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Drowning of microbial mounds on the slopes of the Latemar platform (middle Triassic)

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ABSTRACT

Two microbial mound-shaped carbonate bodies buried below the slope deposits of the middle Triassic Latemar platform (Dolomites, Italy) have been studied. The two sedimentary bodies, after having reached different stages of evolution, drowned and were covered by the slopes of the Latemar carbonate platform. The estimation of the depth and time at which they were located when they were buried made it possible to infer the average rates of relative sea-level rise to which they were subjected, revealing that these latter exceeded the growth rate of the main Latemar buildup. Given the estimated rates of sea-level rise, the two satellite bodies reached a critical depth at which microbial carbonate production stops, or it is significantly reduced, before being buried. As extensional tectonics was active in the area of the Dolomites during the Anisian, subsidence is the more likely cause of sea level rise. It is therefore hypothesized that the cause of the ultimate drowning of the “mounds” were subsidence rates exceeding their aggradation potential and inducing a progressive deepening that brought them below the lower depth threshold of microbial carbonate production.

KEY WORDS: *carbonate platforms, drowning, microbialites, Dolomites, Middle Triassic*

INTRODUCTION

In the geologic record, multiple examples of carbonate platform drowning are found (e.g., SCHLAGER, 1981; KENDALL & SCHLAGER, 1981). To be drowned, a platform must have stopped growing or subsidence must have exceeded its aggradation rate (*geological drowning* of MARINO & SANTANTONIO, 2010). Some notable examples are found in the Triassic and Early Jurassic of the Alps (e.g., COBIANCHI & PICOTTI, 2001; BRACK *et alii*, 2007), in the Early Jurassic of the Apennines and Sicily (e.g., BICE & STEWART, 1991; PASSERI & VENTURI, 2005; MARINO & SANTANTONIO, 2010) and MOROCCO (MERINO-TOMÉ *et alii*, 2012), in the Paleozoic of Poland (e.g., SZULCZEWSKI *et alii*, 1996), in the Cretaceous of the Gulf of Mexico (e.g., SCHLAGER, 1989), in the Holocene of Papua New Guinea (e.g., WEBSTER *et alii*, 2004). However, the growth potential of platforms usually exceeds the rate of sea-level rise that can be

induced by long-term geologic processes (SCHLAGER, 1981). It was pointed out that a platform can drown in one of the following circumstances: anomalously rapid eustatic sea-level change; anomalously fast subsidence induced by local tectonics (e.g., SCHLAGER, 1981; 1989; MUTTI *et alii*, 1997; WEISSERT *et alii*, 1998; MARINO & SANTANTONIO, 2010); or when deterioration of the environment severely hampers carbonate production (e.g., HALLOCK & SCHLAGER, 1986; SCHLAGER, 2003; WOODFINE *et alii*, 2008). Carbonate production potential varies with depth and different types of carbonate factories display different carbonate production/depth profiles (POMAR, 2001; SCHLAGER, 2003; 2005), and this can directly influence the vulnerability to drowning of a carbonate platform. Carbonate production rates of carbonate factories dominated by autotrophic organisms can be very high, but is strongly light-dependent, and therefore it tends to fade out very rapidly with depth. This type of platforms is therefore more vulnerable to drowning. If growth rate is no more able to match subsidence, a platform can rapidly sink below the photic zone. At this point, photozoan carbonate producers are not able to precipitate any more, the carbonate factory comes to a complete stop and drowns (e.g., KENDALL & SCHLAGER, 1981; BOSSCHER & SCHLAGER, 1993; SCHLAGER, 1994; MONTAGGIONI & BRAITHWAITE, 2009).

In microbial platforms, instead, carbonate production is related to the activity of microbial communities and is not strictly related to photosynthesis, as other non-light-dependent processes, e.g., sulphate reduction and organomineralization associated with EPS, come into play (DUPRAZ *et alii*, 2009 and references therein). Consequently, high production rates can be achieved at considerable depth and the availability of light is not a limiting factor. Having a wider production depth range, this type of platforms, which had a major role in carbonate precipitation until the Mesozoic (e.g., SCHLAGER, 2003; RIDING, 2000; KIESSLING *et alii*, 2003; POMAR & HALLOCK, 2007), should be less prone to drowning. Nevertheless, numerous examples of drowned microbial carbonate platform are found, and prominent examples are the Middle Triassic Cernerera and Clapsavon platforms in the Southern Alps of Italy (e.g., CROS & VRIELYNCK, 1986; DE ZANCHE *et alii*, 1995; BLENDINGER *et alii*, 2004; BRACK *et alii*, 2007).

The Latemar (latest Anisian) is a small isolated carbonate platform, which grew in the Dolomites at the same time of the Cernerera and Clapsavon but did not drown. In this contribution, we discuss the evidence of “aborted” microbial mounds adjacent to Latemar. At Latemar, there

