

GRAPTOLITE-BEARING STRATA OF CHINA

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During the past ten years graptolite-bearing strata were repeatedly discovered in various localities by the members of the Geological Survey of China, and by the Expedition of the National Peking University and the collections¹ of graptolites were obtained from different horizons (Tremadocian-Valentian).

In both Ordovician and Silurian beds of China two facies may be recognized—the graptolitic and the shelly facies. These two facies do not represent any distinct period, but characterize different areas rather than different epochs, and owe their characters to the conditions under which they were laid down. As examples we may cite the Ichang limestone and the Yinchufu formation in the Lower Ordovician, and the Machiakou limestone and Pingliang shale in the Middle Ordovician.

The relationship of the Mientian group and the Sintan formation in the Lower Silurian is essentially the same.

The graptolites are abundantly found in the graptolitic facies which was formed much more slowly, and was evidently laid down under special conditions in sediments of the finest of the material derived from the land, and they are rarely found in limestones. The graptolite assemblage² of each of the formations of China are briefly stated as follows:—

1. YEHLI LIMESTONE³

This formation represents the lowest horizon of the Ordovician in China. Its locality is at Chaokaochuang, Kaiping. Three different fossiliferous horizons were reported by the author in 1921. The thickness is approximately 400 m. By far the most important is the discovery of *Dictyonema flabelliforme* in the

1 Y. C. Sun: Cambrian, Ordovician and Silurian of China, pp. 5-9. Extrait du Compte Rendu XIVe Congrès Géologique International, 1926.

2 Y. C. Sun: Ordovician and Silurian Graptolites from China. Palæontologia Sinica, Ser. B, Vol. XIV, Fasc. 1. (Ready for publication).

3 Y. C. Sun: Relationship of the Ordovician Strata of the Kaiping Basin, Bull. Geol. Soc. China, Vol. III, No. 1, p. 17.

lowest part of this formation. The graptolites are abundant and well preserved in the dark shale layers between the limestone beds and furnish the following species:

Dictyonema flabelliforme (Eichwald)

Bryograptus sp.

Goniograptus sp.

This assemblage certainly indicates the Tremadocian age of the English succession. The Yehli limestone is, indeed, the lowest graptolite horizon so far known in China.

2. ICHANG LIMESTONE

The Ichang limestone has the enormous thickness of over 1000 meters. One species of graptolite *Callograptus salteri* Hall, was obtained from the upper part of this formation by the University Expedition under the direction of Prof. J. S. Lee in 1924. This species was reported by Hopkinson and Lapworth from the middle Arenigian of White Sand Bay, St. Davids, Wales and also found by H. F. Cleland in the Beekmantown beds at Tribes Hills, in the Mohawk valley, N. America.

It is almost certain that at least the upper part of the Ichang limestone is equivalent to the Arenig of England and is of Lower Ordovician age.

The same formation (Wushihmen limestone)⁴ at Wushihmen, Kiangsi yielded a second graptolite *Dendrograptus* cf. *persculptus* Hopkinson which is a typical form of the Arenigian of St. Davids rock of Wales and was first described by Hopkinson.

3. YINCHUFU FORMATION⁵

This formation is mainly composed of shales and is an equivalent of the I-chang limestone, but differs in facies. Its thickness is from 600 to 800 meters. The thick horizontal *Didymograptus hirundo* and other species were obtained from the middle part of this formation at two fossil localities (Loc. 1 & 2, see below) by Messrs. Chao and Liu in the vicinity of Lungyu district Chekiang.

⁴ C. C. Wang, Geology of the Shini valley, Kiangsi, Bull. Geol. Surv. China, No. 14, p. 14.

⁵ C. C. Liu & Y. T. Chao: Geology of South-western Chekiang, Bull. Geol. Surv. China, No. 9, pp. 11-28.

The species obtained were:

From Locality 1. Lopingtsun (Yinchufu, Yuchian)

Didymograptus hirundo Salter

Didymograptus erratulus Hall

From Locality 2. Shifu (Lungyu)

Didymograptus nicholsoni Lapworth

Didymograptus simulans Lapworth

Phyllograptus cf. angustifolius Hall

This assemblage is essentially that of the zone of *Didymograptus hirundo* Salter and is of Arenigian age.

4. NEICHIA FORMATION⁶

This formation is widely distributed throughout Central and Southern China. Its thickness ranges from 60 to 180 m. It consists mainly of two parts; the upper part is chiefly of limestone abounding in *Orthoceras chinense* while the lower shale is characterized by a combined fauna of trilobites and graptolites. The most common and striking species is the tuning-fork Didymograptid *Didymograptus murchisoni* which is the leading form of the Llandeillian of Llanviru village in South Wales.

