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## Lower Bajocian (Middle Jurassic) Ammonites of the Manflas area in Atacama Province, Northern Chile, Part 2: Giebeli Zone

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### Abstract

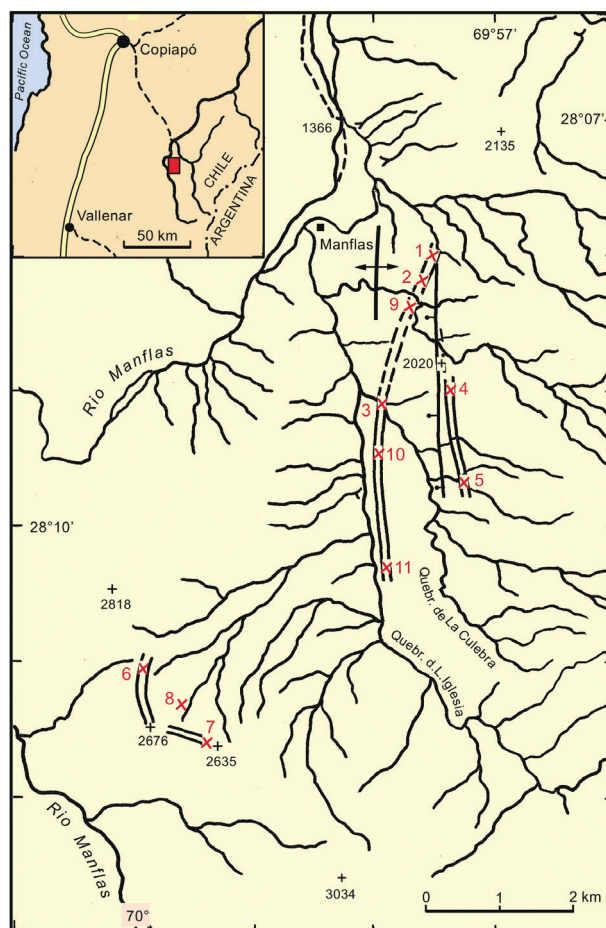
Ammonite faunas are described from the *submicrostoma* (Submicrostoma Subzone) and *giebeli* horizons (Multiformis Subzone) of the Giebeli Zone (Lower Bajocian, Middle Jurassic) of the Manflas area (Chile, Copiapó Province). The faunas are correlated with those from the Giebeli Zone of the Paso del Espinacito section and the Neuquén Basin in Argentina. There is evidence for one additional, still undescribed faunal horizon in the top of the Multiformis Subzone with an “unusual sonniniid assemblage”. One new species, *Latiwitchellia atacamensis* n. sp., is erected.

**Key words:** Ammonites, Chile, Lower Bajocian biozonation, eastern Pacific

### 1. Introduction

For a general introduction we refer to Dietze & Hillebrandt (2012), who described in detail the ammonites and stratigraphy of the Lower Bajocian Singularis Zone of the area around Manflas (Copiapó Province, Northern Chile, SE Copiapó; Text-fig. 1). Here we describe the stratigraphy of the next younger Giebeli Zone (Text-fig. 2) and the ammonites collected from the corresponding beds by one of us (AvH) between 1966 and 1972. The most important studies focusing on the Aalenian and Lower Bajocian ammonites and stratigraphy of the area have been conducted by Westermann & Riccardi (1972, 1979), Hillebrandt (1977, 2001), and Hillebrandt & Westermann (1985). Hillebrandt (2001: fig. 2) distinguished in the Giebeli Zone of the Manflas area the *Emileia giebeli submicrostoma* and *E. g. giebeli* horizons.

**Text-figure 1:** Locality map of the Manflas region and Portezuelo El Padre with sections in the Bajocian shown by double lines (from Dietze & Hillebrandt (2012)). **Eastern block:** locality 4 (field-numbers 720104/8-9), locality 5 (field-number 720106/7). **Western block:** locality 1 (field-number 670812/4), locality 2 (field-numbers 680130/7-9 = 661202/2-3), locality 9 (field-numbers 661203/1-3), locality 3 (field-numbers 670810/2-5), locality 10 (field-numbers 680129/5-6), locality 11 (field-numbers 670115/5-6). **Portezuelo El Padre area:** locality 6 (field-numbers 680129/2-3), locality 7 (field-numbers 670106/13-14), locality 8 (field-number 680129/4).



Stages		Standard Zones North-West European Province		Southamerican Zones		Subzones	horizons		
Bajocian	Upper	Parkinsoni					„Cobbanites“		
		Garantiana				<i>Lobosphinctes</i>			
							<i>Megasphaeroceras magnum</i> ss.	<i>Megasphaeroceras</i> (?)	
	Lower	Niortense		Rotundum				<i>Leptosphinctes</i>	
						Dehmi		<i>dehmi</i>	
		Humphriesianum		Humphriesianum		Chilense		<i>caracolense</i>	
						Romani		<i>Dorsetensia</i> ssp.	
		Sauzei		Giebeli		Blancoensis		<i>blancoensis/Skirroceras</i>	
								?	<i>giebeli</i>
								Multiformis	
		Laeviuscula							<i>submicrostoma</i>
								Laev.	
		Singularis					<i>sphaeroceroides</i>		
Trig.						Altecostata		<i>singularis</i>	
Ovale						Zitteli			
Discites							<i>maubeugei</i>		
Aalenian	Concavum		Malarguensis				Maubeugei	<i>mendozana</i>	
							Mendozana		<i>compressa</i>
							Compressa		

**Text-figure 2:** Standard chronostratigraphy and faunal horizons of the Lower Bajocian of South America and correlation with the North-West European Province (modified from Hillebrandt 2001 and Dietze et al. 2010a). The Giebeli Zone here described is in grey.

The ammonites figured in this paper, as well as the specimens previously described in Dietze & Hillebrandt (2012), are deposited in the collection of the Staatliches Museum für Naturkunde Stuttgart (SMNS), Germany.

## 2. The sections

The sections were already surveyed in a locality map (Dietze & Hillebrandt 2012) (Text-fig. 1). The

Jurassic rocks south of the Hacienda Manflas and east of Quebrada de La Iglesia are subdivided into two blocks by a fault. A third outcrop with Bajocian sediments is found south of Manflas at Portezuelo El Padre (Text-fig. 1, localities 6–8). The Bajocian of the Manflas area is indicated in Text-figure 1 by double lines, and the different localities with ammonite occurrences are numbered. The Giebeli Zone occurs at localities 1–3 and 5–11 (Text-fig. 1); some of these localities are briefly described below.

## 2.1 Eastern block:

Locality 4 (field-numbers 720104/8–9). The ammonites and stratigraphy of the Lower Bajocian Singularis Zone were described by Dietze & Hillebrandt (2012), and the Aalenian and Upper Toarcian by Hillebrandt & Westermann (1985). Ammonites of the Giebeli Zone (Lower Bajocian) have not been recorded from this section.

