Nautiloid and bactritoid cephalopods from the Carboniferous of the Jebel Qamar South area, United Arab Emirates

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Abstract. Nine species of cephalopods from the Ayim Formation of the Jebel Qamar South area, United Arab Emirates are described. They include orthoceratids: Michelinoceras sp. 1, Michelinoceras? sp. 2, Temperoceras ayimense sp. nov., Mooreoceras? sp. 1, Mooreoceras? sp. 2, Mitorthoceras? sp., Spyroceratinae, genus and species indeterminate; oncocerid: Poterioceratidae, genus and species indeterminate; and bactritid: Bactrites cf. quadrilineatus Girty. Based on the fauna, the Early Carboniferous age of the formation is first established herein.

Key words: Ayim Formation, Bactritid, Early Carboniferous, Oncocerida, Orthocerida, United Arab Emirates

Introduction

The cephalopods described herein were collected from the Ayim Formation of previously uncertain age, during fieldwork in the Jebel Qamar South area, United Arab Emirates (Figure 1). Although preservation of the material is poor, we can provide new knowledge concerning age determination for the Ayim Formation and its paleobiogeographical implications for the situation of the Arabian Peninsula prior to the Neo-Tethys rifting.

The specimens studied are housed in the paleontological collections of the Geological Museum of Lausanne, Switzerland, and bear its registration numbers (prefixed MGL).

Geologic setting and fauna

The Jebel Qamar South area, situated in the northern Oman Mountains, is composed of the obducted Sonma Ophiolite and allochthonous units of a large Paleozoic exotic block lying in the Hawasina Nappes (Pillevuit, 1993). The lithostratigraphy of this exotic block was first subjected to reconnaissance study by Hudson et al. (1954), who showed the distribution of the Ordovician and Permian rocks in the area. Robertson et al. (1990) subdivided this Paleozoic sediments into four formations, which are from base to top: Rann, Ayim, Asfar and Qamar Formations. Recently Pillevuit (1993) redefined those sequences as constituents of the Ramaq Group.

The cephalopods occur in sandy limestone and reddish shale located in the lower part of the Ayim Formation (Figure 2). Besides cephalopods, the fossils include serpulids (Spirorbis sp.), bryozoans, ostracodes, echinoderms, fish remains (Robertson et al., 1990), and trace fossils (Pillevuit, 1993). An age between Ordovician and Early Permian for the Ayim Formation is not questionable because of its stratigraphic setting, viz. the Rann and Asfar Formations have been dated by trilobites (Hudson et al., 1954) and brachiopods (Yanagida and Pillevuit, 1994), respectively. However, the lack of biostratigraphic study has left pending a precise age determination. A possible Devonian age has been suggested by Robertson et al. (1990) for this formation, based on lithologic similarities with the Devonian Griotte and Cephalopodenkalk of the Western European Variscan. Pillevuit (1993) stated that similar facies to the Ayim Formation are also recognized in Middle Ordovician to Upper Devonian deposits of the Middle East, i.e. the Middle to Upper Ordovician Qasim Formation in Saudi Arabia (Vaslet, 1990), and the Middle to Upper Silurian unnamed formation (Clark et al., 1975) and the Upper Devonian Shishtu Formation (Stöcklin et al., 1965) in Iran.

