

ORDOVICIAN CHITINOZOANS AND ACRITARCHS FROM THE GEOLOGICAL FORMATIONS OF THE BUGEAC PROMONTORY (NORTH DOBROGEA, ROMANIA)

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Abstract. The Bugeac Promontory represents the north-west end of the North Dobrogea Orogene, where outcrop different metamorphic and sedimentary rocks crossed by veins of igneous ones. Some of the metamorphic geological formations offer interesting chitinozoan and acritarch taxa, very important for their chronostratigraphy and palynostratigraphical correlation. The Boclugea Group is prevalent among the lithological formations that outcrop in the Bugeac Promontory. From this group, the Bugeac Quartzites and Piatra Cernei Phyllites were analysed. These two lithological formations offered an Upper Ordovician assemblage of chitinozoans and acritarchs. The index species *Acanthochitina barbata* and *Lagenochitina baltica* with other characteristic chitinozoans, established the Caradocian - Ashgillian age for the analysed formations. The assemblage comprises acritarch species such as: *Leiovalia scaberula*, *Eupoikilofusa striata*, *Aremoricanium squarrosom*, *Lophosphaeridium edenense*, *Leiosphaeridia tenuissima*, *Petaloferidium* sp. a. o. This complete assemblage with typical chitinozonas and acritarchs can be compared with the assemblage of *Dicellograptus complanatus* and *Climacograptus prominens elongatus* Zones of Vaureal Formation, Anticosti Island, Quebec, Canada. *Lagenochitina baltica* and some characteristic acritarchs were met in Sweden, England, Estonia, Podolia and other regions from Europe as well as, Horia Formation of the North Dobrogea of Romania. So, the age Caradocian-Ashgillian is correctly assigned to the analysed formations. It is not Cambrian, as suggested by the structural super position.

Keywords: Chitinozoans, Acritarchs, Ordovician, Bugeac Promontory, North Dobrogea, Romania.

INTRODUCTION

Generally speaking, the palynological studies of the metamorphic formations of the North Dobrogea County are too few and thus our palynological investigations are very important for the stratigraphy of these geological formations. This palynological study is the first one for the geological metamorphic formations which outcrop in the Bugeac Promontory. The Bugeac Promontory represents the north - west end of the North Dobrogean Orogene. Here crop out metamorphic and sedimentary geological formations of different ages crossed by igneous veins. The aim of this study is to establish the stratigraphical position of analysed formations and to explain the biochronology of the Boclugea Group. The uncertain stratigraphical position of the Boclugea Group metamorphites, without concrete stratigraphic arguments, has required the analysis by palynostratigraphical investigation. The Bugeac Quartzite Formation and the Piatra Cernei Phyllite Formation were analysed. Together with the Priopcea Quartzite Formation, they make up the Boclugea Group, from the Bugeac Promontory (Text-fig. 1).

The age of the Boclugea Group was appreciated to be Ordovician (Mirăuță, 1966), or Cambrian (Seghedi, 1986), but only by the super position of strata, or by the similarity with other geological formations. So, we present the first paleobiological data for understanding of the paleostratigraphy of these geological formations. Unfortunately, only a poor yield of chitinozoans and acritarchs are present in these geological metamorphic formations and some of the important tools of correlations, such as conodonts and graptolites, are lacking.

GEOLOGICAL ASPECTS REGARDING THE BUGEAC PROMONTORY

If we refer to the out cropping formations of the Bugeac Promontory, they have here a structural dome aspect, represented by the Bugeac, Crăcanelor, Pietricica, Monument and Turcilor Hills (Text-fig. 2). These hills are separated by structural depression

zones or valleys. The Boclugea Group outcrops in the Bugeac Promontory only by three lithological formations.

The first is the Priopcea Quartzite Formation (37-40 m thick), which overlaps the basement of the Megina Group, locally named the Amphibolite Formation (Text-fig. 1), 75 m thick. This first formation consists of white, yellowish or grey quartzites and muscovite quartzite schists.

The second is the Piatra Cernei Phyllites, which follows in normal succession over the Priopcea Quartzite Formation (Text-fig. 1). It is represented by sericite - graphite and grey phyllites, 60-65 m thick.

The third is the Bugeac Quartzite Formation typical only for the Bugeac Promontory (Text-fig. 1). This formation is missing in all the other areas and sites of North Dobrogea where the Boclugea Group occurs. The Bugeac Formation is represented by the black quartzites with feldspar, sericite and graphite schists interbedded and sericite, white - yellowish quartzites subordinated, being 75 m thick in the Bugeac Hill. This formation is prevailing in the Bugeac and Crăcanelor Hills (Text-fig. 2) and ends in the upper part the lithological succesion of the Boclugea Group (Text-fig. 1). Only in the southern part of the Bugeac Promontory, in the Turcilor Hills, the Dealul Islamului Muscovite Schists appear but they are poorly separated. All these formations that outcrop in the Bugeac Promontory are crossed especially by dolerite and little granite veins. The lithological column (Text-fig. 1) is ended up by the Silurian Cerna Formation, (25 m thick) consisting of shales, quartzite sandstones, limestones, and grey marly - limestones partly outcropped and probably discordantly overlying the Boclugea Group Formations. This conclusion is not based on palynological data.

PALYNOLOGICAL AND PALYNOSTRATIGRAPHICAL DATA

Palynological data, resulting from the analysed samples, are reflected by chitinozoan and acritarch assemblages.

