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GRAPTOLITES FROM THE DAWAN FORMATION (LOWER ORDOVICIAN) OF W. HUPEH AND S. KUEICHOU

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I. Introduction

The graptolites described in the present paper were collected by Profs. Y. Wang, A. T. Mu, W. T. Chang and others from the Lower Ordovician Dawan formation of the Ichang-Tzekuei area, western Hupeh during 1956—1957 and by Messrs. W. N. Lee, S. S. Chang and the writer from the Dawan formation of the Makiang district, southern Kueichou in the spring of 1959. More than twenty species belonging to 10 genera are recognized. Among them four species and varieties are new.

The writer wishes to express his indebtedness to Prof. A. T. Mu for instruction and critical reading of the manuscript.

2. Stratigraphical Remarks

The Dawan formation is proposed by W. T. Chang and others in 1956, for the strata between the *Cameroceeras* limestone below and the *Yangtzeella* bed (S. S.) above. It is composed of an alternation of shales and limestones. The type locality is Dawan, Fenhsiang, Ichang, W. Hupeh. In 1957, Y. Wang, A. T. Mu and others obtained late lower ordovician graptolites from the upper part of the *Yangtzeella* bed, corresponding to the zone of *Yangtzeella poloi* of K. C. Yang and A. T. Mu (Yang & Mu, 1954).

The Dawan formation is widely distributed in W. Hupeh and S. Kueichou, the lithological characters and faunas are as follows:

(1). W. Hupeh.

Guniutan limestone (Middle Ordovician)

—————Conformity—————

The upper part is composed of an alternation of thin-bedded grey limestones with dirty green shales, yielding *Didymograptus* cf. *nicholsoni* Lapworth, *Tetragraptus* Ap. aff. *bigsbyi* (Hall), *Trigonograptus ensiformis* (Hall), *Glyptograptus sinodentatus* minor Mu (var. nov.) etc. (WM 17, 20, 161, 163). 15—18 M.

The middle part is thick-bedded brownish limestone containing *Protocycloceras* sp. nov. and *Vaginoceras* sp. 4 M.

The lower part is composed of an alternation of thin-bedded grey nodular limestones with green shales, containing *Dictyonema* sp. *Acanthograptus*, sp. *Haplograptus canadensis* Ruedemann, *Didymograptus nicholsoni* Lapw., *D. asperus* H. et T., *Janograptus dawanensis* Lee (sp. nov.) *Azygograptus succicus* Moberg, *Tetragraptus* sp. (aff. *harti*), *T. reclinatus* E. et W., *T. bigsbyi* Hall, *T. serra* (Brongniart), *Phyllograptus anna* Hall, *P. angustifolius* Hall, *P. ilicifolius* Hall, etc. (WM 12B, 14, 157, 158, 159; WH 46 A, 46 B, 209; 210.) 11—14 M.

—————Conformity—————

Cameroceras limestone (Lower Ordovician).

Based on this section, Mu (1959) established two graptolite zones, the *Azygograptus succicus* zone below and the *Glyptograptus sinodentatus minor* zone above. The lower zone is equivalent with the zone of *Didymograptus hirundo* and the upper zone corresponds to the zone of *Didymograptus bifidus* or higher to the zone of *Didymograptus murchisoni*.

(II) S. Kueichou

Wonghsiang series (Middle-Upper Silurian)

—————Disconformity—————

The upper most part is a thick-bedded grey slabby limestone, yielding *Yangtzeella* sp., *Orthis* sp. (GY 2001B—C). ca. 5 M.

The upper part is composed of yellow sandstone and limestone, from the yellow sandstone the following graptolites are obtained: *Tetragraptus bigsbyi* (Hall), *T. serra* (Brongniart), *Glyptograptus sinodentatus minor* Mu (var. nov.) (GY 1199.) 43 M.

The middle part is a thick-bedded grey sandy limestone intercalated with greyish green shales, yielding *Didymograptus* cf. *abnormis* Hsü, *Phyllograptus anna* Hall, etc (GY 2007) 13 M.

The lower part is composed of an alternation of a thick-bedded pinkish nodular sandy limestone and greyish green shales, containing *Dichograptus erectus* Lee (sp. nov.) *Didymograptus abnormis* Hsü, *D. lofuensis* Lee (sp. nov.), *Phyllograptus anna* Hall (GY 1196, 1198). 45 M.

—————Conformity—————

Lower Ordovician *Cameroceras* series.

The middle part and lower part of this section are equivalent with *Azygograptus succicus* zone or *Didymograptus hirundo* zone. For no *Azygograptus succicus* is found and the occurrence of a characteristic form *Didymograptus abnormis*, this zone may be named *Didymograptus abnormis* zone. The upper part is the *Glyptograptus sinodentatus minor* zone, corresponding to *Glyptograptus sinodentatus minor* zone of W. Hupeh.

