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Foraminifera from the Upper Cretaceous of northern James Ross Island (Antarctica): a preliminary report

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Abstract
The Cretaceous biostratigraphy of the James Ross Island region is generally based on palynomorphs and macrofossils (bivalves, ammonites). During geological mapping of the northern James Ross Island a number of samples from Upper Cretaceous lithologies were gathered to test the presence of foraminifers as a possible tool for stratigraphic evaluation of Upper Cretaceous strata. Limited number of samples did not provide foraminiferal content large enough to give relevant information for biostratigraphic conclusions. Samples from older sediments of Whisky Bay and Kotick Point formations (Albian – Turonian) were either not fossiliferous or contained scarce specimens of agglutinated foraminifers. Foraminiferal assemblages from younger sediments of Hidden Lake and Santa Marta formations (Coniacian – Campanian) contained species with both agglutinated and calcareous types of tests. Many of studied marine sediments were barren of foraminifers, probably due to late diagenetic secondary decalcification. Taxonomy of low-diversified assemblages was carried out and a biostratigraphical and palaeobiogeographical significance discussed.

Key words: James Ross Basin, Upper Cretaceous, Kotick Point, Whisky Bay, Santa Marta, Hidden Lake Formations, Foraminifera, biostratigraphy, lithology

Introduction

Early studies of biostratigraphy of James Ross Island region focused primarily on the well-preserved molluscan faunas (*e.g.* Crame 1981, Olivero 1981). Consecutive studies of microfossils from James Ross Island region have clearly shown the potential for establishing biostratigraphic frameworks using foraminifera, diatoms, silicoflagellates and palynomorphs (*e.g.* Sliter 1976, Askin 1988, Harwood 1988, Huber, 1988). Other preliminary studies on James Ross and surrounding islands have also shown the potential of palynomorphs for local and regional biostratigraphical correlation (*e.g.* Askin 1983, Olivero et Palamarczuk 1987, Baldoni et Medina 1989, Keating 1992, Keating et al. 1992, Riding et al. 1992, Riding et Crame 2002).

Field works of the Czech scientific expedition have been carried out in the surroundings of the Czech Johann Gregor Mendel Antarctic Station situated at the northern coast of James Ross Island (Fig.

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1). During the geological research and mapping taken in 2004, and 2005 austral summer seasons, respectively, attention was also paid to the stratigraphical interpretation of Cretaceous strata.

The main aim of this study was to test foraminifer occurrence in various Upper Cretaceous lithologies and interpret their biostratigraphical significance. Studies on foraminifers of various locations in James Ross Basin were recently carried out mainly by Argentinian researchers. However, studies dealing with foraminifers from the northern James Ross Island remained very scarce.

Geological Setting

Regional geology and litostratigraphy of the Upper Cretaceous sediments of the northern James Ross Island were studied by many authors (*e.g.* Ineson et al. 1986, Olivero et al. 1986, Pirrie 1989, Rinaldi 1992). Whereas the Kotick Point Formation (Gustav Group) comprises interbedded sandstones and silty mudstones or claystones, the Whisky Bay Formation is dominated by coarse-grained sediments, although mudstone- and sandstone-dominated intervals also occur (Ineson et al. 1986). The transition between the Whisky Bay Fm. and overlying Hidden Lake Fm. essentially represents the start of a fining-upward cycle from the conglomerate-dominated Whisky Bay Fm. to the sandstone-dominated Hidden Lake Fm. (Whitham et al. 2006). The general upward-fining trend through the Hidden Lake Formation reflects a decreasing supply of coarse volcanic detritus to the basin, with a progressive decrease in water depth (Pirrie et al. 1992).

The Santa Marta Formation (Marambio Group) was originally defined by Olivero et al. (1986) with three members described (members Alpha, Beta and Gamma). Crame et al. (1991) redefined Santa Marta Fm. and combined Alpha and Beta members into the Lachman Crags Member. Studied section (samples KSM) belongs to lower/middle part of the Lachman Crags Member; Gamma member of Olivero et al. (1986) corresponds to the Herbert Sound Member as redefined by Crame et al. (1991). These sediments have been interpreted as deposited within a mid to outer shelf, below storm wave base (Pirrie 1989).

