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Ammonite stratigraphy of the Bajocian in Northern Chile

Axel von HILLEBRANDT

Institut für Angewandte Geowissenschaften II, Technische Universität Berlin, Ernst–Reuter–Platz 1., 10587 Berlin, Germany
E-mail:hill0936@mailszrz.zrz.tu–berlin.de

(with 3 text–figures, 3 tables and 10 plates)

Ammonites of Bajocian age are found in Northern Chile at many localities, but sections with ammonite beds of different age of this stage are rare. The Bajocian is subdivided in ammonite horizons. The distinguishable number of horizons is much smaller than that in Europe and corresponds to the quantity of zones or subzones occuring there. Faunal diversity is much lower than in Europe and many of the South American species are likely to have a longer biostratigraphic range. The lower diversity is probably caused by the special paleogeographic and biogeographic back arc basin situation. The entrance to this basin was restricted and its dimensions was much smaller than the huge area of the European shelf with a high potential of ecologic possibilties.

Proof of the European Discites Zone is difficult. The Ovalis Zone is represented only by one horizon. The Laeviuscula to Subfurcatum Zones can each be subdivided into two horizons. It is not easy to ascertain the middle and upper part of the Upper Bajocian because ammonites of this age are very rare, endemic or unsuitable for an exact age determination.

Two new species are described being important for the biostratigraphy of the lowest Upper Bajocian.

Introduction

STEINMANN (1881) and MÖRICKE (1894) were the first to decribe and figure Bajocian ammonites from northern Chile. WESTERMANN & RICCARDI (1972, 1979) and RICCARDI & WESTERMANN (1991) published monographs on Middle Jurassic ammonites of the Argentine–Chilean Andes. These authors described Bajocian ammonites mainly from Argentina but also some Chilean localities were considered, and they included some ammonites of Bajocian age collected in northern Chile by the author. COVACEVICH & PIRACES (1976) described ammonites of Late Bajocian age from Central Chile and DAVIDSON et al. (1976) those of Lower Bajocian age from Northern Chile. The author (1977) published a new genus and some new species of the Stephanoceratidae from the Bajocian of Northern Chile. WESTERMANN & RICCARDI (1980) described *Strenoceras* and FERNÁNDEZ–LÓPEZ et al. (1994) Late Bajocian and Bathonian ammonites from Northern Chile. KOSSLER (1998) published Bajocian ammonites in her thesis on the Jurassic of the Coastal Cordillera of Iquique, Northern Chile. Ammonites of Bajocian age from Chile were also refigured in WESTERMANN (1992). Additionally, many authors (e.g. in explanations of geological maps) mentioned Bajocian ammonites from different sections and localities of Northern Chile.

The author investigated many sections and localities in Northern Chile with Bajocian ammonites in the period of 1966 to 1997. Only part of the material collected was published up to now.

This paper gives just an overall view of the most important sections and localities with Bajocian ammonites found in Northern Chile and known by the author. An attempt is made to subdivide the Bajocian of Northern Chile into ammonite horizons.

Only part of the existing ammonite material can be figured. Mainly ammonites of the upper part of the Lower and the lower part of the Upper Bajocian are selected because the ammonites of this stratigraphic period are not yet well known from South America and less well represented in Argentina. Stephanocerataceae are mainly considered because of their considerable importance for the biostratigraphy and correlation with Europe. Sonniniidae are frequent up to a horizon that can be correlated with the lower part of the European Humphriesianum Zone. Being very important for the biostratigraphy of the Lower Bajocian and the correlation with Europe, they shall be described separately.

Description of sections and localities

Many sections and localities with Bajocian ammonites are found in Northern Chile. Frequently only a single bed, sometimes a few beds with ammonites of this age occur. Sections with several ammonite horizons, subzones and zones are rarely found. Often the sections are folded, faulted or not well exposed and not useful for biostratigraphic investigations. Many localities yielded only poorly preserved ammonites which could not be determined on the species level and sometimes not even on the generic level.

Only sections and localities yielding Bajocian ammonites of biostratigraphic or taxonomic value are described. Most of the sections und localities are

known from literature but only part of the ammonites found there was figured.

The sections and localities are described from north to south (Fig. 1).

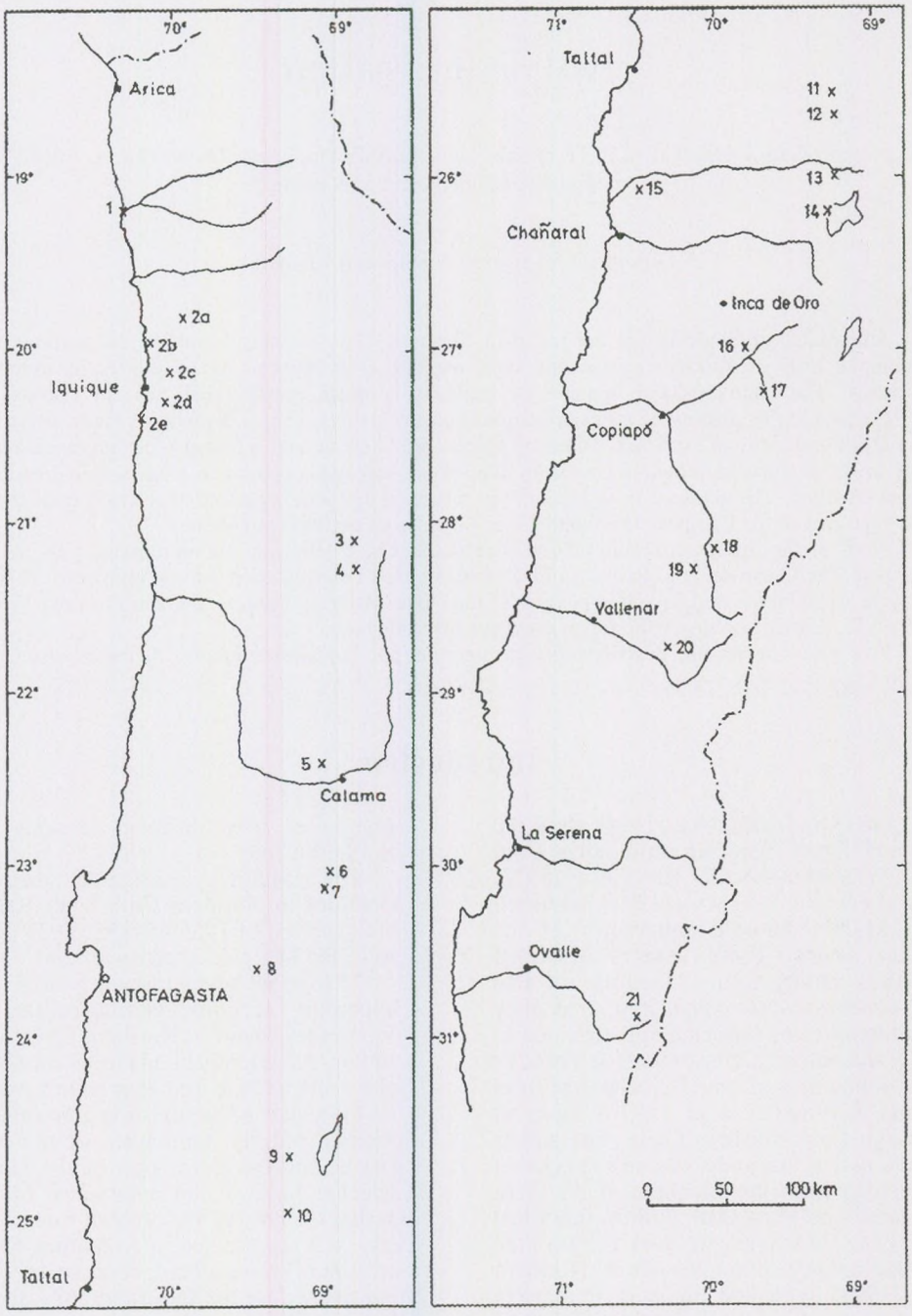

Fig. 1. Map of Northern Chile with Bajocian ammonite localities described. Locality numbers correspond to numbers in the text.

1. Caleta Camarones

The bay called Caleta Camarones is situated 80 km south of Arica. It is the northernmost Chilean outcrop with ammonites of Bajocian age. The locality was first mentioned by CECIONI & GARCIA (1960). The section was studied in detail by Sonja WITTMAN (TU–Berlin, thesis in preparation).

Volcaniclastic sediments are intercalated in volcanic rocks. The beds with ammonites are approximately 6 m thick and yielded the following ammonites (det. S. WITTMANN):

Lupherites dehmi (HILLEBRANDT)
Teloceras (?) sp.
Spiroceras orbignyi (BAUGIER & SAUZÉ)
Spiroceras sp.
Megasphaeroceras sp.

The coiled *Spiroceras* have a diameter of up to 27 cm. At the beginning, the diameter of the shell is 0.5 cm and at the end 4 cm.

The assemblage is of lower Late Bajocian age (*L. dehmi* Horizon).

2. Area of Iquique

Ammonites of Bajocian age from this area were first described by MÖRICKE (1894) and later on by various other authors. KOSSLER (1998) recently studied this area in detail and described Bajocian ammonites from many sections south, north and east of Iquique (Fig. 1, loc. 2a–e). The Humphriesianum Zone was proved with *Sphaeroceras*? sp. at one section. Mainly the *L. dehmi* Horizon, but probably also the *Leptosphinctes* Horizon (= Rotundum Zone in KOSSLER 1998) were found at different sections.The following ammonites were described:

Duashnoceras chilense (HILLEBRANDT)
Lupherites dehmi (HILLEBRANDT)
Teloceras ex gr. *crickmayi chacayi* WESTERMANN & RICCARDI
Megasphaeroceras magnum RICCARDI & WESTERMANN
M. spissum RICCARDI & WESTERMANN
Spiroceras sp.
Leptosphinctinae gen. et sp. indet.

Caumontisphinctes? sp. (? *Leptosphinctes* Horizon) was found approximately 90 m above a bed with *Duashnoceras chilense* (probably *L. dehmi* Horizon).

3. Quebrada Llaretuno

This valley is one of the tributaries of the Quebrada de Tambillo (or Seca) which crosses the Sierra de Moreno. Bajocian ammonites from north of Quebrada Llaretuno (21°31' – 68°52'30") were first cited by MAKSAEV (1978, tab. 1) (det. V. COVACEVICH). Ammonites from the same locality were collected by M. Gröschke in 1983. Two beds were found in a distance of 1 to 2 metres.

Lower bed: *Chondroceras* sp. A, *Oppelia* cf. *subradiata* (SOW.), *Dorsetensia* sp.

Upper bed: *Stephanoceras* ex gr. *St. pyritosum* (QUENSTEDT).

The ammonites of both beds are typical for the *Dorsetensis* ssp. Horizon.

4. Jurassic west of Cerro Jaspe

A Jurassic belt that can be traced from north to south for more than 20 kilometres is exposed east of the Sierra de Moreno and west of Cerro Jaspe. Sections from this belt were described by GRÖSCHKE & WILKE (1986), GRÖSCHKE & PRINZ (1986) and PRINZ (1991).

Bajocian ammonites were cited by GRÖSCHKE & WILKE (1986) from three sections of the northern part and by PRINZ (1991) additionally from one section in the southern part. The sections are numbered 1 to 7 in PRINZ (1991) (sections 1 to 3 are the same as in GRÖSCHKE & WILKE 1986):

Section 1 (beds from below to above):

1. Stephanoceratinae gen. et sp. indet.
2. *Chondroceras* sp. A, *Teloceras* s.l.
3. *Stephanoceras* ex. gr. *St. pyritosum* (QUENSTEDT), *Teloceras* (?) sp.
4. *Megasphaeroceras magnum* RICCARDI & WESTERMANN
5. *Megasphaeroceras spissum* RICCARDI & WESTERMANN, *Spiroceras orbignyi* (BAUGIER & SAUZÉ) (Pl. 9, figs 5A, B), *Leptosphinctes* cf. *leptus* BUCKMAN (Pl. 9, figs 7A, B; text–fig. 3b)

Section 2 (beds from below to above):

1 *Fissilobiceras* (?) sp.
2. and 3. *Emileia* cf. *giebeli* (GOTTSCHE),
4. and 5. *Sonninia* cf. *espinazitensis* TORNQUIST
6. *Teloceras* (?) sp.
7 *Duashnoceras chilense* (HILLEBRANDT), *Duashnoceras profetaense* n.sp.
8. *Duashnoceras* (?) sp.
9. *Megasphaeroceras* cf. *magnum* RICCARDI & WESTERMANN
10. *Cadomites* (?) sp.

Section 3 (beds from below to above):

1 *Sonninia* sp.
2. *Duashnoceras* (?) sp.
3. *Teloceras* (?) cf. *chacayi* WESTERMANN & RICCARDI, *Spiroceras* sp.
4. *Lupherites* sp. or *Duashnoceras* sp., *Spiroceras* sp.
5. *Megasphaeroceras spissum* RICCARDI & WESTERMANN
6. *Leptosphinctes* sp.
7 *Leptosphinctes* sp., *Megasphaeroceras magnum* R. & W., *M.* cf. *spissum* R. & W

Section 6 (beds from below to above):

1. Stephanoceratinae gen. et sp. indet.
2. Stephanoceratinae gen. et sp. indet., *Spiroceras* sp.
3. *Duashnoceras* cf. *chilense* (HILLEBRANDT), *Megasphaeroceras* sp.
4. *Teloceras* (?) sp.
5. *Duashnoceras*(?) *burroense* n.sp. (Pl. 8, figs 3A, B)
6. *Teloceras* (?) cf. *chacayi* WESTERMANN & RICCARDI,
7. *Megasphaeroceras magnum* (RICCARDI & WESTERMANN), *Leptosphinctes* sp.
8. *Leptosphinctes* sp.
9. *Megasphaeroceras spissum* RICCARDI & WESTERMANN
10. *Leptosphinctes* sp.
11 *Cadomites* (?) sp., *Megasphaeroceras* (?) sp.
12. *Megasphaeroceras* (?) sp.
13. *Cadomites* (?) sp., "*Cadomites/Garantiana*" sp., *Cobbanites* cf. *talkeetnanus* IMLAY

The following ammonite horizons could be proved in the Cerro Jaspe Jurassic:

E. giebeli giebeli Horizon (section 2 beds 1?, 2 to 5; section 3 bed 1)
Dorsetensia ssp. Horizon (section 1 beds 2, 3)
Duashnoceras caracolensis Horizon (section 2 bed 6?; section 3 bed 2?)
Lupherites dehmi Horizon (section 1 bed 4?; section 2 beds 7, 8?; section 3 beds 3, 4; section 6 beds 2 to 6)
Leptosphinctes Horizon (section 1 bed 5; section 2 bed 9?; section 3 beds 5?, 6, 7; section 6 beds 7 to 10)
?*Megasphaeroceras* Horizon (section 6 beds 11?, 12, 13?)
"*Cobbanites*" Horizon (section 6 bed 13)

The *Duashnoceras caracolensis* Horizon could not be proved with certainty. Bed 13 of section 6 is probably of Early Bathonian age.

