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

SHUJI NIKO[1], ALAIN PILLEVUIT[2] and GERARD STAMPFLI[3]

[1]*Department of Environmental Studies, Faculty of Integrated Arts and Sciences, Hiroshima University, Higashihiroshima, 739 Japan*

[2]*Institute of Geophysics, University of Paris VII, 75251 Paris Cedex 05, France*

[3]*Institute of Geology and Paleontology, University of Lausanne, BFSH 2, 1015 Lausanne-Dorigny, Switzerland*

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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: Posterioceratidae, 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, Bactritida, Early Carboniferous, Oncocerida, Orthocerida, United Arab Emirates

Introduction

The cephalopods described herein were collected from the Ayim Formation of previously uncertain age, during field work 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 Semail 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 orthoconic 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 (Posterioceratidae, genus and species indeterminate) and bactritid (*Bactrites* cf. *quadrilineatus* Girty). Although our

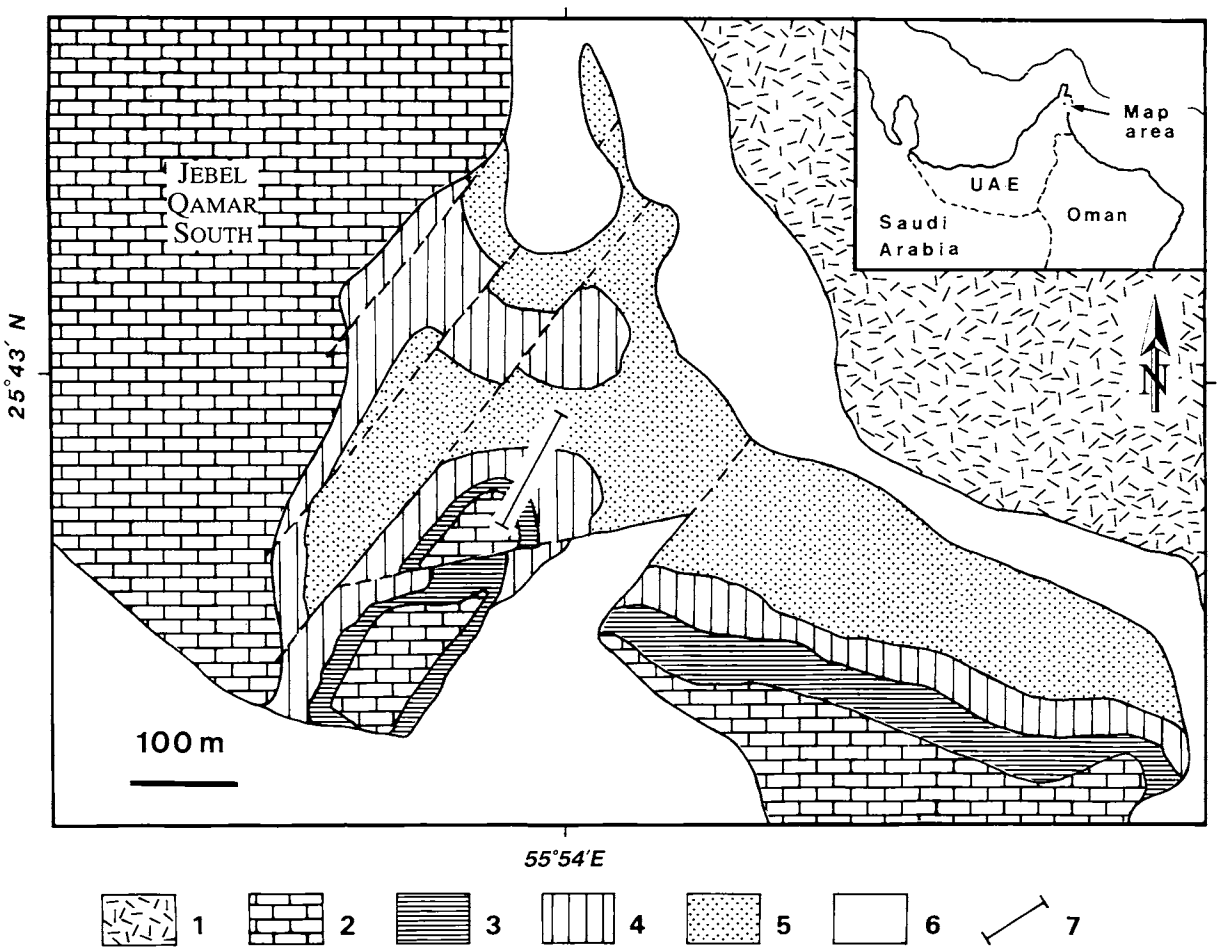

Figure 1. Map showing geology of the Jebel Qamar South area (modified from Pillevuit, 1993). **1**: Semail Ophiolite, **2-5**: exotic block (Ramaq Group), in descending order, 2, Qamar Formation; 3, Asfar Formation; 4, Ayim Formation; 5, Rann Formation, **6**: Alluvium, **7**: location of measured stratigraphic section given in Figure 2.

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 *Mooreoceras*? sp. 1 is known to range from Morrowan to Atokan of North America. Documented range of the family Poteriioceratidae 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

