

Silurian graptolites from the Qusayba Shale (Llandovery) of central Saudi Arabia

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El-Khayal, A. A.: Silurian graptolites from the Qusayba Shale (Llandovery) of central Saudi Arabia. *Bull. geol. Soc. Denmark*, vol. 35, pp. 125–133. Copenhagen, July 1st, 1987.
<https://doi.org/10.37570/bgsd-1986-35-13>

Graptolites of the Qusayba Shale, Al-Qasim Province, central Saudi Arabia, indicate a Llandovery age. Some species found are recorded for the first time and can be referred to species known from British and Bohemian beds. The assemblage includes *Climacograptus* cf. *rectangularis*, *Climacograptus scalaris*, *Glyp-tograptus* (*G*) *incertus*, *Orthograptus cyperoides*, *Orthograptus insectiformis*, *Petalograptus minor*, *P. ova-toelongatus*, *Retiolites perlatus perlatus*, *Pristiograptus regularis regularis*, *Lagarograptus* cf. *tenuis*, *Mono-graptus* ex gr. *barrandei*, *M. convolutus*, *M. decipiens decipiens*, *M. elongatus*. The assemblage is indicative of the *convolutus* Zone.

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Silurian graptolites from the Tabuk Formation were first noted by Steineke *et al.* (1958) who mentioned that probable *Climacograptus* and several other graptolites serve as the basis for a Silurian assignment for beds about 375 metres below the top of Tabuk Formation. The Tabuk Formation was formally defined by Steineke *et al.* (1958).

Powers *et al.* (1966, p. D22) redefined the Tabuk Formation and mentioned (p. D24) that the most complete exposure of Tabuk beds south of the Great Nefud occurs in the Qusayba section, where three shale members within the section form roughly parallel escarpments near the top, middle and at the base. Using these shales as dividers, the Qusayba section can be separated into six informal units. These are from bottom up: 1. Lower shale (Hanadir Member); 2. Lower sandstone; 3. Middle shale (Ra'an Member); 4. Middle sandstone; 5. Upper shale (Qusayba Member); 6. Upper sandstone. This work deals only with the Qusayba Member.

Stratigraphy

The Tabuk Formation is composed of a cyclic series of three graptolite-bearing shales alternating with continental marginal-marine sand units. Powers *et al.* (1966) dated the basal Tabuk For-

mation (Hanadir shale) as Lower Ordovician (Arenig) on the basis of graptolites. Later workers, McClure (1978), Fortey and Morris (1982), and El-Khayal and Romano (1985) showed that the Hanadir Shale Member is of mainly Llanvirn age.

Powers *et al.* (1966, p. D25) mentioned that *Diplograptus* sp. and *Climacograptus* cf. *C. brevis* occur near the middle of the Tabuk Formation. McClure (1978) dated the Ra'an shales as probably of late Caradoc age, although an early Ashgill age cannot be ruled out. The writer recently collected some graptolites from the lower part of the Ra'an shale at Khashm al Ra'an near Qusayba. The graptolites were identified as *Orthograptus amplexicaulus* Hall.

According to Fairbridge (1970) and McClure (1978), the south pole and glacial epicentre were located in the vicinity of North West Africa. The northern margin of an extensive continental ice sheet apparently extended across about 4,000 km of North Africa. McClure, however, noted the presence of Upper Ordovician glaciated boulders and tillites in Saudi Arabia indicating that the vast ice sheet extended about 2,000 km further eastward. Uppermost Ordovician Ashgill beds have not been proved in the Qasim area.

The Qusayba shale sequence overlies the Middle crossbedded, light red and pale yellow medium grained sandstone containing *Cruziana*