## 2.2 Western block:

Locality 1 (field-number 670812/4): lies on the north slope of the crest (Cerro de la Cuesta), 1.5 km SE of Hacienda Manflas (Westermann & Riccardi 1972, 1979; Hillebrandt & Westermann 1985; Dietze & Hillebrandt 2012). A dacitic dyke has intruded nearly parallel to the bedding-plane of the Toarcian to Bajocian series. Below the dyke lies the Fe-oolitic bed with *Bredya manflasensis* (Hillebrandt & Westermann 1985) of Early Aalenian age. This horizon can be followed from the crest downslope until its base. Above the dyke follows a reddish series of ca. 50 m thick sandy marls with reddish limestone beds in the upper part. Ammonites occur in the reddish limestone beds (middle portion of the upper part of the reddish series). The ammonite fauna is dominated by *Sonninia espinazitensis* ♀ & ♂ (Pl. 1, Figs 1–8, Pl. 2, Figs 1–24), rare *Chondromileia submicrostoma* ♀ (Pl. 2, Figs 29–32) and *C. aff. giebeli* ♂ (Pl. 2, Figs 26, 27), as well as a single *Fissiloboceras zitteli* ♀ (Pl. 2, Figs 25, 28). The predominance of *S. espinazitensis*, together with *C. submicrostoma*, and the absence of early representatives of *Emileia multiformis* are indicative of the *submicrostoma* horizon of the Submicrostoma Subzone (Giebeli Zone; Hillebrandt 2001; Dietze et al. 2010, 2012).

Locality 2 (field-numbers 680130/7–9 [= loc. 2(i)] & 661202/2–3 [= loc. 2(ii)]) lies on the crest (Cerro de la Cuesta).

Locality 2(i): Field number 680130/7 comes from the sandy to marly strata that occur above the dyke. Its poor ammonite fauna with *E. cf. constricta* (Pl. 3, Fig. 2) and *Pseudotoites* sp. (Pl. 3, Fig. 1) is either from the Altecosta Subzone (Singularis Zone) or from the Submicrostoma Subzone (Giebeli Zone); both specimens are not enough diagnostic to be sure.

-Field number 680130/8: Beginning from ca. 10 m higher horizons with *Sonninia espinazitensis* ♀ (Pl. 3, Fig. 5) and a fragmentary *Chondromileia* sp. ♂ are found, both characteristic of the *submicrostoma* horizon (Submicrostoma Subzone, Giebeli Zone).

-Field number 680130/9 (ca. 30 m above 680130/8): a 0.3 m thick limestone bed with very abundant *Chondromileia giebeli* (Hillebrandt 2001: pl.

1A–B, refigured here in Pl. 3, Figs 3, 4), which can be assigned to the *C. giebeli* horizon (Multiformis Subzone, Giebeli Zone).

Locality 2(ii): Field number 661202/3 lies also on the crest (Cerro de la Cuesta), with common *Sonninia espinazitensis* ♂ & ♀ (Pl. 4, Figs 3–5, 8, 9), *Sonninia cf. mirabilis* ♀ (Pl. 4, Figs 6, 7) and rare *Chondromileia giebeli* ♂ (Pl. 4, Figs 1, 2), but lacking “*Otoites*”. In respect to the occurrences of *Sonninia espinazitensis* and the very typical *C. giebeli* we assign the beds of field number 661203/3 to the *giebeli* horizon (Multiformis Subzone, Giebeli Zone; Hillebrandt 2001; Dietze et al. 2010, 2012). *Emileia multiformis* was probably coincidentally overlooked during the only visit of AvH to this locality on March 3, 1966.

-Field number 661202/2a with *Chondroceras cf. defontii* (*Duashnoceras caracolense* horizon, Humphriesianum Zone; Hillebrandt 2001: p. 56–57).

-Field number 661202/2: this bed is Fe-oolitic and contains *Duashnoceras* sp. and *Teloceras* sp. (?*Lupherites dehmi* horizon, ?Rotundum Zone; Hillebrandt 2001: p. 56–57).

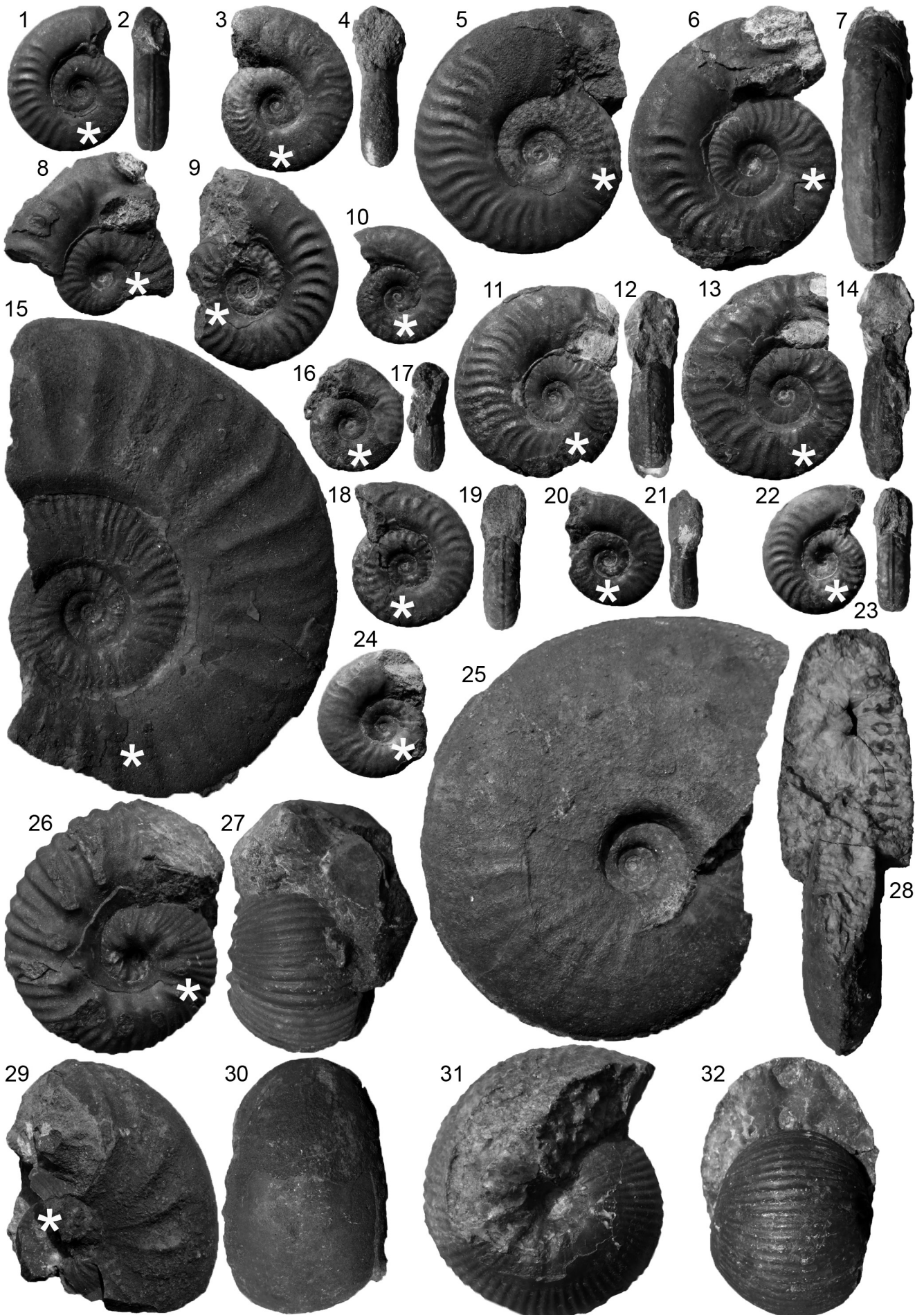
Locality 9 (field numbers 661203/1–3). Field number 661203/1 is corresponding to field number 661202/3 of locality 2(ii). Beneath one *Chondromileia giebeli* ♂ (SMNS 70445/65), typical of the *giebeli* horizon (Multiformis Subzone, Giebeli Zone), only a single nucleus of *Sonninia cf. peruana* (SMNS 70445/66) is available.