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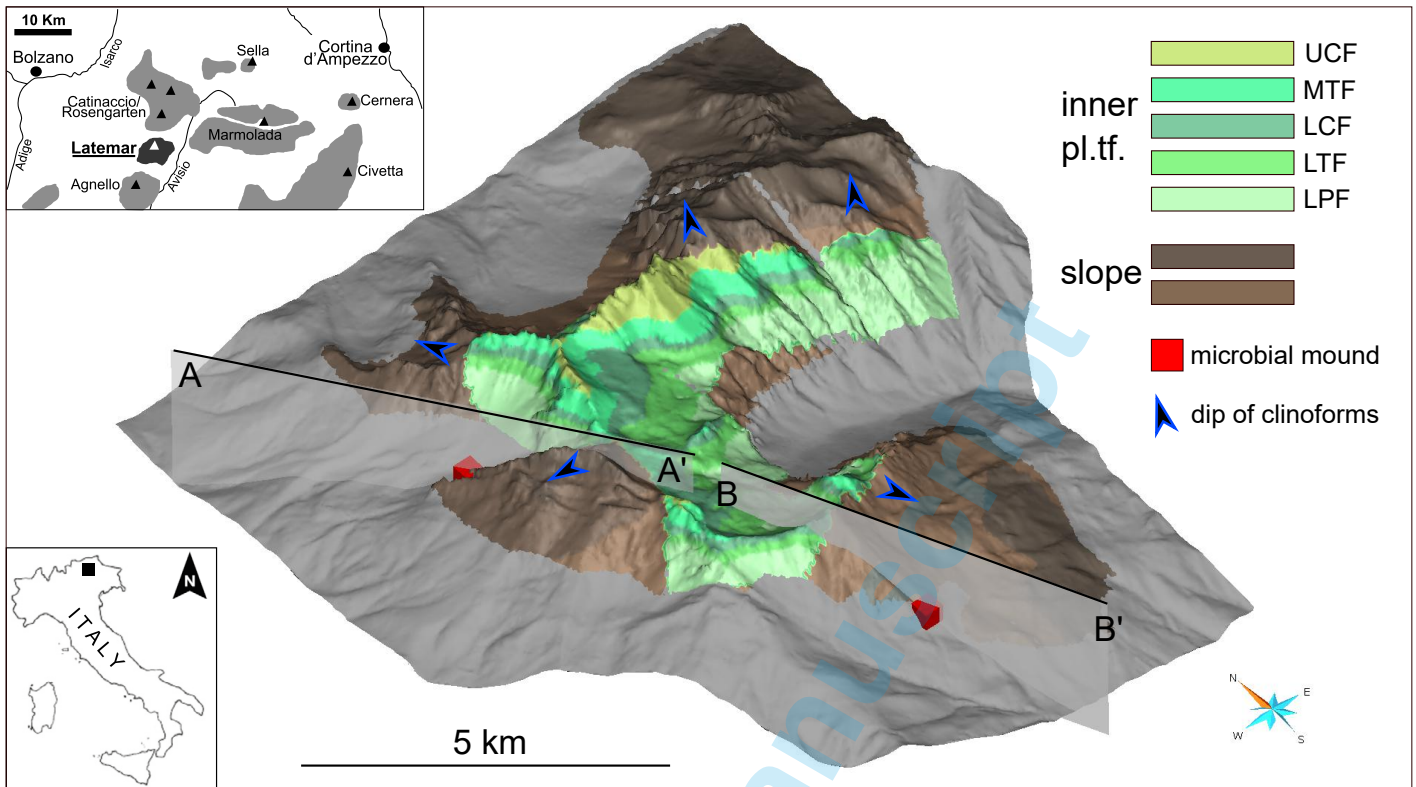


Fig. 1 - Position of the Latemar platform in the Southern Alps of Italy. Simplified geological map with the main units of the platform is draped on a 3D DTM. Arrows mark the prevalent dip direction of the clinoforms. Red cubes mark the position of the two microbial mounds analyzed in this work. A-A' and B-B' are traces of geologic cross-sections displayed in Fig. 4.

is evidence that in the first stages of carbonate platform evolution, multiple microbial mounds started growing on the faulted top of a previous carbonate platform, the Contrin Formation (MASETTI & NERI, 1980; PRETO *et alii*, 2011). Eventually, the central main platform nucleus became dominant and its advancing slope deposits buried nearby satellite mounds. In this contribution, we focus on two of these mounds examining their geometric relationships with the main platform to investigate their evolution, seeking for clues about the causes that led to their demise.

GEOLOGICAL SETTING

The Latemar is late Anisian (Middle Triassic) and located in the Southern Alps of Italy (Fig. 1A). Detailed mapping carried out on the platform made it possible to understand its stratigraphic architecture and characterize facies distribution (MARANGON *et alii* 2011; GRAMIGNA *et alii* 2013; FRANCESCHI *et alii* 2016). The abundant ammonoid faunas allow referring the platform to an interval comprised between the *reitzei* and *secedensis* ammonoid biochronozones (DE ZANCHE *et alii*, 1993; MANFRIN *et alii*, 2005; BRACK & RIEBER, 2019). After being for years the object of a controversy regarding the extent of the time represented by its deposits, recent studies have converged on an interpretation that brackets the time encompassed by the Latemar in an interval of approximately 1 Myr (KENT *et alii*, 2004; BRACK *et alii*, 2007; SPAHN *et alii*, 2013; WOTZLAV *et alii*, 2018).

The platform grew on a rugged submarine morphology made of a series of faulted blocks of the late Anisian (upper Illyrian) Contrin Formation, a carbonate platform with abundant dasycladacean algae, often recognizable in the Dolomites area as a ribbon of dolostone with a thickness ranging from 80 to 150 meters (e.g., MASETTI & NERI, 1980). A pervasive network of faults that date to the middle Triassic and to the Neogene cut the Latemar (BIGI *et alii*, 2015). Triassic tectonics that dissected the Contrin Formation can be mainly referred to the latest Anisian by considering the geometric and crosscutting relationships of the faults with the platform units (PRETO *et alii*, 2011). The submarine morphology on which the platform grew preexisted the nucleation of the buildup, which occurred sometimes later during the late Anisian (*reitzei* ammonoid biochronozone) (PRETO *et alii*, 2011). However, synsedimentary tectonics at Latemar continued also during the platform growth, as testified by the rectilinear trend of the margins that were fault-controlled, by the presence of synsedimentary dykes and by the wedge shape of the inner platform units (PRETO *et alii*; 2011).

Facies analysis has revealed that the carbonate at Latemar is mainly microbial or constituted by early marine cements (HARRIS, 1994; MARANGON *et alii*, 2011), therefore the platform is classified as a microbial platform (or microbial mud mound *sensu* BOSENCE & BRIDGES, 1995) and the principal carbonate factory responsible of the precipitation was an M-factory. The estimation of the amount of marine carbonate precipitated at Latemar in approximately 500 kyr has revealed that the precipitation rate on the platform was three times higher than the average precipitation rates

found in modern tropical carbonate platforms (FRANCESCHI *et alii*, 2016), in agreement with models that predict a saturation state with respect to carbonate of Triassic ocean waters higher than today (RIDGWELL, 2005).

The Latemar can be described as an isolated carbonate platform having slope deposits radially dipping in all directions from a horseshoe-shaped inner platform (Fig. 1B). The inner platform is bounded by vertical margins which testify for a phase of strong aggradation (HARRIS, 1994; PRETO *et alii*, 2011). The areal extent of the slope deposits, which spread up to 2 km afar from the position of the margins, suggests that the aggradational phase was followed by a strong progradational phase, in analogy to what is observed in other Triassic carbonate platforms in the area (e.g., BOSELLINI & STEFANI, 1991; MAURER, 2000; STEFANI *et alii*, 2010; PRETO *et alii*, 2017).

