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Lonsdaleia carnica n. sp., a new colonial coral from the late Mississippian Kirchbach Formation of the Carnic Alps (Austria)

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7 Text-Figures

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Lonsdaleia
Rugose corals
Mississippian
Carnic Alps
Olistolith

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Abstract

A large limestone boulder has been recorded in the Kirchbach Formation (Carboniferous) at the Carnic Alps. It shows reefal facies and contains a diverse assemblage of invertebrates and algae. The main building organisms in the boulder are rugose corals of the genus *Lonsdaleia*, algae and bryozoans. All colonies belong to a single species, *Lonsdaleia carnica* sp. nov. The whole assemblage indicates a Late Viséan to Serpukhovian age for the original sedimentation, but the final deposition in the flysch basin might be somewhat younger.

Lonsdaleia carnica n. sp., eine neue Korallenkolonie aus der Kirchbach-Formation (Mississippium) in den Karnischen Alpen (Österreich)

Zusammenfassung

In der Kirchbach-Formation (Unterkarbon) wurde ein rund 60 kg schwerer, in der Längsachse 65 cm großer Kalkblock gefunden. Nach seiner Zusammensetzung ist er als Riff-Fazies zu deuten und besteht aus einer diversen Gesellschaft aus Invertebraten und Algen. Die Hauptbildner sind rugose Korallen der Gattung *Lonsdaleia*, Algen und Bryozoen. Alle Kolonien gehören zu einer einzigen Art, nämlich *Londsdaleia carnica* n. sp. Diese Gesellschaft spricht für ein Sedimentationsalter in der späten Visé bis Serpukhovium-Stufe; die endgültige Ablagerung im Flyschbecken der Hochwipfel-Formation dürfte hingegen etwas später erfolgt sein.

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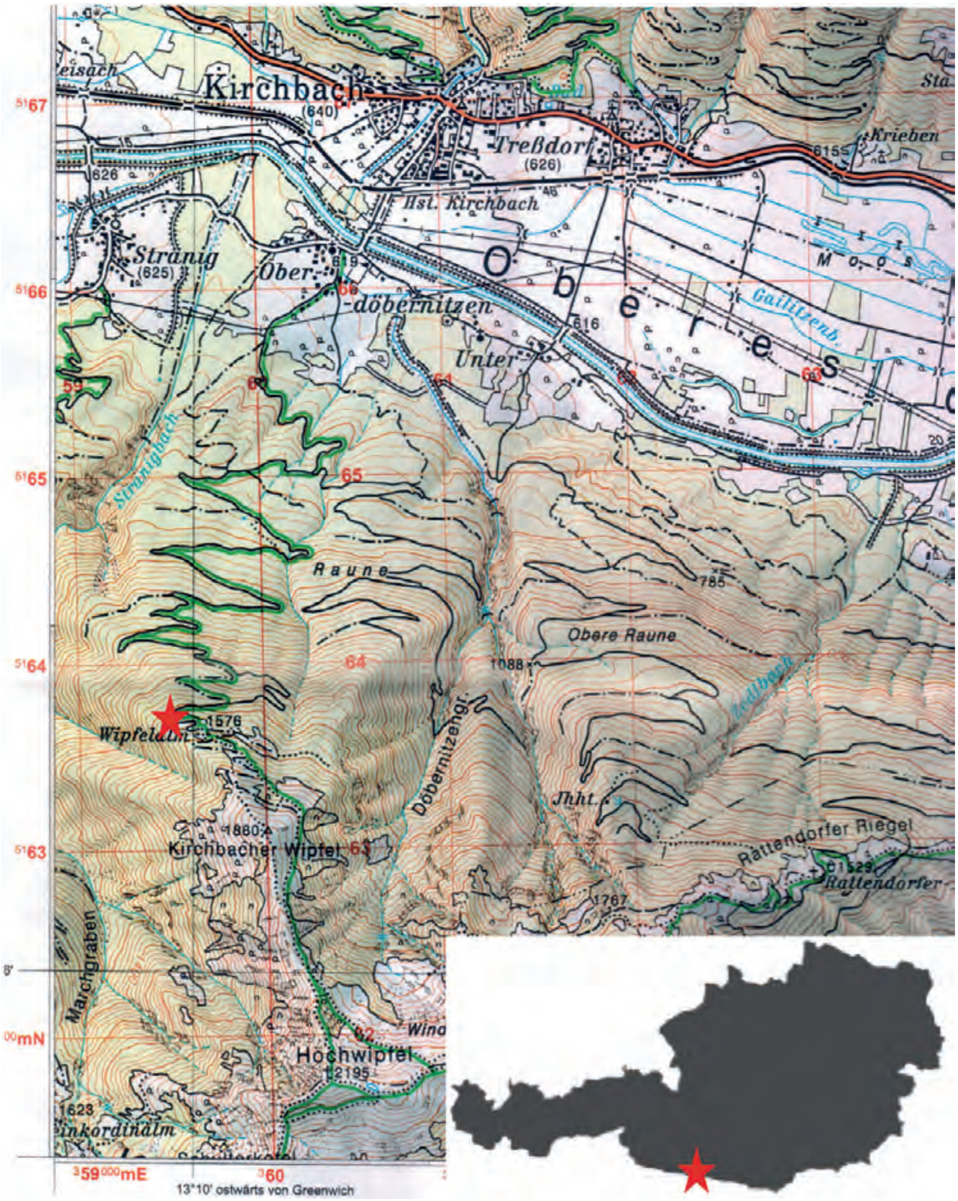
Introduction

