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Triassic Reefs in Slovenia

Triadische Riffe in Slowenien

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SCHLÜSSELWÖRTER: PALÄOGEOGRAPHIE - TRIAS - JUGOSLAWIEN - SLOWENIEN - RIFF-MILIEU

ABSTRACT

The paper deals with the distribution, paleogeography, age and biota of Triassic reefs in Slovenia. Most of these reefs have not been studied in detail up to now, but the paleogeographical distributional pattern can be outlined (Figs. 1 and 2). Triassic reefs are known from Central and Northern Slovenia, predominantly occurring at the margins of the "Slovenian trough" (which separates the northern Julian Platform and the southern Dinaric Platform) and at the margins of an intraplatform trough within the Julian platform.

Reef growth started in the Ladinian and Cordevolian and continued (with interruptions during the Upper Carnian ?) to the Norian and Rhaetian. Anisian en-

vironments are characterized by the predominance of algal mats and dasycladacean algae. Cordevolian patch reefs as well as Norian and Rhaetian reefs were built during the Late Triassic by calcareous sponges and corals, which belong to different species (Tab. 1 and 2). Some smaller Cordevolian patch reefs may have been formed within deeper-water sediments. An interesting facies sequence is developed in the Norian Dachstein Limestone reef of Pokljuka (Julian Alps), starting with deeper-marine cherty limestones, which gradually succeeded by crinoidal limestones followed by reef limestones and lagoonal Dachstein Limestones.

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ZUSAMMENFASSUNG

Die Arbeit gibt einen Überblick über die Verteilung, Paläogeographie, das Alter und den Fossilinhalt der triadischen Riffe in Slowenien. Die meisten dieser Riffe sind noch nicht im Detail untersucht, jedoch ist es möglich die paläogeographische Situation zu umreißen (Fig. 1 und 2). Triadische Riffe sind aus Zentral- und Nordslowenien bekannt. Sie treten überwiegend an den Rändern des "Slowenischen Troges" und an den Rändern eines innerhalb der Julischen Plattform liegenden Troges auf. Der Slowenische Trog trennt ab dem oberen Anis die Julische Plattform im Norden und die Dinarische Plattform im Süden.

Das Riff-Wachstum begann im Ladin und im Cordevol und setzte sich (mit Unterbrechungen im oberen Karn ?) im Nor und

im Rhät fort. Im Anis ist die Plattform-entwicklung durch Algenmatten-Sedimente und Dasycladaceen-Kalke gekennzeichnet. Sowohl die relativ kleinen Fleckenriffe des Cordevol als auch die ausgedehnten norischen und rhätischen Riffe wurden überwiegend durch Kalkschwämme und durch Korallen aufgebaut. In der Zusammensetzung der Riffbildner-Assoziationen zeigen sich deutliche Unterschiede zwischen Ladin/Cordevol einerseits und Nor/Rhät andererseits (Tab. 1 und 2). Einige kleinere cordevolische Fleckenriffe dürften im tiefer-marinen Bereich entstanden sein. Von besonderem Interesse ist die mit den norischen Dachstein-Riffkalen von Pokljuka (Julische Alpen) verknüpfte Faziessequenz, in welcher tiefermarine Hornsteinkalke lateral in Crinoidenkalke und weiter (ohne Vorriff-Brekzie) in Riffkalke übergehen, an welche sich loferitische Lagunenkarbonate anschließen.

1 PALEOGEOGRAPHICAL DEVELOPMENT OF TRIASSIC REEFS

Triassic reefs and algal carbonates are important lithological members in Slovenia, but they have not been systematically studied up to now. We have mapped the occurrence, and have studied the age as well as the fossil associations in a number of places. However, detailed paleoecological and facies investigations as well as detailed paleontological studies still remain to be done.

The reef-complexes are associated with margins of large carbonate platforms, or with platforms themselves. The formation of these platforms started in Slovenia during the Permian; the platforms existed with short interruptions until the end of the Upper Cretaceous. During the Lower Anisian there was a unique platform which almost continuously covered the entire region of Slovenia. No reefs were formed on this platform, but organogenic limestones reflect the growth of extensive algal mats.

During the Upper Anisian the platform was divided by a long, deep-sea trough stretching east to west across the whole of central Slovenia. This "Slovenian trough" divided the formerly homogeneous platform into the northern Julian Platform and the southern Dinaric Platform (Fig. 1). On marginal parts of the platforms and on the upper parts of the slope conditions existed for the growth of larger reefs, which, however, had not yet appeared in the Anisian.

