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PALAEOWORLD online submission:

<http://ees.elsevier.com/palwor/>

PALAEOWORLD full-text (Volume 15 – ) available at:

<http://www.sciencedirect.com/science/journal/1871174X>

## **ROUTE 3: PAIBI, HUNAN PROVINCE (3a); HUANGLIAN, GUIZHOU PROVINCE (3b)**

# **CAMBRIAN STRATIGRAPHY AT PAIBI, HUNAN PROVINCE, CHINA: CANDIDATE SECTION FOR A GLOBAL UNNAMED SERIES AND REFERENCE SECTION FOR THE WAERGANGIAN STAGE**

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## **INTRODUCTION**

Two sections, one exposing the upper Aoxi and Huaqiao formations, and the other exposing the upper Huaqiao Formation through the Lower Ordovician, are present in the vicinity of the village of Paibi, Huayuan County, Hunan Province (Figs. 1, 3). The two sections are on the same limb of a syncline and are separated by a large valley. The two sections are here referred to as the Paibi section, which exposes the lower stratigraphic interval, and the Paibi-2 section, which exposes the upper stratigraphic interval. Some stratigraphic overlap occurs between the upper part of the Paibi section and the lower part of the Paibi-2 section. The uppermost of the Huaqiao Formation through the overlying Zhuitun (or Loushankuan) Formation (latest Cambrian-early Tremadocian age) of the section will not be examined at this locality.

The Paibi section was proposed as a candidate boundary-stratotype (GSSP) for the base of an Upper Cambrian series if the series boundary level chosen is the first appearance of the cosmopolitan agnostoid trilobite *Glyptagnostus reticulatus* (Peng and Robison, 2000). The Paibi section is on the north side of the Jishou-Huayuan highway near the town of Paibi, some 28 km south of Huayuan (Fig. 1). The section was first measured by Chen and members of his brigade during mapping for the 1:50,000 geological sheet of the Paibi area. Between 1984 and 1997, we and others have made extensive collections through the section. In addition to trilobites (e.g., Dong, 1990, 1991; Peng and Robison, 2000), the section contains a rather rich conodont fauna, which has been detailed by Dong (1990, 1991).

The Paibi section is situated along the northwest limb of the Liexi-Zhuitun Syncline (see Fig.

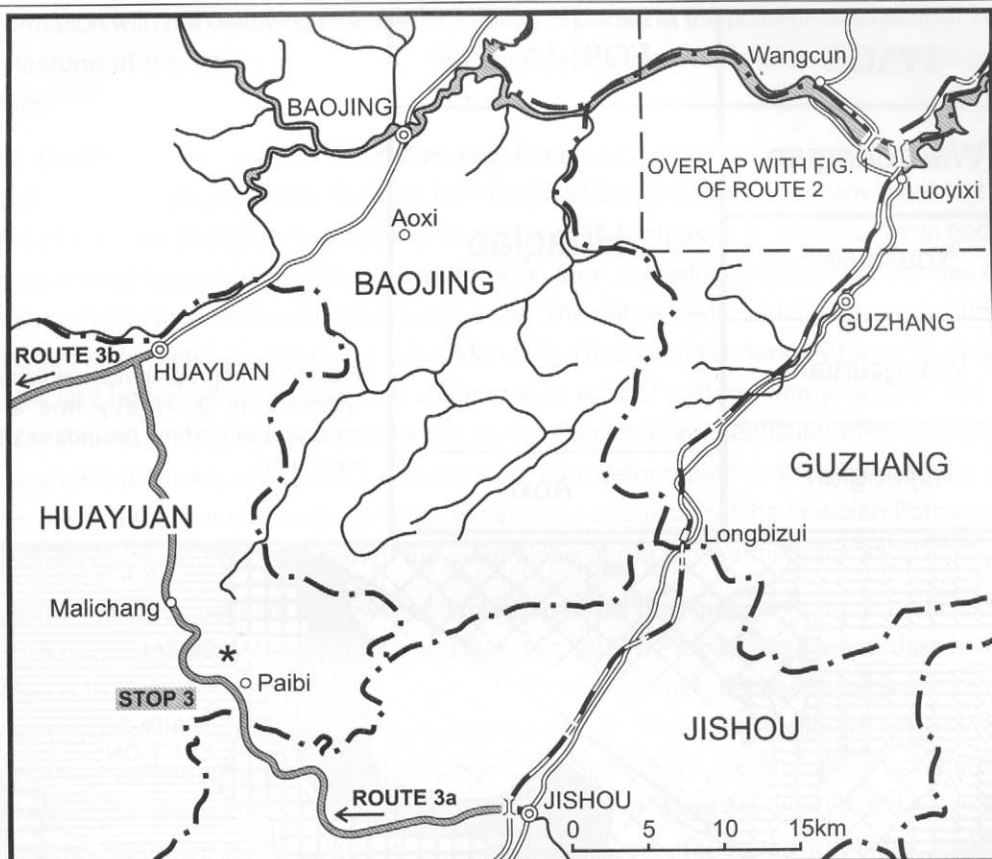


Fig. 1. Map showing location of the Paibi section, and the route (shaded) to the section from Jishou, Hunan Province, China.

