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# Early Callovian Reineckeids from the Back-Arc Basin of Northern Chile

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With 11 figures

**Contents**



**Abstract**

Reineckeiidae of the Early Callovian age from the Coastal Cordillera and the Precordillera of northern Chile are being described. Up to now, these Early Callovian reineckeids have mostly been described as species of *Neuqueniceras* STEHN, 1923, but new detailed studies allow for their placement in the genus *Frikites* JEANNET, 1951. *Frikites*, which hitherto has also been regarded as a subgenus of *Neuqueniceras*, shows such specific morphological characteristics that allow for it to be regarded as an independent genus. Within the genus *Frikites* the following three new species can be distinguished: *Frikites lehmanni* n. sp., *F. zeili* n. sp., and *Frikites* n. sp. In northern Chile, the beginning of the Callovian can be determined by the first appearance of *Frikites*.

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**Zusammenfassung**

Reineckeiidae aus dem unteren Callovium der Küsten- und Präkordillere Nordchiles, die bisher zur Gattung *Neuqueniceras* STEHN, 1923 gestellt wurden, werden nun der Gattung *Frikites* JEANNET, 1951 zugeordnet. Die Gattung *Frikites*, die bisher u.a. als Untergattung von *Neuqueniceras* betrachtet wurde, wird aufgrund ihrer charakteristischen Gehäuseskulptur nun als eigenständige Gattung angesehen. Aus Nordchile werden drei neue Arten von *Frikites* beschrieben: *Frikites lehmanni* n. sp., *F. zeili* n. sp. und *Frikites* n. sp. Mit dem ersten Auftreten von *Frikites* kann in Nordchile der Beginn des Calloviums erfasst werden.

## I. Introduction

In northern Chile, marine Middle Jurassic sediments have been recorded from various localities in the Coastal Cordillera and the Precordillera north of 26°S (e.g. STEINMANN, 1881; MÖRICKE, 1894; GRÖSCHKE & HILLEBRANDT, 1985, 1993, 1994; GRÖSCHKE & PRINZ, 1986; GRÖSCHKE & WILKE, 1986; GRÖSCHKE et al., 1988; PRINZ et al., 1994; KOSSLER, 1998; WITTMANN, 2001). These Cordilleran sediments were deposited in a back-arc basin. They partially consist of volcaniclastic materials resulting from the high input of the Jurassic volcanic arc located to the west. The high sedimentary rate also led to an enormous thickness of the north Chilean Jurassic formations. Additionally, the Bathonian and Callovian formations generally indicate a more pelagic influence that can be traced to sea-level high stands during this time (KOSSLER, 1998; HILLEBRANDT et al., 2000; WITTMANN, 2001). Consequently, the Bathonian/Callovian sections are mainly characterized by thick series of thin-bedded, fine-laminated calcilutites.

Within these sediments, ammonites are rare and for the most part badly preserved; however, a few horizons have provided some well-preserved ammonites. Although many of these have been found and described during the last two centuries (e.g. STEINMANN, 1881; MÖRICKE, 1894; JAWORSKI, 1914; STEHN, 1923), they mostly stemmed from scattered localities and are characterized by the lack of stratigraphic control. Great progress has been made in the understanding and correlation of the different Middle Jurassic ammonite sequences in northern Chile due to the work of members of the Research Group "Mobilität aktiver Kontinentalränder" and the Sonderforschungsbereich 267 "Deformationsprozesse in den Anden" of the Deutsche Forschungsgemeinschaft, who were primarily interested in ammonoid biostratigraphy ( e.g. GRÖSCHKE & ZEISS, 1990; GRÖSCHKE & HILLEBRANDT, 1994; HILLEBRANDT & GRÖSCHKE, 1995; GRÖSCHKE, 1996; GRÖSCHKE & KOSSLER, 1999; HILLEBRANDT, 2001).

This article aims at assigning the Lower Callovian reineckeids of northern Chile to the genus *Frikites*, a genus which was most probably endemic in the Andean realm of northern Chile and Argentina.

## II. Localities

The ammonites examined here, formerly called *Neuqueniceras*, were mostly found in the Jurassic area of the Cerro Jaspe region, E of Sierra Moreno, N of Calama: 1) section I, S of the Quebrada Berilo, 68°58'12"W/21°51'20"S, and 2) section II, S of the Quebrada Berilo, 68°58'10"W/21°52'30"S (see fig. 1). Further information about lithology including locality map are already given in GRÖSCHKE & WILKE (1986: p. 1318 – 1323, fig. 1, 2). The

