Canadian Journal of Earth Sciences
Revue canadienne des sciences de la Terre

**New data on Hirnantian (latest Ordovician) postglacial
carbonate rocks and fossils in northern Guizhou, Southwest
China**

Journal:	<i>Canadian Journal of Earth Sciences</i>
Manuscript ID	cjes-2015-0197.R1
Manuscript Type:	Article
Date Submitted by the Author:	20-Dec-2015
Complete List of Authors:	Wang, Guangxu; Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, ; Zhan, Renbin; Nanjing Institute of Geology and Palaeontology Percival, Ian; Geological Survey of New South Wales
Keyword:	End-Ordovician, postglacial carbonates, rugose corals, brachiopods, South China

SCHOLARONE™
Manuscripts

1 New data on Hirnantian (latest Ordovician) postglacial
2 carbonate rocks and fossils in northern Guizhou, Southwest
3 China

4
5 Guang-Xu Wang, Ren-Bin Zhan, and Ian G. Percival

6
7 **G.X. Wang and R.B. Zhan.** State Key Laboratory of Palaeobiology and Stratigraphy,
8 Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
9 (CAS), 39 East Beijing Road, Nanjing 210008, China (e-mails:
10 gxwang@nigpas.ac.cn; rbzhan@nigpas.ac.cn);

11 **I.G. Percival.** Geological Survey of New South Wales, 947–953 Londonderry Road,
12 Londonderry, NSW 2753, Australia (e-mail: ian.percival@industry.nsw.gov.au).

13
14 **Corresponding author:** Guang-Xu Wang (e-mail: gxwang@nigpas.ac.cn; Tel:
15 +86-25-83282129).

New data on Hirnantian (latest Ordovician) postglacial
carbonate rocks and fossils in northern Guizhou, Southwest
China

Guang-Xu Wang, Ren-Bin Zhan, and Ian G. Percival

Abstract: The Kuanyinchiao Formation (Hirnantian, Upper Ordovician), yielding the typical *Hirnantia* fauna, has commonly been accepted as representing cool-water sediments deposited during the glacial interval in the Hirnantian GSSP region of South China. Recent investigation reveals that the uppermost carbonate-dominated part of this formation yields a warm-water rugose coral fauna with Silurian affinities at many localities of northern Guizhou Province, which substantially differs from the underlying cool-water fauna. This suggests that these carbonates were probably postglacial warm-water sediments, rather than having formed during the Hirnantian glacial interval as previously thought. Such a conclusion is consistent with the evidence from the associated brachiopod fauna, i.e., the *Dalmanella testudinaria*-*Dorytreta longicrura* community, which is similarly distinct from the underlying typical *Hirnantia* fauna. The sedimentological data show warm-water features at the same level (e.g., the presence of oolitic grains), also supporting this new interpretation.

Keywords: End-Ordovician, postglacial carbonates, rugose corals, brachiopods, South China

Introduction

The *Hirnantia* fauna-bearing Kuanyinchiao Formation has commonly been considered as representing the early-middle Hirnantian cool-water carbonate sediments in South China (Zhan et al. 2010; Rong et al. 2010, 2011), where the Global Boundary Stratotype Section and Point (abbreviated GSSP) for the base of the Hirnantian Stage is located (Chen et al. 2006). Furthermore, it has long been believed that there are no postglacial carbonate rocks and fossils present on the Upper Yangtze Platform, with the earliest shelly fauna following the end-Ordovician mass extinction being assigned to the Wulipo Bed (middle Rhuddanian, Llandovery, Silurian) (e.g., Rong and Zhan 2004a; Zhou et al. 2004; Rong et al. 2013). Hence there has always been a problem to make high-resolution correlation between the GSSP area and shallow-water carbonate platforms, especially those in low latitude regions (Delabroye and Vecoli 2010; Bergström et al. 2014), which consequently limits our understanding of shelly faunal turnover through the Ordovician–Silurian transition.

