ABHANDLUNGEN DER GEOLOGISCHEN BUNDESANSTALT

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Viséan and Early Namurian Ammonoids from the Tafilalt (Eastern Anti-Atlas, Morocco)

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Visé- und Unter-Namur-Ammoniten aus dem Tafilalt (östlicher Anti-Atlas, Marokko)

Zusammenfassung

Aus dem Tafilalt (östlicher Anti-Atlas, Marokko) werden Ammonoideen-Faunen aus dem Ober-Visé (Gattungen *Prolecanites*, *Eoglyphioceras*, *Calygirtyoceras* n. gen., *Beyrichoceras*, *Maxigoniatites* n. gen.) und von der Visé/Namur-Grenze (*Prolecanites*, *Sudeticeras*, *Neogoniatites*, *Hypergoniatites*, *Lusitanoceras*, *Dombarites*) beschrieben. Die biogeographische Analyse zeitäquivalenter Faunen führt zu der Unterscheidung von vier Faunenprovinzen: Nord-Gondwana (Nordafrika, Kantabrisches Gebirge), Kazakhia (Südural, Zentralasien), Laurentia (Amerikanischer Midcontinent) und das Subvariszikum (Britische Inseln, Mitteleuropa).

Abstract

From the Tafilalt, eastern Anti-Atlas, Morocco, ammonoid faunas of Late Viséan (genera *Prolecanites*, *Eoglyphioceras*, *Calygirtyoceras* gen. nov., *Beyrichoceras*, *Maxigoniatites* gen. nov.), and the Viséan-Namurian Boundary (*Prolecanites*, *Sudeticeras*, *Neogoniatites*, *Hypergoniatites*, *Lusitanoceras*, *Dombarites*) are described. Biogeographical analyses of time-equivalent faunas lead to the separation of four faunal provinces: a North Gondwanan (North Africa, Cantabrian Mountains), a Kazakhian (South Urals, Central Asia), a Laurentian (American Midcontinent), and a Subvariscan (British Isles, Central Europe) Province.

1. Introduction

Carboniferous ammonoids are known from a number of localities in North Africa, but even the youngest monographic descriptions of the faunas are approximately 40 years old. The richest faunas, representing the Late Tournaisian up to the late Namurian, are known from the vicinity of Colomb-Bechar (region Sud Oranais, Western Al-

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geria), shown in the monograph by PAREYN (1961), the most detailed work on African Carboniferous goniatites.

The Carboniferous ammonoid faunas known from Morocco are poorer in their specific composition, and were collected in various places:

Central Morocco: Goniatites of Late Viséan age are known from Afroug, Sidi-Lamine, Tichdadine, Sidi Mohammed Abdallah, Gueltet-el-Fila, and Ifri-Guertila (DELÉPINE, 1941) and contain the genera *Eoglyphioceras*, *Goniatites*, *Maxigoniatites*, *Metadimorphoceras*, and possibly *Pachylyroceras*.

Western High Atlas: East of Marrakech, few goniatites of Late Viséan age were collected at Aït Ziffa and Tiguert (DELÉPINE, 1941), but were not figured in that publication.

Coal Basin of Djerada: Sections along the road from Oujda to Berghent, at the Oued El Mouater, the Oued Agaïa, the Coupe de Koudiat ès Senn and Chebket el Hamra (DELÉPINE, 1939, 1941; OWODENKO, 1946; BOUCKAERT & OWODENKO, 1965) yielded Late Viséan goniatites and especially Namurian and Westphalian faunas which, according to the latter authors, are similar to those known from Central Europe.

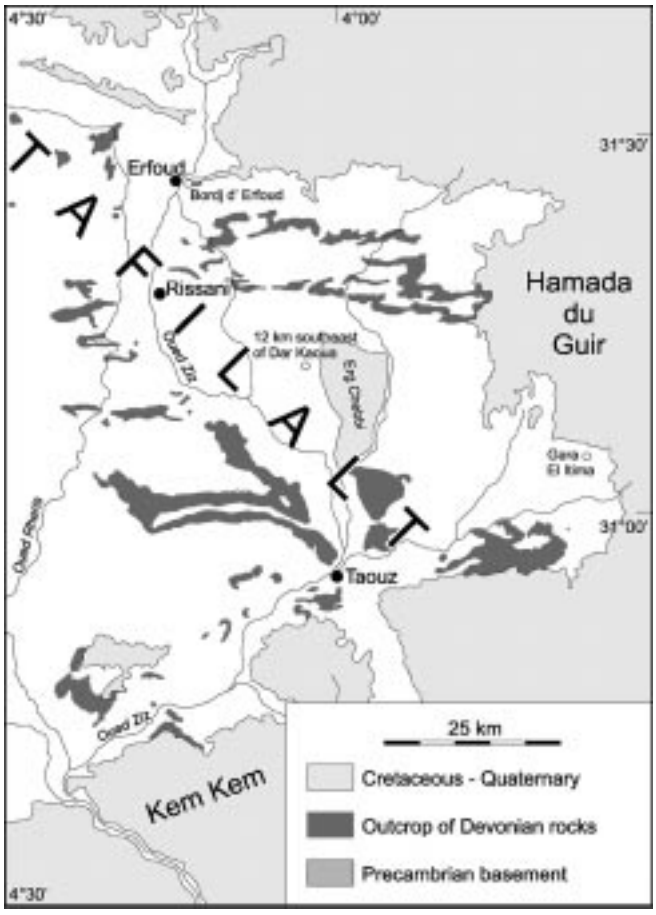
Draa Valley: Few goniatites, obviously of early Tournaisian age, were found near Tinfouchy (HOLLARD, 1956), but were not described.

Tafilalt: DELÉPINE (1941) described and figured Carboniferous ammonoids from several localities:

– Bordj d'Erfoud
  Three different horizons yielded goniatites, two lower with faunas of Late Tournaisian age and a third one, 100 to 150 higher in the section, contained an early Late Viséan fauna. However, re-examination of the outcrop did not lead to new collections of material, and hence a revision of the fauna is currently impossible.

– 12 km south of Dar Kaoua
  Revisiting of the locality, which is along the course from Erfoud to Taouz (Text-Fig. 1), turned out to be very successful; more than 240 well preserved specimens could be assembled. All specimens were loosely collected because of the lack of outcrops at this place, but obviously derive from very closely related horizons. As it will be shown in the systematic section, all the newly collected material is of early Late Viséan age. Identifications of material from this locality provided by DELÉPINE (1941), placing those specimens in the genera *Anthracoceras*, *Nuculoceras*, and *Cravenoceras*, must be doubted; all this material probably belongs to the genera *Eoglyphioceras* and *Goniatites*.
  Another fauna from the same locality was placed by DELÉPINE into the Late Viséan, he listed three species, which require revision:
  "*Goniatites striatus* SOWERBY"
  = *Maxigoniatites saourensis* (PAREYN 1961).
  "*Beyrichoceras micronotum* PHILLIPS".
  "*Beyrichoceras obtusum* PHILLIPS".

– Region of Taouz
  From southeast of Taouz, DELÉPINE (1941) listed five goniatites species, indicating an early Late Viséan age:
  "*Goniatites sphaericus* MARTIN".
  "Fragment de *Goniatites striatus* SOWERBY".
  "Fragment de *Sagittoceras*".
  "*Beyrichoceras micronotum* PHILLIPS".
  "*Beyrichoceras obtusum* PHILLIPS".



Text-Fig. 1.
Location map of the goniatite-bearing localities in the Tafilalt (eastern Anti-Atlas, Morocco).

Late Viséan goniatite faunas are interesting because of their biogeographical implications (KORN, 1997a). It was shown that a striking difference in faunal composition occurs between the Subvariscan Realm (South Portugal, British Isles, Germany, Czech Republik, and Poland) and the other regions such as the American Midcontinent, the Cantabrian Mountains, the South Urals, and China. The newly assembled collection allows us now to discuss the North African faunas once again in terms of palaeobiogeography.

2. Systematic Palaeontology

Order: Goniatitida HYATT 1884
Suborder: Goniatitina HYATT 1884
Superfamily: Pericyclaceae HYATT 1900
Family: Muensteroceratidae LIBROVITCH 1957

Family definition: Pericyclaceae with unribbed and weakly ornamented conch; ornament with biconvex growth lines. Suture line with lanceolate external lobe with parallel flanks.

Included genera:
Muensteroceras HYATT 1884.
Beyrichoceratoides BISAT 1294 (Synonym of *Eoglyphioceras*).
Cluthoceras CURRIE 1954.
Eoglyphioceras BRÜNING 1923.
Eurites KUSINA 1973.
Karakomaroceras MILLER 1931 (Synonym of *Muensteroceras*).
Proannites HAUG 1898 (Synonym of *Muensteroceras*).
Terektytes LIBROVITCH 1957.

Eoglyphioceras BRÜNING 1923

Type species: *Goniatites truncatus* PHILLIPS 1836.

Genus definition: Muensteroceratidae with moderately large, thickly discoidal conch with. Suture line with narrow external lobe (EL/h = 0.35), moderate median saddle (MS/h = 0.30) and broadly rounded ventrolateral saddle. Adventive lobe V-shaped. Conch weakly ornamented with biconvex growth lines.

Included species:

truncatum: *Goniatites truncatus* PHILLIPS 1836: 234. Late Viséan, Yorkshire, Great Britain.

duponti: *Muensteroceras duponti* DELÉPINE 1940: 58. Waulsortian, Belgium.

ergchebbiense: *Eoglyphioceras ergchebbiense* sp. nov. Late Viséan A, eastern Anti-Atlas, Morocco.

implicatum: *Goniatites implicatum* PHILLIPS 1836: 234. Late Viséan, Yorkshire, Great Britain (synonym of *Eoglyphioceras truncatum*).

serotinum: *Eoglyphioceras serotinum* KORN 1997: 39. Murração Formation, Late Viséan B; South Portugal.

(?) *invaginatum*: *Beyrichoceratoides invaginatus* BISAT 1924: 91. E1, Yorkshire, Great Britain.

(?) *komiorum*: *Beyrichoceras komiorum* KUSINA 1980: 62. Kosvinskiy Horizon, North Urals, Russia.

(?) *redesdalense*: *Pericyclus redesdalensis* HIND 1918: 29. Resdesdale Limestone, Northumberland, Great Britain.

Remarks: Two different opinions exist about the validity of *Eoglyphioceras*. KORN (1988) regarded *Eoglyphioceras* BRÜNING 1923 as a valid genus, whereas RILEY (1996) claimed that it is invalid and should be synonymised with *Beyrichoceratoides* BISAT 1924. RILEY (1996: 31) stated that " ... when originally erected, no type species was given (unlike *Beyrichoceratoides*) and it appears that the genus was defined by amalgamation of *Beyrichoceras* and *Muensteroceras*. This lack of clarity in the original description renders *Eoglyphioceras* invalid". Such an opinion cannot be supported. *Eoglyphioceras* was published by BRÜNING (1923) in an excerpt of his thesis, and is hence a valid genus name. With the subsequent designation of "*Goniatites truncatus* PHILLIPS 1836", the first species listed under *Eoglyphioceras* by BRÜNING, as its type species by KORN (1988: 39), the identity of *Eoglyphioceras* was completely cleared. The intention of BRÜNING to amalgamate *Beyrichoceras* and *Muensteroceras* to a new genus cannot be a reason to suppress the name *Eoglyphioceras*.

RILEY's (1996) generic concept of *Beyrichoceratoides* differs in its wider range markedly from the concept of *Eoglyphioceras* as published by KORN (1988). Riley also included *Cluthoceras* CURRIE 1954 as a junior synonym. Also he included several newly described species (Bt. *inflatus*, Bt. sp.1, Bt. sp.2) in the genus, which possess a pouched external lobe, as in *Dzhaprakoceras*, and hence are here excluded from *Eoglyphioceras*.

Comparisons: *Eoglyphioceras* differs in its higher median saddle (MS/h = 0.30) from the very similar *Muensteroceras* (MS/h maximally 0.20), and in the development of a prominent ventrolateral projection of the growth lines. The stratigraphically younger *Cluthoceras* is globular, unlike *Eoglyphioceras* with a discoidal conch.

Stratigraphical and geographical distribution: The genus occurs frequently in the Late Viséan A, but may be present already in the late Early Viséan and also maintains into younger zones (KORN, 1997b). It is known from Central and North-western Europe as well as North Africa.

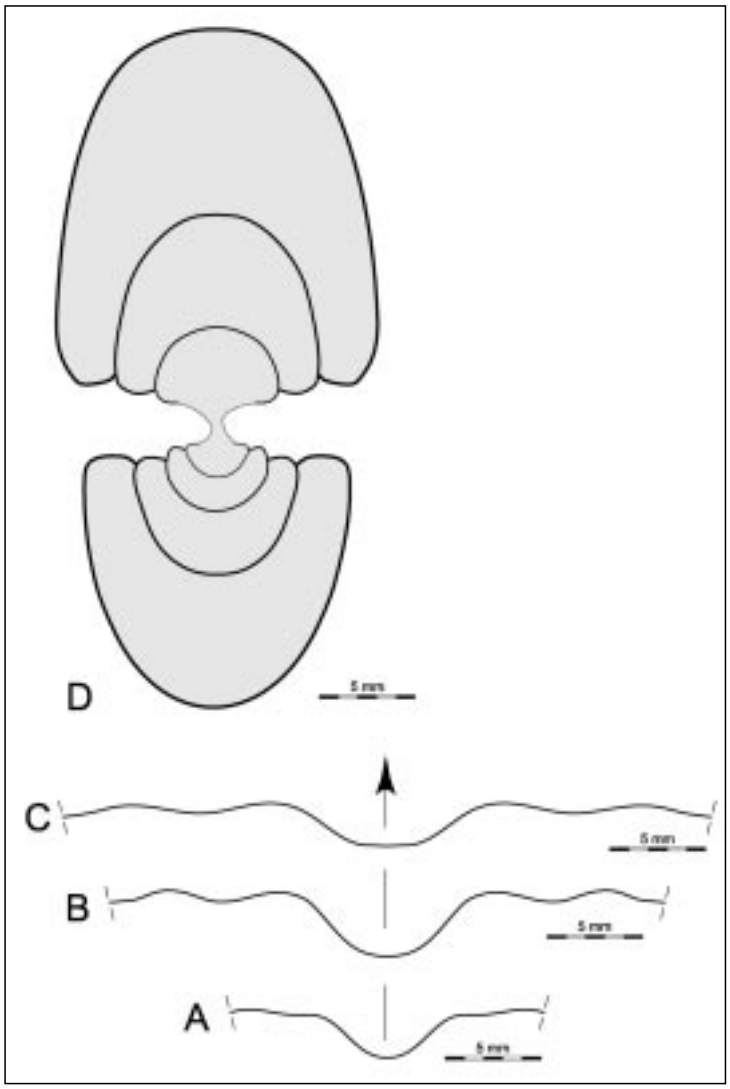
Eoglyphioceras ergchebbiense sp. nov.

(Pl. 1, Fig. 1, 2; Text-Fig. 2A–D)

Derivation of name: After the locality of the material in the vicinity of Erg Chebbi.

Holotype: Specimen GPIT 1851-74, figured in Pl. 1, Fig. 1.

Type locality and horizon: 12 km southeast of the Dar Kaoua Oasis, 32 km southeast of Erfoud (eastern Anti-Atlas, Morocco). Most probably early Late Viséan A.



Text-Fig. 2.
Eoglyphioceras ergchebbiense sp. nov. from 12 km southeast of the Dar Kaoua Oasis.
A) Growth line course of the paratype GPIT 1851-84. × 2.5 (at 18.5 mm conch diameter).
B) Growth line course of the holotype GPIT 1851-74. × 2.5 (at 26.5 mm conch diameter).
C) Growth line course of the paratype GPIT 1851-81. × 2.5 (at 40 mm conch diameter).
D) Cross section of the paratype GPIT 1851-75. × 2.5.

Material: 24 specimens between 16 and 50 mm conch diameter from the type locality. Almost all of them are preserved with shell and do not expose the suture line.

Species diagnosis: *Eoglyphioceras* with small, thickly discoidal conch (ww/dm = 0.55–0.60 at 20 mm dm; 0.45–0.50 at 30 mm dm). Umbilicus narrow in early growth stages (uw/dm = 0.20 at 20–30 mm dm) and closing during ontogeny (uw/dm = 0.10 at 30 mm dm). Whorl expansion rate moderate (1.90–2.00) at 20 to 30 mm diameter. Ornamentation with very fine, uncrenulated growth lines with strongly biconvex and rectiradiate course. Suture line with low median saddle (MS/h = 0.30), broadly rounded ventrolateral saddle, and narrow external lobe (EL/h = 0.55).

Conch form: The cross section (GPIT 1851-75; Text-Fig. 2D) shows the development of the conch geometry between 10 and 35 mm diameter. In all stages in between, the conch has a similar shape, but two trends can be observed. The umbilicus is rather wide in the juvenile stage (ww/dm = 0.25 at 10 mm diameter), and closes during ontogeny to a value of one tenth of the diameter. At the same time, the conch is modified from a pachyconic towards a thickly discoidal form. In all stages, the umbilical margin is narrowly rounded, and the umbilical wall is steep.

Dimensions in mm and ratios:

	dm	ww	wh	uw	ah	WER	ww/dm	ww/wh	u/d
holotype GPIT 1851-74	28.1	12.6	14.6	2.5			0.45	0.86	0.09
paratype GPIT 1851-76	26.3	12.3	13.2	2.9	7.9	2.04	0.47	0.93	0.11
paratype GPIT 1851-86	21.8	11.5	11.2	1.8	6.4	2.00	0.53	1.03	0.08
paratype GPIT 1851-84	21.1	11.6	10.9	3.2			0.55	1.06	0.15
paratype GPIT 1851-79	20.7	11.4	11.2	2.4			0.55	1.02	0.12
paratype GPIT 1851-85	19.6	11.7	9.3	3.0			0.60	1.26	0.15
paratype GPIT 1851-78	19.1	9.6	9.9	3.6	5.6	2.00	0.50	0.97	0.19
paratype GPIT 1851-75	35.4	16.8	18.6	3.7	9.7	1.90	0.47	0.90	0.10
	25.7	14.0	13.0	3.4	6.9	1.93	0.54	1.08	0.13
	18.5	10.7	9.3	3.3	5.9	1.96	0.58	1.15	0.18
	13.2	8.5	6.3	2.9	3.3	1.89	0.64	1.35	0.22
	9.6	6.4	3.9	2.3			0.67	1.64	0.24
Eogl. sp. GPIT 1851-83	46.2	23.9	21.5	6.5	11.8	1.80	0.52	1.11	0.14

Ornamentation: In smaller specimens, such as the paratype GPIT 1851-84, at 17 mm conch diameter the fine and uncrenulated growth lines run in a rursiradiate direction over the flanks, by forming two lateral projections of which the dorsal one is much more prominent. The ventral sinus is deep and broadly rounded.

