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SPIRIDION BRUSINA'S MIOCENE FRESHWATER AND PLEISTOCENE MARINE FOSSILS FROM SINJSKO POLJE

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The examination of the S. Brusina's collection and samples from Sinjsko Polje revealed yet partially undetermined freshwater Miocene gastropods as well as marine fossils such as gastropods (*Caecum*, *Parastrophia* etc.), many foraminiferas, echinoid shell and spike fragments, parts of bryozoa and marine ostracods. The remains of this marine fauna as well as specific identification of foraminiferas suggest the Middle to Upper Pleistocene age of the Brusina samples. These data would further indicate the possible existence of surface sea connection during the Pleistocene between Sinjsko Polje and the Adriatic Sea. Therefore, the consequence of this discovery could be a new interpretation of the Quaternary palaeogeographic relations of that region.

Key words: gastropods, foraminiferas, Pleistocene, Sinjsko Polje, Croatia

U fosilnom materijalu iz Sinjskog polja, koji je sakupio i djelomično odredio S. Brusina, nađeni su uz miocenske slatkovodne fosile i do sada neodređeni marinski gastropodi (*Caecum*, *Parastrophia* itd.), mnogobrojne foraminifere, fragmenti ljuštura i radiola ježinaca, dijelovi briozoa i marinski ostrakodi. Na osnovi te marinske faune, a osobito specifičkih odredbi foraminifera, dokazana je srednjopleistocenska do gornjopleistocenska starost. Na temelju iznesenih podataka pretpostavlja se postojanje površinske morske veze između današnjeg područja Sinja i tadašnjeg mora, što bi moglo imati posljedice u interpretaciji paleogeografskih odnosa tog područja u kvartaru.

Ključne riječi: gastropodi, foraminifere, pleistocen, Sinjsko polje, Hrvatska

INTRODUCTION

During the examination of the noninventoried and partially undetermined samples from the Spiridion Brusina's collection in the Croatian Natural History Museum, the freshwater as well as marine fossils were found. BRUSINA (1905, 1907) collected this material during the excavation of new well (Novi bunar) in Sinj 1901, along the main road to Split and just at Krolo's bridge over the Goručica stream. The depth of the well was nine meters and it was dug in the light marls of the lower levels of the Župić stream.

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The freshwater malacological fauna from this area was described by BRUSINA (1907) and from this particular site in Sinj (well) or in its vicinity sixteen species, four of them being new, were described. These new species were: *Melanopsis kuzmići, Pseudoamnicola ? pauluccii, Orygoceras subula* and *Congeria infantula.* (Unfortunately, Brusina's original description does not contain any illustrations of these new taxa!). The remaining species were: *Ancylus illyricus* NEUMAYR, *Limnaea hyaloleuca* BRUSINA, *Melanopsis astrapaea* BRUSINA, *M. camptogramma* BRUSINA, *Fossarulus hoernesi* BRUSINA, *Prososthenia dalmatina* (NEUMAYR), *P. sepulcralis* (PARTSCH), *Valvata homalogyra* BRUSINA, *Orygoceras stenonemus* BRUSINA, *Neritodonta sinjana* BRUSINA, *Congeria jadrovi* BRUSINA, and *Unio rackianus* BRUSINA.

Part of the above mentioned fauna, and particularly the marine taxa, were not then identified nor inventoried; only the site was recorded. We might assume that Spiridion Brusina was not able to determine this fauna because he died in May of 1908. Explanation of this lies possibly in the fact that this palaeontological sample represents a microfauna and the material requires laboratory preparation and extraction from the matrix. Thus BRUSINA (1905: 34) wrote: (our translation)

"Because there were boulders of hard marls, and a lot of fossils inside, I took several kilograms of sample with me to Zagreb, so I could extract them following my own method by washing them out, during the winter of course, when everything is frozen." On the other hand it is not surprising that Brusina as biologist and palaeontologist of that time never made any comment regarding the occurence of marine taxa in the same sample with a Miocene freshwater fauna, since it requires a knowledge of hidrogeology, tectonics and palaeogeography of the whole region of Dalmatia.

