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The Oligocene coral formations of the Colli Berici (Vicenza, northern Italy)[1])

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ABSTRACT

Two different types of coral formation have been recognized in Oligocene rocks of the Colli Berici:

1. Lens-shaped to dome-shaped concentrations composed predominantly of massive hermatypic scleractinians occur mostly in the lower and middle part of the investigated lithological sequence along the ESE margin of the hills. The colonies are embedded in a calcarenitic and calcilutitic matrix. It seems that in rare cases the colonies were enough closely spaced to form a coherent coral framework. Field observations suggest that no build-up took place above the level of the surrounding sediments. The corals apparently lived below wave base, near the deeper limit of the euphotic zone.

2. Extensive coral carpets formed over the entire carbonate platform of the Colli Berici due to intensive colonization, predominantly by branching hermatypic scleractinians. These carpets, developed in the central and western part of the area, have been observed principally in the middle and upper part of the sediment sequence. Where coral growth was sparse the deposits show distinct bedding, but they become considerably more massive where it was denser. Locally the coral carpets swelled considerably to form reef-like mounds that rose up to more than 2 m above the surrounding sea floor. Although the corals lived above wave base, they seemingly were protected from the destructive action of storm waves and excessive swell by sufficient water depth and by a relatively shallow outer shelf.

In spite of intensive field work no evidence has been found to confirm the alleged existence of a true barrier reef in the Oligocene rocks of the Colli Berici. But such a reef might have existed further to the East. In this hypothetical case the lenses of massive corals associated with red algae might have formed near the inner margin of the barrier.

ZUSAMMENFASSUNG

In den oligozänen Kalken der Colli Berici (Norditalien) wurden folgende 2 Typen von Korallenbildungen festgestellt:

1. Linsen- bis kuppelförmige Konzentrationen vorwiegend massiger Riffkorallen treten im tieferen und mittleren Abschnitt der Schichtfolge am ESE-Rand der Colli Berici auf. Die Scleractinier lebten überwiegend durch Sediment voneinander isoliert und siedelten nur stellenweise genügend dicht, dass sie miteinander verwuchsen. Die Feldbeobachtungen zeigen, dass die Korallen keine über die umgebende Sedimentoberfläche deutlich aufragenden Strukturen bildeten. Sie lebten wahrscheinlich unterhalb der Wellenbasis im tieferen Teil der euphotischen Zone.

2. Ausgedehnte Korallenrasen, vorwiegend von verzweigten hermatypischen Scleractiniern, bildeten sich im zentralen und westlichen Teil des Untersuchungsgebietes vor allem im mittleren und oberen Abschnitt der Schichtfolge. Bei nur geringem Auftreten von Korallen zeigen die Ablagerungen vielfach eine deutliche Bankung. Sie werden aber zunehmend massiger bei dichteren Korallenpopulationen. Örtlich treten in den Korallenrasen auffallende riffartige Anschwellungen auf. Diese ragten zur Ablagerungszeit bis zu mehr als 2 m über die umliegende Sedimentoberfläche. Die Korallen lebten

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oberhalb der Wellenbasis, waren aber offensichtlich genügend vor Sturmwellen und starker Dünung durch ausreichende Wassertiefe und einen verhältnismässig flachen äusseren Schelf geschützt.

Trotz ausgedehnten Geländearbeiten haben sich keine Hinweise für das vermutete Vorkommen eines echten Wallriffes in den Oligozänkalken der Colli Berici finden lassen. Jedoch könnte ein solches Riff weiter im E vorhanden gewesen sein. In diesem hypothetischen Fall hätten sich die linsen- bis kuppelförmigen Konzentrationen massiger mit Rotalgen vergesellschafteter Riffkorallen in der Nähe des Innenrandes des Wallriffes gebildet.

RIASSUNTO

Nelle rocce oligoceniche dei Colli Berici sono stati riscontrati due tipi di formazioni coralligene.

1. Concentrazioni coralligene a forma di lente o di cupola, costituite prevalentemente da forme coloniali ermatipiche massicce, sono state osservate soprattutto nella parte inferiore e media della serie geologica studiata, lungo il margine ESE dei colli. Le colonie sono immerse in una matrice calcarenitica o micritica. In alcuni casi esse sono così strettamente ammassate le une alle altre da formare una salda impalcatura. Le osservazioni di campagna inducono a pensare che non esistesse una barriera organogena o biocostruita sopraelevata rispetto ai sedimenti circostanti e che i coralli vivessero sotto la base dell'onda vicino al limite della zona eufotica.