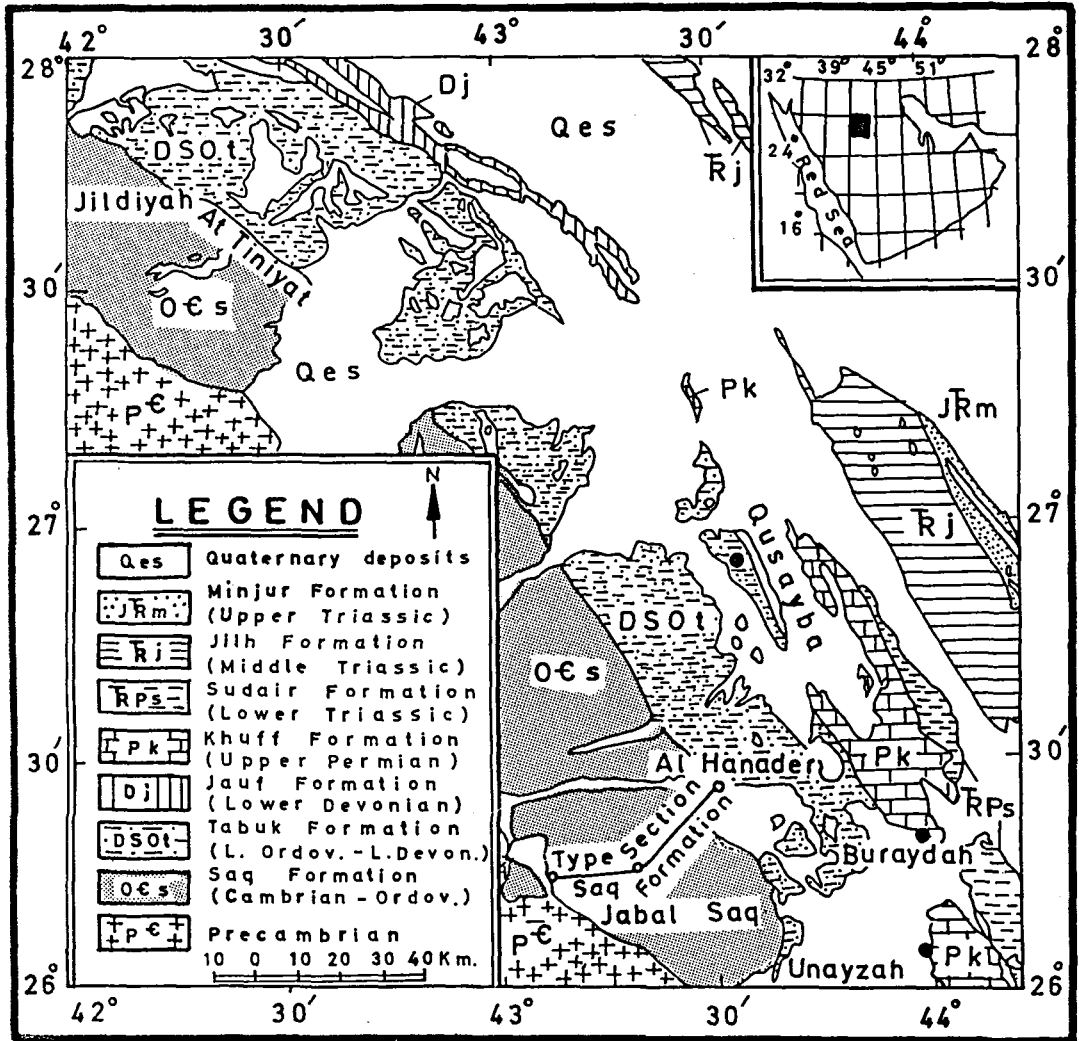


Fig. 1. Geological map of Al Qasim Province, Saudi Arabia. Showing Location of Qusayba village (From Bramkamp et al. 1963).

and *Skolithos* possibly of lower Silurian age (Rhuddanian stage of the Llandovery Series, because of its conformable stratigraphic position below the well dated Qusayba Shale Member (McClure, 1978).

The Qusayba Shale Member forms a vertical cliff facing east, at Al Qusayba, Al Qasim Province (Fig. 1), where 44 metres of mainly varicoloured shales are exposed. (Fig. 2). The unit thickens northwards. It is 126 m thick in the Jildiyah to Ashaybah section south of the Great Nefud (Powers et al. 1966, p. D113, sec. 4, unit 3).

The Qusayba Shale Member was originally measured in 1949 by Pocock and R. P. Kopp

(Fide Powers et al. 1966). The unit was described (*op. cit.*, p. D113, sec. 3, unit 5) as follows: "Shale varicoloured, but mostly grey-green, laminated: more gypsiferous and with thin beds of red, hematitic siltstone in upper part; lower part is graptolitic. Poorly sorted grey medium-grained thin-bedded sandstone and highly weathered calcareous beds at top of unit, 57.4 m."