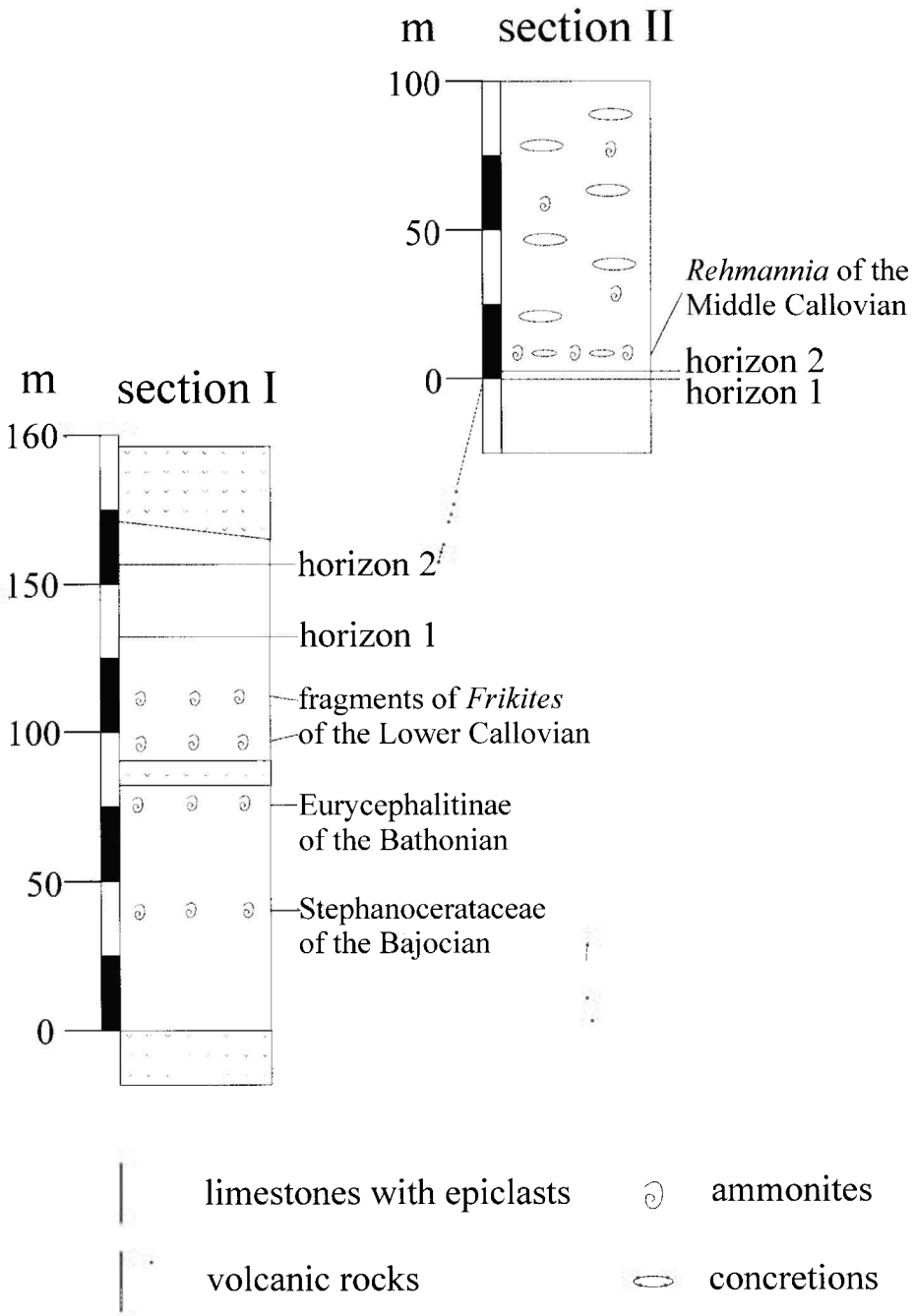


**Fig. 1:** Generalized sections of the Lower Callovian succession, S of the Quebrada Berilo, Cerro Jaspe region, Precordillera (section I: horizon 1=TUB Gr 860206/38a, b, horizon 2=TUB Gr 860206/43a-d, TUB Gr 831223/2; section II: horizon 1= TUB Gr 870423/1a-h, TUB Gr 870324/4, horizon 2 = 870423/2).

locality and the section of the specimens of the Quebrada Tiliviche (Costal Cordillera, E of Pisagua) are described and figured in WITTMANN (2001: p. 23; p. 122, fig. 9-1).

Further information about localities and sections containing *Frikites* (="*Neuqueniceras*") are shown in GRÖSCHKE & HILLEBRANDT (1994: Sierra Candeleros, p. 257; Quebrada del Profeta, p. 257; Sierra de Argomedo, p. 258; Aguada El Oro, p. 258; Cerro Pascua, p. 260; Quebrada San Pedro, p. 260; Cerritos Bayos and Cerros San Lorenzo, p. 260 - 261), HILLEBRANDT & GRÖSCHKE (1995: Portezuelo Azabache, p. 8, fig. 1, 2; Aguada El Oro, p. 9, fig. 1, 2), and in KOSSLER (1998:Costal Cordillera of Iquique, p. 112, Anhang: 13. Profil "Oficina Condor, Abschnitt II").

## III. Biostratigraphy

Despite many new findings (eg. GRÖSCHKE & HILLEBRANDT, 1993, 1995; GRÖSCHKE, 1996; KOSSLER, 1998; HILLEBRANDT, 2001) the subdivision of the north Chilean Middle Jurassic succession in ammonite zones and the correlation with the European Standard Zones frequently remain uncertain. Ammonites and other fossils tend to be scattered throughout extremely thick formations, but they can also be concentrated in few faunal horizons. An additional difficulty is the fact that the Chilean ammonite assemblages are often composed of endemic and/or long living cosmopolitan taxa that do not allow for a definite comparison with the European Standard Zones. For these reasons, the Bathonian/Callovian boundary as it is defined in Europe cannot be exactly determined in northern Chile.

In Argentina, RICCARDI et al. (1989) and RICCARDI & WESTERMANN (1991a, b) could recognize the Steinmanni Zone and the *Stenocephalites gerthi*-Horizon for the Upper and Uppermost Bathonian and the Vergarensis-, Bodenbenderi-, and Proximum Zones for the Lower Callovian; while the first Argentinean neuqueniceratids already occur within the Steinmanni Zone of the Upper Bathonian (RICCARDI et al., 1989; RICCARDI & WESTERMANN, 1991b).

According to GRÖSCHKE & HILLEBRANDT (1993, 1994), KOSSLER (1998), and WITTMANN (2001) this zoning cannot be applied to the Chilean sedimentary succession. In northern Chile, specimens and fragments of *Frikites* occur in numerous localities, but mostly as isolated moulds of body-chambers or in few faunal horizons. Because of the great distances between the different sections in the Coastal- and the Precordillera, these cannot be correlated exactly. But it is certain that *Frikites* always appears above horizons with *Epistrenoceras* BENTZ, 1928 and *Choffatia jupiter* STEINMANN, 1881 (Upper Bathonian) and below horizons with *Rehmannia* SCHIRARDIN emend., 1956, while the latter already indicates the beginning of the Middle Callovian (RICCARDI & WESTERMANN, 1991b; GRÖSCHKE & HILLEBRANDT, 1993). *Frikites* never occurred together with the taxa mentioned above, i.e. neither with *Epistrenoceras* and *Choffatia jupiter* nor with *Rehmannia*. Therefore, the occurrence of *Frikites* provides clear evidence for the Lower Callovian in northern Chile, a period of time, which is characterized by these mostly endemic ammonites. Moreover, according to GRÖSCHKE & HILLEBRANDT (1994) the first appearance of *Frikites* can be used to indicate the beginning of the Callovian. At this moment, a subdivision of the Lower Callovian of northern Chile into ammonite zones is impossible. Therefore, further sections with a continuous and an uninterrupted record of ammonites would be absolutely necessary to introduce a valid zoning.