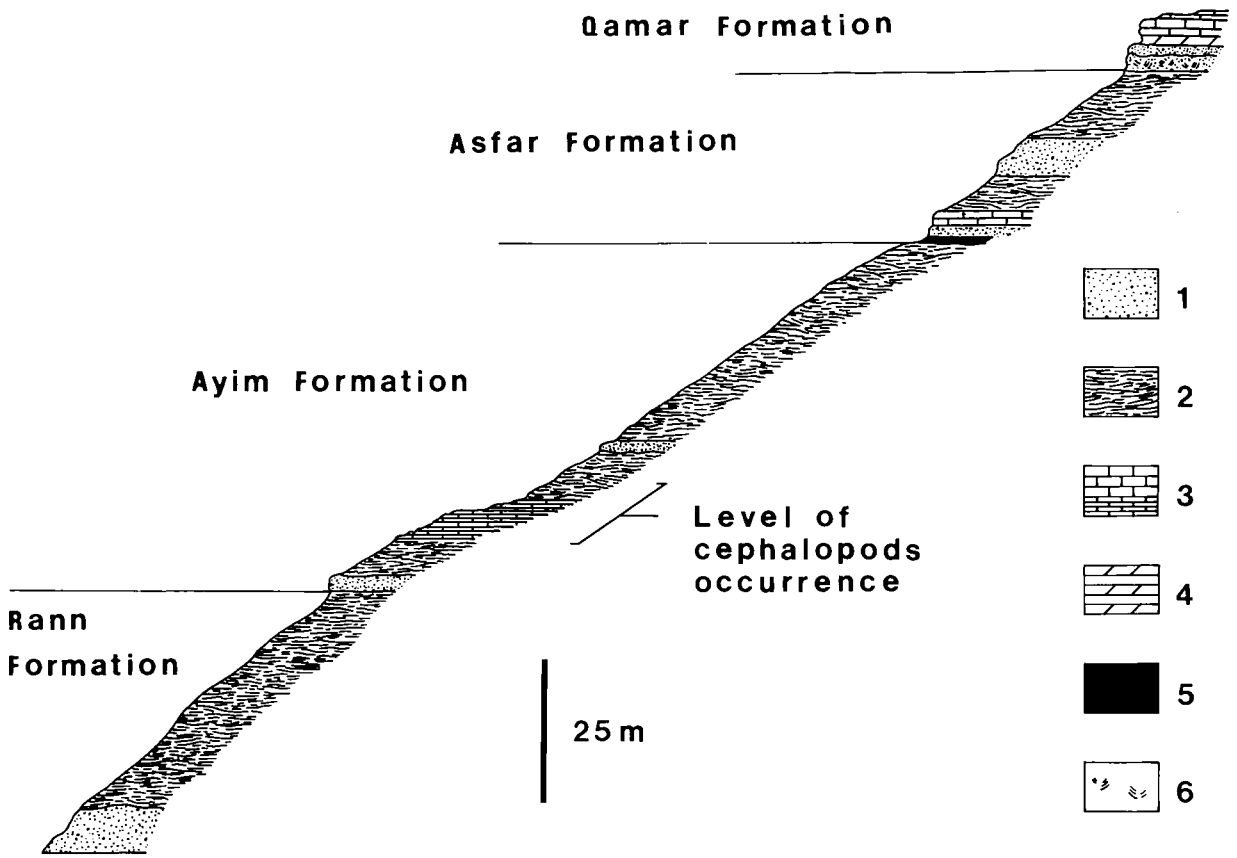

Figure 2. Stratigraphic section showing lithology of the Paleozoic formations of exotic block and stratigraphic position of cephalopods (modified from Pillevuit, 1993). **1**: sandstone, **2**: shale, **3**: limestone, **4**: dolomite, **5**: pillow lava, **6**: cross bedding.