No further details of these beds were given. The sequence is capped by highly weathered calcareous beds of Quaternary duricrust. The section at Qusayba may be correlated with the 47 metres described by Steineke et al. (1958) as grey, purple and green shale, in part silty and mi-

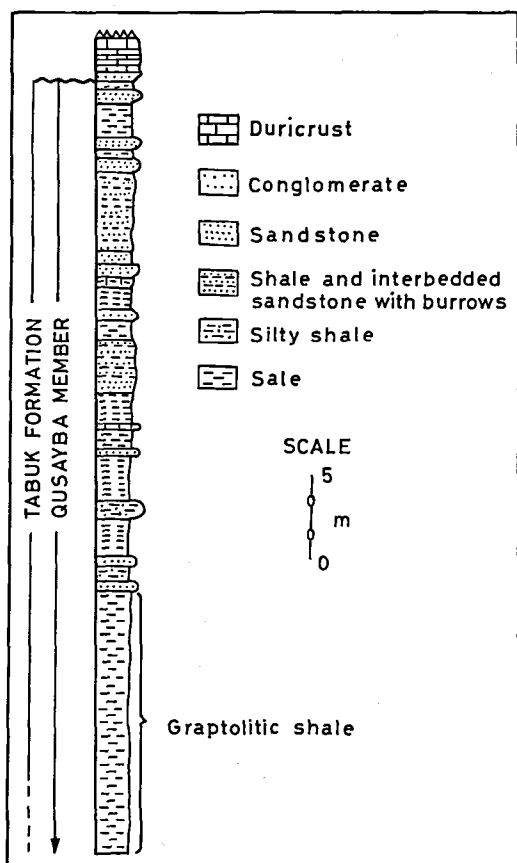


Fig. 2. Stratigraphic section of the Qusayba Shale Member, Qusayba, Al Qasim Province, central Saudi Arabia.

caceous, with layers of light grey platy fine sandstone, with *Climacograptus* at several horizons.

The lower sediments represent a part of the Llandovery transgression which brought the graptolites with it. At higher levels, shallower environments existed where the sandstone and siltstone percentage increases. These beds vary in thickness from 0.3–0.8 m, are rippled, and have a variety of vertical and horizontal burrows which indicate a very shallow marine environment.

Faunal association

Steineke *et al.* (1958) mentioned that probable *Climacograptus* and several other graptolites occur in beds about 375 metres below the top of the Tabuk Formation. Powers *et al.* (1966) reported that several samples collected from the Tabuk

Formation, but without specific locality information, were identified as definitely Silurian on the basis of contained *Monograptus* and some bivalves. They also mentioned the presence of *Rastrites*. Rickards and Koren' (1974) described *Glyptograptus* (*Pseudoglyptograptus*) *tabukensis* sp. nov. of *convolutus* Zone (Llandovery) age from a bore hole near Tabuk, Saudi Arabia. This species has not yet been found in the Qusayba Shale at Al Qusayba, Al-Qasim Province. Rickards (1976) mentioned the presence of *Lagarograptus* cf. *tenuis* from the *convolutus* Zone of the Tabuk Formation.

Thomas (1977) described a trilobite *Platycoryphe dyaulax* sp. nov. from the Qusayba shale. McClure (1978) reported that the Qusayba shales bear a rich graptolite fauna dated as lower Llandovery – *convolutus* Zone of the Aeronian Stage. He also mentioned the presence of a trilobite, and an abundant chitinozoan and acritarch assemblage, but he did not list these species. El-Khayal (1985) mentioned the presence of *Monograptus* ex gr. *barrandei*, *M. convolutus*, *M. decipiens decipiens* and *M. elongatus* from the Qusayba shale. The shales at Al Qusayba contain shelly forms, such as the bivalve cf. *Nucleolites* sp, a brachiopod cf. *Eocoelia*, an ostracode cf. *Ctenobolbina*, orthocones, indeterminate inarticulate brachiopods, conodonts and undetermined eurypterid fragments.

