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Revision of the Ordovician acritarch genus *Ampullula* Righi 1991

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ABSTRACT

After the initial description of *Ampullula* Righi 1991 and *Stelomorpha* Yin 1994, several researchers discussed these two acritarch genera and their relationship. A literature revision and investigation of new material from South China indicate that the genus *Stelomorpha* is a synonym of the genus *Ampullula*, but *Ampullula* is not the synonym of the genus *Tranvikium* Tynni 1982 emend. Uutela and Sarjeant 2000. The generic diagnosis of *Ampullula* is emended. Six species belong to the genus: *Ampullula calix* (Quintavalle and Playford, 2008) comb. nov., *Ampullula composta* (Yin et al., 1998) comb. nov., *Ampullula crassula* (Vavrdová, 1990) comb. et emend. nov., *Ampullula erchunensis* (Fang, 1986) Brocke 1997 emend. nov., *Ampullula princeps* Brocke 1997, and *Ampullula suetica* Righi 1991. *Ampullula* was widely distributed throughout peri-Gondwana and Baltica suggesting a global distribution during the late Early–Middle Ordovician. Biostratigraphically, *Ampullula* is an important genus indicating upper Lower to Middle Ordovician intervals. *Ampullula* was first present in the *eobifidus* graptolite Biozone in South China, where it possibly originated, and subsequently was also present on Baltica and other parts of the margin of Gondwana. Thus, *Ampullula* was an important Early–Middle Ordovician acritarch with a global distribution, which probably was both eurythermic and eurytopic.

1. Introduction

Acritarchs are widely used in Ordovician biostratigraphical correlation, as well as palaeobiogeographic and palaeoenvironmental studies. Formal Global Boundary Stratotype Section and Points (GSSPs) for all Ordovician stages have been selected (Bergström et al., 2009), three of them being located in South China. Several acritarch taxa were selected for stratigraphic correlations (e.g. Li et al., 2002, 2003; Molyneux et al., 2007; Servais et al., 2007; Li et al., 2010) indicating their high potential for the definition of Ordovician boundaries. Several Ordovician acritarch taxa with biostratigraphical and/or palaeogeographical significance have been revised in detail, including *Arbusculidium* (Fatka and Brocke, 1999), *Arkonia–Striatotheca* (Servais, 1997), *Aureotesta* (Brocke et al., 1997), *Coryphidium* (Servais et al., 2008), *Dicrodiacrodium* (Servais et al., 1996), *Frankea* (Servais, 1993; Fatka et al., 1997), *Pachysphaeridium* (Ribecai and Tongiorgi, 1999), *Peteinosphaeridium*, *Liliosphaerdium*, and *Cyclopospheridium* (Playford et al., 1995), *Sacculidium* (Ribecai et al., 2002), and *Veryhachium* (Servais et al., 2007).

Ampullula is a widely recorded Ordovician acritarch genus with a complex and confusing taxonomical history. The genus *Ampullula* has been discussed by several authors (Brocke, 1997; Uutela and Sarjeant, 2000; Ribecai et al., 2002; Tongiorgi et al., 2003). After the initial description of *Ampullula* Righi 1991 and *Stelomorpha* Yin 1994, Brocke (1997) revised *Ampullula* to include *Stelomorpha,* whereas Uutela and Sarjeant (2000) retained and emended *Stelomorpha* and considered *Ampullula suetica* as a junior synonym of *Tranvikium polygonale.* Subsequently, Ribecai et al. (2002) suggested an additional new genus, *Sacculidium*, and included it in a '*Stelomorpha–Tranvikium–Sacculidium* plexus.' Li et al. (2002) determined that *Ampullula* is a very important taxon for the Lower–Middle Ordovician biostratigraphy.

The aim of this work is to revise *Ampullula* Righi 1991 and to discuss its relationship to *Tranvikium* Tynni 1982 and *Sacculidium* Ribecai et al. 2002 by examination of all published literature and analysis of new material from South China. All occurrences of *Ampullula* are plotted on a palaeogeographical reconstruction to show its palaeogeographical distribution. The biostratigraphical distribution of the genus is also reviewed in order to understand its potential for international correlation.

2. Material and methods

More than 100 samples for palynological analysis were collected from five sections in China. These are the Honghuayuan section in Tongzi (Guizhou), the Houping section in Chengkou (Chongqing), the Guanyinqiao section in Qijiang (Chongqing), and the Huanghuachang and Daping sections in Yichang (Hubei), South China (Fig. 1). These sections are located in different lithofacies. The upper Lower–lower Middle Ordovician rocks were deposited in southwest–northeast band-like zones (Zhang et al., 2002), and are well developed with