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

Diagnosis.—Gradually expanding orthocones; siphuncle

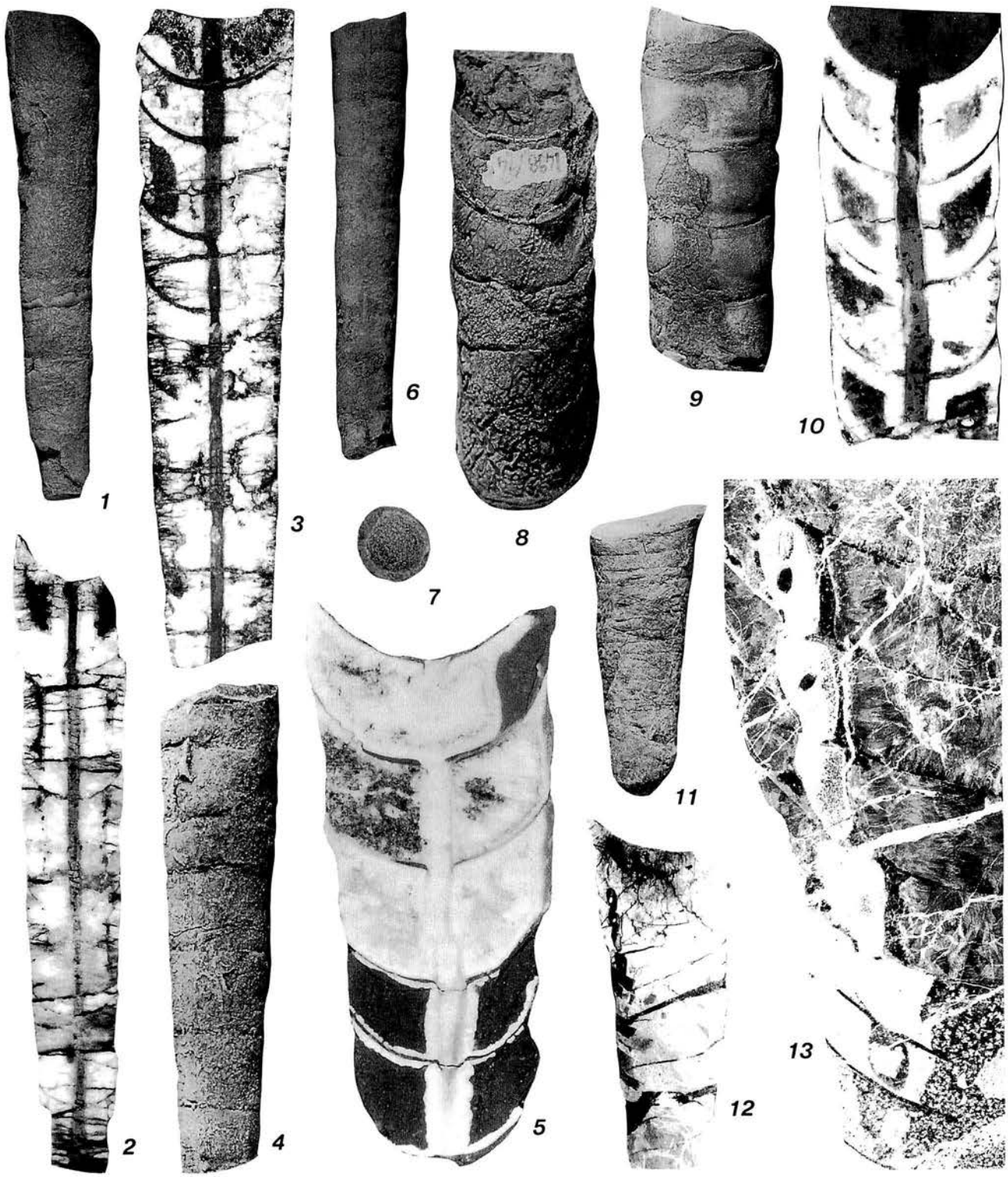

Figure 3. **1-5.** *Michelinoceras* sp. 1. **1, 2**: MGL 72034, 1, side view; 2, longitudinal polished section, **3, 4**: MGL 72033, 3, longitudinal polished section; 4, side view, **5**: MGL 72035, longitudinal polished section. **6, 7.** *Bactrites* cf. *quadrilineatus* Girty, MGL 72059, 6: ventral 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, 8, 9, 11 = ×1.5, 2, 3, 5-7, 10, 12 = ×2, 13 = ×10.

nearly central in position with suborthochoanitic to orthochoanitic septal necks and subcylindrical connecting rings; cameral deposits episeptal-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 72403) 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 episeptal-mural, usually forming circumsiphuncular ridges, and hyposeptal, but adoral camera lacks hyposeptal deposits; endosiphuncular deposits of annuli 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 ayimense* 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 Pseudorthoceratacea Flower and Caster, 1935
Family Pseudorthoceratidae 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.

Mooreoceras ? sp. 1

Figures 4-7—9

Description.—Orthoconic shell with relatively rapid shell expansion (approximately 8°), laterally compressed cross section, dorsoventral shell diameter 15 mm in adoral end; sutures straight, slightly oblique; septa moderately deep; cameral length short, cameral ratio ranges from 4.8 to 6.5; siphuncle subcentral with cyrtochoanitic short septal necks.

Discussion.—This description is based on a single poorly preserved phragmocone. This species resembles *Mooreoceras normale* Miller, Dunbar and Condra (1933, pl. 2, figs. 5-10) from Middle Pennsylvanian of the Midcontinent region of United States, although until more material is obtained identification is pending. *Mooreoceras normale* is known to range from Morrowan to Atokan (Gordon, 1964).

