THE TRILOBITE *PROTOLLOYDOLITHUS* FROM THE MIDDLE ORDOVICIAN OF NORTH PORTUGAL

by M. ROMANO

ABSTRACT. *Protolloydolithus* sp. nov., from beds of Llandeilo age in north Portugal, is described and figured. The genus was previously unknown from Iberia, and the present record indicates faunal links with southern Britain during middle Ordovician times. The appearance of the genus is linked to a transgressive event following an early Llandeilo lowering of the sea level.

IN 1908 Delgado published extensive faunal lists from the Ordovician sequences of Portugal and recognized over thirty trilobite species from his 'Ordovician moyen' of the Valongo area of north Portugal. Many of these species have since been revised (see Henry 1980; Hammann 1974, 1983; Hammann *et al.* 1982; Gutiérrez-Marco *et al.* 1984, and references therein) and the dominantly mudrock sequence comprising Delgado's 'Ordovician moyen' (Valongo Formation of Romano and Diggens 1973–4) is now known to range in age from at least early Llanvirn to probably early Caradoc. No trinucleid trilobites were recorded by Delgado from north Portugal, but *Onnia* and/or *Deanaspis* occur in lower Caradoc strata in central Portugal and Spain (Hammann 1976; Rábano 1984; Young 1985). In Brittany, *Marrolithus* occurs in the upper part of the Postolonnec Formation (upper Llandeilo age, Henry 1980) but has not been recorded from coeval strata in central Portugal, despite the remarkable similarity of the two sequences (Henry *et al.* 1973–4; Henry and Romano 1978; Paris 1981; Romano and Henry 1982; Young 1988). Young (1985) regards their absence in central Portugal as being due to a hiatus on a topographic high.

