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

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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 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.

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).
The Bashkirian age assignment for our corals was derived from associated foraminiferal faunas first identified by B. L. Mamet and C. A. Ross (Mamet, 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.

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

<table>
<thead>
<tr>
<th>GSC locality</th>
<th>Map location</th>
<th>Formation</th>
<th>Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-45444</td>
<td>81°54'59&quot;N, 79°24'1&quot;W</td>
<td>Nansen</td>
<td>365 m above base</td>
</tr>
<tr>
<td>C-45420</td>
<td>81°54'59&quot;N, 79°24'1&quot;W</td>
<td>Nansen</td>
<td>206.5-207.5 m above base</td>
</tr>
<tr>
<td>C-45455</td>
<td>81°56'72&quot;N, 79°12'12&quot;W</td>
<td>Otto Fiord Lower</td>
<td></td>
</tr>
</tbody>
</table>

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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 *Paraherititeschioides* 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 stage 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, nondisseminated 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; Semenov-Tian-Chansky, 1974, 1985; Said & Rodriguez, 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 Bashkirian, whereas representatives of other taxa continued to develop (Rodriguez et al., fig. 2).

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 *Tzraia* Said & Rodriguez, 2007, described by Gorsky (1951) as his new 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.

4. The northern Timan area, located south-west of Novaya Zemlya (Fig. 4, locality 4) has yielded various *Reticuloceras-Bashkortoceras* Biozone (upper Kinderscoutian or upper Krasnopoljan) is a morphologically simplified species endemic to the Donets Basin. The Bashkirian rugose corals of the Sverdrup Basin. The is the only significant difference between the northern specimens and *Tzraia*, and is adequate for no more than a subgeneric distinction.

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,
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.
were located much farther from the Sverdrup Basin than were Northern Timan and Novaya Zemlya. 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 with 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.

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