TRILOBITES FROM THE ORDOVICIAN OF PORTUGAL

by M. ROMANO

ABSTRACT. The following trilobite species from the Llanvirn to Llandeilo of north and central Portugal are recorded or described and their stratigraphical ranges are discussed: *Colpocoryphe* aff. *rouaulti* (Henry), *C.* cf. *thoralis conjugens* Hammann, *C. grandis* (Šnajdr), *Salterocoryphe salteri salteri* (Rouault), *Prionocheilus mendax* (Vaněk), *P.* cf. *pulcher* (Barrande) and *Valongia wattisoni* (Curtis). *Actinopeltis tejoensis* sp. nov. and *Prionocheilus costai* (Thadeu) from the upper Ordovician of central Portugal are described. *Salterocoryphe lusitanica* (Thadeu) is put into synonymy with *Salterocoryphe salteri salteri*; *Prionocheilus* cf. *pulcher* is recorded for the first time from Portugal; authorship of *Prionocheilus costai* is here attributed to Thadeu and a lectotype is chosen. The faunas show similarities with those in central Iberia and northwest France.

CALYMENID, cheirurid and bathycheilid trilobites form an important element of the Ordovician faunas of Portugal. As early as 1849, Sharpe noted the presence of '*Calymene Tristani*' and '*Cheirurus*' from Valongo (Text-fig. 1), and some years later Ribeiro (1853) recorded '*Calymene Tristani*' and '*Calymene Arago*' from Buçaco. Delgado (1897, p. 28; 1908, pp. 57, 80, 106) listed six species of '*Calymene*' from the Ordovician of Buçaco, Amêndoa/Mação and Valongo, but did not describe or figure any of the material. Subsequently, Costa (1942) published a short account on the Calymenidae in which he figured '*Calymene Tristani*' and '*Calymene Salteri*' from Valongo. More recently Thadeu (1947) revised some of the upper Ordovician trilobites from Buçaco, among which he described and figured the following species of '*Cheirurus*': '(?)*Bocagei, claviger, gelasinosus*, (?)*Venceslasi*, aff. *completus* and aff. *verrucosus*', as well as '*Pharostoma costai*'. Two years later Thadeu (1949) revised the Portuguese calymenids and recognized five species of '*Synhomalonotus*' ('*Aragoi, Salteri, Tristani, transiens, lusitanica*') and two of '*Pharostoma*' ('*Costai, pulchra*'). South of the River Douro, along an extension of the Valongo outcrops, Thadeu (1956) again recorded the species '*aragoi*' and '*tristani*', as well as '*Calymeme* cf. *duplicata*'. Curtis (1961) described *Actinopeltis wattisoni* from the Valongo area.

The present paper revises the taxonomy and distribution of the following genera from the Ordovician of Portugal: *Colpocoryphe, Salterocoryphe, Prionocheilus, Actinopeltis* and *Valongia*. Most of the material is restricted stratigraphically to beds of Llanvirn to early Caradoc age; only *Prionocheilus costai* (Thadeu, 1947) is of late Caradoc–?Ashgill age.
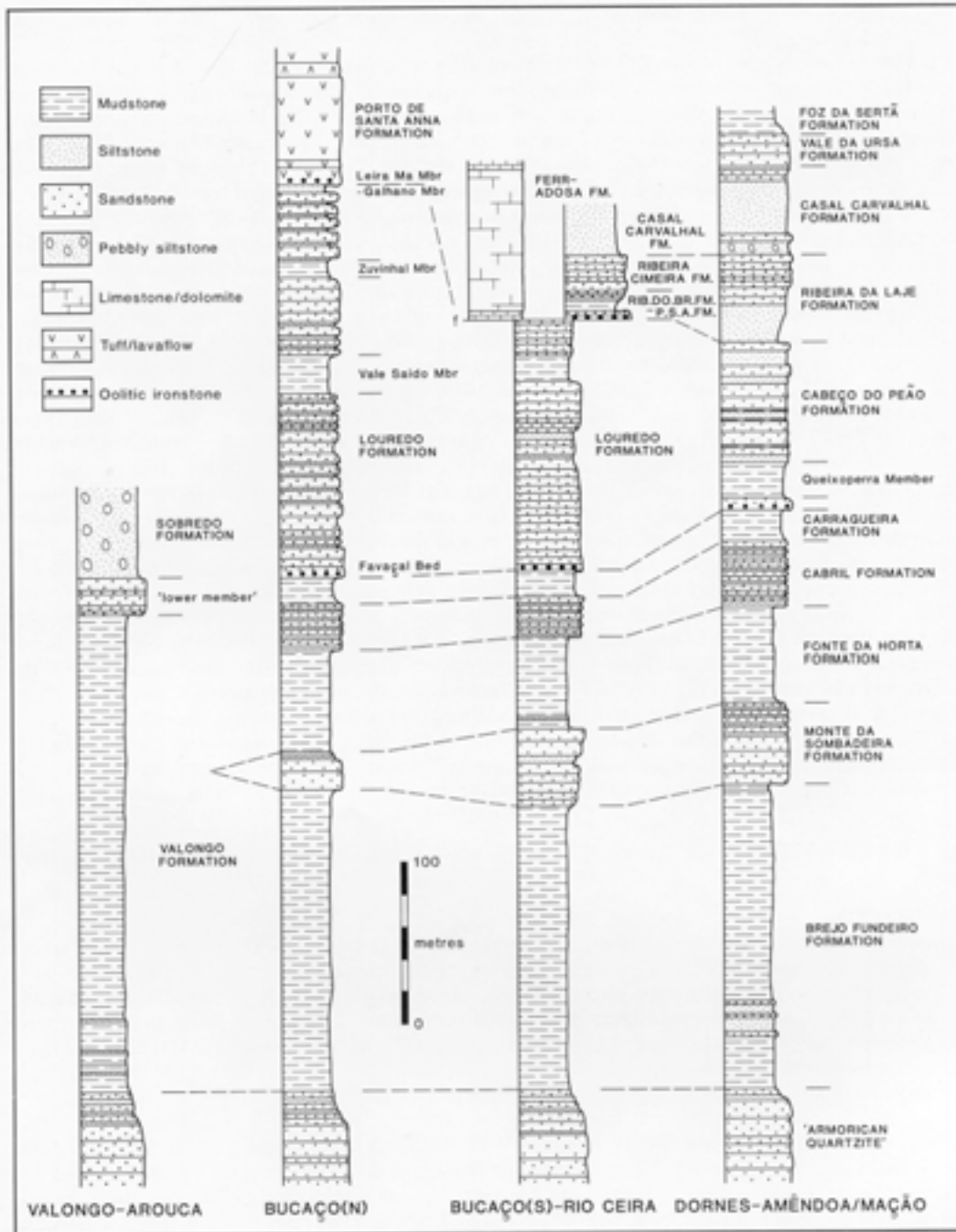
Material used is housed in the collections of the Geological Survey offices, Lisbon (prefixed SG or MR) and Earth Sciences Unit, University of Sheffield (prefixed P or RC). Further material was kindly made available by Dr A. H. Cooper (Cooper 1980) and Dr T. P. Young (Young 1985; prefixed ABO, CST, LOR, MDC, PEN, PG and QXP, at present in the Geology Department, University College of Cardiff).

STRATIGRAPHY

The material studied is mainly from the major outcrops of fossiliferous rocks in Portugal; namely Valongo to Arouca, Buçaco to Rio Ceira, and Dornes to Amêndoa/Mação (Text-fig. 1). The simplified stratigraphic columns in Text-figure 2 illustrate the major lithotypes, formations and members of these regions. More detailed descriptions of the rock units may be found in Romano
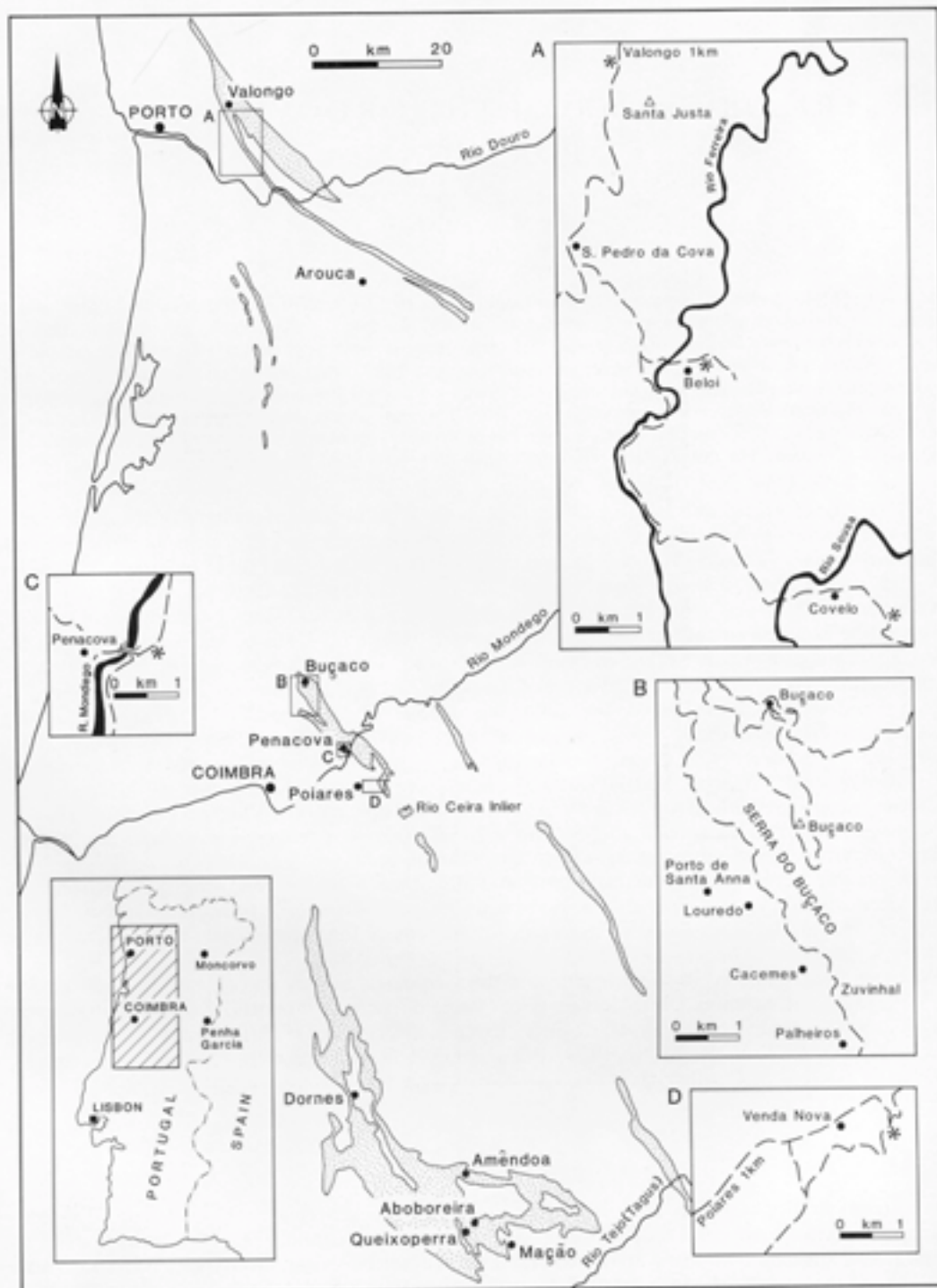
TEXT-FIG. 1. Location maps of north and central Portugal, showing fossil localities mentioned in the text.

