

SEDIMENTOLOGICAL-STRATIGRAPHIC CONSIDERATIONS REGARDING THE TRIASSIC 'REEFS' OF THE DOLOMITES (ITALY)¹

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ABSTRACT

Leonardi, P. 1979 Sedimentological-stratigraphic considerations regarding the Triassic 'reefs' of the Dolomites (Italy). In: W. J. M. van der Linden (ed.): *Fixism, mobilism or relativism: Van Bemmelen's search for harmony* — Geol. Mijnbouw 58: 139-144.

Some authors maintain that a good part of the carbonate assemblages of the Dolomites do not correspond to true 'reefs' in an ecological sense. In contrast, they suggest that these rocks belong to masses of lime mud that are part of the indented edge of a broad, shallow-water platform, the formation of which was only scarcely influenced by corals and other reef-building organisms. This hypothesis is probably correct for several carbonate bodies (i.e. Marmolada, Latemar) in which these organisms are either absent or rare. But this is not the case in other bodies where corals are abundant and are often found in growth position. It is clear that, in some cases at least, the carbonate bodies of the Dolomites correspond to true 'reefs', even in an ecological sense. This is true, above all, for the dolomitic reefs of post-Ladinian age (San Cassian and perhaps lower Raiblian).

It has not been demonstrated that volcanic activity in the Dolomites ceased before the San Cassian period, since a lava bank in the most elevated part of Mount Sciliar (*Schlern*) is included in the Rosetta dolomite, which can be referred precisely to the lower Carnian (San Cassian).

According to the author the *Pachycardia* Formation is synchronous with the upper part of the St. Cassian Formation.

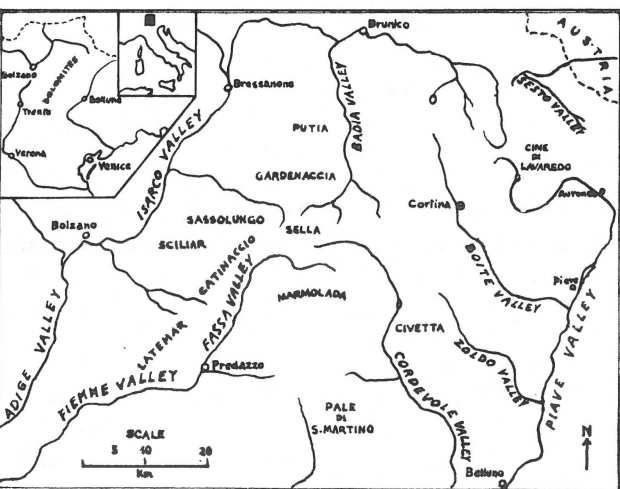


Fig. 1
Location map of the Dolomites and of some 'reefs' (modified after Bosellini & Rossi, 1974).

Certain recent papers about the Dolomites are interesting because of their new and provocative ideas on the origin and reciprocal relationships between the highly diverse formations which make the Dolomite region so picturesque and characteristic from a geological point of view. The authors maintain that the majority of the Triassic carbonate bodies, particularly those which predate Ladinian volcanism, are not true 'reefs' in an ecological sense: that is, constructed by corals or other building organisms such as the Oligocene and present-day coral-algal reefs. They are rather lime mud mounds³ and only subordinately 'small circular patches' that correspond to the 'indented edge of a broad, shallow-water carbonate platform' (BOSELLINI & ROSSI, 1974, p. 209, 230). These organisms played only a limited role in the creation of these formations, and even if they were present, according to the above-quoted authors the coralline formations were 'established at the outer shelf edge' and were 'destroyed when the platform was sub-aerially exposed' (BOSELLINI & ROSSI, 1974, p. 225).

I feel that it is appropriate to formulate certain clarifications of a general nature, and I draw from the vast amount of literature which preceded the above-mentioned studies. Thus, one avoids unfortunate confusion especially for those who have not personally studied this complex subject.