MATERIALS AND METHODS

Two mound-shaped high-relief satellite carbonate bodies, now buried beneath the slope deposits, were identified in external position with respect to the inner platform of the Latemar and were characterized through direct and indirect investigation. One of the two is located on the southern slopes of the platform (Fig. 1 and 2) and is accessible, therefore it was possible to collect samples and observe facies in thin section. In the case of the carbonate body on the northwestern slopes of the platform, instead, direct sampling was not possible, and line drawing on high-resolution photographs was used to determine its shape and highlight the geometric relationships with the substrate and the platform deposits that cover it (Fig. 1 and 3). In the characterization of the two bodies we also referred to conspicuous data on facies already available (MARANGON *et alii*, 2011; PRETO *et alii*, 2011).

The 3D geological model of the Latemar carbonate platform (FRANCESCHI *et alii*, 2016) was used to estimate the paleo-depth of the two satellite bodies at the time of their burial. The applied procedure consisted in drawing a timeline from the top of each of them to the coeval stratigraphic unit of the inner main platform succession. The timelines were drawn parallel to the clinofolds of the slopes. The point of intersection of the timelines with the inner platform approximately coincides with the paleo-sea level at the time when the two sedimentary bodies were buried by the advancing slopes of the main Latemar platform. The paleo-depth was then calculated as the minimum distance between the satellite bodies and the paleo-sea level (Fig. 4). Having the timelines of the burial, it was also possible to refer to the Latemar's age model (SPAHN *et alii*, 2013) to estimate the average rate of relative sea-level rise to which the satellite bodies were subjected.

RESULTS AND DISCUSSION

THE SATELLITE CARBONATE BODIES AT LATEMAR.

The mound on the southern slopes of the Latemar platform is a relatively small object, being approximately 40 m wide and 10 m high (Fig. 2A and B). It nucleated on a tilted block of the Contrin Formation and it is overlapped by well-layered grainstone deposits, interpreted as the tips of

clinofolds at the toe-of-slope of the main platform. These clinofolds contain deep-water fossils as radiolarians and fragments of thin-shelled bivalves (cf. *Daonella* sp.). This southern carbonate body is massive (not layered) and with the shape of a low-relief mound with gently inclined flanks (Fig. 2C).

The facies of the southern mound have been studied on hand samples and thin section. All parts of the mound are made of limestone with clotted peloidal fabric and framework cavities of up to some cm in size (Plate 1). Such cavities are invariably coated by an isopachous rim of radial fibrous cement from less than 1 mm to 3-4 mm thick. These cements are identical to those that have been determined as marine by CHRIST *et alii* (2012) and PRETO *et alii* (2019) on the base of petrographic observations and trace element geochemistry. Overall, the facies association of this mound is identical to those of the main Latemar platform as described by MARANGON *et alii* (2011).

Only samples from the lower part and core of the mound (Plate 1C, D) contain abundant dasycladacean algal tallies and rare calcimicrobes that are embedded in clotted peloidal micrite (Plate 1D). Instead, samples from the upper and external parts of the mound are nearly pure thrombolites (Plate 1A, B) without algae. Cavities in these samples are rimmed by radial fibrous cement and infilled with sediment made of volcanic minerals (e.g., idiomorphic biotite crystals) and fragments of deep-water dwelling thin-shelled bivalves (Plate 1B).

The northwestern satellite carbonate body is significantly larger, about 300 meters wide, and with a maximum thickness of approximately 100 m (Fig. 3). The central sector of the buildup displays horizontal, well-defined bedding (Fig. 3B) that, in the geologic map of the Latemar by GRAMIGNA *et alii* (2013), was erroneously interpreted as inner platform deposits of the main platform. Above, clinofolds that dip to the SSE and NNW imply that the body developed independently from the main platform, had a substantial submarine relief and became convex-up and mound-shaped in its late growth stage (Fig. 3B). Mound slope deposits facing to the southeast may be interfingering with the slope deposit of the main platform (Fig. 3). This sedimentary body was able to reach a height of approximately 100 m above the surrounding sea floor before being buried (Fig. 3B).

MICROBIAL MOUND NATURE OF THE SATELLITE CARBONATE BODIES.

The two sedimentary bodies investigated in this work were carbonate mounds at the time of their shut-off. This is testified by their depositional geometries, which are very well exposed in both cases (Fig. 2, 3). The facies of the southern mound should be interpreted in large part as microbial boundstones, dominated by clotted peloidal micrite. Even in those facies that bear abundant dasycladacean algae, clotted peloidal micrite and radial fibrous cements are volumetrically dominant (Plate 1C). The pure microbial boundstones have a thrombolitic fabric on the hand sample scale, with large primary framework cavities that are filled by cement and, sometimes, allochthonous sediment (Plate 1A, B) as volcanic ash and fine carbonate mud or silt. Laterally, the mound is draped by distal slope deposits of the main Latemar platform (Fig. 2) which bear radiolarians and thin-shelled bivalves (cf. *Daonella* sp.)