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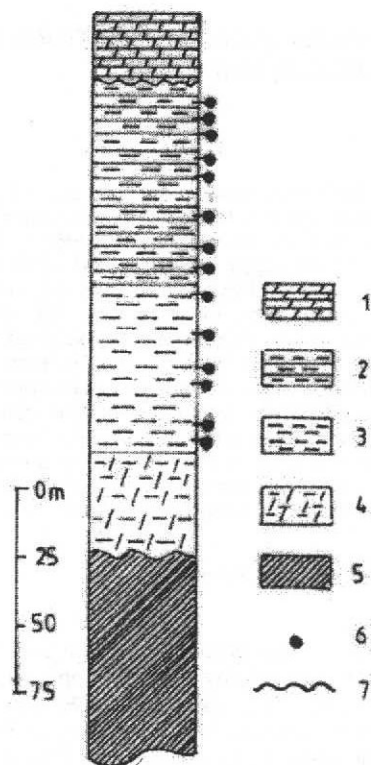


Figure 1 - Lithological column in the Bugeac Hill of Bugeac Promontory. 1. Cerna Formation (shales, quartzite sandstons, limestones and grey marly-limestones). 2. Bugeac Quartzite Formation (low feldspar, sericite, graphite, black quartzites; sericite white-yellowish quartzites). 3. Piatra Cernei Phyllites Formation (grey-silverish sericite, graphite phyllites). 4. Priopcea Quartzite Formation (white quartzites, white-yellowish or grey, muscovite, quartzite schists). 5. Amphibolite Formation of Megina Formation (gneisses with biotite, quartz feldspar gneisses). 6. Palynological samples. 7. Discordant position line.

Chitinozoan assemblage

One chitinozoan assemblage represented by 12 taxa was established (Table 2). Of these taxa, 67 %, represent the Caradocian-Ashgillian stratigraphical interval. Two index species were separated: *Acanthochitina barbata* and *Lagenochitina baltica*.

Acanthochitina barbata (Pl. 1, Fig. 4) was separated only from black quartzites of the Bugeac Formation. This species was mentioned by many authors for the Ordovician of Anticosti Island, Quebec, comparable with a holotype from the Baltic Ordovician (Eisenack, 1962, Estonia). Later this species was described by Jenkins (1967) from Shropshire, Laufeld (1967) from Dalarna, Sweden, Laufeld (1974) from Molodova and Restovo Beds, Podolia, Achab (1977 a), Achab (1978, 1987) from Vaureal Formation, Anticosti, Quebec, Canada and Hartfell Schists, United Kingdom.

All authors who mentioned or described this species attributed it to the Upper Ordovician stratigraphic interval. Achab (1977 a, 1978, 1987, 1989, 1991) considered this species characteristic and typical for the Ashgillian interval and included it in the lower part of the *Dicellograptus complanatus* Zone from Vaureal Formation, Quebec, Canada. This zone was attributed to Pusgillian chronostratigraphic stage by Ingham & Wright (1970) and marked the basement of Ashgillian series. Most of the mentioned authors appreciated that

Acanthochitina barbata is characteristic for the Caradocian-Ashgillian stratigraphic interval.

In the Bugeac Formation there were determined 3 specimens of this taxon, from the outcrop of Bugeac and Crăcanelor Hills. This species is not met in the Horia Formation (Upper Ordovician) of the Tulcea Unit, in the eastern part of North Dobrogea County (Olaru, 1996). In the analysed samples, graptolite or conodont faunas are not preserved, thus we cannot make the comparison with the faunal zonation.

Lagenochitina baltica (Pl. 1, Fig. 9) is the second characteristic taxon of the separated chitinozoan assemblage. It comes from black quartzites (Bugeac Formation) and from grey phyllites (Piatra Cernei Formation) of Bugeac Hill. The frequency of this species is also low, only 4 specimens being separated. *Lagenochitina baltica* has a wider distribution than *Acanthochitina barbata*. The first description of *Lagenochitina baltica* together with *Acanthochitina barbata* in Europe (Estonia) was made by Eisenack (1962) and was attributed to the Caradocian-Lower Ashgillian interval. It was mentioned in the Vaureal Formation of *Dicellograptus complanatus* Zone, Anticosti Island, Quebec (Achab, 1977 a,b; 1978, 1987); in the Fjäckå Formation, Sweden of the *Pleurograptus linearis* Zone (Laufeld, 1967); in the Molodova and Restovo Beds of Podolia, Ukraine (Laufeld, 1971); in the Girvan, Scotland of *Dicellograptus complanatus* Zone (Laufeld, 1971). In Alaska it was mentioned by Carter & Laufeld (1975) and it was identified in Viola Limestone of Oklahoma by Jenkins (1969).

All mentioned authors considered that *Lagenochitina baltica* is the typical taxon for the Caradocian-Ashgillian interval. These two species, *Acanthochitina barbata* and *Lagenochitina baltica* are considered a very good stratigraphical guide for the Caradocian-Ashgillian interval from Europe. In Romania, *Lagenochitina baltica* was determined also in the Horia Formation of Tulcea Unit, in the eastern part of North Dobrogea County (Olaru, 1996).

Cyathochitina kuckersiana (Pl. 1, Fig. 7) is characteristic for the upper part of the Ashgillian Vaureal Formation, *Climacograptus prominens elongatus* Zone, of Anticosti, Island, Quebec (Achab, 1977 b). This species was described also by Laufeld (1967) from Dalarna, Sweden for Caradocian - Ashgillian stratigraphical interval and later its age was extended for Upper Llandeilian - Ashgillian by Jenkins & Legault (1979). From the Bugeac Promontory this species was identified in the Piatra Cernei Phyllite Formation of Bugeac Hill. *Herkochitina minuta* characteristic for Caradocian-Ashgillian interval was also found in this formation.

Cyathochitina kuckersiana latipatagium (Pl. 1, Fig. 5) has a small difference (presents one typical bottom hull), from the *Cyathochitina kuckersiana*. This specimen is widely represented in Shropshire (Jenkins, 1967, 1969), in the Upper part of Viola Formation, Oklahoma (Jenkins, 1969), in the Baltica Caradocian from Estonia (Eisenack, 1962) and in the Vaureal Formation, *Climacograptus prominens elongatus* Zone, Anticosti, Island, Quebec (Achab, 1977 b). Paris (1979) mentioned this specimen for the Louredo Formation (Caradocian) and Porto do Santa Anna Formation (Ashgillian) from Portugal and it may also be present in the Pont-de-Caen Formation, from Normandy (France). In the Bugeac Promontory this species was met in the black quartzites and graphite schists from the Bugeac Formation.