The *Azygograptus succicus* zone or *Didymograptus abnormis* zone is equivalent with *Didymograptus hirundo* zone of upper Arenigian and the *Glyptograptus sinodentatus minor* zone corresponds to the *Didymograptus bifidus* zone or the *Didymograptus murchisoni* zone of Llanvirnian of Europe.

Table 1. Stratigraphical distribution of Dawan graptolites

Name of Fossils	Zone of <i>Azygograptus suecicus</i> or zone of <i>Didymograptus abnormis</i>	Zone of <i>Glyptograptus sinodentatus minor</i>
<i>Dictyonema</i> cf. <i>asiaticum</i> Hsü	+	
<i>Acanthograptus</i> sp.	+	
<i>Haplograptus canadensis</i> Ruede.	+	
<i>Dichograptus erectus</i> Lee (sp. nov.)	+	
<i>Tetragraptus amii</i> Lapw.	+	
<i>T. reclinatus</i> E. et W.	+	
<i>T. bigsbyi</i> Hall	+	+
<i>T. serra</i> (Brongniart)	+	+
<i>T.</i> sp. A	+	
<i>T.</i> sp. B ₁		+
<i>Phyllograptus anna</i> Hall	+	
<i>P. angustifolius</i> Hall	+	
<i>P. ilicifolius</i> Hall	+	
<i>Trigonograptus ensiformis</i> (Hall)		+
<i>Didymograptus abnormis</i> Hsü.	+	
<i>D. lojuensis</i> Lee (sp. nov.)	+	
<i>D. asperus</i> H. et T.	+	
<i>D. similis</i> Hall	+	
<i>D. nicholsoni</i> Lapw.	+	+
<i>Janograptus dawanensis</i> Lee (sp. nov.)	+	
<i>Azygograptus suecicus</i> Moberg	+	
<i>Glyptograptus sinodentatus minor</i> Lee (var. nov.)		+

Description of species

Family Dendrograptidae Roemer, 1897

Genus *Dictyonema* Hall, 1851*Dictyonema* cf. *asiaticum* Hsü

(Pl. 1, fig. 1-2)

cf. 1948 *Dictyonema asiatica*, Hsü, Contr. Inst. Geol. VIII, P. 11, pl. 1, figs. 1, 2a-b, 3, 4.cf. 1955 *Dictyonema asiaticum*, Mu, Inst. Pal. Acad. Sinica, New Ser. B, No. 5, P. 10, pl. II, figs. 1-5.**Material:** only one incomplete specimen.

Description: The axial length of rhabdosome is about 14 mm. and the maximum width is about 2 mm. The stipes are 0.2 mm. in width, Sub-parallel, branching usually at intervals of 0.4 mm. The thecae are tube-like, overlapping $\frac{1}{2}$ and inclined at 25° . There are 3 dissipiments and 7 thecae in 5 mm.

Comparison: This form closely resembles *Diclyonema asiaticum* in chief character, but the apertural spines are absent.

Horizon and Locality: This species occurs in the zone of *Azygograptus suecicus* of the Dawan formation, Ichang, W. Hupeh; in association with *Azygograptus suecicus* Moberg, *Tetragraptus* cf. *bigsbyi* (Hall), etc. (Field no. WM 158; Cat. no. 10500, 10501).

Family Acanthograptidae Bulman, 1938

Genus Acanthograptus Spencer, 1878

***Acanthograptus* sp.**

(Text-fig. 1)

Material: Only one specimen.

Description: The rhabdosome is robust, composed of one main stipe and several lateral stipes, the main stipe is incomplete, about 15 mm. long and 0.8 mm. wide. The lateral stipes are thinner than the main stipe. The twigs are long, about 0.6 mm. in length. There are 3 twigs in 2.5 mm. The thecae are unknown.

Horizon and Locality: This species occurs in the zone of *Azygograptus suecicus* of Dawan formation, Ichang, W. Hupeh; in association with *Azygograptus suecicus* Moberg, *Phyllograptus anna* Hall, *P. angustifolius* Hall, etc. (Field No. WM 159; Cat. No. 10502).

Family Chaunograptidae Bulman, 1955

Genus Haplograptus Ruedemann, 1933

***Haplograptus canadensis* Ruedemann**

(Text-fig. 2)

Material: Only one specimen.

Description: The rhabdosome is composed of only one circular tube, 11 mm. in length and 0.3 mm. wide at the proximal end, widening rapidly to maximum breadth about 1 mm., in the middle portion of the tube, then maintained to the apertural portion.

Horizon and Locality: This species occurs in the zone of *Azygograptus suecicus*, of Dawan formation at Sintan, Tzekuei, W. Hupeh; in association with *Acanthograptus* sp. *Azygograptus suecicus* Moberg, *Phyllograptus anna* Hall, etc. (Field No. WM 209; Cat. No. 10503—10504).