Above all, I would like to recall, as I have pointed out on

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³ The nomenclature in this paper is according to the definitions given or referred to by Wilson (1975, p. 23-27).

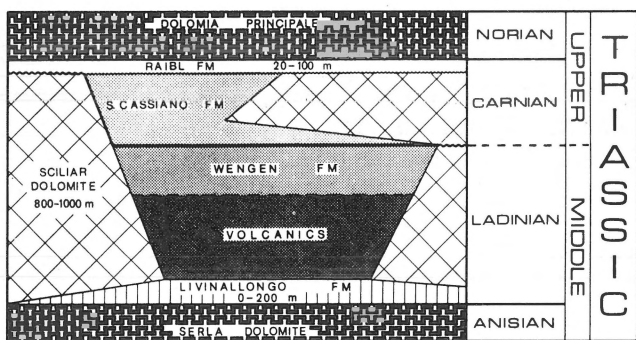


Fig. 2
Schematic representation of stratigraphic relationships of the middle and upper Triassic formations in the Dolomites (according to Bosellini & Rossi, 1974).

various occasions (LEONARDI & ROSSI, 1957; LEONARDI 1961, 1960-1963, 1962, 1968) that, contrary to what some authors believe, the carbonate bodies of the Dolomites which are usually called 'reefs' in geological literature are not all of Ladinian age. A notable part of these bodies may be attributed to the Carnian; this means that they correspond to the St. Cassian Formation⁴ and to the lower Raiblian. The youngest and uppermost part of the 'reefs' passes laterally into these formations with an obvious facies change, as will be discussed later.

At present one tends to believe that the volcanic activity that characterized the Triassic of the Western Dolomites took place entirely (or at least predominantly; we will return to this point) in the Ladinian, postdating the Livinallongo Formation and predating the St. Cassian Formation (BOSELLINI & ROSSI, 1974; BRONDI ET AL., 1976; CASTELLARIN ET AL., 1977). According to recent publications, including some of those quoted above, several of the most characteristic and famous mountains of the region (Latemar, Catinaccio, Sciliar, Marmolada, Pale di St. Martino, Civetta (p.p.), etc.) would have been formed before this volcanic activity and should therefore be attributed to the lower Ladinian.

That this concept is true in various cases and that some of the most important carbonate bodies of the Dolomites show a facies change into the Livinallongo Formation (which represents the lower Ladinian in the normal sequence of the Dolomites), I clarified (LEONARDI, 1962, p. 18; 1967, p. 226, fig.

⁴ According to Italian usage the St. Cassian Formation is, for primarily palaeontological reasons, considered Carnian rather than Ladinian. While keeping in mind the recent discussion by Urlichs (1977, p. 20-21), the author feels that the Cassian fauna, taken as a whole, is closer to Raiblian than to the Ladinian fauna. Particularly worth mentioning is the presence of *Myophoria kefersteini* as early as the strata of St. Cassian of Cadore; this is one of the most characteristic guide fossils of the strata of Raibl (Leonardi, 1932). On the other hand it is often difficult, stratigraphically and sedimentologically, to define a clear limit between the St. Cassian and Raibl Formations in normal facies. It may be remembered that the author's position also agrees with that of Jacobshagen (1961), and is established after a thorough investigation of the subject.

129) before the publications cited above. It is not clear, however, what proof exists that the dolomitic 'reefs' did not continue their development during the late Ladinian in those cases in which there is a gradual transition from the Ladinian carbonate masses into the Cassian, and where the 'reefs' are not covered by volcanics.

In the case of the Sciliar (SCHLERN), for example, it is sufficient to examine a natural section of the carbonate body visible on the face of the group to the north of Mt. Castello (*Burgstall*) (LEONARDI, 1962, Table 12, Fig. 2) (Fig. 3). The entire series is exposed there, from the part lying immediately below the strata of Raibl up to the base of the Sciliar dolomite (*Schlern dolomite*). One can clearly observe that there is *absolutely no trace of a discontinuity* between the dolomites which should be considered to be lower Ladinian and those of a certain Carnian age, which cap the series (ROSSI *in* BRONDI ET AL., 1976).

