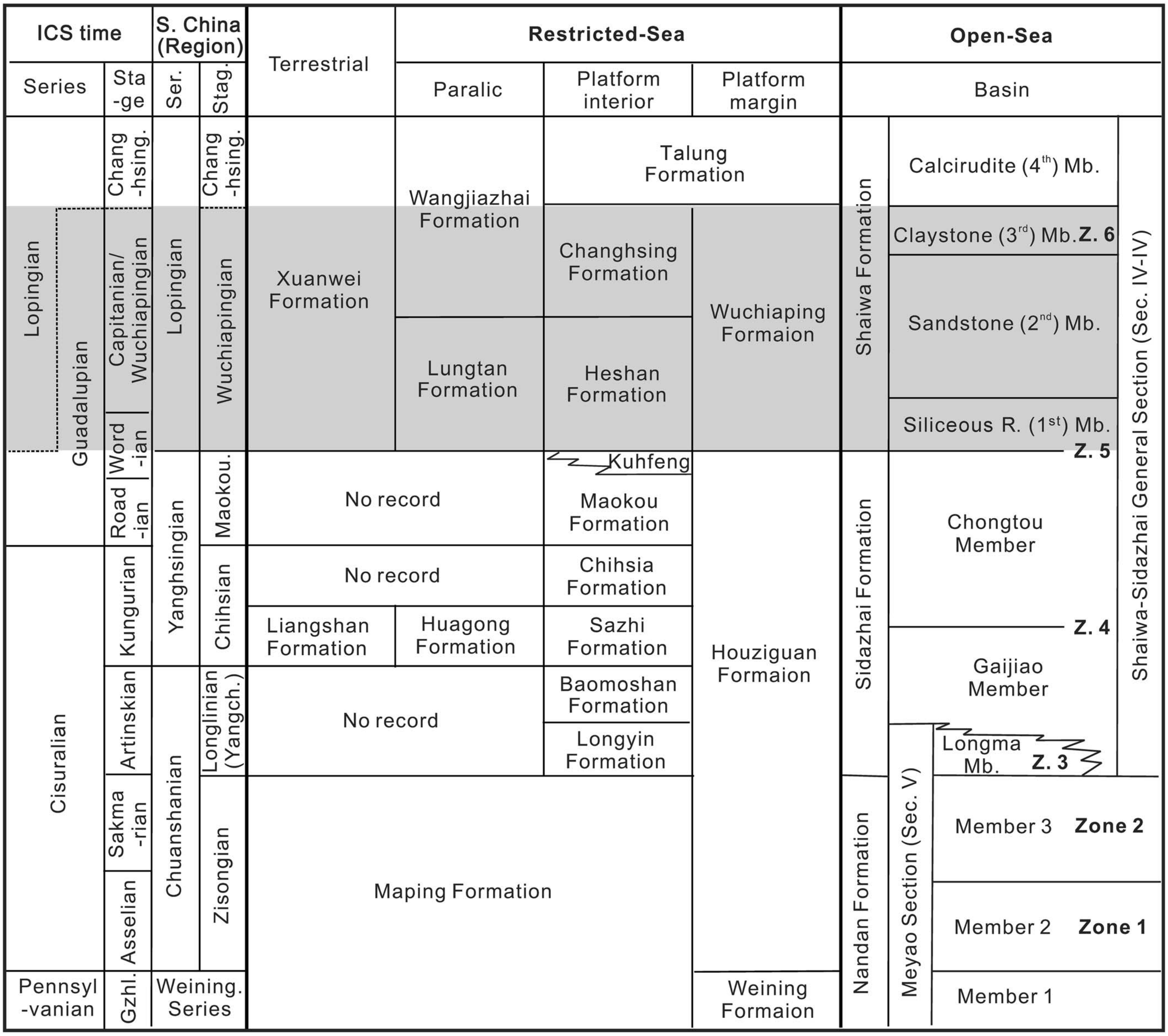

Figure 2. Permian stratigraphic standards, and the subdivisions on background of depositional environments in South China Block—The ICS and regional standards in the left columns, the depositional environments on the top rows. The stratigraphical units are not in proportion with the real thickness, and the boundaries between environments are irregularly zigzag-like, in accordance with migration of the sedimentation. The major environmental framework is modified from Lehrmann et al. (2005). Shadow showing the possible overlap between the Lopingian in South China and the Guadalupian in North America. The regional stages of South China are principally in accord with the Permian biostratigraphical subdivisions in the Chinese Stratigraphic Lexicon (Jin et al., 2000, table 2). Zones 1–6 are the comparable open-sea pandemics found from the Nanpanjiang Basin and documented in the present work.

the ‘top index fossils’ leads to the conclusion that one or more stage inaccuracies may exist in the traditional correlation scheme between the South China (even the entire Tethys) and North America. Most noticeably, the platform-based Lopingian Series partially overlaps with the basinal Guadalupian (Capitanian and probably the upper Wordian Stage) (Figs. 2, 6, 9). This work confirms the previous conclusion that the Dzhulfian in Transcaucasia represents the overlap of at least part of the Capitanian of North America based on the material from Abadeh, central Iran (Zhou et al., 1989, p. 282).

The present memoir is the first to summarize the systematics, occurrences, and zonation of the pandemic ammonoids in Nanpanjiang Basin of South China, and clarifies the biostratigraphical significance upon the new collections. There are two sections, Shaiwa-Sidazhai general (Sec. IV-IV”) (Figs. 4–6, 9) and Meyao (Sec. V) (Figs. 7–9), representing the total basinal Permian in South China (Appendices 1 and 2, respectively).

Permian deposits in Nanpanjiang Basin and adjacent areas

The South China Block consisted of three components: Yangtze Craton (Fig. 1.1), South China Fold-Belt (Fig. 1.2), and Nanpanjiang Basin (Fig. 1.3). The first two combined to

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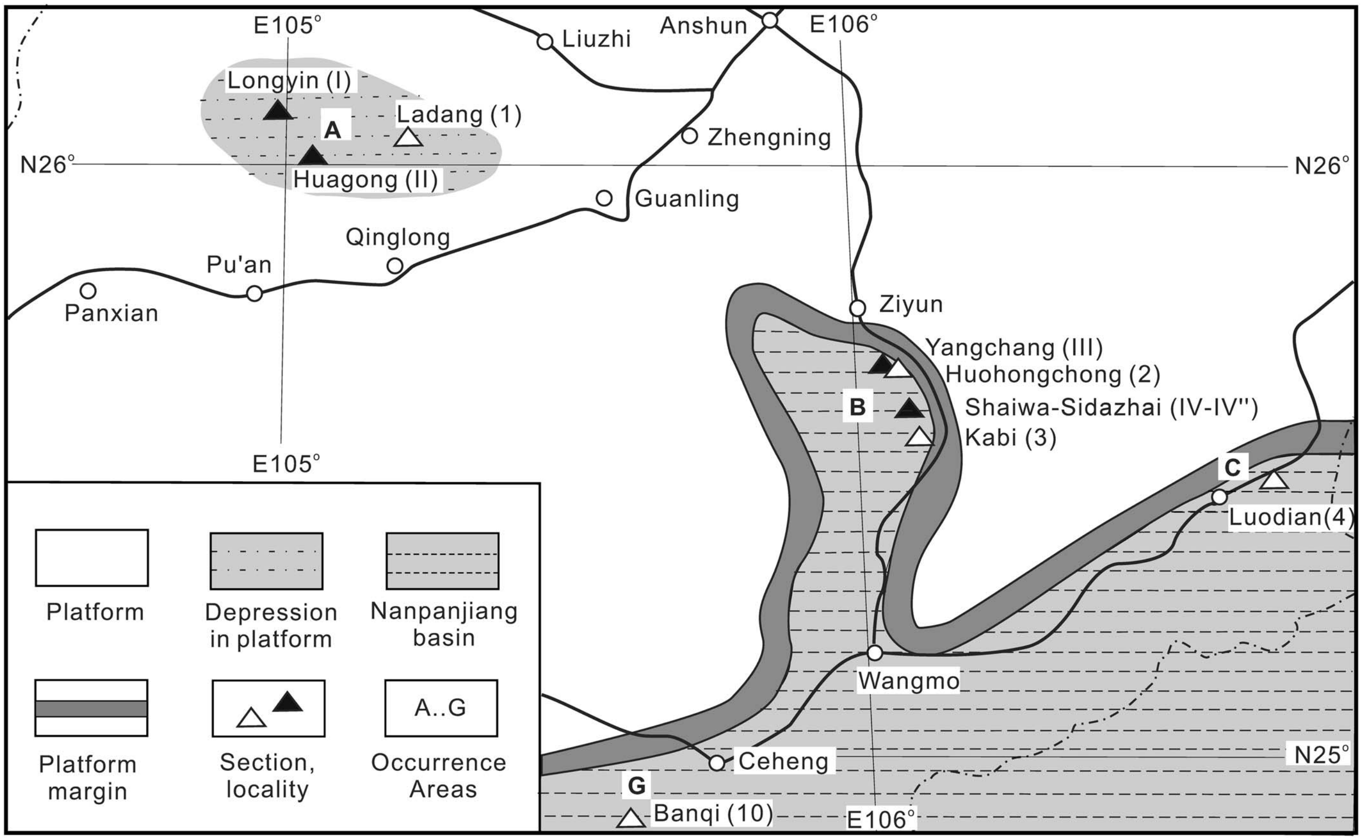

Figure 3. Occurrence of the Permian open-sea pandemic ammonoid faunas in Guizhou, including the northern Nanpanjiang Basin and the Early Permian Pu'an-Qinglong Beipanjiang Fault-Depression in platform interior. Enlarged on the framed part of the basin area in Figure 1.3.

form the South China Platform (Fig. 1.1, 1.2) before the Late Paleozoic.

Comparative study of the environments and sedimentation between the basin and platform helps clarify the ecological differentiation and biostratigraphical sequences of the Permian ammonoids in the areas. A primary comparison had been made in 1980s by the present author (Zhou, 1985–1986), and a visual comparison of the environments vis-à-vis the depositional units in the Permian of southwest Guizhou was made by Lehrmann et al. (2005).

The present memoir, in accordance with Lehrmann and others, catagorizes the stratigraphic units of the Permian in southwest Guizhou and northwest Guangxi into five depositional environments: the basin, platform margin, platform interior, paralic, and terrestrial. The present memoir also follows the Chinese Stratigraphic Lexicon, which subdivides the Permian System into six local Stages, in descending order: Changhsingian and Wuchiapingian in the Upper (Lopingian) Series, Maokouan and Chihsian in the Middle (Yanghsingian) Series, and Longlinian and Zisongian in the Lower (Chuanshanian) Series (Jin et al., 2000). The entire range of five depositional facies is represented in these Permian stratigraphical units (Fig. 2).

The Nanpanjiang Basin.—Lehrmann et al. (2005, p. 153) briefly summarized the basic characters of the basin (Fig. 1.3): "The Nanpanjiang Basin was broad, although rather shallow, but in southern Guizhou it was confined to a narrow gulf. The Early Permian deposits in the basin were dark-gray to black thin-bedded limestone, and mudstone, intercalated with debris-flow breccia" (e.g., Nandan Formation and lower Sidazhai Formation, 300–500 m thick). "The Middle Permian deposits in the basin were claystone and marl with subordinate limestone and shale" (e.g., upper Sidazhai Formation, 350–650 m thick). "In the Late Permian, the Nanpanjiang Basin in Guizhou became even narrower, presumably because of gradual progradation of the platform rimmed by reefs and bioclastics. Basinal deposits are claystone and bedded chert that enclose carbonate breccia and bioclastic limestone, probably turbidities" (e.g., Shaiwa Formation, about 860 m thick in Sidazhai section, VI'-VI"). Generally, deposits in the east basin were not destroyed during the Permian, although there was an obvious "Dongwu Movement" with numerous basalt eruptions around the boundary, between the Maokou Limestone and the Lungtan Coal Measure in the western part of South China (Huang and Chen, 1987; Guizhou Bureau of Geology and Mineral Resources, 1987).

The South China Platform.—There are four primary geographical units within the platform: margin of platform, platform interior, paralic, and terrestrial, respectively (Fig. 2). Facies migration in the platform frequently proceeded along the south-north direction in the Early Permian, altering to the east-west direction in the Late Permian. The major change in the direction of the depositional migration with time probably resulted from the 'Dongwu Movement' with extensive faults

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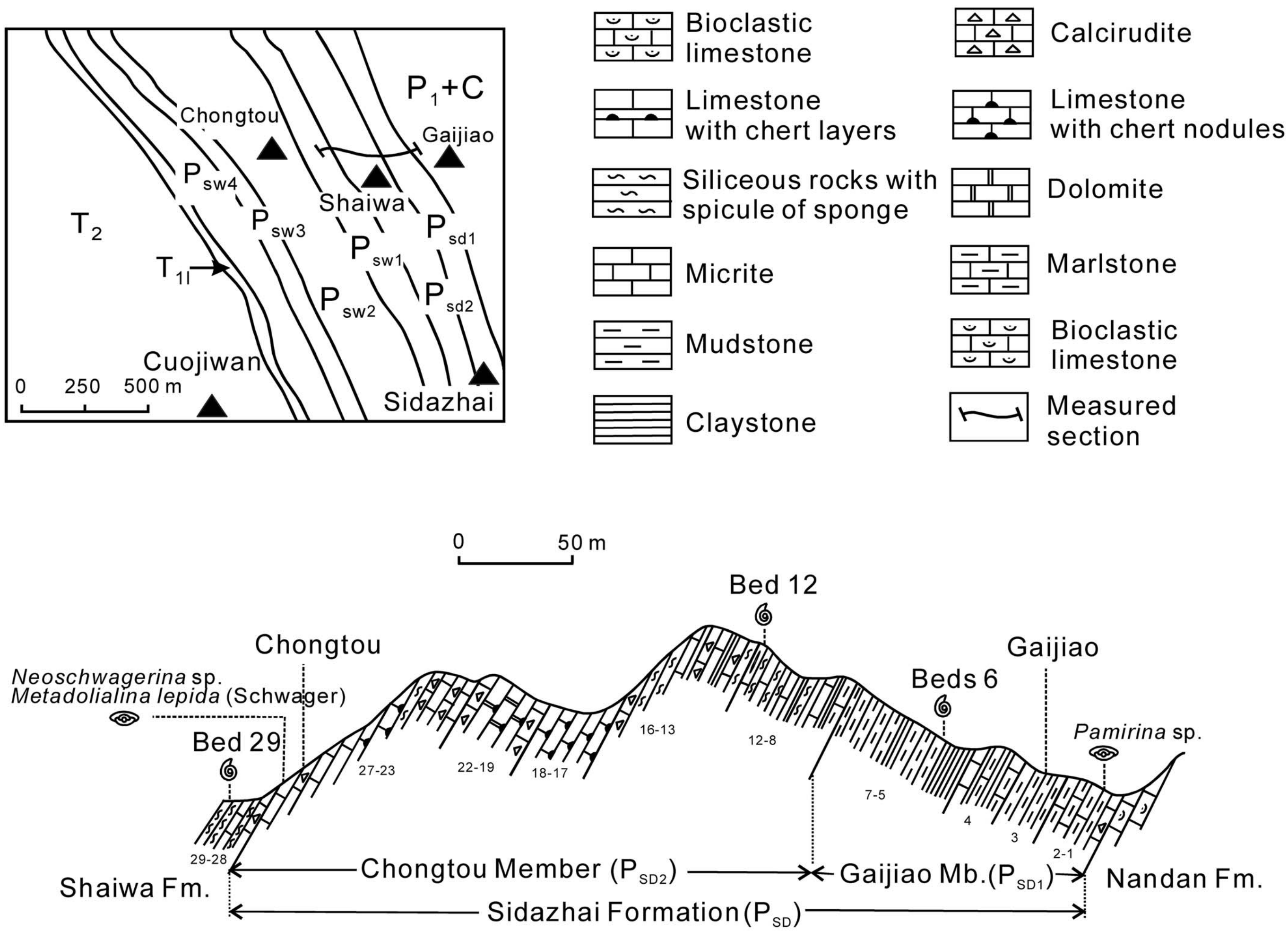

Figure 4. Sidazhai Formation of Shaiwa section (Sec. IV-IV'), started near Gaijiao and ended near Chongtou Villages, Shaiwa, Sidazhai, Ziyun County, Guizhou; coordinates based on Google Maps: origin ~25.6065°N, 106.1577°E, ending ~25.6090°N, 106.1506°E. The section mainly consists of turbid calcareous deposits, overlain by the Shaiwa Formation and overlying the Nandan Formation, both conformably (Modified from Xiao et al., 1986; the present author joined in measurement of the section in 1982).

and large amounts of basalt. In the Late Permian, the material source at the Khamdian Massif was west of the epicontinental restricted sea of South China (Zhou, 1985–1986, fig. 3; Figs. 1, 2).

Platform margin.—The platform margin is a rather narrow belt, in most cases only several kilometers in width, and clearly marked by the reef and/or beach belt approximately westward along the line of county-towns (e.g., Luodian, Wangmo, Ziyun, Ceheng, and Xingning) in southwest Guizhou (Fig. 3). Deposits of the platform margin, which are represented by the Houziguan Formation, below, and the Wuchiaping Formation, above (Figs. 2, 3), mainly consisted of bioclastic limestone and sponge and/or coral boundstone. Although the pandemic *Eumedlicottia kabiensis* n. sp. and *Propinacoceras beyrichi* Gemmellaro, 1887 combination is present in the intercalated claystone of Member XII, Houziguan Formation at Kabi within the marginal zone, it actually represents the progradation of the basinal deposit nearby.

Platform interior.—The platform interior is present in the backreef area, which is characterized by deposits of bioclastic micrite, argillaceous limestone, chert, calcareous siltstone, and claystone, with all shallow-water indicators, and interfingered with the landward paralic deposits during eustacy. As a special case, the transient "Beipanjiang Fault-Depression" in west Guizhou, which is deeply embedded in the platform, probably represents the extension of the basin gulf, or a local faulted diminutive basin in the Early Artinskian, including the Longyin (Pu'an County)-Huagong (Qinglong County)-Langdai (Liuzhi County) area along the northwest tectonic strike, with tens to a thousand or more meters of detrital rocks and limestone containing the open-sea pandemic ammonoid fauna (Figs. 1.A, 3.A). However, rapid filling eliminated the depression by the later Cisuralian. In contrast to the Nanpanjiang Basin, the restricted-sea ammonoid assemblages occur in some marine-mudstone and/or in the platform-interior deposits (e.g., the *Shengoceras* [i.e., '*Kufengoceras*'] Fauna in the Kuhfeng Formation, the *Araxoceras* Fauna in the Heshan Formation, and the *Pseudotirolites* Fauna in the Talung Formation) (Fig. 2). They represent transitional facies (biotopes) between the carbonate and coal-bearing facies in the Middle to Late Permian in South China (Zhou et al., 1995).

Paralic area.—The paralic area is present in a wider belt between the terrestrial and the marine-fossiliferous carbonate

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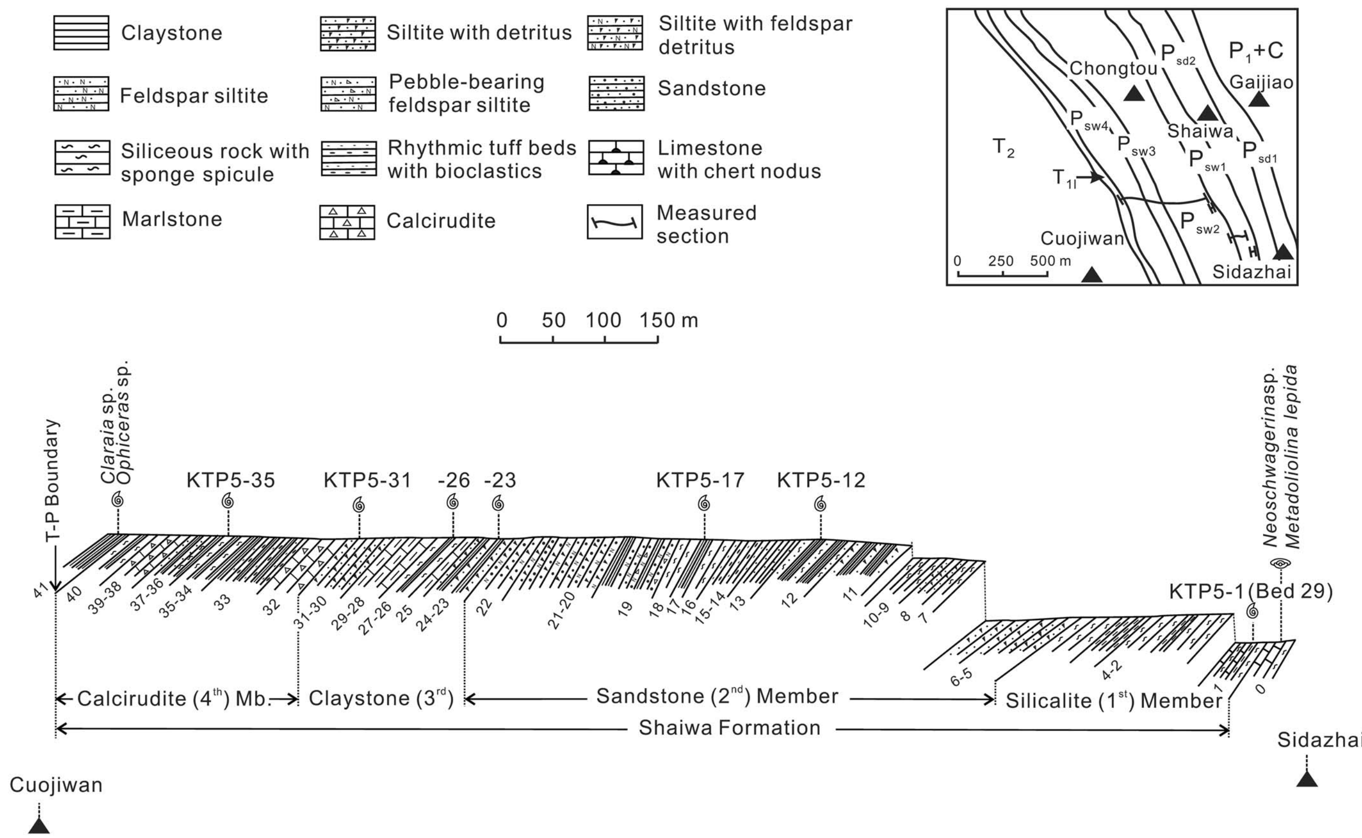

Figure 5. Shaiwa Formation of Sidazhai section (Sec. IV'-IV") starting near the town of Sidazhai, north-west ward, consisting of four segments with a total parallel shift in strike of the strata of 500 m. Measured by Wang C.-W. and Liu A.-M. of the Regional Geological Surveying Academy in 1996; the present author partially joined in the field work; coordinates based on Google Maps; origin ~25.5864°N, 106.1651°E, ending ~25.5990°N, 106.1459°E.

areas, which is along the lines between Weining and Fuyuan in the west, and Bijie and Pu'an in the east (Figs. 1, 2). There are still a few marine layers in the Lungtan and Wangjiazhai coal-bearing formations in the area, even preserving the restricted-sea ammonoid fauna at the top Lungtan Formation (Xiao, 1996, p. 289).

Terrestrial area.—The terrestrial area represents the major siliciclastic source area distributed along the east wing of the Khamdian Oldland, or west of the epicontinental restricted sea of South China (Zhou, 1985–1986, fig. 3; Figs. 1, 2).

Generally, regional deposition with consistent facies distribution indicates the Nanpanjiang area was an autochthonous part of South China in the Permian, tectonically, while the sum of the Shaiwa, Sidazhai, and upper Nandan formations (as basinal Permian units) is equal to or exceeds the total simultaneous deposits within the platform, stratigraphically.

Occurences of Permian open-marine pandemic ammonoids in Nanpanjiang Basin

Although unusual, it is important, that successive marine deposits with Permian comparably pandemic ammonoid zones occurred extensively in the Nanpanjiang Basin of South China. This occurrence provides the ability to correlate the platform-based Permian, Upper (Lopingian), Middle (Yanghsingian), and Lower (Chuanshanian) Series of South China to the basinal Guadalupian Series of North America and the Cisuralian Series of the Urals through the traditional index ammonoid zonation.

Six sections and at least 11 localities in the basin have yielded Permian pandemic ammonoids. These 17 sites are principally distributed in basin-slope or 'micro-intra-basinal platforms', and grouped into A to H districts geographically (Fig. 1.3.A–1.3.H).

Area A: the Longyin-Langdai district in western Guizhou.—Two sections and one locality (Figs. 1.3.A, 3.A). As an exception, the area is near the Beipanjiang River, rather than in the Nanpanjiang Basin, where it probably is integrated as a faulted-depression stretched into the platform, while preserving normal connection with open sea of the Nanpanjiang Basin during Artinskian.

Longyin section (sec. I).—About 27 km linear distance north of the county-town of Pu'an, Guizhou, beginning near Longyin Village and ending near Baomoshan (Zhang et al., 1988, p. 18, fig. 10). Two local stages are included in the Longyin section: the Zisongian below, which is equal to 2nd and 3rd members of the Nandan Formation; and the Yangchangian above, which is approximately equal to the sum of the Baomoshan and Longyin formations. The Longyin (sensu lato) as a stage was replaced by the Longlinian Stage in the Chinese Stratigraphic Lexicon (Jin et al., 2000) (Fig. 2). According to ammonoids collected from the Longyin Formation, the lower

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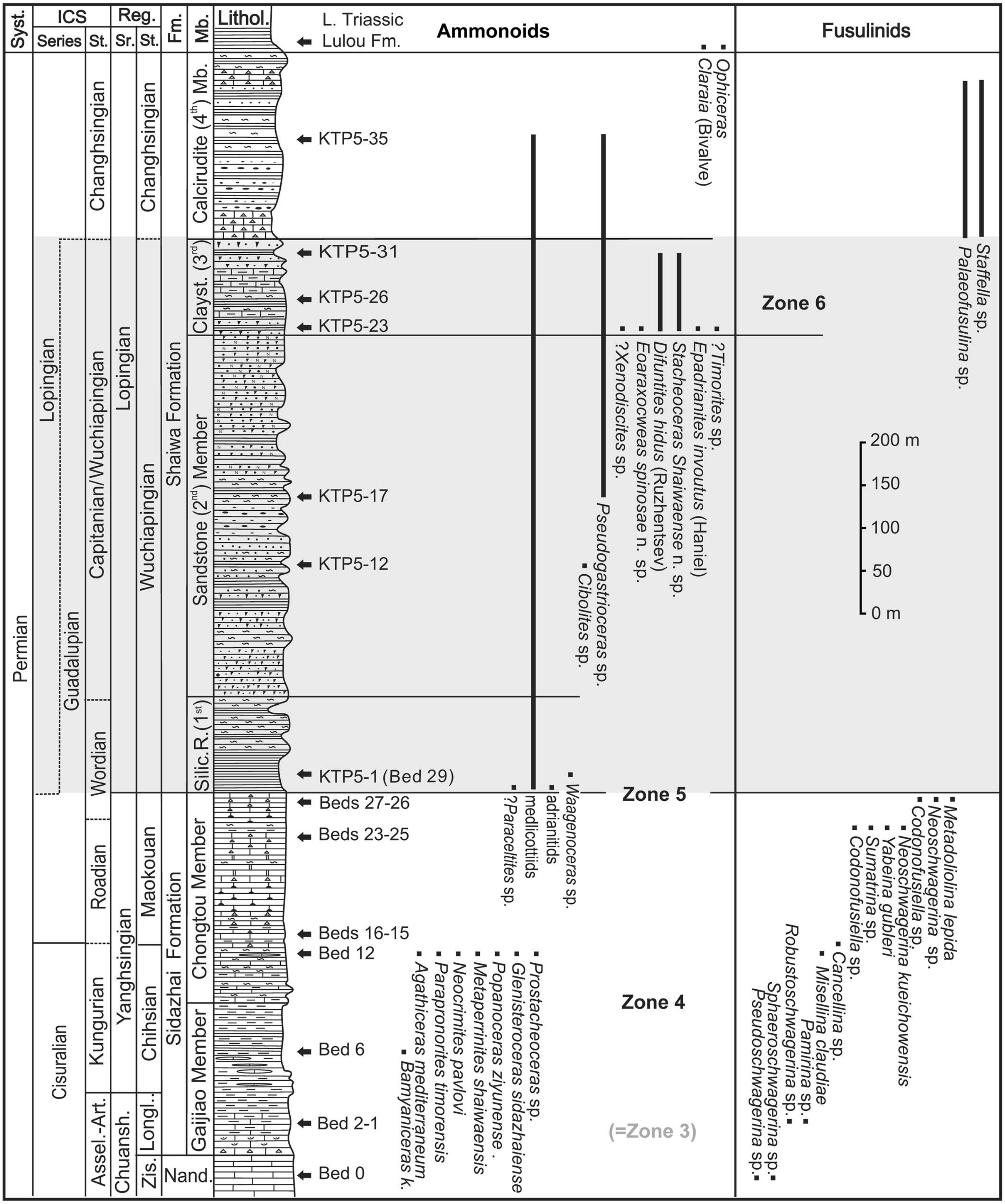

Figure 6. Columnar stratigraphic section of the Sidazhai and Shaiwa formations based upon the Shaiwa-Sidazhai general section (Sec. IV-IV''), Ziyun County, Guizhou, showing the biostratigraphic relationship between the basinal deposits with the open-sea ammonoid zonation (Zones 6 to 4 and the equivalent Zone 3) and the Time Scales (both ICS and Regional) through the control of the T/P boundary and the fusulinid faunas of the Yanghsingian and Chuanshanian Series. The whole sequence contains the Longlinian through the Changhsingian Stages. The shadow represents the possible overlap between the basinal Capitanian with partial Wordian, and the platform-based Wuchiapingian. Legends see Figures 4 and 5.

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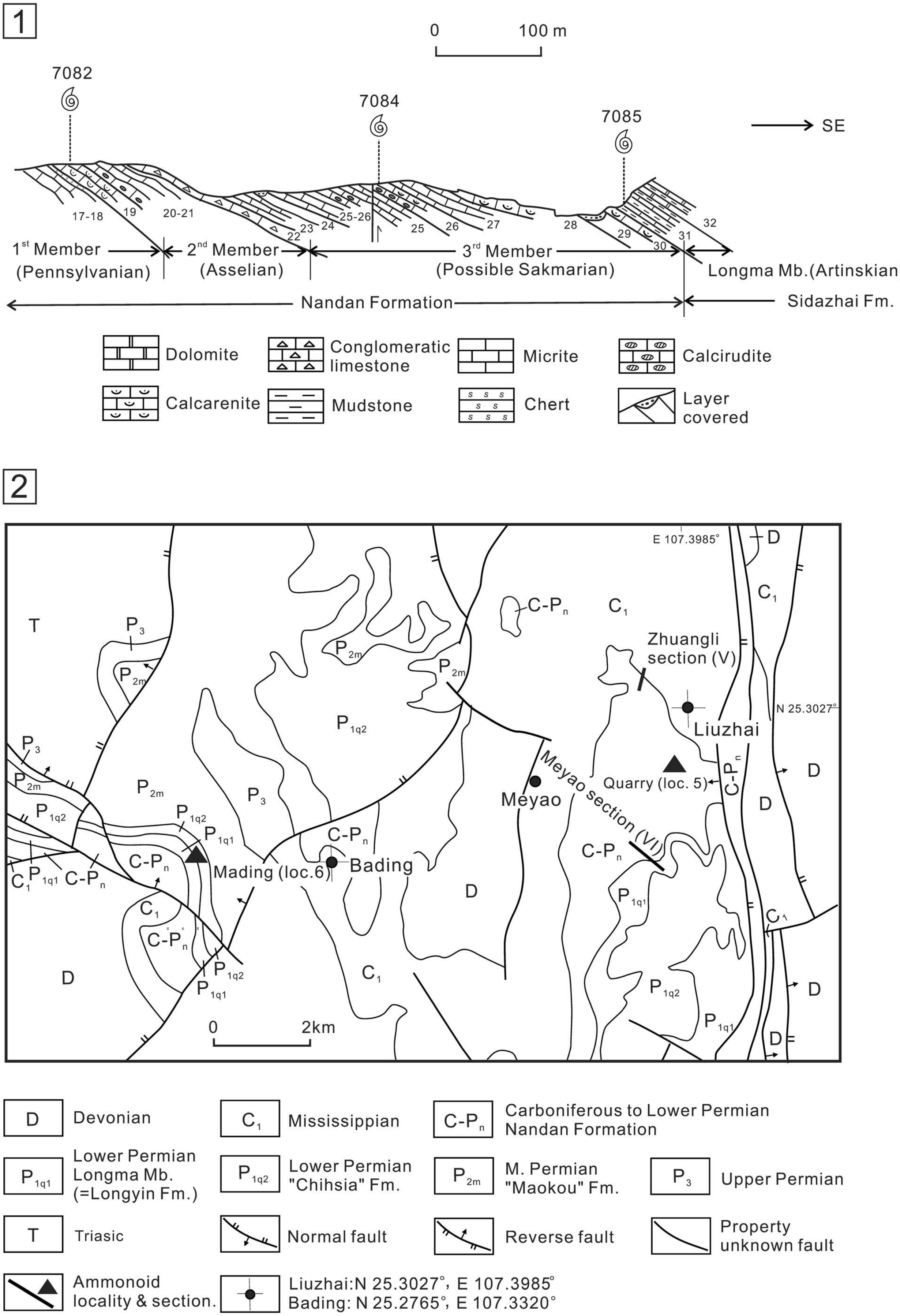

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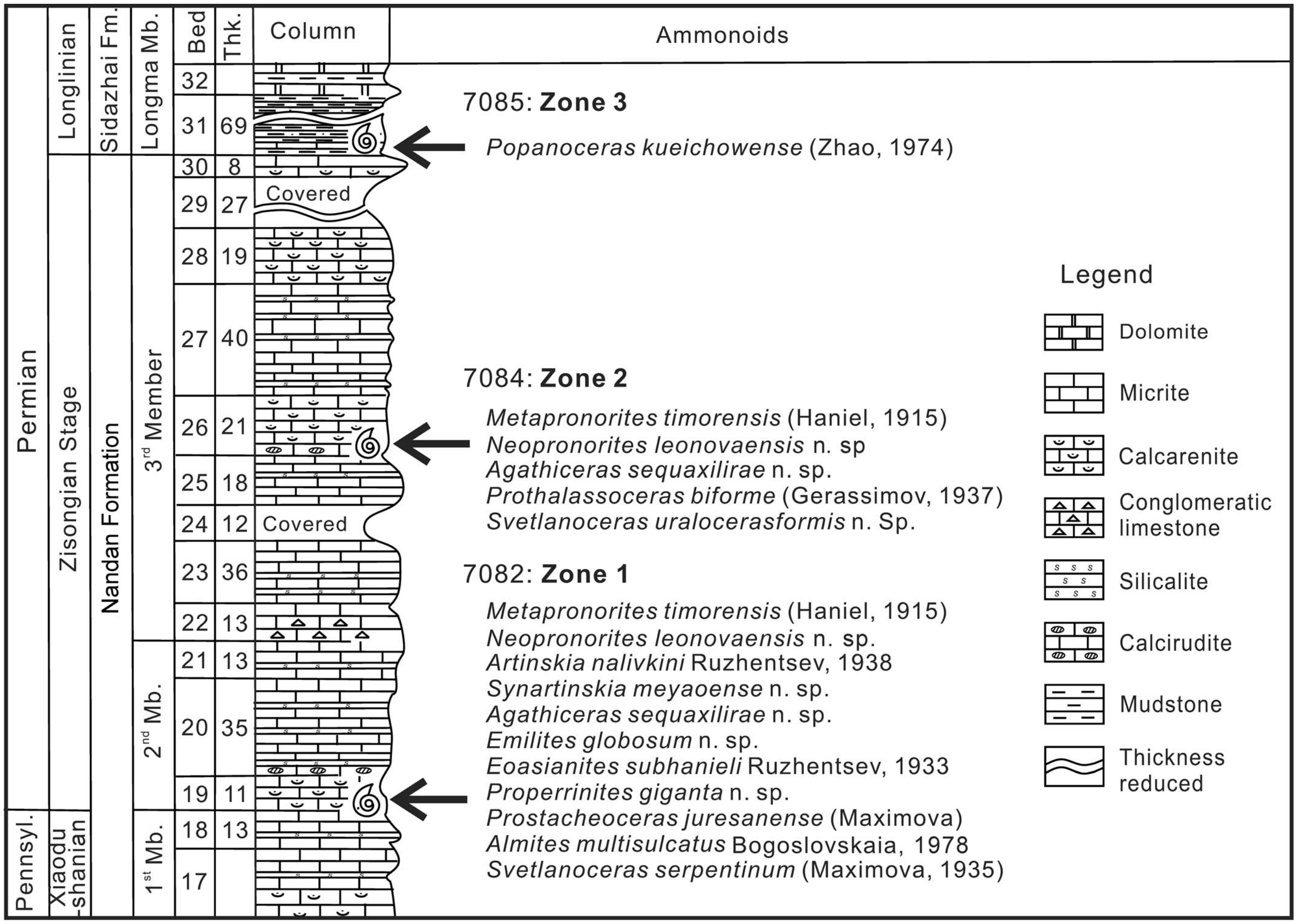

Figure 8. Columnar stratigraphic section of the bottom Sidazhai and the Nandan formations upon Meyao section (Sec. V), showing positions of the Zones 1 to 3, Liuzhai, Nandan County, Guangxi.

part of Longlinian Stage indicates an early Artinskian age (Zhou, 1988–1989), not Sakmarian (Wu et al., 1979), nor Asselian through Sakmarian (Zhang et al., 1988). There are two major ammonoid-bearing claystone beds in the Longyin Formation (early Longlinian Stage), in descending order:

Bed 12:
Bamyaniceras nandanense n. sp. (NIGP 88973)
Eothinites cf. *E. kargalensis* Ruzhentsev, 1933 (NIGP 93752)
Bransonoceras longyinense n. sp. (NIGP 93674, 93662)

Bed 3:
Bamyaniceras nandanense n. sp. (NIGP 88974, 93747–93749, 93751)
Miklukhoceras guizhouense n. sp. (NIGP 154102, 154103)
Sicanites notabilis (Ruzhentsev, 1940c) (NIGP 154109)
Daraelites elegans Chernov, 1907 (NIGP 88980, 88981)
Almites sp. (NIGP 89015)
Bransonoceras longyinense n. sp. (NIGP 93660, 93661, 93685, 93739, 93740, 93743)
Popanoceras kueichowense (Zhao in Zhao and Liang, 1974) (NIGP 154091, 154093)
Eothinites cf. *E. kargalensis* (NIGP 93753)

Huagong section (sec. II).—About 25 km linear distance northwest of the county-town of Qinglong, and 10 km southeast to the Longyin section, beginning near the Huagong Tea-Plantation and measured northward (Xiao et al., 1986; Zhou, 1988–1989). Ammonoids were collected mostly from beds 19–17 of the Longyin Formation, which consists of claystone, silty claystone, intercalating thin quartz sandstone, and lenses of marlstone. This section is approximately equivalent to Bed 3 of the Longyin section (sec. I), also early Artinskian age.

Beds 19–17 (total 14 m thick):
Neopronorites darvasicus Leonova, 1988 (NIGP 93663)
Miklukhoceras guizhouense n. sp. (NIGP 93678–93681)

←

Figure 7. (**1**) Meyao section (Sec. V), showing the Nandan Formation and Longma Member of the Sidazhai Formation (Measured by Huang Z.-X. et al., 1986, the Regional Geological Surveying Academia of Guangxi; published by Kuang et al., 1999); coordinates based on Google Maps; origin ~25.2781°N, 107.3887°E, ending ~25.2755°N, 107.3931°E. (**2**) Geological map of Liuzhai District, Nandan County, Guangxi, with position of sections and ammonoid localities studied herein (Modified from the draft of Huang Z.-X., Regional Geological Surveying Academy of Guangxi Geological Bureau, 1986).

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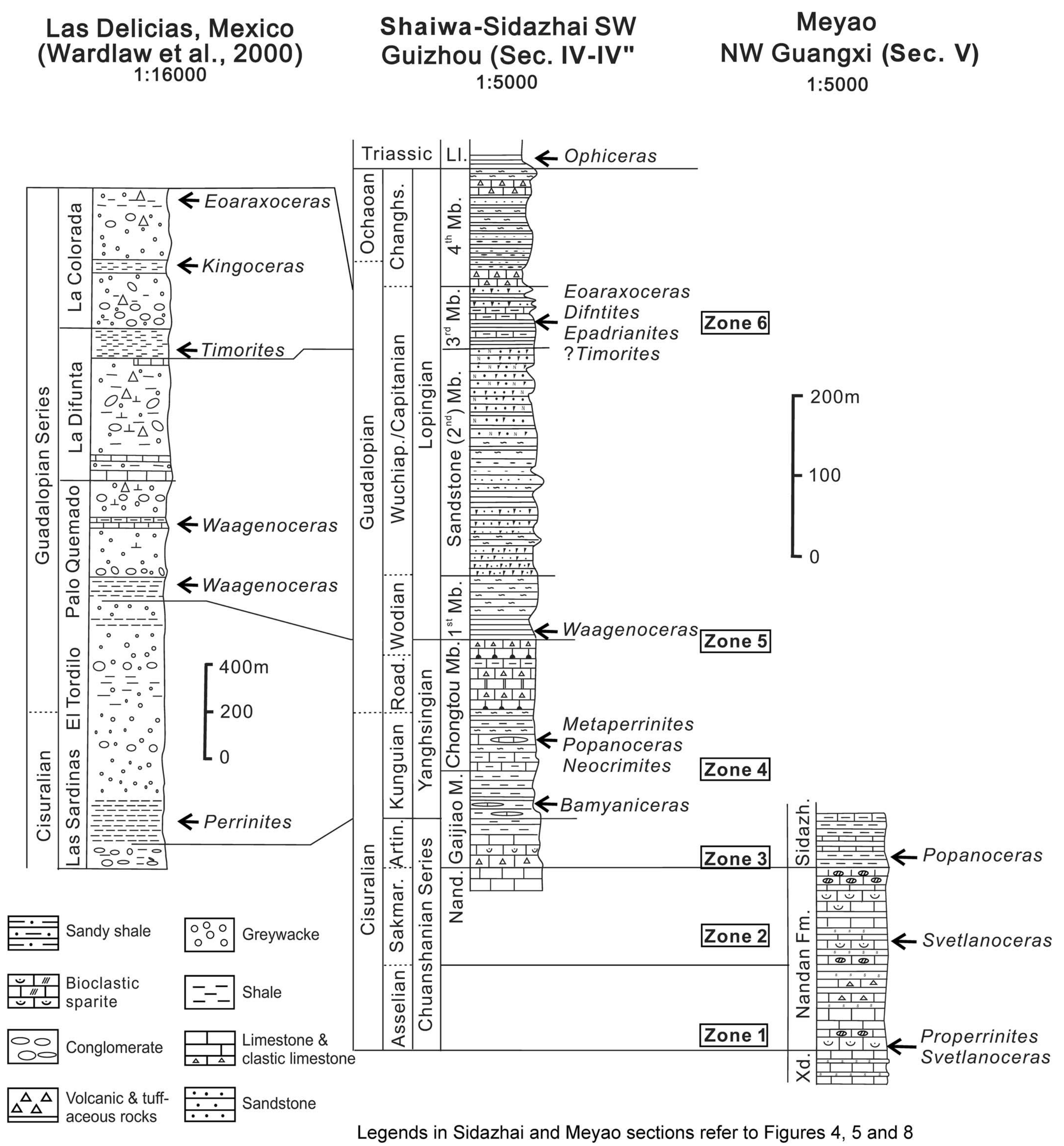

Figure 9. The Permian ammonoid zones 1–6 in Nanpanjiang Basin and the Permian intercontinental correlation between the Coahuila, Mexico in the Western Hemisphere, and the Nanpanjiang Basin, South China in the Eastern Hemisphere based on the ammonoid zones 4, 5, and 6.

Akmilleria parahuecoensis n. sp. (NIGP 93686)
Medlicottia orbignyanus (Verneuil, 1845) (NIGP 93691, 93692)
Agathiceras sp. (NIGP 93708)
Almites sp. (NIGP 93718, 93719)
Pseudoschistoceras sp. (NIGP 93723)
Bransonoceras longyinense n. sp. (NIGP 93724–93727)

Ladang locality (loc. 1).—A well-preserved ammonoid individual collected from the ‘Tongkuangxi’ Formation (e.g., the Longyin Formation in current usage), at Village Ladang (about 26.0455°N, 105.2276°E), 13 km southwest of Langdai, Liuzhi County, Guizhou, near the Beipanjiang River, but now submerged under a huge reservoir, dammed on the river. The

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solitary specimen originally was identified as *Propopanoceras kueichowense* Chao, 1965 (nom. nud.), with an assigned age of Sakmarian, although the formal description was not published until 1974. Finally, it was recombined into the genus *Popanoceras* (Zhou, 1989–1999), with an early Artinskian age. The monotypic *Popanoceras kueichowense* (Zhao in Zhao and Liang, 1974) (NIGP 22029) is the only, but important, representative at the locality.

Area B: the Sidazhai-Yangchang district in southwestern Guizhou.—Area B encompases two sections and two localities in Ziyun County (Figs. 1.3.B, 3.B), including the Shaiwa-Sidazhai general section (sec. IV-IV''), which provides the major references of the Permian ammonoid zonation in the Nanpanjiang Basin.

Yangchang section (sec. III).—This section is 13 km southeast of Ziyun, in ammonoid-bearing claystone within beds 35–32 of the Yangchang Formation (Zhang et al., 1988, p. 5). Ammonoids, which are close to forms from the lower Longyin Formation of the Longyin section (sec. I), also have an early Artinskian age:

Parapronorites cf. *P. rectus* Leonova, 1989 (NIGP 88971, 88972)
Bamyaniceras knighti (Miller and Furnish, 1940a) (NIGP 154106, 154107)
Bamyaniceras nandanense n. sp. (NIGP 93745, 93746)
Bamyaniceras yangchangense n. sp. (NIGP 154098–154101)
Sicanites notabilis (Ruzhentsev, 1940c) (NIGP 88982)
Eothinites cf. *E. kargalensis* Ruzhentsev, 1933 (NIGP 154079, 154080)
Miklukhoceras guizhouense n. sp. (NIGP 154105)

Shaiwa-Sidazhai general section (sec. IV-IV'').—The Shaiwa-Sidazhai general section was measured as two independent, but connected sections by the Regional Geological Survey Academy of Guizhou in 1982 and 1996, respectively (Figs. 2, 4–6, 9; Appendix 1). The author was invited to join in both programs for field investigation and ammonoid study.

The upper section, Sidazhai section (Sec. IV'-IV''), in the Shaiwa Formation, started from north Sidazhai, about 20 km southeast of Ziyun (Figs. 2, 5, 6) (coordinates based on Google Maps: origin about 25.5864°N, 106.1651°E, end about 25.5990°N, 106.1459°E). The section is along the footpath toward the northwest, consisting of four segments, totalling ~500 m, with parallel shifts along the stratum strike.

The Shaiwa Formation, which is ~800 m thick, mainly consists of turbid debris deposits, claystone, and bedded chert. It is subdivided into four members based on the major rock properties: the Calcirudite (4th), the Claystone (3rd), the Sandstone (2nd), and the Siliceous Rocks (1st) members, in descending order. The formation conformably overlies the upper Chongtou Member of the Sidazhai Formation, which preserves a fusulinid-bearing bioclastic calcarenite with *Metadoliolina lepida* (Schwager), *Neoschwagerina* sp., *Reichelina* sp., *Kahlerina sinensis* Sheng, *Codonofusiella* sp., *Verbeekina* sp. (Xiao et al., 1986, identified by Zhang, L.-X. and Dong, W.-L.). This part of the section is equivalent to the upper Maokou Limestone in the platform interior.

The Shaiwa Formation is conformably overlaid by gray, thin-bedded calcareous mudstone with the ammonoid *Ophiceras* sp. and the bivalve *Claraia* sp. of the Lower Triassic Luolou Formation. The formation represents the basinal deposits of Lopingian age in Nanpanjiang area. Ammonoids are present in almost all of the beds of the section, but they are especially abundant in two guide horizons: the *Eoaraxoceras* fauna from the Claystone (3rd) Member, and the *Waagenoceras* fauna from the bottom Siliceous Rocks (1st) Member.

The lower section, Shaiwa section (Sec. IV-IV'), in the Sidazhai Formation, starts near Gaijiao Village and ends near Chongtou Village (Figs. 2, 4, 6) (coordinates based on Google Maps: origin about 25.6065°N, 106.1577°E, and ending about 25.6090°N, 106.1506°E). It was measured in the program "Early Permian Stratigraphy and Faunas in southern Guizhou" in 1982 (Xiao et al., 1986). The section mainly consists of turbid calcareous deposits, conformably underlying the Shaiwa Formation and overlying the Nandan Formation, equal to the sum of the Maokouan with advanced fusulinid neoschwageinids, the Chihsian (sensu lato) with typical *Misellina* fusulinids, and the Longlinian with *Pamirina-Robustoschwagerina* fusulinids from the platform interior. The perrinitid ammonoid fauna is found in siliceous limestone lenses of the Chihsian *Misellina claudiae* horizon.

The Shaiwa-Sidazhai general section presumably represents the most complete Artinskian through the Lopingian sequence of the open-sea facies in South China, and contains the major ammonoid faunas occurring in the American equivalents biostratigraphically. Although there are no ammonoids reported from the underlying Nandan (or Maping) Formation in the Shaiwa section (Sec. IV-IV') so far, the Asselian through the Artinskian pandemics could be supplied by the Meyao section (Sec. V) in the adjacent Liuzhai area, Nandan County, northwest Guangxi (Fig. 2, 7, 8).

Ammonoids collected from the Sidazhai-Shaiwa general section (IV-IV'') are listing in descending order as following:

Shaiwa Formation: Calcirudite (4th) Member:

KTP5-35:

Ammonoid fragments with regular longitudinal lirae probably represent individuals of the genus *Pseudogastrioceras*, and some fragments with two well-preserved rows of rib-like nodes may represent some medlicottids, as well as some remains of trilobites.

Claystone (3rd) Member:

KTP5-31:

Stacheoceras shaiwaense n. sp. (NIGP 139934 and 139940)
Difuntites furnishi n. sp. (NIGP 139933)

KTP5-26:

Difuntites furnishi n. sp. (NIGP 139932)

KTP5-23:

Epadrianites involutus (Haniel, 1915) (NIGP 139941–139944)
Stacheoceras shaiwaense n. sp. (NIGP 139935–139939)
?*Timorites* sp. (NIGP 154112)
Difuntites furnishi n. sp. (NIGP 139931)
?*Xenodiscus* sp. (NIGP 139955)
Eoaraxoceras spinosai n. sp. (NIGP 139945–139954)

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Sandstone (2nd) Member:

KTP5-17:

Ammonoid fragments with regular, longitudinal lirae probably represent individuals of the genus *Pseudogastrioceras.*

Siliceous Rocks (1st) Member:

KTP5-12:

Ammonoid fragments with paraceltitin-shape and ridged venter ?*Cibolites*

KTP5-1 (equal to Bed 29), as the top of the Shaiwa section (Sec. IV-IV'), measured in 1982:

Ammonoid fragments with sculpture of adrianitids and paraceltitins
Waagenoceras sp. (NIGP 93715)
?*Adrianites* sp.
?*Paraceltites* sp.

Sidazhai Formation:

Chongtou Member: Mainly bioclastic calcarenite with turbid characters; the upper part is characterized by *Metadoliolina lepida* (Schwager), *Yabeina gubleri* Kanmera, *Neoschwagerina kueichowensis* Sheng, and many other Maokouan fusulinids (Sheng, 1963).

Lower part, Bed 12, is characterized by *Misellina claudiae* (Deprat) fusulinid fauna and the following ammonoids:

Paraprонorites timorensis Haniel, 1915 (NIGP 93654–93656)
Prostacheoceras sp. (NIGP 93717)
Glenisteroceras sidazhaiense n. gen. n. sp. (NIGP 93728–93729)
Neocrimites guizhouensis n. sp. (NIGP 93711–93712)
Fusicrimites nanpanjiangensis n. gen. n. sp. (NIGP 93713)
Agathiceras mediterraneum Toumanskaya, 1949 (NIGP 93704–93707)
Metaperrinites shaiwaensis n. sp. (NIGP 93714)
Popanoceras ziyunense n. sp. (93734–93738)

Gaijiao Member: Abundant ammonoid fragments are found in almost all the mudstone beds of the member, however the better specimens mainly are concentrated in Bed 6.

Bed 6:
Parapronorites cf. *P. rectus* Leonova, 1989 (NIGP 93658, 93659)
Propinacoceras toumanskayae Leonova, 1989 (NIGP 93672, 93673)
Bamyaniceras knighti (Miller and Furnish, 1940a) (NIGP 93668, 93670, 93671, 154104)
Bamyaniceras cf. *B. spatiosum* Leonova, 1992 (NIGP 93669)
Agathiceras sp.

Beds 2–1: Many fusulinids occur in the carbonate intercalations in these beds, including *Robustoschwagerina* sp., *Pamirina* sp., and schwagerinids. The underlying Nandan Formation contains gray fusulinid-bearing micrite with *Sphaeroschwagerina* sp. and *Pseudoschwagerina* sp.

Huohongchong locality (Loc. 2).—(Fig. 3.B). There is only a solitary, well-preserved specimen of *Bamyaniceras yangchangense* n. sp. (NIGP 154095, holotype), collected from the mudstone, ~400 m southeast of the Yangchang section (Sec. III), which supposedly is Artinskian in age.

Kabi locality (Loc.3).—(Fig. 3.B). Ammonoid-bearing claystone, representing the basinal progradation, is intercalated in the limestone of Member XII, at the top of the Houziguan Formation, which is stratigraphically equal to the top of the Maokou Formation in the platform interior. The Kabi locality is an outcrop 5 km northwest of Houchang, ~300 m west of the Village of Kabi, Ziyun County, Guizhou (coordinates on Google Maps about 25.6469°N, 106.2168°E).

The ammonoid collection presumably comes from a little below Bed 29 in the Shaiwa section (Sec. IV-IV'), but still correlates with the *Waagenoceras* sp. representatives of the *Waagenoceras* sp.-*Propinacoceras beyrichi* Zone, which is Wordian in age biostratigraphically. The ammonoids are listed below:

Eumedlicottia kabiensis n. sp. (NIGP 93693–93698)
Propinacoceras beyrichi Gemmellaro, 1887 (NIGP 93664–93667)
Agathiceras suessi Gemmellaro, 1887 (NIGP 93702–93703)

Area C: the Luodian district in south Guizhou.—There is only one locality in the district (Figs. 1.3.C, 3.C).

Luodian locality (Loc. 4).—The Luodian locality is 5 km east of the county-town of Luodian in south Guizhou. There are many fragments of ammonoids, probably *Agathiceras* and unidentified medlicottids, found in the siliceous limestone of the bottom 'Chihsia' Formation.

Area D: the Liuzhai-Meyao district in northwest Guangxi.—Area D includes two sections and two independent localities around Liuzhai in Nandan County, Guangxi (Figs. 1.3.D, 7.2). The major section at Meyao (Sec. V) exposes a successive lower Cisuralian ammonoid sequence. It is desirable to connect the Meyao Sction with the Shawa-Sidazhai general section (Sec. IV-IV") to compose a successively Permian pandemic ammonoid sequence in the Nanpanjiang Basin (Figs. 2, 9)

Meyao section (Sec. V).—(Figs. 7, 8; Appendix 2). The Meyao section is 2.6 km southwest of Liuzhai town-center (coordinates using Google Maps: origin about 25.2781°N, 107.3887°E, ending about 25.2755°N, 107.3931°E), measured by Huang Z.-X., Regional Geological Survey Academy of Guangxi and the present author in 1986 (Kuang et al., 1999). Ammonoid collections, in ascending order, labeled as 7082, 7084, and 7085, represent the Lower Permian basinal ammonoid sequence of the Asselian through the lower Artinskian. The former two collections (7082 and 7084) were sampled from the white-gray calcarenite of the 2nd and the 3rd members of the Nandan Formation, respectively. The last collection (7085) was sampled from claystone of the Longma Member, which represents the interlayer of the bottom Sidazhai Formation, approximately equal to the Longyin Formation of southwest Guizhou (Fig. 2). Ammonoids from collection 7085 are poorly preserved, but the equivalents sampled from the same member at Mading (Loc. 6), ~8 km west of the Meyao section, are adequately available. The ammonoid assemblages of the Meyao section (Sec. V) are listed in descending order as following:

Coll. 7085 (Bed 31), Artinskian in age, including:
Popanoceras kueichowense (Zhao in Zhao and Liang, 1974) (NIGP 154092, 154094, 154094-1) and numerous ammonoid fragments; correlates with the equivalent collection from Mading (Loc. 6).

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Coll. 7084 (Bed 26), Asselian to Sakmarian in age, including:

Neopronorites leonovae n. sp. (NIGP 88969)
Metapronorites timorensis (Haniel, 1915) (NIGP 88663, 88664, 88966)
Agathiceras sequaxilirae n. sp. (NIGP 88987, 88988)
Svetlanoceras uraloceraformis n. sp. (NIGP 154088–1540090)
Prothalassoceras biforme (Gerasimov, 1937) (NIGP 93741, 93742)

Coll. 7082 (Bed 19), Asselian age, including:

Metapronorites timorensis (Haniel, 1915) (NIGP 88965)
Artinskia nalivkini Ruzhentsev, 1938 (NIGP 88975–88977)
Synartinskia meyaoense n. sp. (NIGP 88978, 88979)
Agathiceras sequaxilirae n. sp. (NIGP 88983, 88985, 88986)
Neopronorites leonovae n. sp. (NIGP 88967, 88968, 88970)
Emilites globosus n. sp. (NIGP 88989–88996, 88998)
Properrinites gigantus n. sp. (NIGP 89002–89004)
Eoasianites subhanieli Ruzhentsev, 1933 (NIGP 88999–89001)
Almites multisulcatus Bogoslovskaia, 1978 (NIGP 89009–89011, 89014)
Svetlanoceras serpentinum (Maximova, 1948) (NIGP 150081–154087)
Prostacheoceras juresanense (Maximova, 1935) (NIGP 89006, 89007)

Zhuangli section (Sec. VI) (Fig. 7.2).—As a supplement, the Zhuangli section, which is 0.9 km northwest of Liuzhai (about 25.3097°N; 107.3911°E), measured by Huang Z.-X., Regional Survey Academy of Guangxi in 1986. Ammonoids with Asselian age are sampled as coll. 7095 (Bed 11), equivalent to coll. 7082 (Bed 19) of the Meyao section (Sec. V).

Coll. 7095:

Agathiceras sequaxilirae n. sp. (NIGP 88984)
Emilites globosus n. sp. (NIGP 88997)
Almites multisulcatus Bogoslovskaia, 1978 (NIGP 89012, 89013)
Aristoceras liuzhaiense n. sp. (NIGP 89008)

Liuzhai Quarry (Loc. 5) (Fig. 7.2).—An abandoned quarry (about 25.3823°N; 107.3928°E), 1 km southwest of Liuzhai, by the road to Bading. The Asselian ammonoid assemblage there had already been described (Zhou, 1987), and is identical with collections 7082 and 7095 from the above-mentioned sections in both taxonomy and chronology. Ammonoids of the Liuzhai Quarry are revised herein, as follows:

Metapronorites timorensis (Haniel, 1915) (NIGP 94446–94451)
?*Artinskia* sp. (NIGP 94452)
Boesites intercalaris Ruzhentsev, 1978 (NIGP 94453–94458)
Agathiceras sequaxilirae n. sp. (formerly *A. vulgatum* Ruzhentsev, 1978) (NIGP 94459–94463)
Emilites globosus n. sp. (NIGP 94471) (formerly *Emilites* cf. *E. prosperus* Ruzhentsev, 1978)
Properrinites gigantus n. sp. (formerly *P. plummeri* Elias, 1938; Zhou, 1987) (NIGP 94472)
Subkargalites liuzhaiensis (Zhou, 1987) (formerly *Kargalites liuzhaiensis* Zhou, 1987) (NIGP 94473)
Kargalites nandanensis Zhou, 1987 (NIGP 94474–94476)
Almites multisulcatus Bogoslovskaia, 1978 (formerly *Marathonites* sp. Zhou, 1978) (NIGP 94477)
Eoasianites subhanieli Ruzhentsev, 1933 (NIGP 94478)

Mading locality (Loc. 6.) (Fig. 7.2).—Abundant ammonoids occur at locality about 25.3558°N, 107.2997°E; 10 km SW250° from Liuzhai, in claystones of the Longma Member, in the lower Sidazhai Formation. It is stratigraphically equivalent to the Artinskian Longyin Formation in Pu'an and Qinglong, Guizhou.

The ammonoid fauna from Mading, which corresponds to collection 7085 of Bed 31, Meyao section (Sec. V), includes:

Parapronorites cf. *P. rectus* Leonova, 1989 (NIGP 93657)
Bamyaniceras nandanense n. sp. (NIGP 93675–93677)
Miklukhoceras guizhouense n. sp. (NIGP 93682–93684)
Sicanites notabilis (Ruzhentsev, 1940c) (NIGP 93689)
Akmilleria parahuecoensis n. sp. (NIGP 93687, 93688)
Daraelites elegans Chernov, 1907 (NIGP 93699–93701)
Agathiceras sp. (NIGP 93709, 93710)
Almites sp. (NIGP 93720, 93721)
Eothinites cf. *E. kargalensis* Ruzhentsev, 1933 (NIGP 93730–93733)
Kargalites sp. (NIGP 93722)

Area E: the Tian'e district in northwest Guangxi.—Two localities are included in Area E (Fig. 1.3.E): Tian'e locality (Loc. 7) and Shiangyang Village (e.g., Xiangyang Cun) locality (Loc. 8).