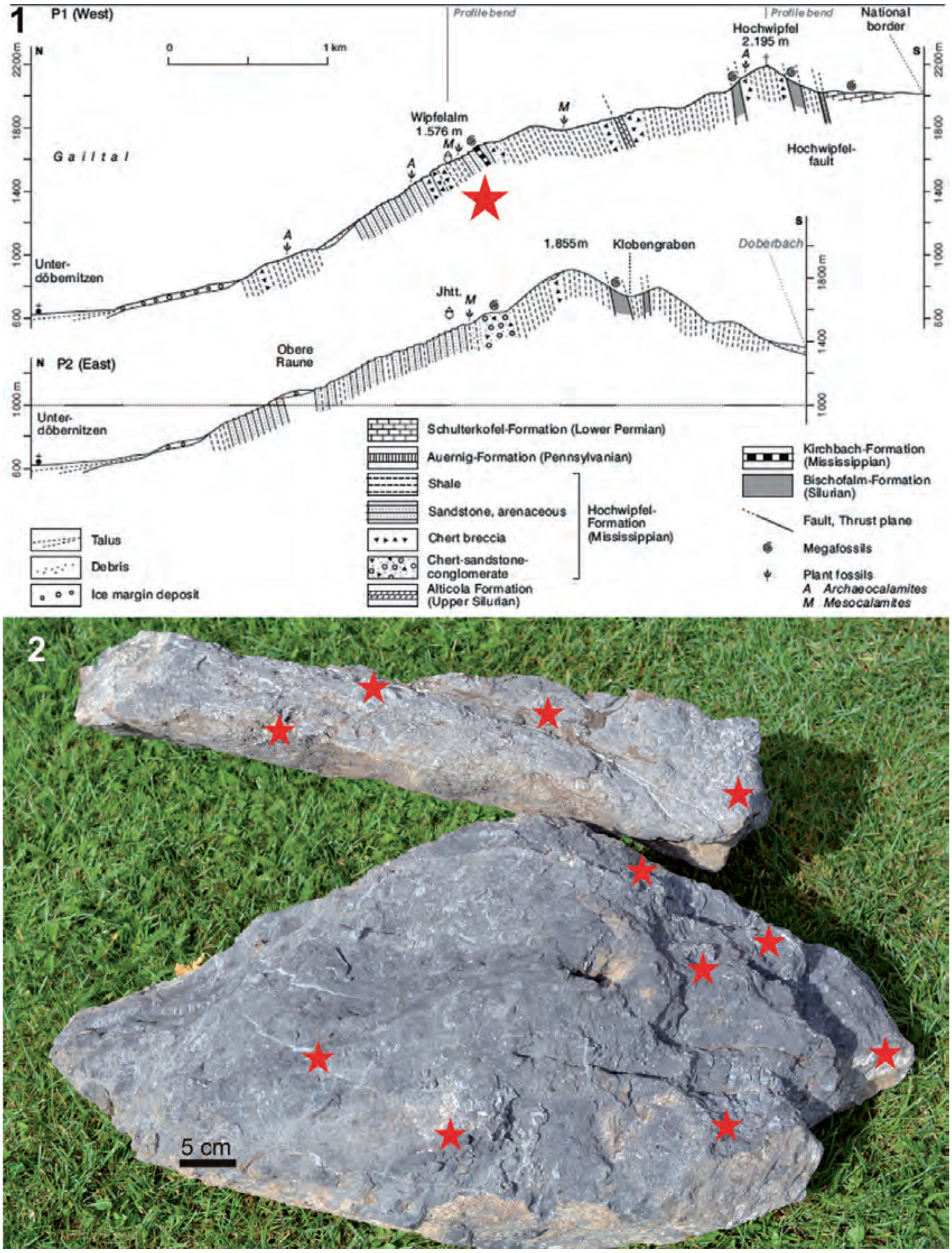
Since the discovery of the bioclastic Kirchbach Formation in the early 1980s, this rock interbedded in the Lower Carboniferous Hochwipfel Formation has attracted Earth scientists in various fields, i.e. biostratigraphy, micro- and macro-palaeontology, sedimentology, geodynamics and palaeogeography (Schönlaub, 1981, 1983, 1987; Flügel & Schönlaub, 1990; Amler et al., 1991; Krainer & Vachard, 2015). During field mapping by one of the authors (Schönlaub, 1981, 1983) it was regarded as a nodular limestone lense of several meters thickness and length containing late Viséan to early Serpukhovian conodonts. They provided an important age assignment for the siliciclastic flysch-type Hochwipfel Formation in the type area of mountain Hochwipfel. However, it soon turned out that the limestone clasts within the Kirchbach Formation were derived from different shallow-water settings none of which are preserved until today. In contrast to these findings, off-shore and deep water conodonts, ammonoids and trilobites also indicated a deep-water environment for some of the limestone nodules. In conclusion, the newly defined Kirchbach Formation (Schönlaub et al., 2015) was regarded as an accumulation of reworked shallow and deep-water bioclastic limestone intercalated within the siliciclastic Hochwipfel Formation which was transported into the flysch basin by debris flows during the late Viséan/ lower Serpukhovian interval of the pre-Variscan sequence of the Carnic Alps.

