GEOLOGICA BELGICA (2012) 15/4: 350-354

# Paleobiogeographic significance of Bashkirian (Pennsylvanian) rugose corals from northernmost Ellesmere Island, Arctic Canada

Jerzy FEDOROWSKI[1] and E. Wayne BAMBER[2]

[1]*Institute of Geology, Adam Mickiewicz University, Maków Polnych 16, Pl 61-606 Poznań, Poland; jerzy@amu.edu.pl*
[2]*Geological Survey of Canada, Calgary, 3303 - 33rd Street NW, Calgary, Alberta, T2L 2A7, Canada; wabamber@nrcan.gc.ca*

**ABSTRACT.** The oldest known Carboniferous rugose coral fauna in the Canadian Arctic Islands occurs on the northwestern margin of the Sverdrup Basin, in the Yelverton Inlet area of northern Ellesmere Island. It was collected from Bashkirian carbonates of the lower Nansen and Otto Fiord formations and includes representatives of the genera *Dibunophyllum* Thomson & Nicholson, *Lonsdaleia* McCoy, *Palaeosmilia* Milne-Edwards & Haime and ?*Tizraia* Said & Rodríguez. Such a combination of genera is unknown elsewhere above the Serpukhovian and in this sense it is unique in the world. It is typical, however, for coral faunas in the Upper Viséan of Europe, North Africa and China. In those areas, genera of this assemblage range into the Upper Serpukhovian and individual genera such as *Dibunophyllum* in the Donets Basin and *Palaeosmilia* in Northern Timan and Novaya Zemlya continue into the Lower Bashkirian. The Yelverton Inlet fauna shows limited similarity to Serpukhovian faunas of several other basins but differs from the Bashkirian faunas of those basins. It is remarkable because of its unusual taxonomic content, high stratigraphic position, and remote geographic location. Faunal comparisons suggest Novaya Zemlya as the most likely source for the Yelverton Inlet fauna. Northern Timan may qualify as another possible source when its Viséan to Bashkirian coral fauna is described in detail.

**KEY WORDS:** Rugosa, mid-Carboniferous, paleobiogeography, Sverdrup Basin.

## 1. Introduction

The rugose corals described in this paper were collected from the Yelverton Inlet area in northernmost Ellesmere Island. They occur on the northwestern margin of the Sverdrup Basin, a southwest-northeast trending rift basin underlying the northern islands of the Canadian Arctic Archipelago (Fig. 1). Within the basin, the Carboniferous succession comprises a marginal facies dominated by siliciclastic rocks, passing basinward into platform carbonates, siliciclastics and basinal deposits (Beauchamp et al., 1989, p. 106). The stratigraphic interval yielding the Yelverton Inlet corals consists of outer shelf, Bashkirian carbonates of the lower Nansen Formation, passing southeastward into the subaqueous evaporite deposits and interbedded, fossiliferous limestone beds of the lower Otto Fiord Formation (Mayr, 1992, fig. 16; Fig. 2, Table 1). The coral specimens available for this study are limited in number (see below) because they were obtained from remote localities (Fig. 1) under arctic conditions, with no opportunity for further collecting.

Our oldest collection [Geological Survey of Canada (GSC) locality C-45455], from the lower Otto Fiord Formation, contains the first newcomers to the Sverdrup Basin (Fig. 2, coral collection 2; Fig. 3). The material available from this locality includes one specimen of *Tizraia*? sp. aff. "*Diphyphyllum*" *carinatum* Gorsky, 1951, five specimens of *Palaeosmilia murchisoni* Milne Edwards & Haime, 1848 and three specimens of *Lonsdaleia duplicata* (Martin, 1809). Such an occurrence at this biostratigraphic level is unusual, because this association of species is typical for much older, Upper Viséan strata. In addition to this lowest fauna, a single specimen of *Dibunophyllum bipartitum* (McCoy, 1849), also characteristic of the Viséan and Serpukhovian, was found in slightly younger Bashkirian limestone of the Nansen Formation (Fig. 2, coral collection 1; GSC locality C-45420; Fig. 3). The youngest coral in our collection is a single specimen of *Paraheritschioides* Sando, 1985, which was collected still higher in the Nansen Formation, from beds of probable late Bashkirian age (Fig. 2, coral collection 1; GSC locality 45444; Fig. 3).