Mudstone

Siltstone

Sandstone

Pebbly siltstone

Limestone/dolomite

Tuff/lavaflow

Oolitic ironstone

PORTO DE
SANTA ANNA
FORMATION

Leira Ma Mbr
·Galhano Mbr

Zuvinhal Mbr

FERR-
ADOSA FM.

FOZ DA SERTÃ
FORMATION

VALE DA URSA
FORMATION

CASAL CARVALHAL
FORMATION

CASAL
CARVALHAL
FM.

RIBEIRA
CIMEIRA FM.

RIB.DO.BR./FM.
·P.S.A./FM.

RIBEIRA DA LAJE
FORMATION

Vale Saido Mbr

LOUREDO
FORMATION

LOUREDO
FORMATION

CABEÇO DO PEÃO
FORMATION

Queixoperra Member

SOBREDO
FORMATION

CARRAGUEIRA
FORMATION

Favaçal Bed

CABRIL FORMATION

'lower member'

FONTE DA HORTA
FORMATION

MONTE DA
SOMBADEIRA
FORMATION

VALONGO
FORMATION

100

metres

0

BREJO FUNDEIRO
FORMATION

'ARMORICAN
QUARTZITE'

VALONGO-AROUCA

BUCAÇO(N)

BUCAÇO(S)-RIO CEIRA

DORNES-AMÊNDOA/MAÇÃO

TEXT-FIG. 2. Generalized lithostratigraphic sections for north Portugal (Valongo-Arouca) and central Portugal (Buçaco, Buçaco-Rio Ceira, Dornes-Amêndoa/Mação).

and Diggens (1976), Henry, Nion *et al.* (1976), Mitchell (1974), Cooper (1980), Brenchley *et al.* (1986) and Young (1985, 1988).

A brief resume is given here of the successions shown in Text-figure 2. The Llanvirn–Llandeilo sequence at Valongo to Arouca is a monotonous sequence of mudrocks overlying the Armorican Quartzite. The mudrocks (Valongo Formation) are abruptly succeeded by quartzites, above which are pebbly siltstones and sandstones of the Sobredo Formation. This latter unit is of glaciogenic origin and is probably of late Ordovician (Hirnantian) age. The region between Buçaco and Rio Ceira shows a general homogeneity and differs significantly in detail from the Valongo sequence. Young (1985, 1988) has recently revised the lithostratigraphy of this region above the Monte da Sombadeira Formation (Brenchley *et al.* 1986) and his terminology is incorporated in Text-figure 2. Graptolitic mudstones of Llanvirn age are known from the Brejo Fundeiro Formation (Cooper 1980) and diverse Llandeilo faunas occur in the Fonte da Horta Formation. The base of the Llandeilo is within the upper part of the Brejo Fundeiro Formation, and the Carregueira Formation is probably of early Caradoc age (Young 1988). The Louredo Formation is entirely Caradoc in age; the fossiliferous basal Favaçal Bed is considered to be of early Caradoc age (Henry and Thadeu 1971; Henry, Nion *et al.* 1976; Paris 1979, 1981), while the faunas from the uppermost mudstone unit (Galhano Member) indicate an upper Caradoc age (Paris 1979, 1981; Young 1988). The overlying Porto de Santa Anna Formation contains a rich fauna in the basal Leira Ma Member. Mitchell (1974) attributed an early Caradoc age to this assemblage but later authors have suggested a late Caradoc/early Ashgill age. Young (1988) suggested a possible Rawtheyan age for the upper part of the Porto de Santa Anna Formation. In the southern part of the Buçaco to Rio Ceira region the Porto de Santa Anna Formation is replaced by a sequence of massive dolomites; in the extreme south around Rio Ceira, clastic sequences overlie an attenuated Porto de Santa Anna Formation and are succeeded by pebbly siltstones of the Casal Carvalhal Formation.

The final column in Text-figure 2 represents the sequences around Dornes and Amêndoa/Mação. The units here, up to the Favaçal Bed, are essentially similar to those around Buçaco. In the lower part of the Cabeço do Peão Formation, however, is a richly fossiliferous unit, termed the Queixoperra Member (Young 1988), of early Caradoc age (includes the Bryozoa Beds of Cooper 1980). Poorly fossiliferous sequences overlie the Cabeço do Peão Formation in this southern region, but the pebbly siltstones of the Casal Carvalhal Formation may be correlated with those of the Rio Ceira section and probably the Sobredo Formation at Valongo. The upper part of the Vale da Ursa Formation (Cooper 1980; Young 1988) contains graptolites indicating an early Llandovery age.

REMARKS ON THE VERTICAL RANGES AND GEOGRAPHICAL DISTRIBUTIONS OF THE TRILOBITE FAUNAS

Vertical ranges

Colpocoryphe aff. *rouaulti* Henry, 1970. This species is first known from the upper Llanvirn where it is present approximately 30 m above the top of the 'Armorican Quartzite' in the Dornes area (Cooper 1980) and persists at least into the Lower Llandeilo (Text-fig. 3). A broadly similar range is known for *C. rouaulti* in Spain (Hammann 1983; Gutiérrez-Marco *et al.* 1984), and in Brittany it is known to occur from the upper Llanvirn to the *Marrolithus bureaui* biozone (Henry 1980a and pers. comm.) where it is common south of Rennes (Traveusot Formation) but rare in the upper part of the Postolonnec Formation in the Crozon Peninsula (Henry 1980a).

Colpocoryphe cf. *thorali conjugens* Hammann, 1983. This species first appears less than one metre above the Armorican Quartzite Formation in the Buçaco syncline where it is of early Llanvirn age (Romano *et al.* 1986); its upper range limit has not yet been established in Portugal. In northeast Portugal it has been recorded from near Moncorvo (Text-fig. 1) in beds low down in the Xistenta Formation (Rebelo and Romano 1988) where it is probably of Llanvirn age. Thadeu (1956, p. 19, pl. 6, fig. 1) recorded *C. aragoi* from the Canelas quarries at Arouca, south-east of Valongo. The specimen figured by Thadeu is poorly preserved but Henry (1970, p. 13) tentatively assigned it to
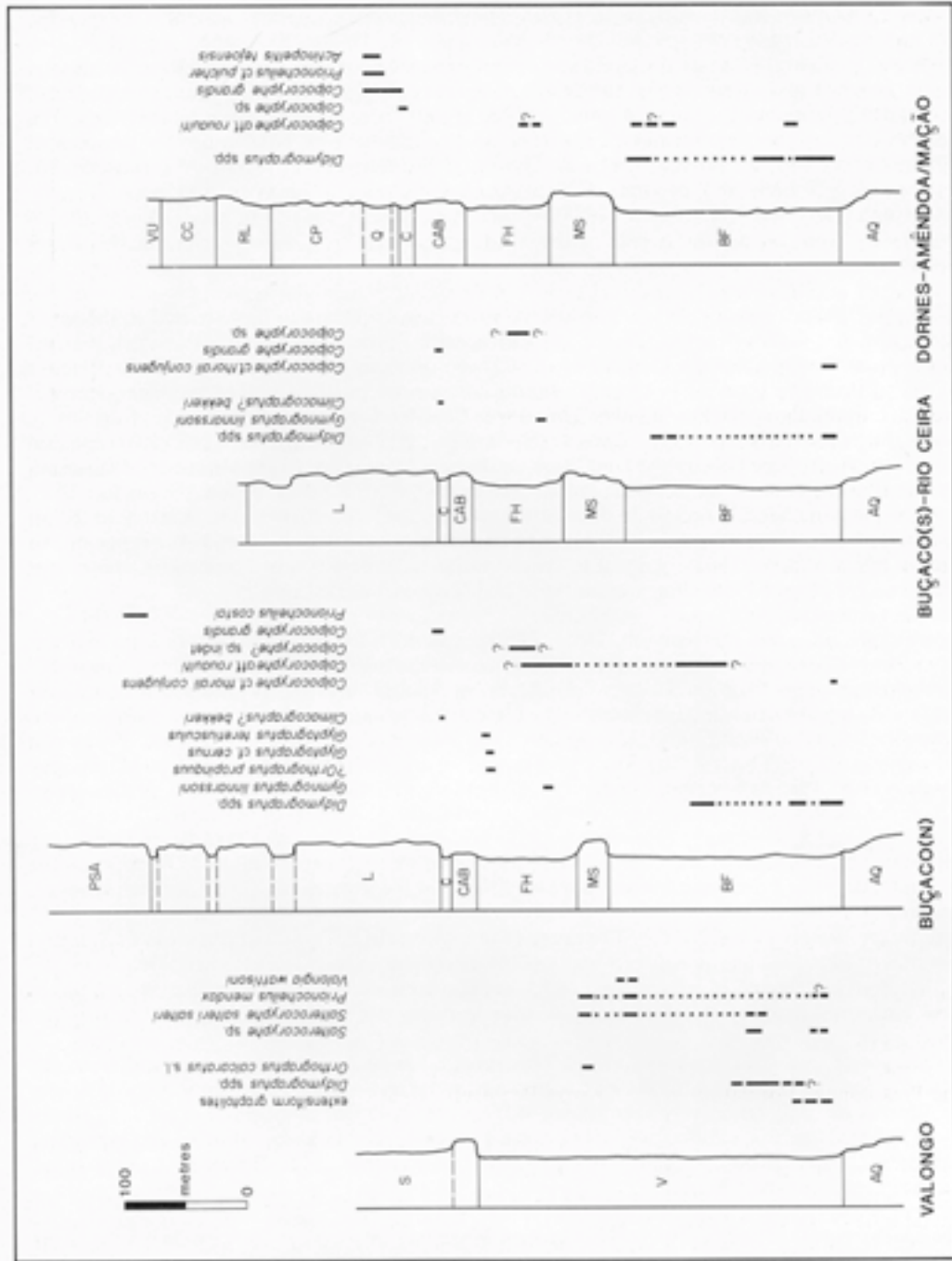
TEXT-FIG. 3. Sections showing ranges of graptolite and trilobite species. Abbreviations refer to lithostratigraphic units shown in Text-figure 2.

C. rouaulti. I have not seen Thadeu's specimen but have collected further material from the quarries which include *Salterocoryphe* sp. (possibly *S. salteri salteri*). Thadeu mentioned the presence of furrows on the pleural lobes of the pygidium of the Arouca specimens which suggests that it may be better assigned to *Salterocoryphe*; the details of the preglabellar area are not easy to distinguish from Thadeu's figure but the apparently bell-shaped glabella is reminiscent of *S. salteri salteri*. The age of the Canelas quarries assemblage was regarded as Llandeilo by Thadeu but the presence of *Hungioides bohemicus* (see Rábano 1983), *Bathycheilus*? *castilianus* and *Nobiliasaphus caudiculatus*, as well as poorly preserved pendent didymograptids, suggests a Llanvirn and possibly early Llanvirn age (Gutiérrez-Marco *et al.* 1984). Courtessole *et al.* (1981) assigned *C. thorali thorali* (Dean, 1966), from the Lower Arenig of the Montagne Noire, to *Salterocoryphe* but this is not accepted here.

Colpocoryphe grandis (Šnajdr, 1956). This species in Portugal appears to be restricted to the lower Caradoc and first makes its appearance in the Carregueira Formation in central Portugal. It is last recorded from the Queixoperra Member of the Cabeço do Peão Formation, some 15–20 m above the Favaçal Bed. The species has a greater stratigraphic range in Brittany (Henry 1980*a*) where it is known from the top of the Postolonnec Formation, Schistes de Raguenez and Riadan Formation. In Spain, Rábano (1984) records it only from the Caradoc but I have collected a deformed cephalon of *Colpocoryphe* from just above the Los Rasos sandstones (equivalent to the Monte de Sombadeira Formation) in the Guadarranque area, Toledo Mountains, central Spain, which is very close to *C. grandis*. Hammann (1983, unit 6 in Guadarranque section) considered this horizon to be of Llandeilo age and, if the identification proves to be correct, thus possibly extends the range of this species in Spain to approximately equal to that in Bohemia, where it is of Llandeilo–Caradoc age (Dobrotivá, Libeň and Letná Formations, see Havlíček and Vaněk 1966).

