Cuadernos de Geología Ibérica
1998, número 24, 241-260

ISSN: 0378-102X

Late Jurassic Elasmobranch and Actinopterygian fishes from Portugal and Spain

Peces Elasmobranquios y Actinopterygios del Jurásico Superior de Portugal y España

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ABSTRACT

The present paper gives a survey of Late Jurassic fishes from Portugal and Spain. For the first time the complete ichthyofauna of the Guimarota coal mine in central Portugal is presented. The material consists of isolated teeth, placoid scales, fin and head-spines of elasmobranchs (*Asteracanthus*, *Hybodus*, *Polyacrodus*, Scyliorhinidae, Rajiformes) and isolated teeth, jaw elements, cranial and postcranial material of actinopterygians (Semionotiformes, Pycnodontiformes, Macrosemiiformes, Ionoscopidae, Amiiformes, Pachycormiformes, Actionpterygii *indet.*). The material is dated as early Kimmeridgian. New material from the marine Late Jurassic (Oxfordian to Tithonian) of the central Iberian Chain is briefly described. It consists of isolated teeth and scales. Neoselachians (*Notidanoides*, *Squalogaleus*, *Squatina*, *?Heterodontus*, Orectolobiformes, Scyliorhinidae, Rajiformes) and actinopterygians (Ionoscopidae, Caturidae, Aspidorhynchiformes) are reported for the first time in the Late Jurassic of the central part of the Iberian Basin.

Key Words: Elasmobranchii, Actinopterygii, Late Jurassic, Portugal, Spain, Central Iberian Chain.

RESUMEN

Los resultados obtenidos sobre los peces del Jurásico Superior de Portugal y España se plasman en este trabajo. Por primera vez se presenta en su totalidad la fauna ictiológica del Kimmeridgiense inferior de la mina de carbón de Guimarota, en la parte central de Portugal. El material analizado consiste en dientes aislados, escamas placoideas y espinas de aletas y cráneos de elasmobranquios (*Asteracanthus*, *Hybodus*, *Polyacrodus*, Scyliorhinidae, Rajiformes) y dientes aislados, elementos mandibulares y material craneal y postcraneal de teleósteos (Semionotiformes, Pycnodontiformes, Macrosemiiformes, Ionoscopidae, Amiiformes, Pachycormiformes, Actionpterygii *indet.*).

También se describe el material encontrado del Jurásico Superior del Sector Central de la Cordillera Ibérica. Elasmobranquios (*Notidanoides*, *Squalogaleus*, *Squatina*, ?*Heterodontus*, Orectolobiformes, Scyliorhinidae, Rajiformes) y peces óseos (Ionoscopidae, Caturidae, Aspidorhynchiformes) se dan a conocer en esta zona por primera vez.

Palabras Clave: Elasmobranchii, Actinopterygii, Jurásico Superior, Portugal, España, Cordillera Ibérica.

RESUMO

Apresenta-se uma visão geral dos peixes do Jurássico Superior de Portugal e do Nordeste de Espanha. Pela primeira vez é abordada a ictiofauna completa da Mina de carvão da Guimarota (Portugal central). O material consiste em dentes isolados, escamas placóides, barbatanas e espinhas da cabeça de Elasmobrânquios, dentes isolados, elementos da maxila, material craniano e póscraniano de Actinopterígios. O material está datado do Kimeridgiano inferior. Material novo do Jurássico superior marinho (Oxfordiano a Titoniano) da Cadeia Ibérica central é descrito sucintamente. Neoseláquios e Actinopterígios são apresentados pela primeira vez no Jurássico Superior da Bacia Ibérica.

1. INTRODUCTION

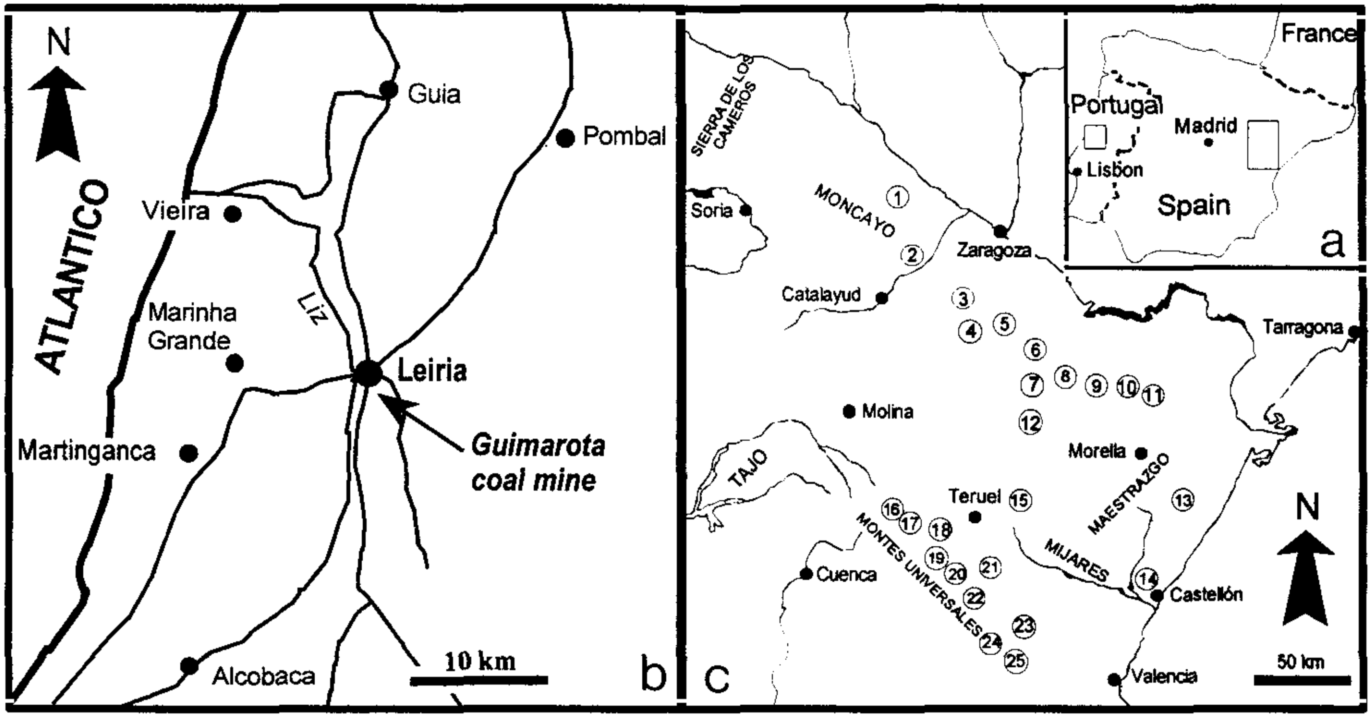
The Jurassic period was an important stage in the evolution and paleogeographic distribution of fishes. In this time, the neoselachian sharks began to radiate and the first teleosts *sensu stricto* appeared (Arratia, 1996). At the end of the Jurassic and the beginning of the Cretaceous, elasmobranch and actinopterygian faunas of modern character developed, leading to living groups.

