

Late Ordovician and Early Silurian graptolites from southern Iran

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Abstract – Graptolites are described for the first time from the Faraghun mountains (Kuh-e-Faraghun) and the Gahkum mountains (Kuh-e-Gahkum) on the northern edge of the southeast part of the Zagros Mountains, Iran. 38 taxa are recorded, including 4 Ordovician and 34 Silurian species; the latter are the first Silurian graptolites described from Iran.

Ashgill (Late Ordovician) graptolite assemblages from Kuh-e-Faraghun include: *Persculptograptus persculptus* and *Orthograptus amplexicaulis*, indicating a *persculptus* Biozone age; and *Orthograptus amplexicaulis abbreviatus*, indicating the latest Ordovician *anceps* Biozone.

Kuh-e-Faraghun Early Silurian faunas include representatives of the Llandovery *leptotheca* Biozone; another assemblage, including *Monograptus convolutus* and *Pseudorthograptus inopinatus*, indicates the slightly younger Llandovery *convolutus* Biozone. Graptolites from Kuh-e-Gahkum comprise a rich *Stimulograptus sedgwickii* assemblage, indicating a slightly higher Llandovery level again (*sedgwickii* Biozone); a *convolutus* Biozone fauna is also probably represented in our collections.

INTRODUCTION

Late Ordovician and Early Silurian graptolites, from two areas in the northern part of the Zagros belt (Figures 1, 2, 3), are described for the first time from Iran. Almost all of the Ordovician, and much of the Silurian material was collected in 1996 by Wright and Hamed from Kuh-e-Faraghun. Two collections of Silurian material from Kuh-e-Gahkum have been studied; one is housed in the Natural History Museum, London, having been donated by British Petroleum, and the other was kindly made available to us by Dr F. Golshani of the Geological Survey of Iran.

The importance of the scarce graptolites of Iran lies not only their potential for establishing correlations between Iran and the rest of the Middle East but also in aiding in the elucidation of the tectonic and biogeographic relationships of the region. No Iranian graptolite was described prior to our description of *Arenig* (Early Ordovician) material (Rickards *et al.* 1994) from the Kerman district, East-Central Iran. No Silurian graptolites have previously been illustrated or described from Iran, although the few previous identifications by Bulman (1937) have been widely repeated in the literature. These old Anglo-Iranian Oil Corporation (A-IOC) materials are lost; we have not been able to locate any of the previously reported graptolite material, nor to recollect from localities other than Kuh-e-Faraghun.

Huckriede *et al.* (1962) reported graptolites from

the Kerman district, East-Central Iran; the fauna they reported is that described in part from the Katkoyeh Formation by Rickards *et al.* (1994), now being fully described on the basis of collections made in 1996 by Hamed and Wright. Kent *et al.* (1951a) stated that *Climacograptus* was also collected from detritus associated with the Kalat salt plug on the Persian Gulf, along with abundant Cambrian trilobites; this occurrence is either Late Ordovician or Early Silurian. Kalantari (1981, pl. 5, fig. 12) illustrated a biserial graptolite from Kuh-e-Faraghun as *Climacograptus scalaris* (Hall).

Setudehnia (1972) listed 3 localities in the Zagros belt from which Ordovician and/or Silurian fossils were known from outcropping strata: Kuh-e-Gahkum and Kuh-e-Faraghun north of Bandar Abbas and Kuh-e-Surmeh south of Shiraz (Figure 1); these are the three main localities discussed here.

HISTORY OF GRAPTOLITE DISCOVERIES IN SOUTHERN IRAN

There are very few references in the literature to Ordovician and Silurian fossils of any sort from southern Iran. Silurian strata in the Zagros were first proved by Allison *et al.* (1937) based on identifications of graptolites from Kuh-e-Gahkum and Kuh-e-Faraghun by O. M. B. Bulman. This find had been reported, in a very preliminary fashion, by de Böckh *et al.* (1929) as being from

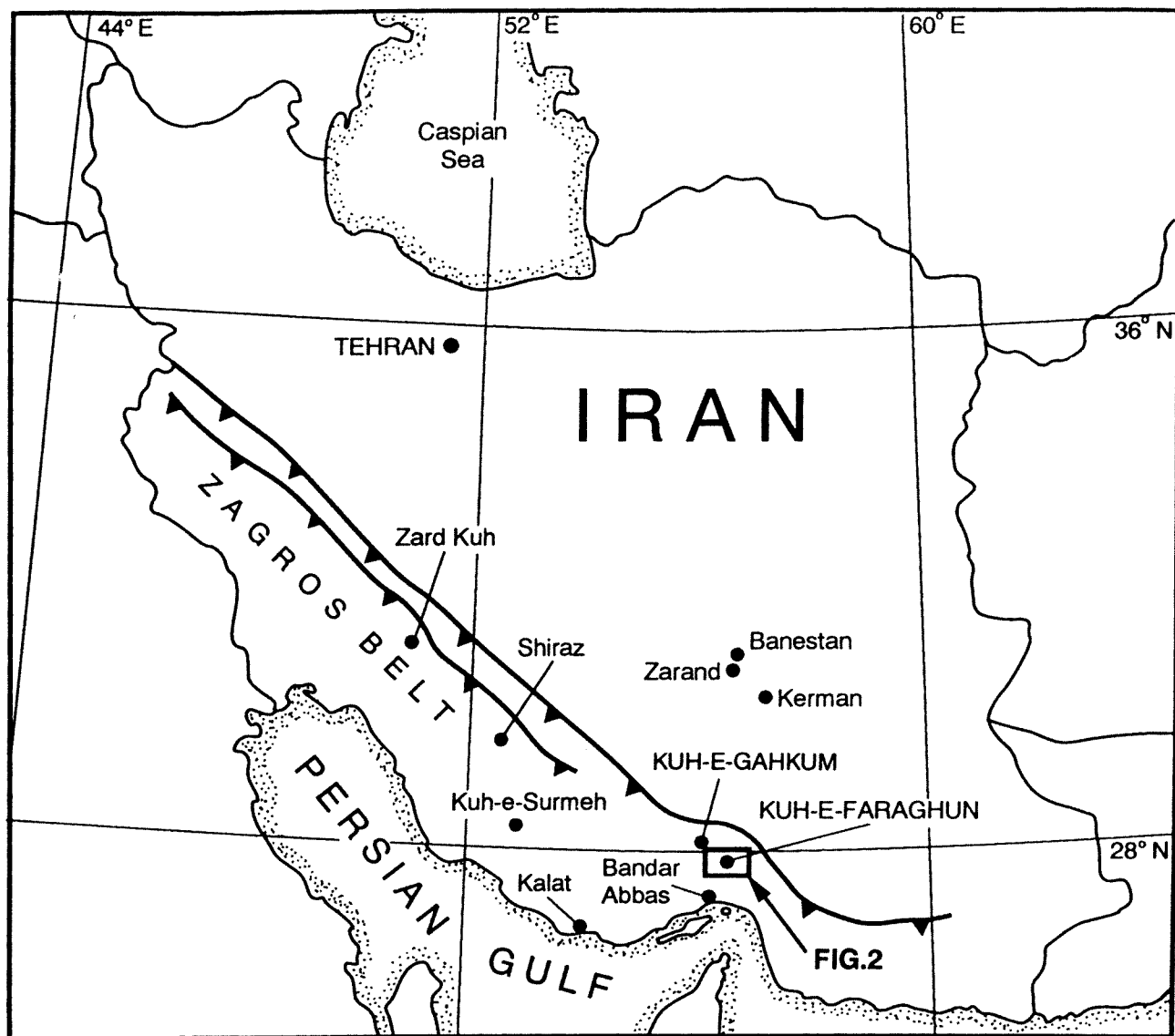


Figure 1 The Middle East region, showing positions of Iranian major cities, towns and localities mentioned in text; base map after Krinsley (1970). Smaller box indicates approximate position of Figure 2.

Furgun. Ordovician strata in the Zagros were proved by Douglas *in* Kent (1951), based on identifications of graptolites and trilobites from Kuh-e-Surmeh by Bulman and C. J. Stubblefield respectively.

Prior to the publication of the southern Iranian section of the International Stratigraphic Lexicon (Setudehnia 1972), reports of graptolites from the Zagros belt were largely confined to unpublished reports of the Anglo-Iranian Oil Company (particularly Allison *et al.* 1937; Kent 1951; Kent *et al.* 1951a, b). Allison *et al.* (1937) stated that graptolites collected in 1928-9 by J. V. Harrison and A. H. Taitt from Kuh-e-Faraghun (Figures 1, 3) were examined by G. L. Elles, although we have not seen any written report by her. Graptolites were collected from both Gahkum and Faraghun in 1936-7 by G. M. Lees and

Harrison (Allison *et al.* 1937), and were examined by Bulman (1937).

Two Silurian graptolite species from the Zagros Mountains were listed by Douglas (1950), who stated that Bulman (1937) identified *Monograptus* aff. *incommodus* Törnquist and *Climacograptus* cf. *scalaris normalis* Lapworth from Kuh-e-Faraghun and stated that "the species present appear to be the same" at Kuh-e-Gahkum. Bulman's report on this cites Kuh-e-Gahkum, but not Kuh-e-Faraghun, although two of his localities must be Faraghun localities (Tang Laumi [Lar. 67] and Zaukeri Bala [Lar. 172]); A-IOC localities Lar. 67 and 172 are shown by Allison's list to be Faraghun localities. Material we have seen from the two areas are quite distinctive faunally and lithologically. Nevertheless, if Bulman's identifications, stated to be of Lees and Harrison

