

Fine-Resolution Ammonite Biostratigraphy at the Río Gazas-Chorro II Section in Sierra de Cazorla (Prebetic Zone, Jaén Province, Southern Spain)

FEDERICO OLÓRIZ, M. REOLID & FRANCISCO JAVIER RODRÍGUEZ-TOVAR, GRANADA*

Abstract

The biostratigraphic analysis of the Río Gazas-Chorro II profile in the Sierra de Cazorla (Prebetic Zone, southern Spain) has enabled the first detailed biochronostratigraphic characterisation in the area for the *Bifurcatus* and *Bimammatum* Zones (Upper Oxfordian), and part of the *Planula* Zone (uppermost Oxfordian or lowermost Kimmeridgian). In addition, the subzones *Bifurcatoides/Stenocycloides*, *Grossouvrei*, *Hypselum*, *Bimammatum*, *Hauffianum/Tiziani* and *Planula* have been identified. The biostratigraphic units recognised are easily correlated with the equivalents of standard proposals for southern Submediterranean Europe. The correlation of the *grossouvrei* and *bifurcatus* biohorizons (*Bifurcatus* Zone, *Grossouvrei* Subzone), *arancensis*, *semimammatum* and *berrense* (*Bimammatum* Zone, *Hypselum* Subzone), and *mogosensis*, *minutum*, *Sutneria* n. sp. gr. *galar* and *planula* in the *Planula* Zone (*Planula* Subzone) is more limited, given the still provisional character of these data.

1 INTRODUCTION

In the Sierra de Cazorla (Province of Jaén, southern Spain), the materials of the Oxfordian represent the first interval with pelagic-hemipelagic sedimentation in the epicontinental platforms of the South Iberian margin, in what is known as the Prebetic Zone. Although the remains of ammonoids are relatively frequent, the biostratigraphic study of the Oxfordian in the central Prebetic is little developed (Foucault, 1971; García-Hernández et al., 1979, 1981; Acosta, 1989; Olóriz et al., 1992). Today, this study offers the possibility of establishing precise correlation that enable comparisons with other nearby epicontinental areas, both in Spain and in Portugal, as well as other more distant sites in Europe, where the Oxfordian biostratigraphy with ammonoids is better known. Complementarily, on this basis, we seek to facilitate comparisons of geobiological evolutionary features in southern European epicontinental areas. Our aim is that of to present the first detailed stratigraphic distribution of the ammonites registered in the Oxfordian from the profile of the Río Gazas-Chorro II in the Sierra de Cazorla (Prebetic Zone).

2 GEOLOGICAL CONTEXT

The Sierra de Cazorla belongs to the External Prebetic (External Zones, Betic Cordillera), in which the Sierra de Cazorla Unit is represented (López-Garrido, 1971) (Fig.1). Palaeogeographically, the External Prebetic represents the neritic platform system related to the Iberian Meseta. The External Prebetic is structured in a series of tectonic sheets in a NNE-SSW direction dipping towards the E (Foucault, 1971).

During the Jurassic, the sedimentation of the central External Prebetic was predominantly carbonate, with some episodes of terrigenous input. The Lower Jurassic is represented by dolomitized limestones among which white limestones with peloids, "*Lithiotis*", foraminifers and algae are recognised (Acosta, 1989). The deposits of the Liassic platform are overlain by oolithic limestones, which evidence the persistence of the internal platform system during the Middle Jurassic. The Oxfordian succession begins with hemipelagic fossiliferous limestone from the Middle Oxfordian and nodular limestones and/or marly-limestone rhythmites from the Middle and Late Oxfordian. The Middle Oxfordian, with ammonites, rests on Middle Jurassic ferruginized horizons (hardgrounds) containing lateritic clays, ferruginous ooliths and bioclastic accumulations (benthic foraminifers,

gastropods, corals, crinoids, among others). Up to now, no ammonites have been recognised from the Lower Oxfordian in the Sierra de Cazorla. Various metres of greyish marls poor in macrofauna are intercalated between the Upper Oxfordian with ammonites and the marly-limestone rhythmite that contains Kimmeridgian ammonites.

3 THE RIO GAZAS-CHORRO II SECTION

The profile of Rio Gazas-Chorro II lies in the province of Jaén (southern Spain), in the western part of the Sierra de Cazorla. The profile can be found by following the forest trail that connects the small village of La Iruela with El Chorro (Fig.1). The co-ordinates of the outcrop are 3°0'25"-35°52'55" on sheet 928 (Cazorla) of the National Topographic Map (scale 1:50,000).

The Oxfordian succession, approximately 22m thick (Fig.2), is composed of a marly-limestone rhythmite in which the limestone levels predominate. Limited outcropping hinders a detailed analysis of the bottom of the succession. The upper limit was established at the contact point with a thick marly intercalation that gives way to materials of the Kimmeridgian.

In the 5 bottom metres (beds 1 to 19), roughly meter-thick buildups of primarily sponges and stromatolites are recognised, these associated with brachiopods, echinoids, crinoids and bivalves (Acosta et al., 1988; Acosta, 1989; Olóriz & Rodríguez-Tovar, 1996a). The authors (research under way) recently collected scant, badly preserved ammonites. Calcareous levels dominate the marly-limestone rhythmite with an average thickness of 20cm. Over the buildups, a thickening-upward interval of 5m thick is recognised (beds 20 to 35), in which the carbonate levels predominate (strata 20 to 45 cm) with respect to the marly intercalations (20cm). A third stretch is composed of two thickening-upward sequences (beds 36 to 54 and 55 to 72) with a total thickness of 7.5 m, in which the limestone strata present thickness of 10 to 40cm and the marls of 10 to 20cm. The upper part of the profile is made up of an interval of 4.5m thick in which marls dominate (beds 73 to 89).

In the microfacies studied, peloidal packstones dominate, but wackestones are also frequent, as are combinations of the two types of textures. The most abundant lithoclasts are peloids, aggregate grains and ooids. The lining material of fossil traces (*Planolites*) shows glauconitized peloids. In the somital part of the Oxfordian section, small quartz grains and carbon remains are recognised. The most common bioclasts are filaments and equinoderm

fragments. No preferential orientation has been identified for the clasts.

4 AMMONITE ASSEMBLAGES

A total of 1,500 fossil remains were collected, of which 1,150 were ammonoids (whole individuals and fragments) preserved as internal moulds; belemnites, brachiopods, echinoids, bivalves and sponges appeared in lesser proportions. Aptychi were scarce despite the abundance of ammonites (*post-mortem* transport). Ammonite breakage proved high, although somewhat less than near the buildups and in the upper part of the section. Normally, the smallest specimens were the best preserved. In general, the body chambers were incomplete and the specimens did not usually exceed 70mm, although some fragments of body chambers of great size were found. The orientation varies markedly, horizontality predominating, but inclination and even verticality is also frequent, the latter clearly showing deformation by compaction.

The distribution of the genera and species of ammonites in the Rio Gazas-Chorro II profile (Fig.2) is:

Horizon RGCH-SP-1/2: *Perisphinctes* (*Dichotomoceras*) sp. gr. *bifurcatoides* ENAY - *stenocyloides* SIEMIRADZKI (s.l.), *P. (Dichotomoceras)* sp. cf. *stenocyloides* (SIEMIRADZKI) (s.l.), *P. (Dichotomoceras)* sp., *Mirosphinctes* sp. aff. *bukowskii* (CHOFFAT), *Perisphinctidae* indet., *Gregoryceras* sp., *Sowerbyceras* sp., *Phylloceras* sp.

