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Darriwilian (Middle Ordovician) graptolites from the northern margin of the Qaidam Basin (Qinghai, China)

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ABSTRACT

A restudy of the early Darriwilian graptolites from the Dameigou section in the Qaidam Basin provides some new information for graptolite biostratigraphy. The section contains a number of biserial faunas and easily identifiable *Holmograptus* Kozlowski, 1957, which are the marked faunas of the early Darriwilian. According to the biostratigraphic occurrences of the species, the *Levisograptus dentatus* Zone and the *Holmograptus lentus* Zone are identified from the Qaidam Basin. At the same time, the identification of these two graptolite zones provides materials for replacing the old, long-ranging *Amplexograptus confertus* Zone.

Introduction

The northern margin of the Qaidam Basin (southern slope of Qilian Mountains) is one of the classic study areas for Middle Ordovician graptolitic strata in northwest China. Of the several sections in this area, the Shihuigou section contains a rich assemblage of Middle Ordovician graptolites.

The graptolites from this region were first studied by Hsü (1959), Mu et al. (1962) and Mu (1963). In 1959, Hsü identified the *Amplexograptus confertus* Zone in this region. Subsequently, Mu et al. (1962) and Mu (1963) identified the *Pterograptus elegans* Zone and the *Amplexograptus confertus* Zone, the latter zone was subdivided into the *Cardiograptus yini* Subzone and the *Paraglossograptus typicalis* Subzone. Chen et al. (2001) restudied the Ordovician graptolites collected from this region and suggested that the *C. yini* Subzone and the *P. typicalis* Subzone should be replaced by the *Archiclimacograptus confertus* Zone and the *Undulograptus austrodentatus* Zone, respectively. In addition, Ge et al. (1990) identified *Tylograptus* Subzone and the *Paraglossograptus typicalis* Subzone from the Miboshan Formation in Tongxin, Ningxia. These strata all belong to the Darriwilian.

Materials and methods

The Shihuigou Formation originated from the ‘Shihuigou Shale’ redefined by Sun (1997). The strata are rich in graptolites, which are only distributed in Shihuigou and Oulongbuluk areas. The Shihuigou Formation is characterized by black shale with thin limestone, which conformably overlies the Duoquanshan Formation. The graptolite specimens were collected from poorly consolidated black or dark grey shales (Fig. 1). The section belongs to the lower part of the Shihuigou Formation (total thickness is 22.72 m), and the graptolite specimens were collected bed by bed, starting from the base of the section. Most specimens were photographed directly. The materials are deposited in the collections of the Institute of Geology, Chinese Academy of Geological Sciences. The electronic documentation of the study on fossils and strata is deposited in the Geological Survey Stratigraphy and Palaeontology Database of China at http://8.140.107.20:8080/navigator/index.aspx.

