CORRESPONDENCE

A PROBABLE *DIDYMOGRAPTUS MURCHISONI* ZONE FAUNA FROM THE LAKE DISTRICT

SIR,—A probable *Didymograptus murchisoni* Zone fauna, the first to be recorded in northern England[1], was recently collected in the eastern Lake District from the Tarn Moor tunnel, driven for Manchester Corporation Waterworks between Heltondale and Ullswater. Graptolites and associated microfossils were collected in the tunnel from dark grey cleaved silty mudstones between 2,311 m and 2,399 m from the southern portal [NY 4949 2069], and from tip-material of the same lithology. It is intended to describe the complete tunnel section at a later date, but the following details put the new fauna in a summarized stratigraphical context.

The major part of the tunnel penetrated a Borrowdale Volcanic Group sequence similar to that described by Moseley (1960) around Ullswater and by Nutt (1968) in the area north of Haweswater. A small up-faulted block of grey mudstones, occurring between 808 m and 818 m from the southern portal, yielded graptolites and microfossils of *D. bifidus* Zone age, similar to those recorded from the Lanshaw–Tailbert tunnel between Haweswater and Wet Sleddale (Skevington, in press). Dark grey mudstones with the *D. murchisoni* Zone fauna were first encountered at 2,311 m, where they are separated from the Borrowdale Volcanic Group by a near-vertical fault with an associated smash zone. The junction between the *D. murchisoni* Zone mudstones and brown-weathering, grey, green and brown silty mudstones recorded at the northern end of the tunnel occurred at 2,399 m according to the tunnel log; the contact is probably faulted, but was not seen by the authors (A. J. W. and M. J. C. N.) since that part of the tunnel was already lined with concrete. The brown mudstones are correlated lithologically with similar beds cropping out in Aik Beck, 549 m to the south-west which yielded *D. bifidus* Zone graptolites to Elles (1933). Preliminary boreholes near the northern end of the tunnel proved considerable thicknesses of drift and indicated that the outcrop of the *D. murchisoni* Zone mudstones thereabouts is entirely masked by boulder clay generally more than 30 m thick.

The graptolites from the mudstones between 2,311 m and 2,399 m are undoubtedly Llanvirnian in age and, more precisely, suggest the *D. murchisoni* Zone. The following forms are present:

Didymograptus sp. cf. *D. artus* Elles & Wood – 1 specimen.
Didymograptus sp. aff. *D. bifidus* (J. Hall) – 2
Didymograptus murchisoni speciosus Ekström – 3
Didymograptus sp(p). [extensiform] – 3
Cryptograptus tricornis schaeferi Lapworth – 6
Amplexograptus confertus (Lapworth) – very common.
Amplexograptus sp. cf. *A. confertus* (Lapworth) – very common.
Glyptograptus sp. – 1
Pseudoclimacograptus sp. cf. *P. scharenbergi* (Lapworth) – 3

The fauna is dominated by specimens of the genus *Amplexograptus*, while other forms which occur are together represented by less than twenty specimens.

Positive indications of the *D. murchisoni* Zone are given by *D. murchisoni speciosus*, *A.* cf. *A. confertus* and *P.* cf. *P. scharenbergi*. The typical material of *speciosus* from Scania (Ekström, 1937) is restricted to the *D. murchisoni* Zone, and a similar age was reported by Berry (1964) for its occurrence in the Oslo region. *A.* cf. *A. confertus* is conspecific with material from Scania which has been referred to '*Amplexograptus maxwelli* Decker' by Ekström (1937) and to '*Amplexograptus* cf. *differtus* Harris & Thomas' by Hede (1951), and there the main range of this form is in

[1] The only previously published reference to an occurrence of the *D. murchisoni* Zone in northern England was by Goodchild (1889) on the basis of graptolites collected from the Milburn Beds of the Cross Fell inlier. Shotton (1935), however, has shown that these beds are of *D. bifidus* Zone age.