Family Dichograptidae Lapworth, 1873

Genus Dichograptus Salter, 1863

***Dichograptus erectus* Lee (sp. nov.)**

(Pl. I, fig. 2)

Material: Only one specimen, but rather well-preserved.

Diagnosis: Rhabdosome consisting of 6 terminal stipes, 28 mm. long and 3.6 mm. wide. Thecae numbering 10 in 10 mm.

Holotype: Pl. I, fig. 2, Specimen 10505.

Description: The stipes are rigid, dividing to the third order, and consisting of 6 terminal stipes. The "funicle" is 2 mm. in length. The stipes of the second order are short, measuring 1.6 mm. in length and bifurcating at 140° . The terminal stipes are 28 mm. long and 36 mm. wide, bifurcating at an angle of 90° .

The sicula is unknown; the thecae are very long about 4.5 mm. and never exceeding 1 mm. in width, four times as long as wide, inclined at 50° . The thecae overlap $4/5$, and number 10 in 10 mm.

Comparison: This new species resembles *Dichograptus octonarius* (Hall) in general character, but the rhabdosome is robust and the stipes are erect; when only 4 stipes are preserved, this form is closely similar to *Tetragraptus serra*, but the thecae of this form are looser in arrangement.

Horizon and Locality: The new species occurs in the zone of *Didymograptus abnormis*, of Dawan formation at Lofu, Makiang, S. Kueichou; in association with *Didymograptus lofuensis* Lee (sp. nov.), *Phyllograptus anna* Hall, etc. (Field No. GY 1198; Cat. No. 10505).

Family Tetragraptidae Mu, 1950

Genus *Tetragraptus* Salter, 1863

Tetragraptus amii Lapworth

(Pl. II, figs. 2a—c; Text-fig. 3)

Material: Three specimens, all preserved as film.

Description: The rhabdosome is composed of four horizontal stipes, the stipes are 8 mm. in length, narrow in their origin (0.3—0.5 mm.), widening rapidly to maximum breadth 2 mm. The "funicle" 2—2.3 mm. in length and 0.3—0.5 mm. in width. The sicula is circular in shape, about 1.6 mm. in length. The thecae are four times as long as wide, overlapping $2/3$ — $3/4$, and inclined at an angle of 45° , number 10 in 10 mm.

Horizon and Locality: The species occurs in the *Azygograptus suecicus* zone of Dawan formation, Ichang, western Hupeh; in association with *Azygograptus suecicus* Moberg, *Tetragraptus bigsbyi* (Hall), *T. reclinatus* E. et W., *T. serra* (Brongniart), etc. (Field No. WM 12B, 158, WH 129; Cat. No. 10507—10509).

Tetragraptus reclinatus Elles et Wood

(Pl. II, figs. 3a—d)

Material: Many specimens, all preserved as film.

Description: The rhabdosome is composed of four reclined stipes, the stipes are 12 mm. in length, narrow in their origin, rapidly widening to maximum breadth about 1.2—1.8 mm. The sicula is long, 1.7 mm. in length. The thecae are three times as long as wide, overlapping $2/3$. There are 12—13 thecae in a length of 10 mm.

Comparison: The species resembles the small individual of *Tetragraptus serra*; but differs in the more slender stipes and closely arrangement of the thecae.

Horizon and Locality: This form occurs in the zone of *Azygograptus suecicus*, of Dawan formation, Ichang, western Hupeh; in association with *Azygograptus suecicus* Moberg, *Tetragraptus amii* Lapworth, *T. bigsbyi* (Hall), *T. serra* (Brongniart), etc. (Field No. WM 12B, 158; Cat. No. 10510—10514).

Tetragraptus bigsbyi Hall

(Pl. II, figs. 6a—c)

Material: Many specimens, all preserved as film.

Description: The rhabdosome is small consisting of four reclined stipes, narrow in their origin, gradually widening to the maximum breadth about 2 mm. at the middle part.

The sicula is about 1.8 mm. in length. The thecae overlap 2/3 to nearly throughout. The apertural margins are concave and oblique, provided with a distinct denticle. The thecae closely arranged, numbering 12—14 in 10 mm.

Comparison: The species closely resembles *Isograptus giberulus* when only two stipes are preserved, but the proximal end is narrow.

Horizon and Locality: The species occurs in *Azygograptus suecicus* zone of the Dawan formation at Dawan, Ichang, western Hupeh; in association with *Azygograptus suecicus* Moberg, *Tetragraptus amii* Lapworth, *T. reclinatus* Elles et Wood, *T. serra* (Brongniart) etc. (Field No. WM 12b, WM 158, Cat. No. 10515—10518). In Makiang, S. Kueichou, this species occurs in the zone of *Glyptograptus sinodentatus minor* of Dawan formation; in association with *Tetragraptus serra* (Brongniart), *Glyptograptus sinodentatus* var. *minor* Mu (var. nov.). Field No. GY 1199; Cat. No. 10519).