Tian'e locality (Loc. 7).—The Tian'e locality is an important occurrence of *Metaperrinites* from the 'Chihsia' Limestone with the fusulinid *Parafusulina*, from the north bank of the Hongshuihe River, suburb of the county-town Tian'e, Guangxi (about 25.0002°N, 107.1619°E). The ammonoid assemblage is dominated by the genera *Metaperrinites* and *Cardiella*. Specially, the relatively high abundance of *Cardiella* specimens show an excellent dimorphism of Paleozoic ammonoids. The whole assemblage is interpreted to be Kungurian in age, and includes:

Parapronorites timorensis Haniel, 1915 (NIGP 88961, 88962, 154096, 154097)
Metaperrinites shaiwaensis n. sp. (NIGP 89005)
Cardiella gracia Pavlov, 1967 (NIGP 89016–89030)
Agathiceras sp.
Medlicottids genera and species indet.

Shiangyang Village (e.g., Xiangyang Cun) locality (Loc. 8).—This locality is within Tian'e County, about 25.04°N, 106.96°E, northwest of Tian'e (Loc. 7). Only *Neocrimites guangsiensis* Zhao and Liang, 1974 (NIGP 22028) is present in the ammonoid-bearing bed, which is thought to be 'Chihsia' limestone, also with a Kungulian age, just as in the Tian'e locality.

Area F: the Linyun district in northwest Guangxi.—There is only one locality in the Linyuan district (Fig. 1.3.F).

Lingyun locality (Loc. 9).—The Lingyun locality is 1 km south of the Lingyun city center, northwestern Guangxi (around 24.33°N, 106.55°E), in the cliff debris accumulated on the southwest side of the road. Only a piece of phragmoconch of *Metaperrinites* was found in the talus in front of the reef zone.

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It is a potential locality for additional examination for the Artinskian-Wordian basinal ammonoid assemblage.

Area G: the Cehong district in south Guizhou.—Only one locality, the Banqi locality, was found in the Cehong district (Fig. 1.3.G).

Banqi locality (Loc. 5).—This is another *Metaperrinites* locality, about 25 km southwest of the county-town of Ceheng, south Guizhou. The exact occurrence is unknown.

Area H: the Longlin district in northwest Guangxi.—Only one locality, the Longlin locality, occurs in Longlin district (Fig. 1.3.H).

Longlin locality (Loc. 11).—The Longlin locality is 20 km southwest of the county-town of Longlin, northwest Guangxi. Some specimens that look like *Agathiceras* had been found in the light gray limestone of the Longlin Formation, which is equal to the topmost Nandan Formation, and might be of an Asselian through Artinskian age.

Permian open-marine pandemic ammonoid zonation of Nanpanjiang Basin

The Permian ammonoid assemblages found in the Nanpanjiang Basin in the recent decades are exclusively open-sea pandemics, with fairly good comparability to those of the classic areas globally. They can be grouped into six zones, in ascending order as follows:

Zone 1. Properrinites gigantus-Svetlanoceras serpentinum.—Zhou's (1987) "First discovery of Asselian ammonoid fauna in China" is the earliest report about the comparable pandemic ammonoids from South China. Collections discussed in the paper were sampled from the Liuzhai Quarry (Loc. 5), which is in the same district as the Meyao (Sec. V) and Zhuangli (Sec. VI) sections in Area D, Liuzhai, Nandan County, northwestern Guangxi (Figs. 1.3.D, 7, 8).

The basinal Asselian ammonoids in Nanpanjiang comprise three collections, respectively labeled as collection 7082 of Bed 19, Meyao section (Sec. V); collection 7095 of Bed 11, Zhuangli section (Sec. VI); and the carbonate talus of the preceding Liuzhai Quarry (Loc. 5; Zhou, 1987, fig. 1). All of them are collected from the Second (2nd) Member, Nandan Formation. Although ammonoids were found from the turbidity-current deposits of the upper slope around the basin, they are still recognized as autochthonous because of the well-preserved body chambers in most cases (Jiang et al., 1987).

The Asselian ammonoid assemblage comprises 15 species (including six new species) of 15 genera: *Boesites intercalaris* Ruzhentsev, 1978, *Metapronorites timorensis* (Haniel, 1915), *Neopronorites leonovae* n. sp., *Artinskia nalivkini* Ruzhentsev, 1938, *Synartinskia meyaoense* n. sp., *Subkargalites liuzhaiensis* (Zhou, 1987), *Kargalites nandanensis* Zhou, 1987, *Almites multisulcatus* Bogoslovskaia, 1978, *Aristoceras liuzhaiense* n. sp., *Emilites globosus* n. sp., *Agathiceras sequaxilirae* n. sp., *Eoasianites subhanieli* Ruzhentsev, 1933, *Prostacheoceras juresanense* (Maximova, 1935), *Svetlanoceras serpentinum* (Maximova, 1948), and *Properrinites gigantus* n. sp.

Five genera (*Neopronorites*, *Metapronorites*, *Boesites*, *Artinskia* and *Synartinskia*) belong to the order Prolecanitida. Individuals of the first three genera are relatively rich in number; but the latter two occur only as a few crushed specimens. The other 10 genera (*Agathiceras*, *Emilites*, *Properrinites*, *Eoasianites*, *Almites*, *Kargalites*, *Subkargalites*, *Svetlanoceras*, *Prostacheoceras*, and *Aristoceras*) belong to the order Goniatitida, of which *Eoasianites*, *Emilites*, and *Agathiceras* are plentiful in the assemblage.

At the generic level, the present Asselian assemblage is conspicuously cosmopolitan, and resembles the synchronous faunas of the Urals, Texas, Pamirs, and Timor, with a basic similarity ratio of 0.8, 0.73, 0.47, and 0.33, respectively (the ratio is calculated by dividing the number of genera in common by the sum of all the genera in the fauna; the meaning is the same in the following faunal comparisons and discussion). All of the old species listed above had been found in Asselian-age strata, and some of them were exclusive to that stage. All genera, except *Properrinites*, are common forms in the type area of the Asselian Stage in Urals.

The seven species of *Svetlanoceras* that have been found thus far range from the lower Asselian through the Tastubian (lower Sakmarian), and, except for Timor, are found in the South Urals, Pamirs, ?East Himalaya, Western Australia, West Texas, Yukon, and Guangxi. *Svetlanoceras serpentinum* (Maximova, 1948) is only recorded in South Urals (Russia) and Guangxi, herein. As a classic Asselian index, it has been collected from the Kholodnolozhian Substage (the lower Asselian Stage) (Chuvashov et al., 2002), and now from the Second (2nd) Member of the Nandan Formation of Meyao (Sec. V).

Properrinites also has seven species, ranging from Asselian through Sakmarian, and is distributed in Texas, New Mexico, Kansas, Nebraska, Nevada, Pamirs, and Guangxi. *Properrinites gigantus* n. sp. is probably the more primitive form in the genus, based on the noticably wider but simply digitate lobes, and therefore, inferred as an Asselian representative. Some of specimens of *P. gigantus* n. sp. had been described as *P. plummeri* Elias, 1938 (Zhou, 1987), but they actually are distinguished from the latter by the wider and simply digitate lobes.

Subkargalites mainly lived during the Carboniferous in the USA, Pamirs, Uzbekistan (Fergana), South Urals of Russia, and the Northwest Territories of Canada, but in South China it seems to have extended its range into the Asselian. Reexamiation of the Asselian species '*Kargalites*' *liuzhaiensis* Zhou, 1987 indicated that the material has a wider and tripartite dorsal lobe—the distinct features of *Subkargalites*, which confirmed the generic revision made by Leonova (2002, p. S78).

The association of *Properrinites* and *Svetlanoceras* in Nanpangjiang is an interesting fact in paleobiogeography because the former had been considered as the distinctive representative of the Tethys realm, whereas the latter was considered a Boreal representative. Actually, the same association previously had been reported from Pamirs as early as the 1970s (Ruzhentsev, 1978).

It is noteworthy that the present ammonoid zone (Zone 1—*Properrinites gigantus-Svetlanoceras serpentinum*) occurs with fusulinid fauna characterized by *Pseudoschwagerina*,

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Sphaeroschwagerina, *Rugosofusulina*, *Triticites* and *Schwagerina* in Liuzhai Quarry (Loc. 5) (Zhou, 1987) and Meyao section (Sec. V). Both fossil groups were widely distributed in carbonate talus, various clastic limestones, and the micrite matrix around the debris flows. They were considered as "approximately simultaneous in age on account of that the debris-flow took place in the upper slope not far from the source area" (Jiang et al., 1987, p. 286).

Zone 2. Svetlanoceras uraloceraformis-Prothalassoceras biforme.—The possible Sakmarian ammonoid assemblage occurs in Bed 26, the Third (3rd) Member of the Nandan Formation in Meyao section (Sec. V) (Figs. 1.3.D, 7, 8). Ammonoids of collection 7084 here include following taxa: *Neopronorites leonovae* n. sp., *Metapronorites timorensis* (Haniel, 1915), *Agathiceras sequaxilirae* n. sp., *Svetlanoceras uraloceraformis* n. sp., and *Prothalassoceras biforme* (Gerasimov, 1937).

There is no typical Sakmarian form in the list above; however, the facts below are reasonably good indicators of the possible Sakmarian age of this fossil complex: (1) ammonoid-bearing deposits at the Third (3rd) Member of the Nandan Formation directly overlie the Asselian Second (2nd) Member of the same formation, and underlie the Artinskian Longma Member of the Sidazhai Formation stratigraphically; (2) the tendency of generic evolution in conch shape of *Svetlanoceras* is towards broader whorl section and diminished umbilical diameter, therefore *S. uraloceraformis*, with an equidimensional whorl section and smaller umbilicus, is relatively more advanced in evolution than the Asselian species, *S. serpendium*; and (3) the consistent association with the *Robustoschwagerina-Charaloschwagerina* fusulinid fauna additionally indicates a Sakmarian age.

Metapronorites timorensis Haniel, 1915 in the list previously had been reported from Timor and Kazakhstan in the South Urals, from Asselian through Artinskian ages. *Prothalassoceras biforme* (Gerasimov, 1937) was reported only from Asselian-age rocks in the Urals, but it seems more desirable to extend its geological range to the Sakmarian outside of its type area.

Zone 3. Popanoceras kueichowense-Medlicottia orbignyanus.—This is the most comprehensively distributed pandemic assemblage in the study area. There are as many as seven occurrences: the Nadang locality (Loc. 1), beds 12–3 of the Longyin section (Sec. I), and beds 19–17 of the Huagong section (Sec. II) in Area A; the Huohongchong locality (Loc. 2) and beds 35–32 of the Yangchang section (Sec. III) in Area B; and the Mading locality (Loc. 6) and collection 7085 in Bed 31 of the Meyao section (Sec. V) in Area D (Figs. 1.3, 2, 3, 7, 8).

The assemblage comprises 16 species (including five new and four unidentified), belonging to 14 genera: *Daraelites elegans* Chernov, 1907, *Parapronorites* cf. *P. rectus* Leonova, 1989, *Neopronorites* cf. *N. darvasicus* Leonova, 1988, *Bamyaniceras yangchangense* n. sp., *B. nandanense* n. sp., *B. knighti* (Miller and Furnish, 1940a), *Miklukhoceras guizhouense* n. sp., *Akmilleria parahuecoensis* n. sp., *Medlicottia orbignyanus* (Verneuil, 1845), *Sicanites notabilis* (Ruzhentsev, 1940c), *Eothinites* cf. *E. kargalensis* Ruzhentsev (1933), *Pseudoschistoceras* sp., *Bransonoceras longyinense* n. sp., *Almites* sp., *Agathiceras* sp., and *Popanoceras kueichowense* (Zhao in Zhao and Liang, 1974).

The ammonoid fauna exhibits a fairly worldwide distribution. Genus-level similarities to classic areas in the Pamirs, Urals, West USA, and Timor are 0.86, 0.79, 0.64, and 0.64, respectively, with the greatest similarity to the Pamirs. The 'Boreal' representatives, *Paragastrioceras* and *Uraloceras*, do not appear in the fauna, but this may be due to inadequate investigation.

The geological ranges of the taxa listed-above are concentrated within the interval Artinskian though Kungurian, but the most likely age of the assemblage is Artinskian based upon the stratigraphic sequence and the evolution level of the major index taxon *Popanoceras kueichowense* (Zhao in Zhao and Liang, 1974). The solitary monotype of *P. kueichowense* was collected from the 'Tongkuangxi Formation' (i.e., the shale below the 'Chihsia limestone' at Ladang Village; Loc. 1), about 13 km southwest of Langdai, Liuzhi County, Guizhou (Chao, 1965, p. 1815; Zhao in Zhao and Liang, 1974, pl. 159, figs. 9–11). The other plesiotypes were collected from Bed 3 of the Longyin Formation, Longyin (Sec. II), Pu'an County, Guizhou and collection 7085 of the Longma Member, Sidazhai Formation, Meyao section (Sec. V), Liuzhai, Nandan County, Guangxi. Stratigraphically, the ammonoid-bearing claystone overlies the Nandang Formation (formerly, the Shazitang Member of the Maping Formation) of Sakmarian age, and underlies the 'Chihsia Formation', a limestone with the fusulinid *Misellina claudiae* (Deprat, 1912). Actually, the species *Popanoceras kueichowense* (Zhao in Zhao and Liang, 1974) is close to the primitive end in evolution of the genus, judging by its simpler serration of the lobe base and relatively less wide prong-width. All the features effectively indicate an Artinskian-age *Popanoceras* group (e.g., *P. annae* Ruzhentsev, 1940d, *P. tschernowi* Maximova, 1935, and *P. kueichowense* [Zhao in Zhao and Liang, 1974]).

Zone 4. Metaperrinites shaiwaensis-Popanoceras ziyunense.—This assemblage in the basin has at least five localities that could be traced. The major occurrence is in the Sidazhai Formation of the Shaiwa section (Sec. IV-IV') (Zhou, 1985–1986; Xiao et al., 1986), which consists of two horizons: the mudstone of Bed 6 in the Gaijiao Member below, and the siliceous limestone lens of Bed 12 in the lower Chongtou Member above (Figs. 1.3.B, 3, 4, 6).

The upper part of the ammonoid zone, a thin siliceous limestone lens that is ~45 cm thick, is intercalated in the thin-bedded micrite and calcarenite of Bed 12 in the lower Chongtou Member of the Sidazhai Formation. It directly overlies Bed 11, the fusulinid-bearing bioclastic limestone with *Misellina claudiae* (Deprat), *Parafusulina splendens* Dunbar and Skinner, *Laxifusulina neimongolensis* (Han), and *Nankinella* sp., and underlies beds 14–13 (interbedded radiolarian-bearing siliceous rocks with micrite-calcarenite) containing the fusulinids *Misellina* sp., *Parafuslinia* sp., *Pseudofusulina* sp. and *Yangchienia* sp.

The lower part mainly includes the ammonoid-bearing claystones of Bed 6, the upper Gaijiao Member, which overlies the micrite and claystone alternations of beds 5–4, with the fusulinids *Robustoschwagerina* aff. *R. schellwieni* (Hanzawa), *Pamirina* sp., *Toriyamaia* sp., *Parafusulina* sp., and *Pseudofusulina* sp. All the ammonoid-bearing beds here certainly belong

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to the local Chihsian Stage based on both the stratigraphic sequence and the *Misellina claudiae* fusulinid assemblage. Additionally, the underlying *Robustoschwagerina-Pamirina* beds might be collectively recognized as Longlinian Stage.

The localities of *Metaperrinites* sp. and *Neocrimites guangsiensis* are within the areas where the 'Chihsia Limestone' is distributed, basically corresponding to the lower Chongtou Member in the Shaiwa section. These localities include: (1) Banqi (Loc. 10), Cehong County, Guizhou (Figs. 1.3.G, 3. G); (2) Lingyun (Loc. 9), Lingyun County, Guangxi (Fig. 1.3. F); (3) Tian'e (Loc. 7), the suburb of the town-city, Tian'e County, Guangxi (Fig. 1.3.E); and (4) Shiangyang Village (Loc. 8), Tian'e County, Guangxi (Fig. 1.3.E).

The *Metaperrinites shaiwaensis-Popanoceras ziyunense* zone is of Kungurian age based on the following 13 species (including two unidentified) of 10 genera (including two new genera): *Parapronorites timorensis* Haniel, 1915, *Bamyaniceras* cf. *B. spatiosum* Leonova, 1992, *B. knighti* (Miller and Furnish, 1940a), *Prostacheoceras* sp., *Glenisteroceras sidazhaiense* n. gen. n. sp., *Neocrimites guizhouensis* n. sp., *N. guangsiensis* Zhao and Liang, 1974, *Fusicrimites nanpanjiangensis* n. gen. n. sp., *Cardiella gracia* Pavlov, 1967, *Agathiceras mediterraneum* Toumanskaya, 1949, *A.* sp., *Popanoceras ziyunense* n. sp., and *Metaperrinites shaiwaensis* n. sp.

Generally, the fauna resembles that of the Bolorian Kochusuisk Formation of the southeast Pamirs in both the generic composition and the association of *Metaperrinites* with *Popanoceras* at a middle evolutionary level. Although *Fusicrimites* is a new genus, diagnostic materials from the Kochusuisk Formation of the Pamirs led to its establishment. Other than the new species described herein, *Fusicrimites* actually contains another four previously established species (*S. pavlovi* [Leonova, 1988], *S. dutkevitchi* [Pavlov, 1972], *S. stuckenbergi* [Karpinskii, 1889], and *S. nalivkini* [Toumanskaya, 1949], in which the first one, *Neocrimites pavlovi* Leonova, 1988 is designed as the type species of the new genus). As has been well established, the Kochusuisk Formation in Pamirs is equal to the local Bolorian (Kungurian) Stage biostratigraphically.

Cardiella gracia Pavlov, 1967 is abundant in the assemblage here in the 'Chihsia Limestone' in Tian'e suburb, which reinforces its equivalence to the Kochusuisk Formation from the Pamirs. However, the species in the present zone is not only an index of the biostratigraphy, but also a fairly good example of ammonoid dimorphism with the paired microconch and macroconch sizes.

So far, there are eight areas in the Tethys in which Kungurian and/or Roadian perrinitids-popanocertids ammonoid faunas are found: (1) Pamirs (Kochusuisk and Shindy Formations), (2) Afghanistan (*Perrinites hilli* and *Bamyaniceras* Fauna), (3) Timor (Bitauni beds), (4) Thailand (Nong Pong and Khao Khad formations), (5) South China (Sidazhai Formation in Nanpanjiang Basin), (6) North-West China (Yesonggan Formation in south Xinjiang), (7) Russian Far East (Abreskiy Bed), and (8) Japanese Kitakami Mountains (Sotokawami Formation). Comparing with above-mentioned areas, the *Metaperrinites shaiwaensis-Popanoceras ziyunense* Zone in South China seems a little bit lower in horizon due to its more primitive taxonomic position of the nominate genera and the association with primitive fusulinid verbeekinids *Misellina*, rather than with the neoschwagerinids with septula. Furthermore, the present fauna is approximately equal to or slightly older than the perrinitid localities in North America (e.g., Leonardian Cathedral Mountain Formation in the Glass Mountains of west Texas and the early Las Sardinas beds in Coahuila, Mexico with the *Perrinites hilli* Fauna).

Zone 5. Waagenoceras *sp.*-Propinacoceras beyrichi.—The Wordian ammonoid assemblage in the Nanpanjiang Basin includes four taxa: *Waagenoceras* sp., *Eumedlicottia kabiensis* n. sp., *Propinacoceras beyrichi* Gemmellaro, 1887, and *Agathiceras suessi* Gemmellaro, 1887.

The only specimen of *Waagenoceras* was sampled from the bottom of the Siliceous Rocks (1st) Member of the Shaiwa Formation at the Shaiwa section (Sec. IV-IV') (Figs. 4–6). Three other species, *Eumedlicottia kabiensis* n. sp., *Propinacoceras beyrichi* Gemmellaro, and *Agathiceras suessi* Gemmellaro, 1887, were collected from the claystone intercalation in the top of the 12th Member of the Houziguan Formation at Kabi (Loc. 3) (Figs. 2, 3.B). The occurrence at Kabi is supposedly a little lower than the horizon of *Waagenoceras* sp. in the Shaiwa-Sidazhai general section (IV-VI''), but both are certainly of Wordian age.

Only five of the 13 species of *Waagenoceras* are found in the Capitanian Stage. The other eight species are from the Wordian Stage. However, in those 'Capitanian' species, only *W. karpingskyi* Miller, 1944 comes from reliably dated Capitanian strata at Coahuila, Mexico. The other four species come from horizons that are thought to be 'Capitanian' (Tibet of China and Amur of Russia), but not reliably dated. In the case of Nanpanjiang, the generally primitive suture and the lower appearace stratigraphically both indicate a Wordian age.

Propinacoceras beyrichi Gemmellaro, 1887, as the type species of the genus, originally was collected from the Wordian Sosio Limestone of Palermo, Sicily, and successively reported from Wordian rocks northeast Iraq, the Cephalopod limestone of Rustaq in north Aman, the Kubergandian of Afghanistan, and the Cache Creek Series of the west Pacific coast at Kamloops, British Columbia, Canada. Especially at Kamloops, *P. beyrichi*, as the senior synonym of *P. americanum* Miller and Warren, 1933, corroborated the Wordian age owing to its association with the Wordian *Waagenoceras* species group and fusulinid fauna *Yabeina cordillerensis*, *Afghanella* sp., and *Pseudodoliolina* sp. etc. (Nassichuk, 1977).

Eumedlicottia is a distinctive genus that is present in Artinskian through Wuchiapingian/Capitanian and distributed widely in Texas, Mexico, British Columbia, Sicily, Oman, Salt Range, Far East Primor'e, Iran Adadeh, Japan Kitakami, and Nanpanjiang Basin. As a component of *Waagenoceras-Propinacoceras-Eumedlicottia* complex in North America, the species *Eumedlicottia burckhardti* (Böse, 1919) appeared in the Wordian Cache Creek Series of Canada. *Eumedlicottia kabiensis* n. sp. is somewhat close to *E. burckhardti* in general suture characters, although the former has one more adventitious lobule in both flanks of the external saddle, even at smaller diameters (D 22 mm versus D 50–80 mm).

Zone 6. Eoaraxoceras spinosai-Difuntites furnishi.—The *Eoaraxoceras spinosai-Difuntites furnishi* assemblage appears

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around beds 31–23 of the Claystone (3rd) Member, Shaiwa Formation in the Sidazhai section (Sec. VI'-VI'') (Figs. 5, 6). Ammonoids mostly occur in the claystone, siliceous mudstone, and lime siltstone as mass-coexisting molds and casts, and in a few cases as solitary individuals. Representatives of the zone include *Eoaraxoceras spinosai* n. sp., *Difuntites furnishi* n. sp., *Stacheoceras shaiwaense* n. sp., *Epadrianites involutus* (Haniel, 1915), ?*Xenodiscus* sp., and ?*Timorites* sp.

The ammonoid zone herein is almost identical with the upper La Colorada beds at Arroyo La Colorada, Las Delicias, Coahuila, Mexico in generic composition, especially the presence of *Eoaraxoceras* and *Difuntites*. In addition, the entire zonation sequence that is present in the Shaiwa-Sidazhai general section (Sec. IV-IV'') also is the same as in the Permian section at Las Delicias. As a whole, the basic sequence in both areas may be summerized in ascending order as: the perrinitids (*Metaperrinites* herein, instead of *Perrnites* in Coahuila) → *Waagenoceras* → *Timorites* → *Eoaraxoceras* (Fig. 9) (King, 1944; Spinosa et al., 1970, 2000; Wardlaw et al., 2000). Correlation of this zonal sequence will greatly increase the reliability of regionally stratigraphic correlations.

Eoaraxoceras is a critical index taxon for this assemblage, although its occurrence is quite rare globally. Undoubted localities are restricted to Coahuila and Nanpanjiang, and possibly Abadeh, central Iran (Bando, 1979; Spinosa and Glenister, 2000). *Xenodiscus* in the ceratitids herein is inadequate; however, it is still a possibly important element in the Claystone (3rd) Member of the Shaiwa Formation.

Difuntites, as a representative of the terminal progenesis of the Paleozoic ammonoid family Medlicottidae, is a secondarily important component of the association in the La Colorada beds and Claystone (3rd) Member of Shaiwa Formation. Because its association with *Cyclolobus* has been reported from the Amarassi beds in Timor (Haniel, 1915; Glenister and Furnish, 1988), the upper Liudianzin Suite in Shkotovo, Maritime Territory in Far East of Russia (Zakharov and Pavlov, 1986, p. 10, fig. 3), and the Ambilobe beds in Anaborano, north Madagascar (Treat, 1933; Besairie, 1936), the geological range of the genus may extend from the upper Capitanian (or the earliest Wuchiapingian, as defined by Spinosa and Glenister, 2000) through the Changhsingian (or Chiddruan). So far, it contains only three species (including an unidentified species): the type species, *Difuntites hidius* (Ruzhentsev, 1976), the new species, *D. furnishi* here, and *D.* sp. from Madagascar.

Timorites is an especially key component in the fauna. Unfortunately, the specimen herein is only a piece of an external cast of the ultimate whorl. The generic designation is only based on conch shape, strong rib-sculpture, and the whole ammonoid association. There have been 16 species of *Timorites* reported previously, with exception of the Pamirs' '*Timorites*' *pamiriensis* (Zakharov, 1983a). The genus is widely distributed in the Xiukang Formation in Tibet, the 'Maokou' Formation (assigned by cross-comparison with the traditional scheme) in Yunnan, the Amarassi beds in Timor, the Wordian through Capitanian formations in both Texas and Coahuila, the Liudianzin Formation in Maritime and the 'Capitanian' in Amur area in far eastern Russia, the Suenosaki Formation of the Toyaman Series in the Kitakami Massif in Japan, and Dzhulfian strata in Iran and Transcaucasia.

Earlier workers first reported that the Capitanian was characterized by appearance of the genus *Timorites*, and overlaid by the Dzhulfian (Wuchiapingian) rocks with *Araxoceras* fauna in an ideal stratigraphic sequence; however, this theoretical sequence is not present in the real world. On the contrary, two unquestionable *Timorites* specimens occur in the collection from Abadeh, Iran area, which is associated with the Dzhulfian *Araxoceras* Fauna in sections at Kuh-e-Ali-Bashi (about 38.9417°N, 45.5154°E) and Kuh-e-Hambast in Abadeh, central Iran (Zhou et al., 1989). Additionally, Glenister and Zhou had acquired a common viewpoint that the solitary specimen of *Krafftoceras* sp. nov. from the *Araxoceras* Bed of the Dzhulfian Stage at section Vedi 2 (about 39.94°N, 44.8842°E) in Armenia (Ruzhentsev, 1965, pl. 17, fig. 3, PIN 1425/194, ~125 km north of the Kuh-e-Ali-Bashi locality in Iran) should be recombined into the same taxon as the one from Abadeh. Zakharov (1983a) restudied the Armenian specimen, upon which the species *Cyclolobus ruzhentsevi* Zakharov, 1983a was established. Comparing the suture of the holotype PIN 1425/194 drawn by Zakharov (1983a, fig. 2b) with those of *Timorites* sp. from Abadeh (Zhou et al., 1989, fig. 3a, b), it seems to be basicly in accordance with the arched trace of the suture, with nine more lateral lobes and the digit outline of both ventral prongs and the first lateral lobe. After restudy of specimen PIN 1425/194 in Moscow by Glenister and Zhou (in 1991, after the Perm conference), they all agreed that the simplified suture details probably resulted from abrasion of the specimen, while the 'tertiary subdivision' near the crest of first external lateral saddle in Zakharov's drawing was probably formed by secondary damage near the first lateral saddle. Actually, all the three specimens from Vedi, Armenia and Adadeh, Iran belong to the same species of *Timorites*, and according to the priority of ICZN Code, *T. ruzhencevi* (Zakharov, 1983a) would be reserved (Spinosa and Glenister, 2000).

Epadrianites is a very common component in the present zone, as well as in the Amarassi beds of Timor (Haniel, 1915), the *Araxoceras latissimum* Zone (Dzhulfian Stage) in Transcaucasia (Zakharov, 1983b, p. 152), the *Timorites* Zone in Coahuila, Mexico (Miller and Furnish, 1944, p. 97), the Langcuo (and Qianggong) Formation from the Indus-Yarlung Suture Zone, and the Upper Cephalopod Limestone (Wordian Age) in north Oman. Review of the type species *Epadrianites timorensis*, and two other related species, *E. involutus* (Haniel, 1915) and *E. kotljarae* (Zakharov, 1983a), reveals that they may belong to the same morphological group with fairly close relationship each other. The morphologies are so close that the last form from the Dzhulfian Transcaucasia was even thought to be the junior synonym of *E. involutus*. Irrespective of their taxonomic relationships, all the forms of the Amarassi beds, the Langcuo (and Qianggong) Formation, the Dzhulfian Stage of the Transcaucasia, and the Claystone (3rd) Member of the Shaiwa Formation of Nanpanjiang are within the same chronological interval, based on current knowledge.

As a eurytopic form, the genus *Stacheoceras* certainly exists in the present ammonoid zone. Among the total 46 species of the genus known, ranging from the Artinskian through the Changhsingian, about one-third (14 species) occur in the Capitanian Stage and the Lopingian Series

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biostratigraphically. Comparisons among these species show that *Stacheoceras shaiwaense* is closest to *S. toumanskaye* Miller and Furnish, 1940a from the Capitanian of La Difunta, Las Delicias, Coahuila in both morphology of individuals and composition of the assemblages, which is similar to the faunal composition from the two areas. It is also interesting that the present species and its whole assemblage are similar to the ammonoids from the Langcuo Formation in south Tibet (Sheng, 1988), in which the species *S. megamultidentatum* Sheng, 1988 shows close similarity to the species here in both the suture and conch shape.

There are three species of *Stacheoceras* from northeast Asia: *Stacheoceras orientale* Zakharov and Pavlov, 1986 from the bottom of the Lydianzin Formation; *S. iwaizakiense* Mabuti, 1935 from the lower part of the Suenosaki Formation (Lowermost Toyoman), southern Kitakami Massif in northeastern Japan (Ehiro and Bando, 1985); and *S. otomoi* Ehiro et al., 1986 from the basal part of the Toyama Formation on the north coast of Obama, Ogatsu District of South Kitakami. All of three species are associated with the *Timorites* and the Dzhulfian araxoceratids, and convincingly show the correlation between the Capitanian from North America and the Dzhulfian from the Tethys.

Two other potential zones.—A complete basinal sequence of Permian ammonoids still is missing two links in the present zonation in Nanpanjiang area: the *Cyclolobus-Xenodiscus-Episageceras* fauna above and the *Perrinites-Demarezites-Paraceltites-Daubichites* fauna below. The former is of Chhidruan/Changhsingian age, and the latter of Roadian age, both of which are expected to be found in the following two stratum intervals: the Calcirudite (4th) Member of the Shaiwa Formation, and the upper part of the Chongtou Member (Bed 17–26) of the Sidazhai Formation, respectively (Figs. 2, 6, 9). Supposedly, inadequate investigation is the only reason for their absence from the present basinal ammonoid zonal sequence in South China.

Shaiwa Formation with Guadalupian ammonoid sequence, but deposited within the Lopingian geological time frame—evidence from conodonts and others

The First (1st) Siliceous Rocks and Third (3rd) Claystone members of the Shaiwa Formation yielded Guadalupian ammonoid zones of definitively Guadalupian age, however, the formation was deposited in the geological interval between the Maokouan fusulinid-bearing limestone below and the lowest Triassic *Claraia-Ophiceras*-bearing Luolou Formation above, which is exactly the Lopingian Series, as acknowledged by most geologists, on various geological maps and publications, and including the updated "Permian System" in the Chinese Stratigraphic Lexicon (Jin et al., 2000). Such recognition upon the basinal ammonoid sequence definitely calls into question all the traditional time scales, even the most recent one (Shen et al., 2013).

Unfortunately, conodonts, which are the main biostratigraphic group, are not well known from the area, probably due to their sparse distribution and/or inadequate sampling. Therefore, records are available only from a few layers, but even these limited works are still helpful for establishing the age interpretation above.

Hao et al. (1999) first reported *Clarkina* cf. *C. guangyuanensis* (Dai et al., 1984), *Clarkina subcarinata* (Behnken, 1975), and *Xaniognathus* sp. from the calcarenite of the upper part of the Calcirudite (4th) Member of the Shaiwa Formation, which indicates a Changhsingian age. However, *Jingondolella aserrata* (Clark and Behnken, 1979) and *J. postserrata* (Behnken, 1975) from the biocalcarenite and the top calcirudite of the Chongtou Member of the Sidazhai Formation, respectively, indicate Wordian through earliest Capitanian age (Shen et al., 2013). The primary conodont sequence confirms a normal Capitanian through Changhsingian interval in the upper part of their Sidazhai section, albeit the real Wuchiapingian conodont record is absent.

Ji et al. (2009) reported the conodonts from the Claystone (3rd) Member, including *Sweetognathus inornatus* Ritter, 1986, *S. paraguizhouensis* Wang, Ritter, and Clark, 1987, and others. The authors pointed out that the range of *Sweetognathus inornatus* in North America may be Wordian through Capitanian, which appears to meet the age of the ammonoid sequence, whereas the *S. paraguizhouensis* seems questionable either in the identification or the occurrence. The Maokouan age of the fossil-bearing strata probably is assigned by cross-correlation with the traditional scheme.

Zeng and Yang (2014) studied Sidazhai and Shaiwa Formations of the Kecheng section in Zhengning County, ~43 km, 313°NW from the Shaiwa-Sidazhai general section (VI-VI") in Ziyun County, roughly along the regional structure strike. They reported that the Shaiwa Formation disconformably overlies the Emeishan Basalt and found the bottom conglomerate of the Shaiwa Formation from the opposite limb of the same anticline. It appears that the Shaiwa Formation should be of Late Permian age based on the presence of the basalt and the bottom conglomerate, both of which, as the series-boundary marker, are broadly distributed in the southwest Yangtze Croton (1) (Fig. 1). Additional evidence reported by Zheng and Yang (2014) include the conodonts *Jingondolella granti* (Mei and Wardlaw in Mei et al., 1994), and *Prioniodella ctenoides* Tatge, 1956 from the limestone immediately underlying the Lopingian bottom conglomerate, although there is dispute on the fossil identification (Shen, S.-Z., personal communication, 2016).

As early as the 1990s, Kozur (1992) reported that the Changhsingian conodonts *Clarkina* cf. *C. changxingensis* and *C. welcoxi* were present in the uppermost Altuda Formation of the latest Capitanian in the Glass Mountains of Texas, and confirmed the overlap between the Guadalupian and the Wuchiapingian (Zhou et al., 1989). However, Henderson and Mei (2003) maintained that *Clarkina* cf. *C. changxingensis* reported by Kozur (1992) is a homeomorphic form of *Jingondolella altudaensis* of the Capitanian, while the *Clarkina welcoxi* is *Jingondolella shannoni* Wardlaw, 1994.

Probably due to insufficienct parameters of shape and sculpture to serve as classification characters in the group, widespread homeomorphism was present in the conodonts (Henderson and May, 2003; Henderson et al., 2008). Nonetheless, it was reasonable to believe that Altuda Formation (Kozur, 1992) identifications were accurate given the ammonoid sequence (e.g., both *Clarkina* cf. *C. changxingensis* and

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C. welcoxi representing the real *Clarkina* rather than *Jingondolella*). Actually, there is a methodological problem of circular reasoning that is overtly employed with fossil identification based on stratigraphic occurrence in the Permian conodont study.

As Kozur (1995, p. 165) summarized, "Conodont provincialism is insignificant, but the facies control of conodonts may be considerable. Problem of conodont zonation are caused by migrations due to large scale facies changes, especially in the Middle Permian Guadalupian Series and at the Guadalupian-Lopingian boundary. Migration events of conodonts are not suitable for definitions of stage boundaries and large scale correlations because they are diachronous." In fact, there is not a believable conodont sequence that commonly occurs in both the Capitanian of North America and the "equivalent" Maokouan of South China. Perhaps future biostratigraphic correlations should give more attention to the index ammonoids, due to their abundant characteristic parameters exteriorly and traceable evolutionary progress interiorly.

Conclusions

This study provided the first systematically based Permian basinal ammonoid sequence, with six comparable pandemic zones, primarily from the well-correlated sections in the Nanpanjiang Basin (Figs. 2, 4–9). The six pandemic zone are, in descending order:

Zone 6. *Eoaraxoceras spinosai-Difuntites furnishi*	Capitanian
Zone 5. *Waagenoceras* sp.-*Propinacoceras beyrichi*	Wordian
Zone 4. *Metaperrinites shaiwaensis-Popanoceras ziyunense*	Kungurian
Zone 3. *Popanoceras kueichowense-Medlicottia orbignyanus*	Artinskian
Zone 2. *Svetlanoceras uraloceraformis-Prothalassoceras biforme*	Asselian–Sakmarian
Zone 1. *Properrinites gigantus-Svetlanoceras serpentinum*	Asselian

A remote intercontinental correlation between South China and North America/South Urals is therefore transformed into an intracontinental relationship between the basin and platform regions in a single South China Block (Figs. 1, 2, 9). Since the basinal Shaiwa Formation is essentially equal to the platform-based Lopingian Series, as stated in the previous section, the upper Guadalupian Series from North America, which characterized by the 6th and 5th Zones, overlaps the lower Lopingian Series of South China. Previous primary reports of the ammonoids of the 4th to 1st Zones from the basinal Sidazhai Formation and the upper Nandan Formation (Zhou, 1985–1986, 1987, 1988–1989; Zhou et al., 1989) had already helped to lower the bottom and the internal boundaries of the Permian in South China at 1–2 stages, respectively, in order to be in accordance with the international time scale (Jin et al., 2000; Shen et al., 2013). In other words, moving the Wuchiapingian down to the Guadalupian Series would be the last step in adjusting the Permian regional correlation scheme of the South China, and even the entire Tethys.

The major gap in the present study is the absence of the Chhidruan/Changhsingian *Cyclolobus-Xenodiscus-Episageceras* fauna above the 6th Zone and the Roadian *Perrinites-Demarezites-Paraceltites-Daubichites* fauna between the 5th and 4th Zones in the sequence. Additional investigation on ammonoids around the corresponding layers in the Nanpanjiang Basin possibly could connect these missing links.

Materials

Repository and institutional abbreviation.—All the specimens studied here are deposited in the Repository of Nanjing Institute of Geology and Paleontology, Chinese Academy of Sciences, #39 East Beijing Road, Nanjing, Jiangsu, P. R. China.

Systematic paleontology

Order Prolecanitida Miller and Furnish, 1954
Superfamily Prolecanitoidea Hyatt, 1884
Family Daraelitidae Chernov, 1907

Genus *Daraelites* Gemmellaro, 1887

Type species.—*Daraelites meeki* Gemmellaro, 1887; original designation; Sosio Limestone (Wordian), Sosio Valley, Sicily, Palermo, Italy.

Diagnosis.—Conch small (<5 cm diameter), discoidal (W/D, 0.35), evolute (Umin/D, 0.25 at 20 mm diameter). Suture characterized by ventral lobe twice width of lateral, serrate lobe bases from venter to mid flank, up to nine pairs of umbilically derived lobes (two pairs of which may be internal) separated by asymmetrical saddles. Sutural formula: $(V_2V_1V_2)$ $LUU^1U^2U^3U^5U^7{:}U^6U^4I(D_1D_1)$.

Occurrence.—Lower Permian (Asselian) to Middle Permian (Wordian); Italy (Sicily), Iraq (Kurdistan), Russia and Kazakhstan (South Urals), Indonesia (Timor), Tajikistan (Pamirs), Afghanistan, Canada (British Columbia), USA (West Texas, Nevada), and South China (southwest Guizhou and northeast Guangxi).

Remarks.—*Daraelites*, the most advanced representative of the family, is similar to *Boesites* in general conch form and sutural pattern, but the ventral lobe of *Daraelites* is twice as broad as the lateral lobe, quite different from *Boesites*, with equal or somewhat narrower width of the corresponding lobes.

Daraelites elegans Chernov, 1907
Figures 10.1–10.6, 11.5

1907 *Daraelites elegans* Chernov, p. 374, pl. 1, fig. 9.
1956 *Daraelites elegans*; Ruzhentsev, p. 80, pl. 1, figs. 1, 2.
1962 *Daraelites elegans*; Bogoslovskaia, p. 30, pl. 1, figs. 1, 2.

Description.—All internal molds, with well-preserved but incomplete sutures. Living chamber might be one volution long at least, based on specimen NIGP 88981 (Fig. 10.5). Conch discoidal, with fairly evolute umbilicus, about one fourth the conch (U/D, 0.25). No sculpture observed on molds. Ventral

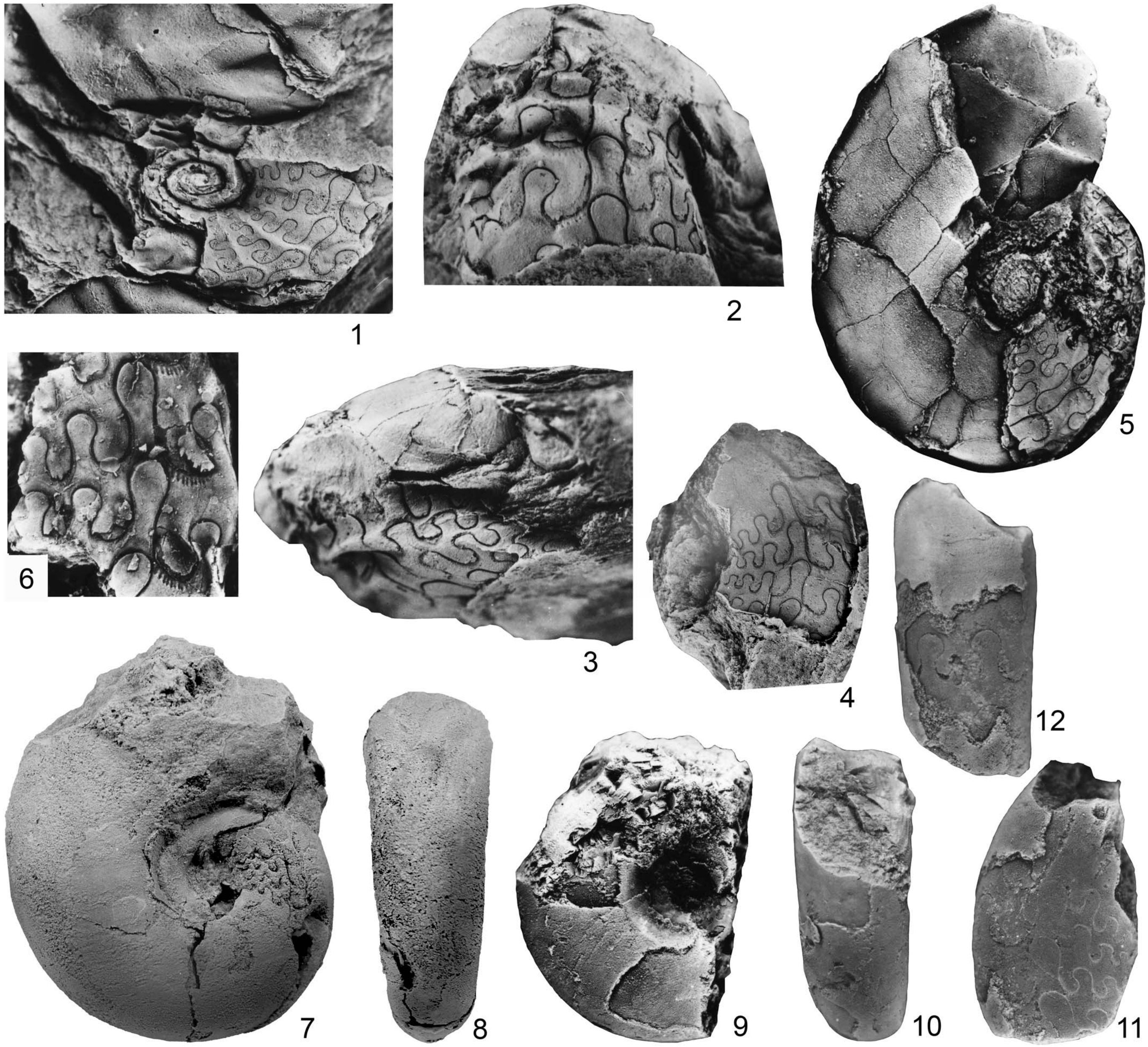

Figure 10. Daraelitids. (**1–6**) *Daraelites elegans* Chernov, 1907; (**1–4**) Longma Member, Sidazhai Formation, Mading (Loc. 6), Liuzhai, Nandan County, Guangxi; (**1**) lateral view, NIGP 93700, ×2.5; (**2, 3**) ventrolateral and lateral views, NIGP 93699, ×3; (**4**) lateral view, NIGP 93701, ×2; (**5, 6**) Bed 3, Longyin Formation, Longyin section (Sec. I), Pu'an, Guizhou; (**5**) lateral view, NIGP 88981, ×2; (**6**) lateral view, NIGP 88980, ×3 (specimen damaged by dehydrated shrinkage); (**7–12**) *Boesites intercalaris* Ruzhentsev, 1978, Asselian talus limestone, 2nd Member, Nandan Formation, Liuzhai Quarry (Loc. 5), Liuzhai, Nandan County, Guangxi (Zhou, 1987, p. 136); (**7, 8**) lateral and ventral views, NIGP 94453 (Zhou, 1987, pl. 1, figs. 9, 10), ×1.5; (**9, 10**) lateral and ventral views, NIGP 94454 (Zhou, 1987, pl. 2, figs. 4, 3), ×4; (**11, 12**) lateral and ventral views, NIGP 94455 (Zhou, 1987, pl. 2, figs. 1, 2), ×1.5.

lobe wide, more than twice the width of the lateral lobe. Medium tooth longer than the wide and shallow lateral subdivisions of the ventral lobe. Lateral and umbilical lobes asymmetrically club-shaped, the former large and curved ventrad; all the umbilically derived lobes curved toward the umbilicus and gradually decreasing in size. Irregularly small serrations appearing in base of the lateral subdivision of the ventral lobe, the lateral lobe, and the first several umbilical lobes.

Materials.—Five internal molds preserved in mudstone, representing five individuals, NIGP 88980, 88981, and 93699–93701.

Occurrence.—Bed 3, Longyin section (Sec. I), Pu'an County, Guizhou, and Longma Member, Sidazhai Formation, Mading (Loc. 6), Liuzhai, Nandan County, Guangxi.

Remarks.—The specimens here are identical with the type materials from Urals in overall conch shape and sutural pattern (e.g., U/D about 0.25 at diameter 25–30 mm), with the lowest middle tooth comparing to the lateral subdivisions of ventral lobe, and the more complicated serration continuously showing up to the third umbilical-derived lobe.

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Genus *Boesites* Miller and Furnish, 1940b

Type species.—*Daraelites texanus* Böse, 1919; original designation; Virgilian (Gzhelian) Gaptank Formation (Upper Pennsylvanian), Glass Mountains, Texas, USA.

Diagnosis.—Similar to *Daraelites*, but ventral and lateral lobes subequal, and with fewer umbilical lobes (5 or 6 pairs, one of which may be internal). Sutural formula: $(V_2V_1V_2)$ $LUU^1U^2U^3U^5{:}U^4I(D_1D_1)$.

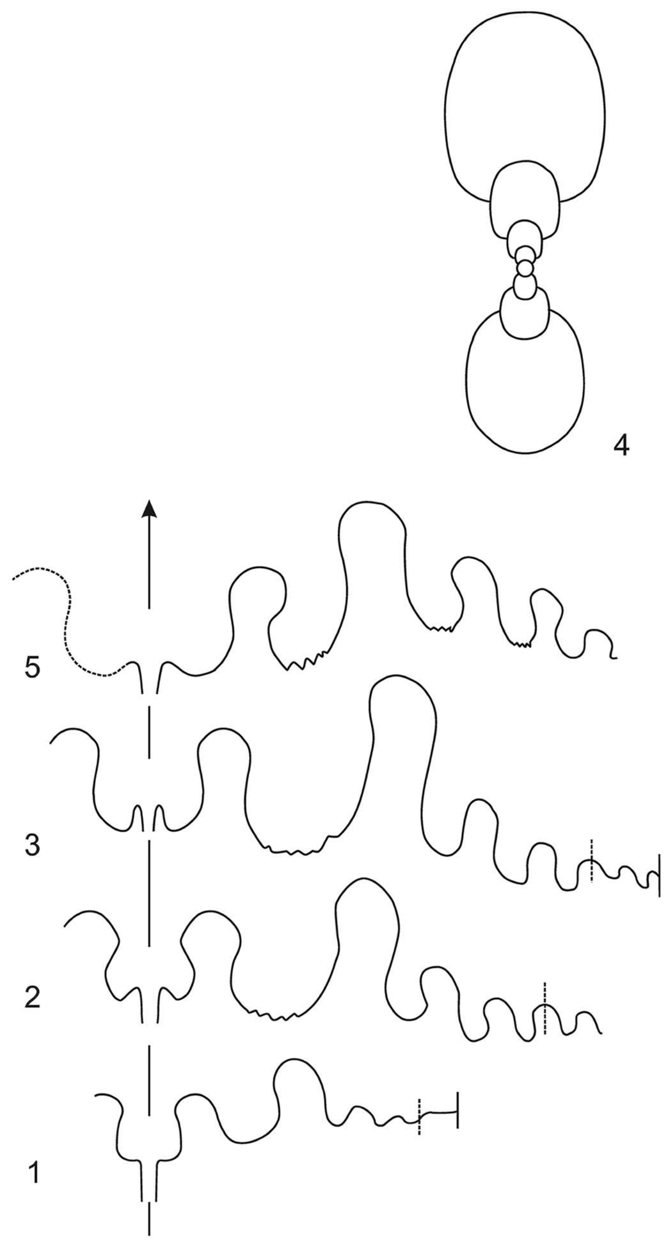

Figure 11. External sutures of daraelitids and cross-section of genus *Boesites* Miller and Furnish, 1940b. (**1–4**) *Boesites intercalaris* Ruzhentsev, 1978, Asselian talus limestone, 2nd Member, Nandan Formation, Liuzhai Quarry (Loc. 5), Liuzhai, Nandan County, Guangxi; (**1**) NIGP 94455, D 7.3 mm; (**2**) NIGP 94454, D ~12 mm; (**3**) NIGP 94453, D ~21 mm; (**4**) cross-section, NIGP 94458, D 13.9 mm. (**5**) *Daraelites elegans* Chernov, 1907, NIGP 93699, D ~15 mm; Longma Member, Sidazhai Formation, Mading (Loc. 6), Liuzhai, Nandan County, Guangxi.

Occurrence.—Pennsylvanian (Bashkirian) through Early Permian (Sakmarian); Russia and Kazakhstan (South Urals), USA (Texas, Oklahoma, Arkansas), Canada (Arctic Archipelago: Ellesmere Island), Spain (Cantabrian Mountains), Tajikistan (Pamirs), Uzbekistan (Fergana), Kyrgyzstan (Tian-Shan), South China (Guangxi), and Japan (SW Honshu).

Remarks.—*Boesites* is similar to *Daraelites*, actually in a transitional series in both suture and conch shape.

Boesites intercalaris Ruzhentsev, 1978
Figures 10.7–10.12, 11.1–11.4

1978 *Boesites intercalaris* Ruzentsev, p. 39, pl. 3, fig. 1.
1987 *Boesites intercalaris*; Zhou, p. 136, pl. 1, figs. 9, 10, pl. 2, figs. 1–10.

Description.—Specimen NIGP 94453 (Fig. 10.7, 10.8) with almost complete living chamber, 37.9 mm in diameter, representing the largest one known hitherto in the genus (Table 1). Conch usually discoidal and fairly evolute. Venter narrowly and flank broadly rounded; dorsum slightly depressed. Living chamber at least three-fourths of volution. Sculpture unknown.

Ventral lobe slightly narrower than lateral lobe in width, WV (width of ventral lobe)/WL (width of lateral lobe) 0.91–0.98, tripartite basally. Both lateral subdivisions shallow and rounded at base in adolescent, and slightly sharpened in adult, with straight ventral flank and gently curved dorsal flank, sometimes, with questionably incipient serration at the subdivision bottom. Middle tooth related with the siphon is long and narrow in shape, and intersected with the lateral subdivision at right angle in adolescent and at bluntly acute angle in adult. Lateral lobe club-shaped, with irregularly denticulated lobe bottom. Four or five pairs of umbilically derived lobes in external suture, decreasing in size dorsad.

Materials.—Six molds, NIGP 94453–94458, only NIGP 94453 shows a relatively well-preserved body chamber.

Occurrence.—Asselian talus limestone, 2nd Member, Nandan Formation, Liuzhai Quarry (Loc. 5), Liuzhai, Nandan County, Guangxi.

Remarks.—The present specimens were described as *Boesites intercalaris* Ruzhentsev (Zhou, 1987), due to the same WV/WL (~0.9), and the similar compressed whorl section with the Pamirs specimens. However, they still have some differences, such as, the oversized conch in the Guangxi specimen, reaching 37.9 mm in diameter, much larger than those from Pamirs. Additionally, the H/W ratios in the Pamirs specimens range

Table 1. Dimensions and ratios of *Boesites intercalis* Ruzhentsev, 1978. D, diameter of conch; W, width of conch; H, height of whorl; U, diameter of umbilicus.

Specimen	D (mm)	W/D	H/D	U/D	H/W
NIGP 94453	37.9	0.32	0.39	0.28	1.29
NIGP 94457	28.5	0.37	0.43	0.31	1.17

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from 1.16 to 1.21, obviously smaller than the 1.38 in the Guangxi specimen, so the sections look much wider than those from the Pamirs. Nevertheless, these differences in conch shape are still thought as an intraspecific variation.

Superfamily Medlicottioidea Karpinskii, 1889
Family Pronoritidae Frech, 1901
Subfamily Pronoritinae Frech, 1901

Genus *Metapronorites* Librovich, 1938

Type species.—*Pronorites uralensis* var. *timorensis* Haniel, 1915; original designation; Somohole and Bitauni beds (Cisuralian), Timor, Indonesia.

Diagnosis.—Conch discoidal, moderately evolute (U/D, commonly 0.1), with flat flanks and rounded to flat venter. Characterized by suture with 26–32 lobes, including 7–9 pairs of external, umbilically derived lobes and 3–5 pairs of internal umbilicals. Sutural formula: $(V_2V_1V_2)(L_1L_1)UU^1U^2U^4U^6U^8U^{10}.....U^9U^7U^5U^3ID$. Saddle separating two prongs of external lateral lobe unconstricted, low, with strongly divergent flanks. Either prong of lateral lobe may be denticulate, as many adjacent primary umbilical lobe.

Occurrence.—Pennsylvanian (Moscovian) through Permian (Artinskian); Kazakhstan (South Urals), Russia (South Urals, north Verkhoyan, Moscow Basin), Tajikistan (Pamirs), Indonesia (Timor), USA (Texas, ?Arkansas), Canada (Yukon, Artic Archipelago), Austria (Carnic Alps), and China (Guangxi).

Remarks.—*Metapronorites* differs from *Stenopronorites* by possessing more umbilical lobes (7–9 instead of 5–6 pairs of external umbilical lobes), and sometimes by serration of lobe bases. The genus differs from *Neopronorites* by possessing a more primitive suture: the undivided dorsal lobe, and the entirely simple prongs of the wide lateral lobe and the entirely simple, umbilically derived lobes.

Metapronorites timorensis (Haniel, 1915)
Figures 12.10–12.18, 13.1, 13.2

1915 *Pronorites uralensis* var. *timorensis* Haniel, p. 25, pl. 46, figs. 1–5.
1927 *Pronorites timorensis*; Smith, p. 13, pl. 10, figs. 1–15.
1938 *Metapronorites timorensis*; Librovich, p. 82.
1987 *Metapronorites timorensis*; Zhou, p. 134, pl. 1, figs. 1–8, pl. 2, figs. 11, 12.

Description.—Conch large, discoidal, involute, and smooth superficially. Venter rounded; flank flat, broad, nearly parallel each other. Umbilicus small, with steep wall and rounded lateral-umbilical shoulder (Table 2). Ventral lobe trifid, more than one-half width of the lateral lobe. Lateral lobe divided by an equilaterally triangular median saddle. Prong undivided, with sharp base. External umbilically derived lobes undivided, as many as eight or nine in number, all with asymmetrically lanceolate shape.

Materials.—Four specimens, with different completeness, preserved in limestone, NIGP 88963–88966.

Occurrence.—Occurs in the 2nd and 3rd members, Nandan Formation, Meyao section (Sec. V), Liuzhai, Nandan County, Guangxi.

Remarks.—*Metapronorites timorensis* specimens are closely similar to the type specimens from Timor in both conch shape and sutural characters. The same forms also have been described from the Asselian talus limestone, 2nd Member, Nandan Formation, the Liuzhai Quarry (Loc. 5) (Zhou, 1987, p. 134, pl. 1, figs. 1–8, pl. 2, figs 11, 12).

Metapronorites timorensis from the Pamirs generally are the same forms with almost the same conch shape and suture, except the bidentate ventrad prong of the lateral lobe (see Ruzhentsev, 1978). However, the difference in lobe base might be only the result of intraspecific variation. Generally, the present species is characterized by eight or nine umbilically derived lobes, instead of seven lobes of the other species from Russia and North America.

Subfamily Neopronoritinae Weyer, 1972

Genus *Neopronorites* Ruzhentsev, 1936a

Type species.—*Parapronorites permicus* Chernov, 1907; original designation; upper Artinskian Stage, Us'va River, South Urals, Russia.

Diagnosis.—Neopronoritins characterized by irregular serration in prongs of mature external lateral lobe and one to three adjacent umbilical lobes. Dorsal and adjacent internal lobes bidentate. Seven or eight pairs of umbilically derived lobes in external suture, one-half as many internally. Sutural formula: $(V_2V_1V_2)(L_1L_1)UU^1U^2U^4U^6U^8.....U^7U^5U^3I(D_1D_1)$.

Occurrence.—Pennsylvanian (Gzhelian) through Permian (Kungurian); Kazakhstan (South Urals), Russia (Urals, Verkhoyan), Tajikistan (Pamirs), China (Guangxi, Guizhou, Xinjiang, Xizang, Gansu), Indonesia (Timor), Thailand (Loei), USA (Texas), and Canada (Ellesmere Island).

Remarks.—*Neopronorites* resembles *Parapronorites* by the general conch form and bidentate dorsal lobe in internal suture,

Figure 12. *Neopronorites* Ruzhentsev, 1936a and *Metapronorites* Librovich, 1938. (**1–8**) *Neopronorites leonovae* n. sp., Nandan Formation, Meyao section (Sec. V), Liuzhai, Nandan County, Guangxi, ×2.5; (**1, 2**) ventral and lateral views, NIGP 88967, holotype, Bed 19, 2nd Member; (**3, 4**) apertural and lateral views, NIGP 88968, Bed 19, 2nd Member; (**5, 6**) lateral and ventral views, NIGP 88969, Bed 26, 3rd Member; (**7, 8**) lateral and ventral views, NIGP 88970, Bed 19, 2nd Member; (**9**) *Neopronorites* cf. *N. darvasicus* Leonova, 1988, lateral view, NIGP 93663, ×2, beds 19–17, Longyin Formation, Huagong section (Sec. II), Huagong Tea-Plantation, Qinglong County, Guizhou; (**10–18**) *Metapronorites timorensis* (Haniel, 1915), Nandan Formation, Meyao section (Sec. V), Liuzhai, Nandan County, Guangxi; (**10, 11**) NIGP 88965, lateral and ventral views, ×1.5, Bed 19, 2nd Member; (**12–18**) Bed 26, 3rd Member; (**12–14**) lateral, apertural, and ventral views, ×1.5, NIGP 88966; (**15, 16**) ventral and lateral views, ×1.5, NIGP 88964; (**17, 18**) lateral and ventral views, ×1, NIGP 88963.

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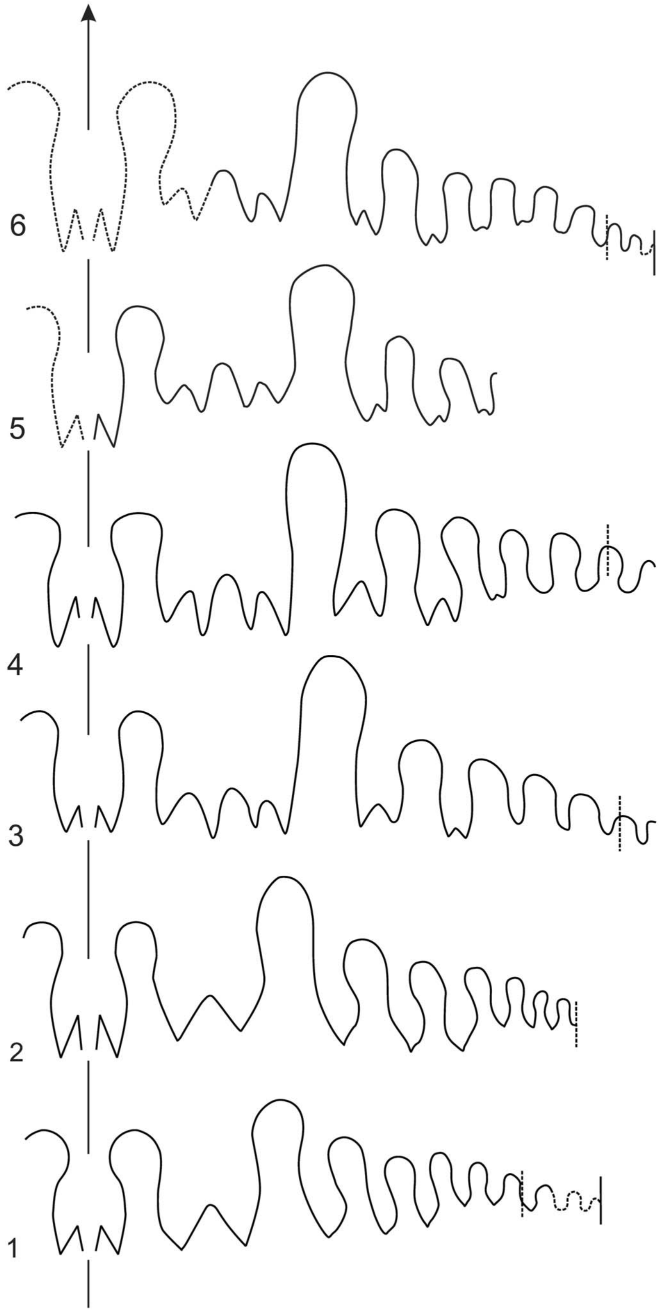

Figure 13. External sutures of *Metapronorites* Librovich, 1938 and *Parapronorites* Gemmellaro, 1887. (**1, 2**) *Metapronorites timorensis* (Haniel, 1915), Nandan Formation, Meyao section (Sec. V), Liuzhai, Nandan County, Guangxi; (**1**) NIGP 88965, Bed 19, 2nd Member, D 28 mm; (**2**) NIGP 88963, Bed 26, 3rd Member, D 55 mm; (**3, 4**) *Parapronorites timorensis* Haniel, 1915; (**3**) NIGP 88962, D 22 mm, 'Chihsia' Limestone, Tian'e suburb (Loc. 7), north of Hongshuihe River, Tian'e County, Guangxi; (**4**) NIGP 93654, D 30 mm, Bed 12, Chongtou Member, Sidazhai Formation, Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou; (**5, 6**) *Parapronorites* cf. *P. lectus* Leonova, 1989; (**5**) NIGP 88971, D ~20 mm, beds 34–32, Yangchang Formation, Yangchang section (Sec. III), Ziyun County, Guizhou; (**6**) NIGP 93657, D 26 mm, Longma Member, Sidazhai Formation, Mading (Loc. 6), Liuzhai, Nandan County, Guangxi.

but is dinstinguised from the latter by the flat venter, more numerous external umbilically derived lobes, and the irregularly secondary serration of the lateral lobe.

