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Tome 7 (2ème série), Fascicule 1
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I.G.C.P. 421, ISFAHAN, DECEMBER 1998.

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SOCIÉTÉ GÉOLOGIQUE DU NORD
59655 VILLENEUVE D'ASCQ CEDEX

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INTRODUCTION

Les notes de ce fascicule entrent dans le cadre d'un Programme International de Corrélation Géologiques (PICG 421) consacré aux " Evénements biologiques globaux gondwans au Paléozoïque moyen - Schémas biogéographiques en relation avec la dynamique crustale.*

Les objectifs principaux de ce programme concernent l'analyse des variations majeures de la biodiversité et de la biogéographie le long de la marge continentale nord gondwane durant le Paléozoïque moyen

L'apparition de critères globalement acceptés pour la définition des séries et des limites d'étages depuis le Silurien jusqu'au Carbonifère basal suggère que le moment était propice pour un exercice à grande échelle de re-corrélations des séquences stratigraphiques au travers des régions du Nord Gondwana. Il est escompté qu'un tel exercice puisse fournir des données suffisamment rigoureuses pour étudier non seulement les modèles transgression-régression (initiatives courantes des sous-commissions stratigraphiques du Silurien et du Dévonien), mais aussi les modèles relatifs aux événements biologiques et à la biogéographie. Un objectif fondamental du PICG 421 est donc de tester jusqu'à quel point les données biogéographiques peuvent éclairer les dispositions et les mouvements des différents blocs/terranes crustaux du Nord Gondwana.

La proportion de taxa problématiques (ou simplement sans valeur) dans la plupart des groupes fossiles est devenue si excessive qu'elle menace le progrès. Ces imperfections ont eu un impact évident sur les synthèses globales de tectonique. Il apparaît clairement qu'une information précise sur les modèles biogéographiques et sur la façon dont ils ont évolué au cours du temps peut contribuer de façon significative à une meilleure compréhension de ce qui a pu réellement arriver. Le point de départ nécessaire pour cela consiste en une base de données taxinomique précise, en un exercice sur un large Nord Gondwana qui évaluera la qualité des travaux antérieurs (spécialement pour une analyse informatique significative) et pour que cette évaluation soit entreprise avec le meilleur organigramme possible.

Pour que les bases de données taxinomiquement compatibles (phylum à phylum) soient disponibles pour les analyses biogéographiques, il est essentiel que l'évaluation soit faite des statuts génériques et spécifiques de tous les taxons du Silurien au Carbonifère inférieur, pour chacun des nombreux blocs/terranes crustaux attribués de façon certaine à la première marge continentale nord gondwane, ainsi que des blocs crustaux qui, logiquement, ont pu être situés près de la marge gondwane durant la tranche de temps du Paléozoïque moyen considérée - depuis l'Australie et la Nouvelle-Zélande, à travers l'Asie du Sud, l'Europe méridionale et l'Afrique du Nord, jusqu'aux Amériques (Amérique centrale et partie septentrionale de l'Amérique du Sud).

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Papers of this issue are some contributions to the International Geological Correlation Programme (IGCP 421) titled " North Gondwanan Mid- Palaeozoic Bioevent -Biogeography Patterns in relation to crustal dynamics ".

(*)Responsables (Leaders) : Raimund FEIST, Institut des Sciences de l'Evolution. Université de Montpellier. France ; John A. TALENT, Centre for Ecostratigraphy and Palaeobiology, School of Earth Sciences. Macquarie University. NSW. Australia.

Emergence of globally accepted criteria for defining series and stage boundaries within the Silurian to Early Carboniferous suggested that the time was ripe for a broad-scale exercise in re-correlation of the stratigraphic sequences throughout the North Gondwana regions. It was anticipated that such an exercise might provide a sufficiently rigorous basis from which to investigate not only transgression-regression patterns (current initiatives of the Subcommissions on Silurian and Devonian Stratigraphy), but bioevent and biogeographic patterns as well. A fundamental aim of IGCP 421 is to test to what extend biogeographic data may illuminate the dispositions and motions of the various North Gondwana crustal blocks/terranes.

The proportion of problematic (and even worthless taxa) in most fossil groups has become so excessive as to threaten progress. These shortcomings have had an obvious impact on global syntheses of tectonics. It became clear that precise information on biogeographic patterns and how these may have changed through time might contribute significantly towards better understanding of what may in fact have occurred. The necessary starting point for this is an accurate taxonomic database, a North Gondwana-wide exercise in evaluating the quality of previous work (specifically for meaningful computer analysis), and for this evaluation to be undertaken with the best possible time-frame at hand.

In order that a taxonomically consistent database (phylum to phylum) becomes available for biogeographic analysis, it is essential that evaluation be made of the generic and specific status of all Silurian to Early Carboniferous taxa for each of the many crustal blocks confidently ascribed to the former North Gondwana continental margin, as well as for crustal blocks which conceivably may have been located close to the Gondwana margin during the mid-Palaeozoic time-slice under consideration - from Australia and New Zealand across southern Asia, southern Europe and North Africa to the Americas (central America and northern South America).

Denise BRICE

Professeur émérite.

Ann. Soc. Géol. du Nord.
T. 7 (2ème série), p. 5-12, Septembre 1999.

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MIDDLE (?) SILURIAN RHYNCHONELLID AND SPIRIFERID BRACHIOPOD FAUNAS FROM EASTERN CENTRAL IRAN

Brachiopodes rhynchonellides et spiriferides du Silurien (moyen ?) de l'Iran central oriental

by Denise BRICE (*)

(Plate I)

Abstract. — Brachiopod faunas collected in 1973 by A.F. de Lapparent from Khanuk in Kerman Province, east-central Iran, include the rhynchonellids *Stegocornu* aff. *procerum* DÜRKOOP, 1970 (*S. procerum* was described from the upper Llandovery of central Afghanistan) and *Rhynchotrema* cf. *fringilla* (BILLINGS, 1862) (*Rhynchotrema fringilla* was first described from the Lower Silurian Merrimack Formation of Anticosti Island). In one horizon, I-KH 2, rhynchonellids are associated with spiriferids — *Nikiforovaena* ? sp. and a coquina of *Howellella* aff. *sarytchumyshensis* ZINCHENKO, 1960. In another horizon, I-KH 3, rhynchonellids and *Nikiforovaena* ? sp. are associated with the spiriferids *Hedeinopsis* sp. 1 and *Hedeinopsis* sp. 2. The taxa are described and their affinities are probed. Unpublished comments by the late Jean LAFUSTE on tabulate corals from Khanuk are appended.

Résumé. — *La présente étude est basée sur des brachiopodes, récoltés en 1973 par A.F. de Lapparent, à Khanuk dans la Province de Kerman, en Iran central oriental. Les rhynchonelles appartiennent à* Stegocornu *aff.* procerum *DÜRKOOP, 1970, espèce découverte dans le Llandovery supérieur en Afghanistan central et* Rhynchotrema *cf.* fringilla *(BILLINGS, 1862) connu dans le Silurien inférieur (Formation Merrimack) de l'île Anticosti au Canada. Dans un premier niveau, I-KH 2, ces rhynchonelles sont associées à un spiriferide assigné à* Nikiforovaena *? sp. et à une lumachelle de spirifers appartenant à* Howellella *aff.* sarytchumyshensis *ZINCHENKO, 1960. Dans un second niveau, I-KH 3, les rhynchonellides et* Nikiforovaena *? sp. sont associés à des spiriferidés rattachés à* Hedeinopsis *sp. 1,* Hedeinopsis *sp. 2. Un texte de Jean Lafuste + (inédit) concernant des coraux tabulés de Khanuk est joint en annexe.*

I. — INTRODUCTION

1) Silurian sequences in Iran

Epeirogenic movements induced regressions over large parts of Iran from Middle Ordovician and Early Silurian time (Alavi-Naini, 1972 ; Wensink, 1991). It is not surprising therefore that Silurian sequences are rather thin in central and southeastern Iran (fig. 1).

A Silurian sequence in the Masuleh area of the northwestern Alborz Mountains was dated Late "Valentian"-early Wenlock by conodonts (Davies *et al.*, 1972). Soon after its discovery a sequence at Robat-e-Gharabil in the eastern Alborz was dated by brachiopods and tabulate corals as Llandovery to Wenlock (Brice *et al.*, 1974) or probably Wenlock (Cocks, 1979).

A sequence found in Ozbak-Kuh Mountains of eastern Iran by Ruttner (1968a) was referred to as the "Lower Series" and dated Silurian by corals (Flügel, 1962). It was subsequently described from the Shirgesht area in the southern part of the Derenjal Mountains, named the Niur Formation, and dated as Middle and Late Silurian by conodonts (Walliser in Ruttner *et al.*, 1968b), brachiopods (Stepanov in Ruttner *et al.* op. cit.) and corals (Flügel in Ruttner *et al.* op. cit.).

The Shabdjereh Formation of Kerman region of southeastern Iran (Hamedi, 1995) appears to equate with the Niur Formation of the Tabas region. Near Kerman, this formation has produced conodonts ranging in age (Aldrige in Hamedi *et al.*, 1997) from "probable Llandovery" to Pridoli as well as faunas considered to be Late Silurian by Hamedi (in Hamedi *et al.*, 1997) ; some macrofossils were considered by Golshani (pers. comm. in Hamedi *et al.*, 1997) to be Wenlock.

A sequence producing Silurian rhynchonellid brachiopods and tabulate corals has been reported from the Djam area of the north-central Iran (Alavi-Naini, 1972). An unfossiliferous sequence north of Esfahan has been attributed (Zahedi, 1971) to the Niur Formation. The same formation has been reported from the Anarak and Khur areas, dated by brachiopods in the case of the former, and by tabulate corals in the case of the latter (Sharkovski *et al.*, 1984 ; Aistov *et al.*, 1984).

A shale sequence in the Zagros Mountains of southwestern Iran has produced Early Silurian graptolites (Harrison, 1930).

In southwestern Iran, in Zagros Mountains, series of shales yielded graptolites Early Silurian in age (Harrison, 1930).

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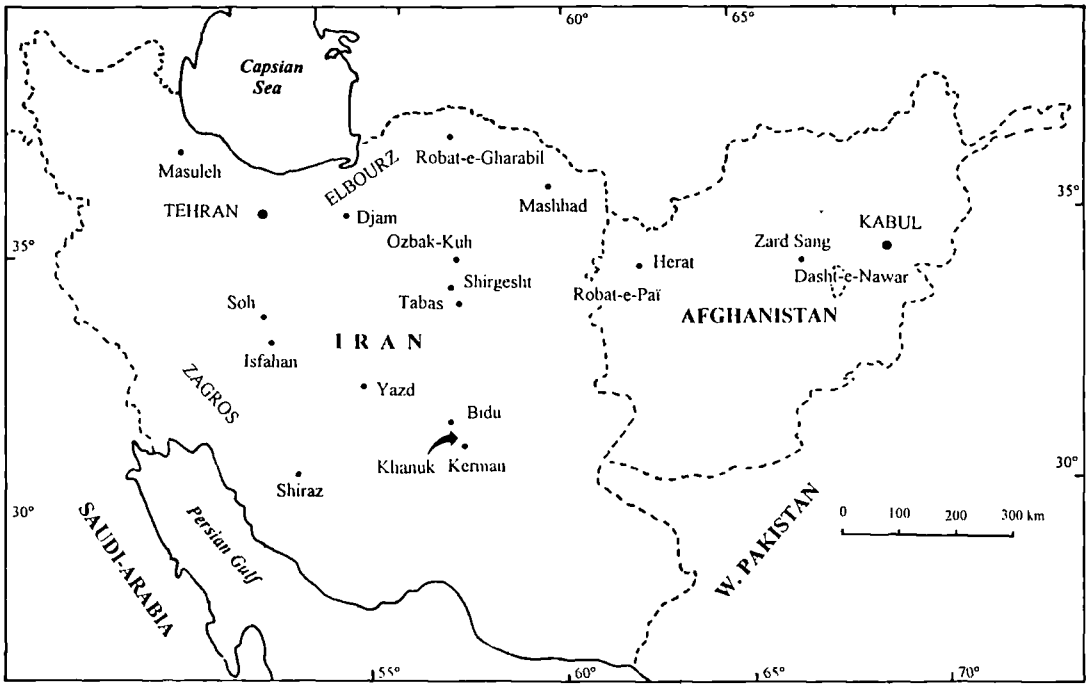

Fig. 1. Map of Iran and Afghanistan with the locations mentioned in text.

Fig. 1. Carte de l'Iran et de l'Afghanistan avec les localités citées dans le texte.

2) Discovery of Silurian dated by brachiopods in Khanuk eastern Central Iran

Brachiopods described here from Kerman Province, east-central Iran, were collected by A.F. de Lapparent in November 1973 in the neighbourhood of Khanuk (N 30°40'30 ; E 46°30'), about 50 km northwest of Kerman (a small outcrop according to Ph. Janvier who has visited the locality). The collection are stored in the Faculté Libre des Sciences in Lille (Catalogue number GFCL). M. de Lapparent died before the collections were studied. We have no stratigraphic information on the locality, knowing only that the faunas were obtained from two levels (I-KH 2 and I-KH 3).

Levels	I-KH 2	I-KH 3
BRACHIOPODS		
Rhynchotrema fringilla (BILLINGS)	cf.	cf.
Stegocornu procerum DURKOOP	aff.	aff.
Nikiforovaena sp.	?	?
Howellella sarytchumyshensis ZINCHENKO	aff.	
Hedeinopsis sp. 2		x
Hedeinopsis sp. 1		x

Tabl. I. Rhynchonellid and spiriferid brachiopods identified in Khanuk levels.

Table I. Brachiopodes Rhynchonellides et spiriferides identifiés dans les niveaux de Khanuk.

II. — NEW PALEONTOLOGICAL DATA

Range and distribution of taxa (Tabl. I).

The type locality and type stratum of *Rhynchotrema fringilla* (BILLINGS, 1862) are Anticosti Island (Canada), Anticosti Group, Middle Silurian ; the species occurs in abundance in the upper Merrimack Formation. The genus is particularly common in North America. According to Jin (1989, p. 44), its presence in the Urals and China is questionable.

The type locality and type stratum of *Stegocornu procerum* DÜRKOOP, 1970, are in central Afghanistan in a sequence dated as upper Llandovery. In the eastern Alborz, *Stegocornu* aff. *procerum* occurs at Robat-e-Gharabil in faunas of "probably" Wenlock age (Brice *et al.*, 1974) or upper Llandovery to Wenlock (Cocks, 1979). The type locality and type stratum of *Howellella sarytchumyshensis* ZINCHENKO, 1960, is in the Salaïr of southwestern Siberia and is upper Llandovery. The genus was cosmopolitan during the Silurian. *Hedeinopsis* GOURVENNEC, 1990, is known from Wenlock to lower Ludlow in Spain (Palencia), Algeria (Tindouf Basin) and in Pre-saharan Morocco. *Nikiforovaena* BOUCOT, 1963, is known in Asia, Australia and Bohemia from "probably" Wenlock to Ludlow horizons. From these data, Middle Silurian (Wenlock ?) age is proposed for faunas from Khanuk.

From the above data, a Middle Silurian (Wenlock ?) age is suggested for the faunas from Khanuk.

III. — SYSTEMATICS

Order *RHYNCHONELLIDA* Kuhn, 1949

Superfamily *RHYNCHOTREMATOIDEA* Schuchert, 1913

Family *RHYNCHOTREMATIDAE* Schuchert, 1913

Subfamily *RHYNCHOTREMATINAE* Schuchert, 1913

Genus *RHYNCHOTREMA* HALL, 1860

Type species : *Atrypa increbescens* HALL, 1847

Rhynchotrema cf. *fringilla* (BILLINGS, 1862)

(Pl. I, fig. 8-13)

Material : A.F. de Lapparent collection, 10 specimens, 2 fragments and 3 isolated valves from Khanuk levels I-KH 2, I KH 3.

Description

Shell large for the genus, dorsi-biconvex, transversely elliptical in outline. Anterior commissure denticulate and uniplicate.

Measurements (mm) : Two specimens have length 13.7 and 15, width 16.7 and 18.5, thickness 11.3 and 12.5.

Ventral valve moderately convex, beak incurved above dorsal apex ; sulcus deep and wide, beginning anteriorly to umbo, with 2 or 3 angular and irregular costae, less high than lateral ones, sometimes increasing up to 4 near anterior margin by intercalation ; tongue occasionally high ; growth lines distinct near the anterior margin on flanks of sulcus ; costae numbering 7 on each flank, strong, angular, generally simple, but one of them may occasionally bifurcate anteriorly near the sulcus.

Dorsal valve strongly convex ; fold low, originating forward of umbo, marked by 3-4 angular costae increasing sometimes by intercalation near anterior margin ; costae numbering 6 on each side, generally simple.

Interior (Text-fig. 2 A-B) with dental plates fused posteriorly to shell walls then free ; deltidial plates present, but disjunct duplex condition noticed by Jin (1989) not clear discernible ; septalium moderately deep ; cardinal process septiform, dorsal median septum present ; muscle fields and crura not observed.

Discussion

Form, ornament, sulcus and fold beginning forward umbo and internal structures are those of *Rhynchotrema.* The specimens may belong to a new species, but the material is insufficient and too poorly preserved to define a new taxon. The Iranian form recalls *Rhynchotrema fringilla* (BILLINGS, 1862) from the upper Merrimack Formation (middle Silurian) of Anticosti Island, Canada (Jin, 1989), particularly in its external morphology : large size, median costae increasing occasionally near anterior margin by intercalation and wide and deep ventral sulcus. The Khanuk specimens are nevertheless smaller and their lateral costae less numerous than in the type specimens of *R. fringilla* from Anticosti Island.

This form resembles some rhynchonellids from Robat-e-Gharabil (levels 4,5 *in* Brice *et al.*, 1974) ; they appear to belong to the same genus but to another species because of their less numerous, stronger costae devoid of intercalation or bifurcation.

Genus *STEGOCORNU* DÜRKOOP, 1970

Type species : *Stegocornu procerum* DÜRKOOP, 1970

Stegocornu aff. *procerum* DÜRKOOP, 1970

(Pl. I, fig. 1-6)

aff. 1970 - *Stegocornu procerum* n. sp. ; Dürkoop, p. 186-188, text-fig. 48.1, pl. 18, figs 1-6 ;

1974 - *Platystrophia* sp. ; Brice *in* Brice *et al.*, p. 183, pl. 21, fig. 13 ;

p.p. 1979 - *Xerxespirifer iranicus* sp. nov.; Cocks, fig. 35-39 (not 34 = *Nikiforovaena* ? sp.).

Material : A.F. de Lapparent collection, Khanuk (Kerman Province) : 35 specimens, 23 isolated valves (level I-KH 2, 28 specimens, 10 ventral valves, 13 dorsal valves ; level 3, 7 specimens, 1 dorsal valve). Robat-e-Gharabil (Alborz Mountains), A.F. de Lapparent collection : 14 specimens and about 14 valves (level 4, 10 specimens ; level 5 : 3 specimens, 7 ventral valves, 7 dorsal valves ; level 6, 1 specimen.

Description

Shell medium-sized, biconvex, wider than long, widest in posterior part ; hingeline long equal or almost equal to maximum width ; valves plicate with costae rounded in cross-section ; margins sharp and denticulate ; anterior commissure uniplicate ; sulcus and fold strongly developed anteriorly.

Ventral beak incurved above dorsal beak ; interarea apsacline ; delthyrium small, open ; sulcus large and deep anteriorly, originating at the apex with one median rib lower than lateral costae ; parietal costae lacking ; tongue trapezoidal.

Dorsal valve with well-defined fold divided by a deep median groove originating at the apex ; costae numbering 4 to 7 on each flank, increasing anteriorwards, the pair bounding the sulcus higher than other ones ; concentric ornament of numerous growth lines beconning very distinct in anterior region.

Interior (Text-fig. 2C) showing strong thickening of shell reducing apical cavities ; dental plates lacking ; teeth large subquadrate in section ; ventral septum lacking ; cardinal plates very developed ; cardinal process small septiform, always lower than internal borders of sockets — which are very high ; crural bases small embedded in posterior callus — as is most of the dorsal septum.

Discussion

The specimens from Khanuk belong to *Stegocornu.* The length/width ratio is similar to that of the type material of *S. procerum* DÜRKOOP, 1970, but the number of lateral costae often reaches 7 and moreover, the hingeline in the Iranian specimens is longer than in the Afghan ones. Specimens from Robat-e-Gharabil have fewer lateral costae (generally 3-4) and the ventral median costa is also wider. Some specimens of *Xerxespirifer iranicus* figured by Cocks (1979, fig. 35-39 not 34) may belong to *Stegocornu* aff. *procerum.* CARTER *et al.* (1994, p.371) rejected *Xerxespirifer* COCKS,1979, from the spiriferidines suggesting it is a rhynchonellid or leptocoeliid.