## IV. Systematic description

Repository of materials: For the moment, the materials used in this study are stored at the Technical University of Berlin, Germany (TUB Gr-No., TUB Wi-No.). In the long run, they will be returned to Chile.

Abbreviations: d, diameter in mm; u, umbilical width as a % of diameter; h, whorl height in mm; w, whorl width in mm; h/w, whorl height/whorl width ratio; p, primary ribs on a whole whorl; p/2, primary ribs on a half whorl; bc, body chamber.

### Suborder Ammonitina Hyatt, 1889

### Superfamily Perisphinctaceae Steinmann, 1890

### Family Reineckeiidae Hyatt, 1900

Cariou (1984: p. 35 - 36) has divided the Reineckeiidae into two new subfamilies, the Neuqueniceratinae with the genera *Neuqueniceras* and *Frikites* and the Reineckeiinae. He concluded that except for the geographical distribution restricted to South America and Mexico, the Neuqueniceratinae differs from the Reineckeiinae by its perisphinctoid inner whorls and the position of furcation points on the whorl sides. Whereas Cariou (1984) still declared all South American reineckeids as belonging to the Neuqueniceratinae, some authors (e.g. Riccardi et al., 1989; Riccardi & Westermann, 1991b; Gröschke & Hillebrandt, 1993; Kossler, 1998; Wittmann, 2001) also proved the occurrence of genera of the Reineckeiinae like *Reineckeia* Bayle, 1878, *Rehmannia*, and *Loczyceras* Bourquin, 1968 in Argentina and Chile.

The present study led to the conclusion that *Frikites* does not fit well into the existing subfamilies, neither into the Neuqueniceratinae nor into the Reineckeiinae. The genus *Frikites* with its very variable morphology of shells shows features like the presence of tubercles on the inner whorls and the tendency to evolve a more or less coronate shell form. Taking into account the diagnostic characteristics proposed by Cariou (1984) and Riccardi & Westermann (1991b), *Frikites* allows neither for a secure assignment to the Neuqueniceratinae nor to the Reineckeiinae. In our opinion, it seems to be doubtful that the subdivision into the two subfamilies can be maintained for the Reineckeiidae.

### Genus *Frikites* Jeannet, 1951

Type species: *Reineckeia bodenbenderi* Tornquist (1898, p. 51 -52 [183 - 184], pl. 10, fig. 1; stored in the Georg-August-University Göttingen, Germany (GAUG 496-453).

Comments: Jeannet (1951) introduced the genus *Frikites* as a subgenus of *Kellawaysites* Buckmann, 1925, while he designated *"Reineckeia" bodenbenderi* Tornquist, 1898 from the Paso del Espinazito of Argentina (San Juan province) as type species of *Frikites*. In this context, he neither described nor discussed nor figured the type species *Frikites bodenbenderi*, but he added a new European species to this genus, *Frikites freii*, from the Callovian beds of Switzerland. According to Cariou (1984) this European species belongs to the reineckeid genus *Rehmannia* and has nothing to do with the South American *F. bodenbenderi*. It should also be mentioned that the type species of *Frikites* is a very rare species, which hitherto has been proved only from the Paso del Espinazito with certainty. All the further specimens specified in Riccardi & Westermann (1991b) are badly preserved fragments; it is doubtful whether these fragments belong to *F. bodenbenderi*.

In contrast to JEANNET (1951), many authors such as BUSNARDO et al. (1964), WESTERMANN et al. (1984), RICCARDI et al. (1989), SANDOVAL et al. (1990), and RICCARDI & WESTERMANN (1991b: *N. (Frikites) bodenbenderi*, p. 136, pl. 16, fig. 1a-c) ranked *Frikites* as a subgenus to *Neuqueniceras* STEHN, 1923, a reineckeid genus which is common and widespread in the Upper Bathonian/Callovian of Argentina (STEHN, 1923; RICCARDI et al. 1989; RICCARDI & WESTERMANN, 1991b). It is noteworthy that SPATH (1928) already included "*Reineckeia*" *bodenbenderi* in *Neuqueniceras*.

ZEISS (1956) and ARKELL et al. (1957) considered *Frikites* as synonymous with *Neuqueniceras*, due to the missing discussion of differences between *Neuqueniceras* and *Frikites* by JEANNET (1951).

So far, the genus *Neuqueniceras* has also been used for the large reineckeids of the Lower Callovian of northern Chile (GRÖSCHKE & HILLEBRANDT, 1985, 1993, 1994; RICCARDI & WESTERMANN, 1991b; KOSSLER, 1998; WITTMANN, 2001). Now, new detailed studies have shown that these large reineckeids are, in fact, closely related to *Frikites bodenbenderi*, but they differ remarkably from the Argentinean genus *Neuqueniceras*, which up to now has never been found in Chile.

