GEOLOGICKY ZBORNIK — GEOLOGICA CARPATHICA, 39, 3, BRATISLAVA, JUNE 1988, Pp. 285—300

JÁN SENEŠ*

PRINCIPLES OF STUDY OF ADRIATIC SHELF ECOSYSTEMS FROM THE VIEWPOINT OF APPLICATIONS IN GEOLOGY

(Figs. 6, Tabs. 2)

Abstract: Geological Institute of the Slovak Academy of Sciences, in cooperation with "Centar za Istraživania Mora" (Centre for Marine Research of the Yugoslavian Academy of Sciences), realized in the years 1964—1974 under the guidance of the author of this paper an actuogeological research of the shelf in the Adriatic Sea. In this introductory paper, basic data are presented on the methodology of the research and standard facies determination applied in the reconstruction of fossile, especially Tertiary marine sediments.

Резюме: Геологический институт Словацкой академии наук, в сотрудничестве с Центром для исследования мора Югославской академии наук, проводил в г. 1964—1974 под руководством автора этой статьи актуогеологическое исследование шельфа в Адриатическом мори. В этой вводной статьи приводятся основные данные о методике исследования и определении стандардных фаций которые были применены при реконструкции фоссильных, прежде всего третичных морских осадок.

One of the most effective methods of the reconstruction of fossile environments in sedimentary, especially Tertiary rocks, is the application of recent facies on the basis of their biological content. However, this requires above all a thorough study especially of fossilizable organisms, of their qualitative and quantitative occurence in various environments in recents shelf regions. At the same time it is, of course, necessary to observe accurately the physical-chemical characteristics of the recent environments in different seasons; except depth they are also the changes of salinity, aeration, pH-values, currents, transparency and the effects of non-fossilizable organisms, including the seasonal extent of phyto- and zooplankton.

As far as the living (but frequently also the extinct) members of recent communities are concerned, we can speak mostly only of thanatocenoses. The physical properties of an environment (e.g. strong swell reaching with its orbits as far as to the depth of 30 m) and biological transportation of living or dead organisms frequently displace and thus mix up the otherwise typical "in situ" communities.

In geology (for the evaluation of fossile communities) it is thus important to know that a great part of fossile fauna or flora communities represent mostly thanatocenoses. However, a significant number of communities occuring recently have common or similar ecologic components with fossile, especially Tertiary communities. They are mostly surviving species or genera from same or very similar physical-chemical environments.

Already in the sixties, actuofacial (actuopaleontologic) research was carried out in the brackish environment of the Baltic and Black Sea by the Geological Institute of the Slovak Academy of Sciences in Bratislava. The results have

* Doc. RNDr. J. Seneš, DrSc., Geological Institute of the Centre of Geoscience Research, Slovak Academy of Sciences, Dúbravská cesta 9, 814 73 Bratislava.

been partially published (Seneš, 1960, 1964). However, in the years 1964—1974 the actuopaleontologic and actuogeologic study was centred on the northern and southern parts of the Adriatic Shelf. The reason for this was the fact that Adriatic Sea of the Mediterranean region proved to be the most suitable one for the identification of fossile facies, especially of marine Tertiary of Paratethys. (The investigations have been thus carried out on the North Adriatic Shelf west of the peninsula Istria (Rovinj) and on the South Adriatic Shelf near the southern part of the peninsula Pelješac, up to the island Mljet).

The author of the presented paper intents to publish in the future a detailed description of the facies with recent ecosystems from the region of North and South Adriatic Shelf, with the purpose of a further application in the reconstruction of fossile facies, especially Tertiary ones.

Earlier studies of East and North Adriatic Shelf

Institutes of Oceanography and Biology working on the East Adriatic Shelf, especially those from Yugoslavia, Italy, Germany and the USA, had mostly other aims than the application of their results in actuogeology.

Studies of marine facies from the viewpoint of geology have been carried out in the shelf regions of the Adria only sporadically, in the last 20 years. Parallelly with our work, a group from the Geological Institute of the University of Bologna started investigations in the delta of the river Po (Ciabatti—Colantoni—Rabbi, 1965, 1967) and a group from the Geological Institute of the University of Göttingen worked above all in the Lim channel (Limfjord) north of the region studied by us (Hinze—Meischner, 1968; Paul, 1970; Uffenorde, 1972). These works had unquestoniably actuogeologic character, especially from the viewpoint of sedimentological application. The relations of recent sediments to the micropaleontologic contents and the history of origin and evolution of Adria have been studied especially in the works of Van Straaten (1965, 1966).

The majority of other publications lacks actuogeologic or actuopaleontologic aspects. They nevertheless provided a basis for our research (Vatova, 1928, 1931, 1940, 1943, 1948, 1949; Riedl, 1963, 1966). They are applicable for the biocenology of all Adria. The important work of Perès—Picard (1964) refers in part to Adria as well, especially as far as bathymetric nomenclature is concerned. Fundamental works on benthic biocenoses are those of Gamulin-Brida (1962, 1965, 1967, 1968) as well as Gamulin-Brida — Požar — Zavodnik (1968) and Zavodnik (1968, 1969) directly from the region of North Adriatic Shelf. In this region, the work of Riedl (1964) is essential for the water dynamics of rocky littoral. Information on the coralligene of the Mediterrarean Sea (Laborel, 1961) are very important and can be applied also in the Adriatic region, as the works of Seneš (1967, 1968). The relation of the biological contents to the character of sediments in the region of Rovinj is also mentioned by Schmidt (1935).

Plawen-Salvini (1968) make us familiar with the lithologic character of some regions of Adria. Hydrographic data, especially on North Adria, are in the works of Marinković (1956), Buljan (1969), Skrivanić

(1969), Lovašan (1969), Kečkeš et al. (1969), Ilić — Bozić (1969), Zore-Armanda (1969), Ott — Svoboda (1970).