The cephalopod fauna of the Ayim Formation is dominated by orthocerid forms, and consists of nine species, including seven orthocerids (Michelinoceras sp. 1, Michelinoceras? sp. 2, Temperoceras ayimense sp. nov., Mooreoceras? sp. 1, Mooreoceras? sp. 2, Mitorthoceras? sp., Spyroceratinae, genus and species indeterminate) and two species of oncocerid (Poterioceratidae, genus and species indeterminate) and bactritid (Bactrites cf. quadrilineatus Girty). Although our
knowledge of the distribution of Late Paleozoic orthoconic cephalopods is not always sufficient, the cephalopods resemble species known from the North American Midcontinent region in overall aspect. The bactritid species from the Ayim Formation is comparable to that of Bactrites quadrilineatus Girty from the Chesterian of Oklahoma. The species *Michelinoceras* sp.1 and *Mitorthoceras*? sp. also suggest affinities with the Late Mississippian species of the Midcontinent region. In addition, similar species to *Mooroceras*? sp.1 is known to range from Morrowan to Atokan of North America. Documented range of the family Poterioceratidae and the genus Temperoceras extends to the Mississippian and the Triassic, respectively. Based on the evidence, the Ayim Formation is considered to be Early Carboniferous in age, with faunal exchange taking place through the seaway between Gondwana and Laurentia. Yanagida and Pillevuit (1994) indicated, however, that the Artinskian brachiopod fauna from the Asfar Formation, resting unconformably upon the Ayim Formation, shows affinity with the faunas of the Gondwana Tethyan and Cathaysia Tethyan provinces. This faunal transition may be caused by the closure of the seaway due to the amalgamation of Pangea during the Late Carboniferous to Early Permian (Scotese and McKerrow, 1990).

**Systematic paleontology**

Subclass Nautiloidea Agassiz, 1847
Order Orthocerida Kuhn, 1940
Superfamily Orthocerataceae M'Coy, 1844
Family Orthoceratidae M'Coy 1844
Subfamily Michelinoceratinae Flower, 1945
Genus *Michelinoceras* Foerste, 1932

Type species.—*Orthoceras michelini* Barrande, 1866.

*Michelinoceras* sp. 1

Figures 3–1–5

**Description.**—Orthocones with moderate shell expansion (approximately 5°), circular cross section; largest specimen
of phragmocone attains 25 mm shell diameter; septal curvature moderate to relatively deep; cameral length somewhat variable, cameral ratio of apical shell 0.9-1.0, adorally camerae become short with 1.6-2.7 in this ratio; sutures straight, transverse; siphuncle central with weak constrictions at septal foramen, lacks endosiphuncular deposits; septal necks moderately long, orthochoanitic; connecting rings cylindrical; cameral deposits mural.

Discussion.—This species shows a superficial resemblance to *Michelinoceras wapanuckense* (Girty, 1909, pl. 6, figs. 11, 12) from the Mississippian (Chesterian) of Oklahoma. However, the internal structure of *M. wapanuckense*, shown by Gordon (1964, pl. 5, fig. 1), indicates longer camerae at the corresponding shell diameter.

Material.—Three specimens of incomplete phragmocones, MGL 72033-72035, were examined. In addition, a deformed specimen (MGL 72036) is questionably assigned to this species.

**Michelinoceras** ? sp. 2

Figures 3–8–10

Description.—Orthocones with gradual shell expansion (3–4°), circular cross section; largest specimen of phragmocone reaches 16 mm in diameter; septa deeply concave; cameral ratio approximately 2; sutures transverse, with broad lobes; siphuncle central with short orthochoanitic septal necks, cylindrical connecting rings.

Discussion.—This species differs from typical species of *Michelinoceras* in having short septal necks and lobate sutures. For these reasons it can be assigned only questionably to *Michelinoceras*.

Material.—Two specimens of incomplete phragmocones, MGL 72037 and 72038, were examined. In addition two ill-preserved specimens (MGL 72039, 72040) are questionably assigned to this species.

Family Geisonoceratidae Zhuravleva, 1959

Genus **Temperoceras** Barskov, 1960

Type species.—Orthoceras temperans Barrande, 1874.

