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3rd Croatian scientific congress about geomathematics and terminology in geology

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SADRŽAJ / CONTENT

Mathematical methods and terminology in geology 2020
(*Matematičke metode i nazivlje u geologiji 2020*)

Preliminary communication

Morphometric characteristics and origin of Paleogene macroids from beach gravels in Stanići (vicinity of Omiš, Southern Croatia)

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Abstract

A collection comprising 322 samples of macroid pebbles was found at the beach at Stanići near Omiš (Dalmatia, southern Croatia), derived from the beach-rocks by the marine erosional processes. Macroids were measured by a digital caliper, providing information on their size and shape. Thin sections microscopy pointed to red algae as the dominant macroid builders, associated with acervulinid foraminifera and some other encrusters. Morphometric analyses of macroid shapes, together with micropaleontological analyses, enable the recognition of two macroid groups. Rhodolits and less complex macroids are dominantly spheroidal, exhibiting normal size distribution with good correlation. Multispecific macroids (composed of red algae, acervulinid foraminifera and other encrusters) exhibit a variety of shapes, mostly discoidal or elongate, with poor correlation. Rhodolits were derived from the Eocene bioclastic rocks rich in nummulitids and other benthic biota, informally known as "Nummulitic breccias". Blocks of these rocks, scattered along the beaches in the vicinity of Omiš, are a part of rockfall and avalanche deposits developed as megabeds during the collapse of Dinaride shelf margins.

Keywords: Macroids, measurements, bioconstructors, Eocene, Croatia

1. Introduction

The wider area of Omiš during the Paleogene was a part of the North Dalmatian Foreland Basin situated in front of the tectonically developed Dinaride structures. A ramp formed on its distal part was characterized by carbonate deposition until the Middle Eocene (**Ćosović et al., 2008; Babić and Zupanič, 2007, 2008, 2012; Vlahović and Velić, 2009; Španiček et al., 2017; Ćosović et al., 2018 and references therein**). The subsidence of carbonate ramp enabled the deposition of a 220 m thick carbonate succession, starting with terrestrial and marginal marine carbonates. Foraminiferal limestones are overlain with clastic/carbonate Transitional Beds and Flysch deposits, mostly deposited in the Middle and Upper Eocene. Shallowing-upward processes resulted in gradual replacement of Flysch with molasse Promina Beds, so these two types of deposits are in some places contemporaneous (**Ćosović et al., 2008**). Molasse deposition continued into the Oligocene and Miocene epochs (**Marinčić et al., 1977; Ćosović et al., 2008, Mrinjek et al., 2012; Ćosović et al., 2018 and references therein**).

During the Upper Eocene rockfall and avalanche processes lead to the formation of broadly distributed megabeds, comprising the foraminiferal packstones (also known as "Nummulite breccias") and blocks of older rocks, as described in several papers (e.g., **Marjanac, 1991, 1996; Marjanac and Ćosović, 2000**).

Paleogene fossils, particularly large benthic foraminifera extracted from megabed olistoliths, occur as bioclasts and within beach pebbles at several places along the eastern Adriatic coast, including the vicinity of Omiš in Dalmatia (**Figure 1**). Macroids, in most cases rhodolits, are also abundant, but they were not previously collected, as they look like common pebbles, except of their slightly tuberculate surface (**Figure 2c**). Such extracted macroid bioconstructions give us insight on their real shape and size, which can easily be observed and measured.

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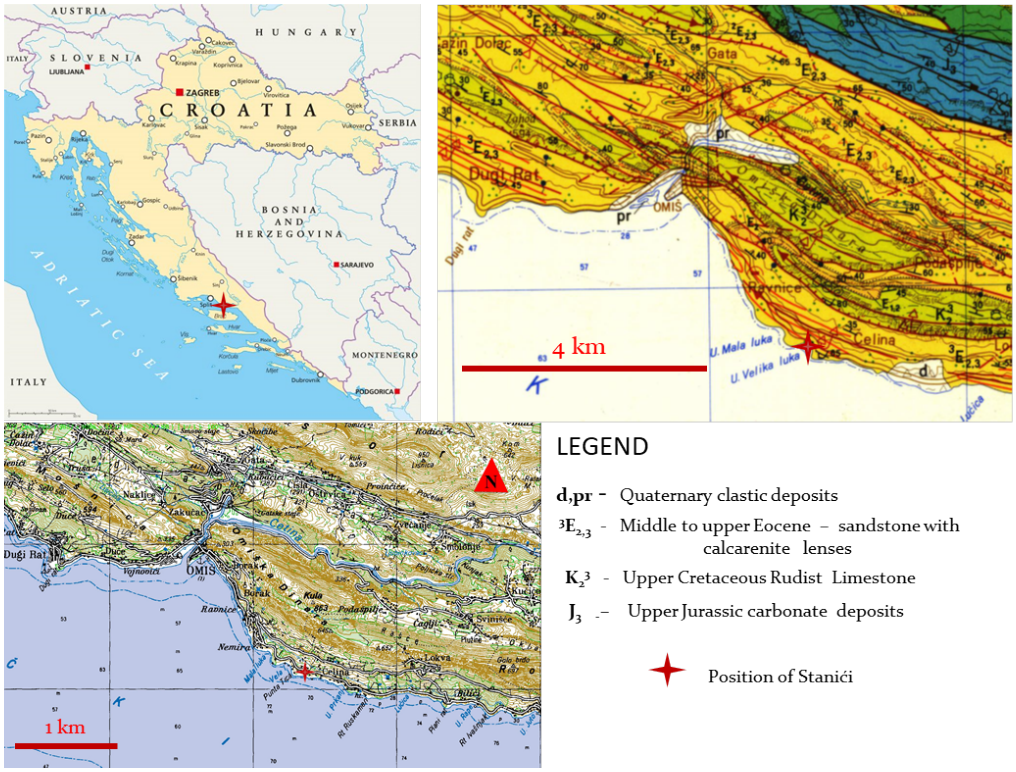


Figure 1: Geographic position (Google Earth, accessed August 2020) and geological map of the Omiš-Stanići area (segment from the Basic Geological Map OMIŠ, K 33-22; **Marinčić et al., 1976**)

The aim of this study is to analyse the connection between the shape/size of the collected macroids with their builders and to compare them with contemporary bioconstructions in the wider region. Authors also tested some statistical tools from other geological fields in order to cross-validate the obtained geomathematical results.

2. Materials and methods

During the several field excursions, between June 2019 and July 2020, we randomly collected 322 samples of macroids on the beaches in the vicinity of Omiš in central Dalmatia. Most of the material was derived after the strong Jugo (south-easterly wind) storm-waves at the Stanići beach, at the position 43° 24' 45,41" N; 16° 43' 54,26" (**Figures 1 and 2**).