3 of Route 2). Paleogeographically, the section was evidently located closer to the margin of the Yangtze Platform than was the Wangcun section, which today is located on the southeast limb of the same syncline.

The Paibi section is reached by a 35 km drive northwest from Jishou along the Chinese National Highway 319 to the Sixin Village; from this point, continued driving eastward along the highway about 0.5 km brings you to an outcrop of dolostone that represents the upper part of the Aoxi Formation on the right (north) side of the highway. This outcrop of dolostone is the base of the Paibi section. The Huaqiao Formation is exposed through most of the adjacent areas of the roadcut and sporadically in the neighboring hills.

### Stop 1

#### Aoxi Formation and lower Huaqiao Formation (*Ptychagnostus atavus* Zone through *Linguagnostus reconditus* Zone)

Lithologically, the uppermost part of the Aoxi Formation is similar to the lithology of the same formation in the Wangcun section. The Aoxi Formation includes mostly dolostone and dolomitic limestone, interbedded with some black shale beds. The gradational contact of the

STAGE	FORMATION
Waergangian	Huaqiao
Youshuian	
Wangcunian	
Taijiangian	Aoxi

Fig. 2. Stratigraphic nomenclature for Stops 1 to 3. Heavy line shows chronostratigraphic boundaries to be examined.

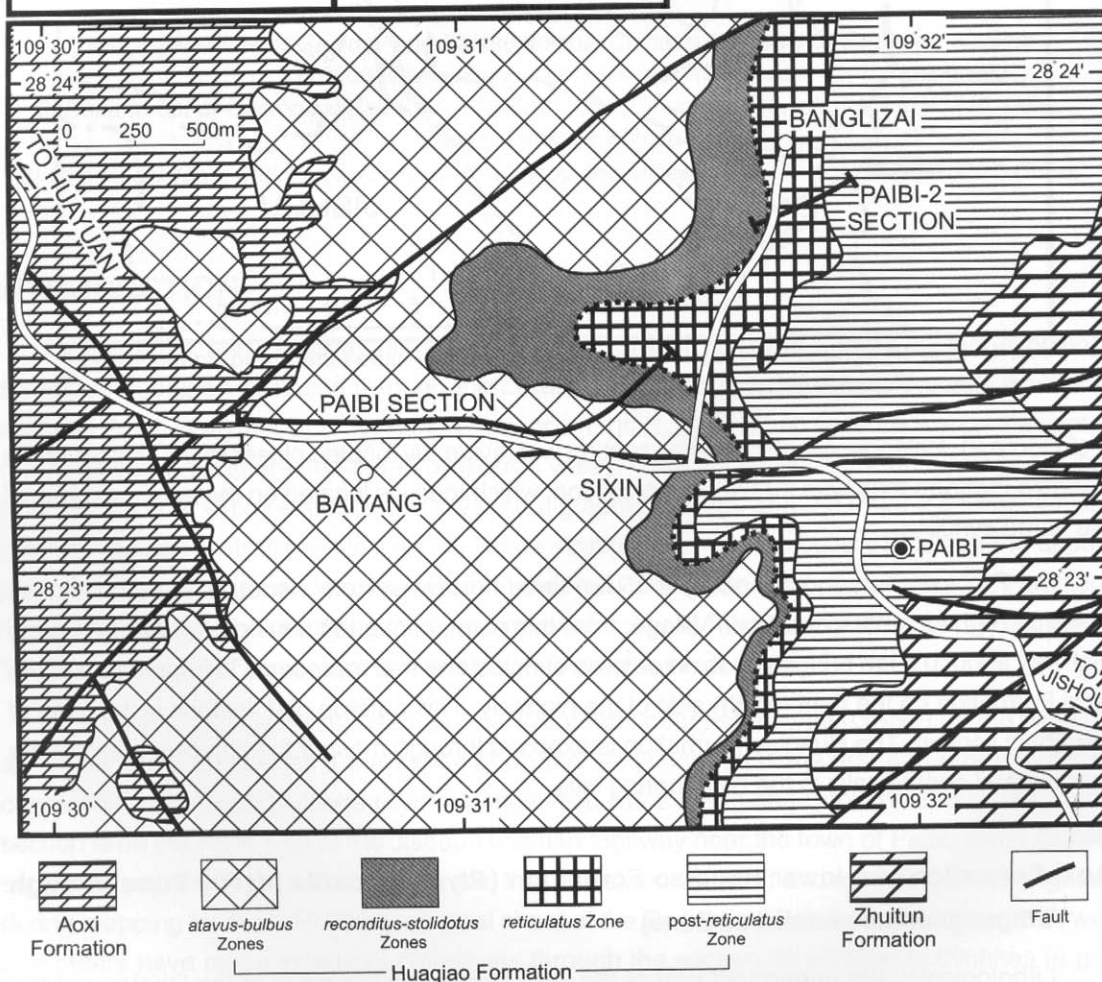


Fig. 3. Map showing the outcrop belt of the Aoxi and Huaqiao formations in the Paibi area, and the location of the Paibi and Paibi-2 sections. Dotted line indicates the base of the *Glyptagnostus reticulatus* Zone. Only the lower part of the Paibi-2 section is indicated.

Aoxi Formation with the overlying Huaqiao Formation is placed at the point of change from shale and dolostone of the Aoxi Formation to thin-bedded argillaceous limestone of the Huaqiao Formation.

The lithology of the Huaqiao Formation is substantially different from the lithology of the formation in the Wangcun section. At Paibi, the Huaqiao Formation contains many more carbonate debris beds. The Huaqiao Formation at Paibi is mostly composed of alternating thin beds of argillaceous limestones and lime mudstones through thin- to medium-bedded grainstones containing Bouma divisions, and carbonate debris beds. The debris beds, which increase in number upsection, contain particles ranging up to boulder-size. These beds commonly have non-erosive flat bases and uniform thicknesses over distances of tens of meters. Many calcarenites and calcirudites contain shelf-derived allochems. In the Paibi section, lenticular and channelized debris beds are relatively uncommon, and soft-sediment deformation is rare; truncation or slide surfaces are absent. Overall, sedimentological evidence suggest that the Huaqiao Formation at Paibi was deposited in the upper part of the outer slope-apron environment (Rees *et al.*, 1992).