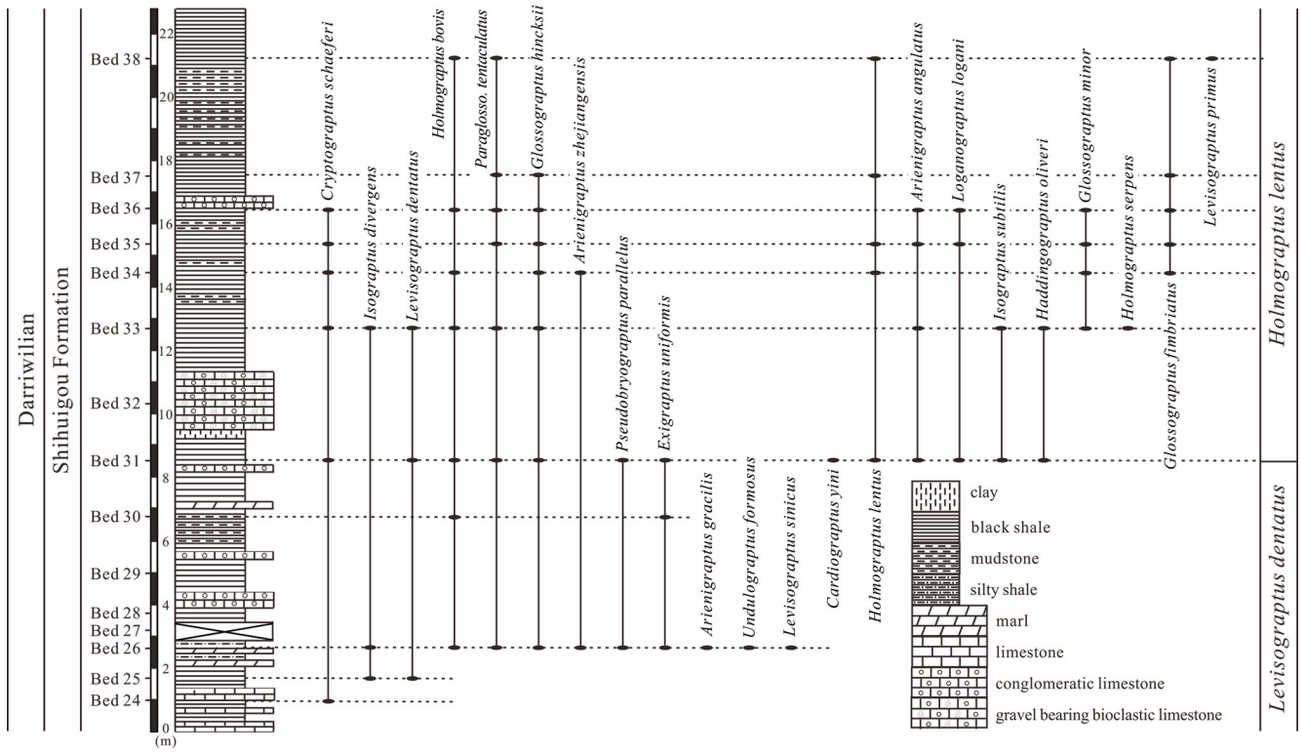

Fig. 1. Graptolite biostratigraphy of the Dameigou section, Qaidam Basin.

The faunal succession

In the Qaidam Basin, the early Darriwilian was identified by *Levisograptus dentatus* Brongniart. In this study, we recognized *L. dentatus* Brongniart, *L. sinicus* Mu and Lee, *Holmograptus lentus* Törnquist (Fig. 2). Since *H. lentus* is the zone fossil of the *Holmograptus lentus* Zone, we identified two zones in the study area: the *Levisograptus dentatus* Zone and the *Holmograptus lentus* Zone.

The *Levisograptus dentatus* Zone

The bottom boundary of the *Levisograptus dentatus* Zone is defined by the first appearance strata (FAD) of *Levisograptus dentatus* Brongniart. In the Qilian Mountains, the FAD of *Levisograptus dentatus* is recognized in Bed 25 (see Fig.1). The graptolite fauna in this zone is very diverse, with many biserial faunas (e.g. *Levisograptus dentatus* Brongniart, *Levisograptus sinicus* Mu and Lee, *Levisograptus primus* Legg and *Undulograptus formosus* Mu and Lee). In our section, *L. dentatus* is associated with *L. sinicus* and *Holmograptus bovis*, and this fossil assembly in the *L. dentatus* Zone is similar to that in Canada and Argentina (Ortega and Albanesi 2003; Maletz 2009; Serra et al. 2017).

Levisograptus dentatus Brongniart (=*Glyptograptus dentatus* (Brongniart)) is a species indicated in the early studies on graptolitic strata in the southern slope of Qilian Mountains. Mu et al. (1962) and Mu (1963) identified the *Amplexograptus confertus* Zone (Fig. 3), including the *Cardiograptus yini* Subzone and the *Paraglossograptus typicalis* Subzone in the Shihuigou section (south of our section). There, in the *Paraglossograptus typicalis* Subzone, *Pseudoclimacograptus formosus* Mu and Lee (=*Undulograptus formosus* Mu and Lee) and *Glyptograptus dentatus* (Brongniart) occur, which are common fossils of the *L. dentatus* Zone from our Dameigou section. The *Paraglossograptus typicalis* Subzone in the Shihuigou section is generally correlated with the *L. dentatus* Zone from the study section.