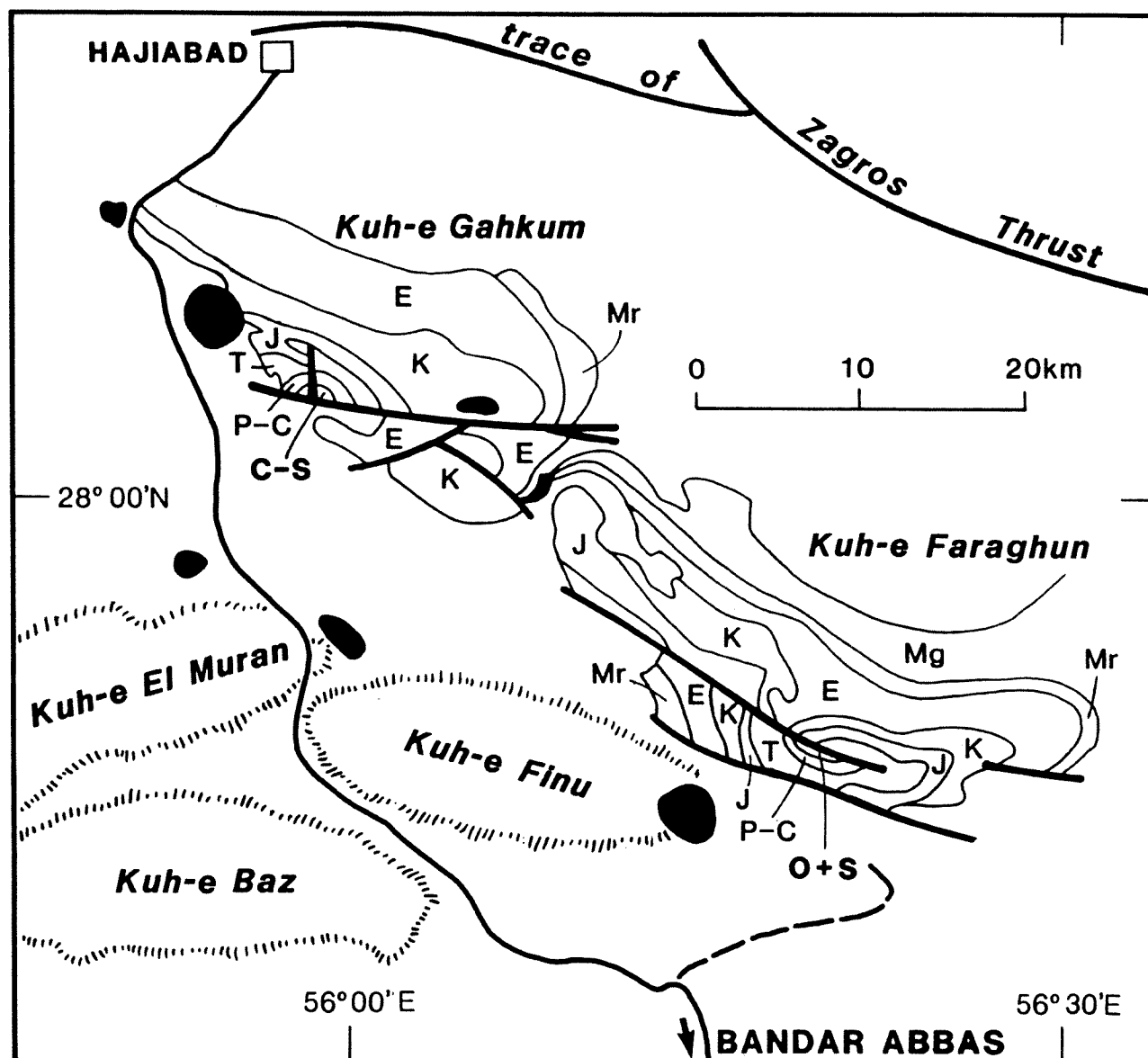


Figure 2 Sketch geological map showing the locations of the Kuh-e-Faraghun and Kuh-e-Gahkum inliers of Lower Palaeozoic strata, based on the 1:100 000 National Iranian Oil Corporation geological map. Symbols for rocks of various ages are: C-S, Cambrian and Silurian. O-S, Ordovician Seyahou Formation and Silurian Sarchahan Formation; P-C, Permian-Carboniferous Khuff Formation. T, Triassic Khanh Kat Formation; J, Jurassic Hith-Surmeh Formation and Khami Group; K, Cretaceous Banestan Group; E, Eocene Jahrom and Padbeh Formations; Mr, Oligocene-Miocene Razak Formation; Mg Miocene Mishan Formation; and solid black, salt diapirs.

material, were correct they indicate a lower level in the Llandovery than we have recognised in this paper for a fauna we have studied. The discussion by Allison *et al.* (1937) of the age of the succession further suggests that there was further confusion as to the levels at which graptolites were collected in 1928-9 and 1936-7, although one would assume that Bulman saw collections from both areas. If Elles examined graptolites from unit 6 (see below: clearly the unit from which Hamedi and Wright collected Ordovician graptolites) at Faraghun, there should have been no Early Silurian ("Valentian") flavour unless collections

from different levels were mixed. In any event she identified *Diplograptus*, *Monograptus* and *Climacograptus* from what must have been Gahkum collections.

From Kuh-e-Faraghun, Ghavidel-Syooki and Khosravi (1995) listed the graptolites *Monograptus intermedius*, *Monograptus socialis* and *Climacograptus scalaris*, and assigned an Early Silurian age to the Sarchahan Formation, as did Ghavidel-Syooki (1994). Possibly these listings can be attributed to identifications by Bulman (1937), and this probably applies to other listings (e.g., Setudehnia 1972).

Ghavidel-Syooki and Khosravi (1995) mentioned

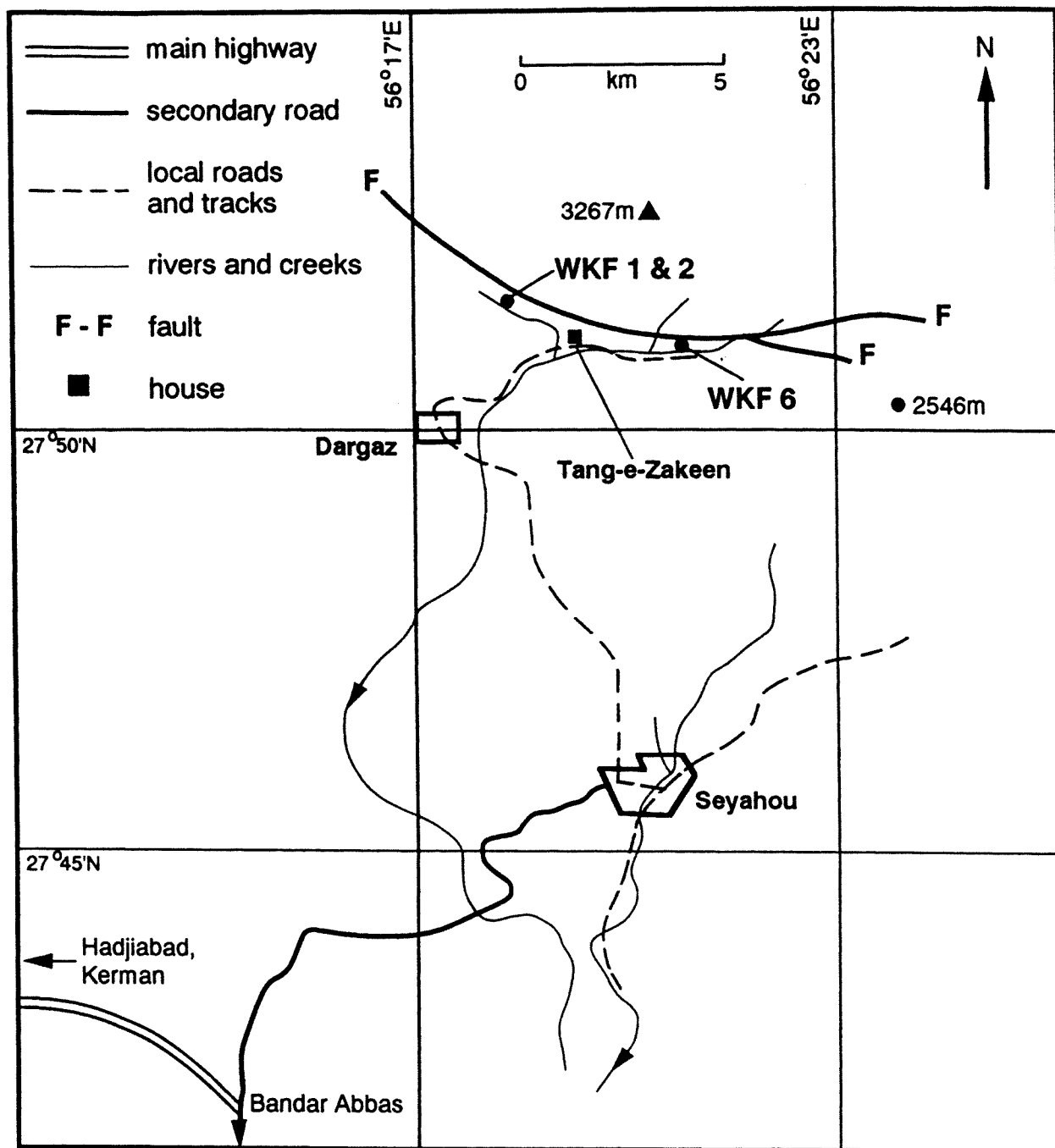


Figure 3 Sketch topographic map of the region of the Seyahou and Dargaz villages, showing topographic features, a major fault and collection sites mentioned in text; latitudes and longitudes are approximate. The river flows west through a gorge in the Faraghun Mountains (Kuh-e-Faraghun).

outcrops of the Seyahou Formation (to which they attributed an Ordovician age) at Kuh-e-Surmeh and Zard-Kuh as well as Kuh-e-Faraghun, and indicated that the unit previously called "Silurian Shale" (which, they noted, is widespread in the Zagros Basin) occurred at Kuh-e-Gahkum and Kuh-e-Faraghun.

The Hadjiabad 1:250,000 geological sheet (Sabzehei 1994) shows "Upper Ordovician to Lower Silurian graptolitic shale and tillite" cropping out

for about 5 km near Seh chahan, on the northern side of a fault; this is the Kuh-e-Gahkom (=Kuh-e-Gahkum) locality (Figure 3).

In summary, prior to this paper, Ordovician graptolites from the Zagros belt have been reported from the Kalat salt plug, Kuh-e-Surmeh (with an associated macrofaunal list), Kuh-e-Gahkum (this record seems suspect) and Kuh-e-Faraghun: Silurian graptolites have been listed from only Kuh-e-Faraghun.

LOWER PALAEOZOIC STRATIGRAPHY IN THE ZAGROS BELT

In the Iranian Stratigraphic Lexicon older Palaeozoic strata in the Zagros Mountains were listed and discussed only under the broad title "Ordovician-Silurian" by Setudehnia (1972).

For the Zagros sequence Ghavidel-Syooki and Khosravi (1995) introduced two new formation names based on the names of towns in the region of Kuh-e-Faraghun: Seyahou (Late Ordovician) and Sarchahan (Early Silurian). They gave a total thickness of 807 m for the Lower Palaeozoic at the type locality of Tang-e Zakeen (23 km N of the town of Seyahou, which they stated to be 103 km N of Bandar Abbas: Figure 1). Of this, a thickness of 741 m was given for the Seyahou Formation and the remainder (66 m) was assigned to the Sarchahan Formation.