The graptolites include the following species collected from the lower part of the Qusayba shale at Qusayba: *Climacograptus* cf. *rectangularis* (McCoy, 1850), *Climacograptus scalaris* (Hisinger, 1837), *Glyptograptus* (*Glyptograptus incertus* (Elles & Wood, 1907), *Orthograptus cyperoides* (Törnquist, 1897), *Orthograptus insectiformis* (Nicholson, 1869), *Petalograptus minor* (Elles, 1897), *Petalograptus ovatoelongatus* (Kurck, 1882), *Retiolites perlatus perlatus* (Nicholsen, 1886), *Pristiograptus regularis regularis* (Törnquist, 1899), *Lagarograptus* cf. *tenuis* (Portlock, 1843), *Monograptus* ex gr. *barrandei* (sensu, Elles & Wood, 1913), *Monograptus convolutus* (Hisinger, 1837), *Monograptus decipiens decipiens* (Törnquist, 1899) and *Monograptus elongatus* (Törnquist, 1899). (See pl. 1 & 2).

These species indicate the *convolutus* Zone (Llandovery). This Zone was defined by Marr and Nicholson (1888) in a mixed shelly and graptolite sequence of zones from the Lake District's

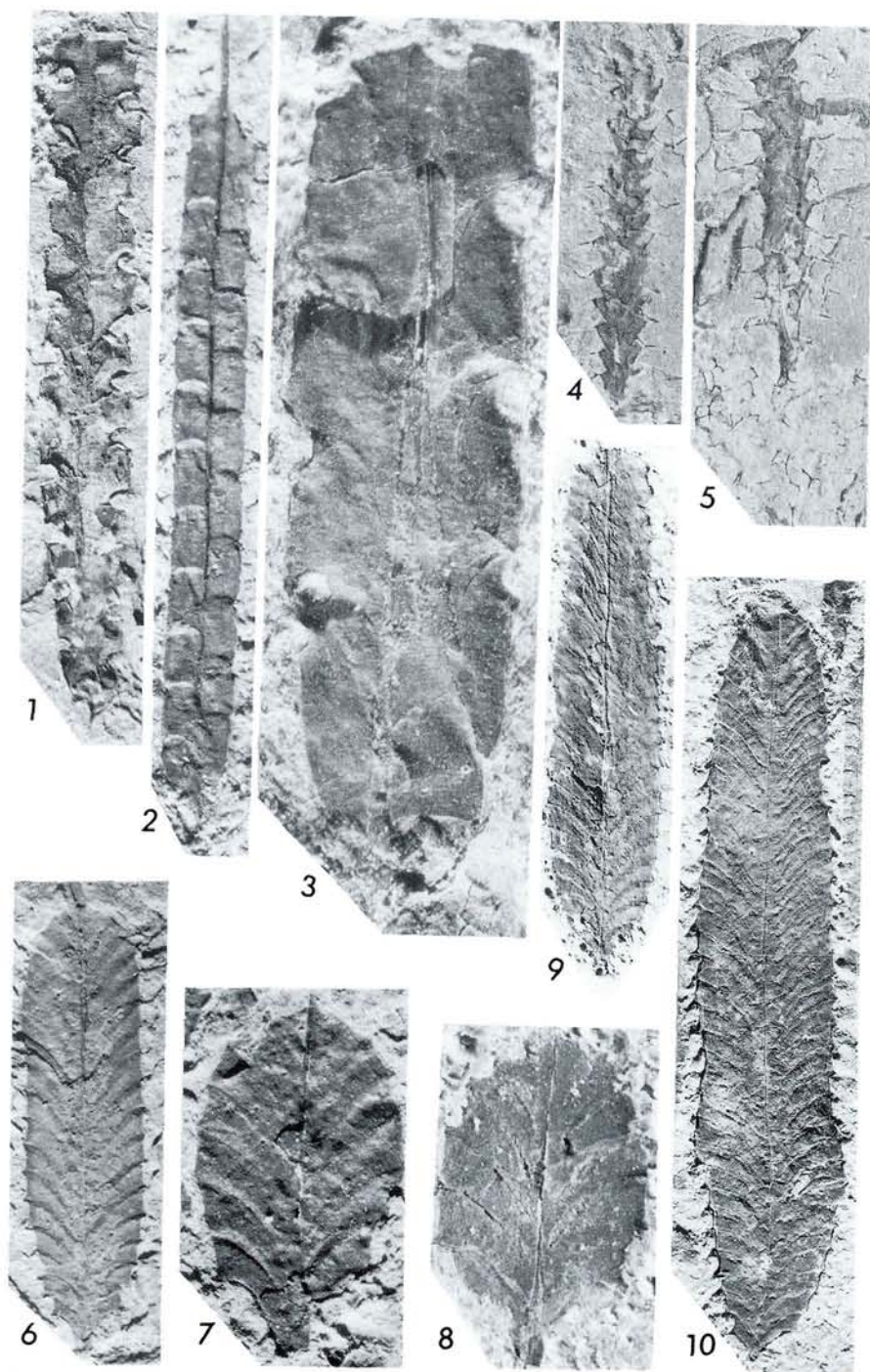


Fig. 1. *Climacograptus* cf. *rectangularis* McCoy, 1850. Complete rhabdosome (KSU.STQ 208). $\times 10$.

Fig. 2. *Climacograptus scalaris* Hisinger, 1837. Complete rhabdosome (KSU.STQ 25 C1). $\times 10$.

Fig. 3. *Glyptograptus* (*G.*) *incertus* Elles & Wood, 1907 Enlarged photograph (KSU.STQ 87 C3). $\times 30$.

Figs 4-5. *Othograptus insectiformis* Nicholson, 1896. 4: Complete rhabdosome (KSU.STQ 109 O1). $\times 6$. 5: Rhabdosome showing thecal spines and strongly divided virgella (KSU.STQ 103 O1). $\times 6$.

Figs 6, 9-10. *Petalograptus ovatoelongatus* Kurck, 1882. 6: Obverse view (KSU.STQ 165). $\times 5$. 9: Intermediate form (KSU.STQ 174). $\times 4$. 10: Mature specimens (KSU.STQ 128b P5). $\times 4$.

Figs 7-8. *Petalograptus minor* Elles, 1897. 7: Obverse view (KSU.STQ 165a P2). $\times 10$. 8: Another rhabdosome, showing the sicula (KSU.STQ 74). $\times 10$.

Skellgill section. Hutt (1974) revised the section and recorded 32 species of graptolites, while Rickards (1976a) recorded the presence of 42 graptolite species from the *convolutus* Zone in the British Isles.