Horizon RGCH-SP-2: *Perisphinctes* (*Dichotomoceras*) *bifurcatoides* ENAY

Horizon RGCH-SP-4: *Perisphinctes* (*Dichotomoceras*) sp. gr. *bifurcatoides* ENAY- duongi MELÉNDEZ

Horizon RGCH-SP-5: *Perisphinctes* (*Dichotomoceras*) *falculae* (RONCHADZÉ), *P. (Dichotomoceras)* sp. aff. *bifurcatoides* ENAY, *P. (Dichotomoceras)* sp. cf. *stenocyloides* (RONCHADZÉ non SIEMIRADZKI), *P. (Dichotomoceras)* sp. cf. *stenocyloides* (SIEMIRADZKI), *P. (Dichotomoceras)* sp. gr. *stenocyloides* (SIEMIRADZKI), *P. (Dichotomoceras)* sp. gr. *stenocyloides* (SIEMIRADZKI) (s.l.) - *falculae* (RONCHADZÉ), *P. (Dichotomoceras)* sp. gr. *bifurcatoides* ENAY- *stenocyloides* (SIEMIRADZKI) (s.l.), *P. (Dichotomoceras)* sp., *Perisphinctidae* indet., *Gregoryceras fouquei* (KILIAN), *Sowerbyceras* sp., *Phylloceras* sp., *Calliphylloceras* sp.

Horizon RGCH-SP-7: *Paraspidoceras* (*Struebinia*) sp. A. cf. *edwardsianum* (D'ORBIGNY in GEMMEL-LARO)

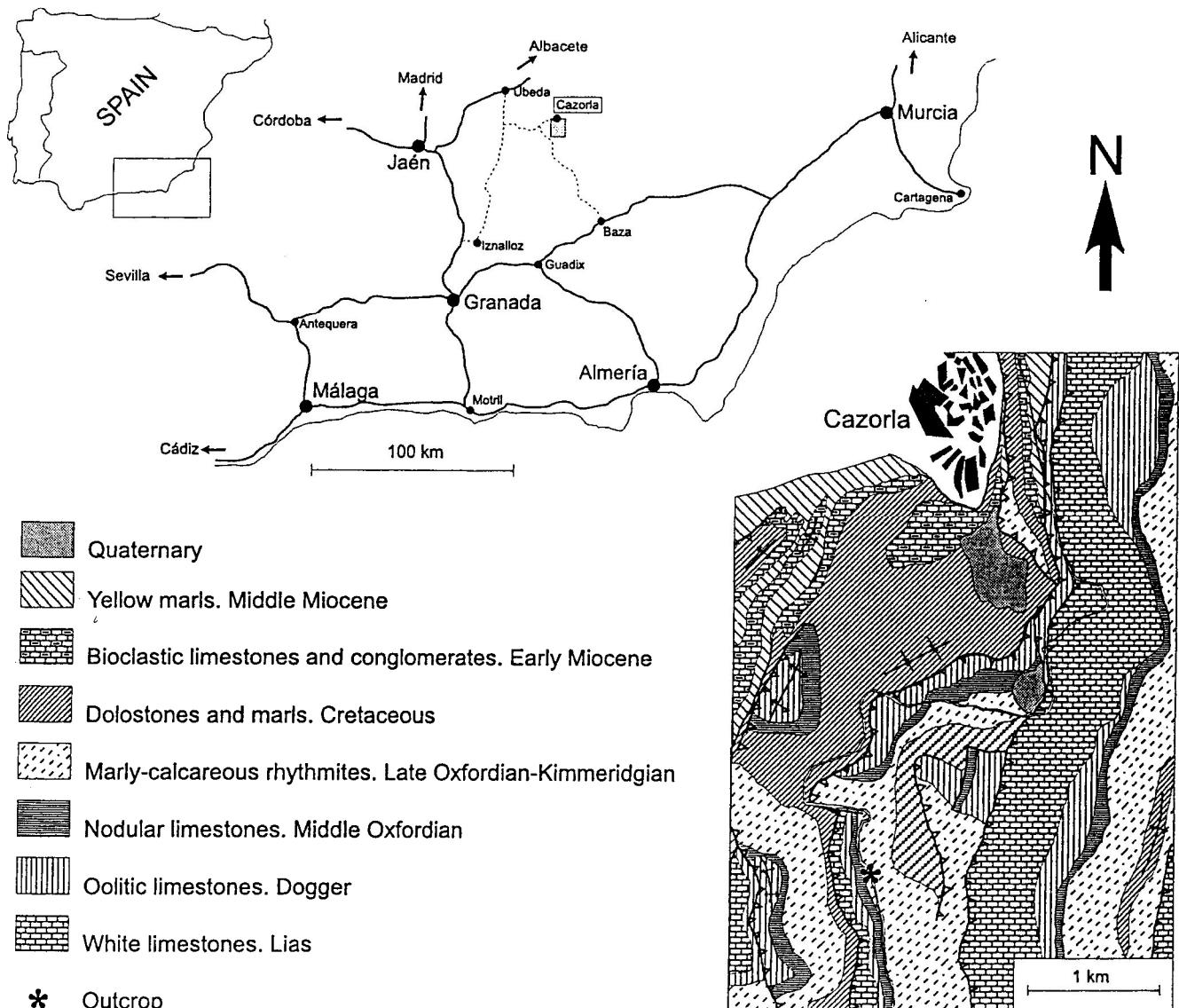


Fig. 1. Geographical and geological location of the Rio Gazas-Chorro II section (External Prebetic).

Horizon RGCH-SP-12: *Perisphinctes* (*Dichotomoceras*) sp. cf. *grossouvrei* (SIEMIRADZKI), *P.* (*Dichotomoceras*) sp., *Mirosphinctes* sp., *Perisphinctidae* indet., *Sowerbyceras* sp., *Phylloceras* sp.

Sponge buildup: *Ochetoceras* sp gr. *hispidum* (OPPEL)-*canaliculatum* (v. BUCH)

Horizon RGCH-SP-21/22 : *Perisphinctidae* indet., *Sowerbyceras* sp., *Holcophylloceras* sp.

Horizon RGCH-SP-24,25: *Perisphinctes* (*Dichotomoceras*) sp., *Mirosphinctes bukowskii* var. *cabritoensis* (CHOFFAT), *Passendorferia* (*Enayites* ?) sp., *Ochetoceras hispidum* (OPPEL), *Euas-*

pidoceras (*Euaspidoceras*) sp. gr. *sublongispinum* (DORN), *Taramelliceras* sp., *Trimarginites* sp., *Sowerbyceras* sp.

Horizon RGCH-SP-29: *Perisphinctes* (*Dichotomoceras*) *bifurcatus* (QUENSTEDT), *P.* (*Dichotomoceras*) sp., *Mirosphinctes* sp., *Perisphinctidae* indet., *Ochetoceras* sp. gr. *raixense* FRADIN-*hispidum* (OPPEL), *Lytoceras orsinii* (GEMMELLARO), *Sowerbyceras* sp.