**Temperoceras ayimense** sp. nov.

Figures 4–1–6, 10

Description.—Gradually expanding orthocones; siphuncle
Figure 3. 1-5. *Michelinoceras* sp. 1. 1, 2: MGL 72034, 1, side view; 2, longitudinal polished section; 3, 4: MGL 72033, longitudinal polished section; 4, side view; 5: MGL 72035, longitudinal polished section. 6, 7. *Bactrites* cf. *quadriplaneatus* Girty, MGL 72059, 6: ventral view; 7: septal view of adoral end, venter down. 8-10. *Michelinoceras ?* sp. 2. 8: MGL 72037, side view; 9, 10: MGL 72038, 9, side view; 10, longitudinal polished section. 11-13. Poterioceratidae, genus and species indeterminate, MGL 72058, 11: lateral view; venter on right; 12: dorsoventral thin section, venter on left; 13: details of siphuncle, negative print of thin section. 1, 4, 5, 9, 11 = x 1.5; 2, 3, 5-7, 10, 12 = x 2; 13 = x 10.
nearly central in position with suborthochoanitic to orthochoanitic septal necks and subcylindrical connecting rings; cameral deposits episepal-mural, hyposeptal; small endosiphuncular deposits occur in apical septal foramen.

**Description.**—Moderately large-sized orthocones with gradual shell expansion (approximately 3), circular cross section, largest paratype (MGL 72043) of phragmocone attains approximately 30 mm (reconstructed) in diameter; sutures straight, slightly oblique; camerae short, cameral length 3.3-5.0 mm in holotype, cameral ratio in paratype (MGL 72043) approximately 4; septal curvature moderately deep; siphuncle nearly central; siphuncular diameter/shell diameter approximately 0.1, septal necks suborthochoanitic in venter, orthochoanitic in dorsum; swollen portion of septal necks usually not preserved, thus they appear "loxochoanitic"; septal neck length short, 0.2-0.3 mm in suborthochoanitic neck in apical holotype; connecting rings subcylindrical, slightly inflated in segments; cameral deposits episepal-mural, usually forming circumsiphuncular ridges, and hyposeptal, but adoral camera lacks hyposeptal deposits; endosiphuncular deposits of annulus weakly developed in apical septal foramen, not fusing.

**Discussion.**—The external shell ornamentation is not known, so that generic assignment of the species is tentative at present. However, the siphuncular morphology and the possession of endosiphuncular annuli are shared by the two geisonoceratid genera: Temperoceras Barskov (1960; type species, Orthoceras temperans Barrande, 1874) and Protokionoceras Grabau and Shimer (1910, type species, Orthoceras medullare Hall, 1868). The gradual shell expansion suggests the species belongs to *Temperoceras* rather than *Protokionoceras*.

The present species somewhat resembles *Pseudotemperoceras pulchrum* Stschastlivtseva (1986, pl. 1, fig. 1; type species of the genus) which occurs in the Lower Triassic of Verkhoyanye, Yakutia. The Triassic species has more inflated connecting rings than *Temperoceras* aymense sp. nov. In the generic comparison *Pseudotemperoceras* differs from *Temperoceras* only in degree of development of endosiphuncular deposits, and is probably a junior synonym of *Temperoceras*.

**Material.**—The holotype, MGL 72041, is an incomplete phragmocone, 84.5 mm in length. Four paratypes of incomplete phragmocones, MGL 72042-72045, are assigned. In addition, a deformed specimen (MGL 72046) was also examined.

**Etymology.**—The specific name is taken from the Ayim Formation, where the type specimens occurred.

**Superfamily** Pseudorthoceratidaeae Flower and Caster, 1935  
**Family** Pseudorthoceratidaeae Flower and Caster, 1935  
**Subfamily** Pseudorthoceratinae Flower and Caster, 1935  
**Genus** *Mooreoceras* Miller, Dunbar and Condra, 1933

**Type species.**—*Mooreoceras normale* Miller, Dunbar and Condra, 1933.
Figure 4. 1-6, 10. *Temperoceras ayimense* sp. nov.: 1-4: holotype, MGL 72041, 1, dorsal view; 2, dorsoventral polished section, venter on left; 3, details of apical siphuncle, thin section, arrow indicates endosiphuncular deposits; 4, details of adoral siphuncle, thin section; 5: paratype, MGL 72042, side view; 6: paratype, MGL 72044, septal view; 10: paratype, MGL 72043, longitudinal polished section. 7-9: *Mooreoceras* sp. 1, MGL 72047, 7: lateral view, venter on right; 8: dorsoventral polished section, venter on right; 9: details of siphuncle, polished section, arrow indicates cyrtochoanitic septal neck. 1, 5, 6 = ×1; 2, 7, 10 = ×1.5; 3, 4, 9 = ×8; 8 = ×2.
MGL 72053–72056, were examined.