The Qusayba section yielded only 14 species of graptolites. Future research could prove the presence of more species. The Qusayba graptolites constituted about one third of the species found in the British Isles.

The *convolutus* Zone is recognizable throughout the world; the British Isles (Hutt, 1974), Poland (Teller, 1969), Alaska (Churkin & Carter, 1970), the U.S.S.R. (Obut *et al.* 1965), Malaya (Jones, 1973), Germany (Stein, 1965), Morocco (Willefert, 1963).

Palaeontological comments

Specimens similar to *Climacograptus rectangularis* are associated with *C. scalaris*. The Arabian forms differ from *C. rectangularis* in the width of the rhabdosome, which does not exceed 1.2 mm compared to 2 mm in *C. rectangularis* McCoy (*sensu*, Elles & Wood, 1906, p. 187). (Plate 1, Fig. 1). Forms which are close to Elles and Wood's concept of *Climacograptus scalaris* occur, but differ in the spacing of the thecae and the nature of the apertural margin. (Plate 1, Fig. 2).

The Qusayba Shale contains specimens of *Glyptograptus (G.) incertus*. The Arabian forms have a smaller proximal width (1.0 mm) than those of Elles & Wood. Hutt (1974) recorded this species from the *convolutus* and *sedgwickii* zones of the Lake District. (Plate 1, Fig. 3).

Specimens of *Petalograptus minor* in association with *P. ovatoelongatus* are present in the Qusayba shale. (See plate 1, Figs 7–8). I found it difficult to distinguish apparent *P. minor* from early growth stages of *P. ovatoelongatus*. A continuous variation in width at th^4 of 2.4–4.2 mm has been observed, while the length range is 3.6–7.7 mm. The sicula is 1.8 mm long, similar to that of *P. ovatoelongatus*. Hutt (1974) also had difficulty in distinguishing *P. minor* from early growth stages of other petalograptids especially *P. ovatoelongatus*. I agree with Hutt that examination of further specimens may show that *P. minor* is an early growth stage of *P. ovatoelongatus*.

