Subaerial exposures in the Tournaisian (Lower Carboniferous) of the central Carnic Alps (Italy)

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ABSTRACT: The documentation of a palaeodoline and the recovery of a loose block with shrinkage cracks in the Rio Sglirs area (central Carnic Alps) suggest subaerial exposure during the late Tournaisian. Both structures have been dated to the *anchoralis* conodont zone. This episode occurred well before the globally documented sequence boundary at the Tournaisian-Visean boundary. These data, combined with other evidence from different areas in the Carnic Alps suggest that the evolution of the Carnic Basin was influenced by high frequency sea-level fluctuations during the late Tournaisian.

INTRODUCTION

The Carnic Alps, located across the Italian-Austrian border, possess the best preserved Palaeozoic succession within the Alps and one of the most complete in the world. This makes the geological evolution of this area important not only for local studies but also for supra-regional reconstructions. The 'Palaeocarnic Chain' is considered as part of the Hercynian (Variscan) ancient core of the Eastern Alps in the Southalpine domain, and extends as a narrow strip for more than 100 km in a W–E direction, with a N–S width that rarely exceeds 15 km.

Rocks deposited between the Late Ordovician and Middle Triassic are exposed in the Carnic Alps. They are organized into three main sequences: the Pre-Variscan, the Permo-Carboniferous, and the Alpine sequence. The Pre-Variscan sequence includes rocks of Late Ordovician to early Late Carboniferous age (Corradini and Suttner 2015) that were affected by the Variscan orogeny during the Bashkirian–Moscovian (Venturini 1990; Schönlaub and Forke 2007; Venturini and Pondrelli 2009). The Permo-Carboniferous sequence ranges from Late Carboniferous–Early Permian. The youngest Palaeozoic rocks of the Carnic Alps represent the basal terms of the Permo-Triassic succession, that is, part of the so-called 'Alpine' sequence (Venturini 1990). Major unconformities and hiatuses separate these sequences, but minor ones are present also in the sequences. In the upper part of the Pre-Variscan sequence a distinctive facies transition occurs between the mainly carbonate units of Devonian and Early Carboniferous age and the siliciclastic rocks of the Variscan flysch (Hochwipfel Formation, latest Mississippian–Early Pennsylvanian).

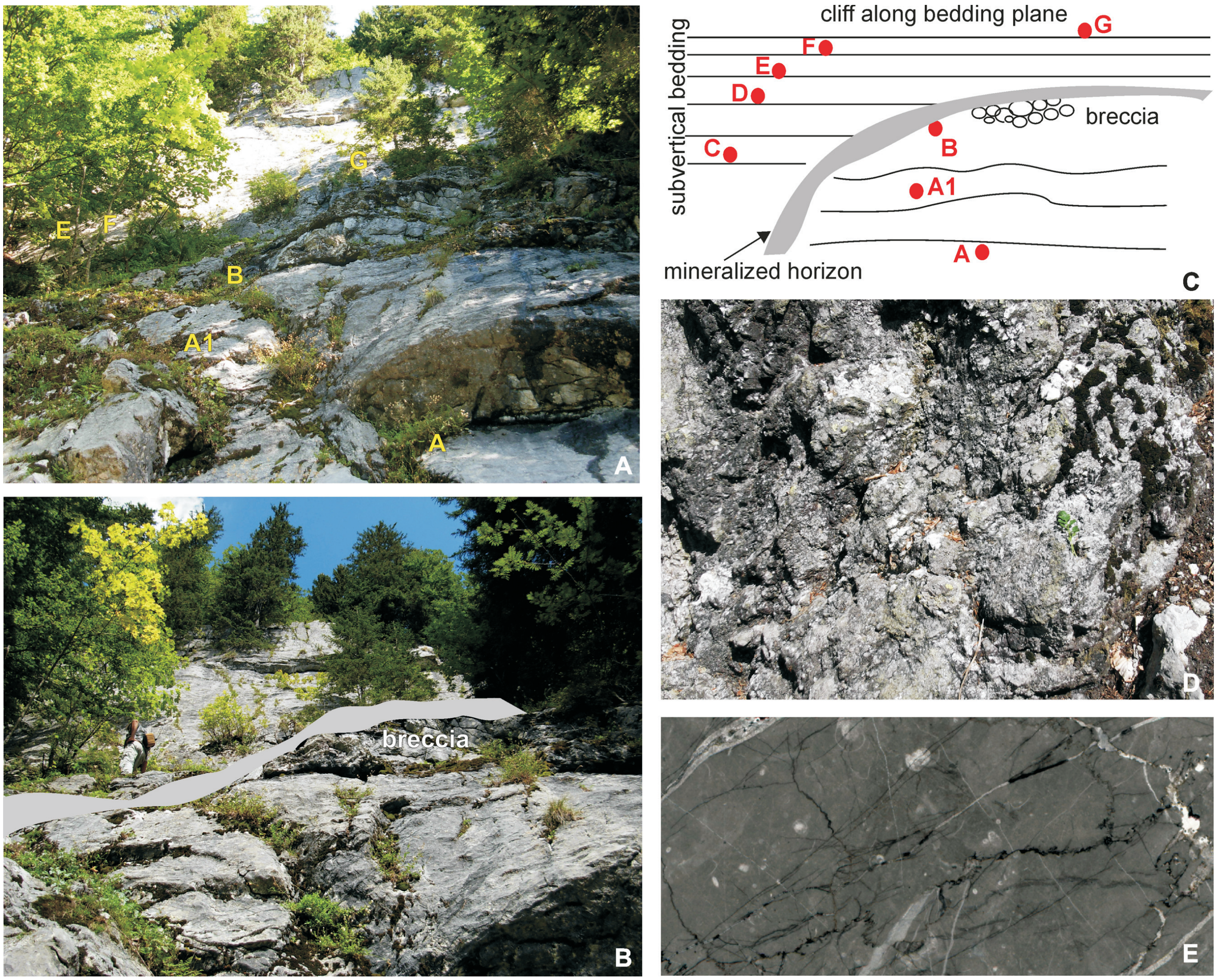
Schönlaub et al. (1991) suggested the presence of a widespread palaeokarst surface at the top of the limestones. Their proposal was based on biostratigraphic, sedimentological, and geochemical features. In the Carnic Alps, Upper Devonian and Lower Carboniferous rocks are mainly represented by the cephalopod limestones of the Pal Grande Formation (Spalletta et al. 2015a), which age has been documented in dozens of sections mainly by means of conodonts and, in some localities, also by cephalopods and other fauna (e.g., Schönlaub et al. 1992; Perri and Spalletta 1998a, b; Spalletta et al. 2015a). According to Schönlaub et al. (1991) the age of the top of the limestone varies considerably from the early Famennian–late Tournaisian. Moreover, in many places the limestones are conformably capped by a cherty horizon (Plotta Formation: Spalletta et al. 2015b). In places "this silcrete closely resembles a residual sediments and thus suggests a regolith origin while at other places it is a conodont-bearing radiolarite. The conodont data available indicate an age within the *anchoralis-latus* Zone" (Schönlaub et al. 1991, p. 93). It should be noted that this *anchoralis-latus* Zone has a different meaning than the present *anchoralis* Zone, which is now limited to the range of the index taxon. Previously its upper boundary was expanded up to the entry of *Lochriea homopunctata* (Ziegler 1960), more or less at the Tournaisian/Visean stage boundary. Beside this regolith, in some localities a breccia horizon consisting of limestone clasts, supported by an ochraceous pelitic matrix, occurs at the top of the limestones at the disconformity surface that separates the limestones from the overlying flysch deposits. The age of the clasts is constrained between the age of the topmost underlying limestone and the *anchoralis-latus* conodont Zone. The breccia was interpreted by Schönlaub et al. (1991) as a 'Dissolution Collapse Breccia'. Also, fissures and caves are present in the uppermost part of the limestones. On the basis of these