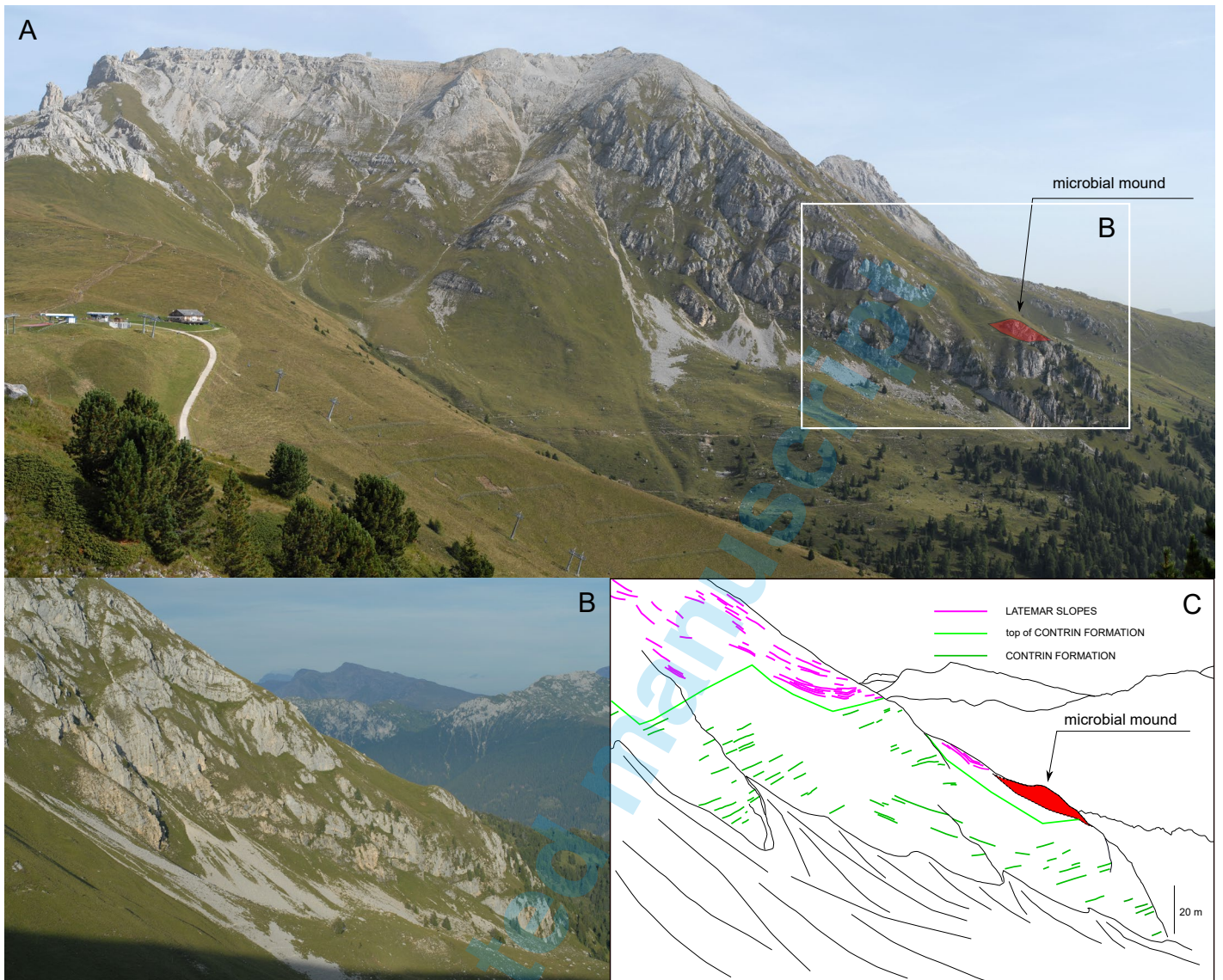


Fig. 2 - A) The mound on the southern slope of the Latemar platform. B) Line drawing highlights the recognizable geometric relationship between the mound and the surrounding rocks.

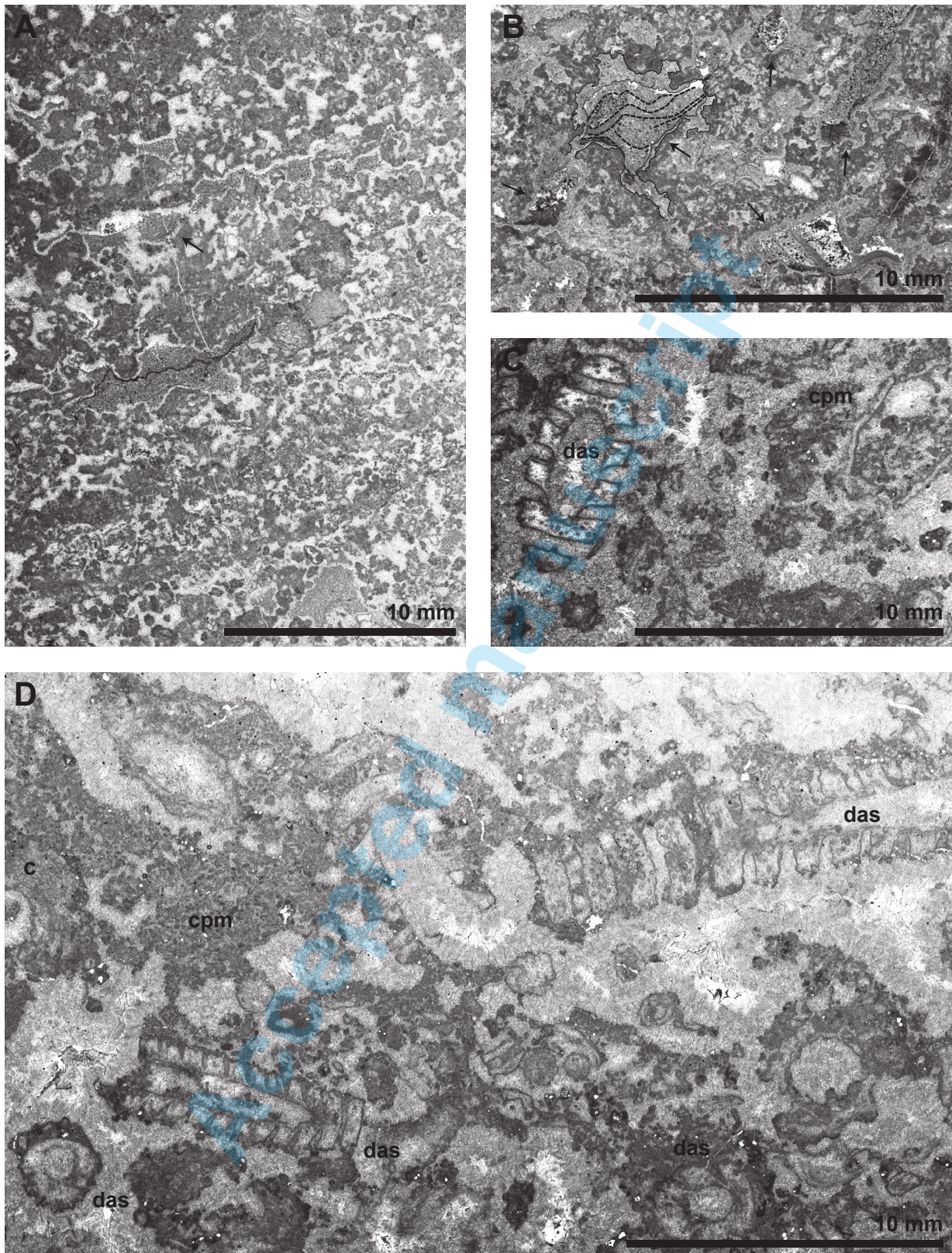
(PRETO *et alii*, 2011; MARANGON *et alii*, 2011). It can be said then that the southern carbonate satellite body is a microbial mud mound, and that it drowned, in a strict and sedimentological sense, before being covered by the slopes of the main platform.