2. Colonie di coralli ermatipici ramificati predominano, invece, nella parte centrale ed occidentale della regione berica dove formano degli estesi tappeti. A questi si alternano calcareniti prevalentemente zeppe di Miliolidi. Laddove la crescita dei coralli è sparsa, i sedimenti mostrano una stratificazione distinta, mentre diventano via via più massicci laddove la crescita è più densa. Localmente il tappeto di coralli si inspessisce considerevolmente fino a formare delle colline simili a piccole scogliere che si sollevano fino a più di 2 m sopra il fondale marino circostante. Tali coralli probabilmente furono protetti dall'azione distruttrice delle onde di tempesta e dai grossi frangenti sia per la sufficiente profondità dell'acqua che per la protezione del bordo della piattaforma.

Dall'intenso lavoro di campagna non è emersa nessuna prova per confermare l'esistenza di una barriera coralligena nelle rocce oligoceniche dei Colli Berici. D'altra parte non si può escludere del tutto la sua esistenza più ad Est. In tal caso le lenti di coralli massici oligocenici e le rocce algali associate potrebbero essersi formate nel margine interno della barriera stessa.

Introduction

The Colli Berici, a cluster of conspicuous hills S of Vicenza, extending over an area of about 20×15 km, rise to more than 400 m above the Quaternary alluvium of the Po river plain. Besides a number of volcanic necks and very limited occurrences of quartz sandstone and tuffs, the bulk of rocks is represented by limestones of Tertiary and to a lesser degree of Cretaceous age.

Extensive outcrops of Oligocene limestones in the area locally yield a wealth of hermatypic scleractinians and skeletons of other shallow-water organisms. From local abundance of fossil coral material it has been commonly concluded that the rocks represent in part a fossil coral reef (Rossi & Semenza 1958, 1962; Coletti, Piccoli, Sambugar & Vendemiati dei Medici 1973, p. 12, Fig. 1), but this assumption has never been substantiated by more detailed investigations.

Also there has been little effort to make ecological interpretations of the coral rocks and adjacent fossil environments. With the exception of Rossi & Semenza (1958), no attempt has been made to outline reef tracts and different facies units. Nevertheless, the concept of a barrier-like coral reef at the ESE margin of the Colli Berici has been generally accepted and has never been contested in the literature.

The lack of more detailed information on the Oligocene coral rocks may be partly due to the almost impenetrable bush, covering vast areas, that often conceals facies relationships between neighbouring outcrops. Moreover, facies investigations

in the field are greatly hampered by wide-spread occurrence of thin caliche-like crusts on bare rock surfaces that make it difficult to distinguish between coral rocks and adjacent calcarenites except on freshly broken surfaces.

This preliminary report is the product of many months of field work. It presents some of our observations on coral distribution and facies relationships in order to modify the current concept of reef formation in the Colli Berici.

Geomorphology and geology of the area

Geomorphology

The interior of the Colli Berici exhibits a morphology of smooth rounded hills separated by dry valleys that are abruptly cut off at marginal escarpments, well above the alluvium of the surrounding Po river plain (Pianura padana). This relatively simple relief has been complicated by active valleys that have eroded their way back from the level of the plain into the interior of the area. Moreover, a pitted landscape surface, due to numerous dolines, together with a multitude of natural caves are good evidence for wide-spread karstic erosion. Along the ESE margin, the hills are bounded by a precipituous escarpment towards the plain. Short and narrow gorges have been cut back locally into it, thus forming high vertical walls that are spectacularly developed in the Oligocene rocks around the village of Lumignano (see ROSSI & SEMENZA 1958, Pl. 1–3).

Based on our observations, we suggest a two-phase development of the present landscape: The smooth rounded hills and dry valleys may well represent a paleorelief presumably of Mio-Pliocene age that, although modified, has been basically conserved in the interior of the area. It was active until a new and destinct uplift of the hills occurred relative to the surrounding plain, probably early in Pleistocene time. As a consequence of the considerable lowering of the drainage system, karstic erosion gave rise to the formation of dolines and caves. The uplift evidently produced the prominent escarpment towards the ESE and caused the development of the active valleys and gorges that lead down to the plain.