In most of the studied area, the Cretaceous sediments are overlain by Cenozoic lavas, hyaloclastite breccias and tuffs (James Ross Island Volcanic Group), but also by Neogene and Quaternary sediments.

Material and Methods

Eighteen samples of Upper Cretaceous sediments of northern James Ross Island were collected for microbiostratigraphical research (Figs. 1, 2 and Table 1) during 2004 and 2005 field seasons (D. Nývlt). One sample comes from Kotick Point Formation (KFC-1), two samples from Whisky Bay Formation (KWB-1 and KWB-3), one sample from Hidden Lake Formation (KHL-1) and fourteen samples were gathered from Santa Marta Formation (KSM-1, 2, 3, 4, 5, 6, 7, 8, 9, 9.2, 10, 10.2, 11 and 11.2). Samples were washed on the sieve of 0.063 mm mesh size at the laboratory of the Czech Geological Survey. Foraminifers were observed using a Nikon C-PS stereomicroscope (Japan).

In the further text, the following abbreviations related to samples are used: Fm. – Formation, Mbr. – Member, KWB – Whisky Bay, KSM – Santa Marta Formation, KFC – Kotick Point Formation, KHL – Hidden Lake Formation.

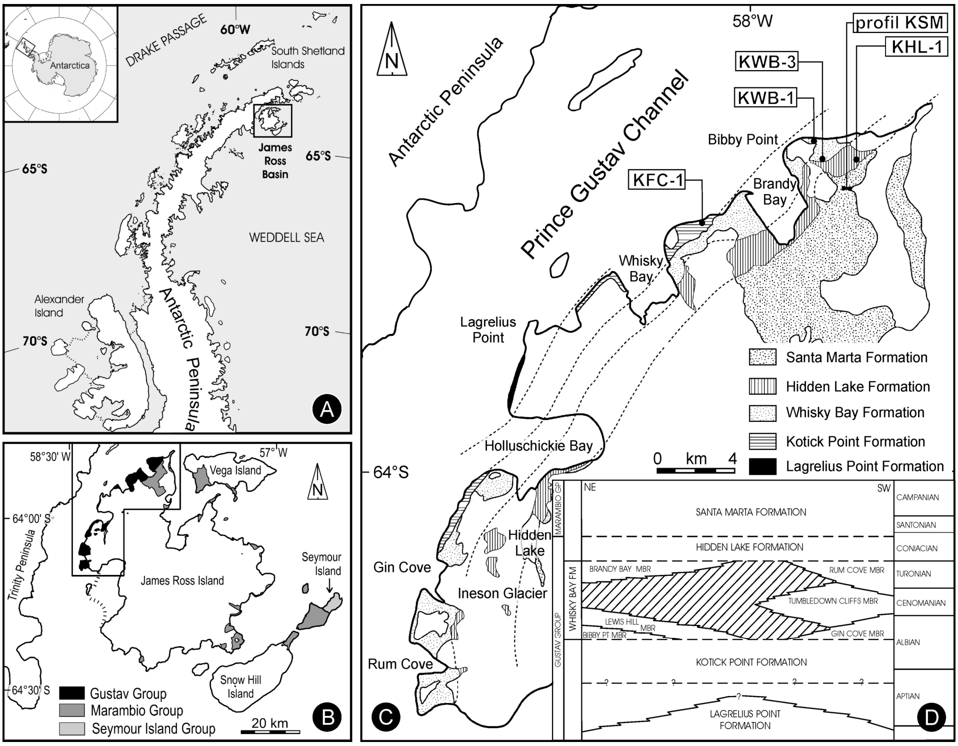

Fig. 1. A, map showing the location of James Ross Island region. Area in the box is shown in more detail in figure 1B. B, geological sketch map of the Gustav, Marambio and Seymour Island Groups for the James Ross Island region, based on Crame et Luther (1997). Area in the box is shown in more detail in figure 1C. C, geological sketch map showing Cretaceous sediments of northwestern James Ross Island with positions of section KSM (*see* Fig. 2) and samples tested for presence of foraminifers. The dashed lines trace formation boundaries across sea and ice cover. Based on Ineson et al. (1986). D, stratigraphic correlation diagram for Cretaceous sediments of northwestern James Ross Island (based on Crame et al. 2006); for geographical location of these sediments see figure 1C.