In larger specimens, such as the holotype GPIT 1851-74 and 1851-81, at 26 mm and 40 mm diameter the ventrolateral salient becomes as strong as the dorsal one, leading to a symmetrically undulating course of the growth lines over the flanks. The growth lines are fine and separated, on the venter, by distances of approximately 0.5 mm. Around the umbilicus, they are strengthened and sometimes bundled.

Suture line: Only one specimen (GPIT 1851-77) displays fragments of the suture line at ww = 10 mm. It shows a V-shaped adventive lobe, and a parallel-sided narrow external lobe with low median saddle; all features typical for the genus.

Comparisons: *E. ergchebbiense* is similar to *E. truncatum*, but differs in its slightly wider umbilicus (uw/dm = 0.10 in *E. ergchebbiense*, 0.06 in *E. truncatum* at 30 mm conch diameter). A better feature to separate *E. ergchebbiense* from the other species of the genus are the much stronger curved growth lines, which in *E. ergchebbiense* have a prominent dorsolateral projection.

Stratigraphical and geographical distribution: All specimens were loosely collected on the surface, hence stratigraphical assignment is based on co-occurrence with *Maxigoniatites saourensis* (PAREYN 1961), most likely early Late Viséan A.

Family: Maxigoniatitidae fam. nov.

Family definition: Pericyclaceae with unribbed conch; ornament with biconvex, sometimes crenulated growth lines or fine spiral lines. Suture line with V-shaped external lobe with mammiform ending prongs; flanks of external lobe sinuous.

Included genera:

Maxigoniatites gen. nov.
Beyrichoceras FOORD 1903
Bollandites BISAT 1952
Bollandoceras BISAT 1952
(?) *Cowdaleoceras* BISAT 1952
Dzhaprakoceras POPOV 1965
(?) *Parahammatocyclus* RILEY 1996
(?) *Rotopericyclus* TURNER 1948

Comparisons: The new family is erected for those simple representatives of the Goniatitina which posses a V-shaped, but pouched external lobe which is characterised by the sinuous flanks leading to mammiform lateral prongs of this lobe. This lobe shape is present in goniatites with involute inner whorls (*Dzhaprakoceras*) as well as in those with evolute inner whorls (*Beyrichoceras*, *Maxigoniatites*). This lobe shape separates the new family from the family Muensteroceratidae and the superfamily Girtyoceratacea.

Genera here assembled in the family Maxigoniatitidae were placed by RILEY (1996) in three different families: *Beyrichoceras* in the Girtyoceratidae, *Bollandoceras* as well as *Dzhaprakoceras* in the Muensteroceratidae, and *Bollandites* in the Pericyclidae. He considered the shape of the inner whorls as an important criterion, whereas here the external lobe shape is regarded as an apomorphic character that defines the taxonomic unit. This interpretation is based on the fact that all the genera listed above display an extremely similar external lobe which can hardly be regarded as being developed independently in different evolutionary lineages. As learned from other goniatite taxa (i.e. Prionoceratacea, Goniatitaceae), opening of the umbilicus in inner whorls is a process that iteratively was developed in ammonoids, and hence should not be overinterpreted.

Genus: Beyrichoceras FOORD 1903

Type species: *Goniatites obtusus* PHILLIPS 1836.

Genus definition: Beyrichoceratidae with moderately large, sometimes spirally ornamented conch that is very evolute in juvenile and involute in adult stages. Suture line with narrow external lobe (EL/h about 0.55), moderate median saddle (MS/h = 0.30) and broadly rounded ventrolateral saddle.

Included species:

obtusum: *Goniatites obtusus* PHILLIPS 1836: 234. Lower Bowland Shale Formation, Yorkshire, Great Britain.
constans: *Beyrichoceras constans* KUSINA 1987: 56. Viséan, Novaya Zemlya, Russia.
delicatum: *Goniatites delicatum* BISAT 1924: 86. Viséan, Derbyshire, Great Britain.

elabiodiense: *Beyrichoceras elabiodiense* sp. nov. Late Viséan A, Tafilalt, Morocco.

parkinsoni: *Goniatites parkinsoni* BISAT 1934: 295. Pendleside Limestone, Yorkshire, Great Britain.

rectangulatum: *Beyrichoceras rectangulatum* BISAT 1934: 294. ? Malham Formation, Yorkshire, Great Britain.

tardum: *Beyrichoceras tardum* RUZHENCEV 1966: 53. Viséan, South Urals, Kazakhstan.

tenue: *Eoglyphioceras tenue* KUSINA 1987: 57. Viséan, Novaya Zemlya, Russia.

vesiculiferum: *Eoglyphioceras vesiculiferum* DE KONINCK 1880: 109. Visé, Belgium.

Comparisons: *Beyrichoceras* is separated by its striking conch morphology with very evolute inner and involute adult whorls from the other genera of the family. In *Dzhaprakoceras* and *Bollandoceras*, for instance, all the growth stages are more or less similar with very narrow umbilicus, and *Bollandites* possesses a cadicone conch in adults.

The new genus *Maxigoniatites* is similar in its conch morphology, but the inner whorls in this genus are much less evolute. The ornament shows strong spiral lines in *Maxigoniatites*, and crenulated growth lines in *Beyrichoceras*.

Remarks: *Beyrichoceras* is a genus of which several species, including the type species, are not sufficiently described. Comparison of the different species is therefore sometimes based on very old descriptions (e.g. PHILLIPS, 1836), which do not allow to formulate convenient diagnoses of the species.

Stratigraphical and geographical distribution: The genus occurs in the highest portion of the Early Viséan and in the early Late Viséan A (stratigraphical scheme according to KORN & HORN, 1997). It is known from Central and North-western Europe, Novaya Zemlya, the South Urals, as well as North Africa.

Beyrichoceras elabiodiense sp. nov.

(Pl. 1, Fig. 3, 4; Text-Fig. 3A, B)

Derivation of name: After the locality of the material near the Oued El Abiodi.

Holotype: Specimen GPIT 1851-67, figured in Pl. 1, Fig. 3.

Type locality and horizon: 12 km southeast of the Dar Kaoua Oasis, 32 km southeast of Erfoud (eastern Anti-Atlas, Morocco). Most probably early Late Viséan A.

Material: 6 specimens of 35 to 75 mm conch diameter, displaying the beautiful shell ornament. One specimen was sectioned and shows the inner whorls. The suture line could not be well studied in the material.

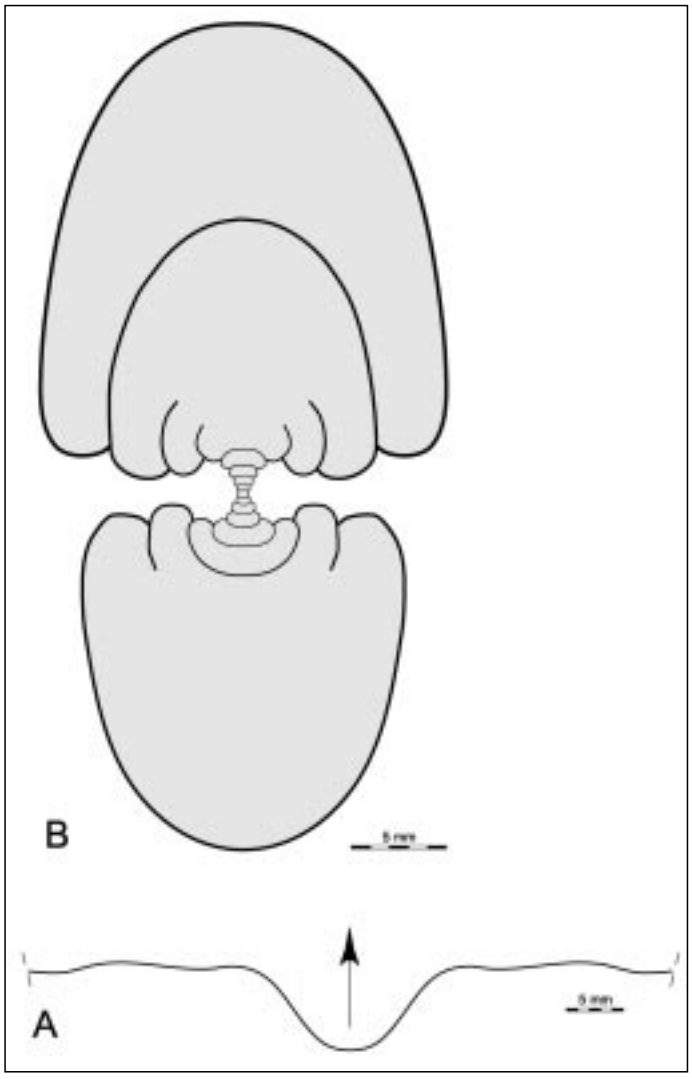
Species diagnosis: *Beyrichoceras* with moderately large conch that is thickly discoidal growth stages over 10 mm conch diameter (ww/dm = 0.50). Umbilicus very wide in early growth stages (uw/dm = 0.50 at 5 mm dm) and rapidly closing during ontogeny (uw/dm = 0.08 at 30 mm dm). Whorl expansion rate low (1.70 to 1.80 at 40 mm diameter). Ornamentation with fine, crenulated growth lines with biconvex and slightly rursiradiate course. No constrictions of the internal mould.

Conch form: The cross section (GPIT 1851-71; Text-Fig. 3B) demonstrates the transformation of the serpenticone inner stage towards the thickly lenticular and involute adult stage. Closure of the umbilicus begins at approximately 12 mm conch diameter, and the width of the umbilicus then remains the same during later ontogeny. The conch is widest at the umbilicus, flanks and venter are broadly rounded.

Dimensions in mm and ratios:

	dm	ww	wh	uw	ah	WER	ww/dm	ww/wh	u/d
holotype GPIT 1851-67	54.1	26.5	29.4	4.1	13.7	1.79	0.49	0.90	0.08
paratype GPIT 1851-71	43.3	21.5	22.7	3.25	10.3	1.72	0.50	0.95	0.08
	33.0	17.0	17.8	2.05			0.52	0.96	0.06
	5.1	3.3	1.48	2.52	1.02	1.56	0.65	2.23	0.49
	4.08	2.4	1.08	2.24	0.82	1.58	0.59	2.22	0.55
	3.25	1.74		1.76	0.68	1.59	0.54		0.54
paratype GPIT 1851-68	40.8	21.2	22.0	3.4			0.52	0.96	0.08
paratype GPIT 1851-82	37.2	18.6	19.5	2.6			0.50	0.95	0.07

Ornamentation: The holotype (GPIT 1851-67; Text-Fig. 3A) best displays the shell ornament at 50 mm conch diameter. The growth lines are fine and crenulated, in the ventrolateral area they are arranged in distances of 0.2 to



Text-Fig. 3.
Beyrichoceras elabiodiense sp. nov. from 12 km southeast of the Dar Kaoua Oasis.
A) Growth line course of the holotype GPIT 1851-67. × 1.5 (at 40 mm conch diameter).
B) Cross section of the paratype GPIT 1851-71. × 2.5.

0.25 mm. They run in slightly rursiradiate direction over the flanks by forming twolow projections, but have a very deep and broadly rounded ventral sinus. Crenulation of the growth lines is strongest on the venter, where it produces faint spiral lines.

Suture line: Only fragments of the suture line can be seen in specimen GPIT 1851-72. The external lobe is V-shaped and slightly pouched, and the median saddle has approximately 0.3 of the ventrolateral saddle height, all features typical for *Beyrichoceras*.

Comparisons: As stated above, the state of descriptions of *Beyrichoceras* species prevents clear separation of the various species. *B. elabiodiense* has a narrower conch than species such as *B. obtusum* (PHILLIPS 1836), *B. constans* KUSINA 1987, *B. parkinsoni* BISAT 1934, and *B. vesiculiferum* (DE KONINCK 1880), whose ratio ww/dm is above 0.55, in contrast to around 0.50 in *B. elabiodiense*. According to BISAT's (1924) description of *B. delicatum*, that species has rather thick inner whorls (ww/dm = 0.77 at 11 mm diameter), unlike *B. elabiodiense* with always lenticular conch. A character in which *B. elabiodiense* differs from the most of the other species of the genus is the lack of steinkern constrictions.

Stratigraphical and geographical distribution: The specimens were loosely collected, hence stratigraphical assignment is based on co-occurrence with *Maxigoniatites saourensis* (PAREYN 1961), most likely early Late Viséan A.

Genus: Maxigoniatites gen. nov.

Derivation of name: After the large conch diameter, which can be exceeded by the type species, and after the conch and ornament homeomorphy with the genus *Goniatites*.

Type species: *Goniatites maximus* var. *saourensis* PAREYN 1961.

Genus definition: Beyrichoceratidae with large, entirely spirally ornamented conch that is slightly evolute in juvenile and involute in adult stages. Suture line with narrow external lobe (EL/h about 0.55), moderate median saddle (MS/h = 0.30) and broadly rounded ventrolateral saddle.

Included species:

saourensis: *Goniatites maximus* var. *saourensis* PAREYN 1961: 146. Étage de Djorf el Morhabar Nord (early Late Viséan) of Sud-Oranais, Algeria.

globostriatus: *Glyphioceras crenistria* var. *globostriata* SCHMIDT 1925: 566.IIIα (*globostriatus*-Zone, early Late Viséan), Rhenish Massif, Germany.

maximus: *Goniatites maximus* BISAT 1934: 298. B2, Derbyshire, Great Britain (Synonym of *globostriatus*).

mempeli: *Beyrichoceras mempeli* SCHMIDT 1941: 152. *Entogonites nasutus* Zone (late Early Viséan), Harz Mountains, Germany.

moorei: *Goniatites moorei* WEYER 1972: 180. B2, Derbyshire, Great Britain (Synonym of *globostriatus*).

tafilaltensis: *Maxigoniatites tafilaltensis* sp. nov. Late Viséan A, eastern Anti-Atlas, Morocco.

(?) *araneus*: *Beyrichoceras araneum* NICOLAUS 1963: 118.IIIα (*hudsoni*-Zone, early Late Viséan), Rhenish Massif, Germany.

Remarks: The lack of adequate material of the European species herein attributed to the new genus has prevented certain generic assignment. KORN (1988, 1990) placed "*G. globostriatus*" under reservation into the genus *Goniatites*, because the suture line of this species was not known. The material from North Africa displays the suture line that excludes assignment to the family Goniatitidae, and rather emphasises the beyrichoceratid nature of the material.

Comparisons: *Maxigoniatites* differs in its strongly spiral ornament and relatively high median saddle from the other genera of the family. The inner whorls resemble *Beyrichoceras*, but are less evolute.

Stratigraphical and geographical distribution: The genus occurs in the highest portion of the Early Viséan and in the early Late Viséan A (stratigraphical scheme according to KORN & HORN, 1997). It is known from Central and North-western Europe as well as North Africa.

Maxigoniatites saourensis (PAREYN 1961)

(Pl. 2, Fig. 1–5; Pl. 3, Fig. 1, 2; Text-Fig. 4A–I)

1941 *Goniatites striatus*. – DELÉPINE: 67, Pl. 4, Fig. 6–9, Pl. 5, Fig. 1,2.

1961 *Goniatites maximus* var. *saourensis* PAREYN 1961: 146, Pl. 13, Fig. 1–8.

Type material: PAREYN (1961) did not select a holotype, but explicitly described the specimen on his Pl. 13, Fig. 4, 5. This specimen is herein selected as the lectotype.

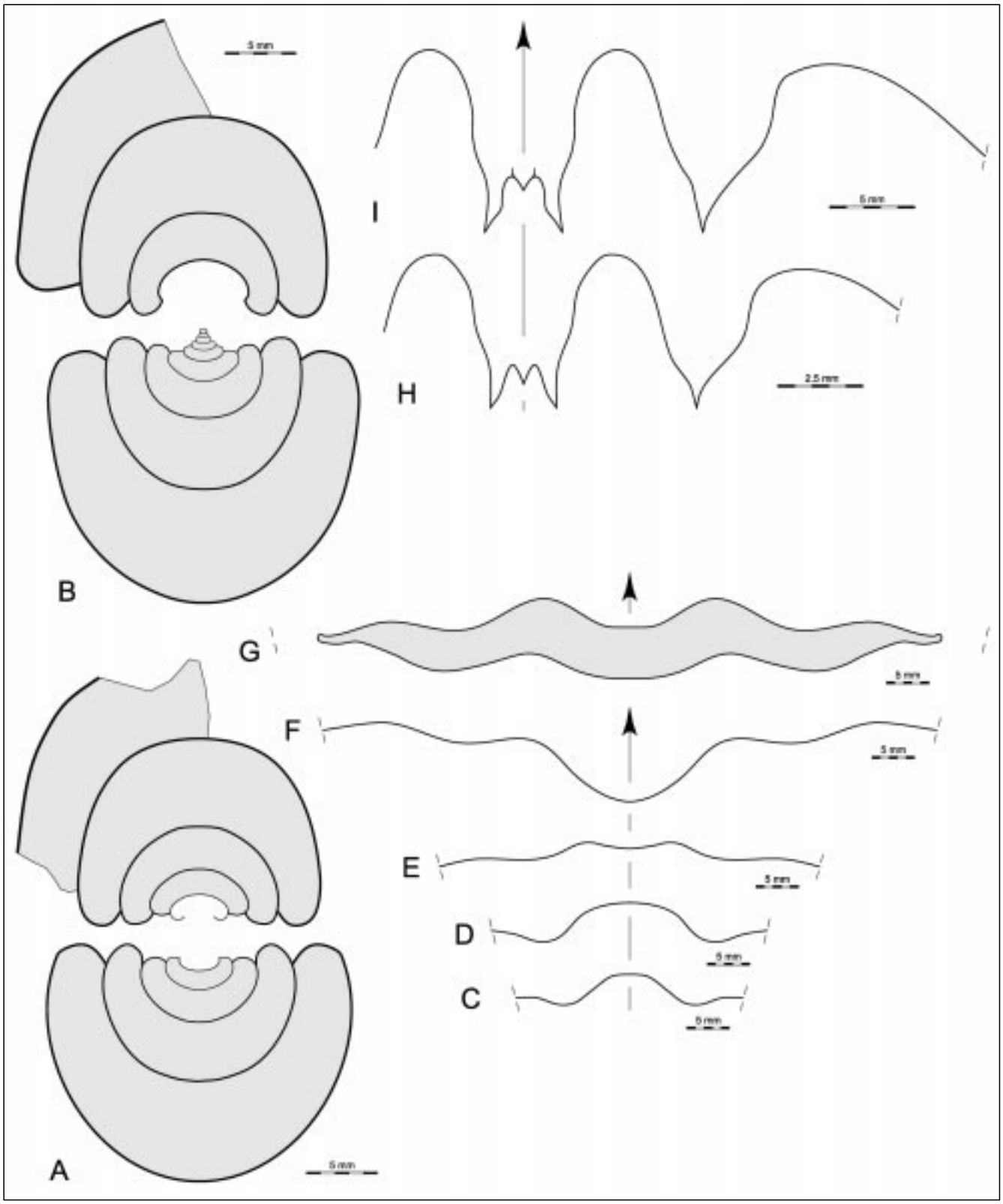
Type locality and horizon: North of Djorf el Morhabar, Sahara Sud Oranais, Algeria. Fauna S^{2c} (Étage de Djorf el Morhabar, Serie d'El Hariga) – early Late Viséan A.