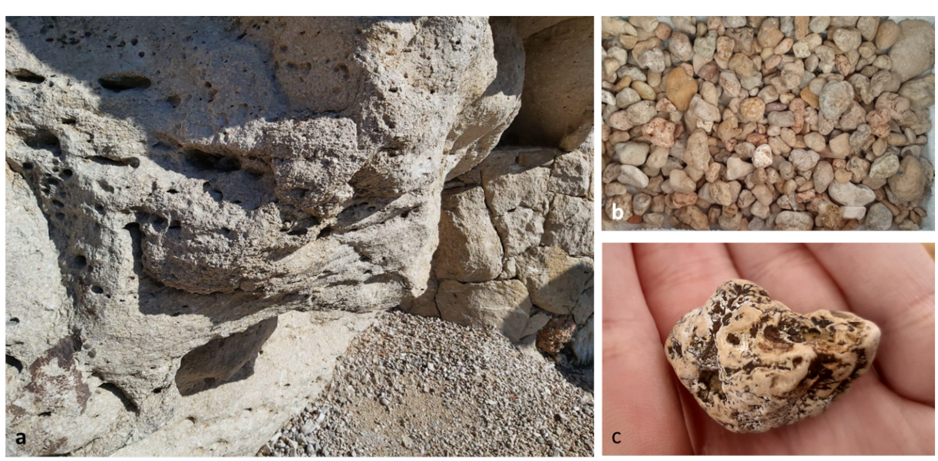


Figure 2: "Nummulitic breccia"(a) and part of the collected macroids (b) from the beach in Stanići. Macroid surface is always a bit bulbous (c).

Altogether thirty thin sections were prepared from randomly picked samples larger than 20 mm (to avoid the destruction of macroids by a saw blade during the cutting process) at the Wet laboratory, Department of Geology, Faculty of Science. Among them, nine were made from the blocks of source rocks (sample FH/M1 – one thin section; sample FH/O – five thin sections; FH/F1 and F2– three thin sections). Twenty-one preparation was made from pebbles, fifteen of which proved to be macroids (samples FH/1, 1.2,1.3,1.x,2.,3.,4.,5.,14, C1, V1a, V1b, V3, V4 and 6) .

Photomicrographs were done using the Olympus SZX10 Microscope with adjusted Canon EOS 1100D Camera at the Department of Geology, Faculty of Science.

Macroid shapes, when analysed from thin sections, were classified according to the basic rhodolith classification (**Sneed and Folk, 1958**; **Bosence, 1983**).

Table I: Classification of rhodoliths as proposed by **Bosence (1983)**, simplified

No. of species	Shape (Sneed and Folk's 1958 pebble shape diagram)	Shape (Bosence, 1983)
Monospecific	Spheroidal (S)	Laminar (L)
Multispecific	Ellipsoidal (E)	
	Discoidal (D)	Branching (B)
		Columnar (C)

Three main perpendicular axes were measured by a digital caliper: x (=a) – the longest axis, y (=b) – intermediate, z (=c) – the shortest one.

Microsoft Excel SHAPE and PAST Programmes (**Hammer et al., 2001**) were applied for morphometric and shape analyses.

Macroid shape was graphically presented by the ternary, TRI-PLOT diagrams (**Sneed and Folk, 1958**), using the Excel spreadsheet method (e.g., **Graham and Midgley, 2000**). TRI-PLOT is available from the Wiley Interscience web site (**www.interscience.wiley.com**) (after **Graham and Midgley, 2000**). To plot the ternary diagram, ratios of the three orthogonal macroid axes need to be calculated: c:a, b:a, and (a-b)/(a-c) (see **Figure 3**). The corners of the diagram are marked by blocks or spheres (upper corner, between c:a and b:a), slabs or discs (left corner, between c:a and (a-b)/(a-c)) and rods (right corner, between b:a and (a-b)/(a-c)) (see more in **Graham and Midgley, 2000** and references therein).

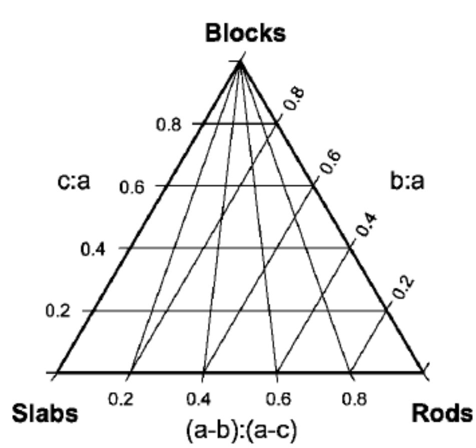


Figure 3: Graphic analyses of particle shape (Sneed & Folk) (from **Graham & Midgely, 2000**)

Shape classification was additionally done according to **Zingg (1935)**, taking into calculations the relations between the shortest and intermediate axis (z/y or c/b) and the relation between the intermediate and the longest axis (y/x or b/a). The results enable macroid division into the four form categories: spheroids, discoids, rods and blades.

3. Results

Monospecific rhodoliths may occur in a variety of growth forms and multispecific rhodoliths are even more diverse (**Lemoine 1910, Bosence, 1983; Foslie, 1984; Pejnović and Pensa, 2017 and references therein**). In such a case it is important to distinguish the rhodolith classification according to their shape from the taxonomical determinations (**Bosence, 1983**). Taxonomical analyses also underwent thorough revision, with the basic division into the geniculate/non-geniculate taxa proposed by **Rasser (2000)**.

In order to classify the macroid shapes, measurements of three axes (x,y and z) were recorded in **Table II**. It is probable that extracted macroids are smaller than the original ones, due to the wave erosion, but the relationships remain more or less similar.