Material.—MGL 72047.

Mooreoceras ? sp. 2

Figures 5-7—9

Description.—Orthoconic shells with relatively rapid shell expansion (approximately 7°), circular cross section, oblique and nearly straight sutures; largest specimen of phragmocone reaches approximately 22 mm (reconstructed) in diameter; septa moderately deep; cameral ratio 2.6-3.7; siphuncle subcentral with cyrtochoanitic to suborthochoanitic septal necks, connecting rings fusiform.

Discussion.—*Mooreoceras* ? sp. 2 is easily distinguished from *M.* ? sp. 1 by its partly suborthochoanitic septal necks. The available specimens are insufficient for adequate assignment.

Material.—Three specimens of incomplete phragmocones, MGL 72048-72050, were examined. In addition, two ill-preserved specimens (MGL 72051, 72052) are questionably assigned to this species.

Subfamily Spyroceratinae Shimizu and Obata, 1935
Genus ***Mitorthoceras*** Gordon, 1960

Type species.—*Mitorthoceras perfilosum* Gordon, 1960.

Mitorthoceras ? sp.

Figures 5-1—4

Description.—Weakly lirated orthocones with moderate to relatively rapid shell expansion (6-8°), circular cross section; largest specimen of phragmocone reaches approximately 10 mm in diameter; sutures straight, transverse; septal curvature moderate to relatively deep; camerae relatively long, cameral ratio approximately 1.6; siphuncle central with suborthochoanitic septal necks.

Discussion.—The available specimens are very poorly preserved, but the surface ornamentation, relatively long camerae, and suborthochoanitic septal necks indicate similarity to the Mississippian species *Mitorthoceras perfilosum* Gordon (1960, pl. 27, figs. 1-4, 8).

