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FIELD-TRIP GUIDEBOOK

Some Carbonate and Clastic Successions of The External Dinarides:

Velebit Mt.
Island of Rab

Zagreb, September 1999.

Middle Permian reef complex on the Velebit Mt.

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The studied section is located near Baske Ostarije on the Velebit Mt., and it is also known as Salopek's "second zone of black limestones, Pv2" (Salopek 1942)(Fig.l). These black limestones have attracted researchers by their rich fossil content, so several paleontological papers were published by Salopek (1942) and Sremac(1984,1988,1991), whereas sedimentology of these limestones was studied by Marjanac&Sremac (1988). Their lateral extent is quite significant (Fig. 2), and on Salopek's map they reach 8 km in strike-wise length.

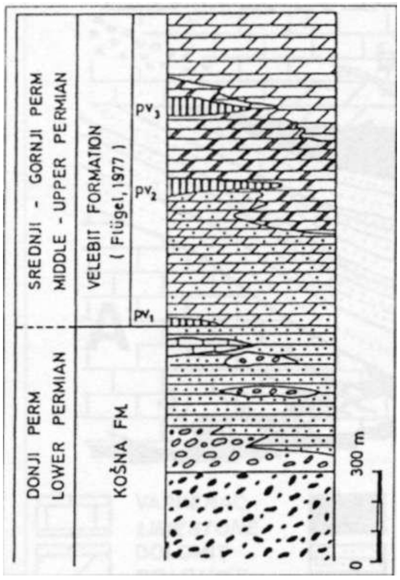

Fig. 1. Geological column of the Velebit Mt. Permian deposits. After Kochansky-Devide (1979)

Limestones of the "second zone" (stratigraphically they belong to ***Neoschwagerina craticulifera*** zone, Kochansky-Devide 1965) occur in thickness of 12 m, and comprise 3 lensoid carbonate bodies (Fig. 3) which are partly divided by calcarenites and shales, and partly amalgamated.

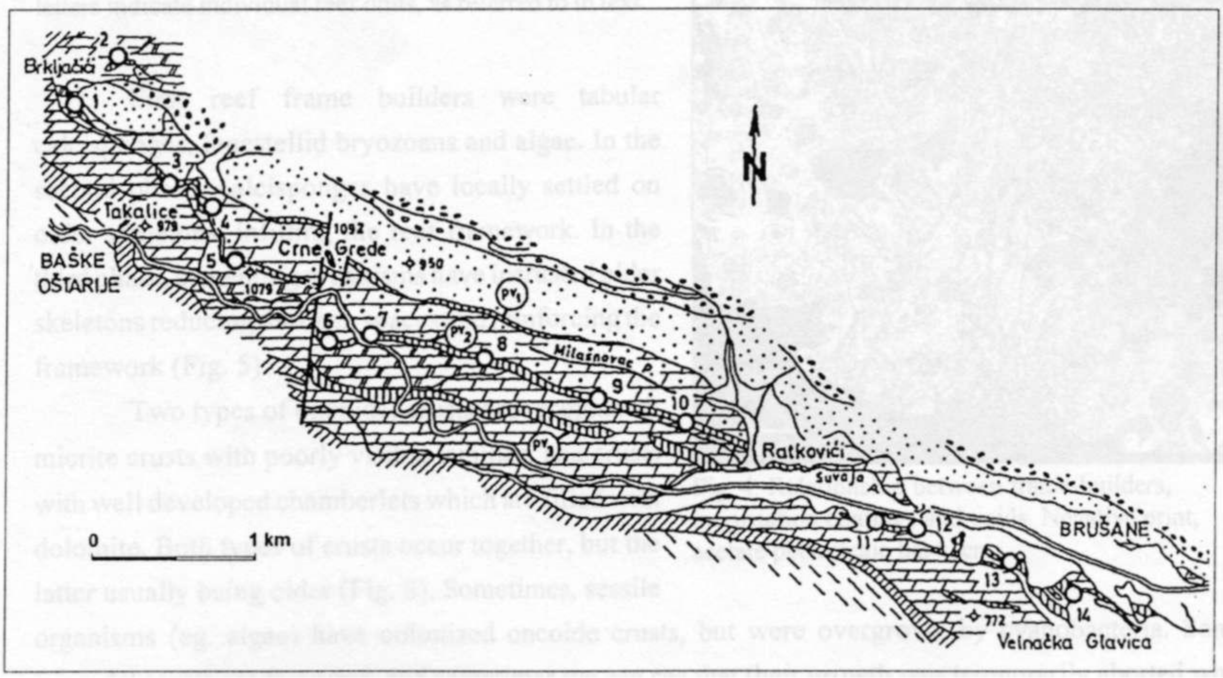

Fig. 2. Geological map of the BaŠke-OŠtarije - Brusane environs.The studied outcrop is indicated by no. 7. After Salopek (1942).