PALAEONTOLOGICAL DESCRIPTION

Gastropoda

Two marine gastropod genera are represented here in the sample in association with foraminiferas: genus *Parastrophia*, which is similar to fossil orygoceras, and genus *Caecum*, which looks like "cutted" orygoceras. BRUSINA (1882) in his work on the new genus *Orygoceras* points to the affinities of this genus with the Recent marine genus *Parastrophia*. Comparison of Miocene freshwater orygoceras with similar rod like marine gastropods found in association with foraminiferas reveals several differences. The later gastropods have a transparent shell, and as a rule, they are smaller in dimensions than the older, fossilized forms. The orthogonal section of the gastropods is rounded (Pl. I, Figs. 1-4) while the fossil orygoceras have an approximately eliptical section, their posterior side is rather compressed and the anterior portion is more oval (Pl. II, Fig. 6).

Class: GASTROPODA
Subclass: PROSOBRANCHIA
Order: MESOGASTROPODA
Superfamily: CERITHIACEA
Family: CAECIDAE
Genus: *CAECUM* FLEMING 1817

Genus *Caecum* has been found in the Atlantic, Mediterranean as well as Adriatic Sea. In the S. Brusina malacological collection, which is kept

at the Zoology Department of the Croatian Natural History Museum,. there are four species of this genus. The most northern location of this genus is the island of Olib. PARENZAN (1970) lists nine species of this genus in the Mediterranean Sea, while RIEDL (1970) mentions two particular species in the Adriatic Sea. It is interesting to point out that the genus *Caecum* appeared in the Palaeocene and in the Pannonian Basin (Paratethys) the species of *Caecum trachea* MONT. from Badenian marine sediments (HOERNES, 1856) is known. In Croatia there is no record of the presence of this genus in the Badenian layers.

Caecum auriculatum FOLIN
(Pl. I, Figs. 5,6)

1968. *Caecum (Brocchina) auriculatum*, NORDSIECK, p. 67, Pl. XI, Fig. 39.51.
1970. *C. auriculatum*, RIEDL, Pl. 132.
1970. *C. auriculatum*, PARENZAN, Pl. XIX, Fig. 339.

Material: 7 specimens
Locality: Sinj (Novi bunar), Mediterranean Sea, Adriatic Sea.

The shell is transparent, and it has a shape of a slightly curved cylinder with a rounded top at the apex. There is a ring-like thickening at the mouth. The length of the shell is cca 2 mm. Recent forms live on the sandy bottom, at depths from 28 to 72 meters (in the so-called coralline zone, following WENZ, 1938-1944).

Age: Pleistocene, Recent.

Caecum cf. *trachea* (MONTAGU)
(Pl. I, Figs. 7-9)

1877. *Caecum trachea*, FOLIN, p. 207, Pl. V
1896. *C. trachea*, BRUSINA, p. 280.
1938-1944. *C. (C.) trachea*, WENZ, p. 683, Fig. 1959.
1968. *C. trachea*, NORDSIECK, p. 67, Pl. X, Fig. 39.20.
1970. *C. (C.) trachea*, STOLFA ZUCCHI, p. 39-40, Pl. IV, Fig. 71.
1970. *C. trachea*, PARENZAN, p. 102, Fig. 341, Pl. XIX.

Material: 3 shell fragments
Locality: Sinj (Novi bunar). Adriatic Sea (Venezia and Trieste), Lake Prokljan (Dalmatia), Mediterranean Sea, England.

On the surface of the tubular shell there is a row of equally spaced transversal rings. The length of the shell is 2 to 5 mm. The habitat of this species is in the littoral down to the depth of 6 meters and on the sandy bottom.

Age: Baden (The Pannonian Basin - Paratethys). Pleistocene, Recent.

Genus: *PARASTROPHIA* FOLIN 1877

This genus is known from tropical and subtropical seas and from the Recent time only (WENZ, 1938-1944).