Material.—Four specimens of incomplete phragmocones,

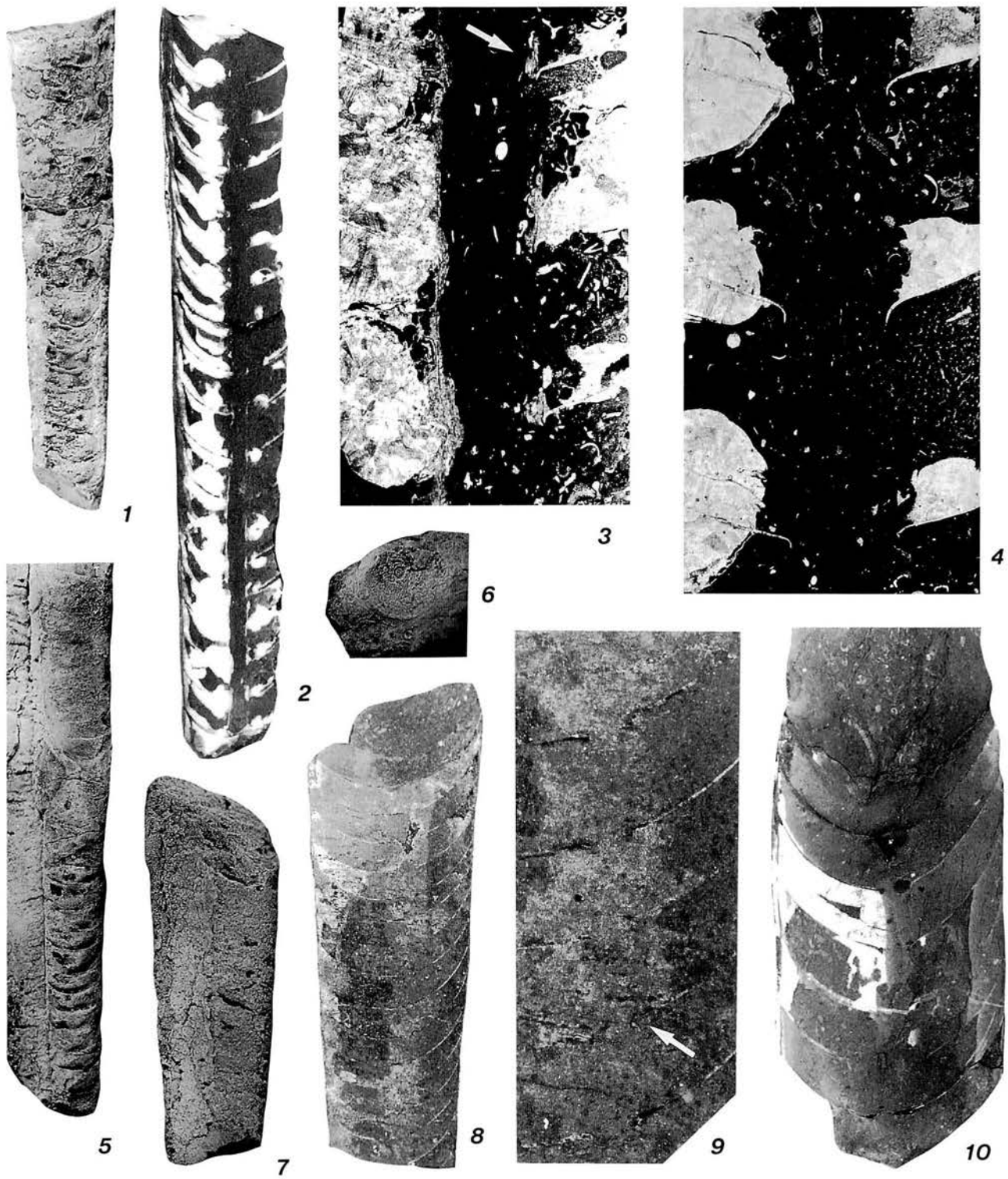

Figure 4. 1-6, 10. *Temperoceras ayimense* sp. nov.. 1-4 : holotype, MGL 72041, 1, dorsal view ; 2, dorsoventral polished section, venter on left ; 3, details of apical siphuncle, thin section, arrow indicates endosiphuncular deposits ; 4, details of adoral siphuncle, thin section, 5 : paratype, MGL 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

