

The living environment of the Cretaceous fauna in the Northwestern Dinarides

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(manuscript received June 8, 1982
accepted December 2, 1982)

KEY WORDS — Rudistae, Reefs, Cretaceous, NW-Dinarides, Yugoslavia.

ABSTRACT — Important for Cretaceous organisms in the southwestern part of the northwest Dinarides is a carbonate platform which was accompanied in the northeast by a pelagic turbiditic flysch myogeosynclinal trough. This trough was rimmed on its northwestern side by an island arc beyond which were situated the lagoonal area and, still farther, the land. The carbonate platform was in existence since Triassic, and began to break in parts at the end of Cretaceous. According to recent authors, the carbonate platform was represented by the Adriatic plate which was moved under the influence of the African craton towards the east and northeast. Due to collision of the Adriatic and Pannonian plates subduction phenomena occurred, as well as uplifting of marginal parts of the Adriatic plate. According to Polšak, these marginal parts emerged also above the sea level, as indicated by bauxite deposits, or formed shallow thresholds on the sea bottom. In parts covered by shallow seas, conditions were favorable for the appearance of the reef fauna, which is considered in the present study.

RIASSUNTO — [L'ambiente di vita della fauna cretacea nelle Dinaridi nordoccidentali] — Per gli organismi cretacei della parte sudoccidentale delle Dinaridi nordoccidentali fu molto importante l'esistenza di una piattaforma carbonatica, accompagnata a Nord-Est da un solco miogeosinclinale con flysch torbiditico pelagico. Questo solco era orlato a Nord-Ovest da un arco di isole, dietro il quale si estendeva un'area lagunare e, più oltre, la terra ferma. La piattaforma carbonatica esisteva fin dal Triassico e cominciò a suddividersi alla fine del Cretaceo. Secondo gli autori recenti la piattaforma carbonatica era rappresentata dalla placca adriatica, che si spostava verso Est e Nord-Est sotto la spinta del cratone africano. In seguito alla collisione delle placche adriatica e pannonica si svilupparono fenomeni di subduzione ed il sollevamento delle parti marginali della placca adriatica. Secondo Polšak queste parti marginali emersero dal mare, com'è indicato da depositi bauxitici, o formarono aree di poca profondità sotto il livello marino. Le condizioni di mare sottile furono favorevoli all'insediamento di una fauna di scogliera.

Lo sviluppo di scogliere zoogeniche può essere osservato lungo il margine della piattaforma carbonatica a partire dal Giurassico superiore nella fascia Trnovski Gozd - Gorjanci. Esse sono formate da idrozoi e più rari coralli e chetetidi. Quasi nella stessa area si estesero nel Cretaceo bioherme e biostrome di rudistidi. In esse la fauna di rudiste si sviluppava con individui concrescenti sulla base rocciosa, strettamente addossati l'un l'altro, con sostegno reciproco. La fauna era data da varie specie di radioliti e di hippuriti. Altre rudiste vivevano infossate nel fango carbonatico, come requenie, monopleuridi e alcuni caprinidi. Tipiche di hippuriti, radioliti e caprine erano temperature superiori ai 24°C. Queste rudiste vivevano in acque limpide e con alto indice di energia, dove i sedimenti si accumulavano solo lentamente. La profondità dell'acqua non raggiungeva i 50 m. Requienidi e monopleuridi vivevano anche a maggiore profondità, dove in parte si infossavano nel fango. Essi sopportavano temperature del mare inferiori a 20°C. Lungo il margine della piattaforma carbonatica si trovano biolititi a partire dal Cretaceo inferiore (Trnovski gozd, Planina, Snežnik, Javornik). Entro la piattaforma carbonatica si trovano piccoli patch-reefs del Cretaceo inferiore.