The Seyahou Formation was reported by Ghavidel-Syooki and Khosravi (1995) also from surface exposures at Kuh-e-Surmeh (58 m) and Zard-Kuh (70 m) NNW of Shiraz (Figure. 1) and near Kuh-e Dina and Ushturan Kuh. This unit was also reported by them in the Zagros region from oil wells at Kuh-e-Siah 1, Zirreh 1, Kabir-Kuh 1 and Darang 1, where thicknesses of 117 m, 156 m, 100 m and 250 m respectively were cited. Ghavidel-Syooki and Khosravi (1995) suggested that the Seyahou Formation rests conformably on the Zard-Kuh Formation at Zard-Kuh and the last three mentioned oil wells, and is conformably overlain by the Sarchahan Formation. The latter authors listed a substantial microflora from both formations in the Faraghun Mountains.

Ordovician graptolites from the Zagros belt

We describe Ordovician graptolites for the first time from Kuh-e-Faraghun, where we have made small collections. The localities from which our collections were made are described herein. Ghavidel-Syooki and Khosravi (1995) reported graptolites from the unit which they named the Seyahou Formation and considered Ordovician; we here describe one species based on material made available to us by Dr Ghavidel-Syooki.

Silurian graptolites from the Zagros belt

Setudehnia (1972), Kalantari (1981), Ghavidel-Syooki (1994) and Ghavidel-Syooki and Khosravi (1995) have listed Silurian graptolite faunas from Zagros localities. From Kuh-e-Faraghun, Setudehnia (1972) listed the graptolites "*Monograptus* aff. *incommodus* Törnquist, *Climacograptus* cf. *scalaris normalis* Lapworth and some *Diplograptus* species", as well as "*Small Orthoceras*, *Leptostrophia* cf. *filosa*, and *Dalmanella*".

Graptolite localities at Kuh-e-Faraghun and Kuh-e-Gahkum, Zagros belt

The collections of graptolites described here from the Zagros Mountains of southern Iran are from two inliers of Lower Palaeozoic strata exposed in the cores of larger structures (Figure 3). In A-IOC reports, different transliterations of Persian names, such as Kuh-i-Gahkum and Kuh-i-Furgun, are frequently used.

Kuh-e-Faraghun. The Kuh-e-Faraghun localities occur, as described by Douglas (1950), on the southern side of a fault in the core of an anticline near the northern edge of the Zagros Mountains about 95 km N of the city of Bandar Abbas on the Persian Gulf (Figure 1). Douglas described the anticline as being located on the SE extremity of the Zagros belt where the strike swings from NW-SE to E-W. Locality details are given below.

Our main Kuh-e-Faraghun localities are N of the main village of Seyahou, and upstream of the smaller village of Dargaz (Figure 3) which lies to the north of Seyahou. The coordinates of our main Silurian locality (WKF6: Figure 3) are 27° 51' 16" N, 56° 19' 09" E; this locality is in the main river bank several hundred metres upstream from a partly ruined cottage, the only dwelling seen by us upstream from the gorge through which the river flows. The Ordovician localities (WKF1, WKF2) and another Silurian locality (WKF3) were located in a south-flowing tributary which joined the main creek just west of the ruined house. The Ordovician graptolites were collected about 500 m upstream from the river junction, from a prominent scree slope in black concretionary slates, just downstream from a prominent quartzite. A single monograptid-bearing sample (WKF3) was collected about 150 m downstream from the Ordovician locality; precise GPS locations for these points were not recorded.

Allison *et al.* (1937) gave for the area a composite section some 1900 feet (579 m) thick, and consisting of (in descending order):

Dark blue paper shale with septarian concretions and graptolites:	180 feet (55 m)
White sandstone	20 feet (7 m)
"Pipe rock", hard thin quartzite and micaceous shales with worm tubes	650 feet (198 m)
Laminated white sandstone with shaley partings	200 feet (61 m)
Shales, silts and sandstones with brachiopods?	350 feet (107 m)
Shaley micaceous silts, shales, and some sandstone <i>Orthoceras</i> , brachiopods, crinoid fragments (lowest unit)	500+ feet (152 m)

In the part of the Kuh-e-Faraghun inlier where Wright and Hamedi collected graptolites in 1996,

Table 1 Summary of taxa present in available collections from Kuh-e-Faraghun and Kuh-e-Gahkum. Species described and figured herein are marked **, those species only figured are marked *, and those species only described are marked +. Specimens listed only are marked O, new recordings for Iran are marked with a dagger.

Kuh-e-Gahkum: Natural History Museum		sedgwickii Biozone
†O	<i>Normalograptus</i> sp.	
†O	<i>Glyptograptus</i> sp.	
†**	<i>Neodiplograptus thuringiacus</i> (Kirste 1919)	
**	<i>Metaclimacograptus undulatus</i> (Kurck 1882)	
†O	<i>Clinoclimacograptus retroversus</i> (Bulman and Rickards 1966)	
†O	? <i>Rhaphidograptus toernquisti</i> (Elles and Wood 1907)	
†+	<i>Pseudoretiolites perlatus</i> (Nicholson 1868)	
O	<i>Pristiograptus cf. regularis</i> (Törnquist 1899)	
**	<i>Monograptus lobiferus</i> (M'Coy 1850)	
†**	<i>Monograptus decipiens</i> (Törnquist 1899)	
†**	<i>Monograptus capis</i> Hutt 1974	
†**	<i>Monograptus fragilis</i> Rickards 1970	
†**	<i>Stimulograptus sedgwickii</i> (Portlock 1843)	
†**	<i>Torquigraptus denticulatus</i> (Törnquist 1899)	
†*	<i>Torquigraptus</i> sp.	
†O	<i>Coronograptus</i> sp.	
Kuh-e-Gahkum: Golshani collection		convolutus Biozone
†+	<i>Glyptograptus cf. serratus</i> Elles and Wood 1907	
†**	<i>Neodiplograptus thuringiacus</i> (Kirste 1979)	
†+	<i>Metaclimacograptus ?hughesi</i> (Nicholson 1869)	
†O	<i>P. (Pseudorthograptus) sp.</i>	
†O	<i>Petalolithus ovatoelongatus</i> (Kurck 1882)	
*	<i>Pristiograptus regularis</i> (Törnquist 1899)	
**	<i>Monograptus lobiferus</i> (M'Coy 1850)	
†O	<i>Monograptus ?decipiens</i> (Törnquist 1899)	
O	<i>Monograptus ?clingani</i> (Carruthers 1867)	
†O	<i>Rastrites cf. longispinus</i> (Perner 1899)	
Kuh-e-Faraghun		convolutus Biozone
WKF6		
†O	? <i>Glyptograptus</i> sp. nov. Koren' and Rickards (in press)	
†**	<i>P. (Pseudorthograptus) inopinatus</i> (Bouček 1944)	
†O	<i>Clinoclimacograptus retroversus</i> Bulman and Rickards 1966	
O	<i>Pristiograptus cf. regularis</i> (Törnquist 1899)	
†*	<i>Pristiograptus jaculum</i> (C. Lapworth 1876)	
†O	<i>P. cf. jaculum</i> (C. Lapworth 1876)	
†**	<i>Monograptus convolutus</i> (Hisinger 1837)	
†**	<i>Monograptus capis</i> Hutt 1974	
†**	<i>Monograptus</i> sp.	
†O	<i>Lagarograptus</i> sp.	
†O	<i>Pribylograptus</i> sp.	
		leptothea Biozone
WKF3†*	<i>Metaclimacograptus ?hughesi</i> (Nicholson 1868)	
†O	<i>Monograptus ?millipeda</i> (M'Coy 1850)	
†*	<i>Monograptus triangulatus cf. separatus</i> Sudbury 1958	
		persculptus Biozone
WKF2		
and WKF1 **	<i>Normalograptus normalis</i> (Lapworth 1876)	
†**	<i>Persculptograptus persculptus</i> (Elles and Wood 1907)	
†*	<i>Orthograptus amplexicaulis</i> (J. Hall 1847) s.l.	
Ghavidel collection		anceps Biozone
††	<i>Orthograptus amplexicaulis abbreviatus</i> Elles and Wood 1907	

the structure is complex, and the stratigraphy of the Ordovician and Silurian sequence is difficult to decipher. On the basis of our brief visit to the area, it is possible to make only superficial observations: firstly, the thickness of the Ordovician graptolitic sequence appears far less (in sections observed by us) than the thickness of 741 m cited by Ghavidel-Syooki and Khosravi (1995); and, secondly, the Silurian graptolitic beds appear to belong to the sequence of shallow marine bioturbated sandy strata which display abundant trace fossils and sedimentary structures including hummocky cross stratification. The (probably) shallow aspect of the latter sequence may account for the low diversity of the graptolite fauna.

Kuh-e-Gahkum. Graptolites were reported from this inlier by Allison *et al.* (1937), who stated that Silurian strata are exposed in the core of a major anticline. All our information on this locality is derived from the report by Allison *et al.* (1937), who stated that the Silurian strata (exposed thickness 400 feet [122 m]) underlie white Carboniferous sandstone, and are cut off at their base by the frontal thrust. The graptolites collected by Lees in 1936 were from the lower division of some 61 m of olive-green fissile shales. This graptolitic unit is overlain by a 1 m band of yellow-weathering sandstone containing orthoid brachiopods; the age of these brachiopods was uncertain, with Late Devonian or Permian ages considered by Allison *et al.* (1937). The unfossiliferous upper part of the sequence consists of alternating thin bands of khaki-weathering shale, and sandstone (Allison *et al.* 1937).

One of our small collections of graptolites from Kuh-e-Gahkum was among BP material deposited in the Natural History Museum; this material occurs in green to grey shales. The material is labelled as from Kuh-e-Gahkum, in which case it was probably collected by Lees (see above). A preliminary list of taxa prepared by Dr Richard Fortey cites: *Pseudoclimacograptus undulatus* (Kurck), *Monograptus lobiferus* (M'Coy), *Pristiograptus? regularis* (Törnquist) and *Monograptus clingani* (Carruthers). The other collection was made available to us by Dr F. Golshani of the Iranian Geological Survey. The composite list of 24 graptolite taxa from these two collections is shown in Table 1.

The legend for the Hadjiabad geological map (Sabzehei 1994) mentions graptolitic strata at Kuh-e-Gahkum.