It has not been adequately proven either that volcanism in the Dolomites ceased before the St. Cassian Formation. It is an indisputable fact that the lava flow located in the uppermost part of the Sciliar 'reef' is clearly included *within* the dolomite of the stratified Rosetta Formation (Fig. 4) (see VALDUGA, 1962, Table 19; LEONARDI, 1962, Table 6, Fig. 3). This 'back reef' passes laterally into the 'reef wall' of the eastern edge of the Sciliar plateau (VON MOJSISOVICS, 1893, p. 163, Fig. 166; LEONARDI, 1962, p. 10, Fig. 5; ROSSI *in* BRONDI ET AL., 1976, p. 168, Fig. 24). The 'fore reef' (*Ueberguss-Schichten*) of the Sciliar is interbedded with the St. Cassian Formation (LEONARDI, 1962, Table 18, section 4) of early Carnian age. Since, among other considerations, it seems extremely probable (if not certain) that the above-mentioned lavas of the Sciliar are linked to those of the Alpe di Tires (Tierser Alpe) (LEONARDI, 1962, p. 24, 63), I believe that an objective re-examination of the entire complex would be appropriate. This would require special attention to the Sciliar lava flow, as discussed by Somnavilla (*in* BRONDI ET AL., 1976, p. 181).

Returning now to the origin and nature of the Dolomite 'reefs' or banks, it is possible that some of the pre-volcanic carbonate bodies (such as the Marmolada, the Latemar, the Viezzena, etc.) which are composed of calcareous rocks in which remains of corals and other builders are either rare or even completely absent, do not correspond to true 'reefs' in an ecological sense, but rather to lime mud mounds. It seems hardly possible, however, that this could be the case in other carbonate bodies such as the Sciliar (at least in its uppermost part), the Sella, the Sasso Lungo (at least in the zone around the Vicenza shelter) and other dolomitic groups in which corals are abundant and often preserved in normal growth position. Furthermore, it is probable that the absence of coral remains and, in general, the absence of frame-building organisms may be due to diagenetic alteration (ROSSI, 1968, p. 284-285). This hypothesis is further supported by the fact (also acknowledged by BOSELLINI & ROSSI, 1974, p. 225) that corals frequently occur in the Cipit limestones which are, for the major part, 'reef' fragments (or banks) that rolled downslope



Fig. 3
The northern walls of the Sciliar Group as seen from the vicinity of Siusi. It is obvious that there is no discontinuity between the Ladinian dolomites of the lower part of the 'reef' and the lower Carnian ones of the upper part (photo by Fränzl, Bolzano).

and that were embedded in the adjacent and contemporary tuffaceous sediments (Fig. 5) of the Ladinian and Carnian pseudoflysch and of the Pachycardia Formation. These are not only the result of the demolition of 'reefs' that were already dead, since blocks of exactly the same type are abundant in the fore-reef zone of reefs in an advancing phase⁵.

Therefore, it is quite clear that, at least in several cases, the carbonate bodies of the Dolomites indeed correspond to true 'reefs', not only in the stratigraphic sense of DUNHAM (1970), but also in a strictly ecological sense. This interpretation is particularly valid for the dolomitic 'reefs' which postdate the Ladinian (St. Cassian and perhaps lower Raiblian) such as the uppermost part of the Sciliar and those of the Sasso Lungo, the Sella and the Gardnaccia.