5. Sierras de San Lorenzo

The Sierras de San Lorenzo are situated north of the Rio San Salvador and approximately 13 km east of Calama. Hettangian to Oxfordian marine sediments are exposed on the western and eastern side of an anticline. Bajocian strata occur in the valley west of the Sierras de San Lorenzo, north and west of point 2560 (topographic map 1:50 000, Cerros de Montecristo). Below these strata beds with Aalenian ammonites are exposed and above beds with Bathonian ammonites (GRÖSCHKE & HILLEBRANDT 1994). Reddish marls with two beds of calcareous concretions at a distance of one metre contain the following ammonites:

Stephanoceras exgr. *St. pyritosum* (QUENSTEDT)
(Pl. 2, figs 1–3, Pl. 4, fig. 2)

Chondroceras sp. A
(Pl. 2, figs 5, 6).

These beds prove the *Dorsetensia* ssp. Horizon.

A similar bed with *Stephanoceras* sp. (Pl. 4, fig. 3) and *Chondroceras* sp. A (Biese collection, National Museum of Natural History, Washington) was found at Cerritos Bayos, south of the Sierras de San Lorenzo. This bed corresponds to the "*Sphaeroceras*–Bank" of BIESE (1957). The "*Ctenostreon*–Bänke" of BIESE (1957) are of Aalenian age and the "Stephanoceraten–Kalk" (=*Peronoceras*) of the same author is of Middle Toarcian age (s.a. GRÖSCHKE & HILLEBRANDT 1994).

6. Caracoles

Many sections and outcrops with Middle to Upper Jurassic ammonites are found in the surroundings of the old silver mine Caracoles. Bajocian ammonites of this classical locality were described by STEINMANN (1881), HILLEBRANDT (1977) and WESTERMANN & RICCARDI (1979, 1980).

WESTERMANN & RICCARDI (1979, 1980) described and figured Bajocian ammonites from a section southwest of Cerro Torcazas that characterize mostly the *Duashnoceras caracolense* Horizon. Above beds with ammonites of this age were found *Strenoceras* cf. *latisulcatum* (QUENSTEDT) (= *Strenoceras* cf. *suevicum* DIETL 1983) and *Cadonites* n.sp. B aff. *C. deslongchampsi* (D'ORBIGNY). These ammonites are of Late Bajocian age (Subfurcatum Zone, probably *Leptosphinctes* Horizon). *Strenoceras suevicum* DIETL was found in the Baculata Subzone (upper subzone of the Niortense (= Subfurcatum) Zone of Southwest Germany (DIETL 1983).

The author studied a section approximately 1 km north of Cerro Torcazas (point 3035, topographic map 1 50 000, Cerros de Caracoles). The first ammonites were found approximately 120 m above the base (beds from below to above):

1. Stephanoceratinae gen. et sp. indet.
2. *Duashnoceras* sp.
3. *Duashnoceras caracolense* (WESTERMANN & RICCARDI) (micro– and macroconch) (Pl. 3, figs 1, 2), *Teloceras* (?) sp.
4. *Duashnoceras* sp., *Teloceras* (?) sp.
5. *Cadomites* sp., Eurycephalitidae gen. et. sp. indet.

Beds 1 to 4 (approx. 120 m thick) are of Bajocian age, at least beds 2 and 3 belong to the *D. caracolense* Horizon. Bed 5 (approx. 30 m above bed 4) is probably of Bathonian age.

Taxonomic note: STEINMANN (1881, pl. 12, fig. 7) described and figured from Caracoles a specimen he named "*Stephanoceras Humphriesianum*" This specimen was included in *Stephanoceras* (= *Duashnoceras*) *chilense* by HILLEBRANDT (1977) but probably it is the microconch of *Duashnoceras caracolense* (WESTERMANN & RICCARDI). A second, not figured, specimen of the STEINMANN collection was included in *Stephanoceras* (= *Duashnoceras*) *andinense* (HILLEBRANDT 1977). The holotype of *Duashnoceras chilense* (HILLEBRANDT) is the phragmocone of an incomplete macroconch from the *Lupherites dehmi* Horizon. *Duashnoceras caracolense* und *D. chilense* are different species from different horizons.

7. Quebrada San Pedro

The Jurassic area of Quebrada San Pedro is situated about 10 km south of Placilla de Caracoles. Ammonites of Late Bajocian to Oxfordian age are found.

The Late Bajocian to Early Callovian part of a section was described by JENSEN & QUINZIO (1981) and RICCARDI & WESTERMANN (1991). The Oxfordian part was published by GYGI & HILLEBRANDT (1991). FERNÁNDEZ–LÓPEZ et al. (1994) and GRÖSCHKE & HILLEBRANDT (1994) described the Bajocian to Bathonian part of the section described by JENSEN & QUINZIO (1981) and RICCARDI & WESTERMANN (1991).

FERNÁNDEZ–LÓPEZ et al. (1994) cite from the lower part of the section (SP33 – SP45 (= a_3 JENSEN & QUINZIO 1981 and sample 790321/2 in RICCARDI & WESTERMANN 1991) ammonites that are typical for the *Lupherites dehmi* Horizon and the *Leptosphinctes* Horizon (*Cadomites*, *Leptosphinctes*).

Only flattened impressions of ammonites occur in the following silty limestones and lutites (SP47 – SP87 in FERNÁNDEZ–LÓPEZ et al. 1994 = lower part of a_4 in JENSEN & QUINZIO 1981). These beds are probably of Late Bajocian age.

In the upper part of bioclastic limestones and lutites (SP87 – SP115 in FERNÁNDEZ–LÓPEZ et al. 1994 = upper part of a_4 in JENSEN & QUINZIO 1981) Eurycephalitidae are frequent which were determinated as *Megasphaeroceras magnum* by RICCARDI & WESTERMANN (1991) (sample 790321/3) and FERNÁNDEZ–LÓPEZ et al. (1994). The specimen figured as *Duashnoceras* aff. *undulatum* by FERNÁNDEZ–LÓPEZ et al. (1994) belongs probably to *Zigzagiceras* (?). Similar specimens were described by GRÖSCHKE & HILLEBRANDT (1994) from the Lower Bathonian. At least the ammonite fauna of beds SP101 – SP115 (FERNÁNDEZ–LÓPEZ et al. 1994) is probably not of late Bajocian but of Early Bathonian age. The specimen figured as *Strenoceras* sp. (FERNÁNDEZ–LÓPEZ et al. 1994, pl. 1, fig. 7) is not well enough preserved as to ensure this genus. *Xenocephalites* cf. *araucanus* (BURCKHARDT) is also cited from these beds. Up to now was described only from the Bathonian. This species *Megasphaeroceras magnum* and some species of *Eurycephalites* (mainly *E. steinmanni*) are very similar and the Eurycephalitids of these beds should be restudied. At least the ammonites of beds SP125 –

SP131 (FERNÁNDEZ–LÓPEZ et al. 1994) and samples 790321/4 to 8 (RICCARDI & WESTERMANN 1991 and GRÖSCHKE & HILLEBRANDT 1994) are of Middle Bathonian age.

8. Cerro Amarillo

GRÖSCHKE & HILLEBRANDT (1985, p.141, fig. 3a) described the Jurassic of this area. Bajocian ammonites are found at the localities 2 and 3. Four beds can be distinguished (from below to above):

1. *Emileia giebeli* s.l. (GOTTSCHE), *Sonninia* sp.
2. *Teloceras* (?) sp., *Chondroceras* sp., *Dorsetensia* cf. *liostraca* BUCKMAN
3. *Duashnoceras caracolense* (W. & R.), *Teloceras* (?) sp., *Megasphaeroceras* (?) sp.
4. *Teloceras* (?) sp., *Spiroceras* sp.
5. *Megasphaeroceras* sp., *Leptosphinctes* sp.

Bed 1 belongs to the *E. giebeli* Horizon, bed 2 to the *Dorsetensia* ssp. Horizon, bed 3 can probably be correlated with the *D. caracolense* Horizon, bed 4 with the *L. dehmi* Horizon, and bed 5 with the *Leptosphinctes* Horizon.

9. Aguada El Oro

BOGDANIC (1983) first described Jurassic sections of this area. Ammonites of Bathonian age were figured by GRÖSCHKE & HILLEBRANDT (1994), of Late Callovian and Early Oxfordian age by HILLEBRANDT & GRÖSCHKE (1995) and of Oxfordian age by GYGI & HILLEBRANDT (1991).

Four beds with Bajocian ammonites can be distinguished (from below to above):

1. *Sonninia espinazitensis* s.l.
2. *Duashnoceras andinense* (HILLEBRANDT) (Pl. 4, fig. 1), *D. caracolense* (WESTERMANN & RICCARDI.) (Pl. 2, figs 10, 11), *Chondroceras* sp. B (Pl. 2, fig. 9; Pl. 3, fig. 5; Pl. 4, fig. 5)
3. *Lupherites dehmi* (HILLEBRANDT), *Duashnoceras chilense* (HILLEBRANDT), *Spiroceras* sp., *Megasphaeroceras magnum* RICCARDI & WESTERMANN

The author received additionally Late Bajocian ammonites from Dr. G. CHONG D: (Universidad Católica del Norte, Antofagasta): *Teloceras* cf. *chacayi* WESTERMANN & RICCARDI, *Duashnoceras chilense* (HILLEBRANDT), *Orthogarantiana* cf. *conjugata* (QUENSTEDT), *Megasphaeroceras* (?) sp. A and *Leptosphinctes* sp..

Bed 1 belongs to the *E. giebeli* Horizon, bed 2 to the *D. caracolense* Horizon and bed 3 to the *L. dehmi* Horizon. *Leptosphinctes* sp. proves the *Leptosphinctes* Horizon. The very involute and coarsely ribbed *Megasphaeroceras* (?) sp. A (Pl. 10. figs 3A, B) was found in younger beds (*Megasphaeroceras* (?) Horizon).

10. Profeta Jurassic

The Jurassic outcrops at the upper course of the Quebrada del Profeta are called Profeta Jurassic. This area was mapped in detail by BOGDANIC (1983). The Jurassic is exposed in a wide syncline. The center of this syncline is built by Oxfordian and Kimmeridgian sediments and an evaporite at the Oxfordian/Kimmeridgian boundary. At the eastern end of the syncline, Lower Jurassic marine and Triassic terrestrial and marine sediments are faulted against and overthrusted by Paleozoic rocks of the Sierra de Varas. Mainly the Middle Jurassic and Oxfordian sediments show special folding, in part with isoclinal folds and imbricate structures. In the westernmost part Bajocian sediments are faulted against younger rocks.

Kimmeridgian ammonites were described and figured by FÖRSTER & HILLEBRANDT (1984), Oxfordian ammonites by GYGI & HILLEBRANDT (1991), HILLEBRANDT & GRÖSCHKE (1995) and HILLEBRANDT et al. (2000), Bathonian ammonites by FERNÁNDEZ–LÓPEZ et al. (1994) and GRÖSCHKE & HILLEBRANDT (1994), Bajocian ammonites by HILLEBRANDT (1977) and FERNÁNDEZ–LÓPEZ et al. (1994), Aalenian ammonites by BOGDANIC et al. (1985) and Early Jurassic ammonites by QUINZIO (1987) and HILLEBRANDT (2000).

The Bajocian sediments consist mainly of marls with calcareous concretions that often contain well–preserved ammonites.

Quebrada Aguada del Minero (western part)

The Bajocian localities described by HILLEBRANDT (1977, fig. 1, loc. 4 and 5) are situated in the westermost part of the Profeta syncline. Locality 4 is found 1.6 km SSW of point 3197 (topographic map 1 : 100 000, Sierra de Varas), immediately north of one of the main valleys called Quebrada Aguada del Minero and crossing the Profeta Jurassic.

The ammonite beds are repeated at locality 4 by isoclinal folding inclined to the east. Three ammonite horizons can be distinguished (from below to above):

1. *Duashnoceras chilense* (HILLEBRANDT) (Pl 5, fig. 2), *D. profetaense* n.sp. (Pl. 5, fig. 5, Pl. 6, figs 2–4; text–fig. 3a), *Lupherites dehmi* (HILLEBRANDT), *L.*(?) *chongi* (HILLEBRANDT), *Teloceras* cf. *chacayi* WESTERMANN & RICCARDI, *Teloceras*(?) sp., *Spiroceras orbignyi* (BAUGIER & SAUZÉ) (Pl. 9, fig. 4), *Megasphaeroceras magnum* (RICCARDI & WESTERMANN), *M. spissum* (R. & W.)
2. *Cadomites* sp. ex gr. *Cadomites. psilacanthus/ deslongchampsi* (Pl. 9, figs 6A, B), *Megasphaeroceras magnum* (RICCARDI & WESTERMANN), *Leptosphinctes* cf. *leptus* BUCKMAN (Pl. 10, figs 1, 2),
3. *Megasphaerocras* (?) sp. A (Pl. 10, figs 4A, B)

Horizon 1 belongs to the *L. dehmi* Horizon, horizon 2 to the *Leptosphinctes* Horizon and horizon 3 to the *Megasphaeroceras* (?) Horizon.

Aguada Colorada

Locality 5 in HILLEBRANDT 1977 (fig. 1) is situated 3.4 km to the north of locality 4 and corresponds to the basal part of the section described by FERNÁNDEZ–LÓPEZ et al. (1994) as section Aguada Colorada.

HILLEBRANDT (1977) figured from this locality *Duashnoceras chilense* (HILLEBRANDT) (Pl. 3, fig. 3), *Lupherites dehmi* (HILLEBRANDT) and *L.*(?) *chongi* (HILLEBRANDT). *Teloceras*(?) sp. (Pl. 5, fig. 3) and *Duashnoceras profetaense* n. sp. (Pl. 5, fig. 4) were also found at this locality. RICCARDI & WESTERMANN (1991) mentioned *Megasphaeroceras magnum* RICCARDI & WESTERMANN and *M. spissum* RICCARDI & WESTERMANN from the same locality (TUB–3–070672).

FERNÁNDEZ–LÓPEZ et al. (1994) described additionally from this locality *Liroxyites* cf. *kellumi* IMLAY, *Oppelia* cf. *subradiata* (SOW.),

Orthogarantiana? sp., *Spiroceras orbignyi* (BAUGIER & SAUZÉ) and *Leptosphinctes (Leptosphinctes)* sp.. At least the *D. dehmi* Horizon is proposed at locality 5. The ammonites of the levels AC3 – AC5 (FERNÁNDEZ–LÓPEZ et al. 1994) are of Late Bajocian or Early Bathonian age and those of the levels AC7 – AC8 are of Early Bathonian and not of Late Bajocian age as proposed by FERNÁNDEZ–LÓPEZ et al. (1994).

Quebrada Aguada del Minero (eastern part)

Bajocian sediments are also found on the eastern side of the Oxfordian/Kimmeridgian syncline where they are exposed between Aalenian and Bathonian sediments.

A short and overturned section is exposed north of Quebrada Aguada del Minero (approx. 900 metres east of point 3616).

From below to above (in stratigraphic sense) following ammonite horizons can be distinguished:

1. Beds with *Emileia* sp. and *Sonninia espinazitensis* TORNQUIST (*E. giebeli giebeli* Horizon).
2. Bed with *Dorsetensia* cf. *romani* (OPPEL) (*Dorsetensia* Horizon).
3. Bed with *Duashnoceras* cf. *andinense* (HILLEBRANDT) (*D. caracolense* Horizon).
4. Beds with Stephanoceratinae, *Megasphaeroceras* and *Leptosphinctes* (*L. dehmi* and *Leptosphinctes* Horizons).