Studies on the plaster casts of the originals in RICCARDI &WESTERMANN (1991b) of *Neuqueniceras steinmanni* STEHN, 1923 (the type species of *Neuqueniceras*) have shown that this genus is characterized by an obviously perisphinctoid shell, which shows non-tuberculate inner whorls and outer whorls with distinct primary ribs bearing blade-like bullae. Except for the bullae *Neuqueniceras* bears a strong resemblance to the Upper Bathonian/Callovian genus *Choffatia* SIEMIRADZKI, 1898 (Perisphinctidae), which is also well-known from Chile (only Upper Bathonian) and Argentina (STEINMANN, 1881; ARKELL et al., 1957; RICCARDI et al., 1989; GRÖSCHKE & HILLEBRANDT, 1994). It is most probable that *Neuqueniceras* evolved from *Choffatia*.

Therefore, the distinctly different morphological features of the ammonites from the Chilean back-arc basin, which were formerly called and described as *Neuqueniceras* in GRÖSCHKE & HILLEBRANDT (1985, 1993, 1994), KOSSLER (1998), and WITTMANN (2001), allow for their placement within the genus *Frikites*. We hereby follow CARIOU (1984) who stated the validity of *Frikites* as an independent genus. It seems to be that these reinickeids, which belong to *Frikites*, evolved independently and parallel to the contemporary Argentinean neuqueniceratids. At the moment, the precise relation between *Neuqueniceras* and *Frikites* is not very clear. Due to the scarce materials, the origin of *Frikites* cannot be traced; it remains unclear whether there was a common ancestor or if they had distinct roots.

Diagnosis: The diagnosis for the genus *Frikites* given in RICCARDI & WESTERMANN (1991b) „Large *Neuqueniceras* with intermediate stage bearing moderately short primaries with mid-lateral tubercles, and outer stage with very prominent and conical mid-lateral spines" must be modified as follows:

Shell evolute, outer whorls depressed and bulky, position of tubercles more or less on mid-flank. Tubercles may occur on innermost whorls, tubercles or spines very prominent on outer whorls, spines may disappear on outer whorl of adult specimens. Outer whorl then covered by distinct simple ribs.

**Fig. 2:** Measurements of the species of *Frikites* examined here and of the type species *F. bodenbenderi* (holotype).

| No. of sample | d | u% | h | w | h/w | p or p/2 |
|---|---|---|---|---|---|---|
| ***Frikites antipodum*** | | | | | | |
| TUB Gr 870423/1a | 196 | 43 | 64 | 72 | 0,89 | 8/2 |
| | 108 | 43 | 36 | 44 | 0,82 | 8/2 |
| | 59 | 41 | 19 | 22 | 0,86 | 12/2 |
| TUB Gr 870423/1b | 194 | 46 | 54 | 62,5 | 0,86 | 14 |
| | 120 | 43 | 40 | 44 | 0,91 | 12 |
| TUB Gr 870423/1c | 146 | 42 | 47 | 56 | 0,84 | 15 |
| | 105 | 42 | - | - | - | 15 |
| TUB Gr 870423/1d | 143 | 41 | 47 | 56 | 0,84 | 14 |
| | 113 | 41 | 38 | 43 | 0,88 | 15 |
| | ~38 | ~45 | - | - | - | - |
| TUB Gr 870423/1e | 243 | 43 | 73 | 79 | 0,92 | 8/2 |
| | 138 | 45 | 39 | 44 | 0,87 | 8/2 |
| TUB Gr 870324/4 | 181 | 44 | 58 | 68 | 0,85 | 16 |
| | 138 | 42 | 46 | 56 | 0,82 | 16 |
| | 57 | 49 | - | - | - | 27 |
| TUB Gr 831223/2 | 146 | 47 | 46 | 55 | 0,84 | 15 |
| TUB Gr 860206/38a | 104 | 40 | 36 | 42 | 0,86 | 12 |
| | 81 | 40 | 29 | 35 | 0,83 | 15 |
| TUB Gr 860206/43a | 135 | 45 | 43 | ~50 | ~0,86 | 15 |
| | 121 | 42 | 36 | - | - | 15 |
| TUB Gr 860206/43b | ~175 | ~46 | - | - | - | 15 |
| | 143 | 43 | 45 | ~50 | ~0,9 | 15 |
| | ~67 | ~47 | - | - | - | 25 |
| TUB Gr 860206/43c | 92 | 38 | 33 | 37 | 0,89 | 8/2 |
| | ~40 | 45 | - | - | - | 27 |
| ***Frikites lehmanni*** | | | | | | |
| TUB Wi 090995/2 | 162 | 49 | 41 | 56 | 0,73 | 14 |
| (holotype) | 130 | 50 | 37 | 53 | 0,69 | 16 |
| | ~68 | ~53 | - | - | - | 25 |
| | ~38 | 50 | - | - | - | 30 |
| TUB Wi 090995/3 | 260 | 52 | 61,5 | 85,5 | 0,72 | - |
| | 145 | 54 | 37 | 58 | 0,63 | 7/2 |
| TUB Wi 090995/5b | 121,5 | 56 | 28 | 39 | 0,72 | ~7/2 |
| ***Frikites zeili*** | | | | | | |
| TUB Gr 870423/1g | 203 | 45 | 64 | 69 | 0,93 | 17 |
| (holotype) | 159 | 44 | 52 | 56 | 0,93 | 17 |
| | 80 | 45 | - | - | - | 22 |
| | 43 | 42 | - | - | - | 35 |
| TUB Gr 870423/1h | 161 | 44 | 49 | 51 | 0,96 | 15 |
| | 115 | 44 | 38 | 41 | 0,93 | 20 |
| | 84 | 44 | 32 | - | - | 30 |
| TUB Gr 860206/38b | 122 | 46 | 39 | 42 | 0,93 | 17 |
| | 66 | 44 | - | - | - | 25 |
| | 31 | 42 | - | - | - | ~27 |
| TUB Gr 860206/40 | 108 | 45 | 33 | 36 | 0,92 | 10/2 |
| | ~60 | 43 | 17 | 19 | 0,89 | 46 |
| TUB Gr 860206/43d | 161 | 44 | 51 | 56 | 0,91 | 8/2 |
| | 82 | 44 | - | - | - | 9/2 |
| | ~39 | - | 16 | 18 | 0,88 | ~34 |
| ***Frikites* ex gr. *zeili*** | | | | | | |
| TUB Gr 870423/1f | 160 | 41 | 51 | 56 | 0,91 | ~8/2 |
| | 79 | 43 | 30 | 32 | 0,94 | 37 |
| ***Frikites* n. sp.** | | | | | | |
| TUB Gr 870423/2 | 162 | 46 | 50 | 54 | 0,93 | ~28 |
| | 113 | 42 | 36 | 38,5 | 0,94 | 49 |
| | ~53 | ~47 | - | - | - | 54 |
| ***Frikites bodenbenderi*** | | | | | | |
| Gau 460 | 178 | 59 | 40 | 48 | 0,83 | - |
| | 140 | 59 | 33 | 41 | 0,8 | 12/2 |
| | 106 | 60 | 24 | 31 | 0,77 | 19 |