Material: 154 specimens from 12 km southeast of the Dar Kaoua Oasis. They range from 20 up to 77 mm in diameter, but the largest fragment assumes that the maximum diameter was about 100 mm. They are preserved in sideritic nodules, from which they have been extracted by aeolian erosion. No specimens have been found in-situ, they were all surface collected in a large desert area. It can, however, be assumed that all derive from the same horizon.

Species diagnosis: *Maxigoniatites* with large pachyconic conch in all growth stages (ww/dm varying between 0.55 and 0.80). Umbilicus wide in early, but very narrow in intermediate growth stages (uw/dm = 0.10 at 20–30 mm dm); then slightly opening during ontogeny (uw/dm = 0.15 to 0.20 at 50–80 mm dm). Whorl expansion rate low and decreasing from 1.75 at 20 mm diameter to 1.55 at 80 mm diameter. Ornamentation with 200 to 230 fine spiral lines and very fine, crenulated growth lines with biconvex and slightly rursiradiate course. Suture line with low median saddle (MS/h = 0.30), broadly rounded ventrolateral saddle, and narrow external lobe (EL/h = 0.55).

Conch form: Three cross sections have been manufactured, of which two are figured (Text-Fig. 4A,B). All display semilunatic whorls between 5 and 54 mm conch diameter, and show several ontogenetic trends:

1) The thickness of the conch decreases from about 0.80 of the diameter at 10 mm towards 0.60 at 50 mm diameter.
2) The umbilicus is wide in early ontogeny, close to a ww/dm ratio of about 0.05 at 25 mm conch diameter, and then opens to a ratio of 0.20 in adults.



Text-Fig. 4.
Maxigoniatites saourensis (PAREYN 1961) from 12 km southeast of the Dar Kaoua Oasis.

A) Cross section of GPIT 1851-24.
× 2.5.
B) Cross section of GPIT 1851-28.
× 2.5.
C) Growth line course of GPIT 1851-41.
× 1.5 (at 20.5 mm conch diameter).
D) Growth line course of GPIT 1851-63.
× 1.5 (at 30 mm conch diameter).
E) Growth line course of GPIT 1851-66.
× 1.5 (at 40 mm conch diameter).
F) Growth line course of GPIT 1851-1.
× 1.5 (at 64 mm conch diameter).
G) Constriction of GPIT 1851-2.
× 1.5 (at 73 mm conch diameter).
H) Suture line of GPIT 1851-41.
× 6 (at ww 14.2 mm).
I) Suture line of GPIT 1851-25.
× 3 (at ww 24.6 mm, wh 16.5 mm).

3) The whorl expansion rate alternates during ontogeny, it ranges from 1.60 to 1.70 at 10–15 mm diameter, increases to 1.75 or more at 25 mm, and then decreases towards 1.55 to 1.60 in adults.

Dimensions in mm and ratios:

	dm	ww	wh	uw	ah	WER	ww/dm	ww/wh	u/d
GPIT 1851-3	77.2	45.7		16.6	15.0	1.54	0.59		0.19
GPIT 1851-2	75.1	40.1		11.0	15.1	1.56	0.53		0.15
GPIT 1851-4	74.7	41.2		11.6			0.55		0.16
GPIT 1851-1	72.6	41.1	33.0	12.8	14.0	1.54	0.56	1.25	0.17
GPIT 1851-5	66.7	38.5		7.8			0.58		0.12
GPIT 1851-44	60.6	41.6		9.3	12.5	1.59	0.69		0.15
GPIT 1851-18	53.6	33.4		7.5	11.0	1.58	0.62		0.14
GPIT 1851-48	48.8	31.7		7.2	10.2	1.59	0.65		0.15
GPIT 1851-7	41.0	27.1	18.7	5.3	9.2	1.66	0.66	1.45	0.13
GPIT 1851-8	33.3	24.6	15.7	3.6	6.7	1.56	0.74	1.57	0.11
GPIT 1851-9	32.6	26.7	15.1	3.0	6.6	1.57	0.82	1.77	0.09
GPIT 1851-31	29.5	20.0		1.9	5.9	1.56	0.68		0.06
GPIT 1851-11	29.4	22.2		3.3	6.4	1.64	0.76		0.11
GPIT 1851-49	28.6	21.2		2.6	6.4	1.66	0.74		0.09
GPIT 1851-55	26.1	19.3		1.7	5.8	1.65	0.74		0.07
GPIT 1851-57	19.5	15.6	10.3	1.9	4.5	1.72	0.80	1.51	0.10
GPIT 1851-21	53.6	32.4	25.4	5.9	10.4	1.54	0.60	1.28	0.11
	43.1	28.0	22.2	3.2	9.9	1.69	0.65	1.26	0.07
	33.2	23.0	17.4	2.05	8.2	1.78	0.69	1.32	0.06
	24.9	18.4	13.2	1.2	6.3	1.77	0.74	1.39	0.05
	18.7	14.5	10.7	0.75	4.8	1.78	0.78	1.35	0.04
	14.0	11.3	7.6	1.05	3.28	1.74	0.81	1.48	0.08
	10.6	8.6	5.2	1.55	2.36	1.63	0.81	1.65	0.15
	8.3	6.3					0.76		
GPIT 1851-24	34.0	22.0	17.7	2.5	8.0	1.72	0.65	1.24	0.07
	25.9	17.5	14.1	1.65	6.7	1.82	0.68	1.24	0.06
	19.2	13.8	10.5	1.75	4.9	1.78	0.71	1.31	0.09
	14.4	10.6	7.1	2.2	3.3	1.69	0.74	1.49	0.15
	11.1	8.3	5.2		2.6	1.70	0.75	1.60	
	8.5	6.2				0.73			
GPIT 1851-28	31.1	21.6	16.7	1.5	7.0	1.66	0.69	1.29	0.05
	24.0	17.1	13.2	1.6	6.0	1.78	0.71	1.30	0.07
	17.9	13.6	9.7	1.45	4.15	1.71	0.76	1.40	0.08
	13.7	11.2	6.7	2.5	2.95	1.64	0.82	1.67	0.18
	10.7	8.2	4.7	3.0	2.25	1.62	0.77	1.74	0.28
	8.4	7.0	3.15	3.0	1.78	1.59	0.83	2.22	0.36
	6.65	4.75	2.28	2.6	1.32	1.57	0.71	2.08	0.39
	5.3	4.05	1.65				0.76	2.45	

Ornamentation: All growth stages display a beautiful spiral ornament, and the number of spirals is about 230 in younger and 200 in older individuals. Characteristic for the spirals is their irregular spacing; in the large specimen GPIT 1851-1, they stand at 70 mm diameter in distances between 0.2 and 0.6 mm and bear a delicate granulation at the crossings with the growth lines. The growth lines are extremely fine and arranged in distances of 0.15 to 0.2 mm. In the large specimen, they run in rursiradiate direction with two equally prominent projections over the flanks and a wide and deep sinus over the venter.

In smaller specimens, such as GPIT 1851-66, at 40 mm conch diameter the ornament resembles the large specimen, but the growth lines show a more prominent ventrolateral projection. This is especially the case in specimens GPIT 1851-41 and 1851-63, where at 21 and 30 mm conch diameter the dorsolateral projection is unimportant. In these specimens, the ventrolateral projection overspans the venter without external sinus. Shallow steinkern constrictions run parallel to the growth lines.

Steinkern constrictions occur frequently in adult specimens, such as individual GPIT 1851-2 at 50–75 mm diameter. They are arranged in angles of about 65°.

Suture line: The suture line is similar in all growth stages over 20 mm diameter (Text-Fig. 4H,I). The external lobe has its characteristic outline with sinuous flanks, inducing the conspicuous asymmetry of the two prongs. The adventive lobe is also slightly asymmetric with stronger curved dorsal flank.

Sutural ratios:

	dm	ww	wh	MS/h	EI/h	VLS/h	AL/h
GPIT 1851-20		24.6	18.5	0.31	0.56	0.52	0.53
GPIT 1851-41		14.2	0.28	0.58	0.58	0.56	

Comparisons: *Maxigoniatites saourensis* and *Maxigoniatites tafilaltensis* sp. nov. are similar species in respect to suture line and conch ornamentation, but are clearly separable by their ratios of conch dimensions. *M. saourensis* has a much lower aperture and hence a lower whorl expansion rate (1.70 in the young and 1.55 in the adult stage) than *M. tafilaltensis* (1.90 to 1.75). Also, the umbilicus opens in adults of *M. saourensis* up to 20 % of the conch diameter, whereas the umbilicus in *M. tafilaltensis* remains very small (maximal 12 % of the conch diameter).

Stratigraphical and geographical distribution: In Algeria, the species occurs in fauna S^{2c}, together with a *Beyrichoceras* and a Nomismoceras species. All the newly specimens were surface collected, thus stratigraphical assignment is not completely clear. However, the specimens are all similarly preserved and co-occur with *Maxigoniatites tafilaltensis* sp. nov., *Eoglyphioceras ergchebbiense* sp. nov., *Beyrichoceras elabiodiense* sp. nov., *Calygirtyoceras darkaouaense* sp. nov., and *Prolecanites* sp., and hence an early Late Viséan A age is most probable.

Maxigoniatites tafilaltensis sp. nov.

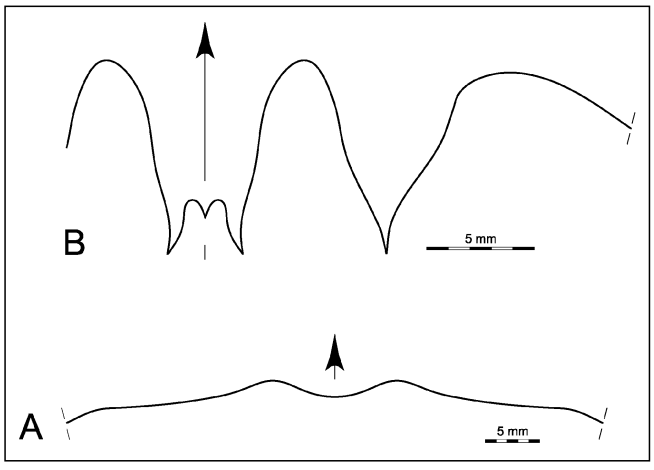
(Pl. 3, Fig. 3, 4; Text-Fig. 5A, B)

Derivation of name: After the locality of the material in the Tafilalt.

Holotype: Specimen GPIT 1851-27, figured in Pl. 3, Fig. 3.

Type locality and horizon: 12 km southeast of the Dar Kaoua Oasis, 32 km southeast of Erfoud (eastern Anti-Atlas, Morocco).

Most probably early Late Viséan A.



Text-Fig. 5.
Maxigoniatites tafilaltensis sp. nov. from 12 km southeast of the Dar Kaoua Oasis.
A) Growth line course of paratype GPIT 1851-65. × 1.5 (at 30 mm conch diameter).
B) Suture line of paratype GPIT 1851-26. × 3 (at ww 17.8 mm, wh 13.0 mm).

Material: 55 rather well preserved specimens between 20 and 67 mm conch diameter. They derive from siderit-ic nodules, such as the materiel of *M. saourensis*.

Species diagnosis: *Maxigoniatites* with moderately large, thickly discoidal to pachyconic conch (ww/dm varying between 0.45 and 0.70). Umbilicus wide in early, but very narrow in intermediate growth stages (uw/dm = 0.08 at 20–30 mm dm); then slightly opening during ontogeny (stages (uw/dm = 0.10 to 0.12 at 40–60 mm dm). Whorl expansion rate moderate and decreasing from 1.90 at 25 mm diameter to 1.75 at 50 mm diameter. Ornamentation with 200 to 230 fine spiral lines and very fine, crenulated growth lines with biconvex and slightly rursiradiate course. Suture line with low median saddle (MS/h = 0.30), broadly rounded ventrolateral saddle, and narrow external lobe (EL/h = 0.55).

Conch form: The list of dimensions shows that the conch form is similar in all growth stages between 25 and 60 mm diameter. The umbilicus has a rounded margin and is always very narrow, about one tenth of the diameter, and the thickness ranges from a ratio ww/dm = 0.65 at 30 mm to about 0.55 in stages over 50 mm conch diameter. The whorl expansion rate is also slightly reduced in larger stages, it decreases from 1.85–1.90 to 1.75. The earliest whorls have not be seen in the cross section, but it is likely that they are open umbilicate as seen in *Maxigoniatites saourensis* (PAREYN 1961).

Dimensions in mm and ratios:

	dm	ww	wh	uw	ah	WER	ww/dm	ww/wh	u/d
paratype GPIT 1851-6	58.8		33.3	6.5			0.57		0.11
paratype GPIT 1851-45	54.0	28.0	25.8	6.7			0.52	1.09	0.12
paratype GPIT 1851-36	53.7	31.9	26.8	5.8	13.7	1.80	0.59	1.19	0.11
paratype GPIT 1851-13	50.8	29,1	25.3	4.7			0.57	1.15	0.09
paratype GPIT 1851-64	47.8	27.9	25.1	3.6	12.0	1.78	0.58	1.11	0.08
paratype GPIT 1851-32	41.6	26.2		3.3	11.0	1.85	0.63		0.08
paratype GPIT 1851-47	39.8	23.4	20.1	3.5	10.6	1.85	0.59	1.16	0.09
paratype GPIT 1851-25	39.3	25.8	19.1	4.0	10.5	1.86	0.66	1.35	0.10
paratype GPIT 1851-26	34.7	20.9	18.7				0.60	1.12	
paratype GPIT 1851-70	33.0	21.1	17.8	2.1	8.8	1.86	0.64	1.19	0.06
holotype GPIT 1851-27	32.5	21.5	17.2				0.67	1.25	
paratype GPIT 1851-65	31.4	19.8	16.2	2.6	8.4	1.86	0.63	1.22	0.08
paratype GPIT 1851-42	29.7	19.7	16.0	2.2	8.4	1.94	0.66	1.23	0.07
paratype GPIT 1851-12	28.1	18.1		2.7	7.7	1.90	0.64		0.10
paratype GPIT 1851-37	28.0	18.8		2.0	7.8	1.93	0.67		0.07
paratype GPIT 1851-51	36.2	20.5		2.9	9.0	1.77	0.57		0.08
27.2	17.7		7.2		1.85	0.65			

Ornamentation: The ornament of *Maxigoniatites tafilaltensis* resembles that of *M. saourensis*, but in intermediate growth stages, some differences are worth mentioning. Specimen GPIT 1851-65 shows, at 30 mm conch diameter, 180 fine spiral lines, set in slightly unequal distances. The growth lines are finer and create, together with the spirals, a reticulate pattern and lead to granulation of the spirals. The course of the growth lines is prorsiradiate-biconvex with a barely visible dorsolateral projection and a prominent ventrolateral projection as well as a deep and broadly rounded ventral sinus.

Suture line: The suture line of paratype GPIT 1851-26 does not markedly differ from the sutures seen in *M. saourensis*.

Sutural ratios:

	dm	ww	wh	MS/h	EI/h	VLS/h	AL/h
GPIT 1851-26	17.8	13.0	0.28	0.53	0.47	0.43	

Comparisons: *M. tafilaltensis* and *M. saourensis* (PAREYN 1961) are superficially similar species, but show clear conch features for separation. *M. saourensis* has a wider umbilicus and a lower whorl expansion rate (1.55 in adult specimens in contrast to 1.75 in M *tafilaltensis*).

M. globostriatus (SCHMIDT 1925) developed a strong transverse adult ornament, and hence cannot be confused with *M. tafilaltensis*. *M. araneus* (NICOLAUS 1963) possesses a similar ornament with spider-web pattern, but has a narrower conch (ww/dm = 0.50) at 36 mm conch diameter, and a deeper external sinus of the growth lines.

Stratigraphical and geographical distribution: All specimens were surface collected, hence stratigraphical assignment is based on co-occurrence with *Maxigoniatites saourensis* (PAREYN 1961), most likely early Late Viséan A.

Superfamily Girtyoceratacea WEDEKIND 1918

Family: Girtyoceratidae WEDEKIND 1918

Family definition: Girtyoceratacea with ontogenetically changing conch shape; inner whorls evolute, umbilicus closing during ontogeny, adult stage often discoidal and oxyconic. Ornament with biconvex growth lines. Suture line with V-shaped external lobe and rounded ventrolateral saddle. Adventive lobe V-shaped with slightly sinuous flanks.

Included genera:

Girtyoceras WEDEKIND 1918
Calygirtyoceras gen. nov.
Cousteauceras KORN 1988
Dryochoceras MORGAN 1924 (synonym of *Girtyoceras*)
Edmooroceras ELIAS 1956
Eumorphoceras GIRTY 1909
Jeminayceras WANG 1983 (synonym of *Girtyoceras*)
Medioloboceras KULLMANN 1962
(synonym of *Eumorphoceras*)
Peytonoceras SAUNDERS 1966
Sagittoceras HIND 1918 (synonym of *Girtyoceras*)
Sulcogirtyoceras RUZHENCEV 1960
Sundernites KORN 1993
Torulites KUSINA 1983
Tumulites MCCALEB, QUINN & FURNISH 1964
Winchelloceras RUZHENCEV 1965

Genus: Calygirtyoceras gen. nov.

Derivation of name: After the well developed "calyx" stage in the conch ontogeny, and the close relation to *Girtyoceras*.

Type species: *Calygirtyoceras darkaouaense* sp. nov.

Genus definition: Girtyoceratidae with large conch that during ontogeny passes through very different morphological stages: in early juveniles widely umbilicate with trapezoidal whorl cross section, later barrel-shaped with sharp umbilical margin, intermediate stage with rounded flanks and venter, and adult stage lenticular-oxyconic. No ventrolateral groove. Suture line with wide V-shaped external lobe, moderately high median saddle, broadly rounded ventrolateral saddle, and V-shaped adventive lobe.