TEXT-FIGURE 1
Location map. A - Rio Sglirs Dolina section; B - loose block with mud cracks.

data, Schönlaub et al. (1991) concluded that the Carnic Alps were subjected to widespread exposure during the *anchoralis-latus* conodont Zone (upper Tournaisian), followed by sudden deepening that generated the deposition of the Hochwipfel Formation.

A different interpretation was provided by Vai (1998 and references therein), who denied the hypothesis of a Late Devonian/Early Carboniferous emergence and attributed the occurrence of sedimentary dykes and breccias to increased extensional tectonic activity in the general geodynamic context of a deepening of the Carnic Basin. According to Vai (1998), this extensional tectonic activity also generated different types of intraclast parabreccias and lithoclast deposits interpreted as olisthostromes. On the basis of conodont data, Vai (1998) concluded that the pelagic limestone sedimentation continued in the Carnic Basin at least up to the early Visean. In fact, in some parts of the Carnic Alps (Mt. Coglians and Mt. Cavallo areas) limestones of the *texanus-homopunctatus* Zone have been documented in continuity with those of the *anchoralis* Zone without any evidence of exposure or variation of facies (Perri and Spalletta 1998b).

Spalletta and Venturini (1995), trying to explain the presence within the Lower Carboniferous sequence of quite contemporary evidences of both deepening and exposure, proposed a possible consistent geodynamic scenario for the Late Devonian–Early Carboniferous tectonic evolution of the Carnic Basin as result of a transtensional-transpressional regime. In this scenario the Carnic Basin was fragmented into fault-bounded blocks. Parts of these blocks were locally uplifted to subaerial exposure, whereas other blocks underwent rapid deepening and the carbonatic pelagic sedimentation persisted to the deposition of radiolarian chert below the CCD (Spalletta and Venturini 1988; Venturini and Spalletta 1998). Fractured zones, fissures and cavities within the Upper Devonian–Lower Carboniferous limestones were infilled with mineralized clastic sediments or siliceous crusts. The origin of the mineralization was explained