As in the Wangcun section, the lower and middle parts of the Huaqiao Formation at Paibi are divided into eight agnostoid zones (Peng and Robison, 2000). Proceeding eastward (upsection) along the north side of the road, the *Ptychagnostus atavus* through *Lejopyge laevigata* zones are encountered. Total thickness of this interval is about 260 m. About 100 m west of Shixin Village, walk northeast until reaching two massive beds carbonate debris beds at 287.6 and 283.6 m. These beds occur within the *Proagnostus bulbosus* Zone. The debris beds are 0.9 and 1.2 m thick, respectively, and form distinct ledges on the slope. Some agnostoid trilobites, including *Aspidagnostus laevis*, *Hypagnostus brevifrons*, *Lejopyge laevigata*, and *Lejopyge sinensis*, are present in the layers between these carbonate debris beds. Continuing upslope and upsection, present in the layers between these carbonate debris beds. Continuing upslope and upsection, the interval containing fauna of the *Linguagnostus reconditus* Zone is encountered, followed by the interval assigned to the *Glyptagnostus stolidotus* and the *Glyptagnostus reticulatus* Zones, which crops out on a gentle slope. The base of the *G. reticulatus* Zone indicates the level of the base of the Waergangian Stage.

A small number of exceptionally preserved, nonmineralizing fossils were recently reported from the upper part of the *P. atavus* Zone in the Paibi section (Babcock and Peng, 2001). Fossils reported include the alga *Yuknessia*; the cyanobacteria *Marpolia* and *Morania*; the bacterium? *Megaspirella*?; a hydrozoan cnidarian, *Archaeocryptolaria*; and an undetermined alga-like form. The occurrence of exceptional preservation in the Huaqiao Formation is of significance partly because it represents one of the few Konservat-Lagerstätten developed in nonconcretionary Cambrian limestones (in this case, the deposit consists of dark gray to black lime mudstones). It is also of significance because it ranks among the youngest non-concretionary Cambrian deposits of exceptional preservation globally. Most such deposits of the Cambrian are constrained to the interval between the FAD of trilobites and the *P. atavus* Zone. For some reason, the "taphonomic window" that permitted the relatively widespread development of Konservat-



Lagerstätten during the Early and Middle Cambrian became considerably restricted near the close of the *P. atavus* Chron.

