

## Recognition of the acritarch-based “*trifidum* flora” (Ordovician) in the absence of the eponymous species

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(edited by William T. DEAN)

### Abstract

The term “*trifidum* flora” was based on acritarchs from, possibly, the *Tetraraptus approximatus* Biozone of northwest England. It has been suggested as an index horizon for the base of the Arenig Series but may represent a number of assemblages of slightly different age, and the index species, *Stelliferidium trifidum*, first described from the Tremadoc Series of Shropshire, is not always present. The diagnostic potential of other acritarchs, especially *Peteinosphaeridium* sp., is noted and relevant material from south central and southeast Turkey reviewed.

**Key-words:** “*trifidum*” flora, acritarchs, Tremadoc-Arenig.

### Résumé

La “flore à *trifidum*” a été définie sur base d’acritarches dont la provenance possible est la Biozone à *Tetraraptus approximatus* du nord-ouest de l’Angleterre. Elle a été proposée comme horizon-index de la base de la série arénigienne. Elle peut cependant réunir des assemblages d’âge légèrement différent et de l’espèce-index, *Stelliferidium trifidum*, dont la première description se base sur du matériel provenant de la Série tremadocienne du Shropshire, n’est pas toujours présente. Le potentiel diagnostique d’autres acritarches, particulièrement de *Peteinosphaeridium* sp., est signalé et du matériel significatif, provenant des parties centrale et orientale du sud de la Turquie, est révisé.

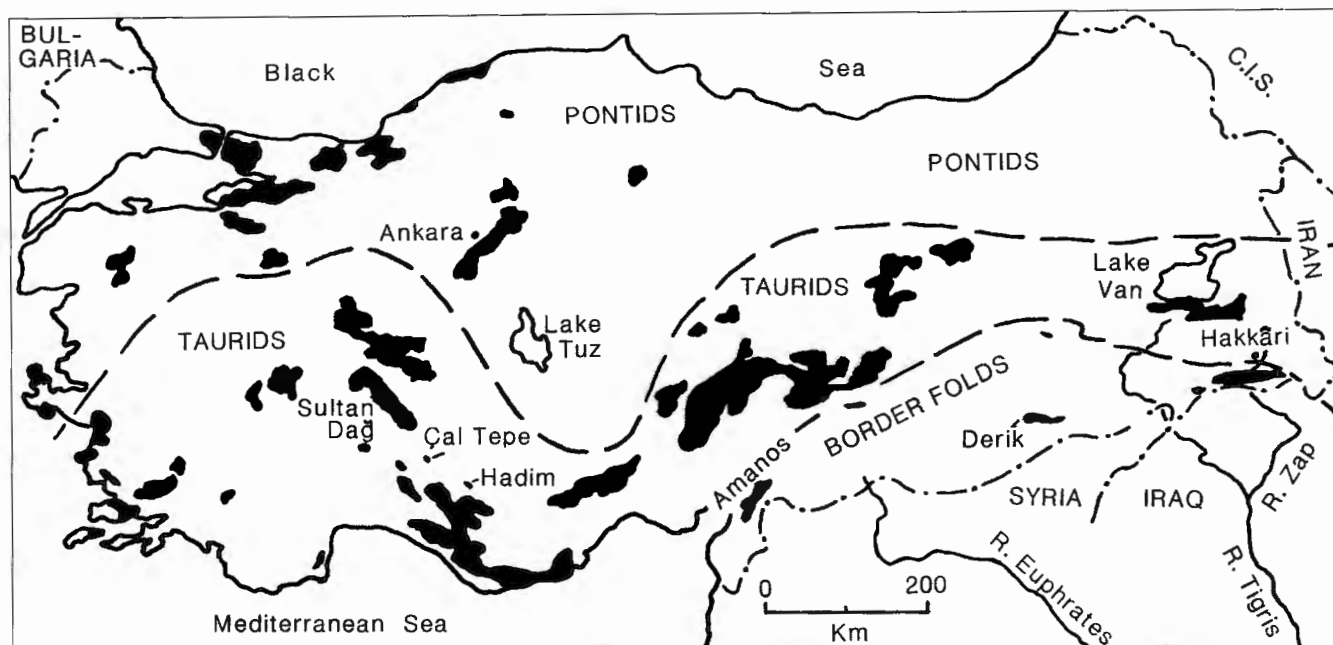
**Mots-clés:** “flore à *trifidum*”, acritarches, Tremadoc-Arenig.