Numerous marine Jurassic fish localities are known from all over the world (Schaeffer & Patterson, 1984; Arratia, 1996). However, only a few show a diversified fauna with articulated and well-preserved specimens. Amongst these, more or less articulated and well-preserved skeletons of Jurassic sharks and bony fishes are known from the Early Jurassic of Lyme Regis, southern England, the Jurassic *Posidonia* Shale of southern Germany, and the Late Jurassic lithographic limestones of Solnhofen and Nusplingen, southern Germany, and Cerin, France. Additionally, Late Jurassic complete shark specimens have been found in the Portlandian of northern France. Specimens from all these localities have been important for reference and comparison in the description of isolated microvertebrate remains, especially teeth (e.g. Thies, 1983; Mudroch & Thies, 1996; Kriwet *et al.,* 1997). Although there exists a rather vast literature on isolated fish teeth, especially of sharks, from several countries, Late Jurassic fishes from the Iberian Peninsula were scarcely reported, mainly from Portugal (e.g. Sauvage, 1897-98). Much more is known about Early and Late Cretaceous fishes (e.g. from Portugal;. Jonet, 1981) and northern Spain (e.g. Poyato-Ariza & Wenz, 1990; Poyato-Ariza *et al.,* Ms.). The aim of this paper is to give an introduction to Late Jurassic fishes from the Guimarota coal mine (Portugal) and to Late Jurassic fish remains from the central Iberian Chain, NE-Spain. A detailed systematic description and discussion is beyond the scope of this paper and will be presented elsewhere. The Portuguese fish material will be housed in the Institute of Palaeontology of the Free University in Berlin, Germany, under the numbers IPFUB-Gui Ela and IPFUB-Gui Act, the Spanish material will be deposited after its final detailed description at the University of Zaragoza.

2. GUIMAROTA COAL MINE, PORTUGAL

The Portuguese fish material for this study comes from the Late Jurassic underground coal mine of Guimarota (Fig. 1a, b), which is currently shut down. It is situated near the village of Leiria in Central-Portugal. It was discovered in 1959 by W.G. Kühne (Berlin) as a vertebrate locality when still operating as a mine. For a complete historical overview see Krebs (1991) and for the geology, Henkel & Krusat (1980).

Two coal seams were exposed in the underground, being mined for paleontological purposes only (Krebs, 1988). The lower coal seam yielded a rich vertebrate fauna including all major clades of vertebrates. It is especially famous for its largest sample of Late Jurassic mammals (Martin, 1997). Between 1973 and 1982 this coal seam was mined, broken up and carefully examined for vertebrate remains by the staff of the Institute of Palaeontology of the Free University, Berlin. The hermetically wrapped specimens were prepared in the laboratory mechanically. Other samples were screen washed. Unfortunately, articulated remains are quite rare. Mammalians are represented by thousands of isolate teeth, some hundred jaws, some skulls and two articulated skeletons. All other vertebrates (fishes, amphibians, lacertilians, turtles and archosaurs) are represented by disarticulated or isolated remains. Coals seams are dated as early Kimmeridgian on the basis of ostracodes (Helmdach, 1971) and charophytes (Schudack, 1993).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Fish remains