It should be added that in these cases there is an unquestionable facies change from the dolomites of the 'reefs' or banks into the deposits that overly the Livinalongo For-

mation and that fill the adjacent basins, especially the St. Cassian Formation and the Pachycardia Formation. This facies change is particularly clear – to cite only some of the more characteristic examples – along the eastern slope of the Sciliar near the Alpe di Siusi (*Seiser Alm*) (LEONARDI, 1962, Table 11, Fig. 1; Table 18, section 4) (Fig. 6) and at the northeastern edge of the Denti di Terrarossa (*Rosszähne*) (VALDUGA, 1962, p. 173, Fig. 2; LEONARDI, 1962, p. 60, Fig. 34, Table 12, Fig. 1) (Fig. 3). An additional example may be found in the Sesto Dolomites, particularly at the Croda dei Baranci where, as stated by ASSERETO ET AL. (1977, p. 375), 'the distance of this platform from eruptive centres explains why its growth was not blocked', since 'at least for the marginal position, there is proof of heterotopy with the basin sediments of the Upper Ladinic age'.

I also feel that it is well to continue the discussion on the question of heterotopy (facies change) between 'reef' formations and volcanic, tuffaceous and normal deposits in interlying basins. Proof of these changes may be found in the most recent study by Urlichs (1977) in which it again is affirmed that a facies change exists not only between the normal and tuffaceous formations (strata of La Valle and strata of St. Cassiano), but even between the Ladinian lavas; this clearly contrasts with the ideas of BOSELLINI & ROSSI (1974)⁶ and those of others quoted above.

I believe that it is opportune to point out that, whatever significance the Dolomite reefs may have – only stratigraphi-

⁵ Consult various figures of the author: Leonardi, 1961, p. 144-145, Figs. 15-16; 1962, p. 46-47, Figs. 24-25; 1967, p. 245, Figs 154-155, related by Wilson (1975, p. 39, Fig. II-17).

⁶ It should be noted that in figure 2 of his paper, Urlichs (1977) compares a diagram that shows his ideas with another one which he attributes to Leonardi, Bosellini & Rossi. With respect to this, the diagram should be exclusively attributed to Bosellini and Rossi. Leonardi is responsible only for the part referring to the Pachycardia tuffs, a contribution based primarily on the research results of Valduga. This subject will be discussed later.

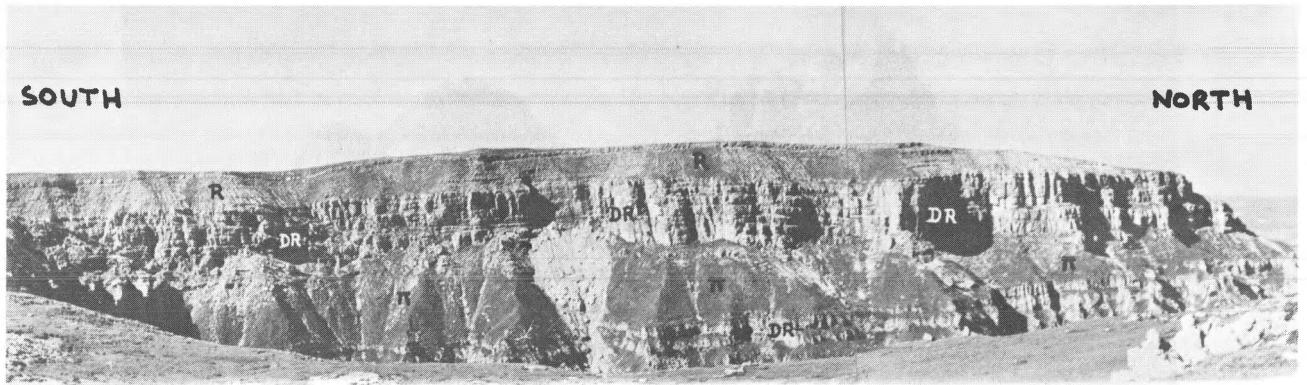


Fig. 4
The Mul Ridge in the northwestern part of the Sciliar Group, clearly showing the lava flow (π) encompassed in the complex of the stratified Rosetta Dolomite (RD) formation in 'back reef' facies. This passes laterally into the barrier ('reef wall') of the eastern edge of the Sciliar reef, which belongs to the early Carnian (St. Cassian and probably also lower Raiblian). R = Raibl strata (photo by Michele Sacerdoti).

cal or truly ecological – their morphological distinction into 'cake reefs' and 'mushroom reefs' remains valid (LEONARDI, 1961, p. 129-130, Fig. 3); this consideration is applicable not only to the Triassic 'reefs' of the Italian Dolomites, but generally to reef formation of all ages.