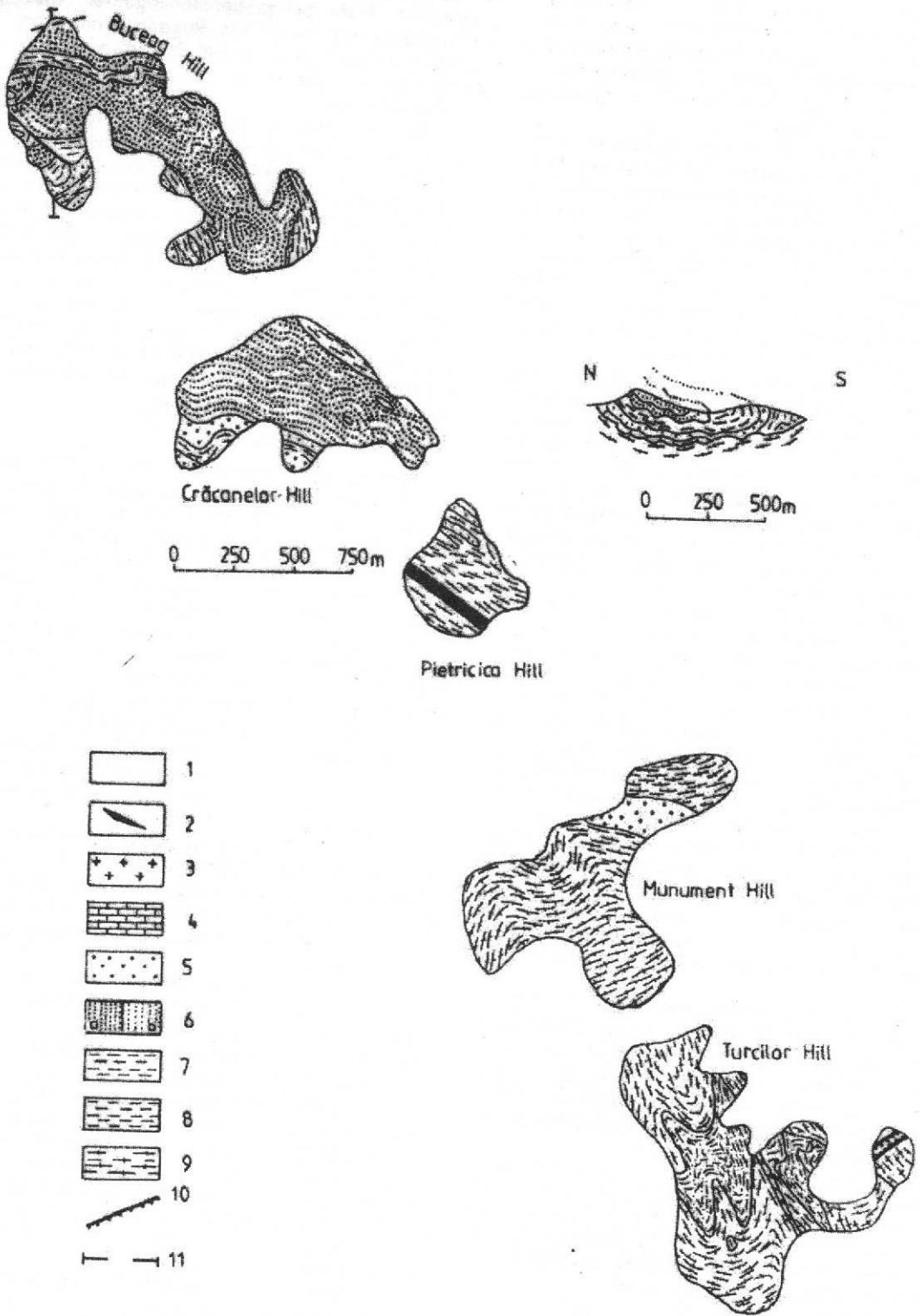


Figure 2. Geological map of the Bugeac Promontory (after Seghedi, 1986). 1. Loess. 2. Dolerites. 3. Granites. 4. Cerna Formation (Silurian). 5. Priopcea Quartzite Formation. 6. Bugeac Quartzite Formation (Ordovician): a. white quartzites; b. black quartzites. 7. Piatra Cernei Phyllites (Ordovician). 8. Dealul Islamului Muscovite Schists. 9. Megina Group. 10. Pre-alpine overthrust. 11. Direction of geological section.

Cyathochitina kuckersiana, *Cyathochitina kuckersiana latipatagium* and *Herkochitina minuta* were determined only in the Bugeac Promontory and missing in the Horia Formation from North Dobrogea County. So, the characteristic stratigraphical interval for these two species is Caradocian-Ashgillian.

Conochitina pygmaea (Pl. 1, Fig. 10) species placed between *Conochitina* and *Lagenochitina* (Achab, 1987) was determined from the Bald Mountain of Saint-Roch, Trenton Group, Quebec and was attributed stratigraphically to the Caradocian - Ashgillian interval. This species is characteristic for *Climacograptus pygmaeus* Zone, from Quebec, Canada (Achab, 1987) and for *Pleurograptus linearis* Zone from the United Kingdom (Jenkins, 1967). This species was also met in the Bugeac Formation in a low frequency.

Conochitina gamachiana (Pl. 1, Fig. 8) was described from the Vaureal Formation (upper part) and the Ellys Bay Formation, Anticosti Island, Quebec, Canada (Achab, 1978). It was mentioned also by Jenkins (1969) from the Ordovician of Viola Limestone and Sylvan Shale, of Oklahoma. In the Bugeac Promontory it was met only in the Piatra Cernei Phyllites from Bugeac Hill with a low frequency (2 specimens). This species is characteristic for Caradocian - Ashgillian like other mentioned species.