Included species:

darkaouaense: *Calygirtyoceras darkaouaense* sp. nov. Late Viséan A, eastern Anti-Atlas, Morocco.
arcticum: *Girtyoceras arcticum* GORDON 1957: 50. Alapah Limestone, Brooks Range, Alaska, U.S.A.

moorei: *Girtyoceras moorei* NICOLAUS 1963: 121. Go(2, Rhenish Massif, Germany.

platyforme: *Girtyoceras platyforme* MOORE 1946: 403. P1a, Lancashire, Great Britain.

Remarks: There occurred some problems about the identity of "*Goniatites calyx* PHILLIPS 1836", solved by BISAT & HUDSON (1943) in designating specimens from the R1 Zone as lectosyntypes, and hence defining *Homoceras* as a Namurian genus. Those "*calyx*" specimens known from the Late Viséan were thus left with the genus *Girtyoceras*. The type species of *Girtyoceras meslerianum* (GIRTY 1909), however, does not display a "*calyx*" stage and will here be separated from those girtyoceratids with such an ontogenetic stage.

Many girtyoceratid species have not been described detailed enough to know if they possess a juvenile morphology of *Girtyoceras* or *Calygirtyoceras*. Species such as *Gt. deani* MOORE 1946, *Gt. simplex* MOORE 1946, *Gt. cowdalense* MOORE 1946, and *Gt. ibergense* KORN 1992 have to be investigated in respect to this feature.

Comparisons: *Calygirtyoceras* differs from *Girtyoceras* in passing through a very peculiar "calyx" stage, in which the umbilicus is almost as wide as the conch diameter, with a very sharp and sometimes nodded umbilical margin. In *Girtyoceras*, the whorls of juvenile stages are crescent-shaped with rounded umbilical margin.

Similar juveniles are seen in *Sulcogirtyoceras*, but this genus shows longitudinal ventrolateral grooves, and is thus separated from *Calygirtyoceras*.

Stratigraphical and geographical distribution: The genus occurs in the Late Viséan A (stratigraphical scheme according to KORN & HORN, 1997). It is known from Central and North-western Europe as well as North Africa.

Calygirtyoceras darkaouaense sp. nov.

(Pl. 1, Fig. 6, 7; Text-Fig. 6A, B)

Derivation of name: After the locality of the material near the Dar Kaoua Oasis.

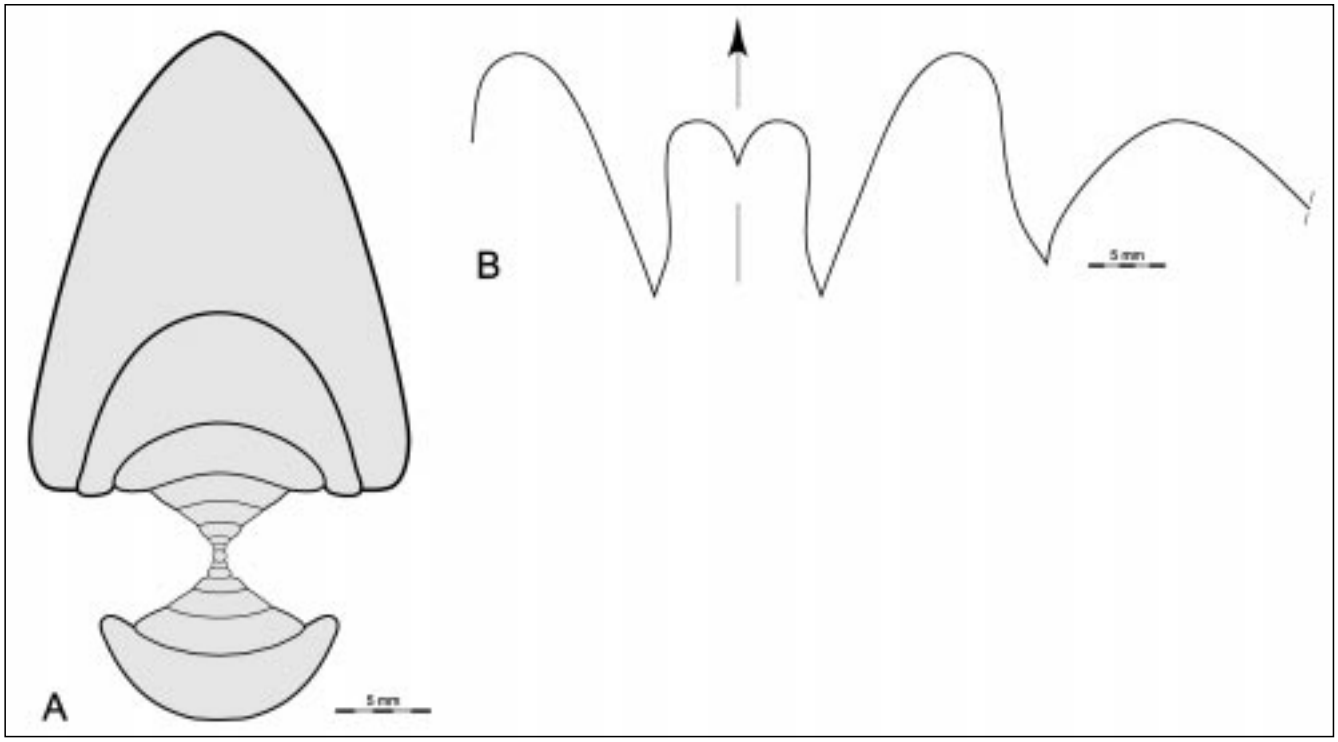
Holotype: Specimen GPIT 1851-87, figured in Pl. 1, Fig. 7.

Type locality and horizon: 12 km southeast of the Dar Kaoua Oasis, 32 km southeast of Erfoud (eastern Anti-Atlas, Morocco). Most probably early Late Viséan A.

Material: 4 adult fragmentary specimens, of which the largest is of a specimen of more than 80 mm conch diameter. Diagnostic features, such as whorl cross section ontogeny, shell ornament, and suture line can be seen in the material.

Species diagnosis: *Calygirtyoceras* with large, thinly discoidal conch (ww/dm varying between 0.45 and 0.70). Umbilicus very narrow in early growth stages (uw/dm = 0.08 at 20–30 mm dm) and slightly opening during ontogeny (stages (uw/dm = 0.10 to 0.12 at 40–60 mm dm). Whorl expansion rate moderate and decreasing from 1.90 at 25 mm diameter to 1.75 at 50 mm diameter. Adult ornamentation with fine, crenulated growth lines with biconvex and slightly rursiradiate course. Suture line with low median saddle (MS/h = 0.30), broadly rounded ventrolateral saddle, and narrow external lobe (EL/h = 0.55).

Conch form: The conspicuous development of the conch can be seen in the sectioned specimen GPIT 1851-88, that allows study of eight volutions. The inner whorls are very evolute, and up to 2 mm conch diameter, they have a crescent-shaped cross section. Between 2 and 10 mm diameter, the umbilical margin is angular and



Text-Fig. 6.
Calygirtyoceras darkaouaense sp. nov. from 12 km southeast of the Dar Kaoua Oasis.
A) Cross section of paratype GPIT 1851-87.
× 2.5.
B) Suture line of paratype GPIT 1851-89.
× 2 (at ww 26.6 mm, wh 41.5 mm).

the venter is broad and flattened. In this stage, the conch has a barrel-shaped form. After 10 mm diameter, the whorl cross section becomes higher, and the umbilicus remains at the same absolute width. The umbilical margin is at 20 mm diameter still exposed, and flanks and venter are broadly rounded. It is not clear when exact the venter begins to become acute, but may begin at approximately 40 mm conch diameter. The largest specimen (GPIT 1851-89) has a completely acute venter at about 60 mm diameter.

Dimensions in mm and ratios:

	dm	ww	wh	uw	ah	WER	ww/dm	ww/wh	u/d
paratype GPIT 1851-88		20.3	23.9					0.85	
	21.3	15.1	9.7	6.3	5.7	1.89	0.71	1.56	0.30
	15.5	12.6	5.6	6.5	3.4	1.64	0.81	2.25	0.42
	12.1	11.2	3.55	6.1	2.6	1.62	0.93	3.15	0.50
	9.5	9.0	2.45	5.1	1.95	1.59	0.95	3.67	0.54
	7.55	7.4	1.96	4.2	1.48	1.53	0.98	3.78	0.56
	6.1	5.6	1.52	3.34	1.28	1.61	0.92	3.68	0.55
	4.8	4.6	1.32	2.72	1.06	1.64	0.96	3.48	0.57
	3.75	2.9		1.95	0.74	1.62	0.77		0.52
	2.95	2.4		1.48	0.66	1.66	0.81		0.50

Ornamentation: The ornament is visible on specimen GPIT 1851-88, where at 21 mm whorl height very fine growth lines with biconvex course can be seen. They form two low lateral projections and a deep external sinus. They are extremely densely arranged; in a distance of 1 mm, 15 growth lines can be counted.

Suture line: The suture line of paratype GPIT 1851-89, drawn at its whorl height of 37 mm displays some typical features of adult girtyoceratids. The wide external lobe is V-shaped with strongly diverging flanks, and the adventive lobe is asymmetrically V-shaped with a concave dorsal side. The median saddle is relatively high (more than two thirds of the ventrolateral saddle).

Sutural ratios:

	dm	ww	wh	MS/h	EI/h	VLS/h	AL/h
paratype GPIT 1851-89	25.0	37.0	0.72	1.05	0.58	0.38	

Comparisons: *Calygirtyoceras moorei* (NICOLAUS 1963) and C. *platyforme* (MOORE 1946) differ in their much narrower conch (ww/dm = less than 0.50), measured at 20 mm conch diameter, from C. *darkaouaense* (0.70).

Stratigraphical and geographical distribution: The specimens were surface collected, and stratigraphical assignment is based on co-occurrence with *Maxigoniatites saourensis* (PAREYN 1961), most likely early Late Viséan A.

Superfamily: Goniatitaceae DE HAAN 1825
Family: Goniatitidae DE HAAN 1825

Family definition: Goniatitaceae with unribbed conch; inner whorls involute or evolute. Ornament with biconvex, crenulated growth lines and fine spiral lines. Suture line with V-shaped external lobe and subacute or acute ventrolateral saddle. Adventive lobe V-shaped with slightly sinuous flanks.

Included genera:
Goniatites DE HAAN 1825
Arnsbergites KORN 1988
Goniatitella KORN 1988
Hibernicoceras MOORE & HODSON 1958
Hypergoniatites RUZHENCEV & BOGOSLOVSKAYA 1970
Lusitanoceras PEREIRA DE SUSA 1923
Neogoniatites RUZHENCEV & BOGOSLOVSKAYA 1970
Paraglyphioceras BRÜNING 1923
Xainzalites SHENG 1983
(probably synonym of *Neogoniatites*).

Genus: Hypergoniatites RUZHENCEV & BOGOSLOVSKAYA 1970

Type species: *Hypergoniatites exiguus* RUZHENCEV & BOGOSLOVSKAYA 1970.

Genus definition: Goniatitidae with moderately small, involute and rapidly expanding conch. Weak ornament with crenulated growth lines. Suture line with narrow external lobe, moderate median saddle (Ms/h = 0.35), subacute ventrolateral saddle, and V-shaped adventive lobe with slightly sinuous flanks.

Included species:
exiguus: *Hypergoniatites exiguus* RUZHENCEV & BOGOSLOVSKAYA 1970: 58. Nm1a1, South Urals, Kazakhstan.
aberratus: *Hypergoniatites aberratus* KUSINA & YATSKOV 1988: 37. Nm1a, Novaya Zemlya, Russia.
afflatus: *Hypergoniatites afflatus* LIANG & WANG 1991: 105. Nm1a, Xinjiang, China.
hypsus: *Hypergoniatites hypsus* LIANG & WANG 1991: 104. Nm1a, Xinjiang, China.
kulcudukensis: *Hypergoniatites kulcudukensis* PITINOVA 1975: 30. Nm1a, Kyzylkuky, Uzbekistan.
mediterraneus: *Goniatites* (*Goniatites*) *crenistria mediterraneus* KULLMANN 1961: 283. "Cañon-Kalk", Province León, Spain.
reticulatus: *Hypergoniatites reticulatus* WAGNER-GENTIS 1980: 7. "Genicera Fm." (= Alba Fm.), Province Palencia, Spain.
serkeshensis: *Hypergoniatites serkeshensis* PITINOVA 1975: 31. Nm1a, Kyzylkuky, Uzbekistan.
tenuiliratus: *Hypergoniatites tenuiliratus* RUZHENCEV & BOGOSLOVSKAYA 1971: 212. Nm1a1, South Urals, Kazakhstan.
vastus: *Hypergoniatites vastus* NIKOLAEVA 1994: 69. *Hypergoniatites-Ferganoceras* genozone, Darvaz, Tajikistan.

Comparisons: *Hypergoniatites* differs in its prominent whorl expansion rate (more than 2.00) from most of the other genera of the family Goniatitidae, which maximally exceed a value of 1.75. Only the genus *Goniatitella* KORN 1988 also has a high aperture, but differs in the suture line with Y-shaped external lobe, and in the rounded ventrolateral saddle.
The suture line of *Hypergoniatites* is unique with its very narrow base of the external lobe, and its almost linear and strongly diverging flanks. Thus the genus cannot be confused with any other goniatite genus.

Stratigraphical and geographical distribution: *Hypergoniatites* is characteristic for horizons near the Viséan-Namurian boundary. In the South Urals, where it is very abundant, it occurs in the Nm1a1 and Nm1a2 zones (RUZHENCEV & BOGOSLOVSKAYA, 1970, 1971), which correspond to the latest Viséan and earliest Namurian. *Hypergoniatites* is known from many regions, it is very abundant the South Urals of Russia, but so far not recorded from the Subvariscan.

***Hypergoniatites* sp.**

(Pl. 4, Fig. 1)

Material: Only one rather well preserved specimen of 38 mm conch diameter (GPIT 1851-91), showing remains of the shell ornament.

Description: The specimen is a pachyconic involute conch with prominent whorl expansion rate of 2.13. Shell remains show biconvex and crenulated growth lines which form two low lateral salients and a deep external sinus. Spirals are extremely fine and only easily recognisable in a narrow zone around the umbilicus.

Dimensions in mm and ratios:

	dm	ww	wh	uw	ah	WER	ww/dm	ww/wh	u/d
GPIT 1851-91	37.7	24.2	20.2	3.4	11.8	2.12	0.64	1.20	0.09

Comparisons: Until further material is discovered, a specific interpretation of the specimen is impossible. The specimen from Taouz differs in its pachyconic conch from many of the other *Hypergoniatites* species. *H. mediterraneus* (KULLMANN 1961) from the Cantabrian Mountains possesses a similar ornament, but has an umbilicus almost twice as wide as *H.* sp. Also similar is *H. reticulatus* WAGNER-GENTIS 1980, but this species has an even smaller umbilicus.

Genus: Neogoniatites RUZHENCEV & BOGOSLOVSKAYA 1970

Type species: *Neogoniatites milleri* RUZHENCEV & BOGOSLOVSKAYA 1970.

Genus definition: Goniatitidae with moderately large, involute and smooth or entirely spirally ornamented conch. Suture line with relatively high median saddle (Ms/h = 0.55), subacute ventrolateral saddle, and V-shaped adventive lobe with slightly sinuous flanks.

Included species:

milleri: *Neogoniatites milleri* RUZHENCEV & BOGOSLOVSKAYA 1970: 56. Nm1a2, South Urals, Kazakhstan.

fortuitus: *Neogoniatites fortuitus* NIKOLAEVA 1994: 70. Aspandoyskaya Svita, Darvaz, Tajikistan.

latus: *Neogoniatites milleri latus* RUZHENCEV & BOGOSLOVSKAYA 1971: 212. Nm1a2, South Urals, Kazakhstan.

platyformis: *Goniatites platyformis* SHENG 1983: 55. Duonageli Fm., Xizang, China.

ruginosus: *Neogoniatites ruginosus* RUZHENCEV & BOGOSLOVSKAYA 1971: 209. Nm1a1, South Urals, Kazakhstan.

xainzaensis: *Neogoniatites xainzaensis* RUAN 1984: 599. Duonageli Fm., Xizang, China. [probably homonym of *Neogoniatites*(?) *xainzaensis* (SHENG 1983)].

(?) *palentinus*: *Goniatites* (*Girtyoceras*) *palentinus* KULLMANN 1961: 314. Lower "Caliza de Montaña", Province Palencia, Spain.

(?) *xainzaensis*: *Xainzalites xainzaensis* SHENG 1983: 58. Duonageli Fm., Xizang, China.

(?) *yongzhuensis*: *Xainzalites yongzhuensis* SHENG 1983: 60. Duonageli Fm., Xizang, China.

Remarks: SHENG (1983) erected the genus *Xainzalites* with its type species X. *xainzaensis* and the additional species X. *yongzhuensis*, both based on material from northern Duonageli, Xizang. Both species have conch dimensions resembling *Neogoniatites*, and both display suture lines which also may attribute them to this genus. Only one year later, RUAN (1984) also described Carboniferous ammonoids from Xizang, and introduced the new species *Neogoniatites xainzaensis*, without referring to *Xainzalites xainzaensis* described by SHENG. This species becomes a junior homonym, when *Xainzalites* in fact falls into synonymy with *Neogoniatites*, but is not renamed here because of the poor preservation of the holotype. "*Goniatites* cf. *striatus kentuckiensis*" of SHENG (1983: 54), which was placed by RUAN (1984: 599) into synonymy with *Neogoniatites xainzaensis*, is probably a species of *Dombarites*.

Comparisons: *Neogoniatites* is separated from other genera of the family Goniatitidae by its simple V-shaped adventive lobe, and the also V-shaped external lobe. The closely related *Paraglyphioceras* has a similar conch (but with rather evolute inner whorls) and suture line, but here the external lobe is narrower (EL/h maximally 0.60 compared with 0.70 in *Neogoniatites*), and the median saddle is lower (MS/h maximally 0.50 compared with 0.55 to 0.60).

Stratigraphical and geographical distribution: *Neogoniatites* is characteristic for horizons near the Viséan-Namurian boundary. In the South Urals, it occurs in the Nm1a1 and Nm1a2 zones (RUZHENCEV & BOGOSLOVSKAYA, 1970, 1971), which correspond to the latest Viséan and earliest Namurian. *Neogoniatites* was recorded in many places where ammonoids of the Viséan-Namurian Boundary were found, but usually the genus is relatively uncommon. It is not yet recorded from the Subvariscan.

Neogoniatites delicatus sp. nov.