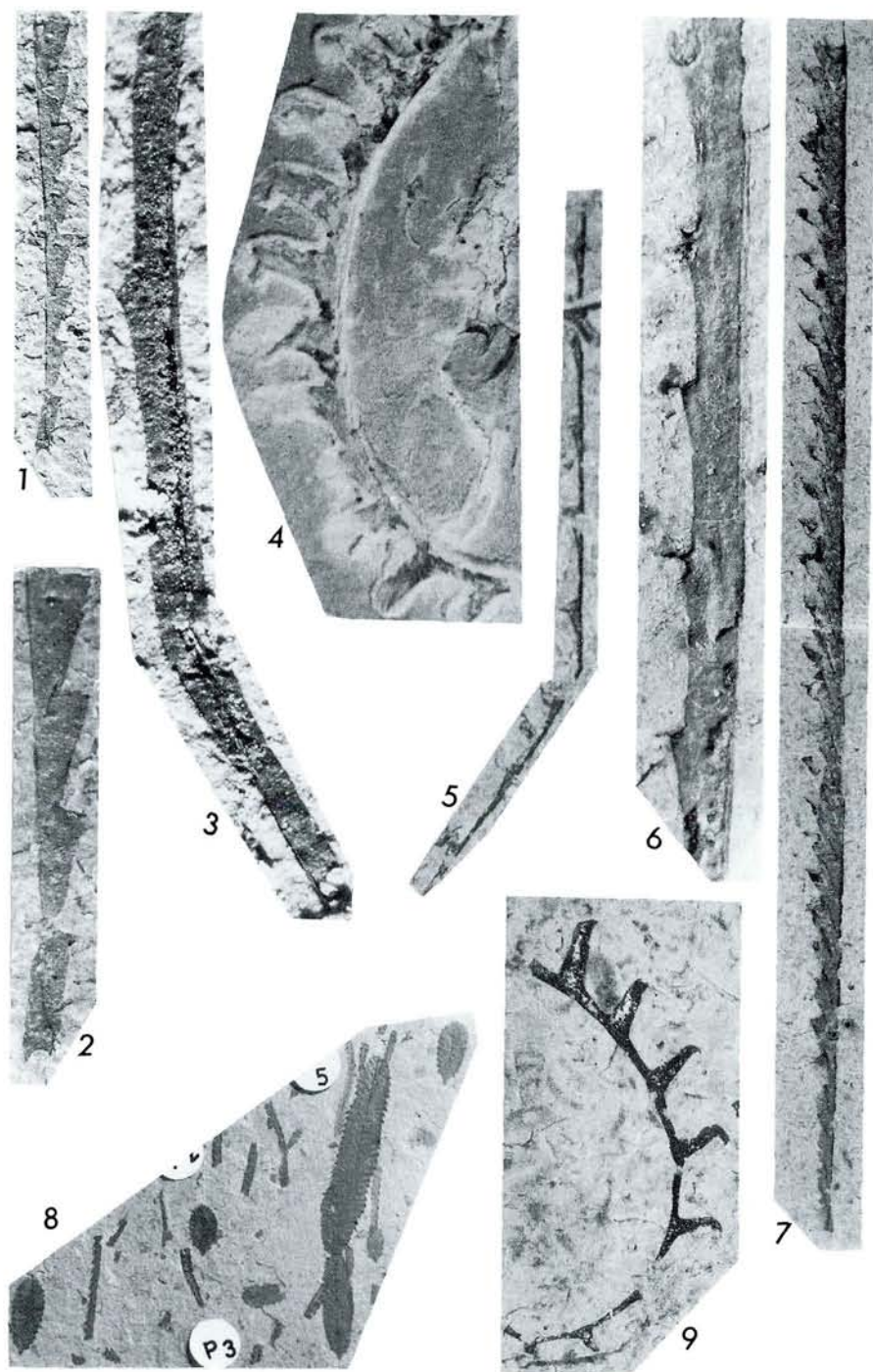
The Arabian specimens of *Petalograptus ovatoelongatus* agree well with Bouček and Přibyl's (1941) dimensions of the species, but most of them do not show the ovato-elongate outline of Kurck's original specimen. Elles and Wood (1908) considered the ovato-elongate character of specific importance. The rhabdosome width in the Qusayba forms ranges from 3.5–5.3 mm at th^1 for specimens ranging in length from 13–26.5 mm and a sicula not more than 1.8 mm long. (Plate 1, Figs 6, 4–10). El-Khayal (1986) have noted that both *P. ovatoelongatus* and *P. minor* may be conspecific with *P. palmeus* Barrande.