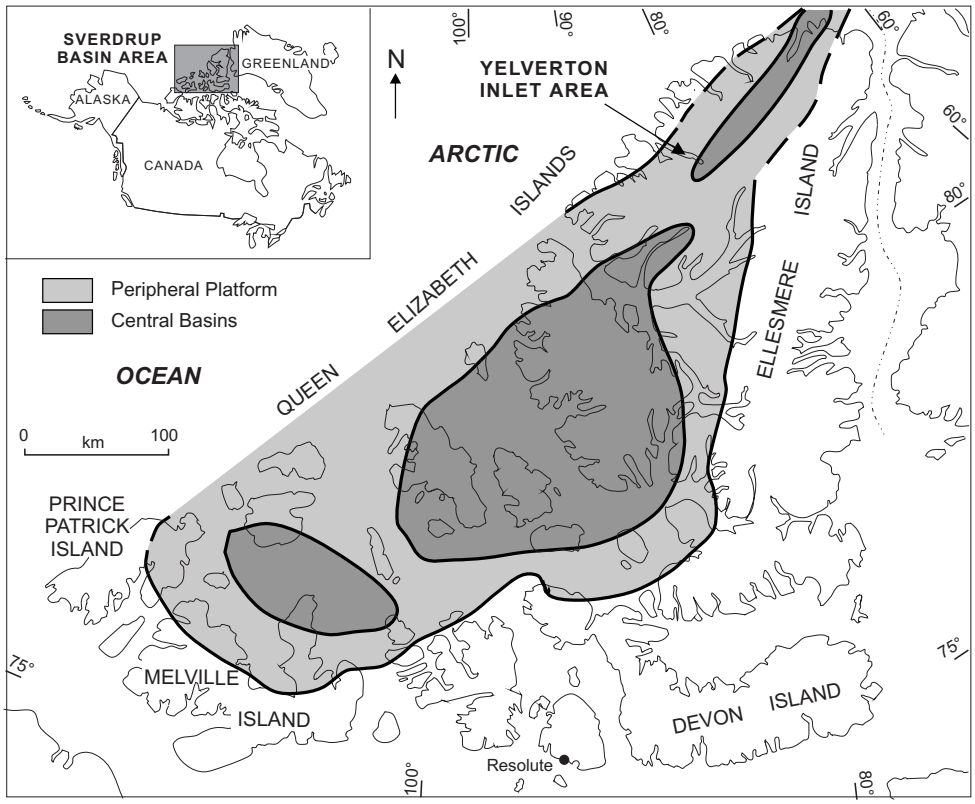


**Figure 1**. Sverdrup Basin, Canadian Arctic Archipelago; after Beauchamp et al. (1989, fig.1).

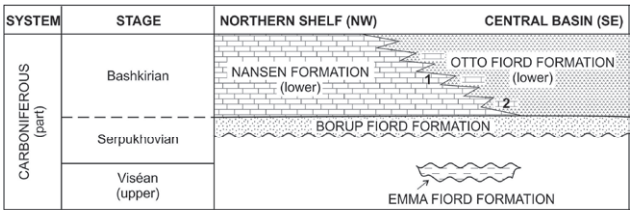


**Figure 2**. Stratigraphic relationships, Upper Viséan-Bashkirian formations, northwestern side of Sverdrup Basin; after Mayr (1992, fig. 16). Coral collections: 1 (GSC localities C-45444, C-45420), 2 (GSC locality C-45455).