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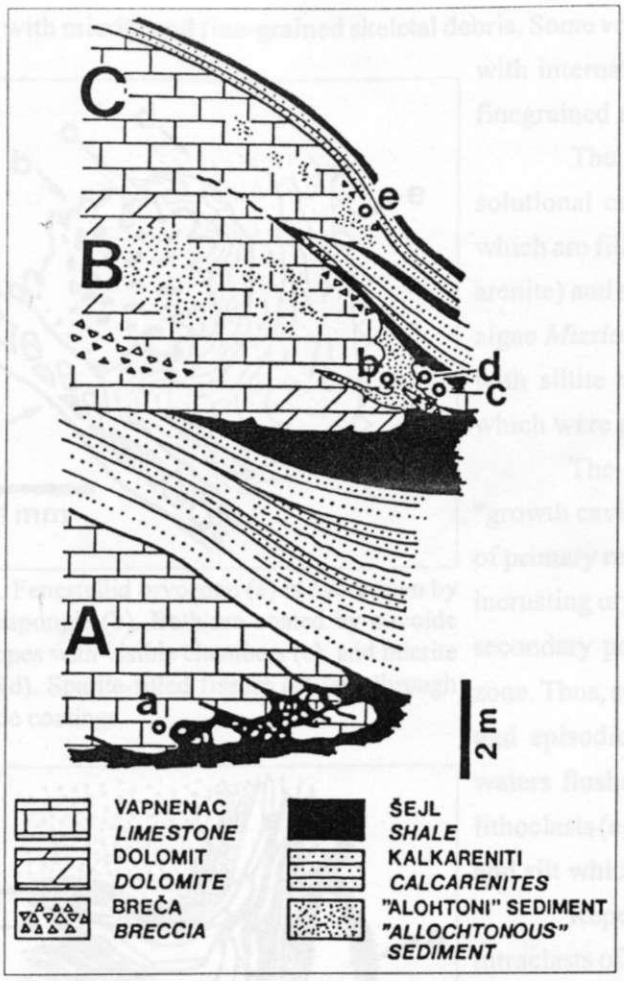

Fig. 3. Vertical section through the reef complex. Bold letters indicate individual reef units, as referred to in text.

The studied black limestones are bluish-black coloured bituminous biomicrites (framestoncs) which overlie some 10 m thick black shales with thin calcarenite interbeds. However, the limestones are light-gray coloured where dolomitized. Primary structures- of limestones are generally well visible, but in dolomitized parts they are visible only sporadically.

The substrate made of skeletal debris and muddy matrix was first colonized by tabular calcisponges, fenestellid bryozoans and algae. Here also occur skeletal debris composed of calcareous algae such as ***Mizzia*** and ***Permocalculus,*** rare gastropods and crinoids. These organisms were incrusted by thick oncoidal (cyanobacterial) crusts (Fig. 4).

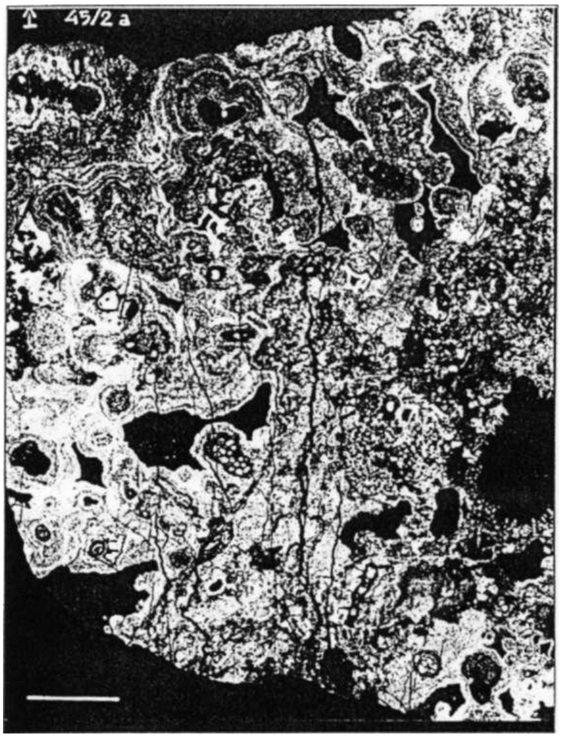

Fig. 4. Relationship between frame-builders, incrustation coatings and voids. Negative print, acetate peel. Scale bar=lcm.