Parastrophia folini (BUQUOY, DAUTZENBERG & DOLLFUS)
(Pl. I, Figs. 1-4)

1896. *Parastrophia Folini*, BRUSINA, p. 280.
1968. *P. folini*, NORDSIECK, Pl. X, Fig. 39.00, p. 66.
1970. *P. folini*, PARENZAN, p. 101, Pl. 19, Fig. 337.

Material: Four specimens
Locality: Sinj (Novi bunar), Lake Prokljan, Mediterranean (Parenzan, 1970).

The shell is almost transparent with a circular cross-section. It is shaped as

a slightly curved small tube that is widened toward the aperture. The embrional part is spiral and it is made of one whorl. The surface of the shell is covered with fine growth lines.

Age: Pleistocene, Recent.

Superfamily: RISSOACEA
Family: HYDROBIIDAE (TAYLOR, 1974)
Genus: *ORYGOCERAS* BRUSINA 1882

The genus *Orygoceras* is characteristic for Miocene freshwater sedimentary basins of Dalmatia and Bosnia and Herzegovina (Ottnangian - Pannonian). It has been found in Pannonian sediments in the Vienna Basin (PAPP, 1953), in Hungary (LOERENTHEY, 1902), Croatia /Markuševec/ (BRUSINA, 1892), Romania (JEKELIUS, 1944) as well. TAYLOR (1974) has identified this genus in Pliocene lacustrine sediments of Idaho (USA) as well Recent specimens in the subterranean waters of Texas.

Orygoceras subula BRUSINA
(Pl. II, Figs. 1-6)

1882. *Orygoceras dentaliforme* ?, BRUSINA, p. 42, Pl. XI, Figs. 9, 10, 13-15.
1905. *O. subula*, BRUSINA, p. 34.
1907. *O. subula*, BRUSINA, p. 219-220.
1923-1930. *O. subula*, Wenz, p. 2490-2491.

Material: several hundred specimens
Locality: Župić stream, Sinj (Novi bunar).

Brusina's figures (1882, Pl. XI) do not exhibit complete specimens. This species is the most similar to the marine genus of *Parastrophia*.

Age: Middle Miocene.

The same faunal association which contains the above taxa also yielded abundant remains of marine snails and in smaller quantities, bivalve shells. The gastropod faunal sample is also represented, besides by the genera *Caecum* and *Parastrophia*, by the following species (following WENZ's systematics, 1938-1944; PARENZAN'S handbook, 1970; NORDSIECK, 1968 and 1972; as well as papers by STOLFA ZUCCHI, 1970): *Scissurella (S.) costata* d'ORB., *Putilla (Coriandria) micrometrica* (SEQUENZA), *P. (C.) ochroleuca* (BRUSINA), *Anabathron (Nodulus) contortum* (JEFFREYS), *Skeneopsis planorbis* (O. FABRICIUS), *Aclis (Graphis) unica* (MONTAGU), *Odostomia sp.*, *Turbonilla (Cyrtoturbonilla)* cf. *pusilla* (PHILIPPI), *Retusa (Retusa) semisulcata* (PHILIPPI), *R. (R.) umbilicata* (MONTAGU), *Philine (Hermania) catena* (MONTAGU).

The bivalves are less frequent and following MILIŠIĆ (1991) the following taxa have been identified: *Tellina albicans* GMELIN and *Bornia sebetia* (O.G. COSTA).

Foraminiferida

The palaeontological analysis of foraminifera in association with the above faunal sample gives the following list of taxa: *Praeglobobulimina ovata* (d'ORB.), *Chilostomella ovoidea* REUSS, *Polymorphina sp.*, *Spiroloculina depressa* d'ORB., *Peneroplis planatus* (FICHTEL & MOLL), *Pyrgoella sphaera* (d'ORB.), and: *Elphidium crispum* (L.), *E. advenum* (CUSHMAN), *E. aculeatum* (d'ORB.), *Ammonia beccarii* (L.), *Globigerina bulloides* d'ORB., *Globigerinoides sacculifer* (BRADY), *G. ruber* (d'ORB.), *Orbulina suturalis* BROENNIMANN, *Melonis soldani* (d'ORB.), *Asterigerinata mamilla* (WILL.), *Protoglobobulimina* cf. *pseudotorta* (CUSHMAN), *Cibicides lobatulus* (WALKER & JACOB), *Adelosina*