During the Ladinian the major parts of both platforms were dissected by faults into several blocks, which subsided to various depths; deeper-marine sediments and abundant volcanic rocks of spilitic-keratophyric types developed upon these blocks.

During the Cordevolian patch reefs (up to several hundred meters in length) appeared in the depositional environment

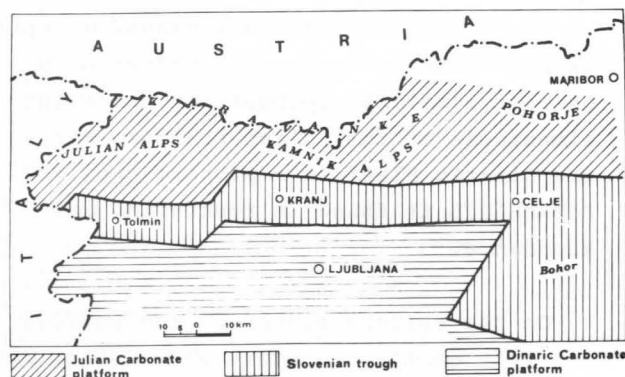


Fig. 1. Paleogeographic sketch of Slovenia during the Cordevolian to the Rhaetian. The Dinaric Platform is separated from the Julian Platform by a deeper-water trough ("Slovenian Trough"). Upper Triassic reefs are developed at the margins of this trough, and also at the margins of an intraplatform trough within the Julian Platform (not shown in the Figure).

Paläogeographische Skizze von Slowenien für den Zeitbereich Cordevol bis Rhät. Die Dinarische Plattform wird durch einen Tiefwasser-Trog ("Slovenischer Trog") von der Julischen Plattform getrennt. Obertriadische Riffe entstanden an den Rändern dieses Troges und auch an den Rändern eines im Inneren der Julischen Plattform liegenden Troges.

2 AGE AND DISTRIBUTION (Fig. 2)

Anisian Organogenic Limestone

The massive and thick-bedded organogenic limestone and dolomites appear first during the Anisian; they are known in the Southern Karavanke Mountains as the "Lower Diplopore limestones". Two belts with algal carbonates can be recognized in Slovenia:

The northern belt extends from the Northern Julian Alps across Mežakla into the Karavanke (eastern part of Storžič, Kozji vrh near Jezersko) and to the rock cliffs on the northern banks of the Savinja river between Solčava and Matkov kot. In the northern Julian Alps east of Kranjska gora limestones with abundant sponges, rare solitary corals, common algal debris, recrystallized foraminifers, echinoderms and mollusks predominate. The most abundant skeletal algae is *Bacinella*

of the heterogeneous, clastic Amphiclina beds. In the other areas of both carbonate platforms extensive algal mats flourished which gave rise to Diplopore limestone.

During the Norian and Rhaetian large barrier reefs grew only in the area of the Julian carbonate platform. On the northern margin of the Dinaric platform only Dachstein limestone with megaldontids was deposited. To the south it changed into the lagoonal area with laminated dolomites. On the Julian platform a more shallow intraplatform trough existed, which was filled by limestones with chert. The sediments pass laterally into reef limestones. On the southern side of the intraplatform trough a large barrier reef was developed whose remains can be found in several localities. North of the intraplatform trench are still traces of a former, probably continuous, barrier reef.

ordinata PANTIĆ growing on sponges and other organic remains. - In Mežakla and Kozji vrh near Jezersko dasycladacean algae (*Physoporella pauciforata* (GÜMBEL) and *P. minutoloidea* HERAK) prevail. - The largest outcrops of the Lower Diplopore limestone are the cliffs on the northern banks of the Savinja river: The thickness of the limestones is about 500 m; The uniform darkish gray algal limestones yield *Physoporella pauciforata* (GÜMBEL), *Diploporella hexaster hexaster* PIA, *D. hexaster helvetica* PIA, *Macroporella* sp., and in places also lumachelles with gervilleid pelecypods.

The southern belt of the Anisian algal carbonates now completely altered into dolomite, outcrops in the area between Idrija, Cerkno, the far surroundings of Ljubljana, Trbovlje, Trebnje and Bohor. The algae, mentioned above, have been

found only in the Višnja gora area.