*Frikites antipodum* (GOTTSCHE, 1878)

(figs. 3-5)

1878 Simoceras Antipodum GOTTSCHE, p. 17, pl. 3, fig. 6.

v pars 1991 *Neuqueniceras (Frikites) antipodum* (GOTTSCHE, 1878) – RICCARDI & WESTERMANN, p. 138 – 140, only specimen TUB 14-060374 (CHONG collection), pl. 20, fig. 1a, b.

Material: 11 specimens. Precordillera, E of Sierra Moreno, Cerro Jaspe region:

1) Section I (see fig. 1) = TUB Gr 860206/38a, mould of phragmocone with fragment of body chamber and partial remains of shell; TUB Gr 860206/43a, mould of phragmocone with fragment of body chamber and partial remains of shell; TUB Gr 860206/43b; mostly complete mould of body chamber specimen; TUB Gr 860206/43c, fragment of phragmocone with partially preserved body chamber; TUB Gr 831223/2, mould of phragmocone with part of body chamber and remains of shell.

2) Section II (see fig. 1) = TUB Gr 870423/1a, mould of phragmocone with partially preserved body chamber and partial remains of shell; TUB Gr 870423/1b, nearly complete body chamber specimen with remains of shell; TUB Gr 870423/1c, mould of phragmocone with partially preserved body chamber and fragments of shell remains; TUB Gr 870423/1d, mould of phragmocone with remains of shell; TUB Gr 870423/1e, incomplete phragmocone with part of body chamber; TUB Gr 870324/4, mould of phragmocone with partial remains of shell.

Description: Shell large, evolute and slightly coronate with irregular ribbing. On inner whorls a ventral interruption of ribbing is existent through a weak band, on outer whorls the broad venter become more or less smooth. Umbilical widths vary between 40% - 47%. Whorl sections subovate, broader than high, h/w between 0,82 – 0,92 (see fig. 2). Umbilical slope moderately deep without pronounced shoulders. Tubercles occur on the furcation points and can be still observed on the innermost whorls. Later they develop to more prominent and hollow spines. Constrictions are irregular and not frequent, they are accompanied on one side by oblique simple ribs.

Up to a diameter of 25 – 40 mm, inner whorls with short, sharp, radiate or slightly prorsiradiate primaries (approx. 26 – 29 per whorl). Primaries branch out in two - three secondaries.

After this first stage with a diameter of 25 – 40 mm, the space between the primaries becomes wider and number of primaries is reduced (approx. 15 per whorl). Primaries branched out in three - five secondaries and intercalatories. Furcation points are situated closely to the umbilical seam.

On the outer whorls primaries and secondaries become more flat and indistinct, secondaries are markedly reduced again. Primaries show the tendency to develop looped ribs.

Remarks: The description of the holotype (holotypy by monotypy) from "Espinazito" (San Juan province, Argentina) given in GOTTSCHE (1878) allows for a definite classification of the Chilean specimens to *antipodum*. *F. antipodum* seems to be the most frequent species of *Frikites*, which has a widespread distribution in the Andean realm of Chile and Argentina.