Our recent investigation, however, has revealed that late Hirnantian postglacial carbonates and fossils are present on the Upper Yangtze Platform of South China (Wang 2014). These occurrences have been partly documented from the Shiqian area of northeastern Guizhou (Wang G.X. et al. 2015). The present paper aims to demonstrate that the uppermost Kuanyinchiao Formation of late Hirnantian age is also represented by postglacial warm-water carbonates at many other localities in northern Guizhou (Fig. 1). Based on such new stratigraphic data, a comprehensive correlation of carbonate rocks across the Ordovician–Silurian boundary on the Yangtze Platform

is compiled.

Geological setting and historical review

The Kuanyinchiao Formation has a typical lithology of dark grey argillaceous limestone on the Upper Yangtze Platform, containing abundant brachiopods (i.e., the typical *Hirnantia* fauna), rugose corals, trilobites and a few other fossil groups (Rong 1979; Zhan et al. 2010). This rock unit is generally conformably underlain and overlain by the black shales of the Wufeng and the Lungmachi formations respectively in many near-shore areas. Graptolites from the underlying shales indicate that the base of the Kuanyinchiao Formation lies generally within the *Metabolograptus extraordinarius* Biozone, while the top is dominantly of the *M. persculptus* Biozone, but never extends to the *Akidograptus ascensus* Biozone of the basal Silurian (Rong et al. 2002, 2010; Zhan et al. 2010). The Kuanyinchiao Formation, which contains brachiopods and rugose corals indicative of cool-water environments, has been generally interpreted as representing the cool-water carbonate sedimentation associated with the major Hirnantian glaciation (Chen 1984; Rong 1984; He et al. 2007; Zhan et al. 2010; Rong et al. 2011).

However, lithological and faunal variations through the Kuanyinchiao Formation have been reported at different localities. He (1978) first noted that the uppermost part of the formation yields the distinctive rugosan *Paramplexoides* at some localities of Bijie, northwestern Guizhou. Rong and Li (1999) recognized a new low-diversity brachiopod community from the same level, termed the *Dalmanella*

testudinaria-Dorytreta longicrura community. Although it includes a few brachiopods found in the lower beds of the Kuanyinchiao Formation, this community lacks characteristic elements of the typical *Hirnantia* fauna (e.g., *Hirnantia*, *Kinnella*, *Cliftonia* and *Paromalomena*) (Table 1), and was considered to be a variant (in response to temperature, water depth and substrate fluctuations) of the *Hirnantia* fauna (Rong and Li 1999). Subsequently, the presence of oolitic grains in this formation, which suggests a warm-water environment, has been confirmed at Dongkala of Fenggang (Li et al. 2005, 2008) and at Zhongshu of Renhuai (Wang Y.C. et al. 2015). The puzzling presence of such warm-water carbonates during the Hirnantian glaciation has been attributed by Li et al. (2005, 2008) to the diversion of cold-water currents by the paleolandmass of South China.

Distribution of warm-water coral fauna

The Late Ordovician warm-water coral fauna occurs at many localities of northern Guizhou, which are grouped into two distinct areas labeled as A and B (Fig. 1).

In area A, the Kuanyinchiao Formation has conformable contacts with the underlying and overlying rocks, and ranges in thickness from 1.3 to 2 m at different localities (Fig. 2a, b). It consists of dark grey calcareous mudstone and argillaceous limestone bearing the *Hirnantia* fauna in the lower part, and bioclastic limestone in its upper part containing a warm-water coral fauna and a distinctive *Dalmanella testudinaria-Dorytreta longicrura* brachiopod community in the uppermost beds

104 (Rong and Li 1999). Ooids were documented from the same level at Zhongshu of
105 Renhuai in the area (Wang Y.C. et al. 2015).

106 At Guanyintang of Fenggang County in area B the Kuanyinchiao Formation
107 shows disconformable contacts with overlying and underlying rocks, and has a
108 reduced thickness of 0.5 m (Fig. 2c) (Rong et al. 2011). The formation is composed of
109 bioclastic limestone, with a warm-water coral fauna similar to that of area A (Fig. 2d).
110 Its brachiopod fauna is still poorly understood. In addition, oolitic grains were
111 reported from the equivalent limestone at Dongkala, about 5 km southwest of
112 Guanyintang (Li et al. 2005).