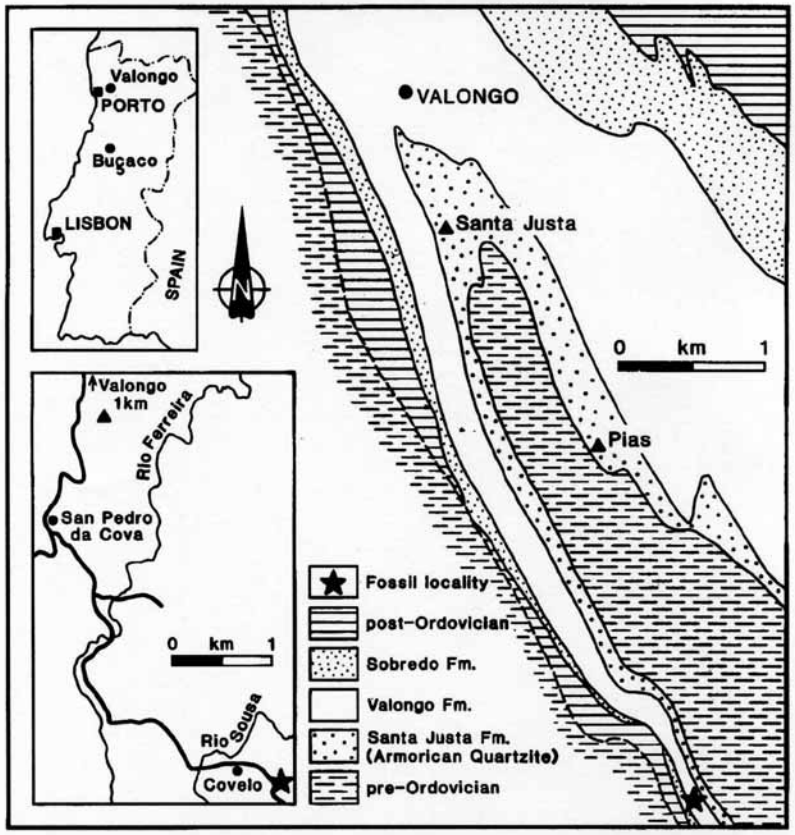
REMARKS ON THE DISTRIBUTION OF *PROTOLLOYDOLITHUS*

A single specimen assigned to *Protolloydolithus* sp. nov. was collected from the upper part of the Valongo Formation near Covelo (text-fig. 1). The beds are within the top of the *Placoparia* (*Placoparia*) *tournemini* Biozone (rarely, specimens of the younger *P.* (*Coplacoparia*) *borni* also occur) of early Llandeilo age (Romano 1976). The specimen is unusual in that at present it is the oldest and only the second marrolithid known from rocks of middle Ordovician age in the Iberian/Armorican part of Gondwana, although rare specimens of 'Hanchungolithinae gen. et sp. inc.' occur in the *P.* (*C.*) *borni* Biozone of Spain (I. Rábano, pers. comm.). It is also the only record of *Protolloydolithus* outside Britain. The genus first appears in the lower Llanvirn of the Shelve inlier and South Wales with *P. ramsayi* (Hicks) and then *P. neintianus* (Whittard) (Thomas *et al.* 1984; Kennedy 1988). *P. salax* (Rushton and Hughes 1981) is known from the Llanvirn of the Great Paxton Borehole, Cambridgeshire, to be replaced in the lower Llandeilo of the Builth area by *P. reticulatus* (Elles) (Hughes 1971).

AFFINITIES OF THE LOWER AND MIDDLE ORDOVICIAN TRILOBITE FAUNAS OF NORTH PORTUGAL

The trilobite faunas from the Arenig of southern Britain (Whittard 1966; Thomas *et al.* 1984; Fortey and Owens 1987) and the lower Llanvirn of North Portugal (Delgado 1908; Romano 1976, 1982*a*, *b*; Rebelo and Romano 1986) have much in common, namely *Neseuretus*, *Placoparia*, *Ectillaenus*, *Selenopeltis*, *?Asaphellus*, *Colpocoryphe* and probably *Ogyginus* at generic level;

[Palaeontology, Vol. 33, Part 2, 1990, pp. 487–493.]

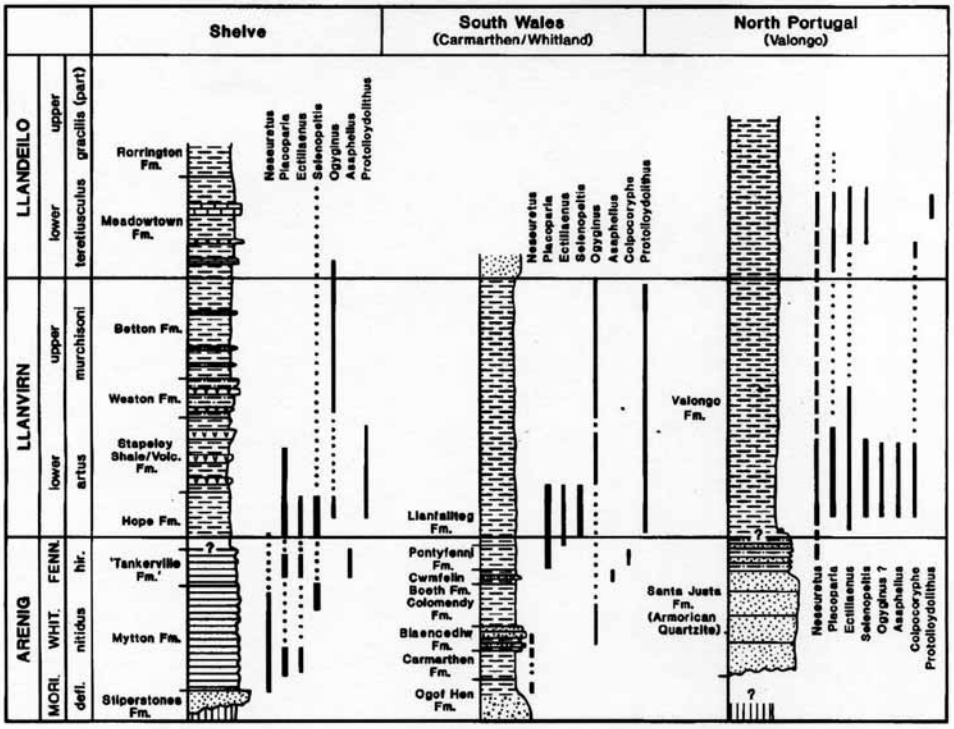


TEXT-FIG. 1. Locality maps and simplified geological map (after Delgado 1908) of Valongo area, north Portugal. Star indicates locality where *Protolloydolithus* sp. nov. was collected.