As far as the methodology of our work and of the sample collecting is concerned, I refer to the works of Seneš (1964, 1966) and to the work of Dörjes — Hertweck (1971). The latter is related to the studies of the Senckenberg Institute in the Gaetan Bay of the Tyrrhenian Sea, where the cited author carried out a research of shallow coralligene near Corsica.

The paper of Schäfer (1962) has been helpful for the ecologic studies of fossilizable organisms, although it does not refer directly to Adria nor to deeper facies.

Methodology used in our study of recent facies

In the years 1964—1974, we investigated the sea-floor of North and South Adriatic Shelf by means of profiles in a length of approx. 27 km. Direct sampling was done up to the depth 55 m. (Dreggage is not sufficient for a more precise application in geology, neither it makes possible the necessary visual observation).

On the North Adriatic Shelf, in the region of Rovinj, profiles have been sampled in a length of almost 15 km to a depth of more than 30 m; on the South Adriatic Shelf, the samples have been collected in a length of approx. 12 km with Scuba diving. On each profile, so-called "quadrates" (1×1 m) have been marked out in typical or type facies. To ensure repeated or long-term observation or sampling, the locations of these quadrates have been fixed by buoys. Material has been collected from the quadrates on sea floor up to a depth of 0.15—0.25 m, together with lithological and biological content. Except this, 5 to 15 samples with a volume of 0.30—0.50 m^3 have been collected along all profiles between the "quadrates", and these have been also evaluated from the viewpoint of lithology as well as biology (living and extinct benthic fauna and plankton). In rocky littoral environment, sessile biologic content has been thoroughly collected and endobios taken from all fissures, cracks and cavities, including biologic representatives of the numerous submarine caves. (Silicasponges prevail in these caves, producing, in recent as well as in fossile environment, a large quantity of redeposited sponge spicules in the surrounding sediments.)

This methodology of research, suitable as a basis for a further geologic interpretation, was for the first time successfully applied in the Carribean Sea (Seneš, 1966) and since 1964 in the Adriatic Sea. Of course, necessary were not only analyses of physical-chemical characteristics of the studied sea and its bottom in the wider surroundings of the profiles, but, above all, also the identification of species of thanatocenoses and biocenoses.*

* As far as the scope of our work is concerned, 32 profiles in total lengths of 14 815 m have been studied and evaluated on North Adriatic Shelf, in the region of Rovinj. 46 quadrates have been sampled and the number of other documentation points on the profiles was 286. 7 profiles in a length of 12 040 m have been made on South Adriatic Shelf, with 68 documentation points or quadrates.

Cooperation with other research institutions

In the first place, it was the cooperation with "Centar za Istraživanja Mora — Jugoslavskoj Akademie Znanosti i Umjetnosti" (Centre for Marine Research of the Yugoslavian Academy of Arts and Sciences) in Rovinj (CIM — JAZU).

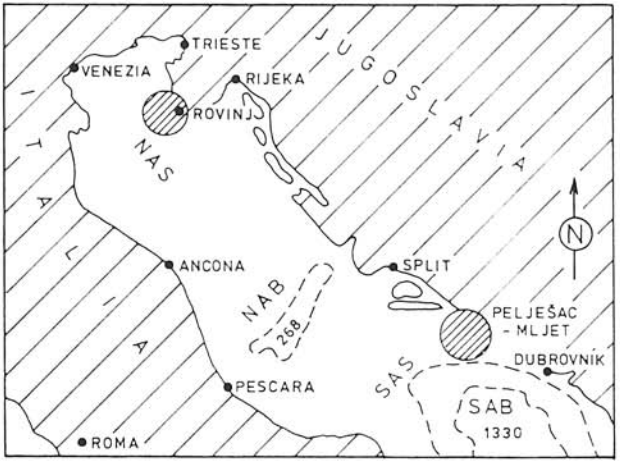

Fig. 1. Oceanographic terminology in the Adriatic region.
Explanations: 1 — Areas of research; 2 — North Adriatic Shelf; 3 — North Adriatic Basin; 4 — South Adriatic Shelf; 5 — South Adriatic Basin.

(A research agreement between Slovak Academy of Science and CIM was signed in the years 1966 and 1969, with a validity to 1974**). As far as the lithologic character of the sea floor and its study is concerned, we have cooperated also with study groups from the Geological—Paleontological Institute in Kiel and from the Geological—Paleontological Institute of the University of Göttingen.

Besides the CIM, colleagues from the Paleontological and Zoological Institute of the University Wien have been helpful in the precise identification and determination of mutual relations in recent biological material. This joint research programme of the Slovak Academy of Sciences and the CIM was also a part of the international programme FICSAS (Federation of Institutions Concerned with the Study of the Adriatic Sea).

** At this occasion I would like to express my gratitude also in the name of our Institute, to Dr. D. Zavodnik (CIM — Rovinj) and Prof. R. Riedel (Univ. Wien) for their cooperation and support.