Tetragraptus serra (Brongniart)

(Pl. II, figs. 4a—c; Text-fig. 4)

Material: Five specimens, in which three are well-preserved.

Description: The rhabdosome is composed of four reclined stipes. The stipes are 26 mm. in length, narrow in their origin, widening rapidly to maximum breadth 2.5—3.2 mm. then maintained distally. The sicula is observed in one specimen, circular in outline, about 2 mm. in length. The thecae are tube-like, four times as long as wide, overlapping 2/3—3/4, inclined at 40°, numbering 11—12 in 10 mm.

Comparison: This form resembles *T. bigsbyi* and *T. reclinatus* in shape; but differs in larger size and looser arrangement of the thecae.

Horizon and Locality: This species occurs in the *Azygograptus suecicus* zone of Dawan formation, at Ichang, W. Hupeh; in association with *Azygograptus suecicus* Moberg, *Tetragraptus bigsbyi* (Hall), *T. reclinatus* E. et W., *Didymograptus* sp., etc. (Field No. WM 12B; Cat. No. 10520, 10521, 10524). In S. Kueichow, the species occurs in the *Glyptograptus sinodentatus minor* zone of Upper part Dawan formation; in association with *Tetragraptus bigsbyi* (Hall), *Glyptograptus sinodentatus* var. *minor* Mu (var. nov.) etc. (Field No. GY 1199, Cat. No. 10522—10523).

Tetragraptus sp. A.

(Pl. II, fig. 1)

Material: Only one specimen.

Description: The rhabdosome is small, composed of four horizontal stipes, the stipes of first order are 2 mm. in length and 0.6 mm. in width, and those of the second order (terminal stipes) are 4.5 mm. in length and 0.7—1.3 mm. in width. The thecae are slender, five times as long as wide. Overlapping 1/2 and inclined at 25°—30°. There are 5—6 thecae in 5 mm.

Comparison: The form resembles *T. harti* in outline, but differs in higher angle of inclination and in the closely arranged thecae.

Horizon and Locality: The form occurs in the zone of *Azygograptus suecicus* Moberg, of Dawan formation, Ichang, W. Hupeh; in association with *Azygograptus suecicus* Moberg, *Tetragraptus amii* Lapworth, *T. reclinatus* E. et W., *T. bigsbyi* (Hall), *T. serra* (Brongniart) etc. (Field No. WM 12B, Cat. No. 10506).

Tetragraptus sp. B.

(Text-fig. 5)

Material: Only one ill-preserved specimen.

Description: The rhabdosome is small, composed of four reclined stipes. The sicula is conspicuous; 1.5 mm. in length. The thecae are tube-like, overlapping 2/3, inclined at 35°. There are 6 thecae in 5 mm.

Comparison: This form resembles *T. bigsbyi* in outline.

Horizon and Locality: This form occurs in the *Glyptograptus sinodentatus minor* zone of Dawan formation, Ichang, W. Hupeh; in association with *Trigonograptus ensiformis* Hall, *Glyptograptus sinodentatus* var. *minor* Mu (var. nov.). (Field No. WM 20; Cat. No. 10525).

Family Phyllograptidae Lapworth, 1873

Genus *Phyllograptus* Hall, 1858

Phyllograptus anna Hall

(Pl. I, figs. 10a—c; Text-fig. 6)

Material: Many well-preserved specimens.

Description: The rhabdosome is small, oval in shape, exceeding 10 mm. in length; 8 mm. long is commonly occurrence, maximum width 3.7—5.7 mm. in the middle part or slight near distal end of the rhabdosome, but 4 mm. in width is usual occurrence. The sicula is not observed, the proximal thecae of the rhabdosome grow outwards and downwards, the later thecae grow gradually upwards and outwards. The thecae are slightly curved, narrow in the origin, widening to the apertural, inclined at a higher angle, overlapping nearly throughout. The apertural margins are concave, provided with a distinct denticle. They are closely arranged, numbering 7—8 mm. in 5 mm.

Comparison: This species easily distinguished from the known forms of the *Phyllograptus* by the small size and closely arrangement of thecae.

Horizon and Locality: This form occurs in *Azygograptus suecicus* zone of Dawan formation, Ichang, W. Hupeh; in association with *Azygograptus suecicus* Moberg, *Phyllograptus angustifolius* Hall, *P. ilicifolius* Hall, etc. and occurs in *Didymograptus abnormis* zone of Dawan formation at Makiang, South Kueicheu; in association with *Didymograptus abnormis* Hsü, *Dichograptus erectus* Lee (sp. nov.), etc. (Field No. WM 159, GY 1196, 1198; Cat. No. 10526—10531).