Until present, some solitary corals, crinoids, and ooids have been found in isolated limestone clasts in debris flows occurring in the neighbourhood of the type Kirchbach Formation. To date, an up to 65 cm large and some 60 kg heavy limestone boulder composed of reefal limestone containing abundant coral colonies has not been recorded in the Kirchbach Formation. It was a mere accident when one of us (H.K.) discovered the loose slab on the road acclivity at Plunger turn from Wipfelalm to Kirchbach Wipfel at an altitude of 1,650 to 1,670 m (UTM 33T, 359864 E / 5163448 N) (Text-Figs. 1, 2).

The main aim of this paper is the description of a new species of the genus *Lonsdaleia*, which is the main component of the limestone block.



Text-Fig. 1.
Location of the studied boulder (red star) in the Gail Valley (Carnic Alps, Austria).

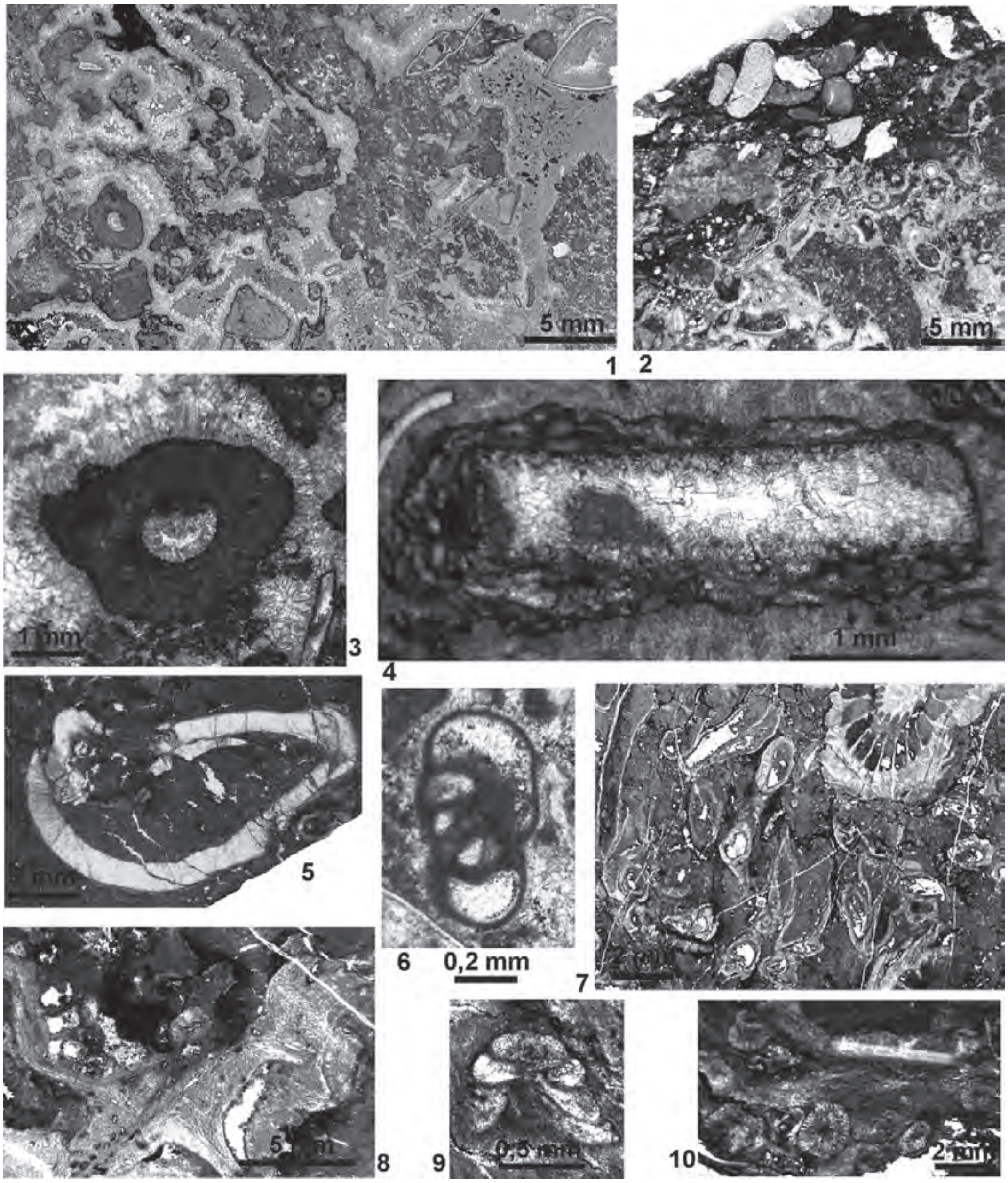


Text-Fig. 2.
1: Diagrams of the stratigraphical succession in the southern hillside of the Gail Valley indicating the location of the boulder (red star). 2: Picture of the boulder showing the location of some *Lonsdaleia* colonies (red stars).