In the case of the Italian Dolomites, the 'cake reefs' are especially characteristic of the most ancient 'reefs' (or banks) which date back to the early Ladinian and which did not further develop in later epochs, either because of biological extinction of the 'reefs' or because of suffocation by overlying volcanics (BOSELLINI & ROSSI, 1974; LEONARDI, 1962, p. 18, Fig. 7). The 'mushroom reefs' (or banks), on the other hand,

remained intact or even developed into platforms in successive ages, and they extended their edges over normal sediments or tuffaceous deposits in the interlying basins. Sometimes, as in the case of the Sella Group (Fig. 7), the development was characterized by alternating phases of growth and retreat.

In this regard it must also be repeated that one should never over-generalize because, even in the same carbonate build-up such as for example the Sasso Lungo, both of the above-mentioned morphological types may coexist (LEONARDI, 1961, p. 132; 1968, p. 227, 230, Fig. 134). Furthermore, whatever the nature of the dolomite 'reefs' may be, distinctive parts of their



Fig. 5
The Terra Rossa, the Denti di Terra Rossa, the Sciliar and the zone of the ex-Dialer Refuge as seen from the Palaccia chain. The transition from the organogenic reef of the Sciliar-Terra Rossa into the contemporaneous sediments of the St. Cassian Formation is evident. There are abundant blocks of Cipit limestone included in the latter formation (photo by Ghedina, Cortina d'Ampezzo).



Fig. 6
Slope facing the Alpe di Siusi of the Sciliar. It corresponds to the 'fore reef' of the original coralline barrier. At its base, near the upper Rio Freddo (Ochsenwald Bach), there are characteristic examples of 'interlocking' between the Ueberguss Schichten of the reef and the St. Cassian strata (early Carnian). The small dolomite wall just below the edge of the plateau (at the right) corresponds to a late Carnian expansion of the reef (photo by Michele Sacerdoti).

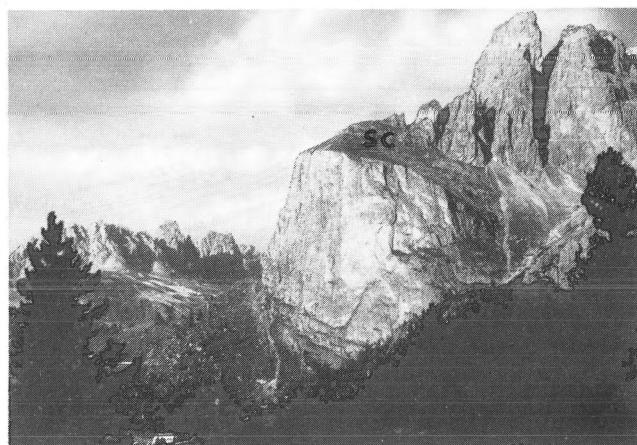


Fig. 7
The wall of the Murfreid at the northern edge of the Sella Group in the Gardena Valley. Notice the wedge of St. Cassian beds between the above-mentioned wall and the dolomite towers situated above. SC = St. Cassian beds (photo by the author).

structure may be recognized that are characteristic of reef formations of any age. Moving from the centre of the carbonate mass to its external edge, these parts are: 'reef core', 'reef back', 'reef wall' and 'fore reef' (HENSON, 1950; FERASIN, 1958; LEONARDI, 1968; Rossi *in* BRONDI ET AL., 1976, p. 168, Fig. 24). These reef components may be more or less well-preserved and more or less evident in each case, especially as a result of the varying effects of diagenetic phenomena, but very often they are at least partially recognizable in the Triassic carbonate bodies of the Dolomites.