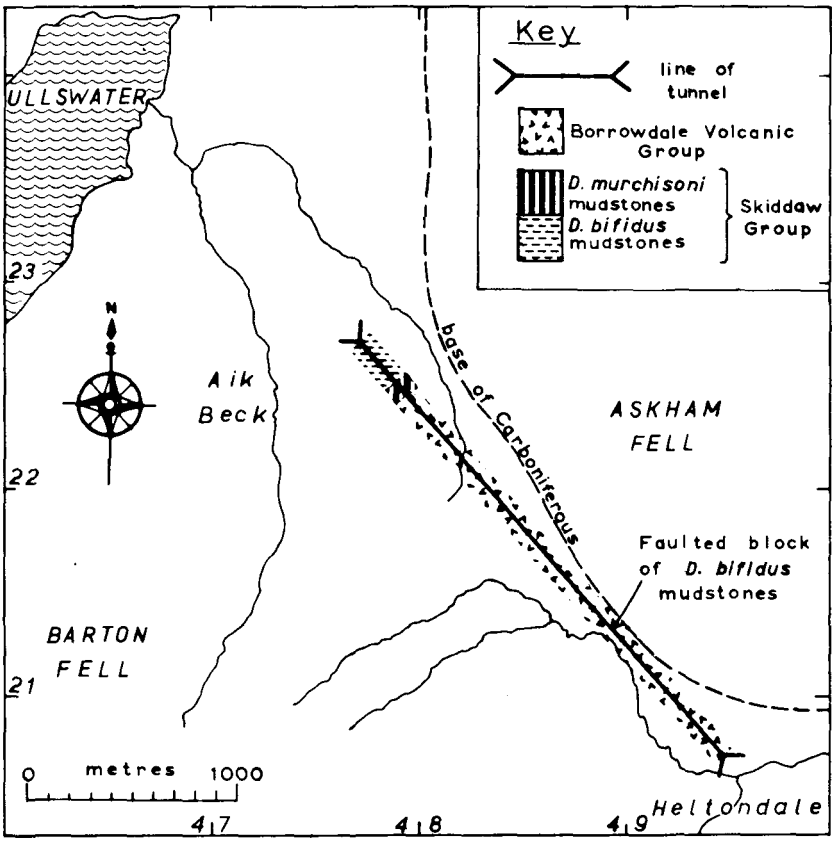

FIG. 1.–A diagrammatic summary of the rocks penetrated by the Tarn Moor tunnel

the *D. murchisoni* Zone; it is also close to *'Amplexograptus* cf. *confertus'* of Bulman (1931) from South America, where the associated fauna is suggestive of the upper Llanvirn. The specimens identified as *P.* cf. *P. scharenbergi* are conspecific with the material referred to *'Climacograptus scharenbergi* Lapworth' by Bulman (1953) and Berry (1964) from the *D. murchisoni* Zone of the Oslo region.

The known stratigraphical ranges of the other graptolites listed above include the *D. bifidus* Zone; however, an early *D. bifidus* Zone age for the fauna seems improbable, while there is a significant absence of the usual late *D. bifidus* Zone indicators present in the Skiddaw Group (Skevington 1966 and in press), namely *Aulograptus cucullus* (Bulman), *Nicholsonograptus fasciculatus* (Nicholson), *Diplograptus ellesi* Bulman, *Glyptograptus austrodentatus* Harris & Keble *sensu lato, Glyptograptus dentatus* (Brongniart) and *Pseudoclimacograptus cumbrensis* Bulman. The conclusion reached is that the fauna is of *D. murchisoni* age. It is certainly younger than any previously recorded from the Skiddaw Group.

A single sample (approximately 50 gm) of the graptolitic shale from the tunnel tip yielded several thousand acritarchs and a small number of chitinozoans. The microfossils were black, more or less opaque, and frequently broken and split.

The following species have been determined: [percentages are derived from a count of 100 specimens; + indicates species not occurring in that count].

Acritarchs	%
B. cf. *alloiteaui* (Deunff)	+
Baltisphaeridium aff. *breviciliatum* Staplin (*in* Martin 1966)	3
B. eisenackianum var. *crozonensis* (Deunff)	3
B. hirsutoides (Eisenack)	+
B. hirsutoides var. *hamatum* (Downie)	5
B. cf. *multipilosum* (Eisenack) (*in* Deunff 1958)	20
B. cf. *suecicum* Eisenack	1
B. trifurcatum var. *paucifurcatum* Eisenack	3
B. uncinatum (Downie) Martin	9
B. sp. indet.	6
Micrhystridium shinetonense Downie	4
Multiplicisphaeridium sp.	+
Veryhachium tetrahedron Deunff	1
V. lairdi (Deflandre)	1
V. ?macroceras Deunff	+
V. trispinosum (Eisenack)	33
Leiosphaeridia sp.	11
Acanthodiacrodium sp.	+

Chitinozoa	*No. of specimens*
Conochitina chydaea Jenkins	1
C. cf. *chydaea* Jenkins	2
C. conulus Eisenack	1
C. fungiformis spinosa Eisenack	1
? *C. lepida* Jenkins	1
C. parviventer Jenkins	1
C. schopfi Taugourdeau	3
Cyathochitina campanulaeformis Eisenack	1
? *C. dispar* Benoit & Taugourdeau	1
Desmochitina minor Eisenack	6
? *D. urna* Eisenack	1
Hoegisphaera complenata Eisenack	1
? *Lagenochitina capax* Jenkins	1
L. cf. *ovoidea* Benoit & Taugourdeau	1
Rhabdochitina turgida Jenkins	1
Siphonochitina clavata Jenkins	1
S. formosa Jenkins	3
S. robusta Jenkins	1
? *Sphaerochitina vulgaris* Jenkins	1

This assemblage indicates a post-Arenigian/pre-Caradocian age; and is of value in establishing the elements of a probable *D. murchisoni* Zone microfauna for the first time in northern England.