Geology

In the central Colli Berici the mostly well-stratified limestones form a recognizable anticlinal structure, the axis of which plunges towards the NE with a parallel syncline in the morphological depression of the Vicenza–Altavilla area. Correspondingly, the stratigraphically older rocks crop out at the SW end of the anticline, whereas relics of the highest strata, that comprise lowest Miocene, have been conserved in the syncline area (Fig. 1).

In surface outcrops of the Colli Berici the sedimentation can be traced from pelagic Upper Cretaceous limestones in "Scaglia Rossa" facies through equally pelagic Late Paleocene/Early Eocene sediments (PREMOLI SILVA & LUTERBACHER 1966, p. 1215–1218) to progressively more neritic deposits from Middle Eocene to Oligocene. This shallowing is emphasized by an increasing number of red algae (Melobesieae), Larger Foraminifera, bryozoans, etc. in the younger strata.

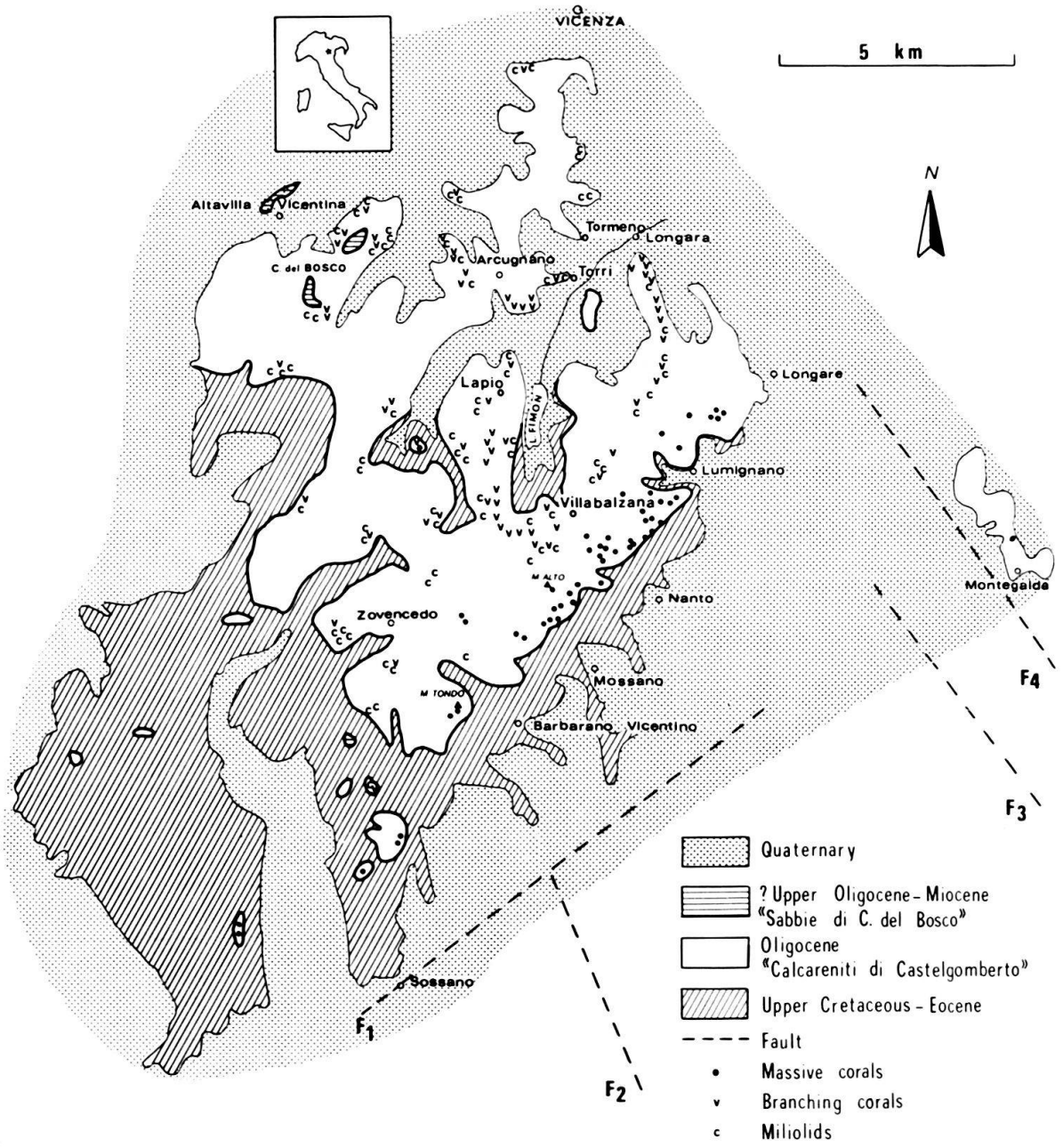

Fig. 1. Simplified geological map of the Colli Berici area. Outcrops of Oligocene massive coral facies, branching coral facies as well as occurrences of abundant miliolids have been indicated by special signatures. Volcanic rocks have been omitted on the map. Position of faults according to BENVENUTI & NORINELLI (1967, Pl. I).