### Introduction

The acritarchs now considered were first recognised as a distinct group, under the name “Watch Hill assemblage”, by MOLYNEUX & RUSHTON (1988, p. 47, table 2), who listed a number of species from the Watch Hill Grits in northwest England, representing an interval that may correspond to the *Tetraraptus approximatus* Biozone, generally accepted as lowest Arenig (WILLIAMS *et al.*, 1994). Seven species considered by MOLYNEUX & RUSHTON to be “particularly characteristic” comprised *Acanthodiacrodium? dilatatum* MOLYNEUX *in* MOLYNEUX & RUSHTON, 1988, *Caldariola glabra* (MARTIN) MOLYNEUX *in* MOLYNEUX & RUSHTON, 1988, *Cymatiogalea deunffii* JARDINÉ *et al.*, 1974, *C. messaoudii* JARDINÉ *et al.*, 1974, *Stellechinatum sicaforme* MOLYNEUX *in* MOLYNEUX & RUSHTON, 1988, *Stelliferidium trifidum* (RASUL,

RASUL, 1979, *Tetraniveum arenigum arenigum* (VAVRDOVA) VAVRDOVA, 1976, and *T. arenigum cumbriense* MOLYNEUX *in* MOLYNEUX & RUSHTON, 1988. The assemblage was later termed “the *trifidum* flora” by FORTEY *et al.* (1991, p. 10), named for *Stelliferidium trifidum* (RASUL) FENSOME *et al.*, 1990, the only species listed by MOLYNEUX & RUSHTON from all their cited localities in the English Lake District, and was said to occur also in South Wales, the Isle of Man and, probably, southwestern Spain, where it was considered to be of “great stratigraphic potential” in recognising the base of the Arenig in parts of Gondwanaland. An assemblage “very similar” to the *trifidum* flora was recognised in boreholes on the Island of Rügen, northeast Germany, by SERVAIS & KATZUNG (1993, p. 720), who illustrated selected taxa, and the published data were summarised by SERVAIS (1994). More recently COOPER *et al.* (1995) recognised in the English Lake District a *Cymatiogalea messaoudii-Stelliferidium trifidum* assemblage, divided into five subassemblages and equivalent to the “*trifidum* flora”; it is succeeded by a *Stelliferidium trifidum-Coryphidium bohemicum* assemblage in which *Coryphidium bohemicum* and *Striatotheca principalis parva* appear but *C. messaoudii* is absent. Compared with the species lists of MOLYNEUX & RUSHTON (1988), those of COOPER *et al.* (1995) referred *Tetraniveum arenigum* and its subspecies to *Vavrdovella*, following LOEBLICH & TAPPAN (1976), and *Caldariola glabra* was omitted.

Present evidence suggests that the term “*trifidum* flora” encompasses a group of assemblages which may differ in composition and span a relatively broad age, and it may be more appropriate to refer to “a” rather than “the” *trifidum* flora. In the Shineton Shale Formation, from which it was described (RASUL, 1974, p. 60), *Stelliferidium trifidum* was recorded only from the *Shumardia (Conophrys) salopiensis* Biozone, in which the species is very rare (author’s observations). Later, RASUL (1979, p. 70) noted *S. trifidum* as stratigraphically important, being confined to Zone 7, highest but one of his acritarch-based zones of the Tremadoc Series in south Shropshire and corresponding to the lower half of the *S. (C.) pusilla* Biozone. *Stelliferidium trifidum* is most often cited from “the *trifidum* flora”, but its absence higher than their *S.*



Text-fig. 1 — Outline map of Turkey, showing location of Hadim, in the central Taurids, and the Şort Tepe area, near the Zap Valley, southeastern Turkey. Principal structural subdivisions after KETIN (1966) and OKAY (1986).

*trifidum* - *C. bohemicum* assemblage in northwest England was noted by COOPER *et al* (1995). The species appears to have a limited geographic distribution and was not recorded from appropriate parts of the Barriga Formation in southwest Spain (METTE, 1989) or of the Seydişehir Formation in the Hadim and Zap Valley areas, south-central and southeastern Turkey respectively, for which preliminary comments were given by MARTIN (in DEAN & MARTIN, 1992, p. 198): all these areas are interpreted as having formed part of peri-Gondwanaland. The present paper reviews briefly the stratigraphic potential for recognising assemblages corresponding to “the *trifidum* flora” when the nominal species is apparently absent.