Results

Foraminifers were present in 10 of 18 samples gathered in the study area (Figs. 1, 2, Table 1).

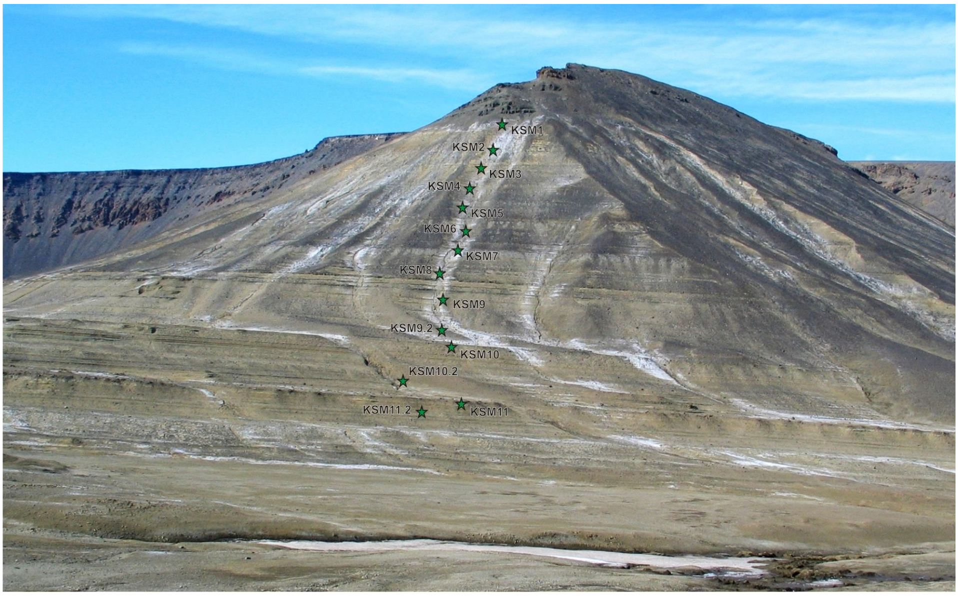

Fig. 2. Slope of Lachman Crags, viewed from the Crame Col (northern James Ross Island), formed by Upper Cretaceous siltstones (Lachman Crags Mbr., Santa Marta Fm.) capped by Cenozoic hyaloclastite breccias and basaltic lavas. Positions of all studied samples within the section are marked on the photograph. For more detail localization of samples *see* Table 1.

Kotick Point, Whisky Bay and Hidden Lake Formations:

No tests of foraminifers were found in samples KWB-1 and KFC-1. In KWB-3 sample, only two poorly preserved specimens of agglutinated species *Tritaxia* sp. and *Tristix* sp. were found.

Sample KHL-1 contains both planktonic and benthic foraminifers, but with low species diversity and low number of specimens. Benthic assemblage was constituted mainly of foraminifers with calcareous tests such as *Lenticulina comptoni* (SOWERBY), *Lenticulina* sp., *Gavelinella* sp. and *Valvulineria lenticula* (REUSS). *Triplasia murchisoni* REUSS is a representative of agglutinated benthos. Findings of planktonic foraminifers *Marginotruncana schneegansi* (SIGAL) and *Archaeoglobigerina bosquensis* PESSAGNO are important from the biostratigraphical point of view (*see* Interpretation and Discussion section).

Santa Marta Formation:

Samples KSM-1, 9.2, 11 and 11.2 gathered from the Crame Col section (Fig. 2, Table 1) contained no foraminifers. Other samples from the same section (KSM-2, 3, 6, 7, 8, 9, 10, 10.2) contained low-diversified assemblages. Poorly preserved tests of *Heterolepa* sp., *Pullenia cretacea* CUSHMAN, *Nuttallinella* ? *coronula* (BELFORD) *Astacolus* sp., *Notoplanulina* sp., *Caudammina ovulum* (GRZYBOWSKI) and *Haplophragmoides apenninicus* MONTANARO - GALLITELLI were found in these samples. Uniserial, ovoidal tests of foraminifers with the calcareous porcelanous wall were also found in above-mentioned samples. They probably belong to species *Brasiliella variabilis* TROELSEN. The occurrence of planktonic species of *Archaeoglobigerina* in sample KSM-3, which has stratigraphic range from the Coniacian to the Cretaceous/Paleogene boundary, is important from the stratigraphical point of view.