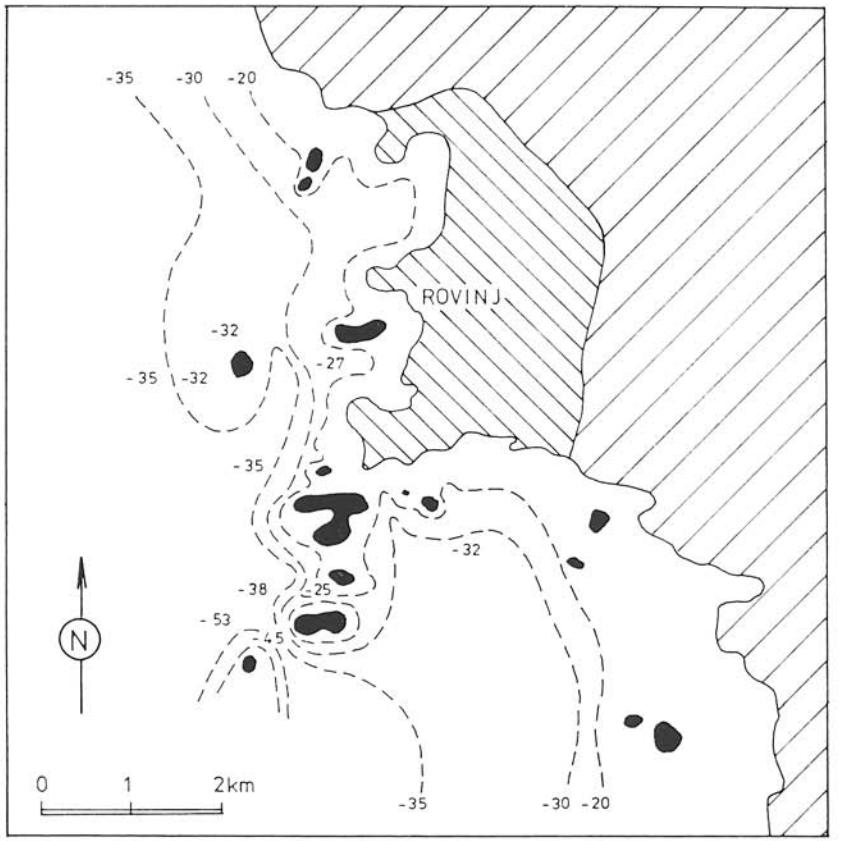

Fig. 2. Bathymetry of North Adriatic Shelf in the Rovinj region.
Explanations: Islands are marked by black colour.

Hydrographic and sedimentologic character of the studied regions

The Adriatic Sea came into existence in its more or less recent form only at the end of Pliocene, in Pleistocene and Holocene. This depression was probably not a foredeep (from the viewpoint of geodynamics) between the Dinarides and Apennines.

The Adriatic Shelf reaches in the south approximately to the region between Gargano (Italy) and Dubrovnik (Yugoslavia), with depths mostly only betveen 25 and 50 m. Only in the Middle Adriatic Basin (or North Adriatic Basin — NAB), between Šibenik and Pescara, in a narrow belt the depth exceeds 200 m. It is probably a tectonically defined depression. In the South Adriatic Basin area, with depth over 1300 m, the shelf belt of South Adria becomes, of course, narrower on its western as well as eastern coast, to a width of 40—60 km.

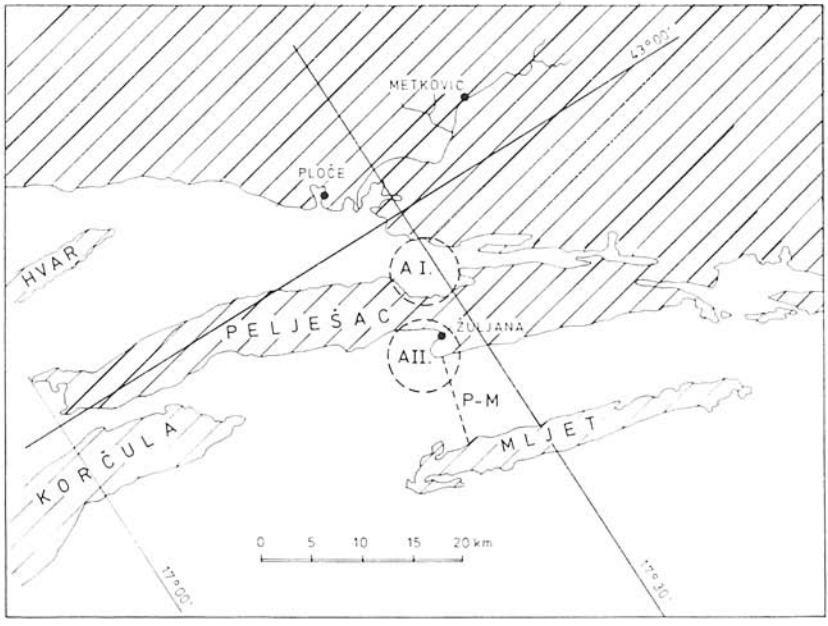

Fig. 3. Areas of research on the South Adriatic Shelf.
Explanations: Profiles A I., A-II., profile PM — Pelješac-Mljet.

The temperature of the surface water of Adria is extraordinarily variable according to the season of the year and geographic latitude: 9—11 °C in winter in northern Adria. The temperature equalizes in open areas of the sea in august, with peaks around 23—24 °C. These large variations are caused by climate conditions — relatively cold winters and subtropical temperatures in summer. Temperature variations in the depth between 100—250 m are minimal — between 10—13 °C. Marked temperature dividing lines (from april to august, in depths mostly 11 and 24 m), caused by strong insolation in spring and summer, are equalized in autumn and winter by the cooling of the surface water layers and convection flow of deeper, warmer water horizons. In such way there is, a thorough vertical exchange of water layers, together with a partial biological exchange (plankton).

The salinity of Adria as well as of the whole Mediterranean region is notably higher than of the world oceans (34—35 $^0/_{00}$). In North Adria it attains in surface horizons its maximum in march — over 38 $^0/_{00}$. An exception are the areas of river mouths or submarine karst springs. The mollusc fauna, e.g. in the area of Omiš (Central Adria), resembles, according to our observations, mostly the composition of benthic fauna of the brackish Black Sea (17 $^0/_{00}$).