Salterocoryphe salteri salteri (Rouault, 1851). This species definitely occurs in beds of Llandeilo age from the upper part of the Valongo formation in north Portugal, but as yet I have not recorded undoubted specimens from the Llanvirn. However, at Arouca, a single pygidium from the lower part of the Valongo Formation (probably early Llanvirn) is tentatively identified as *S. salteri salteri*. Delgado (1908, pp. 134, 137 and 138) questionably identified the species from the 'Schistes à *Didymograptus*' (lower part of the Valongo Formation and considered by Gutiérrez-Marco, *fide* Hammann *et al.*, 1986 to be of early Llanvirn age), but this material has not been seen by the author. In Spain the species occurs in the Llanvirn at Guadarranque and much of the Llandeilo of Corral de Calatrava and El Centenillo (Hammann 1983; Gutiérrez-Marco *et al.* 1984), while in Brittany it appears to be restricted to the Llandeilo (Henry 1980*a*) where it occurs south of Rennes, on the northern flank of the Laval syncline and only very rarely in the western part of the median syncline.

Prionocheilus mendax (Vaněk, 1965). The range of this species in Portugal parallels that of *S. salteri salteri*; it is of Llandeilo age at Valongo but possibly extends down into the Llanvirn (Delgado 1908, pp. 57, 106). In Bohemia it ranges from the Llandeilo to lower Caradoc (Vaněk 1965) while in central Spain and Brittany it is exclusively of Llandeilo age (Rábano 1984; Henry 1980*a*).

Prionocheilus cf. *pulcher* (Barrande, 1846). This species has so far only been recorded from the Caradoc of the Dornes–Amêndoa/Mação region and as far as I am aware does not occur in Spain. In Brittany it has only tentatively been recorded from the lower Caradoc although Dr J.-L. Henry informs me that there are differences in that the French specimen shows shorter and straighter spines on the cephalic border than either *P. pulcher* or *P. verneuili*. In Bohemia it has a range throughout much of the Caradoc.

Prionocheilus costai (Thadeu, 1947). This species in central Portugal is so far only known from beds of late Caradoc or early Ashgill age and is probably of a similar age in Spain (Hammann 1983) where it is known from the 'Bancos mixtos'. It is also present in dropstones from the basal part of

the Casal Carvalhal Formation at Dornes (Dr T. P. Young pers. comm.). In Brittany it occurs in the lower part of the Rosan Formation.

Actinopeltis tejoensis sp. nov. This species is only known from the Queixoperra Member, Amêndoa/Mação region, of Caradoc age. The genus is recorded from Spain, from the Caradoc (Hammann 1972; Rábano 1984), and also from the Rosan Formation of Brittany (J.-L. Henry pers. comm.).

Valongia wattisoni (Curtis, 1961). This monospecific genus is at present only known from the Llandeilo of Valongo.

Geographical distributions

The distribution of the species described in this paper substantiates the previously documented contrast found in the composition of the trilobite faunas in north (Valongo–Arouca, Marão, ?Moncorvo) and central (Buçaco–Amêndoa/Mação) Portugal throughout much of the Ordovician (Hammann and Henry 1978; Henry and Romano 1978; Romano 1982). For example, during the lower Llandeilo *Salterocoryphe salteri salteri, Prionocheilus mendax* and *Valongia wattisoni* are only known from the 'northern' region, while *Colpocoryphe* aff. *rouaulti* is apparently restricted to the 'southern' region (although an imperfectly preserved specimen of ?*Colpocoryphe* is known from the upper part (Llandeilo) of the Valongo Formation in the north). During Caradoc–Ashgill times, trilobite faunas are at present unknown in north Portugal but *C.* aff. *rouaulti, C. grandis, P.* cf. *pulcher, P. costai* and *A. tejoensis* occur further south. However, in the lower Llanvirn, *C.* cf. *thorali conjugens* appears to have had a wider distribution and is recorded from Moncorvo and Buçaco–Rio Ceira.

Within Brittany and Spain, trilobite associations also show restricted distribution (Henry 1980a; Rábano 1984) and it has been frequently noted that, for example, sequences and faunas in the Crozon Peninsula have more in common with the Buçaco area in Portugal (Henry and Thadeu 1971; Paris 1981; Young 1989, 1990) than with the Ordovician succession south of Rennes (Henry and Morzadec 1968; Henry, Mélou *et al.* 1976; Henry, Nion *et al.* 1976).

Two maps are presented (Text-fig. 4) of France and Iberia during early Llanvirn and early Llandeilo times which show the distribution of the trilobites described in this paper. These distributions are now briefly discussed.

Early Llanvirn. C. thorali conjugens, S. salteri salteri and *S. sampelayoi* are known to occur in the Montes de Toledo and Sierra Morena of central Spain. Elsewhere in Iberia and Brittany their presence appears to be patchy. *S. salteri salteri* possibly occurs in the Valongo–Arouca region while *C.* cf. *thorali conjugens* is so far only known from Buçaco and Moncorvo in Portugal and probably a similar form is present in the Traveusot Formation, south of Rennes in Brittany (J.-L. Henry pers. comm.). *S. sampelayoi* (Hammann, 1977) has only definitely been recorded in Spain to date.

Early Llandeilo. As in the lower Llanvirn, central Spain appears to have been environmentally homogeneous in that *C. rouaulti, S. salteri salteri* and *P. mendax* are known across most of the region, and are also present in eastern Portugal. At Valongo *C. rouaulti* is probably absent although, as indicated above, a poorly preserved ?*Colpocoryphe* may belong to this species. In the Buçaco area the author has not seen specimens of either *S. salteri salteri* or *P. mendax* although Delgado (1908) recorded '*Calymene pulchra*' from the Brejo Fundeiro Formation, Louredo Formation and probably Porto de Santa Anna Formation. In Brittany all three species are known from the median syncline, Domfront and south of Rennes, but *P. mendax* does not occur in the Crozon Peninsula.

The distribution of the above species is informative in terms of environmental differences within the Central Iberian Zone (*sensu* Hammann *et al.* 1982) and Brittany. During early Llanvirn times all the areas appear to show a general similarity in that mud/silt was deposited over a broad shelf
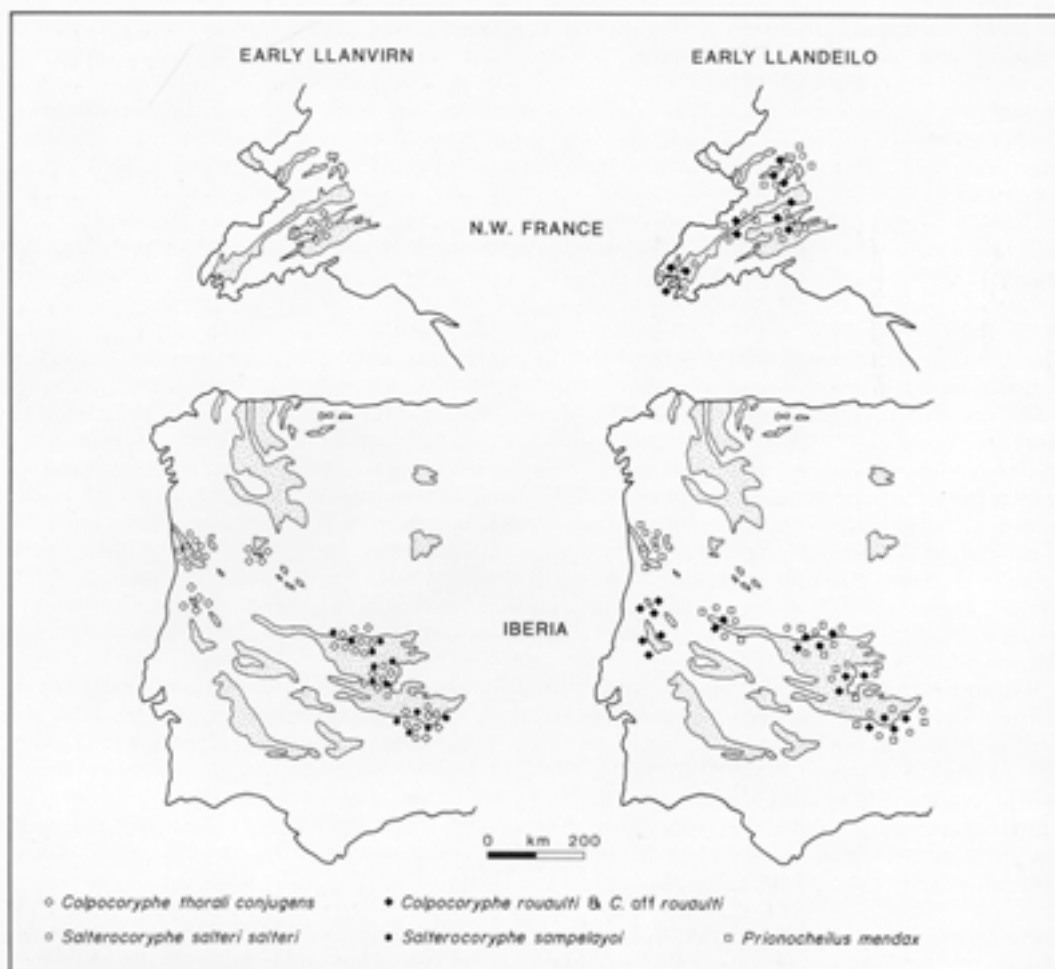
TEXT-FIG. 4. Maps showing distribution of trilobite species during early Llanvirn and early Llandeilo times in Iberia and north-west France. Stippled areas represent outcrop of Ordovician/Silurian rocks.

following the post 'Armorican Quartzite' transgression. Little direct evidence regarding water depth or proximity to shore can be ascertained either from the lithofacies or faunas, and one of the few indications that there was a change in conditions across the Iberian region is seen in the lower diversity of the trilobite faunas from south to north. A similar situation probably existed during early Llandeilo times, although in terms of the species considered here few convincing differences can be seen. However, when consideration is given to a larger sample of the trilobite faunas (Romano 1982), as well as to the lithofacies (Brenchley *et al.* 1986) the differences are considerably more marked. The major contributing factor to the differences in the trilobite assemblages is probably water depth, with its accompanying control on energy level/light/temperature and/or food supply.

It was suggested by Brenchley *et al.* (1986) that the Ordovician shelf in central and western Iberia deepened towards the north in Llandeilo times. This picture fits in well with the observed taphonomy of the trilobite assemblages from Valongo, with their relatively high proportion of

complete specimens (Romano 1976) and frequent dispersal within the rock (low energy conditions) compared with the often disarticulated exoskeletons and common bedding plane accumulations at Buçaco (higher energy conditions), particularly above the Monte da Sombadeira Formation.