#### Notes on relevant acritarchs

In the following notes, taxa are alphabetically arranged and those marked by an asterisk (\*) were stated by MOLYNEUX & RUSHTON (1988) to be particularly characteristic of the “*trifidum* flora”; those with a cross (X) are among selected taxa listed by SERVAIS (1994) from Rügen, northeast Germany. Where practical, first appearances are noted, but macrofossil control of age is often unavailable. Selected taxa found in Turkey and Shropshire are shown in Table I, and most are illustrated in Plate 1.

(\*X) *Acanthodiacrodium?* *dilatatum* MOLYNEUX in MOLYNEUX & RUSHTON, 1988 (Pl. 1, Figs. 9, 10, 13, 17). Recorded by COOPER *et al.* (1995) only from their *C.*

*messaudii* - *S. trifidum* assemblage and the succeeding *S. trifidum* - *C. bohemicum* assemblage in north-western England, a range which traverses the Tremadoc/Arenig boundary. In southern Turkey the species was found both near Hadim and in the Zap Valley. *A.?* *dilatatum* was recorded from the “*trifidum* flora” at Rügen, northeast Germany (SERVAIS, 1994), where, as elsewhere, stratigraphic control is essentially palynological.

(\*X) *Caldariola glabra* (MARTIN) MOLYNEUX in MOLYNEUX & RUSHTON, 1988. Described initially from the Tremadoc of southern France; found in the *Shumardia* (*Conophrys*) *salopiensis* Biozone of Shropshire, U.K., and at all four localities sampled in the Hadim and Zap Valley areas, southern Turkey. The species is one of those said by MOLYNEUX & RUSHTON (1988) to be characteristic of the Watch Hill assemblage but was not listed by COOPER *et al.* (1995).

Coenobial acritarchs *sensu* DI MILIA, 1991 (Pl. 1, Fig. 22). Found at Z.401, Zap Valley, southeastern Turkey. Elsewhere in southern Turkey, similar specimens have been found in the Middle Cambrian of the Penbeğli-Tut inlier, east of Kahramanmaraş (F.M., in preparation) and it is not known whether their presence at Z-401 is due to reworking or to their being ubiquitous and long-ranging.

*Coryphidium* sp. (Pl. 1, Figs. 12, 18). Several species are represented in both the Hadim and Zap Valley areas, those from the latter including *C. cf. elegans* CRAMER *et al.*, 1974 (Pl. 1, Fig. 16), recorded as *C. elegans* by MARTIN (in DEAN & MARTIN, 1992, p. 198). In south-

western Spain *C. elegans*, shown by METTE 1989, pp. 3, 4) as appearing at the base of the Arenig, was said by him to be "among the most indicative species of the Arenig in Europe and North Africa", though its range is essentially palynologically dated. METTE (1989) showed *C. elegans* to range from the basal Arenig to lower Llanvirn, and his list of Tremadoc/Arenig species included both *C. aff. elegans* and *Peteinosphaeridium* sp. *C. cf. elegans* was recorded by COOPER *et al.* (1995, p. 190) from only the two highest sub-assemblages (4 and 5) of their *C. messaoudii* - *S. trifidum* assemblage.

*Cymatiogalea deunffii* JARDINÉ *et al.*, 1974 (Pl. 1, Fig. 1). First appearance probably in strata of the Barriga Formation, southwestern Spain (METTE, 1989), dated by means of graptolites as "within the Tremadoc/Arenig Boundary interval" (ERDTMANN *et al.*, 1987). Widespread in peri-Gondwana, from Algeria to northeast Germany, but found only in the Zap Valley during the present sampling.

(\*X) *Cymatiogalea messaoudii* JARDINÉ *et al.*, 1974. Described from Zone B1 - Argilo-gréseux d'El Louha, 'lower Tremadoc', Algeria. In the Barriga Formation of southwestern Spain the species was recorded with confidence only from the lowest Arenig (METTE, 1989, p. 3), and in southern Turkey it was found in both the Hadim and Zap Valley (Pl. 1, Figs. 2, 3, 6) areas. In northwest England *C. messaoudii* was shown by COOPER *et al.* (1995) to be restricted to their *C. messaoudii* - *S. trifidum* assemblage.