Below San Donato and above Barbarano the first large colonies of massive hermatypic scleractinians have been found in beds as old as Late Eocene. This fact may well testify to a water depth of less than 100 m. The Late Eocene rocks are irregularly stratified and consist mostly of marly biocalcarenites with debris of Melobesieae and bryozoans more concentrated in certain beds or stratigraphical complexes than in others. The stratification has been disturbed locally by the activity of bottom currents that formed synsedimentary erosion channels (BOSELLINI

1964). The Middle to Late Eocene deposits comprise a paleontologically well-documented sequence of some 240 m of shallow-water carbonates (FABIANI 1915; SCHWEIGHAUSER 1953; UNGARO 1969).

Towards the end of the Eocene and in the lower part of the Oligocene sciaphile red algae became more common. During the Early Oligocene, intercalations of at least 2 thick complexes of melobesioid limestone were deposited along the SE scarp in the otherwise mostly well-stratified detrital carbonates. However, hardly any massive algal limestone could be found to the NW of the scarp in the central and western hills where a continuous series of mostly regularly bedded calcarenites is developed. The abundance of hermatypic corals in certain rock complexes indicates that the shallowing of the water progressed throughout Oligocene, and that the sea bottom certainly reached the euphotic zone at that time. The complete sequence of Oligocene sediments in the Colli Berici comprises a series of at least 220 m of shallow marine, platform carbonates.

The facies development in the Colli Berici during the Tertiary is very similar to that of the Lessini Orientali in the N. As a whole, both may be regarded as parts of the same sedimentary platform that existed from Eocene to Early Miocene time, separated today by the Quaternary alluvium of the Vicenza-Altavilla depression. The Oligocene limestones ("Calcareniti di Castelgomberto") are locally covered by at least 15 m of echinoid bearing, marine quartz sands and sandstones ("Sabbie di C. del Bosco"). The lower beds of the sands bear nummulites and therefore have been attributed to the latest Oligocene, whereas the higher strata are considered to be Early Miocene (FABIANI 1915, p. 57-58). These deposits form local erosional relics in the Vicenza-Altavilla syncline with exceptionally good outcrops in a quarry at C. del Bosco, Colli Berici.

Of considerable interest for regional facies development are the low hills of "Montegalda" some 5 km E of Lumignano. They are built of Oligocene calcareous deposits with locally abundant reef corals and volcanic rocks. Lithology, facies and stratigraphical position of the limestones seem closely comparable to the "Calcareniti di Castelgomberto" and indicate apparently an eastward extension of the Oligocene shallow-water platform of the Colli Berici.

On the other hand the geological make-up of the "Monti Euganei" some 10 km to the SE of the Colli Berici contrasts with the facies development described above. Besides a predominance of volcanic rocks, various marine sediments have been encountered that give evidence for deep water conditions from Jurassic up to Eocene and Oligocene (DIENI & PROTO DECIMA 1964; PROTO DECIMA & SEDEA 1966, 1970). Hence we have to state the important fact of an open oceanic facies development contemporaneous and in close proximity to the coralliferous shallow-water platform carbonates of the Colli Berici.

Coral formations of the Colli Berici

Progressive shallowing of the sea from the beginning of Oligocene time permitted the settlement of numerous hermatypic scleractinians on a sedimentary platform that extended from the Colli Berici in the S to the mountains of the Lessini Orientali in the N. Coral growth is not equally distributed over the whole platform, but shows

a distinctive horizontal and vertical variation. Sedimentation of calcareous detritus prevailed throughout the Oligocene, and over vast areas it seemingly hampered reef development to such a degree that many rock complexes are almost free of corals. Locally, however, and at certain stratigraphic levels, associations of reef corals become dense enough to be called coral formations. In the Colli Berici two remarkably different types of such coral formations have been recognized.