longirostra d'ORB., A. *schreibersi* (d'ORB.), *Pyrgo oblonga* (d'ORB.), *P. inornata* (d'ORB.), *P. depressa* (d'ORB.), *Triloculina gibba* d'ORB., *T. austriaca* d'ORB., *Quinqueloculina bicarinata* d'ORB., *Q. oblonga* (MONT.), *Q. aglutinans* d'ORB., *Spiroloculina excavata* d'ORB., *S. canaliculata* d'ORB., *Textularia concava* (KARRER), *T. sagittula* DEFR., *T. truncata* HOEGLUND, *T. agglutinans* d'ORB., *Textularia sp.*

The majority of the identified foraminiferal species span the Middle to Upper Pleistocene. These are: *Praeglobobulimina ovata* (d'ORB.), *Pyrgoella sphaera* (d'ORB.), *Cibicides lobatulus* (WALKER & JACOB), *Pyrgo depressa* (d'ORB.), *Quinqueloculina bicarinata* d'ORB., *Textularia concava* (KARRER), *Globigerinoides sacculifer* (BRADY), *Orbulina suturalis* BROENNIMANN.

The remaining species are also Recent (AGIP, 1982). **Thus, on the basis of foraminifera one can conclude that the age of the marine fauna is within the period of Middle to Upper Pleistocene.**

Miscellaneus fauna

Echinoid radiolae have been found, as well as echinoid plates, several bryozoa fragments, and spiny ostracod shells represented by these taxa: *Pterygocythereis jonesi* (BAIRD), *Bosquetina sp.*, and *Pontocythere sp.* (determined by V. Hajek - Tadesse).

CONCLUSION

The results of this analysis offer some new clues regarding the geology of this region in Dalmatia (Croatia). Furthermore, they may have important implications for our understanding of the Quaternary palaeogeography of this area, as well as the broader Mediterranean region. Therefore, we offer some new hypotheses regarding this problem. The occurence of Quaternary sediments with marine fossils in Sinjsko Polje at a present day elevation of cca 300 meters above sea levels and relation of this fauna with those from marine environments to the West and South suggest the following hypotheses:

a) The passive transport of marine fossils over land to the area of Sinjsko Polje. This transport could be explained by the activity of vertebrates, but this explanation appears unlikely.

b) Transport by surface or subsurface waters was possible only in the opposite direction, toward the west, because of the present day geographic relations between the land and sea.

c) A surface marine connection between the areas of Sinjsko Polje and the former Adriatic Sea. This would imply that most parts of Ravni Kotari or the mountain range heights from Primošten to Omiš and further toward the southeast were under the marine regime in the recent past. Or, perhaps, there may have been a marine bay that reached the area of Sinjsko Polje.

There are many questions to be answered and many of them point to the importance of neotectonic movements in the recent past. Obviously, the amplitude of these movements may be far greater then was thought until now.

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MIOCENSKI SLATKOVODNI I PLEISTOCENSKI MARINSKI FOSILI SPIRIDIONA BRUSINE IZ SINJSKOG POLJA

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Prilikom kopanja bunara blizu Krolina mosta u Sinju 1901. godine Brusina je prikupio veoma bogat fosilni materijal. U Naravoslovnim crticama, četvrti dio (1907) opisao je veći dio miocenske slatkovodne faune, u kojoj je i nekoliko novih vrsta (popis na str. 20). Jedna od njih je *Orygoceras subula* BRUSINA (tab. II). Dok crteže preostalih novih vrsta Brusina nije objavio, crteži navedene vrste objavljeni su još 1882. godine, ali kao dio vrste *Orygoceras dentaliforme* BRUSINA, a potječu s nalazišta Župića potok. U neinventiranom materijalu s nalazišta Novi bunar u Sinju nađen je uz miocenske slatkovodne fosile, koje je djelomično odredio Brusina, i neodređeni materijal. Prozirne kućice štapićastih gastropoda, vrlo sličnih rodu *Orygoceras*, u prvi mah asociraju na recentne primjerke tog roda, kakvi su nađeni u podzemnim vodama Texasa (TAYLOR 1974), međutim, kako su nađeni u zajednici s tipičnim morskim organizmima kao što su foraminifere, može se zaključiti da se radi o marinskim gastropodima. Osim što su prozirne, kućice tih gastropoda su manje od origocerasa, imaju okrugli poprečni presjek, dok origoceras ima eliptični poprečni presjek (sl. 6, tab. II) sa sploštenom stražnjom stranom.