Table II: Measurements of collected macroids

x	y	z	x	y	z	x	y	z	x	y	z
11.12	10.05	8.74	19.45	14.57	12.97	23.49	17.03	9.38	28.70	23.16	13.87
11.28	10.80	6.80	19.53	13.01	6.33	23.55	20.18	12.09	28.72	17.54	10.23
12.11	11.89	10.91	19.54	16.34	14.31	23.55	18.73	14.12	28.90	25.06	14.70
12.47	11.87	10.00	19.56	18.13	13.34	23.57	22.54	12.49	29.03	19.46	10.39
12.58	12.49	10.61	19.63	15.67	7.61	23.57	18.96	10.28	29.51	19.69	13.22
12.60	11.84	8.62	19.64	17.71	12.88	23.61	22.82	15.66	29.59	21.59	20.07
12.84	12.48	9.48	19.67	13.36	8.68	23.66	15.56	12.29	29.61	22.21	18.73
12.98	12.80	9.32	19.71	11.88	12.90	23.70	13.54	11.44	29.72	19.87	17.29
13.39	12.28	9.87	19.74	11.31	11.25	23.75	19.36	17.26	30.03	19.19	16.34
13.47	10.17	7.60	19.76	16.71	10.04	23.78	22.26	10.85	30.10	18.62	14.34
13.86	11.33	7.37	19.82	11.98	11.20	23.84	15.70	13.20	30.20	25.68	16.08
14.21	10.45	9.57	19.90	17.12	11.37	23.88	16.36	11.25	30.22	16.45	12.20
14.46	12.12	6.96	20.00	14.52	12.49	23.97	16.63	12.06	30.32	27.94	10.94
14.84	13.12	7.92	20.04	18.17	10.25	23.97	22.07	16.61	30.32	20.82	11.05
15.00	12.95	10.25	20.05	15.49	14.41	23.99	15.46	10.78	30.48	20.65	13.58
15.12	14.34	11.03	20.16	13.19	8.00	24.05	19.97	14.72	30.50	28.36	16.19
15.36	12.35	11.48	20.17	12.66	8.45	24.10	14.28	11.04	30.58	21.91	13.46
15.45	15.33	9.31	20.19	18.57	6.95	24.16	21.02	11.08	30.62	16.28	10.12
15.50	11.54	6.29	20.34	14.87	12.60	24.20	19.86	17.28	30.64	21.95	11.46
15.52	10.81	10.54	20.34	18.46	9.12	24.22	17.93	10.99	30.72	22.62	18.42
15.55	12.28	11.20	20.53	10.78	7.77	24.23	18.39	11.36	30.95	19.96	16.70
15.76	15.00	13.65	20.58	15.63	8.46	24.24	22.54	16.15	30.96	26.73	20.18
15.97	14.08	12.41	20.67	17.67	13.00	24.29	17.18	10.00	31.00	24.64	15.68
16.09	13.88	8.43	20.68	15.39	13.34	24.33	13.08	10.30	31.04	24.83	14.62
16.12	13.14	9.23	20.75	15.73	11.65	24.35	17.54	14.61	31.07	23.32	19.45
16.34	12.94	11.84	20.87	14.16	10.72	24.38	13.70	10.93	31.11	26.59	24.06
16.35	15.77	9.74	20.87	16.68	13.84	24.65	15.02	7.70	31.45	19.14	9.93
16.39	11.17	10.55	20.89	15.33	8.64	24.68	15.67	14.08	31.49	17.57	7.23
16.47	10.99	8.57	20.91	20.18	11.52	24.69	20.12	12.26	31.63	16.76	13.35
16.60	11.22	10.66	20.94	11.63	7.83	24.70	19.24	11.20	31.72	27.90	18.51
16.64	12.75	7.71	20.95	15.66	10.38	24.76	19.40	6,91	31.73	24.80	23.07
16.65	11.15	7.03	21.02	13.94	8.22	24.82	18.16	12.55	31.82	18.03	16.49
16.72	15.77	11.16	21.12	14.44	13.93	24.97	13.36	11.52	31.88	26.81	14.59
16.73	13.32	10.58	21.13	18.88	9.87	25.17	14.02	7.51	31.88	21.06	17.62
16.78	16.46	13.79	21.19	14.58	7.43	25.23	18.35	15.50	32.00	22.69	9.67
16.83	13.91	11.12	21.19	18.52	11.00	25.24	21.79	11.47	32.11	22.18	15.53
16.96	12.63	8.31	21.20	12.55	11.31	25.29	22.65	11.24	32.46	20.12	17.03
17.05	15.14	10.72	21.25	15.22	8.59	25.32	20.76	15.66	32.61	24.64	23.18
17.09	14.95	7.86	21.26	21.20	7.13	25.36	18.36	10.63	32.74	27.65	21.76

17.21	13.75	13.02	21.34	20.31	13.10	25.38	16.17	14.20	32.93	18.79	10.37
17.22	13.87	6.46	21.38	17.26	11.75	25.39	12.73	12.69	32.97	28.30	24.31
17.26	12.96	8.83	21.43	17.46	11.51	25.44	18.25	14.98	33.19	31.36	18.97
17.30	15.72	9.70	21.50	17.95	15.81	25.47	23.51	14.33	33.31	22.66	11.84
17.43	15.30	7.71	21.50	19.71	13.40	25.58	24.35	13.03	33.52	19.70	18.80
17.44	17.00	13.45	21.55	19.41	10.20	25.66	22.00	20.35	33.60	16.89	9.76
17.46	13.03	11.00	21.58	17.13	11.62	25.76	25.59	14.95	33.72	27.90	27.51
17.66	11.76	8.26	21.63	16.36	13.80	25.76	17.62	15.53	33.76	24.79	19.88
17.73	10.05	9.78	21.69	16.40	14.00	25.81	14.30	13.63	34.16	24.63	21.98
17.80	13.43	7.84	21.77	10.84	9.81	25.82	15.88	9.44	34.35	20.19	12.01
17.85	12.42	6.99	21.87	12.66	8.39	25.84	24.47	14.83	34.36	25.17	14.60
18.00	15.95	11.09	22.04	16.15	12.69	25.90	15.85	12.19	34.60	18.72	10.21
18.04	17.52	13.22	22.06	14.29	12.11	26.00	21.38	15.23	34.71	29.90	23.49
18.08	13.33	10.16	22.10	22.03	12.98	26.02	24.28	14.23	34.94	26.02	18.14
18.09	13.83	7.30	22.18	14.88	10.77	26.02	21.40	8.56	35.17	27.82	23.05
18.13	16.98	13.40	22.18	17.85	15.55	26.21	19.03	16.06	35.20	24.07	22.62
18.20	16.64	16.28	22.22	16.86	10.37	26.27	21.46	19.56	35.20	25.30	16.61
18.24	17.30	11.23	22.28	19.75	7.65	26.45	17.00	10.87	35.46	34.79	21.42
18.26	14.09	12.77	22.29	16.03	13.74	26.50	19.21	19.33	35.84	22.09	15.77
18.26	12.79	8.41	22.30	15.37	15.01	26.54	16.57	10.01	36.27	22.26	20.46
18.33	17.50	9.12	22.31	16.38	7.03	26.57	17.94	11.10	37.24	16.70	12.57
18.36	12.70	12.61	22.38	16.27	9.86	26.57	24.13	16.88	38.17	27.57	20.23
18.37	13.75	10.14	22.44	16.79	11.87	26.62	19.43	11.71	38.33	30.63	17.87
18.38	14.84	8.87	22.51	20.87	9.38	26.64	18.42	16.78	38.83	36.25	21.76
18.40	14.38	10.36	22.54	18.22	7.72	26.68	22.00	14.64	39.31	36.26	13.89
18.52	13.30	6.04	22.56	13.06	9.87	26.69	24.49	15.19	39.53	23.42	10.66
18.57	10.67	10.23	22.58	16.25	10.72	26.73	23.65	18.92	39.66	18.16	11.82
18.57	12.36	9.86	22.59	14.74	10.29	26.88	16.84	10.20	39.73	24.44	17.55
18.59	10.94	5.12	22.66	17.22	9.66	26.95	21.31	10.18	40.08	27.30	11.64
18.62	12.85	8.02	22.71	18.30	11.98	27.21	23.15	11.82	40.83	27.33	23.39
18.68	15.10	8.23	22.92	20.70	15.54	27.32	19.41	11.04	41.19	16.96	13.45
18.72	12.77	6.30	22.93	14.98	14.43	27.36	19.13	17.20	41.81	29.00	26.61
18.75	14.16	13.88	23.01	18.65	12.62	27.37	18.09	10.80	43.79	32.60	16.77
18.85	17.06	12.86	23.02	19.32	11.12	27.38	24.60	16.34	44.90	29.35	27.51
18.98	16.92	8.81	23.06	14.61	9.83	27.41	17.47	15.26	45.59	36.34	29.50
19.03	16.80	16.02	23.06	16.90	8.65	27.66	16.94	10.72	46.51	35.72	26.97
19.05	14.90	9.60	23.13	14.41	11.23	27.87	18.33	14.91	46.53	35.73	27.73
19.18	15.56	8.02	23.30	15.86	10.17	27.97	24.87	11.53	46.90	31.95	18.34
19.18	17.09	10.76	23.43	15.40	11.13	28.03	17.17	9.46	48.16	27.55	19.25
19.24	16.53	9.21	23.43	19.33	6.91	28.03	19.67	12.82	51.44	30.88	16.94
19.28	16.58	16.31	23.47	17.84	13.65	28.42	19.43	18.11			
19.41	13.48	13.61	23.48	19.98	7.04	28.42	20.90	12.38			