The attached table of temperature and salinity in different seasons and depths clearly indicates the importance and variability of seasonal convection flow in relation to the temperature and salinity. These measurements have

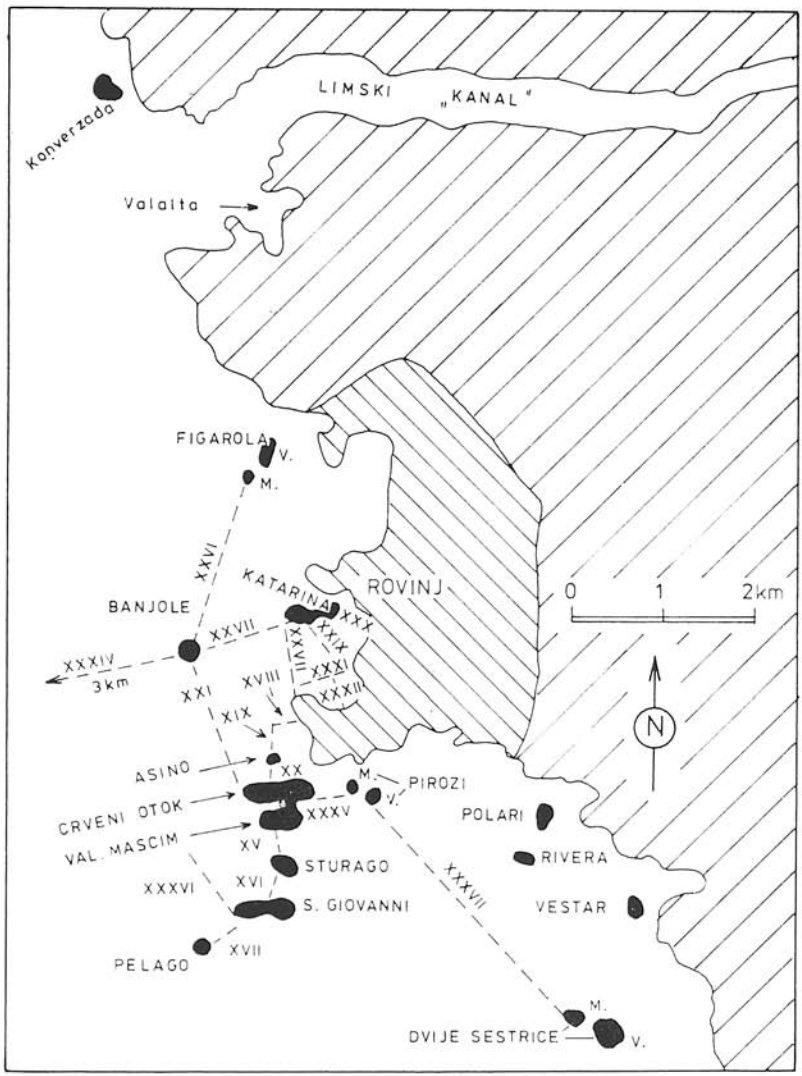

Fig. 4. Directions and numbers of sea-floor profiles in Rovinj region.

been made in the North Adriatic Shelf in the centre of the region studied by us, near Rovinj, between the islands Banjole and St. Katarina (Marinković 1956). In the region of the South Adriatic Shelf the temperature values are substantially higher, the salinity values, however, are lower.

The aeration of Adria can be denoted in the studied areas as almost 100 %, especially in spring. It is, of course, caused also by biological factors. In summer and autumn it attains its minimum, 70—80 %. This deficite is

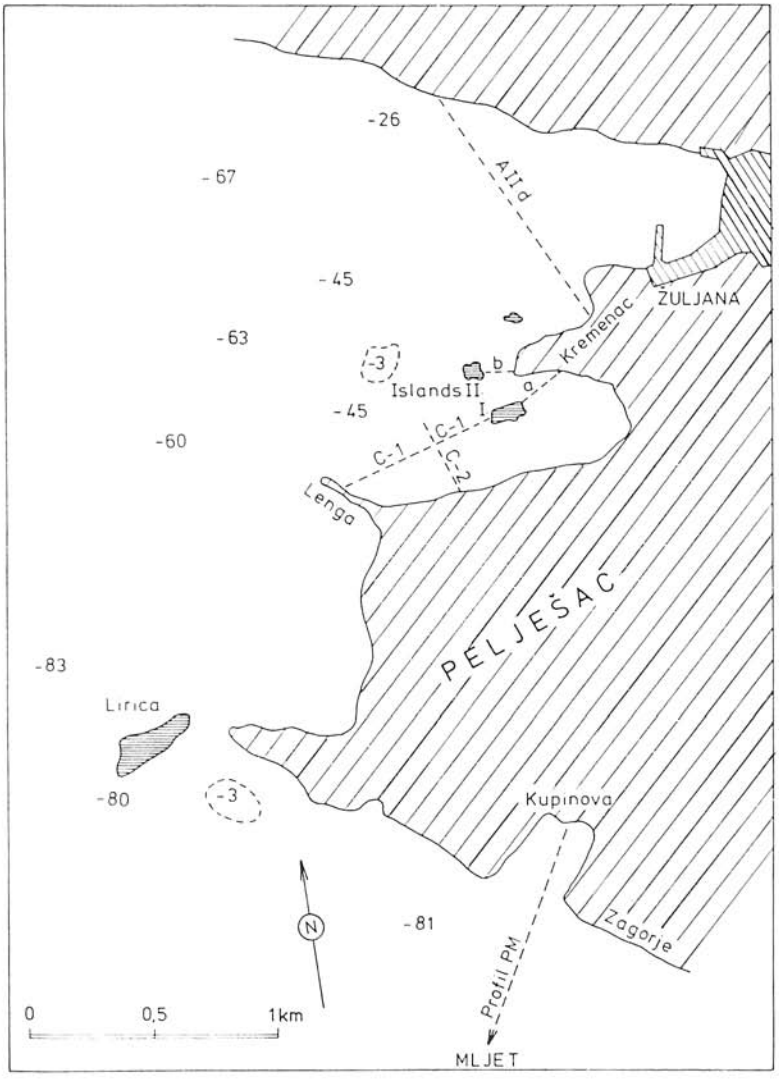

Fig. 5. Directions and numbers of profiles in Pelješac region.
Explanations: Profiles A-II, C-1, C-2, PM.

caused by gradual dying of plankton, but until the season of convection flows in winter it is again equalized.