Kuh-e-Surmeh. Attention was first drawn to this inlier by Kent (1951), and much later by Szabo *et al.* (1977). The sequence was described by Kent as "predominantly of olive green to grey silty micaceous shales, with thin (3-10 inch) micaceous ripple-marked current bedded sandstones. ... The general impression is of a flysch facies, and the beds

are reminiscent of the shalier Early Silurian of the Welsh border".

Kent noted that: "The lowest beds seen, exposed in the tang ["tang" being Persian for gorge or valley bank] of Chasmeh-i-Surmeh, were provisionally diagnosed as early Silurian from indifferently preserved brachiopods collected in 1949-50", and assigned a thickness of 300 feet (91.4 m) to the sequence. Important faunas have been noted from the inlier, as discussed by Douglas (*in* Kent 1951); Douglas opted firmly for a Late Ordovician age, based on fossils collected by Kent and A. McGugan, and the opinions of Bulman and Stubblefield. Kent noted that the trilobites *Eohomalonotus cf. bohemicus* Barrande and *Dalmanitina* sp. and the graptolite *Climacograptus* sp. were collected some 12 feet (3.6 m) below the top of the succession, and fragmentary material was collected some 50 feet (15.2 m) lower; orthoid brachiopods and gastropods also occurred. "A probable *Glyptograptus*" was collected from an isolated position inferred to be very low in the exposed sequence, and was considered unlikely to be older than Middle Ordovician (Kent 1951).

Douglas commented that the brachiopods "are probably all Ordovician Dalmanellids". Cocks and Fortey (1988) illustrated the Ordovician brachiopod *Dalmanella cf. multiplicata* (Bancroft) from the region, based on material donated to the Natural History Museum (London) by Dr W. Hirsch.

Ghavidel-Syooki (1994) concluded from his palynological study that the unnamed Late Ordovician (Caradoc-Ashgill) strata at Kuh-e-Surmeh are overlain, with a major hiatus, by the Early Permian Faraghan Formation (now termed Chal-i-Sheh Formation; see Ghavidel-Syooki [1997] for discussion).

GRAPTOLITE AGES AT KUH-E-FARAGHUN AND KUH-E-GAHKUM

The full faunal lists are shown in Table 1, and the species listed there are either commented upon in Palaeontological Notes or described in the Systematics section, as considered appropriate.

Kuh-e-Faraghun: Four graptolite localities have been collected by us at Kuh-e-Faraghun: WKF1, WKF2, WKF3 and WKF6.

The oldest are unquestionably WKF1 and WKF2 which have the same fauna, referable to the Late Ordovician *Persculptograptus persculptus* Biozone, and which yield the eponymous species as well as *Orthograptus amplexicaulis* Hall and *Normalograptus normalis* (Lapworth). In addition, Dr Ghavidel-Syooki has given us several graptolite specimens from another locality at Kuh-e-Faraghun for study; they are identified here as *Orthograptus amplexicaulis abbreviatus* Elles and Wood, which indicates the *anceps* Biozone.

WKF3 is Silurian, *gregarius* Biozone *sensu lato*, and

possibly referable to the *leptotheca* Biozone (that is uppermost *gregarius* Biozone in old terminology). *Monograptus triangulatus* cf. *separatus* Sudbury occurs, with probable *Metaclimacograptus hughesi* (Nicholson) and possible *Monograptus millipeda* (McCoy).

WKF6 is unambiguously referable to the *convolutus* Biozone, as it yields the eponymous species and eight other taxa. Of these the record of *Pseudorthograptus* (*Pseudorthograptus*) *inopinatus* (Boucek) is of interest, being a rarely-recorded, delicately structured graptolite (see Koren' and Rickards 1996). This occurrence is slightly higher than recorded previously, but there are few global records to make its total range certain.

Kuh-e-Gahkum: From here, we have two collections yielding a total of 24 taxa (Table 1). Our NHM collection is clearly referable to the *sedgwickii* Biozone but the Golshani collection, lacking *M. sedgwickii* (Portlock), is probably from the *convolutus* Biozone: certainly *R. cf. longispinus* (Perner), *G. cf. serratus* Elles and Wood, and *M? clingani* (Carruthers) suggest the *convolutus* Biozone rather than the *sedgwickii* Biozone.

PALAEONTOLOGICAL NOTES

Specimens in the Gahkum Silurian collection, held by the Natural History Museum (BMNH QQ4-QQ19), are preserved almost flattened with a thin goethite infill in a dark siltstone. The Golshani collection is, as far as can be inferred from the age of the fauna, from a slightly lower horizon; it is preserved in a very fragile black shale, usually as carbonaceous films on the bedding plane (SM X.26384-5; 26590-3; 26668; 26670,74-77).

The Late Ordovician *persculptus* Biozone material from Fagahun is preserved as rather poorly preserved chloritic or carbonaceous films flattened on bedding planes of black shale. The *gregarius* and *convolutus* Biozone specimens from Faraghun are, however, well-preserved in detail, if inconspicuous at first examination; they are preserved as more or less carbonised periderm, almost flattened, in a dark mudrock or siltstone. The Ghavidel collection of Ordovician specimens (SM X. 26679-26698) from Faraghun occur in a bioclastic sparry limestone as three dimensional rhabdosomes, or in fine sandstone, as carbonised, and more or less flattened specimens.

Of the 38 taxa listed in Table 1, 33 are new recordings for Iran. In the systematic description below we have described briefly those forms which are well-preserved or which have features of interest in the fauna. Some we have not described, especially if they are badly-preserved or where we have nothing to add to previous descriptions or records. None of the specimens in any of these collections is obviously tectonically deformed.

Where diagnoses are given these refer only to the Iranian material, not to any previous descriptions from other localities. Comments given immediately below refer to material from both Faraghun and Gahkum.

Clinoclimacograptus retroversus (Bulman and Rickards) is often a common species in Llandovery strata, but is difficult to identify from fully flattened rhabdosomes which assume secondarily a climacograptical profile; only a few specimens have been found with the thecal sigmoidal curvature. *Rhaphidograptus toernquisti* (Bulman), an equally common species in many localities, is here quite rare and, in view of the poor preservation of the proximal end, must remain a doubtful record.

Pristiograptus regularis (Törnquist) is quite well-preserved and common in the Golshani material, and a form possibly identical, recorded here cautiously as *P. cf. regularis*, occurs also in the BMNH Gahkum collection, and at Kuh-e-Faraghun (WKF6). We have identified the similar species *P. jaculum* (Lapworth) [and *P. cf. jaculum*] only from the *convolutus* Biozone (WKF6) of Kuh-e-Faraghun: in this form the thecal apertures are more or less horizontal or even turned slightly inwards.

Two triangulate monograptids, *M. clingani* (Carruthers) and *M. millipeda* (McCoy), are here recorded doubtfully from appropriate horizons, namely the *convolutus* Biozone of Gahkum (Golshani collection) and the *gregarius* Biozone *sensu lato* of Faraghun (WKF3). Other Gahkum triangulates not described include a *Torquigraptus* sp. from the *sedgwickii* Biozone and *Rastrites* cf. *longispinus* (Perner) from the *convolutus* Biozone.

Two slender monograptid genera, *Coronograptus* sp. from the *sedgwickii* Biozone of Gahkum and *Lagarograptus* sp. from the *convolutus* Biozone of Faraghun are known. Neither is well enough preserved for full description or specific identification. Another slender monograptid from the *convolutus* Biozone of Kuh-e-Faraghun is referable to *Pribylograptus* sp.

Finally there are two other difficult biserials in the *sedgwickii* Biozone in the Golshani Gahkum material, *Normalograptus?* sp. and *Glyptograptus?* sp., which perhaps hint that further collecting will yield a richer assemblage still. It is possible that both these forms are badly preserved examples of *Clinoclimacograptus retroversus* which does occur here. From Kuh-e-Faraghun there is a further difficult biserial which we have tentatively identified as *?Glyptograptus* sp. nov. Koren' and Rickards (in press), a tiny glyptograptid characterised by high thecal spacing. However, only a single badly preserved specimen (X.26655) is available.

In Table 1 those species described and figured herein are marked **, those species only figured are marked *, and those species only described are

marked +. Specimens listed only are marked O, new recordings for Iran are marked with a dagger. In the following systematics section the basic classification and measuring systems used follows Koren' and Rickards (1996, pp. 10-19) for the reasons stated in that paper. Specimens are deposited in the Sedgwick Museum, Cambridge (SM X. 26383-97 and X.26575-26721) and in the Natural History Museum (BMNH QQ4-QQ19).

SYSTEMATIC DESCRIPTIONS

Class Graptolithina

Suborder Virgellina Fortey and Cooper, 1986

Superfamily Diplograptacea Lapworth, 1873

Family Glyptograptidae Fortey and Cooper, 1986 (emend. Koren' and Rickards, 1996)

This term was first used in print by Fortey and Cooper (1986) on the basis of a name proposed in manuscript form by C. Mitchell who decided against the proposal of this name before his paper appeared in 1987. However, we here follow the usage of Koren' and Rickards (1996) as the mention of this name accompanied by a definition appears to satisfy Article 13 a ii of the ICZN.

Glyptograptus Lapworth, 1873; emend. Koren' and Rickards, 1996

Type species

Glyptograptus tamariscus Nicholson 1868.

Glyptograptus sp. cf. *G. serratus* Elles and Wood, 1907

cf. *Diplograptus* (*Glyptograptus*) *serratus* sp. nov. Elles and Wood 1907: 249, pl. 30, fig. 10a-c, text-fig. 169.

Glyptograptus cf. *serratus*: Koren' and Rickards 1996: 25-6, pl. 1, fig. 10, pl. 2, figs 1-10.

Material

A single well-preserved but flattened specimen (X.26384) and a doubtful specimen (X.26385) from the Golshani collection from Kuh-e-Gahkum, *convolutus* Biozone.

Remarks

The proximal end is badly preserved thus not allowing a sure identification, but the distal dorso-ventral width of 2.50 mm together with a thecal spacing of 10 in 10 mm and geniculate glyptograptid thecae suggests a form very close to *G. serratus* as recently revised by Koren' and Rickards (1996). There is a small, badly preserved glyptograptid (X.26655) from the *convolutus* Biozone

of Kuh-e-Faraghun which we have tentatively identified as ?*G.* sp. nov. Koren' and Rickards (*in press*). Whilst belonging to the same species group, it is characterised by small size and very high thecal density.

Persculptograptus Koren' and Rickards, 1996

Type species

Diplograptus persculptus Elles and Wood 1907.

Persculptograptus persculptus (Elles and Wood, 1907)

Figures 4C-E

Diplograptus persculptus n. sp. ?Salter, *nom. nud.* 1865: 25 (see Strachan 1971).