113 The lithological and faunal data presented above indicates that the Kuanyinchiao
114 Formation in area B is most likely comparable with the uppermost part of the same
115 formation in area A (Fig. 3).

117 **Warm-water coral faunal analysis**

118 As shown in Figure 3 and Table 1, this warm-water coral fauna is dominantly
119 composed of the distinctive solitary rugosans *Paramplexoides* and *Lambeophyllum?*,
120 in contrast to the underlying cool-water forms, which are typified by distinctive
121 solitary streptelasmatisms commonly with much thicker septa and walls (He et al.
122 2007). This older coral fauna, which is more widespread and restricted to the
123 lower-middle Hirnantian in South China, shows some similarity to the coeval
124 Borenshult coral fauna from central and south-central Sweden (Neuman, 1969).

125 Available occurrence data of *Paramplexoides* confirm its warm-water nature and

126 Silurian affinities. This genus has been documented from the uppermost Ordovician
127 Keel Formation, an oolitic limestone from mid-western Laurentia (McAuley and Elias
128 1990), which was situated in the tropic region (Jin et al. 2013). Other records are
129 exclusively from considerably younger Silurian rocks of similarly low latitude regions,
130 including the Shihniulan Formation of northern Guizhou (Kong and Huang 1978) and
131 the Lalong Formation of southern Gansu (South China paleoplate) (He and Chen
132 1999); the Zhaohuajing Formation of central Ningxia, North China (Gao 1987); the
133 Bridge Creek Formation of central New South Wales, Australia (McLean 1974) and
134 the Gun River and Jupiter formations of Anticosti Island, Canada (McLean and Copper
135 2013).

136 The coral *Lambeophyllum?* has been reported from the upper Sandbian (Upper
137 Ordovician) of North America, co-occurring with rugosans *Streptelasma*, *Favistina*
138 and *Palaeophyllum* (Okulitch 1938; Webby et al. 2004; Baars et al. 2013) in the
139 equatorial American-Siberian realm (Webby 1992). Additional possible records come
140 from the upper Katian Sanqushan Formation in southeast China (He and Chen 2004),
141 occupying a warm-water oxygenated environment (Rong and Chen 1987; Rong and
142 Zhan 2004b).

143

144 **Postglacial interpretation for the uppermost Kuanyinchiao**
145 **Formation**

146 The end Ordovician extinction has been generally accepted as consisting of two
147 pulses based on the fossil records, corresponding to the start and end of the Hirnantian

148 glaciation (Harper et al. 2014). However, new sedimentological data suggest that this
149 glaciation may have experienced many episodes of various magnitudes (e.g., Ghienne
150 et al. 2014). Even if this is the case, it is reasonable to assume that the magnitudes of
151 glacial cycles during and after the major Hirnantian glaciation are too small to
152 produce a substantial faunal turnover. In view of this, the glacial interval used in the
153 present paper corresponds to the major Hirnantian glaciation, which possibly include
154 small-scale interglacial intervals. Similarly, the postglacial interval after the major
155 Hirnantian glaciation commonly corresponds to the survival interval following the
156 second pulse of the extinction event, though this interval may also contain small-scale
157 glacial episodes.

158 Corals display a high sensitivity to temperature fluctuation that enables them to
159 be useful for paleoenvironmental analysis, particularly around the Hirnantian
160 glaciation. The warm-water rugose coral fauna from the uppermost Kuanyinchiao
161 Formation occurs immediately above the typical cool-water *Hirnantia* fauna
162 associated with the major Hirnantian glaciation, and shows latest Ordovician
163 transitional to Silurian affinities. These observations argue against the possibility that
164 this rugose coral fauna flourished during short-lived interglacial periods of the major
165 glaciation, because if that was the case, the coral fauna should occur between (rather
166 than above) horizons yielding the *Hirnantia* fauna and would solely display
167 Ordovician affinities. We therefore suggest that the carbonate rocks from this level
168 probably represent postglacial sedimentation, rather than having been deposited
169 during the glacial interval (or possible small-scale interglacial periods within this

170 interval) as was commonly believed (Rong and Li 1999; Li et al. 2005, 2008; Wang
171 Y.C. et al. 2015).