Phyllograptus angustifolius Hall

(Pl. I, figs. 11a—d; Text-fig. 7)

Material: Four specimens, all preserved as film.

Description: The rhabdosome varies with different individuals, the largest one about 40 mm. in length, maximum width 8 mm., but 4 mm. is commonest occurrence.

The sicula is not observed; the proximal thecae nearly horizontal, the later thecae gradually curved upwards and outwards. The thecae are narrow in origin, widening toward to apertural part, inclined at a higher angle, overlapping nearly throughout. The apertural margins are concave and oblique, provided with a distinct denticle, numbering 10—13 in 10 mm.

Comparison: This form is easily distinguished from other forms of the *Phyllograptus* by the narrow rhabdosome; the smaller individual resembles *P. ilicifolius* but differs in the distinct thecal denticle.

Horizon and Locality: This species occurs in *Azygograptus suecicus* zone of Dawan formation at Dawan, Ichang, W. Hupeh; in association with *Azygograptus suecicus* Moberg, *Didymograptus nicholsoni* Lapworth, *D. lofuensis* Lee (sp. nov.), *D. asperus* H. et T., *Acanthograptus* sp., *Dictyonema* sp., *Phyllograptus anna* Hall, etc. (Field No. WM 14, 159; WH 46A; Cat. No. 10532—10535).

Phyllograptus ilicifolius Hall

(Pl. I, figs. 12, Text-fig. 8)

Material: Two specimens.

Description: The rhabdosome is small, about 14—16 mm. in length, and 3.6—5 mm. in width.

The sicula is not observed. The proximal thecae grow nearly horizontal and the later thecae are gradually reclined. The thecae are straight or slightly curved, narrower in the origin, widening to the aperture, overlapping nearly throughout. The apertural margin is concave, provided with a obtuse denticle, numbering 13 in 10 mm.

Comparison: This form resembles the smaller individual *P. angustifolius*, but differs in the obtuse denticle.

Horizon and Locality: This species occurs in *Azygograptus suecicus* zone of the Dawan formation, Ichang, western Hupeh; in association with *Acanthograptus* sp., *Azygograptus suecicus* Moberg, *Didymograptus nicholsoni* Lapworth, *Phyllograptus anna* Hall, *P. angustifolius* Hall etc. (Field No. WM 14, WH 46B; Cat. No. 10536—10537).

Genus *Trigonograptus* Nicholson, 1869

Trigonograptus ensiformis (Hall)

(Pl. II, fig. 5)

Material: Only one incomplete specimen.

Description: The incomplete specimen is 7 mm. in length and 3.2 mm. in width. The thecae are alternate in arrangement, overlapping throughout. The apertural margins is straight, forming thus an even unbroken line. There are 11 thecae in 10 mm.

Horizon and Locality: This species occurs in the zone of *Glyptograptus sinodentatus minor* of the Dawan formation at Fenhsiang, Ichang, W. Hupeh; in association with *Didymograptus* sp., *Tetragraptus* sp., *Glyptograptus sinodentatus* var. *minor* Mu (var. nov.). (Field No. WM 17; Cat. No. 10538).

Family Didymograptidae Mu, 1950
Genus *Didymograptus* McCoy, 1951
***Didymograptus abnormis* Hsü**

(Pl. I, fig. 4, Text-fig. 9)

Material: Three specimens, all preserved as film, in which two are here illustrated.

Description: The rhabdosome is smaller, 2.4 mm. in length and 1.2—1.6 mm. in width. The stipes are straight, diverging from the sicula at 180°. The maximum width in the proximal end of the rhabdosome, but gradual diminution in width soon takes place towards the distal end. The sicula is conspicuous, about 1.8 mm. in length, the first theca (th_1^I) grows from the upper part of the sicula. The thecae are tube-like with slightly concave, apertural margins inclined at 30°. They overlap 1/2 and number 10 in a length of 10 mm.

Comparison: This species may be distinguished from all other *Didymograpti* by the greatest width at the proximal end.

Horizon and Locality: This species occurs in the zone of *Didymograptus abnormis* of Dawan formation at Makiang, S. Kueichow; in association with *Dichograptus erectus* Lee (sp. nov.), *Didymograptus lofuensis* Lee (sp. nov.), *Phyllograptus anna* Hall, etc. (Field No. GY 1196, 1198; Cat. No. 10539—10540, 10540a).

***Didymograptus lofuensis* Lee (sp. nov.)**

(Pl. I, figs. 3a—c; Text-fig. 10)

Material: Two specimens, rather well-preserved.