Aguada Profeta

North of Aguada Profeta, a Bajocian section is exposed with the following beds (from below to above):

1. Beds with *Emileia multiformis* (GOTTSCHE) and *Sonninia espinazitensis* TORNQUIST (*E. giebeli giebeli* Horizon).
2. Bed with ?*Skirroceras* sp. (? *Dorsetensia* Horizon)
3. Beds with Stephanoceratinae gen. et sp. indet. (? *D. caracolense* Horzon)
4. Bed with *Lupherites dehmi* (HILLEBRANDT) and *Megasphaeroceras* sp. (*L. dehmi* Horizon).
5. Bed with *Cadomites* (?) sp. and *Megasphaeroceras* (?) sp. A (? *Megasphaeroceras*(?) Horizon).

Additionally, the author received a specimen of *Orthogarantiana* cf. *conjugata* (QUENSTEDT) (macroconch) (Pl. 10, figs 5A, B) from Dr. Th. BOGDANIC (formerly Universidad Católica del Norte, Antofagasta) not found in situ at Quebrada Vizcachas (southernmost part of the Profeta Jurassic, topographic map 1 : 100 000, Sierra Vaquillas Altas).

11. Quebrada del Puntiagudo

The Quebrada del Puntiagudo is the type locality of *Duashnoceras andinense* (HILLEBRANDT, 1977, fig. 1, loc.3), occuring together with *Teloceras*(?) sp. and *Eocephalites*(?) cf. *primus* IMLAY (RICCARDI & WESTERMANN 1991, p.98, pl. 30, figs 2, 3). The locality was said to be of Late Bajocian age (Subfurcatum Zone) but *Duashnoceras andinense* is more typical for the *D. caracolense* Horizon.

12. Area between Quebrada Incaguasi and Quebrada Agua de La Piedra

In this area the type localities of *Lupherites dehmi* (HILLEBRANDT) and *Duashnoceras chilense* (HILLEBRANDT) (HILLEBRANDT 1977, fig. 1, loc. 1 and 2) appear. Sinemurian to Oxfordian sediments are exposed from east to west. The central and western part of this Jurassic belt with Toarcian to Oxfordian sediments is mainly repeated by folding and faulting. Ammonites of this area were figured as follows: Late Sinemurian ammonites by HILLEBRANDT (1981), Toarcian ammonites by HILLEBRANDT (1987), Bajocian ammonites by HILLEBRANDT (1977) and Oxfordian ammonites by HILLEBRANDT et al. (2000).

A typical fauna of the *L. dehmi* Horizon was found in lutites with calcareous concretions approximately 2.1 km south of the type locality of *Lupherites dehmi* and approximately 1.85 km north of Co. Agua de La Piedra (topographic map 1 : 100 000, Exploradora) (in continuation along the strike of the type locality of *L. dehmi*):

Duashnoceras chilense (HILLEBRANDT) (Pl. 5, figs 1A, B), *D. profetaense* n.sp., *Lupherites dehmi* HILLEBRANDT), *Teloceras*(?) sp. (Pl. 9, figs 3A, B) and *Megasphaeroceras* sp..

Sonninia cf. *espinazitensis* TORNQUIST and *Emileia* sp. (*E. giebeli giebeli* Horizon) occur approximately 1 km southwest of this locality and probably separated by folding and faulting.

Approximately 900 m west of this locality and approximately 1.7 km northwest of Co. Agua de La Piedra once more Bajocian beds are found. Mainly Toarcian and ?Aalenian sediments crop out between both localities. The locality is situated along the strike of the type locality of *D. chilense*, approximately 3km to the north. 5 to 10 m above beds (lutites with large calcareous concretions) with *Sonninia* cf. *espinazitensis* TORNQUIST a bed (lutites with small calcareous concretions) with the following ammonites is exposed:

Stephanoceras ex gr. *St. umbilicum* (QUENSTEDT) (Pl. 2, figs 4A, B), *Chondroceras* sp. A (Pl. 2, figs 7, 8) and *Dorsetensia*(?) sp.

This faunule belongs probably to the *Dorsetensia* ssp. Horizon.

13. Quebrada de Los Burros

The Quebrada de Los Burros is situated at the southern end of the topographic map 1 : 100000, Exploradora. The Lower Jurassic is mainly exposed in this valley and the Middle to Upper Jurassic series are found southeast of it. The complete Jurassic series are more than 2000 m thick. The Bathonian beds were described by GRÖSCHKE & HILLEBRANDT (1994) and ammonites of Late Callovian to Middle Oxfordian age by HILLEBRANDT & GRÖSCHKE (1995).

Beds with ammonites of Bajocian age occur in the lower part of a side valley of the Quebrada de Los Burros, 1.6 km south of point 3837. A series of marls containing several beds with calcareous concretions and Bajocian ammonites is exposed approximately 130 m above a bed with *Bredyia* of Early Aalenian age. The Bajocian beds are at least 250 m thick and the uppermost part is composed of calcareous arenites (layered centimetre to decimetre). From below to above following beds can be distinguished:

1. *Dorsetensia* cf. *liostraca* BUCKMAN
2. *Dorsetensia* cf. *liostraca* BUCKMAN, *D.* cf. *subtecta* BUCKMAN
3. *Dorsetensia* cf. *deltafalcata* (QUENSTEDT)

4. *Duashnoceras andinense* (HILLEBRANDT), *Chondroceras* sp. B
5. *Duashnoceras*(?) *burroense* n.sp. (Pl. 8, figs 2A, B)
6. *Duashnoceras*(?) sp., *Megasphaeroceras* (?) sp.
7 *Cadomites*(?) sp., *Megasphaeroceras*(?) sp.

Beds 1 to 3 belong to the *Dorsetensia* ssp. Horizon, bed 4 to the *D. caracolense* Horizon, bed 5 and ?6 to the *L. dehmi* Horizon and bed 7 probably to the *Leptosphinctes* Horizon.

The following series with more or less sandy limestones and volcanoclastic sediments are of Bathonian age (with Eurycephalitidae).

14. Salar de Pedernales

WESTERMANN & RICCARDI (1972, 1979) described and figured Bajocian ammonites (partly collected by the author) from the northwestern part of the Salar de Pedernales. These ammonites are found above beds with Aalenian ammonites and below beds with Callovian ammonites. Sediments between the Bajocian and Callovian beds contained no ammonites.

The following ammonites of Bajocian age are described by WESTERMANN & RICCARDI (1979):

Stephanoceras aff. *humphriesianum* (SOW.), *St. pyritosum* (QUENSTEDT), *St.* aff. *frechi* (RENZ), *Dorsetensia* aff. *deltafalcata* (QUENSTEDT) and *D. tecta* BUCKMAN.

This ammonite assemblage belongs to the *Dorsetensia* ssp. Horizon.

15. Sierra Minillas

The Sierra Minillas is part of the Coastal Cordillera. Volcanic rocks with intercalations of volcanoclastic sediments are exposed on the western side of the Sierra Minillas. The sediments are in part rich in fossils. Two beds with ammonites were described by DAVIDSON et al. (1976). Both beds can be correlated with the European Sauzei Zone, probably the upper part (*Skirroceras* Horizon). NARANJO (1978b) additionally named from this locality *Sonninia* cf. *espinazitensis* TORNQUIST (= ? *E. giebeli giebeli* Horizon) and NARANJO (1978a) figured a complete and well–preserved *Skirroceras.*

The author found a tuffaceous bed (10 cm thick) with frequent *Chondroceras* cf. sp. A (= ? *Dorsetensia* ssp. Horizon) in the uppermost part of these volcanoclastic rocks.

16. Sierra Fraga

Ammonites of Bajocian age were figured by DAVIDSON, GODOY & COVACEVICH (1976) from the Sierra Fraga. The authors distinguished three levels: A lower level with *Stephanoceras (Skirroceras)* sp., a middle one with *Sonninia* indet. and *Pseudotoites* sp. and an upper level without ammonites. They found *Teloceras* sp. in the Quebrada Pulpo. These ammonites at least prove the European Sauzei and Humphriesianum Zones.

The author found a section with several ammonite beds in the Quebrada Pulpo. Following beds can be distinguished from below to above:

1 and 2. *Dorsetensia* sp.
3. *Stephanoceras* ex gr. *St. umbilicum* (QUENSTEDT), *Chondroceras* cf. sp. A
4. *Duashnoceras* sp., *Chondroceras* sp. B

Beds 1 and 2 and probably also bed 3 belong to the *Dorsetensia* ssp. Horizon and bed 4 to the *D. caracolense* Horizon.

Emileia sp. (microconch) and *Sonninia* s.l. (= *E. giebeli giebeli* Horizon) were found at the Quebrada Corrales, near to the end of this valley and north of the pass crossing the Sierra Fraga.

17. Quebrada San Pedrito

A Toarcian to Bajocian section is exposed at the confluence of the Quebrada San Pedrito with the Quebrada Pelada (HILLEBRANDT 1973, p. 176). Intercalated in marls, a calcareous, lenticular concretion containing a rich and well–preserved Bajocian fauna (*Bositra* and ammonites) was found:

Emileia (Chondromileia) giebeli submicrostoma (GOTTSCHE) (micro– and macroconchs) (Pl. 1, figs 3, 4), *Euhoploceras* sp., *Pelekodites* ssp. and *Fissilobiceras*(?) sp..

This assemblage belongs to the *E. giebeli submicrostoma* Horizon.

18. Manflas

Many Lower to Middle Jurassic sections and outcrops of this famous locality are exposed south of the Hacienda Manflas. MÖRICKE (1894) was the first to describe Bajocian ammonites from this area, however not realizing that two iron–oolites exist, one of Early Aalenian and one of lower Late Bajocian age. Ammonites of Aalenian and Bajocian age were described by WESTERMANN & RICCARDI (1972), of Bajocian age by HILLEBRANDT (1977) and WESTERMAN & RICCARDI (1979) and Aalenian age by HILLEBRANDT & WESTERMANN (1985).

The author investigated various Bajocian sections south and southeast of the Hacienda Manflas (HILLEBRANDT 1977, fig. 2, loc. 1 to 6; HILLEBRANDT & WESTERMANN 1985, fig. 4, loc. 1 to 5).

The Jurassic east and south of the Hacienda Manfls is divided by a N–S fault. The two blocks differ little in facies, the western block having a thicker and more arenaceous development particularly in the Sinemurian. Facies differences are marked mainly in the Toarcian and Aalenian. The Jurassic of the western block from the uppermost Toarcian to the Callovian and some of the Bajocian ammonites were described by WESTERMANN & RICCARDI (1972, 1979). Aalenian and Bajocian ammonites of both blocks were described by HILLEBRANDT (1977) and HILLEBRANDT & WESTERMANN (1985).

Aalenian

The Puchenquia compressa and P mendozana Subzones of Late Aalenian age were proved at different localities. The *Podagrosiceras maubeugei* Horizon of latest Aalenian or earliest Bajocian age was only found at Portezuelo El Padre (HILLEBRANDT & WESTERMANN 1985, fig. 4, loc. 6).

Pseudotoites singularis Horizon

The *P singularis* Horizon occur at locality 4 (HILLEBRANDT & WESTERMANN 1985, Fig.4) with the following species:

Pseudotoites singularis (GOTTSCHE) (micro– and macroconchs), *P.* cf. *argentinus* (TORNQUIST), *Fissilobiceras*(?) *zitteli* (GOTTSCHE).

Pseudotoites sphaeroceroides Horizon

Some metres above the bed with ammonites of the *P singularis* Horizon a bed with ammonites of the *P sphaerocroide*s Horizon appears:

Pseudotoites sphaeroceroides (TORNQUIST) (macroconch), *P.* cf. *corona* ARKELL & PLAYFORD (macroconch), *Emileia* cf. *quenstedti* WESTERMANN (macroconch), *Sonninia altecostata* TORNQUIST.

Emileia giebeli submicrostoma and *Emileia giebel giebeli* Horizons

On the ridge of Cerro de La Cuesta (HILLEBRANDT & WESTERMANN 1985, fig. 4, loc. 2) a section contains from below to above:

1. Lowest bed with *Emileia* cf. *brocchii* (SOW.)
2. 10 m higher several beds with *Sonninia espinazitensis* TORNQUIST
3. 15 m higher bed with *Emileia (Chondromileia) giebeli giebeli* (GOTTSCHE) (Pl. 1, figs 1, 2)

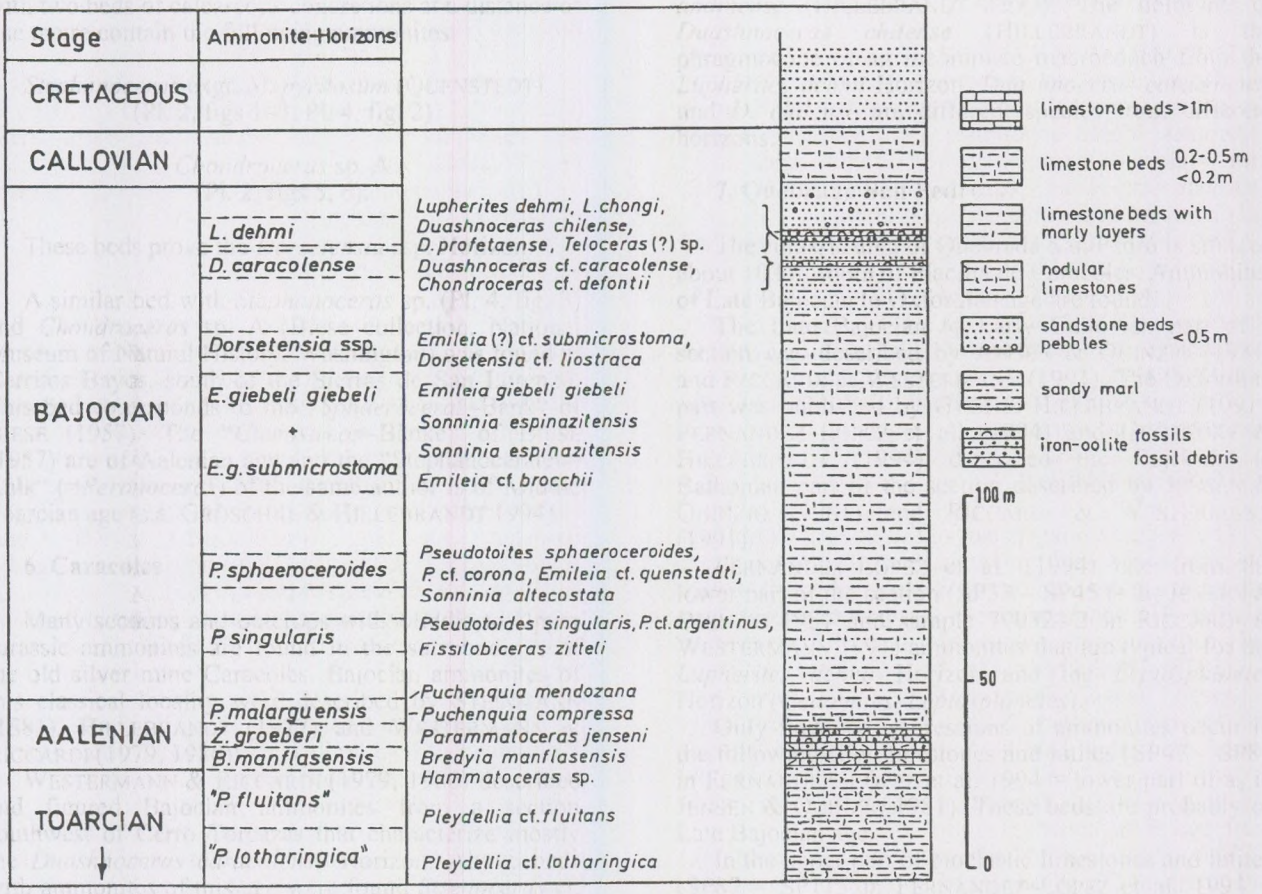

Fig. 2. Stratigraphic section of the uppermost Toarcian and Middle Jurassic of the Manflas area.