The Bashkirian age assignment for our corals was derived from associated foraminiferal faunas first identified by B. L. Mamet and C. A. Ross (Mayr, 1992, p. 110, GSC localities C-45383 and C-45421). This age was confirmed by subsequent foraminiferal studies by D. Baranova (appendix in Fedorowski & Bamber, in review), who identified several species of the genera *Pseudostaffella* Thompson, 1942 (e.g., *P. timanica* Rauser, 1951) and *Parastaffella* Rauser-Chernousova, 1941 in consultation with E. I. Kulagina and N. B. Gibshman.

## 2. Faunal analysis

The Yelverton Inlet rugose coral fauna is significant for several reasons. First, it is the oldest coral fauna in the Sverdrup Basin, with several newly arrived taxa. Second, three species listed below either belong to or are closely comparable to the uppermost Viséan-Serpukhovian coral fauna of the Western European Province. Third, the species in common with that province suggest the development of open marine communication between western Europe and western North America around the northern margin of Euramerica. Communication around its southern margin has been confirmed by Bamber et al. (in preparation). Finally, our specimen of *Paraheritschioides* represents the oldest known occurrence of that genus in the world.

Late Viséan (Brigantian) rugose coral faunas diminished markedly on a world-wide scale near the end of that substage or soon afterward as a result of early Variscan orogenic movements and subsequent drastic environmental changes. Areas inhabited by corals were either uplifted or subjected to shallow water clastic sedimentation preventing both temporary settlement by larvae and permanent colonization by corals. Western and Central Europe exemplifies such changes. Extremely rich and diversified Late Viséan (Asbian and Brigantian) coral faunas were drastically reduced at the end of the Viséan (Fedorowski, 1981), with only a few dissepimented solitary and colonial genera, accompanied by small, nondissepimented taxa, surviving in the British Isles and continuing into the Serpukhovian. In the context of this paper, *Dibunophyllum bipartitum* (McCoy, 1849), *Palaeosmilia murchisoni* Milne Edwards & Haime, 1848 and *Lonsdaleia duplicata* (Martin, 1809) are the most important of these survivors. However, all of them disappeared from the Western European Province before the end of the Serpukhovian. Thus, that area was eliminated as a source area for our fauna.

Representatives of Late Viséan/Serpukhovian faunas continued to develop in several scattered parts of the world (Fig. 4) until the end of the Serpukhovian or slightly longer. The most important of those sites are:

1. The Donets Basin, which occupies the westernmost part of the Eastern European Province. It has yielded diversified coral faunas (Vasilyuk, 1960), which partly resemble the Upper Viséan fauna of Western European Province, but generally range higher in the section, into the Upper Serpukhovian. A few taxa range into the Lower Bashkirian. The Donets Basin species of greatest importance for our study are *D. bipartitum, P. murchisoni* and a probable representative of *L. duplicata*. However, none of those species extended to the Bashkirian in that area. *D. finalis*, known from the upper part of the *Reticuloceras-Bashkortoceras* Biozone (upper Kinderscoutian or upper Krasnopoljan) is a morphologically simplified species endemic to the Donets Basin.

2. North Africa, in which several basins developed during Carboniferous time in various areas presently occupied by the Sahara Desert. Very rich collections have been described from these areas by several authors (e.g., Menchikoff & Hsu, 1935; Semenoff-Tian-Chansky, 1974, 1985; Said & Rodríguez, 2007), but neither *Dibunophyllum bipartitum* nor *Palaeosmilia murchisoni* has been described above the top of the Serpukhovian, either in the listed papers or in the most recent study by Rodriguez et al. (2011). The latter publication contains the first confirmed report of *Lonsdaleia* in North Africa, from the northern Tindouf Basin, southern Morocco. In that occurrence, however, only the genus is listed, but not the species *L. duplicata*. Also, representatives of *Lonsdaleia* disappear in bed M, i.e., well below the top of the Brigantian, whereas representatives of other taxa continued to develop (Rodriguez et al., fig. 2). Only *Palaeosmilia*, not yet identified to species level, has been reported in the Bashkirian of the area by Semenoff-Tian-Chansky (1974) and I. D. Somerville (pers. comm., 2012). Specimens included by Semenoff-Tian-Chansky (ibid.) in Carruthers' (1909) species "*Campophyllum*" *carinatum* from Novaya Zemlya have been excluded by us from that northern taxon (Fedorowski & Bamber, submitted). Despite the few faunal similarities listed above, it would be difficult to find routes leading directly from the scattered Lower Carboniferous basins of North Africa to the northern part of the Sverdrup Basin.