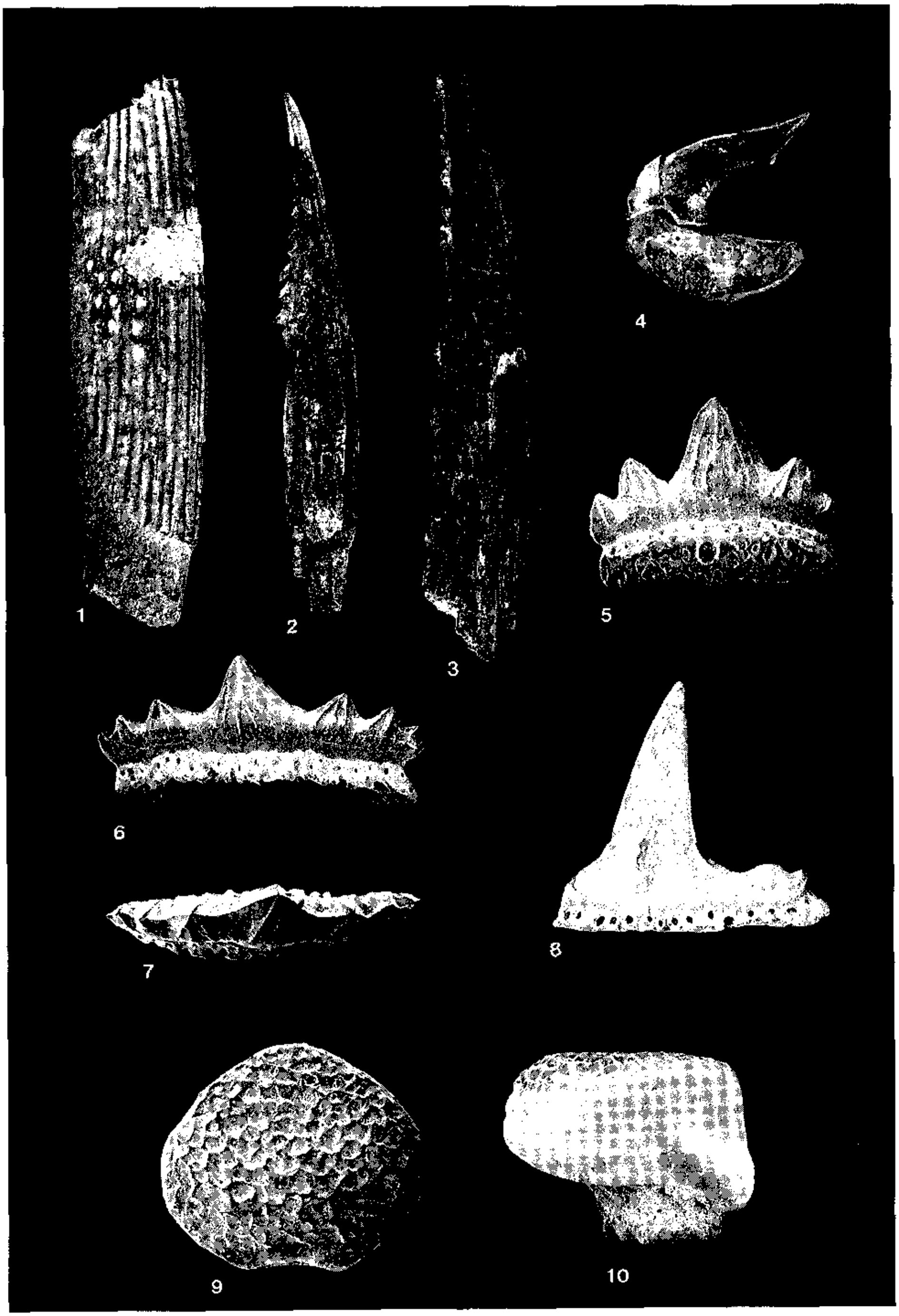
CHONDRICHTHYES

a) *Hybodontiformes*

Hybodont sharks are the predominant element of the Chondrichthyan fauna. They are represented by about five hundred isolated teeth and placoid scales and at least one dozen fin and several head spines. The largest hybodont in this fauna, *Asteracanthus biformatus* Kriwet 1995, is known from a single fin spine with typical star-like tubercles, one rather large oral tooth and one head spine (Plate 1, Fig. 1, 4). This species is the only representative of *Asteracanthus*. The genus *Hybodus* is represented by isolate and mostly fragmentary teeth, and several fin spines (Plate 1, Fig. 2, 3). The state of preservation of the teeth does not allow any specific determination at the moment. However, two different groups are recognized within the assemblage. The first group is characterized by its rather massive and tumid teeth with rather high lateral cusplets. Teeth of the second group are high-crowned with slender principal cusps and very low lateral cusplets (Plate 1, Fig. 8). The Polyacrodontidae are represented by about 250 teeth of 2 or 3 species of *Polyacrodus* (Plate 1, Fig. 5-7). The teeth of *Polyacrodus* differ from those of *Hybodus* in the possession of a more tabular root, which projects linguo-basally (Duffin & Thies, 1997). Since there is a lot of tooth material of nearly all tooth positions within the jaws (anterior to posterior), it is possible to reconstruct the dentition of these sharks. Some fin spines may be attributed to this genus. Astonishingly, no *Lissodus* species have been found so far. There are five teeth of uncertain affinities. Their morphology is rajiform-like, but the enameloid ultrastructure, which is very thin and consists of a single-cristallite layer, shows it to be a hybodont (Plate 1, Fig. 9-10).

FIG. 1.—**a.** Geographical distribution of the investigated Late Jurassic areas. **b.** Geographical position of the Guimarota coal mine (central Portugal). **c.** Geographical distribution of Late Jurassic sections in the central Iberian Chain (NE-Spain): 1. Veruela; 2. Ricla; 3. Tosos; 4. Aguilón; 5. Moneva; 6. Barranco de la Estacas; 7. Alcaine; 8. Gallipuén; 9. Calanda; 10. Torrevelilla; 11. Ráfales; 12. Galve; 13. Salsadella; 14. La Foya; 15. Cedrillas; 16. Frías de Albarracin; 17. Moscardón; 18. Jabaloyas; 19. Arroyo Cerezo; 20. Hontanar; 21. Riodeva; 22. Graja de Campalbo; 23. Villar de Arzobispo; 24. Loriguilla; 25. Sot de Chera.

FIG. 1.—**a.** Situación geográfica de las áreas estudiadas de Jurásico Superior. **b.** Situación geográfica de la mina de carbón de Guimarota (Portugal). **c.** Situación geográfica de las áreas estudiadas en el Sector Central de la Cordillera Ibérica (NE-España): 1. Veruela; 2. Ricla; 3. Tosos; 4. Aguilón; 5. Moneva; 6. Barranco de la Estacas; 7. Alcaine; 8. Gallipuén; 9. Calanda; 10. Torrevelilla; 11. Ráfales; 12. Galve; 13. Salsadella; 14. La Foya; 15. Cedrillas; 16. Frías de Albarracin; 17. Moscardón; 18. Jabaloyas; 19. Arroyo Cerezo; 20. Hontanar; 21. Riodeva; 22. Graja de Campalbo; 23. Villar de Arzobispo; 24. Loriguilla; 25. Sot de Chera.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b) *Neoselachii*

Neoselachians are very rare. Only two teeth have been found to-date. One mesial tooth was referred to the cat sharks (Scyliorhinidae) by Kriwet (1997) (Plate 2, Fig. 1-2), the other is a pavement tooth of a ray (Plate 2, Fig. 3-4). A specific determination of both is impossible. The scyliorhinid tooth differs from all known Late Jurassic cat shark teeth and it may represent a quite different form from those of France and Germany. The ray tooth may best be referred to Rajiformes *indet.* (guitar fishes).