The *Holmograptus lentus* Zone

The bottom boundary of the *Holmograptus lentus* Zone is defined by the FAD of *Holmograptus lentus*. In the Qilian Mountains, the FAD of *Holmograptus lentus* is recognized in Bed 31 (Fig. 1). This unit is rich in *Holmograptus* Kozlowski, the *Holmograptus lentus* Zone of the Dameigou section has different species of *Holmograptus* Kozlowski, including *Holmograptus lentus* Törnquist, *H. bovis* Williams and Stevens, *H. serpens* Brussa (Fig. 2), which is similar to that in Precordillera, Argentina (Ortega and Albanesi 2003).

The relationship between *Holmograptus* Kozlowski and *Tylograptus* Mu is still controversial. Some researchers suggest that these two genera are similar (Jaanusson 1965; Skevington 1965; Maletz 2009). Referring to the aperture and prothecal folds, Zhang and Fortey (2001) suggested that these two genera are still valid. According to the materials in our section and the supplementary figures in Zhang and Fortey (2001, TEXT-FIG. 3.c) and Mu et al. (1962), we found that *Tylograptus geniculiformis* Mu and *Holmograptus lentus* Törnquist share similar aperture features and prothecal folds, and we advocate that these two species are the same.

The *Amplexograptus confertus* Zone is identified in the Miboshan Formation in Tongxin, Ningxia, it includes the *Tylograptus* Subzone and the *Paraglossograptus typicalis* Subzone (Ge et al. 1990). Chen et al. (2001) restudied this formation and revised the *Tylograptus* Subzone to the *Tylograptus* Zone, the *Paraglossograptus typicalis* Subzone to the