Bed 1 probably lies within the European Laeviuscula Zone. Perhaps this bed and the lower part of beds 2 represent the *E. giebeli submicrostoma* Horizon. The upper part of beds 2 and bed 3 belong to the *E. giebeli giebeli* Horizon.

Dorsetensia ssp. Horizon

At localities 3, 4 and 5 (HILLEBRANDT 1977, Fig. 2) *Emileia*(?) cf. *submicrostoma* (GOTTSCHE) (Pl. 1, figs 5A, B) occur above the beds with *Emileia giebeli giebeli* (GOTTSCHE) and *Sonninia espinazitensis* TORNQUIST. This is a transitional species between *Emileia (Chondromileia)* and *Chondroceras*. At locality 4 *Dorsetensia* sp. occurs together with a poorly preserved specimen of this species. *Dorsetensia* cf. *liostraca* BUCKMAN was also found at Portezuelo El Padre, 2 to 4 metres above a bed with *Emileia giebeli giebeli* (GOTTSCHE) and *Sonninia espinazitensis* TORNQUIST.

The beds with *Emileia*(?) cf. submicrostoma and *Dorsetensia* are probably part of the *Dorsetensia* ssp. Horizon.

Duashnoceras caracolense Horizon

A bed with mostly silicified *Chondroceras* and "*Rhynchonella*" *manflasensis* MÖRICKE was found approximately 20 m above the bed with *Emileia*(?) cf. *submicrostoma* (GOTTSCHE). WESTERMANN & RICCARDI (1979) figured from this bed *Chondroceras* cf. *defontii* (MCLEARN). MÖRICKE (1894, p.24)

described from this bed *Sphaeroceras zirkeli* STEINMANN. Silicified specimens labelled by MÖRICKE under this name are preserved in the collection of the "Staatliches Museum für Naturkunde" in Stuttgart.

A coarsely ribbed *Megasphaeroceras*(?) sp. appears together with *Chondroceras* at locality 2 (HILLEBRANDT 1977, fig. 2), 5 m below the iron–oolite. Possibly this *Megasphaeroceras*(?) sp. originates from younger beds.

Duashnoceras cf. *andinense* (HILLEBRANDT) and *D.* cf. *chilense* (HILLEBRANDT) were found at locality 4 (HILLEBRANDT 1977, fig. 2) together with *Chondroceras* cf. *defontii* (MCLEARN).

The *Chondroceras* cf. *defontii* bed is probably part of the *D. caracolense* Horizon.

Lupherites dehmi Horizon

Approximately 4 to 6 metres above the bed with *Chondroceras* cf. *defontii* MCLEARN at localities 1 to 6 in HILLEBRANDT (1977) two beds are found, each 0.3 to 1.0 m thick and rich in ammonites. The lower bed is a more or less sandy and limonitic limestone and the upper bed is mostly an iron–oolite. Micro– and macroconchs of the following genera and species of Stephanoceratinae occur:

Duashnoceras chilense (HILLEBRANDT), *D. burroense* n.sp. (Pl. 9, figs 2 A, B), *D. profetaense* n.sp. (Pl. 6, fig. 1, Pl. 7, figs 1–4, Pl. 8, fig. 1), *Lupherites dehmi* (HILLEBRANDT), *L.*(?) *chongi* (HILLEBRANDT), *Teloceras*(?) sp. (Pl. 9, figs 1A, B).

Both beds are part of the *L. dehmi* Horizon. The lower bed cannot be assigned to the Humphriesianum Zone as formerly supposed by the author (HILLEBRANDT 1977).

19. Quebrada Cepones

The Quebrada Cepones is situated approximately 20 km southwest of Hacienda Manflas. A section was studied 500 m south of this valley and 2.5 km southeast of point 2904 (topographic map 1 : 50 000, Tres Morros) (HILLEBRANDT 1977, p. 43).

Above sediments of Aalenian age the following beds can be distinguished:

1. *Sonninia* cf. *espinazitensis* TORNQUIST
2. *Dorsetensia* cf. *romani* (OPPEL)
3. *Dorsetensia* cf. *liostraca* BUCKMAN
4. Stephanoceras sp., *Chondroceras* sp.
5. Stephanoceratinae gen. et sp. indet.
6. *Duashnoceras* cf. *caracolense* (WESTERMANN & RICCARDI), *Teloceras*(?) sp.

Volcanoclastic beds (derived from the volcanic arc in the west) are frequent. The Bajocian part of the overturned section is approximately 200 m thick.

Bed 1 is part of the *E. giebeli giebeli* Horizon, beds 2, 3 and probably 4 of the *Dorsetensia* ssp. Horizon and beds 5 and 6 of the *D. caracolense* Horizon.

20. Quebrada Chanchoquin

Many Middle Sinemurian to Bajocian sections were studied by the author north and south of the Rio Transito (HILLEBRANDT 1973, fig. 2). Identifiable Bajocian ammonites, however, were only found in the section between the Quebrada Chanchoquin and Acevedo. This is the thicker one of the sections originally described by the author (HILLEBRANDT 1973, fig. 2) under the name Quebrada La Totora, and again described by HILLEBRANDT & SCHMIDT–EFFING (1981, p. 29) and the upper part by HILLEBRANDT & WESTERMANN (1985, p. 13).

Above beds with Aalenian ammonites the following beds with Bajocian ammonites are found:

1. *Pseudotoites sphaeroceroides* (TORNQUIST), *Sonninia altecostata* TORNQUIST
2. *Emileia giebeli* cf. *giebeli* (GOTTSCHE), *Sonninia espinazitensis* TORNQUIST

Bed 1 is part of the *P. sphaeroceroides* Horizon and bed 2 of the *E. giebeli giebeli* Horizon.

21. Mina de Los Pingos

The Jurassic of the Mina de Los Pingos is the southernmost area in the High Cordillera of Northern Chile with Lower and Middle Jurassic sediments.

Jurassic sections were described by MPODOZIS et al. (1973), RIVANO & MPODOZIS (1974) and MPODOZIS & CORNEJO (1988). The author visited the area of the Mina de Los Pingos together with Mr. RIVANO in 1979. The sections Quebrada La Lunca, Ladera Sur (MPODOZIS & CORNEJO 1988, fig. 18, section a; fig. 19a) and a section at the hill south of the Los Pingos mine were studied.

Section Quebrada La Lunca (from below to above):

1. Volcanoclastic rocks and andesitic lavas of probably Aalenian age (level II in MPODOZIS & CORNEJO 1988, p. 62).
2. Conglomerates and calcareous arenites with the following ammonites were described by MPODOZIS & CORNEJO (1988):

Sonninia mammilifera JAWORSKI, *Sonninia (Papilliceras) espinazitensis* TORNQUIST, *Sonninia (Sonninia)* aff. *mirabilis* TORNQUIST, *Sonninia* sp. and *Lytoceras* sp. (*L. eudesianum* D'ORB. in GOTTSCHE).

The author found a microconch of *Pseudotoites* cf. *sphaeroceroides* (TORNQUIST) and *Sonninia* cf. *espinazitensis* TORNQUIST. The *Lytoceras* are very large (up to a diameter of 0.7 m).

The ammonite assemblage assumed to be part of the *P. sphaeroceroides* Horizon.

Section south of the Los Pingos mine

A series of calcilutites with some conglomeratic (?turbiditic) and arenitic beds contain ammonites of Aalenian age (*Tmetoceras* sp. and *Puchenquia* sp.) and is probably repeated by folding. Above calcilutites, limestones and arenites with *Puchenquia* sp. and *Bositra* sp. an ?olistostrome (4 to 6 m thick) with large clasts (diameter up to 0.5 m) was found. Gray limestone clasts contain *Emileia giebeli giebeli* (GOTTSCHE) and *Sonninia* sp. (= *E. giebeli giebeli* Horizon).

Sonninia occur also in the following arenites. Calcilutites with limestone beds are superposed by dm–bedded arenites with conglomeratic beds. This series contains poorly preserved Stephanoceratinae and ?*Megasphaeroceras* (probably *L. dehmi* Horizon).

MPODOZIS & CORNEJO (1988, p. 65) described from this series *Macrocephalites* sp. A, B, C, *Eurycephalites* cf. *rotundus* TORNQUIST and *Kamptokephalites* sp.. They supposed Early Callovian age for this assemblage. All these Eurycephalitidae are likely to belong to the genus *Megasphaeroceras* of early Late Bajocian age.

Biostratigraphy

WESTERMANN & RICCARDI (1979) and WESTERMANN in HILLEBRANDT et al. (1992) elaborated a detailed biozonation with ammonites of the Bajocian stage in South America. This biozonation was correlated with the European Standard Zones. CALLOMON & CHANDLER (1990) and CALLOMON & COPE (1993) introduced a detailed subdivision of the Bajocian of southern England into ammonite faunal horizons. 26 Early and 9 Late Bajocian ammonite faunal horizons are distinguished.

Different ammonite–bearing horizons of Bajocian age are found in Northern Chile but compared with Europe a much less detailed subdivision is possible. The reason could be that these horizons reflect in Northern Chile only part of the originally existing more complete succession of South American Bajocian ammonites. Already originally the possibilities of distinguishing faunal horizons in South America were restricted, at least in Northern Chile. Especially for the Lower Bajocian, sections exist with many beds of the same faunal horizon but representing a time span of an European zone or subzone. It is remarkable that the South American Bajocian ammonite assemblages are much less diverse than those in Europe. This fact at least could be one reason why the South American species had a longer biostratigraphic range. The low faunal diversity is probably connected with the special paleogeographic and paleobiogeographic situation of the South American Jurassic. The South American shelf was much narrower than the huge area of the European shelf with a high potential of ecologic possibilities. Additionally, the back arc basin of Northern Chile was limited by a volcanic arc in the west aggravating the connection with the Paleopacific Ocean.

Endemic South American genera and species often render a more difficult correlation with the European succession of horizons, subzones and zones. In most sections and localities of Northern Chile only one or a few horizons occur yielding Bajocian ammonites and sometimes in between them horizons are missing but found in other sections or localities. Often the horizons are only represented by a single bed or layer, also in sections with high sedimentation rates.

Podagrosiceras maubeugei Horizon

A Zonule/Horizon with *Podagrosiceras maubeugei* was introduced by HILLEBRANDT & WESTERMANN (1985) and correlated with the upper part of the European Concava Zone of uppermost Aalenian age or the lower part of the Discites Zone of lowermost Bajocian age. The last *Tmetoceras* occurs probably together with *P. maubeugei.* In Europe, this genus is restricted to the Aalenian. The endemic South American genus *Podagrosiceras* makes an exact correlation with other faunal provinces impossible.

Above the *P. maubeugei* Horizon two horizons may be distinguished containing the Pacific genus *Pseudotoites.*

Pseudotoites singularis Horizon

The horizon is characterized by *P singularis* (GOTTSCHE), *P.* cf. *argentinus* ARKELL and *Fissilobiceras* (?) *zitteli* (GOTTSCHE). The horizon was proved only at one section in the Jurassic of Manflas (locality 4 in HILLEBRANDT & WESTERMANN 1985, fig. 4). The horizon corresponds to the lower part of the *Pseudotoites singularis* Assemblage Zone of WESTERMANN & RICCARDI (1979) and WESTERMANN in HILLEBRANDT et al. (1992). *Pseudotoites* is an endemic genus of the Pacific Realm and *Fissilobiceras* appears in Europe in the Ovalis Subzone.

Up to now, no horizon was found lying within the European Discites Zone.

Pseudotoites sphaeroceroides Horizon

This horizon yields *P. sphaeroceroides* (TORNQUIST), additional species of *Pseudotoites*, *Emileia* cf. *quenstedti* WESTERMANN and the first *Sonninia (Papilliceras)* (*S. altecostata* TORNQUIST).

The horizon is found in the Manflas area above the *P singularis* Horizon and was also proved at various localities in Northern Chile (localities 20, 21 and localities not described in this paper).

The horizon corresponds to the upper part of the *P singularis* Assemblage Zone of WESTERMANN & RICCARDI (1979). The first *Sonninia (Papilliceras)* are found in Europe at the basis of the Laeviuscula Zone.

Emileia giebeli submicrostoma and *Emileia giebeli giebeli* Horizons

Various species of *Emileia* occur in the beds above the *P. sphaeroceroides* Horizon. In the Manflas area (section 2 in HILLEBRANDT & WESTERMANN 1985, fig. 4) *Emileia* cf. *brocchii* (SOW.) occur in the lowest part of these beds. The beds above this one are characterized by *Emileia (Chondromileia) giebeli giebeli* (GOTTSCHE) (micro– and macroconchs) and *Sonninia (Papilliceras) espinazitensis* TORNQUIST.

Large *Emileia giebeli giebeli* (GOTTSCHE) (micro– and macroconchs) appear together with *Sonninia espinazitensis* (TORNQUIST) at Portezuel El Padre (localities 6 and 7 in HILLEBRANDT & WESTERMANN 1985, fig. 4). Different species of *Euhoploceras* (e.g. *E.* cf. *adicrum* (WAAGEN)) und *Pseudotoite* cf. *sphaeroceroides* (TORNQUIST) occur together with *Emileia giebeli giebeli* (GOTTSCHE) and could not be collected bed by bed.

A well–preserved fauna with *Emileia giebeli submicrostoma* (GOTTSCHE) (micro– and macroconchs), *Euhoploceras* sp. (microconchs), *Sonninia (Papilliceras)* sp. (micro– and macroconchs), *Pelekodites* sp. (microconchs) and *Fissilobiceras*(?) sp. was found at Quebrada San Pedrito (locality 17).

Beds with *Sonninia (Papilliceras)* ex gr. *espinazitensis* (frequent) and *Emileia giebeli* s.l. (less frequent) are exposed at different localities in Northern Chile (localities 4, 8 to 10, 12, 15 to 21).

WESTERMANN & RICCARDI (1979) distinguished within the *E. giebeli* Assemblage Zone an *E. giebeli submicrostoma* Assemblage Subzone, an *E. multiformis* Assemblage Subzone and a *Dorsetensia blancoensis* faunule (? Assemblage Zone). WESTERMANN in HILLEBRANDT et al. (1992) defined these assemblage zones and subzones as standard zones and the *D. blancoensis* faunule was renamed as *D. blancoensis* Horizon.

In Northern Chile at least two horizons can be distinguished:

A lower *E. giebeli submicrostoma* Horizon and an upper *E. giebeli giebeli* Horizon.

The bed with *E.* cf. *brocchii* can be included in the *E. giebeli submicrostoma* Horizon. The *Dorsetensia blancoensis* Horizon was not directly proved in Northern Chile.