3.1. Numerical analysis of macroid measures

The measured collection comprises a variety of macroid sizes, but the longest axis lengths point to a normal distribution (**Figure 4**).

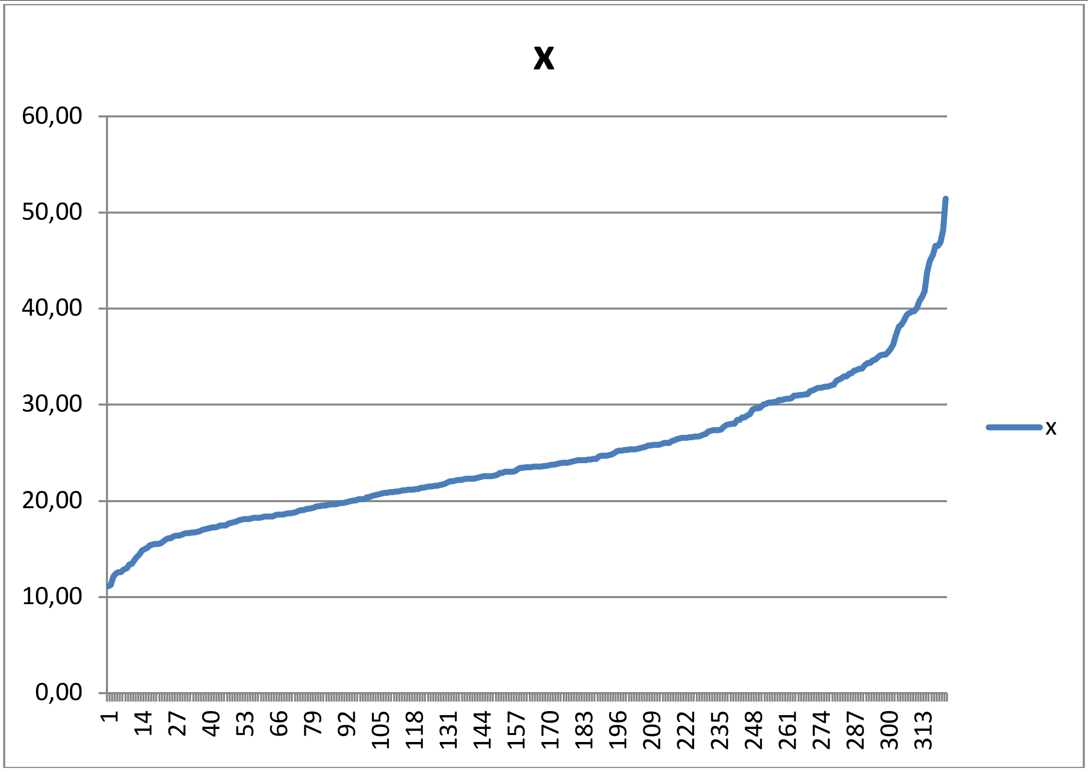


Figure 4: Distribution of sizes of the longest axis (x or a) of measured rhodoliths shown on the line chart (Microsoft Excel Programme), showing normal distribution

Relationship between the macroid axes reveal a variety of forms (**Figures 5, 6**), with regular spherical and subspherical shapes present mostly among the small specimens (**Figure 6**).

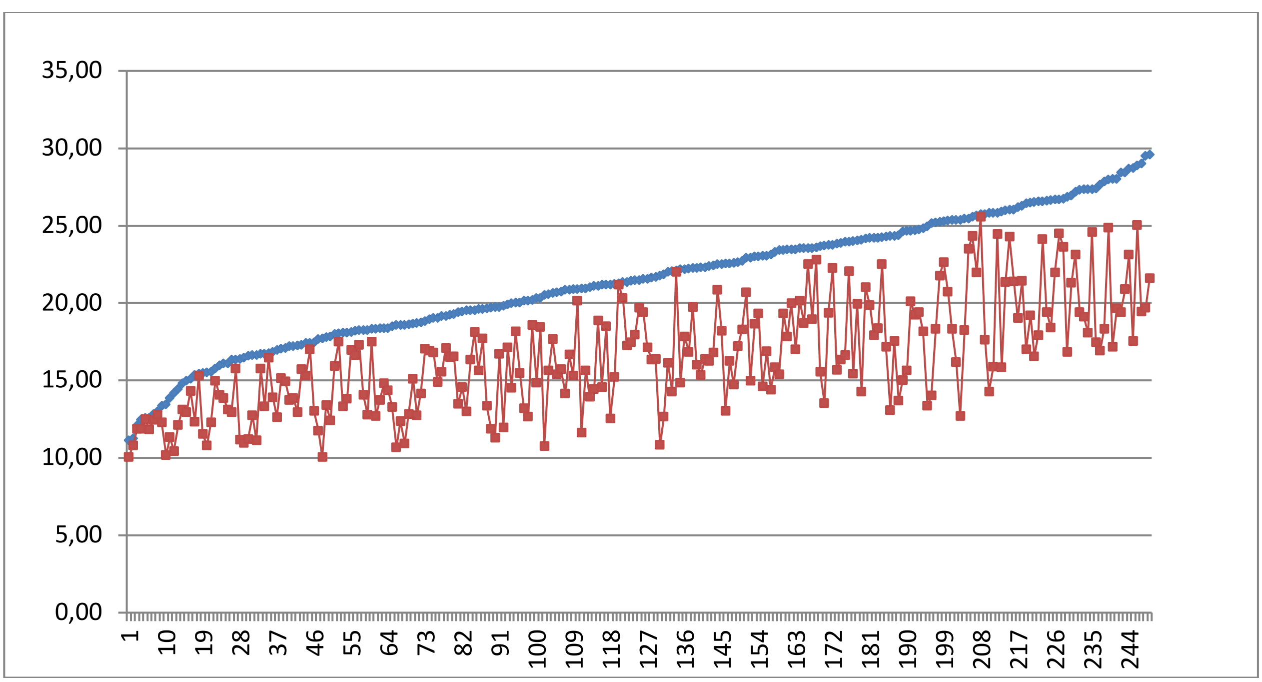


Figure 5: Relationship between the macroid axes x (blue line) and y (red line) presenting the variety of forms. Obtained from the Microsoft Excel Programme.