Lithology

The studied limestone block shows diverse microfacies changing from bindstone to coral bafflestone and packstone (Text-Fig. 3-1). In some areas those microfacies are in erosive contact with a polymictic limestone breccia containing some clasts of the own building facies plus wackestone and mudstone pebbles (Text-Fig. 3-2). The whole block shows strong recrystallization, cementation and fragmentation of components. The main building organisms in the block are fasciculate rugose corals of the genus *Lonsdaleia* McCoy, but the whole assemblage is highly diverse (Text-Fig. 3).

In addition to the rugose corals other main building organisms are bryozoans of the genus *Fistulipora* McCoy (Text-Fig. 3-8) tabulate corals of the genus *Multithecopora* Yoh (Text-Fig. 3-7) and varied red (ungdarellaceans), green (*Anatolipora* Konishi, Text-Fig. 3-10) and incertae algae (*Aphralysia*, Text-Fig. 3-4, *Fasciella*). Cyanobacteria masses of the genus *Girvanella* are also common. Other components of the microfacies are fragments of crinoids, bivalves (Text-Fig. 3-5), ostracods (Text-Fig. 3-2), brachiopods, trilobites and foraminifers (*Endothyra,* Text-Fig. 3-6, *Tetrataxis*, Text-Fig. 3-9). Worm tubes of the genus *Thartharella* are abundant.



Text-Fig. 3.
Microfacies and components of the recorded boulder. **1:** Microfacies of the inter-colonies areas, including diverse bioclasts, algal and cyanobacteria mats, *Tharthar-ella* worm tubes and cemented cavities. **2:** Erosive contact of the built microfacies and limestone breccia. **3:** *Thartharella* worm tube. **4:** *Aphralisia* incrusting a fragment of mollusc. **5:** Bivalve shell. **6:** *Endothyra* sp. **7:** Colony of *Multithecopora* sp.; Note the close relationship with corallites of *Lonsdaleia*. **8:** *Fistulipora* sp. **9:** *Tetrataxis* sp. **10:** *Anatolipora* sp.

Taxonomy

Subclass Rugosa MILNE EDWARDS & HAIME, 1850

Suborder Aulophyllina HILL, 1940

Suborder Lonsdaleiina SPASSKY, 1974

Family Axophyllidae MILNE-EDWARDS & HAIME, 1851

Genus *Lonsdaleia* McCOY, 1849

Diagnosis (modified from POTY & HECKER, 2003): Fasciculate corals. Increase lateral, nonparricidal. Axial column usually well-defined, more or less complex and thickened, comprising a medial plate usually connected to the cardinal septum, radial lamellae, and axial tabellae, or sporadically reduced to a medial plate or absent. Minor septa indistinct to well developed. Dissepimentarium dominated by transeptal dissepiments. Cardinal fossula indistinct. Periaxial tabellae slightly concave, subhorizontal or declined outward or inward, commonly complete. Microstructure of septa fibrous; thickenings of septa, tabulae and dissepiments lamellar.

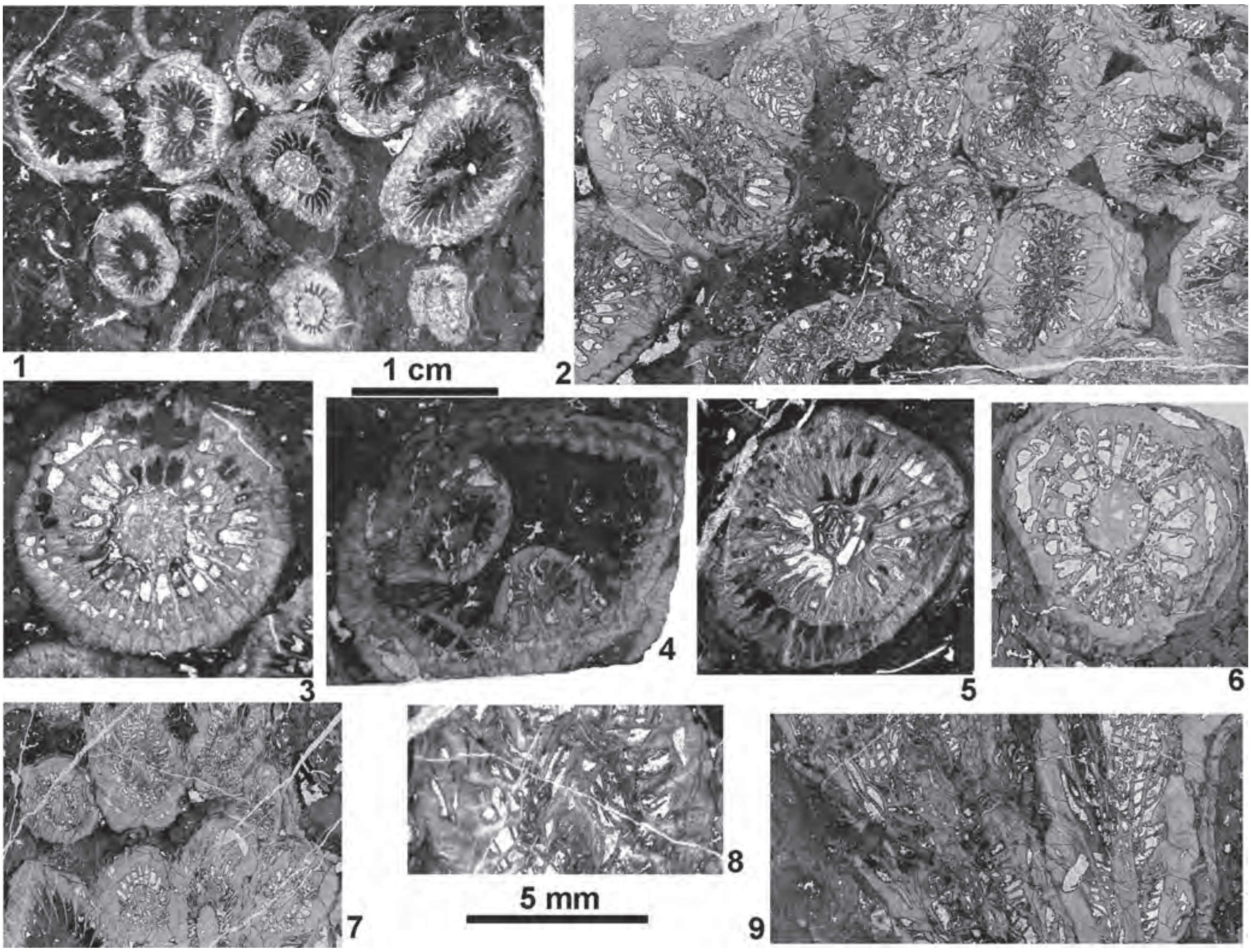
Lonsdaleia carnica sp. nov.