1. Lenses of massive reef corals

Lens-shaped to dome-shaped agglomerations of predominantly massive scleractinians have been found in a rather narrow band that follows the course of the ESE escarpment from Lumignano in the N to Sossano in the S. Their maximum extension to the W of the scarp is about 1.5 km. The bodies of coral rock reach vertical dimensions from 3 m to tens of meters and extend laterally from 10 m to more than 100 m. Some of the scleractinians attain diameters of over 0.5 m (see Fig. 2).

It has been observed near Lumignano and Monte di Nanto that dense coral growth may already commence some 10 m above the Eocene/Oligocene boundary, but more extensive lenses have been found only from about 50 to 100 m above. Those bodies of coral rock that we were able to locate, have been indicated in Figure 1 by black dots.

Fig. 2. Single hemispherical colony of *Montastrea* sp., about 1 m in diameter. This huge scleractinian grew in a patch of massive corals, surrounded by calcarenitic sediments. Oligocene rocks below Cà Bella at Monte di Nanto. Hammer for scale: 32 cm.

Unfortunately, erosional morphology of outcrops, together with weathering and the formation of crusts, generally does not permit direct recognition of the character of the weathered rock involved, and it is therefore a highly laborious task to delimit facies boundaries in the field. However, it has been found that coral rock occasionally weathers back more easily than detrital limestone. Thus, all the vertical walls near Lumignano so far examined, seem to consist entirely of calcarenitic and calcilutitic rocks with several intercalations of beds rich in Melobesieae and bryozoans. The bodies of coral rock have frequently been found in outcrops between or above these walls.

Locally, concentration of corals seems to have been dense enough so that neighbouring colonies were in direct contact. Under these conditions they coalesced to an interlocking reef frame-work. Marginally, however, coral growth became less coherent and the corals appear more or less widely isolated in the mostly calcarenitic matrix. Frequently isolated groups of scattered coral colonies can be found. The rocks grade laterally and vertically into coral-free detrital limestone.

Though stratification is seldom recognizable within this massive coral facies, a more or less clear bedding may be distinguished laterally at certain locations. Moreover, it is evident from over- and underlying parallel stratification that no significant build-up could have taken place which rose notably above the surrounding sediments. Consequently it must be concluded that the upward growth of such coral patches was only rarely able to keep pace with the rate of sedimentation. This conclusion does not contradict the fact that the growth rate of individual colonies evidently exceeded sedimentation to such a degree that they could grow unhampered to full size.

The scleractinians in these coral communities belong predominantly to hemispherical and flat massive colonies. Among these, *Antiguastrea, Actinacis, Montastrea, Porites* as well as meandroid genera have been collected frequently. A few branching forms are of minor importance.

Although the outcrops have been examined carefully, no clear vertical or lateral coral zonation could be recognized. Such a specific coral zonation is a common phenomenon in Recent coral reefs that are under the influence of waves (see GEISTER 1977). Therefore, it seems most likely that our corals lived below wave base or in a protected environment. It has been observed in the Colli Berici, however, that species diversity was greatest where coral growth was most exuberant. In scattered coral communities the fauna seems to have been mostly restricted to *Actinacis, Antiguastrea* and occasional *Porites*. A microfacies of inter-reef sediments locally shows microbreccias of intraclasts with numerous fragments of red algae and corals. This seems to be due to bioerosion mostly by boring organisms. No phenomena have been observed that might unequivocally be attributed to wave erosion. Among the Foraminifera *Asterigerina, Pararotalia, Discorbis* and some *Nummulites* are very common.

The lack of cross-bedding in adjacent calcarenites indicates that there was no lateral transport of sediment that might suggest a high energy environment. No ripple marks were found in these calcarenites that would indicate the influence of waves or currents.

The corals are frequently accompanied by rich growths of nodular, branching or foliaceous Melobesieae that in certain beds form the principal rock constituent. The red algae belong almost exclusively to the genera *Lithothamnium*, *Lithophyllum* and *Archaeolithothamnium* (see FRANCAVILLA, FRASCARI RITONDALE SPANO & ZECCHI 1970). The thalli, although mostly fragmented, are commonly embedded in a micritic matrix which indicates quiet depositional environments. The algae did not form any hard substrate and did not contribute to any frame-work growth. In these algal beds, selective weathering has produced conspicuous notches which are especially well developed today in the vertical walls around Lumignano (see ROSSI & SEMENZA 1958, Pl. II–IV). They are useful for correlating strata over longer distances and clearly indicate a regular stratification across all the vertical faces. The notches, therefore, give indirect evidence that the walls do not represent reef bodies as suggested by ROSSI & SEMENZA (1958, Pl. I–III, V) but that the rocks of the wall should be mostly indistinguishable from those of the adjacent slopes.