E. brocchii is found in England in the Laeviuscula Zone (Bj–8 and Bj–10 in CALLOMON & CHANDLER 1990) and the *E. giebeli submicrostoma* Horizon may be correlated with the upper part of the Laeviuscula Zone. The *E. giebeli giebeli* Horizon represents a time equivalent of part of the Sauzei Zone.

Skirroceras Horizon

Skirroceras sp. was found in the Sierra Minillas section (loc. 15) below beds that can be correlated with the lower part of the Humphriesianum Zone. The bed with *Skirroceras* characterizes probably an ammonite horizon in the upper part of the Sauzei Zone. The Argentinian *Dorsetensia blancoensis* Horizon is probably of the same age.

Dorsetensia ssp. Horizon

Beds with different species of *Dorsetensia* occur at some localities of Northern Chile (localities 8, 10, ?12, 13, 14, 16, 18, 19). Evolute to involute and smooth to more or less strongly and densely–ribbed species are found. *Stephanoceras* ex gr. *St. pyritosum* (QUENSTEDT) (loc. 3 to 5, 14), *St.* ex gr. *St. umbilicum* (QUENSTEDT) (loc. 12) and *Chondroceras* sp. A (loc. 3 to 5, 12) occur together with *Dorsetensia* ssp., at least in the upper part of these beds.

A bed with *Emileia* (?) cf. *submicrostoma* (GOTTSCHE) was found in the Manflas area above the beds with *Emileia giebeli giebeli* (GOTTSCHE). This species is transitional between the subgenus *Chondromileia* and the genus *Chondroceras*. At one of the Manflas localities (loc. 4 in HILLEBRANDT 1977) a poorly preserved specimen of *E.* (?) cf. *submicrostoma* appeared together with *Dorsetensia* sp..

The beds with *Dorsetensia* ssp. (*Dorsetensia* Horizon) can be correlated with the lower part of the European Humphriesianum Zone (Romani Subzone) and possibly with part of the middle part of this zone (Humphriesianum Subzone). WESTERMANN & RICCARDI (1979) and WESTERMANN IN HILLEBRANDT et al. (1992) used for this assemblage the Romani Subzone.

Duashnoceras caracolense Horizon

Above the layers with *Dorsetensia* ssp. beds are found that are dominated by Stephanoceratinae the most frequent genus of which is *Duashnoceras*. *Duashnoceras* is related to *Stephanoceras* s.l. and is distinguished from this genus mainly by curved primaries that often do not meet directly the tubercles and pass adorally around them. This character is found in finely and coarsely ribbed species and in species with a *Stephanoceras*–, *Stemmatoceras*– and *Teloceras*–like cross–section. The cross–section of the inner whorls is like that of *Stemmatoceras* to *Teloceras*. That of the outer whorls, especially the body–chamber, is like that of *Stephanoceras*, *Stemmatoceras* or *Teloceras*. The genus *Teloceras*(?) is maintained for species with a *Teloceras*–like cross–section during the complete ontogeny. The genus *Stemmatoceras* is not used. *Duashnoceras* is found in Mexiko and South America (SANDOVAL & WESTERMANN 1986).

Species of the genus *Duashnoceras* occur in Northern Chile in two horizons. The lower one is characterized by *Duashnoceras caracolense* (WESTERMANN & RICCARDI) and *D. andinense* (HILLEBRANDT). The type specimen of *D. caracolense* is a macroconch. At locality 6 microconchs (with lappets) and macroconchs of this species occur. The microconchs correspond to specimens described from the Caracoles area (locality 6) as *Stephanoceras* (= *Duashnoceras*) *chilense* (HILLEBRANDT 1977, WESTERMANN & RICCARDI 1979). It is striking that the mostly more coarsely ribbed specimens have a wider cross section than the more densely–ribbed ones. At locality 9 *Chondroceras* sp. B (a species related to the North American species *Chondroceras defontii* (MCLEARN)) is found together with microconchs of *Duashnoceras caracolense* and *D. andinense*. The beds with *Chondroceras* and "*Rhynchonella*" *manflasensis* of the Manflas area (loc. 18) also belong to the *D. caracolensis* Horizon.

The *Duashnoceras caracolense* Horizon lies within the upper part of the European Humphriesianum Zone (Blagdeni Subzone). This horizon corresponds to the *Stephanoceras chilense* Assemblage Subzone of WESTERMANN & RICCARDI (1979) (= *Duashnoceras chilense* Subzone of WESTERMANN in HILLEBRANDT et al. 1992).

Lupherites dehmi Horizon

The *L. dehmi* Horizon is the upper horizon with species of the genus *Duashnoceras*. *Duashnoceras chilense* (HILLEBRANDT), *D. burroense* n.sp. and *D. profetaense* n.sp. are found together with *Lupherites dehmi* (HILLEBRANDT) and *L.*(?) *chongi* (HILLEBRANDT). Additionally occur *Teloceras*(?) cf. *chacayi* WESTERMANN & RICCARDI and another species of this genus with a very wide but low cross–section. At least some microconchs of these *Teloceras*–like species show a *Duashnoceras*–like sculpture. Large *Spiroceras orbignyi* (BAUGIER & SAUZÉ), *Megasphaeroceras magnum* RICCARDI & WESTERMANN and *M. spissum* RICCARDI & WESTERMANN are also found in this horizon. *Orthogarantiana* cf. *conjugata* occurs at localities 9 and 10 but the exact beds and horizons are not known. *Orthogarantiana conjugata* (QUENSTEDT) was cited by DIETL & HUGGER (1979) from the middle part of the Subfurcatum Zone. FERNÁNDEZ–LÓPEZ (1985) described *Orthogarantiana* sp. cf. *O. conjugata* (QUENSTEDT) from the lower part of the Garantiana Zone. The first *Leptosphinctes*(?) appear probably also in this horizon.

The *L. dehmi* Horizon was proved at the localities 1, 2, 4, 7 to 10, 12, 13, 18 and ?21. The horizon can be correlated with the lower part of the European Subfurcatum (= Niortense) Zone. The horizon corresponds to the lower part of the (?)*Megasphaeroceras rotundum* Assemblage Zone of WESTERMANN & RICCARDI (1979) and the *Lupherites dehmi* Subzone of WESTERMANN in HILLEBRANDT et al. (1992).

Leptosphinctes Horizon

Above the beds of the *L. dehmi* Horizon beds without the genera *Lupherites*, *Duashnoceras* and *Teloceras* are found. The first specimen of the genus *Cadomites* occur together with *Spiroceras orbignyi* (BAUGIER & SAUZÉ), *Megasphaeroceras magnum* RICCARDI & WESTERMANN, *M. spissum* RICCARDI & WESTERMANN and *Leptosphinctes* ssp. (e.g. *L.* cf. *leptus* BUCKMAN).

The *Leptosphinctes* Horizon appears at localities 2?, 4 , 6 to 8, 10 and ?13. WESTERMANN & RICCARDI (1980) described a bed with *Strenoceras* cf. *latisulcatum* (QUENSTEDT) and *Cadomites* n. sp. B aff. *deslonchampsi* (D'ORB.) from Caracoles belonging to this horizon.

Leptosphinctes leptus BUCKMAN was found in England in the upper part of the Subfurcatum Zone (PARSONS 1976) and was described by SANDOVAL (1983, 1990, 1994) from the upper part of his *Leptosphinctes* Zone (= upper part of the Subfurcatum Zone) and by FERNÁNDEZ–LÓPEZ (1985) from his biohorizon XII (= middle part of the Subfurcatum Zone).

The *Leptosphinctes* Horizon corresponds probably to the upper part of the (?)*Megasphaeroceras rotundum* Assemblage of WESTERMANN & RICCARDI (1979) (not named by WESTERMANN in HILLEBRANDT et al. (1992).

Megasphaeroceras(?) Horizon

Above the *Leptosphinctes* Horizon at locality 10 a coarsely–ribbed, globular *Megasphaeroceras*(?) was found the body–chamber of which closes the narrow umbilicus. This species occurs also at locality 9. Additionally, at locality 10 (Quebrada Aguada del Minero, western part) together with a poorly preserved *Cadomites*(?) a similar, but strongly crushed *Megasphaeroceras*(?) was found dated by GRÖSCHKE & HILLEBRANDT (1994) as probabaly of Early Bathonian age. This apparently endemic *Megasphaeroceras*(?) could also be of Late Bajocian age (Garantiana or Parkinsoni Zone).

Evidence for the European Garantiana and Parkinsoni Zones is difficult to ascertain in Northern Chile, also in sections with continuous sedimentation from the Bajocian to the Bathonian. Ammonites are scarce in this part of the sections and mostly without biostratigraphic significance. FERNÁNDEZ–LÓPEZ et al. (1994) postulated a regional discontinuity for the localities 7 and 10 at the base of the Bathonian. In the opinion of the author this seems to be unlikely and beds designated as of Late Bajocian age are probably of Early Bathonian. Eurycephalitidae from the same beds were determined as *Megasphaerocras magnum* by RICCARDI & WESTERMANN (1991) (= *Megasph. magnum ss.* (? zone or horizon) of WESTERMANN in HILLEBRANDT et al. (1992, tab. 12.2).

"Cobbanites" Horizon

GRÖSCHKE & HILLEBRANDT (1994) cited a large *Cobbanites* cf. *talkeetnanus* IMLAY from the Jaspe Jurassic. *C. talkeetnanus* by CALLOMON (1984, p. 150) is said to be morphologically close to *Leptosphinctes (Vermisphinctes) meseres* (BUCKMAN) (= *Vermisphinctes (Prorsisphinctes) meseres* in SANDOVAL 1983, p. 393 and *Prorsisphinctes meseres* in FERNÁNDEZ–LÓPEZ 1985, p. 511) from the upper part of the Late Bajocian (Garantiana and Parkinsoni Zones) of Europe. Giant Leptosphinctinae are also found in beds of uppermost Bajocian or Early Bathonian age at the Quebrada San Pedro section (GRÖSCHKE & HILLEBRANDT 1994, p. 260). WESTERMANN in HILLEBRANDT et al. (1992, p. 61, fig. 1) figured a large *Lobosphinctes intersertus* BUCKMAN from the *Megasphaeroceras* range zone in Argentina. This species was found in England in the Parkinsoni Zone and in southeastern France and Spain in the lowermost Bathonian (SANDOVAL 1983, p. 414).

Together with *C.* cf. *talkeetnanus Cadomites* sp. and a specimen transitional between *Cadomites* and *Garantiana* appear.

At the moment, it is difficult to decide if these large to giant Leptosphinctinae are of upper Late Bajocian or Early Bathonian age or if they occur in both stratigraphic levels.

Stages Substages		European Standard Zones	Horizons Northern Chile	Southamerican Zones, Subzones, Horizons HILLEBRANDT et al. 1992	
BAJOCIAN	upper	Parkinsoni	*„Cobbanites"*	Lobosphinctes	
		Garantiana	*Megasphaeroceras*(?)	Megasphaeroceras magnum ss.	
		Subfurcatum	*Leptosphinctes*	Rotundum Zone	
			Lupherites dehmi		L. dehmi Sz.
	lower	Humphriesianum	*Duashnoc. caracolense*	Humphries. Zone	D. chilense Sz.
			Dorsetensia ssp.		D. romani Sz.
		Sauzei	*Skirroceras*	Emileia giebeli Zone	D. blancoensis H.
			E. giebeli giebeli		E. multiformis Sz.
		Laeviuscula	*E. giebeli submicrostoma*		E submicrost. Sz.
			P. sphaeroceroides	Pseudotoites singularis Zone	
		Ovalis	*P. singularis*		
		Discites		?	
Aalenian		Concavum	*P. maubeugei*	Puchenquia malarguensis Zone	P. maubeugei Sz.
			P. mendozana		P. mendozana Sz.
			P. compressa		P. compressa Sz.

Table 1 Proposed ammonite horizons for the Bajocian of Northern Chile; compared with the European Standard Zones and the South American Zones proposed by WESTERMANN in HILLEBRANDT et al. (1992).

Description of new species

Two species are described as new being important for the biostratigraphy of the lowest horizon of the Late Bajocian.

Abbreviations: D = diameter, H = whorl height, W = whorl width, U = umbilicus.

Family Stephanoceratidae NEUMAYR, 1875
Subfamily Stephanoceratinae NEUMAYR, 1875

Genus *Duashnoceras* WESTERMANN, 1983

Type species: *Stephanoceras floresi* BURCKHARDT, 1927

Diagnosis:

Primary ribs gently concave forward, more or less densely to coarsely spaced and with tendency to be sharp. At least some of the primaries do not directly meet the tubercles around which they curve adorally. Whorl section of inner whorls stemmatoceratid to teloceratid, outer whorls (body–chamber) stemmatoceratid to stephanoceratid. Microconchs with lateral lappets. Suture–line with subvertical U_2, moderately retracted U_3 and well and deeply developed U_n.

Remarks:

The genus was originally placed by WESTERMANN (1983) in the Zigzagiceratinae, as a subgenus of *Zigzagiceras*. Later he transferred *Duashnoceras* to the Stephanoceratidae (WESTERMANN 1984).

Stephanoceras is distinguished from *Duashnoceras* by the position of the tubercles which are located exactly on the termination of the primaries. Some European and North American species of *Stephanoceras,* however, also show this tendancy. *Cadomites* is mostly more densely–ribbed, especially the outer whorls. The body–chamber slightly egresses and is contracted. The suture–line differs in the radial (not retracted) umbilical lobes. SANDOVAL & WESTERMANN (1986) postulated *Duashnoceras* probably being a transitional genus between *Stephanoceras* und *Cadomites.*

Duashnoceras(?) *burroense* n. sp.

Pl. 8, figs 2, 3; Pl. 9, figs 1, 2

Holotype (Pl. 8, figs 2A, B):

Macroconch, phragmocone, in part with shell, not deformed, but only figured side of umbilicus prepared. Outer whorl filled with a micritic sediment, inner whorls filled with calcite and in part hollow (TUB 790316/4/1).

Diagnosis:

Coronate conch with deep umbilicus. Curved primary ribs, densely spaced in inner whorls, more widely spaced in outer whorls. Some of the primaries do not meet directly the tubercles around which they curve adorally. Whorl section of innermost whorls teloceratid, of outer whorls stemmatoceratid. Suture–line with retracted umbilical lobes.

Derivatio nominis:

Referring to the type locality (Quebrada de Los Burros) where the holotype was found.

Locus typicus:

Quebrada de Los Burros (loc. 13, fig. 1), 1.6 km south of point 3837 (topographic map 1 : 100 000, Exploradora; x = 481.3, y = 7126.4).

Stratum typicum:

Marls with layers of calcareous concretions (bed 5), below (bed 4) layer with *Duashnoceras andinense* (HILLEBRANDT) and *Chondroceras* sp. B, above (bed 6) layer with *Duashnoceras* sp. and ?*Megasphaeroceras* sp..

Distribution:

Lower Late Bajocian, *Lupherites dehmi* Horizon (= lower part of the European Subfurcatum Zone).