Horizon RGCH-SP-30: *Mirosphinctes bukowskii* (CHOFFAT), *Mirosph. bukowskii* var. *cabritoensis* (CHOFFAT), *Passendoferinae* indet., *Clambites* (?) sp., *Ochetoceras marantianum*

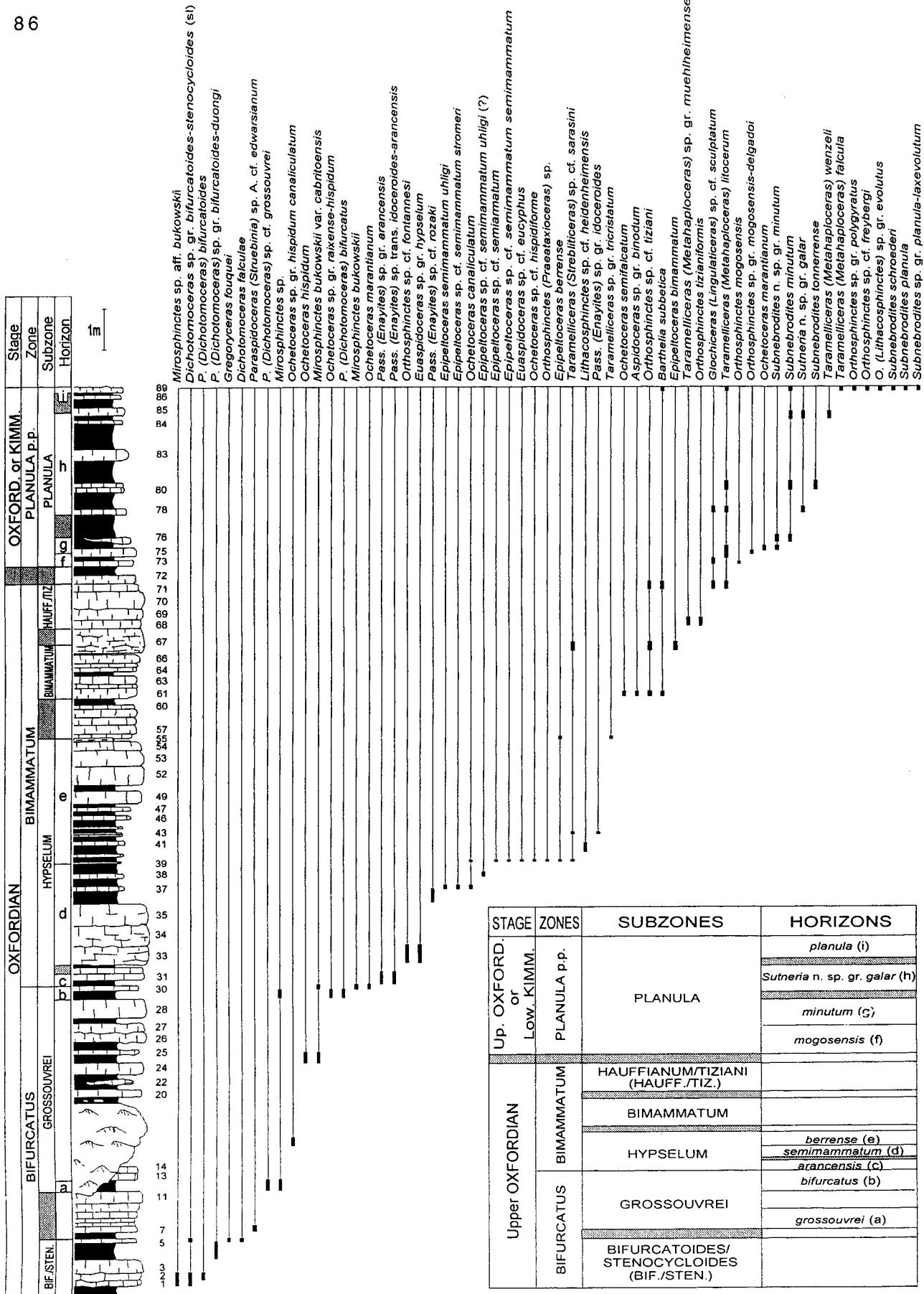


Fig. 2. Rio Gazas-Chorro II section. Lithological column, stratigraphic distribution of selected ammonite species and biochronostratigraphy (OXFORD = Oxfordian, KIMM.= Kimmeridgian).