First reef frame builders were tabular calcisponges, fenestellid bryozoans and algae. In the second phase, calcisponges have locally settled on older skeletons, infilling the reef framework. In the third phase, cementing organisms have incrusted older skeletons reducing the open spaces and reinforcing the framework (Fig. 5).

Two types of oncoidal crusts are recognized; micrite crusts with poorly visible laminae, and crusts with well developed chamberlets which are filled with dolomite. Both types of crusts occur together, but the latter usually being older (Fig. 6). Sometimes, sessile organisms (eg. algae) have colonized oncoide crusts, but were overgrown by cyanobacteria. Some oncoidal crusts are fractured, and sometimes we can see that their growth was temporarily aborted what may be a consequence of early lithification, but also short-lasted emersions.

The reef framework made of incrusted frame-builders hosted numerous reef-dwellers such as foraminifers, calcareous algae, gastropods, and brachiopods. However, incrustants make the most of the rock bulk volume, so the primary reef porosity was significantly reduced. The remaining interspaces were filled with micrite and fine-grained skeletal debris. Some voids in the reef framework are geopetally filled with internal sediment composed of "allochtonous" silt, finegrained arenite, and sparry calcite (Fig. **4).**

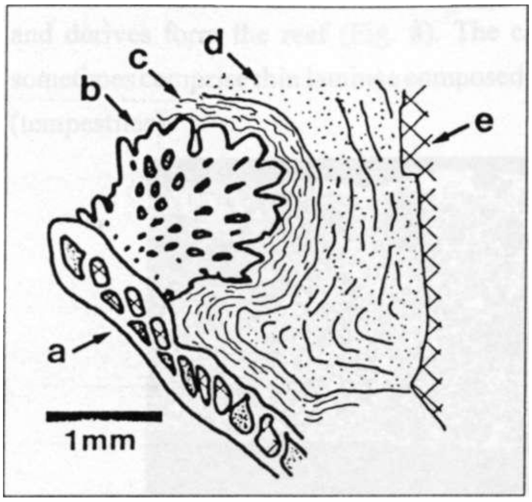

Fig. 5. Fenestellid bryozoan (a) is overgrown by a calcispongia (b). Both are coated by oncoide envelopes with visible chambers (c), and micrite coats (d). Sparite-filled fissure (e) cuts through oncoide coatings.

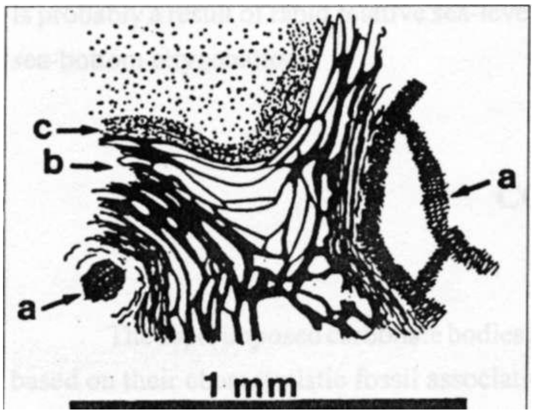

Fig. 6. A detail of oncoide coatings. Skeleton nuclei (a) are coated first by oncoides with chamberlets(b) and then by micrite envelopes (c).

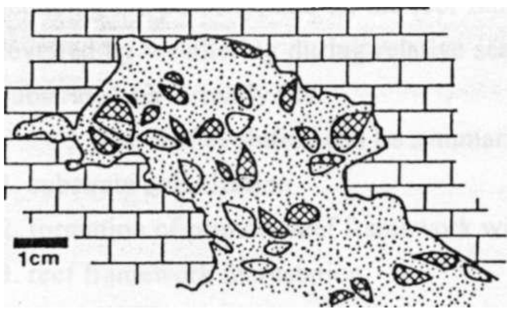

Fig. 7. Solutional cavity was inhabitated by small brachiopods, and infilled with "allochtonous" silt.

The reefal limestones locally contain large solutional cavities, some more than 30 cm in diameter, which are filled with laminated finegrained debris (silt and arenite) and scattered larger skeletal debris (eg. calcareous algae ***Mizzid)*** and lithoclasts. One larger cavity was filled with siltite with numerous small brachiopods, some of which were geopetally filled (Fig. 7).