The following assemblage⁷ of species was first reported by Reed as identified by Elles:

Didymograptus murchisoni var. *geminus* (Hisinger)

Didymograptus indentus (Hall)

Climacograptus cf. scharenbergi Lapworth

The Ordovician shale of Ordos probably represents the same horizon and contains the following.⁸

Didymograptus euodus Lapworth

Climacograptus teilhardi Grabau

Climacograptus licenti Grabau

6 J. S. Lee, Geology of the Gorge District of the Yangtze, Bull. Geol. Soc. China Vol. III, No. 3-4, p. 367-375.

7 F. R. Cowper Reed, Ordovician and Silurian Fossils from Yunnan, Palaeontologia Indica, New Ser. Vol. VI. Mem. No 3, p. 3.

8 A. W. Grabau, Stratigraphy of China pt. I, p. 429.

The same formation (Yenwashan formation) is also found in Chekiang province and characterized by the following species of graptolites.

Glossograptus hincksii

Dicellograptus sp.

Climacograptus sp.

This material furnishes no characteristic assemblage of any certain zone, and probably indicates the Llandeilian age. Further search for graptolites in this region is necessary.

5 PINGLIANG SHALE⁹

This shale was named after Ping Liang district by Prof. P. L. Yuan and is an equivalent of the Machiakou limestone of northeastern China. The assemblage of this formation is as follows:

Didymograptus sagitticaulis Gurley

D. yuani Sun

Nemagraptus exilis (Lapw.)

N. gracilis (Hall)

Dicranograptus kansuensis Sun

Dicellograptus divaricatus (Hall) var. *pinlianensis* Gr. & Sun

Climacograptus Hall

C. bicornis Hall

Diplogr. (*Orthograptus*) *whitfieldi* (Hall)

Diplogr. (*Glyptograptus*) *angustifolius* (Hall)

Diplogr. (*Glyptograptus*) *teretiusculus* var. *kansuensis* Gr.

These assemblages are essentially those of two zones of *Diplograptus* (*Glyptograptus*) *teretiusculus* and *Nemagraptus gracilis* and are certainly of Llandeilian age. This horizon is comparatively higher than that of the Neichia shale. The exact thickness is not known owing to the incomplete exposures.

6. WUFENG SHALE

(Basal part of Sintan shale of Willis)

This formation is the lowest part of the Sintan shale and its type locality is at Yüyangkuan Wufeng district. The beds are mostly light colored shales

⁹ P. L. Yuan: The Ordovician Graptolite Beds of Ping Liang, E. Kansu, Bull. Geol. Soc. China. Vol. IV, No. 1, p. 19.

with abundant fossils. The following are the assemblages of graptolites from that horizon.

Climacograptus supernus Elles & Wood

Climacograptus latus Elles & Wood.

Diplograptus (*Glyptograptus*) cf. *amplexicaulis* (Hall)

Diplograptus (*Orthograptus*) *truncatus* var. *abbreviatus*

Diplog. (*Glyptograptus*) cf. *amplexicaulis* (Hall) was found in the Upper Trenton limestone of the Albany region, at Mt. Mareno, North America, and the other three species are the assemblage of the zone of *Dicellograptus anceps* of Great Britain.

Certainly this assemblage represents the highest beds of the Upper Ordovician, and is of Ashgillian age. This can be further confirmed by the total absence of the *Monograptids*.

Dr. Gortrude L. Elles informed me that the assemblage of the Wufeng collection is essentially of Ashgillian age, Prof. C. Y. Hsieh also reported that the Wufeng horizon occupies the lowest position in the Sintan formation.

The total absence of the Caradocian, and the lithological character of this bed, may suggest that the Wufeng bed with transition assemblage might be considered as the lowest member of the so-called "Lungma" Shale and is of earliest Silurian. Such a classification might be convenient for the field geologists in this country.

7. FUCHIH SHALE

(Sintan Formation)

The name Lungma shale was first proposed by J. S. Lee for the lower graptolite-bearing strata of the Sintan formation which are widely distributed elsewhere in Central and Southern China. The name however was preoccupied by Hayden for a Jurassic formation in Tibet and hence the above name is substituted with Prof. Lee's consent. Several important collection of graptolites have been made from different localities.

A. Lunshan, Kiangsu.

Climacograptus scalaris var. *normalis* Lapw.

C. törnquisti Elles & Wood.

C. medius Törnquist

Diplog. (Glytop.) incertus Elles & Wood.

Monog. incommodus Törnquist

Monog. argutus Lapworth

Climacogr. looi Sun

Dimorphograptus confertus var. *nankingensis* Sun

Both *Monograptus* cf. *incommodus* Törnquist and *Dimorphograptus confertus* (Nicholson) are the typical forms of the zone of *M. cyphus* of England and this assemblage indicates the Lower Valentian age.

B. Fenhsiang (Ichang)¹⁰.

The following assemblage of graptolites was obtained by Messrs. C. Y. Hsieh and Y. T. Chao from deep black shale.

Diplograptus (Orthograptus) vesiculosus Nich.