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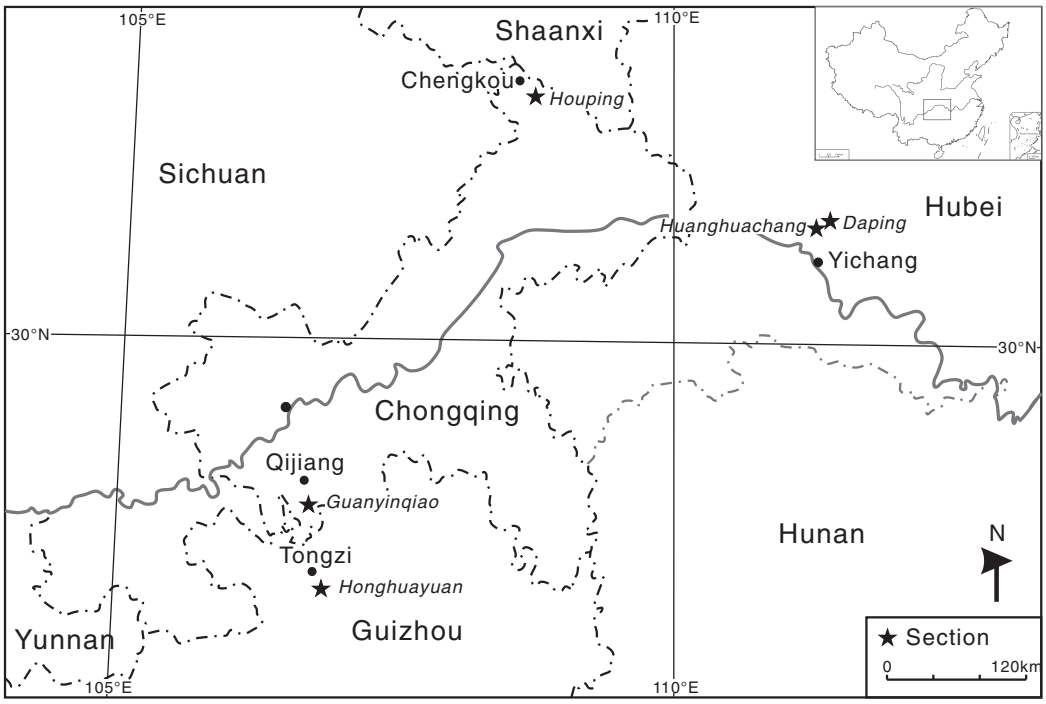

Fig. 1. Location of the five geological sections in South China.

various lithologies including shallow water carbonates intercalated with mudstones, silty mudstones or calcareous mudstones. Accordingly, different formations were named at different localities, such as the Dawan Formation in Yichang, Hubei; the Meitan Formation in Tongzi, Guizhou; and the Yingpan Formation in Chengkou, Chongqing.

Three sections, the Honghuayuan section in Tongzi, the Guanyinqiao section in Qijiang and the Houping section in Chengkou, were located in an inner-shelf mud-carbonate belt during the latest Early–earliest Middle Ordovician which is characterized by the dominance of carbonate sediments mixed with argillaceous and sandy intercalations (Zhang et al., 2002). Two other sections, the Huanghuachang and Daping sections in Yichang are located in a shallower outer-shelf carbonate-mud belt during the late Early Ordovician–earliest Darriwilian (Zhang et al., 2002).

The Meitan Formation is composed of greyish-yellow and greyish-green shale intercalated with nodular limestone beds in the lower–middle part, and thin-bedded sandstone in the upper part. Forty five samples were collected from the Meitan Formation, in the Honghuayuan section, Tongzi, Guizhou Province, and seven from the same formation, in the Guanyinqiao section, Qijiang, Chongqing (Fig. 2).

The Yingpan Formation consists of dark grey to black or grey-green shales intercalated with bioclastic limestone lenses. Thirty six samples including eleven samples for palynological analysis were collected from the Yingpan Formation, in the Houping section, Chengkou, Chongqing (Fig. 2).

The Dawan Formation, which comprises more carbonate rocks than the Meitan Formation and Yingpan Formation in the Yichang area of Hubei, can be divided into three members. The lower member consists of grey thin-bedded, nodular limestone intercalated with yellowish-green shale, the middle member consists of purplish weathered limestone, and the upper member consists of dirty green shale intercalated with nodular limestone. Thirty four samples were collected from the Dawan Formation, Huanghuachang section, and twenty samples from the Daping section, Yichang, Hubei Province (Fig. 2).

All samples were treated in the Palynological Laboratory of the Nanjing Institute of Geology and Palaeontology. About 50 g of each sample were processed following standard palynological techniques of treatment by using 37% HCl and 40% HF to remove the carbonates and silicates respectively, and neutralizing the residues in distilled water after each acid treatment. Samples were not oxidized, and the resultant residues from each sample were sieved through a 15 μm mesh. Samples were observed under a Zeiss Axioskop2 Plus light microscope, and photomicrographs taken by a Sony DSC-S75 digital camera. The slides and residues are housed in the Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing, China.

3. The genus *Ampullula*

3.1. Research on Ampullula Righi 1991 and Stelomorpha Yin 1994

Righi (1991) erected the monospecific genus *Ampullula* on the basis of a neck-like process and a pylome opposite to it. After its original description, several palynologists discussed this genus (Brocke, 1997; Uutela and Sarjeant, 2000; Ribecai et al., 2002; Tongiorgi et al., 2003) which led to a confused taxonomy.

Fang (1986) described the new species *Aremoricanium erchunensis* from the Hongshiya Formation, Erchun, Kunming city, Yunnan Province. Yin (1994) described the new genus *Stelomorpha* based on the material from Yichang, and proposed a new combination *Stelomorpha erchunensis* (Fang 1986) Yin 1994 with an emendation of the original diagnosis of the species.

Based on studies in the Daping section, Tongiorgi et al. (1995) noticed that *Aremoricanium erchunensis* Fang 1986 is similar to *Ampullula* because of the presence of a tubular extension close to those described for the latter genus. Therefore, they "provisionally and doubtfully" transferred this species to *A.*? *erchunensis* because *Ampullula* described by Righi (1991) was devoid of other processes. They also suggested either an emendation of the diagnosis of the genus *Ampullula* or the erection of a new genus close to *Ampullula*. In their addendum, they attributed *A. erchunensis* to the previously erected *Stelomorpha* Yin 1994.

Subsequently, Brocke (1997) emended *Ampullula* based on new material from several sections of the Dawan Formation, Upper