Important secondary contributers to the algal sediments are bryozoans, fragmented mollusks, echinoid debris and also Foraminifera. *Nummulites* and *Astigerina* have been found frequently, whereas *Chapmanina*, *Discorbis* and others are less common.

The excessive abundance of red coralline algae in certain beds as well as the accompanying fauna may indicate that the sediments have been deposited partly in close proximity to the sciaphile zone, where light conditions did not suffice to support growth of green algae and marine phanerogams. At least, similar Recent facies associations of the circalittoral stage (PÉRÈS & PICARD 1964, p. 87–90) that are found at present in the Mediterranean Sea commonly at depths between 25 and 40 m would support such an interpretation. This might be another possible indication for quiet and not too shallow-water conditions during growth of the coral patches. So, sedimentological as well as ecological evidence suggests that the corals lived well below wave base near the deeper limit of the euphotic zone.

It is an interesting fact that these coral patches and the algal limestones have been found almost exclusively along the ESE margin of the hills. In the interior of the Colli Berici the respective rocks are mostly calcarenitic with no significant coral constituent and with only a minor amount of algal debris. Moreover it must be noted that here miliolids clearly dominate the foraminiferal associations which would be indicative of protected or at least more restricted platform conditions.

It has generally been held in literature that there was a barrier reef roughly coinciding in position with the ESE scarp. Based on our field observations we want to stress the fact that we did not find any direct indication of such a structure. We found numerous coral patches in this area aligned roughly in ESE direction. But the bodies of coral rock are not coalescent at all and apparently without exception they are separated from each other by areas of purely detrital sedimentation.

It seems most likely to us that the vertical wall faces at Lumignano, delineated by ROSSI & SEMENZA (1958, Pl. V) as bioherms, are the product of pure geomorphological processes. The cliffs formed when the small gorges near Lumignano cut their way back from the plain in the Oligocene rocks of the hills. They often are delimited on top by the surface of the old (? Pliocene) landscape and at the bottom generally by one of the more conspicuous of the above mentioned notches.

2. Coral carpets

The upper half of the Oligocene section is represented in the central and western Colli Berici by a series of distinctly bedded and more massive carbonate complexes, each generally several meters thick. In some of these complexes corals are widely distributed but vary in abundance from location to location. The scleractinians formed isolated coral thickets as well as extensive, coherent coral carpets, i.e. biostromes built predominantly by in situ skeletons of branching reef corals.

Bedding of the rocks is mostly well recognizable in areas where coral growth was sparse, but it generally becomes indefinite laterally in areas of denser coral populations. Coral carpets may attain thicknesses of a few meters and a lateral extension of at least several 100 m. Locally they swell considerably to form reef-like mounds that rose up to more than 2 m above the surrounding sea floor (Fig. 3).

Among the reef corals, branching species clearly dominate, *Caulastrea* and ramified *Porites* being most abundant, whereas *Euphyllia*, *Stylophora* and *Acropora* are of minor importance. Massive scleractinians are less frequent and belong mostly to *Astreopora*, *Antiguastrea* and *Montastrea* with some massive *Porites* and occasional meandroid forms.

On the whole, branching corals appear particularly well adapted to the adverse effects of rapid sedimentation and shifting sand, because with most of their living tissue they grow well above the level of irritating sedimentation. Moreover, extraor-