172 This interpretation is consistent with the associated brachiopod fauna from this
173 interval (Rong and Li 1999). Considering its low diversity and differences from the
174 typical *Hirnantia* fauna in the underlying beds (Table 1), we suggest that this fauna
175 probably indicates a postglacial survival interval following the major Hirnantian
176 glaciation. The warm-water sedimentological features of these carbonates mentioned
177 above also support this new interpretation (Li et al. 2005, 2008; Wang Y.C. et al.
178 2015). Such a conclusion also explains why the lower and middle parts of the
179 Kuanyinchiao Formation in area A are completely absent in area B, which is probably
180 due to the regression related to the major Hirnantian glaciation. This regression likely
181 resulted in the deposition of argillaceous limestone containing *Hirnantia* fauna in the
182 relatively deeper area A contemporaneous with the stratigraphic gap forming in
183 near-shore area B as the sea level dropped.

184

185 **Correlation of carbonates across the Ordovician and Silurian** 186 **boundary in South China**

187 To date, the postglacial carbonates of late Hirnantian (Ordovician) and
188 early-middle Rhuddanian (Silurian) age on the Yangtze Platform include: 1) the
189 uppermost Kuanyinchiao Formation (upper Hirnantian) in northern Guizhou; 2) the
190 Shiqian Formation (upper Hirnantian, possibly straddling the Ordovician–Silurian
191 boundary) in Shiqian of northeastern Guizhou (Wang G.X. et al. 2015); and 3) the

192 Wulipo Bed (middle Rhuddanian) in Meitan of northern Guizhou (Rong and Zhan
193 2004a; Wang G.X. et al. 2015). A refined correlation of these rocks is presented here
194 (Fig. 4). It should be noted that, because it contains a fauna distinct from that of the
195 Shiqian Formation, the uppermost Kuanyinchiao Formation is suggested to be slightly
196 older than the Shiqian Formation, although their correlation cannot be completely
197 ruled out.

198

199 **Conclusions**

200 In northern Guizhou Province, the uppermost Kuanyinchiao Formation differs
201 significantly both in sedimentological characteristics (being composed of bioclastic
202 limestone with oolitic intervals) and faunal components (containing a warm-water
203 rugose coral fauna of latest Ordovician age with early Silurian affinities) from
204 underlying beds in the same stratigraphic unit that are grey argillaceous limestones
205 bearing the typical *Hirnantia* fauna dominated by cool-water brachiopods. We
206 contend that the carbonates of the uppermost Kuanyinchiao Formation probably
207 represent warm-water sedimentation rather than glacial deposits as was previously
208 thought, and that they most likely postdate the major Hirnantian glaciation phases.
209 Recognition of these postglacial carbonates and fossils adds to a growing list of
210 near-contemporaneous strata of latest Ordovician age in South China that, due to their
211 thinness and limited extension, have previously been overlooked or misinterpreted.
212 Increased awareness of these strata should result in further discoveries that will
213 underpin a better and more accurate understanding of the end-Ordovician mass

214 extinction.

215

216 **Acknowledgements**

217 We thank Wang Yi, Tang Peng, Liang Yan and Luan Xiaocong of NIGPAS (CAS)
 218 for their help in the field. The critical comments of B. Gudveig Baarli and an
 219 anonymous reviewer helped improve the clarity of presentation. Financial supports for
 220 this study came from the National Natural Science Foundation of China (41221001,
 221 41290260, Y526050104, 41472006 and J1210006) and the State Key Laboratory of
 222 Palaeobiology and Stratigraphy. Ian Percival publishes with permission of the
 223 Executive Director of the Geological Survey of New South Wales. This paper is also a
 224 contribution to the IGCP Project 591—The Early to Middle Paleozoic Revolution.