The pH values of Adria vary mostly only between 8.0—8.5, while towards increasing depth they slightly decrease.

As far as the currents are concerned, Adria is noted for a northern current flowing along its eastern regions. This current comes from the Ionian

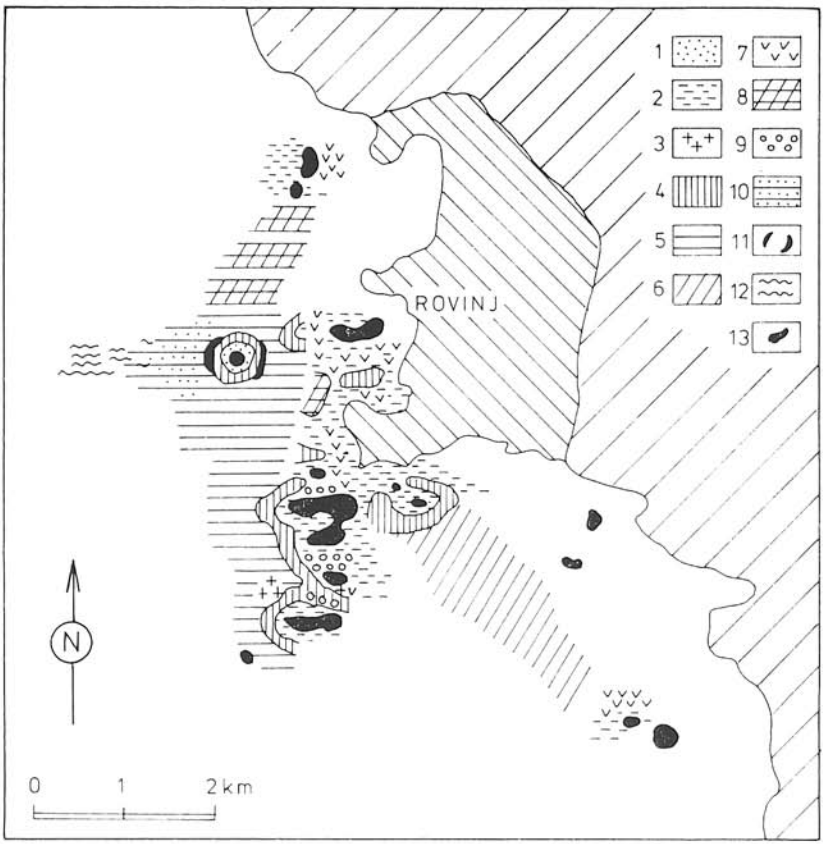

Fig. 6. Extent of principal biofacial types of the sea-floor in Rovinj region. *Explanations:* 1 — *Sargassum;* 2 — *Padina* + *Cystoseira*, or infracoraligene; 3 — eucoraligene; 4 — *Pecten jacobaeus;* 5 — *Hippodiplosia;* 6 — *Turritella* + Aloidis; 7 — *Cymodocea;* 8 — *Apporhais;* 9 — *Lithophyllum racemus;* 10 — *Arca noae* + *Hippodiplosia;* 11 — *Cladocora cespitosa;* 12 — *Chlamys opercularis* + *Ophiotrix quinquemaculata;* 13 — Islands of Rovinj region.

Sea. On the north, along Istria, it touches also eastern parts of the North Adriatic Shelf, it turns southward in the Bay of Trieste and flows along the Italian coast again into the Ionian and Mediterranean Sea. The current reaches a speed of as much as 3 km/hour. It is very important for the distribution of plankton, nekton and benthic fauna. As far as the speed and depth intensity of local interinsular currents are concerned, no exact measurements have been made. Their velocity nevertheless attains up to several dm/s, and they reach (according to our observations) mostly to depths of 20—25 m. On the western infralittoral of the island Banjole, the N-S current, for example, is extraordinarily strong; between the islands Asino-Crveni Otok-St. Giovanni there is a strong current between the open sea and the sedimentation region Pirozi-Sestrice.

Table 1

Average temperatures of the North Adriatic Shelf in °C

Depth in m	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
0.0—0.5	10.9	10.2	9.2	11.5	15.2	20.9	23.0	23.2	22.8	17.9	15.4	12.8
14.0—15.0	10.9	10.2	9.2	11.2	13.9	17.0	19.2	20.7	19.2	17.8	15.7	12.8
29.0—32.0	10.9	10.2	8.9	11.2	13.3	14.9	16.7	17.3	17.5	16.5	15.5	12.8

Table 2

Average salinity of the North Adriatic Shelf in $^{0}/_{00}$

Depth in m	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
0.0—0.5	37.88	37.71	38.17	38.19	37.66	36.48	36.22	36.96	36.32	37.01	37.49	37.66
14.0—15.0	37.87	37.87	38.37	38.25	37.87	37.66	37.61	37.72	38.03	37.43	37.53	37.68
29.0—32.0	37.94	37.75	38.37	38.25	37.96	37.91	37.91	38.21	38.27	38.03	37.43	37.72

Transparency is, especially in the coastal regions, dependent on the seasons, and thus also on the time of phytoplankton reproduction. The transparency on the North Adriatic shelf, in a depth of 30 m, is in spring months at least by 50 % better than in october or november. In spite of this, some species of green algae live on the Middle and South Adriatic Shelf even in depths of 50—60 m.