(\*) *Dactylofusa velifera* COCCHIO, 1982. Found in both the Zap Valley (Pl. 1, Figs. 11, 14, 20) and Hadim (Pl. 1, Fig. 15) areas of southern Turkey. In the Barriga Formation of southwest Spain the species was shown by METTE (1989) to extend from the upper Tremadoc to the middle of the Arenig.

*Peteinosphaeridium* sp. (Pl. 1, Figs. 4, 8) was found at all the listed localities in the Hadim area and Zap Valley. This form may conveniently be considered indicative of an Arenig age as it occurs with several species (Table 1) said by MOLYNEUX & RUSHTON (1988) and by SERVAIS (1994, p. 571) to form part of the "trifidum flora", though the genus is not among the selected taxa listed from the same area by COOPER *et al.* (1995). Elsewhere in peri-Gondwana the genus has been recorded (as *P. trifurcatum*) from the lower part (Arenig) of the Nant Ffrancon Formation in North Wales (MOLYNEUX, 1990),

and (as *P. palmatum* COMBAZ & PENIGUEL, 1972) from the highest Bell Island Group and lower Wabana Group (probably Arenig) of Bell Island, eastern Newfoundland (MARTIN *in* DEAN & MARTIN, 1978). In the East European Platform (PAALITS & ERDTMANN, 1993) *Peteinosphaeridium* sp. was said to appear approximately at the base of the Hunneberg Stage, redefined by LINDHOLM (1991). The first appearance of *Peteinosphaeridium* may have some stratigraphic potential as a basal Arenig indicator outside peri-Gondwana, judging from records (as *P. cf. P. breviradiatum*) in the Rocky Mountains of western Canada (MARTIN *in* DEAN & MARTIN, 1982; MARTIN, 1992). The carbonate succession there forms part of Laurentia on the basis of its macrofossils, and *Peteinosphaeridium* ranges from the upper part of trilobite-based Zone F to Zone J: in palynological terms it occurs in Microflora AU6 (characterised by the *Rhopaliophora pilata*, *R. palmata* and *Peteinosphaeridium* cf. *P. breviradiatum* assemblage). Other records of the genus from the Arenig in Australia, China and the Baltic region were noted by MARTIN (*in* MARTIN & DEAN, 1982; MARTIN, 1992).

(\*X) *Stelliferidium trifidum* (RASUL) FENSOME *et al.*, 1990. First described from the *Shumardia (Conophrys) salopiensis* Biozone of Shropshire, U.K. (RASUL, 1974), where it was found to be very rare at SHIN-24 (Pl. 1, Fig. 7) in the Shineton Shale Formation (F.M. personal observation). The species is most often cited from the "trifidum flora" (see table 1 *in* SERVAIS, 1994), but does not appear in detailed lists from southwest Spain by METTE (1989), and in southern Turkey *S. aff. trifidum* (Pl. 1, Fig. 5) was found at only a single locality, HAD-11, near Hadim.

(\*X for species) *Vavrdovella areniga* aff. subsp. *cumbriensis* (MOLYNEUX *in* MOLYNEUX & RUSHTON, 1988) COOPER *et al.*, 1995. Found in the *Shumardia (Conophrys) salopiensis* Biozone of Shropshire, U.K. (Pl. 1, Fig. 19), and in the Hadim and Zap Valley (Pl. 1, Fig. 21) areas of Turkey, where it was recorded (MARTIN *in* DEAN & MARTIN, 1992) as *Tetraniveum arenigum cumbriense*. In northwest England the species and subspecies were recorded by COOPER *et al.* (1995) as ranging from sub-assemblages 1 to 4 of their *C. messaoudii* - *S. trifidum* assemblage.

"*Vavrdovella* sp. - *Coryphidium* sp. transients". Found only at Z-401., Zap Valley, southeastern Turkey, and their stratigraphic value has still to be demonstrated.

Table 1.  
Distribution of selected acritarch taxa from cited localities in Shropshire, U.K., and southern Turkey.