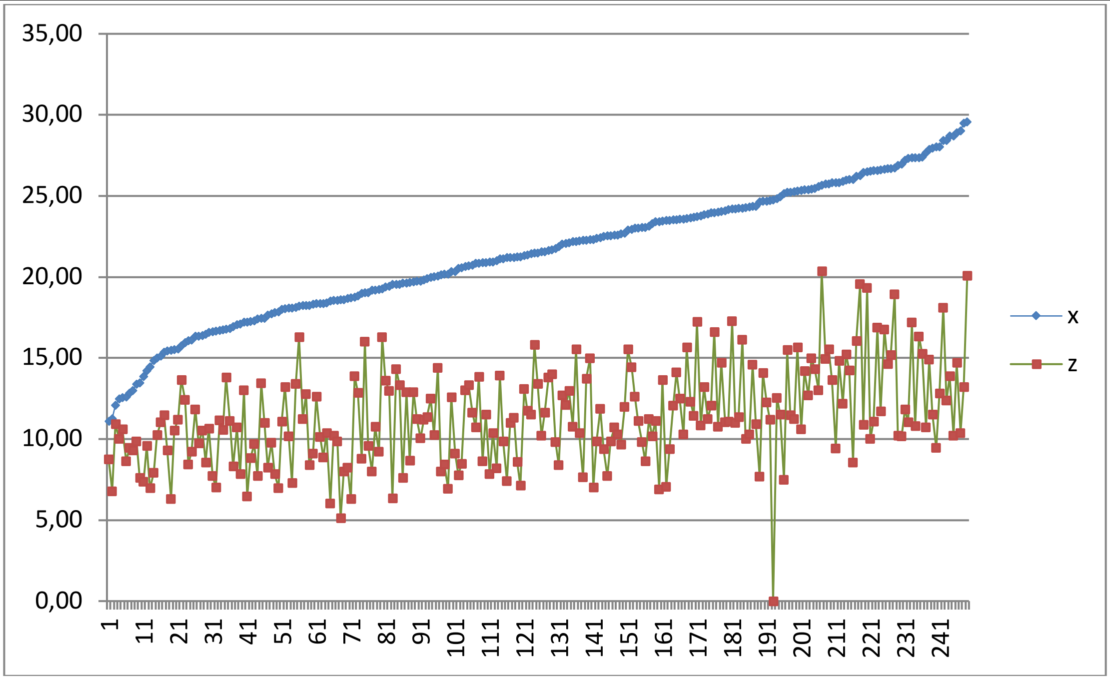


Figure 6: Relationship between the macroid axes x (blue line) and z (green line with red peaks) presenting the discrepancy in macroid growth. Spherical and subspherical forms only occur among the small collected specimens. Obtained from the Microsoft Excel Programme.

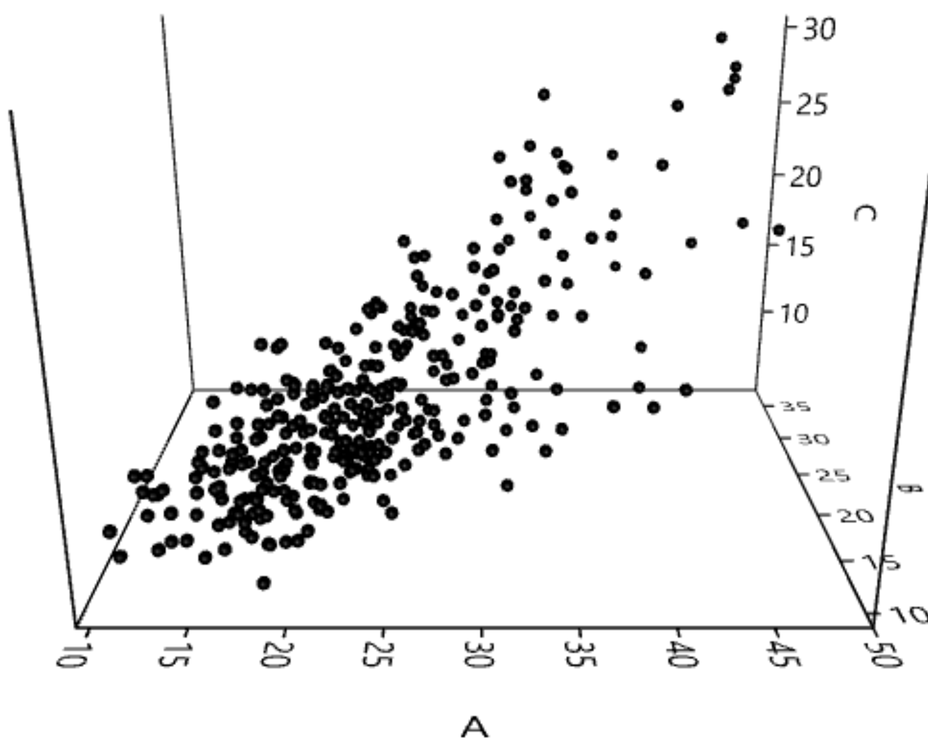


Figure 7: Scattered 3-D diagram presenting the relationship between the longest (x/A), intermediate (y/B) and shortest (z/C) axes of macroids. Obtained from the PAST Programme (**Hammer et al., 2001**).

Scattered 3-D diagrams drawn from the PAST program (**Hammer et al., 2001**) proved to be very useful in our analyses. They show in a simple way how smaller macroids present a more homogenous group, while those with the longest axis (x or A) form a very heterogenous group (**Figure 7**).

3.2. Clast shape and fossil content

Macroid shape analyses using the Zingg diagram (**Zingg, 1935**) and ternary diagram (**Sneed and Folk, 1958**) have shown that collected macroids are mostly represented by the particles of the discoidal and spheroidal shape as shown in **Figures 8, 9 and 10**. Only a small number of particles belong to the blade- and rod-shaped macroids (right corner) (see **Figures 3 and 8-10**).