ACTINOPTERYGII

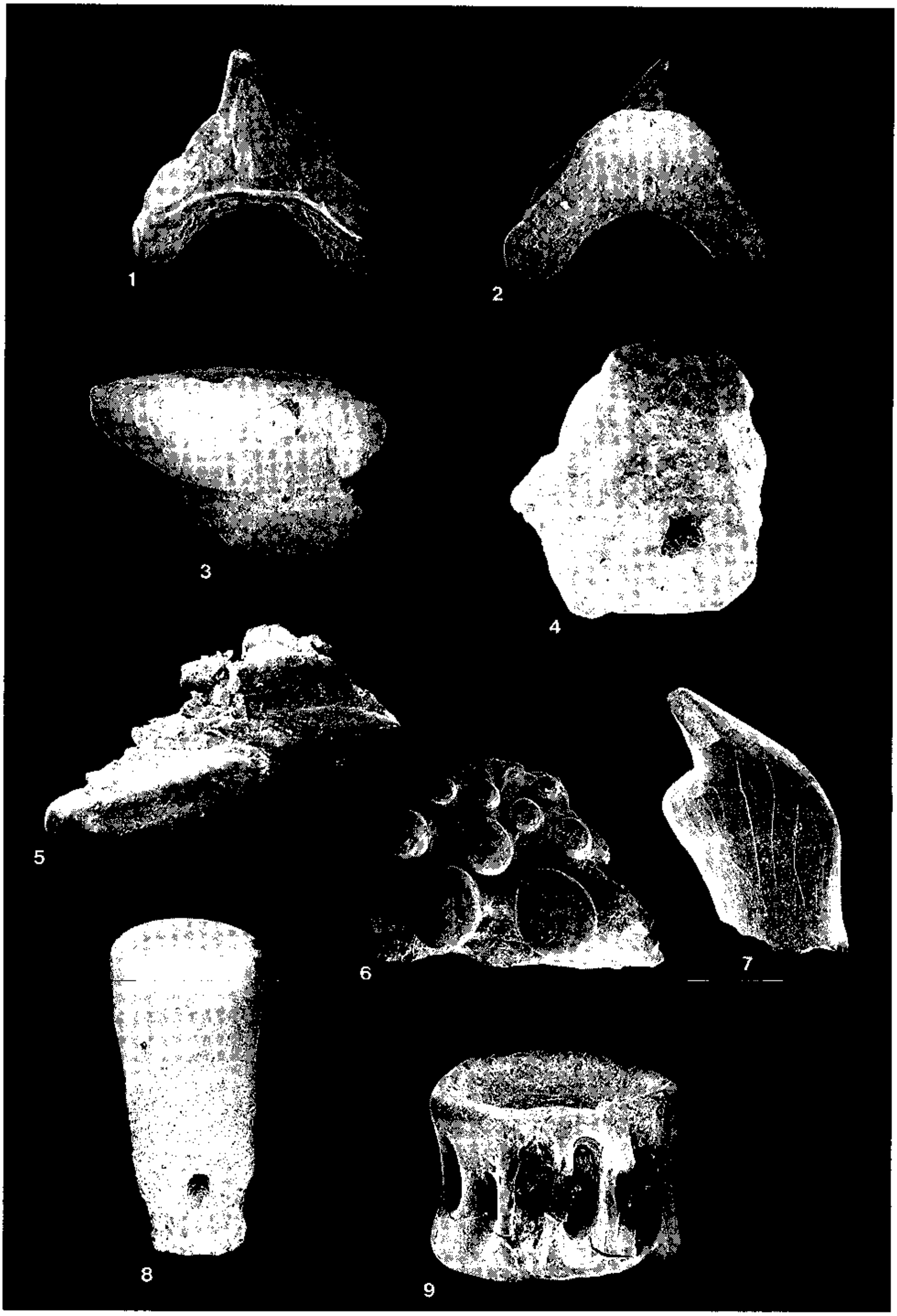
a) *Semionotiformes*

The Semionotiformes are a non-monophyletic group. But the term is used in this paper in its ancient sense to include several similar genera.

The actinopterygian association is dominated by isolated remains of *Lepidotes*-like semionotids. Two different morphospecies can be distinguished by the size and morphology of teeth and scales. The smaller one is represented by two dentalosplenials (Plate 3, Fig. 5-6), dozens of isolated teeth and several ganoid scales with smooth posterior margins. The teeth of the dentalosplenial are more or less styliform. The second morphospecies is much larger and not so common. It is documented by some partially preserved vomerian dentitions with tritoral teeth (Plate 2, Fig. 6), large isolated tritoral teeth and rather large ganoid scales with smooth posterior margins (Plate 3, Fig. 7-8). An isolated preopercle is also assigned to the Semionotiformes (Plate 3, Fig. 3). Additional isolated hook-shaped branchial teeth occur (Plate 2, Fig. 7). Those branchial teeth are referred to *Lepidotes* by Mudroch & Thies (1996) and Thies (1989). But hook-shaped branchial teeth also occur in Pycnodontidae (pers. obs.). The morphology of the teeth, bones and scales is typical semionotid and the remains may belong to *Lepidotes* Agassiz, 1832 or some cloesely related taxa. Nevertheless, the genus *Lepidotes* is by no means a monophyletic group. Late Jurassic species of *Lepidotes* comprise at least 19 taxa (Thies, 1989).

PLATE 1.—Guimarota fishes. **1, 4.** *Asteracanthus biformatus* Kriwet 1995, x1,1; [**1,** Fin spine, x1,1. **4,** Head spine, x2]. **2.** Fin spine of *Hybodus* sp., x2,1. **3.** Fin spine of *Hybodus* sp., x2; **5.** *Polyacrodus* sp.1. Tooth in lingual view, x20. **6-7.** *Polyacrodus* sp.2; [**6,** Tooth in labial view, x18; **7,** Tooth in occlusal view]. **8.** Tooth of *Hybodus* sp., x20. **9-10.** Hybodontiformes *indet.*; [**9,** Tooth in occlusal view, x38; **10,** Tooth in lateral view, x38].