(Text-Figs. 4–7)

Holotype: Specimen KRN-5, Kirchbach Formation, Carnic Alps, Austria, Mississippian.

Derivatio nominis: The name of the species is dedicated to the Carnic Alps, where the new species have been recorded.

Material: A large rock block containing more than 20 fragments of colonies and many loose corallites. Five colonies were sectioned (KRN-1, 2, 3, 4, 5). 12 thin sections including nine transverse and three longitudinal ones. Kirchbach Formation Carnic Alps, Austria, Mississippian.



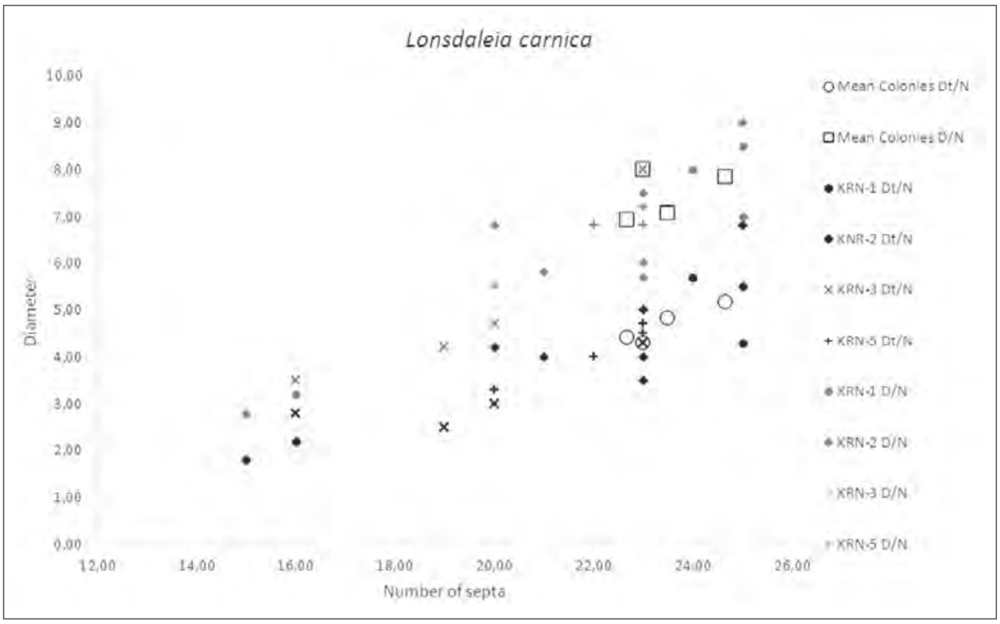
Text-Fig. 4.
Lonsdaleia carnica sp. nov. **1, 3–4:** Specimen KRN-5 (holotype). **1:** Central part of the colony showing corallites in adult and young stages. **3:** Detail of corallite in adult stage showing all diagnostic features of the new species. **4:** Gerontic stage showing two offsets. **2:** Specimen KRN-4 (paratype), showing high degree of fragmentation. **5–6:** Specimen KRN-1 (paratype). Corallite sections showing variants in the development of the axial structure (5) and in the width of the dissepimentarium (6). **7–8:** Specimen KRN-2 (paratype). **7:** Slightly oblique section showing a dense packing of corallites partly due to compression. **8:** Longitudinal section showing the conical shape of axial tabellae and conspicuous thickenings. **9:** Specimen KRN-3 (paratype). Longitudinal section of two corallites. 1cm scale bar for figures 1, 2, 7 and 9. 5 mm scale bar for figures 3, 4, 5, 6 and 8.