225

226 **References**

- 227 Baars, C., Pour, M.G., and Atwood, R.C. 2013. The earliest rugose coral. *Geological*
 228 *Magazine*, **150**(2): 371–380. doi: 10.1017/S0016756812000829.
- 229 Bergström, S.M., Eriksson, M.E., Young, S.A., Ahlberg, P., and Schmitz, B. 2014.
 230 Hirnantian (latest Ordovician) $\delta^{13}\text{C}$ chemostratigraphy in southern Sweden and
 231 globally: a refined integration with the graptolite and conodont zone successions.
 232 *GFF*, **136**(2): 355–386. doi: 10.1080/11035897.2013.851734.
- 233 Chen, X. 1984. Influence of the Late Ordovician glaciation on basin configuration of
 234 the Yangtze Platform in China. *Lethaia*, **17**(1): 51–59. doi:
 235 10.1111/j.1502-3931.1984.tb00665.x

- 236 Chen, X., Rong, J.Y., Fan, J.X., Zhan, R.B., Mitchell, C.E., Harper, D.A.T., Melchin,
237 M.J., Peng, P.A., Finney, S.C., and Wang, X.F. 2006. The Global Boundary
238 Stratotype Section and Point (GSSP) for the base of the Hirnantian Stage (the
239 uppermost of the Ordovician System). *Episodes*, **29**(3): 183–196.
- 240 Delabroye, A., and Vecoli, M. 2010. The end-Ordovician glaciation and the
241 Hirnantian Stage: A global review and questions about Late Ordovician event
242 stratigraphy. *Earth-Science Reviews*, **98**(3/4): 269–282.
243 doi:10.1016/j.earscirev.2009.10.010.
- 244 Gao J.G. 1987. Early Silurian rugose coral faunas and Silurian stratigraphy in the
245 Tongxin-Zhongning area of Ningxia. *In* Palaeozoic biostratigraphy and tectonic
246 evolution of the Alxa Massif Margin. *Edited by* H. Zhu, Z.C. Zheng and others.
247 Publishing house of Wuhan College of Geology, Wuhan. pp. 122–143. (in
248 Chinese with English abstract)
- 249 Ghienne, J.F., Desrochers, A., Vandenbroucke, T.R., Achab, A., Asselin, E., Dabard,
250 M.P., Farley, C., Loi, A., Paris, F., Wickson, S., and Veizer, J., 2014. A
251 Cenozoic-style scenario for the end-Ordovician glaciation. *Nature*
252 *communications*, **5**, 4485. doi: 10.1038/ncomms5485.
- 253 Harper, D.A., Hammarlund, E.U., and Rasmussen, C.M., 2014. End Ordovician
254 extinctions: A coincidence of causes. *Gondwana Research*, **25**, 1294–1307. doi:
255 10.1016/j.gr.2012.12.021.
- 256 He, X.Y. 1978. Tetracoral fauna of the Late Ordovician Guanyinqiao Formation, Bijie,
257 Guizhou Province. *Professional Papers of Stratigraphy and Paleontology*, **6**: 1–45.

- 258 (in Chinese)
- 259 He, X.Y., and Chen, J.Q. 1999. Early Silurian rugose coral fauna of Tewa area, West
260 Qinling. *Acta Palaeontologica Sinica*, **38**(4): 423–434 (in Chinese with English
261 abstract).
- 262 He, X.Y., and Chen, J.Q. 2004. Late Ordovician mass extinction of rugose corals in
263 the Yangtze region. *In* Mass extinction and recovery—evidences from the
264 Palaeozoic and Triassic of South China. *Edited by* J.Y. Rong and Z.J. Fang.
265 University of Science and Technology of China Press, Hefei. pp. 153–168. (in
266 Chinese with English abstract)
- 267 He, X.Y., Chen, J.Q., and Xiao, J.Y. 2007. Combination features, paleobiogeographic
268 affinity and mass extinction of the latest Ordovician (Hirnantian) rugosan fauna
269 from northern Guizhou, China. *Acta Geologica Sinica*, **81**(1): 23–41.
- 270 Jin, J., Harper, D.A.T., Cocks, L.R.M., McCausland, P.J.A., Rasmussen, C.M.O., and
271 Sheehan, P.M. 2013. Precisely locating the Ordovician equator in Laurentia.
272 *Geology*, **41**(2): 107–110. doi: 10.1130/G33688.1.
- 273 Kong, L., and Huang, Y.M. 1978. Tetracoralla. *In* Palaeontological Atlas of Southwest
274 China, Guizhou Volume (Part 1). *Edited by* Guizhou Provincial Work Team of
275 Stratigraphy and Palaeontology. Geological Publishing House, Beijing. pp.
276 35–160. (in Chinese)
- 277 Li, Y., Matsumoto, R., and Kershaw, S. 2005. Sedimentary and biotic evidence of a
278 warm - water enclave in the cooler oceans of the latest Ordovician glacial phase,
279 Yangtze Platform, South China block. *Island Arc*, **14**(4): 623–635. doi:

- 10.1111/j.1440-1738.2005.00472.x.
- Li, Y., Wang, J.P., Zhang, Y.Y., and Gu, C.G. 2008. Paleoclimatic implications of carbonate rocks across the Ordovician and Silurian boundary in South China. *Progress in Nature Science*, **18**(11): 1264–1270. (in Chinese)
- McAuley, R.J., and Elias, R.J. 1990. Latest Ordovician to earliest Silurian solitary rugose corals of the east-central United States. *Bulletins of American Paleontology*, **98**: 1–82.
- McLean, R.A. 1974. The rugose coral genera *Streptelasma* Hall, *Grewinkia* Dyboski and *Calostylis* Lindström from the Lower Silurian of New South Wales. *Proceedings of the Linnean Society of New South Wales*, **99**(1): 36–53.
- McLean, R.A., and Copper, P. 2013. Rugose corals from the Early Silurian (late Rhuddanian-Telychian) post-extinction recovery interval on Anticosti Island, eastern Canada. *Palaeontographica Canadiana*, **33**: 1–263.
- Neuman, B.E.E. 1969. Upper Ordovician streptelasmatic corals from Scandinavia. *Bulletin of the Geological Institutions of the University of Uppsala, New Series* **1**: 1–73.
- Okulitch, V.J. 1938. Some Black River corals. *Proceedings and Transactions of the Royal Society of Canada*, **32**(4): 87–111.
- Rong, J.Y. 1979. The *Hirnantia* fauna of China with comments on the Ordovician-Silurian boundary. *Journal of Stratigraphy*, **3**(1): 1–28. (in Chinese)
- Rong, J.Y. 1984. Ecostratigraphic evidence of the Upper Ordovician regressive sequences and the effect of the glaciation. *Journal of Stratigraphy*, **8**(1): 19–29.

- 302 (in Chinese)
- 303 Rong, J.Y., and Chen, X. 1987. Faunal differentiation, biofacies and lithofacies pattern
304 of Late Ordovician (Ashgillian) in South China. *Acta Palaeontologica Sinica*,
305 **26**(5): 507–535. (in Chinese with English abstract)
- 306 Rong, J.Y., and Li, R.Y. 1999. A silicified *Hirnantia* fauna (latest Ordovician
307 brachiopods) from Guizhou, southwest China. *Journal of Paleontology*, **73**(5):
308 831–849. doi: <http://dx.doi.org/10.1017/S0022336000040683>.
- 309 Rong, J.Y., and Zhan, R.B. 2004a. Survival and recovery of brachiopods in Early
310 Silurian of South China. *In* Mass extinction and recovery—evidences from the
311 Palaeozoic and Triassic of South China. *Edited by* J.Y. Rong and Z.J. Fang.
312 University of Science and Technology of China Press, Hefei. pp. 97–126. (in
313 Chinese with English abstract)
- 314 Rong, J.Y., and Zhan, R.B. 2004b. Late Ordovician brachiopod mass extinction of
315 South China. *In* Mass extinction and recovery—evidences from the Palaeozoic
316 and Triassic of South China. *Edited by* J.Y. Rong and Z.J. Fang. University of
317 Science and Technology of China Press, Hefei. pp. 71–96. (in Chinese with
318 English abstract)
- 319 Rong, J.Y., Chen, X., and Harper, D.A.T. 2002. The latest Ordovician *Hirnantia*
320 Fauna (Brachiopoda) in time and space. *Lethaia*, **35**(3): 231–249. doi:
321 [10.1111/j.1502-3931.2002.tb00081.x](https://doi.org/10.1111/j.1502-3931.2002.tb00081.x).
- 322 Rong, J.Y., Chen, X., Wang, Y., Zhan, R.B., Liu, J.B., Huang, B., Tang, P., Wu, R.C.,
323 and Wang, G.X. 2011. Northward expansion of Central Guizhou Oldland through