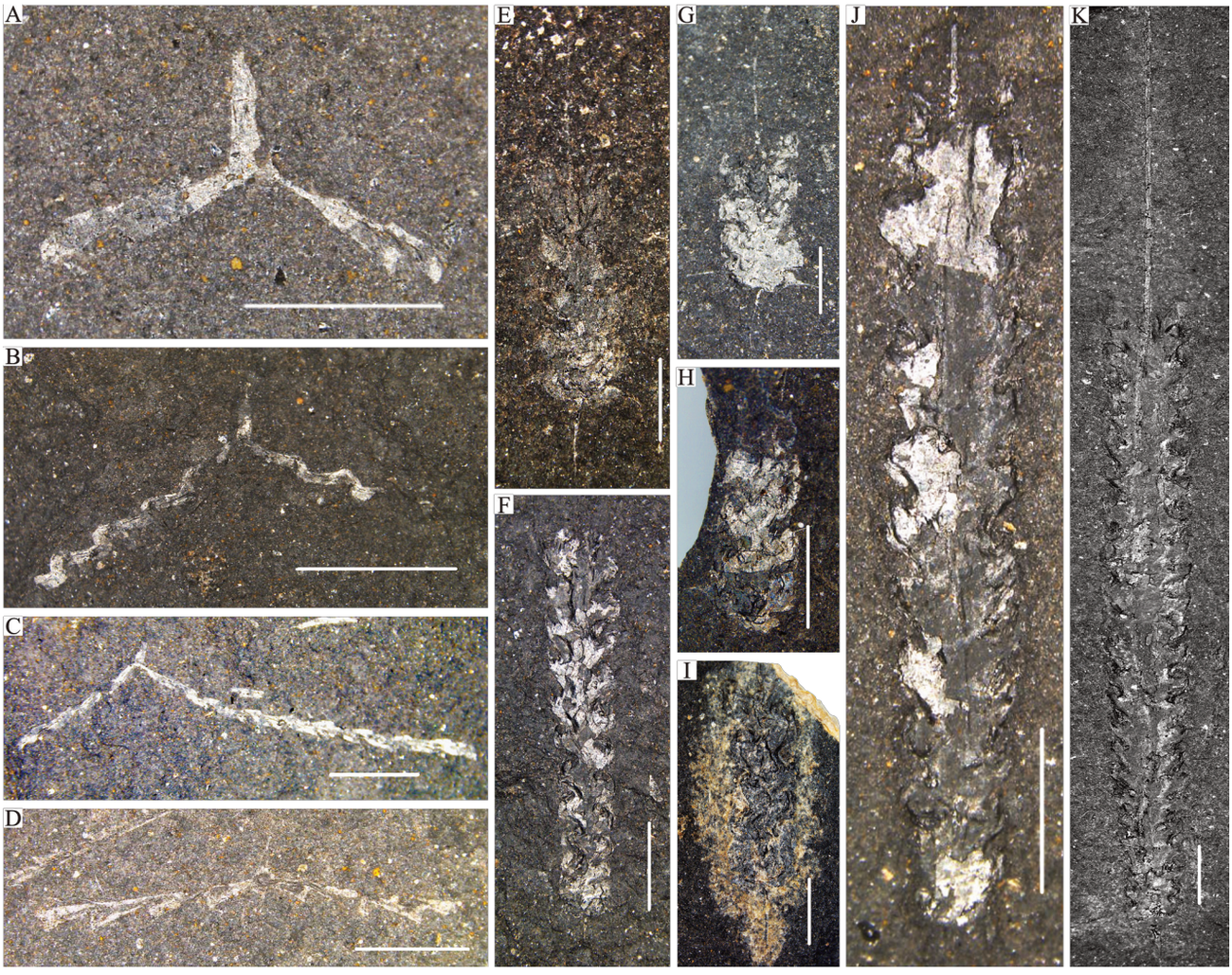

Fig. 2. **A** – *Holmograptus bovis* Williams and Stevens, 8.25–8.45 m; **B** – *Holmograptus serpens* Brussa, 12.11–12.31; **C** – *Holmograptus lentus* Törnquist, 8.25–8.45 m; **D** – *Xiphograptus lofuensis* Lee, 8.25–8.45 m; **E** – *Levisograptus sinicus* Mu and Lee, 1.50–1.70 m; **F** – *Levisograptus sinicus* Mu and Lee, 8.25–8.45 m; **G** – *Undulograptus primus* Legg, 20.54–20.74 m; **H** – *Undulograptus primus* Legg, 16.68–16.88 m; **I** – *Undulograptus formosus* Mu and Lee, 12.11–12.31 m; **J, K** – *Levisograptus dentatus* Brongniart, 8.25–8.45 m, 8.25–8.45 m. Specimen numbers: **A** – QHDM 31-116-05; **B** – QHDM 33-27-07; **C** – QHDM 31-70-03; **D** – QHDM 31-09-02; **E** – QHDM 26-60-01; **F** – QHDM 31-05-01-02; **G** – QHDM 38-23-01; **H** – QHDM 37-10-03; **I** – QHDM 33-14-06; **J** – QHDM 31-02-01; **K** – QHDM 31-65-01. **B**, **D**, **E**, **F**, **H**, **I** were photographed under water. The white bar = 2 mm.

<table>
<tr><th colspan="4">China</th><th>Canada</th><th>Argentina</th></tr>
<tr><th colspan="3">Shihuigou section, Qaidam Basin</th><th>Tongxin section, Ningxia</th><th>Dameigou section, Qaidam Basin</th><th rowspan="2">Maletz 2009</th><th rowspan="2">Ortega and Albanesi 2003; Serra et al. 2017</th></tr>
<tr><th>Hsü 1959</th><th colspan="2">Mu et al. 1962; Mu 1963</th><th>Ge et al. 1990; Chen et al. 2001</th><th>This paper</th></tr>
<tr><td rowspan="4">Amplexograptus confertus Zone</td><td rowspan="4">Amplexograptus confertus Zone</td><td rowspan="3">Cardiograptus yini Subzone</td><td rowspan="4">Tylograptus Zone</td><td></td><td>Holmograptus spinosus Zone</td><td>Holmograptus spinosus Zone</td></tr>
<tr><td>Holmograptus lentus Zone</td><td>Holmograptus lentus Zone</td><td>Holmograptus lentus Zone</td></tr>
<tr><td>Levisograptus dentatus Zone</td><td>Levisograptus dentatus Zone</td><td>Levisograptus dentatus Zone</td></tr>
<tr><td>Paraglossograptus typicalis Subzone</td><td></td><td>Levisograptus austrodentatus Zone</td><td>Levisograptus austrodentatus Zone</td></tr>
</table>

Fig. 3. Correlation chart for China, Canada and Argentina.