Placoparia (*P.*) *cambriensis* and ?*Selenopeltis macrophthalma* at specific level. The ranges of these genera in the Shelve, Carmarthen/Whitland and north Portugal are shown in text-fig. 2.

The Arenig trilobite faunas of Shelve and Carmarthen have many taxa in common but also show important differences. Fortey and Owens (1987) pointed out that the varied trinucleid assemblages from the upper part of the Mytton Formation are absent in South Wales, and the Llanfallteg Formation fauna is not represented in the Shelve area. These authors explained the absence of the Llanfallteg fauna by suggesting that since the fauna and sediment of this unit represent a regressive phase, and as the Shelve area occupied an 'on-shelf' position, the Llanfallteg faunas did not reach the Shelve area.

The importance of transgressive/regressive events in controlling the distribution of shallow-water faunas is also well demonstrated in the composition of the north Portuguese faunas. Although approximately twenty-five and seventy species are present in the Shelve Arenig faunas and deeper-water equivalents in south Wales respectively (Whittard 1966; Fortey and Owens 1987), in north Portugal the shallower-water coeval Armorican Quartzite facies has yielded only *Neseuretus* (similarly for the Stiperstones Formation in the Shelve), and in Brittany some three species are



TEXT-FIG. 2. Simplified Ordovician sequences of Shelve Inlier, south Wales and north Portugal with ranges of selected trilobites (after Whittard 1966, 1979; Fortey and Owens 1987; Kennedy 1988; and author). Abbreviations: MORI. = Moridunian; WHIT. = Whitlandian; FENN. = Fennian. Thick vertical bars indicate similar species are present in all three areas.

recorded (Henry 1971, 1980). Fortey and Morris (1982), Fortey and Owens (1987) and Cocks and Fortey (1988) have previously pointed out the significance of *Neseuretus* in identifying inshore facies, although species of the genus also occur in deeper-water platform sites (Hammann 1983). Fortey and Owens noted that the diverse Arenig trilobite faunas of south Wales only appeared in the more shelfward sites of Gondwana during the Llanvirn or later. In north Portugal this is well shown by the appearance of a relatively diverse trilobite fauna of early Llanvirn age in mudrocks above the thinly bedded, heterolithic Armorican Quartzite sequences (text-fig. 2).

Deeper-water atheloptic assemblages (characterized by 'blind or nearly blind trilobites': Fortey and Owens 1987, p. 106), such as those from the Fennian of south Wales are not known in Portugal; these assemblages were considered to imply a water depth of 300 m or more (Fortey and Owens 1987, p. 106). Estimates based on sedimentological studies in central Portugal suggested that water depth there was probably no more than 80 m during the Llandeilo (Brenchley *et al.* 1986). Assuming a maximum average slope to the north of 0·1° for the Iberian Platform in Llandeilo times (Brenchley *et al.* 1986, p. 252), this would suggest that the water depth in north Portugal was in the order of 100–150 m, well above the inferred depth to support atheloptic assemblages.