## Stop 2

### Base of the Waergangian Stage in the Paibi section

The Youshuian-Waergangian boundary interval at this locality is well exposed on the south slope of a small hill (Fig. 4). Details of agnostoid occurrences and ranges for the Paibi section were published by Peng and Robison (2000). Additional fieldwork since the time of that work has resulted in the discovery of four more horizons bearing *G. stolidotus* in the *G. stolidotus* Zone (Peng *et al.*, 2001). The trilobite occurrences shown in Figure 5 are based on information published previously (Peng and Robison, 2000), supplemented by information from more recent fieldwork.

## Stop 3

### Base of the Waergangian Stage in the Paibi-2 section

A supplementary section through the Youshuian-Waergangian boundary interval, identified as the Paibi-2 section, has received extensive study in recent fieldwork. The supplementary section is located about 0.5 km northeast of the Paibi section, near the Banglizai Village. It is situated on the east side of an unpaved highway that is built in a valley trending eastward from the Paibi section and connecting the village with the National Highway 319. The Paibi-2 section is on the same limb of the fold containing the Paibi section (Fig. 3).

The Paibi-2 section can be reached from the Paibi section on foot along a trail, or by driving north from National Highway 319 at the T-junction about 0.3 km east of the Shixin Village. The boundary interval occurs in the lowest 3 m of the section, as exposed on the east side of a rough highway. Some beds in the boundary interval are resistant enough to form a relatively steep ledge. The lithology in the boundary interval consists of alternating dark, thin-bedded to medium-bedded ribbon limestone and argillaceous limestone.

The Paibi-2 section embraces the uppermost of the *Glyptagnostus stolidotus* and the *G. reticulatus* zones (Fig. 6). The uppermost part of the *Glyptagnostus stolidotus* Zone contains a layer of dark gray, fine-grained, lime-rich to argillaceous limestone that is 8 cm thick, and rich in trilobites. Agnostoids present include *Glyptagnostus stolidotus*, *Agnostardis amplinatis*, *Ammagnostus sinensis*, *Lisogoragnostus* sp., *Nahanagnostus nganashanicus*, and *Peratagnostus obsoletus*. Polymeroids present include *Baikadamaspis* sp., *Chatiania chatianensis*, *Dorypyge perconvexalis*, *Fenghuangella liostracinala*, *Palaeadotes hunanensis*, *Paradamesella typica*, *Rhyssometopus zhongguoensis*, *Teinistion posterocosta*, *Chiawangella* sp., *Distazeris?* sp., *Dorypyge* sp., *Palaeadotes* sp., *Protaizehoia?* sp., and a new genus and species of shumardioid. Phosphatic brachiopods are also present in this interval. This layer begins at -2.75 m in the section (i. e., 2.75 m below the arbitrary zero point of the Paibi-2 section), and the trilobites from this layer are therefore in collection P  $\beta$  -2.75.