The facies of the larger, northwestern mound could not be investigated directly. However, detailed facies analyses of the platform as a whole, based on comprehensive and dense sets of samples, were endeavored in many studies (e.g.: MARANGON *et alii*, 2011; CHRIST *et alii*, 2012; FRANCESCHI *et alii*, 2016; PRETO *et alii*, 2019) and invariably demonstrated the microbial nature of the carbonate production at Latemar. We thus suggest that it is safe to assume that the northwestern mound was microbial as well. Both mounds were thus microbial mud-mounds *sensu* BOSENCE & BRIDGES (1995), i.e., mound-shaped carbonate bodies that “can be considered to have a more or less in situ microbial origin” on the basis of the “dominant texture, microfabric and composition”.

Nevertheless, the northwestern mound did not start up as a mound, and this is testified by its well layered core. It most probably nucleated on the Contrin Formation as it was still in the photic zone and above the wave base, and initially formed a proper, yet very small (ca. 300 m in diameter) microbial platform. It later evolved into a mound, a development that is common to larger carbonate platforms of the Dolomites that eventually drowned (e.g., Cerner platform in BLENDINGER *et alii*, 2004).

TIME OF BURIAL AND CAUSES OF THE MICROBIAL MOUNDS DEMISE.

The geometries of the northwestern carbonate body, which evolved from platform to mound, and the overlap of deep-water facies on the southern mound, testify for deepening of the two structures. This indicates that their growth potential was at a certain point no more able to withstand the rate of the relative sea-level rise. The



Pl. 1 - Microfacies of the southern mud-mound at Latemar: A) Layered thrombolite from the upper part of the mound. Note the absence of dasycladacean algae. The arrow points to a planar cavity bordered by a rim of early cement and partially filled by internal fine carbonate sediment. Sample Fd3. B) Microbialite made of clotted peloidal micrite from the upper part of the mound. Stromatolite-like cavities bordered by a isopachous rim of early cement, and filled by laminae of internal sediment, are indicated by arrows. One cavity is highlighted by line-drawing of the outline and internal lamination. This internal sediment contains quartz and micas from volcanic ash. Sample Fd2. C) Microbialite made of clotted peloidal micrite (cpm) and with dasycladacean algae (*Diplopora anullatissima*) (das), from the lower part of the mound. Sample Fd4. D) Microbialite made of clotted peloidal micrite (cpm) with abundant dasycladacean algae (*Diplopora anullatissima*) (das) and rare calcimicrobes (c), from the base of the mound. Sample Fd5.