-Field number 661203/2 yielded *Dorsetenisa liostraca*, *Dorsetensia* ssp. and an indeterminable *Chondroceras* sp., indicating the *Dorsetensia* ssp. horizon (Hillebrandt 2001). The specimen described by Hillebrandt (2001) as *Emileia* (?) cf. *submicrostoma* (from locality 4 in Hillebrandt 1977: fig. 2; SMNS 70446) is correctly determined as *Chondroceras* sp. A. sensu Hillebrandt (2001). It is labelled to come probably from between field-numbers 661203/2–3. This level also belongs to the *Dorsetensia* ssp. horizon of the Humphriesianum Zone (Hillebrandt 2001: p. 56, 59).

-Field number 661203/3 [= „*Sphaeroceras*“-Schichten in Hillebrandt 1977] with silicified fossils. Rhynchonellid brachiopods are very common. The ammonites (*Chondroceras cf. defontii*, *Duashnoceras cf. andinense*, *D. cf. chilense*) allow an assignment of this bed to the *Duashnoceras caracolense* horizon (Hillebrandt 2001: p. 56–57).

Locality 3 (field numbers 670810/2–5) was measured at the lower part of Quebrada de La Culebra which is a side valley of Quebrada de La Iglesia. The section was described by Hillebrandt (1977) and Hillebrandt & Westermann (1985). Ammonites of Bajocian age were figured by Hillebrandt (1977, 2001) and Hillebrandt et al. (1992). The Jurassic section is





Age	Field number	Thickness	Facies and Fossils
?Callovian	670810/1	15–20 m	Greyish, 20 to 40 cm bedded limestones; nerineids, corals.
?Bajocian		10 m	Greenish to grey sandstones; in part reddish, with polished, angular lithoclasts
<b>Bajocian</b> <i>L. dehmi</i> horizon <i>D. chilense</i> horizon	670810/2	1,5 m	Red-brownish, fossiliferous sandstone Upper part with <i>Lupherites dehmi</i> Lower part with <i>Duashnoceras chilense</i>
		10–20 m	Intrusive porphyrite
			Not exposed
<i>C. submicrostoma</i> horizon	670810/3 670810/4 670810/5	6,5–7 m: topmost 1.5 m below 10/3 ca 5–6 m below 10/4	Alternation of 10 to 30 cm bedded marly limestones with 10 to 50 cm thick sandy marls: <i>C. submicrostoma</i> . <i>S. espinazitensis</i> , <i>C. submicrostoma</i> <i>S. espinazitensis</i>
<b>Aalenian</b>	670810/6a	5–8 m	Increasingly sandy strata; alternation of sandstones (10 to 20 cm thick) with sandy marls (10 to 30 cm thick).
<i>P. malarguensis</i> h. <i>W. groeberi</i> horizon	670810/6	1 m	Greyish limestones, upper part with <i>Puchenquia malarguensis</i> sandy limestones lower part with <i>Westermanniceras</i>
<i>B. manflasensis</i> h.		ca. 1 m	Arenaceous Fe-oolith bed with large poorly preserved <i>Bredya</i>
		5–8 m	Red sandstones, increasingly marly and calcareous downwards

dipping to the East with 65° to 70°. It is approximately 200 m thick and starts near the mouth of Quebrada de La Culebra with Toarcian strata and ends with Callovian limestones in the top.

The beds with field numbers 670810/3–5 and the ammonites from these localities belong to the *submicrostoma* horizon (Submicrostoma Subzone, Giebeli Zone). The *Chondromileia submicrostoma* figured by Hillebrandt (2001: pl. 1, fig. 5A, B, refigured here in Pl. 5, Figs 4, 7), however, is not from the *Dorsetensia* ssp. horizon as supposed by Hillebrandt (2001). The *Sonninia* fauna of these beds consists exclusively of typical *Sonninia espinazitensis* (Pl. 5,

Figs 1–3, 5, 6), which are, together with *Chondromileia submicrostoma* (Pl. 5, Figs 4, 7), characteristic for the *submicrostoma* horizon (Dietze et al. 2012). The specimen figured on Pl. 5, Figs 8, 9 represents an intermediate form between *C. submicrostoma* and *C. giebeli*.

### 2.3 Portezuelo El Padre area:

At Portezuelo El Padre, Aalenian and Bajocian ammonite beds are exposed. The Aalenian ammonites were described by Hillebrandt & Westermann (1985). A detailed Bajocian section could not be measured

(Page 29) Plate 2: (1–14, 16–24) *Sonninia espinazitensis* Tornquist ♂; (1, 2) SMNS 70445/6, (3, 4) SMNS 70445/7, (5) SMNS 70445/8, (6, 7) SMNS 70445/9, (8) SMNS 70445/10, (9) SMNS 70445/11, (10) SMNS 70445/12, (11, 12) SMNS 70445/13, (13, 14) SMNS 70445/14, (16, 17) SMNS 70445/15, (18, 19) SMNS 70445/16, (20, 21) SMNS 70445/17, (22, 23) SMNS 70445/18, (24) SMNS 70445/19. (15) *Sonninia espinazitensis* Tornquist ♀, SMNS 70445/20. (25, 28) *Fissiloboceras zitteli* (Gottsche), SMNS 70445/21. (26, 27) *C. aff. giebeli* (Gottsche) ♂ [= specimen in Hillebrandt (2001, pl. 1, figs 2A, B)], SMNS 70445/22. (29–32) *Chondromileia submicrostoma* (Gottsche) ♀; (29–30) SMNS 70445/23; (31–32) SMNS 70445/24. All specimens from locality 1. Lower Bajocian, Giebeli Zone, Submicrostoma Subzone, *submicrostoma* horizon (field-number 670812/4). \* = beginning of body chamber; all figures × 1.

(Page 31) Plate 3: (1) *Pseudotoites* sp. ♀, SMNS 70445/25. (2) *Emileia* cf. *constricta* Imlay ♀, SMNS 70445/26. (1, 2) field number 680130/7, ?Altecostata Subzone (?Singularis Zone) or ?Submicrostoma Subzone (?Giebeli Zone). (3, 4) *Chondromileia giebeli* (Gottsche) ♀ [= specimen in Hillebrandt 2001, pl. 1, figs 1A, B], SMNS 70445/27, field number 680130/9, *giebeli* horizon, Multiformis Subzone (Giebeli Zone) (5) *Sonninia espinazitensis* Tornquist ♀, SMNS 70445/28, field number 680130/8, *submicrostoma* horizon, Submicrostoma Subzone (Giebeli Zone). All specimens from locality 2 (i), Cerro de la Cuesta (crest). Lower Bajocian. \* = beginning of body chamber; all figures × 1.









bed by bed because the outcrop conditions are insufficient.

