Carbonate Platform Environment from the Middle to Late Permian: Palaeozoic Sediments of the Central Velebit Mt. (Croatia)

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1. Introduction to Stop 6

The Upper Palaeozoic tectonic belt of the Mt. Velebit and Lika region (Fig. 1 in the Introduction to this field trip) represents the best known and most completely developed Palaeozoic area in Croatia. Sediments exposed here range from the Pennsylvanian (Moscovian) to the Late Permian in age (Fig. 6.1). Carbonate sedimentation took part sporadically during the Carboniferous and Early Permian. Intensive tectonic uplift at the beginning of the Middle Permian caused the formation of prominent relief and its rapid erosion, followed by sedimentation of terrigenous molasse sediments.

After the phase of instability, lowering of the relief enabled the stabilization of the area and formation of carbonate platform environment that existed until the end of Permian. Rapid production of carbonate material resulted in more than 900 m of carbonate sediments, dolomites and limestones, rich in diverse and numerous fossils from Middle to Late Permian age (SALOPEK, 1942; KOCHANSKY-DEVIDE, 1965; RAMOVŠ et al., 1989)

Lengthy carbonate sedimentation began after deposition of the red sandstones, with the black limestone of the Eoverbeekina salopeki, zone which can be observed west of Brušane village (near Gospić, central Croatia – Fig. 1 in the Introduction to this field trip). Limestones contain large gastropods (Platystoma, Bellerophon), cephalopods (Orthoceras) and a typical microfauna (Eovrebeekina, Sphaerulina, Staffella). Limestones are overlain by an approximately 300 m thick sequence of grey "spotted" dolomites. White spots represent recrystallized algal, foraminifera1 and microfossil skeletons, predominantly of dasycladacean Mizzia, accompanied with Eovebeekina, Staffella, Neoschwagerina, Waagenophyllurn, Bellerophon, Pleurotomaria, Orthoceras and Edmondia.

The second limestone belt Neoschwagerina *craticulifera,* zone is extremely rich in macrofossils. Numerous brachiopods (45 taxa), predominantly spiriferids, enteletids, productids and oldhaminoids, including several endemic species,, the aberrant bivalve Tanchintongia, calcisponges, bryozoans and gastropods have been collected from the area of Brušane and Baške Oštarije. Foraminifera: (Neoschwagerina, Dunbarula, *Nankinella,* Schubertella, Glomospira, Globivalvulina, etc.) and calcareous algae: (Mizzia, Vermiporella, Gymnocoditim, *Permocalculus* and many other taxa) are extremely abundant. Small patch-reefs produced by calcisponges, bryozoans, cyanobacteria and/or *Tubiphytes* have been found in this horizon (SREMAC, 1991).

The middle and uppermost limestone zones are separated, or at some places, replaced with light grey crystalline dolomite ("Schwagerina"-dolomite sensu SALOPEK, 1942) with Mizzia, Likanella, *Salopekiella,* Goniolinopsis, Neschwagerina, Kahlerina, Dunbarula and gastropods. Fauna from the lowermost limestone zone also occurs sporadically (Stafella, Eoverbeekina). In some parts of the basin, sedimentation of so-called "transitional dolomites" (sensu SALOPEK, 1942) or "early diagenetic supratidal dolomites" – TIŠLJAR et al., 1991), with scarce fossils, had already begun in this period (for more sedimentological characteristics see Stop 5 in Field trip P7 – ALJINOVIĆ et al., this Vol.).

The uppermost limestone zone was named after the dominant fusulinid species – Yabeina syrtalis Zone, although specimens of Yabeina also occur in the middle limestone horizon. Differences in microfossil assemblages are not very distinct from the middle zone, but some new macrofossils occur in the Yabeina-zone, such as brachiopods (Derbya, Streptorhynchus, Orthotetes) and gastropods (Temnocheilus). Dense "transitional" dolomites (sensu Salopek), or "early diagenetic supratidal dolomites" (TIŠLJAR et al., 1991) are well bedded and rather poor in microfossils. In the lower portion of this sequence, Permian microfossils, predominantly gymnocodiaceans, have been found. The uppermost portion contains small foraminifera typical for stressed environments. A continuous transition from the Upper Permian to the Lower Triassic, followed by an increase in the clastic component in dolomites, has been indicated by previous authors (SALOPEK, 1942; RAMOVŠ & KOCHANSKY-DEVIDE, 1981). Nevertheless, a lack of index species in the uppermost dolomite beds leaves the question of the position of the Permian–Triassic boundary open.