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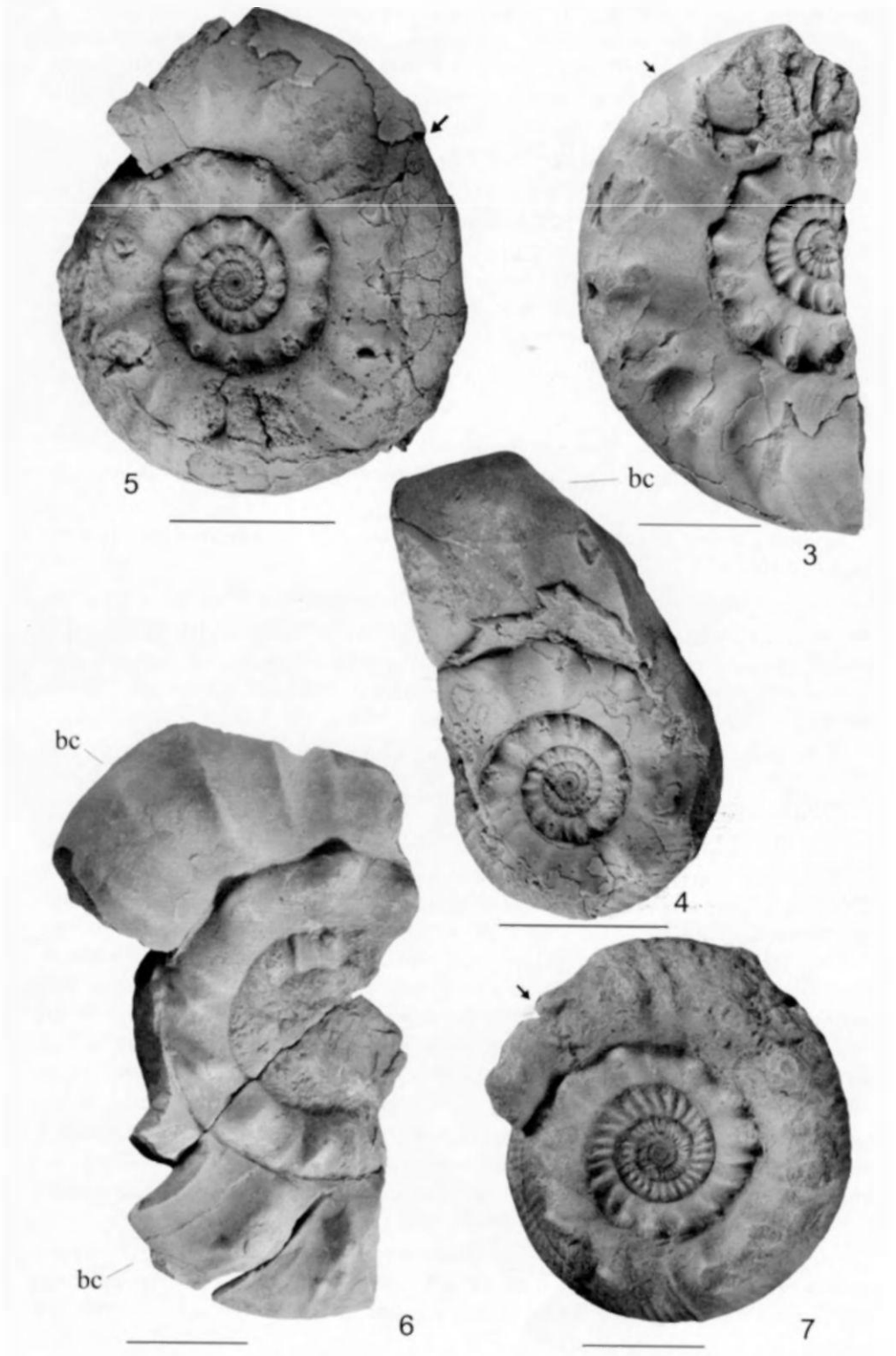
**Figs. 3-5:** *Frikites antipodum* (STEHN, 1923); **3:** TUB Gr 870423/1a, Precordillera, section II, horizon 1; **4:** TUB Gr 860206/38a, Precordillera, section I, horizon 1; **5:** TUB Gr 860206/43a, Precordillera, section I, horizon 2; **Figs. 6-7:** *Frikites lehmanni* n. sp., **6:** TUB Wi 090995/3, Coastal Cordillera, Quebrada Tiliviche; **7:** Holotype TUB Wi 090995/2, Coastal Cordillera, Quebrada Tiliviche. Scale for all figures 5 cm.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Nevertheless, it remains doubtful if the fragments described and figured in RICCARDI et al. (1989: *N. (F.)* cf. *bodenbenderi*, pl. 9, fig. 1-2, considered synonymous with *antipodum* in RICCARDI & WESTERMANN, 1991b) and RICCARDI & WESTERMANN (1991b: pl. 18, fig. 2-4; pl. 19, fig. 1-2) belong to *antipodum*. In our opinion, a classification of any species of *Frikites* is not possible if it is based only on whorl fragments.

Occurence: Lower Callovian of the Chilean/Argentinean Andes.

*Frikites lehmanni* n. sp.

(fig. 6, 7)

2001 *Neuqueniceras* n. sp. A – WITTMANN, p. 49, pl. 1, fig. 1.
2001 *Neuqueniceras* n. sp. B – WITTMANN, p. 49, pl. 3, fig. 1.
2001 *Neuqueniceras* (*Frikites*) *bodenbenderi* (TORNQUIST) – WITTMANN, p. 49 – 50, pl. 3, fig. 10.

Holotype: Fig. 7, original of WITTMANN (2001: pl. 1, fig.1, WITTMANN coll., TUB Wi 090995/2).

Derivation of name: Named in honour of Prof. Dr. Ulrich LEHMANN († 06.04.2003), palaeontologist at the University Hamburg, who performed ground breaking studies of the biology of ammonites.

Type locality: Coastal Cordillera of northern Chile, E of Pisagua, Quebrada Tiliviche (69°59'W/19°33'S).

Type horizon: see section "Profil Tiliviche" in WITTMANN (2001: p. 159).

Material: Coastal Cordillera of Pisagua, Quebrada Tiliviche: TUB Wi 090995/2, mould of phragmocone; TUB Wi 090995/3, fragmentarily preserved mould of body chamber specimen; TUB Wi 090995/5b, fragmentarily preserved mould of phragmocon; TUB Wi 090995/6b, fragment of mould of body chamber.

Diagnosis: Shell large, coronate and evolute, whorl section depressed-subovate. Ribs bear tubercles beginning from inner whorls, in later stages tubercles very prominent, developing to broad conical hollow spines.

Description: Shell evolute and coronate with irregular ribbing. At the venter of the inner whorls ribbing is slightly depressed through a narrow and weak band, later interruption of ribbing is more pronounced by a broad, more or less smooth band. Umbilicus widths vary between 49% - 56% of diameter. Whorl section markedly broader than high, h/w between 0,63 – 0,73 (see fig. 2). Umbilical wall deep without pronounced shoulders. Tubercles occur on the furcation points and can still be observed on the innermost whorls (holotype TUB Wi 090995/2). Later they develop to very prominent, broad conical, and hollow spines, which disappear on the body chamber of large, adult specimens (fig. 6, TUB Wi 090995/3). Constrictions are irregular and not frequent, they are accompanied on one side by oblique simple ribs.

Up to a diameter of approx. 65 mm (TUB Wi 090995/2), ribbing of the inner whorls (innermost whorls are not well-preserved) dense with distinct short primaries (27 – 32 per whorl, see fig. 7, which branch out (as far as recognizable) in two – three secondaries. Primaries are radiate or slightly prorsiradiate.