Neopronorites represents a special genus with probable progenesis in genetic evolution. The earlier representatives of the genus are characterized by irregular serration of prongs of the large lateral lobe and several adjacent umbilically derived lobes; whereas the later forms by the shallower lateral lobe, absence of serrations, and obvious reduction in conch size. The evolutionary tendency of the genus had been summarized as 'regressive' evolution in paedomorphic suture and smaller conch size since the later Artinskian (Ruzhentsev, 1949, p. 90; Leonova, 1988, p. 106, 2002, p. S17). Of the fourteen total species, ten occur from the Pennsylvanian through Sakmarian, with only four ranging from Artinskian through Kungurian. Species in the first group usually have larger conch sizes with stronger serration in lobe base; whereas the second group, in contrast, has smaller conch sizes with simpler digits in lobe base.

Table 2. Dimensions and conch ratios of *Metapronorites timorensis* (Haniel, 1915). D, diameter of conch; W, width of conch; H, height of whorl; U, diameter of umbilicus.

Specimen	D (mm)	W/D	H/D	U/D	H/W
NIGP 88966	~62.0	~0.38	~0.53	~0.12	~1.37
NIGP 88963	55.0	0.34	0.54	0.10	1.60
NIGP 88965	~37.8	~0.38	~0.53	~0.12	1.39

Neopronorites leonovae new species
Figures 12.1–12.8, 14.2–14.5

Diagnosis.—Species with very short lateral lobe and six umbilically derived lobes in external suture.

Description.—Conch discoidal and small, ranging from 20 to 30 mm in diameter. Venter flat with obvious ventrolateral shoulder; flanks nearly flat. Umbilicus moderate in size, U/D ranging from 1/5 to 1/4, with obvious umbilical shoulder and steep wall (Table 3). Sutures characterized by a large, shallow lateral lobe, with as many as six pairs of umbilically derived lobes. The digitations of the lobe bases vary ontogenetically, revealing an increase in the number of bidentate umbilical lobes.

Etymology.—Named in honor of Professor T.B. Leonova of the Borissiak Paleontological Institute, Russian Academy of Sciences.

Materials.—Four phragmocones from silicified limestone, NIGP 88967 (holotype) and NIGP 88968–88970.

Occurrence.—Bed 19, 2nd Member and Bed 26, 3rd Member, Nandan Formation, Meyao section (Sec. V), Liuzhai, Nandan County, Guangxi.

Remarks.—All four specimens from northwest Guangxi assigned to *Neopronorites* are characterized by a flat venter, smaller number of umbilical lobes, and irregular secondary serration of the lateral lobe and first one or two umbilical lobes. Taken together, these features could not be referred to any of the preexisting species of the genus. *Neopronorites leonovae* n. sp. resembles *N. asianus* Leonova, 1988 in the basic outline of the suture, short lateral lobe, and six pairs of umbilical lobes; however, it has a larger conch size, much narrower ventrolateral and first lateral saddles, and is more strongly bidentate in the first two umbilical lobes. *Neopronorites leonovae* n. sp. resembles *N. darvasicus* Leonova, 1988 in both conch size and the

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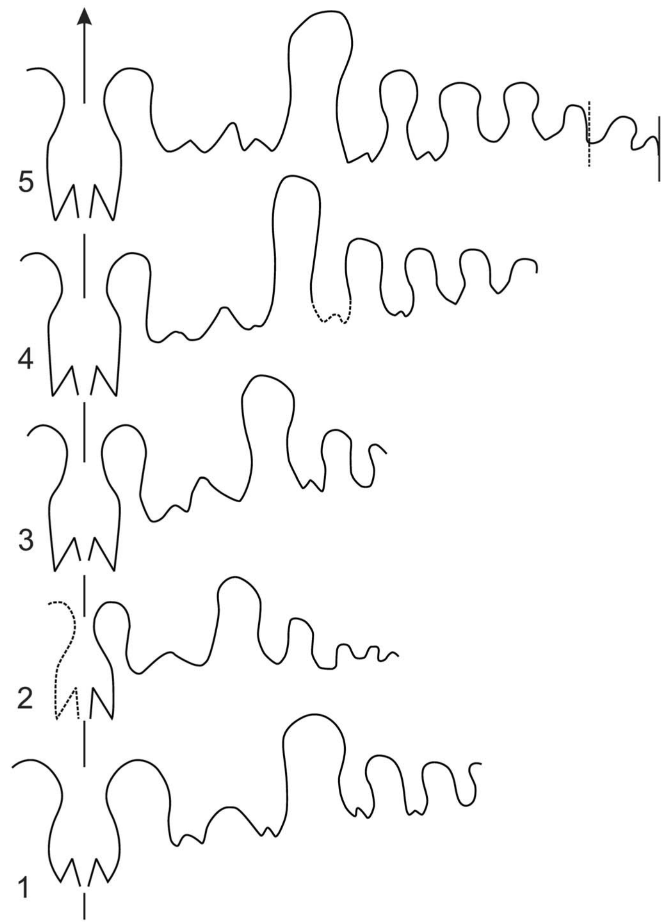

Figure 14. External sutures of *Neopronorites* Ruzhentsev, 1936a. (**1**) *Neopronorites* cf. *N. darvasicus* Leonova, 1988, NIGP 93663, D 20 mm, beds 19–17, Longyin Formation, Huagong section (Sec. II), Huagong Tea-Plantation, Qinglong County, Guizhou; (**2–5**) *Neopronorites leonovae* n. sp., Nandan Formation, Meyao section (Sec. V), Liuzhai, Nandan County, Guangxi; (**2**) NIGP 88970, D 13 mm, Bed 19, 2nd Member; (**3**) NIGP 88968, D 15 mm, Bed 19, 2nd Member; (**4**) NIGP 88969, D 18 mm, Bed 26, 3rd Member; (**5**) NIGP 88967, holotype, D 22 mm, Bed 19, 2nd Member.

Table 3. Dimensions and ratios of *Neopronorites leonovae* n. sp. D, diameter of conch; W, width of conch; H, height of whorl; U, diameter of umbilicus.

Specimen	D (mm)	W/D	H/D	U/D	H/W
NIGP 88967	23.6	0.36	0.50	0.21	1.39
NIGP 88969	22.6	0.35	—	—	—
NIGP 88968	20.8	0.34	0.43	0.24	1.26
NIGP 88970	20.2	0.33	0.42	0.24	1.27

serration of lobes, but has a much shorter lateral lobe and relatively narrower ventrolateral and first lateral saddles. The new species is similar to *N. permicus* (Chernov, 1907) in possessing a large conch size and six pairs of umbilically derived lobes; however, its lateral lobe is much shorter and the ventrolateral and the first lateral saddle relatively narrower.

Neopronorites cf. *N. darvasicus* Leonova, 1988
Figures 12.9, 14.1

1988 *Neopronorites darvasicus* Leonova, p. 107.
2004 *Neopronorites* cf. *darvasicus*; Zhou and Liengjarern, p. 322, figs. 6.1, 6.2, 7.1–7.4.

Description.—Conch poorly preserved in mudstone, partially exposed. By estimate, the flat discoidal phragmocone may reach 16–18 mm in diameter. Lateral lobe short and bifid, prongs of which are secondarily bidentate. Ventrolateral and first lateral saddles broad with rounded top. First three umbilical lobes bidentate.

Materials.—One specimen, NIGP 93663.

Occurrence.—Beds 19–17, Longyin Formation, Huagong section (Sec. II), Huagong Tea-Plantation, Qinglong County, Guizhou.

Remarks.—The specimen resembles types of the Darvas species in sutural details, shorter lateral lobe, and being bidentate both in the prongs of the lateral lobe and the first two umbilically derived lobes. Inadequate material prevents accurate identification. Generally, the specimen here is quite different from the others in the genus by the shorter lateral lobe and absence of irregular serrations at prong and lobe bases.

Genus *Parapronorites* Gemmellaro, 1887

Type species.—*Parapronorites konincki* Gemmellaro, 1887; original designation; Sosio Limestone (Wordian), Sosio Valley, Sicily, Palermo, Italy.

Diagnosis.—Advanced neopronoritins characterized by subequal bidentition of both prongs of external lateral lobe; ventral four to virtually all eight adjacent umbilically derived lobe pairs also bidentate. Internal suture inadequately known (except for *P. rectus* Leonova in Leonova and Dmitriev, 1989), but mature D and I probably bidentate throughout, and umbilical elements simple and number one or two fewer than in external suture.

Occurrence.—Sakmarian through Wordian Stage; Ukraine (Crimea), Tajikistan (Pamirs), Russia (South Urals), Italy (Sicily), Indonesia (Timor), north Oman, Thailand (Muak Lek), and China (Xizang, Xinjiang, Guangxi, and Guizhou).

Remarks.—In general conch shape and suture, *Parapronorites* is most similar to *Neopronorites* in the subfamily, but obviously distinct from the latter by its flatter venter and absence of irregular serration in prongs of mature external lateral lobe and the adjacent umbilically derived lobes. Internal suture with bidentate D and I_1 in maturity (Leonova, 1989).

Parapronorites timorensis Haniel, 1915
Figures 13.3, 13.4, 15.1–15.18

1915 *Parapronorites konincki* var. *timorensis* Haniel, p. 29, pl. 46, figs. 8–11.
1927 *Parapronorites timorensis*; Smith, pl. 10, figs. 16–19.
1983 *Parapronorites* cf. *timorensis*; Sheng and Liu, p. 239, pl. 20, figs. 1a, b.
1988 *Parapronorites timorensis*; Zhou, p. 381, pl. 2, figs. 1–4.

Description.—Conch discoidal and involute, with narrow and rounded venter and flat flanks. Umbilicus slightly wider (Table 4).

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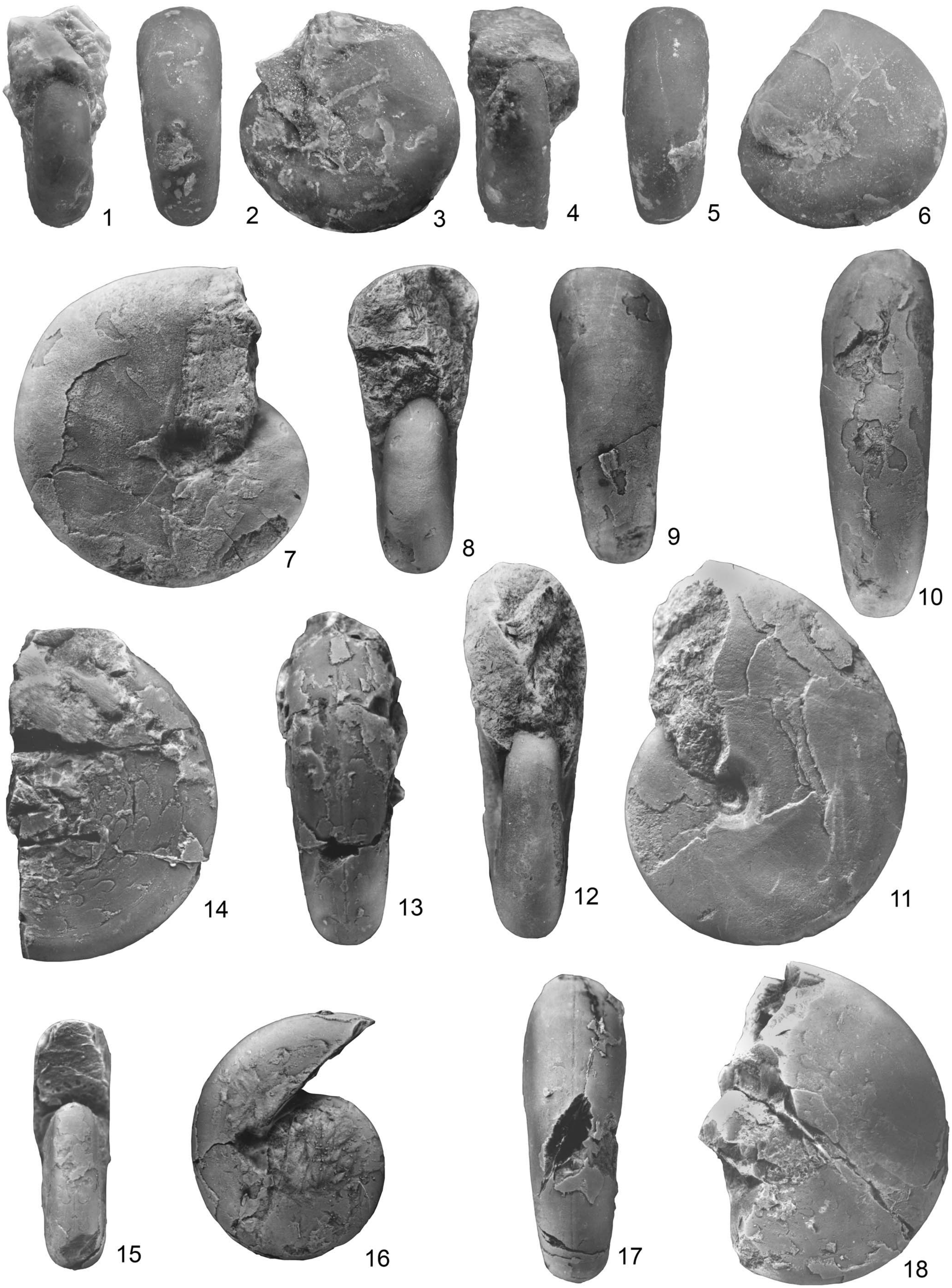

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Table 4. Dimensions and ratios of *Parapronorites timorensis* Haniel, 1915. D, diameter of conch; W, width of conch; H, height of whorl; U, diameter of umbilicus.

Specimen	D (mm)	W/D	H/D	U/D	H/W
NIGP 93656	15.5	0.37	—	—	—
NIGP 154096	15.9	0.32	0.53	—	1.66
NIGP 154097	16	0.38	0.66	—	1.74
NIGP 93655	30.0	0.33	0.48	0.16	1.45
NIGP 93654	37.2	0.34	0.54	0.15	1.59
NIGP 88961	38.4	0.40	0.53	0.17	1.33
NIGP 88962	42.7	0.32	0.55	0.14	1.57

Lateral lobe broad and bipartite, prongs of which and the next two or three umbilically derived lobes strongly bidentate. Outer saddle much lower and narrower than first lateral saddle, while somewhat similar to second one in shape.

Materials.—Seven specimens, rather well preserved from limestone, NIGP 88961, 88962, 93654–93656, 154096, and 154097.

Occurrence.—Bed 12, Chongtou Member, Sidazhai Formation, Shaiwa section (Sec. IV-IV'), Shaiwa, Sidazhai, Ziyun County, Guizhou; 'Chihsia' Limestone, Tian'e suburb (Loc. 7), north of Hongshuihe River, Tian'e County, Guangxi.

Remarks.—The present species may represent the primitive form in the genus, with simple bidentate prongs of the lateral lobe and the next two or three umbilically derived lobes. Specimens here have the same conch shape and general characteristics in suture as the holotype from Timor, except the ventral lobe seems slightly narrower and obviously constricted adorally and the ventral median saddle much more advanced ontogenetically. However, all these differences might be the result of intraspecific variation. Because the living chamber is fully intact in most cases, the ammonoids are supposed to have stayed here (i.e., autochthonous).

Parapronorites cf. *P. rectus* Leonova, 1989
Figures 13.5, 13.6, 16.1–16.5

1960 *Parapronorites timorensis*; Ruzhentsev, fig. 61.
1963 *Parapronorites timorensis*; Toumanskaya, p. 94, pl. 22, figs. 1–3.
1963 ?*Parapronorites timorensis*; Toumanskaya, p. 95, pl. 22, figs. 6, 7.
1989 *Parapronorites rectus* Leonova, p. 81, pl. 1, figs. 3–5.
2004 *Parapronorites rectus*; Zhou and Liengjarern, p. 324, figs. 6.3, 8.1.

Description.—Specimens somewhat deformed during preservation, but basically recognizable to be forms of smooth surface, flat flanks, rounded venter, and small umbilicus, with rounded umbilical shoulder. Diameter of specimen NIGP 93658 may reach to ~40 mm, while the umbilicus may be as small as one fifth of the conch (W/D, 0.14). Venter not exposed in all specimens, width of conch unknown. Suture not completely exposed, but clearly shows the wide lateral lobe and eight umbilically derived lobes beyond the umbilical seam. Wide lateral lobe subdivided by a small and low saddle into two bidentate prongs. The adjacent four umbilical lobes are bidentate.

Materials.—Five specimens, NIGP 88971, 88972, 93657–93659.

Occurrence.—Bed 6, lower Gaijiao Member, Sidazhai Formation, Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou; and beds 34–32, lower part of Yangchang Formation, Yangchang section (Sec. III), Ziyun County, Guizhou, and Longma Member, Sidazhai Formation, Mading (Loc. 6), Liuzhai, Nandan County, Guangxi. The species may range from Artinskian through Kungurian in age; however, additional sampling needs to be done in order to have more exact identification.

Remarks.—Although the conch shape is not precisely described owing to poor preservation, the well-preserved part of the external suture of NIGP 93657 (Fig. 16.1) is useful for specific identification. As many as four adjacent umbilically derived lobes are relatively coincident with the type specimens of *Parapronorites rectus* Leonova, 1989 (p. 81, pl. 1, figs. 3–5, text-fig. 25a) and the plesiotype from Thailand (Zhou and Liengjarern, 2004, p. 324, figs. 6.3, 8.1). The specimens have some similarity to *P. timorensis* Haniel, 1915 from Timor in conch shape and generality of external suture; however, they possess four bidentate umbilically derived lobes, while only two occur in the latter.

Family Medlicottidae Karpinskii, 1889

Remarks.—All juveniles of medlicottids possess evolute conch forms, without exception.

Subfamily Propinacoceratinae Plummer and Scott, 1937

Genus *Propinacoceras* Gemmellaro, 1887

Type species.—*Propinacoceras beyrichi* Gemmellaro, 1887; subsequent designation by Diener, 1912; Sosio Limestone (Wordian), Sosio Valley, Sicily, Palermo, Italy.

Diagnosis.—Conch large (diameter to 20 cm) with strong ventral ribs or nodes separated by median furrow. Suture characterized by undivided ventral flank of ventrolateral saddle and by dorsal subdivision of primary external lateral lobe ($L_{1(d)}$) that is less than one-half size of adjacent primary umbilical lobe. Sutural formula: $(V^2V^1V^2)s^1s^1L_{1(d)}UU^1U^2$......

Occurrence.—Sakmarian through Wordian; Italy (Sicily), Croatia, Iraq (Kurdistan), Oman, Russia and Kazakhstan (South

Figure 15. *Parapronorites timorensis* Haniel, 1915. (**1–12**) 'Chihsia' Limestone, Tian'e suburb (Loc. 7), north of Hongshuihe River, Tian'e County, Guangxi; (**1–3**) apertural, ventral, and lateral views, NIGP 154096, ×2.5; (**4–6**) apertural, ventral, and lateral views, NIGP 154097, ×2.5; (**7–9**) lateral, apertural, and ventral views, NIGP 88961, ×1.5; (**10–12**) ventral, lateral, and apertural views, NIGP 88962, ×1.5; (**13–18**) Bed 12, Chongtou Member, Sidazhai Formation, Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou; (**13, 14**) ventral and lateral views, NIGP 93655, ×2.0; (**15, 16**) apertural and lateral views, NIGP 93656, ×2.5; (**17, 18**) ventral and lateral views, NIGP 93654, ×1.5.

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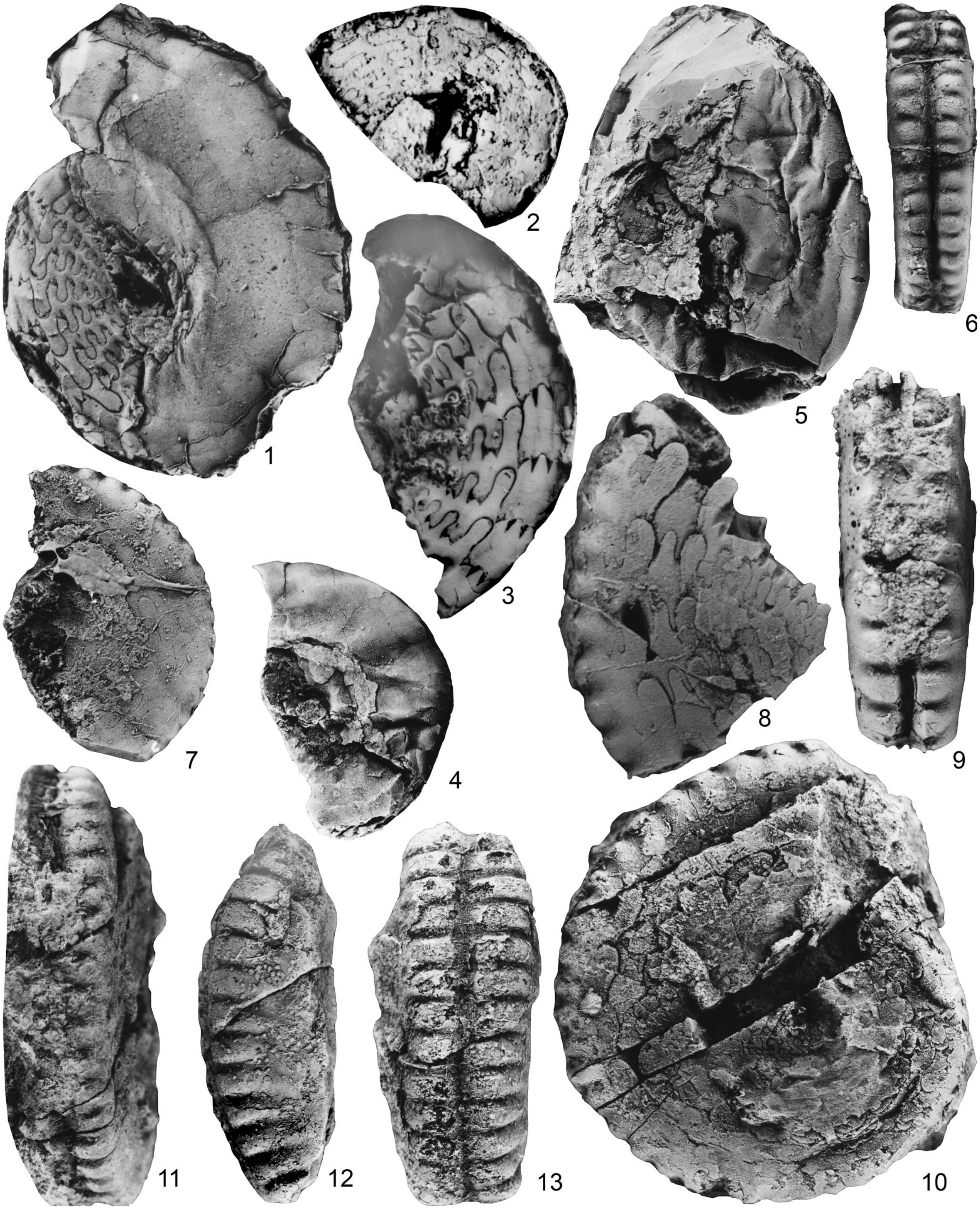

Figure 16. *Parapronorites* Gemmellaro, 1887 and *Propinacoceras*, Gemmellaro, 1887. (**1–5**) *Parapronorites* cf. *P. rectus* Leonova, 1989; (**1**) lateral view, NIGP 93657, ×2.5, Longma Member, Sidazhai Formation, Mading (Loc. 6), Liuzhai, Nandan County, Guangxi; (**2, 3**) beds 34–32, Yangchang Formation, Yangchang section (Sec. III), Ziyun County, Guizhou; (**2**) lateral view, NIGP 88972, ×4.0; (**3**) lateral view, NIGP 88971, ×3.0; (**4, 5**) lateral views, Bed 6, Gaijiao Member, Sidazhai Formation, Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou, ×1.5; (**4**) NIGP 93659; (**5**) NIGP 93658; (**6–13**) *Propinacoceras beyrichi* Gemmellaro, 1887, the ammonoid-bearing claystone intercalated in Member XII, upper Houziguan Formation, Kabi (Loc. 3), Houchang, Ziyun County, Guizhou; (**6, 7**) ventral and lateral views, NIGP 93667, ×3; (**8, 9**) lateral and ventral views, NIGP 93665, ×3; (**10, 11**) lateral and ventral views, NIGP 93664, ×2; (**12, 13**) lateral and ventral views, NIGP 93666, ×1.5.

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Urals), Tajikistan (Pamirs), Afghanistan, Ukraine (Crimea), China (Xizang, Xinjiang, Guizhou, Guangxi, Jilin, Gansu), Mexico (Coahuila), Indonesia (Timor), USA (Texas), Japan (Kitakami Massif), and Canada (British Columbia).

Remarks.—Ruzhentsev (1949, 1956) divided the species of *Propinacoceras* into three groups based on subdivision of the ventrolateral saddle: (1) *Propinacoceras aktubense* Ruzhentsev, 1939a; (2) *Propinacoceras knighti* Miller and Furnish, 1940a; and (3) *Propinacoceras beyrichi* Gemmellaro, 1887.

The *P. knighti* group is remarkably different from the other two in having apical and lateral adventitious lobules. Leonova (1989) reassigned four species of the group (*P. knighti* Miller and Furnish, 1940a, *P. bornemani* Toumanskaya, 1937, *P. australe* Teichert, 1942, and *P. simile* Haniel, 1915) to the genus *Bamyaniceras* Termier and Termier, 1970, and preserved the genus *Propinacoceras* only for the first and the third groups. The apical lobules of *Propinacoceras* might be designated as s^1s^1. The ventrad and/or dorsad branch, s^1, might be further subdivided into $s^{1.1}s^{1.1}$. Sometimes, only the dorsad s^1 might be modified in shape and/or somewhat bidentate at lobule base. All variations may serve as a taxonomic basis at the species level.

Comparing with *Miklukhoceras*, the present genus possesses a much smaller and shorter lateral lobe ($L_{1(d)}$). Conch form and sutural generality of *Propinacoceras* are very similar to *Difuntites*; but the latter, as a paedomorphic genus, is characterized by much smaller conch size, with wider venter and much broader and deeper lateral lobe ($L_{1(d)}$).

Propinacoceras beyrichi Gemmellaro, 1887
Figures 16.6–16.13, 18.1

1887 *Propinacoceras beyrichi* Gemmellaro, p. 56, pl. 5, figs. 12–15, pl. 7.
1933 *Propinacoceras americanum* Miller and Warren, p. 297, figs. 1–3.
1935 *Propinacoceras beyrichi*; Greco, p. 178, pl. 15, fig. 5.
1940a *Propinacoceras beyrichi*; Miller and Furnish, p. 40, pl. 5, fig. 5.
1972 *Propinacoceras beyrichi*; Termier et al., p. 109, pl. 14, figs. 1, 2.
1977 *Propinacoceras beyrichi*; Nassichuk, p. 564, pl. 1, figs. 1–3.
1982 *Propinacoceras affine* Gemmellaro; Liang, p. 647, pl. 2, figs. 1, 2.
1983 *Propinacoceras* cf. *beyrichi* Gemmellaro; Sheng and Liu, p. 241, pl. 20, figs. 3–6.

Description.—Conch involute and thickly discoidal, with flat flanks and nearly flat venter. As shown by phragmoconch NIGP 93664 (Fig. 16.10, 16.11), may reach ~38 mm diameter and ~11.5 mm width. Ventral ribs very strong with flattened crest and narrower interspace (about 2/5 rib width), ventral rib rows separated by a strong median furrow. Ventral lobe narrow, ventrolateral saddle broad, with two nearly equidimensional lobules (s^1s^1) on the crest. The lateral lobe $L_{1(d)}$ small and bidentate. The primary umbilical lobe (U) suddenly enlarged in size more than the lateral lobe ahead and the other umbilically derived lobes behind. The primary umbilical lobe and following first four umbically derived lobes bidentate. Dorsal subdivision of the primary external lateral lobe ($L_{1(d)}$) obviously less than one-half of the adjacent primary umbilical lobe.

Materials.—Four specimens, NIGP 93664–93667, inner mold in mudstone, representing four individuals.

Occurrence.—The ammonoid-bearing claystone intercalated in Member XII, top of the Houziguan Formation, Kabi (Loc. 3), Houchang, Ziyun County, Guizhou.

Remarks.—Specimens here possess two lobules (s^1s^1) on crest of ventrolateral saddle, a large-sized umbilical lobe (U) with strongly bidentate and broader venter with strong ribs. All features are exactly identical to the holotype. There somewhat similarity to *Propinacoceras affine* Gemmellaro, 1887 in conch shape and simple subdivision of ventrolateral saddle with two lobules (s^1s^1); however, *P. affine* has smaller size, different node arrangement on ventrolateral rims, and narrower ventrolateral saddle. According to Gemmellaro (1887), syntypes of *P. affine* have diameters of 17.0 mm at most; whereas *P. beyrichi* Gemmellaro have diameters of at least 22.0 mm, ranging up to more than 50.0 mm.

Termier et al. (1972) considered *P. affine* as the synonym of *P. beyrichi* by ignoring the classification significance of conch size. The present study maintains both as independent taxa by emphasizing the different arrangement of nodes on the ventrolateral shoulder and the different width of the ventrolateral saddle. However, *P. affine* described by Liang (1981) from central Jilin has such a large size, 32 mm in diameter, with parallel arrangement of nodes in both shoulders and fairly wider ventrolateral saddle, that it has to be a real *P. beyrichi* from Northeast China.

The suture and conch of *Propinacoceras americanum* Miller and Warren, 1933 (p. 297, figs. 3, 4) are closely similar to the present species. Nassichuk (1977) mentioned these similarities between Timor and America species, and treated *P. americanum* as a junior synonymy of the present species. Actually, the small difference in the height of the dorsal half of the external saddle in specimens from Sicily and America possibly reflects ontogenetic development or/and preservation. The suture in Nassichuk (1977, text-fig. 2) was exactly cited from Miller and Warren (1933, fig. 4), which was drawn based on the specimen from Sicily, but not based on the specimen (UA type 139) from North America, as stated in the figure caption.

Six specimens from the Jiala Formation of Tibet had been compared by Sheng and Liu (1983) to the Sicilian types of *Propinacoceras beyrichi*. Based on the illustrated details of conch form and suture, they are exactly conspecific.

Propinacoceras toumanskayae Leonova, 1989
Figures 17.1–17.3, 18.2

1989 *Propinacoceras toumanskayae* Leonova, p. 85, pl. 2, figs. 1–4.

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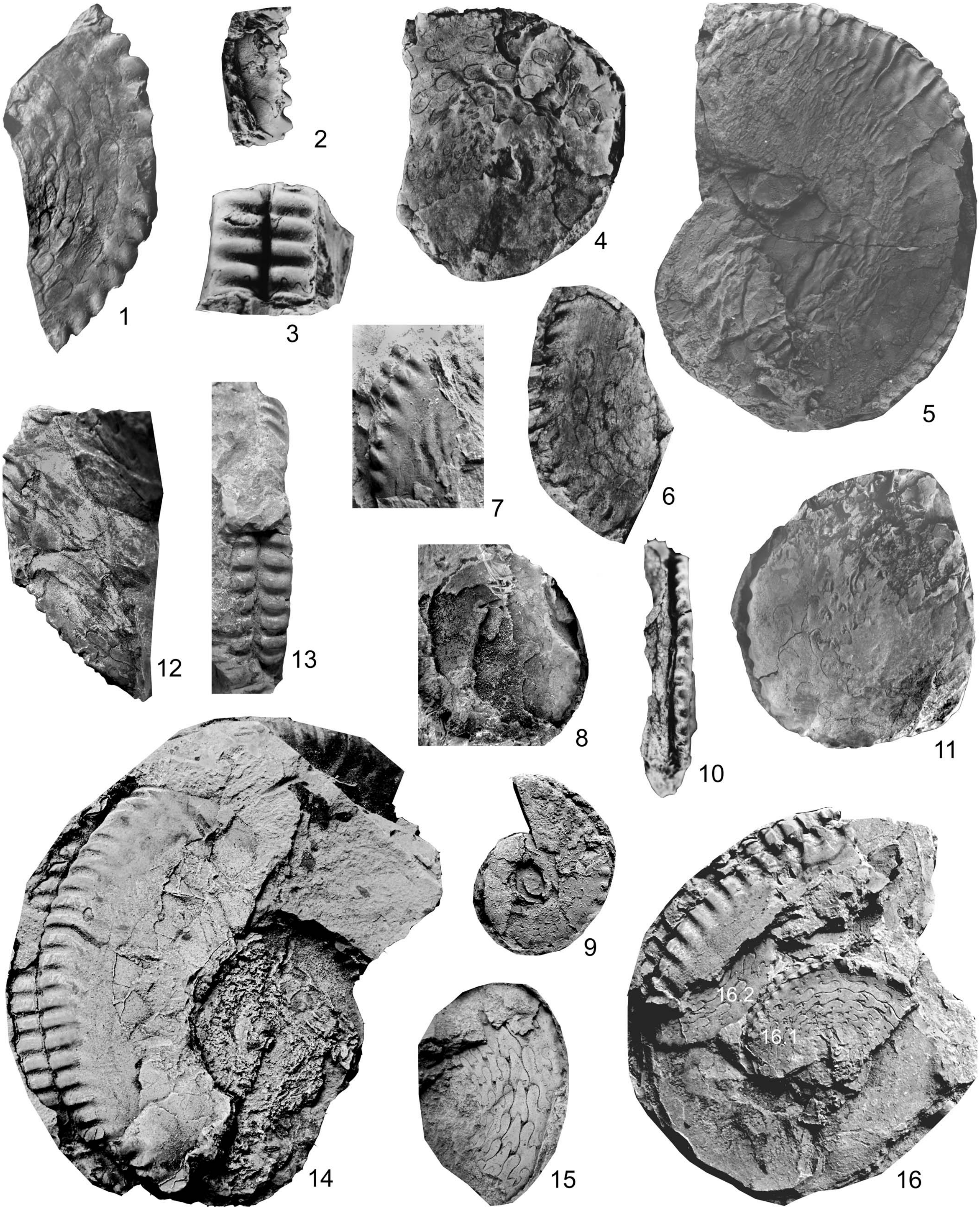

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Description.—Phragmoconch, internal molds, poorly preserved in mudstone, representing two individuals. Flank flat; venter flat, sculptured by two rows of transversal elongate nodes, which abruptly disappeared by the rim of flank. External suture includes narrow and deep ventral lobe, broad external saddle with well-preserved three adventitious lobules: basically symmetric ventrad $s^{1.1}$ and dorsad $s^{1.1}$, and the independent bidentate s^1. Lateral lobe ($L_{1(d)}$) intermediately sized and bidentate. Umbilical lobe (U) is long, narrow, and bidentate; other umbilically derived lobes not preserved.

Materials.—Two fragments of phragmoconch, NIGP 93672 and 93673, with ventral and partially lateral parts of external sutures.

Occurrence.—Bed 6, Gaijiao Member, Sidazhai Formation, Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou.

Remarks.—The present specimens generally resemble the type of *Propinacoceras toumanskayae* Leonova in general characters of suture and three adventitious apical lobules ($s^{1.1}s^{1.1}s^1$) on crest of external saddle, especially the third one (s^1) dorsad obviously bidentate. The transverse nodes on venter shown in Figure 17.3 are quite similar to those of the paratype N3591/215 (Leonova, 1989, pl. 2, fig. 2b). Comparing with corresponding umbilical lobe (U), the lateral lobe ($L_{1(d)}$) in the present specimens is relatively longer than that of the holotype from Pamirs, but such variation seems to be intraspecific.

Genus *Bamyaniceras* Termier and Termier, 1970

1889 *Propinacoceras*; Karpinskii, p 37 (part).
1970 *Bamyaniceras* Termier and Termier, p. 94.
1984 *Bamyaniceras*; Leonova, p. 41 (part).

Type species.—*Bamyaniceras bouyxi* Termier and Termier, 1970; original designation; Artinskian–Kungurian, Bamiyan Mountains, Afghanistan.

Diagnosis.—Conch similar to *Propinacoceras*, suture with undivided ventral flank and 2–4 subdivisions in crest of ventrolateral saddle. Differs in possession of relatively large simple or bifid dorsal subdivision of ventrolateral saddle and retention to maturity of large dorsal subdivision of primary external lateral lobe ($L_{1(d)}$) greater than one-half size of adjacent primary umbilical lobe U, or two elements subequal in extreme cases. Sutural formula $(V_2V_1V_2)s^1s^1l^1L_{1(d)}UU^1$......

Occurrence.—Artinskian through Capitanian; Tajikistan (Pamirs), Afghanistan, USA (Texas), South China (Guizhou, Guangxi), Thailand (Loei), Indonesia (Timor), and Australia (north-west).

Remarks.—*Bamyaniceras* is similar to *Propinacoceras* in both conch shape and general sutural features, but distinct by larger size of the lateral lobe ($L_{1(d)}$) compared with the umbilically derived lobes, and by having a small lateral adventitious lobule (l^1). Although *Miklukhoceras* also possesses the lateral adventitious lobule in the dorsal flank of the ventrolateral saddle, it is characterized by having a conspicuously longer lateral lobe ($L_{1(d)}$) with less alignment to the umbilical lobe (U).

Certainly the origin of lateral and apical adventitious lobules is very important for subdivision of the genera *Propinacoceras* and *Bamyaniceras*. Ontogenetic details of the external saddle would be helpful for distinguishing among similar genera.

Bamyaniceras knighti (Miller and Furnish, 1940a)
Figures 17.4–17.9, 19.4

1940a *Propinacoceras knight* Miller and Furnish, p. 42, pl. 5, figs. 1–4, pl. 6, fig. 7.

Description.—Conch discoidal, involute, with broad venter and strong ventrolateral nodes. Franks flat and broad. The specimen NIGP 93671, as the largest and relatively well preserved, ~62 mm diameter and ~14 mm wide. A living chamber present in the first half volution. Two small adventitious apical lobules (s^1s^1) on top of broad external saddle, and one small adventitious lateral lobule (l^1) obliquely developed at dorsal flank of external saddle. Lateral lobe ($L_{1(d)}$) fairly small and asymmetric. Umbilical lobe large and bifid; remaining umbilically derived lobes decreasing in size, bidentate in the first three.

Materials.—Six mold specimens preserved in mudstone, NIGP 93668, 93670, 93671, 154104, 154106, 154107, with various taphonomic modification.

Occurrence.—Bed 6, Gaijiao Member, Sidazhai Formation, Shaiwa section (Sec. IV-IV'), Sidazhai; beds 34–32, Yangchang Formation, Yangchang section (Sec. III). All from Ziyun County, Guizhou. The type materials from West Texas might come from different formations, aged from upper Artinskian through Roadian; while the appearances in Guizhou seem the same as in Texas, from the higher level in the Bed 6 of the

Figure 17. *Propinacoceras* Gemmellaro, 1887 and *Bamyaniceras* Termier and Termier, 1970. (**1–3**) *Propinacoceras toumanskayae* Leonova, 1989. Bed 6, Gaijiao Member, Sidazhai Formation, Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou, ×2: (**1**) lateral view, NIGP 93673; (**2, 3**) lateral and ventral views of a phragmocone fragment, NIGP 93672; (**4–9**) *Bamyaniceras knighti* (Miller and Furnish, 1940a), lateral views (except **6, 7**); (**4–7**) Bed 6, Gaijiao Member, Sidazhai Formation, Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou; (**4**) NIGP 93668, ×2; (**5**) NIGP 93671, ×1.2; (**6**) ventrolateral view, NIGP 93670, ×1.5; (**7**) ventrolateral view, NIGP 154104, ×2; (**8, 9**) beds 34–32, Yangchang Formation, Yangchang section (Sec. III), Ziyun County, Guizhou, ×1; (**8**) NIGP 154106 (associated with NIGP 154105, *Miklukhoceras guizhouense*, on the other side of the same example); (**9**) NIGP 154107; (**10, 11**) *Bamyaniceras* cf. *B. spatiosum* Leonova, 1992; NIGP 93669, ventral and lateral views, ×2.5, Bed 6, Gaijiao Member, Sidazhai Formation, Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou; (**12–16**) *Bamyaniceras yangchangense* n. sp.; (**12, 13**) lateral and ventral views, NIGP 154095, holotype, ×1, Yangchang Formation, Huohongchong (Loc. 2); Yangchang, Ziyun County, Guizhou; (**14–16**) beds 34–32, Yangchang Formation, Yangchang section (Sec. III), Ziyun County, Guizhou; (**14**) lateral, somewhat ventral view of the largest individual, NIGP 154099, ×1; (**15**) lateral view, phragmoconch, NIGP 154098; (**16**) lateral views of two individuals, inner molds; **16.1**, NIGP 154100, with the ultimate volution outside, and **16.2**, NIGP 154101, embedded during the preservation, all ×1.

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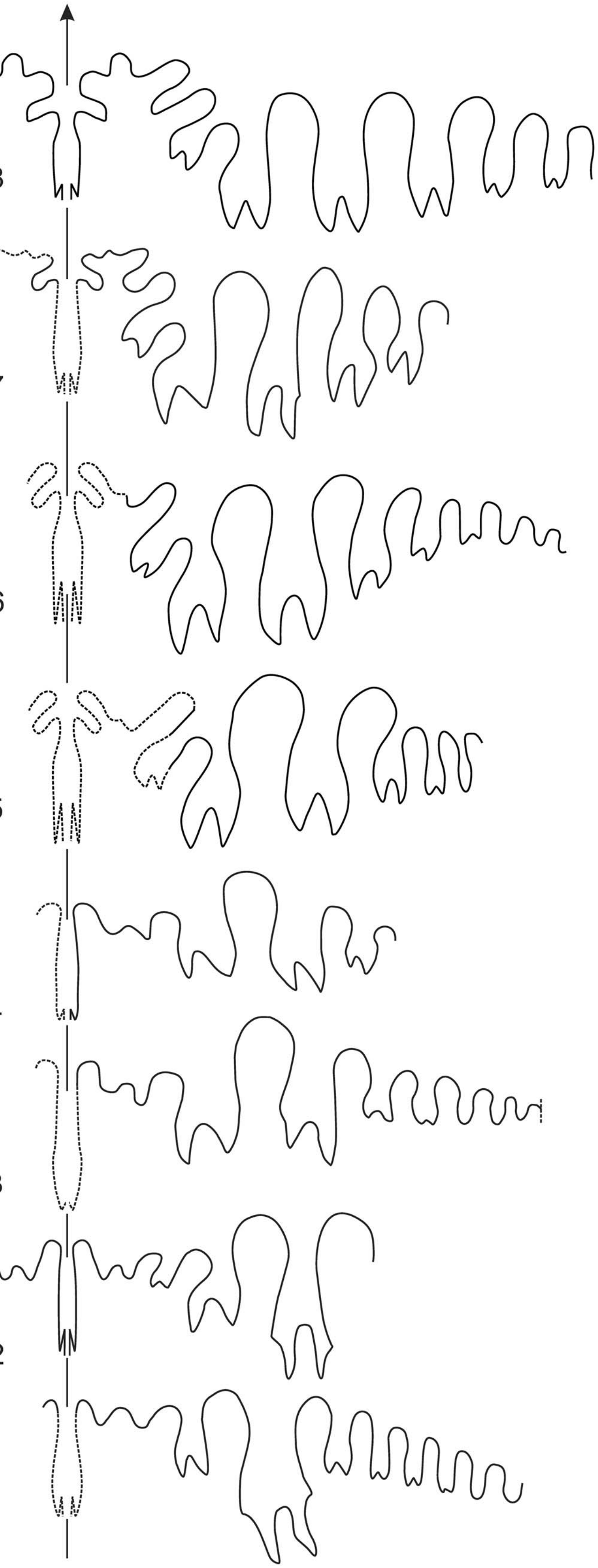

Gaijiao Member of the Sidazhai Formation and the lower level in the beds 34–32 of Yangchang Formation.

Remarks.—Some sutural details, such as wider and more rounded lobes, might differ from those in *B. knighti*, but the basic subdivisions and the relative position of adventitious elements are fairly similar. The minute differences mentioned above were considered to be a result of conch size and/or preservation, given that the suture of the holotype was measured at 65 mm diameter, but the suture herein at only 24 mm. *Bamyaniceras polae* (Toumanskaya, 1949) from the Central Pamirs also possesses similar adventitious subdivisions and shape of ventrolateral saddle, but its third umbilical lobe is very deep and broad, and the adventitious lateral lobe (l) is very small.

Bamyaniceras yangchangense new species
Figures 17.12–17.16, 19.6

Diagnosis.—Species with transversal ventral rib-like nodes and asymmetrically narrower apical lobules (s^1s^1).

Description.—Platyconch, large, involute with broad and flat venter. A deep furrow subdivides venter into two rows of transversal rib-like nodes. Suture somewhat varied in different individuals. Ventral lobe narrow and deep, with three digits. Ventrolateral saddle wide, with two asymmetrically apical lobules (s^1s^1), ventrad deeper than dorsad. The only lateral lobule (l^1) small and oblique, with two digits on bottom. Lateral lobe ($L_{1(d)}$) separated from lateral lobule by somewhat stronger saddle. Umbilical lobe (U), the largest lobe in all external lobes, almost twice the successive umbically derived lobe. All preserved (three to four) umbilically derived lobes bidentate.

Etymology.—Name is derived from the locality where the fossils were found.

Materials.—Four samples, representing five individuals: NIGP 154095 (holotype), and NIGP 154098–154101.

Occurrence.—Bed 34–32, Yangchang Formation, Yangchang section (Sec. III), Ziyun County, Guizhou; and the Yangchang

← **Figure 18.** External sutures of the propinacocertins. (**1**) *Propinacoceras beyrichi* Gemmellaro, 1887, NIGP 93665, D ~29 mm, the ammonoid-bearing claystone intercalated in Member XII, the top Houziguan Formation, Kabi (Loc. 3), Houchang, Ziyun County, Guizhou; (**2**) *Propinacoceras toumanskayae* Leonova, 1989, NIGP 93672, W 9 mm, and inferring D ~37 mm, Bed 6, Gaijiao Member, Sidazhai Formation, Shaiwa section (Sec. VI–VI'), Sidazhai, Ziyun County, Guizhou; (**3, 4**) *Difuntites furnishi* n. sp. Claystone (3rd) Member of Shaiwa Formation, Sidazhai section (Sec. VI'–VI'), Sidazhai, Ziyun County, Guizhou; (**3**) NIGP 139932 (holotype), D ~15.5 mm, Bed 26; (**4**) NIGP 139933, D ~18 mm, Bed 31; (**5, 6**) *Miklukhoceras guizhouense* n. sp., beds 19–17, Longyin Formation, Huagong section (Sec. II), Huagong Tea-Plantation, Qinglong County, Guizhou; (**5**) NIGP 93680, D 13 mm: (**6**) NIGP 93678, holotype, D 43 mm; (**7**) *Akmilleria parahuecoensis* n. sp., NIGP 93688, holotype, D 30 mm, Longma Member, Sidazhai Formation, Mading (Loc. 6), Liuzhai, Nandan County, Guangxi; (**8**) *Akmilleria huecoensis* (Miller and Furnish, 1940a). syntype (University of Iowa, SUI 2042), H 25 mm, lower part of Hueco Limestone at southern end of Hueco Mountains, Texas, United of America (Miller and Furnish, 1940a, p. 45, fig. 8C), for comparing with *A. parahuecoensis* n. sp., herein.

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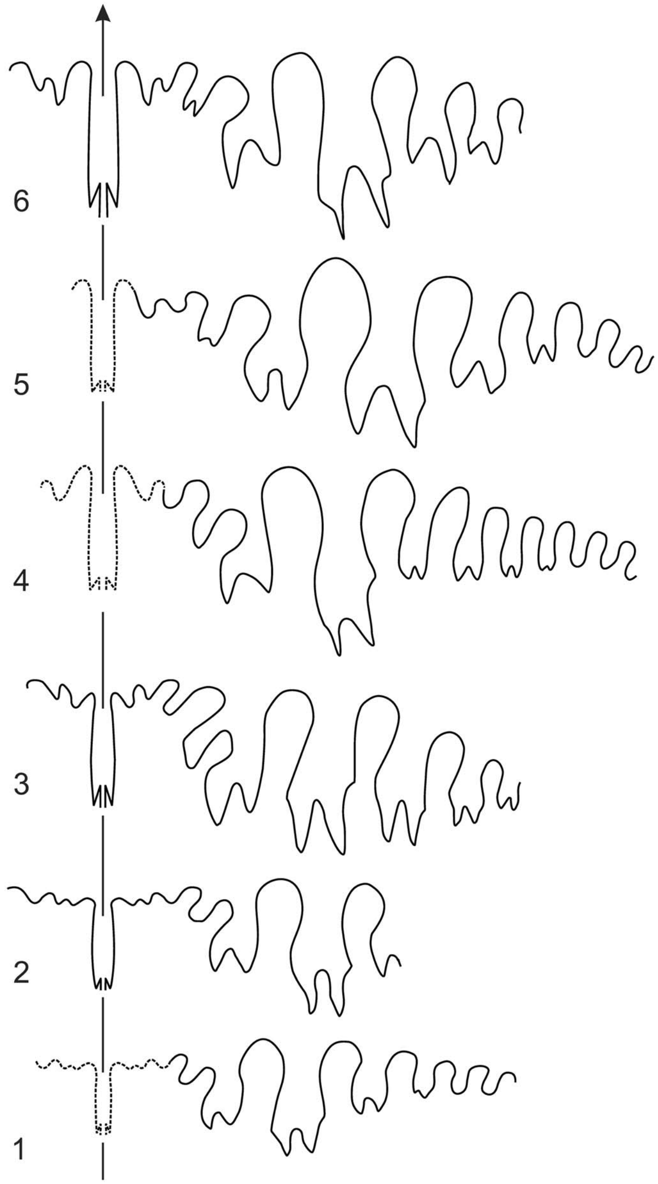

Figure 19. External sutures of *Bamyaniceras* Termier and Termier, 1970. (**1–3**) *Bamyaniceras nandanense* n. sp.; (**1, 2**) Longma Member, Sidazhai Formation, Mading (Loc. 6), Liuzhai, Nandan County, Guangxi; (**1**) NIGP 93676, D ~11 mm; (**2**) NIGP 93675, D 19 mm; (**3**) NIGP 93751, holotype, D 40 mm, Bed 3, Longyin Formation, Longyin section (Sec. I), Pu'an County, Guizhou; (**4**) *Bamyaniceras knighti* Miller and Furnish, 1940a, NIGP 93668, D 24 mm, Bed 6, Gaijiao Member, Sidazhai Formation, Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou; (**5**) *Bamyaniceras* cf. *B. spatiosum* Leonova, 1992, NIGP 93669, D 21 mm, Bed 6, Gaijiao Member, Sidazhai Formation, Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou; (**6**) *Bamyaniceras yangchangense* n. sp. NIGP 154095, holotype, W 10 mm, and inferring D 40 mm or so, Yangchang Formation, Huohongchong (Loc. 2), Yangchang, Ziyun County, Guizhou.

Formation, Huohongchong (Loc. 2), 500 m southwest from the Yangchang section.

Remarks.—*Bamyaniceras yangchangense* n. sp. is similar to *B. simplex* Leonova, 1984 and *B. spatiosum* Leonova, 1992 in basic subdivision of ventrolateral saddle. However, the apical lobules (s^1s^1) in the new species are obviously asymmetrical, and much narrower than those of the corresponding adventitious lobules in the Pamirs species.

Bamyaniceras nandanense new species
Figures 19.1–19.3, 20.1–20.12

1989 *Propinacoceras* sp. nov. Zhou, p. 1368, fig. 1c (nom. nud.)

Diagnosis.—Four entirely adventitious elements on ventrolateral saddle, three ($s^{1.1}s^{1.1}s^1$) on flat crest and one (l^1) at dorsal flank of saddle, probably representing the earlier evolution of *Bamyaniceras loeiense* (Ishibashi et al., 1996).

Description.—The biggest phragmoconch (NIGP 93749) ~55.0 mm in diameter (Fig. 20.12). Ventral furrow and rows of nodes on the venter shown in NIGP 88974 (Fig. 20.6), and the transverse lines on partial flank shown in NIGP 88973 (Fig. 20.1). Unfortunately, conch width not clear from these specimens. Sutures well preserved in most specimens in lateral flanks and illustrated in ontogenetic sequence in two stages (Fig. 19.1–19.3): (1) the adolescent, apical adventitious lobules still in developing process, with the primitive character of the incipient lobules (Fig. 19.1, 19.2); and (2) the adult, lobules fully developed, with the permanently regular shape (Fig. 19.3).

Etymology.—Name is derived from the locality where the fossils were found.

Materials.—Twelve specimens, 11 more or less complete inner molds and one piece of an outer whorl fragment. NIGP 88973, 88974, 93675–93677, 93745–93751, in which NIGP 93751 is assigned as the holotype.

Occurrence.—Bed 3 and Bed 12, Longyin Formation, Longyin section (Sec. I), Pu'an County, Guizhou; Bed 34–32, Yangchang Formation, Yangchang section (Sec. III), Ziyun County, Guizhou; and the Longma Member, Sidazhai Formation, Mading (Loc. 6), Liuzhai, Nandan County, Guangxi.

Remarks.—*Bamyaniceras nandanense* n. sp. is similar with the type species of *Bamyaniceras bouyxi* Termier and Termier, 1970 in both generality of suture and components of adventitious; however, the conspicuously smaller saddle elements V/s and s/l on top of ventrolateral saddle in *B. nandanense* n. sp. make it easy to distinguish from the latter. *Bamyaniceras nandanense* n. sp. resembles *B. loeiense* from Thailand in generality of sutures, but the former is much more primitive in development of the sutures than the latter. The maturity of sutures in *Bamyaniceras nandanense* n. sp. at a diameter of 40 mm may be only equal to that at about 20 mm in the latter. It is probable that *B. nandanense* n. sp., with its early Artinskian age, only represents the predecessor of *B. loeiense* in evolution. The presence of one more lateral adventitious lobules in *Bamyaniceras nandanense* n. sp. easily distinguishes it from *B. yangchangense* n. sp. described above.

Bamyaniceras cf. *B. spatiosum* Leonova, 1992
Figures 17.10, 17.11, 19.5

1992 cf. *Bamyaniceras spatiosum* Leonova, p. 135, pl. 30, figs. 5, 6.

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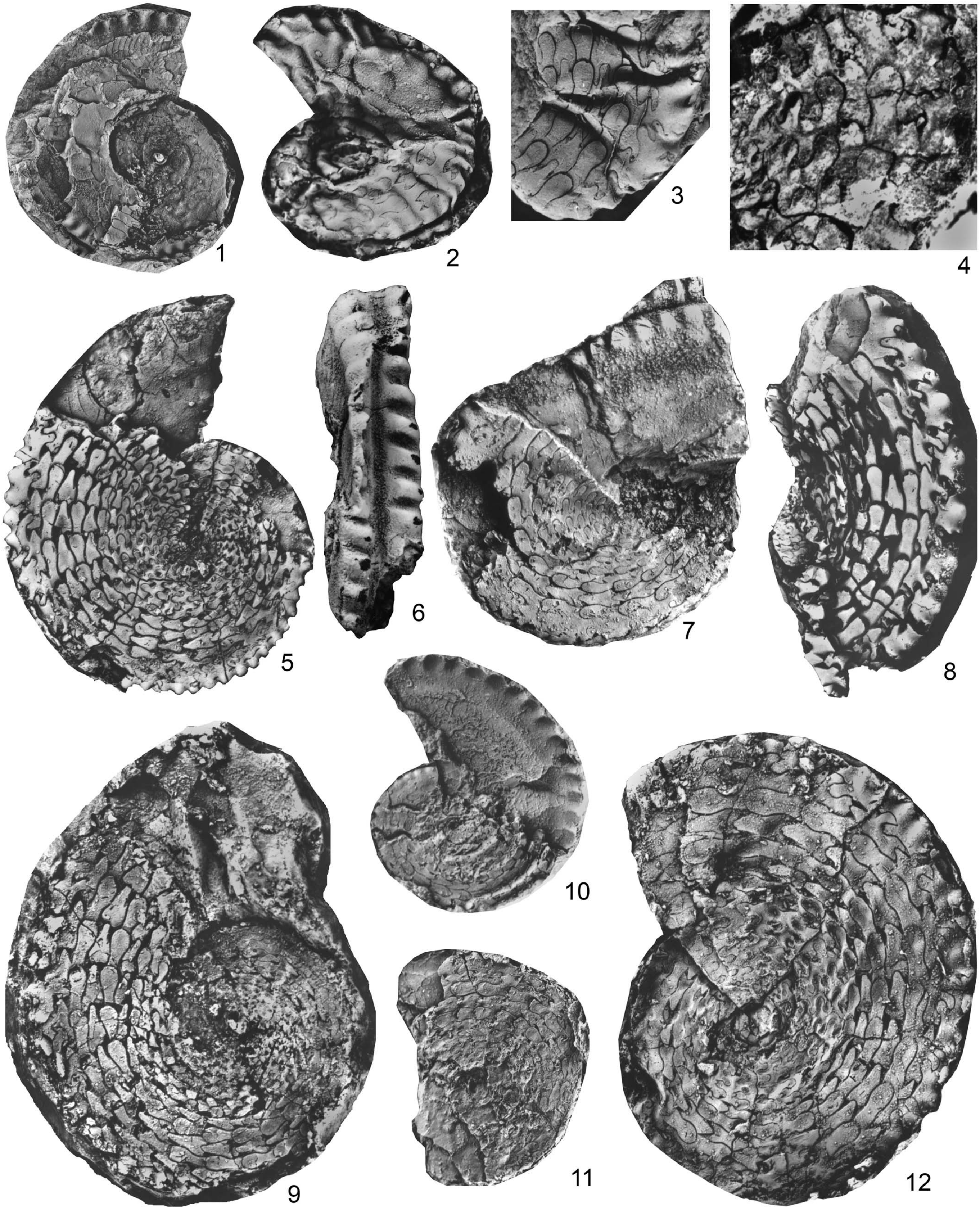

Figure 20. *Bamyaniceras nandanense* n. sp., all lateral views (except **6**). (**1**) One of two opposite parts, NIGP 88973, ×1, Bed 12, Longyin Formation, Longyin section (Sec. I), Pu'an County, Guizhou; (**2, 3, 11**) Longma Member, Sidazhai Formation, Mading (Loc. 6), Liuzhai, Nandan County, Guangxi; (**2**) NIGP 93676, ×3; (**3**) NIGP 93675, ×4; (**11**) NIGP 93677, ×2; (**4–6, 8, 9, 12**) Bed 3, Longyin Formation, Longyin section (Sec. I), Pu'an County, Guizhou; (**4**) NIGP 93750, ×4; (**5**) NIGP 93748, ×1.5; (**6**) ventral view, NIGP 88974, ×1.5; (**8**) NIGP 93751, holotype, ×1.5; (**9**) NIGP 93747, ×1.5; (**12**) NIGP 93749; (**7, 10**) beds 34–32, Yangchang Formation, Yangchang section (Sec. III), Ziyun County, Guizhou, ×1.5: (**7**) NIGP 93745; (**10**) NIGP 93746.

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Description.—A phragmoconch, small, flat discoidal, with almost closed umbilicus; 21 mm in diameter, ~5.9 mm in width (W/D, about 0.28). Venter relatively narrow and subdivided by an intermediate furrow between two rows of prominently rounded nodes. About 5–6 nodes per centimeter in the outer volution. Suture only preserves two adventitious apical lobules (s^1s^1) on the top and a bidentate lateral lobule (l^1) on the dorsal flank of the ventrolateral saddle. Saddle between lobules l^1 and $L_{1(d)}$ fairly large in size and prominent in position. Three of the six preserved umbilically derived lobes bidentate.

Materials.—One solitarily specimen, NIGP 93669, preserved in mudstone.

Occurrence.—Bed 6, Gaijiao Member, Sidazhai Formation, Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou.

Remarks.—The specimen is similar to the holotype from Pamirs in possessing an almost identical general suture, but its exact taxonomic relationship cannot be confirmed due to inadequate knowledge of the ventral lobe. It is close to *Bamyaniceras yangchangense* n. sp. in having the same general sutural elements, but differs by the much wider external saddle than the latter.