2. Observation stop: Paripov Jarak near Baške Oštarije village (central Velebit Mt.)

In the area of the BruSane and Baške OStarije villages, in the central part of the Velebit Mt., dolomite–limestone sediments of Middle and Upper Permian are well developed. Three zones of black limestones can be clearly

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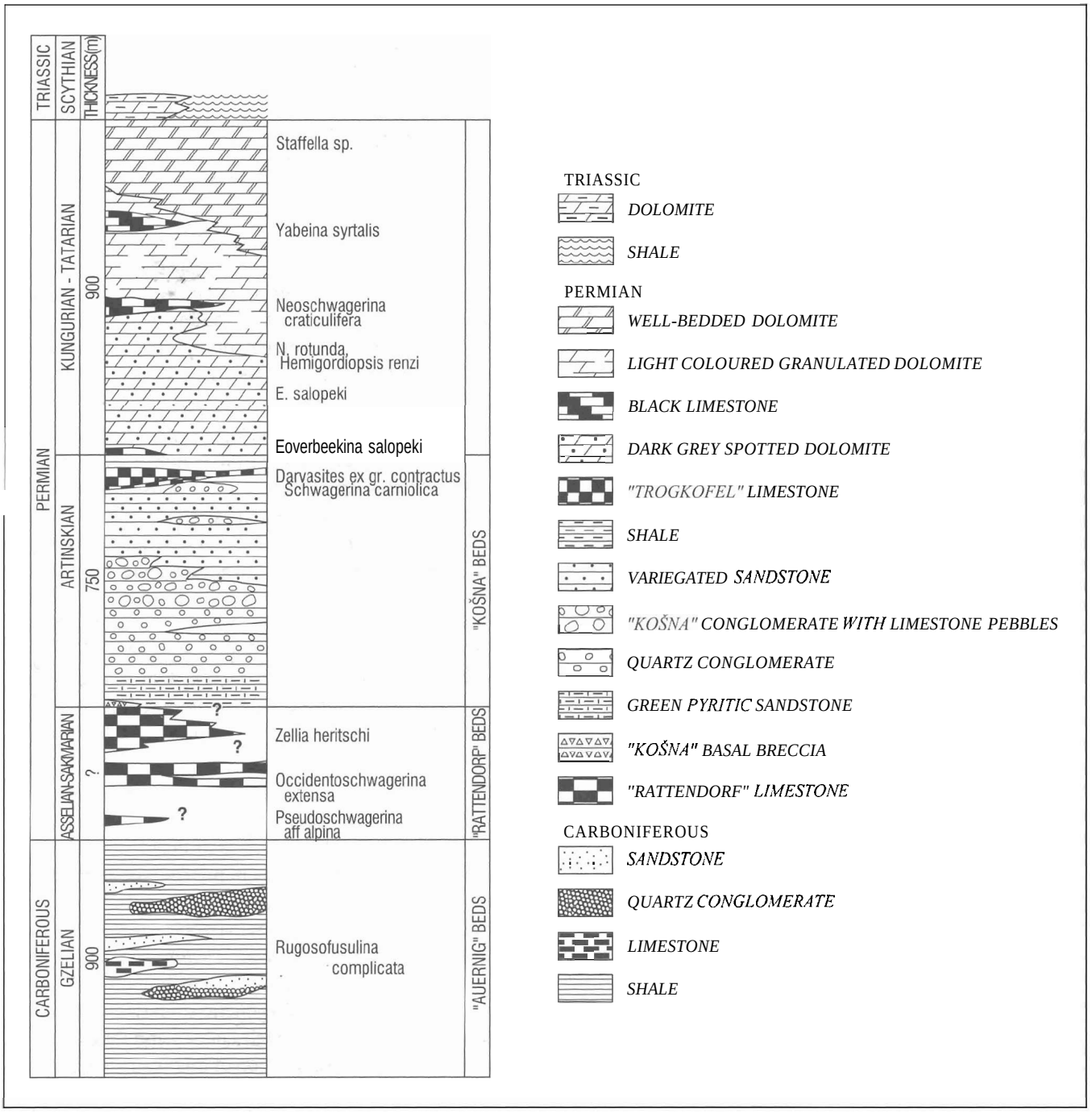