SYSTEMATIC PALAEONTOLOGY

The classification of *Colpocoryphe* and *Salterocoryphe* has recently been comprehensively discussed by Henry (1980*b*) and Hammann (1983). Henry pointed out reasons for excluding the former from the Homalonotidae (Sdzuy 1957; Bergström 1973; Thomas 1977) and included it, with *Salterocoryphe*, in the Calymenidae. Henry further suggested that *Salterocoryphe* could be placed in the Flexicalymeninae (Siveter 1977), supported by the fact that *Flexicalymene (Onnicalymene) jemtlandica* and *Salterocoryphe salteri* have almost identical hypostoma, and that *Colpocoryphe* should be restricted to Colpocoryphinae. Hammann (1983), however, favoured the inclusion of both *Salterocoryphe* and *Colpocoryphe* within the Colpocoryphinae of the Calymenidae and considered that *Prionocheilus* of the subfamily Pharostomatinae should be included in the Bathycheilidae.

The suprageneric level of classification is not further discussed here and in the following section the genera are not grouped into higher ranks.

Genus COLPOCORYPHE Novák *in* Perner, 1918

Type species. Calymene arago Rouault, 1849.

Colpocoryphe aff. rouaulti Henry, 1970

Plate 1, figs 1–13, 15, 17

?1908   *Calymene Aragoi* Rouault; Delgado, p. 57.
 1949   *Synhomalonotus Aragoi* (Rouault); Thadeu, pl. 1, fig. 1.

Material. Two cephala; two cranidia; eight pygidia, with or without attached thoracic segments; thirteen complete, or nearly complete specimens; all preserved as internal and/or external moulds.

Horizon and locality. SG 142 (Thadeu 1949, p. 1, fig. 1), ?143, 500 m N 40° E of Cacemes, Buçaco. SG 144, 450 m S 70° E of Louredo, Buçaco, probably Llanvirn. SG 1326, 100 m N 40° E of Beloi chapel, probably Llanvirn. SG 2190 and MR 59–64, section from Zuvinhal to Santa Ant. do Cantaro, unit 25, Buçaco (Delgado 1908, p. 35), Llanvirn. MR 41, 42, section through Val. San Jorge, unit 20, Buçaco. MR 43–48, same section as specimens 41–42, unit 21, Buçaco (Delgado 1908, p. 42). MR 49–51, Palheiros, Buçaco. MR 52–58, 900 m S 65° E of Venda Nova, Poiares. The material occurs in beds from the Brejo Fundeiro Formation (Llanvirn) to the Fonte da Horta Formation (Llandeilo). MR 41–48 are of Llandeilo age, MR 49–58 are Llanvirn.

Discussion. The material is certainly very close to *C. rouaulti* but differs from it in several respects. In the Portuguese specimens the glabella converges forwards more markedly and the straight anterior margin of the glabella is shorter. The swollen posterior lobe to the central body of the hypostoma is more like that figured by Hammann (1983) while the internal posterior notch is closer to that of Henry's (1970, 1980*a*, *b*) material. The pygidium shows slight differences in the shallower axial and vincular furrows and smaller side lobes. At this stage the author prefers to identify the Portuguese material as *C.* aff. *rouaulti*. Further, the Portuguese material suggests that there may be slight differences between the Llanvirn and Llandeilo forms assigned here to *C.* aff. *rouaulti*. Although the cephala are virtually indistinguishable the pygidial axis of the stratigraphically lower specimens tends to carry less well-defined ring furrows and the vincular furrows are less strongly indented than in the Llandeilo forms. It is possible that the Llanvirn material may prove to be subspecifically distinct from the Llandeilo form, but this must await more and better preserved material.

Colpocoryphe cf. *thorali conjugens* Hammann, 1983

1986   *Colpocoryphe* cf. *thorali conjugens* Hammann; Romano *et al.*, p. 429, pl. 1, figs 2–5.
1988   *Colpocoryphe* cf. *thorali conjugens* Hammann; Rebelo and Romano, p. 54, pl. 1, figs 8–11;
        pl. 2, fig. 5.

Material. Four cranidia; two cranidia, with part thorax; three pygidia; all preserved as internal and/or external moulds.

Horizon and locality. P157/7, 1·2 m above lingulid bed at top of Armorican Quartzite Formation, road section south of River Mondego, Penacova. RC1/2, 10 cm above lingulid bed at top of Armorican Quartzite Formation, track section, north of River Ceira, Vila Nova do Ceira. SG 1154/1–4, 6, 10, Xistenta Formation, 3·5 km ESE of Mos, 13 km east of Moncorvo. P157/7 and RC1/2 are Lower Llanvirn, SG 1154/1–4, 6, 10, probably Llanvirn.

Discussion. For description and discussion of the above material see Romano *et al.* (1986) and Rebelo and Romano (1988). Nothing new can be added. The subspecies is known from lower Llanvirn of the Sierra Morena (Hammann 1983; Rábano 1984; Gutiérrez-Marco *et al.* 1984).

Colpocoryphe grandis (Šnajdr, 1956)

Plate 2, figs 1–3, 7, 8, 11

?1908   *Calymene Aragoi* Rouault; Delgado, pp. 41, 57.
*1956   *Calymene (Colpocoryphe) grandis* Šnajdr; p. 529, pl. 3, figs. 1–9.
1980b   *Colpocoryphe grandis* (Šnajdr, 1956); Henry, text-fig. 3, pl. 2, figs 3 and 4.

(for full synonymy see Henry 1980a, p. 64; and Hammann 1983, p. 85).

Material. Three cephala; three cranidia; two cephala, with part of thorax; five pygidia, with part of thorax; two pygidia; two complete or nearly complete specimens; all preserved as internal and/or external moulds.

Horizon and locality. LOR 1.007–9, Louredo Formation, Favaçal Bed, Louredo village. LOR 2.001, less than 2 m below Favaçal Bed, Louredo village. PEN 1.001–2, less than 10 m below Favaçal Bed, quarry 320 m ENE

EXPLANATION OF PLATE 1

Figs 1–13, 15, 17. *Colpocoryphe* aff. *rouaulti* Henry, 1970. 1–3, SG 142; internal mould of cephalon, dorsal, anterior and lateral views, × 2, Brejo Fundeiro Formation, Buçaco, Llanvirn. 4, MR 41; internal mould of cranidium, dorsal view, × 1·4, Fonde da Horta Formation, Buçaco, Llandeilo. 5, MR 42; internal mould of cranidium, dorsal view, × 2, Fonte da Horta Formation, Buçaco, Llandeilo. 6–8, MR 52; internal mould of cranidium, dorsal, anterior and lateral views, × 1·8, Brejo Fundeiro Formation, Poiares, Llanvirn. 9, MR 44; internal mould of cranidium, dorsal view, × 1, ?Fonte da Horta Formation, Buçaco, Llandeilo. 10, SG 144; internal mould of pygidium, dorsal view, × 2, Brejo Fundeiro Formation, Buçaco, ?Llanvirn. 11, SG ?143; internal mould of pygidium, dorsal view, × 2, Brejo Fundeiro Formation, Buçaco, ?Llanvirn. 12, MR 49; internal mould of pygidium, dorsal view, × 2, Brejo Fundeiro Formation, Buçaco, Llanvirn. 13, MR 53; internal mould of pygidium, dorsal view, × 2, Brejo Fundeiro Formation, Poaires, Llanvirn. 15, MR 46; internal mould of nearly complete specimen, dorsal view, × 1, ?Fonte da Horta Formation, Buçaco, Llandeilo. 17, MR 45; internal mould of nearly complete specimen, × 1, ?Fonte da Horta Formation, Buçaco, Llandeilo.
Fig. 14. *Colpocoryphe* sp. MD 2.001/2; internal mould of incomplete cranidium, dorsal view, × 6, Carregueira Formation, Dornes, Caradoc.
Fig. 16. *Colpocoryphe*? sp. indet. SG 146; partly enrolled specimen with 6 thoracic segments and pygidium, dorsal view of pygidium, × 1·2, Fonte da Horta Formation, Buçaco, Llandeilo.
Fig. 18. *Salterocoryphe salteri salteri* (Rouault, 1851). SG 1681; internal mould of pygidium, dorsal view, × 0·9, Valongo Formation, Valongo, Llandeilo.

PLATE 1
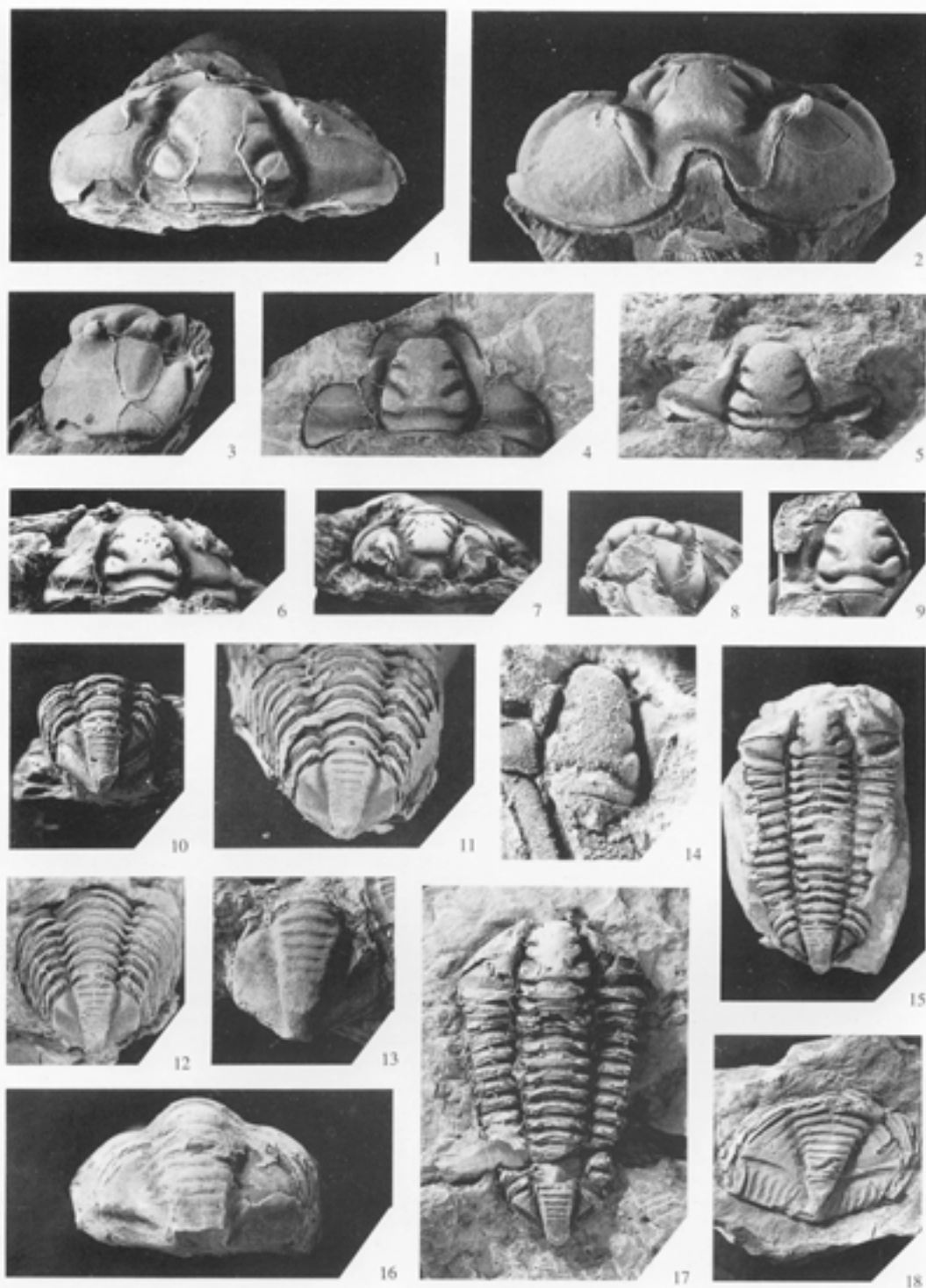
ROMANO, *Colpocoryphe, Colpocoryphe?, Salterocoryphe*

of east end of bridge over River Mondego, east of Penacova. QXP 2.001–5, 40, and Mação specimen of Cooper (1980), '1700 m N 57° E de pyr. de Queixoperra, Mação', probably from 'Bryozoa Beds' (Cooper 1980; Romano 1982) within unit 7 of the 'Schistes à *Orthis Berthoisi*' (Delgado 1908, p. 92), Queixoperra Member of Cabeço do Peão Formation. CST 2.001–4, 1400 m N 62° E of Pereiro, Mação, oolitic beds probably equivalent to basal oolite (Favaçal Bed) of Louredo Formation. ABO 9.001, Aboboreira, Carregueira Formation, from less than 3 m below oolitic beds, and ABO 10.001, basal 'Bryozoa Beds', Queixoperra Member, both approximately 1 km WNW of Carregueira, Mação. T. Young collection, unnumbered specimens from 2 km SSE of Aboboreira [20710, 28915], and west of Pereiro [20975, 29090]; all from Favaçal Bed. Dornes material (loc. 70), grid reference 18992 31368, from 'Bryozoa Beds' of Cabeço do Peão Formation. Fragmental material is also known from near the top of the Carregueira Formation at Rio Ceira (Young 1985). All specimens are probably of early Caradoc age.