Genus *Miklukhoceras* Pavlov, 1967

Type species.—*Miklukhoceras pamiricum* Pavlov, 1967; original designation; Kochusuisk Member, Bolorian Stage (lower Kungurian), southeast Pamirs.

Diagnosis.—Narrowly discoidal propinacoceratins with two rows of ventral nodes. Juveniles characterized by evolute form. At larger size, umbilicus remains open (U/D, 0.2–0.3 at 30 mm diameter), and conspicuous ribs are confined to sigmoidal extensions across ventrolateral flanks from ventral nodes. Suture somewhat as in *Akmilleria*, with single subdivision on ventral flank of ventrolateral saddle.

Occurrence.—Sakmarian through Kungurian; Tajikistan (Pamirs), China (Xinjiang, Guizhou, Guangxi), and Thailand (Muak Lek).

Remarks.—The affiliation *Miklukhoceras* with other medlicottiids is still unclear. The evolute juvenile conch form is a characteristic of the entire family Medlicottiidae, but the open umbilicus in *Miklukhoceras* remained even until the mature stage. The conspicuous ribs present in the internal volutions seem not to be a definitely identical character of the genus, so that the occurrence or not of them in the early stage probably represents only a variety between the species. *Miklukhoceras* differs from *Kunlunoceras* Wang, 1983 from Xinjiang by its distinctively higher ventrolateral saddle. Probably, there is not any relationship between them.

Miklukhoceras guizhouense new species
Figures 18.5, 18.6, 21.1–21.11

Diagnosis.—*Miklukhoceras* species without ribs present in the first three volutions.

Description.—Specimens poorly preserved as molds, however, features for generic and specific identification still available. Mature conch semi-evolute, with wider umbilicus (U/D may be >0.3), and juvenile totally evolute. Holotype NIGP 93678 and paratype NIGP 93680, with wholly evolute inner 2–3 volutions, but no transversal ribs present in these volutions. Conch may reach up to 55–60 mm in diameter. Venter looks broad and flat, divided by a medium furrow to show rows of strong nodes on each side. Transverse ribs (lines) with bi-project and sinus developed on lateral flanks and ended by nodes. All the specimens similar in possessing large and bidentate lateral lobe ($L_{1(d)}$) and umbilical lobe (U), while the other umbilically derived lobes have only the first three or four bidentate, and decrease in size rapidly. The adventitious lobules are obscure in details, except the bidentate lateral lobule (l^1) on the dorsal flank of the ventrolateral saddle.

Etymology.—Name derived from Guizhou Province, where the Permian open sea with pandemic ammonoid faunas were well developed.

Materials.—Ten specimens, NIGP 93678–93684, 154102, 154103, and 154105. NIGP 154105 associated with NIGP 154106, *Bamyaniceras knighti* (Miller and Furnish, 1940a), on the other side of the same sample.

Occurrence.—Bed 3, Longyin Formation, Longyin section (Sec. I), Longyin, Pu'an; beds 19–17, Longyin Formation, Huagong section (Sec. II), Huagong Tea-Plantation, Qinglong, Guizhou; Bed 34–32, Yangchang Formation, Yangchang section (Sec. III), Ziyun County, Guizhou; Longma Member, Sidazhai Formation, Mading (Loc. 6), Liuzhai, Nandan County, Guangxi.

Remarks.—Assignation to *Miklukhoceras* is based mainly on the evolute to semi-evolute conch shape, and the distinctive sigmoid ribs (lines) extending across the flanks and ending at the ventral nodes, although there are no ribs present in the first three internal volutions. The evoluted conch shape, the basic sculpture in outer volutions, and the preserved sutural features essentially ensure the generic identification. *Miklukhoceras guizhouense* n. sp. is similar to the type species of *M. pamiricum* Pavlov, 1967 in the evolute inner volutions and generality of the sutures. However, it may distinguish from the latter by lacking the ribs in the exposed inner volutions, and having an advanced bidentate lateral lobule (l^1). *Miklukhoceras guizhouense* new species resembles *M. pressulum* Leonova, 1984 in having a completely evolute conch shape and having no transverse ribs on the inner volutions, but it has a much larger and longer lateral lobe ($L_{1(d)}$) than the latter.

Genus *Difuntites* Glenister and Furnish, 1988

1915 *Propinacoceras*; Haniel, p. 36 (part).
1976 *Propinacoceras*; Ruzhentsev, p. 39 (part).

Type species.—*Propinacoceras hidium* Ruzhentsev, 1976; original designation; Maritime Territory, Far East, Russia; 'Capitanian' (probably Wuchiapingian).

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Figure 21. *Miklukhoceras guizhouense* n. sp., all lateral views. (**1, 2**) Bed 3, Longyin Formation, Longyin section (Sec. I), Longyin, Pu'an County, Guizhou, ×1; (**1**) NIGP 154102; (**2**) NIGP 154103; (**3**) beds 34–32, Yangchang Formation, Yangchang section (Sec. III), Ziyun County, Guizhou, NIGP 154105 (associated with NIGP 154106, *Bamyaniceras knighti*, on the other side of the same example), ×1; (**4–6**) beds 19–17, Longyin Formation, Huagong section (Sec. II), Huagong Tea-Plantation, Qinglong County, Guizhou; (**4**) NIGP 93680, ×1.5; (**5**) NIGP 93681, ×1; (**6**) NIGP 93678, holotype, ×1; (**7–11**) Longma Member, Sidazhai Formation, Mading (Loc. 6), Liuzhai, Nandan County, Guangxi; (**7**) NIGP 93684, ×2; (**8**) NIGP 93682, ×3; (**9**) NIGP 93683, ×2; (**10, 11**) counterparts of an individual, NIGP 93679, ×1.

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Diagnosis.—Conch small (possibly <35 mm at maturity), broadly discoidal (W/D, 0.3–0.4). Whorl flanks flat and parallel sided. Umbilicus small. Ventrolateral shoulders narrowly and uniformly rounded. Conspicuous median groove on venter confined by two rows of large ventral nodes on shoulders. Suture formula $(V_2V_1V_2)s^1s^1L_{1(d)}UU^1U^2$..... ; lateral lobe $L_{1(d)}$ one-quarter larger than the adjacent umbilical lobe U.

Occurrence.—Wuchiapingian, probably through Changhsingian; Russia (Maritime Territory, Far East), Indonesia (Timor), Madagascar, Mexico (Coahuila), and South China (Southwest Guizhou).

Remarks.—Suture generally similar to *Propinacoceras*, but characterized by dorsal prong of primary lateral lobe ($L_{1(d)}$), the breadth of which exceeds that of adjacent primary umbilical lobe (U) in all growth stages. Representatives of the uddenitins resemble *Difuntites* in possession of a relatively simple first lateral saddle; however, lobes of uddenitins are generally entire, whereas most in *Difuntites* are bidentate.

Difuntites, as the rarest and latest taxon of the Paleozoic propinacoceratins, is an important progenesis representative of the group, but it is a significant component of the *Eoaraxoceras* association as well. The author of its type species (Ruzhentsev, 1976, p. 38) noted that the Capitanian age of the type material in the Maritime Territory occurrence (Shkotovo Area near Vladivostok, Far East) was possibly conspecific with '*Propinacoceras* sp.' from the La Colorada beds in Mexico (Miller, 1944). However, the latest ammonoid sequence in the uppermost part of the Permian section from the Las Delicias area, Coahuila, summarized by Spinosa and Glenister (2000, fig. 18–2) is earliest Dzhulfian (Wuchiapingian) age. Actually, Zakharov and Pavlov (1986) had already indicated that the uppermost occurrence of '*Propinacoceras hidium*' Ruzhentsev, 1976 was located at the left bank of the Artemovka River, in the upper part of Liudianzin Formation, about 60 m above the layer of *Cyclolobus kiselevae* Zakharov, 1983a in the Neizvest Bay section near the Trud Peninsula. Therefore, both latest Capitanian and Lopingian occurrences of the genus are possible. The present author considers that the occurrences mentioned above actually represent Lopingian deposits. Furthermore, the ammonoid association from the 'Lower Layer' of the Permian-Triassic Terrain of Anaborano, north Madagascar contains *Episageceras*, *Xenodiscus*, *Difuntites*, and advanced *Cyclolobus* Waagen, 1879, which could serve as additional evidence of the Lopingian Epoch, including Changhsingian Stage.

Difuntites furnishi new species
Figures 18.3, 18.4, 22.1–22.7

Diagnosis.—A species of *Difuntites* with relatively compressed conch shape, and wider umbilical lobe (U).

Description.—Conchs small, diameter 20–31 mm, W/D close to 0.3 in the large specimen. Umbilicus closed or very small (1 mm). Flanks flat, parallel sided, and smooth on surface; ventrolateral shoulders narrowly and uniformly rounded, venter divided by a conspicuous median groove; prominent rounded nodes paired in opposite positions on the ventrolateral shoulders, ~50 pairs in outer volution occurring in the larger specimen. Sutures have small modifications in shape of lobules (s^1s^1), perhaps due to preservation, dorsal prong of primary lateral lobe ($L_{1(d)}$) wider than the adjacent primary umbilical lobe (U) and aligning approximately in general arc of suture; four of the seven external lobes bidentate.

Etymology.—Nomenclature in honor of late Professor W.M. Furnish, University of Iowa, USA.

Materials.—Three specimens, NIGP 139931, 139932 (holotype), and 139933.

Occurrence.—Beds 23, 26, and 31, Claystone (3rd) Member, Shaiwa Formation, Sidazhai section (Sec. IV'-IV"), Sidazhai, Ziyun County, Guizhou.

Remarks.—Based on conch form and sutural features, the present specimens can be assigned to the genus *Difuntites*, and are considered to be a new species when compared with the previous monotype, *D. hidius* Ruzhentsev, 1976, by the relatively compressed conch shape (W/D, about 0.27 vs. 0.37) and apparently wider umbilical lobe (U) in *Difuntites furnishi* n. sp. Two sutures illustrated in Figure 18.3 and 18.4 show apical lobules (s^1s^1) quite different from each other in both shape and relative length. However, these differences might be caused by deformation of lobules in preservation, similar to the conch deformation shown in NIGP 139932 (Fig. 22.1–22.3) and NIGP 139933 (Fig. 22.6, 22.7).

Genus *Akmilleria* Ruzhentsev, 1940c

1915 *Propinacoceras*; Haniel, p. 34 (part).
1936 *Artinskia*; Miller, p. 491 (part).
1939b *Synartinskia* Ruzhentsev, p. 461 (part).

Type species.—*Propinacoceras transitorium* Haniel, 1915; original designation; Atsabe and Bitauni beds, Artinskian–Kungurian, Timor, Indonesia.

Diagnosis.—Conch narrowly discoidal, with two rows of ventral tubercles. Suture characterized by ventrolateral saddle with 5–8 subdivisions, one on ventral flank, 2–5 on crest, two dorsad, the first of which is bidentate. Sutural formula: $(V_2V_1V_2)v^1s^1s^1l^2l^1L_{1(d)}UU^1U2$......

Occurrence.—Asselian through Kungurian; Kazakhstan (Southern Urals), Indonesia (Timor), USA (Texas, Kansas, Nevada), Thailand (Loei), and South China (Guizhou and Guangxi).

Remarks.—*Akmilleria* resembles *Synartinskia* in conch form, but distinguished from the latter by the sutural alignment. *Synartinskia* belongs to the subfamily Sicanitinae, possessing a longer lateral lobe ($L_{1(d)}$), significantly below alignment of adjacent umbilically derived lobes. Compared with *Artinskia* of the subfamily Medlicottinae, the present genus has one less ventral lobule (v^2) and one lateral lobule (l^3) in adventitious elements.

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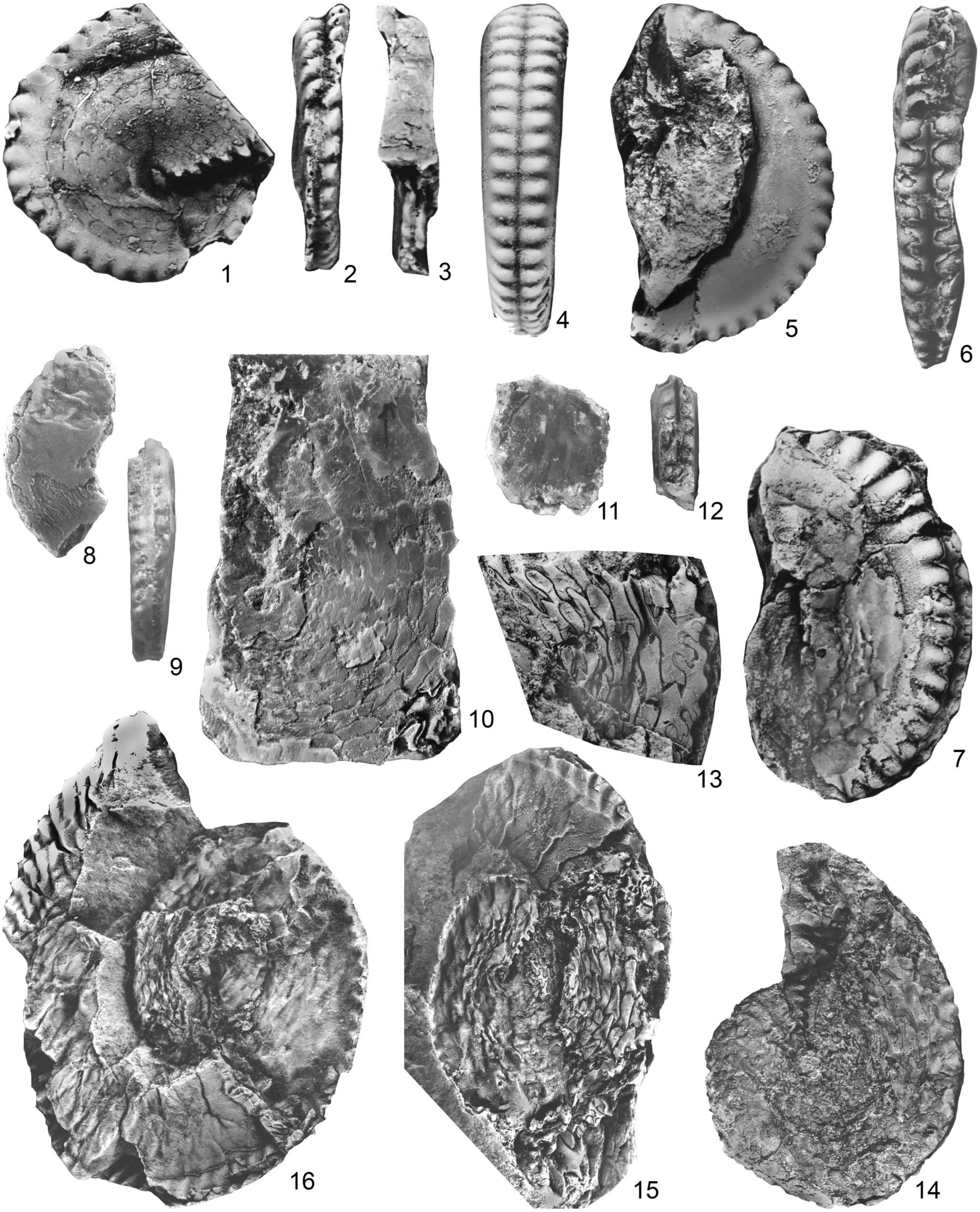

Figure 22. *Difuntites* Glenister and Furnish, 1988, *Artinskia* Karpinskii, 1926, and *Akmilleria* Ruzhentsev, 1940c. (**1–7**) *Difuntites furnishi* n. sp., Claystone (3rd) Member, Shaiwa Formation, Sidazhai section (Sec. IV'-IV''), Sidazhai, Ziyun County, Guizhou; (**1–3**) lateral, ventral, and apertural views, NIGP 139932 (holotype), Bed 26, ×3; (**4, 5**) ventral and lateral views, NIGP 139931, Bed 23, ×2; (**6, 7**) ventral and lateral views, NIGP 139933, Bed 31, ×3; (**8–12**) *Artinskia nalivkini* Ruzhentsev, 1938, Bed 19, 2nd Member, Nandan Formation, Meyao section (Sec. V), Liuzhai, Nandan, Guangxi; (**8, 9**) lateral and ventral views, NIGP 88975, ×2; (**10**) lateral view, NIGP 88977, ×1; (**11, 12**) lateral and ventral views, NIGP 88976, ×1; (**13–16**) *Akmilleria parahuecoensis* n. sp., all lateral views; (**13**) NIGP 93686, ×3, beds 19–17, Longyin Formation, Huagong section (Sec. II), Tea-Plantation, Qinglong County, Guizhou; (**14–16**) Longma Member, Sidazhai Formation, Mading (Loc. 6), Liuzhai, Nandan County, Guangxi, ×1; (**14**) NIGP 93688, holotype; (**15, 16**) NIGP 93687, counterparts of the same individual.

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Akmilleria parahuecoensis new species
Figures 18.7, 22.13–22.16

Diagnosis.—Similar to *Akmilleria huecoensis* (Miller and Furnish, 1940a) and *A. electraensis* (Plummer and Scott, 1937) in generality of the suture, but different from the former by possessing a much narrower ventrolateral saddle, and from the latter by an obviously wider ventrolateral saddle.

Description.—Conch large, thin, discoidal, may reach to 60 mm diameter, flanks flat, and umbilicus small. Venter divided by a prominent medium groove, on both sides exhibiting a row of rounded nodes, largely confined to the ventral side of the ventrolateral shoulder. The ventrolateral saddle is relatively narrower compared with others in the genus, and adventitious elements contain five subdivisions: one ventral (v^1), two apical (s^1s^1), and two lateral (l^1l^2). Lateral lobe ($L_{1(d)}$) bidentate, only a little smaller than the adjacent umbilical (U) in size. The following umbilically derived lobes (only four preserved) all bidentate.

Etymology.—Name is derived from the similarity to the North American species *A. huecoensis* (Miller and Furnish, 1940b).

Occurrence.—Longma Member, Sidazhai Formation, Mading (Loc. 6), Liuzhai, Nandan County, Guangxi; beds 19–17, Longyin Formation, Huagong section (Sec. II), Tea-Plantation, Qinglong County, Guizhou.

Materials.—Four specimens, in different preservation condition, representing three individuals, NIGP 93686, 93687, and 93688 (holotype).

Remarks.—*Akmilleria parahuecoensis* n. sp. is identical with *A. huecoensis* (Miller and Furnish, 1940a, p. 45, fig. 8C) (Fig. 18.8) in the general appearance of the suture and subdivisions of the ventrolateral saddle. However, its ventrolateral saddle is much narrower than that of the American species, with concominantly much thinner subdivisions on the saddle as well. *Akmilleria parahuecoensis* n. sp. is similar to *A. whortani* (Miller, 1936) in width and subdivisions of the ventrolateral saddle, but different from the latter by the bidentate lateral lobe ($L_{1(d)}$) instead of latter's tridentate lateral lobe. It is also similar *A. electraensis* (Plummer and Scott, 1937) in subdivisions of the ventrolateral saddle, but distinguished from the latter by clearly wider ventrolateral saddle.

Subfamily Medlicottinae Karpinskii, 1889

Genus *Artinskia* Karpinskii, 1926

1889 *Promedlicottia* Karpinskii, p. 23 (nom. nud.).
1907 *Prosicanites* Chernov, p. 359 (nom. nud.; non Toumanskaya and Borneman, 1937, p. 113).
1940a *Artinskia*; Miller and Furnish, p. 44 (part).

Type species.—*Goniatites artiensis* Grünewaldt, 1860; original designation; Artinskian Stage, South Urals.

Diagnosis.—Ancestral medlicottiins with subdivision of ventrolateral saddle intermediate in degree between characteristic Medlicottiinae and Propinacoceratinae, and conch resembling Sicanitinae. Conch thinly discoidal, with grooved venter between two rows of prominent ventrolateral nodes bounded by less-conspicuous ribs on ventrolateral flanks. Suture resembles *Medlicottia*, but ventrolateral saddle broader and lower, with 6–8 subdivisions (commonly two ventrad, two or three in crest, three dorsad). Sutural formula: $(V_2V_1V_2)v^1v^2s^1s^1l^3l^2l^1L_{1(d)}UU^1U^2U^3U^5$......

Occurrence.—Pennsylvanian (Gzhelian/Virgilian)–Cisuralian (Artinskian); Kazakhstan (Southern Urals), Tajikistan (Pamirs), Russia (Urals, North Verkhoyan), South China (Guangxi), Thailand (Loei), Japan (Kitakami Massif), Indonesia (Timor), USA (Texas, New Mexico), and Austria (Carnic Alps).

Remarks.—Complex subdivision of the ventrolateral saddle in rare Gzhelian representatives from the Urals initiated lineages that diversified in the Early Permian (Asselian), were rare in the succeeding Sakmarian, but then diversified again in the Artinskian to extend through the Late Permian and eventual extinction of the order in the Early Triassic (Induan).

Artinskia nalivkini Ruzhentsev, 1938
Figures 22.8–22.12, 24.1–24.3

1938 *Artinskia nalivkini* Ruzhentsev, p. 248, pl. 1, figs. 8–11.
1951 *Artinskia nalivkini*; Ruzhentsev, p. 91, pl. 4, figs. 6, 7.

Description.—Inner molds with varied diameters from 19 mm to ~80 mm, subdiscoidal with small umbilicus. Venter narrowly rounded, subdivided by a furrow into two rows with prominent ventrolateral nodes bounded by less-conspicuous ribs on ventrolateral flanks. Lateral flanks flat, in specimen NIGP 88978 showing an obvious depression belt around the ventrolateral shoulder. External saddle consisting of two ventral adventitious lobules (v^1v^2) on ventral flank, entirely apical lobule (s) or slightly subdivided adventitious lobule (s^1s^1) on top of the saddle, and three lateral adventitious lobules ($l^3l^2l^1$) on lateral flank, in which l^1 is bidentate. The really lateral lobe ($L_{1(d)}$) large in size and bidentate; the umbilical lobe (U) generally the largest one in the external lobe series; the remaining umbilically derived lobes decrease in size subsequently. Lateral lobe and adjacent first three or four umbilically derived lobes bidentate.

Occurrence.—Bed 19, 2nd Member, Nandan Formation, Meyao section (Sec. V), Liuzhai, Nandan County, Guangxi.

Materials.—Three specimens, NIGP 88975–88977, phragmoconchs preserved in limestone matrix.

Remarks.—The specimens resemble *Artinskia nalivkini* Ruzhentsev, 1938 in conch form and generality of external suture, with a depressed out-zone in flank and six or seven adventitious lobules, $v^1v^2s^1s^1l^3l^2l^1$ and 12 external 'lateral' lobes in adults. However, the shape of lateral lobules l^1 and l^2 in the present materials are consistent with asymmetrically

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bidentate l^1 and entire l^2, but not as variable as the holotype of the species, tridentate or bidentate. *Artinskia nalivkini* also is similar to the type species *A. artiensis* (Grünewaldt, 1860) in subdivision of ventrolateral saddle, but many fewer bidentate umbilically derived lobes.

Genus *Medlicottia* Waagen, 1880

1845 *Goniatites*; Verneuil, p. 375 (part).
1874 *Sageceras* (*Goniatites*); Karpinskii, p. 287.
1880 *Medlicottia* Waagen, p. 83 (part).
1937 ?*Prosicanites* Toumanskaya, p. 113 (part).
1938 *Artinskia*; Ruzhentsev, p. 246 (part).
1940a *Medlicottia* Miller and Furnish, p. 49 (part).
1992 ?*Paramedlicottia*; Leonova, 1992, p. 138.
2002 ?*Prosicanites*; Leonova, p. S23 (part).

Type species.—*Goniatites orbignyanus* Verneuil, 1845, original designation; Artinskian Stage, Urals, Russia.

Diagnosis.—Conch thinly lenticular; narrow furrowed venter bounded by pair of sharp ventrolateral keels (generally without nodes). Ventrolateral saddle has 8–12 subdivisions, remaining saddles rounded or slightly indented near midheight. External lateral lobe and adjacent umbilical lobes in arched alignment, subequal, but decreasing in size to umbilicus. Sutural formula: $(V_2V_1V_2)v^1v^2v^{3-6}s^1s^1l^{7-5}l^4l^3l^2l^1L_{1(d)})UU^1U^2$......

Occurrence.—Sakmarian though Wordian; Italy (Sicily), Russia (Urals, Volga-Urals), Kazakhstan (South Urals), Ukraine (Crimea), Tajikistan (Pamirs), Indonesia (Timor), China (Guizhou, Gansu, ?Xizang, Xinjiang), Japan (southern Kitakami Massif), Indonesia (Timor), Italy (Sicily), Columbia, Mexico (Coahuila), USA (Texas, New Mexico, Nevada), and Canada (British Columbia, Yukon, Arctic Archipelago, Devon Island).

Remarks.—*Medlicottia* is easily distinguished from genera of the family based on conch form and outline of suture. The oldest species of *Medlicottia*, *M. vetusta* Ruzhentsev, 1949, is similar to *Sicanites* in conch shape, but the latter has a longer lateral lobe ($L_{1(d)}$), significantly below alignment of the adjacent subequal umbilically derived lobes. The younger *Medlicottia* has a narrow and weaker or non-sculptured venter, but the sutures are quite different from other genera in the family. *Artinskia* usually has two ventral and three lateral adventitious lobules, whereas *Medlicottia* has at least three and five, respectively. In addition, the ventrolateral saddle in *Artinskia* is higher and narrower than that in *Medlicottia*.

Medlicottia orbignyana (Verneuil, 1845)
Figures 23.1–23.3, 24.4

1845 *Goniatites orbignyanus* Verneuil, p. 375, pl. 26, fig. 6.
1874 *Sageceras* (*Goniatites*) *orbignyanus*; Karpinskii, p. 287.
1880 *Medlicottia orbignyana*; Waagen, p. 83.
1907 *Medlicottia orbignyi*; Chernov, p. 367, pl. 1, fig. 8.
1989 *Medlicottia* sp. Zhou, p. 1367.
2005 *Medlicottia* cf. *orbignyana*; Zhou and Yang, p. 381, figs. 4.3, 5.21–5.23.

Description.—Shell lenticular with nearly closed umbilicus. Venter narrow with ventral groove, bordered by smooth keels at ventrolateral shoulders, which might be weakly node-sculptured in early ontogeny, and serrated by adventitious lateral lobules on the ventrolateral saddle in the last volution. The phragmoconch (Fig. 23.2, 23.3) of NIGP 93691 reached ~43 mm in diameter.

Ventral and apical adventitious subdivisions (probably v^{1-4} and s^1s^1) of ventrolateral saddle unknown due to incomplete preservation of the external suture. Ventrolateral saddle high and narrow as usual. Lateral adventitious lobules definitely of five elements ($l^1l^2l^3l^4l^5$), although somewhat abraded during preservation, the first one (l^1) the largest with strong bidentition, the secondary saddle between l^1 and $L_{1(d)}$ heavily reduced by secondary erosion, while other secondary saddles, numbered from second to fourth or sixth, decreasing in size upward to top of the saddle. Nine external 'lateral' lobes preserved (Fig. 24.4). Lateral lobe ($L_{1(d)}$) strongly bidentate and shorter than the adjacent umbilical lobe (U), the next umbilically derived lobe (U^1) representing the longest in external lobes. All preserved external lobes bidentate.

Occurrence.—Beds 19–17, Longyin Formation, Huagong section (Sec. II), Huagong Tea-Plantation, Qinglong County, Guizhou.

Materials.—Three specimens, representing two individuals, NIGP 93691 (two opposite pieces) and 93692, poorly preserved in mudstone.

Remarks.—Sutural outline resembles those of the type species, *M. orbignyana*, in shape of ventrolateral saddle, number of lateral adventitious, and subdivisions on ventrolateral saddle. However, the secondary saddles between the lateral lobe ($L_{1(d)}$) and first lateral adventitious lobule (l^1), and between any other two lateral adventitious lobules are shorter than those in the type specimens of the Urals species. After comparison of the components and figures of the adventitious lobules between types and the present specimens, the differences noted above probably are due simply to erosion of specimens.

Genus *Eumedlicottia* Spath, 1934

1880 *Medlicottia* Waagen, p. 83 (part).

Type species.—*Medlicottia bifrons* Gemmellaro, 1887; original designation; Sosio Limestone (Wordian), Rupe del Pass, Sosio Valley, Province Palermo, Sicily, Italy.

Diagnosis.—Conch and suture generally similar to *Medlicottia*, but includes larger specimens (phragmocone may exceed 15 cm diameter), and most saddles in external suture are characterized by distinct paired notches above midheight. Prongs of primary external lateral lobe lie off (above) general lobe alignment.

Occurrence.—Artinskian through Changhsingian (e.g., Chiddruan); Greece (Chios Island), Oman, Pakistan (Salt Range),

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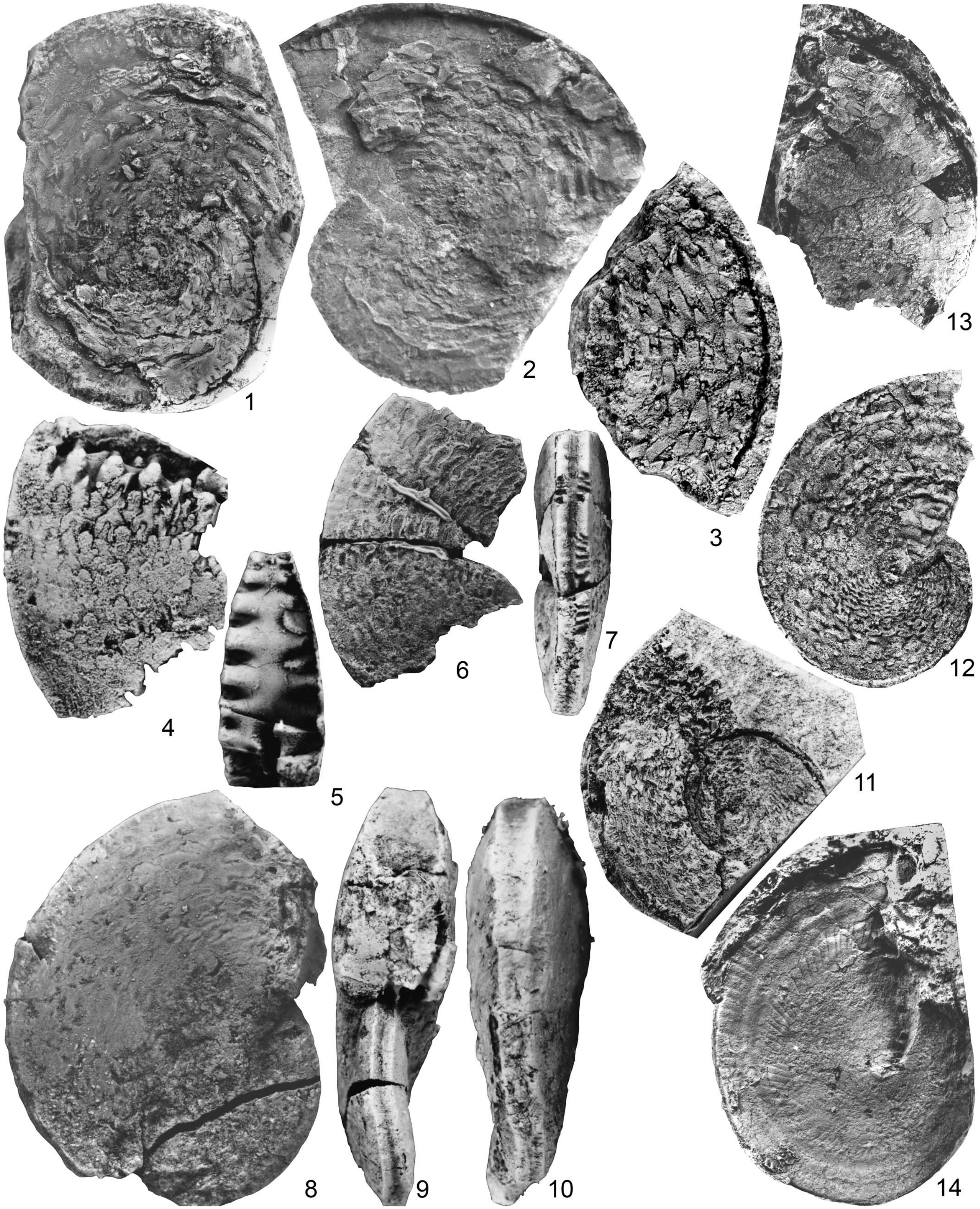

Figure 23. *Medlicottia* Waagen, 1880 and *Eumedlicottia* Spath, 1934. (**1–3**) *Medlicottia orbignyana* (Verneuil, 1845), lateral views, beds 19–17, Longyin Formation, Huagong section (Sec. II), Huagon Tea-Plantation, Qinglong County, Guizhou, ×1.5; (**1**) NIGP 93692; (**2, 3**) counterparts of an individual, NIGP 93691; (**4–14**) *Eumedlicottia kabiensis* n. sp., the ammonoid-bearing claystone intercalated in Member XII, upper Houziguan Formation, Kabi (Loc. 3), Houchang, Ziyun County, Guizhou; (**4, 5**) lateral and apertural views, NIGP 93698, ×3; (**6, 7**) lateral and ventral views, NIGP 93694, ×2; (**8–10**) lateral, apertural, and ventral views, NIGP 93693, holotype, ×3; (**11**) lateral view, NIGP 93697, ×1.5; (**12**) lateral view, NIGP 93695, ×1; (**13, 14**) lateral views, counterparts of the same individual, NIGP 93696, ×1.

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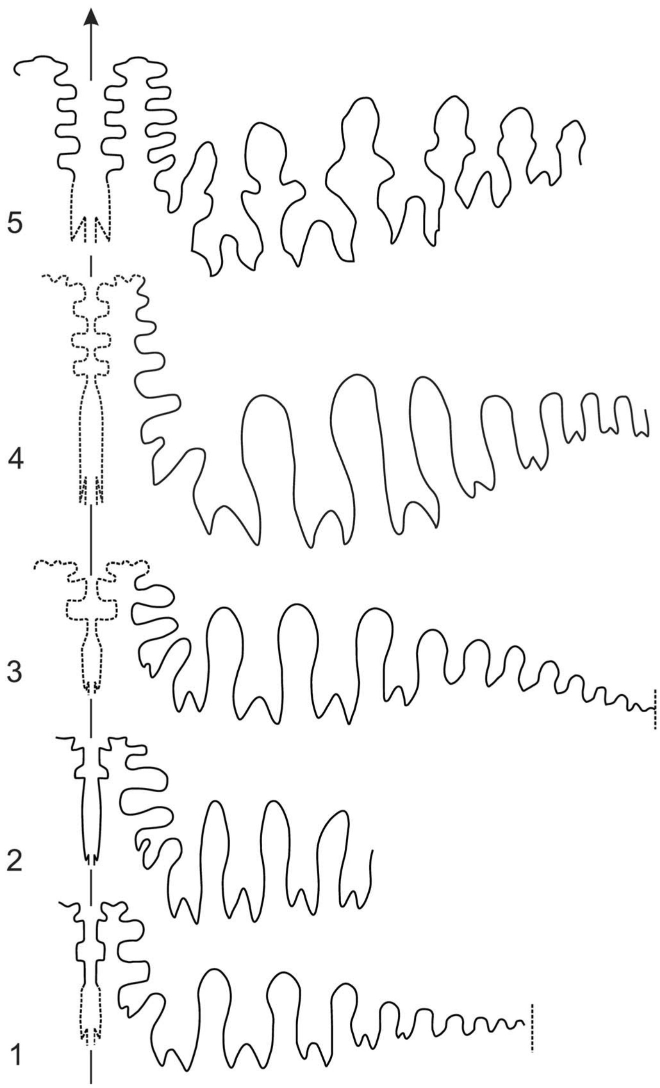

Figure 24. External sutures of medlicottiins. (**1–3**) *Artinskia nalivkini* Ruzhentsev, 1938, Bed 19, 2nd Member, Nandan Formation, Meyao section (Sec. V), Nandan, Guangxi; (**1**) NIGP 88975, D 18 mm; (**2**) NIGP 88976, D 42 mm; (**3**) NIGP 88977, D ~80 mm; (**4**) *Medlicottia orbignyana* (Verneuil, 1845), NIGP 93692, D ~36 mm, beds 19–17, Longyin Formation, Huagong section (Sec. II), Huagon Tea-Plantation, Qinglong County, Guizhou; (**5**) *Eumedlicottia kabiensis* n. sp. NIGP 93693, holotype, D 22 mm, the ammonoid-bearing claystone intercalated in Member XII, upper Houziguan Formation, Kabi (Loc. 3), Houchang, Ziyun County, Guizhou.

Japan (Kitakami Massif), Russia (Maritime Territory), Indonesia (Timor), Mexico Coahuila), USA (west and central Texas, Wyoming), Canada (British Columbia), East Greenland, and South China (Guizhou).

Remarks.—*Eumedlicottia* has been accepted by most authors as an independent valid genus, distinguished from *Medlicottia* by palpable notches of the most outer lobes, even including some lateral adventitious lobules at the lower part.

Eumedlicottia kabiensis new species
Figures 23.4–23.14, 24.5

Diagnosis.—Species characterized by relatively broader ventral lobe, symmetrical fish-bone-like ventrolateral saddle, five adventitious lobules laterally ($l^1l^2l^3l^4l^5$), and four ventrally ($v^1v^2v^3v^4$). Lateral lobe ($L_{1(d)}$) not obviously shorter than the umbilically derived lobes ($UU^1U^2U^3$….).

Description.—Shell sublenticular with narrow, bicarinate, furrowed venter. Keels on ventral rim smooth, flanks generally flat, umbilicus very small. Diameter and basic ratios of holotype NIGP 93693: D 23.6 mm, H/D 0.59, and W/D 0.28, respectively. A shallow longitudinal depression belt and fine transversal growth lines with a broad and shallow lateral salient observed from the outer and inner casts of paratype NIGP 93696. Both ventral lobe and ventrolateral saddle relatively broad with parallel flanks generally; the adventitious elements on the saddle include four square ventral lobules ($v^1v^2v^3v^4$), five square lateral lobules ($l^1l^2l^3l^4l^5$), and two apicals (s^1s^1). First lateral adventitious lobule (l^1) large and bidentate. Lateral lobe ($L_{1(d)}$) and umbilically derived lobes ($UU^1U^2U^3$) broad and bidentate, with obvious and regular notches on flanks; especially, prongs of the former seem not as usual above the general alignment of the latter.

Etymology.—Named from the locality where the new species was found.

Materials.—Six specimens, four phragmocone molds and two casts of body chamber; NIGP 93693 (holotype), and NIGP 93694–93698.

Occurrence.—The ammonoid-bearing claystone, intercalated in the limestone of the XII Member, top of the Houziguan Formation, Kabi (Loc. 3), Houchang, Ziyun County, Guizhou.

Remarks.—*Eumedlicottia kabiensis* n. sp. is similar to the type species, *E. bifrons* Gemmellaro, 1887, in general outline of suture, the wider ventral lobe, and the robust 'lateral' lobes; but differs from the latter by one or two more ventral and lateral adventitious lobules, and fairly longer lateral lobe ($L_{1(d)}$). *Eumedlicottia kabiensis* n. sp. is similar to *E. whitneyi* (Böse, 1919), with broader ventral lobe and ventrolateral saddle, square-like ventral and lateral adventitious lobules, but with more robust 'lateral' lobes, the width/length of lobe (~0.45) different from 0.38 in the latter. Although the species here is similar *E. burckhardti* (Böse, 1919) in the fossil combination in occurrence, the former possesses one more adventitious lobule both laterally and ventrally, even at smaller diameters (D = 22 mm).

Subfamily Sicanitinae Noetling, 1904 (= Artioceratinae Leonova, 1989)

Genus *Sicanites* Gemmellaro, 1887

1887 *Medlicottia*; Gemmellaro, p. 50 (part).
1937a ?*Prosicanites* Toumanskaya, p. 113 (part).
1940c *Artinskia*; Ruzhentsev, p. 475 (part).
1947 *Aktubinskia*; Ruzhentsev, p. 641.
1978 *Vanartinskia* Ruzhentsev, 1978, p. 41.

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Type species.—*Medlicottia schopeni* Gemmellaro, 1887; subsequent designation by Miller and Furnish, 1940a, based on page priority to the junior synonym, *Sicanites mojsisovicsi* Gemmellaro, 1887; Sosio Limestone (Wordian), Rupe del Pass, Sosio Valley, Province Palermo, Sicily, Italy.

Diagnosis.—Conch lenticular, with ventral nodes varyingly bladelike in most species to simulate paired ventrolateral keels. Ventrolateral saddle intermediate in height, with 7–10 subdivisions, the primary external lateral lobe ($L_{1(d)}$) significantly below alignment of subequal adjacent umbilically derived lobes. Sutural formula: $(V_2V_1V_2)v^1v^{2-3}s^1s^1l^{5-3}l^2l^1L_{1(d)}UU^1U^2.....U^{11}$.

Occurrence.—Asselian through Wordian; Italy (Sicily), Croatia, Iraq (Kurdistan), Oman, Ukraine (Crimea), Kazakhstan (Southern Urals), Tajikistan (Pamirs), Thailand (Loei), Indonesia (Timor), USA (western Texas, Nevada), Mexico (Coahuila), and South China (Guizhou, Guangxi).

Remarks.—The type specimen of *Scicanites schopeni* exhibits the polygonal coiling up to a diameter of 15 mm. It may serve eventually for separate generic recognition, but there is insufficient current information about other assigned species. *Sicanites* is very similar to *Artinskia* in subdivision of the adventitious elements on ventrolateral saddle, especially for some Asselian species (e.g., *Artinskia irinae* Ruzhentsev), because it has a long external lateral lobe ($L_{1(d)}$) and nearly the same adventitious subdivision of ventrolateral saddle. However, the difference between them is still obvious in at least three respects: (1) *Sicanites* is characterized by narrower venter, whereas in *Artinskia* the venter is relatively broader; (2) *Sicanites* has obvious lateral ribs and much smaller tubercles near the ventrolateral part of conch, whereas in *Artinskia* the nodes usually are bigger, but not as prominent; and (3) although some primitive species of *Artinskia* possess a longer external lateral lobe like *Sicanites*, the latter has a very large first lateral adventitious lobe and more bidentate umbilical lobes in number.

Sicanites notabilis (Ruzhentsev, 1940c)
Figures 25.1–25.3, 26.1, 26.2

1940c *Artinskia notabilis* Ruzhentsev, p. 475.
1947 *Aktubinskia notabilis*; Ruzhentsev, p. 641.
2004 *Aktubinskia* cf. *notabilis*; Zhou and Liengjarern, p. 327, figs. 7.5–7.7, 9.5, 9.6.
2009 *Sicanites notabilis*; Glenister et al., p. 210, figs. 135, l–n.

Description.—Juvenile evolute, gradually becoming involute when mature. Two rows of tubercles developed on the ventrolateral shoulder and separated by the medium groove. Three lateral adventitious lobules ($l^3l^2l^1$) on lateral flank of the ventrolateral saddle, in which the first one (l^1) is quite large in size and strongly bidentate at base. As shown in NIGP 93689 (Fig. 26.2), the lower digit of the first adventitious lobule (l^1) bidentate secondarily.

Materials.—Three specimens, NIGP 88982, 93689, and 154109, representing three individuals collected from yellow, weathered mudstone of three different localities, but all from the same horizon in the area.

Occurrence.—Longma Member, Sidazhai Formation, Mading (Loc. 6), Liuzhai, Nandan County, Guangxi; Bed 34–32, Yangchang Formation, Yangchang section (Sec. III), Ziyun County, Guizhou; Bed 3, Longyin Formation, Longyin section (Sec. I), Pu'an County, Guizhou.

Remarks.—*Sicanites notabilis* specimens in this study, with a longer lateral lobe ($L_{1(d)}$) and a large and bidentate first lateral adventitious lobule (l^1), are rather similar to the type specimen of *Sicanites notabilis* (Ruzhentsev). The secondary bidentate in the first lateral adventitious lobule (Fig. 26.2) is considered to be a result of intraspecific variation.

Genus *Synartinskia* Ruzhentsev, 1939b

1889 *Propinacoceras*; Karpinskii, p. 37 (part).
1939b *Synartinskia* Ruzhentsev, p. 461.
1985 *Parasicanites* Leonova, p. 77.

Type species.—*Synartinskia pricipalis* Ruzhentsev, 1939b; original designation; Sakmarian, Aktubinsk District, Kazakhstan (Southern Urals).

Diagnosis.—Conch form and ventral sculpture as in *Artioceras*. Suture characterized by deep dorsal prong of primary external lateral lobe in combination with ventrolateral saddle with four or five subdivisions, one of which is ventrad; first dorsal subdivision (l^1) large and variously dentate. Sutural formula: $(V_2V_1V_2)$ $v^1s^1s^1l^1l^2L_{1(d)}UU^1U^2$......

Occurrence.—Sakmarian through Roadian; Russia and Kazakhstan (Southern Urals), Tajikistan (Pamirs), Canada (Arctic Archipelago: Devon Island), and South China (Guangxi).

Remarks.—As a sicanitins, the systematic character of *Synartinskia* is possessing the deep, lateral lobe ($L_{1(d)}$), which is apparently below the alignment of subequal adjacent umbilically derived lobes, although the generic classification is based on possessing only one ventral adventitious lobule (v^1), and as few as only one lateral adventitious lobule (l^1), *Synartinskia* is easily distinguished from *Sicanites* and *Artioceras* in the subfamily.

Synartinskia meyaoense new species
Figures 25.4–25.7, 26.3, 26.4

Diagnosis.—Forms with obviously longer lateral lobe ($L_{1(d)}$), characterized by adventitious components of ventrolateral saddle, which shows a transition to *Artinskia*.

Description.—Conch flat laterally, flanks nearly parallel, but a rather obviously depressed zone around margin of conch (Fig. 25.4). Umbilicus small, U/D ~0.12 at diameter 18.4 mm. Two rows of slightly oblique, but prominent nodes mainly confined in venter (Table 5). External suture includes a narrow ventral lobe, a high and relatively broad ventrolateral saddle with five to six adventitious lobules (e.g., $v^1s^1s^1l^2l^1$ (Fig. 26.3)

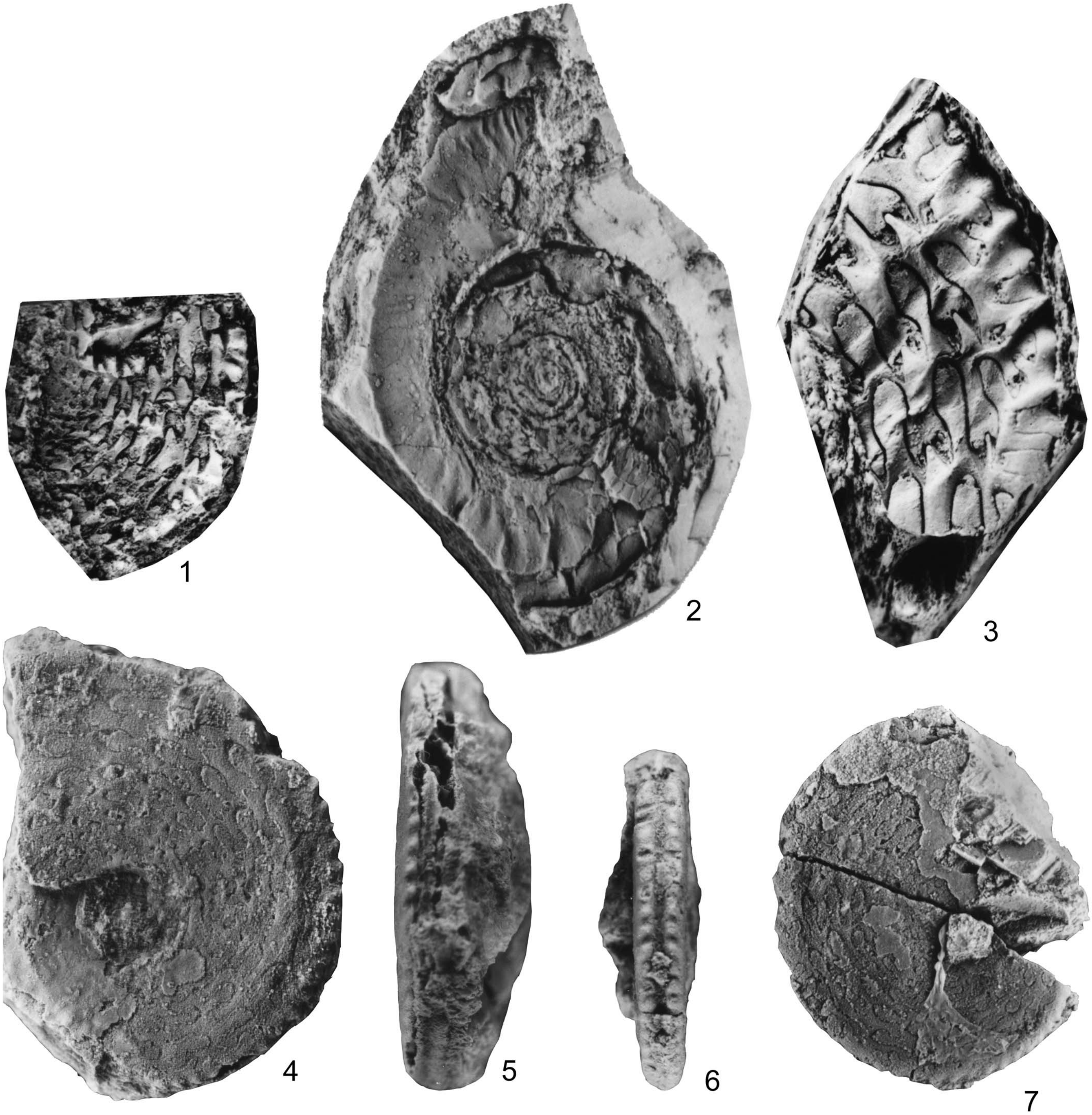

Figure 25. Sicanitins. (**1–3**) *Sicanites notabilis* Ruzhentsev, 1940c; (**1**) NIGP 88982, ×4, beds 34–32, Yangchang Formation, Yangchang section (Sec. III), Ziyun County, Guizhou; (**2**) NIGP 154109, ×2, Bed 3, Longyin Formation, Longyin section (Sec. I), Pu'an County, Guizhou; (**3**) NIGP 93689, ×4, Longma Member, Sidazhai Formation, Mading (Loc. 6), Liuzhai, Nandan County, Guangxi; (**4–7**) *Synartinskia meyaoense* n. sp. Bed 19, 2nd Member, Nandan Formation, Meyao section (Sec. V), Liuzhai, Nandan County, Guangxi, ×3; (**4, 5**) lateral and ventral views, NIGP 88978, holotype; (**6, 7**) ventral and lateral views, NIGP 88979.

to $v^1v^2sl^3l^2l^1$ (Fig. 26.4) ontogenetically, a deep and bidentate lateral lobe ($L_{1(d)}$), and several bidentate umbilically derived lobes (U U^1U^2….).

Etymology.—Named from the Meyao section (Sec. V), Liuzhai area in Nandan County, Guangxi.

Materials.—Two internal molds of phragmocone, septated throughout, NIGP 88978 (holotype) and 88979.

Occurrence.—Bed 19, 2nd Member, Nandan Formation, Meyao section (Sec. V), Liuzhai, Nandan County, Guangxi.

Remarks.—*Synartinskia meyaoense* n. sp. belongs to *Synartinskia* because of its longer lateral lobe ($L_{1(d)}$), which has less than the average alignment of the umbilically derived lateral lobes and the basical adventitious subdivisions of the ventrolateral saddle. It is distinct from other species in the genus by the characters of the adventitious lobules of the ventrolateral

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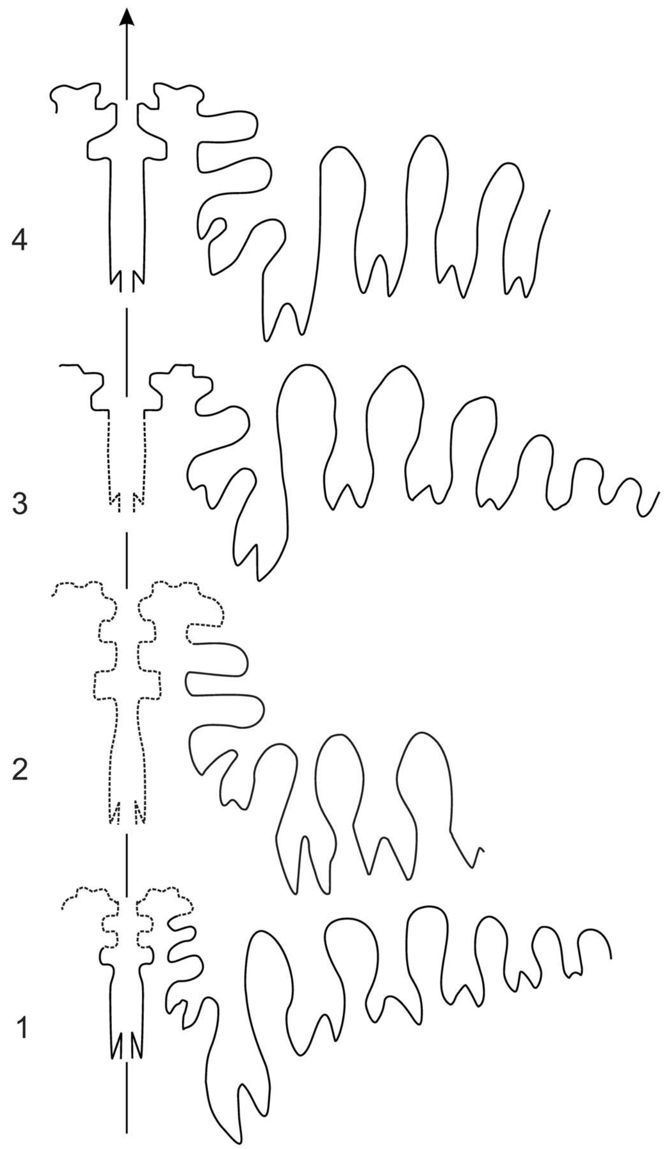

Figure 26. External sutures of sicanitins, the genera *Sicanites* Gemmellaro, 1887 and *Synartinskia* Ruzhentsev, 1939b. (**1, 2**) *Sicanites notabilis* Ruzhentsev, 1940c; (**1**) NIGP 88982, D 17 mm, beds 34–32, Yangchang Formation, Yangchang section, Ziyun County, Guizhou; (**2**) NIGP 93689, D ~28 mm, Longma Member, Sidazhai Formation, Mading (Loc. 6), Liuzhai, Nandan County, Guangxi; (**3, 4**) *Synartinskia meyaoense* n. sp. Bed 19, 2nd Member, Nandan Formation, Meyao section (Sec. V), Liuzhai, Nandan County, Guangxi: (**3**) NIGP 88979, D 17 mm; (**4**) NIGP 88978, holotype, D 20 mm.

Table 5. Dimensions and ratios of *Synartinskia meyaoense* n. sp. D, diameter of conch; W, width of conch; H, height of whorl; U, diameter of umbilicus.

Specimen	D (mm)	W/D	H/D	U/D	H/W
NIGP 88978	23.5	0.18	0.54	0.14	3.0
NIGP 88979	18.4	0.2	0.58	0.15	2.9

saddle, which form a transition to the genus *Artinskia* in subdivision of the ventrolateral lobe. However, there is a depressed zone around margin of the conch (Fig. 25.1), which is quite similar to the genus *Artinskia*. The question is if the genetic feature of the longer lateral lobe ($L_{1(d)}$) could be polyphyletic?

Order Goniatitida Hyatt, 1884
Suborder Goniatitina Hyatt, 1884
Superfamily Agathioceratoidea Arthaber, 1911
Family Agathiceratidae Arthaber, 1911

Genus *Agathiceras* Gemmellaro, 1887

1874 *Goniatites*; Karpinskii, p. 288 (part).
1887 *Agathiceras* Gemmellaro, p. 75 (part).
1915 *Agathiceras*; Haniel, p. 66 (part).
1950 *Agathiceras* (*Paragathiceras*) Ruzhentsev, p. 92.

Type species.—*Agathiceras suessi* Gemmellaro, 1887; original designation; Sosio Limestone (Wordian), Sosio Valley, Sicily, Palermo, Italy.

Diagnosis.—Conch subdiscoidal, involute, commonly with apertural constrictions. Sculpture merely prominent longitudinal lirae. Ventral lobe broad, with pouched and apically pointed branches; median saddle in some forms reaching almost total height of ventral lobe. In adult, adventitious lobe of early whorls developing three discrete and subequal spatulate lobes.

Occurrence.—Upper Carboniferous (Moscovian) through Middle Permian (Wordian); Italy (Sicily), Russia and Kazakhstan (South Urals), Ukraine (Crimea), Slovenia, Tunisia, Iraq, Afghanistan, Oman, Indonesia (Timor), Japan, USA (Texas), Mexico (Coahuila), Canada (British Columbia, North West Territories), Russia (Siberia), Tajikistan (Pamirs), Western Australia, Thailand (Loei, Saraburi), and China (Guangxi, Guizhou, Xinjiang, Xizang, Nei Mongol, Jilin).

Remarks.—Species of *Agathiceras* were the most abundant (number of individuals) late Paleozoic ammonoids in the open sea. In Chinese records, *Agathiceras* is apparently exclusively distributed in a particular environment. The definition of the genus worked out by the earlier workers is relatively extensive. Haniel (1915) even included genera *Adrianites* and *Doryceras*, which actually have totally different phylogenetic origins and can be easily distinguished based on suture and sculpture of test. Ruzhentsev (1938) grouped the forms with transverse lines, represented by '*Agathiceras martini* Haniel, 1915' into subgenus *Agathiceras* (*Gaetanoceras*), which Gerth (1950) raised in rank to an independent genus. At the same time, Ruzhentsev (1950) established another new subgenus, *Agathiceras* (*Paragathiceras*), based to the much-flattened shell forms. However, if subgenus subdivision is based only on conch shape, it may be disturbed by the secondary deformation during preservation.

Agathiceras changed very little with time both in conch shape and suture. Dixon (1960) compared several representative species of *Agathiceras* from various localities and horizons, but in the same ontogenetic phase, and suggested that species in the early stage had more inflated shells, while those in the late stage had more compressed shells. Dixon (1960) recognized a series of trends in conch dimensions with stratigraphic level, certainly is a promising biostratigraphic result for a genus with such a long geological range. Three intervals with different appearance of sculpture are recognized herein in conchs of *Agathiceras*

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specimens from South China, which is significant for identifying species and avoiding potential preservation variation that could occur from using inflation alone.

Agathiceras sequaxilirae new species
Figures 27.5–27.21, 29.3, 30.1–30.3

1987 *Agathiceras vulgatum*; Zhou, p. 137, pl. 2, figs. 13–18, pl. 3, figs. 1–11.

Diagnosis.—A species with relatively large conch size, possessing the secondarily intercalated spiral lirae in maturity.

Description.—Conch subspherical and involute, with diameter >40 mm in the largest specimen, the holotype NIGP 88988 (Fig. 27.20, 27.21). Umbilicus small (U/D usually <0.1). Conch becoming compressed in shape with growth ontogenetically (Table 6). Conch recrystalized during preservation, but the holotype still exhibits well-preserved stratified structure of test. Three layers at least could be recognized from venter and flanks of body chamber (Fig. 30). Inner mold, as the base of the test layers, exhibits faint longitudinal lira traces, indicating that the major sculpture, lirae, even impressed into the inner surface of the test. From interior to exterior: the inner prismatic layer, ~0.23 mm thick, consisting of coarse-grained light calcite; the nacreous layer, about the same thickness as inner prismatic layer, consists of dark, fine-grained calcite, with regular, wide-spaced fine lirae on the bottom of the layer; the outer prismatic layer, consists of coarse-grained, light calcite, with primary and secondaty lirae on surface, and layer thickness usually ~0.4 mm or so, possibly increasing due to some extra calcite wedging during preservation. Diverse colors and grain sizes of calcite in the layers noted above might reveal differences in the primary structure, and, probably, the aragonite component of the ammonoid conch. Primary lirae are stronger and spaced normally, while the secondary lirae are weaker in intensity and intercalated between the primary ones; generally, 22 lirae per 10 mm on the venter at diameter 32.6 mm. However, lirae on the second layer are relatively sparse and slender (Figs. 27.21, 30.3).

Four or five constrictions present in outer volution, becoming stronger on flanks, and weakening again towards venter, with gentle sinus appearing on both venter and flank. Ventral lobe is broad and subdivided by a bottle-shaped medium saddle; all lateral lobes are inflated at rear, slightly pointed at bottom, and constricted in front. Saddles are club-shaped and decrease in height toward the umbilicus.

Etymology.—*Sequax* means secondarily ranked, and *lirae* meaning longitudinal lines on conch surface; both are Latin.

Materials.—Eighteen specimens, of which NIGP 88983–88987 and 88988 (holotype) newly collected, and NIGP 94459–94470, restudied here, which previously had been identified as *Agathiceras volgatum* Ruzhentsev, 1978 (Zhou, 1987, p. 137, pl. 2, figs. 13–18, pl. 3, figs. 1–11).

Occurrence.—Bed 19, Meyao section (Sec. V), Bed 11, Zhuangli section (Sec. VI), and the Asselian talus limestone, Liuzhai Quarry (Loc. 5) are within the 2nd Member; while the Bed 26, Meyao section (Sec. V) is within the 3rd Member. Both members compose the Permian part of the Nandan Formation in Liuzhai, Nandan County, Guangxi.

Remarks.—According to Kulicki (1996), ammonoid walls consist of four consecutive layers, from exterior to interior: periostracum, outer prismatic, nacreous, and inner prismatic. In the present case, specimens here are entirely recrystalized without any possibility to identify the individual layers listed above. However, it may be concluded that the shell of *Agathiceras sequaxilirae* n. sp. possesses three conch layers at least, without the structure details being preserved. Two of the layers, the second and third, bear different types of lirae (with secondary lirae or not) on the layer surface, respectively. It is thus evident that identification of specific taxa in the genus based on lirae has to rely on identification of conch layers.