	SHROPSHIRE		SOUTHERN TURKEY			
	Wrekin area		Hadim area			Zap Valley
	94-SHIN 21	94-SHIN 24	HAD -11	HAD -13	HAD -14	Z-401
<i>Acanthodiacrodium? dilatatum</i> MOLYNEUX in MOLYNEUX & RUSHTON, 1988	–	–	–	–	×	×
<i>Caldariola glabra</i> (MARTIN) MOLYNEUX in MOLYNEUX & RUSHTON, 1988	×	–	×	×	×	×
Coenobial acritarchs <i>sensu</i> DI MILIA, 1991.	–	–	–	–	–	×
<i>Coryphidium</i> (several spp.)	–	–	–	–	×	×
<i>Cymatiogalea deunffii</i> JARDINÉ <i>et al.</i> , 1974	–	–	–	–	–	×
<i>Cymatiogalea messaoudii</i> JARDINÉ <i>et al.</i> , 1974	–	–	×	–	–	×
<i>Dactylofusa velifera</i> COCCHIO, 1982	–	–	×	–	×	×
<i>Peteinosphaeridium</i> sp.	–	–	×	×	×	×
<i>Stelliferidium trifidum</i> (RASUL) FENSOME <i>et al.</i> , 1990	–	×	aff.	–	–	–
<i>Vavrdovella areniga</i> aff. subsp. <i>cumbriensis</i> (MOLYNEUX in MOLYNEUX & RUSHTON, 1988) COOPER <i>et al.</i> , 1995	–	×	–	×	×	×
“ <i>Vavrdovella</i> sp. – <i>Coryphidium</i> sp. transients”	–	–	–	–	–	×

### Summary of conclusions

The so-called “*trifidum* flora”, often considered significant in recognising the base of the Arenig in peri-Gondwana, may include a number of assemblages that vary slightly in composition and age. *Stelliferidium trifidum*, the index species, has a long stratigraphic range (late Tremadoc to early Arenig) and is not always present in peri-Gondwana assemblages probably equivalent to the “*trifidum* flora”. Such assemblages from southern Turkey lack the index species *sensu stricto* but all contain several forms generally considered characteristic of the “*trifidum* flora” together with *Peteinosphaeridium* sp. The latter may be a convenient alternative indicator

of the Arenig or, possibly, Hunneberg Series, and the genus has the merit of being widely distributed, not only in peri-Gondwana but also in Laurentia, Baltica, Australia and China. The first appearance of *Coryphidium* may also be of supplementary value in peri-Gondwana, but is insufficiently well dated by means of macrofossils.