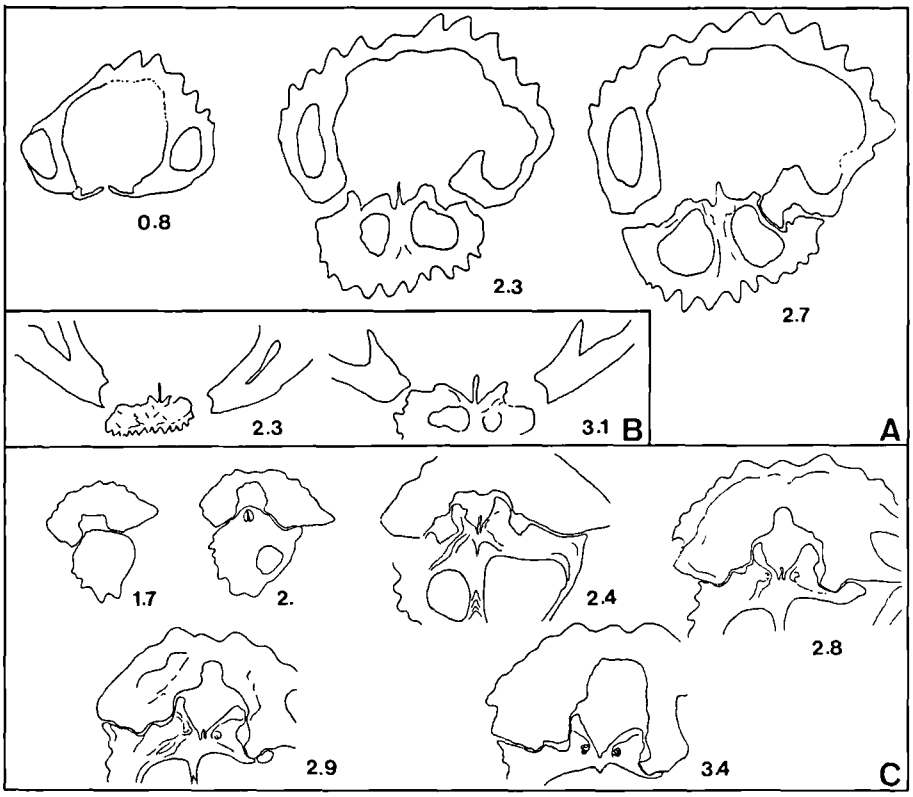

Fig. 2. — Serial transverse sections. Distance in mm from the ventral umbo is given for each figure. Specimens from Khanuk, Kerman Province, eastern Central Iran. A. F. de Lapparent Collections .
A - B : *Rhynchotrema* cf. *fringilla* (BILLINGS, 1862).
A - GFCL 3890 5 : 0,8 mm ; 11 : 2,3 mm ; 13 : 2, 7 mm Gr. = 8,5.
B - GFCL 3891 6 : 2,3 mm ; 11 : 3,1 mm Gr. = 3.
C - *Stegocornu* aff. *procerum* DÜRKOOP, 1970.
GFCL 3874 5 : 1,7 mm; 6 : 2 mm ; 8 : 2,4 mm ; 10 : 2,8 mm ; 11 : 2,9 mm ; 12 : 3,4 mm Gr. = 2,5.

Fig. 2. — Sections sériées transversales. Les distances en mm indiquées pour chaque figure sont mesurées depuis l'umbo ventral. Les spécimens proviennent de Khanuk, Province de Kerman, Iran central oriental. Collection A.F. de Lapparent.
A - B : Rhynchotrema cf. fringilla (BILLINGS, 1862).
A - GFCL 3890 5 : 0.8 mm ; 11 : 2,3 mm ; 13 : 2,7 mm Gr. = 8,5.
B - GFCL 3891 6 : 2.3 mm ; 11 : 3.1 mm Gr. = 3.
C - Stegocornu aff. procerum DÜRKOOP, 1970.
GFCL 3874 5 : 1,7 mm ; 6 : 2 mm ; 8 : 2,4 mm ; 10 : 2,8 mm ; 11 : 2,9 mm ; 12 : 3,4 mm Gr. = 2.5.

Order *SPIRIFERIDA* Waagen, 1883

Suborder *DELTHYRIDINA* Ivanova, 1972

Superfamily *DELTHYRIDOIDEA* Phillips, 1841

Family *DELTHYRIDIDAE* Phillips, 1841

Subfamily *HOWELLELLINAE* Johnson and Hou 1994

Genus *HOWELLELLA* KOZLOWSKI, 1946

Type species : *Delthyris elegans* MUIR-WOOD, 1925

Howellella aff. *sarytchumyshensis* ZINCHENKO, 1960

(Pl. I, fig. 1-6)

aff. 1960 - *Howellella sarytchumyshensis* sp. nov. ; Zinchenko *in* Zinchenko & Kulkov, p. 107, S-29, fig. 3.

Material : A.F. de Lapparent collection, Khanuk : 24 specimens and numerous isolated ventral valves, level I-KH 2.

Description

Shell medium to large-sized for the genus, transversely subpentagonal in outline, moderately ventri-biconvex, equithyrid or slightly brachythyrid ; maximum width of the shell corresponding to hingeline or located posteriorly to mid-lenght ; anterior commissure uniplicate.

Ventral valve with U-shaped sulcus (with flat bottom), originating at the beak, smooth, flanked by 4-6 rounded lateral plications separated by U-shaped interspaces ; beak recurved ; interarea slightly concave and apsacline ; delthyrium open.

Dorsal valve semi-circular in outline, gently convex in lateral profile ; fold beginning at the apex, flat-topped with occasionally a shallow median depression, flanked by 3-4 rounded plications.

Entire surface covered by concentric growth lamellae crossed by seemingly continuous fine radial striae.

GFCL	3876	3877	3878	3879	3880	3886	3888	3889
L	12.7	11.9	11.9	12.6	14	13	11.6	12
W	17	14.8	17	14.2	17.4 ?	15	13.1	15.2
Th	10.8	8.8	10	9.2	12.1	9.5	8.3	10
L/W	0.74	0.80	0.7	0.88	0.80 ?	0.86	0.88	0.78
Th/L	0.85	0.73	0.84	0.73	0.86	0.73	0.71	0.83
Th/I	0.63	0.54	0.58	0.64	0.69 ?	0.63	0.63	0.65

Table. II. — Measurements (in mm) ; Abbreviations : L = Length ; W = width ; Th = thickness.

Tabl. II. — Mesures (en mm).Abbréviations : L = longueur ; W = largeur ; Th = épaisseur.

Interior (Text-fig. 3 A-B) in ventral valve, dental plates long, extrasinal, divergent in their posterior part, almost parallel anteriorly ; cardinal process striated, crural plates present in dorsal valve.

Discussion

This species is very close to *H. sarytchumyshensis* from the upper Llandovery of the Salaïr southwestern Siberia (Kulkov in Iwanowski & Kulkov, 1974) ; the size and number of lateral costae are a little more prominent and dental plate longer in the Iranian species.

In the reference section of the Niur Formation in Shirgesht area, near Tabas in eastern Iran, Stepanov (in Ruttner *et al.*, 1968b, p. 44-45) identified *H.* ex gr. *vanuxemi, H. angustiplicata* and *H.* ex. gr. *crispa* (Hisinger) = *H. elegans*. Some specimens collected by A.F. de Lapparent from the same section all belong to *Howellella* and probably to a single species ; the differences are in size. A ventral valve collected by A.F. de Lapparent at Robat-e-Gharabil (level 4, Brice *et al.*, 1974) belongs to the same species as the material from Khanuk.

Suborder *SPIRIFERIDINA* Waagen, 1883

Superfamily *CYRTIOIDEA* Frederiks, 1924

Family *HEDEINOPSIDAE* Gourvennec, 1990

Subfamily *HEDEINOPSINAE* Gourvennec, 1990

Genus *HEDEINOPSIS* GOURVENNEC, 1990

Type-species : *Hedeinopsis hispanica* GOURVENNEC, 1990

Hedeinopsis sp. 1

(Pl. 1, fig. 14-21)

Material : A.F. de Lapparent collection. Khanuk, level I-KH 3 : 10 specimens and 4 incomplete shells.

Description

Small, transverse and megathyrid spiriferidines (width : 13 to 15 mm ; length : 6.6 to 8.2 mm), biconvex, with maximum thickness in the posterior part ; sulcus and fold smooth, well developed, flanked by 3-4 costae on ventral valve, 2-3 on dorsal valve ; ornament fine, consisting of radiating fila, without spines, crossed by few concentric growth lamellae ; anterior commissure uniplicate.

Ventral beak recurved ; interarea low, apsacline, delineated by a pair of angular ridges ; deltidial or stegidial plates not observed, sinus originating at the beak, well defined by a pair of strong costae, with V-shaped cross section.

Interior (Text-fig. 3 C) ventral valve with extrasinal dental plates; delthyrial plate not observed. Cardinal process striated with few poorly preserved lamellae ; crural plates subparallel in dorsal valve.

Discussion

This species is referred to *Hedeinopspis* because of its megathyrid form, macro- and micro-ornament, and internal characters — striate cardinal process and subparallel crural plates. It recalls the type species *Hedeinopsis hispanica hispanica* but is a little smaller and has fewer lateral costae.

Hedeinopsis sp. 2

(Pl. I, fig. 22-26)

Material : A.F. de Lapparent collection. Khanuk, level I-KH 3 : 2 specimens and 14 incomplete isolated valves (11 ventral valves, 3 dorsal valves).

Description

Shell large, biconvex, megathyrid, transverse (40-50 mm), with 3-4 pairs sometimes 5 (outer ones very weak) of strong rounded costae on each flank separated by rounded interspaces as wide as costae ; surface near cardinal extremities smooth ; fold and sulcus non-costate ; maximum width at hingeline ; ornament consisting of radiating fila (not well preserved) crossed by numerous concentric growth lamellae.

Ventral valve convex with maximum convexity at the umbo ; beak weakly recurved ; interarea apsacline, slightly concave, well defined by one pair of angular ridges ; pseudodeltidium present, sulcus concave, equal to about the width of two lateral costae, limited by one pair of strong costae.

Dorsal valve with fold slightly higher and wider than two adjacent costae, rounded or sub-rectangular in cross-section.

Interior of ventral valve with short obsolete, extrasinal dental plates ; muscle field well defined anteriorly, deeply impressed, extending anteriorly towards the mid length.

Dorsal interior not observed.

Discussion

This species recalls *Hedeina* by its size and macro-ornament but is assigned to *Hedeinopsis* because of its very transverse and megathyrid outline, its delthyrium covered by a pseudodeltidium, strongly excavated ventral muscle field, and its interarea being well limited by a pair of angular ridges.

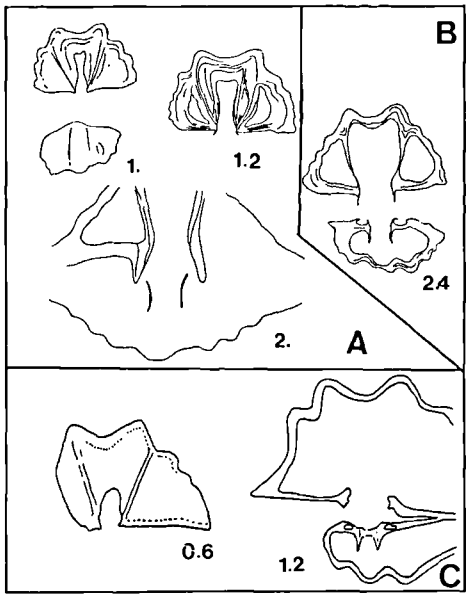

Fig. 3. — Serial transverse sections. Distance in mm from the ventral umbo is given for each figure. Specimens from Khanuk, collections A. F. de Lapparent.
A - B : *Howellella* aff *sarytchumyshensis* ZINCHENKO, 1960.
A - GFCL 3881 4 : 1 mm; 5 : ventral valve : 1,2 mm ; 9 : 2 mm Gr. = 4,5.
B - GFCL 3882 7 : 2,4 mm Gr. = 4,5.
C - *Hedeinopsis* sp. 1.
GFCL 3892 2 : 0,6 mm ; 7 : 1,2 mm Gr. = 5.

Fig. 3. — Sections sériées transversales. Les distances en mm indiquées pour chaque figure sont mesurées depuis l'umbo ventral. Les spécimens proviennent de Khanuk. Collection A.F. de Lapparent.
A - B : Howellella aff sarytchumyshensis ZINCHENKO, 1960.
A - GFCL 3881 4 : 1 mm ; 5 : valve ventrale : 1,2 mm ; 9 : 2 mm grossissement x 4,5.
B - GFCL 3882 7 : 2,4 mm grossissement x 4,5.
C - Hedeinopsis sp. 1.
GFCL 3892 2 : 0,6 mm ; 7 : 1,2 mm grossissement x 5.

Genus *NIKIFOROVAENA* BOUCOT, 1963

Type species : *Spirifer (Eospirifer) ferganensis* NIKIFOROVA, 1937

Nikiforovaena ? sp.

(Pl. I, fig. 27-32)

Material : A.F. de Lapparent collection. Khanuk levels I-KH 2, I-KH 3 : 2 conjoined specimens, 17 isolated valves (7 ventral, 10 dorsal).

Discussion

These specimens are similar in size and macro-ornament to *Hedeinopsis* sp. 2. They are attributed to *Nikiforovaena* because their sulcus and fold bear a faint plication into the former and a corresponding groove on the latter. The fine ornament consists of radial striae (poorly preserved) crossed by fine concentric growth lines resulting in a reticulate appearance. *N. carasia* HAVLICEK, 1980, is similar in outline and size, but has a wider median costa in the sulcus and some bifid lateral costae. *N. khalfini* (KULKOV, 1960 *in* Gratsianova 1967) and *N. unicostata* (KULKOV, 1956 *in* Gratsianova 1967) from the Lower Devonian of the Altaï differ in their smaller size. A media costa, moreover, is seemingly lacking in the ventral sulcus of the former.

Generic determination of Iranian species is however questionable because of poor preservation of micro-ornament and incomplete knowledge of internal features.

AKNOWLEDGEMENTS. — We thank Dr. Rémy Gourvennec for comments on the generic affinity of some spiriferids and critical reading of the manuscript. We are very grateful to Prof. John Talent for polishing the English. This is a contribution to IGCP 421 *North Gondwana biogeography\bioevent patterns in relation to crustal dynamics.*

APPENDIX

Written communication (1972) from the late Jean Lafuste

Lafuste underlines the bad preservation of tabulate corals from Khanuk. He wrote : "Voici ce qui résulte de l'examen de ceux-ci :

A) une colonie rameuse (diamètre 15 à 17 mm), avec calices subperpendiculaires à la surface générale. (une lame longitudinale, une lame transversale). Appartient au genre *Parastriatopora* (Llandovery au Dévonien inférieur). Je ne trouve pas d'affinités spécifiques satisfaisantes avec les documents que j'ai consultés. Par l'irrégularité de ses caractères morphologiques, cette forme me semble devoir être rapprochées des espèces siluriennes plutôt que des formes dévoniennes.

B) Deux colonies rameuses (diamètre 7 à 12 mm), avec des calices qui débouchent obliquement (une lame longitudinale, une lame transversale, une lame oblique; une lame longitudinale, quatre lames transversales). Ces deux échantillons appartiennent au genre *Striatopora* sensu stricto, réparti du Silurien moyen au Dévonien inférieur.

Je pense que l'espèce de Khanuk présente des analogies avec *"Parastriatopora"* (?) *pseudocoreanica* DUBATOLOV 1962, du Dévonien basal de l'Altaï, qui est une espèce très proche de *Favosites coreanica* (OZAKI, 1934), du Silurien supérieur de Corée. Elle peut aussi être rapprochée d'un *Striatopora* possédant une structure interne quelque peu irrégulière, du Wenlock de Sibérie, *S. tungusica* SOKOLOV 1955.

En conclusion, avec toutes les réserves que nécessitent l'examen d'un nombre peu élevé d'échantillons, qui appartiennent malheureusement à deux genres d'assez grande extension stratigraphique, je pense que l'on peut considérer que le gisement de Khanuk se placerait dans le Silurien, moyen ou supérieur".

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PLATE I

Middle (?) Silurian Rhynchonellid and Spiriferid brachiopods from Khanuk, Kerman Province, east-central Iran

Brachiopodes rhynchonellides et spiriferides du Silurien (moyen ?) de Khanuk, Province de Kerman, Iran central oriental

Fig. 1-7. — *Stegocornu* aff. *procerum* DÜRKOOP, 1970 ; 1-5 all Gr. = 1 ; 6 Gr. = 1,8 ; 7 Gr. = 2.

1-6 GFCL 3860 large specimen : 1. Ventral view. 2. Dorsal view. 3. Anterior view. 4. Posterior view. 5. Lateral view. 6. Micro-ornament.

7 GFCL 3861 : Dorsal view of another medium-sized specimen.

1-6 GFCL 3860 grand spécimen : 1. Vue ventrale. 2. Vue dorsale. 3. Vue antérieure. 4. Vue postérieure. 5. Vue latérale. 6. Micro-ornementation.

Fig. 8-13. — *Rhynchotrema* cf. *fringilla* (BILLINGS, 1862) ; 8,10,13 all Gr. = 2 ; 9,11,12 all Gr. = 1.

8-12 GFCL 3862. 8. Posterior view. 9,10. Ventral view showing sinal costae. 11. Lateral view. 12. Dorsal view.

13 GFCL 3863. Another specimen with intercalation of costae in sulcus.

8-12 GFCL 3862. 8. Vue postérieure. 9,10. Vues ventrales montrant une côte médiane dans le sinus.

13 GFCL 3863. Un autre spécimen avec l'intercalation de côtes dans le sinus.

Fig. 14-21. — *Hedeinopsis* sp. 1 ; 14,16-21 all Gr. = 2 ; 15 Gr. = 1.

14-19 GFCL 3864. 14,15. Ventral view. 16. Dorsal view. 17. Anterior view. 18. Posterior view. 19. Lateral view.

20-21 GFCL 3865. 20. Ventral view. 21. Anterior view.

14-19 GFCL 3864. 14,15. Vues ventrales. 16. Vue dorsale. 17. Vue antérieure. 18. Vue postérieure. 19 Vue latérale.

20-21 GFCL 3865. 20. Vue ventrale. 21. Vue antérieure.

Fig. 22-26. — *Hedeinopsis* sp. 2 ; 22-23, 25-26 all Gr. = 1; 24 Gr. = 2.

22-23 GFCL 3866. 22. Ventral valve exterior. 23. The same, interior view showing interarea and deeply impressed muscle field.

24 GFCL 3867. Ventral valve.

25 GFCL 3868. Dorsal view of a bivalved specimen.

26 GFCL 3869. Pseudeltidium and interarea of another specimen.

22-23 GFCL 3866. 22. Vue externe d'une valve ventrale. 23. Iintérieur de la même valve, vue du champ musculaire profondément excavée et vue de l'interarea.

24 GFCL 3867. Valve ventrale.

25 GFCL 3868. Vue dorsale d'un spécimen bivalve.

26 GFCL 3869. Pseudodeltidium et interarea d'un autre spécimen.

Fig. 27-32. — *Nikiforovaena* ? sp. ; 27-32 all Gr. = 1.

27 GFCL 3870, 28 GFCL 3871, 29 GFCL 3872 ventral valves with thin medial costa in the sulcus.

30 GFCL 3873 another ventral valve with a wide medial costa in the sulcus.

31 GFCL 3884, 32 GFCL 3875 dorsal valves with medial groove on the fold.

27 GFCL 3870, 28 GFCL 3871, 29 GFCL 3872. Valves ventrales montrant une faible côte médiane dans le sinus.

30 GFCL 3873. Une autre valve ventrale avec une large côte médiane dans le sinus.

31 GFCL 3884, 32 GFCL 3875. Valves dorsales portant un sillon médian sur le bourrelet.

Fig. 33-42. — *Howellella* aff. *sarytchumyshensis* ZINCHENKO, 1960 ; 33, 35-39, 41-42 all Gr. = 2 ; 34 Gr. = 1 ; 40 Gr. = 4.

33-35 GFCL 3876. 33-34. Dorsal view. 35 Posterior view.

36 GFCL 3877. Dorsal view of another specimen.

37-40 GFCL 3878. Another specimen. 37,40. Ventral view and micro-ornament in the sulcus. 38. Posterior view. 39. Lateral view.