Diplograptus (*Glyptograptus*) *persculptus*: Elles and Wood 1907: 257, pl. 31, figs 7a-c, text-figs 176a, b.

For full synonymy, see Štorch and Loydell (1996).

Material

SM X. 26386-97, X.26575-89, from Faraghun localities WKF1 and WKF2.

Remarks

These forms are identical to flattened specimens from the type locality at Pumpsaint, Wales, in thecal spacing, dorso-ventral width both proximally and distally, inclined supragenicular wall, and slight geniculum of proximal thecae. The thecal curvature and thecal overlap, though less easy to see, appear the same; and the rhabdosomes are similarly septate. A more slender glyptograptid (X.26396, Figure 4F) is associated with this species at locality WKF2 but, as we have few specimens, comparison with other slender *persculptus* Biozone specimens from elsewhere is difficult.

Neodiplograptus Legrand, 1987

Type species

Diplograptus magnus H. Lapworth 1900.

Neodiplograptus thuringiacus (Kirste, 1919) Figures 4A-B

Diplograptus thuringiacus Kirste 1919: 135.

Neodiplograptus thuringiacus: Štorch and Serpagli 1993: 22, text-fig. 5E.

A full synonymy was given in Štorch and Serpagli (1993).

Material

X.26590-93 from the *convolutus* Biozone and

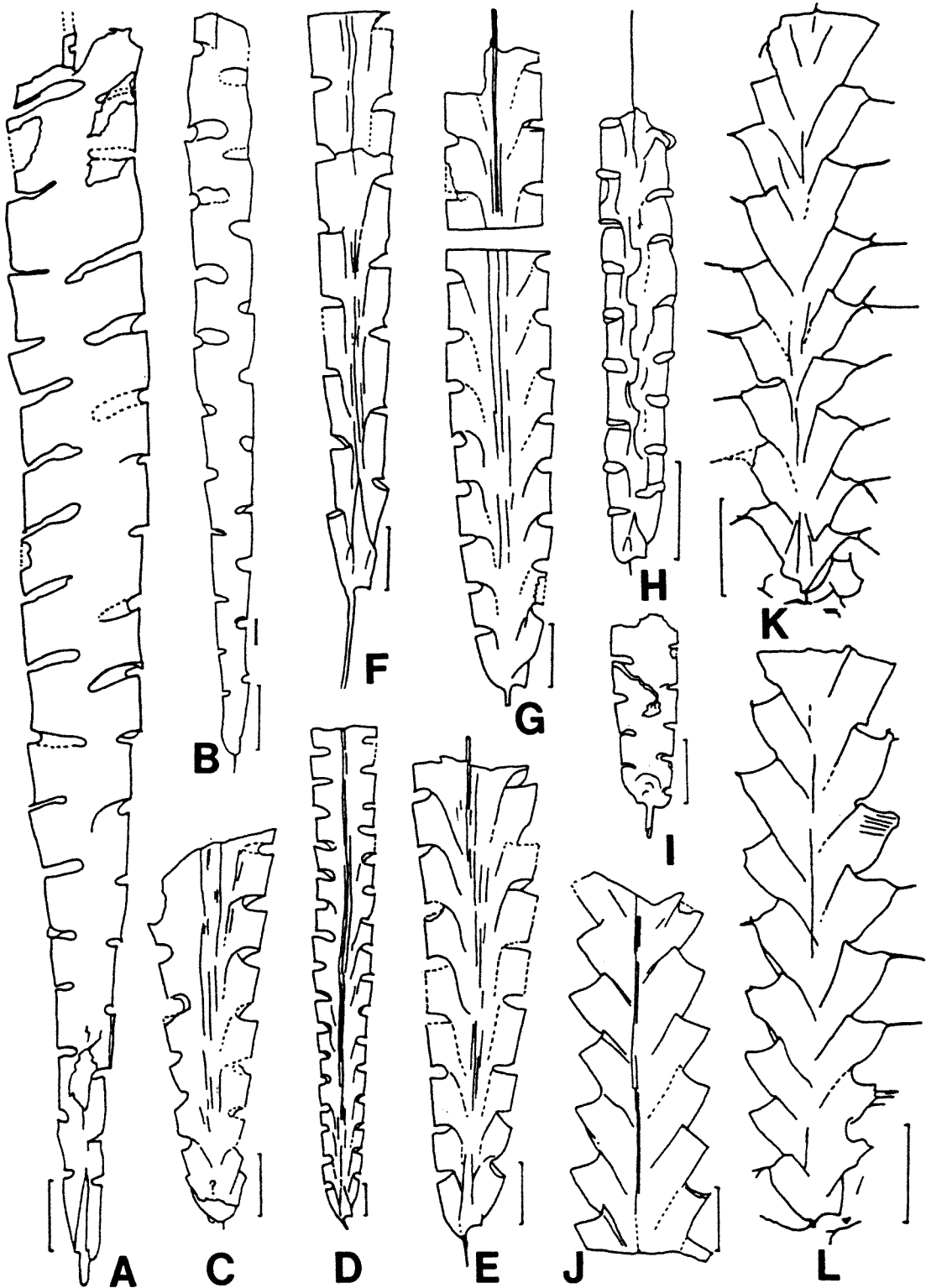


Figure 4 A, B. *Neodiplograptus thuringiacus* (Kirste), respectively BMNH QQ9b and QQ18, the latter tectonically narrowed, from the *sedgwickii* Biozone of Kuh-e-Gahkum. C-E. *Persculptus persculptus* (Salter), respectively SM X. 26386-7, 26391, from locality WKF2, *persculptus* Biozone, Kuh-e-Faraghun. F. *Glyptograptus* sp., SM X.26396, locality WKF2, *persculptus* Biozone, Kuh-e-Faraghun. G. *Normalograptus normalis* (Lapworth), SM X. 26667, locality WKF1, *persculptus* Biozone, Kuh-e-Faraghun. H. *Metaclimacograptus undulatus* (Kurck), BMNH QQ14a, *sedgwickii* Biozone, Kuh-e-Gahkum. I. *Pseudoclimacograptus* cf. *formosus* Mu and Lee, SM X. 26767, locality WB3, Banestan. J. *Orthograptus amplexicaulis* (J. Hall) s.l., SM X. 26701, locality WKF1, *persculptus* Biozone Kuh-e-Faraghun. K-L. *Pseudorthograptus* (*Pseudorthograptus*) *inopinatus* (Bouček), respectively SM X.26628, 26627, from locality WKF6, *convolutus* Biozone, Kuh-e-Faraghun. Scale bars = 1 mm; black bar in Figure 4B indicates tectonic stretching direction.

BMNH QQ9a-b and QQ11a-b from the *sedgwickii* Biozone of Kuh-e-Gahkum (Table 1).

Remarks

This material is very close to that described in detail by Štorch and Serpagli (1993) except in being slightly narrow distally (2.0 mm compared with 2.5 mm). The thecal spacing at 12–10 in 10 mm proximally and 10 in 10 mm distally is more or less the same, as are the dorso-ventral width in the first 20 mm of the rhabdosome and the robust virgella. In our material a three-dimensional sicula is visible, being 1.40 mm long, approximately. The thecal apertures alternate in typical fashion.

Normalograptus Legrand, 1987

Type species

Climacograptus scalaris var. *normalis* C. Lapworth 1876.

Normalograptus normalis (Lapworth, 1876)

Figure 4G

1876 *Climacograptus scalaris* var. *normalis* Lapworth 1877: 138, p. 6, fig. 31.

Material

Numerous specimens (X.26594-26624) from Kuh-e-Faraghun (WKF1 and 2), *persculptus* Biozone, all specimens flattened.

Diagnosis

Rhabdosome up to 15 mm long with a distal dorso-ventral width of 1.30–1.50 mm, parallel-sided after 10 mm; thecal spacing 13–11 in 10 mm proximally to 9–10 in 10 mm distally; apertural excavations narrow and moderately deep occupying about 1/5 of the rhabdosome width, slightly alternating; rhabdosome fully septate.

Pseudorthograptus (*Pseudorthograptus*) Legrand, 1987

Type species

Diplograptus insectiformis Nicholson 1869.

Pseudorthograptus (*P.*) *inopinatus* (Bouček, 1944)

Figures 4K–L, 5A–B

1944 *Orthograptus* (?) *inopinatus* n. sp. Bouček 1944: 2, pl. 1, fig. 8, text-figs 1b–c.

Pseudorthograptus (*Pseudorthograptus*) *inopinatus*: Koren' and Rickards 1996: 69–70, pl. 11, fig. 10, text-figs 16B–F, 17.

For full synonymy, see Koren' and Rickards (1996).

Material

Well-preserved though inconspicuous specimens from locality WKF6 of Kuh-e-Faraghun (X.26626–8, 26631, 26633–39, 26640–54, 26665–6).

Remarks

This rarely-recorded species has recently been redescribed by Koren' and Rickards (1996) from material found in western Kazakhstan. The Iranian specimens agree closely in thecal spacing (14–17 in 10 mm proximally and 12–15 in 10 mm distally) and dorso-ventral width (up to 1.50 mm). The rhabdosomes are a little longer (7 mm compared with 5 mm), but all other measurements are the same. *P.*(*P.*) *inopinatus* can be confused with *P.* (*P.*) *insectiformis minutus* (Churkin and Carter) but differs in having bifurcating stout spines on the thecal apertures, seen clearly in places on the Iranian specimens.

Family *Metaclimacograptidae* Koren' and Rickards, 1996

Metaclimacograptus Bulman and Rickards, 1966

Type species

Diplograptus hughesi Nicholson 1869.

Metaclimacograptus undulatus (Kurck, 1882)

Figures 4H, 7B–E

Climacograptus undulatus Kurck 1882: 303, pl. 14, fig. 11.

1996 *Metaclimacograptus undulatus*: Koren' and Rickards 1996: 100, pl. 14, figs 10–12; text-fig. 23E.

Material

Numerous specimens in three dimensions, infilled with haematite but with periderm preserved, from Kuh-e-Gahkum, *sedgwickii* Biozone (BMNH QQ14, 15, 16 and 19).

Diagnosis

Rhabdosome up to 7 mm long, parallel-sided with a dorso-ventral width of 0.55–0.75 mm, and a thecal spacing of 4 in 2.5 mm; genicular hoods well seen; median septum with characteristic angular undulation; median septum often seen fully as rhabdosomes have often split along their lengths. Th 1¹ grows downwards for 0.25 mm – 0.30 mm to just below the sicular aperture, and upwards for 0.40–0.45 mm.