3. Novaya Zemlya, where strata of probable Late Viséan/Serpukhovian age have yielded highly diversified coral faunas, described by Gorsky (1938, 1951). Unfortunately, collections from this area, which were gathered in conjunction with geological mapping and prospecting, are incomplete and the number of specimens is restricted. As a result, some of the described species are based on insufficient data. Nevertheless, the presence of *Dibunophyllum bipartitum, Palaeosmilia murchisoni* and *Lonsdaleia duplicata* can be accepted with a reasonable degree of certainty. In addition, these three species are associated with corals most probably related to *Tizraia* Said & Rodriguez, 2007, described by Gorsky (1951) as his new species *Diphyphyllum carinatum*. Lonsdaleoid dissepiments, which are variably developed in *Tizraia*, are absent from the Novaya Zemlya specimens and those from the Sverdrup Basin. This is the only significant difference between the northern specimens and *Tizraia*, and is adequate for no more than a subgeneric distinction.

4. The northern Timan area, located south-west of Novaya Zemlya (Fig. 4, locality 4) has yielded various Carboniferous rugose coral faunas from Brigantian, Serpukhovian and younger strata. Unfortunately, neither the old taxonomic paper by Stuckenberg (1895) nor the more recent paper by Kossovaya (1996) dealing with the question of the mid-Carboniferous rugose coral recovery offers modern and comprehensive, illustrated information on those faunas. Thus, we consider northern Timan as only a potential but still unproven source for the Bashkirian rugose corals of the Sverdrup Basin.

5. The Upper Viséan/Serpukhovian coral faunas of China should also be mentioned here as having potential significance for the Yelverton Inlet fauna. Among many species described from that area, at least *Dibunophyllum bipartitum* and *Palaeosmilia murchisoni* should be listed as almost certainly present. *Lonsdaleia duplicata* is mentioned as well (Fan et al., 2003) but the occurrence of that species cannot be confirmed from the published illustrations. During late Viséan-Bashkirian time, however, the Chinese microcontinents, like North Africa,

| GSC locality | Map location | Formation | Interval |
|---|---|---|---|
| C-45444 | 81°54.59'N, 79°24'W | Nansen | 368 m above base |
| C-45420 | 81°54.59'N, 79°24'W | Nansen | 206.5-207.5 m above base |
| C-45455 | 81°56.72'N, 79°12'W | Otto Fiord | Lower |