- (D'ORBIGNY), *Ochet.* sp. cf. *marantianum* (D'ORBIGNY), *Ochet.* sp. gr. *canaliculatum* (v. BUCH), *Sowerbyceras* sp.
- Horizon RGCH-SP-30/31: *Passendorferia (Enayites)* sp. gr. *arancensis* MELÉNDEZ, Pass. (*Enayites*) sp. trans. *idoceroides* (DORN)- *arancensis* MELÉNDEZ, Pass. (*Enayites*) sp., *Perisphinctidae* indet., *Sowerbyceras* sp., *Phylloceras* sp.
- Horizon RGCH-SP-33: *Orthosphinctes (Orthosphinctes)* sp. cf. *fontannesi* (CHOFFAT), *Orthosph. (Orthosphinctes)* sp., *Euaspidoceras (Euaspidoceras)* sp. gr. *hypselum* (OPPEL) (juvenile), *Sowerbyceras* sp., *Holcophylloceras* sp., *Phylloceras* sp.
- Horizon RGCH-SP-34 *Perisphinctidae* indet., *Haploceratidae* indet., *Sowerbyceras* sp., *Phylloceras* sp.
- Horizon RGCH-SP-36: *Passendorferia (Enayites)* sp. cf. *rozaki* MELÉNDEZ
- Horizon RGCH-SP-37↓: *Epipeltoceras semimammatum uhligi* (OPPENHEIMER), *Epip.* sp. cf. *semimammatum stromeri* PRIESER, *Ochetoceras canaliculatum* (BUCH), *Taramelliceras* sp. cf. *callicerum* (OPPEL) var. (DORN)
- Horizon RGCH-SP-37: *Clambites* (?) sp.
- Horizon RGCH-SP-38: *Epipeltoceras* sp. cf. *semimammatum uhligi* (?) (OPPENHEIMER), *Sowerbyceras* sp.
- Horizon RGCH-SP-39: *Orthosphinctes* sp., *Orthosph. (Praeataxioceras)* sp., *Subdiscosphinctes* sp. (M.). *Epipeltoceras berrense* (FAVRE), *Epip.* sp. cf. *semiarmatum* (QUENSTEDT), *Epip.* sp. cf. *semimammatum semi-mammatum* (QUENSTEDT), *Epip.* sp., *Euaspidoceras (Euaspidoceras)* sp. cf. *eucyphus* (OPPEL), *Taramelliceras (Strebliticeras)* sp. cf. *sarasini* (LORIOL), *Ochetoceras* sp. cf. *hispidoform* (FONTANNES), *Ochet.* *canaliculatum* (BUCH), *Sowerbyceras* sp., *Lytoceras* sp.
- Horizon RGCH-SP-40: *Orthosphinctes (Lithacosphinctes)* sp. cf. *heidenheimensis* (WEGELE)
- Horizon RGCH-SP-42: *Orthosphinctes* sp., *Passendorferia (Enayites)* sp. gr. *idoceroides* (DORN) (?), Pass. (*Enayites*) sp., *Euaspidoceras* or *Clambites* sp., *Taramelliceras* sp. gr. *callicerum* (OPPEL) var. (DORN), *Taram. (Strebliticeras)* sp. cf. *sarasini* (LORIOL), *Taram. (Strebliticeras)* sp. (loose specimen)
- Horizon RGCH-SP 50: *Aspidoceras* sp. gr. *sesquindosum* (FONTANNES) (loose specimen), *Sowerbyceras* sp., *Phylloceras* sp.
- Horizon RGCH-SP-55: *Orthosphinctes* sp., *Passendorferia (Enayites)* sp., *Epipeltoceras berrense* (FAVRE), *Epip.* sp. cf. *berrense* (FAVRE), *Taramelliceras* sp. gr. *tricristatum* (OPPEL), *Glochiceras (Lingulaticeras)* sp., *chiceras* (*Lingulaticeras*) sp., *Trimarginites* sp., *Sowerbyceras* sp., *Phylloceras* sp.
- Horizon RGCH-SP-61↓: *Orthosphinctes (Orthosphinctes)* sp. cf. *tiziani* (OPPEL), *Orthosph. (Orthosphinctes)* sp., *Aspidoceras* sp. gr. *binodum* (OPPEL), *Physodoceras (?)* sp., *Barthelia subbetica* OLÓRIZ & SCHAIRER, *Ochetoceras semifalcatum* (OPPEL), *Taramelliceras (Metahaploceras)* *kobyi quenstedti* SCHAIRER, *Sowerbyceras* sp., *Phylloceras* sp.
- Horizon RGCH-SP-67↓: *Orthosphinctes (Orthosphinctes)* sp. cf. *tiziani* (OPPEL), *Orthosph. sp.*, *Orthosph. (?)* sp., *Passendorferia (Enayites ?)* sp., *Epipeltoceras bimammatum* (QUENSTEDT), *Taramelliceras* sp., *Taram. (Strebliticeras)* sp. cf. *sarasini* (LORIOL in DORN) [= *Taram. (Strebliticeras)* sp. inc. cf. *externodosum* (DORN in HÖLDER)], *Taramelliceras/Metahaploceras* sp., *Trimarginites* sp., *Sowerbyceras* sp., *Calliphylloceras (?)* sp.
- Horizon RGCH-SP-68: *Orthosphinctes (Orthosphinctes) tizianiformis* (CHOFFAT) (juvenile), *Orthosph. sp.*, *Ochetoceras* sp. gr. *semifalcatum* (OPPEL), *Taramelliceras/Metahaploceras* sp., *Taram. (Metahaploceras)* sp. gr. *muehlheimense* SCHWEIGERT, *Sowerbyceras* sp., *Phylloceras* sp.
- Horizon RGCH-SP-70: *Orthosphinctes* sp.
- Horizon RGCH-SP-71: *Orthosphinctes (Orthosphinctes)* sp. cf. *tiziani* (OPPEL), *Taramelliceras* sp. cf. *tenuinodosum* (WEGELE), *Taram. (Metahaploceras) litocerum* (OPPEL), *Glochiceras (Lingulaticeras)* sp. cf. *sculptatum* ZIEGLER, *Barthelia subbetica* OLÓRIZ & SCHAIRER
- Horizon RGCH-SP-73↓: *Orthosphinctes (Orthosphinctes) mogosensis* (CHOFFAT)
- Horizon RGCH-SP-73: *Glochiceras (Lingulaticeras)* sp. cf. *sculptatum* ZIEGLER
- Horizon RGCH-SP-74: *Glochiceras (Lingulaticeras) modestiforme* (OPPEL), *Taram. (Metahaploceras) litocerum* (OPPEL), *Holcophylloceras* sp.
- Horizon RGCH-SP-75↓: *Orthosphinctes (Orthosphinctes)* sp. gr. *mogosensis* (CHOFFAT)- *deldagoi* (CHOFFAT), *Orthosph. sp.*, *Subnebrodites* n. sp. gr. *minutum* (DIETERICH), *Taramelliceras* sp. cf. *tenuinodosum* (WEGELE), *Taram. (Metahaploceras) litocerum* (OPPEL), *Taram. (Metahaploceras)* sp. cf. *kobyi wegelei* SCHAIRER, *Glochiceras (Lingulaticeras) modestiforme* OPPEL, *Sowerbyceras* sp., *Phylloceras* sp.
- Horizon RGCH-SP-75: *Subnebrodites* n. sp. gr. *minutum* (DIETERICH), *Ochetoceras marantianum* (D'ORBIGNY), *Taramelliceras (Metahaploceras) litocerum* (OPPEL), *Taram. sp. gr. callicerum* (OPPEL) var. (DORN), *Glochiceras (Coryceras) modestiforme* (OPPEL), *Sowerbyceras* sp., *Phylloceras* sp.

- Horizon RGCH-SP-76: *Subnebrodites minutum* (DIETERICH), *Subneb.* n. sp. gr. *minutum* (DIETERICH), *Holcophylloceras* sp.
- Horizon RGCH-SP-78: *Orthosphinctes* sp., *Sutneria* n. sp. gr. *galar* (OPPEL), *Taramelliceras* (*Metahaploceras*) *litocerum* (OPPEL), *Taram.* (*Metahaploceras*) *kobyi wegelei* SCHAIRER, *Taram.* sp., *Glochiceras* (*Lingulaticeras*) sp. cf. *sculptatum* ZIEGLER, *G.* (*Lingulaticeras*) *modestiforme* (OPPEL), *G.* sp., *Sowerbyceras* sp.
- Horizon RGCH-SP-80/81: *Subnebrodites minutum* (DIETERICH), *Sub.* *tonnerrense* (LORIOL), *Aspidoceras* sp., *Taramelliceras* (*Metahaploceras*) *litocerum* (OPPEL), *Glochiceras* (*Lingulaticeras*) sp. cf. *lingulatum* (QUENSTEDT), *Sowerbyceras* sp.
- Horizon RGCH-SP-84: *Taramelliceras* (*Metahaploceras*) sp. cf. *kobyi wegelei* SCHAIRER, *Glochiceras* (*Lingulaticeras*) *crassum* ZIEGLER, *Lingulaticeras* sp.
- Horizon RGCH-SP-84/85: *Orthosphinctes* sp. cf. *delgadai* (CHOFFAT), *Orthosph.* (*Lithacosphinctes*) n. sp. gr. *evolutus* (QUENSTEDT), *Orthosphinctes* or *Lithacosphinctes* sp., *Subnebrodites minutum* (DIETERICH), *Subneb.* (?) sp., *Sutneria* n. sp. gr. *galar* (OPPEL), *Taramelliceras* (*Metahaploceras*) *wenzeli* (OPPEL), *Taram.* (*Metahaploceras*) sp. cf. *wenzeli* (OPPEL), *Taram.* (*Metahaploceras*) sp. gr. *litocerum* (OPPEL)- *falcata* (QUENSTEDT), *Glochiceras* (*Coryceras*) sp. cf. *modestiforme* (OPPEL), *G.* sp., *Sowerbyceras* sp., *Phylloceras* sp.
- Horizon RGCH-SP-85 *Taramelliceras/Metahaploceras* sp.
- Horizon RGCH-SP-89 *Orthosphinctes* (*Orthosphinctes*) sp. cf. *treybergi* (GEYER), *Orthosph.* (*Orthosphinctes*) sp. gr. *polygyratus* (REINECKE),
- Orthosph.* (*Lithacosphinctes*) sp. gr. *evolutus* (QUENSTEDT), *Orthosphinctes* or *Subdiscosiphinctes* sp., *Subnebrodites minutum* (DIETERICH), *Subneb.* *schroederi* (WEGELE), *Subneb.* *planula* (HEHL), *Subneb.* sp. gr. *planula* (HEHL)- *laxevolutum* (FONTANNES), *Subneb.* n. sp. A. (juvenile), *Subneb.* sp., *Sub.* (?) sp., *Physodoceras* sp., *Taramelliceras* (*Metahaploceras*) *falcata* (QUENSTEDT), *Taram.* (*Metahaploceras*) *litocerum* (OPPEL), *Taram.* (*Metahaploceras*) *kobyi wegelei* SCHAIRER, *Taram.* (*Metahaploceras*) sp. cf. *kobyi wegelei* SCHAIRER, *Taramelliceras/Metahaploceras* sp., *Barthelia subbetica* OLÓRIZ & SCHAIRER, *Glochiceras* sp., *Sowerbyceras* sp., *Holcophylloceras* sp., *Phylloceras* sp., *Lytoceras eudesianum* (D'ORBIGNY), *Lytoceras* sp.
- Horizon RGCH-SP 30 cm above Horizon RGCHSP-89: *Subnebrodites* (?) sp.