**Locality 6** (field numbers 680129/2–3). The ammonites of field number 680129/3 were found approximately 2–4 m above those from field number 680129/2.

–Field number 680129/2: *Chondromileia giebeli* ♀ (Pl. 6, Figs 6, 7), *Emileia multiformis* ♀ (Pl. 6, Figs 8, 9) and common specimens of the *E. espinazitensis* ♀ & ♂ group (Pl. 6, Figs 1–3) indicate the *giebeli* horizon (Multiformis Subzone, Giebeli Zone). *Sonninia stelzneri* (Gottsche) (Pl. 6, Figs 4, 5), *Sonninia adicra* (Waagen) sensu Imlay (Pl. 7, Figs 5, 6), *?Dorsetensia tenuicostata* (Hall, Poulton & Diakow) (Pl. 7, Figs 1, 2) and *?Fontannesia* aff. *kilianii* (Kruizinga) sensu Westermann & Yi-Gang (Pl. 7, Figs 3, 4) were collected from the same level and also come from the Giebeli Zone.

–Field number 680128/3 with *Dorsetensia liostraca* and *Dorsetensia* sp. belongs to the *Dorsetensia* ssp. horizon (Hillebrandt 2001).

**Locality 7** (field numbers 670106/13–14). As already mentioned in Dietze & Hillebrandt (2012) the material of field number 670106/13 comes mostly from the lower part and that of field number 670106/14 mostly from the upper part of the Lower Bajocian section [fieldbook: 670106/13: “mehr liegender Teil”; 670106/14: “mehr hangender Teil”]. Due to the steep topography of parts of this area collection failure cannot be ruled out and it is possible that ammonites from different strata were mixed. However, both levels can be assigned to the Multiformis Subzone (Giebeli Zone). The common *Emileia multiformis* ♀ & ♂ (Pl. 9, Figs 1, 2, 4, 5 and Figs 3, 6) and rare finds of *Sonninia espinazitensis* (Pl. 8, Fig. 4) are typical of the *giebeli* horizon. The “unusual sonniniid assemblage” with *Sonninia mammilifera* (Pl. 8, Figs 9, 10), *Sonninia* aff. *peruana* (Pl. 8, Figs 3, 7), *Sonninia* aff. *crescenticostata* (Pl. 8, Figs 5, 8), *Sonninia gracilis* Tornquist (Pl. 7, Figs 7–9), *?Fontannesia* aff. *kilianii* (Kruizinga) sensu Westermann & Yi-Gang (Pl. 8, Fig. 6) completed by *Strigoceras languidum* (Pl. 8, Figs 8, 9) also comes from the Multiformis Subzone; some of these possibly from a new horizon intercalated between the *giebeli* and the *Skirroceras/blancoensis* horizons (see Section 3): (1) We could not

find any evidence for the subsequent *Skirroceras/blancoensis* horizon or the next younger *Dorsetensia* ssp. horizon. (2) In the Submicrostoma Subzone below both *Sonninia espinazitensis* and *Chondromileia submicrostoma* are by far more common and such unusual sonniniids are missing.

**Locality 8** (field number 680129/4). The ammonites found North of Portezuelo El Padre most likely come from several beds, some of them probably from the same bed as field number 680129/2 (locality 6). Some of the specimens indicate the Submicrostoma Subzone (*Chondromileia submicrostoma* ♂ & ♀ (Pl. 10, Figs 2–5), others either the Submicrostoma or Giebeli zones (*Sonninia espinazitensis*, Pl. 10, Fig. 1; *Pseudotoites sphaerocerooides*, Pl. 11, Figs 3, 7). The “unusual sonniniid assemblage” containing *Sonninia ?mammilifera* Jaworski (Pl. 11, Figs 1, 6), *Sonninia adicra* (Waagen) sensu Imlay (Pl. 11, Figs 5, 8) and *Latiwitchellia atacamensis* n. sp. (Pl. 11, Figs 2, 4) of locality 8 comes from the Multiformis Subzone (Giebeli Zone, Lower Bajocian) for the same reasons as indicated for locality 7.

No ammonites are available from locality 5 (field number 720106/7) in the Eastern block and localities 10 (field numbers 681029/5–6) and 11 (field numbers 670115/5–6), and thus we refrain from describing these sections.

### 3. Stratigraphy and correlation within South America

**Lower Bajocian:** We can confirm the results of Hillebrandt (2001), who recognised two faunal horizons in the Giebeli Zone of the Manflas area, i.e. the *Chondromileia submicrostoma* and *C. giebeli* horizons. There is also evidence for an additional horizon intercalated somewhere between the *giebeli* and the *Skirroceras/blancoensis* horizons [in a restricted sense] (Giebeli Zone). However, our data are not sufficient enough to establish a new horizon.

**Submicrostoma Subzone:** Faunal horizon of *Chondromileia submicrostoma*. At localities 1 (field number 670812/4), 2(i) (field number 680130/8; the position of field number 680130/7 is not clear) and 3 (field numbers 670810/3–5) typical ammonites of

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(Page 32) Plate 4: (1) *Chondromileia giebeli* (Gottsche) ♀, SMNS 70445/29. (3, 8, 9) *Sonninia espinazitensis* Tornquist ♀, (3, 8) SMNS 70445/30, (9) SMNS 70445/31. (4, 5) *Sonninia espinazitensis* Tornquist ♂, SMNS 70445/32. (6, 7) *Sonninia* cf. *mirabilis* Tornquist ♀, SMNS 70445/33. (1–9) field number 661202/3; *giebeli* horizon, Multiformis Subzone (Giebeli Zone). All specimens from locality 2 (ii), Cerro de la Cuesta (crest). Lower Bajocian. \* = beginning of body chamber; all figures × 1.

(Page 33) Plate 5: (1, 3, 5, 6) *Sonninia espinazitensis* Tornquist ♀, (1) SMNS 70445/34, (3, 6) SMNS 70445/35, (5) SMNS 70445/36. (2) *Sonninia espinazitensis* Tornquist ♂, SMNS 70445/37. (4, 7) *Chondromileia submicrostoma* (Gottsche) ♀ [= specimen in Hillebrandt (2001, pl. 1, figs 5A, B)] SMNS 70445/38. (8, 9) *Chondromileia* aff. *submicrostoma* (Gottsche) ♀ [intermediate to *C. giebeli* (Gottsche) ♀] SMNS 70445/39. (1–9) All specimens from Locality 3, lower part of Quebrada de La Culebra. *submicrostoma* horizon, Submicrostoma Subzone (Giebeli Zone, Lower Bajocian). \* = beginning of body chamber; all figures × 1.

(Page 35) Plate 6: (1) *Sonninia espinazitensis* Tornquist ♀, SMNS 70445/40. (2, 3) *Sonninia espinazitensis* Tornquist ♂ SMNS 70445/41. (4, 5) *Sonninia stelzneri* (Gottsche) ♀ SMNS 70445/42. (6, 7) *Chondromileia giebeli* (Gottsche) ♀, SMNS 70445/43. (8, 9) *Emileia multiformis* (Gottsche) ♀, SMNS 70445/44. All specimens from Locality 6. *giebeli* horizon, Multiformis Subzone (Giebeli Zone, Lower Bajocian). \* = beginning of body chamber; all figures × 1.



the *submicrostoma* horizon occur in abundance, including *Sonninia espinazitensis* and *Chondromileia submicrostoma*. *Fissilobicerias zitteli* is an accessory element at locality 1. Discovery of *C. submicrostoma* and *Pseudotoites sphaerocerooides* from locality 8 also indicate the *submicrostoma* horizon. Unfortunately, the ammonites collected at locality 8 cannot be assigned to specific beds.