BRUSINA (1882) u svom radu o novom rodu *Orygoceras* ukazuje na njegovu sličnost s recentnim marinskim rodom *Parastrophia*. Prema sistematici marinske faune (PARENZAN 1970, RIEDL 1970) ovdje se radi upravo o tom rodu, kao i o rodu *Caecum*. Osim više vrsta tipičnih marinskih gastropoda i nekoliko školjkaša (popis na str. 22), najveći dio mikropaleontološkog materijala predstavljaju mnogobrojne vrste foraminifera (popis na str. 22 i 23). Osim foraminifera nađeni su i malobrojni primjerci ljušturica marinskih ostrakoda, fragmenti čahura ježinaca, radiole ježinaca, te po koji fragment briozoa.

Analizom foraminifera utvrđeno je da jedan dio vrsta ima stratigrafski raspon javljanja od srednjeg do gornjeg pleistocena. Iz toga proizlazi da je cjelokupna marinska fauna pleistocenske starosti.

Spomenuta Brusinina fauna, a posebno ona marinska, dijelom je ostala bez odredbi i neinventirana, samo s naznakom lokaliteta. Može se pretpostaviti da to BRUSINA nije dospio učiniti, jer je u svibnju 1908. umro. Također ne treba čuditi da Brusina kao biolog i paleontolog onog vremena nije komentirao tako zanimljivu pojavu marinske faune na istom lokalitetu sa

slatkovodnom miocenskom faunom, jer to zahtijeva i rasuđivanje o hidrogeologiji, tektonici i paleogeografiji šireg dalmatinskog područja. U svezi sa svim dosad izloženim, potrebno se svakako osvrnuti na posljedice koje bi ovi podaci mogli imati u interpretaciji paleogeografije kvartara ovih područja, ali i širih mediteranskih prostora. Ako bismo današnji položaj Sinjskog polja (oko 300 m n/m), zbog nalaza pleistocenskih marinskih fosila u njegovim kvartarnim sedimentima, doveli u vezu s marinskom sredinom na zapadu ili jugu, morali bismo pretpostaviti ove mogućnosti:

a) Pasivan transport marinskih fosila preko postojećeg kopna do današnjeg područja Sinja. Takav bi se transport mogao obaviti posredno pticama ili vodozemcima, što nam se danas gledano čini manje vjerojatnim.

b) Eventualni pak transport površinskim ili podzemnim vodama, uz današnji odnos mora i kopna, mogao se odvijati samo u suprotnom smjeru, dakle prema jugozapadu.

c) Površinska morska veza između današnjeg područja Sinja i tadašnjeg mora. To bi značilo da je npr. barem dio Ravnih Kotara ili vijenaca uzvisina i planina od Primoštena do Omiša, pa i dalje, bilo još u nedavno doba pod morem. Ili je pak moguće da je na sjeveroistoku najmanje do današnjeg Sinja dopirao morski zaljev ?

Pitanja se, dakako, nameću sama od sebe, tako da sugeriraju neotektonske pokrete znatnog intenziteta i velikih amplituda, pomičući ih sve više prema današnjici.

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PLATE I

Sinj (Novi bunar)
Middle - Upper Pleistocene

1-4 *Parastrophia folini* (BUQUOY, DAUTZENBERG, DOLLFUS)
1-2 *25X*, 3 *20X*, 4 *cca 60X*
5-6 *Caecum auriculatum* FOLIN *30 X*
7-9 *Caecum cf. trachea* (MONTAGU) *27 X*

Photos by:
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