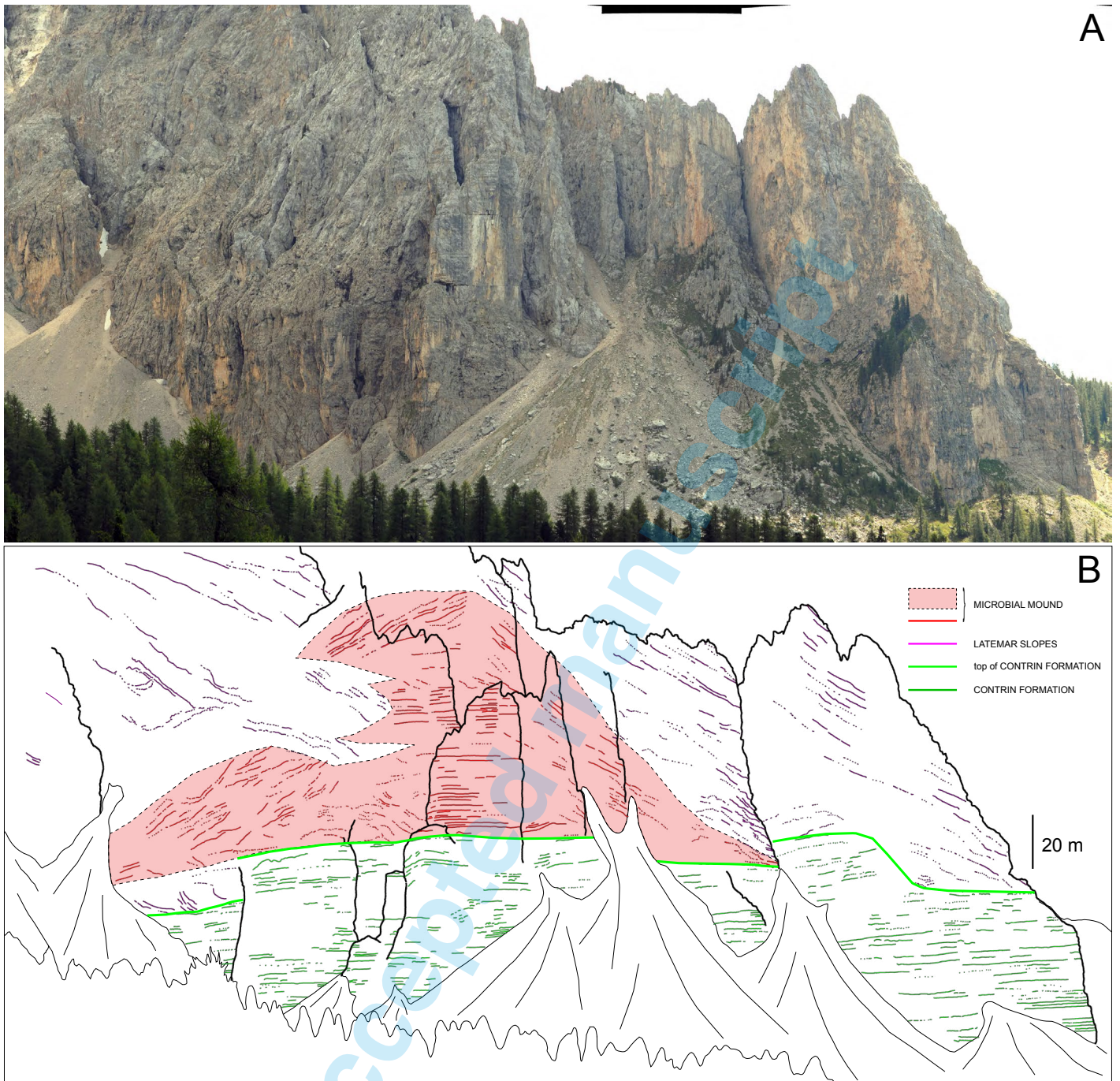


Fig. 3 - A) The mound on the northwestern slopes of the Latemar platform. B) Line drawing highlights the recognizable geometric relationship between the mound and the surrounding rocks. A central portion characterized by horizontal, well-developed layering is surrounded by clinostratified deposits dipping to the SSE and NNW. The approximate outline of the buildup is highlighted in red. Trend of the clinofolds of the mound and the clinofolds of the main Latemar platform suggest interfingering relationships.

mounds progressively sunk and were eventually covered by the slopes of the main Latemar platform. Tracing of the slope bedding from the top of the mounds to the intersection with the inner platform units (EGENHOFF *et alii*, 1999) makes it possible to estimate the depth at which they were located when they were buried, and the time of burial. The main slope deposits covered the southern mound when it was at approximately 450 m water depth, namely when the Lower Teepee Facies unit was depositing during the *reitzei* ammonoid biochronozone. The top of

the northwestern mound was instead buried when it was located at approximately 500 m water depth, at a time roughly coincident with the deposition of the Upper Cyclic Facies unit that is dated to the *secedensis* ammonoid biochronozone of MANFRIN *et alii* (2005) (Fig. 4). The diachronous time of burial is consistent with the location of the carbonate bodies with respect to the margin of the Latemar. The northwestern mound stands at approximately 1.5 km from the margin of the main platform, while the southern mound is closer, at around 600 m distance from

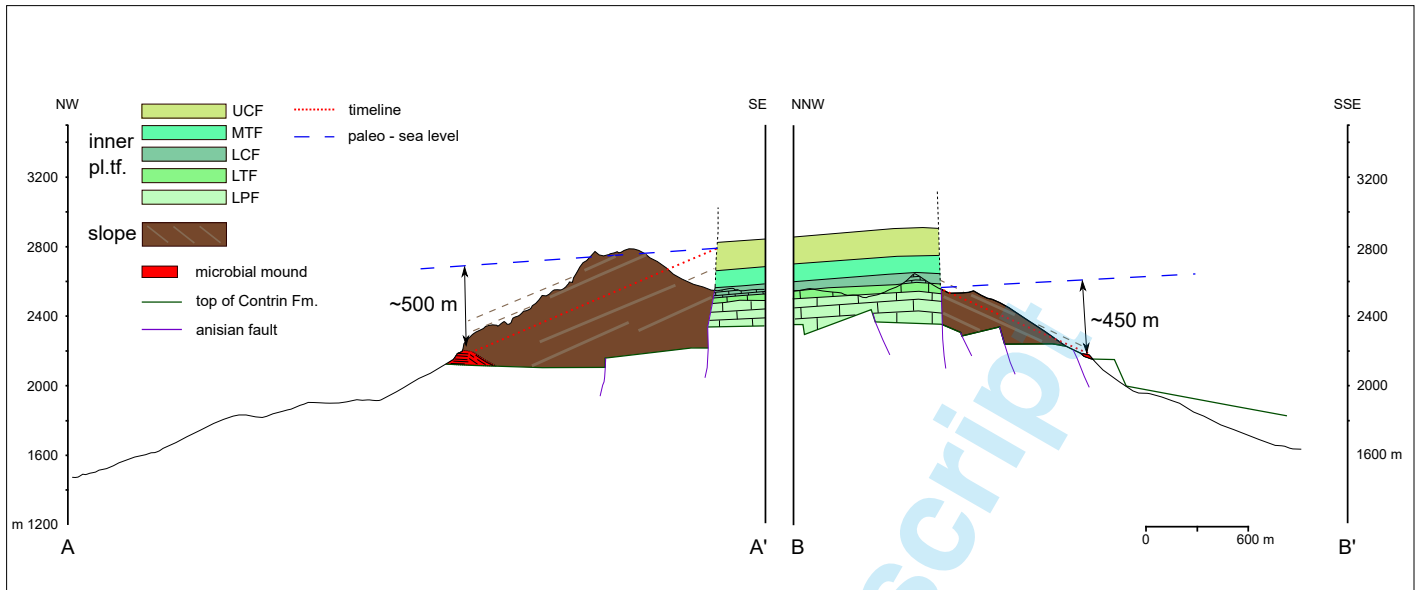


Fig. 4 - Geological cross-sections of the Latemar across the southern (A-A') and northwestern (B-B') slopes of the platform (see Fig. 1 for location of the cross-section traces). Paleo-water depths at which the two mounds were covered by the clinofolds of the main platform are indicated. They were calculated by tracing a timeline parallel to the clinofolds to intersect the margin. The intersection point was considered as approximately correspondent to sea-level at the time of the burial.

the margin, therefore, assuming equal progradation rate in the two directions, the slope sediments of the main platform would have reached the southern mound first.

The average rate of relative sea level rise at which the two mounds were subjected from their nucleation to their burial can be estimated by considering that nucleation was essentially contemporaneous to that of the main platform and occurred at shallow depths. By the time the base of the southern mound reached 450 m water depth and was covered by the slopes, on the platform approximately 200 m of sediments were deposited, corresponding to the entire Lower Platform Facies and part of the Lower Tepee Facies (Fig. 4). The growth rate of the platform was estimated in approximately 600 m/Myr by FRANCESCHI *et alii* (2016). Since in this phase of evolution of the platform the trajectory of margins is vertical (i.e. pure aggradation), this 600 m/Myr must have been close to the maximum growth potential for this carbonate factory, and it was equal to the rate of relative sea-level rise to which the main platform was subjected. Otherwise, the trajectory of the margin would have been either retrograding or prograding. According to the age model of SPAHN *et alii* (2013), 200 m of inner platform sediments deposited in approximately 0.3 Myr and hence this was the time that passed in between the nucleation of the mound and its burial at 450 m paleo-depth. The average rate of relative sea-level rise for the southern mound was therefore equal to 450 m / 0.3·Myr, i.e., of the order of 1500 m/Myr. Applying the same approach to the northwestern mound yields an average rate of relative sea-level rise of ca. 800 m/Myr because when it was buried approximately 400 m of inner platform deposited in 0.7 Myr and the mound (its base) sunk at 600 m depth.