The Quebrada San Pedrito in N Chile (Hillebrandt 2001, locality 17) also yielded a rich, but dwarfish fauna of the *submicrostoma* horizon. The *submicrostoma* horizon of Paso del Espinacito (Argentina) can easily be correlated with the *submicrostoma* horizon of the Manflas area. It also yields *S. espinazitensis* and *C. submicrostoma* in great abundance; in addition, early *Emileia multiformis*, rare *Pseudotoites* and several *Sonninia* spp. have been recorded (Riccardi et al. 1990; Dietze et al. 2010). In the *submicrostoma* horizon of Sierra Chacaico (Neuquén Basin, Argentina) *S. espinazitensis* is very common. The variability of *C. submicrostoma* is greater compared to the variability of this species in the Manflas area (Westermann & Riccardi 1972, 1979; Dietze et al. 2012). The *submicrostoma* horizon is further recorded from the Mendoza Province of Argentina (Westermann & Riccardi 1972, 1979; Riccardi et al. 1990) and from Peru (Westermann et al. 1980).

Multiformis Subzone: Faunal horizon of *Chondromileia giebeli*. At locality 2(i) (field number 680130/9) the *giebeli* horizon is indicated by abundant *Chondromileia giebeli*. At the nearby locality 2(ii) (field number 661202/3) the *giebeli* horizon is represented by common *Sonninia espinazitensis* and rare *Chondromileia giebeli* co-occurring with *Sonninia* cf. *mirabilis*. Locality 6 (field number 680129/2) yields the most diverse fauna of the *giebeli* horizon, including *Chondromileia giebeli*, *Emileia multiformis* and *E. espinazitensis*. The two small ammonites available from locality 9 (field number 661203/1) are not sufficiently diagnostic to assign these beds safely to the *giebeli* horizon. The *giebeli* horizon of the Manflas area can easily be correlated with the *giebeli* horizon of Paso del Espinacito (Westermann & Riccardi 1972, 1979; Dietze et al. 2010), the Neuquén Basin (Westermann & Riccardi 1972, 1979; Dietze et al. 2012) and many other localities in Argentina (for details see Westermann & Riccardi 1972, 1979; Westermann 1992) and N Chile (Hillebrandt 2001).

Horizon of the “unusual sonniniid assemblages” at localities 7 and 8. As mentioned above, some confusion about the assignment of ammonites to their true levels at localities 7 (field-numbers 670106/13–14) and 8 (field-number 680129/4) is plausible. We are therefore not able to decide definitely, (a) whether parts of the sections must be assigned to the *giebeli*

horizon and a new horizon, (b) if all finds represent a new horizon, or (c) if the fauna of the *giebeli* horizon is unusually diverse. There is no doubt about an assignment of the sample sets to the Multiformis Subzone of the Giebeli Zone; in our view hypothesis (a) is the most plausible one. As already mentioned above, we have not recorded any ammonites characteristic of the *Skirroceras* horizon or the Blancoensis Subzone, respectively (see Fig. 2).

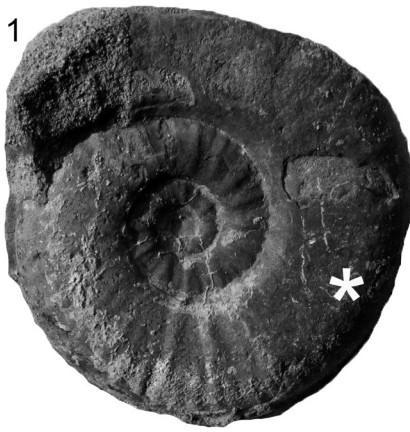
*Sonninia mammilifera*, *S. aff. peruana*, *S. aff. crescenticostatum*, *?Fontannesia aff. kiliani* sensu Westermann & Yi-Gang, *Strigoceras languidum* and *Latiwitchellia atacamensis* n. sp. from localities 7 and 8 are either previously unknown or unusual elements of the *giebeli* horizon. Also some of the ammonites from locality 6 (*Sonninia stelzneri*, *S. adicra* sensu Imlay, *?Dorsetensia tenuicostata* and *?Fontannesia aff. kiliani* sensu Westermann & Yi-Gang) may either come from a slightly higher bed than the rest of the fauna with *S. espinazitensis* and *Chondromileia giebeli*, or these taxa reach up to the tentative new horizon.

#### 4. Comments on the ammonite fauna and description of *Latiwitchellia atacamensis* n. sp.

Family Sonniniidae Buckman, 1892

- Genus *Sonninia* Bayle, 1879 [Type species: *Waa-genia propinquans* Bayle, 1878]
  - *Sonninia espinazitensis* Tornquist, 1898 ♀ [HT: Tornquist 1898: p. 20; pl. 3, fig. 2]
 

The variability of *S. espinazitensis* ♀ [= macroconchs] is well documented by the illustrations in Westermann & Riccardi (1972) and Dietze et al. (2010, 2012), mainly from Paso del Espinacito and the Charahuilla area in Argentina. We can demonstrate the variability of *S. espinazitensis* ♀ from the *submicrostoma* horizon of one single place (locality 1). The variability is very low (Pl. 1, Figs 1–8): Densely ribbed inner whorls lacking papillae are followed by wide-spaced ribs with papillae, only rarely with intercalated ribs (Pl. 5, Figs 1, 2, 5, 6, Pl. 10, Fig. 1). The ammonite illustrated in Plate 2, Figure 15 is somewhat more evolute, with slightly lower whorls and a more irregular ribbing. The variability of the macroconchs in the succeeding Giebeli Zone is higher (Pl. 3, Fig. 5, Pl. 4, Figs 3, 8, 9, Pl. 6, Fig. 1, Pl. 7, Figs 7–9 [*S. gracilis* = variety of *S. espinazitensis*]). In the Giebeli Zone the distinction of *S. espinazitensis* from *S. adicra* sensu Imlay or



*S. cf. altecostata* (Dietze et al. 2010: p. 95) is not easy in some cases.

We can also demonstrate the slightly greater variability of *S. espinazitensis* ♂ [= microconchs] from the bed containing *S. espinazitensis* ♀ at locality 1 (Pl. 2, Figs 1–14, 16–24). Already Westermann & Riccardi (1972: p. 83, 91) mentioned such finds from the “Hacienda Manflas”. Tornquist (1898) had termed the microconchs of *S. espinazitensis* as *S. bodenbenderi*. We here follow Westermann & Riccardi (1972), who regarded the small-sized and lappeted “*S. bodenbenderi*” as the corresponding microconchs of *S. espinazitensis*.