Material:

1. Type locality: Only the holotype was found.
2. Jurassic West of Cerro Jaspe (loc. 4, fig. 1), section 6, bed 5: One incomplete specimen (microconch) (Pl. 8, figs 3A, B) with part of the body–chamber (inner mould with part of shell), calcitic phragmocone with shell (TUB 860206/15/1).
3. Manflas (loc. 18, fig. 1), locality 4 (HILLEBRANDT, 1977, fig. 2): Two large macroconchs (Ø 175 and 165 mm) (TUB 661203/4/3 and 4) and one small specimen (inner whorls of micro– or macroconch) (TUB 661203/4/2)(Pl. 9, figs 2A, B).

Measurements:

	D(mm)	*H(mm)*	*W(mm)*	*H : W*	*U(mm)*	*U% of D*	*Ribs/whorl*
Holotype	151.0	43.0	77.0	0.56	69.0	45.7	ca. 23
790316/4/1	106.0	32.5	52.0	0.63	47.0	44.3	
661203/4/2	46.0	19.0	ca.27.0	0.70	16.0	34.8	22

Description of the holotype:

The whorls are moderately evolute. The umbilical seam is at the outer base of the thick lateral spines. The umbilicus is deep. The whorl section of the inner whorls cannot be seen. The width of the outer whorls is much larger than the whorl height (H : W ca. 0.6). The flanks are convex. They are separated from the gently convex external side by a narrowly rounded lateral edge below the middle of the whorl height. The inner whorls are densely–ribbed. The primary ribs are sharp on the inner whorls and rounded on the outer whorls. They are concave forward and the strongest curvature lies at the inner third of the flanks. They are widely extended forward in direction to the umbilical seam. Mostly the primaries do not meet directly the tubercles which they curve adorally. Three to four secondary ribs are found per primary on the outer whorl and the whorl

before. The suture–line is only partially visible. The umbilical lobes are retracted.

Description of the paratypes:

The inner whorls of the specimen from the locality 4 (TUB 860206/15/1, Pl. 8, figs 3A, B) are very similar to those of the holotype. The preserved part of the outer whorl (body–chamber) starts with the last septum of the phragmocone. This specimen is probably a microconch. The whorl width in relation to the whorl height is smaller than found at the holotype. But no body–chamber is preserved at the holotype. The style of ribbing is very similar. The umbilical lobes are retracted.

The small specimen (TUB 661203/4/2, Pl. 9, figs 2A, B) from the Manflas locality 4 is a phragmocone (micro– or macroconch). The conch is filled with a calcareous iron–oolite. The shell is in part preserved. The whorl width is much larger than the whorl height (H W = 0.7). The specimen is densely–ribbed and the style of ribbing corresponds with that of the holotype.

The large macroconch specimens from the same locality are laterally slightly compressed and make suggest a lower whorl width. They are septate up to the end. The densely–ribbed inner whorls of both specimens are poorly preserved. The style of ribbing of the outer whorls corresponds with the holotype.

Discussion:

The densely–ribbed inner whorls are similar to those of *Duashnoceras andinense* (HILLEBRANDT) but the cross section of the new species is much wider than that of all other species of the genus *Duashnoceras*. The sculpture is *Duashnoceras*–like but the shell shape is stemmatoceratid. Additionally, specimens with a *Teloceras*–like cross section (H : W = 0.5) and a coarse ribbing that is less *Duashnoceras*–like are found in the same ammonite horizon (*L. dehmi* Horizon) of the Manflas area and other localities (e.g. Pl. 9, figs 3A, B). Transitional specimens (Pl. 5, fig. 3 and Pl. 9, fig. 1A, B) between both species also exist.

Age:

The holotype was found above a bed with *Duashnoceras andinense* (HILLEBRANDT) (= *D. caracolense* Horizon) and below a bed with *Duashnoceras* sp. and ?*Megasphaeroceras* sp. (= ?*L. dehmi* Horizon). The stratum typicum of *D.*(?) *burroense* n.sp. can be included in the *L. dehmi* Horizon. The new species was found in the Manflas area in an ammonite assemblage typical for the *L. dehmi* Horizon. In the Jaspe Jurassic (locality 4, section 6) it appears in beds of the *L. dehmi* Horizon.

Duashnoceras profetaense n. sp.

Pl. 5, figs 4, 5; Pl. 6, figs 2–4; Pl. 7, figs 2–4

Holotype (Pl. 6, figs 2A, B):

Macroconch, phragmocone, inner mould with shell remains, conch not deformed, last whorl only on figured side completely preserved, inner whorls preserved on both sides (TUB 720218/1/1).

Diagnosis:

Conch subcoronate (inner whorls) to planulate (outer whorls), umbilicus moderately deep. Widely spaced primary ribs on inner whorls. Primaries frequently do not meet directly the well–developed tubercles around which they curve adorally Two to four convexly curved secondaries. Whorl section of inner whorls (phragmocone) stemmatoceratid and of outer whorls (mainly body–chamber) stephanoceratid. Suture–line with retracted umbilical lobes.

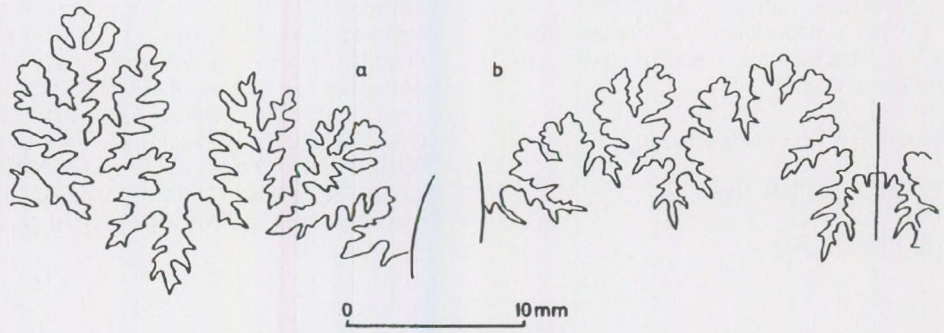

Fig. 3. Suture–lines. a. *Duashnoceras profetaense* n.sp., at whorl height 17.5 mm. b. *Leptosphinctes* cf. *leptus* BUCKMAN, at whorl height 18.0 mm.

Derivatio nominis:

Referring to the type locality (Profeta Jurassic) where the holotype was found.

Locus typicus:

Quebrada Aguada del Minero (loc. 10, fig. 1), section in the western part, locality 4 in HILLEBRANDT (1977, fig. 1), 1.6 km SSW of point 3197 (topographic map 1 100 000, Sierra de Varas; x = 476.4, y = 7243.0).

Stratum typicum:

Marls with layers of calcareous concretions, bed(s) with the ammonite fauna of the *L. dehmi* Horizon.

Distribution:

Lower Late Bajocian, *Lupherites dehmi* Horizon (= lower part of the European Subfurcatum Zone).

Material:

1. Type locality· A well preserved (both sides), incomplete specimen (phragmocone of a microconch) (TUB 670311/8/1 = Pl. 6, figs 1A, B), the inner whorls of a ?microconch (TUB 720218/1/2 = Pl. 6, figs 3A, B) and the phragmocone of a unilaterally preserved microconch (TUB 720218/1/3 = Pl. 5, fig. 5) were found additionally to the holotype.

2. Profeta Jurassic (loc. 10, fig. 1)(LF 22–2 of G. Chong D.): A probably nearly complete microconch (more than half a whorl body–chamber), inner whorls only preserved on figured side (Ch–943 = Pl. 5, fig. 4).

3. Jurassic West of Cerro Jaspe (loc. 4, fig. 1), section 2, bed 7: A laterally compressed and incomplete specimen, preserved part of last whorl body–chamber (TUB 831221/12/1).

4. Manflas (loc. 18, fig. 1): Specimens of the new species were found in the Manflas area at most localities (HILLEBRANDT, 1977, fig. 2).

a. Locality 1: Inner whorl of a phragmocone (Ø 98 mm), probably macroconch (iron–oolitic inner mould)(TUB 670115/5/1).

b. Locality 2: Inner whorls of a phragmocone, probably macroconch (iron–oolitic inner mould)(TUB 680129/6/1).

c. Locality 3: An incomplete, large (original Ø › 180 mm) phragmocone, inner mould (iron–oolite), septation not visible (TUB 670810/2/2 = Pl. 7, fig. 3), an incomplete microconch (phragmocone and ?part of body–chamber), inner mould (iron–oolite), septation not visible (TUB 670810/2/1 = Pl. 7, fig. 2, Pl. 8, fig. 1) and an incomplete microconch (Ø 107 mm), inner mould (iron–oolite), septation not visible (TUB 670810/2/3).

d. Locality 4: A very large phragmocone (Ø › 215 mm) of a macroconch, preserved from both sides (TUB 661203/5/5) and ?inner whorls of a ?phragmocone (Ø 127 mm) of a macroconch (TUB 661203/4/6).

e. Locality 6: A small ?microconch (Ø 46 mm), phragmocone, inner mould (iron–oolite)(TUB 720106/7/1 = Pl. 7, figs 4A, B).

5. 1.85 km north of Cerro Agua de La Piedra (localities 12, fig. 1): A probably nearly complete microconch (Ø ca. 144 mm) (TUB 790310/4/3).

Measurements:

	D(mm)	*H(mm)*	*W(mm)*	*H : W*	*U(mm)*	*U% of D*	*Ribs/diameter*
Macroconchs							
Holotype 720218/1/1	147.0 105.0	44.0 33.5	ca.60.0 45.0	ca.0.73 0.74	65.0 42.0	44.2 40.0	24/105 22/ca.75 mm 20/ca.50 mm 17/ca.25 mm
670810/2/2	114.0	37.0	ca.52.0	ca.0.71	49.0	43.0	18/114 mm
661203/4/5	194.0	52.0	73.5	0.71	94.0	48.5	21/194 mm
661203/4/6	124.0	ca.39.0	54.0	ca.0.72	52.5	42.3	ca.24/124 mm
Microconchs							
670311/8/1	 46.0	28.0 25.5 17.0	33.5 30.0 23.0	0.84 0.85 0.73	 18.0	 39.0	 18/ 46 mm
Ch–943	ca.126.0 ca.107.0	ca.37.5 ca.34.0	ca.36.0	0.94	53.0 43.0	ca.42.1 ca.40.2	28/ca.126 mm 26/ca.107 mm 22/ca.80 mm 19/ca.40 mm
720218/1/3	73.5	25.0	ca.30.0	0.83	28.0	38.1	ca.23/73.5
670810/2/1	117.0 88.0	41.0 31.0	ca.52.0 ca.32.0	ca.0.79 ca.0.97	45.0 35.0	38.5 39.8	20/117 mm 18/88 mm
670810/2/3	104.0	33.0	ca.36.5	ca.0.90	ca.44,0	42.3	20/104 mm
? Microconch 720218/1/2	 22.5	 7.5	 11.8	 0.65	 9.0	 40.0	15/22.5 mm

Description of the holotype:

The holotype is a probably incomplete phragmocone of a macroconch. The innermost whorls are not preserved, the following whorls are preserved on both sides. The moderately evolute shell is subcoronate and the umbilicus is not very deep. The inner flanks are slightly convex. They are separated from the convex external side by a rounded lateral edge at about the middle of the whorl height. The inner whorls are coarsely ribbed (17 to 18 robust ribs per whorl) and the primaries terminate in spines at the umbilical seam. On the following whorls the primaries are more and more curved forward. Some primaries do not meet directly the blunt (inner mould) tubercles. Striations parallel to the primaries are visible in the case of shell preservation. Two secondary ribs are found per primary at the end of the outer whorl and three at the whorl before. The secondaries curve convexly over the external side. The umbilical lobes are retracted on the inner flank.

Description of the paratypes:

Micro– and macroconchs were found. They are distinguished mainly by the size of the conch.

Macroconchs:

In addition to the holotype some specimens were found that can be assigned to macroconchs. None of these are preserved with the body–chamber or parts of it. Also the largest specimen (TUB 661203/4/5) with a

diameter of 215 mm is completely septate. All specimens are subcoronate up to the end. The umbilical width in relation to the diameter increases during growth.

The distance of the primaries of the coarsely ribbed inner whorls is variable. The inner whorls of the holotype have a lower number of ribs per whorl than those of the figured specimen from Manflas (Pl. 7, fig. 3) and this is also the case for the largest specimen (TUB 661203/4/5) from the same locality. The innermost whorls of the figured Manflas specimen (Pl. 7, fig. 3) are not preserved. The curved and relatively sharp primaries of the following whorls do not meet directly the tubercles and pass adorally around them. The striation between the ribs is visible although the specimen is preserved as inner mould (iron–oolite). Three secondaries per tubercle exist and between them often intercalated ribs are present. The holotype is the sole specimen with only two secondaries per tubercle on the last whorl. There are also specimens with four secondaries per tubercle, at least on the inner whorls.

Microconchs:

The specimen CH–943 (Pl. 5, fig. 4) is preserved with a body–chamber which is more than ½ whorl long. The sculpture of the inner whorls of this specimen is very similar to that of the holotype. Primaries of *Duashnoceras*–like appearance are more frequent. The body–chamber slighly egresses. The cross–section of the inner whorls is not visible but the relatively deep umbilicus allows the conclusion of a stemmatoceratid cross–section. The last whorl shows a rounded, stephanoceratid cross–section with a whorl width not too much larger than the whorl height. Three secondary ribs per tubercle are mostly found and intercalatory ribs can be present. At the end of the preserved body–chamber two secondaries per tubercle and an intercalated rib exist. The secondaries are clearly directed forward and curve convexly over the external side.

Specimen TUB 670311/8/1 (Pl. 6, figs 4A, B) is completely septate. The stemmatoceratid cross–section of the penultimate whorl is visible due to the incomplete last whorl. The preserved part of the last whorl shows a rounded, stephanoceratid cross section (H : W ca. 0.85). The number of primaries (inner whorls) is lower than those in the holotype. *Duashnoceras*–like primaries are frequent. The ribs and tubercles of the outer whorl are in part slightly corroded. Three secondary ribs per tubercle and an intercalatory rib are mostly found. The suture–line is visible on most parts of the inner mould (micritic limestone). The U_2 is vertical and the U_3 is clearly retracted.

Specimen TUB 720218/1/3 (Pl. 5, fig. 5) is completely septate and corresponds very well to specimen Ch–943 (Pl. 5, fig. 4).

The small specimen TUB 720218/1/2 (Pl. 6, figs 3A, B) shows well preserved innermost whorls. The shell surface is smooth up to an umbilicus diameter of 0.8 mm. The tubercles appear earlier than the ribs. Weak ribs occur with an umbilical width of 2 mm and *Duashnoceras*–like ribs are developed with an umbilical width of 3 mm.

The Manflas specimen TUB 670810/2/1 (Pl. 7, fig. 2; Pl. 8, fig. 1) shows a relatively small number of primaries in the inner whorls, similar to the Profeta specimen TUB 670311/8/1 (Pl. 6, figs 4A, B). The specimen probably is slightly compressed laterally. The septa are not preserved. The transition from the stemmatoceratid to the stephanoceratid cross section takes place on the last whorl. The continuation of the umbilical seam is visible on the preceding whorl and the end of the last whorl slighly egresses. Two to three secondaries per tubercle and an intercalatory rib are found on the last whorl.

Specimen TUB 720106/7/1 (Pl. 7, figs 4A, B) shows the inner, stemmatoceratid whorls of a ?microconch.

The probably nearly complete micronch (TUB 790310/4/3) of the locality 1.85 km north of Cerro Agua de La Piedra shows a body–chamber with a length of 2/3 of the last whorl. The body–chamber is preserved only on one side. Part of the inner whorls are visible on the other side.