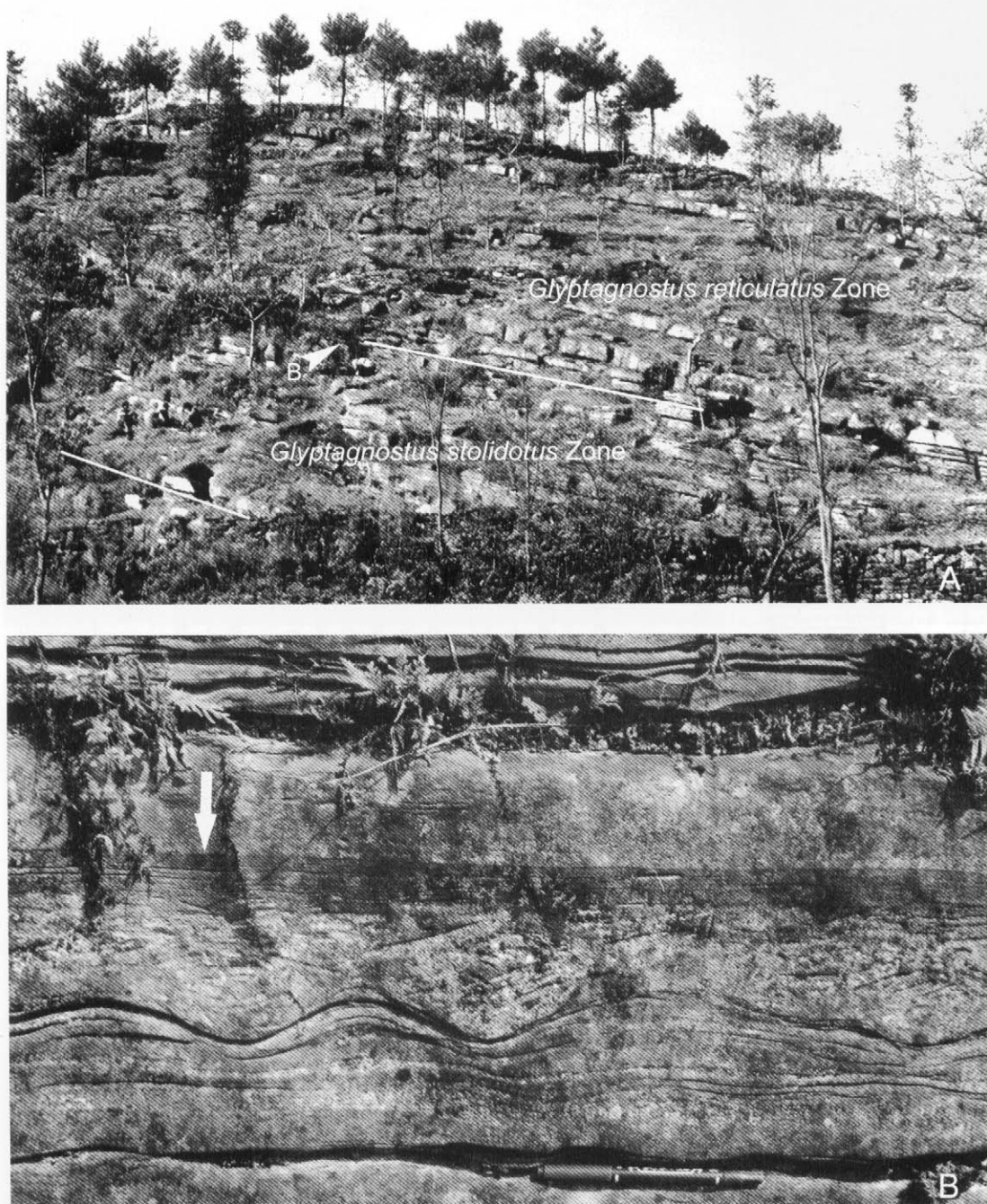


Fig. 4. Exposures of the proposed boundary stratotype for the base of an unnamed Cambrian series in the Paibi section. A. General view of exposure. The lower white line marks the observed first appearance of *Glyptagnostus stolidotus*, and the upper white line marks the observed first appearance of *G. reticulatus*. Arrow indicates the observed boundary position in Photo B; B. Close-up of boundary position (indicated by arrow).