LÁMINA 1.—Restos de peces de Guimarota. **1, 4.** *Asteracanthus biformatus* Kriwet 1995; [**1.** Espina de aleta, x1,1. **4.** Espina cefálica, x2]. **2.** Espina de aleta de *Hybodus* sp., x2,1. **3.** Espina de aleta de *Hybodus* sp., x2. **5.** *Polyacrodus* sp.1. Vista lingual, x20. **6-7.** *Polyacrodus* sp.2; [**6,** Vista labial, x18; **7,** Vista oclusal, x18]. **8.** *Hybodus* sp. Vista labial, x20. **9-10.** Hybodontiformes *indet.*; [**9,** Vista oclusal, x38; **10,** Vista lateral, x38].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b) *Pycnodontiformes*

Pycnodont fishes are quite rare. Only a few isolated teeth and a very fragmentary prearticular dentition have been found, which is interpreted as a dentition of Pycnodontidae *indet.* (cf. *Coelodus* or *Proscinetes*), since the teeth show the typical transversally elongated morphology with a more or less concave posterior margin and with an apical indent, which follows slightly the outer conture of the teeth (Plate2, Fig. 5). All other isolated molarifom fish teeth and a few incisiform and spatulate teeth can also be attributed to Pycnodontidae *indet.* (cf. *Coelodus* or *Proscinetes*) (Plate 2, Fig. 8).

c) *Macrosemiiformes*

Several isolate teeth with typical macrosemiid morphology (styliform teeth with slender and long neck, the apex is conical and bent lingually) are preserved (compare Mudroch & Thies, 1996). Additionallly, an isolated dentalosplenial is attributed to the Macrosemiidae (Plate 3, Fig. 4). The dentalosplenial has a shallow symphysis, a ventral concave margin and a rather well-developed coronoid process. There is a more or less horizontal groove line of the mandibular canal present. The teeth are styliform and pointed, well-spaced and the tooth apices are bent lingually. These features are very similar to those found in *Macrosemius* Agassiz, 1844 from the Late Jurassic of southern Germany (Bertram, 1977; pers. obs.).

d) *Ionoscopidae (order indet.)*

Ionoscopidae (order *indet.*) are known from isolate teeth only. They show the typical lancet-like morphology with acutely pointed apecis. They differ from those of amiids in having a more conical apex, which is not arrow like.

PLATE 2.—Guimarota fishes**1-2.** Scyliorhinidae *indet.*; [**1,** Tooth in labial view, x21; x21; **2,** Tooth in basal view, x21]. **3-4.** Rajiformes *indet.*; [**3,** Tooth in lateral view, x30; **4,** Tooth in occlusal view, x30]. **5.** Fragmentary prearticular dentition of Pycnodontidae *indet.* (cf. *Coelodus/Proscinetes*), occlusal view, x16. **6-7.** Semionotiformes *indet.* (cf. *Lepidotes*); [**6,** Fragmentary vomerian dentition, x14; **7,** Branchial tooth in lateral view, x49]. **8.** Incisiform tooth of Pycnodontidae *indet.* (cf. *Coelodus/Proscinetes*), lingual view, x27. **9.** Teleosteen vertebra, x 18.

LÁMINA 2.—Restos de peces de Guimarota. **1-2.** Scyliorhinidae indet.; [**1,** Vista labial, x21; **2,** Vista basal, x21]. **3-4.** Rajiformes *indet.*; [**3,** Vista lateral, x30; **4,** Vista oclusal, x30]. **5.** Prearticular de Pycnodontidae indet. (cf. *Coelodus/Proscinetes*), vista oclusal, x.16. **6-7.** Semionotiformes *indet.* (cf. *Lepidotes*); [**6,** Vómer, vista oclusal. x14; **7,** Diente laringeo, vista lateral, x49]. **8.** Diente incisiforme de Pycnodontidae *indet.* Vista lingual. x27. **9.** Vértebra de teleósteo, x 18.


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e) *Amiiformes*

The amiiform fishes are represented by a single disarticulate and not completely preserved skull, which will be described in detail elsewhere, and isolate teeth. The disarticulate skull shows the typical arrangement of the palatoquadrate bones, morphology of dentalosplenials and two scales of amiid morphology (Schultze, 1965) (Plate 3, Fig. 1). Additional isolated arrow-like teeth may be referred to amiid fishes.

f) *Pachycormiformes*

Pachycormid fishes seem to be rare. Only few teeth of them have been found so far. They are more or less conical and are compressed labiolingually. The neck bears strong vertical ridges. Since the teeth are rather small, they are attributed tentatively to *Sauropsis* Agassiz, 1832.

g) *Actinopterygii indet.*

About a dozen very small dentalosplenials with acutely pointed teeth have been recovered. At the moment, it is impossible to attribute them to any actinopterygian order. There is also a fragmentary, so far unidentified dentalosplenial present (Plate 3, fig. 2). Teleosts of uncertain affinity are documented by isolated vertebrae (Plate 2, Fig. 9).

3. CENTRAL IBERIAN CHAIN, NE-SPAIN

The Late Jurassic fish material of Spain comes from several localities between the cities of Barcelona, Zaragoza and Valencia in the central Iberian Range (Fig. 1a, c). About 250 samples from 23 stratigraphic sections from Yátova (Late Oxfordian), Sot de Chera (Late Oxfordian to early Kimmeridgian), Loriguilla (Early to Late Kimmeridgian) and Higueruelas Fm. (Tithonian to Berriasian) were collected during a first prospecting field trip in 1996. The studied sections consist of compact limestones, marly limestones and marls as well as

PLATE 3.—Guimarota fishes. **1.** Skull elements of Caturidae *indet.*, x5. **2.** Fragmentary dentalosplenial of Actinopterygii indet., x2. **3.** Preopercle of Semionotiformes indet., x2,6. **4.** Dentalosplenial of ?Macrosemiidae, x2,4 **5.** Left dentalosplenial of *Lepidotes* sp.1, x2. **6.** Right dentalosplenial of *Lepidotes* sp.1, x2,5. **7-8.** Scales of Semionotiformes indet. (cf. *Lepidotes*), x0,6.

LÁMINA 3. Restos de peces de Guimarota **1.** Elementos del cráneo de Caturidae *indet.*, 5. **3.** Preopérculo de Semionotiformes *indet.*, x2,6. **2.** Dentalosplenial de Actinopterygii *indet.*, x2. **4.** Dentalosplenial de ?Macrosemiidae, x2,4. **5.** Dentalosplenial de cf. *Lepidotes* sp.1, x2. **8.** Dentalosplenial de *Lepidotes* sp.1, x2,5. **7-8.** Escama de Semionotiformes *indet.* (cf. *Lepidotes*), x0,6.

sandy layers of «Purbeck» facies. First fish teeth from these sections were recovered by K. Kussius (Berlin) in the course of her study of Late Jurassic ostracods. Marly limestones and marls from Tosos (middle Kimmeridgian), Frías de Albarracín (Oxfordian - Tithonian), Calanda (Oxfordian - middle Kimmeridgian), Barranco de las Estacas (Oxfordian - lower Kimmeridgian), Moneva (Oxfordian) and Moscardón (Oxfordian) yielded most fish remains. These six sections will form the subject of further investigations.