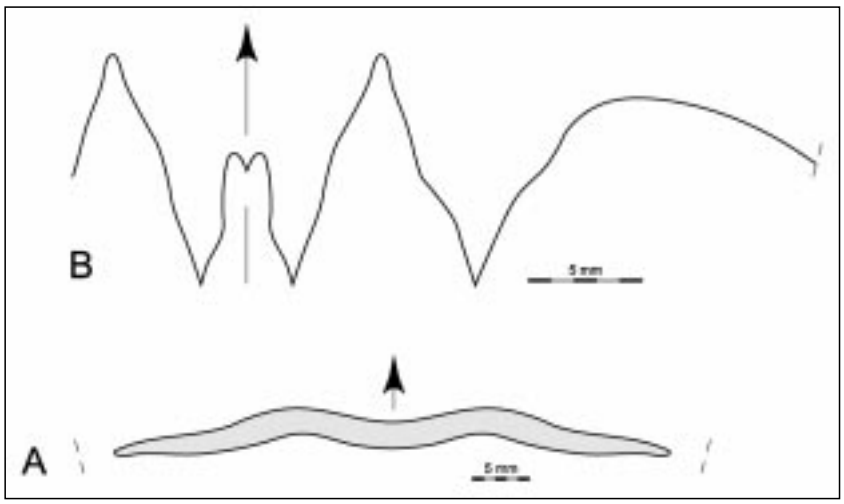
(Pl. 3, Fig. 5–9; Text-Fig. 7A,B)

Derivation of name: From Lat. *delicatus*; after the delicate shell ornament.

Holotype: Specimen GPIT 1851-101, figured in Pl. 3, Fig. 5.

Type locality and horizon: All specimens derive from near Taouz (purchased material).

Material: 81 specimens between 13 and 48 mm conch diameter. Most of them are preserved as barytic septate internal moulds, but a number of specimens bear the shell ornament.



Text-Fig. 7.
Neogoniatites delicatus sp. nov.; Taouz.
A) Constriction of paratype GPIT 1851-131. × 1.5.
B) Suture line of holotype GPIT 1851-101. × 3.

Species diagnosis: *Neogoniatites* with moderately large, pachyconic conch (ww/dm = 0.75 at 20 mm dm, and 0.65 at 40 mm dm). Umbilicus very narrow in all early growth stages (uw/dm = 0.06 to 0.12), without ontogenetic changes. Whorl expansion rate moderate and varying between 1.70 and 1.90. Ornamentation with 180 to 200 fine spiral lines and very fine, crenulated growth lines with biconvex and rectiradiate course. Suture line with high median saddle (MS/h = 0.55), subacute ventrolateral saddle, and moderately wide external lobe (EL/h = 0.70).

Conch form: Preparation of a cross section failed because of the crystalline barytic material of which the specimens are composed of. However, the list of dimensions demonstrates that between 19 and 40 mm diameter the conch has a pachyconic shape with very narrow umbilicus. The umbilicus ha a rounded margin and a vertical wall, flanks and venter are broadly rounded.

Dimensions in mm and ratios:

	dm	ww	wh	uw	ah	WER	ww/dm	ww/wh	u/d
paratype GPIT 1851-131	40.1	25.9	20.8	3.1	10.1	1.79	0.65	1.25	0.08
holotype GPIT 1851-101	35.6	23.8	17.5	3.5	8.5	1.73	0.67	1.36	0.10
paratype GPIT 1851-116	33.3	21.7		3.3			0.65		0.10
paratype GPIT 1851-129	33.1	21.8		3.2			0.66		0.10
paratype GPIT 1851-108	32.7	21.1	17.8	2.2	7.7	1.71	0.65	1.19	0.07
paratype GPIT 1851-128	30.6	19.7	15.5	2.1	7.6	1.77	0.64	1.27	0.07
paratype GPIT 1851-102	30.5	21.3	16.1	2.9	7.5	1.76	0.70	1.32	0.10
paratype GPIT 1851-120	30.3	20.4	16.3	1.9			0.67	1.25	0.06
paratype GPIT 1851-113	30.1	20.1	15.6	2.8	7.4	1.76	0.67	1.29	0.09
paratype GPIT 1851-133	30.0	22.8			7.5	1.77	0.76		
paratype GPIT 1851-118	29.6	18.3	14.5	2.7	7.4	1.75	0.62	1.26	0.09
paratype GPIT 1851-110	26.8	19.9	13.0	2.4	6.8	1.79	0.74	1.50	0.12
paratype GPIT 1851-105	26.7	18.3		1.8	6.7	1.78	0.69		0.07
paratype GPIT 1851-104	25.9	18.1	13.4	1.9	6.8	1.84	0.70	1.35	0.07
paratype GPIT 1851-135	22.4	16.6		1.8	5.9	1.85	0.74		0.08
paratype GPIT 1851-111	21.7	16.6	11.2	1.4	5.8	1.86	0.76	1.48	0.06
paratype GPIT 1851-112	19.0	14.5	10.0	1.4	5.3	1.92	0.76	1.45	0.07

Ornamentation: Specimen GPIT 1851-120 best exposes the shell ornament; in this individual with 33 mm conch diameter, 180 spiral lines can be counted from umbilicus to umbilicus. These spirals are mainly visible as broad and rounded ridges which are much wider than the spaces in between them. On the venter, the spirals are arranged with distances of 0.3 mm. The radial ornament is inconspicuous; fine and crenulated growth lines extend with two weak projections over the flank, and form a broad and relatively shallow external sinus.
Smaller specimens, such as paratype GPIT 1851-118, display the same ornament, but the number of spirals is a little higher (about 200). Internal moulds, e.g. the holotype GPIT 1851-101, bear irregularly arranged, weak constrictions running parallel to the growth lines.

Suture line: The suture line is typical for the genus with the high median saddle within the wide external lobe, the subacute ventrolateral saddle, and the V-shaped adventive lobe. The latter is slightly asymmetric, with a stronger sinuous dorsal flank.

Sutural ratios:

	dm	ww	wh	MS/h	EI/h	VLS/h	AL/h
holotype GPIT 1851-101	35.6	23.8	17.5	0.57	0.69	0.41	0.54

Comparisons: Most of the other species of *Neogoniatites*, such as *N. milleri* RUZHENCEV & BOGOSLOVSKAYA (1970) and *N. ruginosus* RUZHENCEV & BOGOSLOVSKAYA (1971) do not possess spiral ornament, and hence discrimination is easy. The ornament of *N. fortuitus* NIKOLAEVA 1994 is not known, but the species has a narrower conch (ww/dm = 0.58) than *N. delicatus* (ww/dm = 0.65) at comparable growth stages. *N. kentuckiensis* has very asymmetric prongs of the external lobe, a wider umbilicus, and a stronger spiral ornament (120 spiral lines in comparison to 180 in *N. delicatus*).
The Chinese species *N. platyformis* (SHENG 1983) differs in its conch dimensions from *N. delicatus*: it has a narrower conch (ww/dm = 0.55) at 20 mm conch diameter, and a much wider umbilicus (uw/dm = 0.20). *N. xainzaensis* RUAN 1984 has similar conch dimensions, but the rather poorly preserved specimen appears to be smooth and does not possess steinkern constrictions.

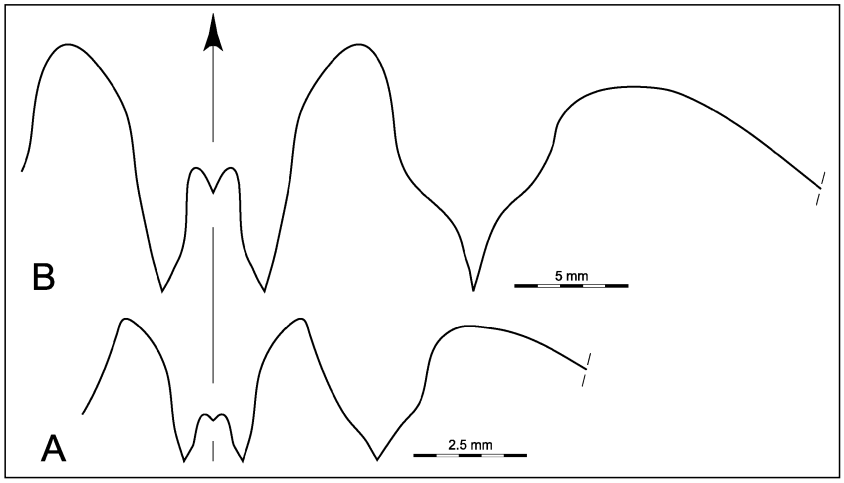
Stratigraphical and geographical distribution: *Neogoniatites delicatus* has been collected from the desert surface, and hence it is difficult to place the species into a stratigraphical scheme. It can, however, be assumed that the species has an occurrence that resembles the other species of the genus, i.e. a horizon near the Viséan-Namurian boundary. The co-occurring *Sudeticeras* sp. and *Lusitanoceras* (?) sp. do not contradict with this opinion.

Genus: cf. *Lusitanoceras* PEREIRA DE SUSA 1923

***Lusitanoceras* sp.**

(Pl. 4, Fig. 2–4; Text-Fig. 8A, B)

Material: Only insufficiently interpretable material is available. From near the Gara El Itima northeast of Taouz, two limonitic internal moulds (GPIT 1851-99 and 1851-100; coll. KAUFMANN) of 15 and 40 mm conch diameter show the suture line (Text-Fig. 8A,B, Pl. 4, Fig. 3). Two additional specimens (GPIT 1851-106 and 1851-132) of 28 and 32 mm diameter (Pl. 4, Fig. 2,4) came from Taouz. It is not clear if the specimens belong to one species, and more material is required to prove if they belong to *Lusitanoceras*.



Text-Fig. 8.
cf. *Lusitanoceras* sp. from near the Gara El Itima (western locality) northeast of Taouz.
A) Suture line of GPIT 1851-100.
× 6.
B) Suture line of GPIT 1851-99.
× 3.

Family: Agathiceratidae ARTHABER 1911

Family definition: Goniatitaceae with unribbed conch; inner whorls involute or evolute. Ornament with biconvex, crenulated growth lines and spiral lines. Suture line with Y-shaped external lobe and subacute or acute ventrolateral saddle. Adventive lobe V-shaped with strongly sinuous flanks, sinuosity of flanks leads to tridentation of the adventive lobe.

Included genera:
Dombarites LIBROVITCH 1957
Agathiceras GEMMELLARO 1887
Gaetanoceras RUZHENCEV 1938
Paragathiceras RUZHENCEV 1950 (synonym of *Agathiceras*)
Pericleites RENZ 1910
Proshumardites RAUSER-TSCHERNOUSSOWA 1928
Revilloceras WAGNER-GENTIS 1980
Trigonoshumardites KULLMANN 1962
(synonym of *Proshumardites*)

Genus: Dombarites LIBROVITCH 1957

Type species: *Dombarites tectus* LIBROVITCH 1957.

Genus definition: Agathiceratidae with large, involute and very slowly expanding conch. Ornament with crenulated growth lines, often with weak or strong spiral lines. Suture line with moderately wide external lobe, moderately high median saddle (Ms/h = 0.50–0.65), acute ventrolateral saddle, and V-shaped adventive lobe with angularly sinuous flanks.

Included species:
tectus: *Dombarites tectus* LIBROVITCH 1957: 258. Nm1b2, South Urals, Kazakhstan.
acicularis: *Goniatites – Mesoglyphioceras – granosus* var. *aciculare* PAREYN 1961: 157. S^{4a} and S^{4b} faunas, Algeria.
applanatus: *Dombarites applanatus* LIBROVITCH 1993: 38. Nm1b, Novaya Zemlya, Russia.
cantina: *Dombarites cantina* WAGNER-GENTIS 1980: 12. "Genicera Formation" (= Alba Formation), Province Palencia, Spain.
carinatus: *Dombarites carinatus* RUZHENCEV & BOGOSLOVSKAYA 1970: 62. Nm1b, South Urals, Kazakhstan.
choctawensis: *Goniatites choctawensis* SHUMARD 1863: 109. Caney Shale, Texas, U.S.A.
darvasicus: *Dombarites darvasicus* NIKOLAEVA 1994: 74. Nm1a, Darvaz, Tajikistan.
falcatoides: *Dombarites falcatoides* RUZHENCEV & BOGOSLOVSKAYA 1970: 60. Nm1a, South Urals, Kazakhstan.
goniolobus: *Dombarites goniolobus* RUAN 1981: 183. Upper Locheng Formation, Guangxi, China.
granofalcatus: *Goniatites* (*Goniatites*) *granofalcatus* KULLMANN 1961: 305. Alba Formation, Province León, Spain.
latilobatus: *Dombarites latilobatum* YANG 1986: 264. Zhongwei Formation, Ningxia, China.
linteroides: *Dombarites linteroides* RUZHENCEV & BOGOSLOVSKAYA 1971: 234. Nm1a, South Urals, Kazakhstan.
liratostriatus: *Dombarites liratostriatus* RUZHENCEV & BOGOSLOVSKAYA 1971: 233. Nm1b2, South Urals, Kazakhstan.
liratus: *Dombarites liratus* RUZHENCEV & BOGOSLOVSKAYA 1971: 232. Nm1b1, South Urals, Kazakhstan.
mapesi: *Goniatites mapesi* DRAHOVZAL & QUINN 1972: 583. Fayetteville Formation, Arkansas, U.S.A.
masculus: *Goniatites masculus* SHENG 1983: 53. Duonageli Formation, Tibet, China.
ningxiaensis: *Dombarites ningxiaensis* GAO 1983: 466. Zhongwei Formation, Ningxia, China.
parafalcatoides: *Dombarites parafalcatoides* RUZHENCEV & BOGOSLOVSKAYA 1971: 231. Nm1a, South Urals, Kazakhstan.
paratectus: *Dombarites paratectus* RUZHENCEV & BOGOSLOVSKAYA 1971: 230. Nm1b2, South Urals, Kazakhstan.
platypersicus: *Dombarites platypersicus* RUAN 1981: 182. Upper Locheng Formation, Guangxi, China.
semiliratus: *Dombarites semiliratus* RUZHENCEV & BOGOSLOVSKAYA 1971: 235. Nm1b1, South Urals, Kazakhstan.
umbilicatus: *Dombarites umbilicatus* LIANG & WANG 1991: 118. Nalinkala Formation, Xinjiang, China.

Comparisons: *Dombarites* is separated from the ancestral *Lusitanoceras*, which has a similar conch morphology, by its stronger curved flanks of the tectiform ventrolateral saddle, and the more Y-shaped external lobe. *Proshumardites* derived from *Dombarites*; in *Proshumardites*, the adventive lobe becomes trifid.

Stratigraphical and geographical distribution: *Dombarites* is characteristic for horizons near the Viséan-Namurian boundary. In the South Urals, it occurs in the Nm1a1 to Nm1b2 zones (RUZHENCEV & BOGOSLOVSKAYA, 1970, 1971), which correspond to the latest Viséan and earliest Namurian. *Dombarites* is extremely common in the faunas collected from localities in the South Urals, and was found in almost all the regions that yielded latest Viséan or earliest Namurian ammonoids. However, it was not recorded from the Subvariscan, i.e. the region spanning from South Portugal over the British Isles, the Rhenish Massif to Poland.

Dombarites granofalcatus KULLMANN 1961

(Pl. 5, Fig. 1–3; Text-Fig. 9A–C)

v 1961 *Goniatites* (*Goniatites*) *granofalcatus* KULLMANN: 305, Pl. 22, Fig. 1, 2.
pt1962 *Goniatites striatus kentuckiensis* PAREYN: 149, Pl. 14, Fig. 1–3 (only).
1980 *Dombarites granofalcatus* WAGNER-GENTIS: 10, Pl. 1, Fig. 1–4.

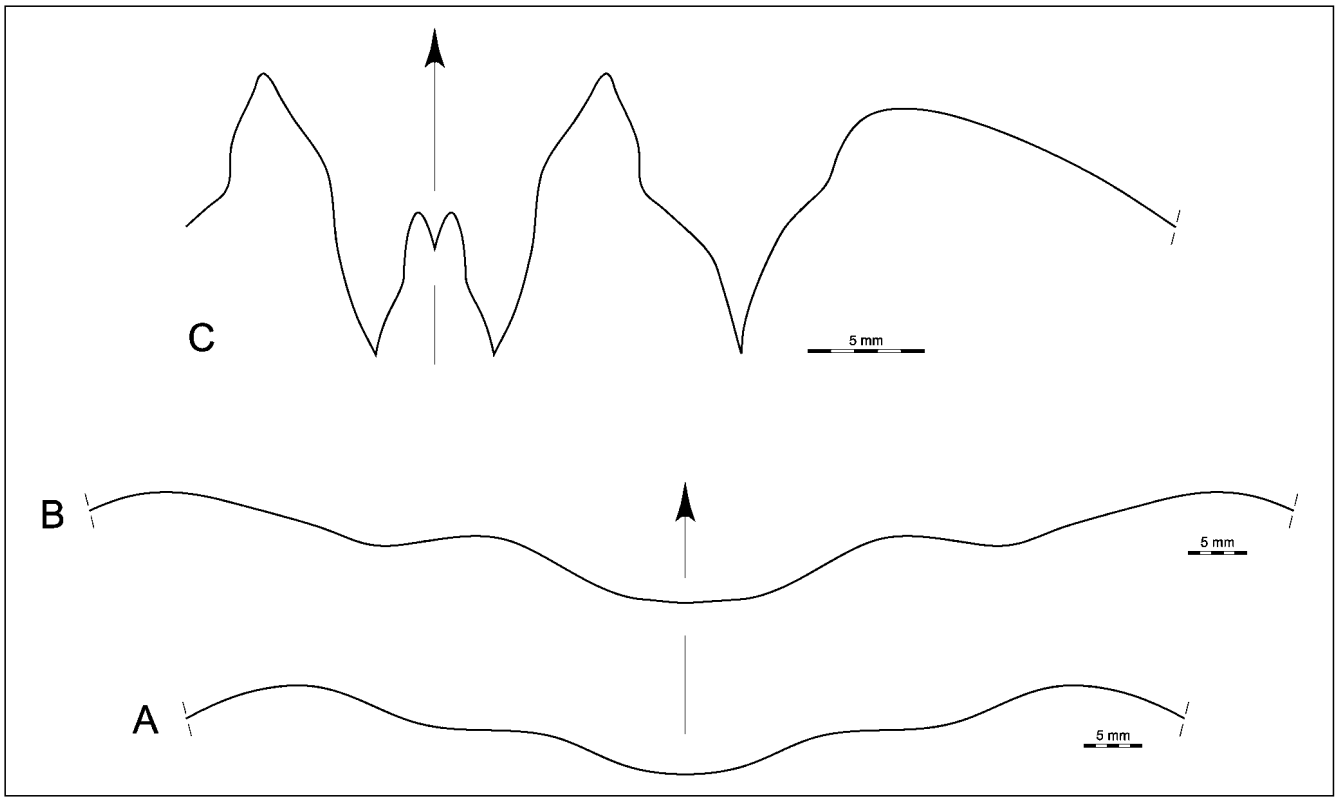
Type material: Holotype is specimen GPIT Ce1160/513, figured by KULLMANN (1961) on Pl. 22, Fig. 1.