Desmochitina minor (Pl. 1, Fig. 11) is characteristic for the same stratigraphical interval, Caradocian-Ashgillian, and was mentioned in the same assemblage from Vaureal and Ellis Bay Formations, Anticosti, Quebec with *Conochitina gamachiana*, *Cyathochitina kuckersiana* and other chitinozoans species (Achab, 1987). Martin (1983) found this species also in the Trenton Group and Utica Group from Lowland of Saint-Lawrence Quebec, Canada. On the other hand Jenkins & Legaut (1979) extended for this species the characteristic interval from Arenigian to Ashgillian. In the Bugeac Promontory this species was found in the Piatra Cernei Phyllites from Bugeac Hill together with *Conochitina gamachiana* and *Cyathochitina kuckersiana*. The chitinozoan assemblage is completed by some species characteristic for a wide stratigraphical interval, such as:

Cyathochitina campanulaeformis (Pl. 1, Fig. 6) is characteristic for the Middle to Upper Ordovician (Llanvirnian-Ashgillian) from Jupiter and Ellis Bay Formations, Anticosti Island, Quebec (Achab, 1981), May-sur-Orne Syncline, Normandy (Rauscher, 1973) and in Romania it was met in the Horia Formation, North Dobrogea (Olaru, 1996).

Lagenochitina ponceti (Pl. 1, Fig. 2) is also characteristic for the Middle to Upper Ordovician (Llanvirnian-Ashgillian) like the *Cyathochitina campanulaeformis*. It is described by Rauscher (1973) from May-sur-Orne Syncline, Normandy and from Horia Formation, North Dobrogea (Olaru, 1996).

Siphonochitina tenuicollis (Pl. 1, Figs. 1, 3) is characteristic only for the Llanvirnian stage and was described from May-sur-Orne Syncline Normandy, by Rauscher (1973). At first sight this species does not justify its presence in the Caradocian - Ashgillian geological formation. It was also mentioned by Achab (1983) from the Table Head Formation, Newfoundland, Canada. Achab (1988) characterises genus *Siphonochitina* as one provincial type for the Middle Ordovician, by the presence of periderrum with siphon. This species is characteristic for the regions of high latitude from south-west Europe (Rauscher, 1973; Paris, 1981), the south of the United Kingdom (Jenkins, 1967)

and in Sahara (personal observation, Achab, 1987). It is possible that its presence together with Upper Ordovician species in the Bugeac Promontory, North Dobrogea can be a result of the extension of the stratigraphical interval for this species or is one of a reworking case.

The chitinozoan assemblage represented by characteristic species, mentioned above, yielded from the Bugeac and Piatra Cernei Formations established the Caradocian - Ashgillian (Upper Ordovician) age for the analysed formations. Some species were separated for the first time from the Ordovician of North Dobrogea. This assemblage is very important, for the stratigraphy of the Boclugea Group, especially because some organic rests, other than graptolites or conodonts, are missing. On the other hand it is possible to correlate this assemblage and the analysed formations with others where the same chitinozoan species and graptolites or conodonts ones are characteristic.

Acritarch assemblage

The acritarch assemblage comes from the same samples yielded from the geological formations of the Bugeac Promontory analysed for the chitinozoan assemblage mentioned above. Comparing them, the acritarch assemblage is richer than the chitinozoan one (29 species) and more variable (Table 1). Some species of acritarchs are characteristic for a wide stratigraphical interval (Llanvirnian-Ashgillian) but most species are grouped together to Upper Ordovician (Caradocian-Ashgillian) (15 species), representing 52 % of the whole assemblage. Some of the species in this last group were mentioned only for the Ashgillian stage:

Leiosphaeridia baltica (Pl. 2, Fig. 10) is characteristic for the Baltic Region and is typical for the North European Ashgillian stage with other paleontological remains (graptolites) (Eisenack, 1962).

One important group of taxa is characteristic together with typical chitinozoan assemblage for the Ashgillian stage from Vaureal Formation, Anticosti Island, Quebec (Jacobson, Achab, 1985), being included in the *Dicellograptus complanatus* Zone. From these taxa we can notice:

Leiovalia scaberula (Pl. 2, Fig. 15), *Navifusa ancepsipuncta* (Pl. 2, Figs. 3, 5), *Peteinosphaeridium intermedium*, *Lophosphaeridium edenense*, *Petaloferidium* sp. *Leiosphaeridia tenuissima* (Pl. 2, Fig. 14), *Eupoikilofusa striata* (Pl. 1, Figs. 12, 13), *Aremoricanium squarrosus*. Some of these taxa were also found in the Horia Formation, North Dobrogea (Olaru, 1996), such as: *Aremoricanium squarrosus*, *Eupoikilofusa striata*, *Leiosphaeridia tenuissima*, *Lophosphaeridium edenense*, *Leiovalia scaberula*.

For the Caradocian - Ashgillian there were found some typical species which come from different geographical regions:

Dactylofusa cucurbita (Pl. 2, Figs. 1, 2; Pl. 2, Fig. 17), *Dactylofusa striatogranulata* (Pl. 1, Fig. 19) and *Veryhachium* cf. *subglobosum* (Pl. 1, Fig. 17) are characteristic for the Algerian Sahara.

Veryhachium reductum (Pl. 2, Fig. 11) comes from South Thuringia and North Bavaria. *Lophosphaeridium* cf. *aequicuspidatum* (Pl. 2, Fig. 13) was described in Canning Basin, Western Australia; Ordovician - Silurian of Russia and Silurian of England. *Lophosphaeridium granulatum* (Pl. 2, Fig. 7) yielded from the Upper Ordovician and Silurian from the south-east part of Armorican Massif, France (Moreau-Benoit, 1971) and *Leiosphaeridia granulata* (Pl. 2, Fig. 12) comes from the

ORDOVICIAN CHITINOZOANS AND ACRITARCHS FROM THE BUGEAC PROMONTORY

Table 1 - Stratigraphic range chart showing distribution of Acritarch species of geological formations from Bugeac Promontory, North Dobrogea, Romania.