The Iberian Range is a large, generally NW-SE extending mountain chain in central-eastern Spain. Sedimentation during the Late Jurassic in the eastern Iberian Peninsula, in the area of the Iberian Massif, took place under shallow marine conditions on wide, gently sloped ramps (e.g., Aurell *et al.*, 1988; Aurell, 1991; Aurell & Meléndez, 1993). These ramps opened towards the Tethyan realm in the east (Maestrazgo basin). Minor tectonic events at the Oxfordian-Kimmeridgian and at the Jurassic-Cretaceous boundaries resulted in an uplift of the marginal areas of these basins (Aurell & Meléndez, 1993). In spite of this, the Late Jurassic was, in general, a tectonically stable period. Major transgressive events in the Middle Oxfordian and the early Kimmeridgian opened a connection with the boreal faunal provinces across the Mid Iberian seaway (Soria seaway) to the northwest (Bulard, 1972; Gómez, 1979; Aurell & Meléndez, 1993).

Gomez & Goy (1979) defined the Jurassic lithostratigraphic units for the central Iberian Chain. Later, Salas (1987, 1989) subdivided the Late Jurassic and Early Cretaceous sediments of the central Iberian Chain into depositional sequences. The Late Jurassic subdivisions were further subdivided into three depositional sequences by Aurell & Meléndez (1993): DS.J1, DS.J2, DS.J3. Systems tracts were introduced as descriptive entities (Aurell, 1991; Bádenas & Aurell, 1997). The systems tracts of the Oxfordian and Kimmeridgian consist of six successive depositional episodes; the Tithonian-Berriasian sequence comprises two further depositional episodes. The depositional sequences were correlated with the lithostratigraphic units by Aurell & Meléndez (1990, 1993). According to these authors, the Yátova Fm. belongs to the Oxfordian depositional sequence (DS.J3.1). This unit represents the highstand systems tracts (TST-HST). Sediments of the Sot de Chera Formation were laid down during a first phase of a new sedimentary cycle, initiated by an increase of tectonic subsidence (Aurell & Meléndez 1990). This unit is interpreted as a lowstand systems tract. The material was deposited on a shallow, restricted platform under partly anoxic conditions. Materials of the Loriguilla Formation belong to the transgressive systems tract during the phase of sea level rising of the early Kimmeridgian. A retrogradation of Loriguilla sediments onto those of the Sot de Chera Formation is observed. Both units are referred to the Late Oxfordian to Early Tithonian depositional sequence (DS.J3.2). A regressive phase during the early Tithonian marks the end of this depositional sequence and the beginning of the latter (Tithonian to Berriasian, DS.J3.3). Sediments of the Higueruelas Fm. represent this sequence in this study.

Most fish material presented in this note comes from marly layers of Sot de Chera or Loriguilla Fm. The mud for these marls was accumulated offshore in the middle and inner ramp areas (Bádenas & Aurell, 1997).

The depositional setting is mainly interpreted as a low-angled carbonate ramp (e.g. Aurell & Meléndez 1990). The depositional setting of the uppermost Callovian to the middle Oxfordian was interpreted as an homogenous plain, which was covered by shallow water. In the middle Oxfordian the sea water level rose and open marine conditions with benthic invertebrates were established on an extensive low-angle slope ramp. During the late Oxfordian two deltaic facies are recognized. The uppermost Oxfordian to lowermost Kimmeridgian is characterized by sediments, which were laid down under shallow water conditions in partly restricted low-angle ramp environments due to reactivation of basal faults at the end of the Oxfordian. A considerably rise of sea level during the early Kimmeridgian resulted in reestablishment of open marine conditions at the edge of the ramps. At the end of the Jurassic, moderate tectonic uplifts resulted in a sea level fall.

Fish remains

CHONDRICHTHYES

Cartilaginous fishes are represented exclusively by oral teeth and placoid scales of modern sharks and rays (Neoselachii). Hybodonts (ancient sharks) have not been recovered to date.

a) *Hexanchiformes*

Hexanchiform sharks are documented by *Notidanoides* Maisey, 1986 (Fig. 2). This genus is characterized by primitive tooth characters (e.g., very thick and massive tooth root) and is considered as a basal form close to the ancestor stock of hexanchids (Cappetta, 1987). *Notidanoides* comprises three species (*Notidanus muensteri* Agassiz, 1843; *Notidanoides arzoensis* Beaumont, 1960; *Notidanoides pockrandti* Ward & Thies, 1987) and is hitherto known from the Early and Late Jurassic of Switzerland and southern Germany and from the Early Cretaceous of north-west Germany and southern France (Cappetta, 1987; Ward & Thies, 1987). In NE-Spain it occurs in the late Oxfordian of Moscardón.

b) *Squaliformes*

Squaliformes are represented by teeth of *Squalogaleus* Maisey, 1986 from the early Kimmeridgian (Plate 4, Fig. 1-2). This genus occurs in the Middle Ju-

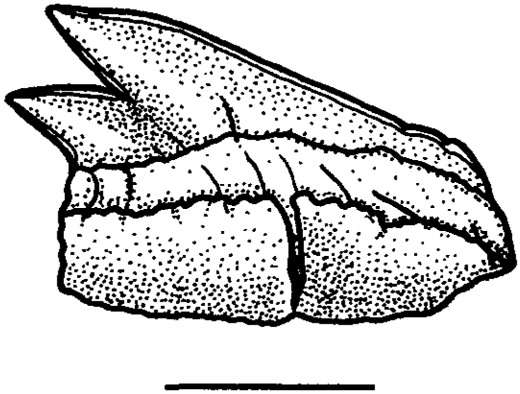


FIG. 2.—Lateral tooth of *Notidanoides* sp. from the late Oxfordian of Moscardón. Lingual view. Scale bar equals 0,5 cm.
FIG. 2.—Diente lateral de *Notidanoides* sp. del Oxfordiense superior de Moscardón. Vista lingual. Escala = 0,5 cm.