**Table 1**. Register of Geological Survey of Canada (GSC) localities.

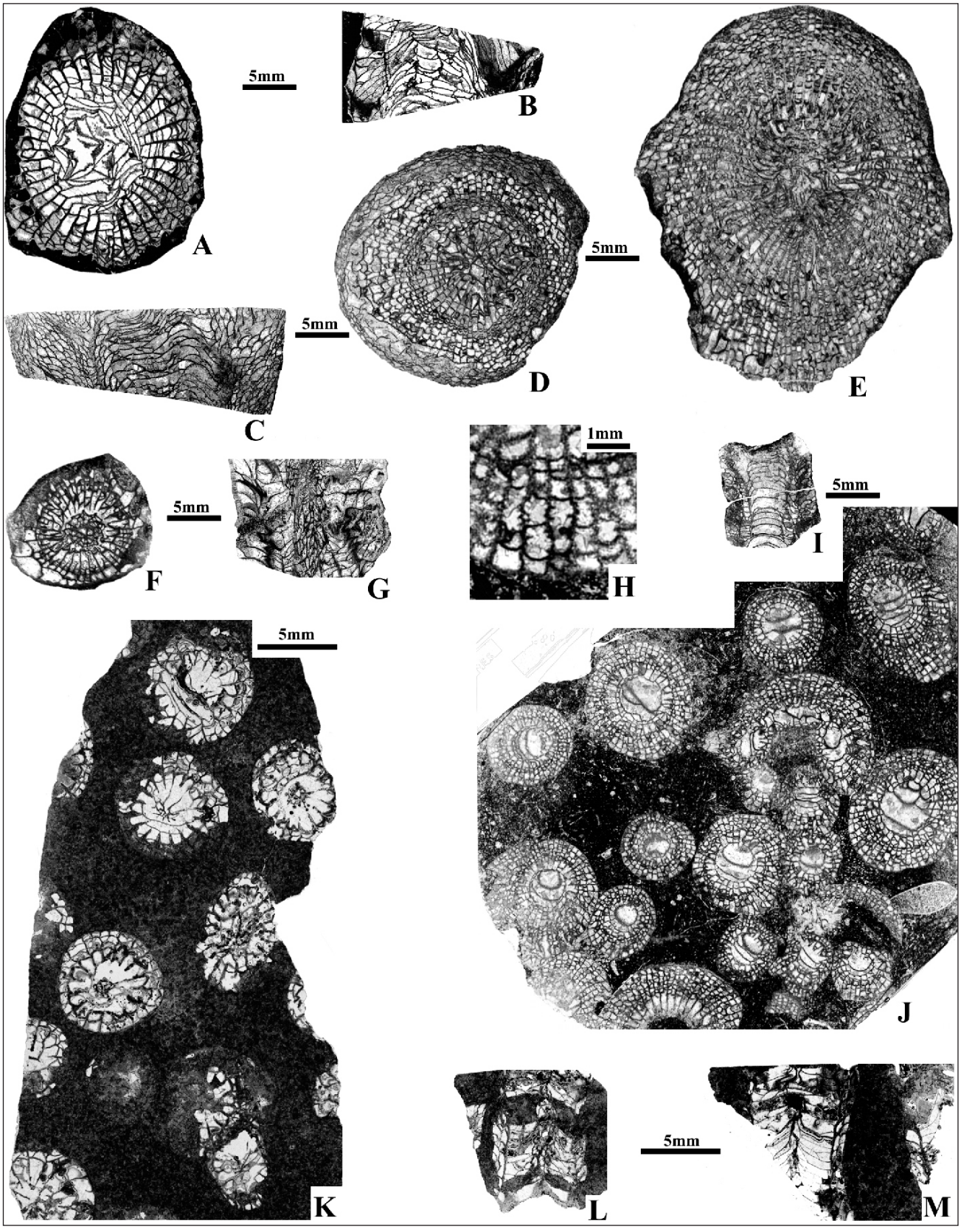


**Figure 3**. Examples of coral specimens studied. All specimens were collected from the Nansen and Otto Fiord formations in the Yelverton Inlet area of northernmost Ellesmere Island (see locality register). All figured specimens are stored in the Geological Survey of Canada type collection, Ottawa; illustrations are from thin sections. In transverse sections of solitary specimens, the cardinal protoseptum is orientated downward. A-B: *Dibunophyllum bipartitum* (McCoy, 1849); hypotype GSC 133208, Geological Survey of Canada (GSC) locality C-45420, Nansen Formation. A: Transverse section. B: Longitudinal section. C-E: *Palaeosmilia murchisoni* Milne-Edwards & Haime, 1851; Otto Fiord Formation. C, D: hypotype GSC 133209, GSC locality C-45455, specimen G. C: Longitudinal section. D: Transverse section. E: Hypotype GSC 133210, GSC locality C-45455, specimen A; transverse section. F, G: *Lonsdaleia duplicata* (Martin, 1809); hypotype GSC 133211, GSC locality C-45455, specimen F; Otto Fiord Formation. F: Transverse section. G: Longitudinal section. H-J: *Tizraia* sp. aff. "*Diphyphyllum*" *carinatum* Gorsky, 1951; hypotype GSC 133212, GSC locality C-45455, specimen C; Otto Fiord Formation. H: Fragment of colony, transverse section. I: Longitudinal section. J: Transverse section showing carinae well preserved (left) and diagenetically altered (right). K-M: *Paraheritschioides* sp.; hypotype GSC 133213, GSC locality C-45444; Nansen Formation. K: Fragment of colony, transverse section. L, M: Longitudinal sections.

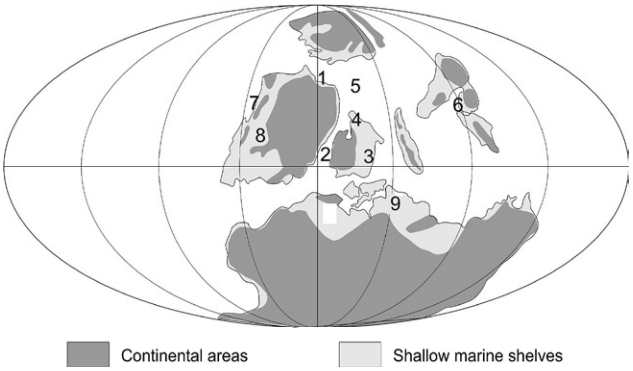