Nel solco delle torbiditi pelagiche la malacofauna è scarsa, mentre è più ricca la fauna di foraminiferi pelagici. Durante il Cretaceo superiore sul margine nordorientale del solco apparvero archi insulari, che davano supporto ad una fauna di scogliera di rudiste e coralli, simile a quella esistente sulla piattaforma carbonatica e dietro ad essa, nelle lagune, dove con i sedimenti della facies di Gosau compaiono anche piccoli patch-reefs (Stranice, Pohorje, valle Labot, Nagylengyel).

Durante il Maastrichtiano superiore al di sopra della piattaforma carbonatica di origine marina apparvero lagune salmastre ed anche laghi con acque dolci. Sui bassi fondali e nelle lagune vissero le ultime radioliti e gyropleure. Le radioliti costruivano patch-reefs, le altre vivevano infossate per breve tratto nel fango carbonatico. Questi ambienti erano sottoposti all'influenza periodica delle maree, che rimaneggiavano le conchiglie morte e le accumulavano in aree tranquille sotto forma di tanatocenosi. Qui prevalevano periodicamente i foraminiferi e, nelle acque salmastre e dolci, i gasteropodi dulcicoli.

The morphologically very differentiated bottom of the Tethys in the area of the northwestern Dinarides during Cretaceous was the main reason for the quite various living environments. In the southwestern Slo-

venia existed the shallow shelf area — the carbonate platform which was slightly rising towards its margin in the northeast. While the depths of the sea on the carbonate platform varied from several tens to 200

meters, they reached in the northeastern marginal areas of the carbonate platform, in the actual area Banjška planota – Nanos – Gorjanci, at most 70 meters, and frequently only several meters. The area was sometimes only at times under water, as indicated by the formation of bauxites. From this shallow sea margin the sea bottom slowly descended towards northeast, and reached in the area of central Slovenia depths from 200 to 1000 meters.

In shallow areas lived during Cretaceous particularly the molluscs, corals, hydrozoans, echinoderms and calcareous algae. For deeper parts only planktonic foraminifers and nannoflora were characteristic.

In the most uplifted part of the carbonate platform existed, from Malm on, most favorable conditions for the growth of reef-building organisms. Here grew the big barrier reef which, however, at times disintegrated into smaller reefs, but can be found during some geological times from Malm to the Upper Cretaceous in its integral development.

In the Lower Cretaceous can be found, in the Trnovski gozd area, in Valanginian beds a modest remain of the hydrozoan reef of the parastromatoporian type, which represents the continuation of the Middle and Lower Malm hydrozoan reef (Turnšek & Buser, 1974).

During Barremian and Aptian existed in the area of Banjška planota a smaller coral reef, built by corals of Urgonian and partly Neocomian fauna, along with sparse hydrozoans and chetetids. In the same reef limestone also orbitolines were found, as well as requienids and caprinids (Turnšek & Buser, 1974).

The Barremian-Aptian reef has been found also on Trnovski gozd, near Trnovo and Voglarji. It was built by requienids and caprinids. The requienid-caprinid reefs have been discovered also on Hrušica, Snežnik and near Kočevje. However, best developed, preserved and investigated is the reef on Trnovski gozd. Investigations show it consisted of a biostrome in which the rudist shells were shallowly buried in calcareous mud. Along with rudists occur foraminifers of genera *Cuneolina*, *Orbitolina*, *Miliolida*, and *Textularia*, which are all planktonic forms. It is interesting to note that smaller forms of requienids occur in the area of the barrier reef, while inside the carbonate platform in Barremian-Aptian beds only larger requienidic shells were found which built only patch-reefs (e.g. at Planina, Kočevje, on the Trieste-Komen plateau).

In the area of the barrier reef Banjška planota – Nanos – Gorjanci the sea was probably also deeper than earlier during Malm, and therefore also those rudist forms which live shallowly buried in mud could develop; otherwise wave action would make such life impossible.