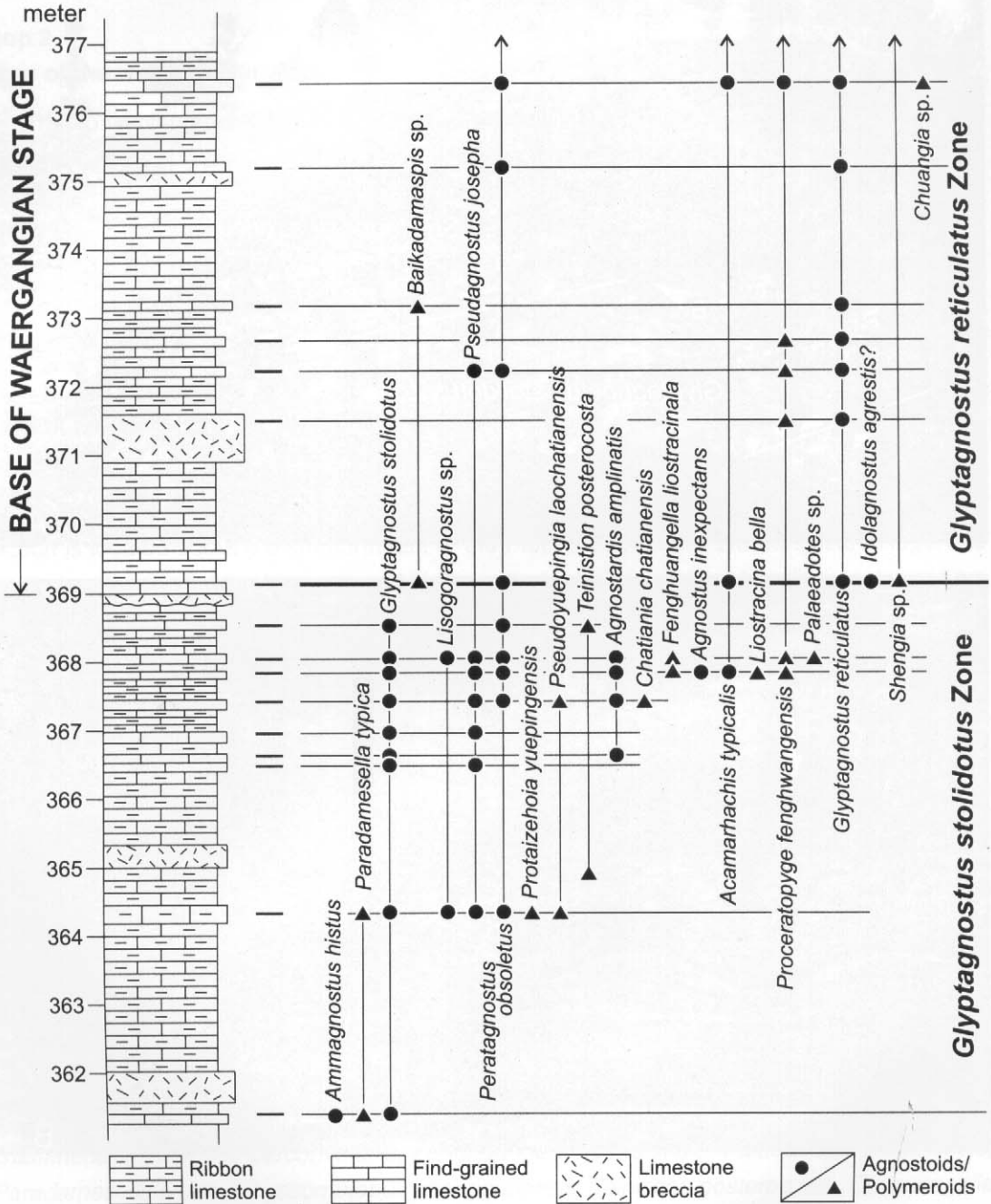


Fig. 5. Trilobite occurrences in the *Glyptagnostus stolidotus* Zone and the *G. reticulatus* Zone in the Paibi section (from Peng *et al.*, 2001).



