

# 华南与美国西部间下、中寒武统界线对比<sup>\*</sup>

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**提要** 根据三叶虫 *Bathynotus*, *Microrhynchocara*, *Pagetia prolata* 和 *Oryctocephalus indicus* 在华南和美国西部地层上相同或相类似的分布, 对冈瓦纳与劳伦古陆下、中寒武统界线进行对比, 并将 *Oryctocephalus indicus* 一种的首次出现作为确定两大古陆中寒武统的底界, 而推荐此种作为界层型中寒武统的标准种。

**关键词** 下、中寒武统界线 对比 华南与美国西部

## CORRELATION OF THE LOWER-MIDDLE CAMBRIAN BOUNDARY OF SOUTH CHINA AND WESTERN UNITED STATES OF AMERICA

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**Abstract:** The Lower-Middle Cambrian boundary in Gondwana and Laurentia is correlated using the trilobites *Bathynotus*, *Microrhynchocara*, *Pagetia prolata*, and *Oryctocephalus indicus* from South China and the western United States. *Oryctocephalus indicus* is suggested as a candidate for the defining taxon for the base of the Middle Cambrian Series and its lowest stage in Laurentia and South China.

**Key words:** Lower-Middle Cambrian boundary, western United States, South China

## 1 INTRODUCTION

Oryctotcephalids and eodiscoids can play a key role in international correlation due to their

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paleoequatorial to subequatorial distributions in the late Early to middle Middle Cambrian. The Lower-Middle Cambrian boundary intervals of Laurentia and Gondwana are here correlated using oryctocephalids, *Pagetia*, and *Bathynotus*, from open shelf sections of the western United States and South China (Sundberg and McCollum, 1997; Yuan *et al.*, 1997; Palmer, 1998b; Jell, written communication, 1998). *Oryctocephalus indicus*, *Microrhyctocara*, and *Pagetia prolata* occur just above the youngest Lower Cambrian trilobites, including *Bathynotus*, in both the redlichiid province of South China and the olenellid province of Laurentia. We suggest that the first occurrence of *Oryctocephalus indicus* be considered for defining the base of the international Middle Cambrian Series.

In China, the traditional lower boundary of the Middle Cambrian (Maochuangian Stage) has been defined immediately above the extinction of redlichiid trilobites and at the first appearance of endemic ptychopariid trilobites (Chang, 1988). However, in South China, the Lower Cambrian redlichiids and ptychopariids of Middle Cambrian aspect actually co-occur (Zhao *et al.*, 1992). If the series boundary is defined on the first occurrence of such ptychopariids, then the traditional Lower Cambrian redlichiid extinction becomes Middle Cambrian. Therefore, Yuan *et al.* (1997) suggested that the Lower-Middle Cambrian boundary be defined at the first occurrence of *Oryctocephalus indicus*.