Discussion. The present material agrees in all important respects with that described and figured by Snajdr (1956), Destombes (1966), Henry (1980*a*) and Hammann (1983).

Colpocoryphe? sp. indet.

Plate 1, fig. 16

?1908   *Calymene transiens* Verneuil and Barrande; Delgado, p. 57.
 1949   *Synhomalonotus transiens* (Verneuil and Barrande); Thadeu, pl. 1, fig. 6.

Material. SG146. Internal mould of enrolled specimen with six thoracic segments and pygidium (Thadeu 1949, pl. 1, fig. 6).

Horizon and locality. '100 m S 80° E of Loredo', Buçaco. Delgado (1908, p. 57) records the species from the 'Schistes à *Homalonotus oehlerti*' (Fonte da Horta Formation) of Llandeilo age.

Description. Thoracic segments of *Colpocoryphe* type (see Henry 1980*a*, pl. 7, fig. 1*a*) carrying sculpture of small tubercles. Pygidial axis wide anteriorly, narrowing evenly backwards and with shallow axial furrows, posterior part not preserved. Eight visible axial rings seen separated by shallow, complete ring furrows. Small triangular pleural lobes extend back to eighth axial ring and carry up to four poorly defined ribs. Lateral borders have wide, open furrows with no trace of segmentation on lower surfaces. Sculpture slightly coarser than on thorax.

Discussion. The absence of segmentation on the lateral borders is typical of the genus *Colpocoryphe* as distinct from *Salterocoryphe*. The ribs on the pleural lobes are more obvious than in *C. rouaulti* and *C. grandis* and there is no median shallowing of the axial ring furrows in the pygidium as in the latter species, although this feature is more apparent on external moulds (Henry 1980*a*, pl. 7, figs 6*a*, *b* and 7; pl. 8, fig. 2*a–d*).

EXPLANATION OF PLATE 2

Figs 1–3, 7, 8, 11. *Colpocoryphe grandis* (Šnajdr, 1956). 1, QXP 2.0001; internal mould of incomplete cranidium, dorsal view, × 1, Cabeço do Peão Formation, Amêndoa/Mação, Caradoc. 2, 7, QXP 2.040; internal mould of pygidium, dorsal and posterior views, × 1 and × 1·4 respectively, Cabeço do Peão Formation, Amêndoa/Mação, Caradoc. 3, PEN 1.002; internal mould of pygidium, dorsal view, × 1, Carregueira Formation, Amêndoa/Mação, Caradoc. 8, CST 2.004; internal mould of cephalon, anterior view, × 0·6, Favaçal Bed, Mação, Caradoc. 11, CST 2.003; internal mould of fragmentary cephalon and hypostoma, anterior view, × 0·7, Favaçal Bed, Mação, Caradoc.

Figs 4–6, 9, 10, 12. *Salterocoryphe salteri salteri* (Rouault, 1851). 4, SG 1687.1; internal mould of incomplete specimen, dorsal view, × 1, Valongo Formation, Valongo, Llandeilo. 5, SG 149; internal mould of complete specimen, dorsal view, × 1·3, Valongo Formation, Valongo, Llandeilo. 6, SG 1686.1; internal mould of partly enrolled specimen, dorsal view, × 1·2, Valongo Formation, Valongo, Llandeilo. 9, SG 1325; internal mould of specimen with hypostoma, dorsal view, × 1·4, Valongo Formation, Valongo, Llandeilo. 10, 12, SG 1687; internal mould of nearly complete specimen, dorsal view, × 1, anterior view, × 1·4, respectively, Valongo Formation, Valongo, Llandeilo.

PLATE 2

ROMANO, *Colpocoryphe*, *Salterocoryphe*

The incomplete specimen precludes specific identification. Delgado and Thadeu referred the species to '*Calymene transiens*' (Verneuil and Barrande 1855, p. 974, pl. 25, fig. 5) from Almadén, Spain, but Verneuil and Barrande's figure and description do not permit a close comparison. Tromelin and Lebesconte (1876, p. 629) reinvestigated the type of *transiens* and regarded it as belonging to '*Calymene salteri*'. Henry (1970, p. 22) pointed out that *Salterocoryphe salteri* is present at Almadén which tends to support Tromelin and Lebesconte's suggestion.

Hammann (1983, p. 90) reported that the type of *Calymene transiens* could not be found and that the species cannot reliably be attributed to either *Colpocoryphe* or *Salterocoryphe*. However, Hammann considered it to be closer to the latter.

Colpocoryphe sp.

Plate 1, fig. 14

Material. MDC 2.001/2, part and counterpart of incomplete cranidium.

Horizon and locality. Carregueira Formation, Dornes, type section (Young 1985), about 5 m below oolitic horizon (at base of Cabeço do Peão Formation). Lower Caradoc.

Description. Glabella (excluding occipital ring) slightly longer than wide, sides gently converging anteriorly. Occipital furrow forwardly flexed, occipital ring carries small median tubercle which is considerably fainter on external mould. Anterior margin of glabella gently rounded with short, straight median part. S2 furrows are short, straight and inclined only slightly backwards; S3 very short and indistinct. Anterior notch of cranidium is broad with widely diverging sides. Cranidium is finely tuberculate.

Discussion. The specimen is small (about 4·5 mm long) and may represent a meraspid stage. The open anterior notch suggests affinities with *Colpocoryphe grandis* but this species does not possess such a narrow glabella, at least in adult specimens, or a median occipital tubercle. The short S2 and S3 furrows and fine sculpture are features of *Salterocoryphe salteri salteri* (Hammann 1977; Henry 1980a) and the juvenile of this species bears a median occipital tubercle (Hamman 1983, pl. 11, fig. 110). However the structure of the anterior cephalic border is typical of *Colpocoryphe* and until juvenile specimens of *C. grandis* are described it is preferable to leave the Portuguese specimen in open nomenclature.

Genus SALTEROCORYPHE Hamman, 1977

Type species. Calymene salteri Rouault, 1851.

Salterocoryphe salteri salteri (Rouault, 1851)

Plate 1, fig. 18; Plate 2, figs 4–6, 9, 10, 12; Plate 3, fig. 9.

*1851	*Calymene salteri* Rouault, p. 358.	
1949	*Synhomalonotus salteri* (Rouault) Thadeu, pl. 1, figs 2–3.	
1949	*Synhomalonotus lusitanica* Delgado; Thadeu, p. 131, pl. 1, figs 7–9; pl. 2, figs 1 and 2.	
1960	*Neseuretus lusitanica* (Thadeu); Whittard, p. 145.	
1966	*Colpocoryphe lusitanica* (Thadeu); Dean, p. 309.	
1982	*Neseuretus lusitanicus* (Thadeu); Fortey and Morris, p. 70.	
1982	*Salterocoryphe lusitanica* Romano, p. 96.	
1982	*Salterocoryphe salteri* Romano *in* Hammann, Robardet and Romano, p. 40.	

(for full synonymy see Henry 1970, p. 18; and Hammann 1983, p. 90).

Material. Five complete or nearly complete specimens; fourteen other specimens; all preserved as internal or external moulds.

Horizon and locality. SG 147 (figured by Thadeu 1949, pl. 2, fig. 2), 'vizinhanças de Valongo'. SG 148 (Thadeu 1949, pl. 1, fig. 9), '800 m NE de Boloi'. SG 149 and 150 (Thadeu 1949, pl. 1, figs 7 and 8), 'Ribeira da Murta, Valongo'. SG 1688, (Thadeu 1949, pl. 2, fig. 1) '1650 m (non 1680 m, Thadeu 1949, p. 131) S 20° W da piramide de Santa Justa'. SG 1323 and 1324, '1000 m S 30° E da igreja de Covelo, Valongo'. Information taken from labels on specimens, slightly modified using Thadeu (1949). Other specimens from Beloi, Covelo, Santa Justa and Penha Garcia (see Text-fig. 1). PG 6.001 from approximately 11 m above Monte da Sombadeira Formation, Penha Garcia. All north Portuguese material is probably from upper part of the Valongo Formation (Schistes à *Uralichas Ribeiroi* of Delgado 1908) of Llandeilo age.

Discussion. The species has been recently described and figured by Henry (1970) and Hammann (1983). Henry (1980a) distinguished two subspecies of *S. salteri* of which the Portuguese material may be assigned to *S. salteri salteri*.

Since Thadeu (1949) first described *Salterocoryphe lusitanica*, various authors (Whittard 1960; Dean 1966) have briefly referred to it in discussions relating to generic assignment. Henry (1970, p. 21) discussed the status of the species when he suggested that it bore a striking resemblance to .*S. salteri* in that the form of the glabella, eye position and number of axial rings were identical. The only difference that Henry noted was that the pleural lobes on the pygidium were more clearly segmented in the Portuguese material, but this he thought could well be the result of deformation. A study of additional material indeed confirms Henry's suggestion that the preservation of the furrows varies with the deformation. The anterior part of the pygidial axis tends to be relatively narrower in the Portuguese specimens but this does not seem to be an important criterion for separating the two forms. Hence I prefer to put *lusitanica* into synonymy with *salteri*. Hammann (1983, p. 93) regarded *lusitanica* as a distinct species but his criteria are not accepted here; for example the range in glabella length: width ratios of *salteri* and *lusitanica* are virtually identical and the ornament of specimens assigned to *lusitanica* is similar to that of *salteri*.

Genus PRIONOCHEILUS Rouault, 1847

(Syn. *Pharostoma* Hawle and Corda, 1847)

Type species. Prionocheilus verneuili Rouault, 1847.

Remarks. The question of the priority of *Prionocheilus* Rouault, 1847 or *Pharostoma* Hawle and Corda, 1847 has been discussed by Dean (1964, 1966, p. 300; 1971, p. 42), Whittington (1965, p. 56), Ingham (1977, p. 103), Siveter (1977, pp. 339, 393), Owen and Bruton (1980, p. 2), Henry (1980a, p. 79) and Hammann (1983, p. 51). For the present paper I prefer to accept Dean's argument and follow his suggestion for using *Prionocheilus*.