High and low tide represent, e.g. on the shelf of northern Istria, as a rule only a few dm. As a result, supra- and mediolittoral are relatively little pronounced, and thus cannot be very well biologically demarcated. The peaks on the South Adriatic Shelf, even in the time of high tide, do not reach the value of one meter.

Lithologic character (sedimentological characteristics) of Holocene of the Istria region sea floor is mentioned in brief, but only generally, by Van Straaten (1965). However, because of the already mentioned strong influence especially of physical factors (especially orbital effect of waves) the lithologic or biologic character changes, especially in a shallower environment.

Sedimentation. Since our research, e.g. of the North Adriatic Shelf, on an area of approx. 40 km^2, was concentrated on the broken line of coast of the Rovinj island region (restricted on the north by the Lim channel and on the south by the islands Dvije Sestrice and the region of Palu), its central parts, between the islands Figarola on the north and San Giovanni on the south, was most thoroughly investigated by our submarine profiles. Morphology (including the elevations in the form of recent islands) shows the terrain of the former karst relief in the time of probably the last glacial, when the level of "Adria" of that time was by 110 to 120 m lower than today.

The rate of sedimentation has been also studied only insufficiently. It was, and is, e.g. in the island region of Istria, very variable. More towards south, in the Central Adriatic Basin, it is estimated by Van Straaten (1965) to be less than 1mm/100 years. In the area of North Adriatic Shelf, in the region of our studies, where the former karst relief of the last glacial is often covered by as much as several meters thick sediments, the sedimentation could be much more rapid. The coastal region between shelf islands is however often without recent sedimentation, mostly because of strong local currents between the islands.

Since the numerous islands, representing one-time elevations, are an evidence of the former karst relief, the numerous traces of Pleistocene and Late Holocene karst hydrographic net occur in the form of flooded caves in various depths under the sea.

The original terrigene-detrital, especially limestone and dolomite material, terra rossa, has been washed out after flooding by sea, and, especially under the influence of benthic organisms, disintegrated, forming the recent sediments. Prevailing sediments in their varied distribution, e.g. in the Rovinj region, are sands with different grain-size, partly of organogenic origin, as well as pelites, especially towards open sea and in non-exposed areas of the islands which are only slightly affected by stronger currents. These are the areas where typical development of eucoralligene occurs sporadically besides muddy sediments.

Flysh material of Istria reached only slightly into the regions of our research. Similarly, the sediments of Alpine rivers from the north and of the river Po

(approx. 100 million tons yearly) are transported by the currents of West Adria along the Italian coast and they do not play any important part in marine sedimentation of western Istria, even less in the eastern regions of Middle and South Adria.

The circalittoral of the Rovinj region, with an average depth of 30—45 m, is represented by arenaceous — detrital mud to mud. Their source region is, except for atmospheric microcomponents, only Pleistocene and Early Holocene senile karst of the Istria peninsula.

Because of only insubstantial trasportation from the recent karst coast of Dinarides, recents sedimentation occurs in the form of organogenic material and carbonate sand disintegrated by organisms, and further as the sedimentation of coralligene. Since the rate of sedimentation is today probably very low, we assume that our samples from the studied profiles are in, according to their age and organic composition, from Early Holocene, maybe even Pleistocene (sediments near Poreč, north of Rovinj, show in the depth of 18 cm from the sea-floor an age of approx. 6500—7000 years (C-14)). P a u l (1970) came therefore to the acceptable conclusion that the rate of sedimentation on the North Adriatic Shelf is equal to approximately 2.7 cm/1000 years. However, we should not forget the geologic factors, i.e. subsidence or emergence of the surrounding relief, which could, or still can, influence the rate of sedimentation in the course of thousands of years. However, the thickness of Holocene, on the basis of recent situation, is - at least theoretically - e.g. on North Adriatic Shelf 3.0 cm/1000 years.

M o r p h o l o g i c a l relief variations in the area of Istria, Pelješac and Mljet provide ideal study possibilities for littoral slopes reaching in numerous cases in the Rovinj region as far as 30 m deep and on the island Mljet in the form of a perpendicular wall up to the depth of 55 m. The last one represents a typical rocky infralittoral. Sandy infralittoral planes, especially between the islands, as well as typical circalittoral, sometimes in several km distances between the islands, are also represented in a classical way. The bottom of the bay Kuvi between the islands Pirozi and Sestrice and further southwards is also a typical circalittoral.

Index of recent shelf facies of the Northern and Southern Adriatic Sea (Alphabetical and numerical)

In the presented introductory paper I find it necessary to mention the alphabetictal and numerical abbreviations of the classification of recent marine facies characterized according to physical-chemical and biological factors. (According to our own studies in the Adriatic Sea and with a partial application of the bathymetric numenclature of P e r è s and P i c a r d (1964)). I use this classification of facies and zones in the description of the studied profiles in our further papers concerning the reults of our research.

S — extent of supralittoral
M — extent of mediolittoral
I — extent of infralittoral
IC — transitory zone between infra- and circalittoral
C — circalittoral

A more detailed classification of recent facies of the Adriatic Shelf reflects all aspects necessary for the reconstruction and identification especially of Tertiary sediments.