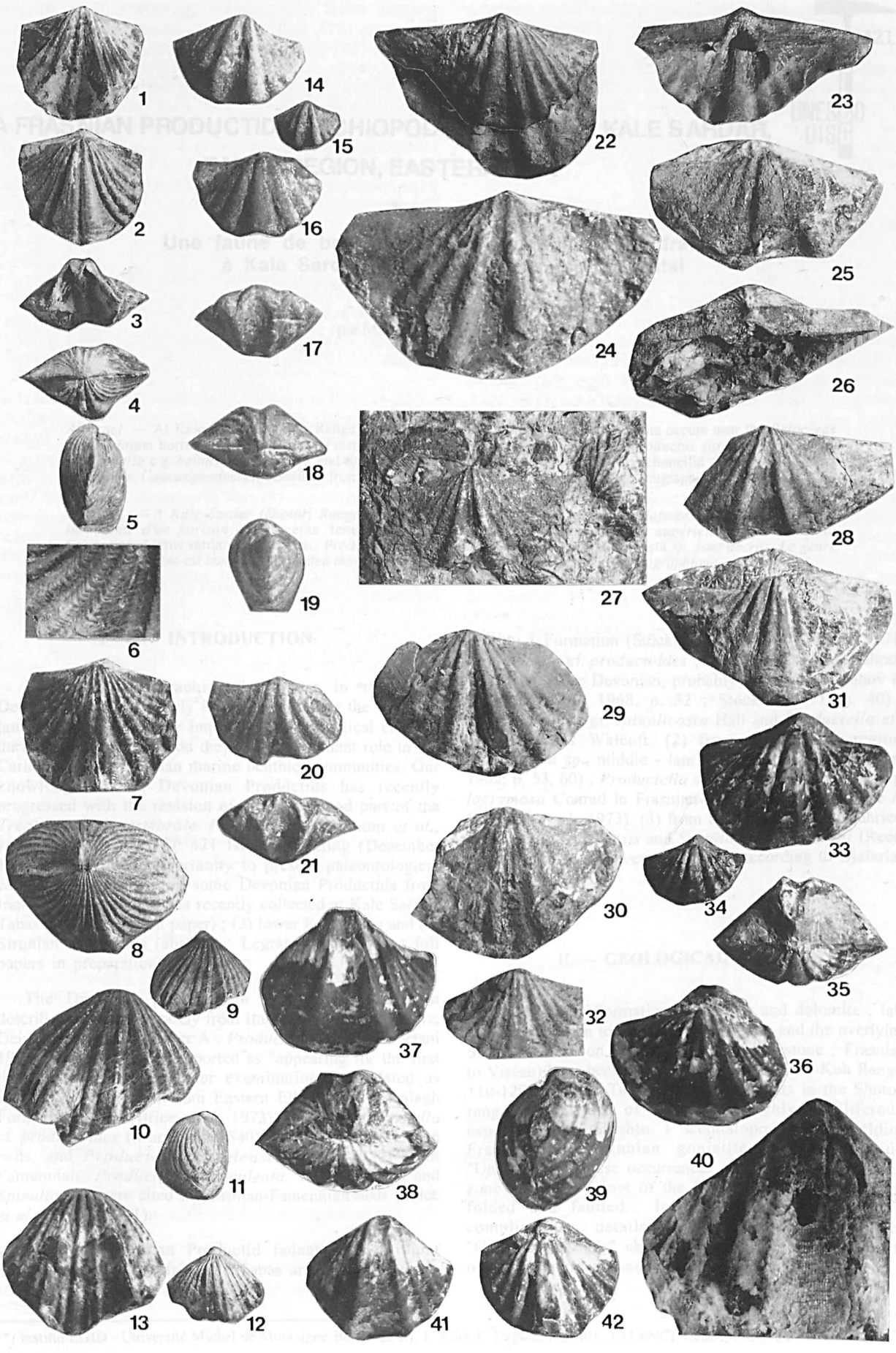
41-42 GFCL 3879. A small specimen. 41. Ventral view. 42. Dorsal view.

33-35 GFCL 3876. 33-34. Vues dorsales. 35. Vue postérieure.

36 GFCL 3877. Vue dorsale d'un autre spécimen.

37-40 GFCL 3878. Un autre spécimen. 37,40. Vue ventrale et micro-ornementation dans le sinus. 38. Vue postérieure. 39. Vue latérale.

41-42 GFCL 3879. Un petit spécimen. 41. Vue ventrale. 42. Vue dorsale.



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A FRASNIAN PRODUCTID BRACHIOPOD FAUNA FROM KALE SARDAR, TABAS REGION, EASTERN IRAN

Une faune de brachiopodes productidés d'âge frasnien à Kale Sardar, région de Tabas, Iran Oriental

par Marie LEGRAND-BLAIN (*)

(Plate II)

Abstract. — At Kale Sardar (Shotori Range, Tabas area, Eastern Iran), a brachiopod fauna occurs near the *Beloceras tenuistriatum* horizon, of middle-upper Frasnian age. It yields the Productids : *Caucasiproductus sardarensis* nov. sp., *Productella* e.g. *belanskii* Stainbrook and *Spinulicosta* sp., in association with the Rhynchonellid *Coeloterorhynchus tabasensis*. *Caucasiproductus*, described from Middle Devonian and Frasnian, has a wide geographical distribution.

Résumé. — *A Kale Sardar (Shotori Range, Iran oriental) un beau gisement à brachiopodes se situe à proximité immédiate d'un horizon à* Beloceras tenuistriatum, *goniatite du Frasnien moyen à supérieur. Les Productida* Caucasiproductus sardarensis *nov. sp.,* Productella *e.g.* belanskii *Stainbrook et* Spinulicosta *sp. sont décrits. Le genre* Caucasiproductus *est connu au Dévonien moyen et Frasnien, avec une large répartition géographique.*

I. — INTRODUCTION

The productid brachiopods appear in the early Devonian, increase slowly in diversity during the middle - late Devonian, and after important morphological changes during the Strunian period they play a dominant role in the Carboniferous - Permian marine benthic communities. Our knowledge of the Devonian Productids has recently progressed with the revision of the brachiopod part of the *Treatise on Invertebrate Paleontology* (Brunton *et al.*, 1995, 1997). The IGCP 421 Isfahan Meeting (December 1998) was a good opportunity to present paleontological contributions concerning some Devonian Productids from Iran : (1) a Frasnian fauna recently collected at Kale Sardar, Tabas area (the present paper) ; (2) lower Famennian and (3) Strunian Productids (abstract : Legrand-Blain 1998 ; full papers in preparation).

The Devonian pre-Strunian Productids have been described and figured rarely from Iran. In the Central Elburz, Geirud Formation member A : *Productella* sp. ind. (Gaetani 1965, p. 698, 706) was reported as "appearing for the first time in the sections under examination" and dated as Famennian. Later on, from Eastern Elburz, Khoshyeilagh Formation, Brice (Brice *et al.*, 1973) figured *Whidbornella* cf. *productoides* (Murchison 1840) from Givetian-Frasnian beds, and *Productella baitalensis* (Reed 1922) from Famennian. *Productella subaculeata, P. baitalensis* and *Spinulicosta* were cited in Frasnian-Famennian beds (Brice *et al.*, 1978, Tab. 1).

Other pre-Strunian Productid faunas cited without descriptions are : (1) from the Tabas area, - Kale Sardar, Shishtu 1 Formation (Stöcklin *et al.*, 1965, Stöcklin 1971) *Strophalosia* cf. *productoides* ; - the Shirgest area, Bahram Formation, Late Devonian, probably Frasnian (Stepanov *in* Ruttner *et al.*, 1968, p. 52 ; Stöcklin 1971, p. 40) : *Spinulicosta* ex gr. *spinulicosta* Hall and *Productella* aff. *hirsutiformis* Walcott. (2) from the Kerman region, *Productella* sp., middle - late Devonian (Huckriede *et al.* 1962, p. 53, 60) ; *Productella* aff. *robertsoni* Reed , *P.* e.g. *lacrymosa* Conrad in Frasnian-Famennian strata (Brice *in* Golshani *et al.*, 1973). (3) from the Isfahan area, Chahrice, *Productella baitalensis* and *Spinulicosta robertsoni* (Reed, 1922) are cited in lower Famennian, according to Djafarian & Brice (1973).

II. — GEOLOGICAL SETTING

The Bahram Formation (limestone and dolomite ; late Middle Devonian to early Late Devonian) and the overlying Shishtu Formation (shale, sandstone, limestone ; Frasnian to Viséan) have been established in the Ozbakh-Kuh Range, 110-120 km N of Tabas. Their equivalents in the Shotori range, E and S-E of Tabas, are highly fossiliferous, especially the Shishtu 1 Cephalopod beds, yielding Frasnian - Famennian goniatites and Clymenids. "Unfortunately these occurrences are situated in the thrust zone at the west-foot of the Shotori range and therefore folded and faulted... In addition to these tectonic complications, details of the sections through the "Cephalopod Beds" change remarkably from outcrop to outcrop in short distances" (Stöcklin *et al.*, 1965).

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At Kale Sardar (fig. 1), 20 km E-NE of Tabas, a number of short sections have yielded collections during the IGCP 421 Tabas excursion (Yazdi & Ghazifard 1998). Conodonts in the Shishtu Formation are of Frasnian age (*jamieae* Zone or older) to latest Tournaisian (Yazdi 1998). One section is of special interest, and yields good Frasnian cephalopods and brachiopods. However, we do not know whether this Frasnian section is overturned or not (Th. Becker, *in litteris* 1999).

Beloceras tenuistriatum (var. nov. ?) enters in the lower half of the *hassi* zone and ranges to the topmost Frasnian. In the brachiopod beds, lying topographically 5-7 m below the *Beloceras* bed, we have collected the Productids *Caucasiproductus sardarensis* nov. sp., *Productella* e.g. *belanskii* Stainbrook and *Spinulicosta* sp. ; the Rhynchonellid *Coeloterorhynchus tabasensis* Sartenaer 1966. *Coeloterorhynchus* is a Frasnian genus known from Afghanistan (zone 7 *in* Brice 1977), Morocco and Western Europe ; at Ferques, it is reported from the Beaulieu Formation : lower - middle *asymmetricus* zone (Brice 1988, table 2 and p. 328).

The brachiopods at Kale Sardar lie either as complete shells free from matrix in weathered shales, or as isolated valves crowded in sandy limestones. Since epibiotic Tabulata and Bryozoa are seen on some Productids on the ventral umbo (Pl. II, fig. 1 and 16), it is likely that the shells were overturned after death.

III. — SYSTEMATIC PALAEONTOLOGY

The specimens have been collected at Kale Sardar by the author (ML 1062...) and by Denise Brice (IKS 1...). The figured specimens (GFCL...) are deposited in the Paleontological Collections : Faculté libre des Sciences, 13 Rue de Toul, F 59046 LILLE France.

Super-family *PRODUCTOIDEA* Gray, 1840

Family *PRODUCTELLIDAE* Schuchert, 1929

Sub-family *PRODUCTELLINAE* Schuchert, 1929

Diagnosis of the Productellinae (Brunton *et al.*, 1995 p. 926)

"Ribs rarely developed and then only anteriorly ; spines evenly distributed over ventral valve only ; corpus cavity shallow ; teeth present ; lateral ridges and ear baffles lacking ; cardinal process lobes divergent, V-shaped dorsally, with pit ; dorsal adductor scars commonly non-dendritic". Later on, the same authors indicate slightly different characters (Brunton & Lazarev 1997, p. 384) : "The Productellinae remained relatively free of surface ornamentation, only gradually increasing their spinosity and, like other productinides, lost their toothed articulation late in the Famennian".

The subfamily appears in the Emsian and ranges during the middle - late Devonian. It includes (Brunton & Lazarev, 1997) (a) three well-known pre-Famennian genera : *Productella* Hall 1867 (type species *Productus subaculeatus* Murchison 1840, Frasnian, N. France), *Chattertonia* Johnson 1976 (type species *Spinulicosta campbelli* Chatterton 1973, Emsian, N.S.W., Australia), *Spinulicosta* Nalivkin 1937 (type species *Productella spinulicosta* Hall 1857, Eifelian, New-York State, USA) ; (b) two poorly know genera : *Sinoproductella* Wang 1955 (type species *Productella hemispherica* Tien 1938, Famennian, Hunan, China - a genus formerly tentatively included in the Leioproductidae characterized by a deep corpus cavity, cf. Lazarev 1990 p. 92, 146) and *Stelckia* Crickmay 1963 (type species *Stelckia galearius* Crickmay 1963, Givetian, Canada).

Genus *PRODUCTELLA* Hall 1867

Diagnosis (Muir-Wood & Cooper 1960, p.146 ; Brousmiche 1973, p.119)

Shell small or medium, subquadrate or hemispherical in outline... Pedicle valve moderately convex ; hinge slightly less than greatest width of shell... Interarea linear.. Pedicle valve ornament of scattered spine bases, spines suberect or recumbent (1) springing from rounded pustules with little definite arrangment, (2) row of suberect spines near hinge margin with spines laterally directed. Concentric growth lines prominent ; rugae rare, near hinge. Presence of dental teeth and sockets... Small bilobate cardinal process ; alveolus separating cardinal process from low medium breviseptum.

Productella e.g. *belanskii* Stainbrook 1943

(Pl. II, fig. 12 to 14 and 16)

Material : 10 specimens from Kale Sardar : ML 1062 b 1-8 and I KS1 b 2-3.

Description

Shell small : length 11-16 mm, width 12-19 mm, depth of corpus cavity 2,5-3,5 mm. Outline rounded, broad ventral umbo, ears not well defined. The lateral and longitudinal profiles are regularly concavo-convex. Ginglymus (= posterior thickening of the ventral valve appearing externally like an interarea) straight, narrow.

Ornamentation : Rare rugae on ears ; no radial costae. Spines on ventral valve only : (1) scattered on the whole surface, springing from radially elongated pustules at very low angles from the shell surface ; when fully preserved (Pl. II, fig. 16 ; notice some spines covered by epizoan Bryozoa) they are recumbent, 3 mm long and 0,3 mm thick. Their density is about 10/25 mm^2 . (2) There is generally a median row of coarser spines, springing from rounded pustules and looking suberect (Pl. II, fig. 12a) ; none of these median spines is fully preserved. (3) On the ears, some coarse spines are directed postero-laterally. On the dorsal valve surface, there are small pits corresponding to the ventral spines (Pl. II, fig. 14b).

Inside the dorsal valve, the cardinal process is bilobed (Pl. II, fig. 13), separated from the base of the septum by a pit (ML 1062 b2) ; the median septum is thin and long (ML 1062 b4).

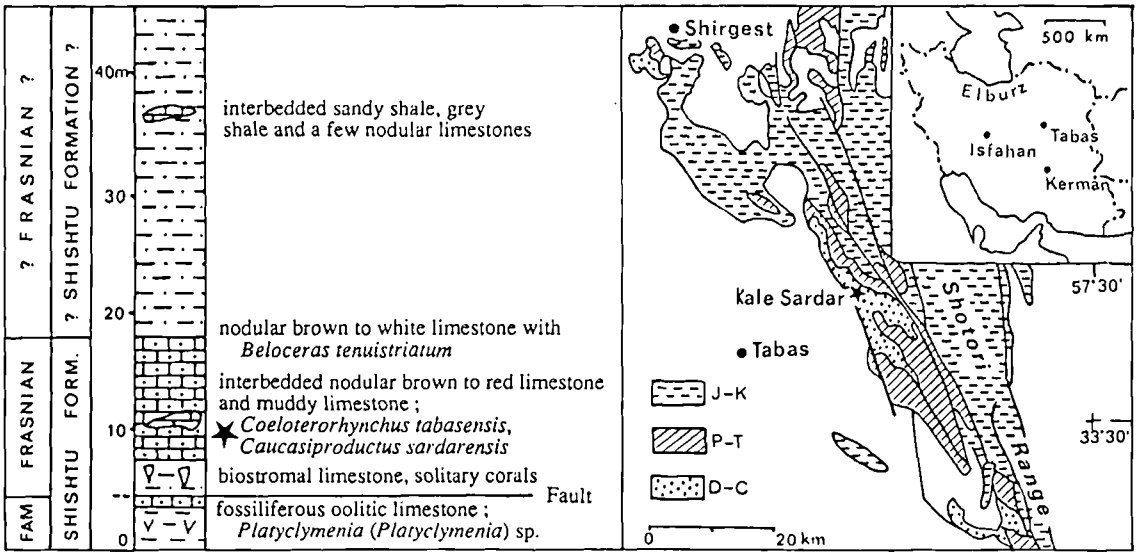

Fig. 1. — Kale Sardar section, after Yazdi & Ghazifard 1998. It is unknown whether the section is overturned or not.

Fig. 1. — Kale Sardar : situation stratigraphique et géographique du gisement étudié, d'après Yazdi & Ghazifard 1998. La succession des couches est soit normale soit renversée : question non élucidée actuellement.

Discussion

The Kale Sardar shells have been compared with many *Productella subaculeata* from the type locality, Ferques (Pas-de-Calais, France). The morphologic variability of *P. subaculeata* (Brousmiche 1973) concerns the shell size and outline, the distribution and diameter of scattered spine bases. On all *P. subaculeata* specimens, the erect or suberect spines are set on rounded tubercles. (Pl. II, fig. 15). The Iranian species has different spines : they are more regularly distributed, springing from elongated pustules, and recumbent, lying at very low angles from the shell surface. Indeed, that character is slightly different from the diagnosis of *Productella* s.s. ; it has been described in species assigned to *Productella* (such as *P. belanskii*), and might consitute the diagnostic character of a separate subgenus, intermediate between *Productella* s.s. and *Spinulicosta*.

P. subaculeata never has the median row of suberect spines observed on the Kale Sardar shells. A median row of coarse erect spines exists on some late Devonian Productoids assigned to various genera, such as *Productella belanskii* Stainbrook, *Nigerinoplica dotswoodae* (Mc Kellar), *Praewaagenoconcha oreliana* (Möller), *Leioproductus plicatus* (Kindle), *Ardiviscus naidovensis* Pushkin etc. According to Mc Kellar (1970, p.14) that median row of erect spines is of specific rather than generic importance : it represents an adaptation for improved anchoring in particularly soft bottom substrata.

P. belanskii is described from the Givetian Cedar Valley Limestone of Iowa (Stainbrook 1943). The American types are larger than the Kale Sardar specimens. *P.* cf. *belanskii* exists in Britain, France, late Givetian (Racheboeuf 1983, p. 152).

Genus *SPINULICOSTA* Nalivkin 1937

Spinulicosta differs from *Productella* in its more regularly arranged spines and elongate spine ridges and development of costae on the anterior part of the shell (Muir-Wood & Cooper 1960, p.154). The range of *Spinulicosta* : Middle and upper Devonian - according to Muir-Wood & Cooper 1960 - has been restricted when Lazarev assigned to *Nigerinoplica* some Famennian species provided with deep corpus cavities. *Spinulicosta* is recorded from late Emsian - Eifelian only by Brunton *et al.* (1995, text-fig. 3). However, the genus is also described from Givetian and Frasnian localities.

Spinulicosta sp.

(Pl. II, fig. 17, 18.)

Material : **2 fragmentary ventral valves : IKS1 b1, ML 1062 b9**

Description

Rather large size, width about 24 mm ; ornamentation of recumbent long spines and anterior incipient radial costae. A median large costa bears a row of coarse suberect spines. The other characters are unknown.

Discussion

The Kale Sardar specimens are too poorly preserved for any specific assignment. A median large costa is described in some Givetian - Frasnian *Spinulicosta* species : *Sp.* aff. *herminae* from the Frasnian of Poland (Balinski 1979, p. 32) ; *Sp. hamata* Mergl from the Givetian-Frasnian Idri Formation, Libya (Mergl & Massa 1992, p. 56).

Super-family *ECHINOCONCHOIDEA* Stehli, 1954

Family *SENTOSIIDAE* Mc Kellar, 1970

Sub-family *CAUCASIPRODUCTINAE* Lazarev, 1987

Diagnosis of the subfamily (Brunton *et al.* 1995, p. 928)

"Sentosiids [shallow corpus cavity ; spines on ventral and dorsal valves, without concentric bands and spine differentiation] with teeth and sockets ; ventral spines relatively thick, suberect ; lateral ridges short, divergent anteriorly".

The subfamily is reported from Eifelian to Famennian (Lazarev 1990, p.109, 148) with three genera : *Caucasiproductus* Lazarev 1987 (type species *C. gretchichnikovae* Lazarev 1987, Givetian, Transcaucasus) ; *Praewaagenoconcha* Sokolskaya 1948 (type species *Productus orelianus* Möller 1871, Famennian, Moscow basin) ; *Strophoproductus* Nalivkin 1937 (type species : *Productella hystricula* Hall 1867, Famennian, New York State).

Genus *CAUCASIPRODUCTUS* Lazarev, 1987

1987 - *Caucasiproductus* Lazarev, gen. nov. : Lazarev, p. 50 (Russian). *Amer. transl.* p. 47.

1990 - *Caucasiproductus* Lazarev 1987 : Lazarev, p.109.

1995 - *Caucasiproductus* : Brunton *et al.*, text-fig. 3-14, 4 H-I.

Diagnosis (Lazarev, 1987)

Shell concavo-convex with moderately low internal cavity ; interarea marginal or absent, no cicatrix of attachment. Both valves covered with a dense network of spines. Within pedicle valve are hinge teeth, lateral ridges, and at tip a conspicuous median "septum" that becomes lower and wider forward ; pear-shaped muscle scars. Within brachial valve, a bilobed V-shaped cardinal process ; dental sockets ; median septum extending for approximately half length of visceral disc ; long lateral ridges diverging from the cardinal margin and fringing postero-laterally the visceral disc.

Caucasiproductus sardarensis nov. sp.

(Pl. II, fig. 1 to 11)

Etymology. The species is named after Kale Sardar, the type locality.

Type locality and horizon. Kale Sardar, Shotori range (Tabas area, eastern Iran). Shishtu Formation, "Shishtu 1, Cephalopod beds". The type horizon is a brachiopod coquina located topographically 5-7 m under a *Beloceras tenuistriatum* bed. Frasnian.

Holotype. Specimen ML 1062 a1 = GFCL 3797 (Pl. II, fig.1 a-d), a shell with spines preserved on both valves.

Material. From the type locality, 44 specimens : ML 1062 a 1-32, IKS1 a 1-12.

Diagnosis

Moderately concavo-convex shell, length usually 13-20 mm, width 15-24 mm, depth of corpus cavity 3-4 mm ; cardinal angles rectangular or slightly rounded ; marginal areas linear ; both valves covered by crowded long spines (> 30/25 mm^2) and sinuous rugae. Short ventral "septum" ; bilobed cardinal process, rounded lateral ridges.