Fig. 6.1 Geological column of the Velebit Mt. Permian deposits (after RAMOVŠ et al., 1990)

distinguished, containing numerous well preserved micro- and macrofossils. The observation point is located near Baške Oštarije on Velebit Mt., also known as "Salopek's second zone of black limestones, pv2". These black limestones have attracted researchers due to their rich fossil content and interesting sedimentological features (KOCHANSKY-DEVIDE, 1965; SREMAC, 1991; MARJANAC & SREMAC, 2000). During sedimentation of these limestones (Neoschwagerina craticulifera zone), the dominant environments were algal meadows of dasycladaceans and gymnocodiaceans. At several places on the platform mound structures were formed. Among them, there is an interesting patch-reef which is today well-exposed along the Gospić–Karlobag road.

Three phases of reef formation can be distinguished (A–C), and lentoid carbonate bodies were divided by clastic sediments – calcarenites (reef debris) and shales (Figs. 6.2 and 6.3).

2.1 Description of the reef complex

The bluish-black limestones are bituminous biomicrites (framestones), which overlie some 10 m thick black shales with thin calcarenite interbeds. The dolomitized parts are light grey in colour (Figs. 6.2 and 6.3).

The substratum, composed of skeletal debris and muddy matrix was first colonized by tabular calcisponges,

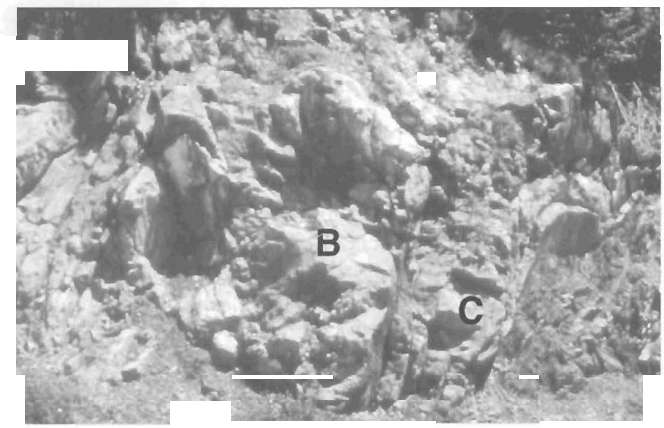

Fig. 6.2 Patch reef in the Paripov jarak near the Baške Oštarije village, along the Gospić–Karlobag road (after SREMAC, 1991).

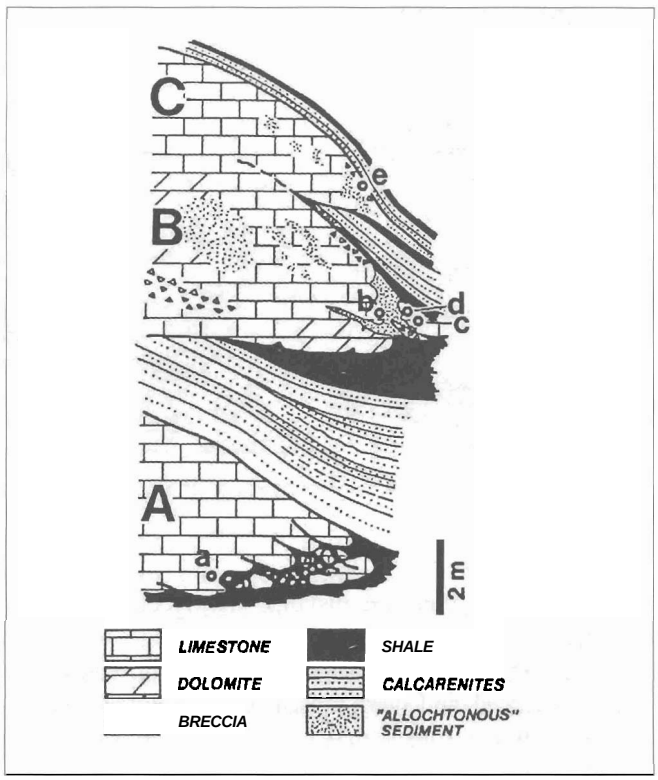

Fig. 6.3 Vertical section through the patch-reef complex in the Paripov jarak near the Baške Oštarije village along the Gospic–Karlobag road (after SREMAC, 1991). Bold letters indicate individual reef units, as referred to in the text.

fenestellid bryozoans and algae. Debris composed of calcareous algae such as *Mizzia* and *Permocalculus,* rare gastropods and crinoids are also present. Thick oncoidal (cyanobacterial) crusts coat the organisms.