S-1 — rocky supralittoral
S-2 — sandy supralittoral
M-1 — rocky mediolittoral
  M-1a — upper
  M-1b — lower
M-2 — "trottoir" of mediolittoral
M-3 — gravel, pebble mediolittoral
I-1 — rock p h y t a l infralittoral
  I-1a — *Acetabularia mediterranea* facies
  I-1b — *Padina pavonia* facies
  I-1c — *Cystoseira* facies
  I-1d — *Sargassum* facies
  I-1e — *Lithotamnium lenormandi — Halimeda tuna — Amphiroa rigida* facies

I-2 — Infracoralligene
  I-2a — *Lithothamnium philippi* facies
  I-2b — *Pseudolithophyllum expansum* facies

I-3 — Shallow, sandy a p h y t a l infralittoral
  I-3a — *Divaricella — Loripes* facies
  I-3b — *Dasycladus clavaeformis* facies

I-4 — Sorted sands of a p h y t a l infralittoral
  I-4a — *Cardium tuberculatum — Pitaria chione* facies

I-5 — Fine- to coarse-detrital sandy a p h y t a l infralittoral
  I-5a — *Pecten jacobaeus* facies
  I-5b — *Cladocora cespitosa* facies
  I-5c — *Lithophyllum racemus* facies

I-6 — Fine-arenaceous to muddy detritus of a p h y t a l infralittoral
  I-6a — *Pitaria rudis — Tellina pulchella* facies

I-7 — Sandy to mud-sandy p h y t a l infralittoral
  I-7a — *Cymodocea nodosa* — shallower facies
  I-7b — *Cymodocea nodosa* — deeper facies
  I-7c — *Posidonia oceanica* — shallower facies
  I-7d — *Posidonia oceanica* — deeper facies

IC-1 — Transitory zone of muddy a p h y t a l detritus between infra- and circalittoral
  IC-1a — *Apporhais pes-pelecani* facies

C-1 — Sandy to muddy organogenic detritus of circalittoral
- C-1a — *Hippodiplosia* facies
- C-1b — *Scrupocellaria—Porella—Hornera* facies
- C-1c — *Arca noae — Hippodiplosia foliacea*
- C-1d — *Sabella pavonina — Spirographis spallanzani* facies
- C-1e — *Chlamys opercularis — Ophiotrix quinquemaculata* facies

C-2 — Sandy organogenic and detrital sand of circalittoral
- C-2a — *Lithothamnium fruticulosum — Tapes gregaria* facies
- C-2b — *Venus casina — Tapes geographicus* facies
- C-2c — *Sabella pavonina — Venus casina* facies

C-3 — Muddy detritus of circalittoral (so-called *Turritella communis* facies)
- C-3a — *Turritella communis — Aloidis gibba* facies
- C-3b — *Turritella communis — Myrtea spinifera* facies
- C-3c — *Leda fragilis — Tellina div.* sp. facies

C-4 — Eucoralligene

I dedicate this introductory paper to the memory of Prof. R. L. Merklin from Moscow and to still active J. Y. Cousteau from Monaco who inspired me in the actuofacial studies of recent seas.

In following papers I intent to publish, step-by-step, the results of the research of the shelf areas of North and South Adria, above all a more detailed lithologic--sedimentologic analysis of profiles, quadrates and the sampled documentation points. The most suitable profiles for actuogeological and actuopaleotological application seem to be those on the North Adriatic Shelf, traced in all directions from the island Banjole, further the profiles between the islands Crveni Otok-Sturago-St. Giovanni, profiles between the islands Crveni Otok-Asino-St. Katarina and towards the mainland and the profiles between Crveni Otok-Pirozi-Sestrice.

On the South Adriatic Shelf, they are the profiles A-II. and C in the Žuljana region and the profile P-M between the islands Pelješac and Mljet.

Translated by K. Janáková

REFERENCES

BULJAN, M. et al., 1969: Oceanographic conditions in the Middle Adriatic area. Thalassia Jugoslavica, 5. pp. 27—34.

CIABATTI, M. — COLANTONI, P. — RABBI, E., 1965: Ricerche oceanografiche nel' Alto Adriatico antistante il Delta del Po. G. Geol. (Bologna), Ser. 2a, 33, 1, pp. 207—232.

DÖRJES, J. — HERTWECK, G., 1971: Der Golf von Geata. IV. Das Makrobenthos und seine küstenparallele Zonierung. Senckenbergiana Maritima. 3, pp. 203—246.

GAMULIN-BRIDA, H., 1962: Contribution aux recherches sur les biocénoses de circalitoral dans la région de l'Adriatique Orientale moyenne. Publ. staz. zool. (Napoli), 32, pp. 91—98.

GAMULIN-BRIDA, H., 1965: Biocenoza muljevitog dna otvorenog Stredjnej Jadrana. Acta Adriatica, 10, 10, pp. 1—27.

GAMULIN-BRIDA, H., 1967: Biocenološka istraživanja pomičnog morskog dna sjeveernog Jadrana kod Rovinja. Thalassia Jugoslavica, 3, pp. 23—33.

GAMULIN-BRIDA, H., 1968: Mouvements des masses d'eau et distribution des organismes marins et des biocenoses benthiques en Adriatique. 2-nd European Symposium on Marine Biology. Ser. 34, pp. 149—162.