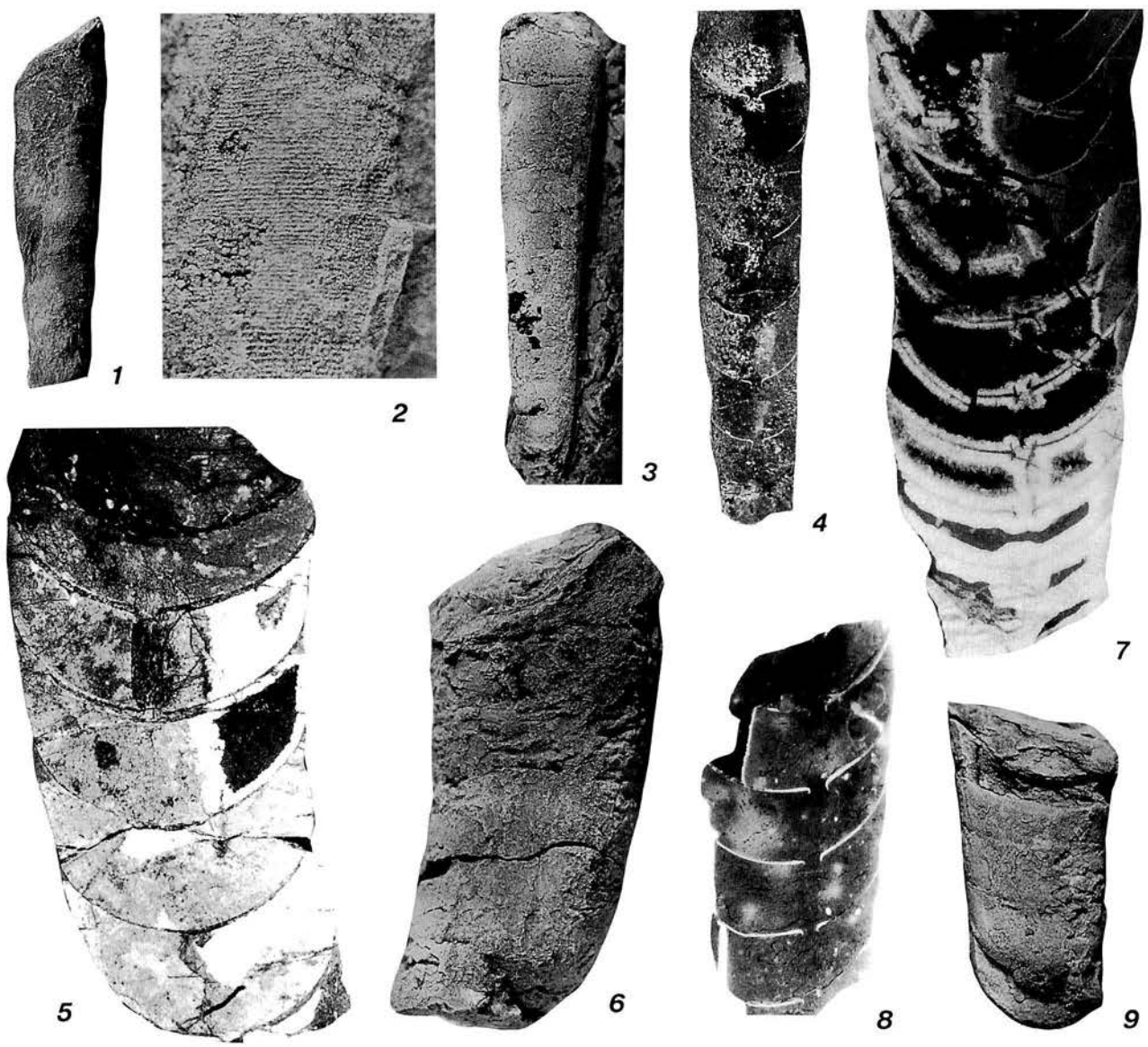

Figure 5. **1-4.** *Mitorthoceras* ? sp., 1, 2 : MGL 72055, 1, side view ; 2, details of surface ornamentation, 3, 4 : MGL 72053, 3, side view ; 4, dorsoventral polished section. **5, 6.** Spyroceratinae, genus and species indeterminate, MGL 72057, 5 : dorsoventral polished section, 6 : side view. **7-9.** *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