Beyond the diameter of 65 mm, the space between the primaries becomes wider and number of primaries is reduced (approx. 15 per whorl). Primaries branch out irregularly in four - seven secondaries and intercalatories. Furcation points are close to the umbilical seam.

On the outer whorls, primaries and secondaries become indistinct, number of secondaries decrease again. Ornamentation of body chamber of adult specimen is characterized by distinct, proconcave, and simple ribs.

Remarks: In contrast to *F. lehmanni* the type species of the genus *Frikites*, *F. bodenbenderi*, has a wider umbilicus and a more or less serpenticone habitus; at comparable growths stages *F. lehmanni* shows stronger bulky whorls.

*F. lehmanni* differs from *antipodum*, *zeili* n. sp., and *Frikites* n. sp. by its distinct coronate habitus, the wider umbilicus, the more depressed whorl sections, and the more prominent spines.

Occurrence: Lower Callovian of the Coastal Cordillera of northern Chile.

*Frikites zeili* n. sp.

(figs. 8, 9)

Holotype: Fig. 8, GRÖSCHKE coll., TUB Gr 870423/1g.

Derivation of name: Named in honour of Prof. Werner ZEIL († 25.10.2003), who conducted significant research in the Andes of South America and who always promoted German/Latin American relations in geosciences.

Type locality: Precordillera of northern Chile, E of Sierra Moreno, Jurassic area of the Cerro Jaspe region.

Type horizon: Horizon 1 of the section II (see fig. 1).

Material: 5 specimens. Precordillera, E of Sierra Moreno, Cerro Jaspe region (for coordinates see II. Localities):

1) Section 1 = TUB Gr 860206/38b, mould of phragmocone with remains of shell and fragment of body chamber; TUB Gr 860206/40, mould of phragmocone with few remains of shell, TUB Gr 860206/43d, fragment of phragmocone with partially preserved body chamber.

2) Section 2 = TUB Gr 870423/1g, nearly complete body chamber specimen with remains of shell; Gr 870423/1h, mould of phragmocone with partially preserved body chamber.

Diagnosis: Shell large, evolute with perisphinctoid inner whorls and bulky outer whorls, with prominent and hollow spines.

Description: Shell large, evolute with perisphinctoid inner stage, ribbing irregular. A ventral interruption of ribbing is existent through a narrow, weak band. Venter of body chamber of adult specimen is more or less smooth. Umbilical widths vary between 42% - 45% (see fig. 2). Whorl section subrounded to subovate, slightly broader than high, h/w between 0,88 – 0,96. Inner whorls with flat whorl sides. Umbilical slope more or less shallow without pronounced shoulders. Tubercles occur on the furcation points and can be observed on the inner whorls, later they become more prominent and develop to hollow spines. Turbercles are situated approx. at mid-flank, on the inner whorls in less proximity to the umbilical seam.

Diameter of the inner perisphinctoid stage varies depending on specimens (TUB Gr 860206/43b = ~45 mm; TUB Gr 870423/1g = ~ 60 mm; TUB Gr 870423/1d = ~75 mm). Perisphinctoid stage with dense, distinct, and projected ribs (approx. 35 – 46 primaries per whorl). Primaries branch out irregularly in two-five secondaries, and intercalatories. Simple ribs also occur.

After the perisphinctoid stage, number of primaries decrease (approx. 20 – 25 per whorl) and they become less sharp and looped. Ribs branch out in four - six secondaries and intercalatories.

On the outer whorls, primaries and secondaries are only flat and indistinctly developed, number of primaries and secondaries decrease again. Shell is covered by distinct growths lines.

Remarks: *F. zeili* n. sp. differs from *antipodum*, *lehmanni* and *bodenbendery* by its distinct perisphinctoid inner whorls, which are characterized by a very dense and fine ribbing.

Occurence: Lower Callovian of the Precordillera of northern Chile.

*Frikites* ex gr. *zeili*

(fig. 10)

Material: One specimen. Precordillera, E of Sierra Moreno, Cerro Jaspe region (for coordinates see II. Localities): Section II = TUB Gr 870423/1f, fragment of phragmocone with partially preserved body chamber.

Description: Shell evolute with perisphinctoid inner whorls, ribbing irregular. At the venter of the body chamber ribbing is depressed through a weak band. Umbilical widths vary between 41% - 43%. Whorl sections subrounded to subovate, slightly broader than high, h/w between 0,91 – 0,94 (see fig. 2). Inner whorls with flat whorl sides. Umbilical slope moderately shallow, which shows on the inner whorls slightly pronounced shoulders. Weak tubercles can be observed firstly at a diameter of approx. 70 mm. From this diameter on, furcation points are situated closely to the umbilical seam. On the body chamber tubercles develop to more prominent and hollow spines. Innermost whorls not preserved.

Up to a diameter of approx. 70 mm, inner whorls perisphinctoid with dense, prorsiradiate ribs (37 primaries per whorl at a diameter of 70 mm). Furcation points at this stage mostly covered by the successive whorl.

Beyond the diameter of 70 mm, the space between the primaries becomes wider, number of primaries is reduced (approx. 8 per half whorl) and they become less sharply and looped.

On the body chamber primaries branch out in two secondaries and intercalatories, ribs are less sharp and indistinct.

Remarks: Due to the fragmentary preservation and the scarce material a definite assignment to a species of *Frikites* is not possible. The perisphinctoid inner whorls and the looped ribs most probably indicate a close relationship to *F. zeili*, but it differs from *zeili* by its less dense inner ribbing and its higher positioned furcation points on the whorl sides.