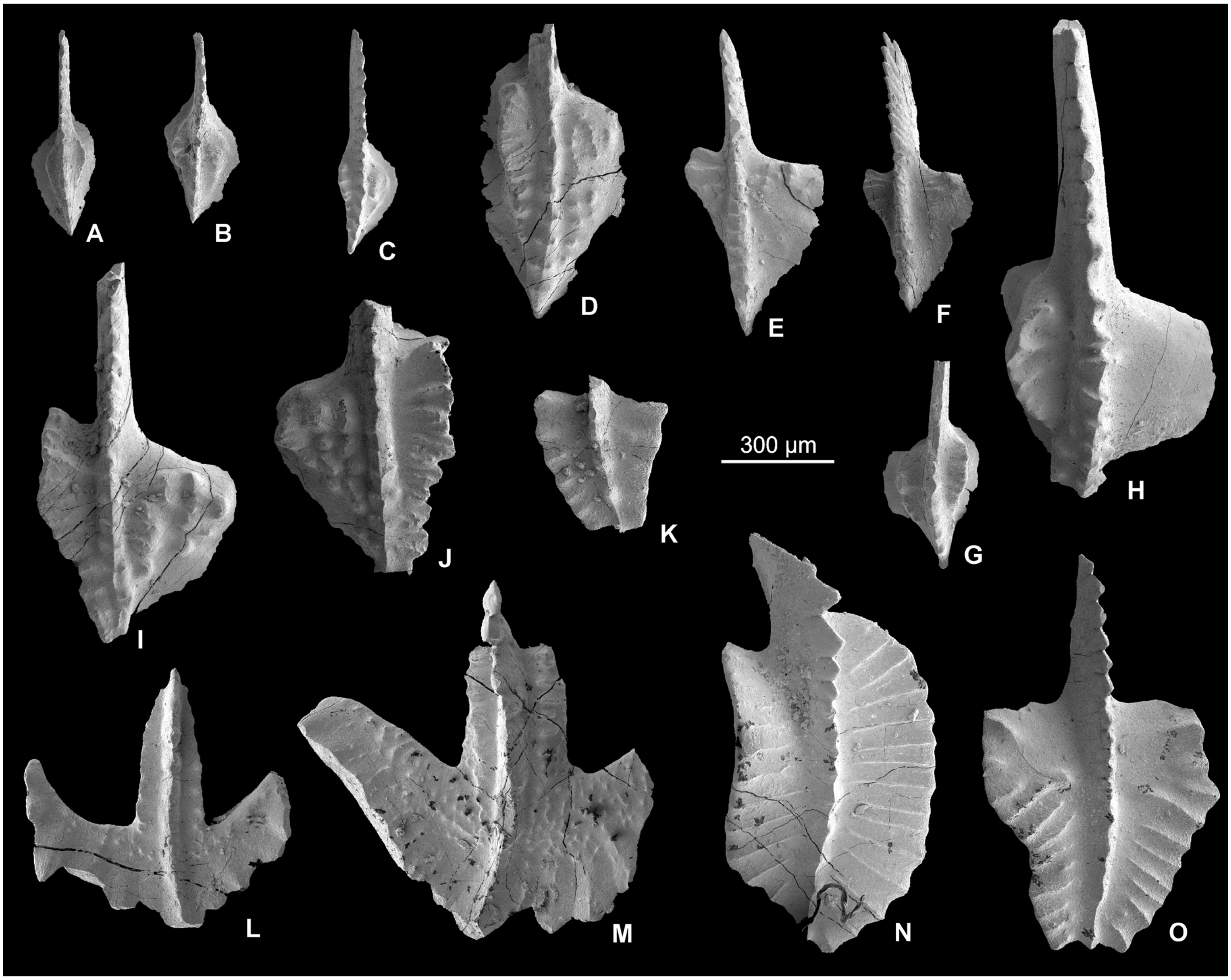
TEXT-FIGURE 2
The Rio Sglirs Dolina section. A - Panoramic view and location with position of the conodont samples indicated by yellow letters. B - Closer panoramic view with better evidence of the mineralized horizon (grey) and the position of the breccia in the internal part of the doline. C - Sketched birds-eye map, not to scale, of the outcrop. Letters indicate the location of the conodont samples. D - Close-up view of the mineralized horizon. E - Thin section of sample RSD A1; scale bar = 500 µm.

as the results of pedogenic processes during exposure (Venerandi-Pirri 1978; Hentschel and Kern 1992), or as connected with volcanic activity (Spalletta, Vai and Venturini 1982). An intermediate interpretation that integrates the two hypotheses was proposed by Brigo et al. (1986, 1988).

In this paper we present the evidence that subaerial exposure occurred in the upper Tournaisian in the Rio Sglirs area (central Carnic Alps): a palaeodoline and a loose block with evident shrinkage cracks. Both the structures are dated to the *anchoralis* conodont Zone. The episodes of exposure are followed by the resumption of limestone deposition.