The appearance of *Protolloydolithus* in the Llandeilo of north Portugal, along with a relatively sudden increase in diversity of the trilobite species, is related to another regressive/transgressive

couplet. The regressive event is documented in central Portugal (and Crozon Peninsula of north-west France) by the sandstones of the Monte da Sombadeira Formation (and Kerarvail Formation of north-west France), followed by a transgressive phase and the return to mudrock deposition with an increase in diversity and individual abundance of the benthos. This sandstone unit is not present in the deeper-water sequences of north Portugal, but work in progress at Valongo with Dr T. Young has identified slight lithological changes which, together with the faunal changeover, reflect the events recognized in central Portugal. However, the diverse Llandeilo faunas of north Portugal do not show such close affinities with the southern British faunas as was apparent in the early Ordovician. Only four trilobite genera are common to both regions in the Llandeilo: *Protolloydolithus*, *Selenopeltis*, *Ogyginus* and *Nobiliasaphus*. Of these, *Protolloydolithus* probably spread from the Builth area of Wales, while the other three were already endemic to Iberia (Delgado 1908; Romano 1982*b*; Romano *et al.* 1986). The reduced faunal affinities of southern Britain and north Portugal in the Llandeilo are considered to be the result of an increased separation of the two regions by middle Ordovician times and/or the relatively smaller magnitude of the transgression compared with that during the Llanvirn.

It is of interest to note that on a global scale Fortey and Cocks (1988) record an early Llandeilo regression followed by a major early Caradoc transgression. In Iberia there is evidence of two Llandeilo shallowing events: that represented by the Monte da Sombadeira Formation and a younger one which reached maximum shoaling during Cabril Formation times (Young 1988, p. 390). Both these formations (or equivalent units) are also recognized in Brittany and crop out in an area of over 75000 km^2. It therefore appears unlikely that the regressive sandstones of these two formations (and the intervening transgressive mudrocks with their relatively enriched benthos) represent a purely local tectonic effect. A more likely scenario is that the Llandeilo regression was composite, prior to the major early Caradoc transgression. Further detailed investigations into other middle Ordovician platform sequences may provide supportive evidence.

SYSTEMATIC PALAEONTOLOGY

Family TRINUCLEIDAE Hawle and Corda, 1847
Subfamily MARROLITHINAE Hughes, 1971
Genus PROTOLLOYDOLITHUS Williams, 1948

Type species. *Trinucleus Ramsayi* Hicks, 1875. Original designation by Williams 1948, p. 66. Lower Llanvirn, Ramsey Island.

Protolloydolithus sp. nov.

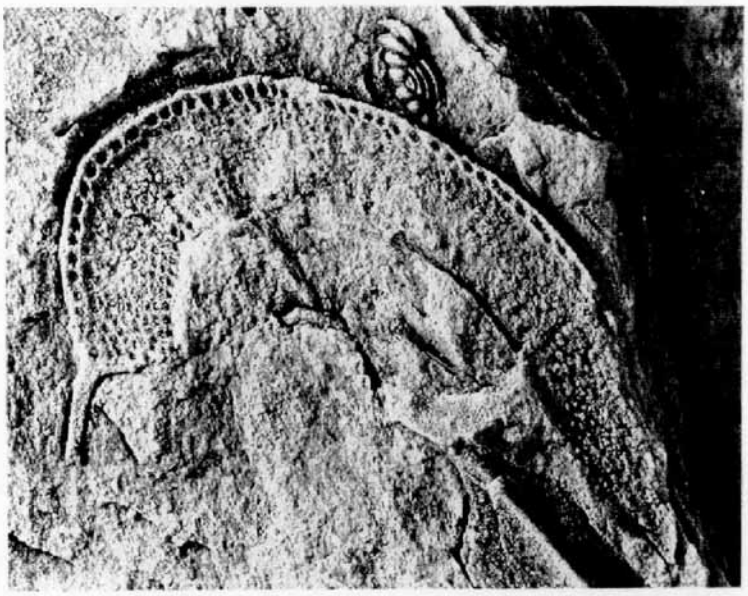
Text-fig. 3

Material. Single specimen (SG 6717); nearly complete but distorted fringe showing internal mould of part of upper lamella and external mould of part of lower lamella. Specimen housed in the museum of the Portuguese Geological Survey, Lisbon.

Horizon and locality. Upper part of Valongo Formation, *c.* 70 m below top of unit; top of *Placoparia* (*P.*) *tournemini* Biozone, lower Llandeilo. Locality 3/41 (see Romano 1976), a small quarry to the east of the road approximately 1 km ESE of Covelo (text-fig. 1).