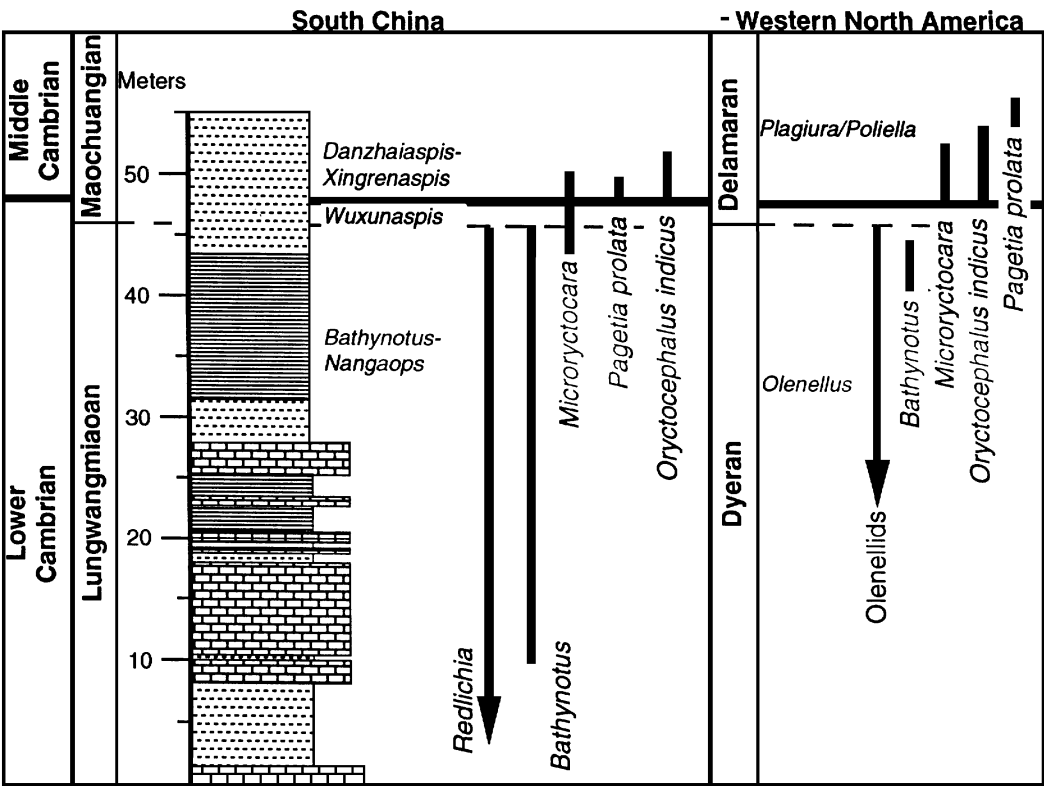
In Laurentia, the lower boundary of the Middle Cambrian (Lincolnian Series, Delamaran Stage) was defined (Palmer, 1998) immediately above the extinction of olenellid trilobites at the appearance of “*Eoptychoparia*” *piochensis*. However, “*E.*” *piochensis* is only found in southern Nevada, and therefore, the boundary can be recognized only locally in Laurentia. We therefore suggest that the first occurrence of *Oryctocephalus indicus* which has been reported by Sundberg and McCollum (1997) from both Nevada and California, should also be considered as the base of the Middle Cambrian of Laurentia.

## 2 BIOSTRATIGRAPHY

In Guizhou Province, *Oryctocephalus indicus* (Plate I, fig. 3) occurs 48 to 52 m above the base of the Kaili Formation, and *Pagetia prolata* (= *P. taijiangensis*; Jell, written communication) occurs 48 to 50 m above the base (Yuan *et al.*, 1997; Text-fig. 1). The lower 46 m of the Kaili Formation contains a Lower Cambrian redlichiid fauna, and is overlain by a sparsely fossiliferous, two meter interval containing a low diversity, endemic trilobite fauna. The Lower Cambrian trilobites *Redlichia takoensis* and *R. coniformis* range from 10 to 46 m above the base of the formation and *Bathynotus elongatus*, *B. kueichowensis* (Plate I, fig. 1), and *B. sinensis* range from 37 to 46 m (Zhao *et al.*, 1990, 1994, 1996; Yuan *et al.*, 1999; Guo and Zhao, 1998). *Microrhyctocara* n. spp. (= *Euarthricocephalus* of Yuan *et al.*, 1997; Plate I, fig. 2) spans the Lower-Middle Cambrian boundary, ranging from 44 to 50 m above the base of the Kaili Formation.

The Mule Spring Limestone contains the highest stratigraphic occurrence of olenellids in western Nevada and eastern California. A lower seven meters of shale in the overlying Emigrant and Monola formations contains a low diversity, endemic trilobite fauna. *Oryctocephalus indicus* and *Microrhynchocara nevadensis* occur immediately above the endemic fauna in an interval between 7 to 20 m (Sundberg and McCollum, 1997). A two-meter-thick, barren siltstone to sandstone interval separates the shale from the overlying silty ribbon limestone, which contains *Pagetia*, *Bathynotus holopygus*, originally described from the uppermost Lower Cambrian Parker Shale of Vermont (Resser and Howell, 1938; Shaw, 1955; Palmer, 1971), has recently been reported by Palmer(1998b) with the youngest olenellid fauna in eastern Nevada.

In both South China and the western United States, *Bathynotus* is associated with either the youngest redlichiids or the youngest olenellids, and *Oryctocephalus indicus* and *Pagetia prolata* occur a few meters above either the highest redlichiids or the highest olenellids. In South China, *Microrhynchocara* is found with both *Redlichia* and *O. indicus*; however, the Middle Cambrian species is most similar to *M. nevadensis*, which is found with *O. indicus* in North America. The limited stratigraphic ranges of *Bathynotus*, *Microrhynchocara*, *P. prolata* and *O. indicus* allow for the precise correlation of the Lower-Middle Cambrian boundary of South China and Laurentia(Text-fig. 1).