GEOLOGICAL SETTING

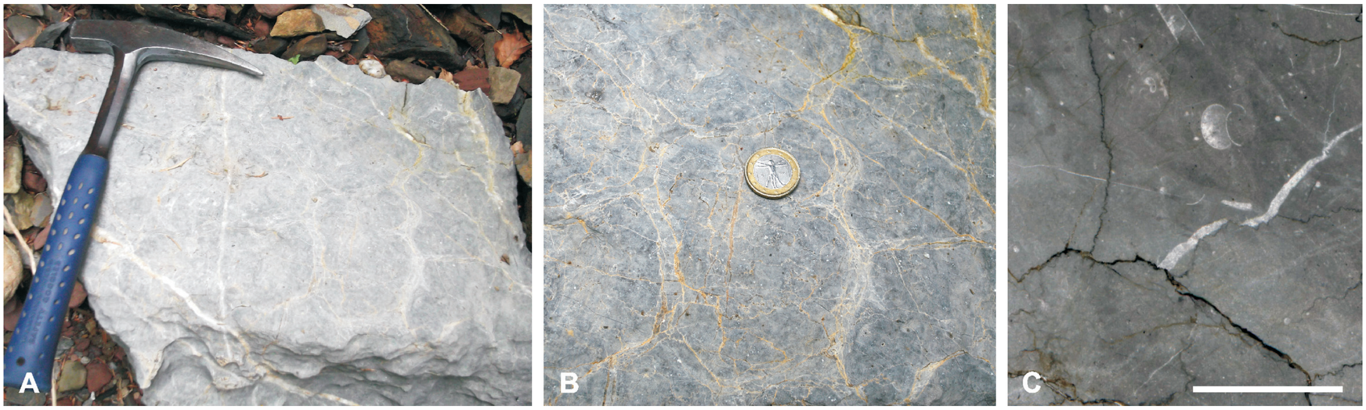
The studied area is located in the central part of the Italian side of the Carnic Alps, south-southwest of Casera Valbertad Alta (text-fig. 1), about 4 km west of Cason di Lanza Pass. In the Cason di Lanza area rocks from the Upper Ordovician–Upper Permian are exposed (Corradini et al. 2012 and references therein), but the units of the Pre-Variscan sequence are largely more common and better exposed. The Pre-Variscan sequence is laterally uniform in lithofacies across the Cason di Lanza Pass area with the exception of the Eifelian–Frasnian interval, when the basin was differentiated into a shallow water part, with the deposition of back reef and reef deposits, and a distal part, with pelagic deposits interlayered by gravity driven redeposited material coming from the shallow water units (Pondrelli et al. 2015). In this area the Variscan orogeny generated a top-to-the-south detachment, leading to the formation of a pluri-kilometric asymmetric NW–SE trending fold with an overturned flank that includes the Zermula and Pizzul mountains and the Rio Malinfier-Rio Sglirs area (Venturini 1990). For a complete discussion of the ge-



TEXT-FIGURE 3
Upper views of conodonts (all P_1 elements) from RSD section and from the Mud-crack block. A - *Gnathodus typicus* Cooper 1939 (Sample RSD B), MDLCA 30264. B - *Gnathodus typicus* Cooper 1939 (Sample RSD C), MDLCA 30265. C - *Gnathodus cuneiformis* Mehl and Thomas 1947 (Sample RSD C), MDLCA 30266. D - *Gnathodus cuneiformis* Mehl and Thomas 1947 (Sample RSD B), MDLCA 30267. E - *Gnathodus pseudosemiglaber* Thompson and Fellows 1970 (Sample Mud crack), MDLCA 30268. F - *Gnathodus pseudosemiglaber* Thompson and Fellows 1970 (Sample Mud crack), MDLCA 30269. G - *Gnathodus semiglaber* Bischoff 1957 (Sample RSD C), MDLCA 30270. H - *Gnathodus semiglaber* Bischoff 1957 (Sample RSD C), MDLCA 30271. I - *Gnathodus delicatus* Branson and Mehl 1938 (Sample RSD A1), MDLCA 30272. J - *Gnathodus delicatus* Branson and Mehl 1938 (Sample RSD A1), MDLCA 30272. K - *Pseudopolygnathus triangulus* Voges 1959 (Sample RSD A), MDLCA 30274. L - *Scaliognathus anchoralis europensis* Lane and Ziegler 1983 (Sample RSD A1), MDLCA 30275. M - *Scaliognathus anchoralis anchoralis* Branson and Mehl 1941 (Sample RSD A1), MDLCA 30276. N - *Polygnathus bischoffi* Rhodes, Austin and Druce 1969 (Sample RSD A1), MDLCA 30277. O - *Pseudopolygnathus pinnatus* Voges 1959 (Sample RSD A1), MDLCA 30277.

ology and stratigraphy of the areas around Cason di Lanza Pass refer to Corradini et al. (2012, 2016a) and Pondrelli et al. (2015).

In the Rio Malinfier-Rio Sglirs area an overturned Ordovician–Lower Carboniferous sequence crops out just north of the important fault known as 'Cason di Lanza line' (Venturini 1990). Despite the severe tectonics that generated several repetitions of sections, the stratigraphic succession is fairly continuous. Various units of the Pre-Variscan sequence crop out, with the Devonian units being better exposed than others (Corriga 2011; Corradini et al. 2012; Corriga et al. 2012). The rocks studied in this work represent the upper part of that sequence and belongs to the Pal Grande Formation. This unit consists mainly of grey to reddish fossiliferous lime mudstones and wackestones of Frasnian–early Visean age. The red color occurs at some places in the lower and middle part of the formation (Mossoni, Corradini and Pondrelli 2013; Pondrelli et al. 2015), whereas the upper part is grey. The original bedding is often concealed by pressure solution and/or burrowing, giving the limestone a characteristic pseudo-nodular look. The fauna is characterized by clymeniids and conodonts, but bivalves, ostracods, radiolaria, brachiopods, trilobites, and crinoids are also observed in thin sections (Pondrelli et al. 2015).