Description

The shell size is relatively small : length usually 13-20 mm, width 15-22 mm ; the largest specimen (ML 1062 a 25, an exfoliated ventral valve) measuring 22 x 24 mm. The outline is regularly rounded, weakly transverse ; maximum width a little anterior to the hinge line ; umbo slightly prominent, ears poorly differentiated ; small ventral beak (slightly abraded on most specimens) probably without cicatrix of attachment ; no true interareas, but low ginglymus on both valves, with the maximum heigth (0,4 mm ventrally and 0,25 mm dorsally) attained under the beaks ; no deltidial cover, the base of the cardinal process closes an obtuse median opening (Pl. II, fig. 9). Lateral profile moderately and regularly concavo-convex. The corpus cavity is shallow, its maximum thickness (3-4 mm) lies at mid-length.

Ornamentation : both valves are covered by (a) sinuous rugae and (b) a dense mat of long hollow spines, directed radially. The ventral spines (2-3 mm length, 0,25 mm maximum diameter ; density about 30 spine bases in 25 mm ^{2}) are suberect to recumbent : their bases protrude at 20-30° from the shell surface, they soon curve slightly and remain straight, lying at lower angles from the shell surface. The dorsal spines are thinner (1,5 mm length, 0,15 mm diameter) ; when fully preserved, they look nearly prostrate (i.e. lying flat on the shell). Close to the hinge there is on each valve a row of cardinal spine bases, a little coarser than the normal spines, and merging in postero-lateral directions (Pl. II, fig. 9, 11b). All cardinal spines are broken on the available material. Some of them have their cavities opening into the shell cavity.

Inside the ventral valve (Pl. II, fig. 6, 8) : in the tip of the umbo, a wide short septum-like ridge separates two deep lateral depressions ; they probably accomodate the cardinal process. The ventral "septum" merges anteriorly to a narrow median groove, separating two ill defined pear-shaped muscle scars. The small teeth are poorly preserved. Along the hinge line, there are sometimes openings of cardinal spines. Inside the dorsal valve (Pl. II, fig. 7, 10, 11a), the V-shaped cardinal process has two widely divergent lobes ; it lies directly on the broad base of the median septum, without an alveolus. The dental sockets are shallow, oblique. Along the hinge line, a pair of vague cardinal ridges bear vertical furrows and some spine openings. Lateral ridges diverge slightly from the hinge, and curve gently distally to surround the posterior part of the visceral disc. The median septum extends to the mid-length of the visceral disc. A pair of conspicuous smooth muscle scars and oblique reniform brachial ridges are seen on one specimen (Pl. II, fig. 10). The anterior part of the visceral disc is covered by crowded endospines.

Discussion

The described species belongs to the Caucasiproductinae because of its general shape, absence of true interareas and deltidium, and ornamentation. The Strophalosiid genus *Eostrophalosia* may be compared as it has spines on dorsal valves, but it differs by its true interareas and deltidial covers. Within the Caucasiproductinae, the iranian species belongs to *Caucasiproductus* : its relatively long lateral ridges are characteristic, more conspicuous than in *Praewaagenoconcha* and *Strophoproductus*. However, the dense mat of spines and the sinuous rugae may be considered as evolving characters, intermediate between *Caucasiproductus* (reported from Middle Devonian and lower Frasnian) and *Praewaagenoconcha* - *Strophoproductus* (two genera described from Famennian).

Comparison with *Caucasiproductus* species : the spines of *C. sardarensis* are thinner and more crowded than in *C. gretchichnikovae*. *C. dissimilis* Oleneva 1998 (Mongolia, lower Frasnian) is characterized by coarse irregular radial plicae. Other species formerly described as *Eostrophalosia* have been attributed to *Caucasiproductus* by Lazarev (1987) : *Eostrophalosia pedderi* Crickmay 1963 (Alberta, Canada, lower Frasnian, middle *asymmetricus* zone) and *E. lanvoiensis* Racheboeuf 1984 (Britain, France, Givetian, *varcus* zone). They are smaller than *C. sardarensis* ; on *E. pedderi* the spine bases emanate "from elongate oval to short radial ridges that generally become more pronounced anteriorly, producing a pseudocostate appearance on the shell" (Norris 1983, p. 22). *E. lanvoiensis* (maximum length 15 mm) has a more prominent ventral umbo (Racheboeuf 1984, Pl. 1 fig. 1-3).

At least *Eostrophalosia callawayensis* (Swallow 1860) from the Frasnian of Missouri looks externally similar to the Iranian species, but may attain a large size (cf. Branson 1922, p. 85 ; Norris 1983, p. 22-23) ; its internal structure is poorly known.

"*Strophalosia productoides* Murchison" has been cited from Givetian-Frasnian Iranian localities, especially Kale Sardar (Stöcklin *et al.* 1965). The type specimens of *productoides*, from Ferques, France, belong to the Strophalosiid genus *Rhytialosia* Lazarev 1989 : the deltidial cover, concentric ornamentation and absence of dorsal spines (Brousmiche 1973, p. 131) are characteristic features (Lazarev 1989). I have nothing similar in the materials collected at Kale Sardar.

"*Productella* aff. *hirsutiformis* Walcott" is cited in Devonian, Shirgest area (Stepanov *in* Ruttner *et al.*,1968, p. 52, 53). The species *hirsutiformis* belongs to *Quadratia* Muir-Wood & Cooper 1960, a Mississippian strophalosioid genus, characterized by the sparsity of spines. The crowded spines of *C. sardarensis* look quite different from the Quadratiid ornamentation.

Distribution

Caucasiproductus is reported from Middle Devonian and lower Frasnian (Lazarev 1990, tab. 1 p. 148), with a wide geographical distribution. In addition to the above-mentioned species, undescribed species are reported from the Middle Devonian of Transcaucasia and from the Frasnian of Siberia (Lazarev, 1987).

IV. — CONCLUSION

The Productid fauna from Kale Sardar is assignable to cosmopolitan Middle Devonian-Frasnian genera.

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EXPLANATION OF PLATE II (*)

Fig. 1-11. — *Caucasiproductus sardarensis* nov. sp.

1 : ML 1062 a1 = GFCL 3797, holotype. A complete shell, with an Auloporid epibiont on the ventral umbo.

1a, ventral view ; 1b, dorsal view, some dorsal spines preserved ; 1c, lateral view ; 1d, posterior view. Gr = 2.

2 : IKS1 a3 = GFCL 3798. A dorsal valve partly exfoliated, abraded cardinal process and some anterior dorsal spines. Gr = 2.

3 : ML 1062 a4 = GFCL 3799. Dorsal view, marginal areas. Gr = 2.

4 : IKS1 a4 = GFCL 3800. A ventral valve with spines. Gr = 2.

5 : ML 1062 a2 = GFCL 3801. A ventral valve.

5a, ventral view ; 5b, profile. Gr = 2.

6 : ML 1062 a22 = GFCL 3802. A partly exfoliated specimen, posterior view : the dorsal valve with a ginglymus, the ventral internal mould with a short median septum and two lateral depressions accomodating the cardinal process. Gr = 5.

7 : ML 1062 a19 = GFCL 3803. Dorsal valve interior ; cardinal process, hinge line with vertical furrows and lateral ridges surrounding the visceral area. Gr = 2.

8 : ML 1062 a25 = GFCL 3804. Ventral valve internal mould ; a long median myophragm and two indistinct muscle scars. Gr = 2.

9 : ML 1062 a33 = GFCL 3805. Posterior view of a complete shell ; the ventral beak truncated either by weathering or by a small attachment cicatrix (?) ; ventral and dorsal ginglymus ; no deltidium, the base of cardinal process closing a low delthyrium ; cardinal spines bases visible on ventral and dorsal valves. Gr = 8.

10 : ML 1062 a20 = GFCL 3806. Dorsal valve interior ; long median septum, strong muscle scars and reniform brachial ridges. Gr = 2.

11 : IKS1 a1 = GFCL 3807. Dorsal valve.

11a, internal view, cardinal process, median septum without alveolus, lateral ridges ; 11b, external view, cardinal process, marginal area, bases of cardinal spines. Gr = 5.

1 : ML 1062 a1 = GFCL 3797, holotype. Coquille complète, dont l'umbo ventral est recouvert d'un Auloporide épibionte. 1a, vue ventrale ; 1b, vue dorsale, quelques épines conservées ; 1c, vue latérale ; 1d, vue postérieure. Gr = 2.

2 : IKS1 a3 = GFCL 3798. Valve dorsale partiellement décortiquée, processus cardinal usé, quelques épines dorsales conservées à l'avant. Gr = 2.

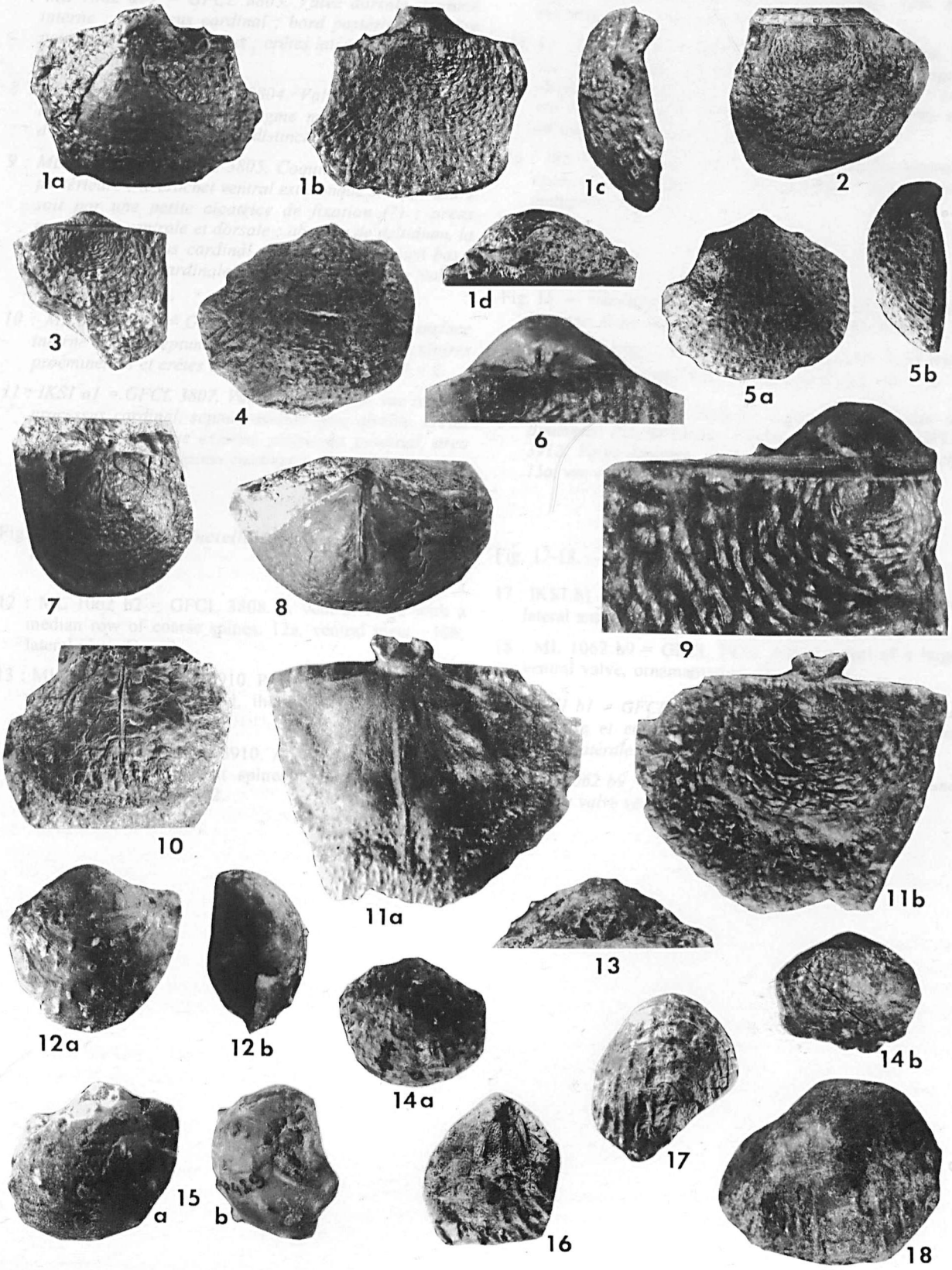
3 : ML 1062 a4 = GFCL 3799. Vue dorsale, areas marginales. Gr = 2.

4 : IKS1 a4 = GFCL 3800. Valve ventrale, épines conservées. Gr = 2.

5 : ML 1062 a2 = GFCL 3801. Valve ventrale. 5a, vue ventrale ; 5b, profil. Gr = 2.

6 : ML 1062 a22 = GFCL 3802. Spécimen partiellement décortiqué, vue postérieure. Valve dorsale pourvue d'un

(*) All figured specimens except fig. 15 from the locality : Kale Sardar (Tabas, Central-East Iran), Shishtu Formation, "Cephalopod beds", 5-7 m topographically under a *Beloceras tenuistriatum* bed. Frasnian.



e area marginale (ginglymus) ; valve ventrale décortiquée, dont le moule interne montre un court septum médian et deux dépressions latérales logeant probablement les lobes du processus cardinal. Gr = 5.

7 : ML 1062 a19 = GFCL 3803. Valve dorsale, surface interne ; processus cardinal ; bord postérieur linéaire pourvu de sillons verticaux ; crêtes latérales entourant la région viscérale. Gr = 2.

8 : ML 1062 a25 = GFCL 3804. Valve ventrale, moule interne ; un long myophragme médian et une paire d'empreintes musculaires indistinctes. Gr = 2.

9 : ML 1062 a33 = GFCL 3805. Coquille complète en vue postérieure ; le crochet ventral est tronqué soit par usure soit par une petite cicatrice de fixation (?) ; areas marginales ventrale et dorsale ; absence de deltidium, la base du processus cardinal obture un delthyrium bas ; bases d'épines cardinales visibles sur les deux valves. Gr = 8.

10 : ML 1062 a20 = GFCL 3806. Valve dorsale, surface interne ; long septum médian, empreintes musculaires proéminentes et crêtes brachiales réniformes. Gr = 2.

11 : IKS1 a1 = GFCL 3807. Valve dorsale. 11a, vue interne, processus cardinal, septum médian sans alvéole, crêtes latérales ; 11b, vue externe, processus cardinal, area marginale, bases d'épines cardinales. Gr = 5.

Fig. 12-14, 16. — *Productella* e.g. *belanskii* Stainbrook 1943.

12 : ML 1062 b2 = GFCL 3808. A ventral valve with a median row of coarse spines. 12a, ventral view ; 12b, lateral view. Gr = 2.

13 : ML 1062 b4 = GFCL 3910. Posterior view of a ventral valve, the umbo abraded, the dorsal valve cardinal process exposed. Gr = 4.

14 : ML 1062 b4 = GFCL 3910. A complete shell ; 14a, ventral view, recumbent spines ; 14b, dorsal view, absence of spines. Gr = 2.

16 : IKS 1 b3 = GFCL 3911. Fragment of a ventral valve, recumbent spines, Bryozoan epibionts. Gr = 2.

12 : ML 1062 b2 = GFCL 3808. Valve ventrale pourvue d'une rangée médiane de fortes épines. 12a, vue ventrale ; 12b, vue latérale. Gr = 2.

13, 14 : ML 1062 b4 = GFCL 3910, coquille complète. 13, vue postérieure, processus cardinal visible après ablation du sommet de la valve ventrale, Gr = 4 ; 14a, vue ventrale, épines décurvées (= recumbent) ; 14b, vue dorsale, absence d'épines, Gr = 2.

16 : IKS 1 b3 = GFCL 3911. Fragment de valve ventrale, épines décurvées (= recumbent), bryozoaires épibiontes. Gr = 2.

Fig. 15. — *Productella subaculeata* (Murchison 1840) from Ferques, *locus typicus* (Boulogne region, N. France).

FPFP 429 = GFCL 3912. Ventral valve with semi-erect spines ; 15a, ventral view ; 15b, lateral view. Gr = 2.

Spécimen provenant de Ferques, locus typicus (région de Boulogne, Pas-de-Calais, France). FPFP 429 = GFCL 3912. Valve ventrale, épines semi-érigées (semi-erect). 15a, vue ventrale ; 15b, vue latérale. Gr = 2.

Fig. 17-18. — *Spinulicosta* sp.

17 : IKS1 b1 = GFCL 3913. Ventral valve, median ridge and lateral anterior short costae. Gr = 2.

18 : ML 1062 b9 = GFCL 3914. Anterior part of a large ventral valve, ornamentation. Gr = 2.

17 : IKS1 b1 = GFCL 3913. Valve ventrale, crête médiane épineuse et courtes côtes radiaires sur les portions antéro-latérales de la valve. Gr = 2.

18 : ML 1062 b9 = GFCL 3914. Fragment antérieur d'une grande valve ventrale, ornementation. Gr = 2.

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NEW DATA ON DISTRIBUTION OF BRACHIOPODS, RUGOSE CORALS AND STROMATOPOROIDS IN THE UPPER DEVONIAN OF CENTRAL AND EASTERN IRAN. PALEOBIOGEOGRAPHIC IMPLICATIONS.

Nouvelles données sur la distribution des brachiopodes, des coraux rugueux et des stromatopores dans le Dévonien supérieur de l'Iran central et oriental. Implications paléobiogéographiques

by Denise BRICE(*), Bruno MISTIAEN(**) and Jean-Claude ROHART(*)

Abstract. — The Upper Devonian (Frasnian and Famennian) of Iran is briefly reviewed, as is the geologic setting of specific sections sampled in eastern and central Iran in the 1970s by A.F. de Lapparent. Recent study or revision of the faunas from these sections in relation to the program of IGCP 421 has included Frasnian and Famennian rhynchonellid and spiriferid brachiopods (Brice, 1999b), stromatoporoids (Mistiaen, 1999) and rugose corals (Rohart, 1999). Taxa discriminated and their stratigraphic distribution are tabulated. Ages, affinities and palaeobiogeographic distribution of these faunas are discussed.

Résumé. — *Après un rappel des connaissances sur le Dévonien supérieur (Frasnien et Famennian) en Iran, les auteurs situent et décrivent des coupes d'Iran oriental et central d'où proviennent des faunes frasniennes et famenniennes collectées par de Lapparent dans les années soixante-dix. Ces faunes ont été étudiées ou révisées dans le cadre du programme IGCP 421 : brachiopodes rhynchonellides et spiriferides par Brice (1999b), stromatoporoes par Mistiaen (1999) et coraux rugosa par Rohart (1999). Les taxa reconnus et leur distribution dans les coupes sont présentés sous forme de tableaux et leur âge discuté. La dernière partie est consacrée à des remarques sur les affinités des faunes et leur répartition paléobiogéographique.*

I. — INTRODUCTION

This paper concerns faunas studied and described in the three recent papers (Brice, 1999b ; Mistiaen, 1999 ; Rohart, 1999), mostly from the Upper Devonian (Frasnian and Famennian) of central and eastern Iran collected by de Lapparent at the beginning of the 1970s. They are housed in the "Laboratoire de Paléontologie stratigraphique", Catholic University of Lille, with numbers prefixed by GFCL.

II. — THE UPPER DEVONIAN OF IRAN BRIEFLY REVIEWED

In Iran, the Upper Devonian (Frasnian and Famennian) is identified in the following regions (fig. 1).

1) Northern Iran

Northwestern Alborz Mountains - southern part of the Masuleh area, dated by brachiopods as Frasnian (Davies *et al.*, 1972), and in the Zanjan section, dated by brachiopods as Frasnian and Famennian (Dastanpour, 1996).

Central Alborz Mountains - The lower member (A Member) of the **Geirud Formation** (Assereto, 1963) of the upper Djadjerud and Lar Valleys has been assigned an Upper Devonian (Frasnian) to Lower Carboniferous (Tournaisian) age on the basis of brachiopods (Gaetani, 1965).

Eastern Alborz Mountains - the **Khoshyeilagh Formation** (Bozorgnia, 1973) is partly Frasnian, partly Famennian (Brice *in* Bozorgnia op. cit.). Brachiopods from this formation at Robat-e Gharabil are unequivocally Frasnian (Brice *et al.*, 1974). Near Khoshyeilagh, north of Sharud, the presence of Frasnian was demonstrated by brachiopods (Ahmadzadeh Heravi, 1975); subsequently Frasnian, Famennian and Etroeungt intervals were demonstrated (Brice *et al.*, 1978).