Figures 3-11—13

Discussion.—A single fragmentary and slightly deformed specimen is assigned to a poterioceratid genus and species indeterminate, based on the following morphology: exogastric cyrtocone, submarginal siphuncle with strongly curved dorsal septal necks and subquadrate 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 Bactritoidea 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

Figures 3-6, 7

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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References cited

Barrande, J., 1866: Système silurien du centre de la Bohème, Première Partie. Recherches paléontologiques, volume 2, Classe des Mollusques, Ordre des Céphalopodes. pt. 7, pls. 108-244.

Barrande, J., 1874: Système silurien du centre de la Bohème, Première Partie. Recherches paléontologiques, volume 2, Classe des Mollusques, Ordre des Céphalopodes. pt. 3, 804 p.

Barskov, I.S., 1960: Siluriyskie i devonskie nautiloidei iz Yuzhnoy Fergany (Silurian and Devonian nautiloids from southern Fergana). *Biulleten Moskovskogo Obshchestva Ispytatelei Prirody, Otdel Geologicheskii*, vol. 35, p. 153-154. (*in Russian*)

Clark, G.C., Davis, R.G., Hamzepour, B. and Jones, C.R., 1975: Explanatory text of the Bandar-e-Pahlavi Quadrangle Map 1: 250,000. *Geological Survey of Iran, Geological Quadrangle no. D3*, 198 p.

Flower, R.H., 1945: Classification of Devonian nautiloids. *The American Midland Naturalist*, vol. 33, p. 675-724.

Flower, R.H., 1951: A Helderbergian cyrtoconic cephalopod. *Bulletin of the Wagner Free Institute of Science, Philadelphia*, vol. 26, p. 1-7, pl. 1.

Flower, R.H. and Caster, K.E., 1935: The stratigraphy and paleontology of northwestern Pennsylvania. Part II: Paleontology. Section A: The cephalopod fauna of the Conewango Series of the Upper Devonian in New York and Pennsylvania. *Bulletins of American Paleontology*, vol. 22, p. 199-271.

Flower, R.H. and Kummel, B., 1950: A classification of the Nautiloidea. *Journal of Paleontology*, vol. 24, p. 604-616.

Foerste, A.F., 1932: Black River and other cephalopods from Minnesota, Wisconsin, Michigan, and Ontario (Part 1). *Denison University Bulletin, Journal of the Scientific Laboratories*, vol. 27, p. 47-136, pls. 7-37.

Foord, A.H., 1888: Catalogue of the fossil Cephalopoda of the British Museum (Natural History), part I, 344 p. The Palaeontological Society, London.

Girty, G.H., 1909: Fauna of the Caney Shale of Oklahoma. *United States Geological Survey, Bulletin*, vol. 377, 106 p., 13 pls.

Gordon, M., 1960: Some American midcontinent Carboniferous cephalopods. *Journal of Paleontology*, vol. 34, p. 133-151, pls. 27, 28.

Gordon, M., 1964: Carboniferous cephalopods of Arkansas. *United States Geological Survey Professional Paper*, no. 460, 322 p., 30 pls.

Grabau, A.W. and Shimer, H.W., 1910: North American index fossils, Invertebrates, vol. 2, p. 16-229. Seiler and Campany, New York.

Hall, J., 1868: Descriptions of new or little-known species of fossils from rocks of the age of the Niagara Group. *20th Annual Report of the New York State Cabinet of Natural History*, p. 347-438, pls. 10-25.

Hudson, R.G.S., Browne, R.V. and Chatton, M., 1954: The structure and stratigraphy of the Jebel Qamar area, Oman. *Proceedings of the Geological Society of London*, vol. 1513, p. 99-104.