- *Sonninia mammilifera* Jaworski, 1926 [HT: Jaworski 1926: p. 231, pl. 3, fig. 1]  
Westermann & Riccardi (1972, 1979) supposed that the HT came from the “*Sonninia zitteli* concretions” [= Singularis Zone] of Arroyo Blanco. However, they were unable to find any topotypes there. Our records from the Manflas area (Pl. 8, Figs 9, 10, Pl. 11, Figs 1, 6) come from the “unusual sonniniid assemblages” of the Giebeli Zone. We disagree with Westermann & Riccardi (1972), who have tentatively assigned this taxon to the subgenus *Fissilobicerias*.
- *Sonninia* aff. *crescenticostata* (Taylor) ♀ [HT: Taylor 1982: p. 131, pl. 2, figs 5, 6]  
The single specimen in our hands, although with similarities to *Sonninia adicra* sensu Imlay, matches best with *S. crescenticostata*. This taxon was originally described by Taylor (1972, 2016) as *Euhoploceras crescenticostatum* from the uppermost Aalenian Packardii Zone of Oregon.
- *Sonninia adicra* (Waagen) sensu Imlay ♀ [LT: Waagen 1867: p. 591, pl. 25, fig. 1a, b]  
Some specimens (Pl. 7, Figs 5, 6, Pl. 11, Figs 5, 8) fall within the high variation of *S. adicra*, as demonstrated by Imlay (1973) from Oregon or by Dietze et al. (2005) from SW Germany. These specimens differ from *S. espinazitensis* by lacking the typical papillae, showing broader whorl sections and often by their spinose inner whorls. In contrast, the inner whorls of *S. espinazitensis* lack any tubercles.
- *Sonninia* aff. *peruana* Jaworski ♀ [LT: Jaworski 1915: p. 401, pl. 8, fig. 3a, c]  
The cast of the LT (Westermann & Riccardi 1972: pl. 27, fig. 1) of this species from beds with “*Otoites sauzei*” at Chunumayo (Peru) does not show papillae on the last preserved whorl of the phragmocone which are said to

be characteristic for this species (Westermann & Riccardi 1972). The nucleus shows delicate spines. The LT and the ammonite figured on Pl. 8, Figs 3, 7 both show a similar ribbing style and whorl-section with more or less parallel flanks and no papillae.

- *Sonninia gracilis* Tornquist ♀, [HT: Tornquist 1898: p. 21, pl. 4, fig. 4]  
Westermann & Riccardi (1972) and Dietze et al. (2010) regarded *S. gracilis* as synonymous or as a variety of *S. altecostata* from the *Altecostata* Subzone. *S. altecostata* is the older chronospecies leading to *S. espinazitensis* in the Giebeli Zone (Westermann & Riccardi 1972; Dietze et al. 2010; Dietze et al. 2012). Our specimens (Pl. 7, Figs 7–9) come from the “unusual sonniniid assemblages” within the Giebeli Zone. Westermann & Riccardi (1972: pl. 23, fig. 6a, b, pl. 24, fig. 1, pl. 27, fig. 2) figured some similar ammonites as *S. espinazitensis* and another one as *S. cf. peruana*, all of these coming from the Giebeli-Zone. The morphospecies *S. gracilis* is the involute and (on the phragmocone) untuberculated variety within the chronocline *S. altecostata* → *S. espinazitensis*, which possibly ends with *S. peruana*. *S. gracilis* differs from phragmocones of *Fissilobicerias zitteli* (e.g., Pl. 2, Figs 25, 28) by a more rounded umbilical edge, a slightly stronger ribbing and a compressed elliptical whorl section.
- *Sonninia stelzneri* (Gottsche) ♀ [LT: Gottsche 1878: p. 12, pl. 1, fig. 6]  
Westermann & Riccardi (1972) and Dietze et al. (2010) regarded the LT of “*Harpoceras stelzneri*” as a ?*Fissilobicerias*. However, the small-sized LT of this species shows more similarities (whorl-section, thin keel, delicate spines on the innermost whorls) with the genus *Sonninia*. The herein figured specimen (Pl. 6, Figs 4, 5) is better comparable to the LT and shows an identical ribbing style and whorl-section.
- *Sonninia* cf. *mirabilis* Tornquist ♀ [HT: Tornquist 1898: p. 23, pl. 4, figs 2, 3]  
The ammonite figured on Pl. 4, Figs 6, 7 is close to the holotype of *S. mirabilis*, which Tornquist (1898) has assigned to his “Formenreihe der *Sonninia Sowerbyi*”. The innermost whorls of both specimens are nearly identical. However, in our specimens the last whorl shows lower and fewer tubercles compared to the holotype. *S. mirabilis* seems to be very rare: Tornquist (1898) had only the holotype from



Paso del Espinacito, Westermann & Riccardi (1972) recorded only one additional specimen from Cerro Puchenque (Mendoza Province, Argentina). The exact stratigraphical provenance of the HT is unknown. The specimen from Cerro Puchenque comes from the Singularis Zone (Westermann & Riccardi 1979: p. 101). Our specimens are from the Multiformis Subzone (Giebeli Zone).

- Genus *Dorsetensia* Buckman, 1892 [Type species: *Ammonites edouardianus* d'Orbigny, 1845]

- ?*Dorsetensia tenuicostata* (Hall, Poulton & Diakow), 1991 ♂ [HT: Hall et al. 1991: p. 141; pl. 6.1, figs 6, 7]

Already Hall et al. (1991) discussed the generic status of their new species "*Sonninia*" *tenuicostata* from British Columbia (Canada). They refrained from its affiliation to *Dorsetensia*, because Morton (1972) had noticed that the specimens figured by him from the Isle of Skye (Scotland) are characterized by a sharp to rounded umbilical angle and steep or even vertical umbilical walls. The type species of the genus, *D. edouardiana*, shares some of these characters (Dietze et al. 2011). However, other members of the probably polyphyletic genus *Dorsetensia* exhibit gently sloping lower flanks and lack a distinct umbilical angle or wall as in ?*D. tenuicostata*: the group of *D. complanata* – *D. romani* (Dietze et al. 2011). In consequence, we assign this taxon to ?*Dorsetensia tenuicostata*. The single specimen from the Giebeli Zone of locality 6 (Pl. 7, Figs 1, 2) matches very well with the holotype (Hall et al. 1991: pl. 6.1, figs 6, 7) and further figured topotypes. The latter authors have dated the loose blocks on the floor of a small quarry, from which they extracted their material of "*Sonninia*" *tenuicostata* (Hall et al. 1991: pl. 6.1, figs 2, 3, 6–13) and *Sonninia dominans* (Hall et al. 1991: pl. 6.1, figs 4, 5) as Discites Zone. However, these blocks may be younger; also their determination of the two illustrated fragmentary sonniniid ammonites as *S. dominans* is doubtful.