Description. Cephalon approximately 14 mm wide across base of genal spines, margin apparently evenly rounded. Fringe more or less flat, although with slightly upturned outer arc of pits, of broadly constant width, but possibly narrows anteriorly in front of glabella. Preserved length of genal spine is 2·5 mm (but possibly at least 5 mm long), extending posteriorly and slightly outwards; lateral margins of fringe and genal spine are not in a straight line. Dorsal surface of spine is flat with very faint median furrow (possibly due to flattening).

Pits (E1) of outer arc larger than other pits; at least forty-five are visible but it is not possible to give an accurate fringe formula. Pits are largest anterolaterally and on the whole are fairly regularly disposed. Internal to E1 there is a well-marked girder, and a girder list which dies out before reaching genal spine. I1 arc



TEXT-FIG. 3. *Protolloydolithus* sp. nov. (SG 6717). Valongo formation, *Placoparia* (*Placoparia*) *tournemini* Biozone, Llandeilo. From small quarry approximately 1 km ESE of Covelo and 11 km SSE of Valongo. ×6·5.

reasonably distinct, pits smaller and more numerous than in E1 (where preserved, six or seven E1 pits lie adjacent to ten I1 pits). Preservation is generally rather poor for the rest of the fringe, and apart from the distinct innermost arcs appears to consist of randomly arranged pits. However, nine or ten A 'arcs' may be present across the fringe between the cheeks and E1. In or F (flange) pits (Hughes *et al.* 1975) cannot be clearly distinguished although on the right-hand side there are possibly a few F pits. Laterally at least two regular inner arcs are present. The pits of these arcs show regular concentric and radial arrangement for at least fourteen radial rows, while two more external arcs are seen (where preservation allows) to continue this regular arrangement for at least six radial rows. Suggestion of very faint facial suture cutting across base of genal spine, running subparallel to distal part of posterior border margin.

Glabella and cheeks not preserved, although part of inner flange of fringe is present on right-hand side. Rest of exoskeleton unknown.

Discussion. The recognition of a single E1 arc, prominent girder and strong girder list, together with the generally irregular arrangement of the pits, indicates that the species may be assigned to *Protolloydolithus*. According to the diagnosis of the genus given by Whittard (1955, p. 40 and 1956, p. 41) and Hughes *et al.* (1975, p. 577), the present species shows some ?minor differences. I1 pits are not noticeably larger than the other inner pits; I pits are not all 'irregularly positioned'; F pits do not appear to be well developed. However, in *P. ramsayi* the I1 pits are not always significantly larger than the other pits (Whittard 1956, pl. V, fig. 11) and there is a tendency in *P. ramsayi* and *P. neintianus* for some regularity of inner I arcs anteriorly, and laterally in *P. salax*.

The specimen is considered to represent a new species since it does not closely resemble any described species of the genus. It is left unnamed at present as only a single specimen is known. The Llanvirn species *P. ramsayi*, *Protolloydolithus* sp. (Kennedy 1988) and *P. neintianus*, as well as the Llandeilo form *P. reticulatus* (Elles) (Hughes 1971) differ mainly from the Portuguese species in not possessing such well-ordered internal I arcs; in addition, the latter species has a much narrower fringe. The well-ordered pits indicate an advanced form (Dr J. K. Ingham, pers. comm.) and are

considerably better ordered than the arrangement seen in the broadly contemporaneous Builth species.

Acknowledgements. I should like to thank Dr J.-L. Henry for encouraging me to 'think again' about the specimen; Drs R. A. Fortey and J. K. Ingham for helpful discussions; Dr T. P. Young for reading the manuscript and photographing the specimen. Dr I. Rábano sent me information on Spanish middle Ordovician trinucleids. Mr M. Cooper redrew the diagrams, and Miss P. Mellor typed the manuscript.