As a concluding point in this paper, I must make it clear that I cannot accept, without the most ample reservations, the conclusions of URLICHS (1977) regarding the chronostratigraphic position of the Pachycardia Formation (*Pachycardienstufe* Auct.), a tuffaceous formation that crops out in many places of the Alpe di Siusi. Based on investigations by the author and his colleagues, particularly VALDUGA (*in*: LEONARDI ET AL., 1968, chapter 22), the conclusion was reached that this tuffaceous formation, both because of its fauna including the Cipit limestones and because of its relationships with the Carnic dolomites of the uppermost part of the Sciliar reef, should be placed at the boundary between the St. Cassian Formation (early Carnian) and the Raibl strata (late Carnian).

According to URLICHS (1977), however, who based his interpretation principally upon several fossils which were found years ago on the Alpe di Siusi, the Pachycardia Formation should be synchronized with the lower part of the St. Cassian Formation. Since he attributes, according to general German usage, the St. Cassian Formation to the Ladinian (note previous comment in this regard), the Pachycardia Formation would therefore be Ladinian.

This is the conclusion that Valduga⁷ and I cannot accept without reservation, because it is absolutely certain that the uppermost part of the Pachycardia Formation lies between the dolomite *Ueberguss-Schichten* which descend from the edge of the reef (quite certain ecological in this case) of the Sciliar at its extremely southeastern ramification of the Terra Rossa and the Denti di Terra Rossa (Fig. 8).

Since the dolomites of the above-mentioned ridge and, in particular, the uppermost ones are commonly accepted as synchronous with the upper strata of St. Cassian (if not, in fact, with the base of the Raibl strata), it is impossible for the upper part of the Pachycardia Formation to be referred to the lower St. Cassian as Urlichs suggests.

With respect to the ammonites that Urlichs discusses, he admits that part of these fossils can no longer be found and that another part lacks a precise locality identification and therefore has no stratigraphic meaning. One might wonder whether these fossils really come from the Pachycardia For-

⁷ Hearty thanks to my colleague and friend for the critical observations referred to me, regarding Urlichs' paper.

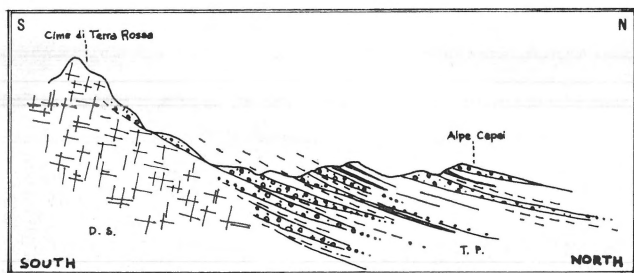


Fig. 8
Relationship between the dolomite of the reef of the Cime di Terra Rossa (D.S.) and the series of 'Tufi a Pachicardie' of the Alpe di Siusi (T.P.). The tongues of clastic material of the Ueberguss-Schichten that lie between the tuffaceous strata mentioned above, show that the most recent part of the latter (T.P.) is contemporaneous with the uppermost part of the Terra Rossa reef dolomite of Carnian age (after Valduga, 1962).

mation or from the underlying St. Cassian Formation. On the other hand, it is certain that the fauna of the Pachycardia Formation has various forms in common with the Raiblian fauna of the Sciliar plateau.

Thus the chronostratigraphic reference made by Urlichs seems highly improbable or at least inadequately documented. A thorough stratigraphical and palaeontological check would be useful. I hope to realise this study in the near future with the collaboration of various specialists.

In the meantime I maintain that there is sufficient proof to affirm – with my colleague Valduga – that, at the very outside, the Pachycardia Formation is formed contemporarily with the upper part of the St. Cassian Formation. It is therefore excluded that it could occupy such a low level – within the lower part of the formation – as is indicated in the stratigraphic diagram presented by URLICHS (1977, p. 21, Fig. 2, right side).

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