Prionocheilus mendax (Vaněk, 1965)

Plate 3, figs 1–5, 8

1908	*Calymene pulchra* Barrande; Delgado, pp. 106, 134, ?138.
1942	*Calymene pulchra* Barrande; Costa, p. 93.
1949	*Calymene pulchra* Barrande; Thadeu, p. 129, pl. 2, figs 3–5.
*1965	*Pharostoma pulchrum mendax*; Vanek, pp. 30–32, fig. 6; pl. 2, fig. 10; pl. 3, figs 6 and 7; pl. 4, figs 2–5.

(for a full synonymy see Vaněk 1965, p. 30; Henry 1980a, pp. 80–81; and Hammann 1983, p. 53).

Material. Three cephala with part thorax; one hypostoma; two free cheeks; twenty-three complete or nearly complete specimens; all preserved as internal and/or external moulds.

Horizon and locality. SG 151, 'Valongo'. SG 1692, 1692.1–3, 1693.1 and MR 38–40, 1400 m S 32° E of Covelo church, Valongo. SG 1327, 1327.1, 1000 m S 30° E of Covelo church, Valongo. SG 1691, 1691.1–3, 800 m S 26° W of 'ermida de Santa Justa, Valongo'. Delgado (1908) records the species from the 'Schistes à Didymograptus' (Llanvirn) to the 'Schistes à *Uralichas Ribeiroi*' (Llandeilo) of the Valongo Formation

(Romano and Diggens 1976; it is not possible to relate his specimens to exact horizons. The author has collected this species from beds of Llandeilo age at Valongo but has not recorded it from the Llanvirn.

Description. A full description is not given since the species is well documented. Cephalon semicircular in outline with evenly rounded anterior and lateral margins. Glabella subtriangular in outline, with evenly curved anterior margin and slightly curved sides. Maximum width of cephalon about two and a half times that of posterior glabellar width. Glabella from 0.7–0.8 times as long as cephalon. Three pairs of glabellar lobes and furrows. Faint oval areas situated on inner side of posterior branch of 1S. Glabella gently convex dorsally. Axial furrows generally deep, expanding into small, crescent-shaped paraglabellar areas abaxial to 1L. Palpebral lobes prominent, situated opposite 2L and nearer to axial furrow than lateral margin. Faint eye ridge runs to 2S. Free cheeks with long, posteriorly directed genal spines. Lateral and anterior margin of cephalon carry at least fifty downwardly directed, slightly curved (posteriorly) spines. Sculpture of small tubercles of uniform size, absent in paraglabellar areas.

Hypostoma consists of gently convex, subovate middle body, longer than wide, with shallow inwardly directed furrows defining a posterior crescent-shaped lobe; lobe consists of two oblique lateral lobes. Anterolateral margins with small outwardly directed pointed wings. Posterior margin of hypostoma has a shallow open notch; posterior projections are rounded.

Thorax consists of thirteen segments. Axial furrows gently outwardly curved; axis widest at about third axial ring where it is over one and a half times as wide as at posterior end. Axial rings lobate laterally. Broad (trans.), horizontal inner parts of pleural region, outer parts bent sharply down. Pleural furrows deep, wide (exsag.) and straight, starting at anterolateral corner of axial ring and running approximately parallel to pleural margins. Posterior border slightly wider (exsag.) than anterior. At geniculation, furrows swing forwards and die out before reaching rounded tip of segment. Thorax finely tuberculate like cephalon.

Pygidium semicircular in outline. Anterior end of axis about one-third maximum width of pygidium. Axis narrows evenly backwards, not reaching posterior margin. Axis carries five rings (sometimes with faint suggestion of a sixth) and a semicircular terminal piece which stands higher than rest of axis. Ring furrows shallow and narrow (sag.) posteriorly. Up to five nearly straight ribs, separated by deep furrows which curve strongly backwards distally. First, three/four ribs carry short furrows extending from axial furrow. Sculpture similar to that of cephalon and thorax.

EXPLANATION OF PLATE 3

Figs 1–5, 8. *Prionocheilus mendax* (Vaněk, 1965). 1, MR 38.3 and 38.5; latex cast of external mould, dorsal view, × 1, Valongo Formation, Valongo, Llandeilo. 2, MR 38.6–8; latex cast of external mould, dorsal view, × 0·8, Valongo Formation, Valongo, Llandeilo. 3, MR 39; internal mould of incomplete specimen, dorsal view, × 1, Valongo Formation, Valongo, Llandeilo. 4, MR 38.1; latex cast of external mould, dorsal view, × 1, Valongo Formation, Valongo, Llandeilo. 5, SG 1692.1; latex cast of internal mould showing hypostoma, dorsal view, × 1, Valongo Formation, Valongo, Llandeilo. 8, MR 38.13; latex cast of external mould of free cheek, dorsal view, × 1, Valongo Formation, Valongo, Llandeilo.

Figs 6, 10, 12, 13. *Prionocheilus* cf. *pulcher* (Barrande, 1846). 6, QXP 2.017; latex cast of external mould of cranidium, dorsal view, × 3, Cabeço do Peão Formation, Amêndoa/Mação, Caradoc. 10, SG 152; internal mould of cranidium, dorsal view, × 1·5, Cabeço do Peão Formation, Amêndoa/Mação, Caradoc. 12, QXP 2.014; internal mould of cranidium, dorsal view, × 2, Cabeço do Peão Formation, Amêndoa/Mação, Caradoc. 13, QXP 2.009; latex cast of external mould of pygidium, dorsal view, × 2, Cabeço do Peão Formation, Amêndoa/Mação, Caradoc.

Fig. 9. *Salterocoryphe salteri salteri* (Rouault, 1851). PC 6.001; latex cast of external mould of cranidium, dorsal view, × 1·75, Fonte da Horta Formation, Penha Garcia, Llandeilo.

Figs 7, 11, 14–16. *Actinopeltis tejoensis* sp. nov. 7, QXP 2.041; internal mould of pygidium, dorsal view, × 2, Cabeço do Peão Formation, Amêndoa/Mação, Caradoc. 11, QXP 2.043; internal mould of incomplete pygidium, dorsal view, × 3, Cabeço do Peão Formation, Amêndoa/Mação, Caradoc. 14, QXP 2.006; internal mould of cephalon, dorsal view, × 2, Cabeço do Peão Formation, Amêndoa/Mação, Caradoc. 15 and 16, SG 225 (holotype); internal mould and latex cast of corresponding external mould, dorsal views, × 1·4 and 1·8 respectively, Cabeço do Peão Formation, Amêndoa/Mação, Caradoc.

PLATE 3
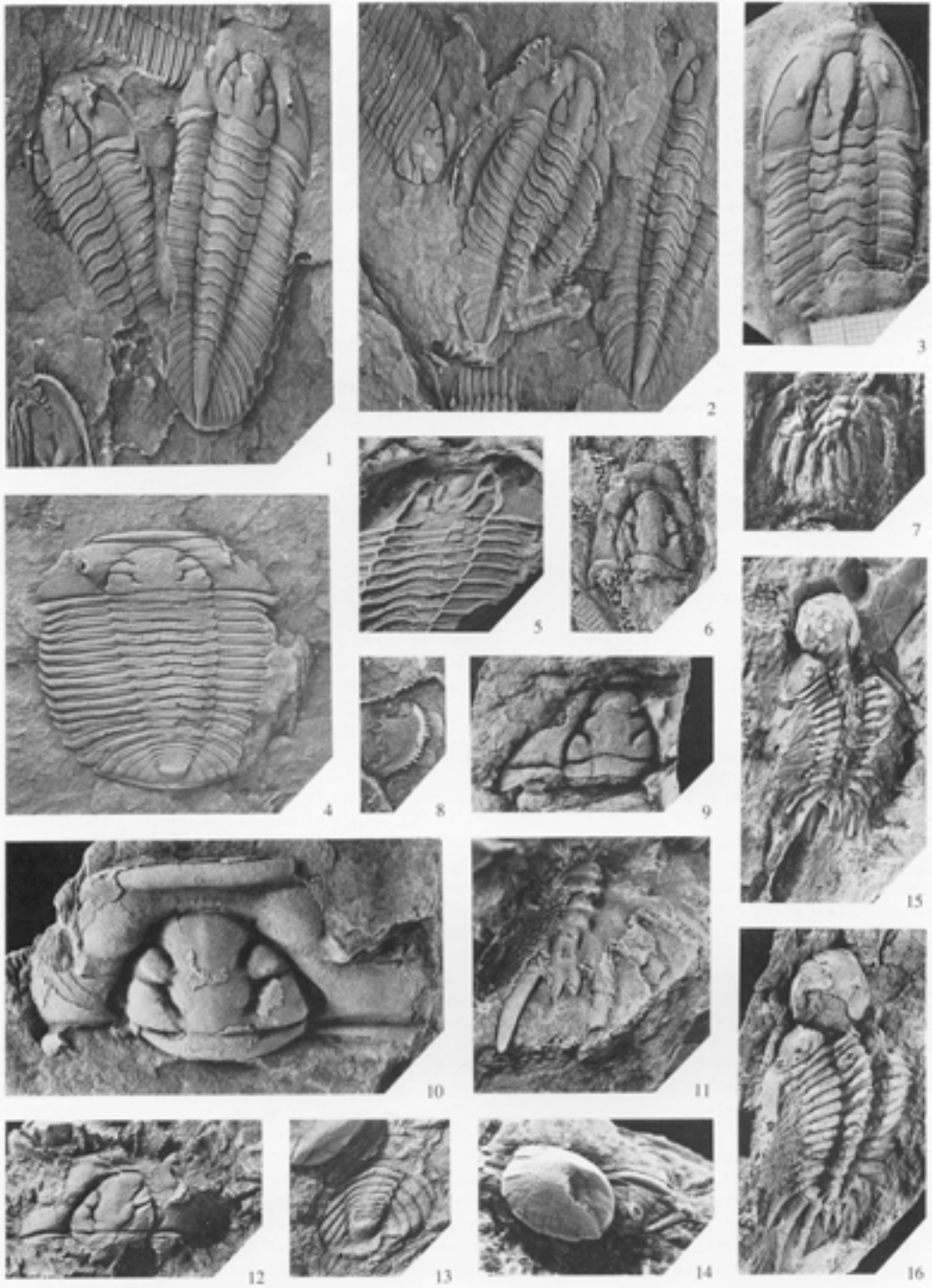
ROMANO, *Prionocheilus, Salterocoryphe, Actinopeltis*

Discussion. The Portuguese material is very similar to that figured by Vaněk (1965) from the Dobrotivá Formation (Llandeilo) to Letná Formation (lower Caradoc) of Bohemia. A minor difference is the shallower posterior axial ring furrows and pleural furrows. This was also noted by Henry (1980a, p. 81) who recorded the species from the upper part of the Traveusot and Andouillé formations (Llandeilo) of Brittany. Henry (1980a) figured an *in situ* hypostoma and commented on the difference between it and that figured by Vaněk (1965, pl. 2, fig. 10). Vaněk's specimen of a hypostoma is incomplete and contrasts with the notched posterior margin of specimens from Brittany (Henry 1980a, fig. 31, pl. 14, fig. 3a) and Spain (Hammann 1983, text-fig. 14). Although the two Portuguese *in situ* hypostomata are not well-preserved, they both show the notched posterior margin; the posterior projections, however, have more rounded outlines than in the Brittany specimen. The minor differences mentioned above are considered insufficient to separate the Portuguese species from *Prionocheilus mendax.*

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Prionocheilus cf. *pulcher* (Barrande, 1846)

Plate 3, figs 6, 10, 12, 13

1908   *Calymene pulchra* Barrande; Delgado, pp. 57, 80.

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Material. Thirteen cranidia; one free cheek; two cephala with part of thorax; four pygidia; all preserved as internal and/or external moulds.