**Figure 4**. Bashkirian paleogeography and coral distribution, simplified and slightly modified after Fedorowski (1981, fig. 2). Legend: 1: Sverdrup Basin, 2: Western European Province, 3: Eastern European Province, 4: Northern Timan, 5: Novaya Zemlya, 6: Chinese microcontinents, 7: Stikine terrane, 8: southern Canadian Rocky Mountains, 9: North Africa.

were located much farther from the Sverdrup Basin than were Northern Timan and Novaya Zemlja. Therefore, an influence from China on our fauna is unlikely.

Our analysis of all important sites in the world yielding Serpukhovian rugose coral faunas (Fedorowski & Bamber, submitted) has eliminated most of them as potential sources for the Yelverton Inlet fauna. Their faunas became extinct too early (Western European Province), differ in their general content (e.g. the Voronezh Uplift, Moscow Basin), or there is doubt concerning the age and number of species in common with the arctic Canadian fauna (China).

Two western North American areas - the cratonal southern Canadian Rocky Mountains and the accreted Stikine terrane - have both yielded many European Upper Viséan and Serpukhovian coral taxa and should be of special value for comparison with the Yelverton Inlet fauna. However, the Rocky Mountain fauna contains no species in common with the arctic fauna (Bamber et al., in preparation) and only a single corallite from the Stikine terrane was identified by the present authors as *Dibunophyllum bipartitum* (Fedorowski & Bamber, in preparation).