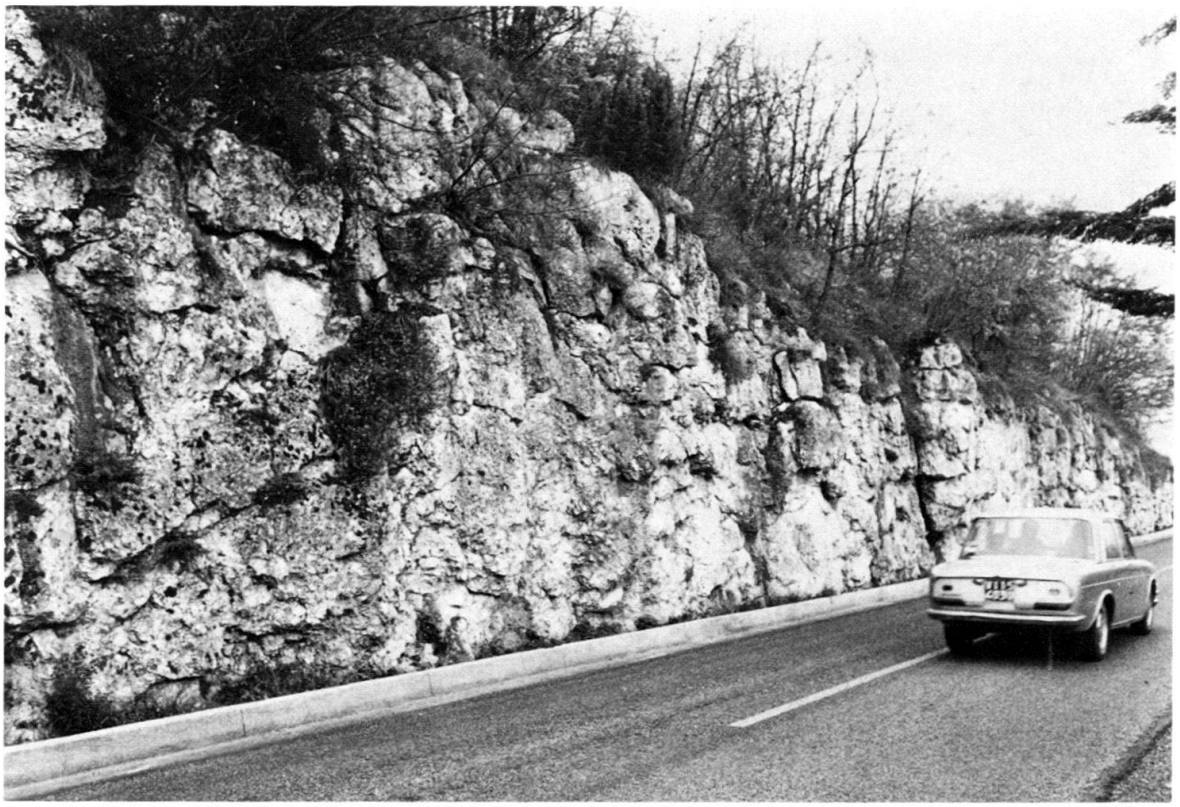

Fig. 3. Reef-like mound (left) that formed by local swelling of Oligocene coral carpet. Road cut between Torri and Arcugnano, some 200 m above kilometerstone 4 of provincial road Tormeno–Arcugnano (southernmost branch).

dinarily high distal growth rates of the ramifying colonies keep the vital parts of the corals above the sea floor. Grouping in coral thickets and coral carpets, on the other hand, assures a certain stabilization of the single colony on sandy bottom against occasional wave action, because neighbouring corals tend to support each other.

Many colonies, particularly in the more isolated coral thickets, are seemingly unbroken and have been embedded in situ in the matrix. This phenomenon could be observed even in the more fragile of the branching scleractinians such as *Caulastrea* and *Porites*. The processes of embedding, therefore, must have been fast enough to prevent the break-down of the colony by bioerosive processes. It should also be kept in mind that rapid sedimentation could have covered entire living colonies. On the other hand sedimentation rates that, at least locally, exceed growth rates of fast-growing branching corals (up to 10 cm per year), would seem highly unlikely, even under tropical shallow-water conditions. It appears more probable to us that the corals acted as sediment traps in accumulating occasional shifting sands or sediments removed from elsewhere by currents. This assumption is supported by the irregular, ripple-like structure of many calcarenites. The latter phenomenon is most conspicuous in certain well-bedded coral-free sediments.

On the other hand, the abundance of unbroken fragile coral skeletons seems to indicate that the influence of destructive storm waves was negligible over most of the platform. This would point towards rather protected conditions of growth in not too shallow water. Protection from high swell and storm waves need not have come from a protective barrier, but could have been attained by the presence of a broad seaward extension of the platform. No conspicuous coral zonation has been seen over the entire area that might indicate appreciable and steady wave influence on the sea floor. In adjacent sediments porcellaneous foraminifers, in particular miliolids and soritids, have been frequently found, with occasional intercalations of beds rich in nummulites, echinoids, gastropods or bivalves. The miliolids may become extremely abundant at many locations, both with and without coral growth. This observation also indicates rather restricted shallow platform conditions.