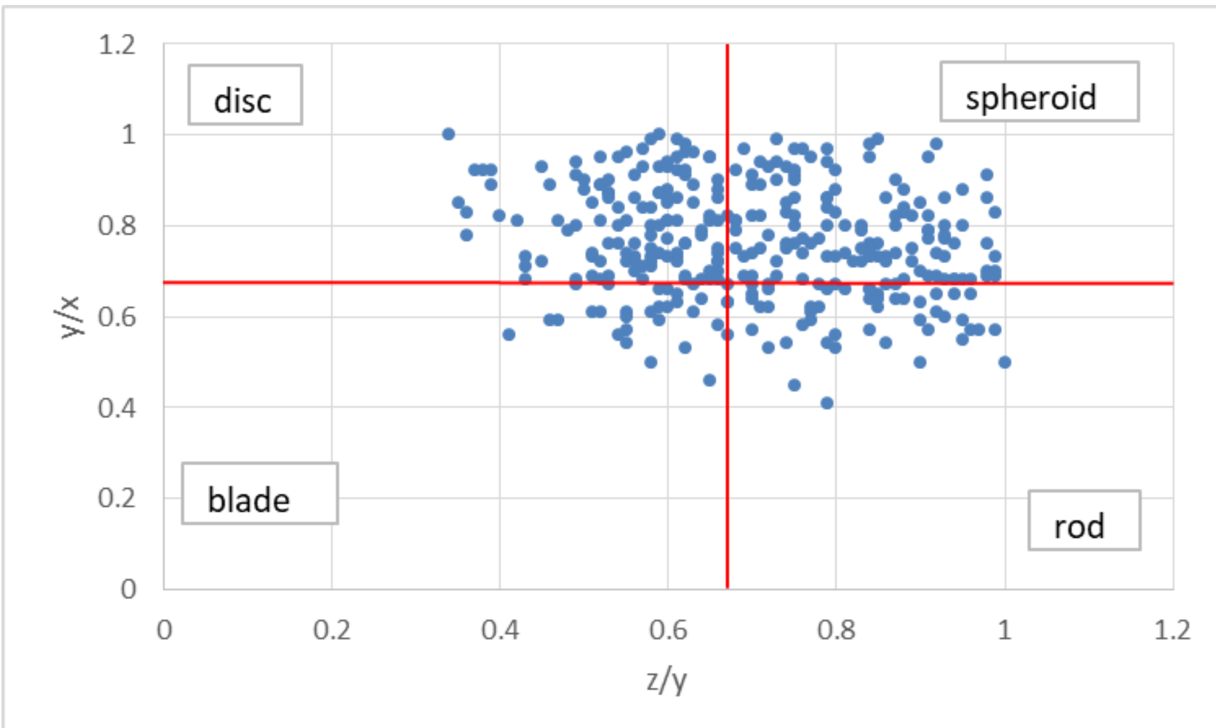
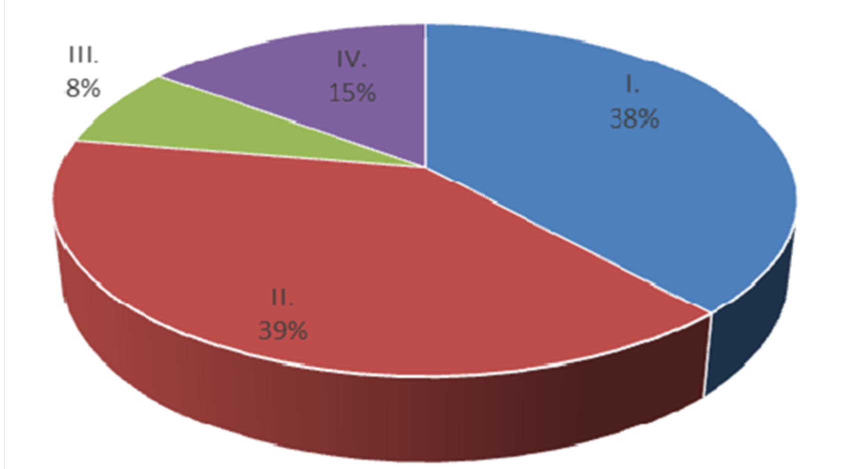


Figure 8: Zingg's diagrams for the measured macroids from the Stanići beach. Discoidal and spherical macroids are the most common.



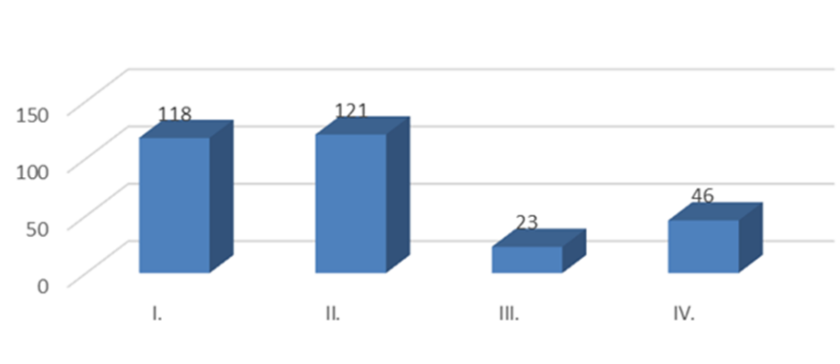


Figure 9: Comparison of Zingg's data for the collected macroids presented as a pie and a histogram. Categories: I. disc; II. sphere; III. blade; IV. rod. Microsoft Excel programme.

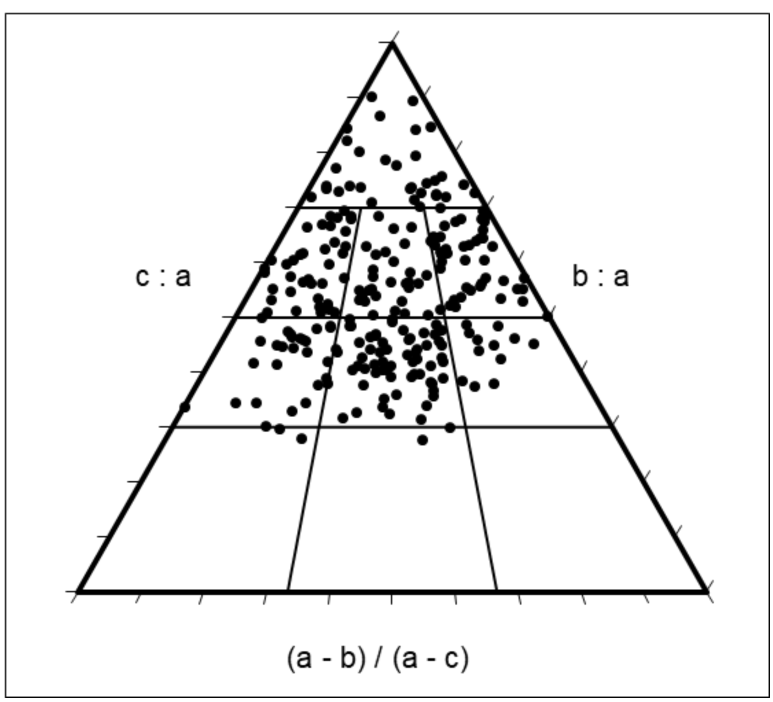


Figure 10: Graphic analyses of macroid shape carried out by ternary (Sneed & Folk) diagram based on measurements of long (a = x), intermediate (b = y) and short (c = z) axes (from **Graham and Midgley, 2000**)

4. Discussion

A hypothesis at the beginning of our research was that, according to previous studies, macroids, composed exclusively of red algae (rhodoliths), or those with a minor amount of other encrusters, will be developed in more regular shapes (subsphaeroidal, or, sometimes discoidal) (**Figure 11 a,b**) than the complex ones, composed by a variety of bioconstructors (**Figure 11 c,d**). The most expressed diversity is expected among the branching forms.