sample No.	Formation, Member	WGS S	WGS W	altitude [m]	foram. abund.
KSM 1	Santa Marta, Lachman Crags	63°49'46.5"	57°53'11.1"	285	-
KSM 2	Santa Marta, Lachman Crags	63°49'46.4"	57°53'12.3"	274	+
KSM 3	Santa Marta, Lachman Crags	63°49'46.1"	57°53'13.6"	264	+
KSM 4	Santa Marta, Lachman Crags	63°49'46.0"	57°53'14.8"	254	+++
KSM 5	Santa Marta, Lachman Crags	63°49'45.7"	57°53'16.1"	244	+++
KSM 6	Santa Marta, Lachman Crags	63°49'45.7"	57°53'18.4"	234	+
KSM 7	Santa Marta, Lachman Crags	63°49'45.6"	57°53'20.3"	224	+
KSM 8	Santa Marta, Lachman Crags	63°49'45.2"	57°53'22.7"	214	+
KSM 9	Santa Marta, Lachman Crags	63°49'45.2"	57°53'24.5"	204	-
KSM 9.2	Santa Marta, Lachman Crags	63°49'44.7"	57°53'27.6"	197	-
KSM 10	Santa Marta, Lachman Crags	63°49'44.9"	57°53'29.1"	194	-
KSM 10.2	Santa Marta, Lachman Crags	63°49'43.5"	57°53'32.7"	189	+
KSM 11	Santa Marta, Lachman Crags	63°49'44.5"	57°53'34.8"	184	-
KSM 11.2	Santa Marta, Lachman Crags	63°49'44.2"	57°53'35.4"	181	-
KHL-1	Hidden Lake	63°48'51.4"	57°52'56.1"	72	++
KWB-1	Whisky Bay, Lewis Hill	63°48'56.8"	57°54'55.0"	121	-
KWB-3	Whisky Bay, Brandy Bay	63°48'12.8"	57°55'30.8"	62	+
KFC-1	Kotick Point	63°51'10.1"	58°04'52.9"	31	-

Table 1. Lithostratigraphy, geographical location and abundance of foraminifers in studied samples.

Only two samples from this section (KSM-4 and 5) contained relatively rich foraminiferal assemblages in which benthic species with the calcareous type of tests prevailed. Genus *Gavelinella*, represented by species *G. lorneiana* (D´ORBIGNY) and *G. sandidgei* (BROTZEN), forms a significant component of the assemblage. Calcareous benthos is represented by *Allomorphina cretacea* REUSS, *Dentalina* sp., *Vaginulinopsis* sp., *Notoplanulina rakaurona* FINLAY, *N. australis* MALUMIÁN ET MASIUK, *Ramulina* sp., *Quadrimorphina allomorphinoides* (REUSS), *Planularia* sp., *Astacolus* sp. and *Globorotalites michelinianus* (D´ORBIGNY). From the agglutinated species *Dorothia conula* (REUSS), *D. mordojovichi* CAÑON ET ERNST, *Spiroplectammina laevis* (ROE-MER), *Gyroidinoides* sp., *Gaudryina cf. cretacea* (KARRER), *Marssonella oxycona* (REUSS) and one fragment of a test of *Ammobaculites* sp. was found. Plankton is very rare, just one specimen of *Archaeoglobigerina bosquensis* PESSAGNO was found in the sample KSM-4; according to Caron (1985) the occurrence of this species decreased near the Santonian/Campanian boundary.

Interpretation and Discussion

Marginotruncana schneegansi (SIGAL) and *Archaeoglobigerina bosquensis* PESSAGNO (sample KHL-1) are of significant stratigraphical importance. *M. schneegansi* has a stratigraphical range from the upper part of Middle Turonian to the base of Santonian (Robaszynski et Caron 1995) and *Archaeglobigerina bosquensis* PESSAGNO from the Coniacian to Santonian within the standard planktonic Zone *Dicarinella concavata – D. asymetrica* (Caron 1985).