REFERENCES

BRENCHLEY, P. J., ROMANO, M. and GUTIÉRREZ-MARCO, J. C. 1986. Proximal and distal hummocky cross-stratified facies on a wide Ordovician shelf in Iberia. 241–255. *In* KNIGHT, R. J. and MCLEAN, J. R. (eds.). *Shelf sands and sandstones*. Canadian Society of Petroleum Geologists, Mem. II, pp. 1–347.

COCKS, L. R. M. and FORTEY, R. A. 1988. Lower Palaeozoic facies and faunas around Gondwanaland. 183–200. *In* AUDLEY-CHARLES, M. G. and HALLAM, A. (eds.). *Gondwana and Tethys*. Geological Society Special Publication No. 37, 317 pp.

DELGADO, J. F. N. 1908. Système silurique du Portugal; étude de stratigraphie paléontologique. *Commission du Service géologique du Portugal*, 1–245.

FORTEY, R. A. and COCKS, L. R. M. 1988. Arenig to Llandovery faunal distributions in the Caledonides. 233–247. *In* HARRIS, A. L. and FETTES, D. J. (eds.). *The Caledonian-Appalachian Orogen*. Geological Society Special Publication No. 38, x + 643 pp.

—— and MORRIS, S. F. 1982. The Ordovician trilobite *Neseuretus* from Saudi Arabia, and the palaeogeography of the *Neseuretus* fauna related to Gondwanaland in the earlier Ordovician. *Bulletin of the British Museum (Natural History)* (Geology), **36**, 63–75.

—— and OWENS, R. M. 1987. The Arenig Series in South Wales. I. *Bulletin of the British Museum (Natural History)* (Geology), **41**, 69–307.

GUTIÉRREZ-MARCO, J. C., RÁBANO, I., PRIETO, M. and MARTÍN, J. 1984. Estudio bioestatrigráfico del Llanvirn y Llandeilo (Dobrotiviense) en la parte meridional de la Zona Centroibérica (España). *Cuadernos geología Ibérica*, **9**, 289–219.

HAMMANN, W. 1974. Phacopina und Cheirurina (Trilobita) aus dem Ordovizium spaniens. *Senckenbergiana lethaea*, **55**, 1–51.

—— 1976. Trilobiten aus dem oberen Caradoc der östlichen Sierra Morena (spanien). *Senckenbergiana lethaea*, **57**, 35–85.

—— 1983. Calymenacea (Trilobita) aus dem Ordovizium von Spanien; ihre Biostratigraphie, Ökologie und Systematik. *Abhandlungen hrsg. von der senckenbergischen naturforschenden Gessellschaft*, **542**, 1–177.

—— ROBARDET, M. and ROMANO, M. 1982. The Ordovician System in southwestern Europe (France, Spain and Portugal). Correlation chart and explanatory notes. *International Union of Geological Sciences*, no. 11, 1–47.

HAWLE, I. and CORDA, A. J. C. 1847. *Prodrom einer Monographie der böhmischen Trilobiten*. J. G. Calve, London, 176 pp.

HENRY, J.-L. 1971. Les trilobites Asaphidae et Eohomalonotidae du Grès Armoricain supérieur (Arenigien) de l'ouest de la France. *Mémoires du Bureau de Recherches Géologiques et Minières*, **73**, 65–77.

—— 1980. Trilobites ordoviciens du Massif Armoricain. *Mémoires de la Société géologique et minéralogique de Bretagne*, **22**, 1–250.

—— NION, J., PARIS, F. and THADEU, D. 1973–4. Chitinozoaires, Ostracodes et Trilobites de l'Ordovicíen du Portugal (serra de Buçaco); essai de comparaison et signification paléogéographique. *Commission du Service géologique du Portugal*, **LVII**, 303–345.

—— and ROMANO, M. 1978. Le genre *Dionide* Barrande, 1847 (Trilobite) dans l'Ordovicien du Massif Armoricain et du Portugal. *Géobios*, No. 11, 327–343.

HUGHES, C. P. 1971. The Ordovician trilobite faunas of the Builth–Llandrindod Inlier, Central Wales. Part II. *Bulletin of the British Museum (Natural History)* (Geology), **20**, 117–182.