TAXONOMIC UNITS	CHRONOSTRATIGRAPHY				OCCURENCES
	Llan-virn.	Llan-dello.	Caradoc.	Ash-gill.	
<i>Aremoricium squarrosum</i>					Vaureal Form., Anticosti, Quebec; Kope Form., Kentucky; Eden Form., Indiana; White Head Form., Quebec; Kosov Form., Czech; May-sur-Orne, Syncl., Normandy; Horia Form., North Dobrogea.
<i>Eupoikilofusa striata</i>					Vaureal Form., Anticosti, Quebec; Horia Form., North Dobrogea
<i>Leiovalia scaberula</i>					Vaureal Form., Anticosti, Quebec; Horia Form., North Dobrogea.
<i>Leiosphaeridia tenuissima</i>					Vaureal Form., Anticosti, Quebec; Horia Form., North Dobrogea.
<i>Lophosphaeridium edenense</i>					Vaureal Form., Anticosti, Quebec; Horia Form., North Dobrogea.
<i>Peteinosphaeridium intermedium</i>					Vaureal Form., Anticosti, Quebec;
<i>Petalofleridium</i> sp.					Vaureal Form., Anticosti, Quebec; Horia Form., North Dobrogea.
<i>Dactylofusa cucurbita</i>					Algerian Sahara
<i>Dictyotidium reticulatum</i>					Ordovician erratic, Baltic Region.
<i>Lophosphaeridium disparipellicum</i>					Canning Basin, Western Australia; English Wenlockian, Silurian of Belgium and U.S.A.
<i>Dicompalla rissae</i>					Gull River Formation, Ontario Canada.
<i>Leiosphaeridia minuta</i>					Ordovician and Silurian Belgium.
<i>Leiovalia oblonga</i>					Fjåcka Dalarna; Baltic Region.
<i>Veryhachium</i> cf. <i>subglobosum</i>					Algerian Sahara.
<i>Leiosphaeridia baltica</i>					Baltic Region.
<i>Leiovalia similis</i>					Visby Gothland; Finland; Kentucky, U.S.A.; Canning Basin
<i>Dactylofusa striatogramulata</i>					Western Australia.
<i>Leiovalia medioeris</i>					Algerian Sahara.
<i>Navifusa ancepsipuncta</i>					Eastern Germany, unidentified locality.
<i>Petalofleridium</i> cf. <i>comptum</i>					Vaureal Form., Anticosti, Quebec.
<i>Veryhachium reductum</i>					Canning Basin, Western Australia, Czech Republic.
<i>Lophosphaeridium</i> cf. <i>aequicuspidatum</i>					Lederschiefer Formation, Southern Thuringia and Northern Bavaria.
<i>Navifusa navicula</i>					Canning Basin, Western Australia; Russian Ordovician-Silurian; English Wenlockian.
<i>Leiovalia baculiformis</i>					Estonia.
<i>Dactylofusa spinata</i>					Eastern Germany, unidentified locality.
<i>Cymatosphaera</i> sp.					Canning Basin, Western Australia; English Tremadoc.; Late Ordov.-Early Sil.; Alger-Sahara; Vaureal Form. Anticosti, Quebec
<i>Leiosphaeridia</i> sp.					North Dobrogea
<i>Lophosphaeridium granulosum</i>					North Dobrogea
<i>Leiosphaeridia granulata</i>					American Massif, France
					Ordovician erratic, Baltic Region

erratic Upper Ordovician, Baltic Region. *Leiovalia similis* (Pl. 1, Fig. 18) is characteristic, strictly for the Caradocian stage mentioned for a diversity of zones, such as: Visby, Gothland; Finland; Kentucky, U.S.A.; Canning Basin, Western Australia, (Playford, Martin 1984). *Lophosphaeridium disparipellicum* Playford & Martin (Pl. 1, Fig. 14) was described also from Canning Basin, Western Australia, English Wenlockian and Silurian from Belgium and U.S.A. A new category of acritarchs have a wider extension of age, Llandeilian-Ashgillian or Llanvirnian-Ashgillian, as:

Aremoricium squarrosum, was found in Kope Formation, Kentucky, U.S.A. and Eden, Indiana, U.S.A.; White Head Formation, Quebec, Canada; Kosov Formation from Czech Republic; Sincine May-sur-Orne, Normandy, France. (Jacobson, Achab, 1985).

Eupoikilofusa striata (Pl. 1, Figs. 12, 13) with a wide extension in Quebec, Canada and in the Horia Formation, North Dobrogea County Romania (Olaru, 1996).

Dictyotidium reticulatum (Pl. 1, Fig. 15) and *Navifusa navicula* (Pl. 2, Fig. 9) were mentioned in the erratic Ordovician from the Baltic Region (Estonia).

Leiosphaeridia minuta (Pl. 2, Fig. 18 a, b) comes from Belgium, Ordovician and Silurian.

Leiovalia ovalis was described from Fjåcka Formation, Dalarna, Sweden (Laufeld, 1971).

Dactylofusa spinata (Pl. 2, Fig. 8) is characteristic for the Middle Ordovician - Upper Caradocian from the Canning Basin, Western Australia (Playford & Martin, 1984); Ashgillian, from Vaureal Formation, Anticosti Island, Quebec (Jacobson & Achab, 1985); Tremadocian from England and Ordovician - Silurian from Algerian Sahara.

Some species are characteristic for the Middle Ordovician (Llanvirnian-Llandeilian), probably reworking in the Bugeac Promontory or by extension of age. From these species we can notice the following: *Dicomopalla risae* (Pl. 1, Fig. 16) found in the Gull River Formation, Ontario, Canada; *Leiosphaeridia mediocris* (Pl. 2, Fig. 4) and *Leiovalia baculiformis* (Pl. 1, Fig. 20), were identified in the East of Germany; *Petaloferidium cf. comptum* (Pl. 2, Fig. 6) comes from Canning Basin, Western Australia; *Leiosphaeridia oblonga* (Pl. 2, Fig. 16) was mentioned in the Baltic Ordovician.