Diagnosis: *Lonsdaleia* with adult corallites ranging 5.5 to 8 mm in diameter, 4 to 5.5 mm in tabularium diameter and 22 to 25 septa of both orders. Minor septa well developed, penetrating slightly in the tabularium. Narrow dissepimentarium. Thick outer and inner walls.

Description: Fasciculate fragments of colonies of diverse size, but not larger than 20 cm in diameter and 15 cm in high. Most of them show compression and fragmentation (Text-Fig. 4-2). All colonies show a high proportion of young corallites. Adult corallites 5.5 to 8 mm in diameter with 22 to 25 septa of both orders (Text-Fig. 5). Major septa reaching or almost the axial structure. Cardinal septum usually connected with medial plate. Major septa thick, their even thicker peripheral border build the external wall. Some of the septa may be bent or additionally thickened in their inner border. Minor septa usually well developed, somewhat thinner than majors, penetrate slightly in tabularium. Both, major and minor septa may be continuous, reaching the external wall or forming crests on the wall and dissepiments (Text-Figs. 4-1, 3, 5, 6). Axial structure is well developed, usually densely packed, having a medial plate, between 8 and 20 radial lamellae and conical axial tabellae. Periaxial tabellae complete, sometimes divided, concave, mostly horizontal and upturned near axial corallite (Text-Figs. 4-3, 5, 6, 8, 9). Periaxial cones present. Dissepimentarium narrow, from one-fourth to one-fifth of corallite radius in width, composed of irregular transeptal and interseptal dissepiments. In longitudinal section dissepiments are in one, sometimes two series, abaxially declined, elongate to subglobose. Inner margin of dissepimentarium usually strongly thickened. Outer wall festooned, composed of the thickened peripheral borders of the septa. Young offsets develop at advanced adult stage of parent corallites. Commonly two or three corallites appear simultaneously (Text-Fig. 4-4).

Microstructure is not described in detail because it is mostly recrystallized. Most septa show relicts of fibrous microstructure, thickenings of septa, dissepiments and tabulae show relicts of lamellae.

Remarks: The genus *Lonsdaleia* McCoy has been usually divided in two subgenera, *L. (Actinocyathus)* D'Orbigny and *L. (Lonsdaleia)*. An additional subgenus, *L. (Serraphyllum)* Poty & Hecker was described by Poty & Hecker (2003) for intermediate forms. The different colonial habit has been re-

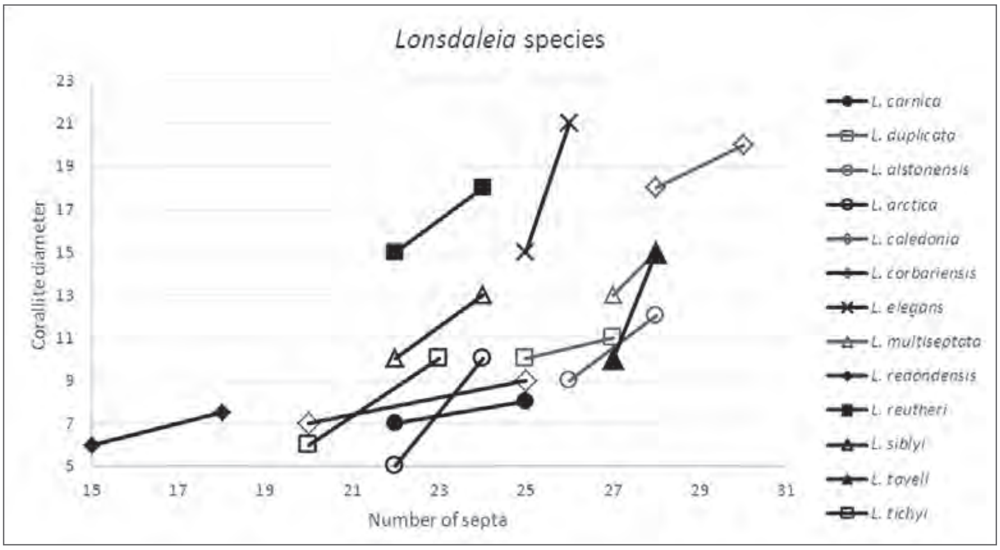


Text-Fig. 5.
Relationships between number of septa and corallite and tabularium diameter. Black symbols indicate the N/Dt relationship in *Lonsdaleia carnica.* Grey symbols indicate the N/D relationship. All measurable sections have been included in the graph, but means of each colony have been calculated including only the sections in adult stage. The colony KRN-4 has been not measured, because it is completely broken and compressed. The low number of measured corallites in each colony is due to the same reason, in this case a partial compression and fragmentation.