2) Eastern Iran

Undifferentiated Middle-Upper Devonian has been reported on the basis of conodonts from the northeast of

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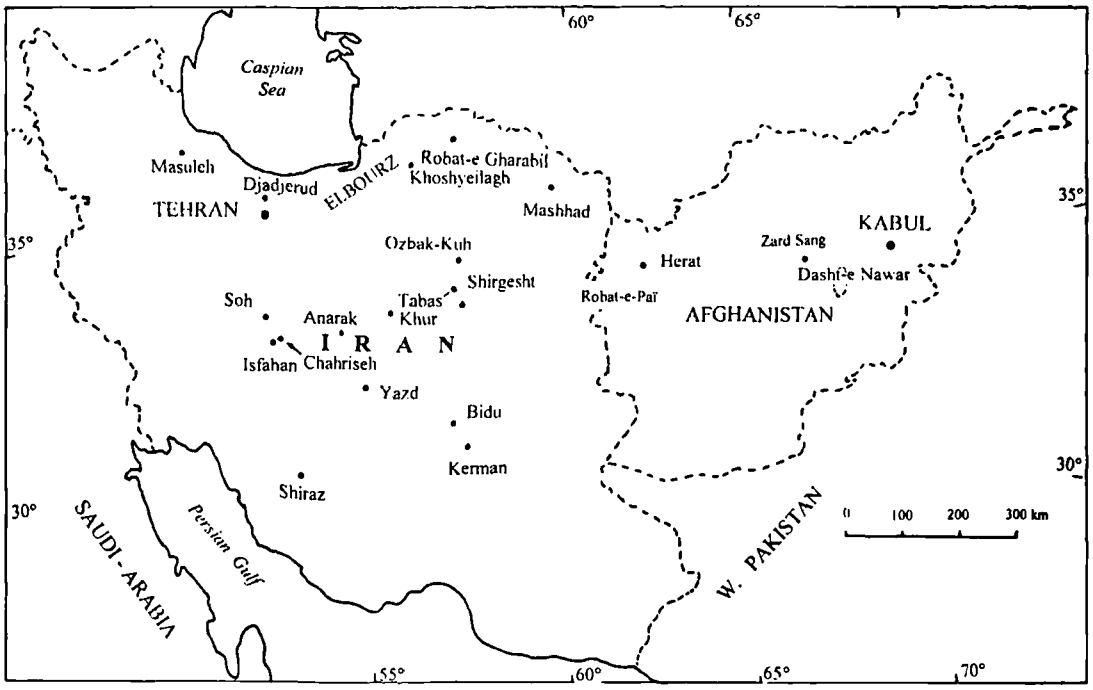


Fig. 1. — Upper Devonian localities mentioned in the text.

Fig. 1. — Carte des localités et des affleurements de Dévonien supérieur cités dans le texte.

the Binalud Mountains in the Mashad region (Weddige, 1984). A black limestone containing conodonts indicating a Late Devonian age has been reported from the eastern Kopet Dagh Range (Wensink, 1991).

The Upper Devonian is represented in the Tabas area by the upper part of the **Bahram Formation** and lower part of the **Shishtu Formation** (= Shishtu 1), the two units are grouped as the **Ozbak-Kuh Group**. These units were proposed by Ruttner *et al.* (unpublished) on the basis of outcrops in the Ozbak-Kuh Mountains north of Tabas ; they were subsequently described by Stöcklin *et al.* (1965) from the Shotori Range, south-southeast of Tabas. They have been used over a large part of eastern and central Iran, sometimes in very different ways. The presence of Frasnian and Famennian intervals was first recognized on the basis of goniatites and clymenoids (Walliser, 1966 ; Gaetani, 1968) and brachiopods (Sartenaer, 1966, 1968). Conodonts have confirmed the Frasnian age of the Bahram Formation and Frasnian-Famennian age of the lower part of the Shishtu Formation (Shishtu 1) (Weddige, 1984 ; Wendt *et al.*, 1997 ; Yazdi, 1999).

In Kerman Province to the southeast, fossiliferous Upper Devonian was first identified from brachiopods, corals and vertebrates in the neighbourhood of Morad, Gask and Hutk - west, north and north-northwest respectively of Kerman (Huckriede *et al.*, 1962). In the Bidu area, (about 70 km north of Kerman), the Frasnian is reliability identified in several sections on the basis of brachiopods and rugose corals (Brice *in* Golshani *et al.*, 1972). Lower Famennian as well as Frasnian were recognized by brachiopods (Brice *in* Golshani *et al.*, 1973) in the Hutk section (about 30 km north-northwest of Kerman). More recently, Wendt *et al.*(1997), using conodonts, demonstrated the presence of a Givetian to lower Tournaisian succession. Rich brachiopod faunas from five sections in the Hutk area are being described by M. Dastanpour and M. Bassett.

3) Central Iran

Intervals assigned to the the Bahram and Shishtu Formations in the Djam area of north-central Iran (Alavi-Naini, 1972) have been dated by brachiopods (Brice *in* Alavi-Naini, *op. cit.*) as Middle Devonian-Upper Devonian (Frasnian and Famennian).

Intervals attributed to the Bahram Limestone in the Anarak and Khur areas have been dated as Middle-Late-Devonian by brachiopods and/or corals ; intervals attributed to the Shishtu Formation have been dated as Famennian (late Famennian in the Anarak area) by brachiopods (Sharkovski *et al.*, 1984 ; Aistov *et al.*, 1984).

Upper Devonian (Frasnian, Famennian and Strunian) has been proved by brachiopod faunas in the Chahriseh area northeast of Isfahan (Djafarian, 1973 ; Djafarian & Brice, 1973). Upper Devonian fossiliferous strata are also exposed to south of Kashan (Dastanpour, 1966).

III. — GEOLOGICAL SETTING

LOCALITIES AND OUTCROPS IN STUDIED SECTIONS

This paper and the three following ones (Brice, 1999b ; Mistiaen, 1999 ; Rohart, 1999) are based on several collections :

- Faunas collected by A.F. de Lapparent in the early 1970s and never published from :

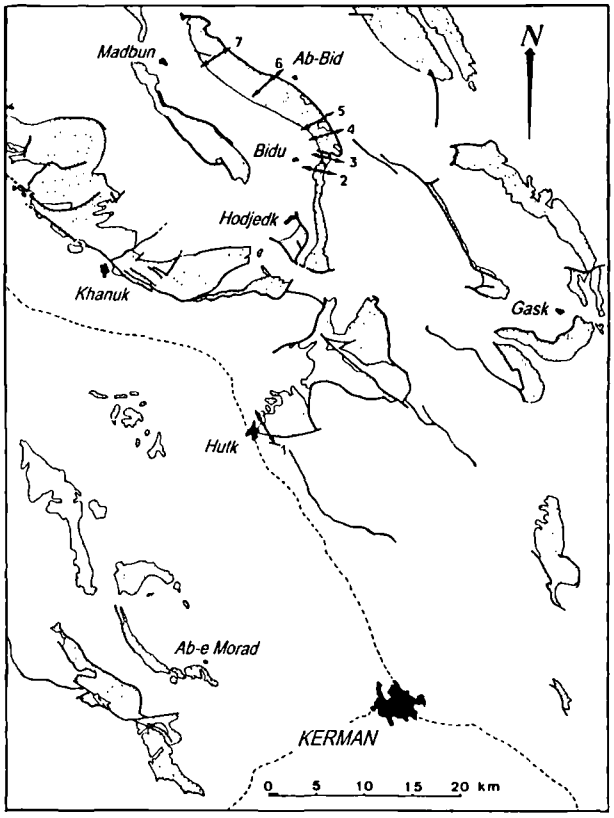


Fig. 2. — Outcropping Palaeozoic (mostly Devonian) North of Kerman (after Huckriede *et al.*, 1962).

Fig. 2. — Affleurements paléozoïques (principalement dévoniens) au nord de la région de Kerman (d'après Huckriede et al., 1962).

- Bidu area (Kerman Province) ;

- Tabas area (Khorasan Province) ;

- Older collections (here revised) made by A.F. de Lapparent in the Bidu area - same sections as in the preceding areas.

- Faunas collected by M. Zahedi from sections and outcrops in the Soh area (Esfahan Province).

1) BIDU **area (Kerman Province)**

The following sections (fig.1,2) are described, from south to north.

a) *Hutk section* (fig. 2)

(Golshani *et al.*, 1973 ; Blieck &. Goujet, 1978 ; Dastanpour, 1996 ; Wendt *et al.*, 1997).

- Geographic situation : 25 km north-northwest of Kerman.

-The section (fig. 3) was sampled by de A.F. Lapparent in 1972 and 1973 ; he gave the following description (unpublished field notes).

From top to bottom :

I-H.72.16	black limestones with numerous fragments of crinoid ossicles
I-H.72.15	dolomitic limestones
I-H.72.14	white quartzites
I-H.72.13	black limestones
I-H.72.12	dolomitic limestones
I-H.72.11	marls and limestones in thin beds with spiriferids
I-H.72.10	coquina limestones with spiriferids
I-H.72.9	grains of phosphate rocks and numerous fish scales
I-H.72.8	limestones and sandstones with numerous productellids
I-H.72.7	black bioclastic limestones with arthrodiran bones
I-H.72.6	limestones, sandstones, marls
I-H.72.5	black limestones
I-H.72.4	limestones, sandstones, marls, dolomitic limestones, remains of brachiopods
I-H.72.3	limestones in thin beds and marls with numerous badly preserved brachiopod shells
I-H.72.2	bioclastic black limestones with dispersed rugose coral *Hexagonaria* and very numerous arthrodiran bones beginning abruptly with one bed of yellow dolomitic limestone
I-H.72.1	red sandstones, rather fine-grained, regular, unfossiliferous
I-H.72.0	white quartzites

b) *Bidu Gorge, Bidu River S and N, Bidu Crest and Bidu Cliff sections* (fig. 2)

(Golshani *et al.*, 1972 ; Dastanpour, 1996 ; Wendt *et al.*,1997).

- Geographic situation : the five sections are situated between 57 and 64 km north of Kerman.

- The sections were measured and sampled by A.F. de Lapparent in the 1970s. A general description in which numerous lateral variation were noted has been published (Golshani *et al.*, 1972), new data on these sections is now provided (fig. 4).

c) *Ab-Bid North section* (fig. 2)

- Geographic situation : about 70 km north of Kerman, and about 10 km north of Bidu village.

- A.F. de Lapparent studied the section in 1973 and gave the following short description (unpublished field notes) from bottom to top :

- black limestones ;

- reefal level with corals and numerous stromatoporoids near the bottom, (samples I-AB.BR 1 ; I-AB.BR 1s) ;

- marly levels followed by limestones with several brachiopods beds (samples I-AB.BR 3-4 ; I-AB.BR 4 ; I-AB.BR 4s).

d) *Madbun East section* (fig. 2)

- Geographic situation : Madbun village is about 12 km west of Ab-Bid ; the Madbun East section is not far west of the Ab-Bid North section.

- In 1973, A.F. de Lapparent noted horizons equivalent to the upper beds of the Ab-Bid section (samples I-ME.AB 1; I-ME.AB 2).

2) TABAS **area (Khorasan Province)**

Howz-e Dorah section (fig. 5)

- Geographic situation, about 35 km southeast of Tabas (fig. 1).

The section was studied and sampled by A.F. de Lapparent in 1969, he gave the following description (unpublished field notes).

From top to bottom :

I-TA 16 **Sardar Formation** beginning with quartzites and conglomerates
I-TA 15 limestones, quartzites, conglomerates with quartz pebbles, shales
I-TA 14 white limestones
I-TA 13 marly limestones and marls, fossiliferous level (2 m) with solitary rugose corals, productid and spiriferid brachiopods, fish teeth
I-TA 12 limestones in regular beds ; at the base, limestones with large solitary rugose corals, numerous *Spirophyton* and spiriferid brachiopods
I-TA 11 marly limestones with productid, spiriferid and rhynchonellid brachiopods
I-TA 10 grey marls ; rare remains of brachiopods
I-TA 9 red and yellow iron oolithes with orthoceratids, rare rhynchonellids : " cephalopod beds " with goniatites and *Receptaculites*
I-TA 8 marls and limestones with spiriferids and some other brachiopods
I-TA 7 red limestones and marls, crinoidal limestones
I-TA 6 massive limestones, light grey, with massive and branched corals, white stromatoporoids
I-TA 5 limestones and marls (one quartzite bed) with spiriferid, rhynchonellid (" *Rhynchonella* " *cuboides* ?) brachiopods and numerous corals samples I-TA 5 = I-TA Fr
I-TA 4 biostrome with branched corals
I-TA 3 **Shishtu Formation** beginning with red marls and quartzites
I-TA 1-2 **Bahram Formation** black limestones and dolomites with rare tentaculites and some brachiopods

3) SOH **area (Esfahan Province)**

We have little stratigraphic data on the Devonian succession of the Soh region which has produced brachiopod and rugose coral faunas. According to M. Zahedi (pers. comm.), who collected them, Z185 to Z190 occur in a continuous section. Localities of the other faunas are scattered over a small region in the neighbourhood of this section.

IV. — NEW PALEONTOLOGICAL DATA

The new data concern only Upper Devonian rhynchonellid and spiriferid brachiopods, rugose corals and stromatoporoids from the above sections. It should be noted that we have not encountered any taxa characteristic of the Lower and/or Middle Devonian in the Iranian collections from these sections stored in Lille.

In the tables, taxa with an asterisk (*) are index fossils of the biozones erected by Brice (1977) in the Devonian of Afghanistan.

1) BIDU **area**

a) Hutk section (fig. 3, Tab. I)

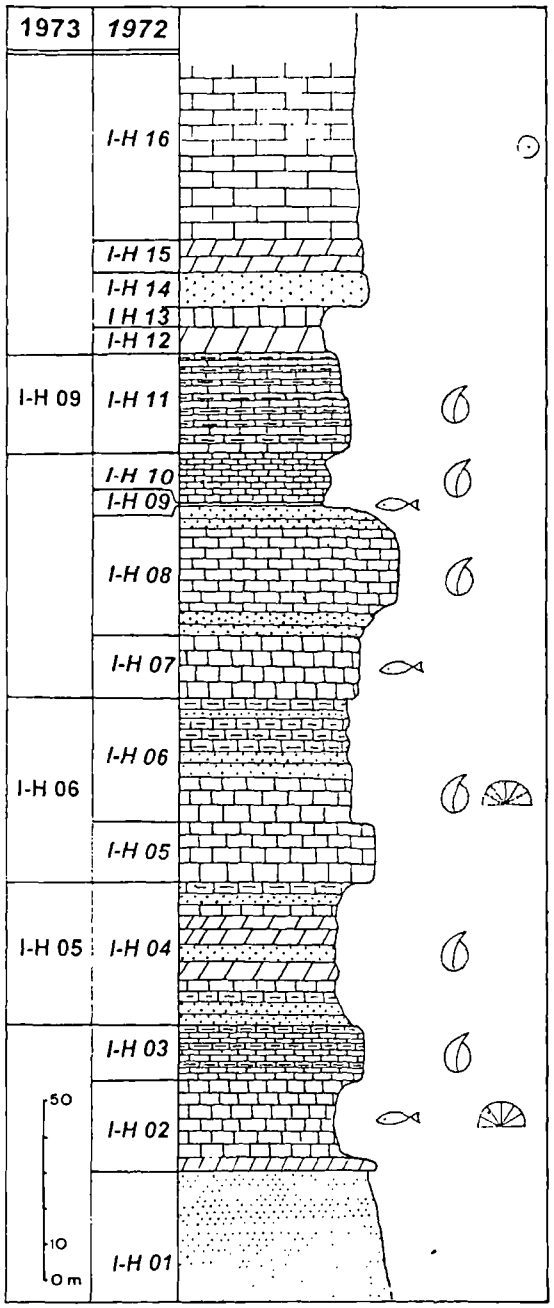
Frasnian faunas

The Frasnian index fossil *Cyphoterorhynchus koraghensis* (REED, 1922) of biozone 6 (Brice, 1977) occurs in faunas of level I-H 5. It was first found in Chitral (Reed, 1922), then in eastern Iran (Ozbak-Kuh and Tabas regions) by Sartenaer (1966) and in Kerman Province (Bidu area) by Brice (*in* Golshani *et al.*, 1972). Brice (1971) and Brice (*in* Mistiaen, 1985) noticed it in several sections in Afghanistan (Axial Zone and Central Mountains) and in northern Iran (eastern Alborz Mountains, Brice *et al.*, 1978). The index fossil *C. koraghensis* is often associated with *C. arpaensis* (ABRAMIAN, 1957), firstly discovered in Armenia, and *Uchtospirifer multiplicatus* BRICE, 1971 found in Afghanistan (Brice, 1971). Their absence here is perhaps due to inadequate collecting.

The age of biozone 6 is Frasnian, probably lower to middle Frasnian. In the Howz-e Dorah section, eastern Iran, southeast of Tabas, *C. koraghensis interpositus* SARTENAER, 1966 have been found with *C. arpaensis* in the Shishtu Formation dated as Frasnian — older than the *jamiae* Zone in terms of conodont zonation (Yazdi, 1998).

Studied samples in ascending stratigraphical succession	I-H 5 1973	I-H 5-6 1973	I-H 6 1973	I-H 8 1972	I-H 9 1973	I-H 11 1972
BRACHIOPODS						
* *Araratella* sp.						x
Dmitria (?) sp.					x	
Centrorhynchus deltidialis (GAETANI, 1965)					x	
Sulcatospirifer iranicus BRICE,1999a				x	x	x
Cyrtospirifer kermanensis BRICE,1999b	x		x			
Ripidiorhynchus aff. *elburzensis* (GAETANI, 1965)	x					
* *Ripidiorhynchus elburzensis* (GAETANI, 1965)			x			
Uchtospirifer sp.	?					
Rigauxia hutkensis BRICE,1999b		x	x			
Ladogilina persanica BRICE,1999b	x					
* *Cyphoterorhynchus koraghensis* (REED, 1922)	x					
RUGOSE CORALS						
Cystihexagonaria e.g. *hexagona sensu* BRICE, 1971			x			
BIOZONES (Brice, 1977)	**6**		**8**		**10 ?**	**11**

Tab. — I.



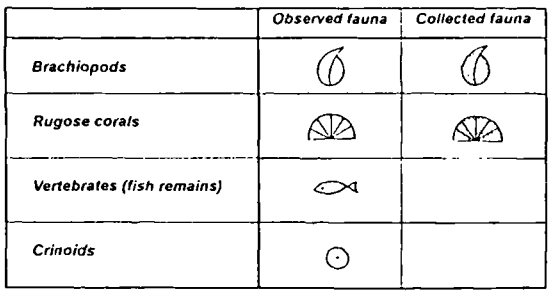


Fig. 3. Hutk section - based on unpublished field data obtained by A. F. de Lapparent in 1972 and 1973. Symbols indicate sources of studied material.

Fig. 3. Coupe de Hutk (selon les observations de terrain faites par A. F.de Lapparent en 1972 et 1973, non publiées). Les fossiles indiqués par des symboles correspondent au matériel étudié.

Biozone 7 (Brice, 1977), characterized by the index fossil *Coeloterorhynchus tabasensis* SARTENAER, 1966, is not recognized in the Hutk section, probably because of inadequate collecting or facies variation. In fact biozone 7 has not been identified in most Devonian successions of the Kerman region, whereas it is well represented to the north - in the Tabas area of eastern Iran, and in the central Mountains of Afghanistan.

The Frasnian index fossil *Ripidiorhynchus elburzensis* (GAETANI, 1965) of biozone 8 (Brice, 1977) occurs in the fauna of level I-H 6 . It has been found in the Geirud Formation (central Alborz Mountains) where it was considered by Gaetani to be lower Famennian or upper Frasnian in age. Association with tentaculites and the massive rugose coral *Hexagonaria* in this level confirms the Frasnian age of this fauna.

Rhynchonellid and spiriferid brachiopods are apparently absent or have not been collected from level I-H 7.

Famennian faunas

The fauna of level I-H 8 has not yielded index fossils of any of Brice's (1977) biozones. In 1972 (Brice in Golshani *et al.*) one spiriferid specimen of this fauna was assigned to *Cyrtospirfer syringothyriformis* and consequently dated as Frasnian. After revision, this specimen is re-assigned to probably Famennian *Sulcatospirifer iranicus* BRICE, 1999a. In other sections of the Kerman region (Madbun East and Ab-Bid North sections) *S. iranicus* is associated with Famennian species such as *Dmitria seminoi* (VERNEUIL, 1850) and/or *Centrorhynchus deltidialis* (GAETANI, 1965).

The probable presence of *Dmitria* associated with *Centrorhynchus deltidialis* (GAETANI, 1965) in the fauna of level I-H 9 is not sufficient to surely identify biozone 10 (Brice 1977).

The index genus of the upper Famennian biozone 11 (Brice, 1977), *Araratella*, occurs in fauna of level I-H 11. In Afghanistan, this genus is generally associated with such genera as *Eobrachythyris, Dichospirifer*, these have not been found here.

b) *Bidu sections* (fig. 2 et 4, Tab. II)

Frasnian faunas

The succession in the four sections have yielded index fossils of biozone 6 (Brice, 1977), lower to middle Frasnian in age. Moreover, the upper level of the northern Bidu Cliff section I-BR 2 has produced the index fossil *Ripidiorhynchus kotalensis* BRICE, 1971 of the biozone 8 (Brice, 1977), upper Frasnian in age. Index fossils of biozone 7 (Brice, 1977) have not been found.

c) *Ab-Bid North section* (fig. 2, Tab. III)

Frasnian faunas

The sequence has produced index fossils of biozone 6 (Brice, 1977), lower to middle Frasnian in age. Index fossils of biozone 7 and 8 (Brice, 1977) have not been found.