Type locality and horizon: Montó region, Province León, Cantabrian Mountains, Spain; "Marbre Griotte" (= Alba Formation); most probably near the Viséan-Namurian Boundary.

Material: 3 large and well preserved, almost complete conchs (65 to 85 mm in diameter) and 1 fragment of a large specimen from the Gara El Itima northeast of Taouz.

Species diagnosis: *Dombarites* with moderately large, pachyconic conch (ww/dm = 0.60 to 0.65); umbilicus narrow (uw/dm = 0.20 to 0.27). Whorl expansion rate very low (1.45). Ornamentation with 80 to 90 coarse spiral lines and fine but rhythmically strengthened, crenulated growth lines with biconvex and rursiradiate course. Suture line with moderately high median saddle (MS/h = 0.50), acute ventrolateral saddle, and moderately wide external lobe (EL/h = 0.75).

Conch form: Only large specimens are available for study. At 65 mm diameter (GPIT 1851-93), the pachyconic conch has a relatively wide umbilicus with angular margin. The conch is widest at the umbilicus, and the flanks converge only slightly to continue into the broad and rounded venter. The two larger specimens GPIT 1851-94 and 1851-95 are similar conchs, in both spe-



Text-Fig. 9.
Dombarites granofalcatus (KULLMANN 1961) from Gara El Itima northeast of Taouz.
A) Growth line course of GPIT 1851-94. × 1.5.
B) Growth line course of GPIT 1851-95. × 1.5.
C) Suture line of GPIT 1851-93. × 3.

cimens a very low whorl expansion rate of about 1.45 could be calculated.

Dimensions in mm and ratios:

	dm	ww	wh	uw	ah	WER	ww/dm	ww/wh	u/d
GPIT 1851-95	84.4	52.0	35.8	18.3	14.2	1.44	0.62	1.45	0.22
GPIT 1851-94	78.0	46.5	32.2	20.0	13.5	1.46	0.60	1.44	0.26
GPIT 1851-93	65.8	42.3	27.3	18.0			0.64	1.55	0.27

Ornamentation: The ornament of the specimens slightly suffered from aeolian weathering, but can be described in detail. Specimen GPIT 1851-93 displays, at 65 mm diameter, 80 coarse and sharp spiral lines which are arranged in equal distances of 0.8 to 1.0 mm. The growth lines are not well preserved in this specimen, but their rhythmical strengthening can be seen from more than 55 mm conch diameter. One volution bears four steinkern constrictions, which are only barely visible on the shell surface.

The larger specimens GPIT 1851-94 and 1851-95 display the growth lines, which occur in distances of 0.4 to 0.5 mm, and produce a granulation when crossing the spiral lines. About every tenth growth line is strengthened and lead to a relatively coarse radial ornament. The course of the growth lines is rursiradiate and biconvex with two low lateral projections and a shallow and wide external sinus. Four constrictions of the shell are present on one volution.

Suture line: At 32 mm whorl width, the suture line of specimen GPIT 1851-93 resembles that of *D. parafalcatoides* RUZHENCEV & BOGOSLOVSKAYA 1971. The external lobe is Y-shaped with strongly sinuous flanks, and the subacute ventrolateral saddle is tectiform. The ventral flank of the adventive lobe is stronger curved than the dorsal flank.

Sutural ratios:

	dm	ww	wh	MS/h	EI/h	VLS/h	AL/h
holotype GPIT 1851-93		32.8	21.5	0.51	0.73	0.48	0.49

Comparisons: *Dombarites granofalcatus* is one of the coarsely ornamented species of the genus. Other strongly ornamented species, such as *D. falcatoides* RUZHENCEV & BOGOSLOVSKAYA 1970, *D. parafalcatoides* RUZHENCEV & BOGOSLOVSKAYA 1971, *D. masculus* (SHENG 1983) and *D. mapesi* (DRAHOVZAL & QUINN 1972) have a much smaller umbilicus (uw/dm 0.10 to 0.15), in contrast to 0.25 in *D. granofalcatus*. Another clear character to distinguish between *D. granofalcatus* and other species of the genus is the rursiradiate direction of the growth lines, together with their rhythmical strengthening.

Remarks: Within the genus *Dombarites*, *D. granofalcatus* belongs to the species with relatively ancient suture line, indicating close relations to the ancestral *Lusitanoceras*. Assignment to *Dombarites* was preferred here because of the pointed ventrolateral saddle, and the angularly sinuous flanks of the adventive lobe.

Stratigraphical and geographical distribution: The stratigraphical distribution is not completely clear. According to the co-occurrence of *Hypergoniatites*, it falls within the latest Viséan or earliest Namurian. The species is known from several places in the Cantabrian Mountains of Spain, from the Tafilalt of Morocco, and from Sahara Sud-Oranais in Algeria.

3. Palaeobiogeographical Implications

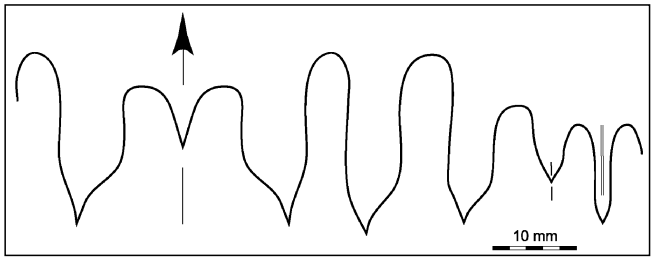
During the late Early Carboniferous, a trend towards more prominent provincialism in the distribution of ammonoid faunas took place (KORN, 1997a), resulting in

clearly separated faunistic realms in the Namurian (KULLMANN, 1962; KORN, 1997b). Until the late Tournaisian, ammonoid faunas from Central and North-western Europe (HOLZAPFEL, 1889; DELÉPINE, 1940; SCHINDEWOLF, 1951; FOORD, 1901, 1903), Southern Europe (BÖHM, 1935; KULLMANN, 1961), North Africa (DELÉPINE, 1941; PAREYN, 1961), and Central Asia (LIBROVITCH, 1927; POPOV, 1968), show a very similar composition in genera and even in species. This suggests an intensive correspondence between the various regions that prevented the formation of faunal provinces. Also rather similar are faunas collected from the Northern Urals, but this fauna contains components largely unknown from other areas (KUSINA, 1980).

Faunal representation of the Early Viséan is very patchy, and hence biogeographical pattern can hardly be recognised. Only with the Late Viséan, ammonoid faunas are known from many distant places in the world, which allow biogeographical interpretations.

The oldest North African Viséan ammonoid fauna was collected near the Dar Kaoua Oasis; it consists of the following species:

Prolecanites sp. (Text-Fig. 10)
Eoglyphioceras ergchebbiense sp. nov.
Beyrichoceras elabiodiense sp. nov.
Maxigoniatites saourensis (PAREYN 1961)
Maxigoniatites tafilaltensis sp. nov.
Calygirtyoceras darkaouaense sp. nov.



Text-Fig. 10.
Prolecanites sp. from 12 km southeast of the Dar Kaoua Oasis. suture line of GPIT 1851-73; × 1.

Faunas of time-equivalent strata are known from other places in the world, but richer assemblages are only known from Central and North-western Europe, from North England (BISAT, 1934, 1952) and the Rhenish Massif (KORN, 1988, 1990) in Germany. The comparison of the faunas shows that the North African assemblage is not principally different from the others; all the genera from Dar Kaoua also occur in Europe with very similar species.

The genus *Goniatites*, however, appears to be rare in the Tafilalt (a specimen of *Goniatites* sp. from Erfoud is figured in Pl. 4, Fig. 5); it was already shown by DELÉPINE (1941) from a locality in Central Morocco.

Faunas from near the Viséan-Namurian Boundary of the Tafilalt and the are relatively rich and contain the following species:

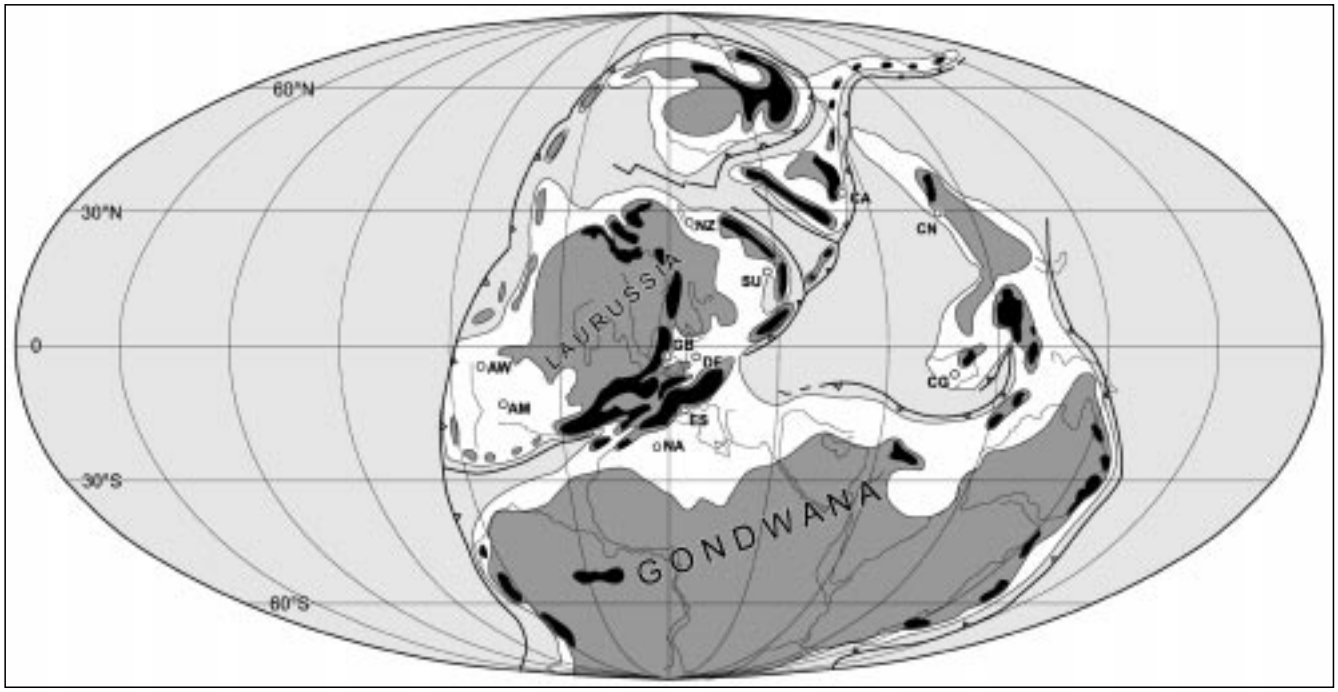
Prolecanites sp.
Sudeticeras sp.
Sulcogirtyoceras vel. *Edmooroceras* sp.
Neogoniatites delicatus sp. nov.
Hypergoniatites sp.
cf. *Lusitanoceras* sp.
Dombarites granofalcatus (KULLMANN 1961)

Together with the faunas from the neighbouring region of Colomb-Béchar in Algeria (PAREYN, 1961), they are rich enough for a biogeographical analysis.

3.1. Methods

For better comparison, biogeographical analyses are performed using four different methods (summarised by NEWTON, 1990): C = number of taxa common in both faunas; N_1 = total number of taxa present in the less diverse fauna; N_2 = total number of taxa present in the more diverse fauna.

SIMPSON coefficient: C / N_1
Correlation ratio: $C^2 / N_1 N_2$
JACCARD coefficient: $C / N_1 + N_2 - C$
SØRENSEN coefficient: $C / N_1 + N_2$



Text-Fig. 11.
Palaeogeographical map of the Viséan, showing the Late Viséan-Namurian ammonoid occurrences.

Table 1.
Matrix showing the ammonoid genera recorded from the various regions.
GB = North England, Great Britain; DE = Rhenish Massif, Germany; SU = South Urals, Russia, Kazakhstan; CA = Central Asia (Uzbekistan, Tajikistan, Xinjiang); CN = Ningxia, China; AM = American Midcontinent; ES = Cantabrian Mountains, Spain; NA = North Africa (Morocco, Algeria); NZ = Novaya Zemlya, Russia; CG = Guangxi, China; AW = Western U.S.A.

genera/regions	GB	DE	SU	CA	CN	AM	ES	NA	NZ	CG	AW
Prolecanites			■	■		■	■				
Dombarocanites			■	■			■				
Praedaraelites			■	■	■	■	■	■		■	■
Megapronorites			■	■			■	■		■	■
Uralopronorites			■	■							
Stenopronorites			■	■	■		■	■			
Irinoceras			■	■			■				
Cunitoceras							■				
Cluthoceras	■				■	■		■			
Sudeticeras	■	■	■			■		■		■	
Zhongningoceras					■						
Anthracoceras	■	■			■	■		■		■	■
Nomismoceras			■	■		■			■		
Cavilentia			■		■				■		
Applanoceras					■						
Girtyoceras	■	■	■	■	■	■	■	■			■
Coustaeuceras	■	■									
Sulcogirtyoceras			■			■					
Edmooroceras	■	■	■			■		■		■	■
Tumulites	■	■	■		■	■					
Sundevnites	■	■									
Eumorphoceras	■	■	■	■	■	■	■			■	■
Peytonoceras						■					
Trizonoceras			■	■	■	■		■	■	■	
Asturoceras	■						■				
Glyphiolobus	■		■	■	■	■		■	■		■
Metadimorphoceras	■	■	■	■	■	■		■	■		
Sulcodimorphoceras								■			
Kazakhoceras	■	■	■	■	■		■		■	■	
Eogonioloboceras			■							■	
Stenoloboceras										■	
Arcanoceras			■		■	■	■		■	■	
Hypergoniatites			■	■				■	■		
Neogoniatites			■	■		■		■			■
Platygoniatites			■	■	■		■		■	■	■
Delepinoceras			■	■		■	■	■		■	
Lusitanoceras	■	■	■	■		■	■	■	■		
Dombarites			■	■	■	■	■	■		■	
Revilloceras							■				
Proshumardites			■	■			■	■		■	
Sygambrites		■									
Pachylyroceras			■	■		■	■				
Dombarigloria			■								
Aisoceras			■								
Emstites	■	■	■	■		■	■				
Cravenoceras	■	■	■	■	■	■	■	■	■		■
Collefoceras			■								
Lechroceras					■						
Aravanites				■							
Tympanoceras			■	■			■				
Kardailites			■						■		
Lyrogoniatites	■	■	■	■	■	■		■	■		
Caenolyroceras	■		■		■						
Quasicravenoceras			■						■		
Verancoceras			■								
Nuculoceras	■	■	■		■						
Neoglyphioceras	■	■	■		■	■	■	■	■		■
Lytheoceras			■								
Lusitanites	■	■	■	■		■	■	■	■		■
Mirlentia			■		■						
Ferganoceras			■	■		■		■		■	
Nummoceras			■								
Ophilyroceras			■								
Rhymmoceras			■	■	■		■				
Fayettevillea			■	■	■	■	■		■		
Glaphyrites	■	■	■	■	■	■	■				■
Pseudoglaphyrites			■					■			
Syngastrioceras			■	■		■	■			■	■
Rhadinites			■			■					
Richardsonites			■	■		■					
Stenoglaphyrites	■		■	■		■					■
Zephyroceras			■	■			■				
Euroceras			■				■				
Cravenoceratoides	■	■	■	■				■			
Ramosites				■							
Bisatoceras										■	
total	24	21	59	38	28	32	33	27	17	17	15

As can be seen from the similarity matrices, analyses of the same data set lead to slightly differing results. This is mainly caused by the different weight of the more diverse fauna, i.e. in the SIMPSON coefficient this is not respected at all.

The analysed time unit spans the British P2 (Late Viséan C), E1, and E2 zones, correlative with the Russian Nm1a to Nm1c zones (*Hypergoniatites – Ferganoceras*, *Uralopronorites – Cravenoceras*, and *Fayettevillea – Delepinoceras* genozones). The choice of this relatively long timespan was necessary because of the difficulties that arise when correlating faunas of distant areas without common index fossils. The lack of common species between the various regions also prevented a species-based analysis of palaeobiogeography, thus in the following, a genus-based analysis is achieved (matrix see Tab. 1). Included are only areas in which relatively rich faunas (more than 15 genera), and in which a rather continuous succession of faunas are known. Most of the data, 76 ammonoid genera with their geographical distribution, were obtained from the GONIAT database (KORN & KULLMANN, 1996).

The following regions with rich Namurian ammonoid assemblages were included (in brackets some of the main references):

- British Isles (BISAT, 1924, 1952; BISAT & HUDSON, 1943; MOORE, 1946)
- Rhenish Massif (SCHMIDT, 1925; KORN, 1988)
- South Urals (RUZHENCEV & BOGOSLOVSKAYA, 1971, 1978)
- Central Asia (PITINOVA, 1975; NIKOLAEVA, 1994)
- North China (GAO, 1983; YANG, 1986; RUAN & ZHOU, 1987; LIANG & WANG, 1991)
- South China (RUAN, 1981; SHENG, 1983)
- American Midcontinent (GORDON, 1965; SAUNDERS, 1973)
- Western United States (YOUNGQUIST, 1949; MILLER et al., 1952)
- Spain (KULLMANN, 1961, 1962; WAGNER-GENTIS, 1980)

Table 2.
Matrix showing the generic diversity of ammonoid superfamilies recorded from the various regions.
Abbreviations see Tab. 1.

superfamilies/regions	GB	DE	SU	CA	CN	AM	ES	NA	NZ	CG	AW
Prolecanitaceae	-	-	3	3	1	2	3	2	-	1	1
Medlicottiaceae	-	-	3	3	1	-	2	2	-	1	1
Prionoceratacea	-	-	1	1	-	-	2	-	-	-	-
Pericyclaceae	3	2	1	-	4	3	-	3	-	2	1
Nomismoceratacea	-	-	2	1	2	1	-	-	2	-	-
Girtyoceratacea	6	6	5	2	3	6	3	2	-	2	3
Dimorphoceratacea	4	2	5	3	4	2	2	3	4	4	-
Goniatitaceae	1	2	7	7	2	4	8	6	3	4	2
Neoglyphioceratacea	7	7	22	10	9	8	8	6	7	1	1
Somoholitaceae	2	1	8	5	1	5	4	1	-	1	3
Neodimorphoceratacea	1	1	1	2	-	-	-	1	-	-	-
Thalassoceratacea	-	-	-	-	-	-	-	-	-	1	-

– North Africa (DELÉPINE, 1941; PAREYN, 1961; this paper)
– Novaya Zemlya (KUSINA & YATSKOV, 1988)

Postulation of ammonoid provinces are based on two criteria:

1) relations expressed by similarity coefficients (Tabs. 3–5), and
2) relations expressed by the occurrence or absence of higher taxa (i.e. superfamilies; Tab. 2).