Diagnosis: Rhabdosome small with two horizontal stipes, extending 10 mm. in length, and 1 mm. in wide; sicula small; 5 thecae in 5 mm.

Holotype: Pl. I, figs. 3a, Text-fig. 10a, specimen 10541.

Description: The rhabdosome is small. Two stipes diverge from the sicula at 180°. They are about 10 mm. in length, narrow at their origin, then gradually widened, with a maximum width about 1 mm. in the distal end. The sicula is conspicuous, 1.2 mm. in length, with fine nema. The thecae are simple, overlapping 1/2, inclined at an angle of 30°. The apertural margins are straight or slightly concave. There are 5 thecae in a length of 5 mm.

Comparison: This new species resembles *Didymograptus similis* in general aspect but differs in smaller size and closer arrangement of the thecae.

Horizon and Locality: This new species occurs in the zone of *Didymograptus abnormis* of Dawan formation at Makiang, S. Kueichow; in association with *Dichograptus erectus* Lee (sp. nov.), *D. abnormis* Hsü, *Phyllograptus anna* Hall, etc. (Field No. GY 1196, WM 14; Cat. No. 10541—10543).

***Didymograptus asperus* Harris et Thomas**

(Pl. I, fig. 8)

Material: Only one specimen.

Description: The two stipes diverge at 180°, about 7 mm. in length and 1 mm. in width. The sicula is conspicuous, about 1 mm. in length. The first theca originates from the upper part of the sicula. The thecae are tube-like, four times as long as wide, overlapping 1/3—1/2.

The thecae in the proximal end of rhabdosome are inclined at about 20° , those in the distal portion are increased to 30° , then bend downward, forming with the axis of the stipes an angle of about 35° . The apertural margins are slightly concave, there are 5 thecae in 5 mm.

Horizon and Locality: This species occurs in the zone of *Azygograptus suecicus* of Dawan formation, Fenshiang Ichang, W. Hupeh; in association with *Phyllograptus anna* Hall, *Didymograptus nicholsoni* Lapworth, *D. lofuensis* Lee (sp. nov.), (Field No. WM. 14; Cat. No. 10544).

Didymograptus similis (Hall)

(Pl. I, fig. 5; Text-fig. 11)

Material: Only one specimen.

Description: The two stipes diverge at 180° , about 2.2 cm. in length and 11 mm. in width. The sicula is conspicuous, about 1.9 mm. in length. The first theca originates from the middle part of the sicula. The thecae are tube-like, three times as long as wide, overlapping $1/2$, inclined at 30° . The apertural margins are slight concave. There are 10—11 thecae in 10 mm.

Comparison: This species resembles *Didymograptus suecicus* in outline, but differs in the smaller width and looser arrangement of the thecae.

Horizon and Locality: This form occurs in the Dawan formation of Ichang, W. Hupeh (Field No. WM 125; Cat. No. 10545).

Didymograptus nicholsoni Lapworth

(Pl. I, fig. 6; Text-fig. 12)

Material: Two one specimens, one of which is rather well-preserved.

Description: The rhabdosome is small, consisting of two declined stipes. They diverge from the sicula at 150° , about 3 mm. in length and 0.7 mm. in width. The sicula is 1.4 mm. in length, with a fine nema. The thecae are inclined at an angle of 15° — 20° , overlapping $1/2$. The apertural margins are straight or slightly concave. Thecae number 5 in a length of 5 mm.

Horizon and Locality: The species occurs in the zone of *Azygograptus suecicus* and *Glyptograptus sinodentatus minor* of Dawan formation at Ichang, W. Hupeh; in association with *Azygograptus suecicus* Moberg, *Didymograptus lofuensis* Lee (sp. nov.), *Phyllograptus anna* Hall, etc. (Field No. WM 14, 161; Cat. No. 10546—10547).

Genus *Janograptus* Tullberg, 1880

Janograptus dawanensis Lee (sp. nov.)

(Pl. I, fig. 7; Text-fig. 13)

Material: Only one well-preserved specimen.

Diagnosis: Rhabdosome small, 10 mm. long and 1 mm. wide, two stipes horizontally extending; sicula obscure, thecae $3\frac{1}{2}$ in 5 mm.

Holotype: Pl. I, fig. 7, Text-fig. 13; specimen 10548.

Description: The rhabdosome in small. Two stipes diverge from the origin at an angle of 180° , but it is slightly reclined in the distal end. They are 10 mm. in length, narrow at their origin (th_1 , th_2), widening gradually to maximum breadth of 1 mm. and then maintained to the distal end. The sicula is absent. The thecae are very long, about 2.7 mm. in length, narrow in origin

and widening to apertural part, about 0.4 mm., 7 times as long as wide, inclined at a low angle of about 10° , overlapping $1/2$. The apertural margins are slightly concave. There are $3\frac{1}{2}$ in a length of 5 mm.