The presence of *G. lorneiana* (D´ORBIGNY) and *G. sandidgei* (BROTZEN) in KSM-4 and KSM-5 samples (Santa Marta Fm.) is of stratigraphical value especially when considering the fact that plankton was absent in these samples. The last occurrence of both of these species in Europe is in Lower Campanian (*e.g.* in Austria – Hradecká 2002), *Globotruncanita elevata* Zone sensu Robaszynski et Caron (1995).

Foraminiferal assemblages of Hidden Lake Formation indicate environment of outer shelf to outer neritic zone with maximum water-depth of 200–300 m (*cf.* Sliter 1976). This is also evidenced by planktonic foraminifers with globular type of test (*Archaeoglobigerina).*

The character of foraminiferal assemblages from Lachman Crags Member, Santa Marta Formation confirmed the formerly presented opinion that gradual global fall in temperature occurred at thisstratigraphical level (Crame 1992). This opinion is supported by the presence of *Gaudryina, Gavelinella, Gyroidinoides, Dorothia* and other species in our material. Studied foraminiferal assemblage is thus comparable with transitional type of assemblages from epicontinental European basins such as Bohemian Cretaceous Basin or Anglo-Paris Basin, where boreal faunal components prevail. The occurrence of simple planktonic forms such as *Hedbergella, Globigerinelloides* or *Heterohelix* characterizes the cold Australian province with occurrence of Upper Cretaceous planktonic and benthic foraminifers (*cf.* Huber 1991). Foraminifer taphocoenosis of Austral province in our samples was typically characterized by low diversity of calcareous benthos and very rare occurrence of plankton with the exception of younger sediments (*e.g.* Huber 1991).

The absence of foraminifers in some samples from Kotick Point, Whisky Bay and Hidden Lake and partly also Santa Marta Formations could be of secondary origin and may be caused by partial or total early diagenetic decalcification of sediments. This interpretation might be also supported by sporadic findings of calcareous nannofossils in most of studied samples (Švábenická et al., submitted) and scarcity of calcareous invertebrate shells in the studied area. Especially conglomerates, tuffitic sandstones and siltstones of Kotick Point, Whisky Bay and Hidden Lake Formations are almost barren of original calcitic/aragonitic shells of invertebrates. On the other hand, the siliceous macrofossils from the above-mentioned formations are well-preserved (*e.g.* Vodrážka et Crame 2011), suggesting that the main demineralization process (*i.e.* late diagenetic carbonate dissolution) affected just calcified macrofossil remains and carbonate matrix of the sediment.

Conclusions

Microbiostratigraphical research of 18 samples of Upper Cretaceous sediments from the Kotick Point, Whisky Bay, Hidden Lake and Santa Marta Formations of James Ross Basin showed the character of foraminiferal assemblages and possibilities of stratigraphical classification of studied samples.

The oldest sediments which were studied by some former authors (*e.g.* Ineson et al. 1986) from the Whisky Bay and Kotick Point Formations were of Late Albian to Turonian age. Samples KWB-1 and KWB-3 (Whisky Bay Fm.) and sample KFC-1 (Kotick Point Fm.) were non-fossiliferous or just sporadic and poorly preserved agglutinated foraminifers without any stratigrafical significance have been found.

Coniacian age of sample KHL-1 (Hidden Lake Fm., *e.g.* Crame et al. 2006) is supported by the presence of planktonic species *Marginotruncana schneegansi* and *Archaeglobigerina bosquensis*, although their stratigraphical range is wide (Caron 1985, Robaszynski et Caron 1995).

Samples from the KSM section (Santa Marta Formation) comprised Coniacian to Santonian rocks (*cf.* Fig. 1D, *e.g.* Crame et al. 2006). Foraminiferal assemblages were abundant just in two samples (KSM-4 and KSM-5) where predominantly benthic *Gavelinella* (*G. lorneiana, G. sandidgi*) were found. Other benthic species with calcareous and agglutinated tests also supported the Santonian age of studied samples (*cf.* Crame et al. 2006).

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