Text-figure 1 Correlation chart of the Lower-Middle Cambrian boundary of South China and Western North America  
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### 3 INTERNATIONAL BOUNDARY FOR THE LOWER AND MIDDLE CAMBRIAN

A lower boundary for an international Middle Cambrian series based on the first occurrence of *O. indicus* has the potential for both regional and local correlations. *Oryctocephalus indicus* occurs in deeper water, open-shelf strata in South China (Yuan *et al.*, 1997), Korea (Saito, 1934; Sundberg and McCollum, 1997), India (Reed, 1910; Jell and Hughes, 1997), and North America (Sundberg and McCollum, 1997). It also occurs with endemic trilobite faunas stratigraphically close to the traditional Lower-Middle Cambrian boundary as recognized in both Gondwana and Laurentia. *Temnoura*, *Pagetia*, *Probowmania*, and *Probowmaniella* are present in the Lower-Middle Cambrian boundary interval in shelf sections of North China as well as in the Kaili Formation of South China (Yuan *et al.*, 1999). In North America, *O. indicus* is associated with *Kochina*, *Syspacephalus*, *Peronopsis brighamensis* (Robison, written communication), *Wenkchemnia*, *Amecephalus*, and two new genera that are also found in the shoreward sections in the western United States and Canada.

An international stratotype for this proposed boundary of Middle Cambrian series is yet to be defined. The Kaili Formation near Balang (Yuan *et al.*, 1997) is a potential stratotype. At this section, the boundary interval: 1) consists of open shelf deposits of monofacial mudstones and siltstones with only minor variation in fissility; 2) mostly free from structural complications; 3) has a diverse fauna that is present in other regions of China; 4) contains other oryctocephalid trilobites which can potentially provide additional biostratigraphic correlation; and 5) is accessible for scientific study. A potential problem, which is typical of most outer to offshore deposits, is the rarity of trilobites within the boundary interval. Because of this problem, we are actively looking for other more fossiliferous sections in South China prior to proposing an international boundary stratotype.

Sections containing *Oryctocephalus indicus* in the Emigrant and Monola formations of western North America are also appropriate for both a Laurentian and international boundary stratotypes because: 1) the first occurrence of *O. indicus* is in monofacial strata; 2) widespread oryctocephalids, eodiscoids, and agnostoids occur near the boundary, in association with endemic trilobites; and 3) *Oryctocephalus* and *Microrhyctocara* have wide geographic occurrences (Sundberg and McCollum, 1997).

### 4 CORRELATION TO OTHER REGIONS

Faunal elements associated with *Oryctocephalus indicus* have been found in other regions. *Pagetia significans* occurs with *O. indicus* in India (Jell and Hughes, 1997) and is present in the *Xystridura templetonensis* Biozone of Australia (Jell, 1975), which is the lowermost zone of the Templetonian Stage (Opik, 1975). *Pagetia prolata* also occurs in the *Xystridura templetonensis* Biozone of Australia (Jell, 1975). These occurrences indicate that the

Templetonian Stage is early Middle Cambrian in age and the underlying Ordian, which contains *Redlichia* (Opik, 1970), is latest Early Cambrian in age, not Middle Cambrian as suggested by Opik (1967, 1970, 1975). *Bathynotus* is found in two horizons in Russia (Lermontova, 1940). The upper horizon is the *Anabaraspis splendens* Biozone (= *Edelstenapis-Kooteniella* Biozone) of the uppermost Toyonian (Zhao *et al.*, 1990). *Bathynotus* is also present in other regions of South China (Zhao *et al.*, 1990).

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PLATE I CAPTION

Biostratigraphically important Lower and Middle Cambrian fossils from the Kaili Formation, Balang, South China.

1. Lower Cambrian *Bathynotus kueichouensis* Lu, x<sup>4</sup>.0;

2. Lower Cambrian species of *Microrictocara*, x<sup>6</sup>.0;

3. Middle Cambrian *Oryctocephalus indicus*(Reed), x<sup>6</sup>.0.