5 BIOCHRONOSTRATIGRAPHY

In accord with the distribution established from the ammonite remains, the biochronostratigraphic interpretation of the Rio Gazas-Chorro II profile enables the recognition of the standard zones in the southern European Submediterranean Upper Oxfordian (Cariou et al., 1971, 1991). In addition, most of the subzones and of some horizons were identified, although the precise correlation of the horizons is not possible with the data collected. Below, we present the biochronostratigraphic units recognised (Fig.2), together with commentaries on significant ammonites for the biochronostratigraphic interpretations.

Specimen depicted at natural size

Fig. 3-4. *Subnebrodites planula* (HEHL) RGCH-SP-89.91. Right-side and ventral views. Horizon RGCH-SP-89.

Fig. 5-6. *Subnebrodites minimum* (DIETERICH) RGCH-SP-89.28. Right -side and ventral views. Same horizon.

Fig. 7. *Ochetoceras hispidum* (OPPEL) RGCH-SP-24,25.19. Left-side view. Horizon RGCH-SP-24,25.

Fig. 8-9. *Epieltoceras berrense* (FAVRE) RGCH-SP-55.26. Left-side and ventral views. Horizon RGCH-SP-55.

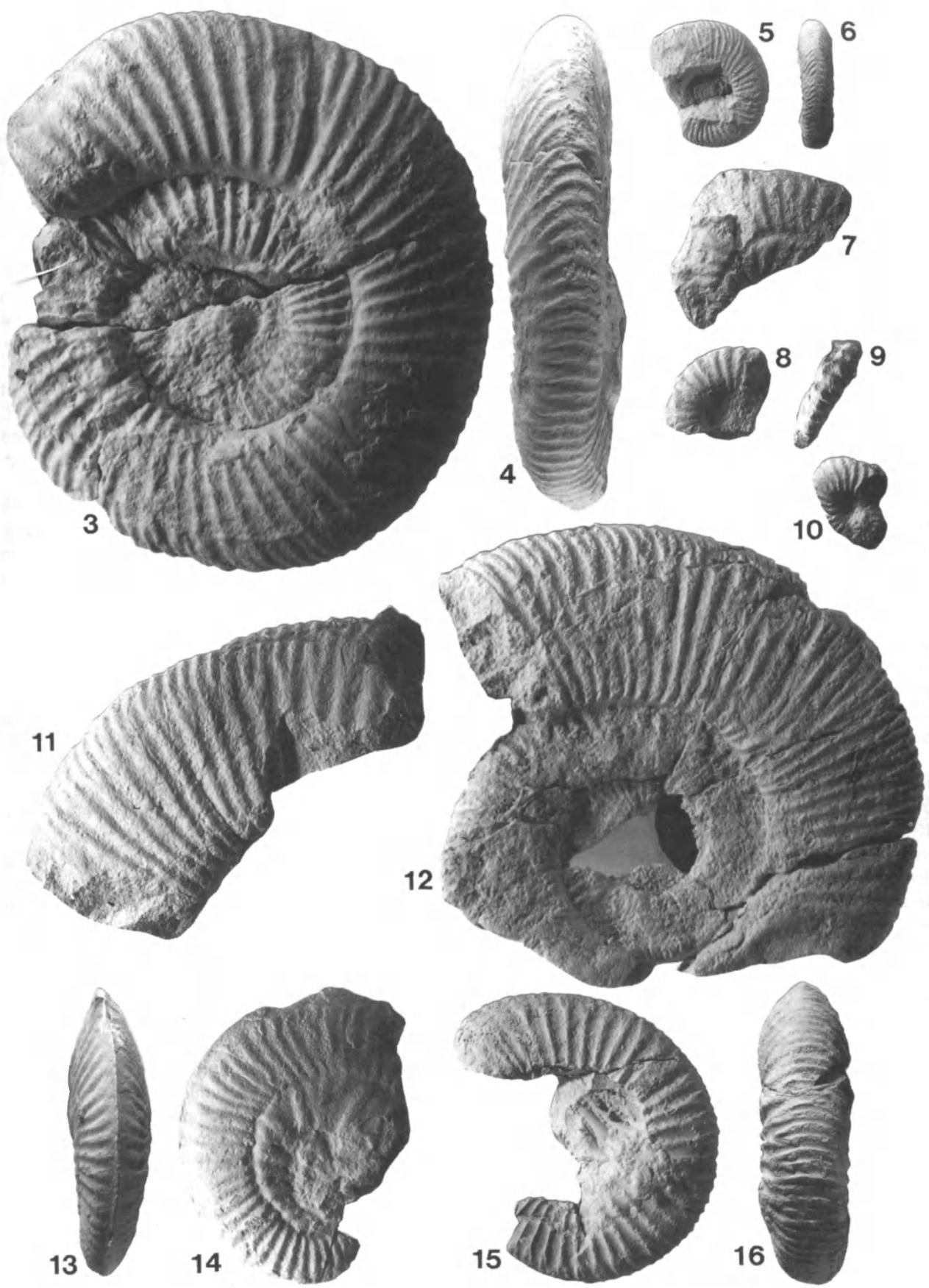
Fig. 10. *Epieltoceras semimammatum uhligi* (OPPENHEIMER) RGCH-SP-37↓.3. Left-side view. Horizon RGCH-SP-37↓.

Fig. 11. *Orthosphinctes* (*Orthosphinctes*) sp. cf. *fontannesi* (CHOFFAT) RGCH-SP-33.1. Left-side view of a body chamber fragment. Horizon RGCH-SP-33.

Fig. 12. *Perisphinctes* (*Dichotomoceras*) *bifurcatoides* ENAY RGCH-SP-2.7. Right-side view. Horizon RGCH-SP-2.

Fig. 13-14. *Ochetoceras canaliculatum* (BUCH) RGCH-SP-37↓.11. Ventral and left-side views. Horizon RGCH-SP-37↓.

Fig. 15-16. *Perisphinctes* (*Dichotomoceras*) *falcatae* (RONCHADZÉ) RGCH-SP-5.75. Right-side and ventral views. Horizon RGCH-SP-5.