It is interesting that the specimen of *Agathiceras suessi* Gemmellaro, 1887 illustrated in Miller and Furnish (1940a, pl. 31, fig. 12; Yale Peabody Museum 15229, collected from Sosio beds, Calcare Compatto, Palermo) has noticeably two conch layers with lirae, but which have almost the same shape and numbers on these layers. Some lirae might even be traced on the inner mold of that specimen, which would distinguish it easily from *A. sequaxilirae* n. sp. here by lira type, although the species of Gemmellaro (1887) is the best analogue to recognize new species in conch shape and size.

The specimens identified as *A. vulgatum* Ruzhentsev, 1978 by Zhou (1987) were collected from the Asselian talus limestone at Liuzhai Quarry (Loc. 5), near Liuzhai. After review, these specimens, which are characterized by two-ranked lirae, also should be conspecific with *Agathiceras sequaxilirae* n. sp., herein.

Agathiceras suessi Gemmellaro, 1887
Figures 27.1–27.4, 29.2

1940a *Agathiceras suessi*; Miller and Furnish, p. 118, pl. 31, figs. 8–12

Description.—Shell small, involute and discoidal with a small umbilicus. The larger specimen (NIGP 93702, Fig. 27.3, 27.4) more compressed than the smaller one (NIGP 93703, Fig. 27.1, 27.2) in conch shape. About 60 fine but distinct spiral lirae on conch surface, consistently maintain such a number on volutions observed. The smaller conch is measured as: D 14.7 mm, W/D 0.65, H/D 0.61, U/D <0.1. Ventral lobe subdivided by a

Figure 27. *Agathiceras* Gemmellaro, 1887. (**1–4**) *Agathiceras suessi* Gemmellaro, 1887, the ammonoid-bearing claystone intercalated in Member XII, upper Houziguan Formation, Kabi (Loc. 3), Houchang, Ziyun County, Guizhou. ×2.5; (**1, 2**) lateral and apertural views, NIGP 93703; (**3, 4**) apertural and lateral views, NIGP 93702; (**5–21**) *Agathiceras sequaxilirae* n. sp. Nandan Formation, Meyao section (Sec. V) (except **8, 9, 12–14**), Liuzhai, Nandan County, Guangxi; (**5–7**) lateral, apertural, and ventral views, NIGP 88983, Bed 19, 2nd Member, ×3; (**8, 9**) apertural and lateral views, NIGP 88984, Bed 11, 2nd Member, Zhuangli section (Sec. VI), ×3; (**10, 11**) lateral and ventral views, NIGP 88985, Bed 19, 2nd Member, ×3; (**12–14**) lateral, apertural, and ventral views, NIGP 94462 (Zhou, 1987, pl. 3, figs. 3–5), Asselian talus limestone, 2nd Member, Liuzhai Quarry (Loc. 5), ×2; (**15, 16**) ventral and lateral views, NIGP 88986, Bed 19, 2nd Member, ×3; (**17–19**) ventral, lateral, and apertural views, NIGP 88987, Bed 26, 3rd Member, ×1.5; (**20, 21**) ventral and lateral views, NIGP 88988, holotype, Bed 26, 3rd Member, ×1.5.

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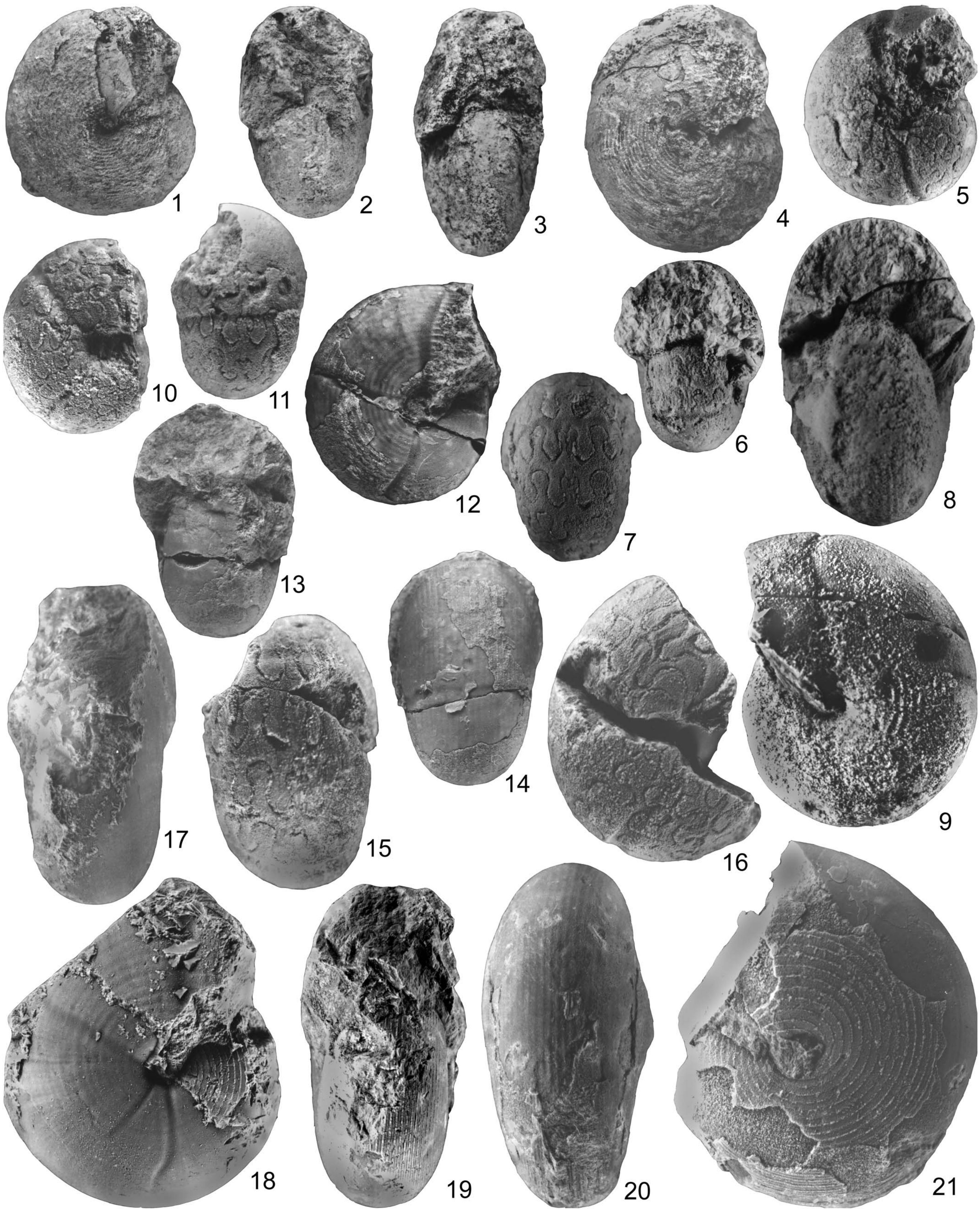

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wider medium saddle; prongs near the same or a little broader than the first lateral lobe. Lobes apparently constricted at the middle of flanks, third lateral lobe unusually broad. Saddles club-shaped with rounded top.

Occurrence.—The ammonoid-bearing claystone intercalated in the limestone of the Member XII of the top Houziguan Formation, Kabi (Loc. 3), Houchang, Ziyun County, Guizhou.

Materials.—Only two specimens preserved in mudstone, NIGP 93702, 93703.

Remarks.—Both the fine spiral lirae and the general suture appearance have the same features as the types from Sicily at a similar diameter,. Specimens herein also resemble *Agathiceras uralicus* (Karpinskii, 1874) in the expanded rear part and the almost rounded base of the lobes; but the former has broader branches, and much sparser spiral lirae than the latter.

Agathiceras mediterraneum Toumanskaya, 1949
Figures 28.1–28.10, 29.4

1915 *Agathiceras sundaicum* Haniel, p. 66, pl. 49, figs. 15a, b.
2004 *Agathiceras mediterraneum*; Zhou and Liengjarern, p. 327, figs. 8.2–8.7, 10.1, 10.2.
2005 *Agathiceras mediterraneum*; Zhou and Yang, p. 383, figs. 5.6–5.12, 6.1, 6.2, 8.8–8.15.

Description.—Shell thickly discoidal, involute with a small umbilicus. Venter narrowly rounded; flanks fairly convex. Four to five constrictions present on the outer volution. Sculpture preserved only as faint trail of spiral lirae and some transverse growth lines. Ventral lobe rather broad and subdivided by a high, medium saddle into two prongs, which approximately equals the first lateral lobe in width. All lobes constricted in front, expanded at rear, sharpened at base. The third lateral saddle high, broad, and asymmetric.

Materials.—Four phragmoconchs preserved in silicified limestone, NIGP 93704–93707.

Occurrence.—Bed 12, Chongtou Member, Sidazhai Formation; Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou.

Remarks.—Specimens here are similar to the holotype from the Pamirs in having a narrowly rounded venter, convex flanks, small umbilicus with constrictions, spiral lirae, and some transverse growth lines. Additionally, the relatively higher medium saddle of the ventral lobe, the high and broad third lateral saddle, and the broader prongs, also are present in the Pamirs types. The specimens studied here resemble *Agathiceras suessi* in general shell shape, but their medium saddles are higher and the lobes are longer than the latter.

Agathiceras sp.
Figures 28.11–28.14, 29.1

Description.—Shells involute, with small umbilicus. About 16 thin and sparse spiral lirae appearing on the flank of the outer cast. Total number of lirae nearly 50 or fewer. No constriction observed. Only three lateral lobes preserved, all of them expanded at rear, constricted in front and sharpened at the base.

Materials.—Three individuals, NIGP 93708–93710, but preserved as four pieces, in which NIGP 93708 includes an external cast and an internal mold.

Occurrence.—Beds 19–17, Longyin Formation, Huagong section (Sec. II), Huagong Tea-Plantation, Qinglong County, Guizhou; and Longma Member, Sidazhai Formation, Mading (Loc. 6), Liuzhai, Nandan, Guangxi.

Remarks.—Specimens are similar to *Agathiceras uralicum* (Karpinskii, 1874) in general lobe shape, but they are apparently sharpened at the base and lack constrictions. They are somewhat similar to *Agathiceras suessi* in suture, but their spiral lirae on exterior shell are much fewer in number than the latter.

Superfamily Adrianitoidea Schindewolf, 1931
Family Adrianitidae Schindewolf, 1931
Subfamily Adrianitinae Schindewolf, 1931

Genus *Neocrimites* Ruzhentsev, 1940a

1885 *Waagenia* Krotov, p. 204 (part).
1887 *Adrianites* Gemmellaro, p. 19 (part).
1888 *Waagenina* Krotov, p. 474 (part).
1889 *Agathiceras*; Karpinskii, p. 63, (part).
1915 *Agathiceras*; Haniel, p. 66 (part).
1940a *Neocrimites* Ruzhentsev, p. 838.
1943 *Adrianites* (*Neocrimites*); Teichert and Fletcher, p. 161.
1997 *Millerites* Cantú Chapa, p. 66.

Type species.—*Adrianites fredericksi* Emel'iancev, 1929; original designation; Baigendzhinian, Artinskian Stage, South Urals.

Diagnosis.—Similar to *Crimites*, globular and involute, but longitudinal sculpture may be much stronger than transverse. Sutural trace directly transverse with four or five pairs of external 'lateral' lobes, three or four pairs of internal 'laterals', and two or three smaller lobes on umbilical wall.

Occurrence.—Late Artinskian through Capitanian; Kazakhstan (Southern Urals), Tajikistan (Pamirs), Russia (Urals, Northern Caucasus), USA (Texas), Mexico (Coahuila), Indonesia (Timor), ?Western Australia, and China (Xizang, Guangxi, Guizhou, Gansu).

Remarks.—Ruzhentsev (1950), based upon the number of lateral lobes, subdivided *Neocrimites* into three subgenera: *N.* (*Metacrimites*), with four external and three internal 'lateral' lobes; *N.* (*Neocrimites*), with four lobes in both exterior and interior; and *N.* (*Sosiocrimites*), with seven external lobes. However, as independent genus-level taxa, only *Sosiocrimites* and *Neocrimites* were retained. The subgenus *Metacrimites* was

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Figure 28. *Agathiceras* Gemmellaro, 1887. (**1–10**) *Agathiceras mediterraneum* Toumanskaya, 1949, Bed 12, Chongtou Member, Sidazhai Formation; Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou, ×2; (**1–3**) ventral, lateral, and apertural views, NIGP 93707; (**4, 5**) lateral and ventral views, NIGP 93705; (**6, 7**) ventral and lateral views, NIGP 93706; (**8–10**) apertural, ventral, and lateral views, NIGP 93704; (**11–14**) *Agathiceras* sp.; (**11, 12**) NIGP 93708, ×3, counterparts of the same individual, lateral view, beds 19–17, Longyin Formation, Huagong section (Sec. II), Huagong Tea-Plantation, Qinglong County, Guizhou; (**13, 14**) Longma Member, Sidazhai Formation, Mading (Loc. 6), Liuzhai, Nandan County, Guangxi; (**13**) lateral view of phragmocone piece NIGP 93709, ×2.5; (**14**) lateral view, NIGP 93710, ×3.

included within *Neocrimites* (Glenister et al., 2009), because the number of 'lateral' lobes in both *Metacrimites* and *Neocrimites* successively varied and any subdivision of them might be artificial. There probably is a modification in the genus ontogenetically that the whorls are more depressed in juveniles and more compressed in adults.

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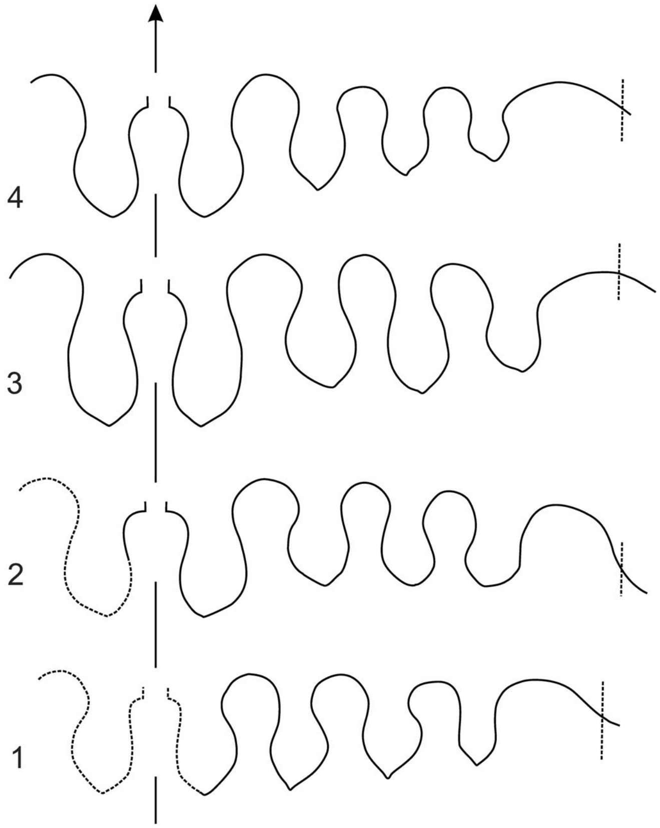

Figure 29. The external sutures of *Agathiceras* Gemmellaro, 1887. (**1**) *Agathiceras* sp. NIGP 93708, D 15 mm, beds 19–17, Longyin Formation, Huagong section (Sec. II), Huagong Tea-Plantation, Qinglong County, Guizhou; (**2**) *Agathiceras suessi* Gemmellaro, 1887, NIGP 93703, D 12 mm, the ammonoid-bearing claystone intercalated in Member XII, upper Houziguan Formation, Kabi (Loc. 3), Houchang, Ziyun County, Guizhou; (**3**) *Agathiceras sequaxilirae* n. sp., NIGP 88986, D 15 mm, Bed 19, 2nd Member, Nandan Formation, Meyao section (Sec. V), Liuzhai, Nandan County, Guangxi, Guangxi; (**4**) *Agathiceras mediterraneum* Toumanskaya, 1949, NIGP 93706, D 26 mm, Bed 12, Chongtou Member, Sidazhai Formation; Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou.

Neocrimites guizhouensis new species
Figures 31.2–31.4, 34.3

1980 *Neocrimites* cf. *N. guangsiensis*; Lee, p. 67, pl. 3, figs. 4–6.

Diagnosis.—Shell small and relatively narrower in width, five pairs of external lobes.

Description.—Conch small, globular and involute. Both venter and flanks rounded, with small umbilicus and rounded umbilical shoulder. Conch surface covered by fine reticule sculpture; 2–3 broad and shallow constrictions in the outer volution. Suture includes a bipartite ventral lobe with narrow and undivided prongs, five pairs of external 'lateral' lobes, slightly constricted adorally and sharpened at base. All lobes slightly narrower than the saddles next to them.

Etymology.—Name derived from Guizhou, southwest part of the province, which constitutes the major part of the Permian Nanpanjiang Basin.

Materials.—Two pieces of inner and outer molds, imperfectly stripped from the matrix, representing two individuals, NIGP 93711 (holotype) and 93712.

Occurrence.—Bed 12, Chongtou Member, Sidazhai Formation; Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou.

Remarks.—*Neocrimites guizhouensis* n. sp. resembles *Neocrimites guangsiensis* Zhao and Liang, 1974 in sculpture, but is distinct from the latter by the relatively narrower conch form. *Neocrimites guizhouensis* n. sp. is similar to the type species of genus *Aricoceras*, *A. discoidalis* (Haniel, 1915), in conch form and the reticulate sculpture, but different from the latter by suture, with at least one more external 'lateral' lobe.

Neocrimites guangsiensis Zhao and Liang, 1974
Figures 31.5–31.7

1965 *Neocrimites* sp. Chao, p. 1815, pl. 2, figs. 1–3.
1974 *Neocrimites guangsiensis* Zhao and Liang, p. 303, pl. 159, figs. 4, 5.

Materials.—One specimen, NIGP 22028 (holotype).

Occurrence.—The locality and the horizon of the specimen are not exactly known. According to the label attached on the specimen, it was collected from limestone of the 'Chihsian Formation' of Shiangyang Village (i.e., Xiangyang Cun) (Loc. 8) of Tian'e County, Guangxi (Zhao and Liang, 1974).

Description.—Shell small, globular and involute, with small umbilicus and steep umbilical wall. Umbilical shoulder somewhat angular. Venter and flanks rounded uniformly, whorl section crescent. Conch surface decorated with fine reticule sculpture. Two to three broad and shallow constrictions in outer volution. Dimension and ratios of the conch are: D 18.4 (mm), W/D 1.0, H/W 0.57, U/D 0.18. Although suture not exposed on conch surface of monotype, five pairs of external and internal 'lateral' lobes well preserved in septal folds at aperture, respectively.

Remarks.—The specimen discussed here was first reported and illustrated by Chao (1965). although formal description of the monotypic species was made by the original author and Liang about ten years later (Zhao and Liang, 1974). The single specimen is an entire phragmoconch with the suture not exposed, although the apertural septa look well preserved.

Neocrimites guangsiensis resembles *Neocrimites guizhouensis* n. sp. in having five pairs of external lobes; but differs from the latter by more globular in conch shape, hence wider whorl section. *Neocrimites globosa* (Haniel, 1915),

Figure 30. Sculpture and conch layers in *Agathiceras sequaxilirae* n. sp. NIGP 88988, holotype, Bed 26, 3rd Member, Nandan Formation, Meyao section (Sec. V), Liuzhai, Nandan County, Guangxi. (**1, 2**) ×2.5; (**3**) partial enlargement of the square white-framed in 1, ×7.5; M, conch inner mold; I, inner prismatic layer; N, nacreous layer, with primary spiral lirae; O, outer prismatic layer, with both primary and secondary spiral lirae.

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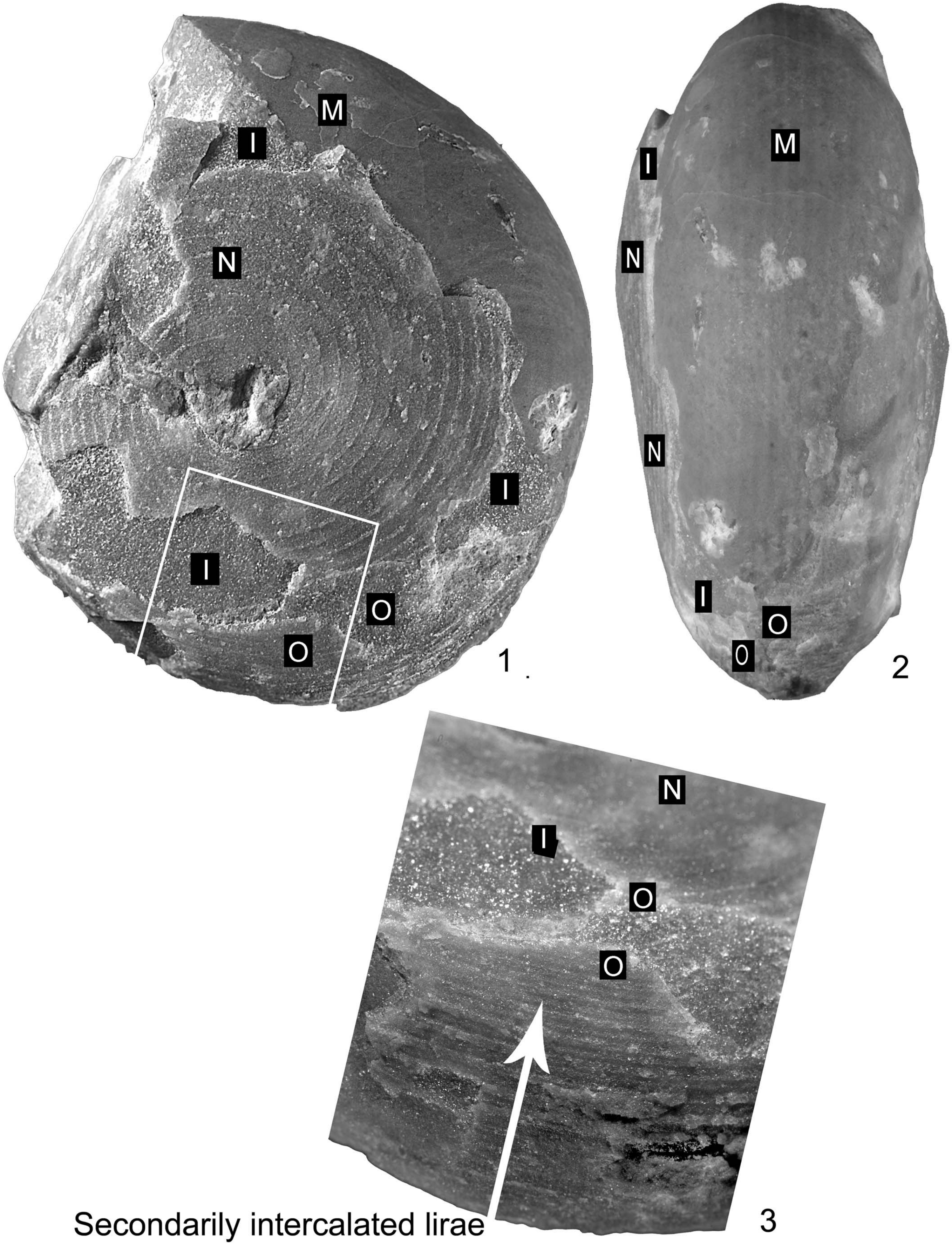

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Table 6. Dimensions and ratios of *Agathiceras sequaxilirae* n. sp. D, diameter of conch; W, width of conch; H, height of whorl; U, diameter of umbilicus.

Specimen	D	W/D	H/D	U/D	H/W
NIGP 88988	42.0	0.53	0.59	~0.07	1.1
NIGP 88987	38.7	~0.54	~0.56	~0.07	1.0
NIGP 88984	18	0.63	0.63	~0.04	1.0
NIGP 88983	11.3	0.76	0.64	~0.04	0.84

another species with five pairs of external lobes, may represent the closest form in the globular conch; however, the Timor species has a very small umbilicus.

Genus *Fusicrimites* new genus

1889 *Agathiceras*; Karpinskii, p. 65 (part).
1949 *Adrianites*; Toumanskaya, p. 74 (part).
1962 *Neocrimites* (*Neocrimites*); Bogoslovskaia, p. 95.
1963 *Waagenina*; Toumanskaya, p. 73.
1967 Adrianitids; Pavlov, p. 75, pl. 4, fig. 1 (upper-left specimen).
1972 *Neocrimites*; Pavlov, p. 109 (part).
1989 *Neocrimites* (*Neocrimites*); Leonova, p. 164 (part).

Type species.—*Neocrimites* (*Neocrimites*) *pavlovi* Leonova, 1989, original designation herein, upper Kochusuisk Formation, Bolorian Stage (Kungurian), southeast Pamirs.

Other species.—*Fusicrimites stuckenbergi* (Kapinskii, 1889), *F. nalivkini* (Toumanskaya, 1949), and *F. dutkevitchi* (Pavlov, 1972), from the Bolorian Stage, southeast Pamirs, along with the new species, *F. nanpanjiangensis* n. gen. n. sp., described herein.

Diagnosis.—Conch small (usually <25 mm in diameter), obvious fusiform shape (W/D > 1, usually ranging from 1.01 to 1.8), and completely involute. Convex venter uniformly shifts to lateral flanks without sudden change; however, umbilical shoulder between lateral flank and umbilical wall conspicuously with blunt angle. Umbilicus small, with steep umbilical wall. More than four to ten umbically derived external 'lateral' lobes in a traversal trace. All lobes narrow and pointed at base.

Etymology.—Fusiform conch shape of the new adrianitid taxon.

Occurrence.—Artinskian through Kungurian; Tajikistan (southeast Pamirs) and Guizhou (South China).

Remarks.—The sutural of the new genus is close to the ancestor *Neocrimites*, but increasing 1–4 or more umbilically derived lobes, while the most identified character, the W/D value of the new genus, is always larger than 1.0, although in a few cases the value of *Neocrimites* may reach to 1.19 (Leonova and Boiko, 2015). In genus *Crimites*, *C. doliaris* Leonova, 1988, the W/D value may be larger than 1.0, but the case only occurred in the very early ontogeny of the species.

As pointed out by T.B. Leonova (personal communication, 2016), B.F. Glenister and W.M. Furnish in the 1990s had suggested establishing the new genus '*Netrionoceras*' to cover the forms of *Neocrimites* with barrel and fusiform conch shape. Schiappa (1993) described such spindle representatives of adrianitids as Genus B (gen. nov.) in her unpublished thesis.

Fusicrimites nanpanjiangensis new species
Figures 31.1, 34.4

Diagnosis.—Well-built fusiform shape, with the largest value of W/D (1.8) and the most numerous 'lateral' lobes in the genus.

Description.—Small spindle-shaped inner mold, with small umbilicus. Venter and lateral flanks uniformly transitive without obvious subdivision; umbilical shoulder conspicuous, with rounded angle. Conch dimension and ratios: D 11.2 mm, W/D 1.8, U/D ~0.23. Sculpture unknown, however, it supposedly has longitudinal lirae and reticulately transverse lines as in the congenetic *S. pavlovi* (Leonova, 1988). Suture typical adrianitid, 9–10 'lateral' lobes aligned with straight trace transversally. Ventral lobe divided by a broad medium saddle into two narrow and asymmetric prongs. All lobes narrow and entire, slightly constricted adorally and sharpened at base, with width about 2/3 of adjacent saddle.

Etymology.—Name derived from the Nanpanjiang Basin.

Materials.—One inner mold available, NIGP 93713 (holotype).

Occurrence.—Bed 12, Chongtou Member, Sidazhai Formation, Shaiwa section (Sec. VI–VI'), Sidazhai, Ziyun County, Guizhou.

Remarks.—*Fusicrimites nanpanjiangensis* n. sp. is similar to *F. pavlovi* (Leonova, 1988) in possessing obviously fusiform conch shape and numerous 'lateral' lobes, but distinct from the latter by more strongly fusiform shape and many more umbically derived lobes in number.

Genus *Emilites* Ruzhentsev, 1938

1919 *Paralegoceras*; Böse, p. 99 (part).
1937 *Glaphyrites*; Plummer and Scott, p. 274 (part).
1940a *Plummerites* Miller and Furnish, p. 103.

Type species.—*Paralegoceras incertum* Böse, 1919; original designation; Wolfcampian Formation, northwest Wolf Camp, Glass Mountains, west Texas, USA.

Diagnosis.—Conch globular with small umbilicus (U/D, commonly 0.1) and scalloped transverse sculpture. Suture comprises two pairs of external lateral lobes and two pairs of internal laterals. External suture characterized by irregularly denticulate third lateral saddle across umbilical wall. Sutural formula: $(V_1V_1)LU{:}U^1ID$.

Occurrence.—Pennsylvanian in USA (Texas and Oklahoma), Orenburgian (Gzhelian) in Russia and Kazakhstan (Southern Urals), and Early Permian in Canadian Arctic, Tajikstan (Pamirs), Uzbekistan (Fergana), and South China (Guangxi).

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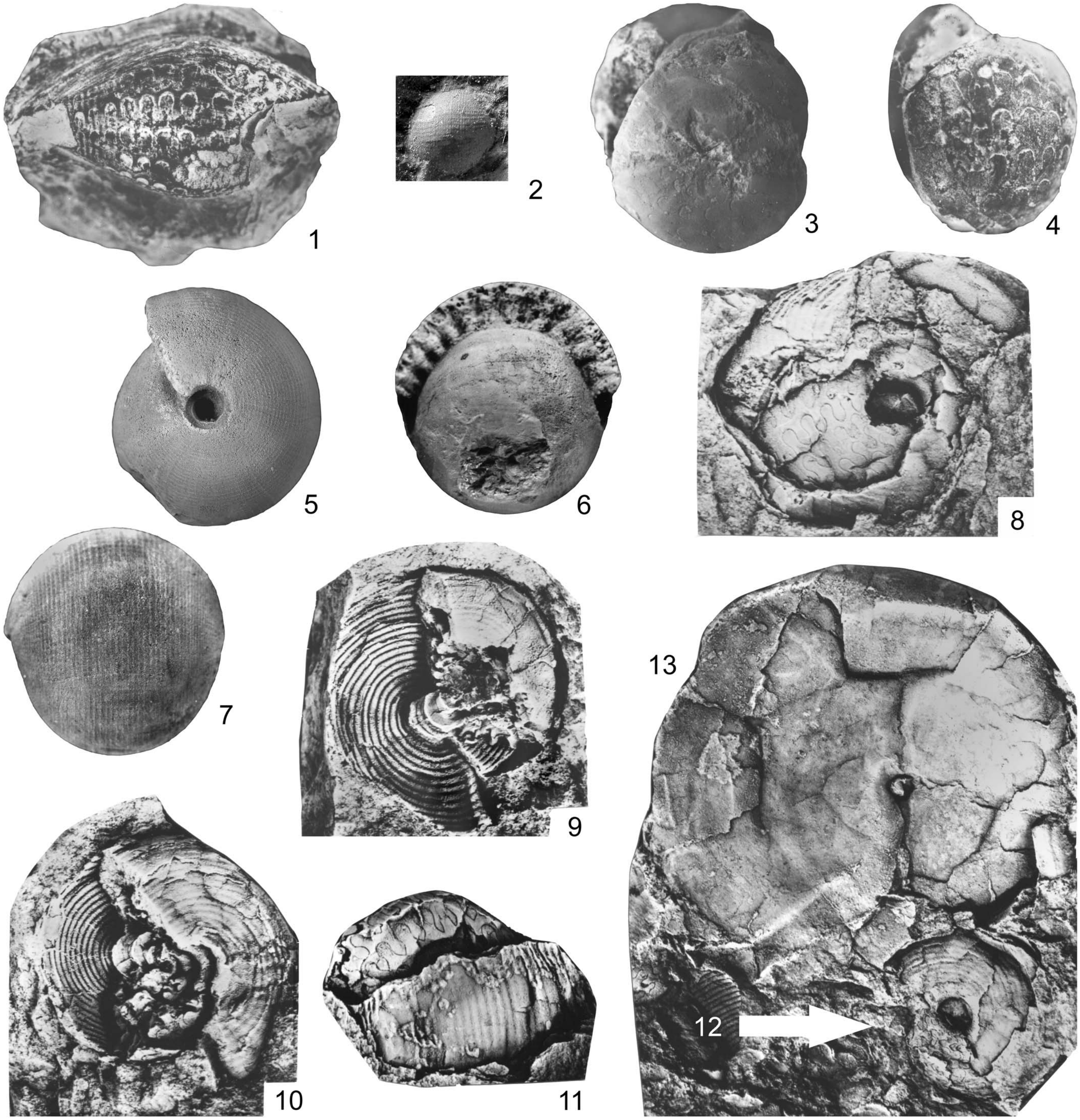

Figure 31. Adrianitids and *Stacheoceras* Gemmellaro, 1887. (**1**) *Fusicrimites nanpanjiangensis* n. gen. n. sp., NIGP 93713, holotype, ×3, lateral view, Bed 12, Chongtou Member, Sidazhai Formation, Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou; (**2–4**) *Neocrimites guizhouensis* n. sp., Bed 12, Chongtou Member, Sidazhai Formation, Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou; (**2**) lateral view, NIGP 93712, ×5; (**3, 4**) lateral and ventral views, NIGP 93711, holotype, ×2; (**5–7**) *Neocrimites guangsiensis* Zhao and Liang, 1974, lateral, apertural, and ventral views, NIGP 22028, ×2, 'Chihsia' Limestone, Shiangyang Village (i.e., Xiangyang Cun) (Loc. 8), Tian'e County, Guangxi; (**8–12**) *Epadrianites involutus* (Haniel), Bed 23, Claystone (3rd) Member, Shaiwa Formation, Sidazhai section (Sec. IV'-IV''), Sidazhai, Ziyun County, Guizhou; (**8**) lateral view, NIGP 139943, ×3; (**9, 10**) NIGP 139944, counterparts of the specimen, lateral views, ×2; (**11**) ventral, but somewhat lateral view, NIGP 139942, ×2; (**12**) lateral view, NIGP 139941, ×1.5; (**13**) *Stacheoceras shaiwaense* n. sp. lateral view, NIGP 139939, ×1.5, in association with (**12**) *Epadrianites involutus* (Haniel) herein.

Remarks.—*Emilites*, a common form occurring from the Asselian fauna in northwest Guangxi, the Nanpanjiang Basin, represents the latest presence of the genus. It mainly is characterized by denticulated umbilical saddle, even the independent adventitious lobes in umbilical region in some specimens. However, Mapes and Boardman (1988) thought that the degree of denticulation was not of taxonomic importance because they noted a moderate amount of variation in different specimens of the same species, even in the left or right side in a single individual. *Emilites* was thought as the root stock for the family

Adrianitidae because the goniatitic suture, consisting of two external and two internal 'lateral' lobes, and the denticulate umbilical saddle on each side, represent the most primitive pattern of the family.

Emilites globosus new species
Figures 32.1–32.23, 34.1, 34.2

1987 *Emilites* cf. *prosperus*; Zhou, p. 137, pl. 4, figs. 1–3.

Diagnosis.—The youngest species of *Emilites* with almost spherical form, nearly closed umbilicus, and more advanced diversity of umbilical lobe.

Description.—Conchs globular, with some sphericity variation ontogenetically. The largest sphericity appears at about 15.8 mm diameter, but flattens inversely with growth (Table 7). Sculpture not preserved. One or two faint and broad constrictions on the inner mold of the specimens NIGP 88996 (Fig. 32.11, 32.12) and 88994 (Fig. 32.13, 32.14), with oral constriction as an adult modification present in the largest specimen, NIGP 88997 (Fig. 32.22, 32.23) at 35 mm diameter. Ventral lobe divided into two narrow lanceolars. External 'lateral' lobes broad and V-shaped. Two small adventitious lobes with different shapes near the umbilicus in specimen NIGP 88997 (Fig. 34.2). The first lateral saddle somewhat pointed at crest and a little higher than the outer saddle.

Etymology.—Name derived from the spherical conch shape of the types.

Materials.—Eleven specimens, NIGP 88997 (holotype), NIGP 88989–88996, 88998, and NIGP 94471, from the limestone matrix, usually well preserved with body chamber.

Occurrence.—All from the 2nd Member, Nandan Formation, Liuzhai, Nandan County, Guangxi: including Bed 19, Meyao section (Sec. V); Bed 11, Zhuangli section (Sec. VI); and the Asselian talus limestone, Liuzhai Quarry (Loc. 5).

Remarks.—*Emilites globosus* n. sp. resembles both *E. plummeri* Ruzhentsev, 1941 and *E. prosperous* Ruzhentsev, 1978 in conch shape and generality of suture, but is distinguished from them by more spherical shape and more acute first lateral saddle. The specimens of the Liuzhai Quarry previously had been described as *E.* cf. *prosperous* (Zhou, 1987). After reviewing, it is more desirable to unify all the *Emilites* forms from the 2nd Member, Nandan Formation of Liuzhai area as *E. globosus* n. sp.

Genus *Epadrianites* Schindewolf, 1931

1950 *Basleoceras* Ruzhentsev, p. 203.

Type species.—*Agathiceras timorense* Boehm, 1908; original designation; Amarassi beds (Capitanian, probably equal to the lower Lopingian), Amarassi, Timor, Indonesia.

Diagnosis.—Conch large (diameter at maturity up to 7 cm), globular, with moderately large umbilicus and longitudinal lirae much stronger than transverse sculpture. Mature modifications incompletely known, but comprise slight geniculation, reduction of umbilical diameter, subterminal constriction, and terminal flare that probably extended into ventrolateral lappets. Sutural trace transverse; suture comprises four or five pairs of external lateral lobes, three or four pairs of internal lateral lobes, and two or three additional lobes on each umbilical wall.

Occurrence.—Wordian through Lopingian; Indonesia (Timor), Italy (Sicily), Oman, Croatia, Mexico (Coahuila), Azerbaijan (Dzhulfa) and China (Jilin, Guizhou).

Remarks.—*Epadrianites* is similar to the genus *Sociocrimites* in the longitudinal lirae, the subterminal constriction, and the numerous 'lateral' lobes, but distinct from the latter by much stranger lirae on surface and the transverse sutural trace.

Epadrianites involutus (Haniel, 1915)
Figures 31.8–31.12, 34.5, 34.6

1915 *Agathiceras timorensis* var. *involuta* Haniel, p. 80, pl. 5, figs. 8–11.
1979 *Epadrianites timorensis* var. *involutus*; Zheng and Chen, p. 17, pl. 1, figs. 26, 29, 30.

Description.—Conchs incompletely preserved as compressed molds, moderate size and fairly involute, with relatively narrow umbilicus; umbilical shoulder bluntly rounded, sometimes indefinite; prominent longitudinal lirae with faint transverse growth lines on surface. Prongs of the ventral lobe curved, pointedly tongue-shaped; secondary medial saddle less than one-half of the ventral lobe in height; four to five 'lateral' lobes pointedly tongue-shaped on each side beyond the indefinite umbilical shoulder.

Materials.—Four poorly preserved individuals, two of which show external sutures; NIGP 139941–139944.

Occurrence.—Bed 23, Claystone (3rd) Member, Shaiwa Formation, Sidazhai section (Sec. VI'-VI"), Sidazhai, Ziyun County, Guizhou.

Remarks.—Specimens resemble the type species, *Epadrianites timorensis* (Haniel, 1915), in basic conch form, sculptures, and generality of suture; however, they differ from the latter by one 'lateral' lobe less. They also resemble *Epadrianites dunbari* (Miller and Furnish, 1940a) from the *Timorites* Zone of the La Difunta Bed in Las Delicias in both conch shape and primary sutural characteristics, but they possess stronger longitudinal lirae and subequally broader interlirae. Additionally, *Epadrianites kotljarae* (Zakharov, 1983a) from the *Araxoceras* Bed of Dorasham II, Transcaucasia, actually are the same as *E. dunbari* in suture and the wider interlirae, and probably represents the junior synonym of the latter. In any case, the reports on the Transcaucasia form are sufficient to interpret biostratigraphical equivalence of the *Araxoceras* bed in Transcaucasia to the *Timorites* beds in Coahuila of Mexico, and even with the 3rd Member containing *E. involutus*, *Eoaraxoceras*, *Difuntites*, and others from the Shaiwa Formation here.

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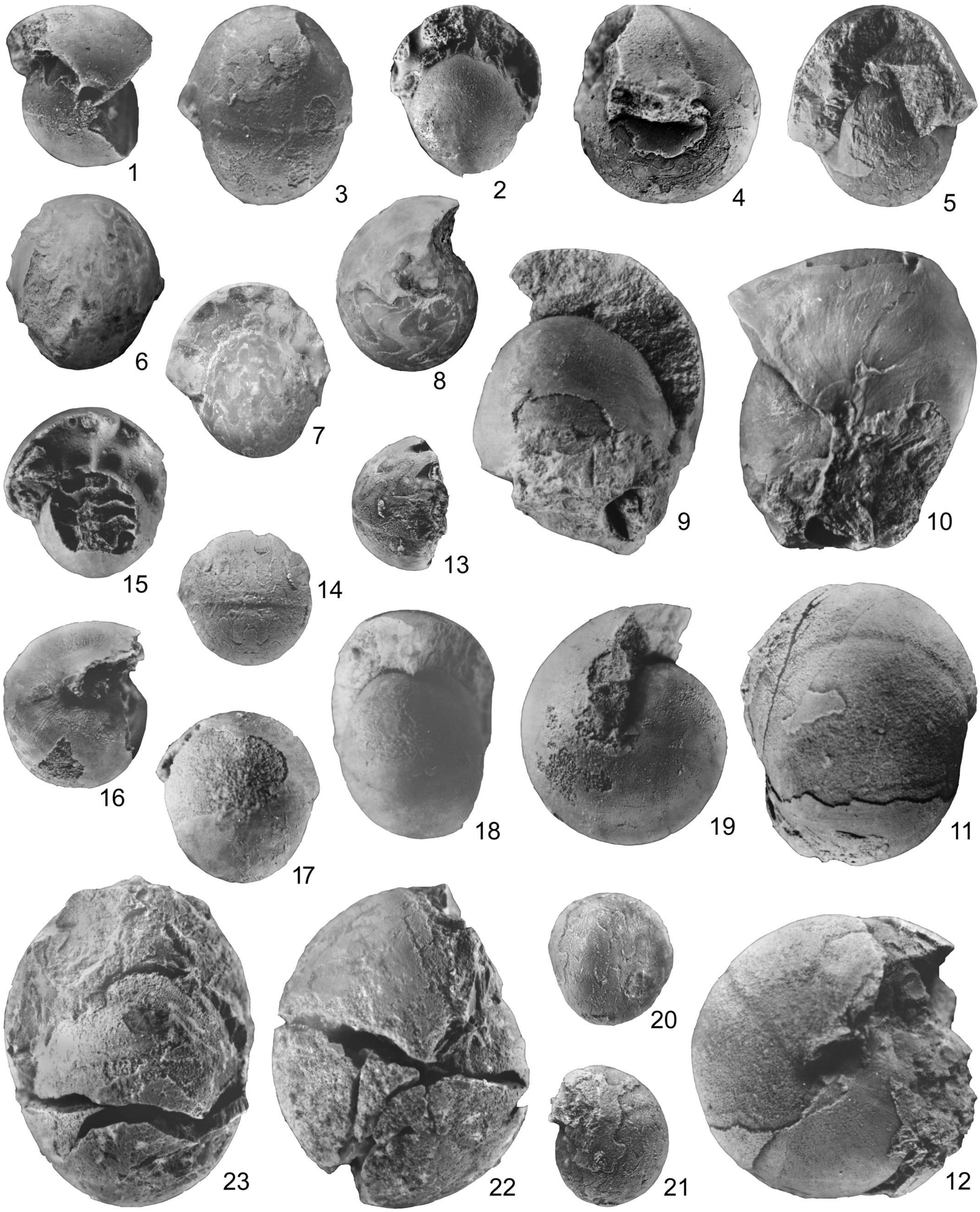

Figure 32. *Emilites globosus* n. sp. (**1–21**) Bed 19, 2nd Member, Nandan Formation, Meyao section (Sec. V), Liuzhai, Nandan County, Guangxi, ×2.5; (**1, 2**) lateral and apertural views, NIGP 88991; (**3–5**) ventral, lateral, and apertural views, NIGP 88992; (**6–8**) ventral, apertural, and lateral views, NIGP 88998; (**9, 10**) apertural and lateral views, NIGP 88995; (**11, 12**) ventral and lateral views, NIGP 88996; (**13, 14**) lateral and ventral views, NIGP 88994; (**15–17**) apertural, lateral, and ventral views, NIGP 88989; (**18, 19**) apertural and lateral views, NIGP 88990; (**20, 21**) ventral and lateral views, NIGP 88993; (**22, 23**) Bed 11, 2nd Member, Nandan Formation, Zhuangli section (Sec. VI), Liuzhai, Nandan County, Guangxi, ×1.5, lateral and apertural views, NIGP 88997, holotype.

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Table 7. Dimensions and ratios of *Emilites globosus* n. sp. D, diameter of conch; W, width of conch; H, height of whorl; U, diameter of umbilicus.

Specimen	D (mm)	W/D	H/D	U/D	H/W
NIGP 88997	35.0	0.78	0.50	0.07ca	0.64
NIGP 88996	20.0	0.85	0.49	0.06	0.58
NIGP 88992	15.8	0.84	0.47	0.10	0.56
NIGP 88990	14.9	—	0.44	?	—
NIGP 88998	13.6	0.86	0.43	0.07	0.5
NIGP 88991	13.5	0.85	0.44	0.06	0.52
NIGP 88989	12.2	0.91	0.49	0.06	0.54
NIGP 94471	11.5	0.89	0.42	?	0.47

Superfamily Shumarditoidea Plummer and Scott, 1937
Family Perrinitidae Miller and Furnish, 1940a

Remarks.—Tharalson (1984) proposed the subfamily Paraperrinitinae (non Toumanskaya, 1939) as differing from the Perrinitinae in complete subdivision of the third internal lateral lobe. Because the taxonomic character somewhat depends on ontogenetic development, the scheme was rejected (Glenister et al., 2009). An obvious evolutionary succession *Properrinites*—*Metaperrinites*—*Perrinites* in the family is marked by a general tendency that may be summed up as: (1) increasing complexity of sutural subdivision, and (2) more compressing of conch shape with the reducing of umbilicus diameter.

Genus *Properrinites* Elias, 1938

1932 *Shumardites*; Miller, p. 93.
1937 *Perrinites*; Plummer and Scott, p. 303 (part).
1984 *Properrinites*; Tharalson, p. 823 (part).
1984 *Subperrinites* Tharalson, p. 809.

Type species.—*Perrinites bösei* Plummer and Scott, 1937; original designation by Elias (1938), and confirmed by Miller and Furnish, 1940a on fide ICZN Code Article 24; Indian Creek Shale, Admiral Formation (Asselian–Sakmarian), Wichita Group of Coleman County, Texas, USA.

Diagnois.—Ancestral perrinitids of medium size (maximum conch diameter 15 cm) with depressed whorls (H/W, 0.6–0.9), moderate umbilicus (Umin/D, 0.2–0.5), and shallow hyponomic sinus. Mature sutures have a single discrete first-order subdivision on ventral flank of each prong of ventral lobe (V_1) and a dorsal lobe (D) that is prominently trifid; second-order subdivisions are either absent or incipient and confined to first lateral saddle. Crests of fourth external lateral saddle and fourth internal lateral saddle lie beneath general sutural alignment. Sutural formula: $(V_1V_1)L_2L_1(L_{2.1}L_{2.2})U^2U^1{:}U^2(I_{2.2}I_{2.1})\ I_1I_2D$.

Occurrence.—Asselian through Kungurian; southwest USA (Texas, New Mexico, Nevada, Kansas), Mexico (Puebla), Canada (Yukon), Pamirs (Tajikistan), and South China (Guangxi).

Remarks.—*Properrinites*, which was established by Elias in 1938 to represent the most primitive perrinitids, is phylogenetically intermediate between *Shumardites* and *Perrinites*. Furthermore, Ruzhentsev (1950) established *Metaperrinites* to include species possessing more complicated sutural diversity than *Properrinites*, but simpler than *Perrinites*. Although *Properrinites* is intermediate between *Shumardites* and *Metaperrinites*, it has already dissected near the upper part of the flanks of the lobes and gained the new systematic features of the family Perrinitidae.

Properrinites gigantus new species
Figures 33.1–33.9, 35.1, 35.2

1987 *Properrinites plummeri*; Zhou, p. 138, pl. 4, figs. 6–8. (non Elias, 1938, p. 104, pl. 20, figs. 8a, b.).

Diagnosis.—A *Properrinites* species possessing more compressed and largest conch size, and simpler sutural digitations, as compared with *P. bösei* (Plummer and Scott, 1937), and even the more primitive *P. backeri* (Plummer and Scott, 1937).

Description.—Conch somewhat fusiform in juvenile, whereas large, thickly discoidal, and moderately involute in adult, with medium-sized umbilicus, but in attendance as a continuous variation ontogenetically; both W/D and U/D getting smaller with individual growth. Whorl section crescent-shaped in juvenile, gradually changing into bell-shaped, with rounded venter and fairly convex flanks. Umbilical shoulder bluntly rounded and umbilical wall steep with a few spiral lirae. Finely transverse growth lines on flanks and venter. Dimension and ratios of the holotype NIGP 94472 (Fig. 33.7–33.9): D 112 mm, W/D 0.49, H/D 0.50, U/D 0.22.

The juvenile specimen NIGP 89003 (Fig. 33.3) at diameter ~7.7 mm displays the external lateral lobe that is incipiently tripartite. In specimen NIGP 89002 (Fig. 33.1, 33.2) at diameter ~45.8 mm and NIGP 94472 at diameter 56.6 mm, the third external and internal lateral lobes subdivided into two nearly independent branches, respectively. The digitations of the first and the second external lobes in the fully mature specimen NIGP 94472 having four and five digits, respectively. Three small umbilical lobes on both umbilical shoulder and umbilical wall. Dorsal lobe preserved on the surface of the previous volution obviously tripartite (Fig. 33.1).

Etymology.—Name derived from the character of huge size of the holotype.

Materials.—Four specimens, NIGP 89002–89004, and NIGP 94472 (holotype, Zhou, 1987, p. 138, pl. 4, figs. 6–8, revised here).

Occurrence.—Asselian talus limestone, Liuzhai Quarry (Loc. 5); Bed 19, Meyao section (Sec. V). Both are from the 2nd Member, Nandan Formation, Liuzhai, Nandan County, Guangxi.

Remarks.—Miller and Furnish (1940a) and Tharalson (1984) thought that *Properrinites plummeri* Elias, 1938 is similar to the typical *P. backeri* (Plummer and Scott, 1937), so it was a junior synonym for the latter. Both restudy on the specimen NIGP 94472 (Zhou, 1987) and study of the newly collected specimens NIGP 89001–89004 indicate that the Guangxi materials are

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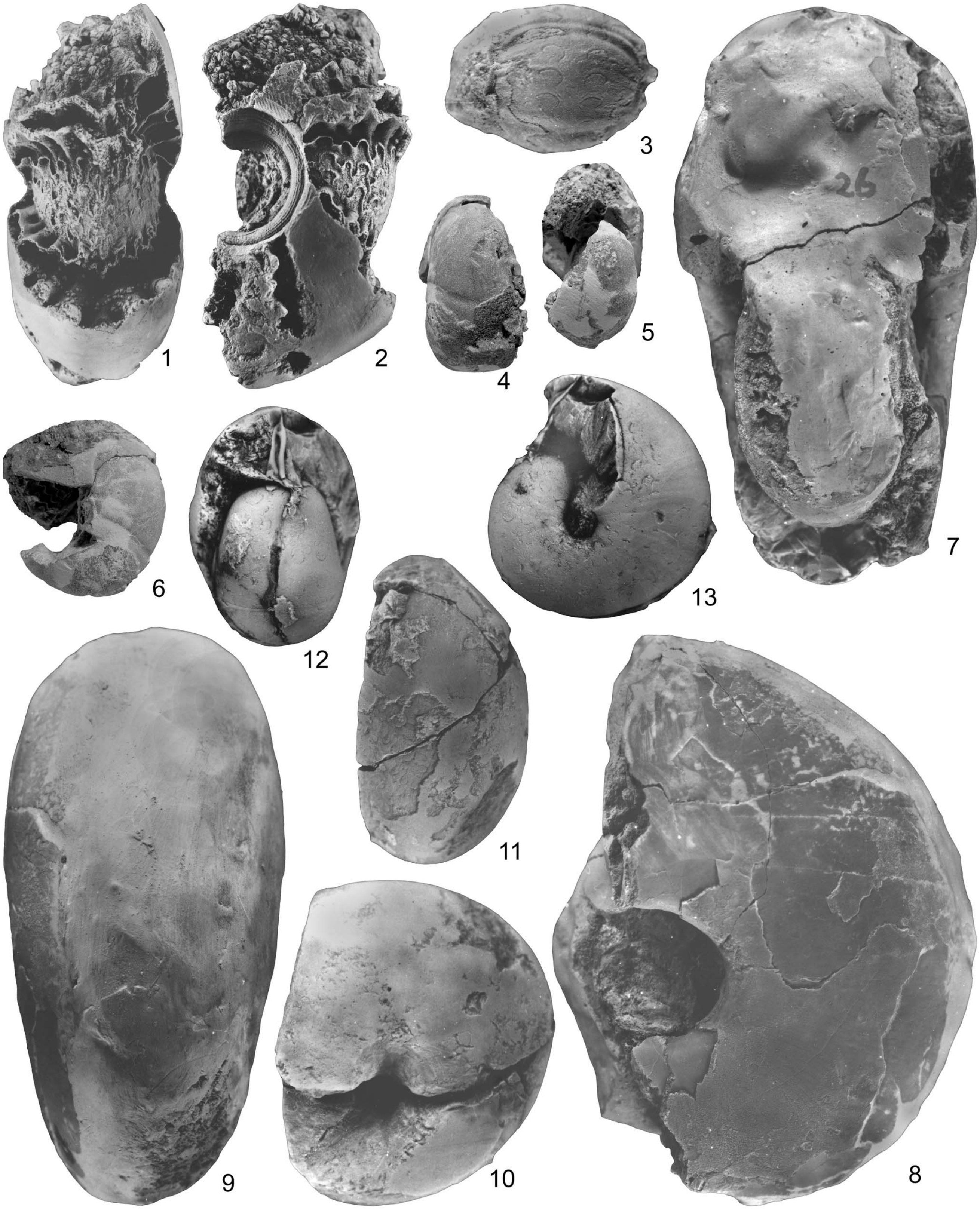

Figure 33. *Properrinites gigantus* n. sp. and *Metaperrinites shaiwaensis* n. sp. (**1–9**) *Properrinites gigantus*; (**1–6**) Bed 19, 2nd Member, Nandan Formation, Meyao section (Sec. V), Liuzhai, Nandan County, Guangxi; (**1–2**) ventral and lateral views, partially exposed the inner suture on surface of the former volution, with tripartite dorsal lobe and three simply serrate inner lobes, NIGP 89002, ×1.2; (**3**) ventral view, NIGP 89003, ×3; (**4–6**) ventral, apertural, and lateral views, NIGP 89004, ×1; (**7–9**) Asselian talus limestone, 2nd Member, Nandan Formation, Liuzhai Quarry (Loc. 5), Liuzhai, Nandan County, Guangxi (Zhou, 1987, pl. 4, figs. 6–8), apertural, lateral, and ventral views, NIGP 94472, holotype, ×1; (**10–13**) *Metaperrinites shaiwaensis* n. sp.; (**10, 11**) lateral and ventral views, NIGP 89005, ×1.2, 'Chihsia' Limestone, Tian'e suburb (Loc. 7), north of Hongshuihe River, Tian'e County, Guangxi; (**12, 13**) apertural and lateral views, NIGP 93714, holotype, ×2.5, Bed 12, Chongtou Member, Sidazhai Formation, Shaiwa section (Sec. VI–VI'), Sidazhai, Ziyun County, Guizhou.

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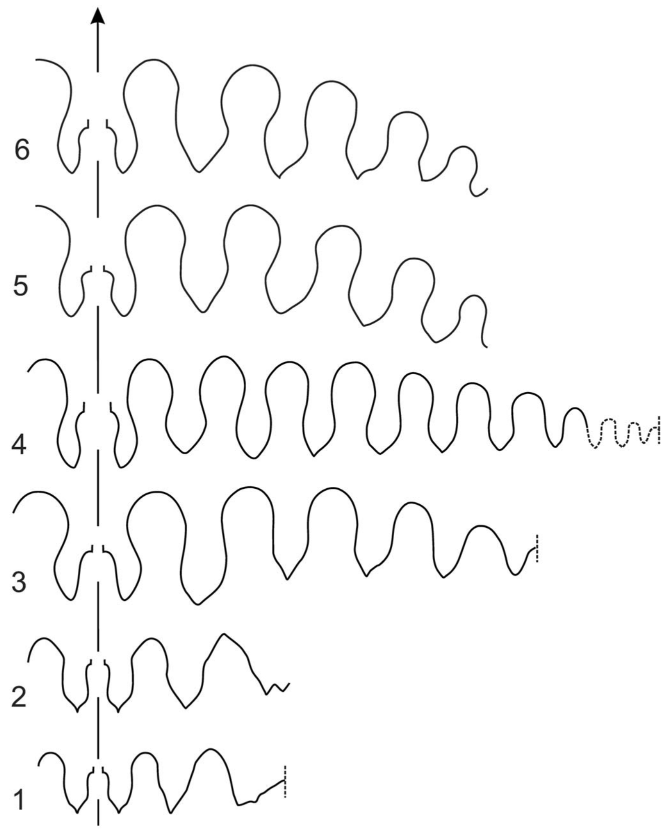

Figure 34. External sutures of adrianitids. (**1, 2**) *Emilites globosus* n. sp., 2nd Member, Nandan Formation, Liuzhai, Nandan County, Guangxi; (**1**) NIGP 88993, D 10.4 mm, Bed 19, Meyao section (Sec. V); (**2**) NIGP 88997, holotype, D 20 mm, Bed 11, Zhuangli section (Sec. VI); (**3**) *Neocrimites guizhouensis* n. sp., NIGP 93711, holotype, D 9 mm, Bed 12, Chongtou Member, Sidazhai Formation, Shaiwa section (Sec. VI–VI'), Sidazhai, Ziyun County, Guizhou; (**4**) *Fusicrimites nanpanjiangensis* n. gen. n. sp., NIGP 93713, holotype, D. 7.6 mm, Chongtou Member, Sidazhai Formation, Shaiwa section (Sec. VI–VI'), Sidazhai, Ziyun County, Guizhou; (**5, 6**) *Epadrianites involutus* (Haniel, 1915), Bed 23, Claystone (3rd) Member, Shaiwa Formation, Sidazhai section (Sec. VI'–VI'), Sidazhai, Ziyun County, Guizhou; (**5**) NIGP 139943, D ~15 mm; (**6**) NIGP 139942, D ~25 mm.

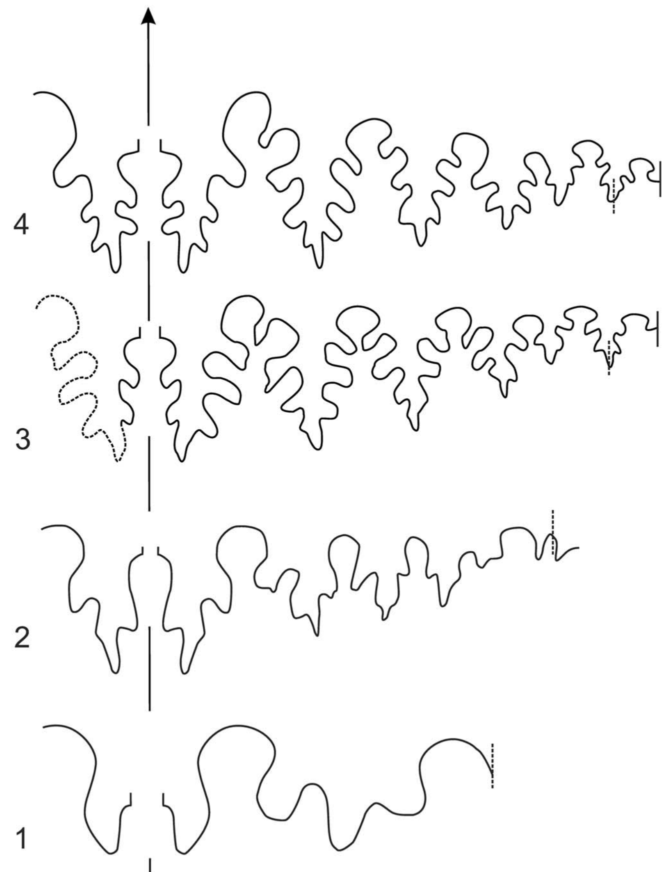

Figure 35. External sutures of perrinitids. (**1, 2**) *Properrinites gigantus* n. sp., 2nd Member, Nandan Formation, Liuzhai, Nandan County, Guangxi; (**1**) NIGP 89003, D ~7.7 mm, Bed 19, Meyao section (Sec. V); (**2**) NIGP 94472, holotype, D 56.6 mm, Asselian talus limestone, Liuzhai Quarry (Loc. 5) (Zhou, 1987, p. 138, 6, pl. 4, figs. 6–8); (**3, 4**) *Metaperrinites shaiwaensis* n. sp.; (**3**) NIGP 93714, holotype, D 16.4 mm, Bed 12, Chongtou Member, Sidazhai Formation, Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou; (**4**) NIGP 89005, D 46 mm, 'Chihsia' Limestone, Tian'e suburb (Loc. 7), north of Hongshuihe River, Tian'e County, Guangxi.

distinct from the species *P. backeri* by the wider lobes and the narrower saddles.