- Genus *Fontannesia* Buckman, 1902 [Type species: *Dumortieria grammoceroides* Haug, 1887]

- ?*Fontannesia* aff. *kiliani* (Kruizingai) sensu Westermann & Yi-Gang [HT: *Grammoceras kiliani* Kruizinga 1926: p. 38; pl. 7, fig. 2]

The best matches for two ammonites (Pl. 7, Figs 3, 4, Pl. 8, Fig. 6) from the Giebeli Zone of the Manflas area we could find in the literature are ammonites figured by Westermann & Yi-Gang (1988: pl. 20, figs 1–4) from South

Tibet as *Fontannesia kiliani* (Kruizinga) and by Westermann & Getty (1970: pl. 49, figs 1a–2b, 4a, b) from New Guinea as *Fontannesia* aff. *F. clarkei* (Crick) [?subsp. *kiliani* (Kruizingai)], both dated as "Lower Bajocian" (Sato & Westermann 1991). Our finds differ from the holotype of "*Grammoceras*" *kiliani* Kruizinga (refigured in Westermann & Getty 1970: text-fig. 5 [left]) by their less dense ribbing, their smoother nucleus and their less prominent keel. "*Grammoceras*" *baumbergeri* Kruizinga (holotype refigured in Westermann & Getty 1970: text-fig. 5 [right]) is also similar, however, the holotype is too damaged for a precise determination. Phragmocones of *Newmarraceras clarkei* (Crick) and *N. fairbridgei* (Arkell) from Western Australia (Arkell & Playford 1954; Hall 1989) are on first sight also very close to our specimens. However, Hall (1989: p. 6) demonstrated that the genus *Newmarraceras* differs from *Fontannesia* especially by its smooth body chamber, a different whorl-section and more simplified suture lines. We use the genus *Fontannesia* with a question mark, (1) due to the still unknown occurrence in strata of the Giebeli Zone (= Sauzei/Propinquans Zone of the European standard). The acme of this genus lies around the Aalenian/Bajocian boundary. (2) In contrast to our specimens, the holotype of the type species *F. grammoceroides* (refigured in Howarth 2013: fig. 82.2a, b) exhibits a steep umbilical wall.

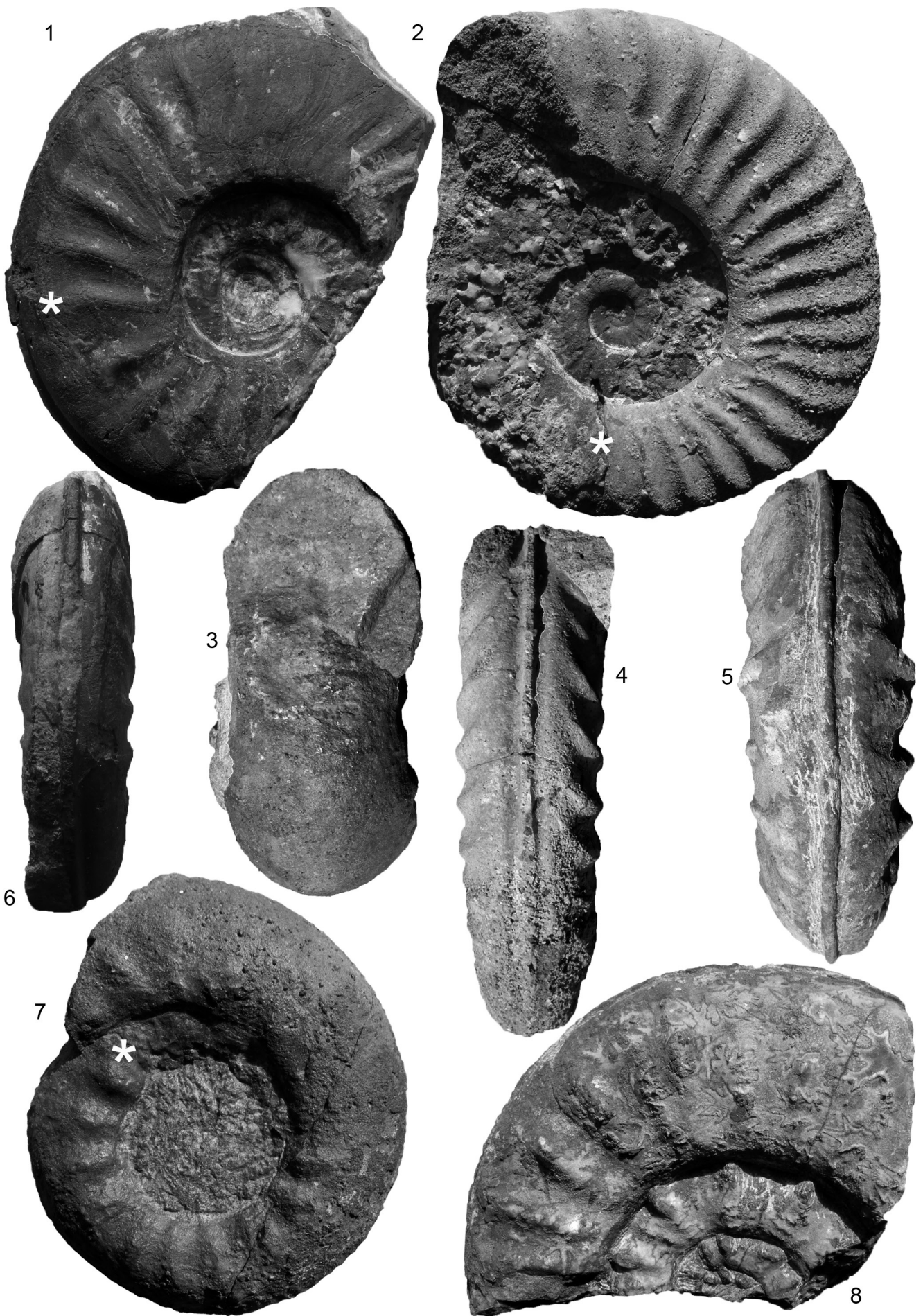
- Genus *Latiwutchellia* Imlay 1973 [Type species: *Witchellia (Latiwutchellia) evoluta* Imlay 1973]

Remarks: The taxonomic status of *Latiwutchellia* is discussed controversially. It was introduced by Imlay (1973) as a subgenus of *Witchellia* Buckman, 1889 within the family Sonniniidae Buckman, 1892. Donovan & Callomon (1981) regarded this genus as a synonym of *Fontannesia* Buckman, 1902, also within the subfamily Sonniniidae. Smith & Taylor (1992: p. 72) elevated the rank to genus level. Sandoval et al. (2012) regarded *Latiwutchellia* within the line *Vacekia* → *Asthenoceras* → *Latiwutchellia* as a member of the subfamily Grammocerotinae Buckman, 1904. Howarth (2013) overlooked this taxon in the new "Treatise" volume. Like Imlay (1973) we regard *Latiwutchellia* as closely related to the genus *Witchellia*, enclosing evolute members of the group with a low body chamber (*Witchelliinae* Chandler et al., 2006 within the Sonniniidae). The genera *Vacekia* and *Asthenoceras* of the Grammocerotinae differ especially by their much smaller size and their thin and very high keel.









*Latiwitchellia atacamensis* n. sp.  
(Pl. 11, Figs 2, 4)

? 1970 *Fontannesia* aff. *F. clarkei* (Crick) [subsp. *kiliani* (Kruizinga)]. – Westermann & Getty: p. 238; pl. 48, figs 1a–3b.

Derivatio nominis: After the type area (Atacama Province, N Chile)

Holotype [by monotypy]: Specimen figured on Pl. 11, Figs 2, 4; SMNS 70445/62

Type locality: Loc. 8 at Portezuelo El Padre S of Manflas (Fig. 1), field number 680129/4

Age: Giebeli Zone (Lower Bajocian)

Material: Holotype

Diagnosis: Evolute specimen with strong, undivided primaries without intercalatories on the body chamber, fine ribs on the inner whorls and subquadrate whorl section, venter bisulcate.