3.2. Palaeobiogeographical Units

3.2.1. Subvariscan

In all of the analyses, the British Isles and the Rhenish Massif (Text-Fig. 11) show very close relation in displaying a similarity index much higher than in comparison with any other region. Furthermore, this province is characterised by the lack of advanced taxa of the superfamily Goniatitaceae (such as *Neogoniatites*, *Delepinoceras*, *Proshumardites*) as well as the apparent lack of the order Prolecanitida. The Girtyoceratacea is well represented with five genera.

3.2.2. Kazakhian

The occurrences in the South Urals (South Russia and North Kazakhstan) as well as Central Asia (Darvaz, Tajikistan; Fergana, Uzbekistan; Xinjiang, China) form the second group, and Novaya Zemlya may also be included. Faunal analyses are difficult because of the different sizes of the faunas, i.e. the South Urals fauna is outstanding with 59 genera. Almost all of the genera known from Central Asia and Novaya Zemlya also occur in the South Urals, and agreements do also occur on the species level. Typical for this second province is the frequent presence of prolecanitids (6 genera), advanced Goniatitaceae (7 genera), and extremely rich Neoglyphioceratacea (22 genera in the South Urals, 10 in Central Asia). Girtyoceratids are present, but except for *Girtyoceras* and *Sulcogirtyoceras*, extremely rare components in the fauna.

3.2.3. North Gondwanan

North Africa and the Cantabrian Mountains of Spain compose the North Gondwanan faunal province, which shows close relation to the Kazakhian province. The two regions contain rich assemblages of Goniatitaceae (8 genera), and rather rich Prolecanitida (5 genera). Neoglyphioceratids are well represented with 7 genera. It is puzzling, however, that the North African and Cantabrian faunas show some common species (such as *Dombarites granofalcatus*), but markedly differ in other features, expressed in rather low similarity indices.

3.2.4. Laurentian

The American Midcontinent is characterised by rich development of girtyoceratids (6 genera which are widely distributed and very abundant), together with moderate representation of the Goniatitaceae (4 genera), fewer pro-

Table 3.
Matrix showing the common ammonoid genera in the various regions.
Abbreviations see Tab. 1.

	GB	DE	SU	CA	CN	AM	ES	NA	NZ	CG	AW
GB (24)		20	19	13	14	15	10	13	8	5	9
DE (21)			17	11	13	13	10	11	7	5	8
SU (59)				36	23	29	30	24	17	15	14
CA (38)					15	22	25	18	13	11	12
CN (28)						16	10	14	10	9	9
AM (32)							18	18	10	11	13
ES (33)								15	9	11	12
NA (27)									9	9	10
NZ (17)										4	5
CG (17)											7
AW (15)											

Table 4.
Similarity matrices for ammonoid genera in the various regions, calculated using the SIMPSON coefficient and Correlation ratio.
Abbreviations see Tab. 1.

SIMPSON coefficient: C / N_1

	GB	DE	SU	CA	CN	AM	ES	NA	NZ	CG	AW
GB		0.95	0.79	0.54	0.58	0.63	0.42	0.54	0.47	0.29	0.60
DE	0.79		0.81	0.42	0.62	0.62	0.48	0.52	0.41	0.29	0.53
SU	0.25	0.23		0.95	0.82	0.90	0.91	0.89	1.00	0.88	0.93
CA	0.19	0.15	0.58		0.54	0.69	0.76	0.67	0.76	0.65	0.80
CN	0.28	0.29	0.32	0.21		0.57	0.36	0.52	0.59	0.53	0.60
AM	0.29	0.25	0.45	0.40	0.29		0.56	0.67	0.59	0.65	0.87
ES	0.13	0.14	0.46	0.50	0.11	0.31		0.56	0.53	0.65	0.80
NA	0.26	0.21	0.36	0.32	0.26	0.38	0.25		0.53	0.53	0.67
NZ	0.16	0.14	0.29	0.26	0.21	0.18	0.14	0.18		0.24	0.33
CG	0.06	0.07	0.22	0.19	0.17	0.22	0.22	0.18	0.06		0.47
AW	0.23	0.20	0.22	0.25	0.19	0.35	0.20	0.25	0.10	0.19	

Correlation ratio: C^2 / N_1N_2

Table 5.
Similarity matrices for ammonoid genera in the various regions, calculated using the JACCARD coefficient and SØRENSEN coefficient.
Abbreviations see Tab. 1.

JACCARD coefficient: $C / N_1 + N_2 - C$

	GB	DE	SU	CA	CN	AM	ES	NA	NZ	CG	AW
GB		0.80	0.30	0.27	0.37	0.37	0.21	0.34	0.24	0.14	0.30
DE	0.44		0.27	0.23	0.36	0.33	0.23	0.30	0.23	0.15	0.29
SU	0.23	0.21		0.59	0.35	0.49	0.48	0.39	0.29	0.25	0.23
CA	0.21	0.19	0.38		0.29	0.46	0.54	0.38	0.31	0.25	0.29
CN	0.27	0.27	0.26	0.23		0.36	0.24	0.34	0.29	0.25	0.26
AM	0.27	0.24	0.32	0.31	0.27		0.38	0.44	0.26	0.29	0.38
ES	0.18	0.19	0.33	0.35	0.16	0.28		0.33	0.22	0.28	0.33
NA	0.25	0.23	0.28	0.28	0.25	0.31	0.25		0.26	0.26	0.31
NZ	0.20	0.18	0.22	0.20	0.22	0.20	0.18	0.20		0.13	0.19
CG	0.12	0.13	0.20	0.17	0.20	0.22	0.22	0.20	0.12		0.28
AW	0.23	0.22	0.19	0.19	0.21	0.28	0.25	0.24	0.16	0.21	

SØRENSEN coefficient: $C / N_1 + N_2$

lecanitids (2 genera), and moderate Neoglyphioceratataceae (8 genera). In the similarity matrices, the American Midcontinent is most closely related to the South Urals, Central Asia, and North Africa. Obviously, the Western United States also belong to this province.

The other regions included in the matrices (North China, South China) so far cannot be attributed to distinct faunal provinces. According to the SIMPSON coefficient, they are doubtless more related to the South Urals than to the Rhenish Massif and British Isles. However, this may be due to the extremely rich Uralian fauna in which almost all the genera of the analysed timespan are represented.

Correspondences between the less diverse Central Asian and North China (occurrences in Ningxia) are comparatively low. North China shows closer relations to the Subvariscan, the American Midcontinent, and North Africa. This pattern may reflect a facies pattern, in the three regions the ammonoids were mainly collected from nodules which are intercalated in an argillaceous sequence. Already RUAN & ZHOU (1987) considered such a reason for the apparent differences in faunal composition of Chinese assemblages, postulating ecological properties of the various goniatites as being responsible for their biogeographical pattern. The fauna of the pure limestone succession of Guangxi (South China) shows closest affinities to the South Urals, Central Asia, the Cantabrian Mountains, and the American Midcontinent.

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Plate 1

Goniatites from 12 km southeast of the Dar Kaoua Oasis (1–8), and from the Gara El ltima northeast of Taouz (9).

Fig. 1: *Eoglyphioceras ergchebbiense* sp. nov.
Holotype GPIT 1851-74.
× 1.75.

Fig. 2: *Eoglyphioceras ergchebbiense* sp. nov.
Paratype GPIT 1851-84.
× 2.

Fig. 3: *Beyrichoceras elabiodiense* sp. nov.
Holotype GPIT 1851-67.
× 1.25.

Fig. 4: *Beyrichoceras elabiodiense* sp. nov.
Paratype GPIT 1851-82.
× 1.5.

Fig. 5: *Eoglyphioceras* sp.
GPIT 1851-83.
× 1.25.

Fig. 6: *Calygirtyoceras darkaouaense* sp. nov.
Paratype GPIT 1851-88.
× 1.5.

Fig. 7: *Calygirtyoceras darkaouaense* sp. nov.
Holotype GPIT 1851-87.
× 1.25.

Fig. 8: *Sulcogirtyoceras* vel. *Edmooroceras* sp.
GPIT 1851-90.
× 2.

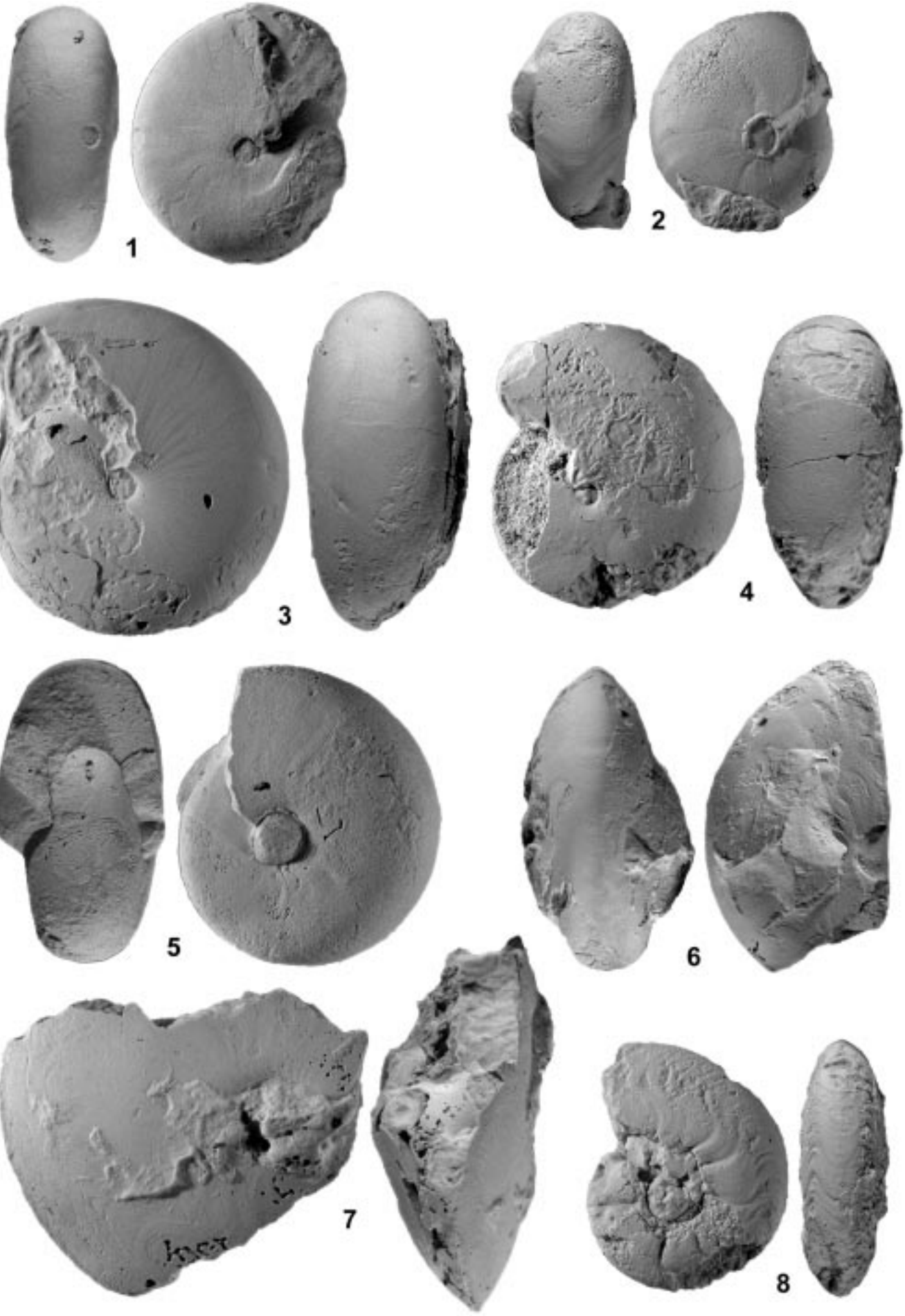
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Plate 2

Maxigoniatites saourensis (PAREYN 1961)
from 12 km southeast of the Dar Kaoua Oasis.

Fig. 1: Specimen GPIT 1851-1.
× 1.
Fig. 2: Specimen GPIT 1851-66.
× 1.5.
Fig. 3: Specimen GPIT 1851-5.
× 1.
Fig. 4: Specimen GPIT 1851-63.
× 1.5.
Fig. 5: Specimen GPIT 1851-2.
× 1.

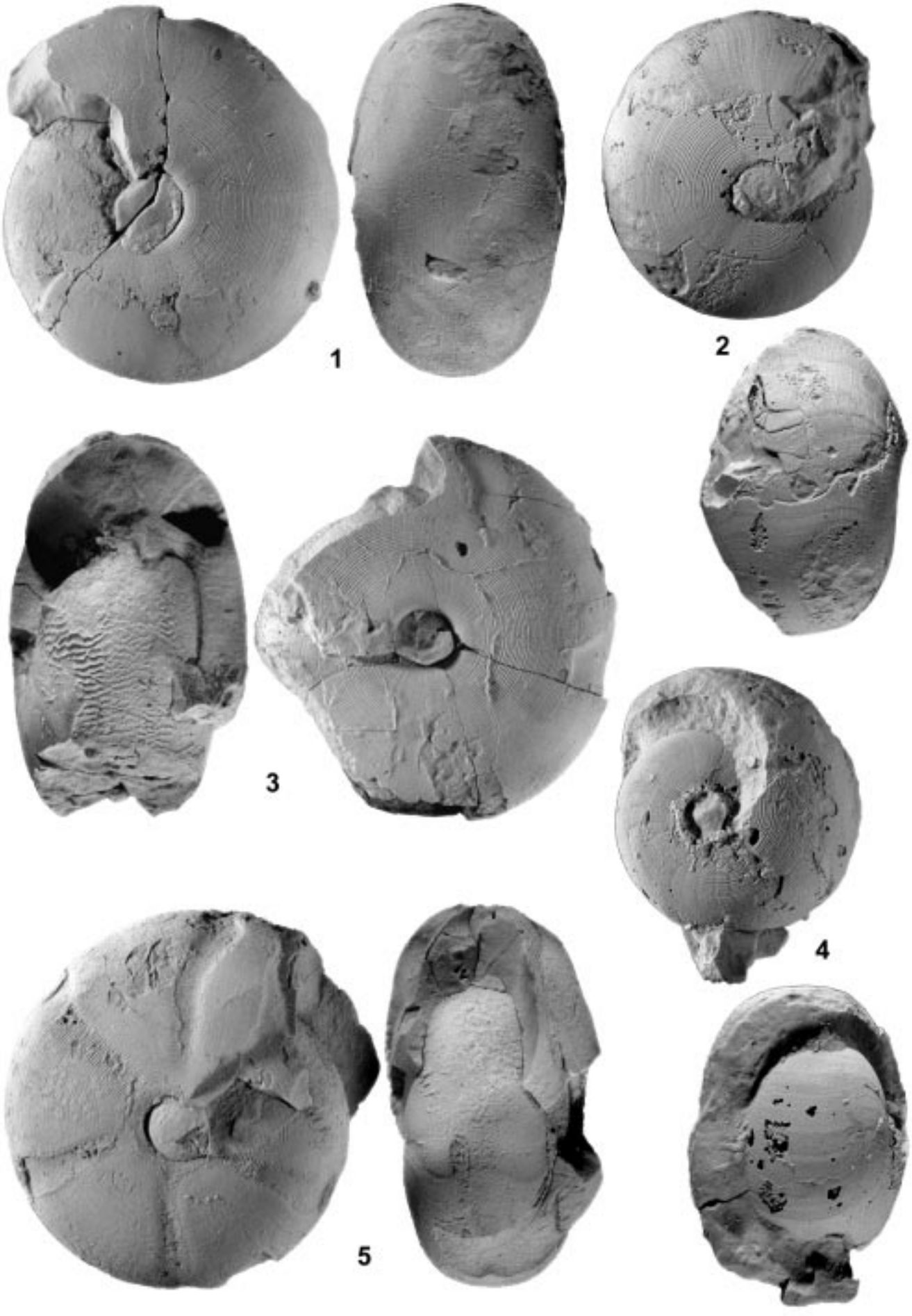
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Plate 3

Goniatites from 12 km southeast of the Dar Kaoua Oasis (1–4), and from Taouz (5–9).

Fig. 1: Maxigoniatites tafilaltensis sp. nov.
Paratype GPIT 1851-36.
× 1.25.

Fig. 2: *Maxigoniatites saourensis* (PAREYN 1961)
GPIT 1851-41
× 2.

Fig. 3: *Maxigoniatites tafilaltensis* sp. nov.
Holotype GPIT 1851-27.
× 1.5.

Fig. 4: *Maxigoniatites tafilaltensis* sp. nov.
Paratype GPIT 1851-26.
× 1.5.

Fig. 5: *Neogoniatites delicatus* sp. nov.
Holotype GPIT 1851-101.
× 1.5.

Fig. 6: *Neogoniatites delicatus* sp. nov.
Paratype GPIT 1851-118.
× 1.75.

Fig. 7: *Neogoniatites delicatus* sp. nov.
Paratype GPIT 1851-129.
× 1.5.

Fig. 8: *Neogoniatites delicatus* sp. nov.
Paratype GPIT 1851-111.
× 2.

Fig. 9: *Neogoniatites delicatus* sp. nov.
Paratype GPIT 1851-112.
× 2.5.