TEXT-FIGURE 4
The Mud-cracks block. A - General view. B - Detail of the upper surface. C - Microfacies, thin section of the conodont sample, collected in the lower part of the block; scale bar = 500 µm.

NOTES ON UPPER TOURNAISIAN CONODONT BIOSTRATIGRAPHY

Compared with the lower and middle Tournaisian conodont zonations (Lane, Sandberg and Ziegler 1980; Sandberg et al. 1982) that are still in use with only some modifications in the lower part (Kaiser et al. 2009; Corradini et al. 2016b), the upper Tournaisian scheme is less stable, and a standard, global zonation still does not exist. For a long time the *anchoralis-latus* Zone was considered as the youngest Tournaisian zone, followed around the base of the Visean by a *texanus* Zone or a *homopunctatus* Zone depending on the geographic area (e.g., Groessens 1974; Lane, Sandberg and Ziegler 1980; Higgins and Austin 1985; Ziegler and Lane 1987; Perret and Delvolve 1994). In the Carnic Alps, Schönlaub et al. (1991) used the old concept of the *anchoralis-latus* Zone, extended to all the upper Tournaisian, and Perri and Spalletta (1998b) proposed for the base of the Visean a *texanus-homopunctatus* Zone immediately following the *anchoralis-latus* Zone. In their sections at the Tournaisian/Visean boundary Perri and Spalletta (1998b) recognized a stratigraphic interval characterized by "a monotonous, long ranging gnathodid fauna" between the last appearance of the scaliognathids and the first appearance of *Lochriea homopunctata*.

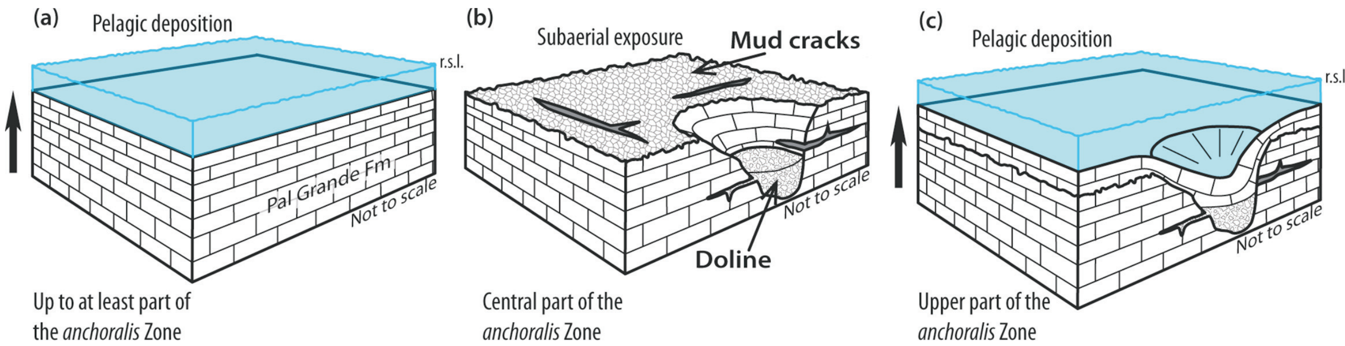
After the redefinition of the base of the Visean to correspond to the first occurrence of the foraminifer *Eoparastaffella simplex* (Vdovenko 1954) (Devuyst et al. 2003), ratified in 2008 by the ICS (International Commission on Stratigraphy), the conodont zonation had to be refined. The event that better approximates the Tournaisian/Visean boundary is the first occurrence of *L. homopunctata*, which enters slightly above the boundary, whereas representatives of *Scaliognathus anchoralis* Branson and Mehl 1941 became extinct well below the boundary. The interval between the LAD (last appearance datum) of *Sc. anchoralis* and the FAD (first appearance datum) of *L. homopunctata* has been named differently by various authors (e.g., Devuyst et al. 2003; Devuyst and Kalvoda 2007; Babek et al. 2010) and is characterized by the presence of several long-ranging species of *Gnathodus*. In this paper we follow the scheme suggested by Devuyst and Kalvoda (2007), with the *anchoralis* Zone in the upper Tournaisian and a *Gnathodus* interregnum across the Tournaisian/Visean boundary.