Discussion:

The typical *Duashnoceras*–like ornament is mostly better developed in the microconchs. *Duashnoceras floresi* (BURCKHARDT) shows a similar ribbing but the diameter of the macro– and microconchs of this Mexican species are much smaller. The inner whorls of the North American Late Bajocian microconch *Dettermanites vigorosus* IMLAY are similar. However, mainly the body–chamber of *D. profetaense* n. sp. is different. The macroconch of the North American *Stephanoceras (Stemmatoceras) dowlingi* (MCLEARN) is similar but does not show the *Duashnoceras*–like ribbing.

A specimen (TUB 661202/2/1 = Pl. 6, fig. 1, Pl. 7, fig. 1) was found at the Manflas locality 5 (HILLEBRANDT, 1977, fig. 2) which is transitional between *Duashnoceras profetaense* n. sp. and *Lupherites*(?) *chongi* (HILLEBRANDT). *L.*(?) *chongi* is more densely–ribbed and the planulate (stephanoceratid) stage starts earlier.

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Plates

Plate 1

(Small arrow marks the beginning of the body–chamber)

Figs 1, 2. *Emileia (Chondromileia) giebeli giebeli* (GOTTSCHE).
Manflas (loc. 18), Cerro de La Cuesta (HILLEBRANDT & WESTERMANN 1985, fig. 4, loc. 2), bed 3, *E. giebeli giebeli* Horizon.

1A–C. Macroconch, complete specimen with peristome, body–chamber inner mould mostly without shell, phragmocone mostly with shell (TUB 680130/9/1).

2A, B. Microconch, nearly complete specimen, at one side (not figured) peristome with lappets, body–chamber inner mould with shell remains, phragmocone with shell (TUB 670812/4/1).

Figs 3, 4. *Emileia (Chondromileia) giebeli submicrostoma* (GOTTSCHE).
Quebrada San Pedrito (loc. 17), *E. giebeli submicrostoma* Horizon.

3A, B. Macroconch, nearly complete specimen with part of peristome, body–chamber in part with shell, phragmocone with shell (TUB 711215/2/1).

4A, B. Microconch, complete specimen. Peristome with lappets, body–chamber nearly without shell (TUB 711215/2/2).

Figs 5A, B. *Emileia*(?) cf. *submicrostoma* (GOTTSCHE).
Manflas (loc. 18) (HILLEBRANDT 1977, fig. 2, loc. 3), probably *Dorsetensia* ssp. Horizon.
Macroconch, complete specimen with peristome, inner mould, boundary between body–chamber and phragmocone scarcely visible (TUB 670810/3/1).

(All figures in natural size)

Plate 1

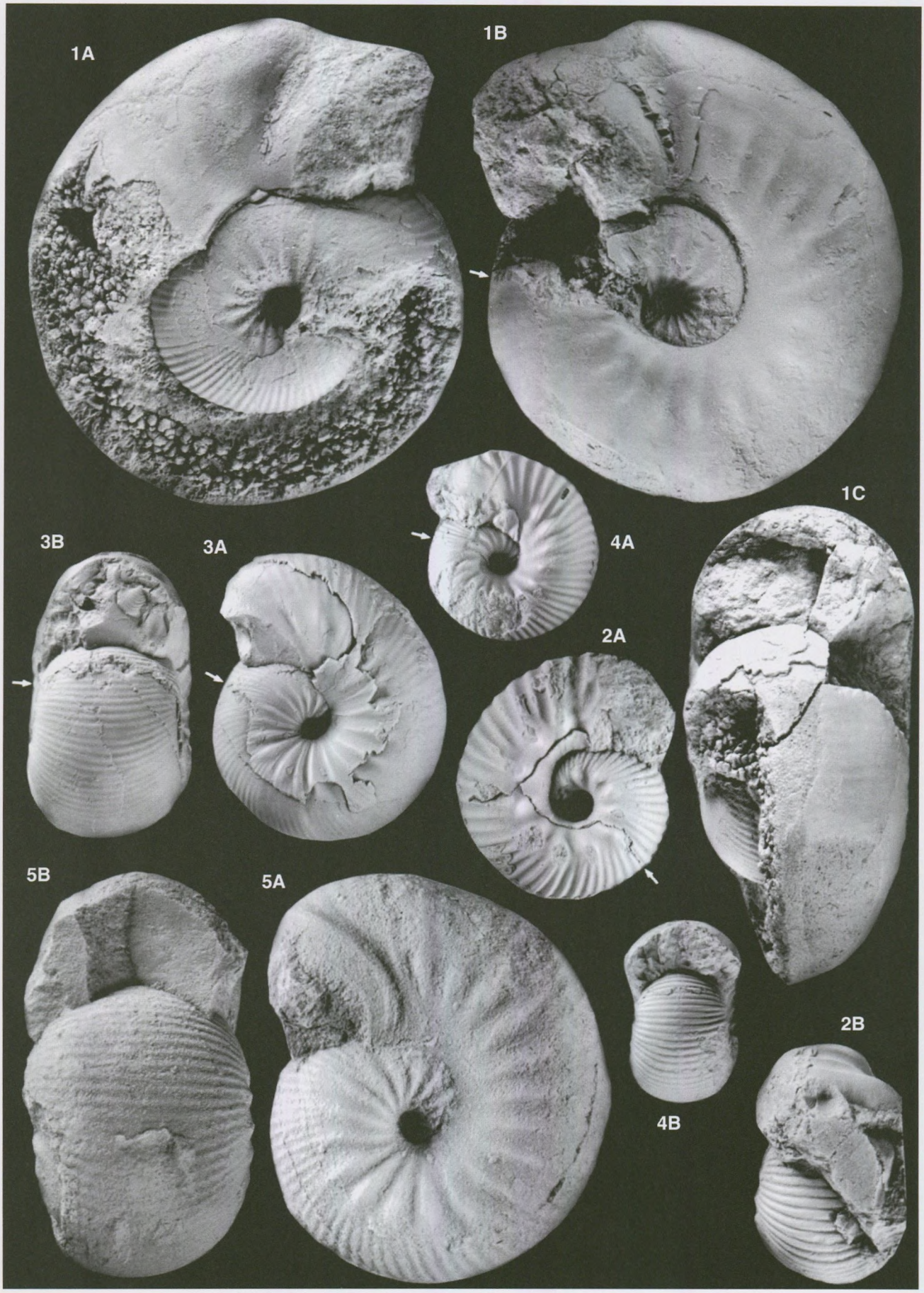

Plate 2

(Small arrow marks the beginning of the body–chamber)

Figs 1–4. *Stephanoceras* ex gr. *St. pyritosum* (QUENSTEDT).

1–3. Sierras de San Lorenzo (loc. 5), *Dorsetensia* ssp. Horizon.

1A, B. Phragmocone, in part with shell (TUB 860310/21/1).

2A, B. Phragmocone, mostly with shell (TUB 860310/21/2).

3A, B. Phragmocone with shell (TUB 860310/21/3).

4A, B. 1.7 km NW of Cerro Agua de La Piedra (loc. 12), *Dorsetensia* ssp. Horizon, phragmocone, in part with shell (TUB 790311/4/1).

Figs 5–8. *Chondroceras* sp. A.
5, 6. Sierras de San Lorenzo (loc. 5), *Dorsetensia* ssp. Horizon.

5. A., B. ?Macroconch, complete specimen with peristome and shell, boundary between body–chamber and phragmocone not visible (TUB 860310/21/4).

6. A., B. ?Macroconch, phragmocone with ? most part of body–chamber, body–chamber in part with shell, phragmocone with shell (TUB 860310/22/1).

7., 8. 1.7 km NW of Cerro Agua de La Piedra (loc. 12), *Dorsetensia* ssp. Horizon.

7. ?Microconch, phragmocone (with shell) and part of body–chamber (end compressed on body–chamber) (TUB 790311/4/2).

8. ?Microconch, ?complete body–chamber (external side incomplete), body–chamber mostly without shell, phragmocone with shell (TUB 790311/4/3).

Fig. 9. A., B. *Chondroceras* sp. B.
Aguada El Oro (loc. 9), bed 2, *D. caracolense* Horizon.
Phragmocone (with shell) and beginning of body–chamber (without shell) (TUB 890307/7/1).

Figs 10–11 *Duashnoceras caracolense* (WESTERMANN & RICCARDI).
Aguada El Oro (loc. 9), bed 2, *D. caracolense* Horizon.

10. Microconch, inner whorls phragmocone (mostly with shell), outer whorl body–chamber (inner mould) (TUB 890307//4).

11. Microconch, phragmocone mostly with shell, body–chamber inner mould (TUB 890307/7/5).

Fig. 12. *Duashnoceras* sp.
Aguada El Oro (loc. 9), bed 2, *D. caracolense* Horizon. Microconch, phragmocone with shell, coarsely ribbed variety with *Stemmatoceras*–like cross section (TUB 890307/7/6).

(All figures in natural size)

Plate 2

Plate 3

(Small arrow marks the beginning of the body–chamber)

Figs 1, 2. *Duashnoceras caracolense* (WESTERMANN & RICCARDI).
Caracoles (loc. 6), N Cerro Torcazas, bed 3, *D. caracolense* Horizon.

1A, B. Microconch, complete specimen, peristome with lappets (at both sides), mostly with shell (TUB 871218/5/1).

2. Macroconch, body–chamber mostly without shell, phragmocone mostly with shell (TUB 871218/5/2).

Fig. 3. *Duashnoceras chilense* (HILLEBRANDT).
Profeta Jurassic (loc. 10), Aguada Colorada, *L. dehmi* Horizon.
Microconch, body–chamber ¾ of the last whorl, most part laterally crushed inner mould (without shell), phragmocone mostly with shell (GCH 4–070672).

Figs 4, 5. *Chondroceras* sp. B.

4A, B. Quebrada de Los Burros (loc. 13), ?bed 4, *D. caracolense* Horizon. Phragmocone with beginning body–chamber, mostly with shell (TUB 790315/8a).

5A, B. Aguada El Oro (loc. 9), bed 2, *D. caracolense* Horizon. Phragmocone, mostly with shell (TUB 890307/7/2).

(All figures in natural size)

Plate 3

Plate 4

(Small arrow marks the beginning of the body–chamber)

Fig. 1. *Duashnoceras andinense* (HILLEBRANDT).
Aguada El Oro (loc. 9), bed 2, *D. caracolense* Horizon.
Microconch, body–chamber mostly with shell, phragmocone with shell (TUB 890307/7/7).

Figs 2, 3. *Stephanoceras* ex gr. *St. pyritosum* (QUENSTEDT).

2A, B. Sierras de San Lorenzo (loc. 5), *Dorsetensia* ssp. Horizon. Phragmocone, mostly with shell (TUB 860310/22/2).

3A, B. Cerritos Bayos (S loc. 5) (Biese collection, Nacional Museum of Natural History, Washington) (labelled: W L_{24} *Spaeroceras* Bank). Phragmocone, in part with shell.

Fig. 4. *Duashnoceras chilense* (HILLEBRANDT).
Aguada El Oro (loc. 9), *L. dehmi* Horizon.
Macroconch, body–chamber (nearly one whorl), in part with shell, phragmocone mostly with shell (GCH–98).

Fig. 5. *Chondroceras* sp. B.
Aguada El Oro (loc. 9), bed 2, *D. caracolense* Horizon.
Fragment of body–chamber, inner mould, in part with shell (TUB 890307/7/3).

(All figures in natural size)

Plate 4

Plate 5

(Small arrow marks the beginning of the body–chamber)

Figs 1, 2. *Duashnoceras chilense* (HILLEBRANDT).

1A, B. 1.85 km North of Cerro Agua de La Piedra (loc. 12), *L. dehmi* Horizon.
Macroconch, phragmocone, mostly with shell (TUB 790310/4/1).

2. Profeta Jurassic (loc. 10), Quebrada Aguada del Minero (western part), bed 1, *L. dehmi* Horizon.
Microconch, complete specimen with lappets, mostly with shell, boundary between body–chamber and phragmocone not visible, innermost whorls not preserved (TUB 670311/6/1).

Fig. 3. *Teloceras*(?) sp.
Profeta Jurassic (loc. 10), Aguada Colorada, *L. dehmi* Horizon.
Phragmocone, mostly with shell (GCH 3–070672).

Figs 4, 5. *Duashnoceras profetaense* n. sp.
4. Profeta Jurassic (loc. 10), Aguada Colorada, *L. dehmi* Horizon.
?Microconch (oppsite side of figured side not prepared), body–chamber (2/3 of last whorl) in part with shell, at the end slightly crushed and opposite side not preserved, phragmocone with shell (CH–943, LF 22–2).

5. Profeta Jurassic (loc. 10), Quebrada Aguada del Minero (western part), bed 1, *L. dehmi* Horizon.
Microconch, phragmocone, only one side preserved, in part with shell (TUB 720218/1/3).

(All figures in natural size)

Plate 5

Plate 6

Fig. 1. *Duashnoceras* cf. *profetaense* n. sp.
Manflas (loc. 18), locality 5 in HILLEBRANDT (1977, fig. 2), *L. dehmi* Horizon.
?Microconch, phragmocone, inner mould (iron–oolite), septation not visible (TUB 720106/7/1).

Figs 2–4. *Duashnoceras profetaense* n. sp.
Profeta Jurassic (loc. 10), Quebrada Aguada del Minero (western part), bed 1, *L. dehmi* Horizon.

2A., B. Holotype, phragmocone, inner mould with shell remains (TUB 720218/1/1).

3A., B. Inner whorls of phragmocone, inner mould with shell remains (TUB 720218/1/2).

4A., B. Microconch, phragmocone, inner mould with shell remains (TUB 670311/8/1).