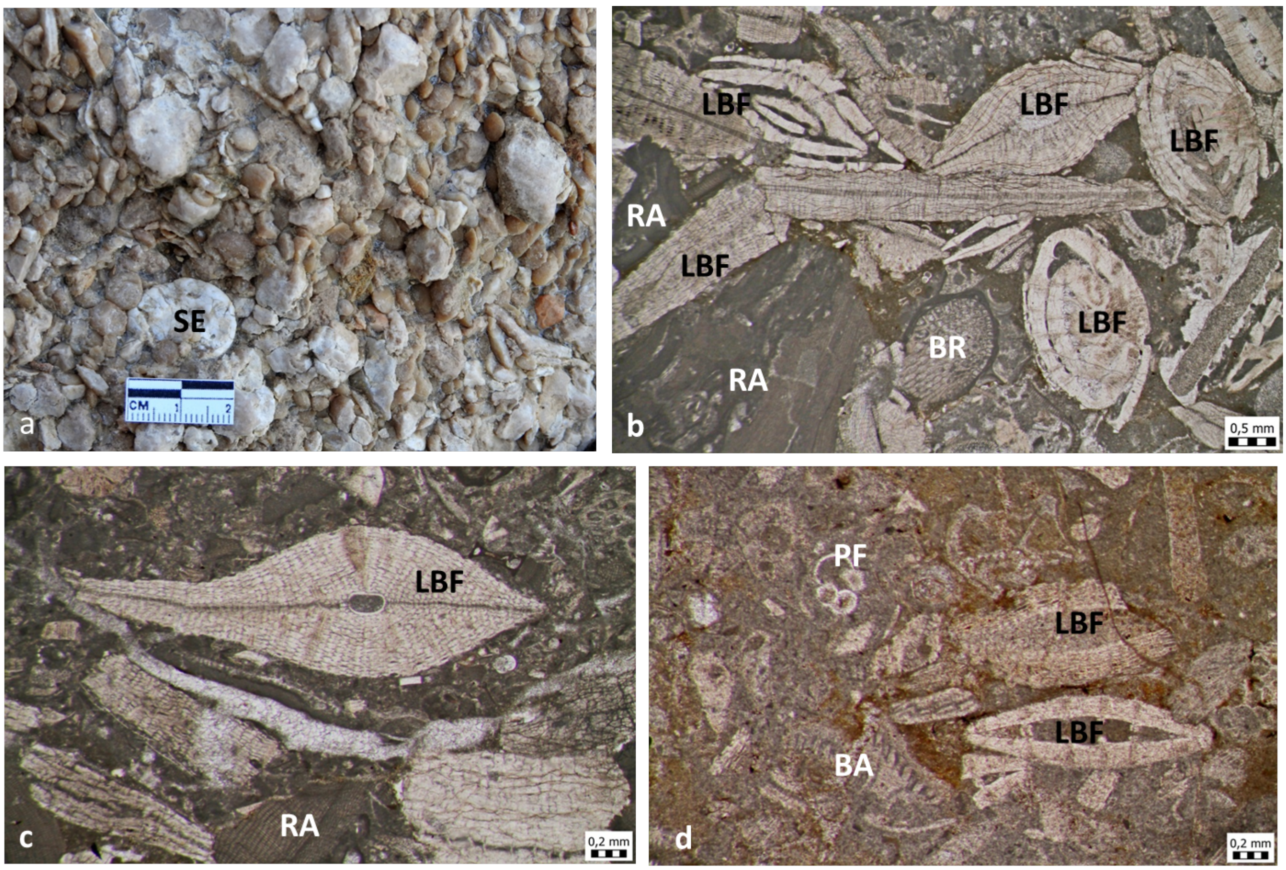


Figure 11: Source rock on the Stanići beach (a); photomicrographs presenting packstone-type of biocalcarenites (b-c) from the sample FH/O and wackestone, sample FH/M1 (d). Fossils: large benthic foraminifera (LBF), planktic foraminifera (PF) red algae (RA), balanids (BA), serpulids (SE) and bryozoans (BR).

After the macroscopic analyses of source rocks (**Figure 11**), thirty thin sections with macroids (ca. 10% of the bulk sample) were studied. The results so far fit into the presumption that small and regularlly-shaped macroids are dominantly composed of red algae, while larger pebbles represent complex macroids (**Figure 12**). Rhodoliths are mostly derived from the coralline algal packstone, with bioclasts transported from the inner to mid-ramp by storms, similar to the Microfacies MF5 described by **Ćosović et al. (2018)** from the Dinaric Foreland Basin in Northern Dalmatia. Combined macroids, particularly those with large amount of acervulinid foraminifera, point to the middle to lower photic zone, moderate water energy and/or increased turbidity. They sometimes comprise planktic foraminifera (**Figure 11d**). Similar bioconstructions were described from Northern Dalmatia as foraminiferal packstone/grainstone from the middle ramp environment (Microfacies MF6 in **Ćosović et al., 2018)**, but also from younger, Miocene deposits found in different regions (e.g., in Zagros, Iran; **Roozpeykar et al., 2019**). In the Dinaric Foreland Basin, the succession of Microfacies types MF5 into MF6 (in this case rhodoliths into acervulinid-rhodalgal macroids) reflects the deepening of the basin and the transition into the flysch-type deposition. Further research, with preparation of thin sections from a larger amount of macroids, is in progress.

Here presented research offered the opportunity to compare the results obtained from the different methods revealing the shape of the measured object in paleontological and geological (sedimentological) programmes. **Zingg (1935)** and **Sneed and Folk (1958)** calculations can both generate similarly valuable results, and we would recommend them as cross-validating methods in both research topics.

Furthermore, graphics presenting the relationship among the three variables (in this case macroid axes: x/a, y/b and z/c), obtained from the open-access paleontological PAST programme (**Hammer et al., 2001**), could be successfully applied to other similar cases aside from paleontology (e.g., pebble morphometry).