Diplograptus (Mesograptus) modestus Lapw.

Climacograptus medius Törnquist

Petalograptus palmeus (Barrande)

Diplogr. (Orthograptus) vesiculosus & *Climacograptus medius* are practically confined to the zone of *Orthograptus vesiculosus* while *Diplogr. (Mesograptus) modestus* and *Petalograptus palmeus* are characteristic of that zone. This assemblage is certainly that of the zone of *Orthograptus vesiculosus* and is of early Valentian age.

C. Lengshuichao, Chang Yang district.

The following species of graptolites¹¹ were collected by Messrs. C. Y. Hsieh and C. C. Liu from black shale with striking white colored graptolites.

Petalograptus palmeus (Barrande)

Petalograptus minor Elles

Monograptus gemmatus (Barr.)

Monograptus clingani (Carruthers)

Monograptus crenularis Lapworth

¹⁰ C. Y. Hsieh & Y. T. Chao: Geology of Ichang & neighbouring districts. Bull. Geol. Surv. China, No. 7, p. 35.

¹¹ C. Y. Hsieh & C. C. Liu: Geology and Mineral Resources of S. W. Hupeh, Bull. Geol. Surv. China, No. 9, p. 38.

Monograptus changyangensis Sun

Rastrites hybridus (Lapworth)

This assemblage with *Petalograptus minor*, *P. palmeus* and *Monogr. clingani* corresponds to that of the zone of *M. gregarius* and of *M. convolutus*, and certainly belongs to the upper part of the Lower Valentian.

D. Lungma, Ichang.

A large collection of graptolites was made by the National University Expedition under the direction of Prof. J. S. Lee, and the following species were obtained:

Diplogr. (Glyptogr.) lungmaensis (Sun)

Petalograptus palmeus (Barrande)

Cephalograptus cometa (Geinitz)

Monograptus intermedius (Carruthers)

Monogr. marri Perner

Monogr. raitzhainiensis (Eisel)

Monogr. communis (Lapworth)

Monogr. regularis Törnquist

Monogr. turriculatus (Buv.) var. *dimorphus* Sun

Monogr. crenularis Lapworth

Monograptus sedgwickii (Portlock)

This assemblage of species corresponds mostly is that of the upper Valentian (particularly the zone of *M. sedgwickii* and that of *M. turriculatus*).

E. Shitien, Yunnan.

Two horizons were reported by Reed:

1. A lower horizon with the following species;

Monogr. incommodus Törnquist

Monogr. regularis Törnquist

M. tenuis Portlock

Climacogr. rectangularis McCoy

C. törnquisti Elles & Wood

Mesogr. modestus Lapw.

This assemblage may correspond to that of the zone of *Orthogr. vesiculosus*.

2 An upper horizon with the following species.

Monogr. sedgwickii Portlock.

M. lobiferus McCoy

M. tenuis Portlock.

M. leptotheca Lapw.

M. alatus Jones

M. jaculum Lapw.

M. concinnus Lapw.

M. geminatus Barr.

Glytogr. serratus Elles & Wood

G. incertus Elles & Wood

Climacogr. scalaris His.

Climacogr. perlatus Nich. & Wood

Mesogr. magnus Lapw.

This assemblage is essentially the same as that of the zone of *M. sedgwickii* and the lower part of upper Valentian.

F. Tungtze.

The collections made by Dr. V. K. Ting comprise the following graptolites

Monogr. regularis var. nov.

M. crenularis Lapw.

M. argutus Lapw.

M. concinnus Lapw.

M. decipiens Törnquist

M. cf. sandersoni Lapw.

Rastrites sp.

This assemblage is essentially the same as that of the Fuchih Shale collected by J. S. Lee and is of early upper Valentian age.

We may summarize these assemblages in the following table:

Assemblage of Sintan formation (particularly Fuchih shale).....	$\left\{ \begin{array}{l} \textit{Monogr. crenularis} \\ \textit{Monogr. turriculatus} \\ \textit{Monogr. sedgwickii} \\ \textit{Orthogr. vesiculosus} \end{array} \right\}$	Valentian	L. Sil.
Assemblage of Wufeng shale (lower part of Sintan formation).....	<i>Climacogr. supernus</i>	Ashgillian	U. Ord.

Assemblage of Pingliang shale.....	<i>Nemagr. gracilis</i>	} Llandeilian M. Ord.
	<i>Glyptogr. teretisculus</i>	
Assemblage of Neichia shale.....	<i>Didymogr. murchisoni</i>	
Assemblage of Yinchufu shale (in part).....	<i>Didymogr. hirundo</i>	} Ardenigian } L. Ord.
Assemblage of Ichang limestone (in upper part)	<i>Callograptus</i> sp.	
Assemblage of Yehli limestone.....	<i>Dictyonema flabelli-</i> <i>forme</i>	Tremadocian }