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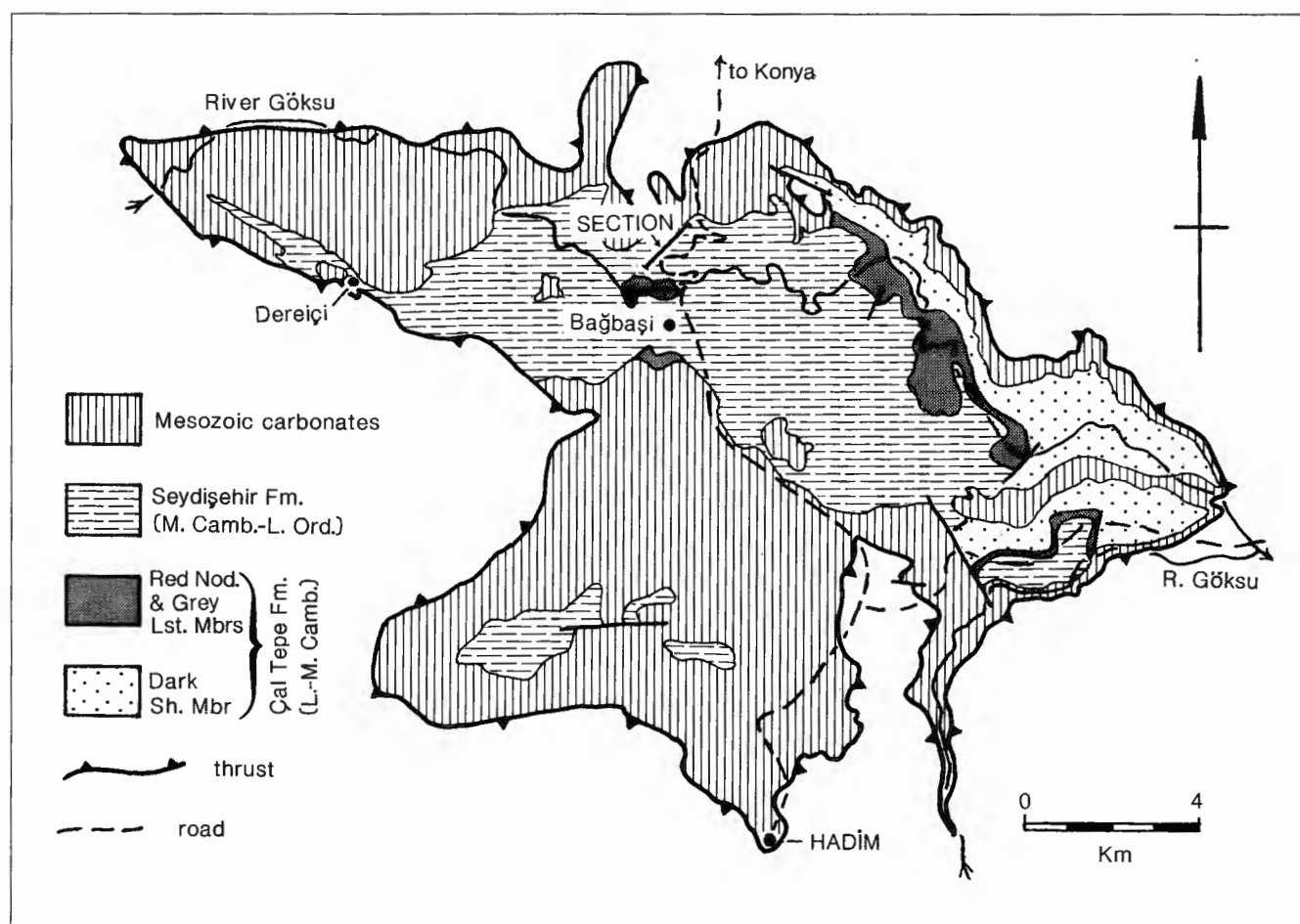
## Appendix: location of cited samples and specimens

### Shropshire, United Kingdom

Sample SHIN-24 is from the Shineton Shale Formation at locality RR2 of STUBBLEFIELD & BULMAN (1927, p. 112, pl. V) in what was then termed the *Shumardia pusilla* Zone, since renamed *Shumardia (Conophrys) salopiensis* Biozone (FORTEY & OWENS, 1991). The sample comes from the middle of a continuous exposure [National Grid Reference SJ 6075

0370], 4 m thick, of laminated, grey mudstone in the west bank of Sheinton Brook, about 250 m south of Sheinton Farm, 2.5 km east of Cressage village; the unit probably forms part of STUBBLEFIELD & BULMAN's (1927, p. 112) horizon E.2, 11.3 m thick.

The highest part of the Shineton Shale Formation was named Arenaceous beds (thickness not stated) by STUBBLEFIELD & BULMAN (1927), based on an outcrop in the bed of Coundmoor



Text-fig. 2 — Generalised geological map (after ÖZGÜL in ÖZGÜL & GEDİK, 1973) showing location of cited section in Seydişehir Formation north of Bağbaşı, near Hadım, southern Turkey.



Brook, near Evenwood, 4.5 km southwest of Cressage village and close to the unconformable base of the Caradoc Series. FORTEY & OWENS (1991) formalised the unit as Arenaceous Member and recorded a measured section at least 33 m thick, beginning at “the first substantial (10 cm thick) grit horizon” which marks the base of the member. The grit bed is followed by, first, a 20 m unexposed interval, and second, a 5 m unit of silty mudstone and interbedded sands. Sample SHIN-21 {National Grid Reference SJ 5550 0150} is from the east bank of Coundmoor Brook at a level 4.3 m above the base of the 5 m unit, and its age, like that of SHIN-24, is *Shumardia (Conophrys) salopiensis* Biozone.