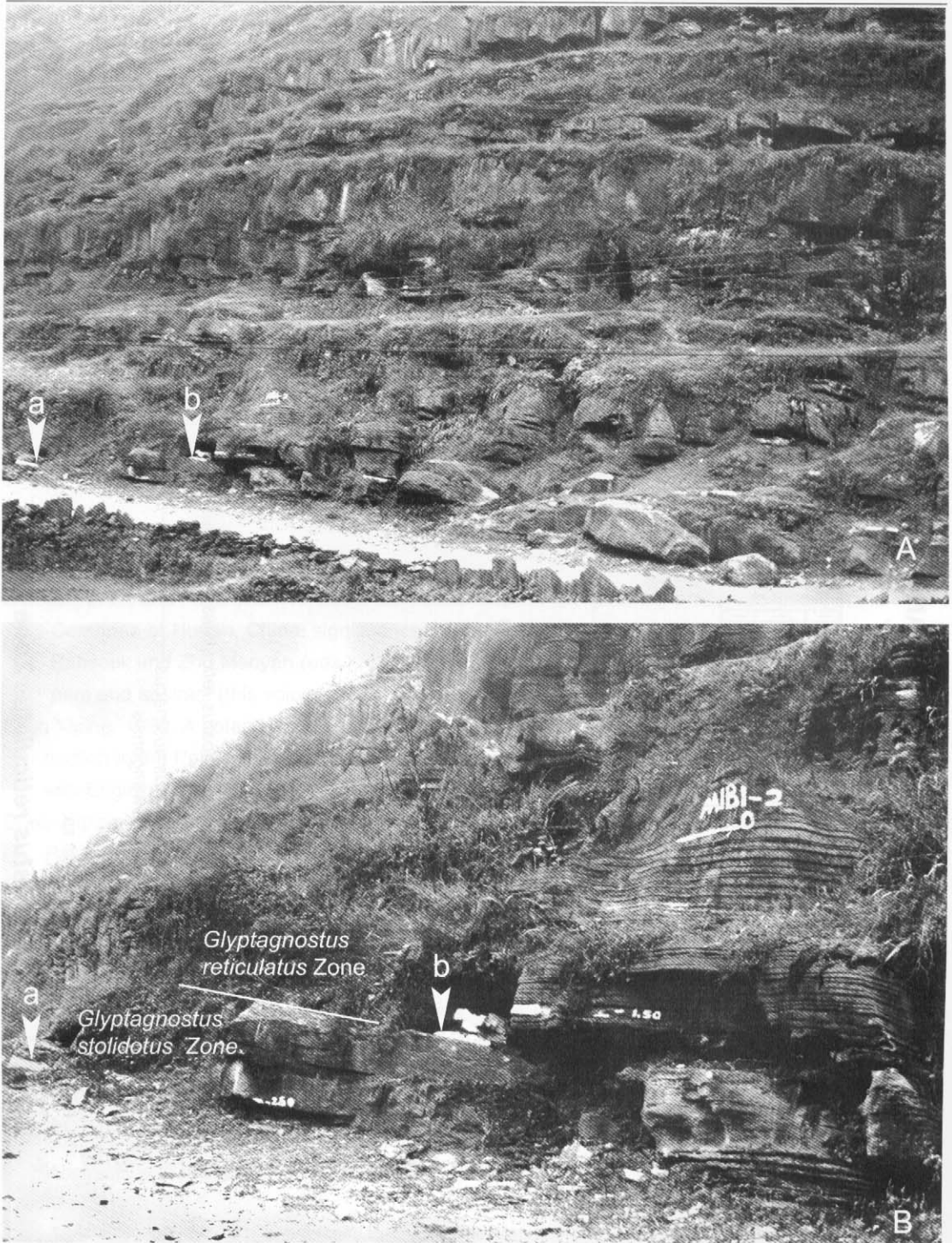


Fig. 6. Exposures of the proposed boundary stratotype for the base of an unnamed Cambrian series in the Paibi-2 section. A. General view of exposure. Arrow a shows the observed last occurrence of *Glyptagnostus stolidotus* in the bed marked by white paint at  $-2.75$  m in the section (collection P  $\beta$  -2.75). Arrow b shows the observed first appearance of *G. reticulatus* in the bed marked by white-paint at  $-1.80$  (collection P  $\beta$  -1.80 m). B. Close-up of the observed boundary position.

The base of the Waergangian Stage is marked by the first occurrence of *Glyptagnostus reticulatus* at 1.80 meters below the arbitrary zero position in the Paibi-2 section (collection P $\beta$ -1.80), which is 0.95 m higher than P $\beta$ -2.75. *Glyptagnostus reticulatus* specimens from this collection are primitive in morphology, showing weak reticulations in the anterior part of the cephalic genae and the posterior part of the pygidial pleurae. This kind of reticulation in *G. reticulatus* was previously formalized in the subspecies name *G. reticulatus angelini*, which, so far as known, always occurs lower in section than other recognized subspecies. The base of the Waergangian Stage is marked by notable changes in the composition of trilobite faunas and in their diversity compared to collections from the Waergangian Stage. Taxa occurring in associa-