—— INGHAM, J. K. and ADDISON, R. 1975. The morphology, classification and evolution of the Trinucleidae (Trilobita). *Philosophical Transactions of the Royal Society of London, Series B*, **242**, 537–607.

KENNEDY, R. J. 1988. Ordovician (Llanvirn) trilobites from SW Wales. *Palaeontographical Society [Monograph]*, (Publ. No. 576, part of Vol. 141 for 1987), 1–55.

PARIS, F. 1981. Les chitinozoaires dans le Paléozoique de sud-ouest de l'Europe. *Mémoires de la Société géologiques et minéralogique de Bretagne*, **26**, 1–412.

RÁBANO, I. 1984. Trilobites Ordovícicos de Macizo Hespérico Español: una visión bioestratigráfica. *Cuadernos geología Ibérica*, **9**, 267–287.

REBELO, J. A. and ROMANO, M. 1986. A contribution to the lithostratigraphy and palaeontology of the Lower Palaeozoic rocks of the Moncorvo region, northeast Portugal. *Comunicações dos Serviços Geológicos de Portugal*, **72**, 45–57.

ROMANO, M. 1976. The trilobite genus *Placoparia* from the Ordovician of the Valongo area, north Portugal. *Geological Magazine*, **113**, 11–28.

—— 1982*a*. The Ordovician biostratigraphy of Portugal – a review with new data and re-appraisal. *Geological Journal*, **17**, 89–110.

—— 1982*b*. A revision of the Portuguese Ordovician Odontopleuridae (Trilobita): *Selenopeltis* and *Primaspis*. *Comunicações dos Serviços Geológicos de Portugal*, **57**, 213–223.

—— BRENCHLEY, P. J. and MCDOUGALL, N. D. 1986. New information concerning the age of the beds immediately overlying the Armorican quartzite in central Portugal. *Géobios*, No. 19, 421–433.

—— and DIGGENS, J. N. 1973–4. The stratigraphy and structure of Ordovician and associated rocks around Valongo, north Portugal. *Comunicações dos Serviços Geológicos de Portugal*, **57**, 23–50.

—— and HENRY, J.-L. 1982. The trilobite genus *Eoharpes* from the Ordovician of Brittany and Portugal. *Palaeontology*, **25**, 623–633.

RUSHTON, A. W. A. and HUGHES, C. P. 1981. The Ordovician trilobite fauna of the Great Paxton Borehole, Cambridgeshire. *Geological Magazine*, **118**, 623–646.

THOMAS, A. T., OWENS, R. M. and RUSHTON, A. W. A. 1984. Trilobites in British Stratigraphy. *Special Report of the Geological Society of London*, **16**, 1–78.

WHITTARD, W. F. 1955. The Ordovician trilobites of the Shelve Inlier, west Shropshire. *Palaeontographical Society [Monograph]*, part I, 1–40.

—— 1956. The Ordovician trilobites of the Shelve Inlier, west Shropshire. *Palaeontographical Society [Monograph]*, part II, 41–70.

—— 1966. The Ordovician trilobites of the Shelve Inlier, west Shropshire. *Palaeontographical Society [Monograph]*, part VIII, 265–306.

—— 1979 (compiled by W. T. DEAN). An account of the Ordovician rocks of the Shelve inlier in west Salop and part of north Powys. *Bulletin of the British Museum (Natural History)* (Geology), **33**, 1–69.

WILLIAMS, A. 1948. The Lower Ordovician cryptolithids of the Llandeilo district. *Geological Magazine*, **85**, 65–88.

YOUNG, T. P. 1985. The stratigraphy of the upper Ordovician of central Portugal. Unpublished Ph.D. Thesis, University of Sheffield.

—— 1988. The lithostratigraphy of the upper Ordovician of central Portugal. *Journal of the Geological Society of London*, **145**, 377–392.

MICHAEL ROMANO
Department of Geology
University of Sheffield
Beaumont Building
Brookhill
Sheffield S3 7HF, UK

Typescript received 23 April 1989
Revised typescript received 14 June 1989