Comparison: This new species closely resembles *Janograptus gracilis* in general shape of the rhabdosome and the character of the thecae, but differ in larger width and inclined at a low angle.

Horizon and Locality: This new species occurs in the zone of *Azygograptus suecicus* of Dawan formation, Dawan, Ichang, W. Hupeh; in association with *Didymograptus* sp., *Azygograptus suecicus* Moberg, *Phyllograptus anna* Hall, *P. angustifolius* Hall, etc. (Field No. WH 46A; Cat. No. 10548).

Family Azygograptidae Mu, 1950

Genus *Azygograptus* Nicholson et Lapworth, 1875

Azygograptus suecicus Moberg

(Pl. I, figs. 9a—b)

Material: Many well-preserved specimens.

Description: The rhabdosome is slender, consisting of only one declined stipe.

The largest specimen, measures about 20 mm. in length, 1 mm. in breadth. The sicula is about 2 mm. in length, with a fine nema. The first theca (th_1^1) grows from the apertural part of the sicula; the thecae are long and slender, 3 mm. in length, 6 times as long as wide, inclined at a small angle of about 15° . The apertural margins are straight or slightly concave. The thecae overlap $1/2$ and numbering 6 in 10 mm.

Comparison: This species is easily distinguished from other Azygograpti by its small size and rigid outline.

Horizon and Locality: This species occurs in zone of *Azygograptus suecicus* of Dawan formation, Ichang and Tzekuei, W. Hupeh; in association with *Dictyonema* sp., *Acanthograptus* sp., *Didymograptus nicholsoni* Lapworth, *D. lofuensis* Lee (sp. nov.), *Phyllograptus anna* Hall, etc. (Field No. WM 12A, 14, 159, 201; Cat. No. 10549—10552).

Family Diplograptidae Lapworth, 1873

Genus *Glyptograptus* Lapworth, 1873

Glyptograptus sinodentatus var. *minor* Mu (var. nov.)

(Pl. II, figs. 7a—e; Text-fig. 14)

Material: Many well preserved specimens.

Diagnosis: Rhabdosome small, with square base, about 12 mm. long and 2.8—3.2 mm. wide; thecae long, overlapping $2/3$, and numbering 12 in 10 mm.

Holotype: Pl. II, fig. 7e; Text-fig. 14g; Specimen 10559.

Description: The rhabdosome is small, with nearly parallel sides and square base, about 12 mm. in length and 2.8—3.2 mm. in width, the width is somewhat diminished distally.

The sicula is 1.6 mm. long, with a distinct virgella, situated in the middle part of the proximal end; the thecae are long, overlapping $1/3$, and numbering 12 in 10 mm.

Comparison: This new variety very closely resembles *G. sinodentatus* Mu et Lee in general aspect and the theca character but the size is much smaller. It occurs in a higher horizon.

Horizon and Locality: The new variety occurs in the *Glyptograptus sinodentatus minor* zone of the Dawan formation, Ichang, W. Hupeh and Makiang, S. Kueichou. At Ichang, W. Hupeh it occurs in association with *Tetragraptus* sp. *Trigonograptus ensiformis* (Hall), *Didymograptus* sp., etc. (Field No. WM 17, 163; Cat. No. 10552, 10557), and at Makiang it is associated with *Tetragraptus bigsbyi* (Hall), *T. serra* (Brongniart), etc. (Field No. GY 1199; Cat. No. 10553—10560).

EXPLANATION OF PLATE I

- Fig. 1a—b. *Dictyonema cf. asiaticum* Hsü
1a. Plesiotype, enlarged ($\times 5$), zone of *Azygograptus suecicus*, Dawan formation, Ichang, W. Hupeh. Cat. No. 10500.
1b. Another specimen, enlarged ($\times 3$). Cat. No. 10501.
- Fig. 2. *Dichograptus erectus* Lee (sp. nov.).
Holotype, natural size, zone of *Didymograptus abnormis*, Dawan formation, Makiang, S. Kueichou. Cat. No. 10505.
- Fig. 3a—c. *Didymograptus lofuensis* Lee (sp. nov.).
3a. Holotype, enlarged ($\times 3$). Same locality. Cat. No. 10541.
3b. Paratype, enlarged ($\times 3$). Same locality. Cat. No. 10542.
3c. Another paratype, enlarged ($\times 3$). Zone of *Azygograptus suecicus*, Dawan formation, Ichang, W. Hupeh. Cat. No. 10543.
- Fig. 4. *Didymograptus abnormis* Hsü
Plesiotype, enlarged ($\times 3$). Zone of *Didymograptus abnormis*, Dawan formation, Makiang, S. Kueichou. Cat. No. 10539.
- Fig. 5. *Didymograptus similis* (Hall).
Plesiotype, enlarged ($\times 2$). Dawan formation, Ichang, W. Hupeh, Cat. No. 10545.
- Fig. 6. *Didymograptus nicholsoni* Lapworth.
Plesiotype, enlarged ($\times 3$). Zone of *Azygograptus suecicus*, Ichang, W. Hupeh, Cat. No. 10546.
- Fig. 7. *Janograptus dawanensis* Lee (sp. nov.)
Holotype, enlarged ($\times 3$). Same locality. Cat. No. 10548.
- Fig. 8. *Didymograptus asperus* Harris et Thomas
Plesiotype, enlarged ($\times 3$). Same locality. Cat. No. 10544.
- Fig. 9a—b. *Azygograptus suecicus* Moberg
Plesiotypes, enlarged ($\times 2$ and $\times 3$). Same locality. Cat. No. 10550, 10552.
- Fig. 10a—c. *Phyllograptus anna* Hall
Plesiotypes, enlarged ($\times 2$). Same locality. Cat. No. 10526, 10527, 10529, 10530, 10531.
- Fig. 11a—d. *Phyllograptus angustifolius* Hall
Plesiotypes, natural size. Same locality. Cat. No. 10532—10535.
- Fig. 12. *Phyllograptus ilicifolius* Hall
Plesiotype, natural size. Same locality. Cat. No. 10537.