Remarks

The Iranian specimens differ from recently-described material (Koren' and Rickards 1996) only

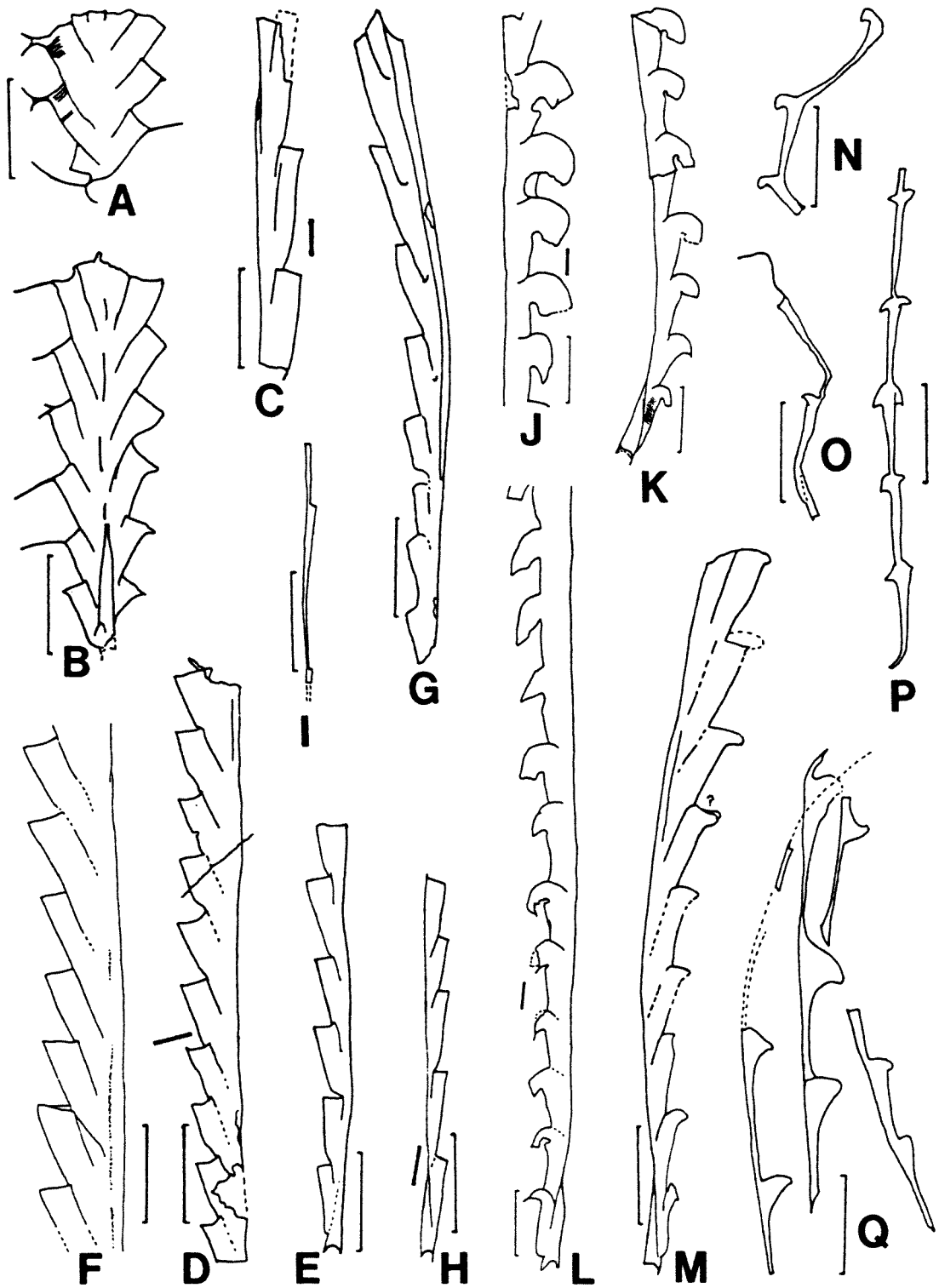


Figure 5 A, B. *Pseudorthograpus* (*Pseudorthograpus*) *inopinatus* (Bouček), respectively SM X. 26631, 26626, both preserved in three dimensions infilled with pyrites, from locality WKF6, *convolutus* Biozone, Kuh-e-Faraghun. C–E, *Pristiograpus* cf. *regularis* (Törnquist) respectively BMNH QQ7, from the *sedgwickii* Biozone, Kuh-e-Gahkum, and SM X.26632 from locality WKF6, *convolutus* Biozone Kuh-e-Faraghun. F–H, *Pristiograpus* cf. *jaculum* (Lapworth), respectively BMNH QQ4, *sedgwickii* Biozone, Kuh-e-Gahkum, SM X.26629, locality WKF6, *convolutus* Biozone, Kuh-e-Faraghun and BMNH QQ7, *sedgwickii* Biozone Kuh-e-Gahkum. I, *Monograpus fragilis* Rickards, BMNH QQ7, *sedgwickii* Biozone Kuh-e-Gahkum. J–K, *Monograpus lobiferus* (M'Coy), both BMNH QQ7, *sedgwickii* Biozone, Kuh-e-Gahkum. L, *Stimulograpus sedgwickii* (Portlock), BMNH QQ5, *sedgwickii* Biozone, Kuh-e-Gahkum. M, *Monograpus* sp., SM X. 26630, from locality WKF6, *convolutus* Biozone, Kuh-e-Faraghun. N–Q, *Monograpus capis* Hutt, respectively BMNH QQ13a, QQ7, QQ7, and QQ7 from *sedgwickii* Biozone, Kuh-e-Gahkum. Scale bars = 1 mm; heavy bars = tectonic stretching direction.

in having a slightly shorter th 1¹ (up to 0.85 mm in material from Kazakhstan).

***Metaclimacograptus ?hughesi* (Nicholson, 1869)**

?*Diplograptus hughesi* Nicholson 1869: 234, pl. 11, figs 9–10.

?*Metaclimacograptus hughesi*: Zalasiewicz 1996: 2–3, text-fig. 2, 2A–C.

Material

A few specimens (X.26671-2, X26673) from the *gregarius* Biozone of Kuh-e-Faraghun (WKF3) and the *convolutus* Biozone of Kuh-e-Gahkum (Golshani collection), poorly preserved in low relief.

Remarks

These poorly-preserved specimens appear to have the gently undulating median septum of *M. hughesi*. Zalasiewicz (1996) has recently redefined the species and the Iranian material is closer to Nicholson's types which have a dorso-ventral width of 1.0 mm – 1.2 mm in contrast to *M. slalom* Zalasiewicz which is about half that width. Furthermore *M. hughesi*, as redefined by Zalasiewicz, ranges up into the *convolutus* Biozone which is in accord with our record.

Family Orthograptidae Mitchell, 1987

***Orthograptus* Lapworth, 1873**

Type species

Graptolithus quadrimucronatus J. Hall 1865

***Orthograptus amplexicaulis abbreviatus* Elles and Wood, 1907**

Text-figures 8B–C

Diplograptus (*Orthograptus*) *truncatus* var. *abbreviatus* var. nov. Elles and Wood: 1907: 235–6, pl. 29, figs 6a–e, text-figs 155a–d.

For full synonymy, see Williams (1981).

Material

Sixteen specimens (X.26679-88, X.28111-2, X.28257-9, and X.28263) from the Ghavidel collection, Kuh-e-Faraghun, Late Ordovician buff-coloured siltstone, and ten specimens (X.26689-98), same collection and locality from a bioclastic sparry limestone; preservation is in full relief in the limestone and in low relief in the siltstone.

Remarks

In all dimensions and characters, the beautifully preserved Iranian specimens closely resemble the Elles and Wood (1907) originals, and especially

agree well with the detailed redescription by Williams (1981). *Orthograptus amplexicaulis abbreviatus* is, in our opinion, so close to *O. a. amplexicaulis* that it is best retained as a subspecies. Williams (1981) considered *O. a. abbreviatus* typical of the Late Ordovician *anceps* Biozone. This is the only evidence we have for the age of these two Ghavidel samples.

***Orthograptus amplexicaulis* (J. Hall, 1847)**

sensu lato

Figures 4J, 8A

Graptolites amplexicaule sp. nov. Hall 1847: 79–80, 316.

Material

X.26699-700 and X.28113 from the *persculptus* Biozone, (WKF1 and WKF2) of Kuh-e-Faraghun. Preservation is good, but incomplete, so that positive identification is not at the moment possible.

Remarks

Williams (1981) dismissed the claimed occurrences of *O. amplexicaulis abbreviatus* from the *persculptus* Biozone. We note that there are unquestionable members of the species group, not as yet fully described, from that biozone (see Rickards 1988). The present material, although well preserved, is fragmentary but does allow us to note that, in support of Williams' view, the first and second thecae of the rhabdosome grow strongly upwards (Figure 8A) in contrast to *O. amplexicaulis abbreviatus*.

Family Retiolitidae Lapworth, 1873

***Pseudoretiolites* Bouček and Münch, 1944**

Type species

Retiolites perlatus Nicholson 1868.

***Pseudoretiolites perlatus* (Nicholson, 1868)**

Retiolites perlatus Nicholson 1868: 530, pl. 19, figs 21, 22.

Retiolites perlatus perlatus: Hutt 1974: 47, text-fig. 12, fig. 4.

A fuller synonymy is given in Hutt (1974) and Loydell (1993).

Material

A single fragmentary specimen of meshwork (BMNH QQ6) from the *sedgwickii* Biozone of Kuh-e-Gahkum, and a possible specimen (QQ7) from the same locality and horizon.

Remarks

The species may range as high as the *maximus* Sub-biozone of the *turriculatus* Biozone, so that a *sedgwickii* Biozone record is not out of place. Hutt (1974), however, only recorded the species as high in the *convolutus* Biozone. Specimen QQ6 is about 4 mm by 2 mm broad and appears to be close to the proximal end, has the typical open clathrial meshwork, and a slender nema is present.

Superfamily Monograptacea Lapworth, 1873**Family Monograptidae Lapworth, 1873*****Monograptus* Geinitz, 1852 *sensu lato*****Type species**

Lomatograptus priodon Bronn 1835.

***Monograptus capis* Hutt, 1974**

Figures 5N–Q

Monograptus capis sp. nov. Hutt 1974: 79–80, pl. 19, fig. 7; text-fig. 19, figs 1–3.

Material

Numerous fragmentary though well-preserved specimen (X.26657 and BMNH QQ6-7, 11-12) from the *convolutus* Biozone of Kuh-e-Faraghun and the *sedgwickii* Biozone of Kuh-e-Gahkum.