As far as the causes of the demise of the two mounds are concerned, in the Dolomites there is no sedimentological or geochemical evidence of global Anisian environmental changes that may have impacted on carbonate production (e.g., EGENHOFF *et alii*, 1999; PRETO *et alii*, 2010; 2011; CHRIST

et alii, 2012; STEFANI *et alii*, 2010 and many others). This seems to exclude ecological stress induced by external climatic/oceanographic forcing. One option could be attributing the demise of the mounds to the engulfing by the slope deposits of the main platform. This would be in agreement with the position with respect to the main platform and the different degree of development of the two structures. The slopes of the Latemar would have soon reached the southern mound, located in a more proximal position with respect to the margin, burying it in the early stages of its growth. It would have taken instead a longer time to the slope sediments to prograde and reach the northwestern mound that would have been able to develop a larger and more complex architecture. There are, however, several elements against this scenario. The finding of deep-water faunas (fragments of thin-shelled bivalves) in the sediments filling the framework cavities of microbial boundstones of the southern mound (Plate 1) suggests that it ceased to grow before being covered by the slopes. Secondly, the interfingering of the northwestern mound with the main platform sediments testifies that it was still able to aggrade when the slope deposits reached and started covering it (Fig. 3). It has been shown that, although not being limited by the availability of light, microbial carbonate precipitation is depth dependent. A notable example is represented by the Paleozoic mounds of the Asturias and Caspian region, where microbial boundstones disappear below 300 m paleo-depth (KENTER *et alii*, 2005; DELLA PORTA *et alii*, 2017). DELLA PORTA *et alii* (2003; 2004; 2013) proposed that this depth-sensitivity could be due to variations in the saturation of seawater with respect to carbonate minerals that may prevent the precipitation of microbial carbonate even though microbial communities are still present. PRETO *et alii* (2019) found that at Latemar a sharp decrease and disappearance of microbial boundstones on the slopes of the platform occurs at approximately 350 m paleo-water depth and connected

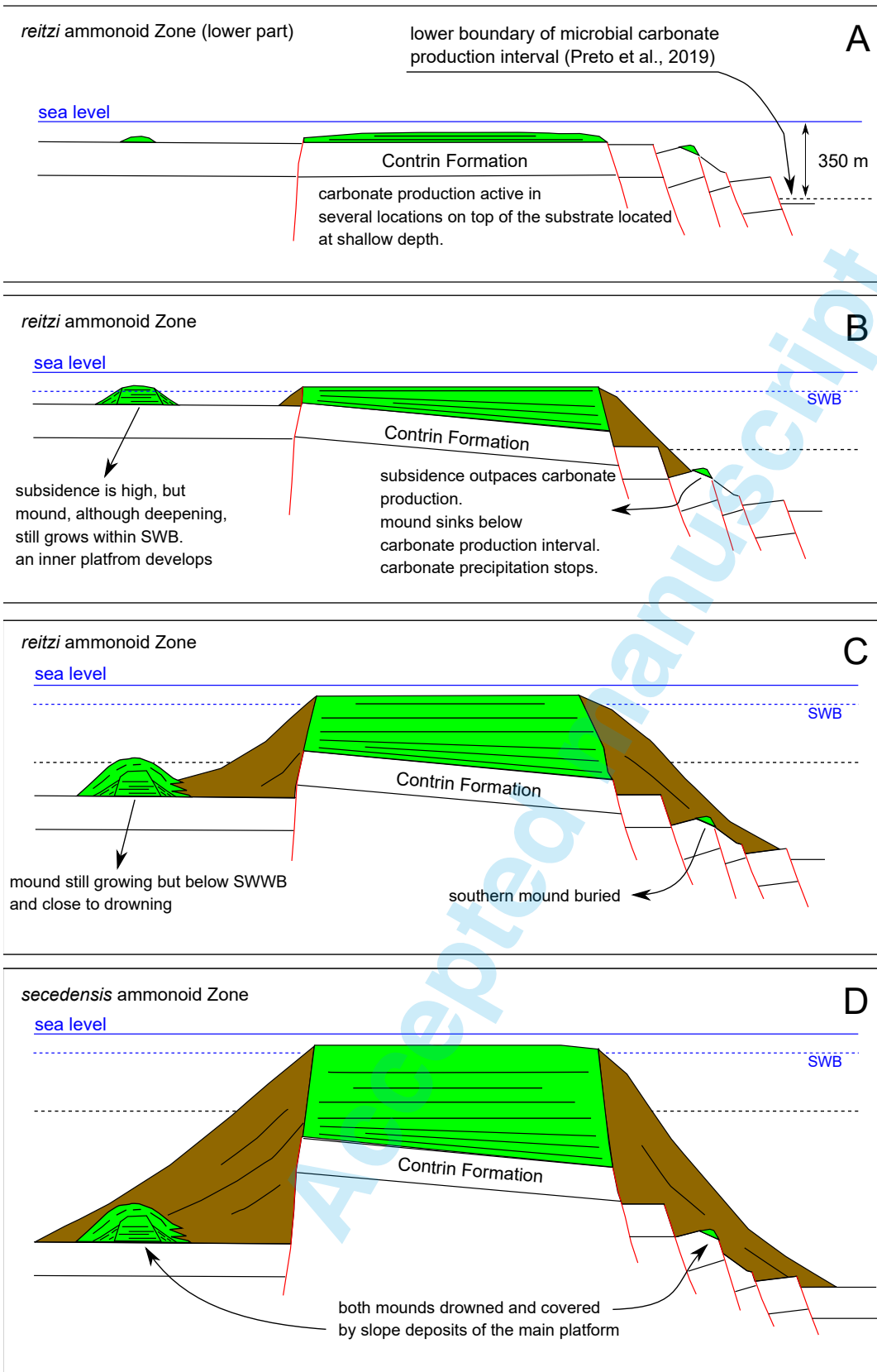


Fig. 5 - Depositional transect across the Latemar platform describing its evolution, from nucleation to demise and final burial of the nearby microbial mounds. A) Nucleation of the first microbialites on top of the Contrin Formation in the lower part of the reitzi ammonoid biochronzone. B) Drowning of the southern microbial mound, drawn below the critical depth of carbonate precipitation by high subsidence rates. C) The main platform continues to aggrade. In the middle portion of the reitzi ammonoid biochronzone its prograding slopes bury the demised southern mound. Meanwhile, the northwestern mound is still growing, but in a deepening trend as the vertical growth rate is not able to counter local subsidence-induced sea level rise. Clinostratified slope deposits of the main platform interfinger with the mound deposits. D) Final drowning and subsequent burial of the northwestern mound by the main platform's slopes in the secedensis ammonoid biochronzone.

it to the lack of nutrients and dispersed organic matter under a maximum respiration zone in the water column.