The proper reef, i.e. the rather compact biolithitic formation, appeared during Cenomanian. Sea temperature of about 20°C and shallow depths were favorable conditions for the growth of large radiolites of genera *Sphaerulites*, *Radiolites* and big caprinids of genera *Caprina*, *Neocaprina*, *Mitrocaprina*, *Sphaerucaprina* and *Ichthyosarcolithes*.

The majority of these shells evidently did not live buried in mud like requienids and small caprinids during Barremian and Aptian. This can be asserted at least for the radiolites and for the genus *Ichthyosarcolithes*. The species of the genus *Ichthyosarcolithes* had strong supporting crests which enabled them to stand upright, fixed to the rock foundation with their lower part only. Beside them were found fragments of rock, biolithites, on which it can be seen that radiolites grew on them closely grouped, supporting each other. The reef was most probably several kilometers wide, and in its inner part, on the reef-plate was the living environment of radiolitids and caprinids. In marginal parts of the reef-plate grew ostreidic shells of the genus *Chondrodonta*. On both sides of the reef were the areas of the forereef and the back-reef (on the shelf side). There the broken material accumulated, and also undamaged shells of stronger caprinidic shells. The latter were ground by the wave action into rounded pebbles which were later cemented into conglomerate.

Within the carbonate platform patch-reefs were then relatively scarce. In this area the sea was in general deeper. In gray micritic limestones the orbitoid fauna predominates. On the Trieste-Komen plateau during those times the facies of black platy limestones with fish fauna was deposited.

The biolithitic complex on the margin of the carbonate platform persisted in spite of the less favorable temperature conditions also during Turonian. There lived smaller radiolites of genera *Gorjanovicia*, *Durania*, *Praeradiolites*, and smaller forms of hippuritids, e.g. *Hippurites* (*Hippuritella*) *resectus* Defrance. They built proper biostromes which grew in height only several to 50 centimeters, were interrupted, and then appeared again. Rich biostromes occur towards the end of Turonian, when the temperature of the sea rose to about 25°C (Polšak, 1973).

During Senonian repeated the explosive development of the biolithitic rudist fauna. In Santonian and Campanian large hippuritids developed on the barrier reef as well as in the patch-reefs. The large forms of shells stand up to 60 percent of their height out of the limy mud which can be inferred from different color of the fossils in the buried and in the free part. Some rudists, e.g. distefanelles, were not even partly buried in mud. These rudists grew closely one next to other.

The culmination of the reef development occurred during Maastrichtian, when also the back-reef and fore-

reef formation are developed, like during Cenomanian. Microfauna, especially foraminifers, are sparse in the reef area. During Maastrichtian the horizon is richer with foraminifera *Keramosphaerina tergestina*, but no rudists occur in it. This horizon is not a reef formation.

In marginal parts of the reef-plate lived also during Senonian exogyres. Their shells were found in many places in accumulations (thanatocenoses) in calm areas of the depositional environment.

During Senonian the patch-reefs within the carbonate platform appear frequently in the form of bioherms. These are the well-known deposits of the Karst ornamental stone interbedded with micritic limestone. Very characteristic bioherms of this type occur at Lipica (quarry), Kopriva (quarry) and Divača.

During the Upper Maastrichtian the emersion of the carbonate platform occurred. Shallow lagoons, and brackish and fresh-water lakes appeared. In these environments fresh-water gastropod fauna lived, while in the marine environments the rudist fauna persisted (tiny forms of the genus *Biradiolites* and *Gyropleura*). During this time an abundant deposition of calcareous mud was in course, and shells were shallowly buried in mud. Frequent are benthonic foraminifers.

The marginal parts of the carbonate platform of the Outer Dinarides, where the barrier reef grew, gently dropped towards the Northeast. Above this slope extended the pelagic environment in which pelagic foraminifers lived – mostly globotruncanas – and nannoflora. Farther northeastwards the sea bottom dropped into greater depths, where also flysch deposition occurred.

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