Some species of *Leiosphaeridia* sp. and *Cymatosphaera* sp. ended this rich acritarch assemblage from the Bugeac Promontory (Table 1).

PALYNOSTRATIGRAPHICAL DISCUSSION AND STRATIGRAPHICAL CORRELATION

The Boclugea Group, palynologically analysed for the first time in Romania, offered two interesting assemblages, very important for the stratigraphical correlation: the chitinozoan and the acritarch assemblage, presented in the previous chapter.

These assemblages come from the two investigated geological formations: Bugeac Formation and Piatra Cernei Formation, both outcropping in the Bugeac Promontory (Figs. 1, 2). The two separated assemblages allowed palynostratigraphical discussion and stratigraphical correlation, especially the chitinozoan assemblage.

For the Upper Ordovician, the Romanian territory together with the whole Mediterranean and North Gondwanian Region was placed in the high latitude zone around the pole. Therefore the benthic faunas express the cold environment being significantly different from present day faunas of the warm environment (Paris, 1992).

Besides this wide area around the Mediterranean and the North Gondwanian Region, other two important regions beside Baltica and Laurentia (Achab, 1978), offered characteristic chitinozoan assemblages.

For the chitinozoan assemblage from North Dobrogea County, the influence of these three regions is very significant.

In the assemblage separated from the Bugeac and Piatra Cernei Formations of the Boclugea Group from the Bugeac Promontory, North Dobrogea County, the two characteristic index species are: *Acanthochitina barbata* and *Lagenochitina baltica*. These two species are cosmopolitan species met in Sweden (Laufeld, 1967) and in other zones beside the Baltic Region: Estonia (*Leiosphaeridia baltica* Eisenack, 1962), England (Jenkins, 1967), Scotland (Laufeld, 1971), Lybia (Molyneux & Paris, 1985) and Anticosti Island, Quebec (Achab, 1977 a,b, 1978, 1988). These two species attest the latest Caradocian (Onnian) to early Ashgillian (Pusgillian) age. These species characterise the *Pleurograptus linearis* Zone in Sweden (Laufeld,

1967), in other zones of the Baltic Region and in Scotland (Laufeld, 1971). In Laurentia these two species are present in Anticosti Island, Quebec in *Dicellograptus complanatus* Zone, and in *Climacograptus prominens elongatus* Zone (only *Acanthochitina barbata*) from Vaureal and Ellis Bay Formations (Achab, 1977, a, b). In Romania, only *Lagenochitina baltica* was met in the Horia Formation (Caradocian-Ashgillian) from North Dobrogea (Olaru, 1966). These two species represent a stratigraphical guide for the Caradocian-Ashgillian from Europe. Now a new area like the North Dobrogea of Romania, is included by these two analysed zones from the Bugeac Promontory and the Horia Hill, to the territory dominated by these two species in the Upper Ordovician.

In North Dobrogea, because of the low degree metamorphism and tectonic influence on the Ordovician Formations, conodont remains as well as graptolite and trilobite remains were not preserved for so long. Consequently, the stratigraphical comparison and correlation with other regions can be made only having in view classic regions such as Baltica, Laurentia and Northern Gondwana, using only chitinozoan and acritarchs assemblages. The two index species, *Acanthochitina barbata* and *Lagenochitina baltica* are not enough in order to assign the analysed formations to the Caradocian-Ashgillian. Other chitinozoan species are also associated these two index species: *Cyathochitina kuckersiana*, *Cyathochitina kuckersiana latipatagium*, *Conochitina pygmaea*, *Conochitina gamachiana*, *Desmochitina minor*, *Herkochitina minuta* (Table 2). This complete assemblage compares favourably many other assemblages analysed in geological formations from the Laurentia Region, Anticosti Island, Quebec and the Baltic Region but not in Northern Gondwana. It is difficult to establish a very exact correlation and stratigraphical position of analysed geological formations because other marks are missing, such as: graptolites, conodonts and trilobites. Thus, using chitinozoan assemblage we can be sure that the analysed geological formations from the Bugeac Promontory are of Caradocian-Ashgillian age, and can be correlated with *Dicellograptus complanatus* Zone and *Climacograptus prominens elongatus* Zone from Anticosti Island, Quebec (Laurentia) and with *Pleurograptus linearis* Zone from Sweden and Scotland (Baltoscandia). In order to establish the stratigraphical position of the geological analysed formations by the chitinozoan assemblage some useful species are missing, such as: *Cyathochitina vaurealensis*, typical for *Dicellograptus complanatus* Zone and *Plectochitina spongiosa*, both of them marking together with the two index species the Onnian stage from the latest Caradocian of Laurentia, Baltica and Northern Gondwana. On the other hand, the lack of *Belonechitina tangourdeaui* which ended the chitinozoan succession in the latest Ordovician (Porkunnian) from Baltoscandia and Laurentia and the presence in the assemblage of some species, such as: *Desmochitina minor* and *Herkochitina minuta*, indicate for the chitinozoan assemblage and the analysed geological formations a middle stratigraphical position in the Caradocian - Ashgillian interval equivalent to the Onnian - Pusgillian stage.

The lack of some species typical for the Caradocian-Ashgillian interval from Northern Gondwana, such as: *Lagenochitina deunffi*, *Armoricochitina nigerica*, *Calpichitina lenticularis*, *Spinachitina bulmani* and *Jenkinochitina lepta* (Elaouad-Debbaj, 1984; Paris, 1992; Soufiane & Achab, 1993; Paris, 1996) is still a

Table 2 - Stratigraphic range chart showing distribution of Chitinozoan species of geological formations from Bugeac Promontory, North Dobrogea, Romania.