Sections from S to N	BIDU GORGE	BIDU RIVER SOUTH							BIDU CREST		BIDU CLIFF	
Samples collected in 1972	I-BR 1bc	I-BR 1ab	I-BR 1bc	I-BR 1c	I-BR 1d	I-BR 1ef	I-BR 2c	I-BR 3	I-BR 1ab	I-BR 2c	I-BR 1abc	I-BR 2
Samples collected in 1971			I-BR 2									
BRACHIOPODS												
* *Ripidiorhynchus kotalensis* BRICE, 1971												x
Ripidiorhynchus minutissimus BRICE,1999b										x		
Ripidiorhynchus kermanensis BRICE,1999b			x									
Cyrtospirifer kermanensis BRICE,1999b	x	x	x	x	x		x		x			
* *Cyphoterorhynchus arpaensis* (ABRA., 1957)									x			
C. gr. arpaensis (ABRAMIAN, 1957)					x							
* *Uchtospirifer multiplicatus* BRICE, 1971	x		x								x	
* *U. multiplicatus minor* BRICE, 1971	x		x						x			
Cyphoterorhynchus sp.												
* *C. koraghensis* (REED, 1922)									x		x	
Rhynchonellid indet.											x	
RUGOSE CORALS												
Hexagonaria cf. *magna sensu* BRICE, 1971					x							
Cystihexagonaria e.g. *hexagona sensu* BRICE, 1971					x							
Hexagonaria cf.*taurensis* (HUBMANN, 1992)					x							
Peneckiella ? cf. *cylindrica* (YOH, 1937)			x		x							
Disphyllum sp. 1			x	x	x							
Temnophyllum lapparenti ROHART, 1999			x									
STROMATOPOROIDS												
Clathrocoilona cf *inconstans* STEARN, 1962.								x				
Clathrocoilona sp.			x									
Dendrostroma sp.			x									
Stictostroma saginatum LECOMPTE, 1951								x				
Stachyodes australe (WRAY, 1967)					x							
Stachyodes cf. *costulata* LECOMPTE, 1952						x						
BIOZONES (Brice, 1977)	6							?	6	?	6	8

Tab. — II.

Samples	I-AB. BR 1	I-AB. BR 1s	I-AB. BR 3-4	I-AB. BR 4s
BRACHIOPODS				
* *Araratella* sp.				x
* *Leptocaryorhynchus jamensis* BRICE, 1971				x
Cyrtiorina iranicus BRICE,1999				x
**Dmitria seminoi* (VERNEUIL, 1850)				x
Sulcatospirifer iranicus BRICE,1999a			x	x
cf. *Dmitria* sp.			x	
Ripidiorhynchus kermanensis BRICE,1999b		x		
Tenticospirifer aff. *cyrtiniformis* (HALL & WHIT., 1875))		x		
* *Cyphoterorhynchus koraghensis* (REED, 1922)	x			
* *Cyphoterorhynchus arpaensis* (ABRAMIAN, 1957)	x			
* *Uchtospirifer multiplicatus minor* BRICE, 1971	x			
* *Uchtospirifer multiplicatus* BRICE, 1971		x		
RUGOSE CORALS				
Hexagonaria sp.		x		
STROMATOPOROIDS				
Habrostroma cf. *dubia* (LECOMPTE, 1952)	x			
Habrostroma sp.	x	x		
Actinostroma filitextum LECOMPTE, 1951	x			
Hermatoporella cf. *pertabulata* (ZUKALOVA, 1971)	x			
Actinostroma ? sp..	x	x		
Stictostroma saginatum (LECOMPTE, 1951))	x	x		
Clathrocoilona cf. *inconstans* STEARN, 1962	x	x		
Stictostroma brylkini (YAVORSKY, 1955)	x			
Stromatopora sp.	x	x		
BIOZONES (Brice, 1977)	6	6		10-11

Tab. — III.

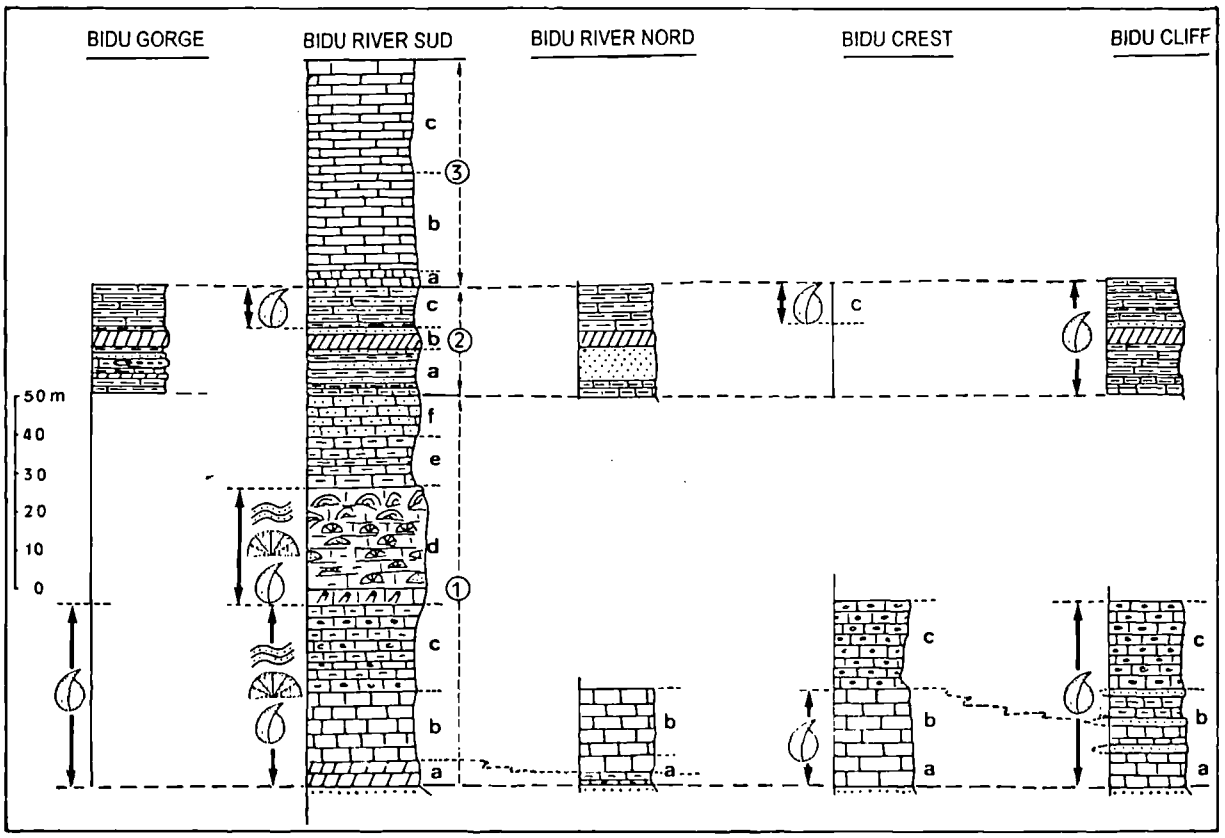


Fig. 4. — Sections near Bidu village showing lateral facies variations in the Devonian - based on unpublished field data obtained by A. F. de Lapparent in 1972 and 1973.

Fig. 4. — Différentes coupes près du village de Bidu montrant les variations latérales de faciès dans le Dévonien (selon les observations de terrain faites par A. F.de Lapparent en 1972 et 1973, non publiées).

Samples	I-ME.AB 1	I-ME.AB 2
* *Centrorhynchus deltidalis* (GAETANI, 1965)	x	
Sulcatospirifer iranicus BRICE,1999a	x	x
* *Leptocaryorhynchus jamensis* (BRICE, 1971)		x
* *Dmitria seminoi* (VERNEUIL, 1850)		x
BIOZONES (Brice, 1977)		**10**

Tab. — IV.

Famennian faunas

Level I-AB.BR 3-4 is probably Famennian (cf. earlier discussion) but index fossils of its biozones have not been found.

Level I-AB.BR 4s has yielded index fossils of biozone 10 (Brice 1977) : *Leptocaryorhynchus jamensis* BRICE, 1971 and *Dmitria seminoi* (VERNEUIL, 1850) ; it is middle Famennian in age but with the index genus of the upper Famennian biozone 11 (Brice 1977). It may be possible to distinguish the two biozones with more precise collecting.

d) *Madbun East section* (fig. 2, Tab. IV)

This northern section has produced only Famennian faunas. In previous sections in the Bidu area, Frasnian faunas were always present ; here Frasnian faunas are not recognized whereas Famennian fauna is well represented.

Famennian faunas

Level I-ME.AB 1 includes *Sulcatospirifer iranicus* BRICE, 1999a, genus considered to be Famennian in age in the Mount Morgan District, northeastern Australia. In the Madbun East section it is associated with *Centrorhynchus deltidialis* (GAETANI, 1965) a form characteristic of the Famennian in the Alborz Mountains and found together with *Leptocaryorhynchus jamensis* (BRICE, 1971) in the eastern Alborz Mountains (Brice *et al.*, 1978, tabl. 1) ; it is the index fossil of the middle Famennian biozone 10 (Brice, 1977).

Level I-ME.AB 2 has produced index fossils of biozone 10.

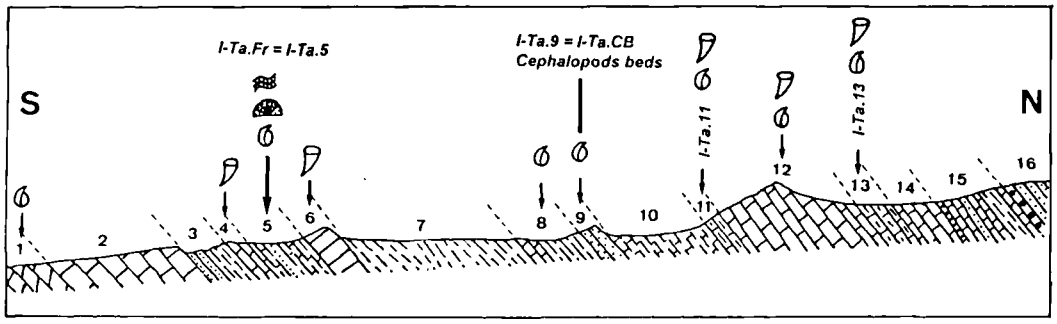


Fig. 5. — Howz-e Dorah section, Tabas area - based on unpublished field data obtained by A. F. de Lapparent in 1969.

Fig. 5. — Coupe de Howz-e Dorah, région de Tabas (selon les observations de terrain faites par A. F.de Lapparent en 1969, non publiées).

Sample	I-TA 5 = I-TA FR
RUGOSE CORALS	
Disphyllum caespitosum tricyclicum von SCHOUPPÉ, 1965	x
Disphyllum sp. 1	x
Sinodisphyllum sp.	x
Macgeea desioi von SCHOUPPÉ, 1965	x
STROMATOPOROIDS	
Clathrocoilona irregularis (LECOMPTE, 1951)	x

Tab. — V.

2) TABAS **area** (fig. 1)

Howz-e Dorah section (fig. 5, Tab. V)

Rugose corals and stromatoporoids are associated with the index fossils *Cyphoterorhynchus koraghensis* (REED, 1922) and *Uchtospirifer multiplicatus* BRICE, 1971 of biozone 6 (Brice, 1977), it is lower to middle Frasnian in age, older *jamiae* Zone in terms of conodont zonation (cf. earlier).

3) SOH **area** (fig. 1, Tab. V)

ZAHEDI COLLECTIONS

Fossiliferous faunas Z185 to Z190 were obtained from a continuous section.

Frasnian faunas

Index fossils of biozone 6 (Brice, 1977) are poorly represented in level Z111 of Zahedi's collections (stored in Lille). According to Zahedi, rhynchonellids of Z176 were obtained from an isolated outcrop in the vicinity of the section. They recall *Ripidiorhynchus barroisi* (RIGAUX, 1908), abundant in the lower Frasnian of the Boulonnais of northern France. This is the first report from Iran.

Frasnian-Famennian faunas

Z185 is from the lower part of the section sampled by Zahedi. It has produced : *Ripidiorhynchus kotalensis* BRICE, 1971, the upper Frasnian index fossil of biozone 8 (Brice, 1977), and *Pampoecilorhynchus arianus* SARTENAER, 1968, index fossil of lower Famennian biozone 9 (Brice, 1977),. The Frasnian/Fammennian boundary is probably expressed in this section.

Famennian faunas

Z177, Z113, Z115 are also from isolated outcrops ; all are Famennian. Biozonal index fossils have been found in only the last two outcrops. From level Z187 in the continuous section, we have identified index fossils of upper Famennian biozone 11 (Brice, 1977).

V. — AFFINITIES AND PALEOGEOGRAPHIC IMPLICATIONS

1) Brachiopods

Previous comments, based on Upper Devonian rhynchonellid and spiriferid brachiopods, confirm a fact previously emphasized (Brice, 1977), that there are numerous common brachiopod taxa in the Upper Devonian Frasnian and Famennian between (fig. 6.):

- faunas from Axial Zone and Central Mountains of Afghanistan ;

- faunas from various regions of Iran in the Alborz Mountains and central and eastern Iran.

In more western regions, such as Armenia (Transcaucasia), are rhynchonellid species described by Abramian (1954, 1957) that occur as well in Afghanistan and Iran, e.g., the Frasnian *Cyphoterorhynchus arpaensis*, and the Famennian *Araratella dichotomians dichotomians, A. dichotomians assimulata, Megalopterorhynchus chanackchiensis*, *Paurogatroderhynchus nalivkini*. One

Samples	Z 111	Z 173	Z 176	Z 185	Z 177	Z 113	Z 115	Z 187	Z 188
BRACHIOPODS									
**Paurogastroderhynchus nalivkini* (ABR., 1954)									x
**Araratella dichotomians dichotomians* (ABR., 1954)							x		x
**Megalopterorhynchus chanackchiensis* (ABR., 1954)						x		x	
**Araratella dichotomians assimulata* (ABR., 1954)						x			
**Eobrachythyris proovalis* BRICE, 1971						x		x	
**Prospira* aff. *struniana* (GOSSELET, 1879)							x		
Araratella sp.								x	
Cyrtiorina iranica BRICE, 1999b						x		x	
*« *Cyrtiopsis* » *graciosa chakhaensis* BRICE, 1971						x	x		x
Centrorhynchus sp.						x			
**Centrorhynchus charakensis* (BRICE, 1971)					x				
**Pampoecilorhynchus arianus* SARTENAER, 1968				x					
**Ripidiorhynchus kotalensis* BRICE, 1971				x					
Ripidiorhynchus cf. *barroisi* (RIGAUX, 1908)			x						
**Cyphoterorhynchus* cf. *koraghensis* (REED, 1922)	x								
RUGOSE CORALS									
Hexagonaria cf. *magna sensu* BRICE, 1971		x							
Sinodisphyllum sp.			x						
Macgeea multizonata (REED, 1922))	x								
BIOZONES (Brice, 1977)	**6**			**8-9**		**11**	**11**	**11**	**12**

Tab. — VI.

Frasnian rhynchonellid species : *Cyphoterorhynchus koraghensis,* from Chitral, northwestern Pakistan (Reed, 1922), is very common in the Frasnian of Iran and Afghanistan.

In view of the above, we conclude that for at least the Upper Devonian, the above regions belonged to the same platform situated on the northern Gondwana margin.

The affinities of the brachiopod faunas of Iran and Afghanistan with those of other regions will be given after the number of common genera.

Rhynchonellidine brachiopods. The biogeographic distribution of rhynchonellidines recognized in Afghanistan, Iran and neighbouring regions and cited in the tables, is as fellows :

Frasnian genera. *Cyphoterorhynchus* SARTENAER, 1964, occurs in Europe (Spain) ; western and southeastern Australia and North Africa (Libya). *Ladogilina* LIASHENKO, 1973, is known from Russian (Volga-Urals and southern Timan). *Ripidiorhynchus* SARTENAER, 1966, is known from Europe (northern France, Belgium, Great Britain and Spain), the Russian Platform, North Africa (Algeria and Libya) and China (Hunan). It has been reported from the Famennian of Libya, various localities in the former Soviet Union (Russian Platform, Arctic region, Mugodjar Mountains and Tian Shan), southeastern Poland and North America (New Mexico), but some of these the attribution is uncertain (Sartenaer, 1985).

Famennian genera. *Araratella* ABRAMIAN, PLODOWSKI, SARTENAER, 1975, is known from Europe (northern France, Belgium, Germany and Spain) ; northern Africa (Algeria) ; the southern Urals and Kazakhstan. *Centrorhynchus* SARTENAER, 1970, *is* known from Europe (northern France, Belgium, Germany and Spain) ; Asia (Kazakhstan and Uzbekistan) ; Western Australia (Canning Basin) and North America (New York and Pensylvannia). *Megalopterorhynchus* SARTENAER, 1965, is known from Europe (Spain) ; North Africa (Algerian Sahara) and North America (Montana and Alberta). *Pampoecilorhynchus* SARTENAER, 1968, is known from Europe (Belgium and Germany) and North America (Nevada). *Paurogastroderhynchus* SARTENAER, 1970, is known from Europe (Spain) and North Africa (Algerian Sahara).

Spiriferidine brachiopods. The biogeographic distribution of the spiriferidines identified from Afghanistan, Iran and neighbouring regions, is as follows :

Frasnian genera. *Uchtospirifer* LIASHENKO, 1957 — Frasnian and Upper Givetian ? — from the Russian Platform; northwestern Europe, South China, North America (New Mexico ?).

Frasnian and Famennian genera. *Cyrtospirifer* NALIVKIN *in* FREDERIKS, 1924, is cosmopolitan. *Rigauxia* BRICE, 1988, is known from Europe (northern France and Spain), and probably from South China.

Famennian genera. *Cyrtiorina* COOPER & DUTRO, 1982, is known from North America (New Mexico). *Eobrachythyris* BRICE, 1971, is known from North Africa (Morocco) and Europe (Poland ?). *Sulcatospirifer* MAXWELL, 1954, is known from the Mount Morgan district of northeastern Australia.

Famennian and Lower Carboniferous genera. *Prospira* is known from western and eastern Australia (Bonaparte Gulf and Mount Morgan district) ; Europe (northern France, Belgium and Germany) ; North Africa (Algeria, Libya and Morocco) ; North America (Iowa and Alberta).

2) Rugose corals

During this first phase of the work, Iranian Devonian corals were compared with those from the Axial Zone and

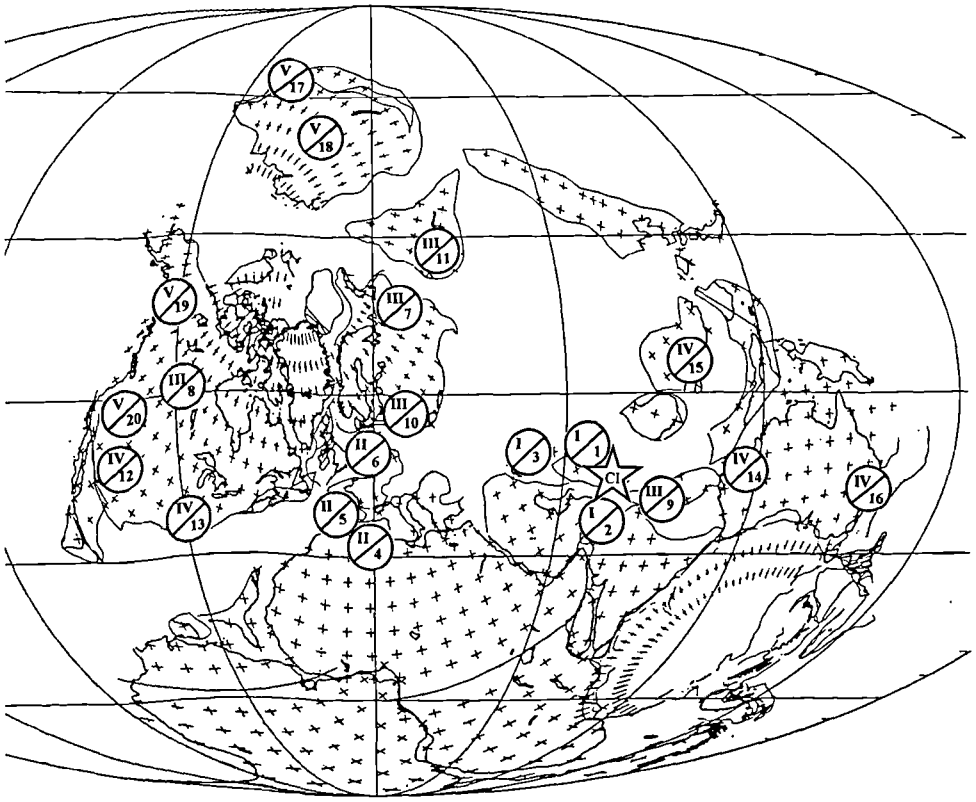


Fig. 6. — Palaeobiogeographic affinities from I (= important) to V (= weak) ; plotted on the Scotese and McKerrow (1990) palaeogeographic reconstruction for the Upper Devonian (Famennian). 1 to 20 : regions where Frasnian and Famennian faunas are compared with coeval faunas from central and eastern Iran - with number of common taxa cited.