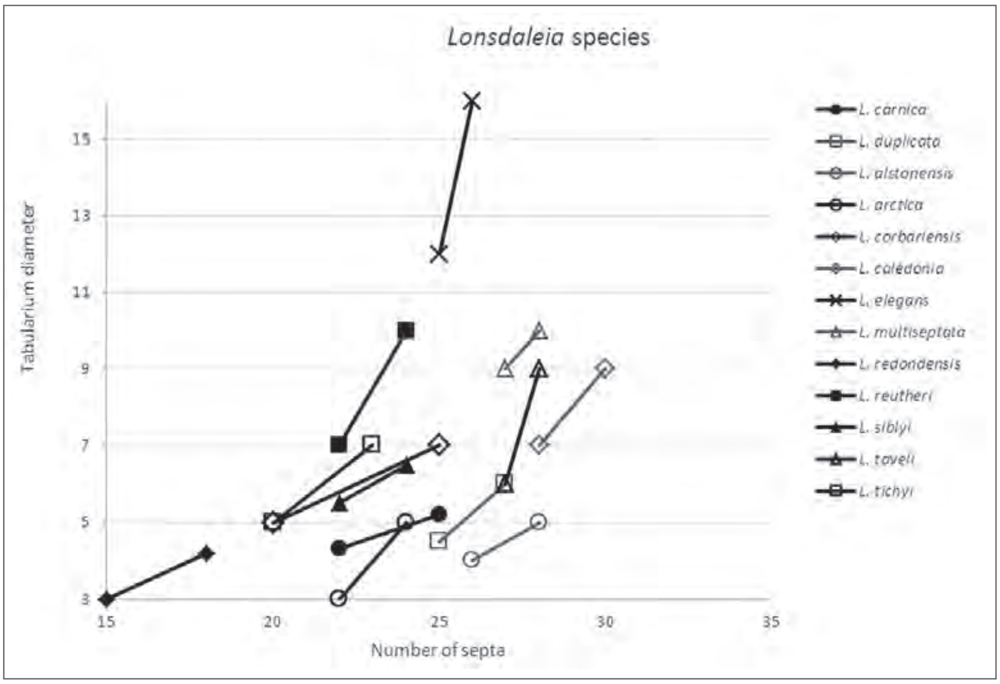
garded usually as diagnostic for distinguishing genera. So, we consider here only the fasciculate species under the generic name of *Lonsdaleia* regarding *Actinocyathus* as a separate genus. More than forty species have been assigned to the genus *Lonsdaleia* from which nearly thirty have been described in the Central and Western Palaeotethys. Important analysis on the morphology of the genus can be found in SMITH (1915), DOBROLYUBOVA (1958), POTY & HECKER (2003) and HECKER (2010, 2012). The main features used for discriminating species are: 1) development of the minor septa, 2) development of lonsdaleoid (transeptal) dissepiments, 3) size and complexity of the axial structure, 4) thickening of structures, 5) diameter and number of septa. We checked the features 1 and 2 in most if not all the species described in the Central and Western Palaeotethys in order to compare with the specimens from Carnic Alps, and discarded those that show absence or low development of minor septa and wide lonsdaleoid dissepimentarium. Those species showing well-developed minor septa and narrow dissepimentarium were included in the N/D and N/Dt graphs of Text-Figures 6 and 7 for comparison. In addition, the type species and some species that are quite close geographically were also included in the graphs. Both, tabularium diameter and corallite diameter have been used in the comparison because the tabularium diameter is the most reliable dimension to compare with the number of septa, but in some old descriptions this feature is not included.

Most species represented in Text-Figures 6 and 7 are clearly distinguishable from the specimens from Hochwipfel Formation by much higher number of septa or larger diameter (Text-Fig. 6). So, *L. duplicata* (MARTIN), *L. alstonensis* SMITH, *L. multiseptata* DOBROLYUBOVA, *L. taveli* ALTMARK and *L. caledonia* SMITH show much higher number of septa and *L. siblyi* SMITH, *L. reutheri* BOLL and *L. elegans* DOBROLYUBOVA show much larger corallite diameter. *L. redondensis* POTY & HECKER shows smaller diameter and number of septa.

Some other species show similar dimensions and number of septa (*L. arctica* GORSKY, *L. tichyi* DOBROLYUBOVA and *L. corbariensis* SEMENOFF-TIAN-CHANSKY & OVTRACHT) and need further comparisons. Text-Figure 7, where the comparison is made on the basis of the tabularium diameter, shows also conspicuous differences of the Carnic specimens



Text-Fig. 6.
Comparison of the relationship number of septa/corallite diameter in some of the species described in the Central and Western Palaeotethys.



Text-Fig. 7.
Comparison of the relationship number of septa/tabularium diameter in some of the species described in the Central and Western Palaeotethys.

with *L. tichyi* Dobrolyubova and *L. corbariensis* Semenoff-Tian-Chansky & Ovtracht, which have larger tabularium diameter. Consequently, the most similar species seems to be *L. arctica* Gorsky, which shows well-developed minor septa and similar dimensions. But that species shows much thinner structures, larger development of lonsdaleoid dissepiments and more regular axial structure. Consequently, the specimens from Hochwipfel Formation can be regarded as a new species.

Discussion

The assemblage recorded in the studied block is quite diverse and can be interpreted as being developed in mounds or reefs. The occurrence of both, micropeloidal texture and skeletal components defines the environment as a cluster or segment reef (Riding, 2002). As the main skeletal components seem to be coral colonies and algae mats in growth position, it can be regarded as a cluster reef. The complete assemblage and the disposition of components indicate that the block originated in a patch reef or skeletal mound. The presence of abundant algae and cyanobacteria indicates a shallow environment in the photic zone.