- the Ordovician and Silurian transition: Evidence and implications. *Science in China Series D, Earth Sciences*, **41**(10): 1407–1415. (in Chinese)
- Rong, J.Y., Chen, X., Zhan, R.B., Fan, J.X., Wang, Y., Zhang, Y.D., Li, Y., Huang, B., Wu, R.C., Wang, G.X., and Liu, J.B. 2010. New observation on Ordovician-Silurian boundary strata of Southern Tongzi Country, northern Guizhou, Southwest China. *Journal of Stratigraphy*, **34**(4): 337–348. (in Chinese with English abstract)
- Rong, J.Y., Huang, B., Zhan, R.B., and Harper, D.A.T. 2013. Latest Ordovician and earliest Silurian Brachiopods succeeding the *Hirnantia* Fauna in Southeast China. *Special Papers in Palaeontology* **90**: 1–142. doi: 10.1111/pala.12056.
- Wang, G.X. 2014. Coral faunas across the Ordovician-Silurian transition of South China: implications on paleobiogeography and macroevolution. Ph.D thesis. University of Chinese Academy of Sciences, Beijing. 179pp.
- Wang, G.X., Zhan, R.B., Percival, I.G., Huang, B., Li, Y., and Wu, R.C. 2015. Late Hirnantian (latest Ordovician) carbonate rocks and shelly fossils in Shiqian, northeastern Guizhou, Southwest China. *Newsletters on Stratigraphy*, **48**(3): 241–252. doi: 10.1127/nos/2015/0062.
- Wang, Y.C., Liang, W., Mou, C.L., Zhou, K.K., and Ge, X.Y. 2015. The sedimentary response to Gondwana glaciation in Hirnantian (Ordovician) of the Eastern Chongqing and the northern Guizhou region, South China. *Acta Sedimentologica Sinica*, **33**(2): 232–241. (in Chinese with English abstract)
- Webby, B.D. 1992. Global biogeography of Ordovician corals and stromatoporoids. *In*

- 346 Global Perspectives on Ordovician Geology. *Edited by* B.D. Webby and J.R.
347 Laurie. A. A. Balkema, Rotterdam. pp. 261–276.
- 348 Webby, B.D., Elias, R.J., Young, G.A., Neuman, B.E.E., and Kaljo, D. 2004. Corals.
349 *In* The great Ordovician biodiversification event. *Edited by* B.D. Webby, F. Paris,
350 M.L. Droser and I.G. Percival. Columbia University Press, New York. pp.
351 124–146.
- 352 Zhan, R.B., Liu, J.B., Percival, I.G., Jin, J.S., and Li, G.P. 2010. Biodiversification of
353 Late Ordovician *Hirnantia* fauna on the Upper Yangtze Platform, South China.
354 Science China, Earth Sciences, **53**(12): 1800–1810. doi:
355 10.1007/s11430-010-4071-3.
- 356 Zhou, Z.Y., Yuan, W.W., Han, N.R., and Zhou, Z.Q. 2004. Survival and recovery of
357 brachiopods in Early Silurian of South China. *In* Mass extinction and
358 recovery—evidences from the Palaeozoic and Triassic of South China. *Edited by*
359 J.Y. Rong and Z.J. Fang. University of Science and Technology of China Press,
360 Hefei. pp. 127–152. (in Chinese with English abstract)

361 Figure and Table Captions

362 **Fig. 1.** Locality map showing study areas (A and B) and localities in the text,
363 indicated by hollow triangles. Note that the thick dashed line represents the inferred
364 shore-line during the late Hirnantian interval, based on Rong et al. (2011) and Wang
365 G.X. et al. (2015).

366

367 **Table 1.** Taxonomic list of brachiopods and corals from the Kuanyinchiao Formation
368 in the study area. Brachiopod identification is from Rong and Li (1999), and coral
369 faunal list is based on He et al (2007) and our unpublished data.