Rickards *et al.* (1977) noted that *P. ovatoelongatus* ranges from the *triangulatus* to the lower part of the *convolutus* zones.

Hutt (1974) described *Orthograptus cyperoides* (Törnquist, 1897) from the *convolutus* Zone in the Lake District. The Qusayba material agrees well with Törnquist's figures and with Elles & Wood's (1907), Rickards's (1970) and Hutt's description and figures. The latter author reported the presence of apertural spines on specimens assigned to *O. cyperoides*. I agree with Hutt that *O. cyperoides* may be conspecific with the spiny *O. insectiformis*. Both species are always present together on the same slabs in the Qusayba section. It is possible that the spines were so delicate that they were easily broken and did not preserve well on some specimens.

The Arabian specimens of *Orthograptus insectiformis* compare with Nicholson's (1869) figure and Hutt's (1974) description of the species. Churkin and Carter (1970) recognized the presence of paired apertural spines, while Hutt (1974) noticed the presence of a strongly divided virgella. Both features are also present in the Arabian forms. (Plate 1, Figs 4,5). The species is recorded from the U.K. (Nicholson, 1869; Lapworth, 1876; Elles and Wood, 1907; Rickards & Koren, 1974 and Hutt, 1974), Morocco (Waterlot, 1945), U.S.S.R. (Obut *et al.*, 1968), Alaska (Churkin and Carter, 1970) and Australia (Thomas, 1960). (Plate 1, Figs 4,5).

The Arabian material fits Nicholson's (1868) description of *Retiolites perlatus* the species which Bouček and Münch (1944) made the type of their subgenus *Pseudoretiolites*. The Qusayba specimens have thecae numbering 9–10 mm. Elles & Wood (1908) gave higher thecal counts,



Figs 1-2,7. *Pristiograptus regularis regularis* Törnquist, 1899. 1: Proximal fragment showing sicula (KSU.STQ 89P). $\times 10$. 2: Same specimen as in fig. 1 enlarged showing the sicula and four thecae. $\times 20$. 7: A longer rhabdosome with sicula (KSU.STQ 144P). $\times 6$.
 Figs 3,6. *Lagarograptus cf. tenuis* Portlock, 1843. 3: Proximal fragment showing sicula and three thecae (KSU.STQ 229). $\times 25$. 6: Well preserved fragment showing the triangular apertural process (KSU.STQ 109a). $\times 18$.
 Fig. 4. *Monograptus convolutus* Hisinger, 1837. Fragment of a rhabdosome (KSU.STQ 94). $\times 10$.
 Fig. 5. *Monograptus elongatus* Törnquist, 1899. Part of a rhabdosome showing the elongated thecae (KSU.STQ 89me). $\times 6$.
 Fig. 8. A photograph of a slab from the Qusayba shale with *P. minor*, *P. ovatoelongatus*, *C. scalaris* and a fragment of *Pr. regularis regularis* (KSU.STQ 128B). c. $\times 1.3$.
 Fig. 9. *Monograptus decipiens* Törnquist, 1899 showing a proximal fragment (KSU.STQ 94 Md). $\times 10$.
 N.B.: KSU = King Saud Univ., S = Silurian, T = Tabuk, Q = Qusayba. All specimens are kept in the Geology Dept. Collection, King Saud Univ. Riyadh, Saudi Arabia.

16–12 in 10 mm, while Hutt (1974) mentioned that the type specimen has a spacing 7.5 in 10 mm proximally to 9 in 10 mm distally.

The specimens of *Pristiograptus regularis regularis* conform to Törnquist's (1899) illustrations and to Elles & Wood's (1911) description. The type Scanian specimens, however, have a slightly longer sicula (1.0 mm) than the Arabian material (0.80 mm).