Ladinian and Cordevolian Reefs

The second period of Triassic reef growth in Slovenia started in the eastern Northern Karavanke Mountains during the Ladinian (Langobardian), and lasted without interruption until the end of the Cordevolian (Wetterstein development). The uniform Langobardian-Cordevolian reef development exceeds 1000 m in the Peca Mountain and its southern cliffs. Corals and sponges predominate within the light gray and gray, massive limestones. Corals are represented by solitary and ramose colonies; no incrusting or massive forms are known. Sponges are represented by segmented and nonsegmented forms. Besides these, hydrozoans, bryozoans, chaetetids, echinoderms and green algae occur. Stromatolites are also important in reef-building. The fore-reef development is characterized by organogenic breccias; the backreef development by non-bedded limestones containing green algae as well as gastropods (*Chemnitzia* (*Omphalophychia*) *rosthorni* HOERNES, *Gradiella* sp., *Naticidae*, *Neritidae*).

A patch reef, several hundred meters long and about 80 meters thick, occurs within the clastic Ladinian Pseudozilian beds (slates, sandstones and tuffs) on the castle hill in Celje. The light gray, recrystallized reef limestones yield abundant sponges and rare corals. Upwards the massive reef limestone passes into platy micritic limestone without reef organisms. In the tuff beds, overlying the reef limestones *Daonella lommeli* WISSMANN was found.

Cordevolian reef limestones occur in the Julian Alps in the Ponce, Vitranc, Prisojnik and Špik Mountains. The maximum thickness is about 800 m, in Špik and Prisojnik. Fossil remains are strongly recrystallized and generally undeterminable. In Vitranc numerous corals occur within the central reef. Corals are often surrounded by the calcareous algae *Bacinella*

ordinata. In the limestone massif of Špik, parts of the central reef consist only of recrystallized sponges. In the algal limestones of the Julian Platform and the Dinaric Platform *Diplopora annulata* SCHAFFHÄUTL is found in rockbuilding abundance.

On the eastern slopes of the Storžič Mountain corals, sponges, chaetetids, abundant calcareous algae and echinoderms were found within the reef limestones.

Patch reefs (several hundred meters long, up to 30 m thick) occur between Tolmin, Hudajužna, Jesenica, Leskovica, Novaki and Dolenja vas in the Selca valley intercalated with slates and alternating with sandstones (Amphiclina beds). They consist of massive, dark gray limestones with various reef organisms. Large, isolated blocks (several m³ in size) may be derived from the margin of reefs. They are best exposed and are currently being studied in the abandoned quarry southwest of Hudajužna, (see SENOWBARI-DARYAN, 1981). Sponges predominate, corals are abundant. Less abundant are hydrozoans, pelecypods and brachiopods, algae, foraminifers and problematica. In the upper part of the reef limestone at Leskovica abundant, locally rockbuilding echinoderms occur, in places represented by numerous *Cidaris* spines. The age of this reef complex is still under discussion. Sponges and corals seem to indicate Ladinian to Cordevolian age, Langobardian can probably be excluded. The reefs occur in the lower part of the Amphiclina beds whose upper part was determined by conodonts as belonging to the upper part of Carnian. Between the reefs and the conodont-bearing beds clastites with a thickness of at least 150 m thick are developed.

Another reef formation is represented by the limestones in Hotavlje, Lučine and Lesno brdo. These massive, predominantly gray, sometimes red sparitic Cordevolian limestones are associated with irregular, red and green argillaceous beds; they show irregular dolomitization. Prevailing

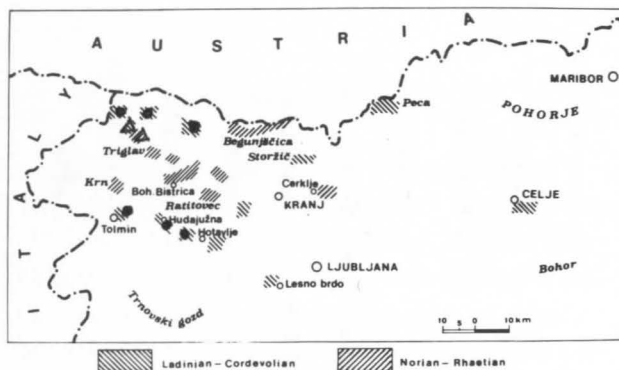


Fig. 2. Distribution of Triassic reefs in Slovenia.