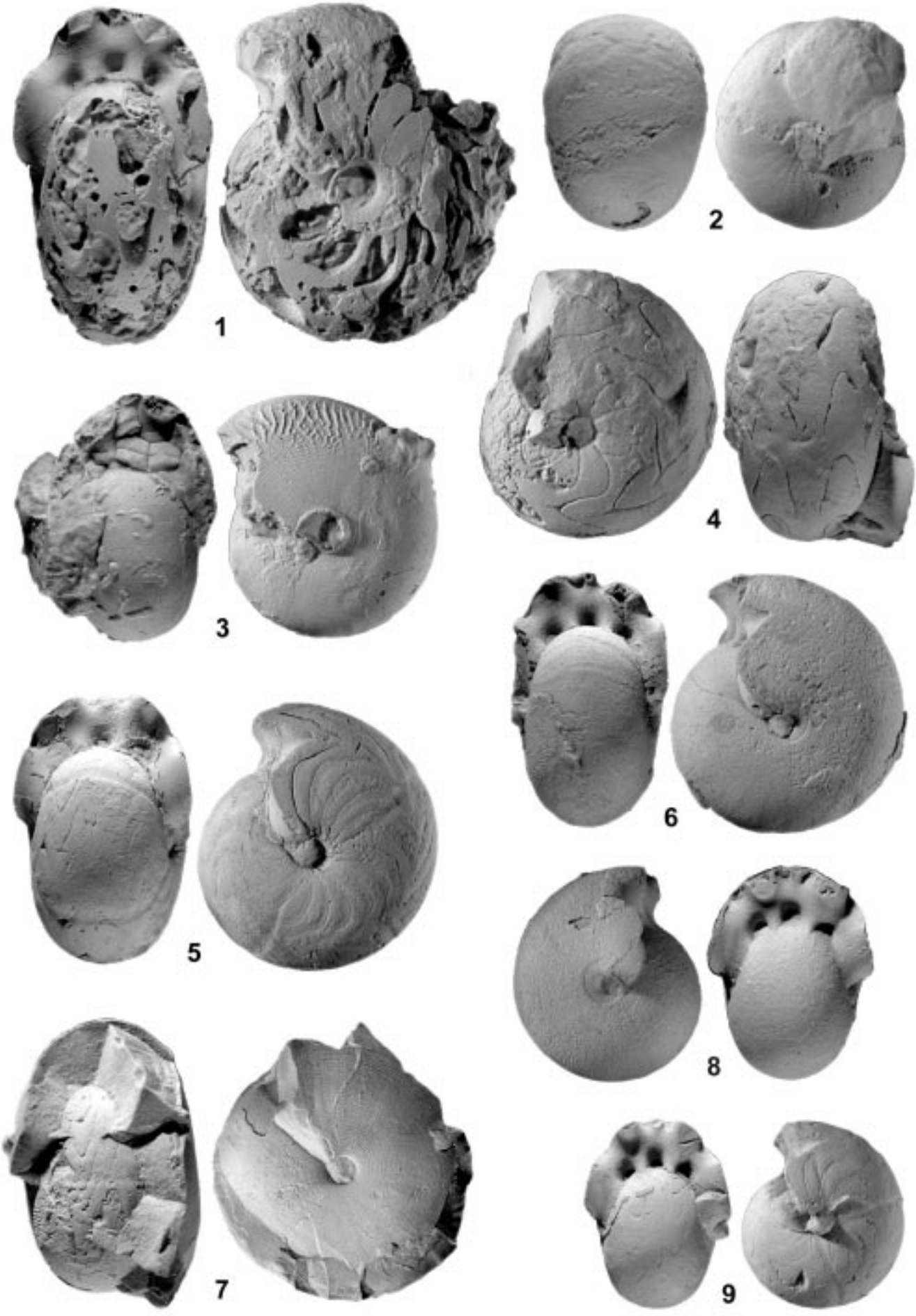
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Plate 4

Goniatites from various places in the eastern Anti-Atlas.

Fig. 1: *Hypergoniatites* sp.
GPIT 1851-91; Gara El Itima northeast of Taouz.
× 1.5.

Fig. 2: cf. *Lusitanoceras* sp.
GPIT 1851-106; Taouz.
× 1.5.

Fig. 3: cf. *Lusitanoceras* sp.
GPIT 1851-99; from near the Gara El Itima northeast of Taouz.
× 1.25.

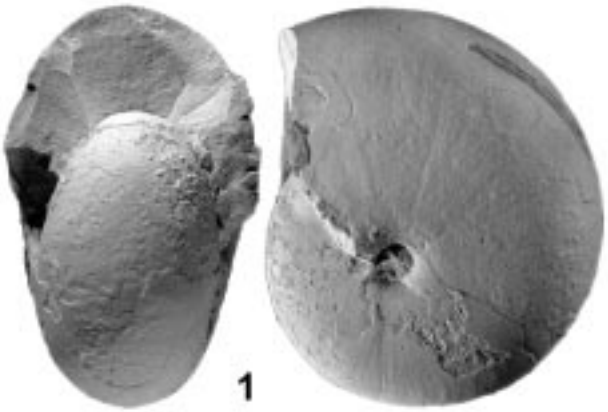
Fig. 4: cf. *Lusitanoceras* sp.
GPIT 1851-132; Taouz.
× 1.5.

Fig. 5: *Goniatites* sp.
GPIT 1851-97; Erfoud.
× 1.

Fig. 6: *Goniatites* sp.
GPIT 1851-98; locality unknown, probably eastern Tafilalt.
× 1.

Fig. 7: *Sudeticeras* sp.
GPIT 1851-92; Gara El Itima northeast of Taouz.
× 1.25.

Fig. 8: *Sudeticeras* sp.
GPIT 1851-107; Taouz.
× 1.5.



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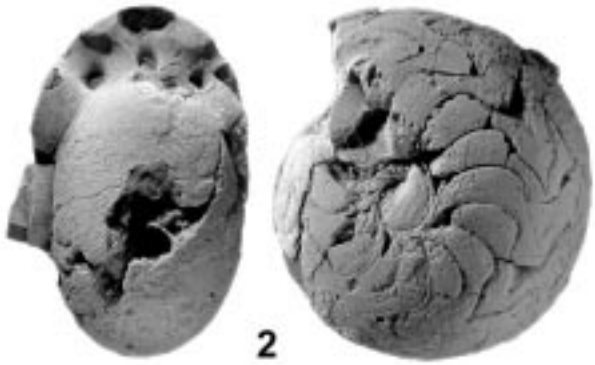

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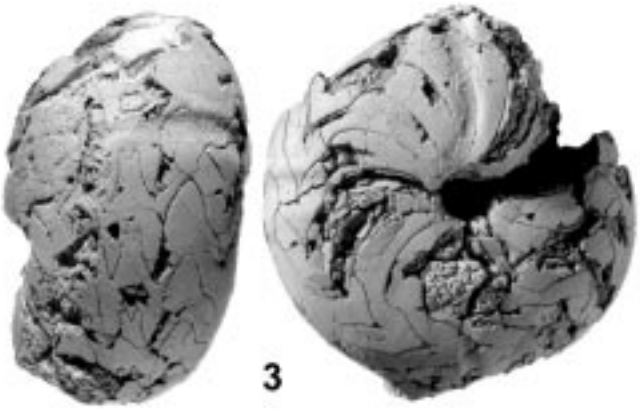

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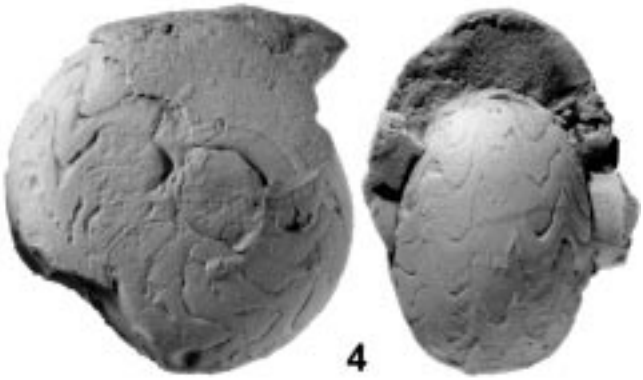

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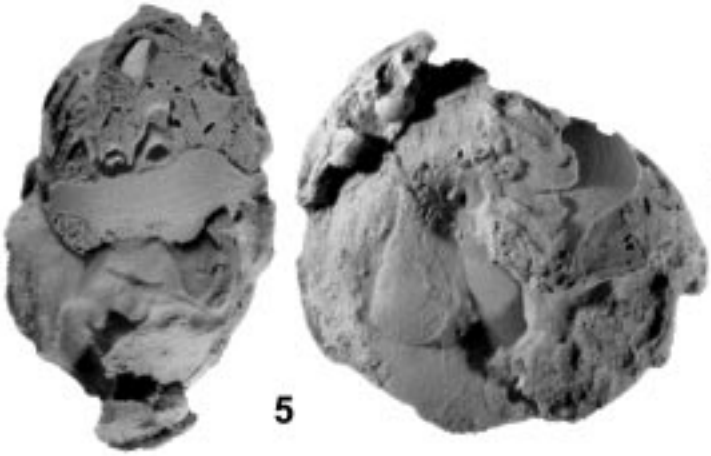

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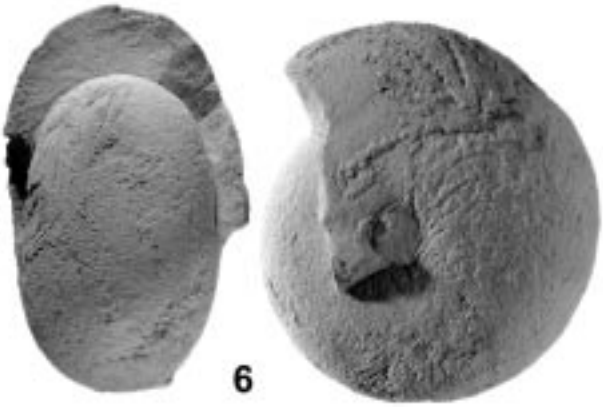

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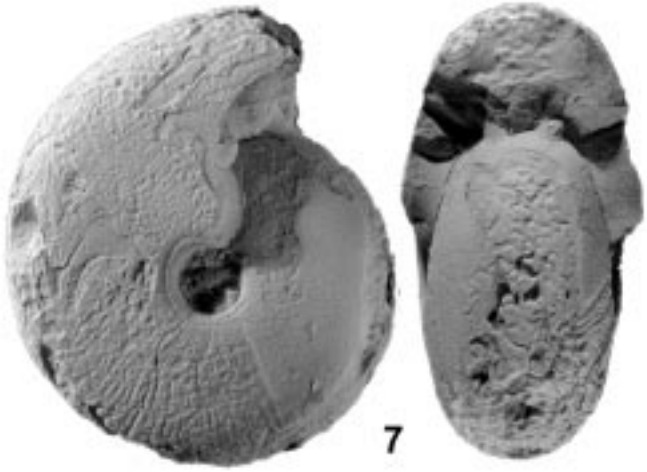
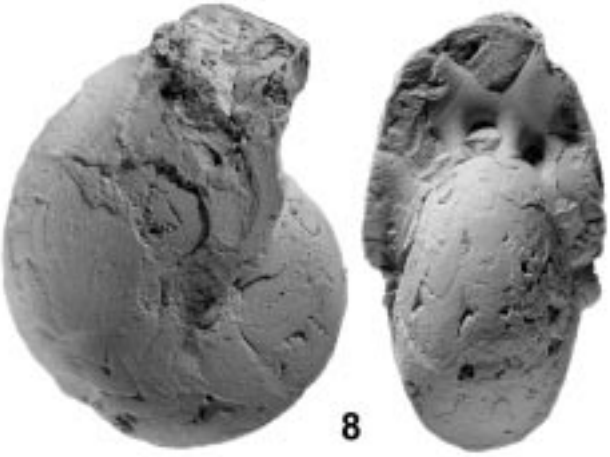


7

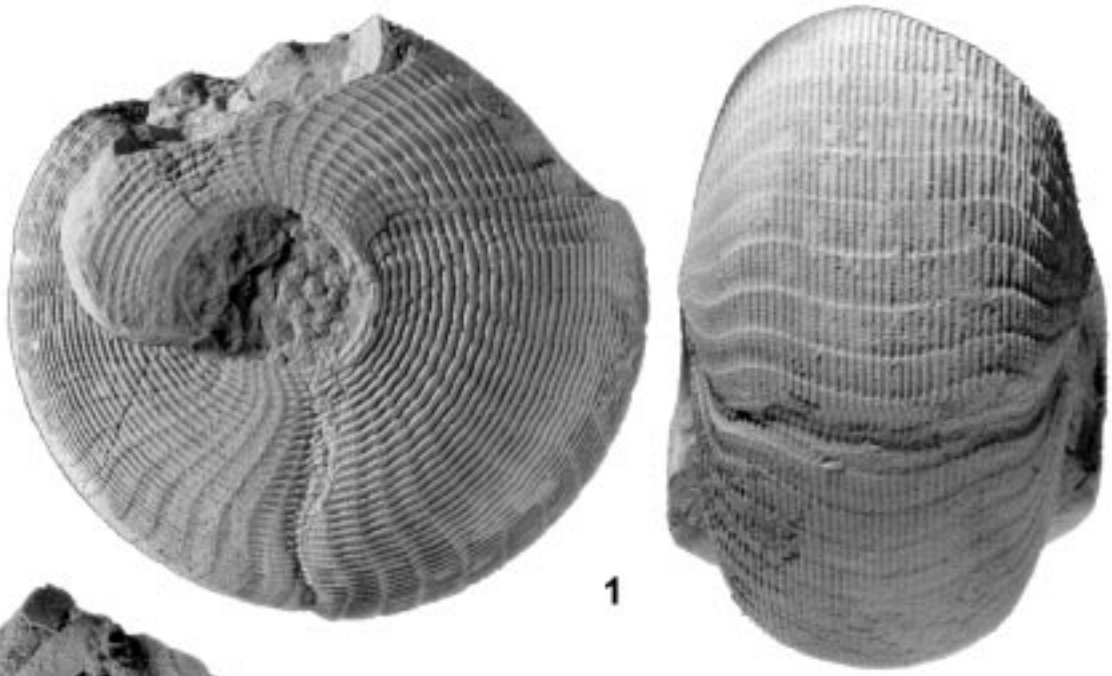


8

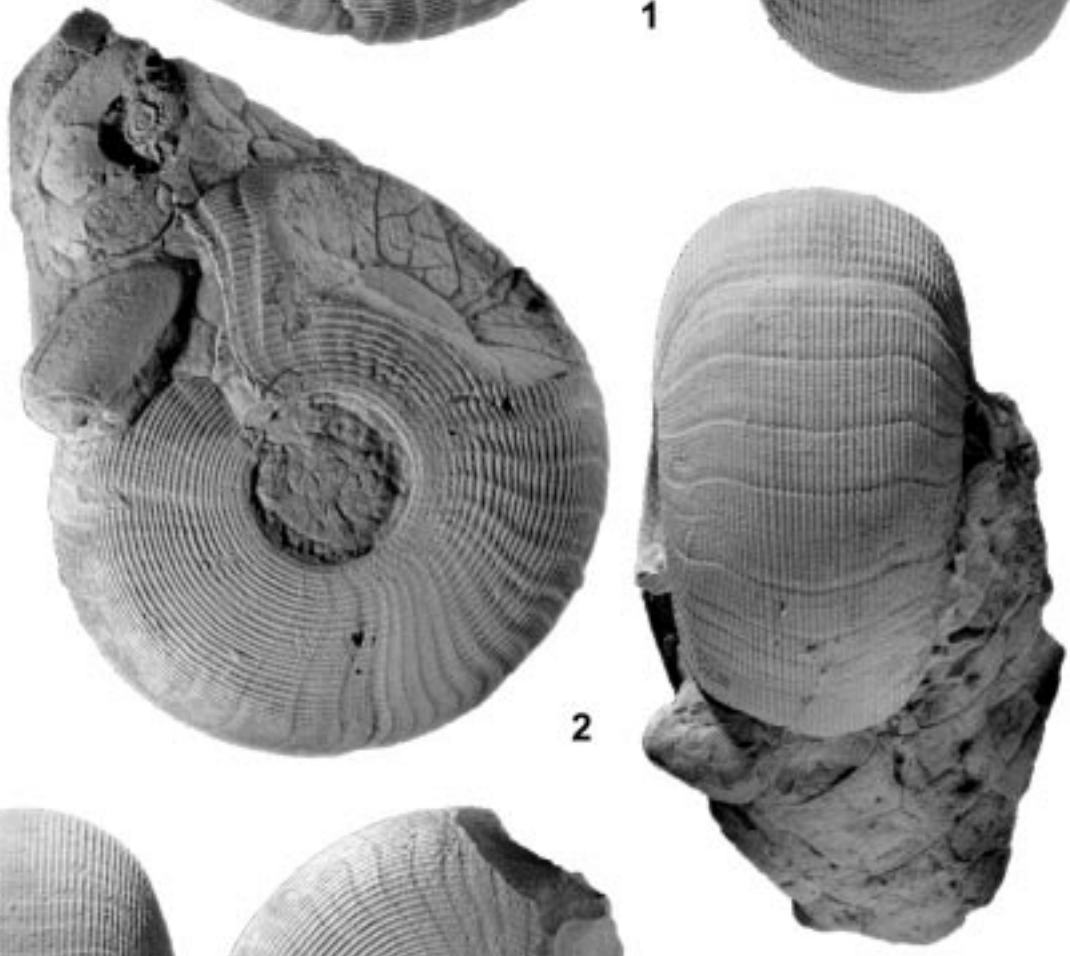
Plate 5

Dombarites granofalcatus (KULLMANN 1961)
from the Gara El Itima northeast of Taouz.

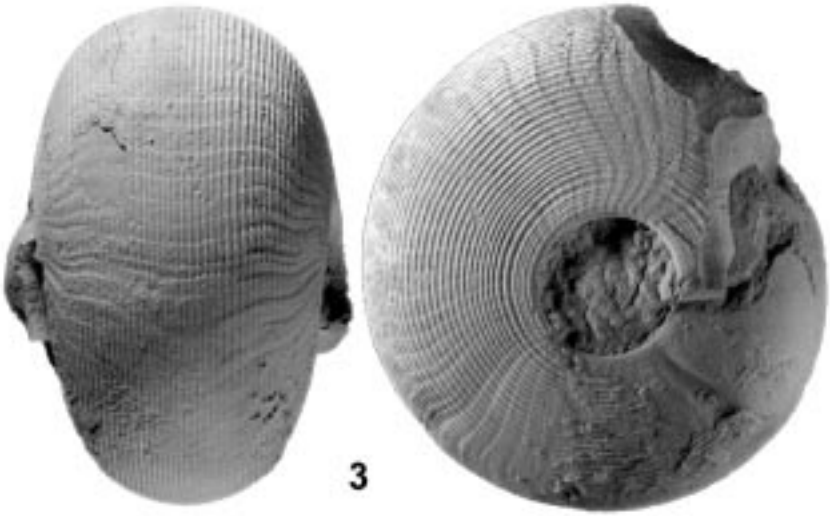
Fig. 1: Fig. 1: GPIT 1851-95.
× 1.
Fig. 2: GPIT 1851-94.
× 1.
Fig. 3: GPIT 1851-93.
× 1.



1



2



3

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