Whatever the cause that makes the 300-350 m depth critical for microbial carbonates, at an average sinking rate

of 1500 m/Myr, the southern mound would have reached it in approximately 0.2 Myr, before being buried by the Latemar slopes. Similarly, the northwestern mound, at an average sinking rate of 800 m/Myr, would have reached

the critical depth in approximately 0.5 Myr while the time between its nucleation and the burial is estimated in 0.75 Myrs. Therefore, in both cases the mounds reached a paleo-depth of 300-350 m before being buried. As this depth represent the lowermost threshold of microbial production at Latemar (and in other microbial platforms) it is fair to say that on the mounds microbial carbonate production ceased, or was substantially reduced, because they reached the critical depth. This is confirmed by the occurrence of deep-water and pelagic fossils in beds overlying the southern mound. We infer that it was the combination of anomalously high rates of relative sea-level rise and the existence of a critical depth for microbial carbonates that caused the drowning of the two microbial mounds at Latemar.

The magnitudes and rates of relative sea level rise observed at Latemar exclude a significant contribution of eustatic fluctuations, because glacio-eustasy, the only mechanism that could explain rapid and ample eustatic sea-level change (MÖRNER, 1980), should be unlikely in the Middle Triassic greenhouse time (PRETO *et alii*, 2010). Therefore, subsidence remains as the main phenomenon that could have caused the foundering. The thick platform succession corresponds to a very thin coeval pile of basinal sediments which could contribute little to a possible compaction. For the limestones of the Latemar, compaction was prevented by early cementation (FRANCESCHI *et alii*, 2016). Lastly, the Latemar grew on top of a thick carbonate body (the Contrin Formation) that was also early lithified, as proven by its dissection by Middle Triassic faults. Hence, differential compaction could not have had a relevant role in determining subsidence.

It is well known that the late Anisian was characterized in the Dolomites by strong subsidence and extensional synsedimentary tectonics, which is well evident at Latemar (PRETO *et alii*, 2011, and references therein). Multiple Anisan faults dissect the Contrin formation on the southern side of the platform with displacements of several hundred meters with respect to the horst on which the inner platform deposited (Fig. 4). These faults testify of a syn-sedimentary extensional phase that is also confirmed by the wedge-shape of some of the inner platform units (PRETO *et alii*, 2011). It is therefore fair to say that tectonics-induced subsidence was the cause of the anomalously high rates of relative sea level rise that foundered and drowned the microbial satellite sedimentary bodies at Latemar. The role of syn-sedimentary tectonics in leading to the mounds drowning was hypothesized by BRACK *et alii* (2007) for the Cerner and Clapsavon carbonate platforms (coeval to the Latemar). Isolated, high-relief carbonate platforms are a typical feature of the paleogeography of the Dolomites in the Middle Triassic. Evidence presented in this work suggest that the phase of extensional syn-sedimentary tectonics that interested the area in the Anisan could be the major factor that determined where nucleating carbonate build-ups were able to grow and become isolated carbonate pinnacles or sunk under the action of fast subsidence and ultimately drowned.

CONCLUSIONS

Two carbonate mounds, buried by the slope deposits of the middle Triassic Latemar Platform, have been investigated. The burial beneath the slopes occurred in the

reitzei ammonoid biochronozone for the southern mound and in the *secedensis* ammonoid biochronozone for the northwestern mound. The different life span of the two buildups is reflected in their different architecture. The southern mound remained small and ceased to grow early in the history of the Latemar platform, while the northwestern mound remained productive for a longer time and developed a well layered inner platform and a significant submarine relief.

The evolution that can be reconstructed from the observations presented in this work is described in Figure 5. The onset of microbial carbonate precipitation on top of the Contrin Formation took place sometimes in the *reitzei* ammonoid Zone. Precipitation was occurring at shallow depths within the photic zone (Fig. 5A). Subsidence rates were in the order of 600 m/Myr for the main platform, but up to 1500 m/Myr for the peripheral carbonate bodies. In this circumstance, the smaller southern mound quickly sunk below the critical depth of 350 – 400 m, and drowned (Fig. 5B). To the northwest, instead, precipitation was occurring on a larger area in a context of intermediate subsidence rates. This permitted the growth of a larger mound that stood for a certain time above the SWB, developing a flat top and a well layered core, and gaining enough relief for the formation of true clinostratified slopes. Nevertheless, even there subsidence-induced sea level rise outpaced production and eventually this mound also progressively sunk below the SWB. In this phase, the carbonate factory remained active and the slopes of the main platform started interfingering with those of the mound (Fig. 5C). Finally, the northwestern mound surpassed the critical depth and microbial carbonate production ceased. The main platform slope deposits progressively expanded and buried both mounds (Fig. 5C and D)

Average rates of relative sea level rise of 1500 m/Myr and 800 m/Myr are found for the two mounds and are faster than the vertical growth rate of the Latemar that in that phase of its evolution was purely aggrading. These rates exceed those that could be caused by eustasy. It is then hypothesized that the drowning of the mound was caused by high subsidence that outpaced the albeit elevated growth potential of the microbial carbonates, bringing the sedimentary bodies below the critical ~350 m depth at which cessation of microbial carbonate precipitation occurs.

Results of this work reveal a so far poorly investigated complexity in the architecture and evolution of the Middle Triassic microbial carbonate platforms of the Dolomites in which differential subsidence induced by synsedimentary tectonics assumes a key role in determining where carbonate production persisted, leading to the development of the isolated buildups that characterize the area.

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