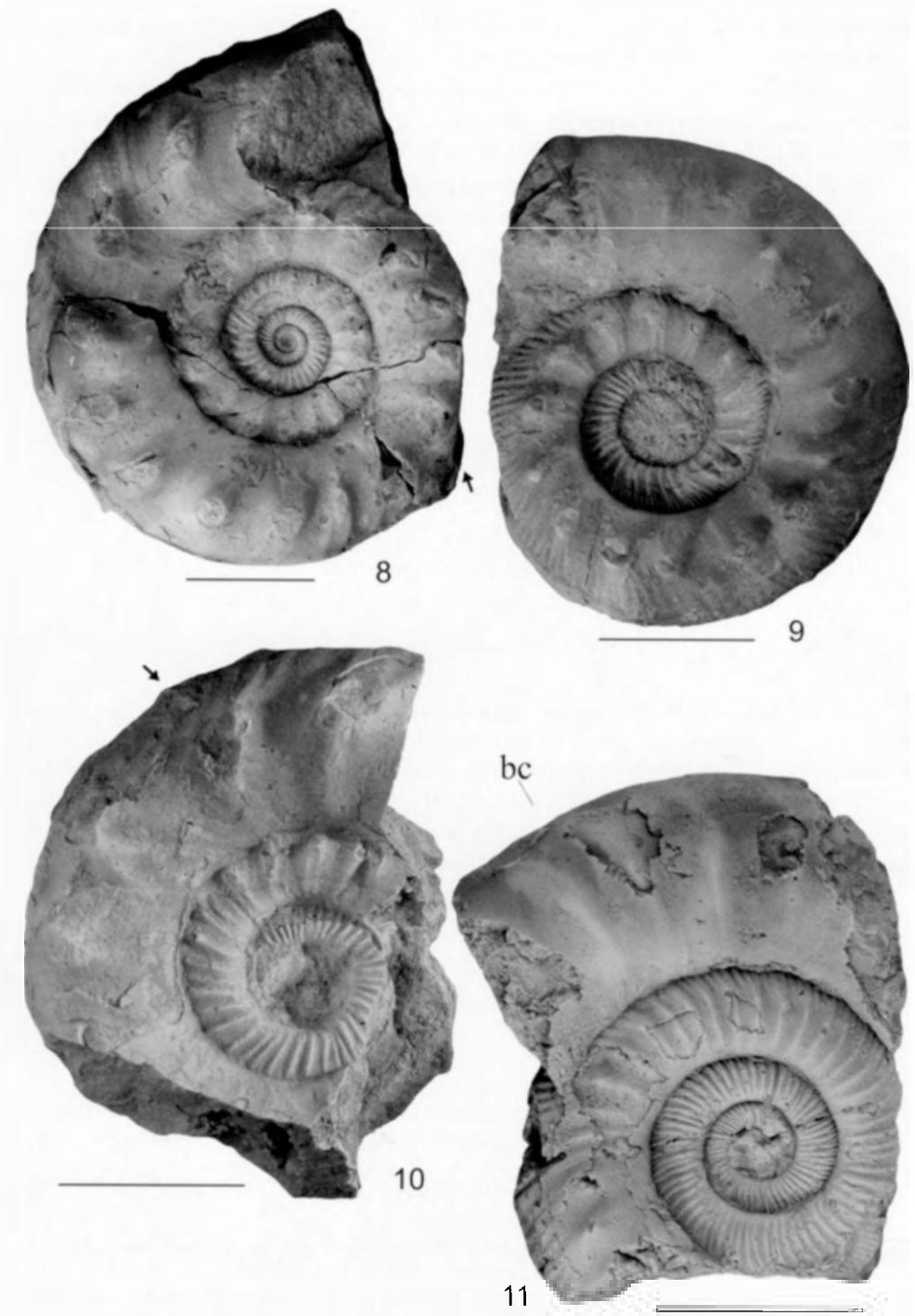
Occurence: Lower Callovian of the Precordillera in northern Chile.

*Frikites* n. sp.

(fig. 11)

Material: One specimen. Precordillera, E of Sierra Moreno, Cerro Jaspe region: Section II = TUB Gr 870423/2, phragmocone with partially preserved body chamber and remains of shell.

Description: Shell evolute with inner perisphinctoid stage, ribbing irregular. Umbilical widths approx. 42%. Whorl section subrounded, slightly broader than high, h/w is 0,93. The inner perisphinctoid stage shows flat flanks. Umbilical slope more or less shallow. On




**Figs. 8-9:** *Frikites zeili* n. sp.. **8**: Holotype TUB Gr 870423/1g, Precordillera, section II, horizon 1; **9:** TUB Gr 870423/1h, Precordillera, section II, horizon 1; **Fig. 10**: *Frikites* ex gr. *zeili* , TUB Gr 870423/1f, Precordillera, section II, horizon 1; **Fig. 11:** *Frikites* n. sp., TUB Gr 870423/2, Precordillera, section II, horizon 2.
Scale for all figures 5 cm.

the furcation points small, weak tubercles appear irregularly. They can only be observed starting from a diameter of approx. 25 mm, because the innermost whorls are not preserved. Later they develop to more prominent spines.

Up to a diameter of 100 mm, whorls are distinctly perisphinctoid with projected ribs, primaries branch out in two - three ribs, and intercalatories. Most of the furcation points are situated with less proximity to the umbilical seam.

Beyond the diameter of ~100 mm, the space between ribs becomes wider and number of primaries is reduced.

Ornamentation of body chamber is characterized by proconcave, simple ribs and growths lines.

Remarks: Due to the fragmentary preservation of the scarce material a definite assignment to a new species is not possible. *Frikites* n. sp. differs from *zeili* by its larger perisphinctoid stage, which only shows weakly developed tubercles on the furcation points. Within the Lower Callovian succession, *Frikites* n. sp. is the youngest Lower Callovian species, which occurred just below horizons of the Middle Callovian bearing *Rehmannia* (see fig. 2). *Frikites* n. sp. shows partly morphological affinities to *Rehmannia.* It is likely that *Frikites* n. sp. is a transitional species and an immediate ancestor of *Rehmannia*. In contrast to this suggestion, RICCARDI & WESTERMANN (1991b) regard the Argentinean neuqueniceratids as ancestors of *Rehmannia.*

Occurence: Lower Callovian of the Precordillera of northern Chile.

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