THE 'RIO SGLIRS DOLINA' SECTION

The RSD ('Rio Sglirs Dolina') section is located southwest of Casera Valbertad Alta and a few tens of meters west of Rio Sglirs, at coordinates 46°34'47.5" N, 13°08'20.8" E, at an altitude of 1440 m. It was measured just below a steep vertical wall of limestone belonging to the Pal Grande Formation, where a conspicuous mineralized horizon ≤50 cm thick is present. The limestone consists of thin- to medium-bedded lime mudstone to wackestone deposited in an open marine setting. The mineralization follows approximately a curved line and cuts diagonally across the stratification with a variable angle and becomes almost parallel to the bedding close to the cliff (text-fig. 2). The bedding is subvertical and regular on the outside of the mineralization, whereas it is irregular in the inner part. The bedding is more chaotic in the deeper internal part, where some breccia has also accumulated, then becomes progressively more regular (text-fig. 2D). The breccia consists of centimeter–decimeter, large, moderately angular clasts that are poorly sorted and clast supported, with little to no evidence of transport. The structure is ~20-m wide and 10-m deep. The mineralization consists of an original deposition of sulfates and sulfides in silicified hardpans. The alteration of Cu-sulfides (tetrahedrite) gave rise to secondary Cu-carbonates such as azurite and malachite. Sphalerite occurs disseminated and more rarely forms monomineralic masses ≤30 cm in diameter. Barite is common, whereas fluorite is rather rare. We interpret this area as a palaeodoline, which developed in the limestones during an episode of subaerial exposure, and was partly filled with breccia and other material collapsed from the sides, before marine conditions were restored. Eight conodont samples were collected from the RSD section: five in the undisturbed part of the section, outside of the palaeodoline, and three in the internal part. Beside conodonts, rare foraminifera and a fragment of a fish tooth have been recovered.

Conodont data and biostratigraphy

Eight samples, weighting 1.0–3.3 kg each, were collected from the RDS section, for a total amount of ~19 kg of limestone. The samples were dissolved with a conventional formic acid technique. Of the five samples collected outside of the doline four were barren, and only sample RSD C, picked in the youngest bed, was productive, as well as the three samples picked in the filling of the doline (RSD A, RSD A1, and RSD B). About 450 conodont elements were isolated (table 1). The state of preservation is



TEXT-FIGURE 5
Outline of geological evolution of the area. A - Pelagic deposition of the mudstone/wackestone deposits of the Pal Grande Formation reached at least part of the *anchoralis* Zone. B - Subaerial exposure affected the study area during the central part of the *anchoralis* Zone as shown by the presence of the doline and the mud cracks. C - Pelagic deposition of the mudstone/wackestone deposits of the Pal Grande Formation resumed in the upper part of the *anchoralis* Zone.

quite poor, because many specimens are broken or incomplete. About one-third of the association cannot be identified to species level. Approximatively 25% of the association is represented by ramiform elements, often incomplete. Conodont element color is dark brown (Color Alteration Index = 4). The conodont collection is housed in the MDLCA (Museum of Palaeontology 'Domenico Lovisato' of Cagliari University); catalog numbers of illustrated elements (text-fig. 3) are given in the figure caption.

Ten taxa (species and subspecies) belonging to five genera (*Bispathodus*, *Gnathodus*, *Polygnathus*, *Pseudopolygnathus*, and *Scaliognathus*) have been recognized. The association of *Gn. cuneiformis* Mehl and Thomas 1947, *Gn. pseudosemiglaber* Thompson and Fellows 1970, *Gn. semiglaber* Bischoff 1957, and *Gn. typicus* Cooper 1939 represents the majority of the fauna. All the productive samples can be dated to the central and upper part of the *anchoralis* Zone by the occurrence of *Gn. pseudosemiglaber* and/or the index taxa *Scaliognathus anchoralis anchoralis* Branson and Mehl 1941 and *Sc. a. europensis* Lane and Ziegler 1983. According to Lane, Sandberg and Ziegler (1980) *Gn. pseudosemiglaber* enters within the zone. Samples RSD A1 and RSD A likely are slightly younger and come from the uppermost part of the zone, because of the occurrence of *Polygnathus bischoffi* Rhodes, Austin and Druce 1969, which enters in the upper part of the zone, above the first occurrence of *Gn. pseudosemiglaber* (Lane, Sandberg and Ziegler 1980).