Hyatt, A., 1883-1884: Genera of fossil cephalopods. *Proceedings of the Boston Society of Natural History*, vol. 22, p. 253-338.

Kuhn, O., 1940 : *Pälaozoologie in Tabellen*, 50 p. Fischer, Jena.

Mapes, R.H., 1979 : Carboniferous and Permian Bactritoidea (Cephalopoda) in North America. *The University of Kansas Paleontological Contributions, Article 64*, 75 p., 41 pls.

M'Coy, F., 1844 : *A Synopsis of the Characters of the Carboniferous Limestone Fossils of Ireland*, 274 p. Privately published. (reprinted by Williams and Norgate, London, 1862).

Miller, A.K., Dunbar, C.O. and Condra, G.E., 1933 : The nautiloid cephalopods of the Pennsylvanian System in the Mid-continent region. *Nebraska Geological Survey, Bulletin 9, second series*, 240 p., 24 pls.

Miller, A.K. and Furnish, W.M., 1940 : Studies of Carboniferous ammonoids : Parts 1-4. *Journal of Paleontology*, vol. 14, p. 356-377, pls. 45-49.

Pillevuit, A., 1993 : Les blocs exotiques du Sultanat d'Oman. *Mémoires de Géologie (Lausanne)*, no. 17, p. 1-249.

Robertson, A.H.F. Blome, C.D., Cooper, D.W.J., Kemp, A.E.S. and Searle, M.P., 1990 : Evolution of the Arabian continental margin in the Dibba Zone, northern Oman Mountains. *In*, Robertson, A.H.F., Searle, M.P. and Ries, A.C. *eds.*, *The Geology and Tectonics of the Oman Region*, p. 251-284. Geological Society Special Publication no. 49, London.

Sandberger, G., 1843 : Schilderung der paläontologischen Verhältnisse der älteren Formationen Nassaus. *Versammlung Deutscher Naturforscher und Aerzte Mainz, Bericht 20*, p. 154-160.

Scotese, C.R. and McKerrow, W.S., 1990 : Revised world maps and introduction. *In*, McKerrow, W.S. and Scotese, C.R. *eds.*, *Palaeozoic Palaeogeography and Biogeography*, p. 1-21. The Geological Society Memoir, no. 12, London.

Shimanskiy, V.N., 1951 : K voprosu ob evoliutsii verkhnepaleozoishikh pryamykh golovonogikh (On the evolution of the Upper Paleozoic straight nautiloids). *Doklady Akademii Nauk SSSR*, vol. 79, p. 867-870, pl. 1. (*in Russian*)

Shimizu, S. and Obata, T., 1935 : New genera of Gotlandian and Ordovician nautiloids. *Journal of the Shanghai Science Institute, Section 2, Geology, Paleontology, Mineralogy and Petrology*, vol. 2, p. 1-10.

Stschastlivtseva, N.P., 1986 : Nekotorie triasovie orthoceratidei i nautilidei severo-vostoka SSSR (Some Triassic orthoceratids and nautilids from north-east USSR). *Biulleten Moskovskogo Obshchestva Ispytatelei Prirody, Otdel Geologicheskii*, vol. 61, p. 122-129. (*in Russian with English abstract*)

Stöcklin, J., Eftekhar-Nezhad, J. and Hushmand-Zadeh, A., 1965 : Geology of the Shotori Range (Tabas area, East Iran). *Geological Survey of Iran, Report,* no. 3, 69 p.

Vaslet, D., 1990 : Le Paléozoïque (Anté-Permien supérieur) d'Arabie Saoudite. *Documents du Bureau de Recherches Géologiques et Minières*, no. 191, 210 p.

Yanagida, J. and Pillevuit, A., 1994 : Permian brachiopods from Oman. *Memoirs of the Faculty of Science, Kyushu University, Ser. D, Earth and Planetary Sciences*, vol. 28, p. 61-99.

Zhuravleva, F.A., 1959 : O semeistve Michelinoceratidae Flower, 1945 (On the Family Michelinoceratidae Flower, 1945). *Materialy k "Osnovam Paleontologii"*, part 3, p. 47-48. (*in Russian*)