Horizon and locality. SG 152, 'Aboboreira, 300 m N 60° W (Mação)', from the 'Schistes à *Orthis* (= *Svobodaina) Berthoisi'* (Delgado 1908, p. 80, but not listed in following descriptions of stratigraphic sections). QXP. 2.008–2.028, '1700 m N 57° E de pyr. de Queixoperra', Mação; 'Bryozoa Beds', Queixoperra Member, 'Schistes à *Orthis Berthoisi'*. ABO 10.002, approximately 1 km WNW of Carregueira, Mação; basal 'Bryozoa Beds', Queixoperra Member, Cabeço do Peão Formation. All material of Caradoc age (probably early).

Description. Glabella subtriangular in outline with nearly straight anterior margin, length just over three-quarters the basal width. Glabella nearly two-thirds as long as cranidium. Occipital ring about same length as anterior border medially. Behind L1, occipital ring is constricted and swings forwards where at posterolateral corner of L1 it is half of its median length. Occipital furrow shallow and straight behind central glabellar lobe; at inner posterior corner of L1 furrow deepens and remains so to axial furrow. Three pairs of unequal glabellar lobes. L1 largest, length just under half that of glabella, with nearly straight lateral and posterior margin, and angular anterolaterally. S1 shallow near axial furrow, deepest at inner anterior corner of L1 where furrow bifurcates. Posterior branch runs backwards and curves inwards; anterior branch shallow and short, directed inwards and forwards. L2 just over half the length of L1, with more or less straight anterior and posterior margins. S2 straight, shallow near axial furrow, directed inwards and backwards at a smaller angle to the midline than S1. L1 and L2 separated from central glabellar lobe by very faint furrow. L3 very small and delimited anteriorly by very faint S3. Oval areas situated adaxial to posterior branch of S1. Glabella gently convex (trans. and sag.). Axial furrow gently curved, convex outwards, shallowest opposite L2 and at posterior end of L1. Outside L1, axial furrow expanded into crescent-shaped paraglabellar areas. Anterior pit associated with slightly inwardly placed large tubercle situated on outer side of axial furrow, just anterior to S3. Preglabellar field separated from glabella by narrow, shallow furrow; preglabellar field of same length as anterior border and slopes gently backwards. Prominent, convex (sag.) anterior border separated from preglabellar field by well marked furrow which shallows abaxially. Posterior border narrow (exsag.) at axial furrow, widening abaxially. Back of palpebral lobe level with where S1 meets axial furrow, anterior margin of palpebral lobe approximately level with anterior corner of L2. Palpebral lobe slopes inwards and merges with fixed cheek. Faint eye ridge running inwards and forwards from palpebral lobe to meet axial furrow just behind anterior pit. Anterior branch of facial suture runs in slightly sigmoidal curve to cut anterior margin in-line approximately with outer part of paraglabellar areas (preservation poor). Posterior branch of facial suture runs outwards and backwards (posterolateral parts of fixed cheeks not preserved). Free cheek narrow, extending into long, posteriorly directed genal spine reaching back to at least 6th thoracic segment. At least nineteen ventrally directed and slightly curved spines (just under 0·5 mm long) situated along border. Sculpture on cephalon of fine tubercles, about twenty per square mm; absent in furrows and very sparse on preglabellar field.

Hypostoma not known. Thorax of *Prionocheilus* type, tuberculate except in furrows. Pygidium strongly curved anteriorly, gently curved posterior margin. Pygidium two and a half times as wide as anterior part of

axis; latter narrows evenly posteriorly and about four-fifths length of pygidium. Seven axial rings narrowing (sag.) posteriorly, 6th and 7th axial ring furrows weak to absent medianly. Terminal piece about one-quarter axial length, broadly rounded and sloping down steeply posteriorly. Six pairs of ribs separated by deep furrow which terminate just before lateral margins. Surface of pygidium tuberculate.

Discussion. In most features the Mação specimens are very close to *Prionocheilus pulcher* (Barrande 1852, pl. 19, figs 1–3, 6; see also Vaněk 1965, p. 31, pl. 3, figs 3–5, pl. 4, fig. 1, text-fig. 5). Minor differences include the straighter anterior border in the Portuguese specimens and the less dense ornament, particularly on the fixed cheeks (cf. Vaněk 1965, pl. 3, fig. 4). *P. pulcher* is known from the Vinice, Zahořany and Bohdalec Formations of Bohemia (Havlíček and Vaněk 1966) but is only tentatively recorded from NW France (Henry 1980a, p. 187) where, however, the very similar *P. verneuili* Rouault is known from beds of Caradoc age to the south of Rennes (Riadan Formation) and possibly in the Crozon Peninsula (top of Postolonnec Formation) (Henry 1980a, p. 80). Henry stated, as Dean (1966, p. 303) had noticed, that the deformation of the Riadan specimens made some of the distinguishing features less certain; thus the status of *verneuili* is still in doubt.

Prionocheilus costai (Thadeu, 1947)

Plate 4, figs 1–9

1908   *Calymene Costai* Delgado, p. 57.
*1947   *Pharostoma Costai* (Delgado); Thadeu, p. 218, pl. 2, figs 5–10.
1949   *Pharostoma Costai* (Delgado); Thadeu, p. 130.
1960   *Pharostoma Costai* (Delgado); Whittard, p. 138.
1976   *Prionocheilus costai* (Delgado); Hammann, p. 39, pl. 4, figs 46–51; pl. 5, figs 52–58; text-fig. 7.
1980a   *Prionocheilus costai* (Delgado); Henry, p. 80.
1982   *Prionocheilus costai*; Hammann *et al.*, p. 23.
1983   *Prionocheilus costai* (Delgado 1908); Hammann, p. 55, pl. 3, figs 34–36.
1984   *Prionocheilus costai* (Delgado); Rábano, p. 272.

Material. Designated lectotype: SG 160 (Thadeu 1947, pl. 2, fig. 8). Paralectotypes: SG 161–163 (Thadeu 1947, pl. 2, figs 7, 5 and 6 respectively). Three cephala with part of thorax; two nearly complete specimens; all preserved as internal and/or external moulds.

Horizon and locality. All specimens are listed by Delgado (1908) as occurring in the 'Schistes culminants et schistes diabasiques', 250–300 m N 40° W of Louredo. Porto de Santa Anna Formation, late Caradoc-Ashgill age. The specimens are probably from the lower part of the unit, the Leira Ma Member.

Description. Since the species has already been described by Thadeu (1947) and a further full account was given by Hammann (1976), only additional notes will be given here.

Thadeu noted that only two pairs of glabellar furrows are present. However, on specimens SG 160 and 161, short, shallow inwardly directed S3 start level from where the eye ridge meets the axial furrow. The L3 thus defined are very short (exsag.) and less than half the length of L2. Over sixty downwardly directed short spines are present on the convex cephalic doublure and are continuous around the anterior margin of the cephalon. The axial rings and posterior and anterior bands on the pleurae carry numerous large tubercles. On specimen SG 162 these tubercles are seen to form the bases of short posterodorsally directed spines up to 0·5 mm in length. The pygidium is nearly three times as wide as long. The axis consists of five rings and a terminal piece, and four (five) backwardly directed pleural furrows with less distinct interpleural furrows.

Discussion. Delgado first used the specific name *costai* in a faunal list (1908, p. 57). Although he did not describe or figure the species, later authors (see synonymy above) have credited it to Delgado, following the practice of Thadeu (1947) who was the first to formally describe the species. In this work authorship is attributed to Thadeu.

All the differences between *P. costai* and *P. pulcher* (Barrande) (authorship attributed to Beyrich by Whittard 1960, p. 134) listed by Whittard (1960, p. 138) are now known not to be valid. Thus *P. costai* does possess a spinose cephalic border and preglabellar field (although in Hammann 1976,

text-fig. 7 the spines do not appear to be continuous around the anterior margin). Also the glabella has straighter sides in the Iberian species, there are fewer pygidial ribs and the granular sculpture is coarser.

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Genus ACTINOPELTIS Hawle and Corda, 1847

</div>

Type species. Actinopeltis globosa (Barrande, 1852).

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Actinopeltis tejoensis sp. nov.

Plate 3, figs 7, 11, 14–16; Text-fig. 5

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1908   *Cheirurus* sp. n.; Delgado, p. 80.

Diagnosis. Species of *Actinopeltis* with the following characteristics: large, inflated, spherical anterior part of glabella; small isolated basal glabellar lobes separated from inflated glabellar lobe by long (*sag.*) furrow. Eyes situated far back, with eye ridge running to just anterior of S2. Pygidium with four pairs of spinose pleurae; posterior pair short to nearly as long as third pair.

Type material. Holotype: SG 225, part and counterpart of nearly complete individual. Paratypes: QXP 2.006, 2.007, 2.026, internal moulds of incomplete cephala. QXP 2.041/2, 2.043/4, parts and counterparts of pygidia.

Horizon and locality. SG 225 from '500 m N 52° E do logar do Pereiro (Mação)'. Other specimens from '1700 m N 57° E de pyr. de Queixoperra', Mação. All specimens from 'Schistes à *Orthis Berthoisi*' (Delgado 1908, p. 80), Queixoperra Member of the Cabeço do Peão Formation, of Caradoc age.

Derivation of name. From the Portuguese name Rio Tejo (River Tagus), into which drain the rivers of the Mação area.

Description. The total length of specimen SG 225 is 28 mm of which the cephalon constitutes nearly 8 mm and the thorax about 12 mm. The specimen is obliquely deformed and crushed; the right side has been damaged.

Cephalon dominated by large, approximately spherical anterior part of glabella, which is slightly wider than long and covered with small, closely spaced tubercles (barely visible on internal mould). Narrow (trans.) posterior part of glabella (though varies with preservation) comprises pair of small, nodular basal lobes, anterior to which a broad furrow separates them from inflated anterior part of glabella. Occipital furrow indistinct, merging with transverse furrow anterior to L1 which are thus isolated at abaxial portions of broad (sag.) furrow. Occipital ring convex (sag. and trans.) and carrying similar ornament to glabella. Faint, shallow S2 start just posterior to where eye ridge meets axial furrow; S2 possibly directed slightly forwards but fracturing of glabella makes this uncertain. Short, shallow S3 situated approximately level to where lateral border furrow meets axial furrow. Axial furrows deep, without sculpture, and widely divergent.

Cheeks small, triangular in outline, highest part lying adjacent to basal glabellar lobes. Lateral border strongly convex, of more or less constant width, extending with posterior border into long genal spine back to at least seventh thoracic segment. Genal spine oval(?) in cross-section and covered with small, densely

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<div align="center">

EXPLANATION OF PLATE 4

</div>

Figs 1–9. *Prionocheilus costai* (Thadeu, 1947). 1–3, SG 160 (designated lectotype); internal mould and latex cast of external mould of nearly complete specimen, dorsal and anterodorsal views, ×2·7, ×3 and ×3 respectively, Porto de Santa Anna Formation, Buçaco, Caradoc/Ashgill. 4, SG 2849; latex cast of external mould of incomplete cephalon and thorax, dorsal view, ×3, Porto de Santa Anna Formation, Buçaco, Caradoc/Ashgill. 5, SG 162; internal mould of cephalon and part thorax, dorsal view, ×3, Porto de Santa Anna Formation, Buçaco, Caradoc/Ashgill. 6, 9, SG 161; latex cast of external mould and internal mould of incomplete specimen, dorsal views, ×2·4, Porto de Santa Anna Formation, Buçaco, Caradoc/Ashgill. 7 and 8, SG 163; internal mould and latex cast of external mould of nearly complete specimen, dorsal views, ×3 and ×3·4 respectively, Porto de Santa Anna Formation, Buçaco, Caradoc/Ashgill.