TAXONOMIC UNITS	CHRONOSTRATIGRAPHY				OCCURENCES
	Llan- virm.	Llan- dello.	Car- doc.	Ash- gill.	
<i>Acanthochitina</i> <i>barbata</i>					Vaureal Form., <i>Dicellograptus complanatus</i> Zone, Anticosti, Quebec; Hartfell Schists, U. K.
<i>Lagenochitina</i> <i>baltica</i>					Vaureal Form., <i>D. complanatus</i> zone, Anticosti, Quebec; Fjäckå Form., <i>Pleurograptus linearis</i> Zone. Sweden; Girvan, Scotland; Onnia str., Shropshire, U.K.; Podolia, Ukraine; Estonia; Alaska, Viola Limest. Oklahoma, U.S.A.; Horia Form., North Dobrogea.
<i>Herkochitina</i> <i>minuta</i>					Vaureal Form., <i>Climacograptus prominens elongatus</i> , Anticosti, Quebec; Ellis Bay Form., Anticosti, Quebec.
<i>Cyathochitina</i> <i>kuckersiana</i>					Limit Vaureal Form. - Ellis Bay Form., Anticosti, Quebec.
<i>Conochitina</i> <i>pygmaea</i>					Saint-Roch, Macasty Form, Anticosti, Quebec.
<i>Cyathochitina</i> <i>kuckersiana</i>					Vaureal Form., Anticosti, Quebec; Shropshire; Viola Limestone, Oklahoma.
<i>Conochitina</i> <i>gamachiana</i>					Vaureal Form. (rarely), Ellis Bay Form. (prevalent), Anticosti, Quebec.
<i>Desmochitina</i> <i>minor</i>					Vaureal Form., Anticosti, Quebec; St. Lawrence Lowlands Quebec; May-sur-Orne Syncl., Normandy, Horia Form. North Dobrogea.
<i>Cyathochitina</i> <i>campanulaeformis</i>					Jupiter Form., Ellis Bay, Anticosti, Quebec; May-sur-Orne, Syncl. Normandy; Horia Form., North Dobrogea.
<i>Lagenochitina</i> <i>ponceti</i>					May-sur-Orne Syncl., Normandy; Horia Form., North Dobrogea.
<i>Siphonochitina</i> <i>tenuicollis</i>					May-sur-Orne Syncl., Normandy.

confirmation that the chitinozoan assemblage from Northern Gondwana had a low influence on the territory of North Dobrogea. Consequently, this territory has remained under the influence of Laurentia and the Baltic Regions. The Caradocian-Ashgillian assemblage is completed with some species with wide stratigraphical extinction, such as: *Cyathochitina campanulaeformis*, *Lagenochitina ponceti* and *Siphonochitina tenuicollis*.

So that, the age of the Bugeac Group from the Bugeac Promontory, represented by the analysed Bugeac and Piatra Cernei Formations, is Caradocian-Ashgillian, and not the Cambrian one estimated only by super position of strata and structural arguments (Seghedi, 1986). In North Dobrogea, the two analysed regions, the Bugeac Promontory in the west side and the Horia Hill in the east side, have offered geological formations with similar chitinozoan and acritarch assemblages. Thus the Bugeac Formation and the Piatra Cernei Formation, from the Bugeac Promontory are lithologically, palynologically and chronostratigraphically equivalent to the Horia Formation and can be correlated. These two areas from North Dobrogea are the first Ordovician points analysed and correlated by means of palynological data with classic regions of Laurentia and the Baltic plates.

The second assemblage which comes in discussion is the acritarch one. Although the acritarchs are very well developed in the Ordovician, they have a stratigraphical significance more reduced than the chitinozoans. But, together with, the chitinozoans, the acritarchs increased their stratigraphical value and became a good tool for the correlation of analysed geological formations.

As in the case of the chitinozoan assemblage, in the composition of the acritarch assemblage there can be observed the influence of the three large regions of

Upper Ordovician: Laurentia, Baltica, Gondwana. An important number of species are characteristic for the Vaureal Formation of Anticosti Island, Quebec, being attributed to *Dicellograptus complanatus* Zone of Ashgillian stage. From these species there can be noticed: *Lophosphaeridium edenense*, *Navifusa ancepsipuncta*, *Peteinosphaeridium intermedium*, *Aremoricanium squarrosus*, *Leiosphaeridia tenuissima*, *Eupoikilofusa striata*, *Eupoikilofusa striatifera*, *Petalofleridium* sp. At the same time, *Leiosphaeridia baltica* represented the influence of the Baltic Region. The assemblage of acritarchs separated from the analysed formations of the Bugeac Promontory is wide and diverse in composition (Table 1). Beside the typical species for Laurentia and the Baltic Regions mentioned above very important for the stratigraphical value of the assemblage are the following species: *Leiovalia scaberula*, *Leiovalia similis*, *Veryhachium reductum*, *Leiosphaeridia ovalis*, *Lophosphaeridium granulosum*, *Leiosphaeridia granulata*, typical for the same two regions, Laurentia and Baltica.

As compared to the chitinozoan assemblage, many more typical species from the Gondwana Region are present in the acritarch one: *Dactylofusa cucurbita*, *Dactylofusa striatogranulata*, *Veryhachium* cf. *subglobosum*, all of these coming from Algerian Sahara. Other species as: *Lophosphaeridium disparipellucum*, *Lophosphaeridium aequicuspidatum*, *Leiovalia similis*, *Dactylofusa spinata* are characteristic for Western Australia. Therefore, the acritarch assemblage reflects, as the chitinozoan one, the same marine environment conditions, typical for high latitudinal regions where initial deposits of Upper Ordovician time were sedimented. The cosmopolite spreading of acritarchs compared to the chitinozoan more restrictive one, represented for Upper Ordovician the presence of acritarch species in

the wider areas than chitinozoan ones. Consequently in the Bugeac Promontory, acritarch species from the Gondwana Region are present but the same chitinozoan ones, are lacking.

For the analysed formations from the Bugeac Promontory, the assemblages of chitinozoan and acritarch are characteristic for the same stratigraphical interval and together established the Caradocian-Ashgillian age for the discussed formations.