THE MUD-CRACKS BLOCK

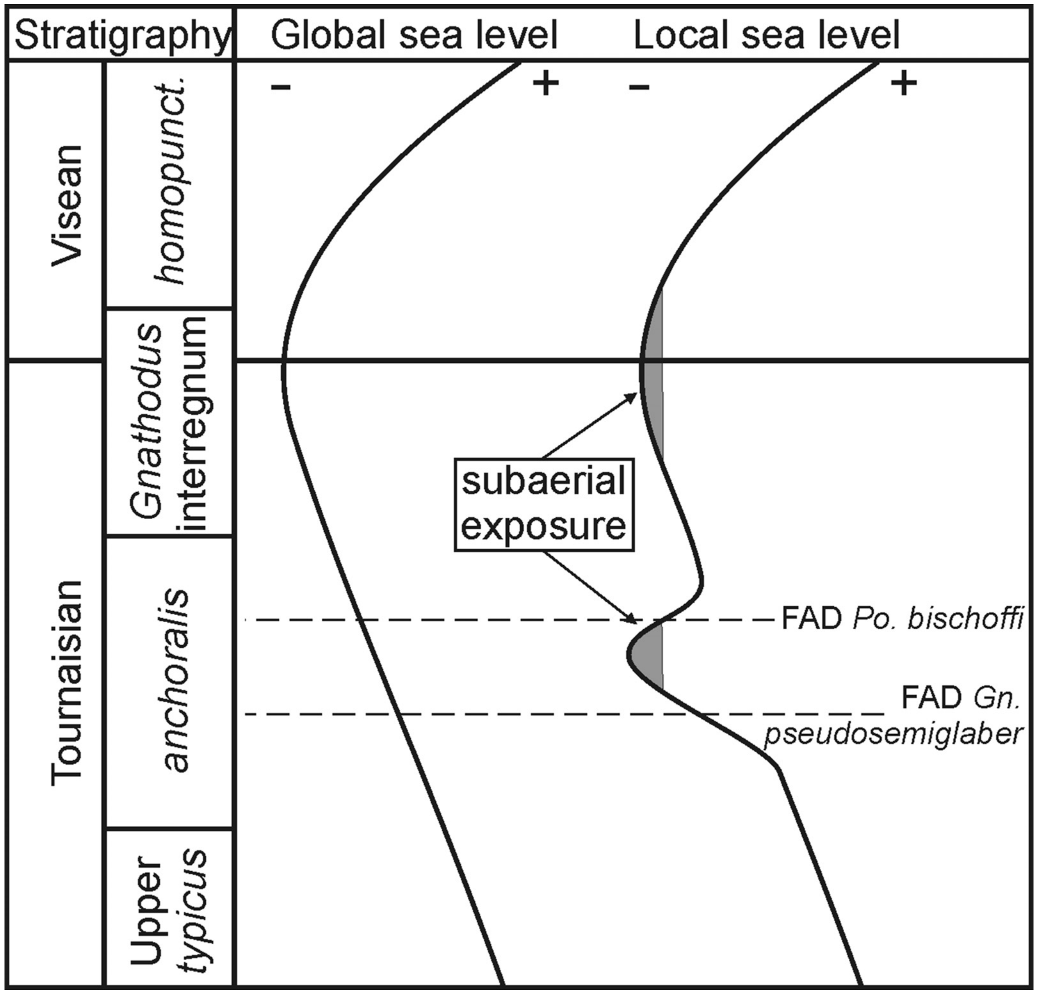
The loose block with polygonal cracks (text-fig. 4) was found in the upper part of Rio Sglirs, at about 1450 m height, at coordinates 46°34'46.6" N, 13°08'26.4" E. The block has a surface of ~50 × 30 cm, is covered by cracks on the upper side, and is ~25-cm thick. The microfacies is a lime mudstone/ wackestone with a few remnants of cephalopods, consistent with the Pal Grande Formation. The cracks are ~10-cm long in plain view and propagate in depth for a couple of centimeters showing a V-shape in cross section. Although the block is too small to allow a complete description, the crack shape appears to be fairly hexagonal. Almost 600 gr of rock, collected from the lower part of the block, have been processed for conodonts (table 1). Most of the recovered conodonts are broken, but a few specimens of *Gn. pseudosemiglaber* suggest at least a late Tournaisian age (from within the *anchoralis* to the *bilineatus* zones).

DISCUSSION AND CONCLUSION

We interpret the association of morphologies, facies, and structures of the Rio Sglirs as suggestive of an episode of subaerial exposure which occurred during the late Tournaisian. The lower part of the limestone succession defines a roughly round depression infilled with breccia and mineralization. We documented a hiatus between the deposits below and above this surface. The breccia possesses textural characteristics consistent with a very limited transport or almost in-situ reworking. The mineralized horizon was placed along the discontinuity surface between the bedrock and the filling of the doline, and in the field the presence of the karstic structure is evident. It is possible to hypothesize a synsedimentary origin of the polymetallic mineralization, which filled paleokarst morphologies through both chemical precipitation and mechanical deposition. Moreover, mineralization has been altered by recrystallization and remobilization. Further analyses, such as rare earth element analysis, will be necessary to identify the origin of the mineralized horizon.

Shrinkage cracks can be generated by desiccation of a wet mud surface in a subaerial environment at a sediment-water interface, or substratally by synaeresis processes. Local dissolution generated by tectonic pressure can be considered, too. Unambiguous interpretation in absence of other associated sedimentary structures is impossible, particularly in such a small block as the one we found. Synaeresis cracks tend preferentially, although not exclusively, to show a spindle to sinuous shape, but polygonal shapes can be rarely developed (Plummer and Gostin 1981), and it is unlikely for tectonic pressure to produce regular geometrical forms. Even if the hexagonal shape of the Rio Sglirs shrinkage cracks appears to be more consistent with desiccation cracks, a certain genesis for these structures cannot be constrained. The Pal Grande Formation is very well described across the whole Carnic Alps (Spalletta et al. 2015a and references therein), but the presence of synaeresis cracks has never been reported.

Several of the features described here, taken singularly, do not allow a straightforward interpretation of the formative event. Still, the association between the morphologies, structures,



TEXT-FIGURE 6
Tentative reconstruction of the sea-level variations in the Rio Sglirs area, plotted against the simplified global curve.

mineralogies, and textures is consistent with a genesis connected with an exposure event, followed by a later mineralization, as demonstrated by Brigo et al. (1988, 2001) and Brigo and Venerandi Pirri (2008) in other areas of the Carnic Alps and by various authors elsewhere (e.g., Mississippi Valley type deposits; Plumlee et al. 1994).