Rickards (1976b) mentioned the presence of *M. cf. tenuis* from the *convolutus* Zone of the Tabuk Formation, and noticed that the Arabian forms display a genicular hood and occasionally, apertural process. The Arabian forms of *Lagarograptus cf. tenuis* shares with *Lagarograptus tenuis* (Portlock) and *Lagarograptus inexpeditus* Obut and Sobolevskaya (1968), the semicircular, thecal excavation, the geniculum, triangular ventral apertural process, subparallel dorsal and ventral rhabdosomal walls and generally the thecal count. The Qusayba specimens differ from *L. tenuis* and *L. inexpeditus* in the level to which the sicular apex reaches. In the Arabian forms the apex reaches a little higher than th2 aperture. The sicular apex reaches about halfway between the aperture of th1 and th2 in *L. tenuis* (Hutt, 1968) and about the level of the aperture of th1 in *L. inexpeditus* according to Rickards (1976b). The specimens figured and described by Hutt (1975) as *L. acinaces* have a longer sicula and a much longer first theca (3.2 mm). (Plate 2, Figs 3 & 6). El-Khayal (1987, in press) restudied the specimens of *Lagarograptus* collected from the Qusayba Shale and came to the conclusion that the Arabian specimens belong to a new species.

The Arabian specimens of *Monograptus ex gr. barrandei* compare well with figures given by Elles & Wood (1913). Bouček & Přibyl (1952) discussed this species and mentioned that the original specimens of *M. barrandei* are lost and they rejected the figured British specimens from the synonymy but did not rename them. Earlier Přibyl (1948) had accepted Elles & Wood's figures as *M. barrandei*.

Monograptus convolutus was discussed at length by Přibyl and Münch (1942). It is a common species in the Qusayba shale. The specimens match Hisinger's figure and Sudbury's (1958) description. *M. convolutus* is widely distributed. It has been recorded from Europe (Hisinger, 1837; Carruthers, 1868; Törnquist, 1892; Perner, 1897;

Eisel, 1912; and many others), the British Isles (Elles & Wood, 1913; Rickards, 1970; Hutt, 1975), North Africa (Waterlot, 1945 and Willefert, 1963), Canada (Lenz, 1982), the U.S.S.R. (Obut & Sobolevskaya, 1967; Koren' & Enokyan, 1970).

Specimens identified as *Monograptus decipiens decipiens* match the descriptions of Törnquist (1899), Sudbury (1958), Rickards (1970) and Hutt (1975). Complete specimens were not found. This is the first time that *M. decipiens decipiens* has been recorded from Saudi Arabia. This species has been recorded from Sweden (Törnquist, 1899); the British Isles (Elles & Wood, 1913; Sudbury, 1958; Rickards, 1970 and Hutt, 1975), the U.S.S.R. (Chaletskaya, 1962; Nikiforova & Obut, 1965) and Canada (Lenz, 1982).

Přibyl (1945) discussed *M. elongatus* (Törnquist, 1899) and later (Přibyl, 1948) as proposed by Gortani (1923) put it into synonymy with *M. intermedius* Carruthers. Strachan (1969), however, redescribed Carruthers' type graptolites and showed that *M. elongatus* Törnquist is not a junior synonym of *M. intermedius* Carruthers. The Qusayba specimens of *M. elongatus* agree well with figures given by Törnquist (1899). (Plate 2, Fig. 5).

Acknowledgements. The author wishes to thank King Saud University, Riyadh, Saudi Arabia for financial support, Dr. Mike Romano, Sheffield University for reading the manuscript, and also to Dr. R. B. Rickards who invited me to compare material housed in the Sedgwick Museum.

Dansk sammendrag

Graptolitter fra Qusayba skifferen i Al-Qasim provinsen i Saudi Arabien indicerer at alderen er Llandovery. Nogle af arterne er fundet for første gang i denne region og kan bestemmes til former fra britiske og bøhmiske aflejringer. Artssammensætningen peger på *convolutus* Zonen og omfatter *Climacograptus cf. rectangularis*, *C. scalaris*, *Glyptograptus (G.) incertus*, *Orthograptus cyperoides*, *O. insectiformis*, *Petalograptus minor*, *P. ovatoelongatus*, *Retiolites perlatus perlatus*, *Pristiograptus regularis regularis*, *Lagarograptus cf. tenuis*, *Monograptus ex gr. barrandei*, *M. convolutus*, *M. decipiens decipiens* og *M. elongatus*.

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