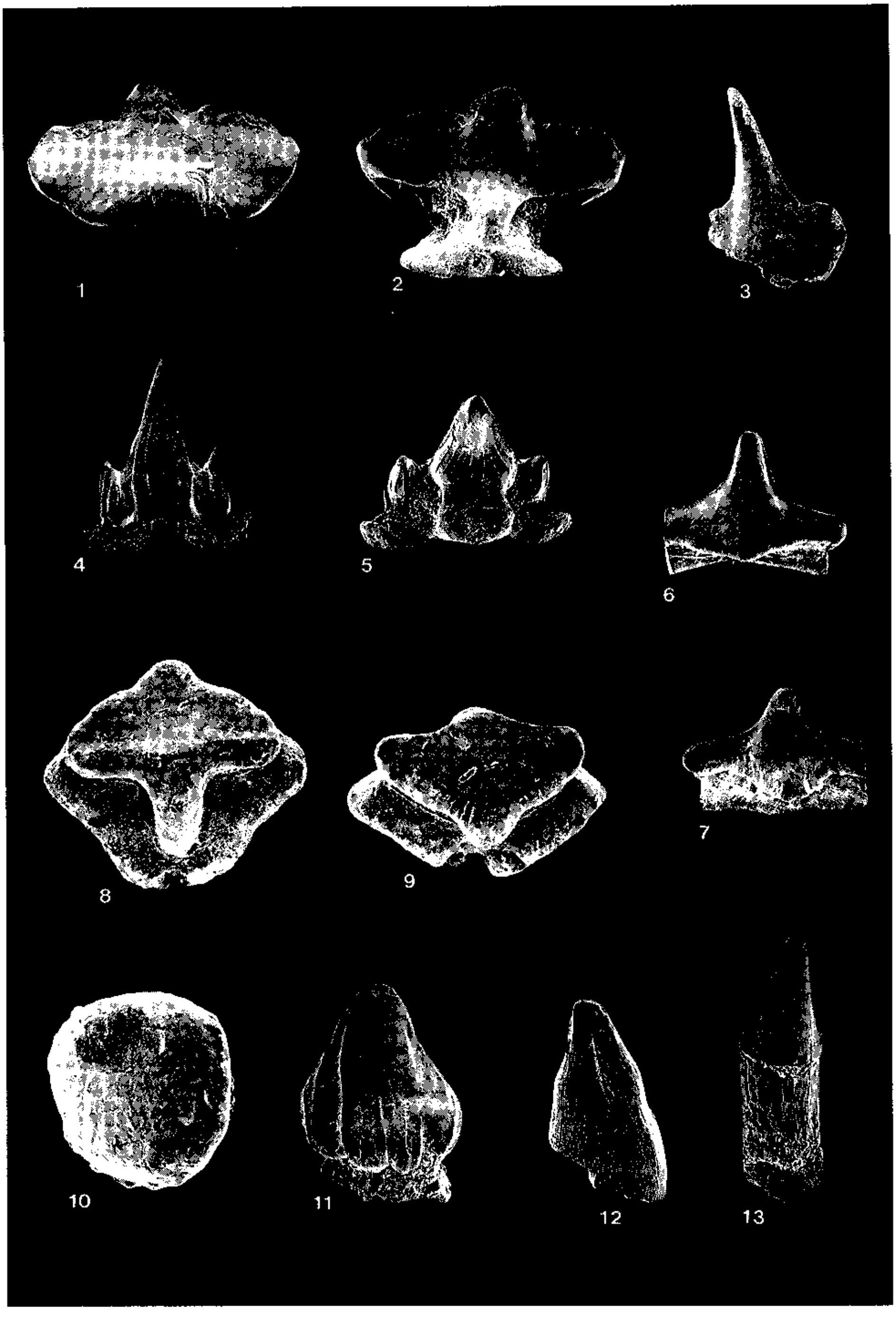
rassic of England and Late Jurassic of Germany (Thies, 1983; Cappetta, 1987). The Spanish species differs significantly from all hitherto known species and enlarges the distribution of *Squalogaleus* farther South.

c) *Squatiniformes*

Angel sharks (*Squatina* Duméril, 1906) are represented by one imperfect tooth from the early Kimmeridgian (Plate 4, Fig. 6-7). Unfortunately, teeth of *Squatina* show only few specific characters and dentitions were very stable over time. Therefore, the Spanish specimen can not be attributed to any known or new species.

PLATE 4.—Spanish fishes. **1-2.** *Squalogaleus* sp.; [**1,** Labial view, x92; **2,** Lingual view, x92]. **3.** Orectolobiformes *indet.* Labial view. x55. **4-5.** Scyliorhinidae *indet.*; [**4,** Labial view, x26; **5,** Lingual view, x32.] **6-7.** *Squatina* sp.; [**6,** labial view. x50; **7,** lingual view, x50]. **8-9.** Rhinobatoidei *indet.* (cf. *Spathobatis/Asterodermus*); [**8,** occlusal view, x50; **9,** labial view, x50]. **10.** Placoid scale of Batomorphii *indet.*, x 90. **11.** Placoid scale of cf. *Palaeoscyllium* sp., x60. **12.** *Ionoscopus* sp. Lateral view, x60. **13.** *Caturus* sp. Lingual view, x60.

LÁMINA 4.—Peces de España. **1-2.** *Squalogaleus* sp.; [**1,** Vista labial, x92; **2,** Vista lingual, x92.]. **3.** Orectolobiformes *indet.* Vista labial. x55. **4-5.** Scyliorhinidae *indet.*; [**4,** Vista labial, x26; **5,** Vista lingual, x32]. **6-7.** *Squatina* sp.; [**6,** vista labial. x50; **7,** vista lingual, x50]. **8-9.** Rhinobatoidei *indet.* (cf. *Spathobatis/Asterodermus*); [**8,** Vista oclusal, x50; **9,** Vista labial, x50]. **10.** Escama de Batomorphii *indet.*, x 90. **11.** Escama de cf. *Palaeoscyllium* sp., x60. **12.** *Ionoscopus* sp. Vista lateral, x60. **13.** *Caturus* sp. Vista lingual, x60.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d) *Heterodontiformes*

Heterodontids are probably represented by a few, very small teeth of presumably young individuals. These teeth lack lateral cusplets and have upright main cusps.