For the North Dobrogea County, the correlation, according to chitinozoan and acritarch criteria, between Bugeac and Piatra Cernei Formations of the Boclugea Group, from the western side (Bugeac Promontory) and Horia Formation (Horia Hill) from the eastern side, is well made, both regions having characteristic species from classic regions Laurentia, Baltica and Gondwana.

CONCLUSIONS

The following conclusions can be drawn about the study of geological formations that outcrop in the Bugeac Promontory:

- Geological formations analysed by chitinozoan and acritarch assemblages are the Bugeac Formation and Piatra Cernei Formation, both of them belonging to the Boclugea Group, outcropping in the Bugeac Promontory. The third formation, Priopcea one, included in the Boclugea Group is not analysed because it is palynologically barren.

- The relative age of these formations established by the palynological criterion is Caradocian-Ashgillian (Upper Ordovician) and not the Cambrian one, previously estimated.

- The chitinozoan assemblage is typical for the Laurentia Region (Anticosti Island, Quebec) and the

Baltic Region (England, Sweden, Estonia) and does not contain typical species from Northern Gondwana. Index species for the Caradocian-Ashgillian: *Acanthochitina barbata* and *Lagenochitina baltica* are present.

- The acritarch assemblage is complementary to the chitinozoan one and accounts for the Caradocian-Ashgillian age of the analysed formations, but it reflects with more accuracy the influence of the third high latitudinal regions of the Upper Ordovician (Laurentia, Baltica and Gondwana).

- The correlation with other regions by biozonation is possible only by comparison with chitinozoan and acritarch assemblages from typical zones with graptolites and conodonts, such as: Vaureal and Ellis Bay Formations (Anticosti Island, Quebec) and those from Estonia, Sweden, Scotland and England.

- In the geological formations from the Bugeac Promontory and the Horia Formation (Horia Hill) of North Dobrogea County, conodonts, graptolites and trilobites are lacking, because these initial geological deposits were low metamorphosed and tectonised. So, the stratigraphical control and biozonation is difficult to make. These are possible only in comparison with other classic regions, mentioned above.

- By the chitinozoan and acritarch assemblages the two zones of western and eastern side of North Dobrogea County can be correlated, being represented by analysed geological formations, both of them being of Caradocian - Ashgillian age.

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PLATES

Plate I

1. *Siphonochitina tenuicollis* Jenkins - Llanvirnian.
2. *Lagenochitina ponceti* Rauscher - Llanvirnian - Ashgillian.
3. *Siphonochitina tenuicollis* Jenkins - Llanvirnian.
4. *Acanthochitina barbata* Eisenack - Ashgillian.
5. *Cyathochitina kuckersiana latipatagium* Jenkins-Caradocian-Ashgillian.
6. *Cyathochitina campanulaeformis* Eisenack - Llanvirnian - Ashgillian.
7. *Cyathochitina kuckersiana* Eisenack - Caradocian - Ashgillian.
8. *Conochitina gamachiana* Achab - Caradocian - Ashgillian.
9. *Lagenochitina baltica* Eisenack - Caradocian - Ashgillian.
10. *Conochitina pygmaea* Achab - Caradocian - Ashgillian.
11. *Desmochitina minor* Eisenack - Caradocian - Ashgillian.
12. *Eupoikilofusa striata* (Staplin, Jansonius & Pocock) Loeblich & Tappan - Llanvirnian-Ashgillian.
13. *Eupoikilofusa striata* (Staplin, Jansonius & Pocock) Loeblich & Tappan - Llanvirnian-Ashgillian.
14. *Lophosphaeridium disparipellucum* Playford & Martin - Llanvirnian.
15. *Dictyotidium reticulatum* (Eisenack) - Ordovician.
16. *Dicomopalla rissae* Wendy & Legaut - Middle Ordovician.
17. *Veryhachium* cf. *subglobosum* Jardiné - Upper Ordovician.
18. *Leiovalia similis* Eisenack - Caradocian.
19. *Dactylofusa striatogranulata* Jardiné, Combaz, Magloire, Peniguel & Vachey - Upper Ordovician.
20. *Leiovalia baculiformis* Burmann - Upper Llanvirnian

All figures were increased by 800 X without figures numbers 2 and 3, increased by 320 X; figures 4, 5, 12, 13 increased by 1260 X and figure 1, increased by 2520 X

Plate II

1. *Dactylofusa cucurbita* Jardiné, Combaz, Magloire, Peniguel & Vachey - Upper Ordovician.
2. *Dactylofusa cucurbita* Jardiné, Combaz, Magloire, Peniguel & Vachey - Upper Ordovician.
3. *Navifusa ancepsipuncta* Loeblich - Upper Ordovician.
4. *Leiovalia mediocris* Burmann - Upper Llanvirnian.
5. *Navifusa ancepsipuncta* Loeblich - Upper Ordovician.
6. *Petaloferidium* cf. *comptum* Playford & Martin - Llanvirnian.
7. *Lophosphaeridium granulosum* (Staplin) - Upper Ordovician.
8. *Dactylofusa spinata* Staplin, Jansonius & Pocock - Middle Ordovician - Upper Caradocian.
9. *Navifusa navicula* Eisenack - Middle Ordovician.
10. *Leiosphaeridia baltica* Eisenack - Ordovician.
11. *Veryhachium reductum* (Deunff) Downie & Sarjeant - Upper Ordovician.
12. *Leiosphaeridia granulata* (Eisenack) - Upper Ordovician.
13. *Lophosphaeridium* cf. *aequicuspidatum* Playford & Martin - Upper Ordovician.
14. *Leiosphaeridia tenuissima* Eisenack - Ordovician.
15. *Leiovalia scaberula* Loeblich & Tappan - Caradocian - Ashgillian.
16. *Leiovalia oblonga* Eisenack - Ordovician.
17. *Dactylofusa cucurbita* Jardiné, Combaz, Magloire, Peniguel & Vachey - Upper Ordovician.
- 18 a, b. *Leiosphaeridia minuta* Staplin - Ordovician.

All figures were increased by 800 X without figures 1, 2, 5 increased by 1260 X and figure 15 increased by 320 X.