Remarks

M. capis is a long-ranging species, according to Hutt (1974), from the *magnus* to *turriculatus* biozones. Our material agrees with the original in thecal spacing (7–10 in 10 mm), the thread-like prothecal part, and in dorso-ventral width (0.30 mm – 0.50 mm), but differs slightly in having a slightly concave free ventral wall. A specimen from QQ7 (Figure 5P) clearly shows transverse expansion of the thecal apertural region, something which Hutt (1974, p.81) doubted in the case of *M. capis*. However, as pointed out by Hutt, *M. elongatus* Törnquist **does** show transverse thecal expansion and has straight or concave free ventral walls. But our material exhibits the rapid metathecal expansion of *M. capis* not the gradual expansion of *M. elongatus*. For the present we prefer to retain the Iranian material in *M. capis*. It may be that such long-ranging species show more variation than has yet been recognised.

***Monograptus convolutus* (Hisinger, 1837)**

Figure 6A

Prionotus convolutus Hisinger 1837: 114, pl. 35, fig. 7.

Monograptus convolutus: Hutt 1974: 83–4, pl. 19, fig. 3; pl. 25, fig. 3; text-fig. 22, figs 2, 6.

A fuller synonymy is given by Hutt (1974).

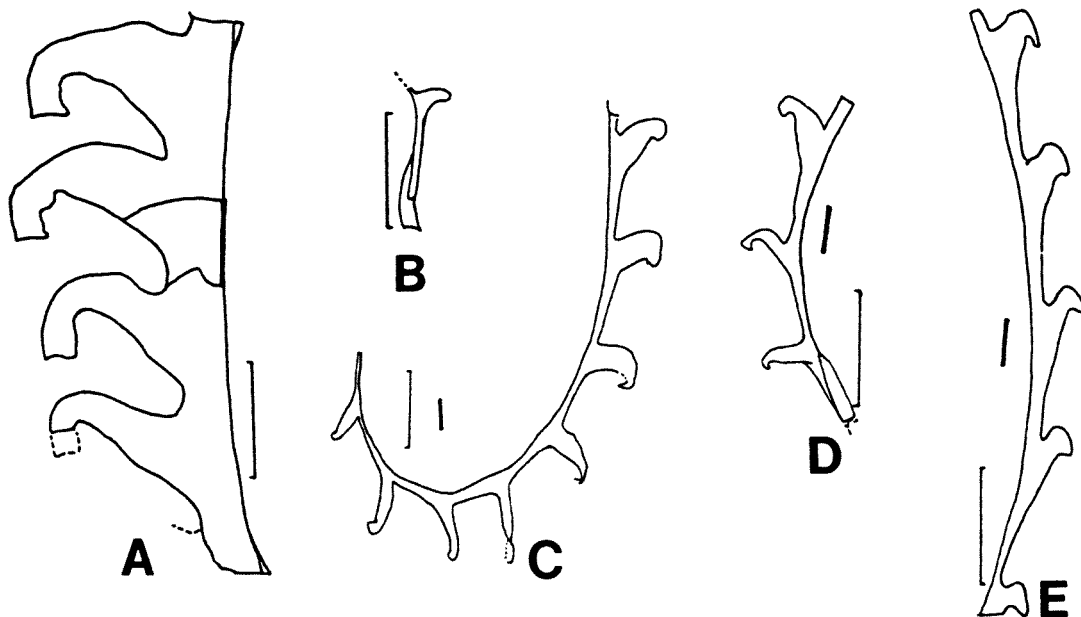
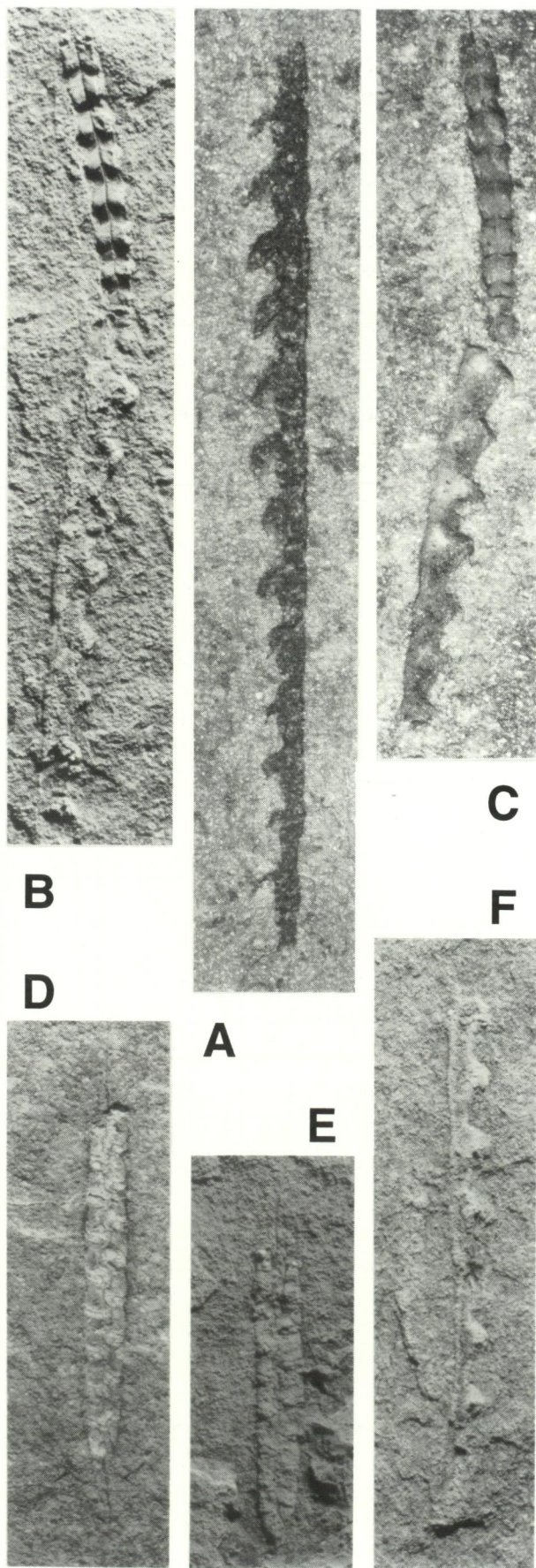


Figure 6 A, *Monograptus convolutus* (Hisinger), SM X. 26625 from the *convolutus* Biozone, Kuh-e-Faraghun. B–C, *Torquigraptus denticulatus* (Törnquist), BMNH QQ13a, *sedgwickii* Biozone, Kuh-e-Gahkum. D, *Monograptus decipiens* Törnquist, BMNH QQ19, *sedgwickii* Biozone, Kuh-e-Gahkum. E, *Torquigraptus* sp., BMNH QQ5, *sedgwickii* Biozone, Kuh-e-Gahkum. Scale bars = 1 mm



Material

A few fragmentary specimens (X.26637, X26625a,b, X.26673) from Kuh-e-Faraghun (WKF6) preserved in low relief with periderm preserved, but poorly; *convolutus* Biozone.

Remarks

These fragmentary specimens have the typically high metathecae (2.00 mm – 2.50 mm) with transversely expanded apertures and a thecal spacing of 8–10 in 10 mm. Traces of the typical rhabdosomal curvature can be detected, but no rastritiform proximal end has been found. The species has not been recorded from the *convolutus* Biozone of Kuh-e-Gahkum.

Monograptus decipiens Törnquist, 1899

Figure 6D

Monograptus decipiens n. sp. Törnquist 1899: 20, pl. 4, figs 9–14.

Monograptus decipiens: Sudbury 1958: 510, pl. 21, figs 74–75.

Monograptus decipiens decipiens: Hutt 1974: 85–6, pl. 21, figs 2–4; text-fig. 17, fig. 5; text-fig. 20.

Material

A small number of specimens (BMNH QQ13a–b, QQ19) from the *sedgwickii* Biozone of Kuh-e-Gahkum and, more doubtfully, from the *convolutus* Biozone in the Golshani collection (X.26674) has been studied.

Remarks

The thecal spacing at 8–10 in 10 mm and thecal height at 1.30 mm – 1.40 mm agrees well with Hutt's (1974) description and with Sudbury's (1958) detailed redescription of Törnquist's form. In this material only mesial to distal fragments have been identified and there are no associated (rastritiform) proximal thecae. The transverse expansion of the

Figure 7 A, *Monograptus lobiferus* (M'Coy), QQ5, *sedgwickii* Biozone, Kuh-e-Gahkum. B–F, *Metaclimacograptus undulatus*, all *sedgwickii* Biozone, Kuh-e-Gahkum. B–C, BMNH QQ15, *M. undulatus* [upper specimen]. B shows bases of interthecal septa clearly, and *Stimulograptus sedgwickii* (Portlock) [lower specimen], and C shows the undulating median septum and position of the virgula within it. D–E, BMNH QQ16, D shows characteristic undulating median septum in profile, whilst E shows thecal genicular hoods clearly. F, *Stimulograptus sedgwickii* (Portlock), BMNH QQ5, *sedgwickii* Biozone, Kuh-e-Gahkum. Scale bars = 1 mm.

thecal apertures detected by Sudbury (1958) and Hutt (1974) is preserved on this material. Sudbury was at pains to show how the transverse thecal expansion flattened to the bedding in a characteristic manner resulted in a distal edge to the metathecae looking chisel-like. This is identifiable in the present material and is not to be confused with the laterally twisted metatheca of *Torquigraptus*. The species has not been found at Kuh-e-Faraghun.

Monograptus fragilis Rickards, 1970

Figure 5I

Monograptus fragilis sp. nov. Rickards 1970: 89, text-fig. 17, fig. 17.

Pristiograptus fragilis fragilis: Hutt 1974: 60, text-fig. 14, fig. 6.

Material

A single specimen of two thecae only (BMNH QQ 7) from the *sedgwickii* Biozone of Kuh-e-Gahkum.

Remarks

This is a long-ranging species (*acinaces* to

convolutus biozones in Hutt 1974) and this record extends the range to the *sedgwickii* Biozone. It was suggested by Rickards (1970) that the species might be a slender pristiograptid and Hutt acted upon this suggestion. However, it must be said that thecal details have not yet been well seen and it is possible that there is as yet undetected temporal variation. For that reason we prefer to leave the species in the portmanteau concept of *Monograptus* for the present.

Monograptus lobiferus (M'Coy, 1850)

Figures 5J-K, 7A

Graptolites lobiferus M'Coy 1850: 270.

Hutt (1974) has given a full synonymy of the species.