Properrinites gigantus n. sp. resembles *Properrinites dmitrievi* Ruzhentsev, 1978 from the Pamirs in conch shape and generality of suture; however, the former is thinner in conch shape and much narrower in the width of the ventral lobe. The secondary subdivision on the ventral flank of the first external lateral lobe in specimen NIGP 94472 is quite similar to *P. furnishi* Nassichuk, 1971, but the latter is more complicated in generality of suture. The similarity also exists between the new species and *P. bösei* (Plummer and Scott, 1937), but the latter has more complicated dissection in lobes.

Genus *Metaperrinites* Ruzhentsev, 1950

1915 *Cyclolobus*; Haniel, p. 113 (part).
1919 *Perrinites* Böse, p. 155 (part).
1939 *Paraperrinites* Toumanskaya, p. 17.
1940a *Properrinites*; Miller and Furnish, p. 143 (part).
1982 *Shuangyangites* Liang, p. 650.
1983 *Mapirites* Leonova, p. 44; 1989, p. 132.
1983 *Shyndoceras* Leonova, p. 47.
1983 *Nepirrites* Leonova, p. 48.
1983 *Ripernites* Leonova, p. 50.

Type species.—*Properrinites cumminsi vicinus* Miller and Furnish, 1940a; original designation; Clyde Formation (Artinskian), Wichita County, Texas, USA.

Diagnosis.—Perrinitids intermediate and gradational between *Properrinites* and *Perrinites* in size, conch form, depth of hyponomic sinus, and overall complexity of suture. Whorls generally depressed (H/W, 0.7–1.2), and umbilicus variable (Umin/D, 0.1–0.4). Mature sutures display 1–3 first-order subdivisions on ventral fl;ank of each prong of ventral lobe (V_1); dorsal lobe (D) has either one or two prominent notches on each flank; second-order subdivisions generally weakly developed, but may occur in all external saddles in advanced species. Both fourth external lateral saddle and fourth internal lateral

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saddle generally lie beneath but close to alignment of adjacent saddles.

Occurrence.—Artinskian through Kungurian; USA (Texas, New Mexico, California, Nevada), Tajikistan (Pamirs), Ukraine (?Crimea), Thailand (Loei), Indonesia (Timor), North China (Jilin, Qinghai, Xinjiang), and South China (Guizhou and Guangxi).

Remarks.—The present genus previously had been referred to as *Paraperrinites* with type species *P. brouweri* (Smith, 1927) by Toumanskaya (1939, 1940), but she did not give a generic definition. Hence, the name is an invalid nomen nudum. *Metaperrinites*, as used in this paper, approximately includes all of the species of Toumanskaya's *Paraperrinites*.

Leonova (1983) established another five new genera of perrinitids based on materials from Pamirs. Sutures and figures of the Pamirs specimens indicate that their classification features probably are within the specific level of *Metaperrinites*, with the singular exception of *Perrimetanites*, which represents a primitive taxon of the genus *Perrinites*. Tharalson (1984) referred all species of *Metaperrinites* into his *Properrinites* based on the incipient division of the third internal lateral lobe (I_2) strengthening to become two independent lobes ($I_{2.1}I_{2.2}$). The classification scheme of perrinitids is considered as unrealistic, and probably contains too many different external suture types in *Properrinites*. Leonova (2002) previously moved *Perrinites tardus* Miller and Furnish, 1940a into genus *Metaperrinites*. This probably is incorrect because it has such an advanced and complicated sutural system compared with the latter.

Metaperrinites shaiwaensis new species
Figures 33.10–33.13, 35.3, 35.4

Diagnosis.—Subglobal form with smaller umbilicus and nearly independent branches of the third external lobe.

Description.—Conch subglobular, involute with smaller umbilicus. Venter rounded, flank fairly convex, and whorl-section crescent in shape. Dimension and ratios of the holotype NIGP 93714: D 16.1 mm, W/D 0.75, H/D 0.58, U/D 0.14. All lobes broad with inverted triangle shape. In small specimen NIGP 93714, the serrated lobes possess six digits in prong of ventral lobe, seven in both first and second lateral lobes, and six and four in the nearly independent third and fourth lateral lobes, respectively. In the larger specimen NIGP 98005, in contrast, the digitation appears simpler than the former, but such simplifying is supposedly due to enhanced erosion of conch surface. Branches of third external lateral lobe in both specimens are subdivided into relatively independent lobes.

Etymology.—Name derived from locality where the holotype was discovered.

Materials.—Two specimens, NIGP 93714 (holotype), and NIGP 89005.

Occurrence.—'Chihsia' Limestone, Tian'e suburb (Loc. 7), north of Hongshuihe River, Tian'e County, Guangxi; Bed 12, Chongtou Member, Sidazhai Formation; Shaiwa section (Sec. VI–VI'), Sidazhai, Ziyun County, Guizhou.

Remarks.—*Metaperrinites shaiwaensis* n. sp. resembles the type species *M. cumminsi vicinus* Miller and Furnish in the generality of suture, but it has much thicker and subglobal conch, and smaller umbilicus than those of the North America species. *Metaperrinites shaiwaensis* n. sp. is similar to *M. toumanskayae* Leonova, 1983 in the subglobal conch and the generality of external suture, but it has smaller umbilicus and stronger digitations of the ventral lobe.

Superfamily Cycloloboidea Zittel, 1895

Family Vidrioceratidae Plummer and Scott, 1937

Remarks.—The genera *Prostacheoceras* and *Stacheoceras* are fairly eurytopic ecologically, with broad distribution in both the Permian open-sea and restricted-sea settings in South China, and other areas.

Genus *Prostacheoceras* Ruzhentsev, 1937

1887 *Stacheoceras* Gemmellaro, p. 38 (part).
1935 *Marathonites*; Maximova, p. 283.
1938 *Martoceras* Toumanskaya, p. 106 (part).

Type species.—*Martoceras juresanensis* Maximova, 1935; original designation; Asselian, Russian South Urals.

Diagnosis.—Conch relatively narrow, with rounded ventrolateral flanks. Two subdivisions of the third external lateral lobe ($L_{2.1}L_{2.1}$) almost fully isolated at 2 cm conch diameter. Sutural formula: $(V_1V_1)L_2L_1(L_{2.1}L_{2.1})\ U^2U^1U^{2.1}{:}U^{2.1}I_2I_1I_2D$.

Occurrence.—Asselian through Wordian; Russia and Kazakhstan (South Urals), Ukraine (Crimea), Tajikistan (Pamirs), Italy (Sicily), Canada (British Columbia), Afghanistan (Bamiyan Mountains), USA (Texas), Malaysia (Perak), Thailand (central and north), North China (Jilin, Xinjiang), and South China (Hunan, Guangxi).

Remarks.—*Prostacheoceras* is intermediately situated between *Vidrioceras* and *Stacheoceras* phylogenetically, however, they can be distinguished from each other by simply comparing their sutural formulas. *Prostacheoceras* is relatively close to *Vidrioceras*, but has one more internal 'lateral' lobe ($U_{2.1}$). It differs from *Martoceras* by the paired lobes present only at the 3–4 lobes, and not at the 4–5 or 5–6 lobes.

Prostacheoceras juresanense (Maximova, 1935)
Figures 36.3–36.8, 38.2, 38.3

1935 *Marathonites juresanensis* Maximova, p. 283, figs. 9–11.
1938 *Prostacheoceras juresanensis*; Ruzhentsev, p. 256, pl. 4, figs. 1–8.

Description.—Conch thickly discoidal to subglobal, involute with very small umbilicus. Whorl-section a little squarish,

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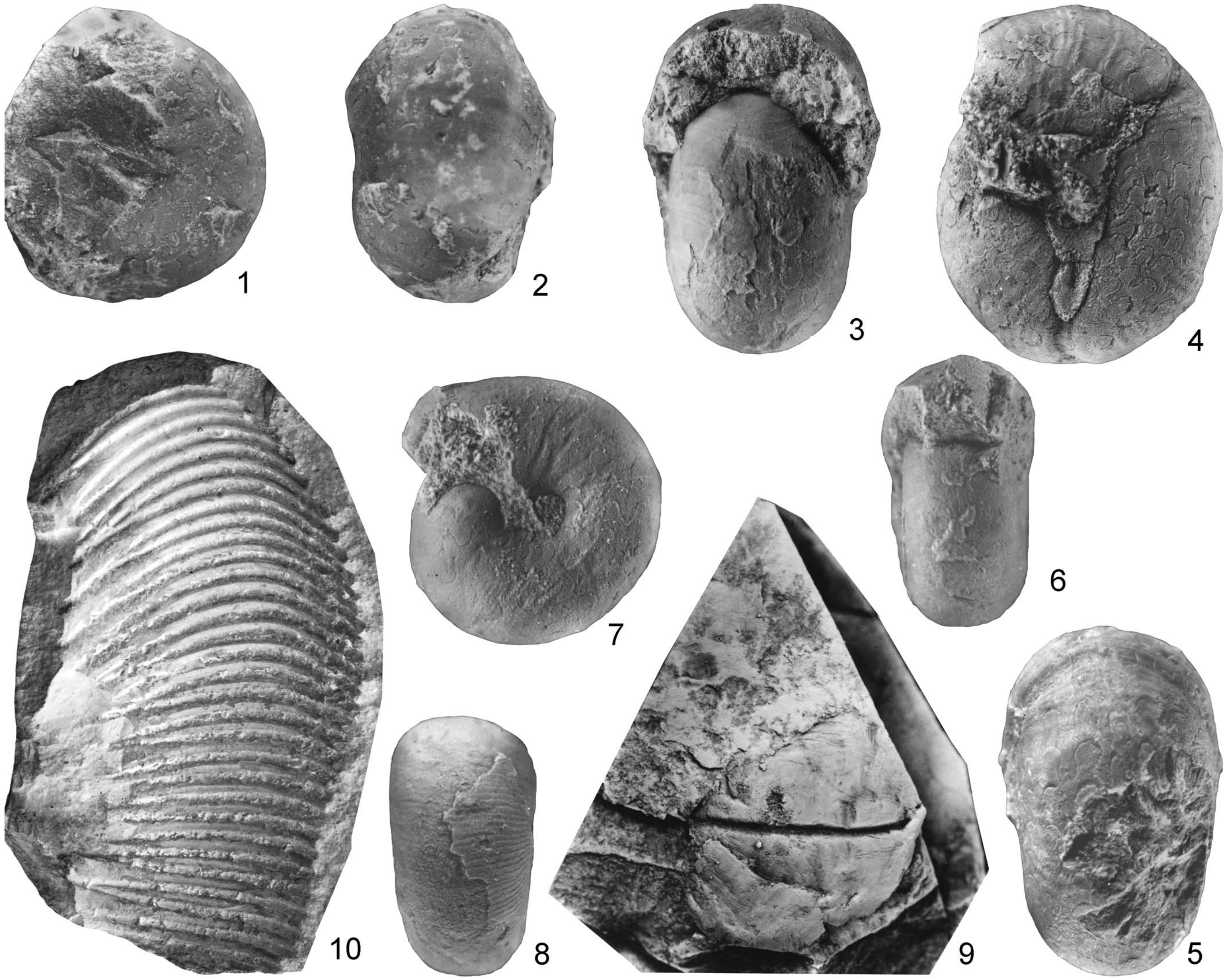

Figure 36. *Prostacheoceras* Ruzhentsev, 1937, *Waagenoceras* Gemmellaro, 1987, and ?*Timorites* Haniel, 1915. (**1, 2**) *Prostacheoceras* sp. NIGP 93717, ×3, lateral and ventral views, Bed 12, Chongtou Member, Sidazhai Formation; Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou; (**3–8**) *Prostacheoceras juresanense* (Maximova, 1935), Bed 19, 2nd Member, Nandan Formation, Meyao section (Sec. V), Liuzhai, Nandan County, Guangxi; (**3–5**) apertural, lateral, and ventral views, NIGP 89007, ×2; (**6–8**) apertural, lateral, and ventral views, NIGP 89006, ×3; (**9**) *Waagenoceras* sp., a piece of phragmoconch, ventral view, with part of external suture and a creal constriction, NIGP 93715, ×2.5, Bed 29, Siliceous Rocks (1st) Member, Shaiwa Formation, ~22 m above the base the Formation, Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou; (**10**) ?*Timorites* sp. A piece of living chamber, external cost, lateral view, NIGP 154112, ×1, Bed 23, Claystone (3rd) Member of Shaiwa Formation, Sidazhai Sction (Sec. VI'–VI''), Ziyun County, Guizhou.

Table 8. Dimensions and ratios of *Prostacheoceras juresanense* (Maximov, 1935). D, diameter of conch; W, width of conch; H, height of whorl; U, diameter of umbilicus.

Specimen	D (mm)	W/D	H/D	U/D	W/H
NIGP 89006	13.1	0.54	0.42	?0.05	0.77
NIGP 89007	25.9	0.63	0.48	?0.05	0.76

slightly compressed due to obvious crushing of the venter near the end of the outer volution in specimen NIGP 89007 (Fig. 36.3–36.5) (Table 8). Sparse, fine lamellae, with a faint salient on the venter, decorating the surface of the shell. Two faint constrictions present on the outer volution of the large specimen. Ventral lobe subdivided into two relatively narrow and incipient bidentate prongs. The first external lobe bidentate, the second tridentate with a longer middle tooth, the third very broad and bipartite (ventrad branch narrow and simple; the dorsad wide and bidentate), the fourth (U_2) small and simple, near the umbilical border.

Occurrence.—Bed 19, 2nd Member, Nandan Formation, Meyao section (Sec. V), Liuzhai, Nandan County, Guangxi.

Materials.—Two phragmoconchs from limestone matrix, body chambers lost during sample preparation, NIGP 89006 and 89007.

Remarks.—The topotype of *Prostacheoceras juresenense* (Maximova, 1935) from Zaksy-Kargaly River of Aktyubinsk District, Kazakhstan (South Urals), which is deposited in the repository of the University of Iowa, displays identical features with the Guangxi specimens in conch form and generality of

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suture. However, the two digits of the prong of the ventral lobe are just incipient in the Guangxi specimens, while the saddles are slightly broader than those of the type specimens. Nevertheless, these differences are still considered as individual variations ontogenetically.

As an important Asselian fossil, *Prostacheoceras juresenense* is rather primitive, without the secondary digitation in the external lateral lobes. The absence of high-ranked digitation is just one of the indicative criteria that can be used to distinguish *P. juresenense* from other later species.

Prostacheoceras sp.
Figures 36.1, 36.2, 38.1

Description.—Conch small, thickly discoidal and involute, with small umbilicus. Venter rounded, flank convex, with crescent whorl section. More than two constrictions on the outer volution. Measurements: D 13.2 mm, W/D 0.71, H/D 0.4, U/D ?0.05. Ventral lobe normally subdivided by a middle saddle into two narrow, very incipiently bidentate prongs. However, the external lateral lobes in both sides are asymmetric. The first external lateral lobes seem to be tridentate in both sides. The second ones display asymmetry: the right one very small, like a small adventitious lobe on a big saddle; the left one normally broad, tridentate with a longer middle tooth. The third external lateral lobes almost the same in both sides, very broad, bipartite, representing a pair of nearly independent lobes: the ventrad one broader, bidentate/tridentate; the dorsad one narrower, bidentate. There probably is a small fourth lateral lobe near the umbilicus, but it is incompletely exposed.

Occurrence.—Bed 12, Chongtou Member, Sidazhai Formation; Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou.

Materials.—A steinkern of phragmoconch from the siliceous limestone matrix, body chamber lost in preparation; NIGP 93717.

Remarks.—Inadequate material prevents full description of sutural asymmetry. The single specimen may be merely a physically distorted individual.

Genus *Stacheoceras* Gemmellaro, 1887

1885 *Waagenia* Krotov, p. 204.
1888 *Waagenina* Krotov, p. 474 (part).
1931 *Neostacheoceras* Schindewolf, p. 201.
1997 *Furnishites* Cantú Chapa, 1997, p. 73.
2005 *Parastacheoceras* Ehiro and Misaki, p. 9.

Type species.—*Stacheoceras mediterraneum* Gemmellaro, 1887; subsequent designation by Diener, 1921; Sosio Limestone (Wordian), Rupe del Pass, Sosio Valley, Province Palermo, Sicily, Italy.

Diagnosis.—Advanced vidrioceratids that may exceed 10 cm in mature conch diameter. Mature modifications comprise deep subterminal constriction with associated flare (expansion) of the peristome and long narrow ventrolateral lappets. External suture consists of 6–12 pairs of lateral lobes; prongs of ventral lobe (V_1) are bidentate or tridentate, and first external lateral lobe (L_2) is bidentate to quadridentate. Internal suture generally has one less pair of lobes than external; most internal lobes exhibit conspicuous dorsal flexure adapically. Sutural formula for moderately complex forms: $(V_1V_1)L_2L_1L_{2.1}L_{2.1.1}L_{2.1.1.1}L_{2.1.1.1.1}(L_{2.1.1.1.1.1}L_{2.1.1.1.1.1})U^2U^1U^2{:}I_{2.1.1.1}L_{2.1.1.1}I_{2.1.1}I_{2.1}I_1I_2D$.

Occurrence.—Artinskian through Changhsingian; Italy (Sicily), Slovenia, Ukraine (Crimea), Azerbaijan (Caucasus), Tajikistan (Pamir), Afghanistan, Iraq (Kurdistan), Oman, Tunisia (Djebel Tebaga), Pakistan (Salt Range), India (Himalayas), Indonesia (Timor), Malaysia, Madagascar, Japan (Kitakami), Mexico (Coahuila, ?Guerrero), USA (Texas, California, Wyoming), Canada (Ellesmere Island, British Columbia), East Greenland, North China (Gansu, Xinjiang, Xizang), and South China (Yunnan, Guizhou, ?Hunan, ?Guangxi, Zhejiang, Sichuan).

Remarks.—As the most advanced vidriocertid, *Stacheoceras* has the most numerous lateral lobes, usually more than six pairs of external sutures. As an eurytopic component, *Stacheoceras* occurred in both open-sea and restricted-sea ammonoid assemblages. Among the total 46 species of the genus known so far, 14 species (about one third) appear to be related with the Capitanian Stage and Lopingian Series biostratigraphically.

Stacheoceras shaiwaense new species
Figures 31.13, 37.1–37.14, 38.4, 38.5

Diagnosis.—Thick subdiscoidal conch, seven pairs lateral lobes, in which the sixth and seventh incompletely divided; secondarily ordered digitation appears in first lateral lobe.

Description.—Conch thickly subdiscoidal, moderately large; whorl section rounded both ventrally and laterally, deeply impressed dorsally; umbilicus small, umbilical shoulder broadly rounded, indefinite; living chamber about one whorl long (Table 9). Two or three constrictions in the ultimate whorl; mature modifications, including deep subterminal constriction, associated flare (expansion) of the peristome, and a pair of long narrow ventrolateral lappets. Ventral lobe spherical, inflated at mediate part, subdivided by a low, secondary ventral saddle into two narrow curving bidentate prongs. Seven pairs of lingulate lateral lobes in flanks, but the sixth and seventh seem incompletely divided; three pairs of small lobes in umbilical areas; first lateral lobe asymmetrically bidentate with secondarily ordered digitation, second through fifth tridentate, and the rest intact.

Etymology.—Name derived from the Shaiwa Formation where the type material was collected.

Materials.—Seven individuals, five of them are well-preserved individuals. NIGP 139934–139940.

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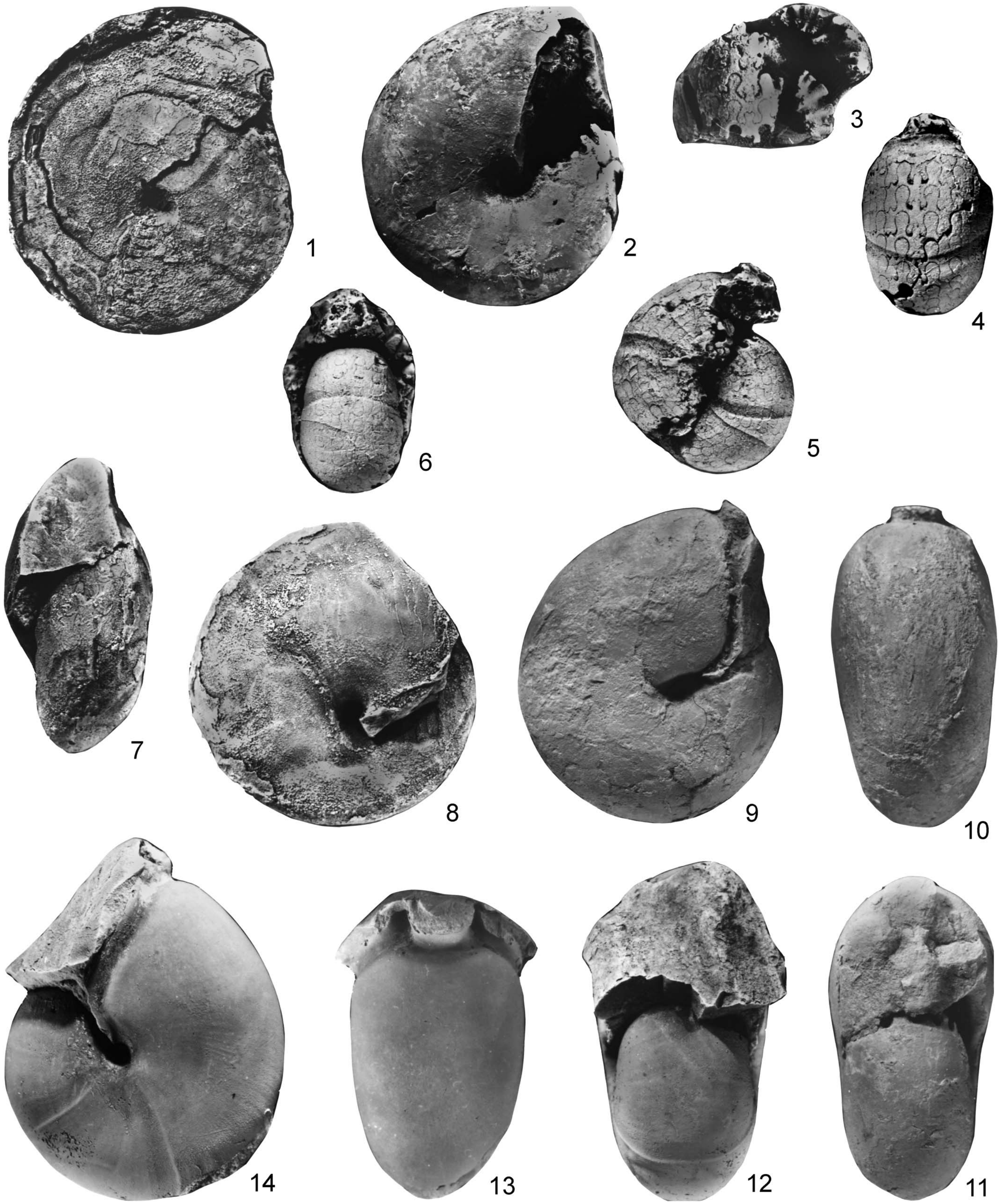

Figure 37. *Stacheoceras shaiwaense* n. sp., Claystone (3rd) Member, Shaiwa Formation, Sidazhai section (Sec. IV'-IV''), Sidazhai, Ziyun County, Guizhou. (**1–3, 9–14**) Bed 23, ×1.5; (**1**) lateral views, NIGP 139938; (**2, 3**) lateral view and ventral view of the broken part of the **2**, NIGP 139935; (**9–11**) lateral, ventral, and apertural views, with terminal constriction, NIGP 139937; (**12–14**) apertural, ventral, and lateral views, well-showing the terminal constriction and a pair of ventrolateral lappets at aperture, NIGP 139936; (**4–8**) Bed 31; (**4–6**) ventral, lateral, and apertural views, NIGP 139940, ×2; (**7, 8**) apertural and lateral views, NIGP 139934, ×1.5.

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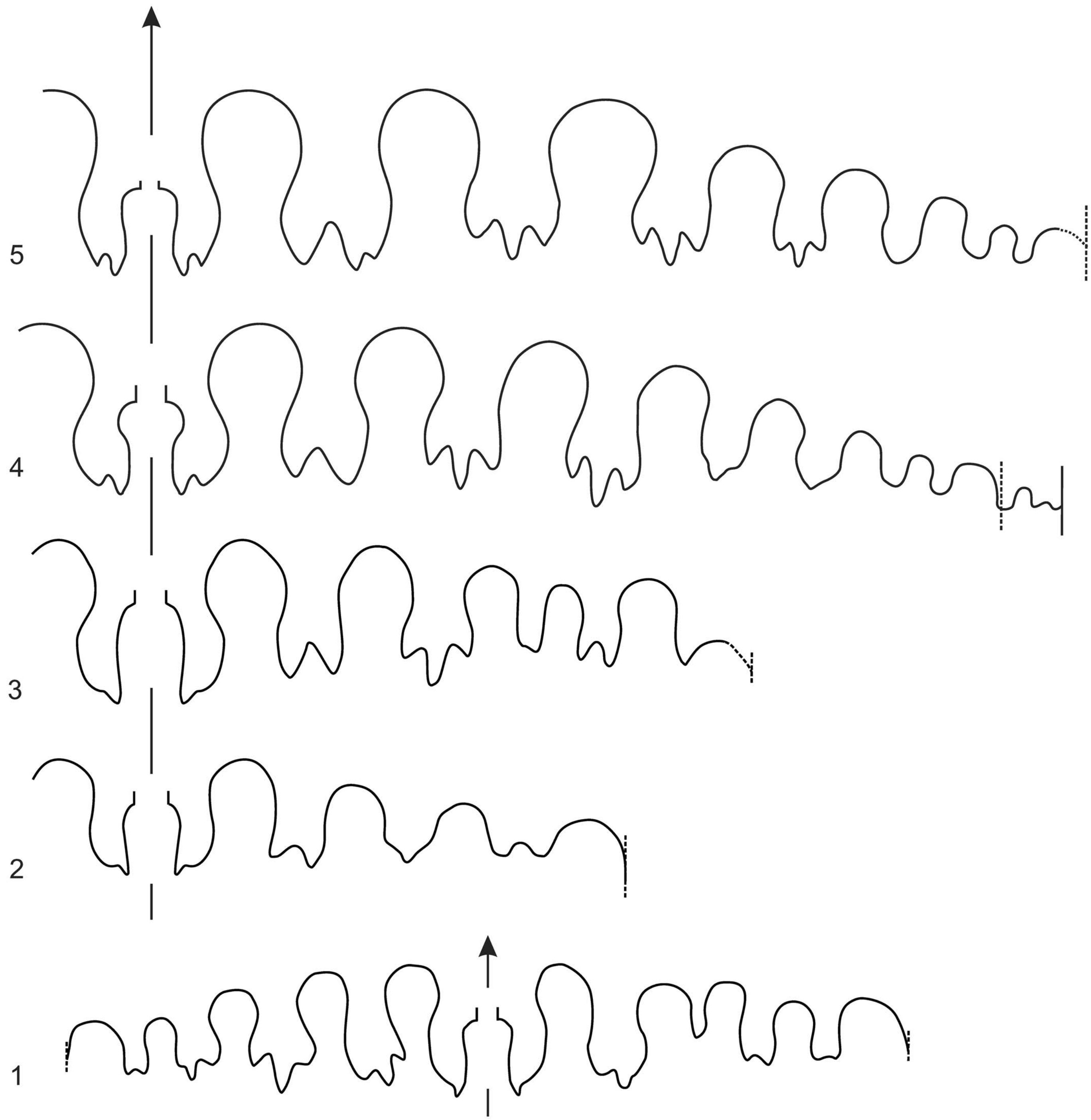

Figure 38. External sutures of vidrianitids. (**1**) *Prostacheoceras* sp. NIGP 93717, D 13 mm, showing asymmetrical suture in both side, with different serrate details of the corresponding lobes, probably representing a distorted individual physically, Bed 12, Chongtou Member, Sidazhai Formation, Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou; (**2, 3**) *Prostacheoceras juresanense* (Maximova), Bed 19, 2nd Member, Nandan Formation, Meyao section (Sec. V), Liuzhai, Nandan County, Guangxi; (**2**) NIGP 89006, D 12.5 mm; (**3**) NIGP 89007, D 23 mm; (**4, 5**) *Stacheoceras shaiwaense* n. sp., the Claystone (3rd) Member of Shaiwa Formation, Sidazhai section (Sec. IV'-IV''), Sidazhai, Ziyun County, Guizhou; (**4**) NIGP 139935, D ~24 mm; (**5**) NIGP139941, D ~15 mm.

Occurrence.—Beds 23 and 31, Claystone (3rd) Member, Shaiwa Formation, Sidazhai section (VI'–VI'), Sidazhai, Ziyun County, Guizhou.

Remarks.—*Stacheoceras shaiwaense* n. sp. is fairly similar to *S. iwaizakiense* Mabuti, 1935 from the lowermost Toyama Formation of the southern Kitakami in both conch shape and generality of suture, especially the secondarily ordered digitation of the first lateral lobe, and the incompletely divided sixth and seventh lateral lobes in the type specimen of the latter (no. 51723). However, the new species is thicker than the latter in shape, with W/D 0.54–0.58 versus 0.44–0.49.

Stacheoceras shaiwaense n. sp. is similar to *S. toumanskyae* Miller and Furnish, 1940a from Capitanian of Coahuila in general

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Table 9. Dimensions and ratios of *Stacheoceras shaiwanense* n. sp. D, diameter of conch; W, width of conch; H, height of whorl; U, diameter of umbilicus.

Specimen	D (mm)	W/D	H/D	U/D	H/W
NIGP 139936	37.1	0.56	0.57	0.05	1.02
NIGP 139937	36.4	0.54	0.5	0.05	0.93
NIGP 139934	34.8	0.55	0.55	0.05	~1.00
NIGP 139935	33.5	0.58	0.57	0.05	0.98

conch shape and some sutural details; however, its conch is much smaller, and one lateral lobe less than the Mexico species in number. *Stacheoceras shaiwaense* n. sp. is similar to the earlier species in west Texas, *S. rothi* Miller and Furnish, 1940a in generality of suture, but it is quite different from the latter by more advanced sutural details, the spherical ventral lobe with lower ventral saddle, and lacking secondarily ordered digitation. *Stacheoceras shaiwaense* n. sp. also resembles *S. timorensis* forma *delta* (Haniel, 1915) and *S. lijiangense* Liang, 1983 in the lateral lobe number and their dentition condition, but differs from them by much smaller mature conch size.

Family Cyclolobidae Zittel, 1895
Subfamily Cyclolobinae Zittel, 1895

Genus *Waagenoceras* Gemmellaro, 1887

Type species.—*Waagenoceras mojsisovicsi* Gemmellaro, 1887; subsequent designation by Diener, 1921; Sosio Limestone (Wordian), Rupe del Pass, Sosio Valley, Province Palermo, Sicily, Italy.

Diagnosis.—Intermediate in size, conch form, and sutural complexity between *Demarezites* and *Timorites*. External suture has seven or eight pairs of lobes to umbilical shoulders, each more complexly denticulate than in *Demarezites*; lobe pairs seven to eight incompletely isolated. Sutural formula for advanced forms: $(V_1V_1)L_2L_1L_{2.1}L_{2.1.1}L_{2.1.1.1}L_{2.1.1.1.1}(L_{2.1.1.1.1.1}L_{2.1.1.1.1.1})$ $U^2U^1U^2$: $(I_{2.1.1.1.1}I_{2.1.1.1.1})I_{2.1.1.1}I_{2.1.1}I_{2.1}I_1I_2(D_2D_1D_2)$.

Occurrence.—Wordian to Capitanian; Italy (Sicily), Iraq (Kurdistan), Oman, Indonesia (Timor), Russia (Amur), Mexico (Coahuila, Sonora, ?Guerrero), USA (west Texas), Canada (British Columbia), South China (Fujian, Guizhou), and North China (Gansu).

Remarks.—*Waagenoceras* is intermediate between *Demarezites* and *Timorites* in size, conch form, and sutural complexity. *Demarezites* possesses a spherical conch with the smallest umbilicus of the above three genera, the lateral lobe pair is incompletely isolated and occurs at the 5–6 lobe, the seventh denticulate lobe lies ventrad of the umbilical shoulder, and the ventrad flanks of the ventral lobe is complicated by a weak sinus rather than a denticulate form. *Waagenoceras* has a transitional subglobular conch with a relatively large umbilicus, in which the 7–8 lobe represent the incompletely separated pairs, and ventrad flanks of the ventral lobe are simply digitate.

The most advanced genus, *Timorites*, is a thickly discoidal conch, evolute in early ontogeny, with relative broad umbilicus and strong transversal ribs, retaining the characters until adult. External lateral lobes are more than nine and flanks of the ventral lobes are deeply digitate. The secondary dissection of lobes is common and strong.

Waagenoceras sp.
Figures 36.9, 39

Description.—A fragment representing the venter of phragmoconch. Complete conch form not clear; only an apparent constriction, with accompanying growth lines, tracing a shallow and broad sinus on venter. Ventral lobe and two external lateral lobes well preserved. Ventral lobe broad ring-shaped, inflated rear and constricted front. Ventrad flank of ventral prong only one digit; dorsad flank has four first-ranked digits and two second-ranked digits. Dissection of lateral lobes reaches upper part of both flanks. First lateral lobe has eight first-ranked digits and approximately five second-ranked digits; second lateral lobe with seven first-ranked digits and three second-ranked digits; third lateral lobe has seven first digits and two second-ranked digits. Secondary digitation limited in lower part of lobes. Saddles mushroom-shaped. Three preserved lateral lobes follow an obviously arched trace.

Materials.—One specimen, NIGP 93715, representing venter and ventrolateral part of phragmoconch.

Occurrence.—Bed 29, Siliceous Rocks (1st) Member, Shaiwa Formation, ~22 m above base of formation, Shaiwa section (Sec. VI–VI'), Sidazhai, Ziyun County, Guizhou.

Remarks.—In spite of poor preservation, the major features, such as broader ring-shaped ventral lobe, digitation of lobes of external suture, development of secondary digits, and arched trace of suture, are coincident with the definition of *Waagenoceras*. Present specimen somewhat similar to *W. dieneri* Böse in digitation of lobes and shape of ventral lobe; however, present material is inadequate for exact identification at the species level.

Genus *Timorites* Haniel, 1915

1933 *Hanieloceras* Miller, p. 413.
1937 *Wanneroceras* Toumanskaya, p. 93.
1983b ?*Subeothinites* Zakharov, p. 151.
1997 *Coahuiloceras* Cantú Chapa, p. 82.

Type species.—*Timorites curvicostatus* Haniel, 1915; subsequent designation, by Diener, 1921; Amarassi beds (Capitanian, probably equal to the lower Lopingian), Amarassi, Timor, Indonesia.

Diagnosis.—Similar to *Cyclolobus*, but conch broader and commonly retaining ribs to maturity. External suture with 8–11 pairs of lobes to umbilical shoulders, lacking tertiary subdivision near crest of first lateral saddle.

Occurrence.—Capitanian, supposedly equal to Wuchiapingian; Indonesia (Timor), USA (West Texas), Mexico (Coahuila), Russia (Maritime Territory, Amur), Azerbaijan (Julfa), Iran

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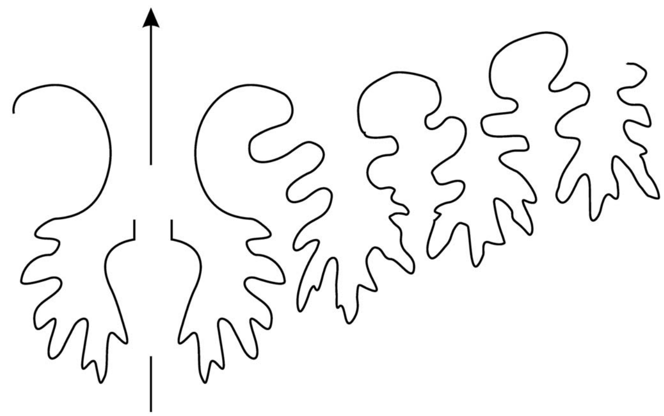

Figure 39. External suture of *Waagenoceras* sp. NIGP 93715, D ~35 mm, Bed 29, Siliceous Rocks (1st) Member, Shaiwa Formation, ~22 m above the base of the Formation, Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou.

(north, central), Tajikistan (?Pamirs), Japan (Kitakami), and China (Yunnan, Xizang, ?Guizhou).

Remarks.—In practice, some misidentifications occur between the genera *Timorites* and *Cyclolobus* because their generic assignments were mostly experienced on external conch features. Actually, the tertiary subdivision near the crest of the first lateral saddle in *Cyclolobus* might be the most effective character for disginguishing it from *Timorites*.

?*Timorites* sp.
Figure 36.10

Description.—Specimen only a piece of external cast of living chamber. Conch larger in size, probably >110–120 mm in diameter, sculptured with very strongly transversal ribs. Ribs rounded at top, as wide as inter-rib, increased in number by furcating near the ventrolateral zone. Suture unknown.

Materials.—An external cast, NIGP 154112.

Occurrence.—Bed 23, Claystone (3rd) Member, Shaiwa Formation, Sidazhai section (Sec. VI'-VI"), Sidazhai, Ziyun County, Guizhou.

Remarks.—Within the ammonoid assemblage found from the Bed 23, Claystone (3rd) Member, Shaiwa Formation, Sidazhai section (Sec. IV'-IV"), this fragment of living chamber probably represents the genus *Timorites*. The questionable specimen here also resembles *Timorites yunnanensis* Liang, 1983 from Youhua, Yongning Town, Ninglong County, West Yunnan (Liang, 1983).

Superfamily Marathonitoidea Ruzhentsev, 1938
Family Marathonitidae Ruzhentsev, 1938

Genus *Almites* Toumanskaya, 1941

1921 *Staceoceras* Gemmellaro; Fredricks, p. 91 (part).
1927 *Perrinites* Smith, p. 55 (part).
1933 *Marathonites*; Ruzhentsev, p. 173 (part).
1938 *Kargalites* Ruzhentsev, 1938, p. 259 (part).
1939 *Paraperrinites* Toumanskaya, p. 17.
1940a *Peritrochia*; Miller and Furnish, 1940a, p. 121 (part).
1941 *Marathonites* (*Almites*) Toumanskaya, p. 261.
1950 *Marathonites* (*Neomarathonites*) Ruzhentsev, p. 190 (part).
1978 *Almites*; Bogoslovskaia, 1978, p. 56.

Type species.—*Marathonites sellardsi* Plummer and Scott, 1937; original designation; Indian Creek Shale, Admiral Formation (Sakmarian), Coleman County, central Texas.

Diagnosis.—Similar to *Marathonites*, but dorsal lobe narrow and weakly tridentate.

Occurrence.—Upper Pennsylvanian (Virgilian [Gzhelian]): USA (Texas); Lower Permian Cisuralian (Asselian—Artinskian): USA (Texas, New Mexico, California, Nevada), Guatemala, Ukraine (Crimea), Russia and Kazakhstan (South Urals), Tajikistani (Pamirs), Indonesia (Timor), Austria (Karawanken Mountains), and South China (Guangxi, Guizhou).

Remarks.—*Almites* is distinguished from *Marathonites* by the narrower dorsal lobe, and from *Pseudovidrioceras* by the bidentate prongs of the ventral lobe. *Almites* resembles *Cardiella* in general suture, but is distinguished from the latter by regular coiling in conch growth, without geniculation. Smith (1927) described a new species, '*Perrinites*' *brouweri*, but restudy of the types by Glenister and Furnish in the 1970s indicated that his figs. 1 and 2 were really marathonitids, probably forms of genus *Almites* (Glenister et al., 2009, p. 160).

Almites multisulcatus Bogoslovskaia, 1978
Figures 40.1–40.15, 41.2–41.6

1978 *Almites multisulcatus* Bogoslovskaia, p. 56.
1987 *Marathonites* sp. Zhou, p. 140, pl. 4, figs. 4, 5.

Description.—Pachyconic, involute, with body chamber at 31.7 mm diameter in the largest specimen (NIGP 89014, Fig. 40.13–40.15). Rounded venter merges with flanks continuously, without ventrolateral shoulder. Whorl-section semi-ellipsoidal. Umbilicus small, with narrow and stepped wall (Table 10). Shell surface covered by fine lamellae, extended obliquely forward from umbilical shoulder, subsequently backward to trace a broadly shallower sinus in venter. Five to six constrictions, parallel with lamellae, obviously present in internal mold, but faint on exterior of test. Ventral lobe relatively broad, subdivided into two wide and bidentate prongs. First three external lateral lobes clearly tridentate; fourth lobe situated near umbilical shoulder, much smaller than previous three, bidentate or undivided. Dorsal lobe narrow, tridentate (Fig. 41.6); first to third internal lateral lobes narrow and bidentate. Denticulation in ventral lobe and the first two lateral lobes somewhat irregular, probably caused by second-order subdivision of the denticles in the relatively large-sized specimen NIGP 89013 (Fig. 41.5).

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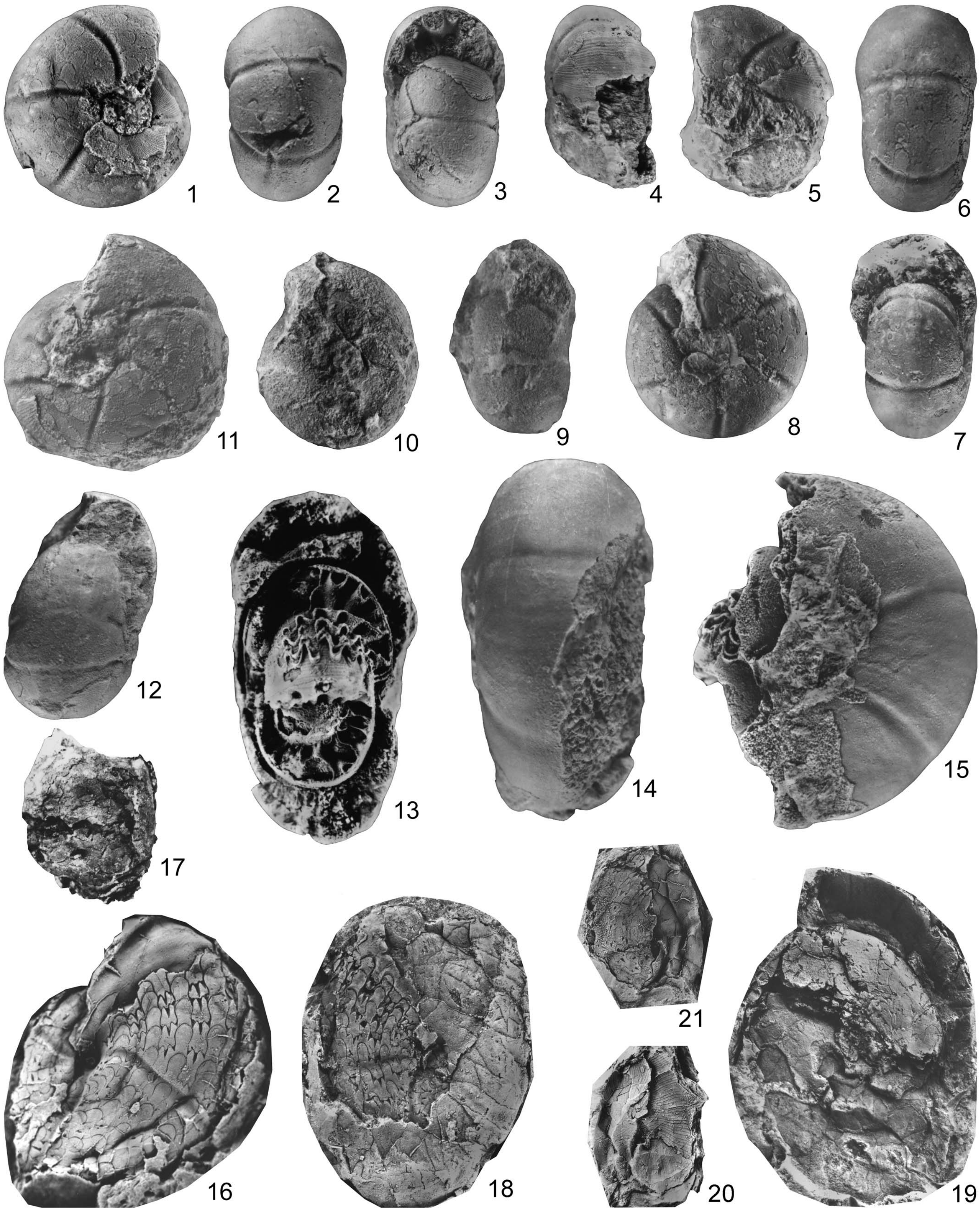

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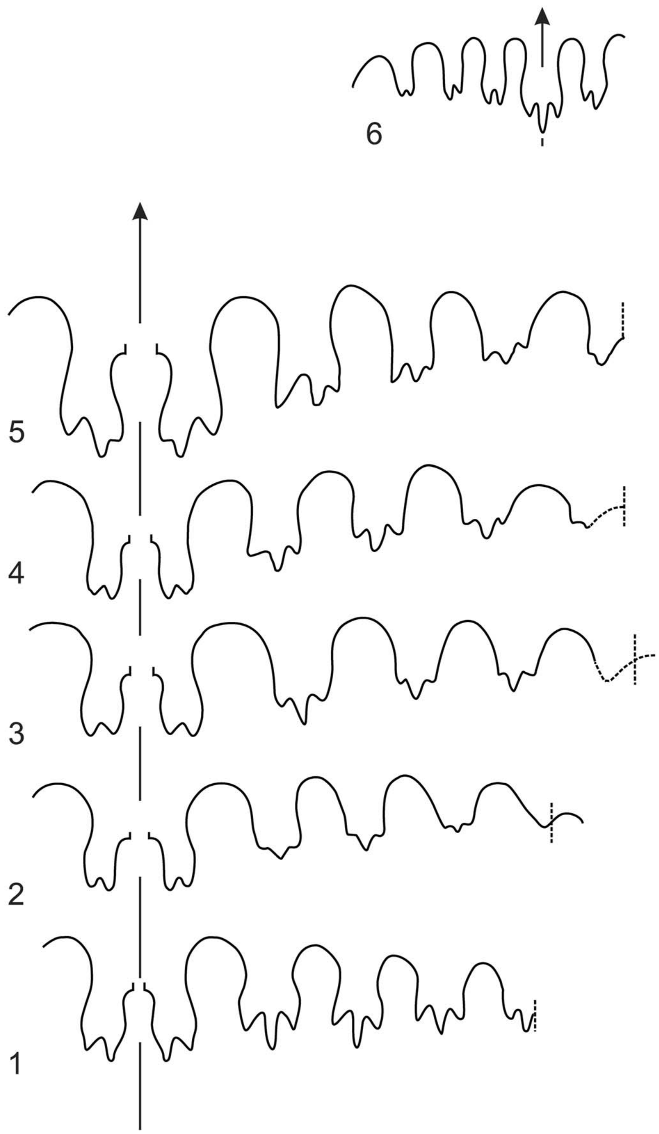

Figure 41. Sutures of *Almites* Toumanskaya, 1941. (**1**) *Almites* sp., NIGP 93720, D ~25 mm, Longma Member, Sidazhai Formation, Mading (Loc. 6), Liuzhai, Nandan County, Guangxi; (**2–6**) *Almites multisulcatus* Bogoslovskaia, 1978, all from the Bed 19, 2nd Member, Nandan Formation, Meyao section (Sec. V), Liuzhai, Nandan County, Guangxi (except **5**); (**2**) NIGP 89011, D 17.1 mm; (**3**) NIGP 89010, D 17.2 mm; (**4**) NIGP 89009, D 18.5 mm; (**5**) NIGP 89013, D 21.2 mm, Bed 11, 2nd Member, Nandan Formation, Zhuangli section (Sec. VI), Liuzhai, Nandan County, Guangxi; (**6**) NIGP 89014, internal suture, D 21 mm.

Materials.—Six specimens, NIGP 89009–89014 from limestone matrix. Except NIGP 89014, all phragmoconchs; body chambers lost in process of specimen preparation.

Table 10. Dimensions and ratios of *Almites multisulcatus* Bogoslovskaia, 1978. D, diameter of conch; W, width of conch; H, height of whorl; U, diameter of umbilicus.

Specimen	D (mm)	W/D	H/D	U/D	H/W
NIGP 89014	31.7	0.57	0.45	0.18	0.79
NIGP 89013	21.1	0.62	0.47	0.19	0.76
NIGP 89009	18.5	0.61	0.45	0.17	0.73
NIGP 89011	17.5	0.66	0.49	0.18	0.74
NIGP 89010	17.2	0.66	0.47	0.17	0.71
NIGP 89012	16.6	0.64	0.48	0.18	0.75

Occurrence.—Bed 19, Meyao section (Sec. V), Liuzhai; Bed 11, Zhuangli section (Sec. VI), Liuzhai; Asselian talus limestone, Liuzhai Quarry (Loc. 5), Liuzhai. All from the 2nd Member, Nandan Formation, Nandan County Guangxi.

Remarks.—Specimens herein resemble types from the Pamirs in conch shape, sculpture, and sutural generality, especially possessing 5–6 constrictions on the internal mold of both phragmoconch and body chamber. However, the existence of irregular denticulation in NIGP 89013 (Fig. 41.5) is still questionably either intraspecific variation among individuals or new, distinct features with taxonomic significance. The specimen NIGP 94477 (Zhou, 1987) collected from the Liuzhai Quarry (Loc. 5) formerly was identified as *Marathonites* sp., but it has been reassigned to *Almites* now owing to discovery of a narrowly tridentate dorsal lobe in NIGP 89014 with the same conch shape in the fauna.

Almites sp.
Figures 40.16–40.21, 41.1

Description.—Conchs compressed, fairly deformed in mudstone matrix. Original shells presumably pachyconic and involute, with very small umbilicus. Lamellae sculpture on conch surface; 3–4 constrictions on internal mold of outer volution. Ventral lobe relatively broad. Prongs bidentate, wider than ventral saddle, with a longer digit ventrad. First to third external lateral lobes wide, completely tridentate, with a longer middle digit; fourth external lateral lobe with two asymmetric teeth. All saddles constricted adorally. As an exception, NIGP 89015 possesses a bidentate third lateral lobe (see Fig. 40.17) instead of the usually tridentate third lateral lobe.

Materials.—Five specimens, NIGP 93718–93721 and NIGP 89015.

Occurrence.—Beds 17–19 of the Longyin Formation, Huagong section (Sec. II), Huagong Tea-Plantation of Qinlong County, Guizhou; Longma Member, Sidazhai Formation, Mading

←

Figure 40. *Almites* Toumanskaya, 1941. (**1–15**) *Almites multisulcatus* Bogoslovskaia, 1978, all ×2; (**1–8**) Bed 19, 2nd Member, Nandan Formation, Meyao section (Sec. V), Liuzhai, Nandan County, Guangxi; (**1–3**) lateral, ventral, and apertural views, NIGP 89009; (**4, 5**) ventral and lateral views, NIGP 89010; (**6–8**) ventral, apertural, and lateral views, NIGP 89011; (**9–12**) Bed 11, 2nd Member, Nandan Formation, Zhuanli section (Sec. VI), Nandan County, Guangxi; (**9, 10**) apertural and lateral views, NIGP 89012; (**11, 12**) lateral and apertural views, NIGP 89013; (**13–15**) apertural with ventral inner volution, ventral, and lateral views, NIGP 89014, Bed 19, 2nd Member, Nandan Formation, Meyao section (Sec. V), Liuzhai, Nandan County, Guangxi; (**16–21**) *Almites* sp.; (**16**) lateral view, NIGP 93720, ×2, Longma Member, Sidazhai Formation, Mading (Loc. 6), Liuzhai, Nandan County, Guangxi; (**17**) lateral view, NIGP 89015, ×2, Bed 3, Longyin Formation, Longyin Setion (Sec. I), Pu'an, Guizhou; (**18, 19**) ×1, beds 19–17, Longyin Formation, Huagong section (Sec. II), Huagong Tea-Plantation, Qinglong County, Guizhou; (**18**) lateral view, NIGP 93718; (**19**) lateral view, NIGP 93719; (**20, 21**) ventrolateral views, NIGP 93721, ×1; Longma Member, Sidazhai Formation, Mading (Loc. 6), Liuzhai, Nandan County, Guangxi; (**20**) inner mold with sutures; (**21**) partial external cost with growth lines.

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(Loc. 6), Liuzhai, Nandan County, Guangxi; Bed 3 of Longyin section (Sec. I), Longyin village, Pu'an County, Guizhou.

Remarks.—Closely similar to *Almites leveni* Leonova, 1992 from Sakmarian Stage of the southeast Pamirs in conch shape and size, and general characters of suture, but the Pamirs species has and obviously wider secondary ventral saddle and less-constricted saddles. The species also resembles *Almites ruzhentsevi* Leonova, 1981 from the Urals in shape of ventral lobe, but differs from it by narrower and deeper lateral lobes.

Genus *Cardiella* Pavlov, 1967

1949 *Marathonites* (*Almites*) Toumanskaya, p. 68 (part).
1967 *Aksuites* Pavlov, p. 77.
1972 *Marathonites*; Davis, p. 85 (part).

Type species.—*Cardiella gracia* Pavlov, 1967; original designation; Kochusuisk Formation, Kungurian, Lower Permian, Southeast Pamirs.

Diagnosis.—Small- to medium-size marathonitids (1.5–4.0 cm mature diameter), similar to *Almites* in suture and juvenile conch, but characterized by moderate to extreme geniculate coiling and modification of cross section in ultimate volution. Terminal restriction reduced apertural area to one-half, accompanied by shell thickening that closed umbilicus and produced deep furrow on internal mold.

Occurrence.—About 15 species, but some of these species might be the representatives of dimorphologic pairs; Upper Pennsylvanian (Missourian–Virgilian): USA (Texas, Oklahoma, Kansas); Permian (Asselian–Kungurian): Tajikistan (Pamir), Ukraine (Crimea), Russia and Kazakhstan (Southern Urals), southern China (Guangxi), Indonesia (Timor), and USA (Nevada).

Remarks.—*Cardiella* is distinguished from similar marathonitids mainly by conch shape. Some modification on conch shape is present in the terminal stage of ontogeny (i.e., umbilicus becomes very narrow, even closed, and outer volution changes to steamline-shaped with an obvious geniculate). Modifications might be caused by changes of life style ontogenetically, including difference of dimorphology due to the sex producing relatively clear dimorphologic pairs in the genus. In addition, lamellae on the conch surface usually are much more curved, and the ventral lobe and its prongs are relatively wider, which are different from the other marathonitids.

Cardiella gracia Pavlov, 1967
Figures 42.1–42.16, 44.5–44.7

1967 *Cardiella gracia* Pavlov, p. 76 (part), pl. 5, fig. 1.
1981 *Cardiella amygdala* Leonova, p. 43, pl. 2, figs. 7, 8.

Description.—Conchs small to intermediate (20–47 mm), consisting of obviously two size-groups of individuals recognized as dimorphologic pairs (Table 11). Heart-shaped or irregularly oval, with geniculation observed at about half the ultimate volution in terminal stage. Secondary thickening around umbilical shoulder relatively tightened, even sealing the umbilicus. Conch interior thickening in living chamber probably emerged in the preservation process (NIGP 89020, Fig. 44.7). Conch surface covered with evenly spaced growth lamellae and trace a salient in flank and a wide and shallow sinus in venter. Several faint longitudinal lirae sparsely present in venter of specimen NIGP 89020, in which periostracum of test partially well preserved. Subterminal constriction approximately parallel to those of earlier growth lamellae, with a high dorsolateral salient, shallow ventrolateral sag, and a broadly rounded, shallow hyponomic sinus. First to third lateral lobes fairly well preserved. Lobe bases tridentate, axial denticle conspicuously longest.

Materials.—15 individuals; NIGP 89021–89030 (microconchs), NIGP 89016–89020 (macroconchs); six of them illustrated herein.

Occurrence.—'Chihsia' Limestone, Tian'e suburb (Loc. 7), north of Hongshuihe River, Tian'e County, Guangxi.

Remarks.—All specimens of *Cardiella* herein were extracted from a limestone block, which was sampled from Tian'e suburb. The occurrence of ammonoids suggests a living assemblage. The mature individuals, except the 'jumbo'-sized NIGP 89020, could be referred to two groups according to dimension of conchs: the smaller ones, including NIGP 89021–89030, with average Dmax (largest diameter) 22.4 mm and Dmin (smallest diameter) 19.5 mm; and the larger ones, including NIGP 89016–89020, with average Dmax 34.4 mm and Dmin 23.6 mm. Both groups are characterized by strongly geniculate body chamber due to modification of coiling radius, and alternation of whorl-section. It probably is more reasonable to refer the two size-groups of conchs to dimorphism pairs than to different species.

Comparing specimens from South China with those of the Pamirs, the smaller group coincides with *Cardiella amygdala* Leonova, 1981 in conch form, dimensions, ornament, and generality of suture, while the larger group is similar to *Cardiella gracia* Pavlov, 1967 in the same items. In particular, the Pamirs species appear to be paired, and have similar early ontogenies with each other. Therefore, all of them from both South China and Pamirs probably represent a pair of dimorphic *Cardiella*. According to the priority of the nomenclature, the species *Cardiella gracia* Pavlov should be preserved.

Genus *Kargalites* Ruzhentsev, 1938

1915 *Popanoceras*; Haniel, p. 88 (part).
1927 *Marathonites*; Smith, p. 44 (part).

Figure 42. *Cardiella gracia* Pavlov, 1967, ×2, 'Chihsia' Limestone, Tian'e suburb (Loc. 7), north of Hongshuihe River, Tian'e County, Guangxi. (**1–6**) Macroconchs: (**1–3**) NIGP 89016, apertural, ventral, and lateral views; obvious subterminal constriction showing in 3; (**4–6**) NIGP 89017, ventral, lateral, and apertural views. (**7–16**) Microconchs: (**7, 8**) NIGP 89022, apertural and lateral views; (**9–11**) NIGP 89021, lateral, apertural, and ventral views; (**12–14**) NIGP 89024, apertural, ventral, and lateral views; obvious subterminal constriction showing in 13, and geniculation showing in 14; (**15, 16**) NIGP 89023, ventral and lateral views.

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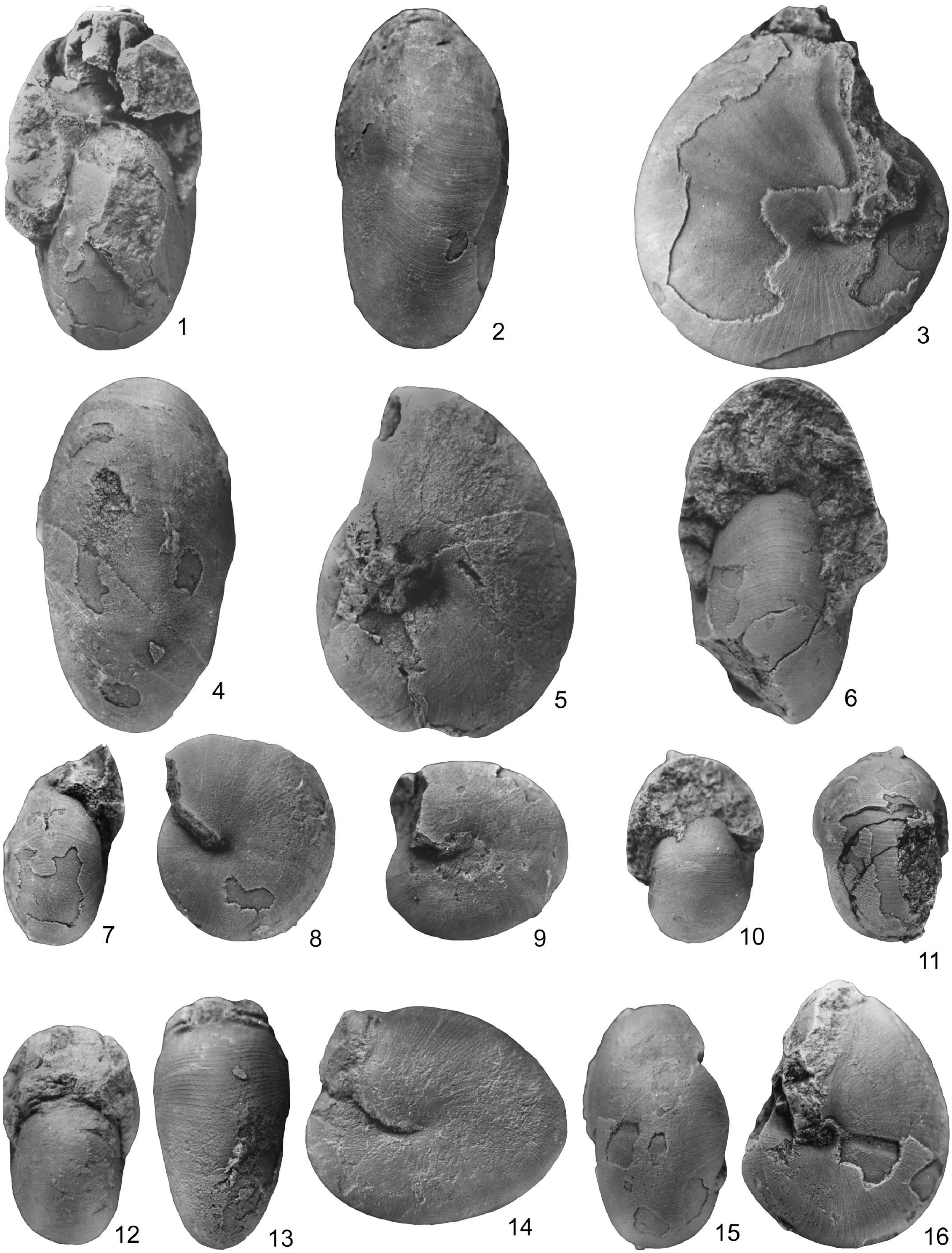

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Table 11. Dimensions and ratios of *Cardiella gracia* Pavlov, 1967; measurements taken in both long- (Dmax, above) and short- (Dmin, lower) axis directions, respectively. D, diameter of conch; W, width of conch; H, height of whorl; U, diameter of umbilicus.