Genus and species indeterminate

Figures 5–5, 6

Discussion.—A single fragmentary specimen of a gently cyrtoconic phragmocone with circular cross section, nearly straight sutures, central siphuncular position is suggestive of a pseudorthoceratid rather than an oncocerid or nautilid. Furthermore, in siphuncular structure the specimen seemingly belongs to the Spyroceratinae. This species is unlike any known Late Paleozoic cephalopod, and may represent a new genus.

Material.—MGL 72057.

Order Oncocerida Flower in Flower and Kummel, 1950
Family Poterioceratidae Foord, 1888

Figure 5. 1–4. Mitorthoceras ? sp., 1, 2: MGL 72055, 1, side view; 2, details of surface ornamentation, 3, 4: MGL 72053, 3, side view; 4, dorsoventral polished section. 5, 6. Spyroceratinae, genus and species indeterminate, MGL 72057, 5: dorsoventral polished section, 6: side view. 7–9. Mooreoceras ? sp. 2, 7: MGL 72048, dorsoventral polished section, 8, 9: MGL 72050, 8, dorsoventral polished section; 9, lateral view. 1, 3, 6, 9 = ×1.5, 2 = ×10, 4, 5, 7, 8 = ×2.
Genus and species indeterminate

Discussion.—A single fragmentary and slightly deformed specimen is assigned to a poterioceratid genus and species indeterminate, based on the following morphology: exogastric cyrcone, submarginal siphuncle with strongly curved dorsal septal necks and subquadrangular connecting rings in longitudinal section.

The thick connecting rings of this species suggest relationship to the Early Devonian genus Xenoceras (Flower, 1951; type species, X. oncoceroides Flower) from New York. However, this species lacks the pendent deposits in septal foramen which are a diagnostic feature of Xenoceras.

Material.—MGL 72058.

Subclass Bactritoeidea Shimanskiy, 1951
Order Bactritida Shimanskiy, 1951
Family Bactritidae Hyatt, 1884
Genus Bactrites Sandberger, 1843

Type species.—Bactrites subconicus Sandberger, 1843.

Bactrites cf. quadrilineatus Girty, 1909

Compare with.—Bactrites quadrilineatus Girty, 1909, p. 50–52, pl. 6, figs. 1–4.

Bactrites quadrilineatus Girty. Miller and Furnish, 1940, pl. 45, fig. 5; Mapes, 1979, p. 35, 36, pl. 1, figs. 6–9, pl. 2, figs. 7–9, pl. 3, figs. 1–3, 7–11, pl. 4, figs. 10, 12–16, pl. 12, fig. 3.

Description.—Single juvenile phragmocone of longiconic orthocone, 38.5 mm in length, with circular cross section; angle of expansion approximately 3°; adoral end attains 6.5 mm in diameter; sutures transverse, straight with ventral lobe; camera relatively long, cameral ratio approximately 1.4, marginal siphuncle has orthochoanitic septal necks and cylindrical connecting rings.

Discussion.—In the combination of numerical value of angle of shell expansion, straight sutures and cameral ratio, this specimen is strongly reminiscent of Bactrites quadrilineatus Girty known from the Mississippian (Chesterian) of the midcontinental United States. The outer shell wall with surface ornamentation and wrinkle-layer are eroded away making reliable specific assignment impossible.

Material.—MGL 72059.

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