e) *Orectolobiformes*

Orectolobiform sharks are common in the early Kimmeridgian and are represented so far by placoid scales and one broken tooth only (Plate 4, Fig. 3). The placoid scales can be referred by their outstanding morphology (Thies, 1995) to the genus *Palaeoscyllium* (Plate 4, Fig. 11). *Palaeoscyllium* is regarded as link between the orectolobiform and lamniform sharks (e.g. Duffin, 1988). One unrooted tooth with its strong main cusp, one pair of low lateral cusplets and well-pronounced labial apron may represent some kind of orectolobiform shark.

f) *Carcharhiniformes*

Carcharhinid sharks are represented by exceptionally well preserved teeth of cat sharks (Scyliorhinidae) from the early Kimmeridgian (Plate 4, Fig. 4-5).

g) *Neoselachii indet.*

Several different groups of Neoselachian sharks are documented by isolated tooth crowns or placoid scales. At the moment, these remains can not be referred to any genus or species.

h) *Batomorphii*

Guitar fishes are represented by oral teeth of «rhinobatid» morphology from the Early Kimmeridgian. Although the Rhinobatoidei do not represent a monophyletic group (Brito & Seret, 1996; McEachran et al. 1996) the term «rhinobatid» is used in this paper to express a certain kind of tooth morphology. The teeth show characters of both Late Jurassic «rhinobatids» *Belemnobatis* Thiollière, 1854 and *Spathobatis* Thiollière, 1854 (Plate 4, Fig. 8-9). At the moment, it is impossible to attribute these teeth to one of these closely related genera. Some placoid scales may also be referred to «rhinobatid» rays (Plate 4, Fig. 10).

ACTINOPTERYGII

a) *Ionoscopidae (order indet.)*

Teeth of ionoscopids are rather common in the early Kimmeridgian. They can easily be recognized by their striking morphology and their typically ornamentation of tooth necks (Plate 4, Fig. 12). They differ from the similar caturid teeth in the lack of an arrow-like apex.

b) *Amiiformes*

Teeth of pelagic predators as Caturids are very common in the early Kimmeridgian (Plate 4, Fig. 13). They are characterized by their lancet-like morphology. The tooth apices are arrow-like with sharp lateral edges and are set off from the tooth neck.

c) *Aspidorhynchiformes*

Some acute teeth with their well differenciated tooth apices and ornamentated tooth necks may be attributed by their overall morphology to aspidorhynchids.

4. CONCLUSIONS

Microvertebrate remains, especially of sharks and bony fishes from the Late Jurassic of the Iberian Peninsula, are still poorly known. Poyato-Ariza *et al.* (MS.) give an overview of Late Jurassic fish localities of Spain and its faunal contents. The new material from several localities in the central Iberian Chain (Fig. 1b) enlarges our knowledge about the distribution of Late Jurassic fishes. But the investigation of the new material is still at its beginning and therefore it is only possible to draw several general consclusions.

The material from Portugal was collected in an underground coal mine of early Kimmeridgian age. Most material can be referred to the hybodont shark *Polyacrodus* or semionotid *Lepidotes*-like actinopterygians. *Polyacrodus* and semionotids are interpreted as fishes with greater tolerance of salinity fluctuations («euryhaline forms»). Exclusively marine fishes, like neoselachian sharks or caturid, ionoscopid, pachycormid and ichthyodectid actinopterygians are quite rare or missing (e.g. aspidorhynchid fishes) or still not found. The amiid and pycnodont fishes may also represent euryhaline forms. This fish assemblage in association with the other faunal contents (see Helmdach, 1971 and Krebs, 1991) and the sedimentological background (see Henkel & Krusat,

1980) may indicate a restricted environment at the edge of the marin realm with reduced salinity for the Guimarota coals.

In 1996, a new project on Late Jurassic fishes from the central Iberian Range in northeastern Spain was initiated. The material comes from three lithostratigraphic units (Sot de Chera, Loriguilla and Higueruellas Formation). These units belong to two depositional sequences (DS.J3.2 and DS.J3.3), which range from Late Oxfordian to Berriasian. Relatively small selachian and actinopterygian samples were collected from marly layers of six sections (Late Oxfordian to Tithonian). Up to now only few actinopterygians were known from four Late Jurassic localities from Spain: *Lepidotes* sp. from two Tithonian localities of northeastern central Spain; *Lepidotes* sp. from the Tithonian-Berriasian of northern central Spain and *Lepidotes* sp., *Aspidorhynchus* sp. and «*Sphaerodus*» *semiglobosus* from the Tithonian-Berriasian of northern central Spain (Poyato-Ariza *et al.*, MS.). All these localities are interpreted either as freshwater or continental environments. The new Late Jurassic fish localities are interpreted as marine (see citations in chapter 2). This interpretation is confirmed by the occurence of marine ostracodes (K. Kussius, in prep.). Similarities of these fish assemblages are found to fish assemblages from the Late Jurassic tethyan realm (France, southern Germany) as well as to those of the boreal realm (northern Germany and England). Faunal exchanges between the tethyan and boreal realms were possible through the mid-Iberian seaway (Soria seaway), which was still open during Late Jurassic times.

5. AKNOWLEDGMENTS

I would like to express my gratitude to Dipl.-Geol. K. Kussius for providing specimens, assistance during the 1996 field trip and for her helpful suggestions on the geology and stratigraphy of the Iberian Chain. Dr. Manfred Krautter (Stuttgart) is thanked for providing a tooth of *Eonotidanus*. Thanks are also due to Dr. Bernard Krebs (Berlin) for his permission to work on the Guimarota fishes. Dr. D. Thies and Dipl.-Geol. A. Leitner (Hannover) are thanked for discussions. P. Böttcher (Berlin) improved the language and Margarita Cruz Almanza (Berlin) assisted in preparing the Spanish abstract. The Portuguese abstract was translated by Dr. M.C. Cabral (Lisbon). I am very grateful to Dr. S. Wenz (Paris) and Dr. F.J. Poyato-Ariza (Madrid) who made incisive comments on the manuscript, of which it has been improved. Dr. F. J. Poyato-Ariza also corrected the Spanish abstract and the Spanish legends. Dr. H.-P. Schultze (Berlin) is thanked for all his help and encouragement. Financial support for the field trip in 1996 was provided by H. Kriwet (Kaufbeuren).

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Manuscrito recibido: 20 de Septiembre de 1997
Manuscrito aceptado: 15 de Octubre de 1998