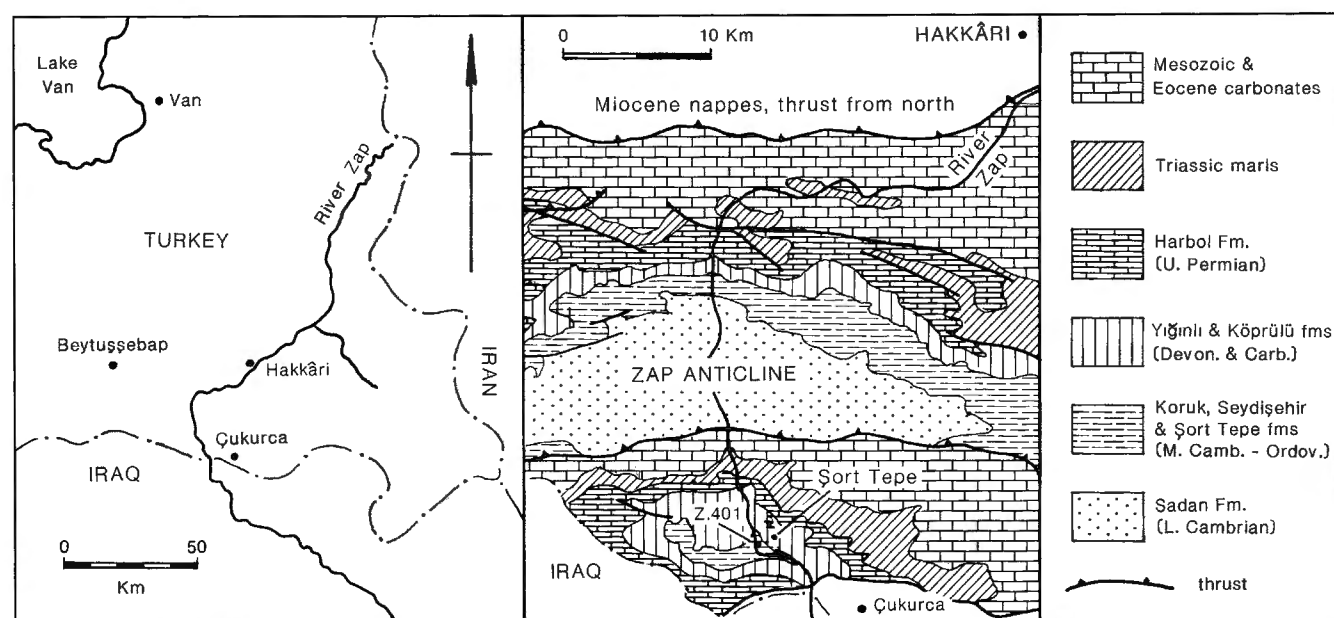
#### Hadim area, south central Turkey

In the central Taurids, shales and siltstones of the Seydişehir Formation form a large outcrop within a tectonic window at and near the valley of the River Göksu, 70 km south of Konya (ÖZGÜL *in* ÖZGÜL & GEDİK, 1973; ÖZGÜL *in* DEAN & ÖZGÜL, 1981). Near the village of Bağbaşı, 11.5 km north of Hadim (Fig. 2), Middle Cambrian carbonates of the Çal Tepe Formation are succeeded by Seydişehir Formation clastics which are Middle Cambrian at the base and become progressively younger northwards, ascending the north side of the Göksu valley. ÖZGÜL (*in* ÖZGÜL & GEDİK, 1973, Fig. 2) divided the Seydişehir Formation into four successive units, 27 m, 82 m, 30 m and 570 m thick, the last of which is overlain by unconformable Mesozoic carbonates. Samples HAD-11 and HAD-13 are from levels 229 m and 276 m above the base of ÖZGÜL’s 570 m unit, and sample HAD-14 is estimated to be 309 m above the base of

the same unit. Corresponding estimated distances above the base of the Seydişehir Formation are 368 m, 415 m and 448 m. Acritarchs from HAD-13 and HAD-14 were noted and figured by MARTIN (*in* DEAN *et al.*, 1993, p. 265, pl. 1, figs. 4-7), and those from HAD-14 were subsequently considered (MARTIN *in* DEAN & MARTIN, 1992, p. 198) to be possibly transitional from “latest Tremadoc - earliest Arenig”.