Specimen	D (mm)	W	H	W/D	H/D	H/W
		Microconchs				
NIGP 89024	23.3	10.8	11.8	0.46	0.51	0.90
	20.0	12.5	11.0	0.63	0.55	1.14
NIGP 89025	—	—	—	—	—	—
	20.4	12.0	11.0	0.59	0.54	1.09
NIGP 89026	21.5	10.3	12.5	0.48	0.58	0.83
	18.2	11.7	10.0	0.64	0.50	1.17
		Macroconchs				
NIGP 89016	28.9	17.1	21.5	0.59	0.74	1.25
	28.0	15.0	16.8	0.54	0.67	1.25
NIGP 89018	31.5	15.5	16.5	0.49	0.53	1.06
	30.8	—	16.0	—	0.52	—
NIGP 89017	32.8	19.0	20.0	0.58	0.61	1.05
	23.8	15.4	14.4	0.65	0.61	0.94
NIGP 89019	34.2	17.3	20.8	0.51	0.61	1.20
	33.3	15.4	14.0	0.46	0.42	0.91
NIGP 89020	~44.7	21.7	24.5	~0.49	~0.55	1.12
	—	17.7	19.5	—	—	—

1931 *Vidrioceras*; Schindewolf, p. 197 (part).
1941 *Peritrochia*; Mullerried et al., p. 404.
1949 *Marathonites* (*Almites*) Toumanskaya, p. 68 (part).

Type species.—*Marathonites timorensis* Haniel var. *typica* Ruzhentsev, 1933; original designation; Artinskian, South Urals.

Diagnosis.—Marathonitids, dorsal lobe is narrow and undivided to weakly tridentate.

Occurrence.—Upper Pennsylvanian: USA (Texas and Ohio); Asselian through Kungurian: Indonesia (Timor), Urals (Russia and Kazakhstan), Tajikistan (Pamirs), Japan (Kitakami), Canada (Ellersmere Island), Mexico (Chiapas), and South China (Guangxi).

Remarks.—As Ruzhentsev (1956, p. 242) pointed out, intraspecific variation is extreme in this genus, and even in all the marathonitids, "populations of the type species display ventral prongs that range from undivided to bidentate; irregularly bidentate first external lateral lobes that may possess third-order subdivision of the denticles; and a dorsal lobe that ranges from undivided through asymmetrically bidentate to narrowly tridentate." It seems true, given that the sutures shown in Figure 44.5 and 44.6 are so different in both shape and length, especially, the in the third lateral lobes near the umbilicus.

Kargalites is similar to *Almites* in conch form, ornament, and generality of suture, but is distinguished from the latter by bidentate first external lateral lobe. *Kargalites* and *Subkargalites* are similar to each other in major features, but the former, like *Almites*, possesses a relative narrow dorsal lobe, which is undivided through asymmetrically bidentate to narrowly tridentate, whereas in the latter, the dorsal lobe is broad and deeply tripartite ($D_2D_1D_2$).

Kargalites nandanensis Zhou, 1987
Figures 43.4, 43.5, 44.3

1987 *Kargalites nandanensis* Zhou, p. 140, pl. 3, figs. 14–18.

Materials.—Three specimens, NIGP 94474–94476.

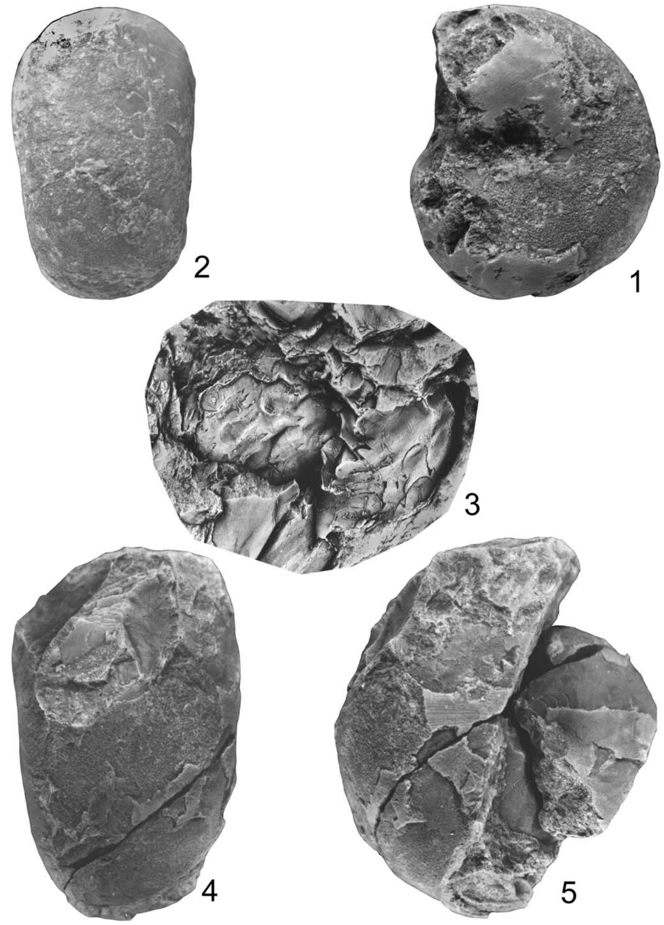

Figure 43. *Subkargalites* Ruzhentsev, 1950 and *Kargalites* Ruzhentsev, 1938. (**1, 2**) *Subkargalites liuzhaiensis* (Zhou, 1987), ventral and lateral views, ×1, NIGP 94473 (Zhou, 1987, pl. 3, figs. 12, 13), Asselian talus limestone, 2nd Member, Nandan Formation, Liuzhai Quarry (Loc. 5), Liuzhai, Nandan, Guangxi; (**3**) *Kargalites* sp. NIGP 93722, ventrolateral view of a piece of fragment, ×2, Longma Member, Sidazhai Formation, Mading (Loc. 6), Liuzhai, Nandan County, Guangxi; (**4, 5**) *Kargalites nandanensis* Zhou, 1987, ventral and lateral views, ×1.5, NIGP 94474 (Zhou, 1987, pl. 3, figs. 17, 18), Asselian talus limestone, 2nd Member, Nandan Formation, Liuzhai Quarry (Loc. 5), Liuzhai, Nandan, Guangxi.

Occurrence.—Asselian talus limestone, 2nd Member, Nandan Formation, Liuzhai Quarry, Liuzhai, Nandan County, Guangxi.

Remarks.—The present species is still assigned to the genus *Kargalites* as done in 1987 because no inner suture is available. The associated species '*Kargalites*' *liuzhaiensis* is re-assigned to *Subkargalites* due to the well-preserved tripartite in the broad dorsal lobe ($D_2D_1D_2$). The species is similar to *Subkargalites liuzhaiensis* in conch shape, but different in sutural details. It also is similar to *Subkargalites neoparkeri* Ruzhentsev, 1950, but the latter is characterized by a wider umbilicus and broader prong of the ventral lobe.

Kargalites sp.
Figures 43.3, 44.4

Description.—Only a piece of internal mold, representing two different whorls, preserved in mudstone. Conch looks thicker discoidal with narrow umbilicus. Suture only preserved on first three external lateral lobes. First lateral lobe broad and bidentate, then secondary subdivisions appearing on the primary

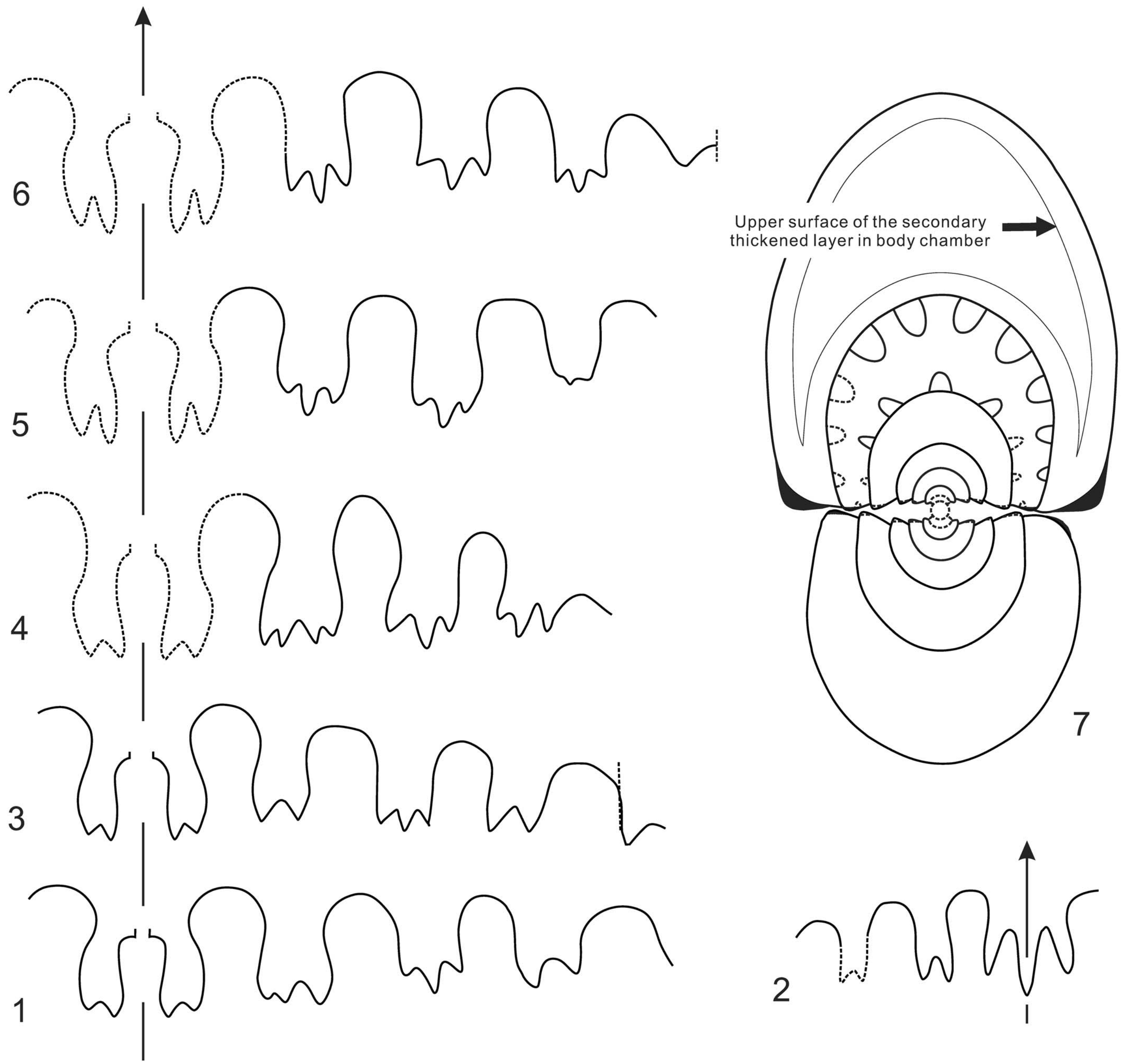

Figure 44. Sutures of *Subkargalites* Ruzhentsev, 1950, *Kargalites* Ruzhentsev, 1938 and *Cardiella* Pavlov, 1967, and the cross-section of *Cardiella gracia* Pavlov, 1967. (**1, 2**) *Subkargalites liuzhaiensis* (Zhou, 1987), NIGP 94473, D ~16 mm, Asselian talus limestone, 2nd Member, Nandan Formation, Liuzhai quarry (Loc. 5), Liuzhai, Nandan County, Guangxi (Zhou, 1987, p. 139, pl. 3, figs. 12, 13); (**3**) *Kargalites nandanensis* Zhou, 1987, NIGP 94474, D ~29 mm, Asselian talus limestone, 2nd Member, Nandan Formation, Liuzhai Quarry (Loc. 5), Liuzhai, Nandan County, Guangxi (Zhou, 1987, p. 140, pl. 3, figs. 14–18); (**4**) *Kargalites* sp. NIGP 93722, D ~25 mm, Longma Member, Sidazhai Formation, Mading (Loc. 6), Liuzhai, Nandan County, Guangxi; (**5–7**) *Cardiella gracia* Pavlov, 1967, 'Chihsia' Limestone, Tian'e suburb (Loc. 7), north of Hongshuihe River, Tian'e County, Guangxi; (**5**) NIGP 89022, D 13 mm; (**6**) NIGP 89025, D estimated 13 mm; (**7**) NIGP 89020, cross-section, D 44.7 mm, showing conspicuously fake growth of living chamber during fossilized process, and secondarily thickening of umbilical shoulder (black area) in the heart-shaped terminal stage.

digits, respectively. Second and third lobes all tridentate, but third one quite asymmetric. Ventral lobe poorly preserved; its prongs presumably bidentate as usual.

Materials.—Internal mold of phragmoconch, NIGP 93722.

Occurrence.—Longma Member, Sidazhai Formation, Mading (Loc. 6), Liuzhai, Nandan County, Guangxi.

Remarks.—Inadequate material makes it impossible to recognize species exactly. The basic character of the first lateral lobe confirms the generic assignment, although there is secondarily bidentate in each division.

Genus *Subkargalites* Ruzhentsev, 1950

1884 *Ammonoites* Heilprin, p. 53 (part).
1919 *Marathonites* Böse, p. 133 (part).

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1938 *Kargalites* Ruzhentsev, p. 259 (part).
1950 *Kargalites* (*Subkargalites*) Ruzhentsev, p. 191.
1992 *Subkargalites*; Popov, p. 57.

Type species.—*Marathonites hargisi* Böse, 1919; original designation, Asselian, lower Gaptank Formation, West Texas, USA.

Diagnosis.—Ancestral marathonitids, similar to *Kargalites*, but dorsal lobe broad and deeply tripartite (D2D1D2), conch diameters may exceeding 2 cm.

Occurrence.—Carboniferous in Russia (South Urals) and Uzbekistan (Fergana: Karachatyr); Asselian in USA (Texas, Oklahoma, Kansas), Canada (Ellesmere Island), and South China (Guangxi).

Remarks.—The critically generic feature (e.g., broader dorsal lobe, with a deeply tripartite base or completely separated three lobules) lies in the inner suture.

Subkargalites liuzhaiensis (Zhou, 1987)
Figures 43.1, 43.2, 44.1, 44.2

1987 *Kargalites liuzhaiensis* Zhou, p. 139, pl. 3, figs. 12, 13.
2002 *Subkargalites liuzhaiensis*; Leonova, p. S76.

Materials.—Monotype NIGP 94473.

Occurrence.—Asselian talus limestone, 2nd Member, Nandan Formation, Liuzhai Quarry (Loc. 5), Liuzhai, Nandan County, Guangxi.

Remarks.—Leonova (2002) emended the generic assignment of the present Asselian species, which is characterized by smaller umbilicus, narrower prongs of ventral lobe, secondarily ranked dentition of the first lateral lobe, and tripartite dorsal lobe. It can be distinguished from the type species, *S. hargisi* (Böse, 1919), and Late Carboniferous *S. neoparkeri* Ruzhentsev, 1950 by the features mentioned above.

Superfamily Neoicoceratoidea Hyatt, 1900
Family Neoicoceratidae Hyatt, 1900

Genus *Eoasianites* Ruzhentsev, 1933

1927 *Gastrioceras*; Smith, 1927, p. 27 (part).
1936b *Prometalegoceras* Ruzhentsev, p. 505.
1937 *Trochilioceras* Plummer and Scott, p. 181.

Type species.—*Eoasianites subhanieli* Ruzhentsev, 1933; original designation; Artinskian, Aktyubinsk, South Urals, Kazakhstan.

Diagnosis.—Conch subdiscoidal, evolute, with low height of aperture. Transverse striae usually with oral salient. Umbilical tubercles confined to immature stages; constrictions may be present. Ventral lobe with slightly pouched prongs, median saddle exceeding two-thirds height of entire ventral lobe. First lateral saddle subacute.

Occurrence.—Pennsylvanian (Kasimovian) through Permian (Asselian); Russia and Kazakhstan (South Urals), USA (Texas, Oklahoma, Kansas, Alaska), Canada (Yukon), Tajikistan (Pamirs), and China (Guangxi, Xinjiang).

Remarks.—The type species of *Trochilioceras* and *Pronoceras* are regarded as congeneric with *Eoasianites*. *Eoasianites* resembles shumarditoidean *Somoholites* and *Preshumardites* in outline of both conch shape and sutural elements, but differs from them by the obviously less-pouched lateral lobe and dorsal lobe that resulted basically from phylogenetic divergence. *Eoasianites*, which lacks spiral lirae in its sculpture, also is distinct from *Somoholites*. *Eoasianites* is similar to the gastrioceratoidean *Glaphyrites* in generality of conch shape and suture, but mature *Glaphyrites* is more involute with smaller umbilicus, and possesses spiral lirae in the sculpture.

Eoasianites subhanieli Ruzhentsev, 1933
Figures 45.1–45.9, 46.1, 46.2

1948 *Eoasianites subhanieli* morpha *alta*; Maximova, p. 15, pl. 2, figs. 4–6.

Description.—Conchs subglobal, fairly evolute, with wide and deep umbilicus; estimated full size with living chamber may reach to 70–80 mm diameter (Table 12). Sculpture unknown, supposedly smooth, no nodes or ribs except for fine transverse striae. Ventral lobe relatively narrow. Median saddle as high as half to two-thirds of lobe height; prongs aside narrow, pouched at middle part, pointed at base. External lateral lobe almost same in width as first lateral saddle. Lateral lobe rather pouched, asymmetric, pointed at base. First lateral saddle somewhat subacute at top.

Occurrence.—Asselian talus limestone, Liuzhai Quarry (Loc. 5) and Bed 19, Meyao section (Sec. V), all from the 2nd Member, Nandan Formation, Nandan County, Guangxi

Materials.—Four specimens, three incomplete phragmoconchs, most external suture details well-exposed, NIGP 88999–89001 herein, and one specimen, NIGP 94478 in Zhou (1987).

Remarks.—The present specimens are identical with the types of *Eoasianites subhanieli* Ruzhentsev from the Urals in both conch shape and outline of suture, although they are much larger in conch size than the holotype PIN 318/1207 from the Asselian Stage of the Sholak-Say River, Aktyubinsk, Kazakhstan. However, the paratypes, PIN 318/411 from the Yuresan River, Bashkorstan, Russia (Ruzhentsev, 1951, pl. 7, figs. 1a, b), are even larger (to 57 mm in diameter). Therefore, conch size in the species may have a very large range.

Family Paragastrioceratidae Ruzhentsev, 1951
Subfamily Paragastrioceratinae Ruzhentsev, 1951

Genus *Svetlanoceras* Ruzhentsev, 1974

1948 *Uraloceras*; Maximova, p. 7 (part).
1951 *Paragastrioceras*; Ruzhentsev, p. 142 (part).
1963 *Ruzhentsevites* Moyle, p. 183 (nom. nud.).

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Figure 45. *Eoasianites subhanieli* Ruzhentsev, 1933, the 2nd Member, Nandan Formation, Nandan County, Guangxi, ×1.5. (**1–6**) Bed 19, Meyao section (Sec. V), Liuzhai; (**1, 2**) ventral and lateral views, NIGP 89001; (**3, 4**) ventral and lateral views, NIGP 89000; (**5, 6**) apertural and lateral views, NIGP 88999; (**7–9**) lateral, ventral, and apertural views, Asselian talus limestone, Liuzhai Quarry (Loc. 5), Liuzhai, NIGP 94478 (Zhou, 1987, pl. 1, figs. 12–14).

Type species.—*Uraloceras serpentinum* Maximova, 1948; original designation; Asselian Stage, Bashkortostan, Yuresan River, South Urals.

Diagnosis.—Small (commonly <2.5 cm mature diameter), thinly discoidal paragastrioceratins (W/D, <0.4) with depressed whorls (H/W, <0.8) and wide umbilicus (Umin/D, 0.4–0.7). Numerous ribs across umbilical wall and shoulder multiply by intercalation and bifurcation to produce finer ornament across flanks and venter; ribs and constrictions form high ventral salient; longitudinal lirae less pronounced than transverse ornament. Suture primitive: prongs of ventral lobe narrower and deeper than lateral lobe; lateral lobe approximately symmetrical, with flanks diverging adorally.

Occurrence.—Asselian through the lower Sakmarian (Tastubian); Russia and Kazakhstan (South Urals), Tajikistan (Pamirs), India (?Eastern Himalaya), West Australia, USA (west Texas), Canada (Yukon), and South China (Guangxi).

Remarks.—As an ancestral paragastrioceratid, *Svetlanoceras* is characterized by small mature size, along with wide umbilicus, numerous, but weakly umbilical plicae, weaker longitudinal lirae, and primitive suture (e.g., narrower prongs and shorter lateral lobe). *Svetlanoceras* is transitional to descendant *Uraloceras*, but a very broad prong, smaller umbilicus, and closely equidimensional whorl section in the latter distinguish it from the former. Although *Svetlanoceras* resembles *Paragastrioceras* by similar width of prong, the latter has a longer lateral lobe, more depressed and wide whorl section, obviously stronger transverse ribs or nodes around the umbilical region, and, especially, more pronounced longitudinal lirae on the venter and flanks.

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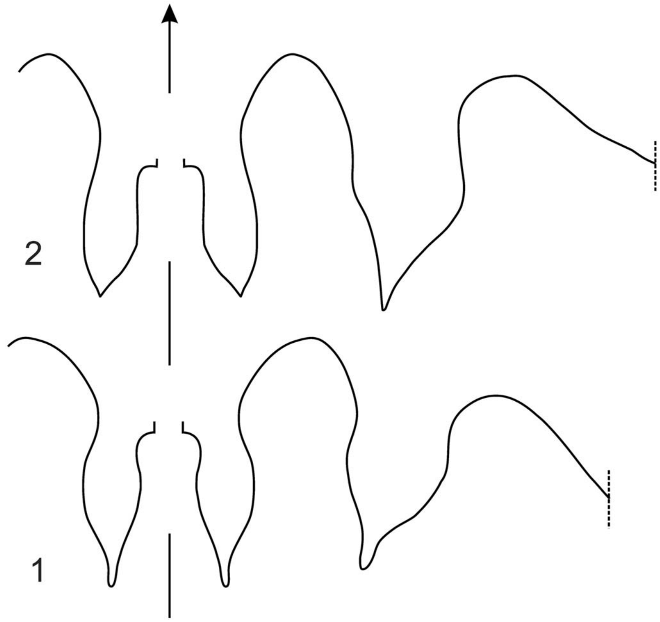

Figure 46. External sutures of *Eoasianites subhanieli* Ruzhentsev, 1978, Bed 19, 2nd Member, Nandan Formation, Meyao section (Sec. V), Liuzhai, Nandan County, Guangxi: (**1**) NIGP 89000, D 32.7 mm; (**2**) NIGP 88999, D 33 mm.

Table 12. Dimensions and rations of *Eoasianites subhanieli* Ruzhentsev, 1933. D, diameter of conch; W, width of conch; H, height of whorl; U, diameter of umbilicus.

Specimen	D (mm)	W/D	H/D	U/D	H/W
NIGP 88999	60.0	0.68	0.38	0.40	0.56
NIGP 89000	47.7	0.68	0.38	0.42	0.56

Svetlanoceras resembles *Stenolobulites* of the subfamily Pseudogastriocertinae in both suture and conch shape, with open umbilicus, strong ribs near umbilical shoulder, and numerous constriction, even with ventral salient. However, both genera belong to different subfamilies, with the major difference being a sinus at the crest of the salient in *Stenolobulites*, which is a major character of the subfamily Pseudogastrioceratinae.

Svetlanoceras serpentium (Maximova, 1948)
Figures 47.1–47.13, 48.1, 48.2

1940 *Uraloceras serpentinum* Maximova and Ruzhentsev, p. 161 (nom. nud.).

1951 *Paragastrioceras serpentinum*; Ruzhentsev, p. 143, pl. 11, figs. 7–9.

1974 *Svetlanoceras serpentinum*; Ruzhentsev, p. 23.

Description.—Whorl section depressed, with rounded venter and ventrolateral shoulder, and bluntly rounded umbilical shoulder. Umbilicus broad, slightly convex umbilical wall, decorated by numerous transverse ribs. Specimen NIGP 154087 (Fig. 47.12, 47.13), with diameter 31 mm, probably represents the maximum-sized individual in the species (Table 13). Surface weakly ornamented by growth lines and less-pronounced lirae. Prominently ventral salient traces in growth lines. Deeply incised constrictions in most specimens examined. Ventral lobe with broad medium saddle and narrow lanceolate prongs conspicuously constricted at two-thirds height of lobe. Lateral lobe asymmetric, broadening adorally, shorter than ventral lobe. Umbilical lobe broad, funnel-shaped.

Materials.—Seven solitary specimens in different growth stages from the detritus limestone, NIGP 154081–154087.

Occurrence.—Bed 19, 2nd Member, Nandan Formation, Meyao section (Sec. V), Liuzhai, Nandan County, Guangxi.

Remarks.—Eight species of *Svetlanoceras* have been established: *S. serpentinum* (Maximova, 1948) (upper Asselian–Sakmarian); *S. strigosum* (Ruzhentsev, 1952) (upper Asselian–Sakmarian); *S. notium* Ruzhentsev, 1978 (upper Asselian–Sakmarian); *S. primore* Bogoslovskaia and Popov, 1986 (upper Asselian–Sakmarian); *S. uraloceraformis* n. sp. (Sakmarian); *S. tenue* Bogoslovskaia, Leonova, and Shkolin, 1995 (Sakmarian–lower Artinskian); *S. irwinense* (Teichert and Glenister, 1952) (Artinskian); and *S. moylei* Mikesh in Glenister, Baker, Furnish, and Thomas, 1990 (Artinskian). As shown in the sequence above, the ratios of U/D reduce within the series from 0.6 to 0.4, while the stratigraphic levels go from upper Asselian, via Sakmarian, through Artinskian, successively. The present specimens are evolute with the largest U/D value, most close to that of *S. serpentinum* (Maximova), in addition to general conch form, ornament, and basic feature of suture. Although slightly larger in size than those from Urals, it probably represents the result of different individual development among special regional populations. The specimens herein also are similar to *S. moylei* Mikesh in basic features of the external suture, but the former has a wider whorl section (H/W 0.69 versus 0.75), allowing it to be distinguished from the latter.

Svetlanoceras uraloceraformis new species
Figures 47.14–47.21, 48.3, 48.4

Diagnosis.—A species with the typical sutural pattern of genus *Svetlanoceras*, with a conch shape somewhat like the genus *Uraloceras*.

Description.—Shell discoidal, evolute with approximately equidimensional whorl section, H/W 0.93–1.00; umbilicus relatively small for genus, U/D 0.43–0.48 (Table 13). Shell surface marked by closely spaced longitudinal lirae, four or five in a millimeter on venter, and growth lines, both resulting in

Figure 47. Genus *Svetlanoceras* Ruzhentsev, 1974. (**1–13**) *Svetlanoceras serpentinum* (Maximova, 1948), Bed 19, 2nd Member, Nandan Formation, Meyao section (Sec. V), Liuzhai, Nandan County, Guangxi: (**1–8**) ×3; (**1, 2**) lateral and ventral views, NIGP 154083; (**3, 4**) lateral and apertural views, NIGP 154082; (**5, 6**) ventral and lateral views, NIGP 154084; (**7, 8**) ventral and lateral views, NIGP 154081; (**9–13**) ×2; (**9**) lateral view, NIGP 154085; (**10, 11**) lateral and ventral views, NIGP 154086; (**12, 13**) ventral and lateral views, NIGP 154087; (**14–21**) *Svetlanoceras uralocerasformis* n. sp., Bed 26, 3rd Member, Nandan Formation, Meyao section (Sec. V), Liuzhai, Nandan County, Guangxi; (**14, 15**) ventral and lateral views, NIGP 154088, ×3; (**16–18**) lateral, apertural, and ventral views, NIGP 154089, holotype, ×3; (**19–21**) ventral, cross-section of the conch, and lateral views, NIGP 154090, ×2.

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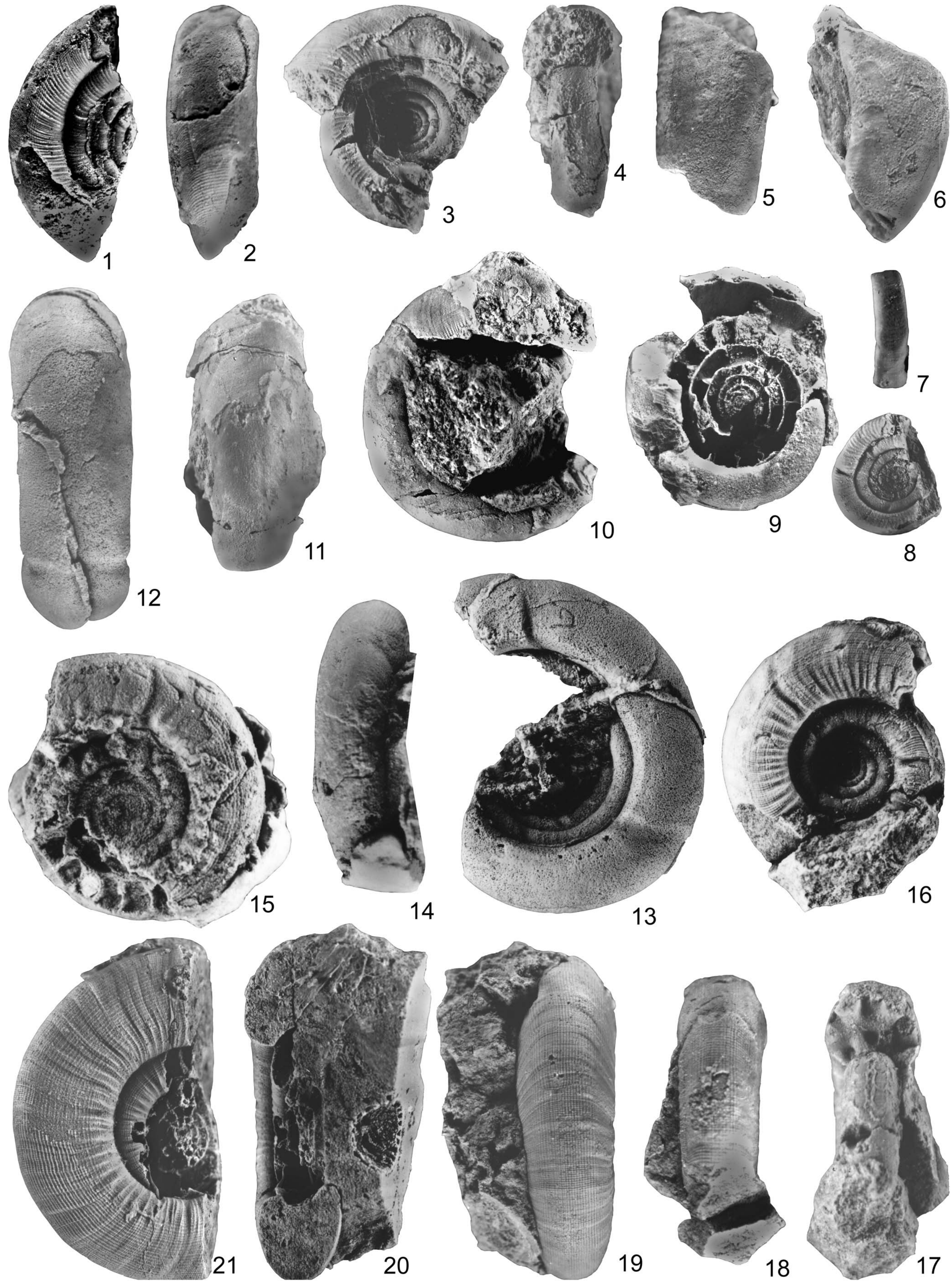

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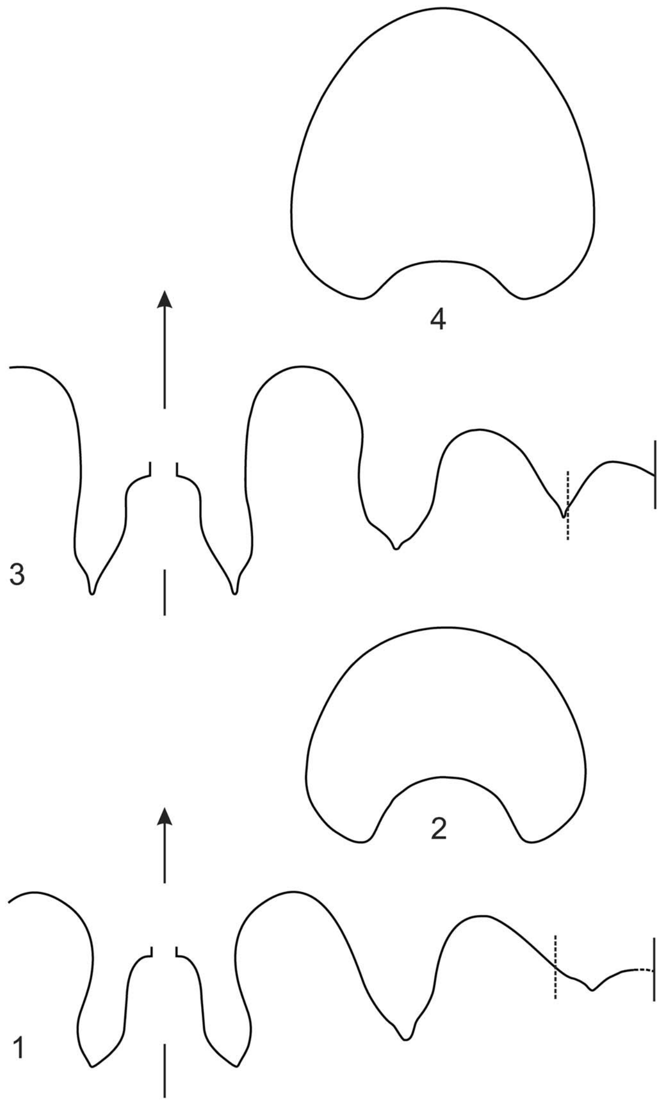

Figure 48. External sutures and whorl cross-sections of *Svetlanoceras* Ruzhentsev, 1974 from Nandan Formation, Meyao Sction (Sec. V), Liuzhai, Nandan County, Guangxi. (**1, 2**) *Svetlanoceras serpentinum* (Maximova), NIGP 154084, Bed 19, 2nd Member: (**1**) D ~17 mm; (**2**) W 6.7 mm; (**3, 4**) *Svetlanoceras uraloceraformis* n. sp., Bed 26, 3rd Member: (**3**) NIGP 154089, holotype, D 16 mm; (**4**) NIGP 154090, W 7.8 mm.

finely reticular pattern. Numerous ribs across umbilical wall and shoulder, multiplying by intercalation and bifurcation to produce finer growth lines across flanks and venter to form fasciculate bands. Transverse lines generally more prominent and more irregular than longitudinal lirae, especially on rounded umbilical shoulder where the former bifurcate and the latter are interposed between rib-like coarser lines. Three or more constrictions in a whorl, along with transverse growth lines to form pronounced salient on venter. Ventral lobe possesses wider medium saddle and symmetric lanceolate prongs; lateral lobe relatively shorter and umbilical lobe funnel-like.

Etymology.—Name derived from the relative similarity to genus *Uraloceras* in basic conch shape and sculpture.

Materials.—Three solitary individuals, relatively well preserved, NIGP 154089 (holotype), 154088, and 154090.

Table 13. Dimensions and conch proportions of *Svetlanoceras serpentinum* (Maximova) and *S. uraloceraformis* n. sp.. D, diameter of conch; W, width of conch; H, height of whorl; U, diameter of umbilicus.

Specimen	D	H/D	W/D	U/D	H/W
	Svetlanoceras serpentinum (Maximova)				
NIGP 154087	31.0	0.24	0.34	0.58	0.69
NIGP 154086	25.0	0.27	0.40	0.62	0.68
NIGP 154085	19.7	0.27	0.43	0.57	0.62
NIGP 154084	—	—	—	—	0.68
NIGP 154083	—	—	—	—	0.66
NIGP 154082	14.0	0.25	0.38	0.55	0.66
NIGP 154081	7.1	0.21	0.32	0.68	0.65
	Svetlanoceras uraloceraformis n. sp.				
NIGP 154090	31.0	0.32	0.32	0.43	1.00
NIGP 154089 (Holotype)	18.5	0.29	0.31	0.48	0.93
NIGP 154088	17.1	0.28	0.28	0.45	1.00

Occurrence.—Bed 26, 3rd Member, Nandan Formation, Meyao section (Sec. V), Liuzhai,, Nandan County, Guangxi.

Remarks.—*Svetlanoceras uraloceraformis* n. sp. is rather similar to the genus *Uraloceras* in conch shape and sculpture pattern, supposedly representing the innovative node in *Svetlanoceras* transition to descendant *Uraloceras*. However, its suture, with fairly narrower prongs and shorter lateral lobe, still allows assignment to *Svetlanoceras* rather than *Uraloceras*. The equidimensional whorl section and smaller umbilicus differ from the rest of the species of *Svetlanoceras*, except for *S. irwinense* (Teichert and Glenister). Nevertheless, *Svetlanoceras uraloceraformis* n. sp. is characterized by parallel flanks of the ventral lobe, which is different from the adorally widened ventral lobe of *S. irwinense*.

Svetlanoceras uraloceraformis n. sp. from the 3rd Member of the Nandan Formation is more advanced than *S. serpentinum* (Maximova) from the 2nd Member of the formation in both evolutive level and the practical stratigraphic position. *Svetlanoceras uraloceraformis* n. sp. is similar to the species of *Stenolobulites* in subfamily Pseudogastrioceratinae in general contour of suture, with relatively narrower ventral prong ($V_1/L < 0.5$); however, the former lacks the generic character of the latter (e.g., hyponomic sinus in the central venter, and much more depressed conch shape than the latter).

Family Metalegoceratidae Plummer and Scott, 1937
Subfamily Metalegoceratinae Plummer and Scott, 1937

Genus *Pseudoschistoceras* Teichert, 1944

1927 *Paralegoceras*; Smith, p. 30 (part).
1979 ?*Gaoyaonites* Xu, p. 42.

Type species.—*Pseudoschistoceras simile* Teichert, 1944; original designation; Barrabiddy Shale Series, Artinskian–Kungurian, Cisuralian, Carnarvon Basin, West Austalia.

Diagnosis.—Conch relatively narrow (W/D, 0.45–0.6) with small umbilicus (Umin/D, 0.25–0.35). Suture characterized by second tripartition of umbilical lobe to form a total of 16 lobes, nine external. Sutural formula: $(V_1V_1)LU^2(U^{1.2}U^{1.1}:U^{1.2})U^3ID$.

Occurrence.—Artinskian; Indonesia (Timor), West Australia, and South China (Guizhou, ?Guangdong).

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Remarks.—*Pseudoschistoceras* is characterized by the second order of tripartition of the primary umbilical lobe to form a total of 16 lobes at maturity, nine external. The appearance of $U_{1.2}$ inside the umbilical seam is the basis on which *Pseudoschistoceras* can be distinguished from *Schistoceras*. As the most advanced genus in the family, there are two or more extra lobes than in other metalegoceratins in the external suture.

Pseudoschistoceras sp.
Figures 49.13, 50.1

Description.—Conch poorly preserved, pachyconch presumably moderately evolute, with open umbilicus, but measurement not available. Sculpture unknown. Ventral lobe narrow and subdivided into two extremely narrow prongs that are asymmetric and have sharpened posteriors. First and second external 'lateral' lobes (L and U_2) broad, constricted in medium part, and sharpened adorally. Third external 'lateral' lobe ($U_{2.1}$) well developed, almost compeletely independent, even a little deeper than first and second ones.

Materials.—One phragmoconch inner mold in mudstone, NIGP 93723.

Occurrence.—Beds 19–17, Longyin Formation, Huagong section (Sec. II), Qinglong County, Guizhou.

Remarks.—The narrow prongs of the ventral lobe and three pairs of 'lateral' lobes exposed beyond the umbilical shoulder indicate the genus *Pseudoschistoceras*. Comparing three well-known species (*P. gigs* [Smith, 1927], *P. simile* Teichert, 1944, and *P. irianense* Glenister, Glenister, and Skwarko, 1983), the specimen herein probably represents the most progressive in sutural development, because the third external 'lateral' lobe is compeletely differentiated as an independent lobe beyond the umbilical shoulder. It may be a new species, but could not be named based only on a single deformed specimen.

Genus *Bransonoceras* Miller and Parizek, 1948

1962 *Metalegoceras*; Ruzhentsev, p. 385 (part).
1979 ?*Pericycloceras*; Glenister, Nassichuk and Furnish, p. 238.
1989 *Eolegoceras* Leonova, p. 123.

Type species.—*Bransonoceras bakeri* Miller and Parizek, 1948; original designation, middle Hueco Formation, Artinskian, Cisuralian, New Mexico, USA.

Diagnosis.—Conch variable in relative width and umbilical diameter, with strong transverse ribs retained to maturity. Suture has 12 lobes, seven external; three umbilical elements ($U^2U^1U^3$) are fully isolated; U^2 subequal to or larger in area than U^1, both external; U^3 internal and subequal to U^1. Sutural formula: $(V_1V_1)LU^2U^1{:}U^3ID$.

Occurrence.—Lower Artinskian through ?Roadian; USA (New Mexico), Tajikistan (Pamirs), and South China (Guizhou, Zhejiang).

Remarks.—*Bransonoceras* is similar to *Metalegoceras* in conch form and suture details, but the former is distinct from the latter by its more compressed whorl-section and retention of strong ribs up to maturity. Glenister et al. (1979) tended to synonymize the heavily ribbed genus *Pericycloceras* Zhao and Zheng, 1977 with *Bransonoceras* owing to similarities in sutural outline and conch ornamentation; however, the ribs of *Pericycloceras* are quite sporadic and coarse as compared with those of *Bransonoceras*, and the conch of the former also is wider and much more depressed than the latter. It is supposed that *Pericycloceras* only represents the localized variety of the genus *Bransonoceras* in the restricted sea of South China, so it is provisionally listed as a synonym of the latter.

The single specimen referred to *Pericycloceras costatum* exhibits a shallow crenulation on the fourth external saddle, close to the umbilical seam. Such features, which are developed sporadically in other metalegoceratids, are regarded as presumably pathologic or capricious (Glenister et al., 1973).

Bransonoceras longyinense new species
Figures 49.1–49.12, 50.2

Diagnosis.—A species of *Bransonoceras* with apparent constrictions and fine spiral lirae.

Description.—Mainly the inner molds of phragmoconch, partially with suture, preserved in mudstone matrix, with secondary deformation during preservation; however, the generality of conch form and sculpture still could be determined. Shell pachydiscoidal with fairly open umbilicus, estimated about one-fourth to one-third of conch diameter. Crowded small transverse lines and finer spiral lirae present in cast of NIGP 93726 (Fig. 49.12); traces of ribs and three or more clear constrictions present on surface of molds. Ventral lobe broad, with a wider middle saddle and two narrow prongs. First lateral lobe (L) broad and diverging adapically. Second 'lateral' lobe (U_2) small and near umbilical shoulder. Umbilical lobe sharp and small.

Etymology.—Name derived from the locality where the typical material was collected.

Occurrence.—Bed 3 and Bed 12, Longyin Formation, Longyin Setion (Sec. I), Pu'an; beds 19–17, Longyin Formation, Huagong section (Sec. II), Qinglong. All from Guizhou.

Materials.—12 specimens: NIGP 93660–93662, 93674, 93685, 93724–93727, 93739, 93740, 93743; including 93725 (holotype).

Remarks.—Specimens of *Bransonoceras longyinense* n. sp. are similar to the type species of *Bransonoceras* in conch form and generality of suture, but apparent constrictions and finer spiral lirae are well developed in the present materials. Also, there are some similarities to the questionable Zhejiang species, '*Pericycloceras*' *costatum* Zhao and Zheng, 1977, but the umbilical lobe in *Bransonoceras longyinense* n. sp. displays a more primitively evolved suture, which is rather less differentiated than the latter.

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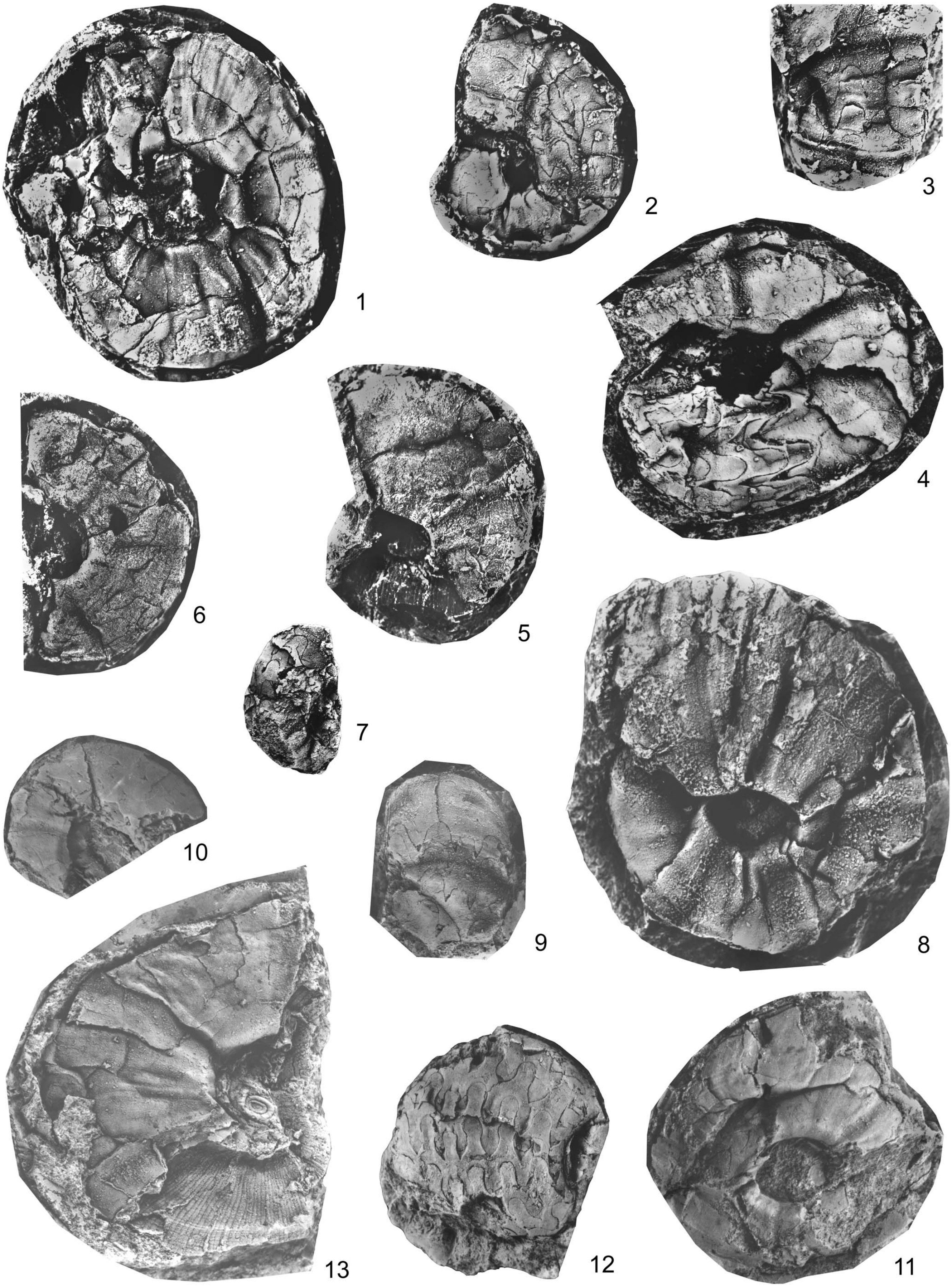

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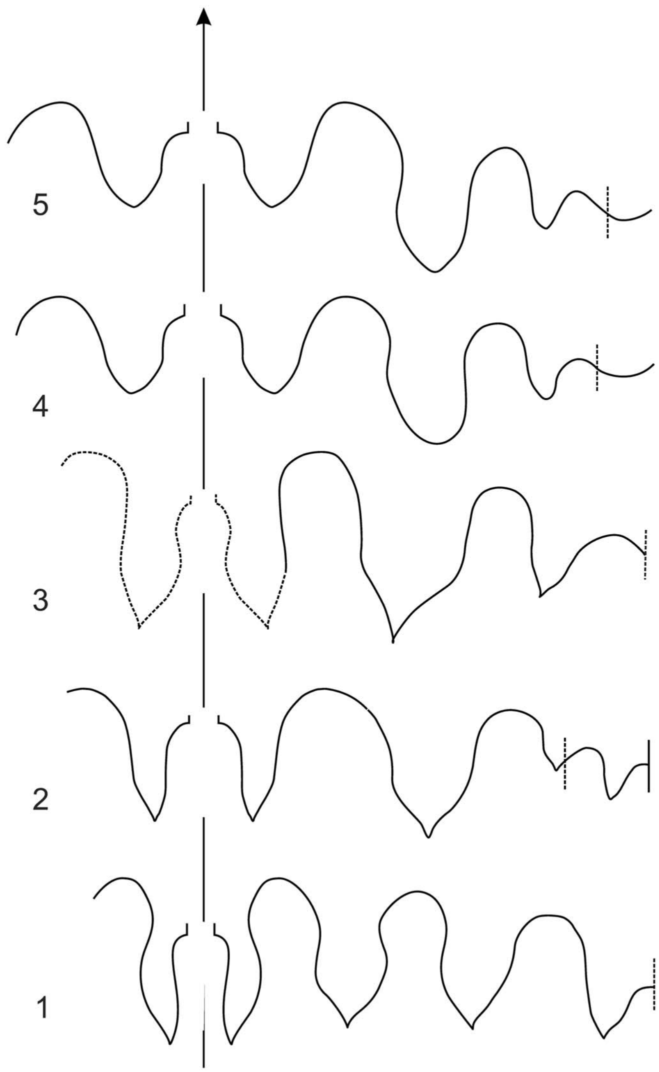

Figure 50. External sutures of metalegoceratins: genera *Pseudoschistoceras* Teichert, 1944, *Bransonoceras* Miller and Parizek, 1948, *Eothinites* Ruzhentsev, 1933, and *Glenisteroceras* n. gen. (**1**) *Pseudoschistoceras* sp., NIGP 93723, D ~14 mm, beds 19–17, Longyin Formation, Huagong section (Sec. II), Qinglong, Guizhou; (**2**) *Bransonoceras longyinense* n. sp., NIGP 93725, holotype, D 19 mm, collected from the same horizon and locality as **1**; (**3**) *Eothinites* cf. *E. kargalensis* Ruzhentsev, 1933. NIGP 93752, D ~30 mm, Bed 12, Longyin Formation, Longyin section (Sec. 1), Pu'an, Guizhou; (**4, 5**) *Glenisteroceras sidazhaiense* n. gen. n. sp., Bed 12, Chongtou Member, Sidazhai Formation, Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou; (**4**) NIGP 93729, D 17 mm; (**5**) NIGP 93728, holotype, D 25 mm.

Subfamily Eothinitinae Ruzhentsev, 1956
Genus *Eothinites* Ruzhentsev, 1933

1907 *Uralites* Chernov, p. 292 (nom. nud.).
1915 *Paralegoceras* Haniel, p. 58 (part).
1927 *Lecanites* Smith, p. 24 (part).
1930 *Epiglyphioceras* Spath, p. 40 (part).
1933 *Rhiphaeites* Ruzhentsev, p. 171.

Type species.—*Eothinites kargalensis* Ruzhentsev, 1933; original designation; Aktastinian (lower Artinskian), Aktubinsk area, South Urals.

Diagnosis.—Conch subdiscoidal (W/D, 0.2–0.4) with moderately wide umbilicus (Umin/D, 0.35–0.7). Ribs commonly bifurcate on umbilical shoulder and may be associated with weaker longitudinal lirae; shallow sinus across flanks separated from deeper ventral sinus by prominent ventrolateral salient. Prongs of ventral lobe generally much narrower than corresponding lateral lobe, but may be up to 1.5 times that width.

Occurrence.—Artinskian; Russia and Kazakhstan (Urals), Ukraine (Crimea), Tajikistan (Pamirs), Indonesia (Timor), USA (Texas), Northwest China (Xinjiang), and South China (Guizhou, Guangxi).

Remarks.—Prongs of ventral lobe generally rather narrower than corresponding lateral lobe, but may be up to 1.5 times that width. Extreme variation in relative width of prongs of ventral lobe indicates polyphyletic derivation; narrow prongs resemble those of *Paragastrioceras*, while wider ones resemble *Uraloceras*, each of which may warrant full generic status.

Eothinites cf. *E. kargalensis* Ruzhentsev, 1933
Figures 50.3, 51.5–51.14

1933 cf. *Eothinites kargalensis* Ruzhentsev, p. 170.

Description.—Ophiocone flat discoidal, evolute with broad and shallow umbilicus. Volutions like worm-tube, growing slowly. Venter rounded, flanks relatively convex, umbilical border rounded but obvious. Sculpture mainly consisting of transverse ribs and a few spiral lines near umbilical border. Ribs stronger in inner volutions, getting slender in outer volutions; each 2–3 fine ribs combining to a rib-shaped node near umbilical border. Only two lateral lobes (L, U_2) preserved on specimen NIGP 93752 (Fig. 50.3).

Materials.—10 casts or molds incompletely preserved in mudstone, representing eight individuals, NIGP 93730–93733, 93752, 93753, 154079, 154080.

Occurrence.—Longma Member, Sidazhai Formation, Mading (Loc. 6), Liuzhai, Nandan County, Guangxi; Bed 3 and Bed 12, Longyin Formation, Longyin Setion (Sec. I), Pu'an, Guizhou; Bed 34–32, Yangchang Formation, Yangchang section (Sec. III), Ziyun County, Guizhou.

Figure 49. Metalegoceratins, lateral views (except **3, 7, 9, 13**). (**1–12**) *Bransonoceras longyinense* n. sp., ×2: (**1–6**) Bed 3, Longyin Formation, Longyin Setion (Sec. I), Pu'an, Guizhou; (**1**) NIGP 93743; (**2**) NIGP 93661; (**3**) NIGP 93660, ventral view; (**4**) NIGP 93685; (**5**) NIGP 93739; (**6**) NIGP 93740; (**7, 8**) Bed 12, Longyin Formation, Longyin Setion (Sec. I), Pu'an, Guizhou; (**7**) ventrolateral view, NIGP 93674; (**8**) NIGP 93662; (**9–12**) beds 19–17, Longyin Formation, Huagong section (Sec. II), Qinglong, Guizhou; (**9**) NIGP 93727, ventral view; (**10**) NIGP 93725, holotype; (**11**) NIGP 93724; (**12**) NIGP 93726, transverse lines and finer spiral lirae shown in the cast part below. (**13**) *Pseudoschistoceras* sp. NIGP 93723, ventrolateral view, ×2, beds 19–17, Longyin Formation, Huagong section (Sec. II), Qinglong County, Guizhou.

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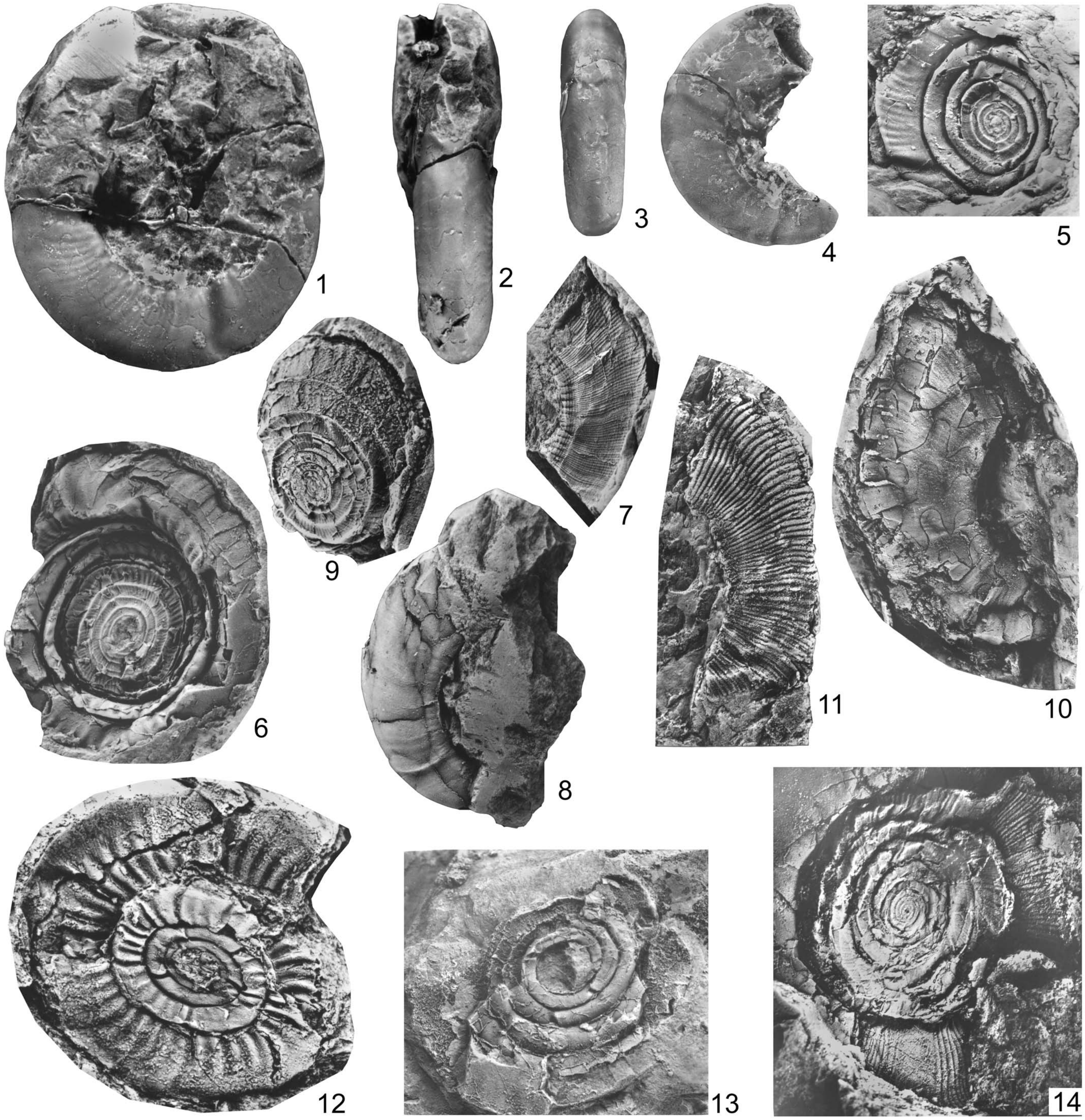

Figure 51. Eothinitins. (**1–4**) *Glenisteroceras sidazhaiense* n. gen. n. sp. Bed 12, Chongtou Member, Sidazhai Formation, Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou, ×2: (**1, 2**) lateral and apertural views, NIGP 93729; (**3, 4**) ventral and lateral views, NIGP 93728 holotype. (**5–14**) *Eothinites* cf. *E. kargalensis* Ruzhentsev, 1933, all lateral views: (**5–9**) Longma Member, Sidazhai Formation, Mading (Loc. 6), Liuzhai, Nandan County, Guangxi; (**5**) NIGP 93731, ×2.5; (**6**) NIGP 93733, ×1.5; (**7, 8**) counterparts, NIGP 93730, ×1.5; (**9**) NIGP 93732, ×2.5; (**10–12**) Longyin Formation, Longyin Setion (Sec. I), Pu'an, Guizhou; (**10, 11**) counterparts, NIGP 93752, Bed 12, ×1.5; (**12**) NIGP 93753, Bed 3, ×1.5; (**13, 14**) beds 34–32, Yangchang Formation, Yangchang section (Sec. III), Ziyun County, Guizhou: (**13**) NIGP 154079, ×1; (**14**) NIGP 154080, ×2.

Remarks.—Conch form, sculpture, and even incomplete suture of specimens indicate the genus *Eothinites*. Furthermore, the specimens are similar to the Urals *E. kargalensis* Ruzhentsev, especially the sculpture in inner volutions and shape of the lateral lobe. However, inadequate feature combination prevents further exact identification.

Genus *Glenisteroceras* new genus

Type species.—*Glenisteroceras sidazhaiense* n. gen. n. sp., monotypy, original designation herein; the lower Chongtou Member, Kungurian, Sidazhai Formation; Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou, South China.

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Diagnosis.—Conch small, compressed, evolutively discoidal with open umbilicus, sculptured by ribs, outlining deeper sinus across venter, and a few identically traced constrictions. Tripartition of primary umbilical lobe completed as early as about 10 mm diameter. Ventral lobe much shallower than lateral lobe (L) and extremely wide, consisting of a broad medium saddle and two widened, V-shaped prongs with strongly diverging flanks. Lateral lobe long, tongue-like, fairly asymmetric; second 'lateral' lobe triangle-shaped, much smaller and shallower than previous one.

Etymology.—Named in honor of late Professor Brian F. Glenister, the University of Iowa, USA.

Occurrence.—Kungurian, Cisuralian; South China (Guizhou).

Remarks.—*Glenisteroceras* n. gen. resembles *Epiglyphioceras* in the same subfamily Eothinitinae in conch shape, sculpture, and outline of suture; however, *Glenisteroceras* n. gen. has an extremely short and wide ventral lobe with strongly diverging flanks. *Glenisteroceras* n. gen. resembles juveniles of the large ancestor *Eothinites*; it was probably the diminutive terminal paedomorph of subfamily Eothinitinae.

Glenisteroceras sidazhaiense new species
Figures 50.4, 50.5, 51.1–51.4

Diagnosis.—Eothinitins, with evolute conch, and the especially broad, shallow, and divergent ventral lobe.