## 3. Concluding remarks

Our brief analysis of the main areas of Upper Viséan/Serpukhovian rugose coral occurrences with rare species extending into the Lower Bashkirian allows some general conclusions to be drawn. (1) Faunas of that age, derived from the widely separated sites discussed above, may be comparable in having several taxa in common, but they differ considerably when their entire contents are analyzed. This may have resulted not only from isolation of these sites, but also from the influence of living conditions. Compared to the other faunas discussed above, the Yelverton Inlet fauna contains relatively few taxa. However, from their low stratigraphic occurrence it may be concluded that the Yelverton Inlet corals were undoubtedly pioneers in the Sverdrup Basin. (2) The almost complete absence from the Rocky Mountains and Stikine terrane of species in common with the Yelverton Inlet fauna suggests there was no direct marine communication between these northern and western regions through northwestern Euramerica. Northward migration from the western areas must have been prevented by physical or sedimentological barriers presently unknown to us (Fig. 4). (3) From faunal comparisons it appears that Novaya Zemlya and perhaps Northern Timan are the most likely sources for the Yelverton Inlet fauna. Unfortunately, the late Viséan/early Bashkirian rugose coral faunas of Northern Timan cannot be reliably assessed without an up-to-date, completely illustrated study. We have drawn our conclusion on the source of our fauna despite some reservations concerning the indefinite Late Viséan/Early Namurian age assignments given by Gorsky (1951). In our opinion there is a good possibility that the corals identified by that author as *Dibunophyllum bipartitum, Palaeosmilia murchisoni, Lonsdaleia duplicata* and "*Diphyphyllum*" *carinatum* belong to those species and are in common with the Yelverton Inlet fauna. Thus, it appears that these corals must have migrated to the northwestern Sverdrup Basin along the northern margin of Euramerica. This conclusion may change when the Northern Timan rugose coral faunas are better known, but it is presently supported by the geographic positions of both areas - the northern limit of the Eastern European Province for Novaya Zemlya and the northern part of the Sverdrup Basin in northernmost Euramerica for the Yelverton Inlet area. Both of those areas were located at relatively low latitudes in mid-Carboniferous time and appear to have been connected by open marine seaways with conditions suitable for coral migration. It is important to note, however, that the age of our fauna has been determined as Bashkirian, possibly middle Bashkirian, whereas the Novaya Zemlya corals were assigned an indefinite Late Viséan/Early Namurian age by Gorsky (1951). If the latter age is correct, then the fauna must have survived in a refuge of unknown location during the intervening time interval.

## 4. Acknowledgements

We wish to thank U. Mayr, who collected corals from Yelverton Inlet for the Geological Survey of Canada during the field seasons of 1975 to 1982. The numerous thin sections used in our study were prepared by G. Martin and M. Bartkowiak, M.Sc., and the digital drafting of our text-figures was completed by D. Then. Foraminiferal studies by D. V. Baranova (University of Calgary), in consultation with E. I. Kulagina (Ufa Research Center) and N. B. Gibshman (Paleontological Institute, Moscow), provided valuable information on the age of our collections. Helpful observations and suggestions were given by the reviewers of our manuscript, I. D. Somerville, K. E. Dewing and G. E. Webb. Geological Survey of Canada contribution number 20110228. The paper was also granted by the National Science Centre, Grant number NN 307 074140.

## 5. References

Bamber, E. W., Rodríguez, S., Richards, B. C. & Mamet, B. L., in preparation. Uppermost Viséan and Serpukhovian (Mississippian) rugose corals and biostratigraphy, Canadian Cordillera.

Beauchamp, B., Harrison, J. C. & Henderson, C. M., 1989. Upper Paleozoic stratigraphy and basin analysis of the Sverdrup Basin, Canadian Arctic Archipelago: Part 1. Time frame and tectonic evolution. In Current Research, Part G, Geological Survey of Canada, Paper 89-1G, 105-113, Ottawa.

Carruthers, R. G., 1909. Notes on corals. In Lee, G. W., A Carboniferous fauna from Novaja Semlja, collected by W. S. Bruce. Royal Society of Edinburgh, Transactions, 47/ 1, 143-186.

Fan, Yingnian, Yu Xueguang, He Yuanxiang, Pan Yuntang, Li Xin, Wang Fengyu, Tang Duajia, Chen Shijun, Zhao Peirong and Liu Jianjun, 2003. The Late Palaeozoic rugose corals of Xizang (Tibet) and adjacent regions and their palaeobiogeography. National Natural Science Foundation of China, Series of Geoscience, Earth, Hunan Science and Technology Press, 679 p.