Verteilung der Trias-Riffe in Slowenien.

reef-building organisms are calcareous sponges. Corals are relatively rare, they have not yet been studied. Stromatolites are abundant, gastropods and calcareous algae are common in parts of the reef. Redeposited ammonites are very rare. - A list of the Cordevolian reef fossils is given in Table 1.

Norian and Rhaetian reefs

Thick-bedded Dachstein Limestones, frequently characterized by Lofer cyclothems, are occasionally overlain by massive reef limestone.

An intraplateform trench existed in the Julian Alps (near Pokljuka) from the Carnian to the Rhaetian. Reefs grew on the northwestern side of this trench in the following areas: Dovški križ - Kopice - Šplevta, Mali and Veliki Oltar, and Veliki Rokav, the highest parts of the Razor and Planja Mountains, and Glava pod Planjo, as well as some peaks near Mount Triglav, and on Pokljuka between Rudno Polje and Mrzli studenec. A large reef was developed on the southwestern side of the trench, between Rdeči rob near Krn, on Kobla in the Bohinj ridge, at Bohinjska Bistrica, in Jelovica and Ratitovec. The continuation of this reef should probably be found in the southern Karavanke Mountains on the southwestern slopes of Stol, Begunjščica (thickness of reef limestones about 300 m)

and Košuta. In the Kamnik Alps the reef is preserved northeast of Cerklje (Fig. 2).

On Pokljuka a lateral transition can be observed between reef limestone and the deeper-marine limestone deposited in the intraplateform trench. East of Rudno polje deeper-marine, gray, platy micritic limestones with large irregular nodules of chert occur. These sediments pass northwards into light red unbedded limestones without cherts, but with numerous ammonites which are missing in the southern cherty limestones. Still farther to the north the micritic unbedded limestones pass into a belt characterized by massive, crinoidal limestones with numerous holothurian spicules and rare tiny corals. The crinoidal limestone passes into massive reef limestone built by abundant corals and hydrozoans; this limestone represents a genuine reef formation. It is interesting that typical forereef breccias are completely lacking. Still farther north the light gray to gray reef limestones pass laterally into lagoonal Dachstein limestones with loferitic cyclothems.

Corals and sponges predominate within the reef biota, but hydrozoans and chaetetes are also common. Incrusting mats of bryozoans are rare. On Pokljuka, the Bohinj ridge and in Bohinjska Bistrica the main reef-builders are corals or spongiomorphid hydrozoans. On Jelovica hydrozoans and bryozoans prevail, exhibiting low, dome-shaped growth forms. Corals are represented by solitary forms; nonsegmented sponges and calcareous algae may be found, too. Mollusk remains are generally rare. Thick-shelled, sometimes rock-building gastropods, occurring in ecological niches within the reef complex are abundant especially in the Begunjščica Mountains. The gastropod shells are often encrusted by hydrozoans and sponges. Megalodontids are less common; small pectinid pelecypods are common in certain horizons.

Interesting mass occurrences of halobian pelecypods are found in pockets of the

Norian - Rhaetian

Corals

Astraeomorpha crassisepta Reuss
 Distichophyllia gosaviensis (Frech)
 Distichophyllia norica (Frech)
 Distichophyllum caespitosum (Reuss)
 Gablonzeria major (Frech)
 Procyclolites triadicus Frech
 Retiophyllia clathrata (Emmrich)
 Retiophyllia minima (Melnikova)
 Retiophyllia paraclathrata Roniewicz
 Parathecasmilia sellae (Stoppani)
 Stylophylloopsis paradoxum (Frech)
 "Thamnasteria delicata" (Reuss)
 Archaeosmilia sp.
 Meandrovolzeia sp.
 Protoheterastraea sp.

Hydrozoans and Chaetetids

Bauneia originalis Boiko
 Heptastylopsis ramosa Frech
 Lamellata wöhneri E. Flügel
 Stromatomorpha actinostromoides Boiko
 Stromatomorpha rhaetica Kühn
 Stromatomorpha stylifera Frech
 Parachaetetes sp.

Sponges

Annaecoelia cf. A. maxima Senowbari-Daryan
 Cheilosporites tirolensis Wöhner
 Dictyocoelia investiculosa Senowbari-Daryan
 Stellispongia cf. S. timorica Vinassa de Regny
 Peronidella sp.