[1] Alborz (most brachiopod species present in central and eastern Iran are also present in the Alborz). *Elbourz (la plupart des espèces de brachiopodes présentes en Iran central et oriental sont aussi présentes dans l'Elbourz).* [2] Afghanistan: Central Mountains and Axial Zone (13 brachiopod genera, 5 rugose coral species and 5 stromatoporoid species). *Afghanisiatn : Montagnes Centrales et Zone Axiale (13 genres de brachiopodes, 5 espèces de coraux rugueux et 5 espèces de stromatopores).*[3] Turkey, Armenia : (7 brachiopod genera and 1 rugose coral species).*Turquie, Arménie (7 genres de brachiopodes et 1 espèce de coraux rugueux).* [4] N Africa : Algeria, Libya, Morocco (8 brachiopod genera). *Afrique du Nord : Algérie, Libye, Maroc (8 genres de brachiopodes).* [5] Spain (9 brachiopod genera). *Espagne (9 genres de brachiopodes).*[6] N France, Belgium, Germany, Great Britain (7 brachiopod genera, 1 rugose coral species and 6 stromatoporoid species). *Nord de la France, Belgique, Allemagne, Grande Bretagne (7 genres de brachiopodes, 1 espèce de coraux rugueux et 6 espèces de stromatopores).* [7] Volga, Urals, Timan, Russian Platform (5 brachiopod genera and 1 rugose coral species). *Volga Oural, Timan, Plateforme russe (5 genres de brachiopodes et 1 espèce de coraux rugueux).* [8] Alberta, Montana (3 brachiopod genera and 4 stromatoporoid species). *Alberta, Montana (3 genres de brachiopodes et 4 espèces de stromatopores).* [9] Pamir, Chitral, Tibet, Tian-Shan (5 brachiopod genera, 4 rugose coral species and 1 stromatoporoid species). *Pamir, Chitral, Tibet, Tian-Shan (5 genres de brachiopodes, 4 espèces de coraux rugueux et 1 espèce de stromatopores).* [10] Poland, Moravia (3 brachiopod genera and 3 stromatoporoid species). *Pologne, Moravie (3 genres de brachiopodes et 3 espèces de stromatopores).* [11] Kazakstan, Kuznetsk Basin (4 brachiopod genera and 1 stromatoporoid species). *Kazakhstan, Bassin de Kouznesk (4 genres de brachiopodes et 1 espèce de stromatopores).* [12] New Mexico (4 brachiopod genera). *Nouveau Mexique (4 genres de brachiopodes).* [13] New York, Pennsylvania, Iowa (3 brachiopod genera and 1 stromatoporoid species). *New York, Pennsylvanie, Iowa (3 genres de brachiopodes et 1 espèce de stromatopores).* [14] Western Australia : Canning Basin, Bonaparte Gulf, Carnavon Basin (3 brachiopod genera and 1 stromatoporoid species). *Australie occidentale : Bassin de Canning, Golfe de Bonaparte, Bassin Carnavon (3 genres de brachiopodes et 1 espèce de stromatopores).* [15] South China : Guangxi, Sichuan (2 brachiopod genera and 3 stromatoporoid species). *Chine du Sud : Guangxi, Sichuan (2 genres de brachiopodes et 3 espèces de stromatopores).* [16] Eastern Australia : Queensland, Morgan District (3 brachiopod genera). *Australie orientale : Queensland, District de Morgan (3 genres de brachiopodes).* [17] Omolon (2 brachiopod genera and 1 stromatoporoid species). *Omolon (2 genres de brachiopodes et 1 espèce de stromatopores).* [18] Siberia (1 stromatoporoid species). *Sibérie (1 espèce de stromatopores).* [19] Northwest Territories, Yukon, Alaska (1 brachiopod genus, 1 stromatoporoid species). *Territoires du Nord Ouest, Yukon, Alaska (1 genre de brachiopodes et 1 espèce de stromatopores).* [20] Nevada (1 brachiopod genus). *Nevada (1 genre de brachiopodes).*

The Palaeobiogeographic affinities displayed clearly accord with progress in the paleontological studies in the areas discussed. On the other hand, the Famennian palaeogeographical reconstruction used here (Scotese and McKerrow, 1990) is not completely appropriate. Some regions, such as Siberia, where warm benthic water faunas are present, were obviously situated at too high latitudes but in more recent reconstructions, Scotese locates Siberia in lower latitudes. However, it will be difficult to say which faunal differences are due to biogeographic positions and which are due to ecological factors. For that, a better knowledge of faunal communities will be necessary.

Fig. 6. — Affinités paléogéographiques estimées de I (= importante) à V (= faible) indiquées sur la reconstruction paléogéographique proposée par Scotese et McKerrow (1990) pour le Dévonien supérieur (Famennien). 1 à 20 : différentes régions où les faunes frasniennes et famenniennes sont comparées avec celles de même âge en Iran central et oriental avec l'indication sous-jacente du nombre de taxons communs.

Il est manifeste que les affinités paléogéographiques sont clairement liées aux progrès des études paléontologiques dans les régions concernées. Par ailleurs, la reconstitution paléogéographique au Famennien proposée par McKerrow & Scotese (1990) et utilisée ici n'est pas tout à fait satisfaisante. Certaines régions, comme la Sibérie, où des faunes benthiques sont présentes, sont apparemment situées à des latitudes trop septentrionales ; toutefois, dans des reconstructions paléogéographiques plus récentes, Scotese place la Sibérie à des latitudes moins élevées. Enfin, il sera toujours difficile de préciser si les différences observées sont dues à la position biogéographique des faunes concernées ou à des facteurs écologiques liés à l'environnement.

from the Central Mountains in Afghanistan. Rugose corals from these areas were collected by de A. F. de Lapparent, D. Brice and B. Mistiaen and partly described (Brice, 1971) or merely listed (Rohart *in* Mistiaen, 1985).

At the generic level the studied fauna is cosmopolitan in the Frasnian. *Disphyllum, Hexagonaria, Temnophyllum, Sinodisphyllum, Macgeea* have been described in coralliferous areas in Australia, Asia, Europe and North America. *Cystihexagonaria* is here used for *Hexagonaria*-like corals with presepiments which, elsewhere, were referred to as *Donia, Cosjuvia* or *Wapitiphyllum*. *Peneckiella* ? (with relatively large exsert dissepimentarium, consisting of very convex but normal dissepiments, without horseshoe or peneckielloid vesicles) is not known elsewhere. It appears to be close to *Cyathophyllum cylindricum* of Givetian age or lower Frasnian age from Guangxi.

At the specific level, the fauna is more geographically circumscribed. *Disphyllum* sp. 1 is part of a widespread group of *Disphyllum* with short septa and stereozone between the dissepimentatium-tabularium (*Disphyllum virgatum* group). This group is known from western Europe, Australia, Pakistan, Afghanistan at the end of Givetian or at the beginning of Frasnian. *Disphyllum caespitosum tricyclicum* and *Macgeea desioi* occurs in Pakistan (Chitral, Pamir) and Russia (Urals). *Macgeea multizonata* has been reliably identified from Pakistan (Chitral), Afghanistan and Europe. *Hexagonaria taurensis* has been found in the Taurus, Turkey. Geatest similarity is with faunas from the Central Mountains of Afghanistan, five forms occur in the two regions among which are the three species of *Hexagonaria*.

3) Stromatoporoids

Frasnian stromatoporoid faunas are cosmopolitan at the generic level, with genera such as *Actinostroma, Stictostroma, Clathrocoilona, Stachyodes* being often reported from Frasnian reefal environments in Europe and North America, as well as from Asia and Australia. In this regard the stromatoporoid fauna from the Bidu area, and also some stromatoporoid samples collected in the Tabas area, are characteristically Frasnian. When brachiopods occur with the stromatoporoids they are exclusively forms indicative of the lower to middle Frasnian biozone 6 (Brice, 1977).

At the species level this Iranian stromatoporoid fauna has very close affinities with the stromatoporoid fauna described from the Central Mountains and Axial Zone of Afghanistan (Mistiaen, 1985). Five of the eight species recognized in the Iranian material (*Actinostroma filitextum, Stictostroma saginatum, S. brylkini, Stachyodes costulata* and *S. australe*) also occur in Afghanistan. Likewise the fauna is also related to the well known, cosmopolitan Frasnian stromatoporoid fauna of the Old World Realm present in western Europe (Boulonnais and Avesnois in northern France; Dinant and Namur Basins in Belgium; the Holy Cross Mountains in Poland; and Moravia in the Czech Republic), Australia (Canning Basin), South China (Sichuan and Guangxi), and to some extent in North America (Indiana Alberta and the Yukon). It corresponds to the *Syringostromella ? cooperi* biozone discriminated in the Frasnian of the Boulonnais (Mistiaen, 1988); in this area, this (not present in Iran) is always associated with *Stictostroma saginatum* and *Stachyodes australe* and, in the upper part of the biozone, with *Actinostroma filitextum*, three species which are now identified from the Frasnian of Iran.

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ON SOME DEVONIAN (FRASNIAN) STROMATOPOROIDS FROM KERMAN PROVINCE, EASTERN IRAN.

Sur quelques stromatopores dévoniens (frasnien) de la Province de Kerman, Iran oriental.

by Bruno MISTIAEN (*)

(Plates III, IV and V)

Abstract. — The present study is based on material consisting of twenty or so stromatoporoid specimens, collected by de Lapparent, at the beginning of the seventies, in Kerman Province (Bidu River and Ab-Bid sections), in East-Central Iran.

Although stromatoporoids have been noted several times in the Devonian of Iran, until now, no systematic studies have been published. However, *Actinostroma stellulatum* Nicholson, 1886*a*, was identified from the Tabas area by Flügel (1961), and *Amphipora* sp. was cited from the Kerman area, by Wendt *et al.* (1997).

The following stromatoporoids species have been recognized and are here described: *Actinostroma filitextum* Lecompte, 1951, *A.* sp., *Stictostroma saginatum* (Lecompte, 1951), *S. brylkini* (Yavorsky, 1955), *Clathrocoilona* cf. *inconstans* Stearn, 1962, *C.* sp., *Dendrostroma* sp., *Hermatoporella* cf. *pertabulata* (Zukalova, 1971), *Habrostroma dubia* (Lecompte, 1952), *H.* sp., *Stachyodes costulata* Lecompte, 1952, and *Stachyodes australe* (Wray, 1967).

This stromatoporoid fauna clearly shows very close relations (fig. 1) with the Frasnian Afghan stromatoporoid fauna, recognized by Mistiaen (1985) in the Central Mountains and in the Axial Zone, and, more generally, with the well known very cosmopolitan Frasnian stromatoporoid fauna of the Old World Realm (Brice *et al.*, 1999).

Résumé. — *Le matériel sur lequel est basée la présente étude a été collecté au début des années soixante-dix par de Lapparent ; il consiste en une vingtaine de spécimens provenant des coupes de Bidu River et de Ab-Bid, dans la province de Kerman, Iran central.*

La présence de stromatopores a été signalée à plusieurs reprises dans le Dévonien d'Iran. Toutefois, jusqu'à présent, aucune étude systématique ni même aucune détermination spécifique n'a été publiée, à l'exception de Actinostroma stellulatum *Nicholson, 1886, cité par Flügel (1961) dans la région de Tabas. Par ailleurs, Wendt* et al. *(1997) signalent la présence du genre* Amphipora *dans la région de Kerman.*

Dans ce travail, les espèces suivantes sont reconnues et décrites : Actinostroma filitextum *Lecompte, 1951,* A. *sp.,* Stictostroma saginatum *(Lecompte, 1951),* S. brylkini *(Yavorsky, 1955),* Clathrocoilona *cf.* inconstans *Stearn, 1962,* C. *sp.,* Dendrostroma *sp.,* Hermatoporella *cf.* pertabulata *(Zukalova, 1971),* Habrostroma dubia *(Lecompte, 1952),* H. *sp.,* Stachyodes costulata *Lecompte, 1952 and* Stachyodes australe *(Wray, 1967).*

Cette faune de stromatopores présente d'étroites affinités (fig. 1) avec celle reconnue dans le Frasnien des Montagnes Centrales et de la Zone axiale d'Afghanistan (Mistiaen, 1985) et, plus généralement, avec la faune très cosmopolite de stromatopores frasniens du domaine du Vieux Monde (Brice et al., *1999).*

I. — INTRODUCTION

The presence of stromatoporoids has been pointed out several times in Devonian outcrops of East-Central Iran. However, until now, no systematic studies and only one specific determination has been published. *Actinostroma stellulatum* Nicholson, 1886, was identified from the Tabas area by Flügel (1961) associated with some other Devonian fossils (*Macgeea* sp., *Cyrtospirifer* sp., *Icriodus* sp., *Polygnathus* sp., *Hindeodella* sp.). Also from the Kerman province, *Amphipora* sp. was cited by Wendt *et al.* (1997).

II. — DATA ON THE STROMATOPOROIDS OF KERMAN PROVINCE

The studied stromatoporoids were collected during the seventies by de Lapparent, in Kerman Province.Up to now, in this area, the occurrence of stromatoporoids and/or reefal levels, has been pointed out North of Kerman but no systematic study was devoted to these fossils.

1) Huckriede *et al.* (1962) studied several profiles in Kerman Province. In the Hutk section, Northwest of Bidu,

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		Actinostroma filitextum LECOMPTE, 1951	*Stictostroma saginatum* (LECOMPTE, 1951)	*Stictostroma brylkini* (YAVORSKY, 1955)	*Clathrocoilona inconstans* STEARN, 1962	*Hermatoporella pertabulata* (ZUKALOVA, 1971)	*Habrostroma dubia* (LECOMPTE, 1952)	*Stachyodes costulata* LECOMPTE, 1952	*Stachyodes australe* (WRAY, 1967)
IRAN		X	X	X	cf.	cf.	X	X	X
AFGHANISTAN	Axial Zone			Fr					
	Central Mts.	Fr < ?	Fr <	Giv > ?				Giv & Fr	Fr
BELGIUM	Dinant B.	Fr =	Fr >				Giv >	Fr >	Fr
	Namur B.		Fr >					Fr	
FRANCE	Avesnois	Fr =	Fr =						Fr =
	Boulonnais	Fr =	Fr =		Giv >				Fr =
POLAND	Holy Cross Mt						Dev. = & >	Giv & Fr <	Fr
CZECH REP.	Moravia					Fr <		Fr	
RUSSIA	Kutznesk B.			Fr					
	Omolon							Fr	
	Sibena							Dev >	
CHINA	Sichuan	Dev							
	Guangxi						Dev =	Dev >	
	S.W.	Dev >							
	Tibet							Giv.	
AUSTRALIA	Canning B.								Fr
CANADA	Alberta				Fr			Dev = & >	Fr
	Yukon							Giv	
U.S.A.	Indiana						Dev =		

Fig. 1. – The Frasnian stromatoporoid species recognized in Kerman area (eastern Iran) with stratigraphical distribution in other countries. Underlined: type material of the concerned species.
(Giv : Givetian; Fr : Frasnian; < : Lower; = : Middle; > :Upper)

Fig. 1. – Les espèces de stromatopores frasniens reconnus dans la région de Kerman (Iran oriental) et leur répartiotion stratigraphique dans les autres régions. Souligné = maréríel type de l'espèce concernée.
(Giv. : Givétien ; Fr. : Frasnien ; < : inférieur ; = : moyen ; > : supérieur).

they pointed out (p. 59) the presence of stromatoporoids, and proposed (fig. 40) a paleogeographical reconstruction for the Upper Devonian, with distributions of facies, with carbonate facies in the Kerman area and more detrital facies northeastward.

2) Golshani *et al.* (1972) gave a description of the stratigraphical succession in the Bidu area and reported the presence of reefal limestones, with very numerous stromatoporoids and corals, inside a black limestone deposit, about one hundred meter thick, associated with a rich brachiopod fauna, fish scales and plants. All the fauna is Frasnian in age. The authors also added to the paleogeographical reconstruction proposed by Huckreide *et al.* (1962) a barrier reef on the western part of an emerged area, the Lut Desert.

3) Wendt *et al.* (1997) also gave a geological description of the Kerman area and point out the occurrence, in the Bahram Formation, of well developed coral-stromatoporoid biostromes in several sections, with important lateral facies variations, from North to South.

-According to Wendt *et al.* (p. 301), in the **Gerik section**, several biostromes, up to 0.5 m thick, with dome-shaped or digitate stromatoporoids, are present in the lower part (about 40 m) of the Bahram Formation, which is Middle ? and Upper Devonian (Frasnian) in age.

- In the **Hodjedk section,** 15 km southeast of Gerik, the authors point out several biostromes with stromatoporoids, of which *Amphipora* sp. These levels constitute the 30 m thick " Biostrome bearing Member ", lower member of the Bahram Formation.

-In the **Hutk section**, about 25 km South of Gerik, the biostrome facies is much more poorly developed, with only four half-meter beds, Givetian to Early Frasnian in age (Wendt *et al.*, 1997, p. 303).

4) Dastanpour and Basset (1998) also describe succinctly the Gerik section and pointed out the presence of stromatoporoids.

The stromatoporoid fauna studied in this paper was collected from two sections, situated near Bidu village, about 60 km North of Kerman (Brice *et al.*, 1999, fig. 2, 4).

- The **Bidu River section** is located about 10 km East-Northeast of the Gerik section studied by Wendt *et al.* (1967); stromatoporoids samples were collected by de Lapparent in 1971 and 1972.

- The **Ab-Bid section** is situated about 10 km North of the Bidu River section; stromatoporoids samples were collected by de Lapparent in 1973.

Apparently, all the studied material was collected in the geological series attributed by de Lapparent to the Bahram Formation. According to this author's observations, in Bidu River and Ab-Bid sections, the Bahram Formation commences in black, well bedded and marly limestones, overlain by a typical autogenic reefal succession, with successively branched, then massive corals and finally abundant stromatoporoids.

The stratigraphical succession in the two sections (Bidu River and Ab Bid), and the position of the samples are specified by Brice *et al.* (1999, fig. 4).

The studied material consists of twenty or so stromatoporoid specimens. Majority of the specimen are poorly preserved.

III. — DESCRIPTION OF SPECIES

Actinostroma filitextum Lecompte, 1951

(Pl. III, fig. 1-4)

v * 1951 - *Actinostroma filitextum* nov. sp. - Lecompte M., p. 121, pl. 13, fig. 1

1968 - Actinostroma filitextum Lecompte - Flügel E. et Flügel-Kahler E. p. 162. (With synonym list from 1951 to 1968).

? 1974 - *Actinostroma* cf. *filitextum* Lecompte. - Mu A.T *et al.*, p. 223, pl. 103, fig. 7-8.

v. 1976 - *Actinostroma* cf. *filitextum* Lecompte. - Mistiaen B., p. 86, pl. 3, fig. 2-4.

v. 1985 - *Actinostroma filitextum* Lecompte. - Mistiaen B., p. 46, pl. 1, fig. 8-10, pl. 2, fig. 6.

v. 1988 - *Actinostroma* cf. *filitextum* Lecompte. - Mistiaen B., p. 168, fig. 5-7, pl. 20, fig. 1-3, pl. 21, fig. 3-4.

1988 - *Actinostroma filitextum* Lecompte. - Wang Shitao, p. 78, pl. 8, fig. 3a-b.

v. *1993 - Actinostroma filitextum* Lecompte. - Mistiaen B. *in* Brice et al., p. 97.

Material : Only one specimen from Ab-Bid section : I-AB.BR 1.6 (GFCL 3893). Two thin sections.

Description.

1) *External features.* Fragment of a hemispherical specimen reaching at least 10 cm high.

2) *Internal features.*

- **In vertical section** (Pl. III, fig. 1, 2, 3), regular latilamination, about 5 to 8 mm thick, more or less developed, usually expressed by alternation of two successive phases : Zones with well developed, thick and continuous pillars, associated with rectilinear laminae. Zones with thinner pillars, where laminae are more gently undulated and anastomosed.

In thick zones 1 of latilaminae, laminae are regular , plane and about 50 to 80 µm thick (up to 100 µm). In zones 2, they are thinner (30 to 50 µm) more undulated, locally dissepiment-like and commonly anastomosed or rarely reduced to arrangement in a line of dots. Laminae are about 22 to 28 per 5 mm. Pillars show successively two different aspects according to the two zones of the latilamination. In zones 1, they are thick (120-180 µm), continuous, and about 16 to 18 per 5 mm. In zones 2, they are smaller (50 to 100 µm thick), locally confined to one interlaminar space and up to 5 per 1 mm. Nevertheless, pillars can be continuous for 5 mm. Galleries are usually quadrangular, 120-150 µm high and 150-200 µm wide (even more when pillars are not present). No astrorhizae are obviously observable, except some small undulations, one mm wide or less, with numerous small irregular vertical elements. Skeletal is crossed by some vertically aligned oval sections of parasitic worms (*Streptindytes* sp.).

- **In tangential section**, in spite of bad preservation, locally a typical thin hexactinellid network is preserved (Pl. III, fig. 4), where laminae are cut, associated with small rounded sections of pillars (50 to 80 µm in diameter); in other places, pillars are cut like large dots usually 100 to 180 µm in diameter.

3) *Microstructure* appears to be compact to flocculent.

Discussion

Even if not always well expressed, the hexactinellid aspect is present, so the specimen undoubtedly belongs to the genus *Actinostroma* Nicholson, 1886. The presence of two types of pillars is reminiscent of the genus *Bifariostroma* Khalfina, 1968, but in fact it appears that there are only one kind of pillars, which are locally thicker and more continuous.

I connect the Iranian specimen to the species *A. filitextum* Lecompte, 1951. It just slightly differs, from the type material, in the weaker density of the laminae.

Distribution

The holotype of *A. filitextum* comes from the Middle Frasnian of Dinant Basin, Belgium.

The species was also previously described from the Ferques Formation (Du Bois Member), Middle Frasnian, (Boulonnais, North of France); from the " Calcaire noir " of Ferrière-la-Grande, Middle Frasnian (Avesnois, North of France); from the Sin Ghar Formation, Lower ? Frasnian (Central Mountains, Afghanistan); from the Longmenshan Facies, Devonian (Sichuan, South Central China); and from the Upper Devonian of SW China.

Actinostroma ? sp.

(Pl. III, fig. 5-8)

Material : Three specimens from Ab-Bid section: I-AB.BR 1.2 (GFCL 3894); I-AB.BR 1.7 (GFCL 3895); I-AB.BR 1s.5. Five thin sections.

Description

1) *External features.* Fragments of hemispherical specimens, about 5 cm high.