5.1 Upper Oxfordian

5.1.1 Bifurcatus Zone

Horizons RGCH-SP-1/2 to RGCH-SP-29; RGCH-SP-30 (?). The range of the genus *Dichotomoceras* identifies the Bifurcatus Zone. The larger forms, belonging to the groups of *stenocycloides* and *bifurcatoides*, are restricted to the interval defined by the horizons RGCH-SP-1/2 to RGCH-SP-5. In this interval the subzone Bifurcatoides/ Stenocycloides is identified. The remains of the species cited are dominant and are accompanied towards the upper part of this subzone by less frequent records of smaller species, such as *duongi* and *falculae*. The presence of *Gregoryceras* in the Bifurcatus Zone was recognised by Sequeiros (1974) in the Oxfordian epioceanic ammonitico rosso of the Subbetic Zone (Mediterranean facies s.str.), admitted by Gygi (1977) and recently confirmed in epioceanic outcropping deposits in nearby areas such as Majorca (Olóriz et al., 1998). In the profile studied, *Gregoryceras* is limited to the lower part of the Bifurcatus Zone (Bifurcatoides/Stenocycloides Subzone). At present the precise upper boundary of the Bifurcatoides/Stenocycloides Subzone is not possible to identify because of sampling difficulties at the levels preceding the buildups of sponges. The Bifurcatoides/Stenocycloides Subzone proposed is equivalent to the Stenocycloides Subzone, as it is recognised in the Iberian Chain (Meléndez, 1989; Cariou & Meléndez, 1990; Bello et al., 1995), as well as to the Bifurcatoides Subzone proposed by Cariou et al. (1991) as a standard for Submediterranean Europe.

The only record of *P. (Dichotomoceras)* sp. cf. *grossouvrei* (SIEMIRADZKI) was recognised in the lower part of the interval with buildups (horizon RGCH-SP-12) and was used to identify a restricted *grossouvrei* biohorizon. This record is the first indication in the Prebetic Zone of the existence of the Grossouvrei Subzone, equivalent to that of the same name both in the Iberian Chain (Meléndez, 1989; Cariou & Meléndez, 1990; Bello et al., 1995) as in the standard for Submediterranean southern Europe (Cariou et al., 1991). The record of *Dichotomoceras* extends to the RGCH-SP-29 horizon, in which the species *bifurcatus* QUENSTEDT is recognised and used as an index of the existence of a possible *bifurcatus* biohorizon, the significance of which will be evaluated in the future.

Notable among the accompanying fauna in this subzone are *Mirospinctes*, related to *bukowskii* CHOIFFAT, and *Ochetoceras* of the groups of *hispidum* OPPEL, *canaliculatum* v. BUCH and *marantium* D'ORBIGNY. Despite the absence of records of *Dichotomoceras* in the RGCH-SP-30 horizon, the upper boundary of the Bifurcatus Zone was inter-

preted indirectly from the establishment of the bottom of the Bimammatum Zone with the record of *Passendorferia (Enayites)* sp. gr. *arancensis* MELÉNDEZ in the RGCH-SP-30/31 horizon. This biochronostratigraphic interpretation is not definitive, given that it limits the record of *Mirospinctes* to the Bifurcatus Zone, although Olóriz & Rodríguez-Tovar (1996b) demonstrated its presence at the bottom of the Bimammatum Zone near the profile studied.

5.1.2 Bimammatum Zone

The bottom of the Bimammatum Zone is interpreted in relation to the recognition of the *arancensis* biohorizon (horizon RGCH-SP-30/31), which cannot be formally defined until its presence can be corroborated in other profiles of the Prebetic Zone. As is known in southern European epicontinental deposits, *Epipeltoceras* can be rare or even absent at the extreme bottom of the Bimammatum Zone (cf. Meléndez, 1989 for the Iberian Chain). At these bottom levels without *Epipeltoceras*, *Orthospinctes* related with *fontanesi* CHOIFFAT has been collected in association with *Euaspidoceras* of the group *hypselum* OPPEL, and therefore these levels are interpreted as the lowest part of the Hypselum Subzone, commonly used in Submediterranean Europe (Marques, 1983; Atrops & Marques, 1988; Meléndez, 1989; Cariou & Meléndez, 1990; Atrops & Meléndez, 1993; Meléndez et al., 1995; Schweigert, 1995; Schweigert & Callomon, 1997). The record of *Epipeltoceras* of the group of *semimammatum* QUENSTEDT enables the recognition of the *semimammatum* biohorizon of the Hypselum Subzone (horizons RGCH-SP-36 at 39 pp.), in which forms related to *Passendorferia (Enayites)* sp. cf. *rozaki* MELÉNDEZ was recorded. Nevertheless, the record of *Epipeltoceras* of the group of *semimammatum* QUENSTEDT, together with *berrense* FAVRE in the RGCH-SP-39 horizon, is interpreted as evidence of condensation and, therefore, this horizon is considered to include part of the *berrense* biohorizon. The stratigraphic record of *Epipeltoceras berrense* for which the last appearance datum (LAD) was gathered in the RGCH-SP-55 horizon identifies the *berrense* biohorizon. Limitations in the fossil record in the RGCH-SP-56 to RGCH-SP-61 hamper the establishment of the precise boundary between the lower and middle parts of the Bimammatum Zone. That is, hamper the recognition of the boundary between the widely used Hypselum and Bimammatum Subzones (Enay, 1962; Cariou et al., 1971; Marques, 1983; Meléndez, 1989; Atrops & Meléndez, 1993; Schweigert & Callomon, 1997) or among the recently proposed subzones Berrense and Bimammatum (Cariou et al., 1991). The bottom of the Bimammatum Subzone is in-

terpreted in the horizon RGCH-SP-61 with the appearance of *Orthosphinctes* related to *tiziani* OPPEL, *Aspidoceras* of the group *binodum* OPPEL, *Physodoceras*, and the first appearance datum (FAD) of *Barthelia*. The index species *Epieltoceras bimammatum* QUENSTEDT is not very frequent but has been recorded in the lower part of the RGCH-SP-67 horizon together with *Orthosphinctes* (*Orthosphinctes*) sp. cf. *tiziani* (OPPEL). Thus, the youngest remains of *Epieltoceras* are interpreted as evidence of the upper boundary of the Bimammatum Subzone. With the data obtained (loose specimen in the RGCH-SP-50 horizon), it is not possible to establish whether the FAD of the genus *Aspidoceras* appears in the Hypselum Subzone or in the Bimammatum Subzone.

Up to now, the Hauffianum Subzone has not been characterised formally by the record of the index species in southern Spain (Caracuel et al., 1999). However, this species was previously recognised by García-Hernández et al. (1979) in the Prebetic Zone (assemblage "d" of these authors, of essentially Bimammatum age), and indications have recently been found of its presence in the Sierra Norte of the island of Mallorca (Olóriz et al., 1998). In the Iberian Chain, a precise characterisation of this subzone has not been made (Meléndez, 1989), due, at least, to local stratigraphic gaps (Aurell et al., 1997). The record of the index species in the Algarve (southern Portugal) is scant and little known, according to Marques (1983), although it appears to be present in the Lusitanian Basin (Atrops & Marques, 1988). In the profile of Rio Gazas-Chorro II, our interpretation is that the horizons RGCH-SP-68 to RGCH-SP-71, between the LAD of *Epieltoceras* and the FAD of *Orthosphinctes mogosensis* CHOFFAT, may represent a frequently preserved stratigraphic interval, which provisionally we label as the Hauffianum/Tiziani Subzone. This stratigraphic interval shows a greater frequency of *Orthosphinctes* of the groups *tiziani* OPPEL-*tizianiformis* CHOFFAT, as in other European epicontinental areas (Atrops & Meléndez, 1993; Meléndez et al., 1995; Schweigert & Callomon, 1997). The presence of "*Metahaploceras* gr. *wenzeli* (OPPEL)" [=*T. (Metahaploceras)* sp. gr. *muehlheimense* SCHWEIGERT & CALLOMON] reinforces this interpretation. In agreement with the data gathered up to now in southern Spain, more research is necessary for a formal characterization of the upper subzone of the Bimammatum Zone, using *Taramelliceras hauffianum* OPPEL as the index species.