The chitinozoan assemblage indicates a Llanvirnian age, particularly through the presence of *Siphonochitina formosa* and *S. robusta,* which have been found by Jenkins (1967) in Shropshire to be restricted to the Hope Shales (*D. bifidus* Zone) and have been identified by one of the authors (T. R. L.) from Skiddaw Slates of *D. bifidus* Zone age in the Cross Fell and Bampton inliers. *Siphonochitina clavata, Conochitina fungiformis spinosa* and *C. schopfi* have not been recorded so far from horizons earlier than the *D. murchisoni* Zone.

The acritarch assemblage, dominated by simple-spined acanthomorphs and triangular polygonomorphs, is generally similar to that recorded from beds of *D. bifidus* Zone age, from Ellergill in the Cross Fell inlier and from the Tailbert Tunnel in the Bampton inlier, and also to assemblages described by Martin (1966) from the Llanvirn-Llandeilo of Belgium. The presence of *V? macroceras* and *B.* cf. *alloiteaui,* however, may suggest an

age younger than the *D. bifidus* Zone, as Deunff recorded these forms from the basal Caradocian of Brittany.

REFERENCES

BERRY, W. B. N. 1964. The Middle Ordovician of the Oslo Region, Norway. 16: Graptolites of the *Ogygiocaris* Series. *Norsk geol. Tidsskr.*, **44**, 61–170.

BULMAN, O. M. B. 1931. South American Graptolites. *Ark. Zool.*, **22A**, 1–111.

—— 1953. Some graptolites from the *Ogygiocaris* Series (4a) of the Oslo district. *Ark. Miner. Geol.*, **1**, 509–517.

EKSTRÖM, G. 1937. Upper *Didymograptus* Shale in Scania. *Sver. geol. Unders. Afh.*, ser. C, no: 403, 3–53.

ELLES, G. L. 1933. The Lower Ordovician graptolite faunas with special reference to the Skiddaw Slates. *Mem. geol. Surv. Summ. Prog.*, vol. for 1932, 94–111.

GOODCHILD, J. G. 1889. An outline of the geological history of the Eden Valley or Edenside. *Proc. Geol. Ass.*, **11**, 258–284.

HEDE, J. E. 1951. Boring through Middle Ordovician-Upper Cambrian strata in the Fågelsång district, Scania (Sweden). *Acta Univ. lund.*, **46**, no: 7, 5–84.

JENKINS, W. A. M. 1967. Ordovician Chitinozoa from Shropshire. *Palaeontology*, **10**, 436–488.

MARTIN, F. 1966. Les Acritarches de Sart-Bernard (Ordovician Belge). *Bull. Soc. belge Géol., Paléont. Hydrol.*, **74**, 1–22.

MOSELEY, F. 1960. The succession and structure of the Borrowdale volcanic rocks southeast of Ullswater. *Q. Jl geol. Soc. Lond.*, **116**, 55–84.

NUTT, M. J. C. 1968. Borrowdale Volcanic Series and associated rocks around Haweswater, Westmorland. *Proc. geol. Soc.*, no. 1649, 112–113.

SHOTTON, F. W. 1935. The stratigraphy and tectonics of the Cross Fell inlier. *Q. Jl geol. Soc. Lond.*, **91**, 639–704.

SKEVINGTON, D. 1966. The morphology and systematics of *'Didymograptus' fasciculatus* Nicholson, 1869. *Geol. Mag.*, **103**, 487–497.

—— *in press.* A Lower Llanvirn graptolite fauna from the Skiddaw Slates, Westmorland. *Proc. Yorks. geol. Soc.*

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THIN SECTIONS OF FREE GRAINS USING TWO MOUNTING MEDIUMS

SIR,–The numerous techniques which have been employed to make thin sections of free grains are generally time consuming and require considerable practice. During the course of our studies of glauconite grains and phosphatic particles from unconsolidated sediments, a quick and simple technique was derived which rendered excellent results even with the very friable glauconites.

The technique utilizes two mounting mediums, one which remains hard after it has cured and a second which may be remelted after it has set. The two particular mediums used in our studies were Hysol Epoxi-Patch and Lakeside 70 (both obtainable from Ward's Natural Science Establishment, Inc., Rochester, N.Y.); however, other comparable materials could be used.