370

371 **Fig. 2.** Outcrops showing some key Ordovician and Silurian boundary successions in
372 study areas. (a)-(c) showing Hirnantian sequence at Zhonggou of Bijie, Shichang of
373 Renhuai and Guanyintang of Fenggang in northern Guizhou respectively; (d) close-up
374 view of the Kuanyinchiao Formation at Guanyintang of Fenggang, showing the
375 abundant warm-water rugose corals; coin for scale is 20.5 mm in diameter.

376

377 **Fig. 3.** Stratigraphic correlation of the Ordovician–Silurian boundary successions
378 between the study areas A (Zhougou of Bijie) and B (Guanyintang of Fenggang).
379 Representative rugose corals from the Kuanyinchiao Formation are illustrated with
380 their stratigraphic levels indicated.

381

382 **Fig. 4.** Correlation of carbonate rocks across the Ordovician–Silurian boundary on the

383 Yangtze Platform of South China.

Draft

Fig. 1. Locality map showing study areas (A and B) and localities in the text, indicated by hollow triangles. Note that the thick dashed line represents the inferred shore-line during the late Hirnantian interval, based on Rong et al. (2011) and Wang G.X. et al. (2015).

102x64mm (600 x 600 DPI)

Fig. 2. Outcrops showing some key Ordovician and Silurian boundary successions in study areas. (a)–(c) showing Hirnantian sequence at Zhonggou of Bijie, Shichang of Renhuai and Guanyintang of Fenggang in northern Guizhou respectively; (d) close-up view of the Kuanyinchiao Formation at Guanyintang of Fenggang, showing the abundant warm-water rugose corals; coin for scale is 20.5 mm in diameter. 186x138mm (300 x 300 DPI)

Fig. 3. Stratigraphic correlation of the Ordovician–Silurian boundary successions between the study areas A (Zhougou of Bijie) and B (Guanyintang of Fenggang). Representative rugose corals from the Kuanyinchiao Formation are illustrated with their stratigraphic levels indicated.
179x92mm (300 x 300 DPI)

Fig. 4. Correlation of carbonate rocks across the Ordovician–Silurian boundary on the Yangtze Platform of South China.
68x39mm (600 x 600 DPI)

Table 1. Taxonomic list of brachiopods and corals from the Kuanyinchiao Formation in the study area. Brachiopod identification is from Rong and Li (1999), and coral faunal list is based on He et al (2007) and our unpublished data.

Kuanyin-chiao Fm.	Brachiopods	Corals
Uppermost part	<i>Dalmanella testudinaria</i>-<i>Dorytreta longicrura</i> community dominant elements: <i>Dalmanella testudinaria</i> , <i>Dorytreta longicrura</i> , others: <i>Plectothyrella crassica</i> , <i>Hindella crassa incipiens</i> , <i>Fardenia modica</i> , <i>Eostropheodonta</i> sp.	dominant elements: <i>Paramplexoides brevisseptatum</i> , <i>P. cylindricus</i> , <i>Lambeophyllum?</i> <i>corniculum</i> others: <i>Palaeophyllum</i> sp., <i>Brachyelasma</i> cf. <i>fenggangense</i>
Lower-middle part	Typical <i>Hirnantia</i> fauna <i>Hirnantia sagittifera</i> , <i>Hirnantia</i> sp., <i>Triplesia</i> sp., <i>Cliftonia</i> sp., <i>Eostropheodonta parvicostellata</i> , <i>Plectothyrella crassica</i> , <i>Hindella crassa incipiens</i>	<i>Amplexobrachyelasma</i> , <i>Brachyelasma</i> , <i>Bodophyllum</i> , <i>Dalmanophyl-</i> <i>lum</i> , <i>Densigrewingia</i> , <i>Eurogrewingia</i> , <i>Helicelasma</i> , <i>Kenophyllum?</i> , <i>Leolasma</i> , <i>Pycnatoides</i> , <i>Salvadorea</i> , <i>Sinkiangolasma</i> , <i>Siphonolasma</i> , <i>Streptelasma</i> , <i>Ullermelasma</i> and some other genera