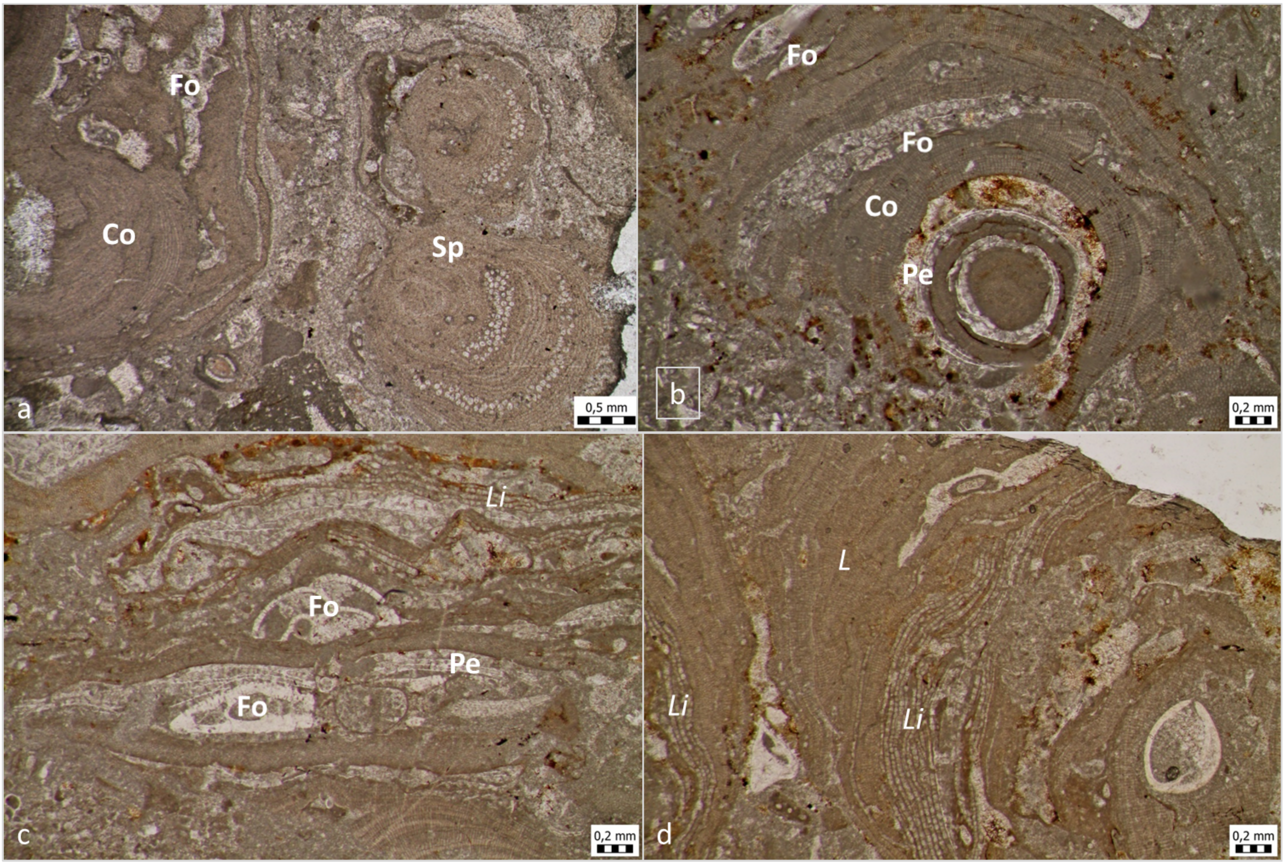


Figure 12: Photomicrographs of macroids from the source rock ("Nummulitic breccia") at the Stanići beach . Algal remnants: Co – Corallinales (*L – Lithothamnion?* sp.*; Li – Lithoporella*); Sp – Sporolithales; Pe - Peyssonneliales . Fo – foraminifera.
(a) Corallinales and regularly-shaped *Sporolithon* rhodoliths, with scarce foraminifera; (b) a partly crushed rhodolith composed of rhodalgal layers and encrusting foraminifera; (c) Complex laminar crusts composed of red algae and sessile foraminifera from an elongate, box-shaped pebble; (d) Crushed complex rhodoliths with dominant coralgal laminae and with sporadic layers composed of encrusting foraminifera. Cross section of a macrofossil is visible in the macroid core.

5. Conclusions

- Macroids collected at the Stanići beach near Omiš are of variable shape and size.
- Regularly formed, in most cases sphaeroidal macroids are rhodoliths of monospecific composition or composed from a small number of taxa. They were mostly formed in the inner ramp environment and transported into the middle ramp milieu by storms.
- Larger and less regular-shaped macroids are commonly multispecific, with a significant amount of sessile foraminifera and other bioconstructors. They originate from the middle ramp environment with increased turbidity.
- Macroids were extracted from the Eocene "Nummulitic breccias" scattered as olistolites along the beaches in this part of Dalmatia, reflecting the gradual transition from the carbonate ramp into the flysch-type deposition.
- Some of the morphometrical methods applied in paleontology can be successfully used in sedimentological research and *vice versa*.

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SAŽETAK

Morfometrijske karakteristike i porijeklo paleogenskih makroida iz šljunaka na plaži u Stanićima (okolica Omiša, južna Hrvatska)

Na plaži u Stanićima kraj Omiša prikupljena je zbirka od 322 makroidna klasta, koje je more ispralo iz okolnih bioklastičnih naslaga. Makroidi su mjereni digitalnim mjeračem (kaliperom) kako bi se zabilježile njihove dimenzije (najduža, srednja i najkraća os). Morfometrijske analize, zajedno s mikropaleontološkim analizama, omogućile su razlikovanje dviju skupina makroida. Jednostavni rodoliti ili makroidi složeni od malog broja inkrustanata, pretežito su sferoidnog ili diskoidalnog oblika i pokazuju normalnu raspodjelu veličina i dobru korelaciju. Multispecifički makroidi (načinjeni od lamina crvenih algi, acervulidnih foraminifera i drugih inkrustanata) pojavljuju se u raznolikim oblicima, najčešće su diskoidalni ili štapićasti i na dijagramima pokazuju slabu korelaciju. Makroidi su erodirani iz obalnih bioklastičnih stijena eocenske starosti, gdje se pojavljuju uz izobilje numulita i drugih foraminifera te fragmente skeleta makrofosila, a često ih neformalno nazivamo "Numulitnim brečama". Blokovi ovih stijena razbacani su duž plaža na cijelom širem području Omiša, a dio su megaslojeva, nastalih tijekom urušavanja rubova Dinaridskoga šelfa. Rodoliti su nastajali u okolišima unutarnje do srednje rampe, a složeni makroidi, nastali proslojavanjem crvenih algi i acervulinidnih foraminifera, upućuju na postupno produbljavanje mora, uz porast turbiditeta, koji obilježava završetak karbonatne sedimentacije i početak taloženja flišnih naslaga u Dinarskom predgorskom bazenu. Istraživanje je pokazalo da se neki sedimentološki programi i metode mogu uspješno primjenjivati u paleontologiji, dok sedimentolozima neki paleontološki morfometrijski programi mogu poslužiti za kontrolu i usporedbu njihovih rezultata.

Ključne riječi: makroidi, morfometrija, biokonstruktori, eocen, Hrvatska

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Author's contribution

Jasenka Sremac (1) (Dr, Full Professor, geology, paleontology, paleoenvironment) provided the fieldwork, paleontological analyses, description of geological settings, interpretation and presentation of the results. **Filip Huić (2)** (student, anthropology, paleontology) provided the fieldwork, measuring, taking photomicrographs and part of preliminary fossil determinations. **Marija Bošnjak (3)** (Dr, senior curator, paleontology, geomathematics) provided the numerical analyses and methodological data. **Renato Drempetić (4)** (electrotechnics engineer), contributed with fieldwork, field- and macro-photography, measuring macroids and preparing computer tables and graphics.