5.2 Uppermost Oxfordian or lowermost Kimmeridgian

5.2.1 Planula Zone

The lack of significant fossils in the RGCH-SP-72 horizon hampers the establishment of the precise boundary between the Bimammatum and Planula Zones. The FAD of *Orthosphinctes mogosensis* CHOFFAT in the RGCH-SP-71 horizon is used to recognise a lower part of the Planula Subzone, but its upper boundary has not been possible to establish due to sampling limitations in the marly deposits with which the profile ends. The *mogosensis* biohorizon (horizons RGCH-SP-71 to the lower part of the RGCH-SP-75) includes a stratigraphic interval of little thickness below the FAD of *Subnebrodites* of the group *minutum* DIETERICH. Among the FAD of *Subnebrodites* n. sp. gr. *minutum* (DIETERICH) in the lower part of the RGCH-SP-75 and the FAD of *Sutneria* n. sp. gr. *galar* (OPPEL) in the RGCH-SP-78 horizon, the *minutum* biohorizon was recognised. This biohorizon shows only an early part of the range of the index species without enabling the establishment of the precise boundary with the upper biohorizon. The range of *Sutneria* n. sp. gr. *galar* (OPPEL) determines the biohorizon of the same name between the RGCH-SP-78 and RGCH-SP-84/85 horizons (the latter includes only the lower part of the calcareous bed with the 85), the interval in which a juvenile specimen of *Subnebrodites tonnerrense* (LORIOL) was recorded.

Again, the combination of marly deposits and the lack of significant fossil fauna impede a clear biostratigraphic characterisation, but the presence of *Subnebrodites planula* (HEHL) and *Subnebrodites* sp. gr. *planula* (HEHL)-*laxevolutum* (FONTANNES), accompanied by *minutum* DIETERICH, *schroederi* WEGELE and possible new morphologies joined in *Subnebrodites* n. sp. A in the RGCH-SP-89 horizon, which shows a ferruginized upper surface and is undoubtedly condensed, enables the interpretation of the presence of a *planula* biohorizon. This condensation could include several horizons in the Planula Subzone and even part of the Galar Subzone, if we admit the distribution of the biohorizons proposed by Schweigert & Callomon (1997). However, *Sutneria galar* (OPPEL) was not found, being this species well known from the south of Iberia (Olóriz & Rodríguez-Tovar, 1996c; Marques et al., 1998), including the Prebetic Zone (García-Hernández et al., 1979). In addition, the distribution of ammonite species appears to have more affinity with that in central Poland (Matyja & Wierzbowski, 1997). In accord with this, the degree of condensation of the RGCH-SP-89 horizon should be evaluated in the future through the comparison with new data from sections under study in the Prebetic Zone.

As mentioned above, it was not possible to specify the precise upper boundary of the Planula Zone in the Rio Gazas-Chorro II section. We consider that sampling was not even carried out for the upper interval or the Galar Subzone, in which index-species remains are frequent in southern Iberia (García-Hernández et al., 1979, 1981; Olóriz et al., 1992; Olóriz & Rodríguez-Tovar, 1993a,b, 1996; Marques et al., 1998). The Galar Subzone, if preserved, would be found in the somital marls, which do not offer good sampling conditions. The Planula Subzone identified is equivalent to the standard of the same name recognised in the Submediterranean European epicontinental deposits. For the moment, it is difficult to establish a strict correlation of the biohorizons recognised. The *mogosensis* biohorizon is only partially equivalent to the interval with the development of *Orthosphinctes* of the group *delgadoi-mogosensis* mentioned by Atrops & Meléndez (1991), as well as to the stratigraphic interval called *delgadoi* by Atrops & Meléndez (1993).

6 FINAL REMARKS

The biostratigraphic analysis performed in the Rio Gazas-Chorro II section has enabled us to track the ranges of index species in order to recognise the biochronostratigraphic units of the standard proposed for Submediterranean southern Europe at the zone and subzone level. The minor differences identified are probably due to data that should be considered provisional. The somewhat stronger differences observed at the level of the biohorizons recognised should be interpreted in this same context. Thus, those identified in the Bifurcatus Zone represent lesser stratigraphic intervals than their equivalents recognised in other epicontinental areas. The correlation is more equivalent in the case of those recognised in the Bimammatum Zone, but again significant differences are appreciated in those proposed for the lower part of the Planula Zone.

In our estimation, the accompanying fauna of *Mirosphinctes*, *Passendorferia* (*Enayites*), *Orthosphinctes* and *Subnebrodites* will provide, potentially, the best complement for a detailed biostratigraphic analysis; this contention is supported by the observed significant differences with respect to the ranges known in other epicontinental areas. Comparing recent information from European epicontinental areas to the north of Iberia, it is worth

emphasising that ranges of *Subnebrodites* species, as well as of *Taramelliceras* (*Metahaploceras*), show greater affinity with those known in central Poland (Matyja & Wierzbowski, 1997) than with those from southern Germany (Schweigert & Cal-lomon, 1997).

7 CONCLUSIONS

In the Sierra de Cazorla, the Rio Gazas-Chorro II section (central Prebetic Zone, southern Spain) enables the detailed analysis of Oxfordian ammonite ranges and the identification of zones, subzones and horizons. The biostratigraphic characterisation at the level of zones and subzones does not differ significantly with respect to the proposals in other European Submediterranean areas. The Bifurcatus and Bimammatum Zones (Upper Oxfordian) and part of the Planula Zone (Upper Oxfordian or Lower Kimmeridgian) have been recognised. In these, the subzones Bifurcatoides/Stenocycloides, Grossouvrei, Hypselum, Bimammatum, Hauffianum/Tiziani and Planula have been identified.

For the first time, the following biohorizons have been identified in the Oxfordian of the Prebetic Zone: *grossouvrei* and *bifurcatus* (Bifurcatus Zone, Grossouvrei Subzone); *arancensis*, *semimammatum* and *berrense* (Bimammatum Zone, Hypselum Sub-zone); and *mogosensis*, *minutum*, *Sutneria* n. sp. gr. *galar* and *planula* (Planula Zone, Planula Subzone).

Contrary to the potential for correlation that zones and subzones offer, biohorizons can be correlated only partially. The difficulty in correlation of the biohorizons recognised is related, at least partly, with the provisional character of the information obtained.

Stratigraphic horizons with variable degrees of condensation and scarce and/or little significant fossils are relatively frequent and have made it difficult, punctually, to establish the biostratigraphic boundaries. The information from the research under way by the present authors will be necessary for the evaluation of the biostratigraphic significance of the horizons that present these features.

ACKNOWLEDGEMENTS

This research was made with financial support of Project PB97-0803 (DGYCIT) and the EMMI Group (RNM-178, Junta de Andalucía).