Foraminifera

Alpinophragmium perforatum E. Flügel
 Frondicularia woodwardi Howchin
 Glomospirella friedli Kristan-Tollmann
 Involutina cf. I. communis (Kristan)
 Involutina parva Brönniman & Zaninetti
 Involutina sinuosa sinuosa (Weynschenk)

Algae

Solenopora styriaca E. Flügel

Microproblematica

?Microcodium bornemanni Rothpletz
 Microtubus communis E. Flügel

	Pokljuka	Bohinjska Bistrica	Rdeči rob	Jelovica, Ratitovec	Begunjska	NE Cerklje
Astraeomorpha crassisepta Reuss	•			•		
Distichophyllia gosaviensis (Frech)		•	•			
Distichophyllia norica (Frech)		•		•	•	
Distichophyllum caespitosum (Reuss)	•					
Gablonzeria major (Frech)	•					
Procyclolites triadicus Frech	•			•		
Retiophyllia clathrata (Emmrich)	•	•	•		•	•
Retiophyllia minima (Melnikova)		•				•
Retiophyllia paraclathrata Roniewicz		•	•			
Parathecasmilia sellae (Stoppani)	•					
Stylophylloopsis paradoxum (Frech)		•				
"Thamnasteria delicata" (Reuss)		•			•	
Archaeosmilia sp.		•	•			
Meandrovolzeia sp.		•				
Protoheterastraea sp.					•	
Bauneia originalis Boiko	•					
Heptastylopsis ramosa Frech	•			•	•	
Lamellata wöhneri E. Flügel		•				
Stromatomorpha actinostromoides Boiko	•		•	•	•	
Stromatomorpha rhaetica Kühn		•		•		
Stromatomorpha stylifera Frech					•	
Parachaetetes sp.						
Annaecoelia cf. A. maxima Senowbari-Daryan		•				
Cheilosporites tirolensis Wöhner		•		•	•	
Dictyocoelia investiculosa Senowbari-Daryan		•				
Stellispongia cf. S. timorica Vinassa de Regny					•	
Peronidella sp.					•	
Alpinophragmium perforatum E. Flügel	•	•				
Frondicularia woodwardi Howchin	•	•				
Glomospirella friedli Kristan-Tollmann	•				•	
Involutina cf. I. communis (Kristan)					•	
Involutina parva Brönniman & Zaninetti	•	•				•
Involutina sinuosa sinuosa (Weynschenk)	•		•	•		
Solenopora styriaca E. Flügel	•				•	
?Microcodium bornemanni Rothpletz	•			•		
Microtubus communis E. Flügel		•		•		

Tab. 2. Biota of the Norian and Rhaetian reefs in Slovenia. Preliminary determinations.

reef limestones east of Rudno polje on Pokljuka (*Halobia* cf. *H. paraceltica* KITTL, det. B. Jurkovšek). The thickness of these lumachelles often attains two meters. The contact of the lumachelles with the surrounding reef limestone is well defined, but uneven. The possible biotope of the halobians within the reef limestone is still unknown. They might have lived in protected niches of the outer part of the reef, which were open towards the deeper sea of the intraplatform trough. The limestones of the latter are found in the close vicinity of the reef, and laterally pass one into the other. Another possibility might have been transportation and accumulation of the shells, but the thin intact shells could not have endured a rather long transport. Therefore the first interpretation seems to be more reasonable. Undeterminable ostracods are rare within the reef limestones. Echinoderms, foraminifers and algae are common, as are microproblematica. The central reef is characterized by the sponge *Cheilosporites tirolensis* WÄHNER. Some of the species found in the Norian-Rhaetian reefs are

listed in Table 2.

Until now the Upper Triassic reef limestones were attributed mainly to the Rhaetian. This is true for the Begunjščica, area where the reef limestones overlie Norian Dachstein limestones with megalodontids. Reef growth in the Julian Alps however, definitely started during the Middle Norian, perhaps even as early as the Lower Norian. East of Rudno polje on Pokljuka halobian pockets with conodonts (*Epi-gondolella ponsera* (KOZUR & MOSTLER)) were found within micritic limestones. The micritic limestones, passing into reef limestones on Pokljuka Upper Norian conodonts (*Misikella hernsteini* (MOSTLER) and *Gondolella steinbergensis* MOSHER, det. T. Kolar-Jurkovsek) were found in Praprotnica. There is strong evidence that lower parts of the reef on Pokljuka are of Upper Carnian age. The reef development in the Slovenian part of the Southern Alps seems to be comparable with that of the Northern Alps with respect to the timing of reef growth.

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