The genesis of cavities in reefs is twofold; the "growth cavities" (reef primary porosity) are the remnants of primary reef framework porosity and occur between the incrusting organisms, whereas the solutional cavities (reef secondary porosity) originated by corrosion in a vadose zone. Thus, solutional cavities document early lithification and episodic exposures of the reef, when atmospheric waters flushed and corroded parts of the reef, providing lithoclasts (eg. limestones with ***Mizzid),*** finegrained arenite and silt which infilled some of the cavities and voids.

Repeated exposure episodes are documented by intraclasts of "allochtonous" silt, which also occur in some geopetally filled cavities. Laminations in internal sediment document gradual infilling and tractional sorting of debris.

The reef top surface of individual sedimentary bodies at the outcrop studied is characterized by breccia composed of clasts of early lithified limestones (eg. limestones with ***Mizzia,*** oncoidal limestone) and skeletal debris. Here also occur fragments of large bivalve ***Tanchintongia ogulineci*** (which were found also in some lithoclasts). These lithoclasts were formed by weathering of early lithified sediments, whereas the skeletal debris probably originated by biodestruction (predating fish, endoskeletal borings). The reef top is sometimes characterized by a relief represented by protruding incrusted organisms, which was filled with silt and mud.

Laterally, the role of skeletal debris in finegrained matrix increases. In that way the body C laterally turns into a thin calcarenite bed. The body A, however, laterally completely ends and is bound by shale rich in scattered cobble-sized lithoclasts and incrusted organisms. Locally, there occur breccias which form channelized beds (eg. laterally to the body B). This lateral debris accumulations were a substrate for subsequent colonization by pioneering organisms, and their incrustants.

The reef bodies are onlapped and overtopped by calcarenites (floatstones) with more-or-less well developed normal grading, sometimes cross-laminated, and sharp tops. The debris is generally skeletal and derives form the reef (Fig. 8). The calcarenites are interbedding with thin black shales, which sometimes comprise thin laminae composed of ***Mizzia*** skeletal debris. These are interpreted as storm-beds (tempestites),

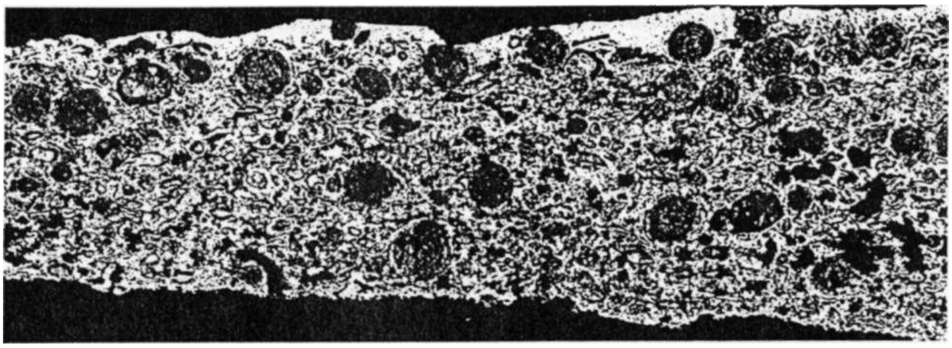

Fig. 8. Calcarenite with scattered fusulinid foraminifers. Negative print, acetate peel.

The reef bodies **A** and **B,** as well as their related calcarenites are laterally partly eroded, so the reef-cores become amalgamated.

The reef growth was finally aborted when the reefs were buried beneath thick black shales. This is probably a result of rapid relative sea-level rise, but we cannot rule-out some other causes, such as low sea-bottom oxygenation.

CONCLUSIONS

The superimposed carbonate bodies are interpreted as ecological and morphological reef complex, based on their characteristic fossil association, body geometry, and characteristic internal organisation. The superposition of the reefal bodies and the sediments studied document rapid sea-level changes, so that reef vertical growth was aborted during relative sea-level falls, and resumed during sea-level rise.

Subaerial weathering created debris which was deposited in internal cavities and voids - further reducing the porosity, and on the reef flanks. The reef main body, as well as the flanking debris was levelled by weathering during relative sea-level falls, so that at the time of renewed colonization the substrate was virtually flat.

The reef evolution can be summarized in 7 phases:

1. substrate colonization
2. formation of primary reef framework with dwellers
3. reef framework incrustation
4. early lithification
5. shallowing (relative sea-level fall) followed by weathering and erosion
6. infilling of secondary reef porosity
7. deepening (relative sea-level rise) followed by recolonization (or final burial as after reef body C)

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