Fragmentation is common in many bioclasts, indicating an environment of high energy, but most fragmentation can be interpreted as produced during the shift of the block in submarine debris flows. The presence of abundant micrite and micropeloidal texture of microbial origin indicates long periods of quiet water. If periods of high energy affected to the environment, they were not persistent, allowing the deposition of fine calcareous lime during the quiet periods. In addition, crinoidal rests show long portions of stems with articulated plates, indicating that their first sedimentation was in an environment with low water movement. On the contrary, those stems would be completely disarticulated (Text-Fig. 2: 2, upper left). The abundance of colonial rugose corals that need a hard substrate indicates that condition, but the presence of burrowers such as *Thartharella* indicates initial soft bottom, probably due to the sedimentation of micrite and the production of micropeloidal boundstone by microbial communities (Samankassou, 2001). So, the hard substrate, necessary for the attachment of the coral larvae, was probably provided by the abundance of bioclasts.

The complete assemblage shows many similarities with previously described facies in the same Formation (Flügel & Schönlaub, 1990; Amler et al., 1991; Krainer & Vachard, 2015), but also some conspicuous peculiarities. Most components have been previously recorded in the Kirchbach limestone (corals, bryozoans, brachiopods, molluscs, ostracods, echinoderm plates, cyanobacteria and algae, etc.), but the presence of syringoporoids and colonial rugose corals in growth position and dasycladaceans of the genus *Anatolipora* have been not previously recorded. The building microfacies previously described was bindstone with fenestral fabric or bafflestone of "*Pseudodonezella*", but coral-bryozoan boundstone is new in this Formation. Most limestone clasts coming from shallow water in the Kirchbach limestone have been regarded as originated in "*fully marine shelf environment of moderate to high water energy*" or in "*very shallow restricted environment*" (Krainer & Vachard, 2015: 418). The facies of the studied block does not fit with the second possibility but represents a different facies in the fully marine shelf environment.

The recorded corals, foraminifers and algae have long-range stratigraphical distribution (Cózar, pers. com.). Therefore, the age of the assemblage could be either late Viséan or Serpukhovian. The genus *Lonsdaleia* is absent in the Upper Viséan from some areas in the Western Palaeotethys such as Southwest Spain (Rodríguez et al., 2016), North Africa (Semenoff-Tian-Chansky, 1985; Said et al., 2013) and is common in the Serpukhovian from Moscow and Donets Basins (Dobrolyubova, 1958; Vassiljuk, 1960), but it has been also recorded in the Upper Viséan from Britain (Hill, 1940), Belgium (Poty, 1981), Moscow (Dobrolyubova, 1958) and Donets Basins (Vassiljuk, 1960). Therefore, a Serpukhovian age is more probable but a latest Viséan one cannot be discarded.

A peculiarity of the genus *Lonsdaleia* is, that most occurrences of this genus in the northern rim of the southern branch of Palaeotethys (Vachard et al., 2006; Somerville et al., 2013; Krainer & Vachard, 2015) are located in limestone debris or turbidite facies. That is the case in the debris of Marbella Formation at the Betic Cordillera, Spain (Herbig, 1986), in the Culm from Hautes Corbieres, France (Semenoff-Tian-Chansky & Ovtracht, 1965), in the olistoliths of the Roque Redonde and Rock de Murviel Formations at the Montaigne Noir (Poty & Hecker, 2003). They are always species having small corallites. The age of these occurrences varies from latest Viséan to Serpukhovian. Such distribution of occurrences is related with the Variscan geodynamics that in the Viséan produced a quick approach between Gondwana and Laurussia, producing the collapse of shallow platforms in Flysch basins, but also is related with the habitat occupied by the species with small corallites of that genus, that in many cases lived close to the border of those platforms, whereas most species living in shallow stable platforms such as the Moscow Basin (Dobrolyubova, 1958; Poty & Hecker, 2003) or the Tindouf Basin (Rodríguez et al., 2013) had large corallites and broad dissepimentariums.

Conclusions

1. A large boulder of reefal limestone, which we regard as has been recorded as olistolith in the Kirchbach Formation, contains corals, bryozoans and algae as main building organisms and microbial textures. Accessory components are highly diverse, including crinoids, brachiopods, molluscs, trilobites, ostracods, worms and foraminifers.
2. The main builder components are colonies of the rugose coral *Lonsdaleia carnica* sp. nov., which show small corallites, well developed minor septa, narrow lonsdaleoid dissepimentarium and conspicuous thickenings as main diagnostic features.
3. Microfacies are diverse in one single block: mostly bafflestone, bindstone, packstone and wackestone. A polymictic limestone breccia shows erosive contact on the built microfacies.
4. The fossil assemblage is composed mostly of long-range genera; consequently, no precise age is given. The most probable age is Serpukhovian, but latest Viséan cannot be discarded.
5. Since the limestone slab was transported from a shallow water platform into the Flysch basin of the Hochwipfel Formation, the time of deposition might be slightly younger. To conclude, a Serpukhovian or even an early Bashkirian age is suggested for the Kirchbach Formation interbedded in the synorogenic Hochwipfel Formation, which, according to Herbert Kabon, roughly coincides with the appearance of the floral subgenus *Mesocalamites* at the base of the Serpukhovian.

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