PLATE 4
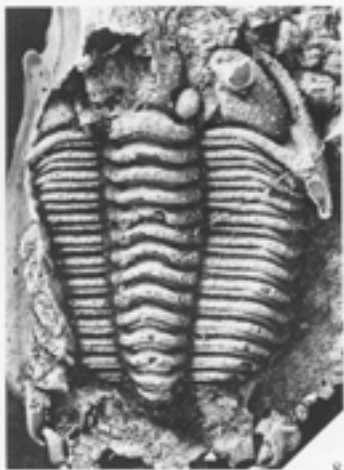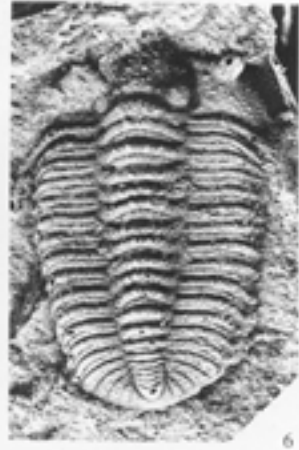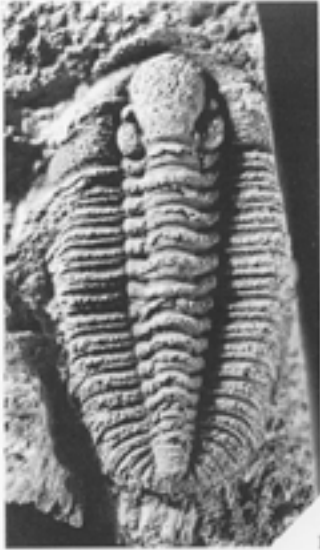
ROMANO, *Prionocheilus*
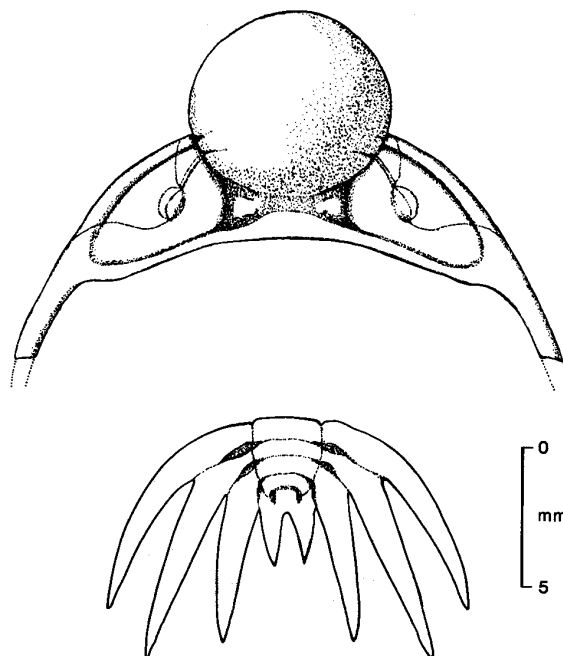
TEXT-FIG. 5. *Actinopeltis tejoensis* sp. nov. Reconstruction of cephalon and pygidium.

spaced tubercles. Prominent eye on short stalk, situated on highest part of cheek and fairly close to posterior border furrow. Eye lenses visible on QXP. 2.002. Well marked, low, eye ridge runs from eye to axial furrow just anterior to where S2 starts. Anterior branch of facial suture runs anterolaterally from the eye, approximately parallel to axial furrow, to margin. Posterior branch curves outwards and then backwards in even curve to cut lateral margin just anterior to base of genal spine. Lateral and posterior border furrows deep, except around base of genal spine. Posterior border convex (exsag.); narrowest near midline, widening evenly and gradually to genal spine. Free and fixed cheek covered with coarse pits of irregular size and distribution.

Thorax consists of eleven segments. Axis narrow, strongly convex, and delimited by rather weak axial furrows. Axial rings gently curved forwards, broadest (sag.) along mid-line. Rings consist of convex (sag. and trans.) posterior band which broadens laterally. Anterior part of ring consists of broad, nearly flat band which narrows toward axial furrow where there is a shallow apodeme. Convex articulating half-ring separated from axial ring by marked change of slope. Pleurae consist of inner part (approximately one-third their transverse width) which is flat lying, and an outer spinose part which is outwardly inclined. Inner part of pleural segment consists of wide (exsag.), convex band bounded by narrow anterior and posterior bands. Wide band carries rows of pits, generally about 6, along midlength (appears as almost continuous groove on internal mould). Posterior pleural band is constricted at the fulcrum, where there is a prominent fulcral process and socket. Axial rings carry fairly dense ornament of faint tubercles while spinose parts of pleurae are very sparsely tuberculate.

Pygidial axis about one and a half times as long as wide, delimited by shallow furrows which become less well defined posteriorly. Axis consists of 4 rings which decrease in length posteriorly. Ring furrows shallow medially. Posterior to fourth axial ring are pair of short, longitudinally aligned furrows which lie in series with the deeper inner parts of pleural furrows. Pleurae consist of inner flattish part in which, from front to back, pleurae are progressively directed more posteriorly. Pleural furrows end in deep apodemal pits at axis. Outer parts of pleurae are slender spines; the first two being long, slightly curved and approximately of equal length; the third is a little shorter and curved proximally, while the fourth pair are much shorter (about one-quarter as long as second pair and less than half as long as third pair), more slender and directed backwards. In one specimen (QXP. 2.029a, b) the fourth pair of spines are considerably longer than in the other two examples and

extend posteriorly to terminate level with the tips of the third pair. Axis and flat pleural region carry a few scattered tubercles while the spines have an ornament similar to that of the glabella.

Discussion. The genus had previously been recorded in Portugal from Valongo and Buçaco. At Valongo, Curtis (1961) recorded *A. wattisoni* sp. nov. (referred to *Valongia wattisoni* by Přibyl and Vaněk 1984) which differs from the Mação species in possessing 12 thoracic segments, a less swollen median glabellar lobe, more forwardly placed eyes and shorter genal spines. The 'faint horizontal rib furrow' which Curtis (1961, p. 9) described appears to consist of a row of faint pits as in the present material (see Curtis 1961, plate 4). Also, the pygidial rib furrows on *wattisoni* may be deformational features. At Buçaco, Delgado (1908, p. 57) listed a number of '*Cheirurus*' species from the upper Ordovician, some of which have been more recently described by Thadeu (1947). Of these, *A.* aff. *completa* (Barrande) (Thadeu 1947, pl. 3, figs 6 and 7) from the Porto de Santa Anna Formation has been recently compared to *A. vercingetorix* Přibyl and Vaněk (1969) by Hammann (1974, p. 105). Both of these species show a more forwardly placed eye and coarser sculpture on the glabella than *Actinopeltis tejoensis*. *A. spjeldnaesi* (Hammann 1972, p. 372, pl. 1, fig. 3; 1974, p. 102, pl. 12, figs 200–207, text-fig. 38; 1976, p. 65, pl. 5, figs 64–68) from the upper Caradoc–lower Ashgill (Hammann *et al.*, 1982, p. 23) of Almadén (Sierra Morena, Spain) is fairly close to *A. tejoensis*. Rábano (1984) considered *A. spjeldnaesi* to be of Caradoc age. The Spanish species possesses more forwardly placed eyes, basal glabellar lobes which are not clearly delimited adaxially, and lacks the broad (sag.) furrow posterior to the swollen part of the glabella. The anterior pygidial spines are also more outwardly flexed in *A. spjeldnaesi*. It is of interest to note, however, that in both *A. spjeldnaesi* and *A. tejoensis* the fourth pair of pygidial spines are of variable length (see Hammann 1974, pl. 12, fig. 203; 1976, fig. 65; and Pl. 3, figs 7, 11 herein). This characteristic appears to be independent of preservation.

Delgado (1908) first recorded the Mação species as '*Cheirurus* sp. n. aff. *gryphus* Barrande' (Barrande 1872, pl. 3, figs 10–17) but the Bohemian specimens clearly differ from the Portuguese material in having less prominent eyes situated closer to the glabella and considerably shorter genal spines. Among other Bohemian species of *Actinopeltis*, the type species, *A. globosa* (Barrande 1852, pl. 35, figs 1–7, pl. 40, figs 26 and 27, pl. 43, fig. 27; Whittington 1968, text-fig. 7, p. 104), and the closely related *A. rivanol* (Šnajdr, 1982) have less well delimited L1 adaxially, and shorter genal and pygidial spines; the latter being well rounded distally. *A. insocialis* (Barrande, 1852, pl. 40, figs 28–31) does not possess genal spines, and the pygidial spines are shorter and rounded at the ends. Kielan (1959) assigned the specimens of *A. insocialis* from the Králův Dvur beds to a new species, *A. barrandei*, which also differs from *Actinopeltis tejoensis* in the absence of genal spines, the very small eye and the only slightly pointed pygidial spines. *Actinopeltis* sp. 'a' from the *S. clavifrons* Zone of Poland (Kielan 1959, pl. 24, fig. 4, text-fig. 36) has a similar structure to the pygidial axis as *Actinopeltis tejoensis* but the tuberculation is coarser and more densely spaced.

Genus VALONGIA Přibyl and Vaněk, 1984

Type species. Actinopeltis wattisoni Curtis, 1961.

Valongia wattisoni (Curtis, 1961)

1961   Actinopeltis wattisoni sp. nov.; Curtis, p. 8, pl. 3, fig. 2, pl. 4, fig. 1.
1974   *Actinopeltis wattisoni* Curtis; Hammann, p. 105.
1982   *Actinopeltis wattisoni*; Romano, p. 96.
1984   *Valongia wattisoni* (Curtis); Přibyl and Vaněk, p. 126, fig. 4, 3.

Material. In 49184, holotype, part and counterpart of nearly complete specimen.

Horizon and locality. Upper part of Valongo Formation, near Covelo; Llandeilo.

Discussion. The species was described and figured by Curtis (1961) and no further material has been found. Curtis assigned the species to *Actinopeltis*. Recently Přibyl and Vaněk (1984) erected a new genus, *Valongia*, for this species since they considered the specimen showed important morphological features which distinguished it from those assigned to *Actinopeltis*. These included size of free cheek, course of facial suture, position of palpebral lobes, number of axial segments and structure of pygidial axis. The present author is in agreement with Přibyl and Vaněk that Curtis' species shows significant differences from those of *Actinopeltis*, but is more reluctant to follow their procedure of erecting a new genus, based on a single deformed specimen. However, for the present, their proposal is followed here.

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NOTE ADDED IN PROOF

After this manuscript was completed the author was kindly sent an important paper by Rábano (1990) on middle Ordovician trilobites of the Central Iberian Zone in Spain. Rábano recognized *S. lusitanica* (Thadeu, 1949) as a distinct species and pointed out that it was distinguishable from *S. salteri* by a number of cephalic features (Rábano 1990, pp. 120–122). However, the variability of the sculpture and the frequently deformed nature of the Portuguese specimens do not allow confident separation of these two forms. Rábano also stated that *S. lusitanica* is a characteristic species of the Lower Llanvirn of the Central Iberian Zone, and designated the specimen figured by Thadeu (1949), pl. 2, fig. 1) as the lectotype. This specimen (SG ?1688) was collected from '1650 m [not 1680 m] S 20° O da piramide de Santa Justa (Valongo)'. From the same locality, *Eccoptochile almadenensis*, *E.* cf. *clavigera* and *Eodolmanitina ?destombesi destombesi* occur. The known ranges of these three species indicate a Llandeilo age for this assemblage.

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