(All figures natural size)

Plate 6

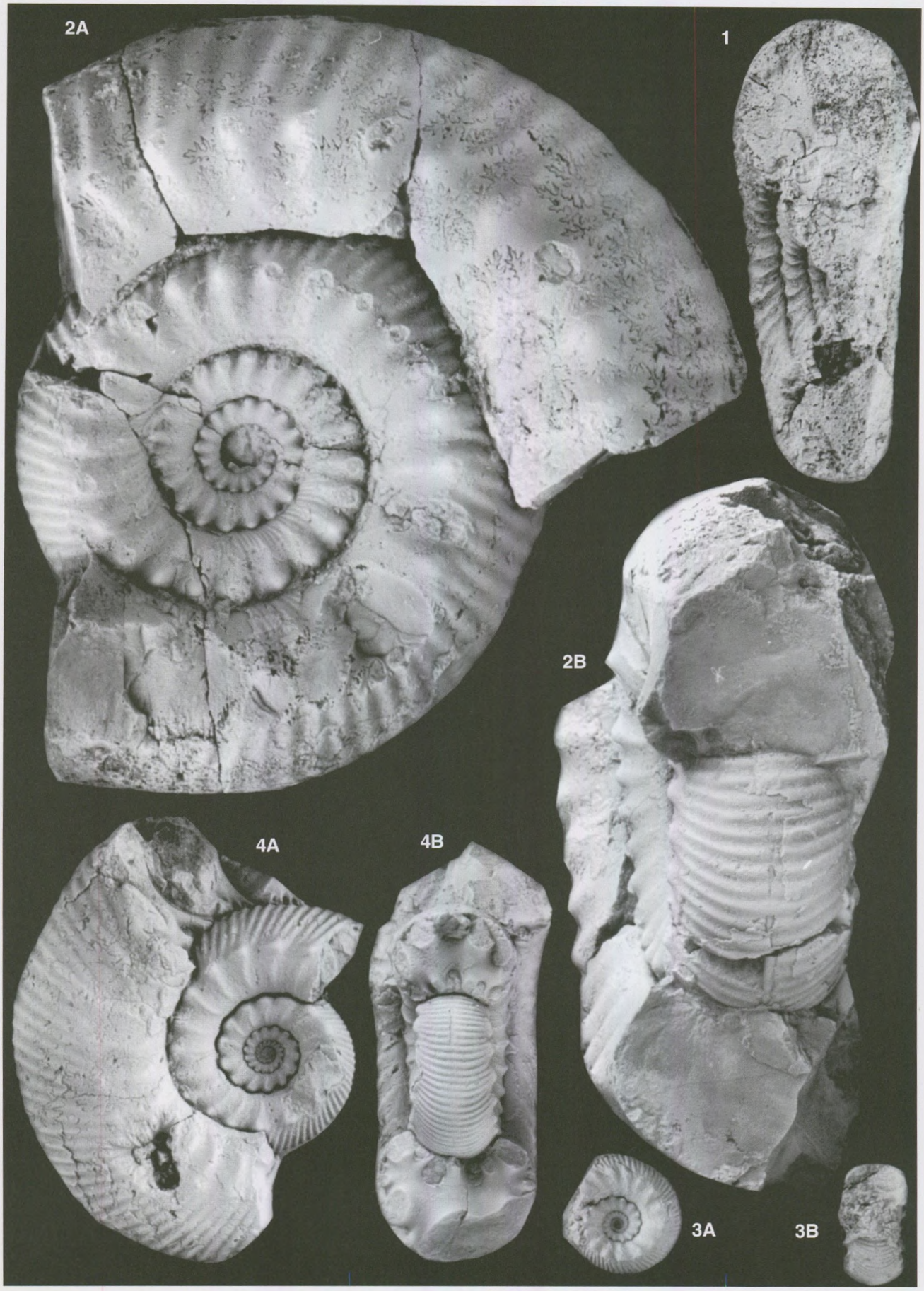

Plate 7

Fig. 1. *Duashnoceras* cf. *profetaense* n. sp.
= Pl. 6, fig. 1; Manflas (loc. 18), *L. dehmi* Horizon.

Figs 2–4. *Duashnoceras profetaense* n. sp.

2, 3. Manflas (loc. 18), locality 3 in HILLEBRANDT (1977, fig. 2), *L. dehmi* Horizon.

2. Microconch, phragmocone, inner mould (iron–oolite), septation not visible (TUB 670810/2/1).

3. Macroconch, phragmocone, inner mould (iron–oolite), septation not visible (TUB 670810/2/2).

4A, B. Manflas (loc. 18), locality 6 in HILLEBRANDT (1977, fig. 2), *L. dehmi* Horizon.
?Microconch, phragmocone, inner mould (iron–oolite) (TUB 720106/7/1).

(All figures natural size)

Plate 7

Plate 8

Fig. 1. *Duashnoceras profetaense* n. sp.
= Pl. 7, fig. 2; Manflas (loc. 18), *L. dehmi* Horizon.

Fig. 2, 3. *Duashnoceras*(?) *burroense* n. sp.

2A, B. Quebrada de Los Burros (loc. 13), bed 5, *L. dehmi* Horizon.
Holotype, macroconch, phragmocone, in part with shell (TUB 790316/4/1).

3A, B. Jurassic west of Cerro Jaspe (loc. 4), section 6, bed 6, *L. dehmi* Horizon.
Microconch, last whorl body–chamber (at the beginning with last septum), inner mould in part with shell, calcitic phragmocone with shell (TUB 860206/15/1).

(All figures natural size)

Plate 8

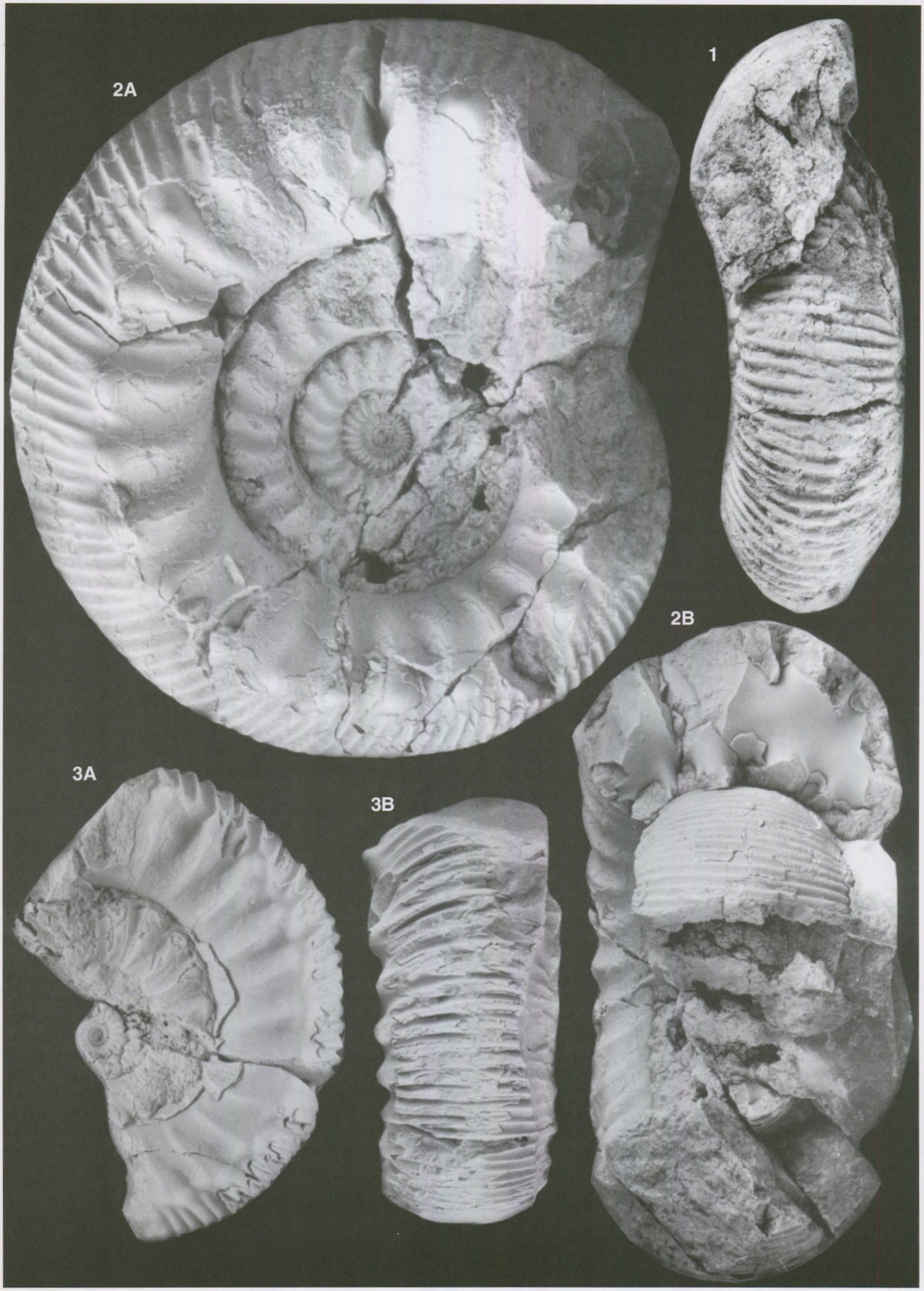

Plate 9

(The small arrow marks the beginning of the body–chamber)

Figs 1, 3. *Teloceras*(?) sp.

1A, B. Manflas (loc. 18), locality 4 in HILLEBRANDT (1977, fig. 2), *L. dehmi* Horizon.
Phragmocone, calcitic mould with shell (TUB 661203/4/1).

2A, B. *Duashnoceras*(?) *burroense* n. sp.
Manflas (loc. 18), locality 4 in HILLEBRANDT (1977, fig. 2), *L. dehmi* Horizon.
Phragmocone, mostly with shell (TUB 661203/4/2).

3A, B. 1.85 km N of Cerro Agua de La Piedra (loc. 12), *L. dehmi* Horizon.
Macroconch, phragmocone, mostly with shell (TUB 790310/4/2).

Figs 4, 5. *Spiroceras orbignyi* (BAUGIER & SAUZÉ).

4. Profeta Jurassic (loc. 10), Quebrada Aguada del Minero (western part), bed 1, *L. dehmi* Horizon.
?Macroconch, phragmocone and part of body–chamber (in part with shell) (TUB 720218/1/4).

5A, B. Jurassic west of Cerro Jaspe (loc. 4), section 1, bed 5, *Leptosphinctes* Horizon.
Phragmocone, inner mould (in part with shell) (TUB 830304/13/1).

Figs 6A, B. *Cadomites* sp. ex gr. *C. psilacanthus/deslonchampsi*.
Profeta Jurassic (loc. 10), Quebrada Aguada del Minero (western part), bed 2, *Leptosphinctes* Horizon.
Macroconch, fragment of outer whorl = body–chamber (in part with shell), phragmocone mostly with shell (TUB 670311/4/1).

Figs 7A, B. *Leptosphinctes* cf. *leptus* BUCKMAN.
Jurassic west of Cerro Jaspe (loc. 4), section 1, bed 5, *Leptosphinctes* Horizon.
?Macroconch, phragmocone, inner mould with remains of shell (TUB 830304/13/2).

(All figures natural size)

Plate 9

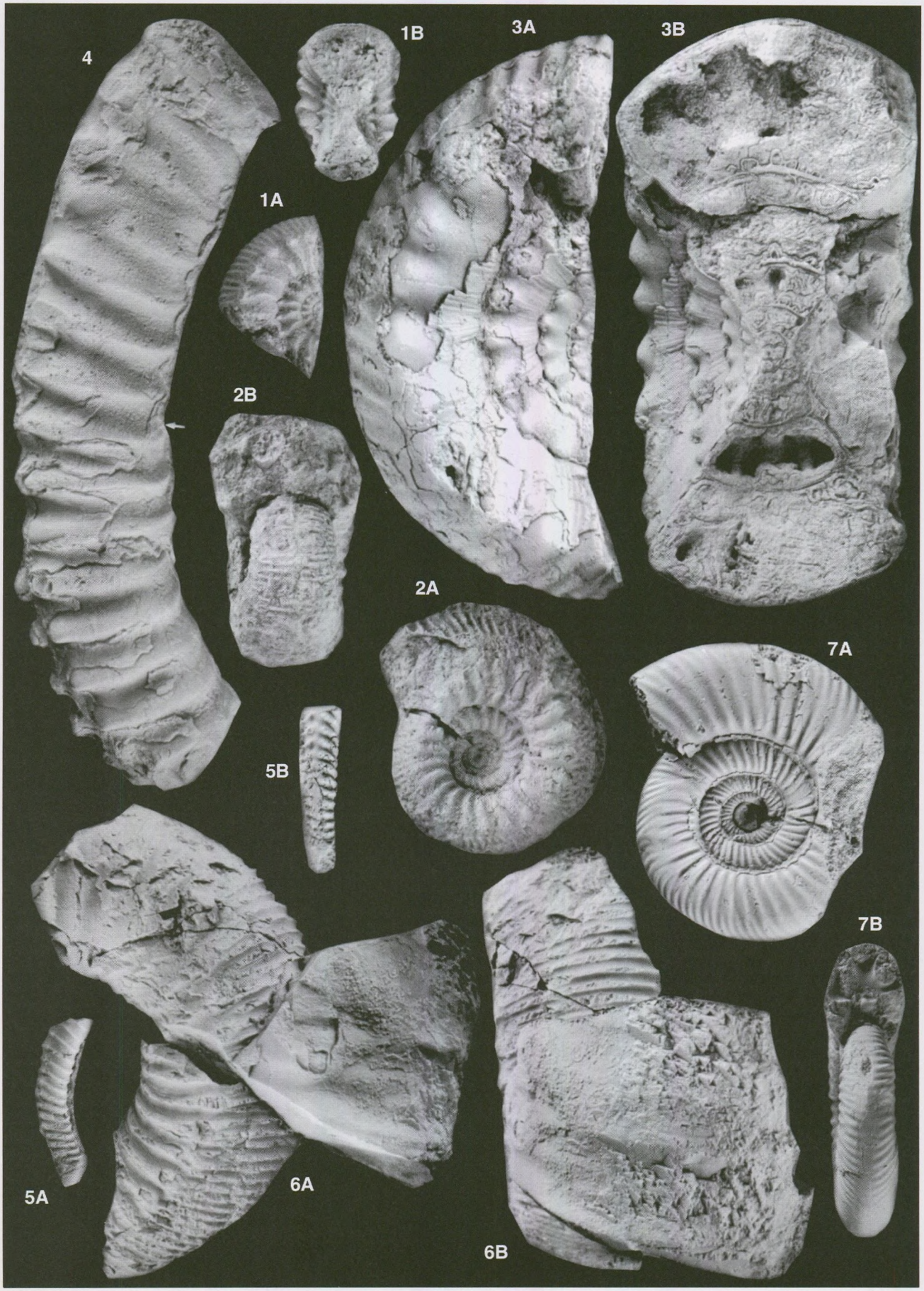

Plate 10

(The small arrow marks the beginning of the body–chamber)

Figs 1, 2. *Leptosphinctes* cf. *leptus* BUCKMAN.
Profeta Jurassic (loc. 10), Quebrada Aguada del Minero (western part), bed 2, *Leptosphinctes* Horizon.

1. ?Macroconch, nearly complete specimen with part of peristome (only one side preserved), body–chamber and phragmocone mostly with shell (TUB 720218/2/1).

Figs 2A, B. Microconch, nearly complete specimen with peristome and incomplete lappets, body–chamber preserved as inner mould (with shell remains), phragmocone plastic cast of outer mould (TUB 720218/3/1).

Figs 3, 4. *Megasphaeroceras*(?) sp. A.

3A, B. Aguada El Oro (loc. 9), *Megasphaeroceras*(?) Horizon.
Phragmocone (with shell) and inner border (umbilical seam) of ?beginning of body–chamber closing the umbilicus (ded. G. Chong, p–14).

Figs 4A, B. Profeta Jurassic (loc. 10), Quebrada Aguada del Minero (western part), bed 3, *Megasphaeroceras*(?) Horizon.
Phragmocone, mostly with shell (TUB 670311/9).

Figs 5, 6. *Orthogarantiana* cf. *conjugata* (QUENSTEDT).

5A, B. Profeta Jurassic (loc. 10), Quebrada Vizcachas, *L. dehmi* or *Leptospinctes* Horizon.
Macroconch, phragmocone (with shell) and part of body–chamber (inner mould) (leg. et ded. T. Bogdanic).

6A, B. Aguada El Oro (loc. 9), *L. dehmi* or *Leptosphinctes* Horizon.
Microconch with complete body–chamber and lappet (preserved only on figured side), body–chamber with shell remains, phragmocone with shell (ded. G. Chong, GCH–106).

(All figures natural size)

Plate 10