Faunal distribution as well as sedimentological observations seem to indicate that the environment was shallow marine, probably above the base of storm waves but sufficiently protected against their disastreous effects. The corals lived rather sheltered from normal wind waves and oceanic swell. The ecological conditions seem to be closely comparable to those of certain modern coral patches on the level floor of shallow lagoons. Such patches may develop to extensive carpets that hardly rise above the surrounding sediments in ten or more meters of water depth. Within such carpets, accumulation of detritus and coral growth appear to be equally important phenomena. The lack of a sharp antecedent topography (PURDY 1974) on the Oligocene sedimentary platform did not permit a clear separation into lagoonal and reef environments, as is the case in most contemporaneous coral reef complexes. No indication of local emergence of the coral carpets has been found in the region.

About three to four different well-developed coral carpets have been recognized at different levels in the Oligocene succession. However, correlation with distant outcrops is generally impossible, so their number may be somewhat higher. Good examples have been found in road cuts N of Lapio, between C. Nogarazza and Valmarana, between S. Gottardo and Perarolo and from Lapio to Villabalzana and

Lóngara along the road that leads around the Lago di Fimon in the hills. The most instructive outcrops are found in cuts on the provincial road that leads from Torri to Arcugnano, some 2 km before reaching Arcugnano (Fig. 3). Here the reef-like bodies within the carpets are especially well exposed and it is clearly recognizable that they have formed self-supporting structures that appeared as topographic crests on the sea floor. It seems that these are the only structures within the Colli Berici to show certain structural, topographical and ecological features that are prerequisites of genuine coral reefs.

Discussion

The divergence in facies development since Middle Eocene time between the Colli Berici and the Monti Euganei can most obviously be explained by a more rapid subsidence of the latter area relative to the rather stable Berici/Lessini Orientali platform. Therefore, a major fault or a series of faults would be expected that is at present covered by the Quaternary alluvium of the Po river plain (Pianura padana). Recent geophysical investigations in the area (BENVENUTI & NORINELLI 1967, Pl. I) were in fact able to demonstrate the existence of at least one major fault that runs from Sossano in a northeasterly direction and which could have caused the ESE escarpment of the Colli Berici of today. The Oligocene coral limestones of Montegalda, on the other hand, seem to indicate that the principal break-off was farther to the SE. However, this assumption might not be valid because the Montegalda corals could have grown on an isolated Oligocene seamount. Consequently, the localization of this important line of deplacement and the knowledge of facies development on either side of it could have major repercussions on the interpretation of the coral formations in the Colli Berici.

The outline of Recent reefs seems to be frequently determined by a distinct antecedent topography (PURDY 1974). On a larger scale, extensive barrier reefs may be linked to submarine escarpments which have been formed by major faults, as is exemplified by the Recent British Honduras barrier reef (STODDART 1962, p. 7–10, Fig. 5).

In these cases the reefs appear to have formed by intensive coral colonization along the outer margin of the raised fault block, evidently favoured by better aeration of water, currents rich in nutrients, favourable light conditions and often less interference by sediments, whereas pelagic sedimentation prevailed on the adjacent depressed fault block.

It should be kept in mind that similar conditions might have existed in the studied area during Oligocene time. Probably subsurface investigations of the Oligocene facies development on either side of the decisive fault would be required to shed light on this problem. Evidence from geophysical investigations (BENVENUTI & NORINELLI 1967), however, suggests that the basement below the alluvium is mostly of Cretaceous age. Moreover, drilling for thermal water carried out on the alluvial plain during recent years indicates that at the locations drilled the Tertiary has been eroded completely, so that Quaternary alluvium covers Cretaceous rocks ("Scaglia") (personal communication from Dr. Gp. De Vecchi to S. Ungaro). It is hoped that future drilling will finally bring up Oligocene samples that may place the discussion on a firmer basis.

Until this evidence is at hand it should not be entirely ruled out that an Oligocene barrier reef, associated with a fault, developed somewhere midway between the Berici and the Euganei. Its relics, if preserved, should be composed of true coral reef rocks. If this case should be proved, the lenses of Oligocene massive reef corals and associated algal rocks found today along the ESE escarpment could have developed in the deeper part of the lagoon near the inner margin of the barrier. Under these circumstances the coral carpets would have extended over the bottom of the shallower inner lagoon.

No unequivocal solution of this problem is presently at hand. Although we now tend to believe that a true Oligocene barrier reef was nowhere developed in or around the Colli Berici, no firm statements can be made and this assumption will remain on a somewhat speculative basis until more and better evidence can be presented. Detailed field investigations will continue in the future to gather more informations pertinent to this particular problem.

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