REFERENCES

- Acosta, P., García-Hernández, M. & Checa, A. (1988): Biohermos de esponjas y estromatolitos en la secuencia transgresiva oxfordiense de la Sierra de Cazorla. *Geogaceta*, **5**: 36-39.
- Acosta, P. (1989): *Estudio del Jurásico de un sector de la Sierra de Cazorla (Zona Prebética)*. Tesis de Lic. Univ. Granada, 117 p.
- Atrops, F. & Marques, B. (1988): Précisions stratigraphiques sur les formations à ammonites du Jurassique supérieur dans le Massif du Montejunto (Nord du Tajo, Portugal). *2nd Inter. Symp. Jurassic Stratigraphy*, I: 505-516.
- Atrops, F. & Meléndez, G. (1991): On the *Orthosphinctes* succession and the biostratigraphic subdivisions for the Upper Oxfordian of subMediterranean province (southern Europe). *3rd Inter. Symp. Jurassic Stratigraphy, Abstract* vol.: 12.
- Atrops, F. & Meléndez, G. (1993): Current trends in systematics of Jurassic ammonoidea: The case of Oxfordian-Kimmeridgian perisphinctids from southern Europe. *Geobios*, **M.S. 15**: 19-31.
- Aurell, M., Pérez-Urresti, I., Meléndez, G. & Bádenas, B. (1997): The angular unconformity of Moyuela (Zaragoza): remarks on extensional tectonic events at the Oxfordian-Kimmeridgian boundary in the Iberian Basin. *Geogaceta*, **22**: 23-26.
- Bello, J., Meléndez, G. & Pérez-Urresti, I. (1995): The Transversarium-Bifurcatus Zone boundary (Middle Oxfordian) in the northeastern Iberian Chain (Spain): associated discontinuities and stratigraphic gaps. *Geogaceta*, **18**: 113-116.
- Caracuel, J.E., Olóriz, F. & Rodríguez-Tovar, F.J. (1999): Oxfordian biostratigraphy from the Lugar section (External Subbetic, southern Spain). *Geo-Research Forum (in press)*.
- Cariou, E., Atrops, F., Hantzpergue, P., Enay, R. & Rioult, M. (1991): Oxfordien. Réactualisation des échelles d'ammonites. *3rd Inter. Symp. Jurassic Stratigraphy, Abstract* vol.: 132.
- Cariou, E., Enay, R. & Tintant, H. (1971): Oxfordien. Les zones du Jurassique en France. *C. R. S. Soc. geol. France*, **6**: 18-21.
- Cariou, E. & Meléndez, G. (1990): A modified perisphinctid zonation for the Middle Oxfordian of southern Europe, submediterranean province. *1st Oxfordian Meeting*, Zaragoza: 129-151.
- Enay, R. (1962): Contribution à l'étude paléontologique de l'Oxfordien supérieur de Trept (Isère). I. Stratigraphie et ammonites. *Trav. Lab. Géol. Lyon, N.S.* **8**: 7-81.
- Foucault, A. (1971): Étude géologique des environs des sources du Guadalquivir (Provinces de Jaén et de Grenade, Espagne méridionale). These Univ. Paris, 633p.
- García-Hernández, M., López-Garrido, A.C. & Olóriz, F. (1979): El Oxfordense y el Kimmeridgense inferior en la Zona Prebética. *Cuad. Geol. Univ. Granada*, **10**: 527-533.
- García-Hernández, M., López-Garrido, A.C. & Olóriz, F. (1981): Étude des calcaires noduleux du Jurassique supérieur de la Zone Prébétique (Cordillères Bétiques, SE de l'Espagne), *Rosso Ammonitico Symposium Proceeding, Tecnoscienza*: 419-434.
- Gygi, R. (1977): Revision der Ammonitengattung *Gregoryceras* (Aspidoceratidae) aus dem Oxfordian (Oberer Jura) der Nordschweiz und von Süddeutschland. Taxonomie, Phylogenie, Stratigraphie. *Eclogae Geol. Helv.*, **70(2)**: 435-542.
- López-Garrido, A.C. (1971): Geología de la Zona Prebética, al NE. de la Provincia de Jaén. Tesis Doctoral Univ. Granada: 317p.
- Marques, B. (1983): O Oxfordiano-Kimeridgiano do Algarve Oriental: estratigrafia, paleobiología (Ammonoidea) e paleobiogeografía. Ph D Thesis, Univ. Nova de Lisboa, 547pp.
- Marques, B., Olóriz, F. & Rodríguez-Tovar, F.J. (1998): La limite Oxfordien-Kimmeridgien établie par une espèce index d'ammonites (*Sutneria*) (Algarve, Portugal). *C.R. Acad. Sci. Paris*, **326**: 641-645.
- Matyja, A. & Wierzbowski, A. (1997): The quest for a unified Oxfordian/Kimmeridgian boundary: implications of the ammonite succession at the turn of the Bimammatum and Planula Zones in the Wielun, Central Poland. *Acta geol. Pol.*, **47 (1-2)**: 77-105.
- Meléndez, G. (1989): El Oxfordense en el sector central de la Cordillera Ibérica (provincias de Zaragoza y Teruel). Tesis Doctoral, 418p.
- Meléndez, G., Pérez-Urresti, I. & Bello, J. (1995): Biostratigraphic subdivisions of Bimammatum Zone (Upper Oxfordian) in the nororiental Iberian Chain: facies and range of discontinuities. *Geogaceta*, **18**: 117-120.
- Olóriz, F., Marques, B. & Caracuel, J.E. (1998): The Middle-Upper Oxfordian of Central Sierra Norte (Mallorca, Spain), and progressing ecostratigraphic approach in western Tethys. *Geobios*, **31(3)**: 319-336.
- Olóriz, F. & Rodríguez-Tovar, F.J. (1993a): The Oxfordian-Kimmeridgian boundary in the Puerto Lorente section (External Prebetic) revisited. *Geogaceta*, **13**: 92-94.
- Olóriz, F. & Rodríguez-Tovar, F.J. (1993b): Lower Kimmeridgian biostratigraphy in the Central Prebetic (southern Spain, Cazorla and Segura de la Sierra sectors). *N. Jb. Geol. Paläont. Mh.*, **3**: 150-170.
- Olóriz, F. & Rodríguez-Tovar, F.J. (1996a): Facies, fossil assemblages and eco-sedimentary evolution in epicontinental shelves (Sierra de Cazorla). *IV Inter. Symp. Cephalopods -Present and Past, Field Guide Book*, Granada: 11-20.
- Olóriz, F. & Rodríguez-Tovar, F.J. (1996b): Presencia de *Mirospinctes frickensis* (MOESCH) en el Oxfordense superior de la Sierra de Cazorla. *Geogaceta*, **19**: 94-96.
- Olóriz, F. & Rodríguez-Tovar, F.J. (1996c): The ammonite *Sutneria* from the Upper Jurassic of southern Spain. *Palaeontology*, **39, 4**: 851-867.
- Olóriz, F., Rodríguez-Tovar, F.J. & Schairer, G. (1992): New record of *Barthelia subbetica* OLORIZ & SCHAIRER (Jurassic Ammonitina) from the South Iberian paleomargin (prebetic zone, Spain). *N. Jb. Geol. Paläont. Mh.*, **6**: 343-350.
- Sequeiros, L. (1974): Paleobiogeografía del Calloviano y Oxfordense en el sector central de la Zona Subbética. Tesis Doctoral Univ. Granada, **65**: 625p.
- Schweigert, G. (1995): Zum Auftreten der Ammonitenarten *Amoebooceras bauhini* (OPPEL) und *Amoebooceras*

schulginae MESEZHNIKOV im Oberjura der Schwäbischen Alb. *Jh. Ges. Naturk. Württ.*, **151**: 171-184.
Schweigert, G. & Callomon, J.H. (1997): Der bauhini-Faunenhorizont und seine Bedeutung für die Korre-

lation zwischen tethyalem und subborealem Oberjura.
Stuttgarter Beitr. Naturk., Ser B, **247**: 1-69.