#### Zap valley, south of Hakkâri, southeastern Turkey

Clastics of the Seydişehir Formation form part of an inlier, elongated east-west, in and west of the valley of the River Zap, 7.5 km northwest of the town of Çukurca and a few km north of the Turkey - Iraq border (Fig. 3). A SW-NE section (DEAN, MONOD & PERİNÇEK, 1981, p. 276, fig. 6) from the east bank of the Zap towards the adjacent high ground of Şort Tepe exposes about 200 m (estimated) of alternating quartzites and silty shales. The latter lack body fossils but the former contain numerous examples of the trace fossil *Cruziana furcifera* d’ORBIGNY, 1842; the age is probably Arenigian, by analogy with other parts of southern Turkey, and the unit is overlain with marked disconformity by oolitic limestone at the base of the Şort Tepe Formation (Ashgill). The section in Seydişehir Formation extends downhill, past the unmade road, to the river’s eastern edge, where sample Z.401 is from a level 2 m above the lowest beds exposed. The locality was noted by MARTIN (*in* DEAN & MARTIN, 1992, p. 198), who stated that it could be latest Tremadoc or earliest Arenig, depending on whether *Coryphidium elegans* and *C. baraka* CRAMER & DIEZ, 1976 are accepted as indicative of the Arenig.



Text-fig. 3 — Generalised geological map (after DEAN, MONOD & PERİNÇEK, 1981) showing location of cited section in Seydişehir Formation at base of east bank of River Zap, 7.5 km north-northwest of Çukurca, southeastern Turkey.

## Explanation of Plate I

Sample SHIN-24 is from the Shineton Shale Formation in Sheinton Brook, near Cressage, Shropshire, U.K.; Z-401 is from the Seydişehir Formation, east bank of the River Zap, 7.5 km north-northwest of Çukurca, southeastern Turkey; HAD-11 and HAD-14 are from the Seydişehir Formation near Bağbaşı, south central Turkey. Specimens in the Institut royal des Sciences naturelles de Belgique (IRScNB), Brussels.

- Fig. 1 — *Cymatiogalea deunffii* JARDINÉ *et al.*, 1974. IRScNB No. b 3088 (x 1000), Z-401.  
 Figs. 2, 3, 6 — *Cymatiogalea messaoudii* JARDINÉ *et al.*, 1974, IRScNB No. b 3089 (x 1000), Z-401.  
 Figs. 4, 8 — *Peteinosphaeridium* sp. IRScNB No. b 3090, Z-401. 4, x 500; 8, detail, x 1500.  
 Fig. 5 — *Stelliferidium* aff. *trifidum* (RASUL) FENSOME *et al.* 1990. IRScNB No. b 3091 (x 1000), HAD-11.  
 Fig. 7 — *Stelliferidium trifidum* (RASUL) FENSOME *et al.*, 1990. IRScNB No. b 3092 (x 1000), SHIN-24.  
 Figs. 9, 10, 13, 17 — *Acanthodiacrodium? dilatatum* MOLYNEUX *in* MOLYNEUX & RUSHTON, 1988. Z-401, 9, IRScNB No. b 3093 (x 1000); 10, IRScNB No. b 3094 (x 1000); 13, detail of Fig. 10 (x 2000); 17, IRScNB No. b 3100 (x 1000).  
 Figs. 11, 14, 15, 20 — *Dactylofusa velifera* COCCHIO, 1982, 11, IRScNB No. b 3095 (x 1000), Z-401; 14, IRScNB No. b 3097 (x 1000), Z-401; 15, IRScNB No. b 3098 (x 1000), HAD-14; 20, detail of Fig. 14 (x 2000).  
 Figs. 12, 18 — *Coryphidium* sp. IRScNB No. b 3096 (x 1000), HAD-14.  
 Fig. 16 — *Coryphidium* cf. *elegans* CRAMER *et al.*, 1974. IRScNB No. b 3099 (x 1000), Z-401.  
 Figs. 19, 21 — *Vavrdovella areniga* aff. subsp. *cumbriensis* (MOLYNEUX *in* MOLYNEUX & RUSHTON, 1988) COOPER *et al.* 1995. 19, IRScNB No. b 3101 (x 750), SHIN-24; 21, IRScNB No. b 3102 (x 1000), Z-401.  
 Fig. 22 — Coenobial acritarch *sensu* DI MILIA, 1991. IRScNB No. b 3103 (1000), Z-401.