Material

SM X.26675-7 from the Golshani collection of Kuh-e-Gahkum, *convolutus* Biozone. Preservation is good, in low to moderate relief, the periderm being unfilled with goethite or haematite after pyrite. Numerous specimens from the *sedgwickii* Biozone of Kuh-e-Gahkum (BMNH QQ6, 10, 14, 15, 16, 17 and 19).

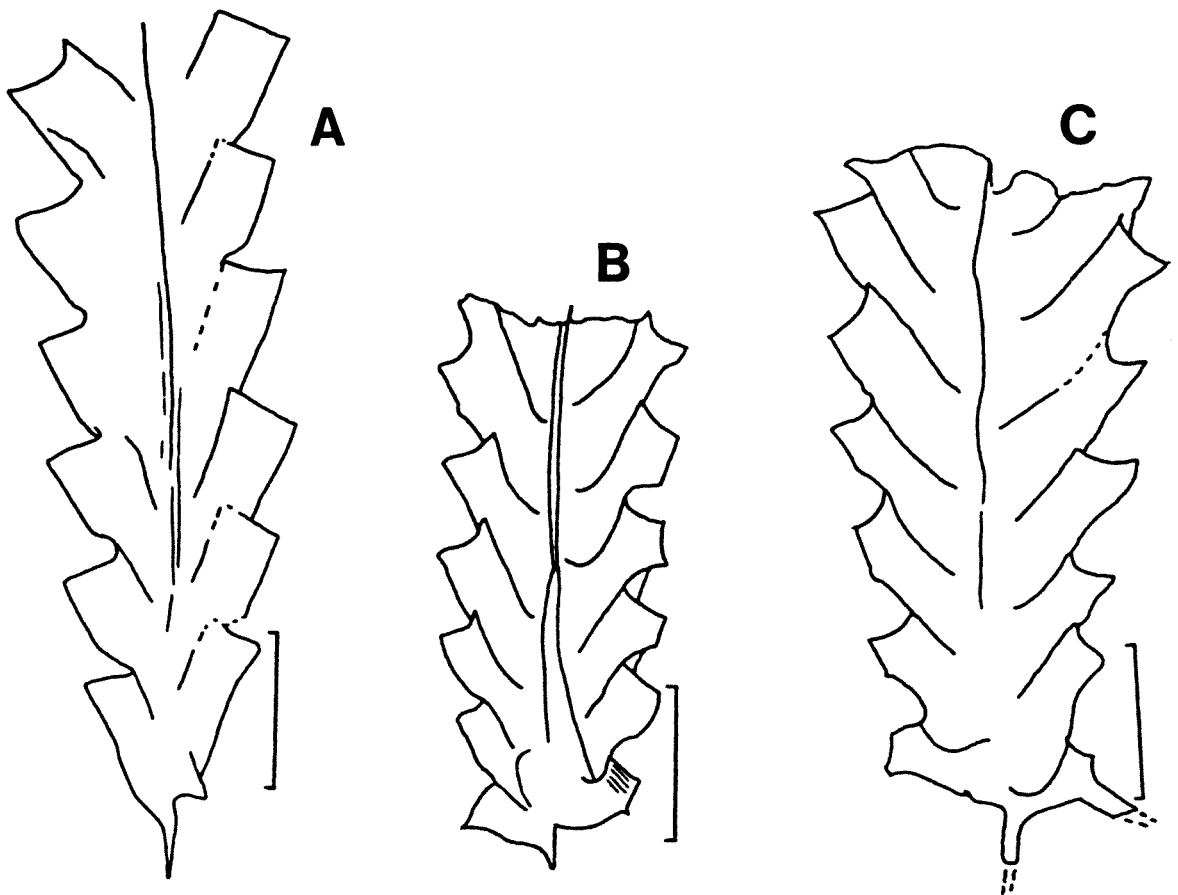


Figure 8 A, *Orthograptus amplexicaulis* (J. Hall 1847) *sensu lato*, Ghavidel collection. X.28113, x20. B-C, *Orthograptus amplexicaulis abbreviatus* (Elles and Wood 1907), Ghavidel collection. B, X.28111, x20; C, X.28112, x20. All Seyahou Formation, Kuh-e-Faraghun.

Remarks

These are well-preserved specimens showing all the typical *M. lobiferus* features including the slight lateral apertural process of the dorsal part of the hook (Figure 5J) normally very inconspicuous. The only surprising feature is the lack of clarity of the thecal overlap, perhaps reflecting the manner in which the original pyrite infill has decayed. The species has not yet been recorded from the *convolutus* Biozone material of Kuh-e-Faragun.

Monograptus triangulatus cf. *separatus*
Sudbury, 1958

cf. *Monograptus separatus separatus* var. nov.
Sudbury 1958: 496, pl. 19, figs 33–39.

Material

A single well-preserved though flattened specimen (X.26678) from Kuh-e-Faragun, *gregarius* Biozone *sensu lato* (locality WKF3).

Remarks

In thecal height (1.50 mm) and thecal spacing mesially (10 in 10 mm) this triangulate monograptid fits in *M. triangulatus* (Harkness). However, the extreme proximal end is missing, but there are no more than 4 or 5 rastritiform thecae. On these grounds, the WKF3 specimen is probably referable to *M. t. separatus* Sudbury. Previous records of the subspecies suggest an upper limit of *magnus* Biozone but unpublished information of one of us (R.B.R.) indicates that it may reach the *leptotheca* Biozone. Its occurrence at WKF3 with forms resembling *Monograptus millipeda* (McCoy) and *Metaclimacograptus hughesi* (Nicholson) perhaps suggests *leptotheca* level in this instance also.

Monograptus sp.
Figure 5M

Material

X.26630 from the *convolutus* Biozone of Kuh-e-Faragun, in low relief.

Remarks

This unusual form has similar size and dimensions to *M. lobiferus* (compare Figures 5K and 5M) but differs in having considerable thecal overlap, a gentle ventral curvature, and very inconspicuous hooks. It is possible that the hooks are actually lateral apertural lappets. We are unable to equate this specimen with any of the species groups of *Monograptus* which necessitates it being left under open nomenclature.

Stimulograptus Přibyl and Štorch, 1983

Type species

Graptolithus halli Barrande 1850

Stimulograptus sedgwickii (Portlock, 1843)

Figures 5L, 7B, F

Graptolithus (Prionotus) Sedgwickii Portlock 1843: 318–9, pl. 19, figs 1–3 (?6).

Stimulograptus sedgwickii: Loydell 1993: 79–81, text-fig. 15, figs 3, 4, 17–20.

Material

Occurs rarely in the *sedgwickii* Biozone of Kuh-e-Gahkum (BMNH QQ5) moderately well-preserved in low relief.

Remarks

In dorso-ventral width and thecal spacing this

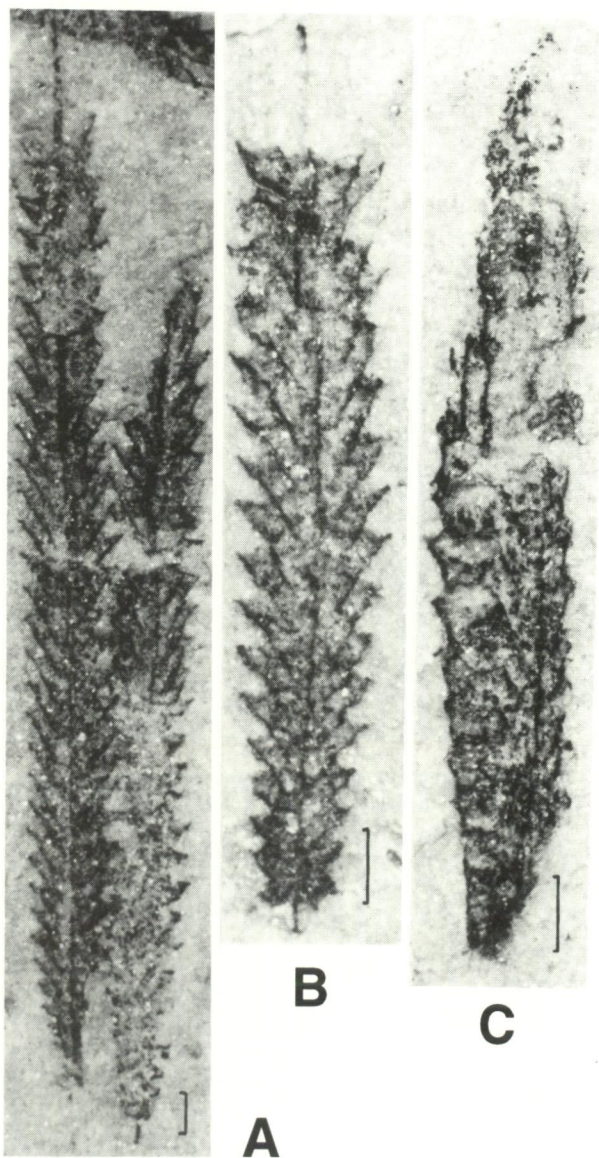


Figure 9 A-C, *Orthograptus amplexicaulis abbreviatus* (Elles & Wood, 1907); X.28263 and X.28257, adult specimens; X.28259, earlier growth stage showing well-preserved proximal end; and X.28258, subventral view. Scale bar 1 mm., specimens in moderate relief. All Seyahou Formation, Late Ordovician, Kuh-e-Faragun, Iran; Ghavidel collection.

material agrees with Loydell's recent revision of this species from Welsh material. Ours does not show the thecal spines so clearly but they are present. The thecal hooks, dimensions thereof, and thecal overlap are all identical to the types. We have no specimens of distal thecae.

Torquigraptus Loydell, 1993

Type species

Graptolithus proetus var. *plana* Barrande 1850

Torquigraptus denticulatus (Törnquist, 1899) Figure 6B–C

Monograptus denticulatus n. sp. Törnquist 1899: 18, pl. 3, figs 19–23.

1993 *Torquigraptus denticulatus*: Loydell 1993: 112–3.

Material

A few specimens (BMNH QQ13a) from the *sedgwickii* Biozone of Kuh-e-Gahkum, moderately well preserved.

Remarks

The torsion laterally of the thecal apertural region, detected by Loydell (1993), is visible in our specimens (Figure 6C) and distinguishes *T. denticulatus* (Törnquist) from *Monograptus paradenticulatus* Zalasiewicz 1996. The latter is more typical of the *leptotheca* Biozone (Zalasiewicz 1996) and the former of the *convolutus* Biozone, although our specimens are from the *sedgwickii* Biozone.

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