GAMULIN-BRIDA, H. — POŽAR, A. — ZAVODNIK, D., 1968: Contributions aux recherches sur la bionomie benthique des fonds meubles de l'Adriatique du Nord. Biološki Glasnik, 21, pp. 157—201.
HINZE, C. — MEISCHNER, D., 1968: Gibt es rezente Rot-Sedimente in der Adria? Mar. Geol. (Amsterdam), 6, pp. 53—71.
ILIĆ, K. — BOŽIĆ, E., 1969: Neka hidrografska zapaženja u okolini Rovinja. Thalassia Jugoslavica, 5, pp. 133—140.
LABOREL, J., 1961: La concrétionnenement algal „Coralligène" et son importance géomorphologique en Mediterranée. Rec. Trav. Station Marine Endoume, 23, 37, pp. 37—60.
MARINKOVIĆ, M., 1956: Hydrographische Terminbeobachtungen bei Rovinj im Jahre 1954—55. Thalassia Jugoslavica, 1, 4—5, pp. 183—192.
MEISCHNER, D., 1973: Formation processes and dispersal patterns of the sediments along the Istrian coast of the Adriatic. Rapp. Comm. Int. Mer. Médit., 21, 11, pp. 843—846.
OTT, J., — SVOBODA, A., 1970: Messungen der qualitativen Lichtverteilung in Phytalbeständen. Thalassia Jugoslavica, 6, pp. 185—188.
PAUL, J., 1970: Sedimentologische Untersuchungen im Limski Kanal und vor der istrischen Küste. Göttinger Arbeiten z. Geol. und Paläont., 7, pp. 1—75.
PERÈS, J. M. — PICARD, J., 1964: Nouveaux manuel de bionomie benthique de la Mer Mediterranée. Rec. Trav. Station Marine Endoume, 31, 47, pp. 1—137.
RIEDL, R., 1963: Fauna und Flora der Adria. Paul Parey Verlag, Hamburg.
RIEDL, R., 1964: Die Erscheinungen der Wasserbewegung und ihre wirkung auf Sedentarier im mediterranen Felslitoral. Helgol. Wiss. Meeresuntersuchungen, 10, 1—4, pp. 155—186.
RIEDL, R., 1966: Biologie der Meereshöhlen. Paul Parey Verlag, Hamburg.
SENEŠ, J., 1960: Beitrag zur Frage der fossilen brackischen Biotopen. Geol. Práce, Spr. (Bratislava), 19, pp. 27—58.
SENEŠ, J., 1964: Grundlegende Analysen für die biofazielle Bewertung fossiler Brackischer Biotope. Biologické Práce (Bratislava), X, 2, pp. 1—17.
SENEŠ, J., 1966: Recent facies of Guanabo shelf (Cuba). Geol. Sbor. Geol. carpath. (Bratislava), 17, 2, pp. 283—304.
SENEŠ, J., 1967: Répartition bathymetrique des Algues fossilisables en Méditerranée. Geol. Sbor. Geol. carpath. (Bratislava), 18, 1, pp. 141—150.
SENEŠ, J., 1968: Versuch einer Zonierung der rezenten Algenablagerungen und Ihrer Applikation in der Geologie. Geol. Práce, Spr. (Bratislava), 46.
SENEŠ, J., 1971: Zonal distribution of Recent algae sediments and the possibilities of application in geology. I. CMAS Congress, Havana.
SCHÄFFER, W., 1962: Aktuo-Paläontologie. Kramer Verlag, Frankfurkt/Mein.
SKRIVANIĆ, A. et al., 1969: Hydrography and biotical conditions in North Adria. II. Repetration of light into the sea. Thalassia Jugoslavica, 5, pp. 329—336.
UFFENORDE, H., 1972: Ökologie und jahreszeitliche Verteilung rezenter benthonischer Ostracoden des Limski Kanal bei Rovinj (nördliche Adria). Göttinger Arbeiten z. Geol. und Paläont., 13, pp. 1—121.
VAN STRAATEN, L.M.J.U., 1965: Sedimentation in the north-western part of the Adriatic sea. Colston Papers, 17, pp. 143—162.
VAN STRAATEN, L.M.J.U., 1966: Micro-malacological Investigation of cores from the Southeastern Adriatic sea. Konicl. Nederl. Akad. Wettensch. Ser. B., 69, 3, pp. 429—445.
VATOVA, A., 1928: Compendic della Flora e Fauna del Mare Adriatico presso Rovigno. Memoria CXLIII del R. Comitato talass. ital. pp. 1—14.
VATOVA, A., 1931: La fauna di bentonica del Canal di Leme in Istria. Memoria CLXXXXI, pp. 1—10.
VATOVA, A., 1940: La Fauna bentonica del Bacino di Pomo (Medio Adriatico). Note 1st.-Italogerm. Biol. mar. Rovigno, 2, 15, pp. 1—12.
VATOVA, A., 1943: Le zoocenosi dell'Alto Adriatico presso Rovigno e loro variasioni nello spezio e nel tempo. Thalassia Jugoslavica, 5, 6, pp. 1—61.
VATOVA, A., 1948: Osservazioni idrografiche periodiche nello Alto Adriatico (1937—1944). Nova Thalassia Jugoslavica, 1, pp. 3—30.
VATOVA, A., 1949: La Fauna bentonica dell'Alto e Medio Adriatico. Nova Thalassia Jugoslavica, I, 3, pp. 21—29.

ZAVODNIK, D., 1968: Dynamisme annuel de quelques zoocenoses des fonds meubles dans les environs de Rovinj. (Adriatique du Nord). Rapp. Réunion Comm. Int. Explor. Scient. Mer. Méditerran. 19, 2, pp. 97—99.
ZAVODNIK, D., 1969: La Communauté a Acetabularia mediterranea Lamour, dans l'Adriatique du Nord. Int. Revue Hydrobiol., 54, 4, pp. 543—551.
ZORE-ARMANDA, M., 1969: Oceanographic conditions in the Middle Adriatic area. II. System of currents in the surface layer and their effect on the temperature distribution. Thalassia Jugoslavica, 5, pp. 465—475.

Manuscript received July 28, 1986.