We are able to date this event in the correspondence of both the paleodoline and the shrinkage cracks, and this age is consistent with the *anchoralis* conodont zone (late Tournaisian). In fact, the age of the shrinkage cracks of the Mud-cracks block is the same as the age of the limestones in which the doline was formed. A slightly younger age (upper part of the *anchoralis* Zone) can be inferred for the external part of the filling of the doline (sample RSD A1 and above). Therefore, we can constrain the timing of the subaerial exposure to a short interval within the central part of the *anchoralis* Zone, after the first occurrence of *Gnathodus pseudosemiglaber* and before the first occurrence of *Polygnathus bischoffi*. After this exposure episode, the marine sedimentation of limestone restarted well before the deposition of the siliciclastic Hochwipfel Formation. (text-figs. 5, 6).

During the late Tournaisian a prominent global regression took place, followed by a sharp transgression during the early Visean. The sequence boundary occurred above the last occurrence of *Scaliognathus. anchoralis anchoralis* (Babek et al. 2010) and is more or less coincident with the stage boundary. In several regions where the Tournaisian sequences are mainly represented by shallow-water sediments, evidence of subaerial exposure has been documented as karst surfaces in China (Hance et al. 1997), as karst and variation of facies in northern continental Europe and the British Isles (Hance, Poty and Devuyst 2001; Babek et al. 2010), and as deposition of evaporites in North America (Petty 2010).

In the Carnic Alps the Tournaisian depositional setting was an open sea, where pelagic, but not deep-water, limestones accumulated. The area was quite far from any land and, therefore, the global regression did not result in facies changes. The hiatus documented in our study is older than the aforementioned global regression. The karstic features of the Rio Sglirs area suggest a short-term exposure within the central part of the *anchoralis* Zone, followed by deepening within the upper part of the zone, when the carbonate deposition restarted. Even if a more detailed analysis, including an evaluation of the hierarchies and scales at both a local and regional level, is necessary to understand the controls on the exposure event, local, tectonically-controlled crustal uplift appears to represent the primary cause.

The Pal Grande Formation ranges in age from Frasnian–Visean. Still, Carboniferous deposits are not very widespread and limited to selected areas, often disconformably overlying reefal rocks (i.e., Schönlaub and Kreutzer 1993 and unpublished data). Also, a complete section of the Carboniferous part of the unit is not known (Perri and Spalletta 1998a), and the sequence has been reconstructed combining findings in different parts of the area. In addition it should be noted that a few conodont zones have been documented only in the deeper parts of the basin (e.g., Kronhofgraben; Schönlaub et al. 1992; Plan di Zermula, Perri and Spalletta 2001; Kaiser et al. 2009), whereas in more proximal areas some zones are locally missing (e.g., Lower *crenulata* Zone; Perri and Spalletta 1998a).

A possible emergence during the latest Tournaisian or at the Tournaisian/Visean boundary is documented a few km southwest of the study area at Mt. Pizzul (Pondrelli et al. 2015) and represents a different subaerial exposure that the one documented here in connection with the global low stand (text-fig. 6). This fact can be tentatively explained by a series of high frequency eustatic cycles during the Tournaisian and/or by local tectonic events, which produced subaerial exposure of at least parts of the area, preceding the possible more widespread emergence at the Tournaisian/Visean boundary, connected with the global lowstand. In the Rio Sglirs area one of these sea-level fluctuations produced the local exposure that we document within the *anchoralis* Zone (text-fig. 6). After this exposure event, widespread deposition of limestones is well documented in the lower Visean of the Carnic Alps as in the upper part of the Pal Grande Formation (Spalletta et al. 2015a).

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TABLE 1
Distribution of conodonts in the Rio Sglirs Dolina section and in the Mud-cracks block.

	Rio Sglirs Dolina (RSD)								Mud crack	TOT.
	G	F	E	D	C	B	A1	A		
Bispathodus stabilis					6	15	3	1	1	26
Gnathodus cuneiformis					25	19	12	5		61
Gnathodus pseudosemiglaber					17	9	11	5	3	45
Gnathodus semiglaber					16	2	11	1		30
Gnathodus typicus					20	10	5	1		36
Polygnathus bischoffi							2			2
Pseudopolygnathus pinnatus							1			1
Pseudopolygnathus triangulus					1	2				3
Scaliognathus anchoralis anchoralis						2	3			5
Scaliognathus anchoralis europensis						4	7	4		15
Ramiforms					36	36	38		13	123
Gnathodus sp.					27		26	7	4	64
Pseudopolygnathus sp.						8				8
Scaliognathus sp.								2		2
Unidentified					15		23	13	10	61
TOTAL	0	0	0	0	163	107	142	39	31	482
Weight	2,4	1,0	2,3	2,4	3,3	2,4	2,3	1,7	0,6	18,4
Abundance (elements/Kg)	0,0	0,0	0,0	0,0	49,4	44,6	60,7	22,9	51,7	26,1

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