Undulograptus austrodentatus Zone, respectively (Fig. 3). In this section, the *Tylograptus* Zone includes *Tylograptus* sp., *T. spinatus* Mu, *T. regularismus* Mu and *T. globiformis* Mu. There, *T. globiformis* Mu is related to *Holmograptus lentus*. Thus, the *Tylograptus* Zone in the Miboshan Formation of Ningxia is comparable to the *Holmograptus lentus* Zone in our section. Mu et al. (1962) recognized that *Cardiograptus yini* M., G. and Y. are associated with *L. dentatus* and *H. lentus*

(*H. lentus* was named *Tylograptus geniculiformistong* in Mu et al. 1962) in the *Cardiograptus yini* Subzone of the *Amplexograptus confertus* Zone. The FAD of *H. lentus* is at the base level of the *Cardiograptus yini* Subzone (Mu et al. 1962). In our study area, *Cardiograptus yini* M., G. and Y., *H. lentus* Törnquist also appeared in the same layer, whereas the *Cardiograptus yini* Subzone was including *Cardiograptus yini*, *H. lentus* and *L. dentatus* in the Shihuigou section. Therefore, we supposed that the *Cardiograptus yini* Subzone in the Shihuigou section is comparable to the *Holmograptus lentus* Zone in the Dameigou section.

Conclusions

The Dameigou section in the northern margin of the Qaidam Basin represents early Darriwilian stratigraphic successions in the lowest portion of the Shihuigou Formation. The Darriwilian graptolite fauna includes biserial elements (e.g. *Undulograptus* Bouček and *Levisograptus* Maletz). Referring to our collections, two zones (the *Levisograptus dentatus* Zone and the *Holmograptus lentus* Zone) have been identified. Nowadays, the Darriwilian stratigraphic successions identified in the northern margin of the Qaidam Basin include the *Undulograptus austrodentatus* Zone, the *Levisograptus dentatus* Zone, the *Holmograptus lentus* Zone, the *Pterograptus elegans* Zone (from bottom to top).

Acknowledgements

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References

Chen, X., Zhang, Y. D. and Mitchell, C. E. 2001. Early Darriwilian graptolites from central and western China. *Alcheringa*, **25**(2), 191–210.

Ge, M. Y., Zheng, Z. C. and Li, Y. Z. 1990. *Research of Ordovician and Silurian Graptolites and Graptolite Bearing Strata from Ningxia and the Neighbouring Districts*. Nanjing University Press, Nanjing (in Chinese).

Hsü, S. C. 1959. A new graptolite fauna from the Lower Ordovician shale of Tsaidam, Chinghai Province. *Acta Palaeontologica Sinica*, **7**(3), 161–192.

Jaanusson, V. 1965. Two multiramous graptoloids from the lower didymograptus shale of Scandinavia. *Geologiska Föreningens i Stockholm Förhandlingar*, **86**(4), 413–432.

Maletz, J. 2009. *Holmograptus spinosus* and the Middle Ordovician (Darriwilian) graptolite biostratigraphy at Les Méchins (Quebec, Canada). *Canadian Journal of Earth Sciences*, **46**(10), 739–755.

Mu, A. T. 1963. Research in graptolite faunas of Chilianshan. *Scientia Sinica*, **12**(3), 347–371.

Mu, E. Z., Li, J. J., Ge M. Y. and Yin, J. X. 1962. *Graptolites from the Qilian Mountains*. Science Press, Beijing (in Chinese).

Ortega, G. and Albanesi, G. 2003. Los Azules Formation, Cerro Viejo, Huaco, Precordillera of San Juan Province. *Instituto Superior de Correlación Geológica, Miscelánea*, **10**, 65–79.

Serra, F., Feltes, N. A., Ortega, G. and Albanesi, G. L. 2017. Lower middle Darriwilian (Ordovician) graptolites and index conodonts from the Central Precordillera of San Juan Province, Argentina. *Geological Journal*, **53**(5), 2161–2177.

Skevington, D. 1965. Graptolites from the Ontikan Limestones (Ordovician) of Öland, Sweden. 2. Graptoloidea and Graptovermida. *Bulletin of the Geological Institute of the University of Upsala*, **43**(3), 1–74.

Sun, C. R. 1997. *Multiple Classification and Correlation of the Stratigraphy of China (63): Stratigraphy* (*Lithostratic*) *of Qinghai Province*. China University of Geosciences Press, Wuhan (in Chinese).

Zhang, Y. D. and Fortey, R. A. 2001. The proximal development and thecal structure of the Ordovician graptolites *Tylograptus* and *Sinograptus*. *Palaeontology*, **44**(3), 553–573.