Description: The ammonite is completely preserved as a “steinkern” with its mouthborder. The subquadrate body chamber is about half of a whorl, ending with a ventral extension. The single, slightly sinuous and prorsiradiate ribs start just above the rounded umbilical edge and bound forward near the ventrolateral edge, where they disappear. The keel is laterally bordered by sulci. The last whorl of the phragmocone is partly broken. The inner whorls show fine, distant ribs. The suture line is not visible.

Comparisons: The new species shows a close resemblance to *Latiwitchellia evoluta* Imlay, 1973 from Oregon. However, the venter of the holotype of *L. evoluta* (Imlay 1973: pl. 32, figs 1, 2, 5, 6) is rounded, with only small sulci along the keel. Some paratypes figured by Imlay (1973: e.g., pl. 31, figs 1, 2, 7, 8, 10, 11), however, show a very similar ventral aspect as our specimen. The ribbing of *L. evoluta* is more irregular compared to *L. atacamensis* n. sp. Another close species is *W. sutneroides* Westermann from Alaska. This species differs, however, as from all “European” species, by its higher whorl section of the body chamber, a stronger ribbing on the inner whorls and more irregular ribbing style (Westermann 1969: pls 28–31). Very close are also specimens figured by Westermann & Getty (1970: pl. 48, figs 1a–3b) from New Guinea as *Fontannesia* aff. *F. clarkei*

(Crick) [? subsp. *kiliani* (Kruizinga)]. However, these specimens are extreme variants of a highly variable species (see Westermann & Getty 1970: pl. 48, fig. 4a, b, pl. 1a–4b) with a more rounded venter and missing sulci beneath the keel. The broad, strongly ribbed varieties from New Guinea also show a stronger ribbing on the inner whorls; these specimens are slightly more involute.

Measurements (in mm [at final diameter]):

	d	w	Wb	wh	ribs on body chamber
Holotype	100	42	25	32	19

Family Hammatoceratidae Buckman, 1887

- Genus *Fissilobicer* Buckman, 1919 [Type species: *Ammonites fissilobatus* Waagen, 1867]
  - *Fissilobicer zitteli* (Gottsche, 1878 ♀ [HT: Gottsche 1878: p. 10, pl. 1, fig. 4] Only a single, very well-preserved phragmocone of the genus *Fissilobicer* which shows its acme in the Singularis Zone (Westermann & Riccardi 1979: tab. 2), is available (Pl. 2, Figs 25, 28).

Family Otoitidae Mascke, 1907

- Genus *Pseudotoites* Spath, 1939 [Type species: *Stephanoceras leicharti* Neumayr, 1885] As already shown by Westermann & Riccardi (1979), Riccardi et al. (1990) and Dietze et al. (2010), last representatives of the genus *Pseudotoites*, which is most abundant in the Singularis Zone, range up to the Submicrostoma Subzone and is possibly very rare in the Multiformis Subzone of the Giebeli Zone. *Pseudotoites* sp. (Pl. 3, Fig. 1) comes from the Altecostata Subzone (Singularis Zone) or the Giebeli Zone.
  - *Pseudotoites sphaeroceroides* (Tornquist, 1898 ♀ [LT: Tornquist 1898 : p. 25, pl. 6, fig. 2] The specimen of *Pseudotoites sphaeroceroides* (Pl. 11, Figs 3, 7) comes most likely from the Submicrostoma Subzone; no further ammonites typical of the Altecostata Subzone – where *Pseudotoites sphaeroceroides* is common – were found at locality 8. The exact provenance of these ammonites cannot be fixed with confidence.

(Page 42) Plate 10: (1) *Sonninia espinazitensis* Tornquist ♀, SMNS 70445/58. (2, 3) *Chondromileia submicrostoma* (Gottsche) ♂, SMNS 70445/59. (4, 5) *Chondromileia submicrostoma* (Gottsche) ♀, SMNS 70445/60. (1) Giebeli Zone. (2–5) Submicrostoma Subzone (Giebeli Zone). All specimens from Locality 8; Lower Bajocian. \* = beginning of body chamber; all figures × 1.

(Page 43) Plate 11: (1, 6) *Sonninia ?mammilifera* Jaworski ♀, SMNS 70445/61. (2, 4) *Latiwitchellia atacamensis* n. sp., SMNS 70445/62. (3, 7) *Pseudotoites sphaeroceroides* (Gottsche) ♀, SMNS 70445/63; Singularis or Giebeli zones. (5, 8) *Sonninia adicra* (Waagen) sensu Imlay, ♀, SMNS 70445/64. All specimens from locality 7. (1, 2, 4–6, 8) Multiformis Subzone (Giebeli Zone, Lower Bajocian). \* = beginning of body chamber; all figures × 1.

- Genus *Emileia* Buckman, 1898 [Type species: *Ammonites brocchii* J. Sowerby, 1818]
  - *Emileia* cf. *constricta* (Imlay, 1964 [HT: Imlay 1964: p. B40, pl. 11, figs 1, 6])  
The partly preserved body chamber of the specimen on Pl. 3, Fig. 2 is worn and does not show any sculpture. The rounded, finely ribbed venter of the specimen, its broad whorl section, becoming high-ovate and the depressed body chamber resemble *E. constricta*. *E. brocchii* (J. Sowerby) differs from our specimen by its broader whorl section, a much bigger size of complete specimens (coll. VD from S England) and its less depressed body chamber (Imlay 1964: B41). *E. constricta* comes from the Crassicostatus Zone (Westermann 1992) of Cook Inlet (Southern Alaska), which correlates with the Giebeli Zone of South America (Taylor 1988; Westermann 1992).
  - *Emileia multiformis* (Gottsche, 1878 [HT: Gottsche 1878: p. 14, pl. 2, fig. 7; NT: Westermann & Riccardi 1979: p. 123, pl. 3, fig. 2])  
The specimens of *Emileia multiformis* from the Manflas area (Pl. 6, Figs 8, 9, Pl. 9, Figs 1–5) are very similar to those collected in the Neuquén Basin of Argentina (Westermann & Riccardi 1979; Dietze et al. 2012). The characteristic features of this species (relative small and constant final diameter, coarse and prominent primaries restricted to the lower part of the flanks, broad oval whorl section; Dietze et al. 2012: p. 133) can be observed as well.

#### Family Strigoceratidae Buckman, 1924

- Genus *Strigoceras* Quenstedt, 1886 [Type species: *Ammonites truellei* d'Orbigny, 1845]
  - *Strigoceras languidum* (Buckman, 1924 ♀ [HT: Buckman 1924: pl. 477A])  
Our material consists of only a half whorl of this rare genus. Our specimen (Pl. 8, Figs 1, 2) fits well with *S. languidum* as described by Schweigert et al. (2007).

### 5. Conclusions

The ammonites from the *submicrostoma* horizon (Submicrostoma Subzone) and the *giebeli* horizon (Multiformis Subzone) confirm the previously known stratigraphical data (Westermann & Riccardi 1990). The variation of *S. espinazitenis* ♀ & ♂ in the *submicrostoma* horizon could be demonstrated from one locality and shows that the ♂ exhibit a lappeted mouthborder. Probably from a new horizon between the *giebeli* horizon and the Blancoensis Subzone [possibly including the lower part of this subzone] a “unusual sonniniid assemblage” is recorded. Some of these ammonites could be helpful for improvements of the correlation between the Andean Pro-

vince with Tibet, Papua Neuguinea, and Canada.

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