The first reef frame builders were tabular calcisponges, fenestellid bryozoans and algae. Two types of oncoidal crusts can be recognised: micrite crusts with poorly visible laminae, and crusts with well developed chamberlets which are filled with dolomite. Sometimes sessile organisms colonized oncoid crusts, but were later overgrown by cyanobacteria.

The reef framework composed of incrusted frame-builders hosted numerous reef-dwellers such as foraminifera, calcareous algae, gastropods, and brachiopods (Fig. 6.4). The primary porosity was reduced by this process. The remaining inter-space is filled with micrite and fine-grained skeletal debris. Some voids in the reef framework are geopetally filled with internal sediment composed of carbonate silt, fine-grained calcarenite and sparry calcite.

The reef limestones locally contain large solution cavities (some more than 30 cm in diameter) filled with laminated fine-grained debris (carbonate silt and calcarenite), scattered skeletal debris and lithoclasts.

The genesis of the reef cavities is twofold; the "growth cavities" are remnants of primary reef framework porosity, and "solution cavities" developed within the vadose zone during episodic exposures and atmospheric water flushing.

The reef top surface of individual sedimentary bodies is characterized by breccias composed of clasts of early-lithified limestones and skeletal debris. Large bivalves *Tanchintongia ogulineci* are also present. The reef top relief consists, in places, of protruding incrusted organisms, filled with silt and mud.

Laterally, the role of skeletal debris in fine-grained matrix increases, and the body **C** laterally turns into a thin ca'lcarenite bed (Fig. 6.3). The body **A,** however, ends laterally, bounded by shale, rich in scattered cobble-sized lithoclasts and incrusted organisms. Locally the breccia forms channelized beds (eg. laterally to the body B) as a substrate for subsequent colonization by pioneering

Fig. 6.4 *Martinia velebitica* in the sponge cavity. The reef framework made of encrusted frame-builders hosted numerous reef-dwellers such as foraminifera, calcareous algae, gastropods, and brachiopods (after SREMAC, 1991).

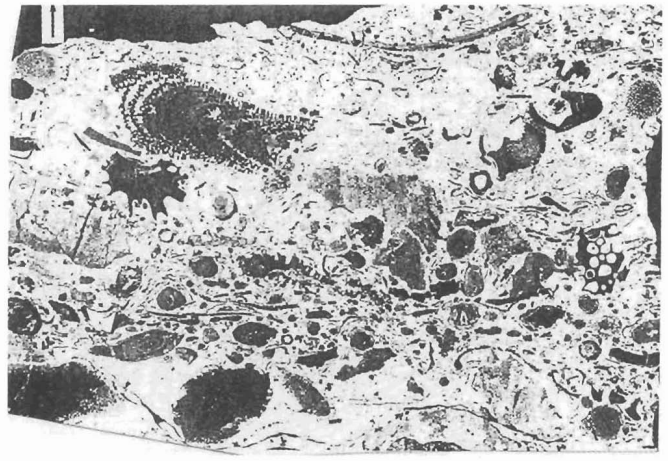

Fig. 6.5 Floatstone with unsorted reef debris (after SREMAC, 1991).

organisms, and their encrustants. The reef bodies are onlapped by calcarenites (floatstones, Fig. 6.5) with more-or-less well developed normal grading, sometimes cross-laminated, and sharp tops. The calcarenites are interbedded with thin black shales, interpreted as storm-beds (tempestites).

The reef growth was finally aborted, and the reefs buried beneath thick black shales. This was probably a result of rapid relative sea-level rise.

2.2 Short scenario of reef building events

The reef evolution can be summarized in 7 phases:

1) substrate colonization;
2) formation of primary reef framework with dwellers;
3) reef framework encrustation;
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).

The Palaeozoic sediments of the Velebit Mt. can be considered as a foundation of the later carbonate platform environment, subsequently developed, here and elsewhere in External Dinarides in the course of Mesozoic time.

3. References

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