图 版 II

- 图 1. 甲种四笔石 *Tetragraptus* sp. A.
放大($\times 3$),湖北宜昌分乡,下奥陶统大湾组下部 *Azygograptus suecicus* 带,登记号码:
10506。
- 图 2a-c. 阿氏四笔石 *Tetragraptus amii* Lapworth
近型标本,放大($\times 2$),产地同上,登记号码: 10507—10509。
2b-c. 同一标本的两面。
- 图 3a-d. 上斜四笔石 *Tetragraptus reclinatus* Elles et Wood
近型标本,原大,产地同上,登记号码: 10510—10512—10514。
3a-b. 同一标本的两面。
- 图 4a-c. 锯状四笔石 *Tetragraptus serra* (Brongniart)
近型标本,原大,产地同上,登记号码: 10520, 10521, 10524。
- 图 5. 剑形三角笔石 *Trigonograptus ensiformis* (Hall)
近型标本,放大($\times 3$),产地同上,登记号码: 10538。
- 图 6a-c. 毕氏四笔石 *Tetragraptus bigsbyi* (Hall)
6a-b. 近型标本,原大,产地同上,登记号码: 10517—10518。
6c. 近型标本,贵州麻江乐埠下奥陶统大湾组上部 *Glyptograptus sinodentatus minor* 带,
登记号码: 10519。
- 图 7a-e. 中国肉状雕笔石,小型变种 *Glyptograptus sinodentatus* var. *minor* Mu (新变种)
7a. 幼年标本,放大($\times 3$),产地同上,登记号码: 10554。
7b-d. 副型标本,产地同上,登记号码: 10556, 10560, 10561。
7e. 正型标本,产地同上,登记号码: 10559。

EXPLANATION OF PLATE II

- Fig. 1. *Tetragraptus* sp. A
Enlarged ($\times 3$), zone of *Azygograptus suecicus*, Dawan formation. Ichang, W. Hupeh. Cat. No. 10506.
- Fig. 2a-c. *Tetragraptus amii* Lapworth
Plesiotypes, enlarged ($\times 2$). Same locality and same horizon. Cat. No. 10507—10509.
- Fig. 3a-d. *Tetragraptus reclinatus* Elles et Wood
Plesiotypes, natural size. Same locality. Cat. No. 10510—10512, 10514.
- Fig. 4a-c. *Tetragraptus serra* (Brongniart)
Plesiotypes, natural size. Same locality. Cat. No. 10520, 10521, 10524.
- Fig. 5. *Trigonograptus ensiformis* (Hall)
Plesiotype, enlarged ($\times 3$). Same locality. Cat. No. 10538.
- Fig. 6a-c. *Tetragraptus bigsbyi* (Hall)
6a-b. Plesiotypes, natural size. Same locality. Cat. No. 10517—10518.
6c. Another plesiotype, natural size. Zone of *Glyptograptus sinodentatus minor*, Dawan formation, Ma-kiang, S. Kueichou. Cat. No. 10519.
- Fig. 7a-e. *Glyptograptus sinodentatus* var. *minor* Mu (var. nov.)
7a. Young form, enlarged ($\times 3$). Zone of *Glyptograptus sinodentatus minor*, Dawan formation, Ichang, W. Hupeh. Cat. No. 10554.
7b-d. Paratypes, enlarged ($\times 3$). Same locality. Cat. No. 10556, 10560, 10561.
7e. Holotype, enlarged ($\times 3$). Same locality. Cat. No. 10559.