Fedorowski, J., 1981. Carboniferous corals: distribution and sequence. Acta Palaeontologica Polonica, 26/2, 87-160.

Fedorowski, J. & Bamber, E.W., submitted. An unusual occurrence of Bashkirian (Pennsylvanian) rugose corals from the Sverdrup Basin, arctic Canada. Journal of Paleontology, submitted.

Gorsky, I. I., 1938. Carboniferous corals from Novaya Zemlya. In Nalivkin, D. V. (ed.), Palaeontology of the Soviet Arctic. Arctic Institute of the U.S.S.R., 93, 2, 8-221. Leningrad. [In Russian with English summary].

Gorsky, I. I., 1951. Carboniferous and Permian corals of Novaya Zemlya. Trudy Nauchno-Issledovatel'skovo Instituta Geologii Arktiki, 32, 5-168. [In Russian].

Kossovaya, O. L., 1996. The mid-Carboniferous rugose coral recovery. In Hart, M. B. (ed.), Biotic recovery from mass extinction events. Geological Society of London, Special Publication 102, 187-199.

Martin, W., 1809. Petrificata derbiensia (Figures and descriptions of petrifactions collected in Derbyshire). D. Lyon. Wigan, 1-102.

Mayr, U. 1992. Reconnaissance and preliminary interpretation of Upper Devonian to Permian stratigraphy of northeastern Ellesmere Island, Canadian Arctic Archipelago. Geological Survey of Canada, Paper 91-08, 1-117.

McCoy, F., 1849. On some new genera and species of Palaeozoic corals and Foraminifera. Annals and Magazine of Natural History, second series, 3, 1-20, 119-136.

Menchikoff, N. & Te-you Hsu, 1936. Les Polypiers carbonifères du Sahara occidental. Geological Society of France, Bulletin, 4-5, 229-261.

Milne Edwards, H. & Haime, J., 1848. Observations sur les polypiers de la famille des Astréides. Academy of Science, Paris, vol. 27, p. 465-470.

Rodríguez, S., Somerville, I., Said, I. & Cózar, P., 2011. An upper Viséan (Asbian-Brigantian) coral succession at Djebel Ouarkziz (northern Tindouf Basin, Morocco). In Aretz, M., Delculée, S., Denayer, J. & Poty, E. (eds), 11th Symposium on Fossil Cnidaria and Porifera, Liège (Belgium), August 22-26, 2011, Abstract Volume, Kölner Forum für Geologie und Paläontologie, 19, 144-146.

Said, I., & Rodríguez, S., 2007. A new genus of coral (Rugosa) from the Adarouch area (Brigantian, NE Central Morocco). Coloquios de Paleontologia, 27, 23-35.

Sando, W. J., 1985. *Paraheritschioides*, a new rugose coral genus from the Upper Pennsylvanian of Idaho. Journal of Paleontology, 59, 979-985.

Semenoff-Tian-Chansky, P., 1974. Recherches sur les tétracoralliaires du Carbonifère du Sahara occidental. National Museum of Natural History, New Series, 30, Paris, 1-316.

Semenoff-Tian-Chansky, P., 1985. Corals, North Africa, 374-381. In Wagner, R.H., Winkler Prins, C.F. & Granados, L.F. (eds), The Carboniferous of the world, 2. Australia, Indian Subcontinent, South Africa, South America, and North Africa. Madrid.

Stuckenberg, A. A., 1895. Korallen und Bryozoen der Steinkohlenablagerungen des Ural und des Timan. Trudy Geologicheskogo Komiteta, 10, 3, 1-244. [In Russian and German].

Vasilyuk, N. P., 1960. Lower Carboniferous corals of the Donets Basin. Akademiya Nauk Ukrainskoy SSR, Trudi Instituta Geologicheskikh Nauk, Seriya Stratigraphii i Paleontologii, 13, 1-178. [in Russian].

Manuscript received 29.09.2011, accepted in revised form 29.03.2012, available on line 15.09.2012.