Description.—Conch flat discoidal, evolute with broad umbilicus. Venter narrowly rounded, flank flat convex, dorsum slightly depressed. Height of whorl-section about equal to or a little greater than the width. Umbilical shoulder rounded; umbilical wall narrow and steep. Outer volution decorated with transverse ribs, which form deeper sinus on venter; 2–3 ribs converge as small nodes near umbilical shoulder; 3–4 constrictions appear in the outer volution. Ventral lobe very short, broad and opens adapically, subdivided by a wide medium saddle into two short and wide V-shaped prongs. First lateral lobe (L) tongue-like, asymmetrical, much narrower and longer than ventral lobe, whereas second 'lateral' lobe (U_2) very small in size, looks like a 'lobule'.

Etymology.—Species name derived from the fossil locality, Sidazhai, Ziyun County, southwest Guizhou.

Materials.—Two specimens, NIGP 93728 (holotype), NIGP 93729.

Occurrence.—Bed 12, Chongtou Member, Sidazhai Formation, Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou.

Remarks.—*Glenisteroceras sidazhaiense* n. gen. n. sp. is characterized by a wider and shorter ventral lobe and deeper and narrower first lateral lobe (L). *Glenisteroceras sidazhaiense* n. gen. n. sp. is similar to *Eothinites stenomphalus* Ruzhentsev, 1956 and *E. pseudomeneghinii* (Haniel, 1915) in the shape of whorl-section and the height being a little greater than the width, but the new species has a completely different suture than the latter two by its extremely wide and shallow ventral lobe. *Glenisteroceras sidazhaiense* n. gen. n. sp. resembles *Epiglyphioceras meneghinii* (Gemmellaro, 1887) in the shallower and wider ventral lobe and basic conch shape, but is distinct from the latter by the much wider and specially diverging flanks of the ventral lobe.

Superfamily Popanoceratoidea Hyatt, 1900
Family Popanoceratidae Hyatt, 1900

Genus *Popanoceras* Hyatt, 1884

1844 *Popanoceras* Hyatt, p. 337 (part).
1845 *Goniatites* Verneuil, p. 372 (part).
1919 *Stacheoceras*; Böse, p. 127 (part).
1965 *Propopanoceras*; Chao, p. 1815.
1989 *Pamiropopanoceras* Leonova. p. 174.

Type species.—*Goniatites sobolewskyanus* Verneuil, 1845; subsequent designation by Gemmellaro, 1887; Artinskian Stage, South Urals.

Diagnosis.—Prong of ventral lobe (V_1) equal to or wider than adjacent lateral lobe, bidentate to quadridentate; four or five external lateral lobes moderately dentate.

Occurrence.—Artinskian through Roadian; USA (Texas), Russia (Urals), Kazakhstan (South Urals), Ukraine (Crimea), Madagascar, Tajikistan (Pamirs), Indonesia (Timor), West Canada (north-west Territories), West Australia (Carnarvon Basin), North Thailand (Loei), Japan (Fukushima Prefecture), and China (Xizang, Jilin, Guizhou, and Guangxi).

Remarks.—The genus is similar to *Propopanoceras*, but different from it in a transitional status: the prong of the ventral lobe in the former is equal to or slightly broader than the first lateral lobe, whereas in the latter it usually is narrower than the corresponding lateral lobe.

Popanoceras ziyunense new species
Figures 52.1–52.10, 53.3–53.5

Diagnosis.—Venter flat, with simple, denticulated prongs, the second lateral lobe widest, and incompletely subdivided fourth lateral lobes (or the paired fourth and fifth lobe). Average diameter of umbilicus is larger than other species at the corresponding stage ontogenetically.

Description.—Conch discoidal, compressed, and involute. Venter narrowly rounded in adolescence and flattened in adult. Flank broad and nearly flat; ventrolateral and umbilical shoulders bluntly angular. Umbilicus relatively larger (Table 14). All specimens inner molds, absent sculptures on conch surface; only 7–8 prominent transverse-elongate depressions occur on outer volution. Ventral prongs simply bidentate in base, approximately equal to adjacent lateral lobe in width. Four lateral lobes total, conspicuously constricted adorally, somewhat irregular in shape, second lobe widest, fourth

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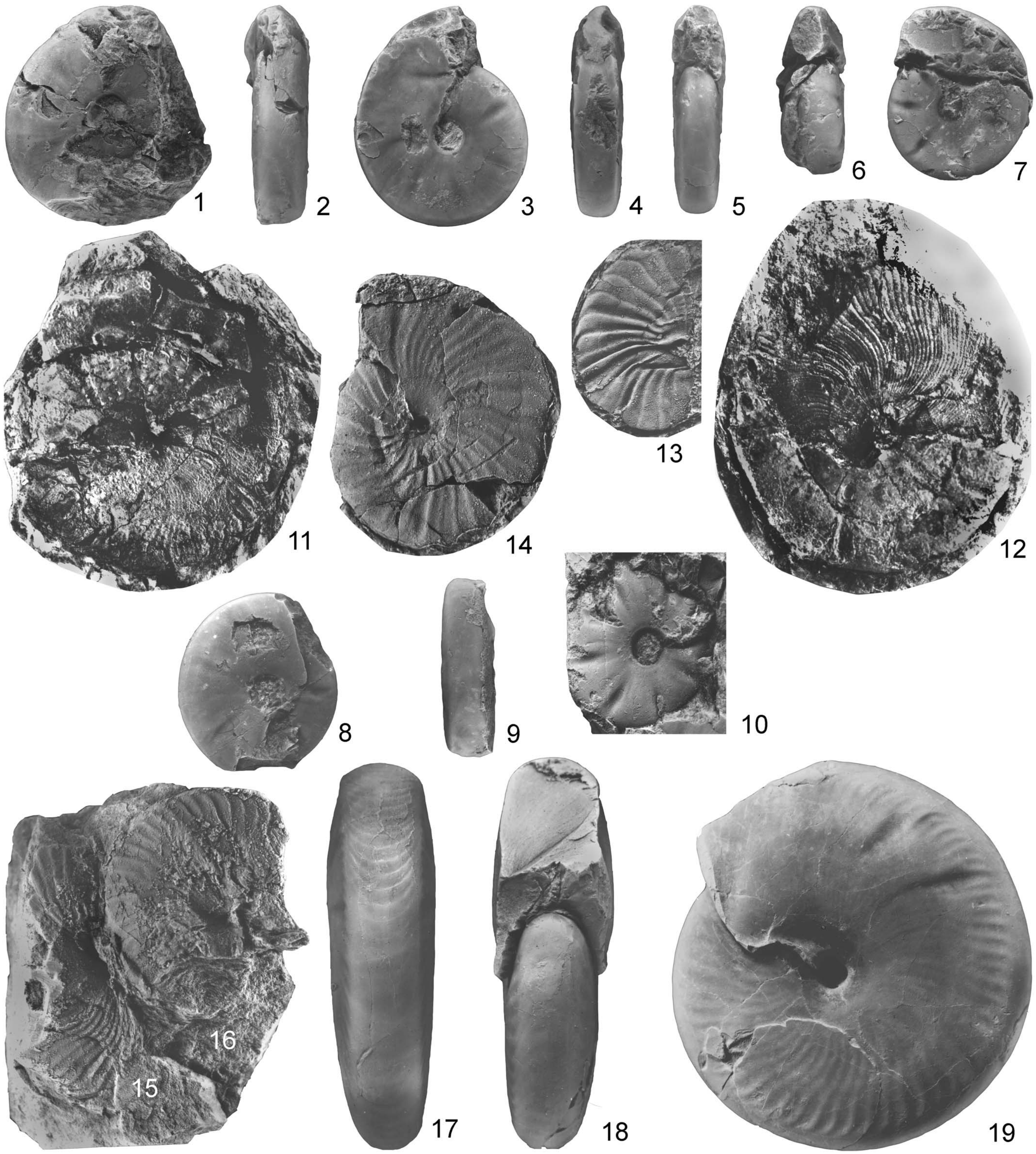

Figure 52. Genus *Popanoceras*. (**1–10**) *Popanoceras ziyunense* n. sp. Bed 12, Chongtou Member, Sidazhai Formation, Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou, all ×1 (except **10**): (**1, 2**) lateral and ventral views, NIGP 93736; (**3–5**) lateral, ventral, and apertural views, NIGP 93734, holotype; (**6, 7**) apertural and lateral views, NIGP 93738; (**8, 9**) lateral and ventral views, NIGP 93737; (**10**) lateral view, NIGP 93735, ×1.5. (**11–19**) *Popanoceras kueichowense* (Zhao in Zhao and Liang, 1974), all ×1: (**11–13**) Bed 3, Longyin Formation, Longyin section (Sec. I), Pu'an County, Guizhou; (**11, 12**) counterparts, lateral view, NIGP 154091; (**13**) lateral view, NIGP 154093; (**14–16**) Bed 31, Longma Member, Sidazhai Formation, Meyao section (Sec. IV), Liuzhai, Nandan County, Guangxi: (**14**) lateral view, NIGP 154092; (**15**) lateral view, NIGP 154094; (**16**) lateral view, NIGP 154094-1; (**17–19**) Tongkuangxi Formation (supposedly equal to Longyin Formation), Ladang (Loc. 1), Langdai, Liuzhi County, Guizhou; ventral, apertural, and lateral views, NIGP 22029, holotype (Chao, 1965, p. 1815, pl. 1, figs. 14, 15; Zhao and Liang, 1974, p. 304, pl. 159, figs. 9, 10).

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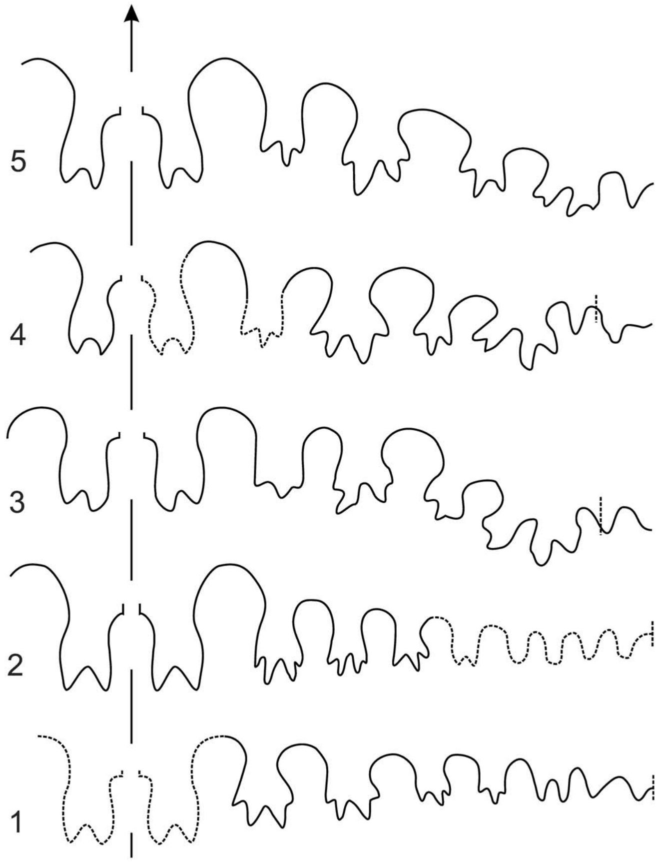

Figure 53. External sutures of *Popanoceras* Hyatt, 1884. (**1, 2**) *Popanoceras kueichowense* (Zhao in Zhao and Liang, 1974): (**1**) NIGP 154091, D 35 mm, Bed 3, Longyin Formation, Longyin section (Sec. I), Pu'an, Guizhou; (**2**) NIGP 22029, D 39 mm, Tongkuangxi Formation (supposedly equal to Longyin Formation), Ladang (Loc. 1), Langdai, Liuzhi County, Guizhou (Chao, 1965, p. 1815, text-fig. 1a). (**3–5**) *Popanoceras ziyunense* n. sp. Bed 12, Chongtou Member, Sidazhai Formation, Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou: (**3**) NIGP 93738, D 14.4 mm; (**4**) NIGP 93735, D ~18 mm; (**5**) NIGP 93734, holotype, D 21 mm.

Table 14. Dimensions and conch proportions of *Popanoceras ziyunese* n. sp. and *P. kueichowense* (Chao, 1965). D, diameter of conch; W, width of conch; H, height of whorl; U, diameter of umbilicus.

Specimen	D (mm)	W/D	H/D	U/D
		Popanoceras ziyunense n. sp.		
NIGP 93736	34.5	0.29	0.48	0.19
NIGP 93734	33.4	0.28	0.48	0.15
NIGP 93737	29.2	0.30	0.48	0.19
		Popanoceras kueichowense (Chao, 1965)		
NIGP 22029	64.8	0.30	~0.50	0.07
NIGP 154091	51.4	—	—	0.07
NIGP 154092	47.6	—	0.51	0.06

primarily subdividing into two dependent bidentate lobules. First three lateral lobes tridentate or quadridentate with normally transversal trace; fourth complex lobe traces down adorally. Top of saddle globe-shaped. Umbilical lobe bipartite, ventrad group of U^1U_1 transferred to flank ontogenetically.

Materials.—Five well-preserved specimens, NIGP 93734 (holotype), and NIGP 93735–93738.

Occurrence.—Bed 12, Chongtou Member, Sidazhai Formation; Shaiwa section (Sec. IV-IV'), Sidazhai, Ziyun County, Guizhou.

Remarks.—Specimens described herein represent late adolescence, but not full maturity due to well-developed flank depressions. *Popanoceras ziyunense* n. sp. is characterized by the compressed conch, even venter in last volution with angularly ventrolateral shoulder, and distinct features of suture: only two serrations in prong of the ventral lobe, the widest and bipartite second lateral lobe, and incompletely subdivided fourth lateral lobe. Also, the umbilicus is relatively larger as compared with *Popanoceras kueichowense* Zhao in Zhao and Liang, 1974.

Popanoceras kueichowense (Zhao in Zhao and Liang, 1974)
Figure 52.11–52.19, 53.1, 53.2

1965 *Propopanoceras kueichowense* Chao, p. 1815, pl. 1, figs. 14, 15 (nom. nud.).
1974 *Propopanoceras kueichowense* Zhao in Zhao and Liang, p. 304, pl. 159, figs. 9, 10.
1989 *Popanoceras kueichowense*; Zhou, p. 1367, fig. 1b, pl. 1, figs. 8–10.
2002 *Pamiropopanoceras kueichowense*; Leonova, p. S96.

Description.—Conch large, discoidal, and involute with small umbilicus. Venter narrowly rounded, flanks flattened. Ornamented by prominent fine ribs and/or strong plications transversely, depending on preservation status. Both ribs and plications form slight sinus on flanks and deeply rounded sinus on venter. Four constrictions present on outer volution. Apertural constriction present in ultimate volution of holotype (NIGP 22029). External suture forms a broad bifid ventral lobe, five lateral lobes, and two small subangular umbilical lobes. Bidentate prong slightly wider than adjacent lateral lobe. First four lateral lobes quadridentate or tridentate, fifth wide and bidentate. All lateral lobes successively decreasing in size toward umbilicus.

Materials.—Six specimens, including original holotype NIGP 22029 (Zhao in Zhao and Liang, 1974), and newly collected plesiotypes NIGP 154091–154094 and 154094-1.

Occurrence.—Tongkuangxi Formation (supposedly equal to Longyin Formation), Ladang (Loc. 1), Langdai, Liuzhi County, Guizhou; Bed 3, Longyin Formation, Longyin section (Sec. I), Pu'an County, Guizhou; Coll. 7085, Bed 31, Longma Member, Sidazhai Formation, Meyao section (Sec. IV) Liuzhai, Nandan County, Guangxi.

Remarks.—*Popanoceras kueichowense* represents a primitive species of *Popanoceras*, with a small umbilicus, wide but bidentate prongs, and subequal lateral lobe series decreasing in size to umbilicus. The well-preserved holotype was named and figured as *Propopanoceras kueichowense* Chao, 1965 without description. Afterwards, it was formally published by the original author (Zhao in Zhao and Liang, 1974), but still without providing the occurrence details. The new plesiotypes were

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collected from the lower part of the Longyin Formation and the Longma Member of the Sidazhai Formation in the typical area—the open-sea area of southwest Guizhou and northeast Guangxi. The prongs of the ventral lobe on the holotype NIGP 22029 are slightly wider than the adjacent lateral lobe in width. Therefore, the specimen had already been recombined as *Popanoceras* by the present author (Zhou, 1989). *Popanoceras kueichowense* (Zhao in Zhao and Liang, 1974) resembles *P. walcotti* White, 1891 and *P. annae* Ruzhentsev, 1940d in the simple denticulation of the prongs in the ventral lobe and the lateral lobes, but is distinguished from both Urals and North America species by the position of the paired last two lateral lobes, which are the fifth and sixth lobes in Guizhou species versus the fourth and fifth lobes in the latter two.

Leonova (1989, 2002) reassigned the present species into her new genus *Pamiropopanoceras* based on features of the inner sutures (e.g., lacking the 'fused' first internal lateral lobe). Actually, because the inner suture is not entirely exposed in the Chinese specimens, it is relatively reasonable to reassign the *Popanoceras kueichowense*-bearing stratum in Nanpanjiang Basin to Artinskian age, probabaly the early part of the stage.

Superfamily Thalassoceratoidea Hyatt, 1900
Family Thalassoceratidae Hyatt, 1900

Genus *Aristoceras* Ruzhentsev, 1940b

1934 *Uralites* Voinova, p. 352 (nom. nud.) (non. Chernov, 1907, p. 292).
1937 *Prothalassoceras*; Plummer and Scott, p. 352 (part).
1940a *Eothalassoceras* Miller and Furnish, p. 105 (part).

Type species.—*Aristoceras chkalovi* Ruzhentsev, 1940b; original designation; Orenburgian Stage, Carboniferous, South Urals.

Diagnosis.—Conch discoidal, with narrow or closed umbilicus; venter flat, with ventrolateral grooves. Coarse sinuous growth lamellae forming deep ventral sinus and narrow ventrolateral salient. Constrictions may be present. Suture similar to *Eothalassoceras*.

Occurrence.—Kasimovian through Asselian, Lower Permian; Russia and Kazakhstan (South Urals), Spain, USA (Oklahoma, Texas), and South China (Guangxi).

Remarks.—*Aristoceras* is rather close to *Eothalassoceras* and *Prothalassoceras* in general conch shape and suture, but distinguished from the latter genera by the prominent ventrolateral double-grooves on each side of conch.

Aristoceras liuzhaiense new species
Figures 54.1, 54.2, 55.1, 55.2

Diagnosis.—Thickly discoidal conch with broader prong of ventral lobe, ~1.5 times width of lateral lobe. Both lobes of approximately even but denticulated base.

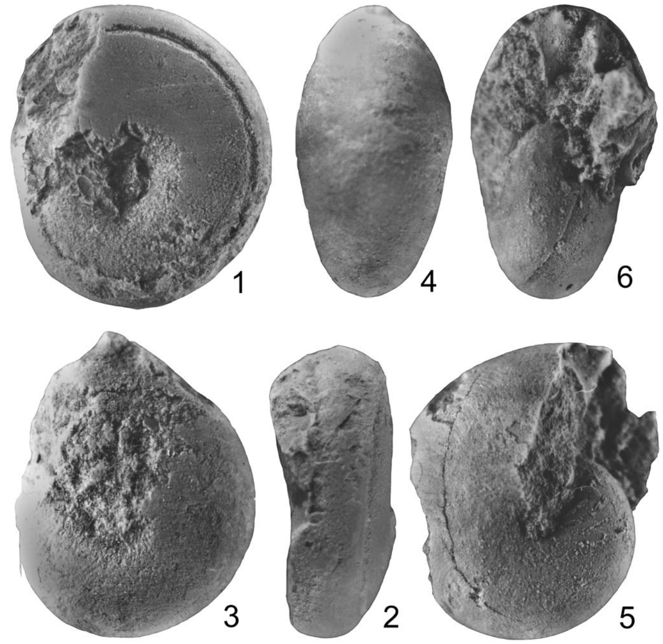

Figure 54. Thalassoceratids. (**1, 2**) *Aristoceras liuzhaiense* n. sp., lateral and ventral views, NIGP 89008, ×2, Bed 11, 2nd Member, Nandan Formation, Zhuangli section (Sec. VI), Liuzhai, Nandan County, Guangxi. (**3–6**) *Prothalassoceras biforme* (Gerasimov, 1937), ×3, Bed 26, 3rd Member, Nandan Formation, Meyao section (Sec. V), Liuzhai, Nandan County, Guangxi: (**3, 4**) lateral, ventral views, NIGP 93741; (**5, 6**) lateral and apertural views, NIGP 93742.

Description.—Shell thickly discoidal, involute; venter rounded; flanks relatively flattened. Umbilicus narrow and umbilical shoulder indefinite. Greatest width of whorls near umbilical shoulder (Table 15). Double-spiral grooves present at ventrolateral shoulder on each side of conch, obscurely diminutive one situated ventrally, obviously principal one situated laterally. Ornament on surface unknown. Suture lines closely spaced adorally. Venter lobe broader, subdivided by a high and wide secondary saddle. Prongs about one-third wider than lateral lobe, both denticulated with asymmetric serrations in lobe base.

Etymology.—Name derived from the locality where the fossil was collected.

Materials.—One specimen, NIGP 89008 (holotype).

Occurrence.—Bed 11, 2nd Member, Nandan Formation, Zhuangli section (Sec. VI), Liuzhai, Nandan County, Guangxi.

Remarks.—Among the five species of *Aristoceras*, *A. liuzhaiense* n. sp. most closely resembles *A. appressum* Ruzhentsev, 1950 in both conch shape and sutural features. However, the prong of the former is narrower, while the first lateral saddle is wider than that of the latter. *Aristoceras liuzhaiense* n. sp. is similar to *A. serum* Bogoslovskaia and Popov, 1986 in conch shape, but the former has a much wider ventral lobe than that of the latter.

Genus *Prothalassoceras* Böse, 1919

1927 *Thalassoceras*; Smith, p. 23 (part).
1940a *Eothalassoceras* Miller and Furnish, p. 105 (part).

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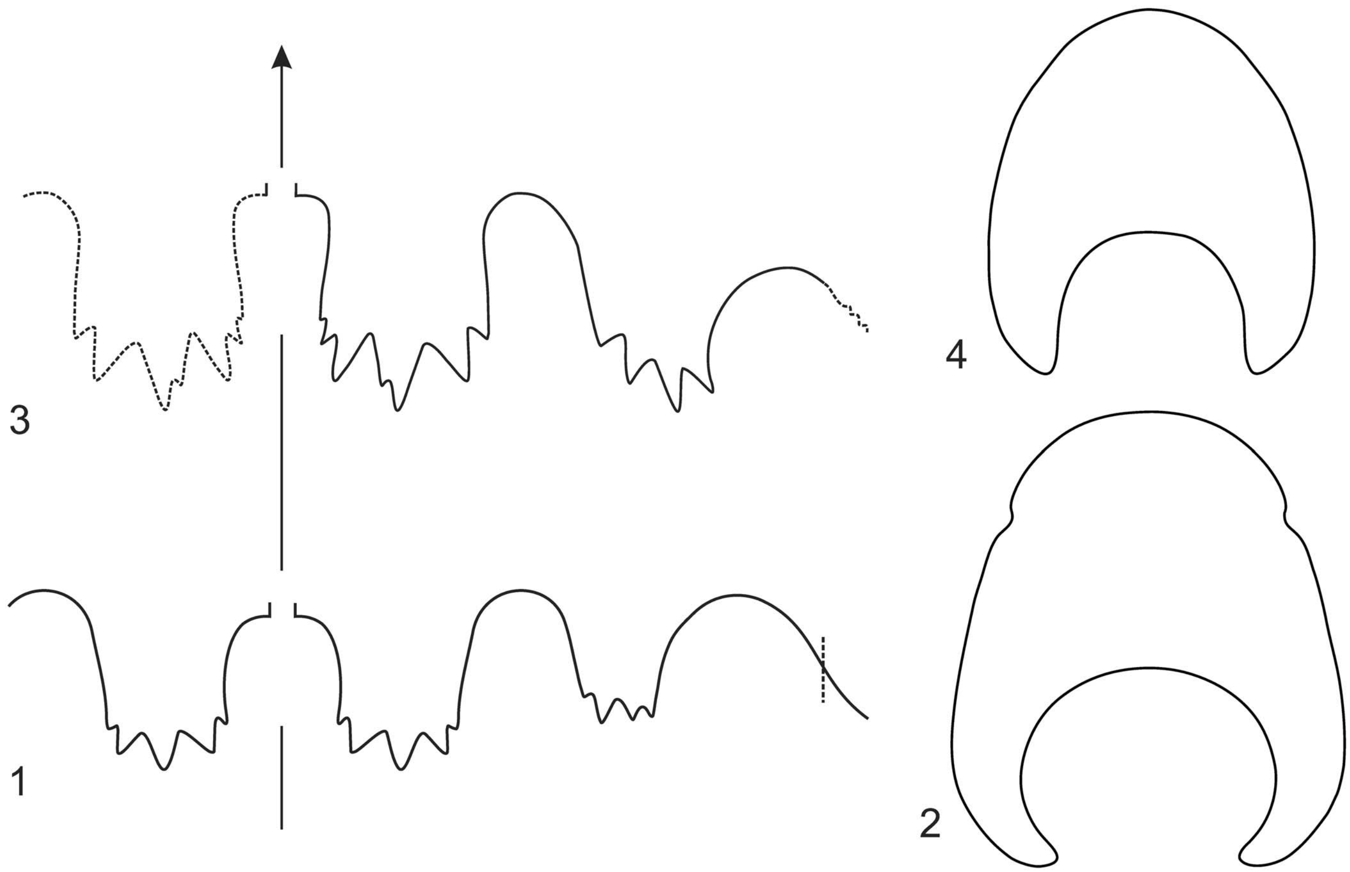

Figure 55. External sutures and conch cross-sections of *Aristoceras* Ruzhentsev, 1940b and *Prothalassoceras* Böse, 1919. (**1, 2**) *Aristoceras liuzhaiense* n. sp., NIGP 89008, monotype, D 21 mm, Bed 11, 2nd Member, Nandan Formation, Zhungli section (Sec. VI), Liuzhai, Nandan County, Guangxi; (**3, 4**) *Prothalassoceras biforme* (Gerasimov, 1937), NIGP 93742, D about 12.2 mm, Bed 26, 3rd Member, Nandan Formation, Meyao section (Sec. V), Liuzhai, Nandan County, Guangxi.

Table 15. Dimensions and conch proportions of *Aristoceras liuzhaiense* n. sp. and *Prothalassoceras biforme* (Gerassimov, 1937). D, diameter of conch; W, width of conch; H, height of whorl; U, diameter of umbilicus.

Specimen	D (mm)	W/D	H/D	U/D	H/W
	Aristoceras liuzhaiense n. sp.				
NIGP 89008	21.4	0.51	0.52	~0.13	1.03
	Prothalassoceras biforme (Gerassimov, 1937)				
NIGP 93742	14.5	0.57	0.67	—	1.14
NIGP 93741	12.9	0.58	0.68	~0.10	1.17

Type species.—*Prothalassoceras welleri* Böse, 1919; subsequent designation by Plummer and Scott, 1937; upper part of the Hueco Limestone Formation, Sakmarian–?Artinskian, west Texas, USA.

Diagnosis.—Subdiscoidal to subglobular conch, with very narrow to closed umbilicus. Prongs of ventral lobe wider than lateral lobe. Denticulation of external lobes limited in lobe-base and lower part of flanks, never reaches to saddles.

Occurrence.—Kasimovian through Kungurian; Russia and Kazakhstan (South Urals), Tajikistan (Pamirs), USA (Kansas, Nevada, New Mexico, Oklahoma, Texas), Canada (Yukon Territory), Indonesia (Timor), and South China (Guangxi).

Remarks.—*Prothalassoceras* is characterized by wider prongs of the ventral lobe and a narrower lateral lobe, whereas *Eothalassoceras* and *Thalassoceras* are characterized by a narrower prong and wider lateral lobe. Additionally, dentition in *Eothalassoceras* is more primitive and restricted only in the lobe base, whereas in *Thalassoceras* dentition is much stronger and extensively distributed in both lobe base and flanks, even reaching to the saddle. *Prothalassoceras* resembles *Aristoceras* in both conch shape and suture, but differs from the latter by lacking ventrolateral groves.

Prothalassoceras biforme (Gerasimov, 1937)
Figures 54.3–54.6, 55.3, 55.4

1937 *Thalassoceras biforme* Gerasimov, p. 17, pl. 1, fig. 8.
1938 *Prothalassoceras biforme*; Ruzhentsev, p. 253, pl. 3, figs. 6–8.
1948 *Prothalassoceras biforme* var. *latilobata* Maximova, p. 25, pl. 3, figs. 3, 4, 15.

Description.—Shell thickly discoidal and involute, with small umbilicus. Whorl-section nearly ellipsoidal in form, with strong depression in dorsum. Ornament unknown. Ventral lobe subdivided by a high, narrow secondary saddle. Prong much broader than lateral lobe. Secondary saddle and first lateral

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saddle nearly equal in both height and width. Secondary lateral saddle lower, broader, and rounded. Denticulation of lobes restricted in base of lobes and asymmetric in both prongs. Umbilical lobe unknown.

Materials.—Two specimens, NIGP 93741 and 93742.

Occurrence.—Bed 26, 3rd Member, Nandan Formation, Meyao section (Sec. V), Liuzhai, Nandan County, Guangxi.

Remarks.—Specimens here resemble the holotype of the species in general characters of external suture (e.g., high ventral secondary saddle and similar width of lobes and saddles). However, the conch shape of the Urals specimens looks thinner than those of the present specimens (e.g., W/D 0.45 at conch diameter 26.8 mm in holotype 472/118 versus 0.58 at conch diameter 12.9 mm in NIGP 93741). Even if the difference really is present, it presumably is the result of ontogenetic development. The present specimens are actually similar to the Sakmarian *P. umbilicatum* Ruzhentsev, 1952 from Urals in general features of the suture; however, their thinner conch shape and narrower ventrolateral saddle are quite distinctive.

Order Ceratitida Hyatt, 1900?
Suborder Otoceratitina Hyatt, 1900?
Superfamily Otoceratoidea Hyatt, 1900
Family Araxoceratidae Ruzhentsev, 1959

Genus *Eoaraxoceras* Spinosa, Furnish, and Glenister, 1970

1944 *Kingoceras* Miller, p. 125 (part).

Type species.—*Eoaraxoceras ruzhentsevi* Spinosa, Furnish, and Glenister, 1970; original designation; upper La Colorada beds (Capitanian/Wuchiapingian), the Valle de Las Delicias, Coahuila, Mexico.

Diagnosis.—Conch moderately to strongly evolute with anglar venter and pronounced umbilical flange. Suture has ten basic lobes, primitively serrated at base of first two external “lateral lobes.” Ventral and dorsal lobes bifid; a complex of incipient lobules crosses umbilical area.

Occurrence.—Capitanian (e.g., the equivalent Wuchiapingian); Mexico (Coahuila), South China (southwest Guizhou), and possibly Iran (Abadeh).

Remarks.—The definition of *Eoaraxoceras* was summarized once again by two of the original authors since it was first published by Spinosa, Furnish, and Glenister in 1970: “Ancestral araxoceratins with strongly evolute conch (U/D ranges from 0.2 to 0.45 at D 25–35 mm), broadly acuminate venter and pronounced umbilical flange. Sutures of mature and submature specimens comprise ten lobes; lobes serrate, except dorsal and ventral elements bifid” (Spinosa and Glenister, 2000, p. 400). However, it is important to emphasize that the primitive property of the sutural serration might even persist until the conch diameter is as large as 23 mm (holotype, SUI 32895) (Spinosa et al., 1970).

According to the characterization mentioned above, there probably are only two species could be accepted as *Eoaraxoceras*, sensu stricto: the type species, *E. ruzhentsevi* Spinosa et al., 1970 and *E. spinosai* n. sp., herein. The former was collected from the type locality, Coahuila, Mexico, and from Abadeh, Iran (the hypotype GSI 69 T 123, but not GSI 69 T 127; Spinosa and Glenister, 2000), while the latter is from the upper Shaiwa Formation, southwest Guizhou. As for the third one, *E. robusta* Spinosa and Glenister, 2000 from Abadeh, Iran, it is actually a questionable designation because of the indistinct or simply absent flange along the umbilical shoulder on the holotype GSI 69 T 120, and possibly on specimens GSI Ab-72174 and Ab-72158 (Bando, 1979, pl. 2, figs. 3a, b, 6a, b).

Eoaraxoceras spinosai new species
Figures 56.1–56.10, 57.1–57.4

Diagnosis.—*Eoaraxoceras* with relatively smaller umbilicus and stronger serration in lobe base.

Description.—Conch diameter 20–25 mm, with fairly open umbilicus, U/D approximately 0.3 or a bit less. Conch flanks subparalell but concave, ventrolateral shoulder somewhat prominent, venter tectiform, umbilical shoulder conspicuously flanged; prorsiradiate rib-shaped nodes well developed in inner volutions, growth lines apparent in out volutions. Sutures possess a pair of narrow underrate prongs in venter, two intervening lobes with simple serration in flank, and three to five incipient elements developed on umbilical wall.

Etymology.—Named in honor of Professor Claude Spinosa, Boise State University, USA.

Materials.—10 specimens, including nine laterally compressed molds (NIGP 139945–139953) and one ventral mold (NIGP 139954), of which NIGP 139953 is assigned as holotype.

Occurrence.—Bed 23, Claystone (3rd) Member, Shaiwa Formation, Sidazhai section (Sec. IV’-IV”), Ziyun County, Guizhou.

Remarks.—*Eoaraxoceras spinosai* n. sp. resembles the type species of the genus in conch shape, sculpture, and general shape of suture, but differs from the latter by its smaller conch size, obviously smaller umbilicus, and stronger serration in lobes L and I.

Suborder Paraceltitina Shevyrev, 1968
Superfamily Xenodiscoidea Frech, 1902
Family Xenodiscidae Frech, 1902

Genus *Xenodiscus* Waagen, 1879

1895 *Xenaspis* Waagen, p. 161.
1903 *Proceratites* Kittle, p. 28.
1940a *Xenodiscites* Miller and Furnish, p. 74.

Type species.—*Ceratites carbonarius* Waagen, 1872 (*Xenodiscus plicatus* Waagen, 1879, subjective synonym, by Spinosa et al., 1975), subsequent designation by Waagen, 1895; Chhidru Formation, latest Permian, Salt Range, Pakistan.

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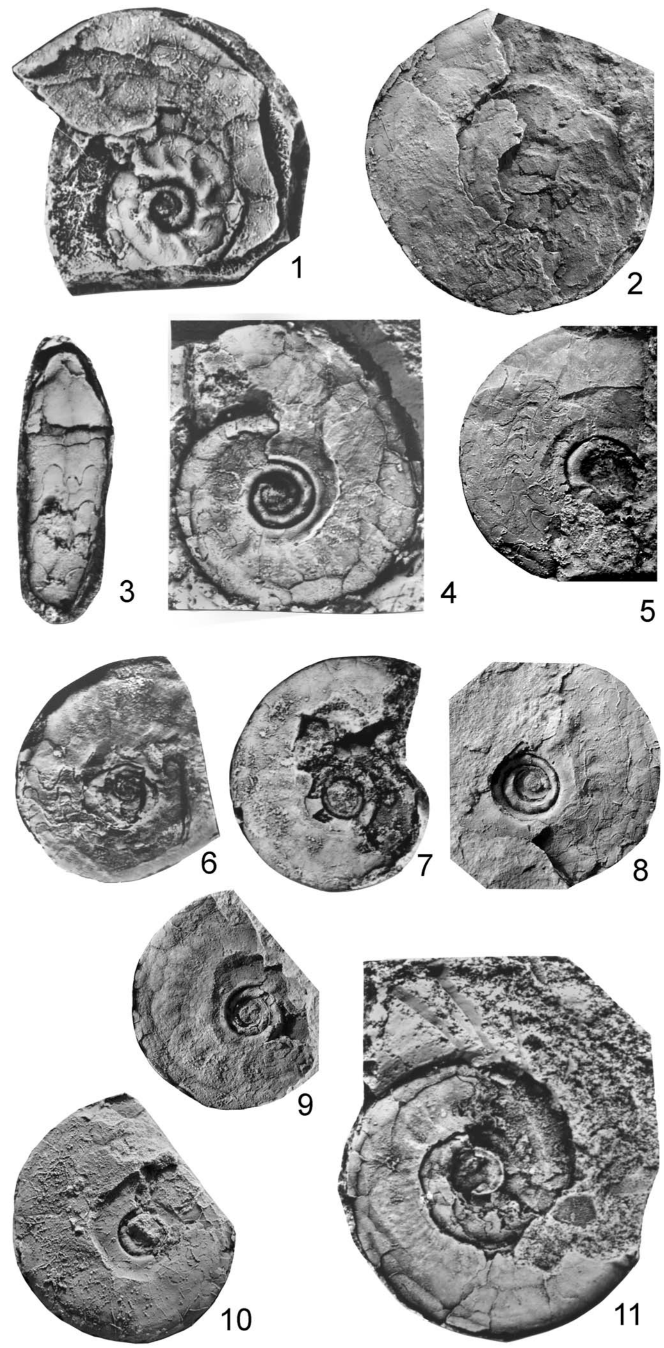

Figure 56. Ceratitids, Bed 23, Claystone (3rd) Member, Shaiwa Formation of Sidazhai section (Sec. IV'-IV"), Ziyun County, Guizhou. (**1–10**) *Eoaraxoceras spinosai* n. sp., all lateral views (except **3**): (**1**) NIGP 139950, ×3; (**2**) NIGP 139945, ×2; (**3**) ventral view, NIGP 139954, ×3; (**4**) NIGP 139953, holotype, ×2; (**5**) NIGP 139951, ×3; (**6**) NIGP 139946, ×2; (**7**) NIGP 139947, ×2; (**8, 9**) NIGP 139948 and NIGP 139949 in the same example, all ×2; (**10**) NIGP 139952, ×2. (**11**) ?*Xenodiscus* sp. NIGP 139955, lateral view, ×2.

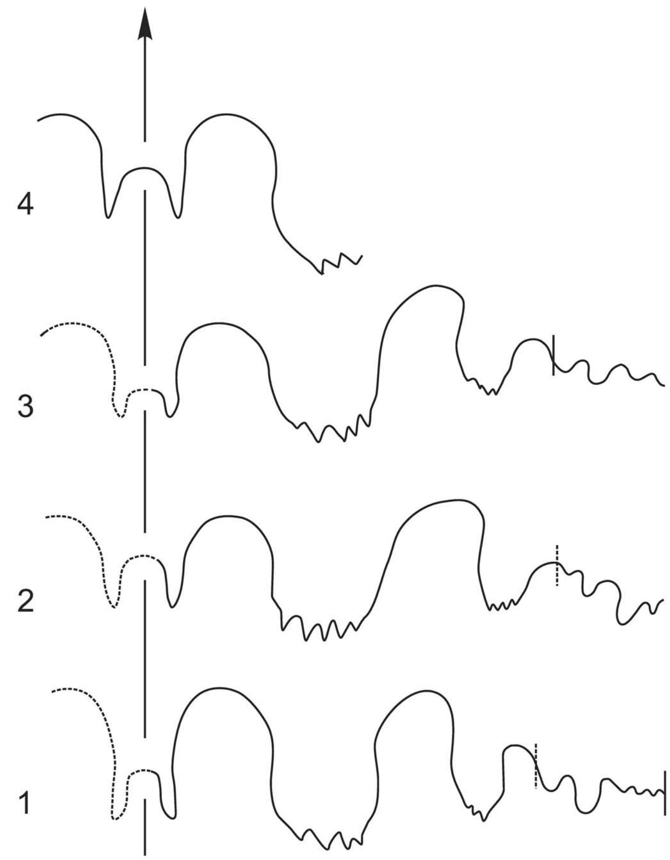

Figure 57. External sutures of *Eoaraxoceras spinosai* n. sp., Bed 23, Claystone (3rd) Member, Shaiwa Formation of Sidazhai section (Sec. IV'-IV"), Ziyun County, Guizhou. (**1**) NIGP 139953, holotype, D 14 mm; (**2**) NIGP 139951, D 16 mm; (**3**) NIGP 139948, D 17 mm; (**4**) NIGP 139954, D approximately 17 mm.

Diagnosis.—Conch subdiscoidal and evolute. Whorls flattened laterally, slightly depressed dorsally, and rounded or slightly flattened ventrally. No prominent ornamentation on conch. Suture forms broad bifid ventral lobe, two pairs of lateral lobes, a pair of small lobes near umbilical seam, and a narrow bifid dorsal lobe. Lateral lobes and prolongs of lateral lobe denticulate, but denticules confined to base of lobes.

Occurrence.—Capitanian/Wuchiapingian through Changhsingian/Chhidruan; Indonesia (Timor), Mexico (Coahuila), Pakistan (Salt Range), India (Himalayas), Madagascar, New Zealand, Japan (Kitakami), Central and Northwest Iran, Azerbaijan (Caucasus), North Thailand, and China (Xizang, Sichuan, Guangxi, and Guizhou).

Remarks.—*Xenodiscus*, paraceltitins with a serrated lobe base, while absent the flange around umbilical shoulder, represent eurytopic forms of the Late Permian with a broad distribution.

?*Xenodiscus* sp.
Figure 56.11

Description.—Only a single specimen, discoidal, rather evolution, W/D ~0.38. Suture with only a serrated lateral lobe preserved.

Materials.—A compressed specimen, NIGP 139955.

Occurrence.—Bed 23, Claystone (3rd) Member, Shaiwa Formation of Sidazhai section, Ziyun County, Guizhou.

Remarks.—The present specimen with a wider umbilicus and more advanced evolution is easily distinguished from other

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ceratitid specimens studied herein. Inadequate knowledge of the sutural details and conch shape prevent precise identification of the specimen.

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Appendix 1

Shaiwa-Shidazhai General Section

Figures 1.3.B, 3–6, 9

General section (Sec. IV-IV") measured in Area B, Yangchang-Sidazhai District, ~20 km southeast of the county-city of Ziyun County in southwest Guizhou. The general section consists of two independent parts: the Shaiwa Section (Sec. IV-VI') (Fig. 4), measuring the Sidazhai Formation; and the Sidazhai Section (Sec. IV'-IV") (Fig. 5), measuring the Shaiwa Formation. Both parts constitute a successively integrated Permian sequence, representing the interval from the Artinskian through the Changhsingian, which is conformably overlain by the Lower Triassic Lulou Formation with ammonoid *Ophiceras* sp. and bivalve *Claraia* sp.

Measurement was carried out in different programs of the Regional Geological Survey Academy of Guizhou in 1982 and 1996, respectively. Present author was invited to join in the programs.

The sections are described below in descending order:

Sidazhai Section (IV'-IV")

Section starts from north side of Sidazhai Town and ends near Cuojiwan Village. Coordinates here based on Google Maps: origin ~25.5864°N, 106.1651°E, ending ~25.5990°N, 106.1459°E (Figs. 5, 6, 9). Section line is relatively parallel with the strata strike, with were four parallel shifts of ~500 m distance during measuring.

Overlying Lower Triassic Luolou Formation:

Dark-gray, thin-bedded "starved" pelagic limestone and shale, representing relatively deep-marine sediments, yielded a few ammonoids, *Ophiceras* sp., and bivalves, *Claraia* sp.

—Conformation—

Shaiwa Formation: **863 m**

Calcirudite (4th) Member: *205 m*

40. Grayish black, radiolarian-bearing cryptocrystalline siliceous rock, intercalating a few thin-bedded claystone units — 15 m
39–38. Dark-gray to gray biocalcirudite with micrite gravel — 15 m
37–36. Dark-gray, medium-bedded, fine-grained sandstone and siltite, intercalating claystone in the upper part, and grayish-black siliceous rock occasionally intercalating claystone in the lower part — 22 m
35–34. Dark-gray, medium- to thin-bedded claystone in upper 4 m; cyclothemic sandstone, claystone, and siliceous rock elsewhere; KTP5-35: Ammonoid fragments medlicotticottids and ?*Pseudogastrioceras* — 81 m
33. Dark-gray, thin-bedded, silt-bearing claystone, with occasional intercalations of siliceous rock — 42 m
32. Dark-gray massive calcirudite, intraclasts composed of micrite, bioclastic limestone, and calcarenite — 30 m

Claystone (3rd) Member: *122 m*

31–30. Dark-gray, massive siltite with feldspathic and volcanic basaltic debris, intercalating claystone in upper part; thick-bedded litharenite at the lower 5 m;. KTP5-31: *Stacheoceras shaiwaense* n. sp. (NIGP 139934 and 139940), *Difuntites furnishi* n. sp. (NIGP 139933) — 36 m
29–28. Gray, thin-bedded siltite; intercalating limestone lens, dark-gray micrite with sponge spicules, and dark-gray, medium- to thick bedded bioclastic silicious marlstone — 24 m
27–26. Dark-gray, thin-bedded siliceous claystone in upper part, intercalating thin-bedded siliceous rock occasionally; lower part mainly gray, thick-bedded biosilty siliceous rock; KTP5-26: *Difuntites furnish* n. sp. (NIGP 139932) — 24 m
25. Dark-gray, medium- to thick-bedded micrite; ammonoid fragments: *Eumedlicottia* sp.; Fusulinids: *Reichelinia* sp. — 6 m
24–23. Dark-gray, medium- to thick-bedded, massive siltite, intercalating dark-gray, thin-bedded claystone; KTP5-23: *Epadrianites involutus* (Haniel, 1915) (NIGP 139941–139944), *Stacheoceras shaiwaense* n. sp. (NIGP 139935–139939), ?*Timorites* sp. (NIGP 154112), *Difuntites furnishi* n. sp. (NIGP 139931), ?*Xenodiscus* sp. (NIGP 139955), *Eoaraxoceras spinosai* n. sp. (NIGP 139945–139954) — 32 m

Sandstone (2nd) Member: *423 m*

22. Gray, massive, fine-grained feldspathic litharenite — 28 m
21. Dark-gray, massive siltite with fine-grained feldspathic detritus, intercalating dark-gray, thin-bedded claystone — 43 m
20. Four cyclothems, consisting of dark-gray, thick-bedded, fine-grained arkosic detritus with laminated structures below, and fine-grained to silty arkosic detritus above — 34 m

19. Two cyclothems, each consisting of three components (in ascending order): (1) gray, thick-bedded, pebble-bearing feldspathic siltite; (2) gray, massive feldspathic siltite; and (3) dark-gray, thin-bedded claystone; silt mainly consists of feldspathic detritus and a small amount of volcanic basaltic debris 54 m
18. Dark-gray, medium-bedded biodetritus-bearing cryptocrystal siliceous rock intercalating dark-gray, thin-bedded claystone 26 m
17. Several cyclothems, each one includes three components (in ascending order): (1) dark-gray, thick-bedded bioclastic calcareous conglomerate; (2) dark-gray, medium- to thick-bedded bioclastic calcarenite; and (3) dark-gray argillaceous and silicious bioclastic limestone; KTP5-17: ammonoid fragments with regular longitudinal lirae, probably representing individuals of *Pseudogastrioceras* 17 m
16. Dark-gray, medium-bedded, bioclastic, calcareous siliceous rock, with parallel bedding throughout 21 m
15–14. Multiple cyclothems, each consisting of an incomplete Bouma sequence: A—dark-gray conglomerate, subangular gravel, consisting of mudstone and sandstone; B—dark-gray, medium- and thin-bedded, bioclastic, feldspathic arenite, with parallel bedding; D—dark-gray, medium- and thin-bedded, bioclastic micrite, with parallel bedding; E—dark-gray claystone, with vague lamina. Dark-gray, medium- and thick-bedded feldspar-bearing arenite with intercalating dark-gray, thin-bedded claystone in the lower 3 m 19 m
13. Dark-gray, medium-bedded to massive siltites to sandstone, intercalating silty claystone; debris mainly is of eruptive basaltic rock detritus 16 m
12. Lower part consists of interbedded medium- to thick-bedded siltite or fine-grained sandstone and thin-bedded claystone, debris consisting of eruptive basaltic rock detritus; middle part consists of gray, medium- to thick-bedded, fine-grained feldspathic arenite; upper part consists of rhythmite between dark-gray, medium- to thin-bedded, fine-grained sandstone and thin-bedded claystone; KTP5-12: ammonoid fragments with well-preserved ammonoid paraceltitin-shape and ridged venter, probably representing *Cibolites* 41 m
11. Cyclothems consisting of three layers (in ascending order): (1) dark-gray psephitic to legume-like claypan with uneven erosion surface, (2) feldspathic-debris-bearing siltite, and (3) greenish-gray silicious claystone 43m
10–9. Dark-gray, medium- to thin-bedded sponge spicule-bearing siliceous rock intercalating dark-gray claystone; dark-gray bed of medium- and thick-bedded bioclastic and dolomitic micrite in the lower 1.5 m 13 m
8. Dark-gray, medium-bedded silty to fine-grained feldspathic arenite, debris mainy consists of basaltic rock and feldspar 18 m
7. Grayish-black, medium- and thin-bedded cryptocrystal siliceous rock, partly intercalating claystone 13 m
6–5. Gray-green rudaceous siltite; rudaceous sandstone in the lower 5 m 47 m

Siliceous (1st) Member: *112 m*

4–2. Grayish-black, medium- to thin-bedded sponge spicule-bearing siliceous rock; dark-gray claystone with parallel bedding in middle 11 m 89 m
1. Dark-gray claystone, parallel bedding; grayish-black, medium- and thin-bedded siliceous rock in lower 6 m; KTP5-1, in upper 22 m (equal to Bed 29 of Shaiwa Section; Sec. IV-IV') *Waagenoceras* sp. (NIGP 93715); ammonoid fragments: adrianitids, medlicottiids, ? *Paraceltites* sp. 23 m

—Conformation—

Underlying: Sidazhai Formation

Chongtou Member:

Dark-gray, medium- to thick-bedded, gravel-bearing micrite, intercalating grayish-black thin-bedded siliceous rock

Shaiwa Section (Sec. IV-IV')

Section encompases the basinal Sidazhai Formation, stretching from Gaijiao to Chongtou Villages, with Artinskian through lower Wordian deposits (Figs. 4, 6, 9). The coordinates based on Google Maps: origin ~25.6065°N, 106.1577°E, ending ~25.6090°N, 106.1506°E. Section description is based on Xiao et al. (1986); fusulinids were identified by Zhang L.-X. and Dong W.-L.

Overlying Shaiwa Formation:

Dark-gray, thin-bedded siliceous rock, Wordian age with primitive *Waagenoceras* sp. (NIGP 93715) in Bed 29, ~22 m above base of Shaiwa Formation

—Conformation—

Sidazhai Formation: **345 m**

Chongtou Member: *200 m*

27–26. Dark-gray, medium- to thin-bedded calcarenite, micrite debris with Bouma sequence, a few intercalations of thin-bedded siliceous rock; fusulinids: *Metadoliolina lepida* (Schwager), *Neoschwagerina* sp., *Reichelina* sp., *Kahlerina sinensis* Sheng, *Codonofusiella* sp., and *Verbeekina* sp. 25 m
25–23. Gray, medium- to thick-bedded, calcarenite, micrite debris with Bouma sequence, interbedded with thin-bedded siliceous rock; fusulinids: *Yabeina gubleri* Kanmera, *Metadoliolina* sp., *Neoschwagerina kueichowensis* Sheng, *Sumatrina* sp., *Verbeekina* cf. *V. verbeeki* (Geinitz), *Chusenella ishanensis* Hsu, and *Schwagerina* sp. 31 m

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22–21. Gray, massive, medium-grained dolomite, many chert bands, with a layer of dolomitized limestone breccia in upper 5 m; fusulinids: *Afghanella* sp., *Parafusulina yabei* Hanzawa, *Verbeekina* sp., *Pseudodolialina chinghaiensis* Sheng, and *Sumatrina* sp. — 31 m

20–19. Light-gray to gray, thick-bedded biosparcalcarenite, partially dolomitized, with chert concretion; fusulinids: *Afghanella* sp., *Neoschwagerina craticulifera* (Schwager), *N. haydeni* Dunbar and Skinner, *Sumatrina* sp., *Praesumatrina* sp., *Verbeekina* sp., *Pseudodoliolina chinghaiensis* Sheng, *Parafusulina* cf. *P. boesei* Dunbar and Skinner, *P. splendens* Dunbar and Skinner, *Yangchienia haydeni* Thompson, *Y. iniqua* Lee, *Y. compressa* (Ozawa), and *Russiella* sp. — 15 m

18–17. Dark-gray, medium-bedded micrite with intercalating thick-bedded micrite, locally bearing pebbles; fusulinids: *Neoschwagerina* cf. *N. simplex* Ozawa, *Praesumatrina kwangsiana* Sheng, *Minojapanella wutuensis* (Kuo); ammonoid: *Agathiceras* sp. — 10 m

16–15. Calcirudite, ~4 m on the top, *Afghanella* sp.; dark-gray to gray, medium- to thick-bedded spar to micrite and silty calcarenite, intercalated with a few marlstones and thin-bedded siliceous rocks — 10 m

14–13. Grayish-black, thin-bedded radiolarian siliceous rock interbedded with a few dark-gray, medium- and thick-bedded micrite and calcarenite units, along with a few shale beds; fusulinids: *Misellina* sp., *Parafusulina* sp., *Pseudofusulina* sp., and *Yangchienia* sp. — 26 m

12. Gray medium- to thin-bedded micrite to silty calcarenite, occasionally intercalating thin-bedded siliceous rock with shale, ammonoid-bearing lens ~45 cm in the upper part; ammonoids: *Parapronorites timorensis* Haniel (NIGP 93654–93656), *Prostacheoceras* sp. (NIGP 93717), *Glenisteroceras sidazhaiense* n. gen. n. sp. (NIGP 93728, 93729), *Neocrimites guizhouensis* n. sp. (NIGP 93711, 93712), *Fusicrimites nanpanjiangensis* n. gen. n. sp. (NIGP 93713), *Agathiceras mediterraneum* Tumanskaia, 1949 (NIGP 93704–93707), *Metaperrinites shaiwaensis* n. sp. (NIGP 93714), and *Popanoceras ziyunense* n. sp. (93734–93738) — 10 m

11. Gray to dark-gray, medium- to thick-bedded biodebris-bearing micrite, occasionally intercalating dark-gray, thin-bedded siliceous rock and shale, a 50 cm thick fusulinid-bearing calcarenite lens near the bottom; fusulinids: *Misellina claudiae* (Deprat), *Parafusulina splendens* Dunbar and Skinner, *Nankinella* sp., and *Laxifusulina neimongolensis* (Han) — 10 m

10–8. Dark-gray, medium- to thin-bedded limestone and grayish-black laminated siliceous rock, interbedded with euxinic shale, bearing ammonoid fragments — 32 m

—Conformation—

Gaijiao Member: 145 m

7. Dark- and grayish-green claystone, intercalated with a few grayish-white, light-yellow tuffaceous claystones, yielding ammonoid fragments — 30 m

6–5. Light-gray, brownish-yellow claystone, with intercalated marlstone; ammonoids collected from upper part of Bed 6: *Parapronorites* cf. *P. rectus* Leonova, 1989 (NIGP 93658, 93659), *Propinacoceras toumanskayae* Leonova, 1989 (NIGP 93672, 93673), and *Bamyaniceras knight* (Miller and Furnish, 1940) (NIGP 93668–93671) — 40 m

4. Grayish-black, thick-bedded, carbon-bearing micrite interbedded with calcareous-organic claystone, 30 cm thick, gray biomicritic calcarenite at bottom of bed with fusulinids: *Robustoschwagerina* aff. *schellwieni* (Hanzawa), *Pamirina* sp., *Toriyamaia* sp., *Parafusulina* sp., and *Pseudofusulina* sp. — 26 m

3. Grayish-brown, intercalating with black calcareous claystone, occasionally containing marlstone lenses — 27 m

2. Dark-gray medium- to thick-bedded biodebris-bearing marlstone; fusulinids: *Pamirina* cf. *P. darvasica* Leven, *P.* aff. *pulchra* (Wang and Sun), *Sphaerulina* sp., *Eoparafusulina* sp., and *Rugosofusulina* sp.; coral: *Lansdaleiastraea* sp. — 13 m

1. Grayish-black, calcareous, organic claystone; one meter of micritic calcirudite at base; fusulinids: *Pamirina* sp., *Pseudofusulina kueichowensis* Sheng, *P. kraffti* Toriyama, *Eoparafusulina* sp. (equal to the ammonoid-bearing Longma Member in Liuzhai area, Nandan County, Guangxi) — 9 m

—Conformation—

Underlying Nandan Formation (Zisongian, Asselian–Sakmarian):

Dark-gray, thick-bedded bioclastic micrite; fusulinids: *Sphaeroschwagerina* sp., *Pseudoschwagerina* sp., etc.

Appendix 2

Meyao Section (Sec. V)

Figures 1.3.D, 7–9

The Meyao section, located in Area D, Liuzhai District, Nandan County, Guangxi, 2.6 km southwest of town-center of Liuzhai, was measured by Huang Z.-X., Regional Geological Survey Academy of Guangxi, and the present author in 1986 (published in Kuang et al., 1999). The coordinates based on Google Maps: origin ~25.2781°N, 107.3887°E, ending ~25.2755°N, 107.3931°E. Ammonoids and fusulinids were identified by the present author. Conodonts were identified by Wang C.-Y. in the 1980s.

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Section primarily consists of carbonate deposits, including calcirudite, calcarenite with medium- to fine-grained biodetritus, micrite, and dolomite, occasionally intercalating with thin-bedded siliceous rock. Top of the section mainly consists of ammonoid-bearing mudstone. The Asselian through Artinskian pandemic ammonoid sequence in this section defines the lower Permian (Cisuralian Series) in South China.

Sidazhai Formation:

Longma Member:

31. Gray, thin-bedded mudstone and silty mudstone, with interbedded bioclastic limestone and micrite, parallel-bedded to bottom of Member; Collection **7085**: *Popanoceras kueichowense* (Zhao, 1974) (NIGP 154092, 154094, 154094-1) and many ammonoid fragments — 69 m

—Conformation—

Nandan Formation:

Third (3rd) Member: — *189 m*

30. Dark-gray, medium- to thin-bedded micrite, intercalating with thin-bedded silicious rock, with a layer of bioclastic limestone at the bottom, parallel bedding well developed; fusulinids: *Triticites* spp., and *Staffella* sp. — 8 m
29. Covered — 27 m
28. Gray bioclastic limestone, thick bedded above, thin bedded below; fusulinid: *Schwagerina* sp. — 19 m
27. Dark-gray, medium- to thin-bedded micrite, intercalated with thin-bedded siliceous units. — 40 m
26. Dark-gray, thick-bedded bioclastic limestone, biocalcirudite; detritus, up to >10–15 cm diameter, consisting of bioclastic limestone and micrite; fusulinids: *Robustoschwagerina* sp., *Schwagerina* spp., *Rugosofusulina* sp., *Pseudoschwagerina* sp., *Sphaeroschwagerina* sp., and *Quasifusulina* sp.; ammonoid collection **7084**: *Neopronorites leonovae* n. sp. (NIGP 88969); *Metapronorites timorensis* (Haniel, 1915) (NIGP 88663, 88664, 88966); *Agathiceras sequaxilirae* n. sp. (NIGP 88987, 88988); *Svetlanoceras uraloceraformis* n. sp. (NIGP 154088–154090); *Prothalassoceras biforme* (Gerassimov, 1937) (NIGP 93741, 93742) — 21 m
25. Dark-gray, medium- to thin-bedded micrite, intercalated thin-bedded chert — 18 m
24. Covered — 12 m
23. Dark-gray, medium- to thin-bedded micrite, lower part dark-gray argillaceous limestone, intercalated with siliceous rock — 36 m
22. Light-gray, thick-bedded bioclastic breccia, consisting of light-colored bioclastic limestone and a few gray-black micrite units; bottom surface uneven, might truncate the underlying surface; intercalated thin-bedded siliceous rock in upper part yielding fusulinids *Robustoschwagerina* sp. and *Pseudoschwagerina* sp. — 13 m

—Slight unconformation—

Second (2nd) Member: — *59 m*

21. Dark-gray, medium- to thin-bedded micrite, intercalating chert bands — 13 m
20. Dark-gray, medium- to thin-bedded micrite, intercalating biocalcrudite and siliceous rock bands; fusulinids: *Pseudofusulina* sp., *Rugosofusiella* sp., and *Qusifusulina* sp.; conodonts: *Streptognathodus elongatus* (Gannell, 1933) — 35 m
19. Gray bioclastic limestone; ammonoid collection **7082**: *Metapronorites timorensis* (Haniel, 1915) (NIGP 88965); *Artinskia nalivkini* Ruzhencev, 1938 (NIGP 88975–88977); *Synartinskia meyaoense* n. sp. (NIGP 88978, 88979); *Agathiceras sequaxilirae* n. sp. (NIGP 88983, 88985, 88986); *Neopronorites leonovae* n. sp. (NIGP 88967, 88968, 88970); *Emilites globosus* n. sp. (NIGP 88989–88996, 88998); *Properrinites gianta* n. sp. (NIGP 89002–89004); *Eoasianites subhanieli* Ruzhencev, 1933 (NIGP 88999–89001); *Almites multisulcatus* Bogoslovskaya, 1978 (NIGP 89009–89011, 89014); *Prostacheoceras juresanense* (Maximova, 1935) (NIGP 89006, 89007); *Svetlanoceras serpentinum* (Maximova, 1948) (NIGP 154081–154087); associated fusulinids include *Pseudoschwagerina* sp. and *Quasifusulina* sp. — 11 m

—Conformation—

First (1st) Member: Pennsylvanian (upper Carboniferous) — **>31 m**

18. Dark-gray, medium- to thin-bedded micrite, with intercalating thin layer of siliceous rock, layer of bioclastic limestone at bottom of interval; fusulinids: *Triticites* sp., and *Staffella* sp. — 13 m
17. Dark-gray, medium- to thin-bedded micrite, bioclastic limestone near bottom; fusulinids: *Triticites* spp.; conodonts: *Streptognathodus elongatus* Gurrell, 1933, *S. elegantulus* Stauffer and Plummer, 1932; ammonoids: *Agathiceras* sp. — 18 m

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