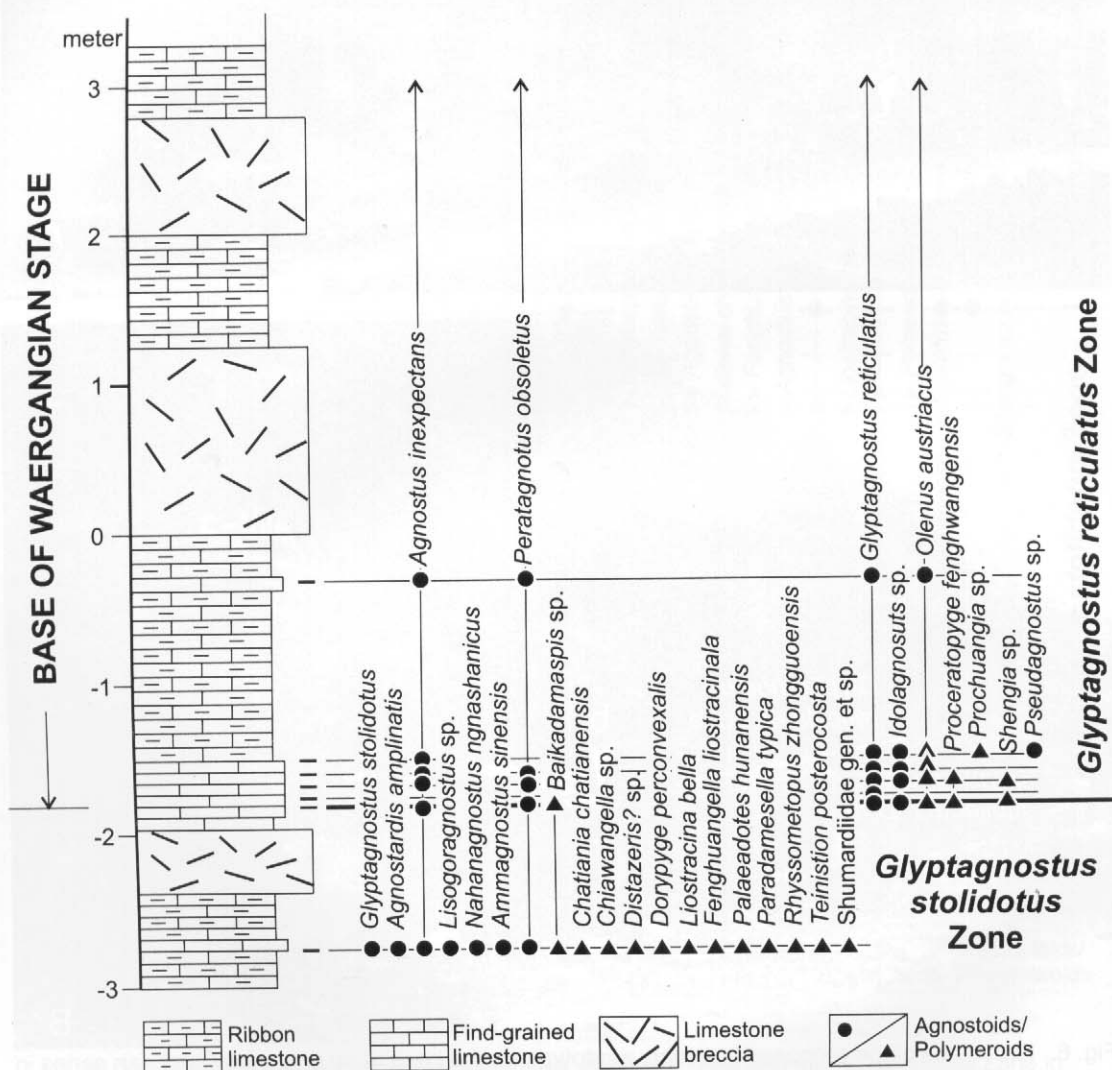


Fig. 7. Trilobite occurrences through the *Glyptagnostus stolidotus* and *G. reticulatus* Zones in the Paibi-2 section (from Peng *et al.*, 2001).

tion with *G. reticulatus* in collection P $\beta$ -1.80 include the agnostoid trilobites *Agnostus inexpectans*, *Idolagnostus agrestis*?, *Peratagnostus obsoletus*; the polymeroid trilobites *Olenus austriacus*, *Proceratopyge fenghwangensis*, *Prochuangia* sp. and *Shengia*? sp.; and inarticulate brachiopods.

*Glyptagnostus reticulatus* specimens showing complicated reticulation occur in P $\beta$ -1.72 and higher collections (P $\beta$ -1.65, -1.60, -1.50, and -0.30). Except for a species questionably assigned to *Chuangia*, all identified taxa in collection P $\beta$ -1.80 range upward into these other collections. As shown in Figure 7, the base of the Waergangian Stage is marked by a significant decrease in trilobite diversity and a notable change in generic composition of the trilobite fauna.

**Acknowledgments** Ms. Wu Minghua for computer-drawing Text-figures. This work has been supported by grants from the National Natural Science Foundation of China (NSFC 40023002 and 40072003), and the Ministry of Science and Technology of China (G99-A-05b) to Peng, and the U.S. National Science Foundation (EAR 0073089 and 0106883) to Babcock.

## REFERENCES

- BABCOCK, L. E., and PENG Shanchi, 2001. New occurrence of exceptionally preserved fossils in the Middle Cambrian of Hunan, China: significance with respect to global correlation. In Peng Shanchi, L. E. Babcock and Zhu Maoyan (eds.), *Cambrian System of South China*, South China 2001: Short papers and abstract (this volume).
- DONG Xiping, 1990. A potential candidate for the Middle-Upper Cambrian boundary stratotype – an introduction to the Paibi section in Huayuan, Hunan. *Acta Geologica Sinica*, **1990**(1):62-79 (In Chinese with English abstract).
- DONG Xiping, 1991. Late Middle and early Late Cambrian agnostids in Huayuan, Hunan. *Acta Palaeontologica Sinica*, **30**:439-457 (In Chinese with English abstract).
- PENG Shanchi, L. E. BABCOCK, LIN Huanling, CHEN Yongan, and ZHU Xuejian, 2001. Potential Global Stratotype and Point for the base of an Upper Cambrian Series defined by the first appearance of the *Glyptagnostus reticulatus*, Hunan Province, China. *Acta Palaeontologica Sinica*, **40**, supplement (in press).
- PENG Shanchi, and R. A. ROBISON, 2000. Agnostoid biostratigraphy across the Middle-Upper Cambrian boundary in Hunan, China. *Paleontological Society Memoir* **53**, supplement to *Journal of Paleontology*, **74**(4) : 1-104.
- REES, M. N., R. A. ROBISON, L. E. BABCOCK, CHANG W. T., and PENG Shanchi, 1992. Middle Cambrian eustasy: evidence from slope deposits in Hunan Province, China. *Geological Society of America Abstracts with Programs*, **24**(7): A108.