2) *Internal features.* Specimens are very badly preserved; nevertheless it is possible to count, in vertical section, about 18 to 23 laminae per 5 mm and 17 to 19 pillars per 5 mm.

Tangential sections appear very recrystallized in some specimens.

3) *Microstructure* compact to flocculent when not recristallized.

Discussion

I put together, in open nomenclature, these three badly preserved specimens which resemble the preceding species, *Actinostroma filitextum*. They possess in common with this species the same aspect, the same density in pillars, and also the same type of latilamination but more irregular. They differ slightly in the following characters.

A lower density in laminae (18 to 23 per 5 mm against 22 to 28), but this may be caused by the obliquity of the vertical sections;

The presence, in the coenosteum, of zones where laminae appear differently; in some places they appear more undulated, arch-like between pillars, in other places they are thick and straight giving, with pillars, a regular quadratic aspect;

The uncertain presence of hexactinellid network, in tangential section (probably due to the very bad preservation of the material).

Stictostroma saginatum (Lecompte, 1951)
(Pl. III, fig. 9-12; pl. IV, fig. 1-2)

v * 1951 - *Stromatoporella saginata* nov. sp. - Lecompte M., p. 171, pl. 22, fig. 5-7, pl.23, fig. 1-3

1968 - *Clathrocoilona saginata* (Lecompte) - Flügel E. et Flügel-Kahler E., p. 373. (With synonym list from 1951 to 1968).

1971 - *Stromatoporella saginata* Lecompte - Groessens E., p. 3.

1972 - *Stromatoporella saginata* Lecompte - Lacroix D., p. 209.

1957 - *Stromatoporella saginata* Lecompte - Cornet P., p. 17, 156, 158, 185, 187, pl. 12, fig. 8, tabl. 3, an. 2a, 4a, 5a, 6a, 7a.

v . 1976 - *Stromatoporella saginata* - Lecompte. - Mistiaen B., p. 125, pl. 6, fig. 3.

v . *1976* - *Stromatoporella saginata* - Lecompte. - Mistiaen B., *in* Brice et al., p. 144-145.

v . *1977* - *Stromatoporella saginata* - Lecompte. - Mistiaen B., *in* Brice et al., p. 144-147.

? 1983 - *Clathrocoilona* cf. *saginata* (Lecompte) - Stearn C.W., p. 549, fig 5 G-H.

non 1984 - *Clathrocoilona saginata* (Lecompte) - Cockbain A., p. 25, pl. 10 A-D.

v. 1985 - *Stictostroma saginatum* (Lecompte) - Mistiaen B., p. 115, fig. 68-70, pl. VIII, fig. 6-11.

v . 1988 - *Stictostroma saginatum* (Lecompte) - Mistiaen B., p. 176, fig. 10-11, pl. 21, fig. 5-9.

v . *1993* - *Stictostroma saginatum* (Lecompte) - Mistiaen B., *in* Brice et al., p. 97.

Material : Four specimens; three from Ab-Bid section : I-AB.BR 1.1; I-AB.BR 1s.2 (GFCL 3896); I-AB.BR 1s.3; another one doubtful from Bidu River section I-BR.3b.1. Eleven thin sections.

Description.

1) *External features* Small lamellar specimens, the smaller is only 2 mm thick, the largest is 2 cm thick; two specimens are associated with another lamellar stromatoporoid (*Clathrocoilona* cf. *inconstans*).

2) *Internal features*

- **In vertical section**, latilamination is difficult to observe, suggested by alternation of small zones, 1 to 2 mm thick, with thicker and thinner coenosteal elements. Laminae are rectilinear and usually continuous, but interrupted by some foramina; they are 60 to 100 µm thick, and generally 23 to 25 per 5 mm. Pillars, about 80 to 120 µm thick, are poorly superposed, slightly spool shaped but a little wider in their upper part than at the bottom, and spaced 18 to 20 per 5 mm. Galleries are about 120-180 µm high with scarce dissepiments. Astrorhizae are present and are the cause of some undulations in the coenosteum in which some large openings (350 to 400 µm wide) are obvious, prolonged by galleries without pillars and 220 to 300 µm high.

- **In tangential section**, pillars are cut as rounded to irregular dots, 80 to 180 µm in diameter. Some sections of astrorhizal canals (250 to 450 µm wide) are observable.

3) *Microstructure* is compact.

Discussion

The described specimens typically correspond to the genus *Stictostroma* Parks, 1936, emend. Galloway & St. Jean, 1957. They correspond perfectly to the type specimens of *S. saginata* (Lecompte, 1951).

Distribution

The holotype of *S. saginata* comes from the Assise de Frasnes, Upper Frasnian (Dinant Basin, Belgium). The species is also present in the Rhisnes Formation, Upper Frasnian, (Namur Basin, Belgium); in the Beaulieu Formation (Noces Member) and in the Ferques Formation, Middle Frasnian, (Boulonnais, North of France); in the "Calcaire noir" of Ferrière-la-Grande, Middle Frasnian, (Avesnois, North of France); in the Badragha, Sin-Ghar and Cawak Formations, Lower Frasnian (Central Mountains, Afghanistan).

Stictostroma brylkini (Yavorsky, 1955)
(Pl. IV, fig. 3-6)

1955 - *Stromatoporella brylkini* sp. nov. - Yavorsky V.I., p. 119, pl. 63, fig. 1-9, pl. 64, fig. 1.

1968 - *Stromatoporella brylkini* Yavorsky. - Flügel E. & Flügel-Kahler E., p. 52. (With synonym list from 1955 to 1968).

v.1985 - *Stictostroma brylkini* (Yavorsky) - Mistiaen B., p. 111, fig. 65-66, pl.7, fig. 10; pl. 8, fig. 1-5.

Material :Two specimens from Ab-Bid section: I-AB.BR 1.4 (GFCL 3897) and I-AB.BR 1.5 (GFCL 3898). Four thin sections.

Description

1) *External features* Lamellar specimens, about 1.5 to 2 cm thick, associated with lamellar tabulate corals (*Alveolites* sp.).

2) *Internal features*

- **In vertical section**, the specimens show latilaminae, 0,8 to 1 mm thick, in many places separated by algal layers (*Girvanella* sp.). Laminae are 50 to 100 µm thick (sometimes up to 150 µm), commonly interrupted by foramina, 90 to 120 µm wide; generally 20 to 22 per 5 mm. Pillars, 90 to 150 µm thick, and 17 or 18, sometimes 20, per 5 mm. are poorly superposed. Dissepiments are scarce except where they close foramen. Galleries are generally rounded voids 90 to 150 µm high. Astrorhizae are well developed, separated by 8 to 15 mm, and forming small coenosteal undulations; they are not large but very distinct; around astrorizae the structural elements are thicker (up to 250 µm). In these astrorhizae axial canals are wide (300-400 µm, but sometimes up to 750 µm in diameter), with some dissepiments.

- **In tangential section**, usually pillars appear like dark dots 100-180 µm in diameter, sometimes joined together by some dissepiments, but in some places, pillars are smaller and irregular (50 µm in diameter). Laminar

sections show openings corresponding to the foramina. Concentric structures with thick elements characterize the location of astrorhizae where sections of canals reach 300 to 360 µm in diameter.

3) *Microstructure* is compact to flocculent.

Discussion

By their coenosteal density, and the important thickness of coenosteal elements in astrorhizae, the described specimens correspond closely to the type specimen of *S. brylkini* (Yavorsky, 1955). They present some affinities with *Stictostroma saginatum* (Lecompte, 1951), but they clearly differ by thicker elements and well developed astrorhizae.

Distribution

The type material of *S. brylkini* comes from the Kuznetsk Basin (Russia), Frasnian.

The species is also present in the Dewal Formation, Upper Givetian ? (Central Mountains Afghanistan), and in the Frasnian from Ghouk area (axial Zone, Afghanistan).

Clathrocoilona cf. *inconstans* Stearn, 1962
(Pl. IV, fig. 7-9)

cf. 1962 - *Clathrocoilona insconstans* n. sp. - Stearn C.W. p. 15, pl. 7, fig. 1-5, pl. 8, fig. 6-7.

Material : Five specimens; four from Ab-Bid section: I-AB.BR1.1 (GFCL 3899); I-AB.BR 1.4; I-AB.BR 1.13 (GFCL 3900); I-AB. BR 1s.2; one doubtful specimen from Bidu River section: I-BR 3.a.71.16. Thirteen thin sections.

Description.

1) *External features.* All the specimens are lamellar. The biggest reaches about 3 cm thick and more than 15 cm wide.

2) *Internal features*

- **In vertical section** a very well expressed thin latilamination can be observed in whole specimens. Latilaminae are about 1.5 to 2 mm thick, in some specimens a little more (4 mm), with common intercalation of algae layers (*Girvanella* sp.); and lamellar stromatoporoids (*Stictostroma saginatum*). The structure is highly variable within a latilaminae and two successive phases can be distinguished. The lower part of each latilamina (half or third of the latilamina) is in places very dense, without any skeletal element discernible, and locally some small rounded openings reaching about 100 µm in diameter. In the upper part, two or three laminae, rarely more, are visible; they are about 50 to 100 µm thick, often discontinuous, and very variably spaced (2 to 5 per 1 mm). The upper lamina of each latilamina always has a very plane and regular upper surface. Vertical elements, only observable in the upper parts of latilaminae, are about twenty in 5 mm (but also with large variations: 3 to 6 per 1 mm); they are thicker than laminae, generally 90 to 180 µm, but with important variations (60 to 300 µm); they can be straight, spool-shaped and well superposed, but more commonly irregularly disposed and oblique or subdivided. In some places of vertical sections, the coenosteal structure appears more irregular and it is difficult to distinguish laminae or pillars.

- **In tangential section** the laminae present very dense areas with some circular, meandriform and more or less ramified openings, 150 to 250 µm wide; pillars are cut as large rounded dots about 160 to 200 µm in diameter. When the thin section crosses the basal part of a latilamina, very dense areas are observable with some scarce circular or irregular openings 150 to 250 µm wide.

3) *Microstructure* is compact to flocculent; in the best preserved specimen (I-AB.BR1.1), very thin light lines are present in laminae.

Discussion

The Iranian specimens seem to be like *C. inconstans* Stearn, 1962; they differ in that the pillars are apparently a little more numerous (6 to 12 per 2 mm) than in the Canadian species (4 to 9 per 2 mm).

Distribution

The holotype of *C. insconstans* comes from the Moberly Member, Waterway Formation, Lower Frasnian, Alberta, Canada; the species is also present in other Frasnian places in Northwest Territories.

C. inconstans was also described from Boulonnais (North of France), in the Bastien Member of the Blacourt Formation, uppermost Givetian.

Clathrocoilona sp.
(Pl. IV, fig. 11)

Material. Three thin specimens in same sample from Bidu River section : I-BR2.71.2 (GFCL 3901). One thin section

Description.

1) *External features* not observed.

2) *Internal features.*

- **In vertical section**. The three small specimens are very thin lamellas, between 1.5 and 3 mm thick, associated, in the same thin section, with *Dendrostroma* sp., a small fragment of ? *Stachyodes* sp., and a solitary rugose coral. Laminae, 120 to 180 µm thick, are only distinct in some part of the specimens. Vertical elements, not observable everywhere, are about 90 to 250 µm thick. Galleries are rounded or irregular openings. No astrorhizae are observable.

- No tangential section was obtained.

3) *Microstructure* is flocculent to fibrous.

Discussion

With its very thick structure the specimens belongs undoubtedly to the genus *Clathrocoilona* Yavorsky, 1931.

The very small size of the samples do not allow any specific attribution.

Dendrostroma sp.
(Pl. IV, fig. 10)

Material : Two specimens from Bidu River section: I-BR2.71.2 (GFCL 3902)}; I-BR3a.71.14. Two thin sections.

Description

1) *External features* not observed.

2) *Internal features*

- **In longitudinal section**, the branch, 3 mm wide and 12 mm long, is associated, in the same thin section, with *Clathrocoilona* sp., a small fragment of ? *Stachyodes* sp., and a solitary rugose coral. Concentric elements (laminae) are 90 to 150 µm thick and about 3 or 4 per 1 mm. Radial elements (pillars) are irregularly distributed and about 150 µm wide. Galleries with some dissepiments are 125 to 180 µm high. Astrorhizal axial canal, up to 450 µm wide and crossed by dissepiments is well expressed.

- The **transverse section** is 4 mm wide, with a well expresed axial canal, up to 750 µm wide, crossed by numerous dissepiments; laminae, 90 to 120 µm thick, are about 4 to 5 per 1 mm; some like ring-pillar sections, with lumen 90 µm wide, are visible; pillars not superposed are disposed 4 to 5 per 1 mm.

- 3) *Microstructure* appears compact to fibrous.

Discussion

The dendroid morphology, the structural and microstructural features of these samples correspond typically to the genus *Dendrostroma* LECOMPTE, 1952.

Hermatoporella cf. *pertabulata* (Zukalova, 1971)
(Pl. V, fig.1-3)

cf. 1971 *Trupetostroma pertabulatum* sp. nov. Zukalova V., p. 79, pl. 26, fig. 1-4.

Material : Only one specimen from Ab-Bid section : I-AB.BR1.19 (GFCL 3903). Two thin sections.

Description

1) *External features* Small fragment of a flat specimen, about 5 cm wide and 1.5 cm hight.

2) *Internal features*

- **In vertical section** latilamination is not present. Laminae are very thin (30 to 60 µm) and commonly reduced to a microlamina; few of them are thicker (up to 150 µm); they are about 20 or so per 5 mm. The vertical elements, represented by coenosteles, are 150 µm wide, irregularly distributed and difficult to count (2 or 3 per 1 mm). Sometimes they are superposed through 4 or 5 interlaminar spaces. Dissepiments are very numerous, many are convex, and associated with laminae. Normal galleries, about 100 to 180 µm high, are commonly crossed by numerous dissepiments. Well developed and superposed astrorhizae, with numerous dissepiments, characterize this specimen; the axial astrorhizal canals reach 600 to 900 µm wide, and numerous lateral canals, up to 450 µm high, cross the tissue.

- **In tangential section,** the structure is like a screen, with rounded openings 150 to 200 µm wide and common astrorhizal canals (300 to 450 µm wide).

3) *Microstructure.* In vertical section and more in tangential section, the microstructure clearly appears melanospherique, with in some places well arranged dark dots and also some spherical voids reaching 30 to 50 µm wide.

Discussion

The studied specimen is very similar to *Trupetostroma laceratum* Lecompte, 1952 and to "*T.*" *pertabulatum* Zukalova,1971; for that matter, Cockbain (1984) considers *pertabulatum* as a junior synonym of *laceratum*. In his description, Lecompte (1952, p. 229) ascribes to the pillars of *laceratum* a coarse cellular microstructure but, stet to the illustrations, microstructure appears typically vacuolar; so, Stearn (1966*a*), removing a lot of the Lecompte's *Trupetostroma* species from this genus as having cellular tissue, considered that *laceratum* is a true *Trupetostroma*. The macrostructure of *pertabulatum* is very similar to *laceratum*, but the microstructure appears very different. According to Zukalova (1971, p. 79), the microstructure of the tissue, containing vacuities, is specked (= melanospheric) in vertical section. So, *pertabulatum* does not belong to the genus *Trupetostroma* Parks, 1936; the species seems better related to the genus *Hermatoporella* Khromich, 1969 (Stearn, pers. com.) which differs from *Trupetostroma* by laminae very thin, reduced to microlaminae and well developed coenosteles forming a labyrinthine network in tangential section. It also shows some relations with the genus *Pseudotrupetostroma* Khalfina and Yavorsky, 1971, which "differs from *Trupetostroma* Parks, 1936 in its coarsely cellular tissue throughout the coenosteles and their union into a network in tangential section" (Stearn, 1993, p. 218) but the microstructure of the iranian specimen is not coarsely cellular..

The Iranian specimen differs from the Moravian type specimens of *Hermatoporella pertabulata* in the smaller astrorhizae and apparently less superposed pillars.

Distribution

The type material of *Hermatoporella pertabulata* comes from Lower Frasnian of Moravian Karst.

Habrostroma dubia (Lecompte, 1952).
(Pl. V, fig. 4-6)

cf. 1952 - *Stromatopora dubia* nov. sp. – Lecompte M., p. 279, pl. 57, fig. 1-2.

non 1966 - *Ferestromatopora dubia* (Lecompte). – Klovan J.E., p. 25, pl. 8, fig. 1a-b.

1968 - *Stromatopora dubia* Lecompte - Flügel E. & Flügel-Kahler E., p. 141. (With synonym list from 1952 to 1968).

1971 - *Ferestromatopora dubia* (Lecompte). – Kazmierczak J., p. 104, pl. 27, fig. 1a-c.

1979 - *Ferestromatopora dubia* (Lecompte). – Yang & Dong, p. 53, pl. 23, fig. 1-2.

1993 - Habrostroma dubia (Lecompte). Stearn C.W., p. 5.

Material : Ten specimens from Ab-Bid section: I-AB.BR 1.8; I-AB.BR 1.12 (GFCL 1904); I-AB.BR 1.21; I-AB.BR 1.22 (GFCL 1905); I-AB.BR 1.27; I-AB.BR 1.29; I-AB.BR 1.10 I-AB.BR 1.11; I-AB.BR 1.16; I-AB.BR 1.18 (the last four ones are bad preserved). Sixteen thin sections.

Description

1) *External features* All the specimens are lamellar. The biggest reaches about 2.5 cm thick.

2) *Internal features*

- **In vertical section** latilamination is very poorly expressed but can be observed in the distribution of laminae. Laminae, 60 to 120 µm thick, are the most regular coenosteal elements, they are between 19 and 24 (more commonly 20 – 22) per 5 mm, but variously distributed in alternated zones; in some zones they are more distinct, rectilinear and about 5 or 6 per 1 mm, in other zones, they are more irregular and spaced (4 in one mm). Coenosteles, 90 to 150 µm thick, are not superposed and seem very irregularly distributed (mean, 17 to 20 per 5 mm). Galleries are well rounded, about 120 to 150 µm high, with dissepiments more common in zones with irregular laminae. Astrorhizae are numerous and well expressed but also localized in the coenosteum: axial canals, 250 to 350 µm wide, are vertical, straight, and continuous for several centimeters, commonly crossed by dissepiments.

- **In tangential section,** numerous concentric sections of astrorhizal undulations are observable, distant, in some sections, 6 to 8 mm from centre to centre. Laminae present dense areas with numerous foramens, 50 to 120 µm in diameter. Vertical elements are cut as isolated dots or, more commonly as irregular sections more or less connected together and 100 to 150 µm wide. Axial astrorhizal canals are well rounded, 300 to 350 µm in diameter, and locally with numerous lateral bifurcated canals, 250 µm wide, crossed by some dissepiments.

3) *Microstructure* In vertical and tangential sections, microstructure appears clearly melanospherique. Locally, in the best preserved specimens, a microreticulate aspect is observable in vertical section and microcolliculi are visible in tangential section. Dark microlamina is also present in some of the laminae, commonly located at the top of few laminae.

Discussion

These specimens clearly belong to the genus *Habrostroma* Fagerstrom, 1982, but the microreticulate microstructure is not well preserved (that seems common in *Habrostroma* species).

They are very similar to *H. dubia* (Lecompte, 1952); they differ only in the spacing of laminae which are farther apart.

Distribution

The type material of *Habrostroma dubia* comes from the Upper Givetian of the Dinant Basin. The species was also pointed out in the Middle Devonian from U.S.A., the Middle-Upper and the Upper Devonian of Holy Cross Mountains (Poland) and the Middle Devonian from Guangxi (South China).

Habrostroma sp.
(Pl. V, fig. 7-8)

Material : Seven specimens from Ab-Bid section: I-AB.BR 1.3 (GFCL 1906); I-AB.BR 1.17; I-AB.BR 1.20; I-AB.BR 1.25; I-AB.BR 1.26; I-AB.BR 1.28; I-AB.BR 1 s 4. Nine thin sections.

Description

1) *External features.* Lamellar to tabular specimens, up to 4 cm thick.

2) *Internal features.*

- **In vertical section** latilamination is very poorly developped, in places expressed by some that are laminae thicker than usual. Laminae, are 20 to 40 µm thick (up to 60 µm), usually regular but also anastomosed in some places. They are closely spaced (between 24 and 29 per 5 mm). Coenosteles, 60 to 90 µm thick, are rarely superposed and irregularly distributed (up to 6 per 1 mm). Galleries are in most places well rounded, about 120 to 150 µm high, with dissepiments more common in zones with irregular laminae. Astrorhizae are numerous in most samples and distant 6 to 10 mm from centre to centre, but not very large: the central astrorhizal canal reaches 200 to 350 µm in width, crossed by some dissepiments.

- **In tangential section,** numerous concentric sections are observable, where astrorizae are cut. Laminae appear as narrow areas of meandered to riddled appearance. Vertical elements are cut as delicate dot-like to vermiform structures 60 to 90 rarely up to 150 µm wide. Astrorhizal canals, usually 120 to 300 µm wide, merge within a short distance with the galleries.

3) *Microstructure.* In vertical section, the microreticulate microstructure appears locally. The microstructure seems better preserved in tangential sections, where microcolliculi appear clearly in pillars.

Discussion

The described specimens differ from the preceding specimens connected to *H. dubia* (Lecompte, 1952) by thinner and more numerous coenosteal elements.

Stachyodes costulata Lecompte, 1952

v * 1952 - *Stachyodes costulata* nov. sp. – Lecompte M., p. 309, pl. 64, fig. 3, pl. 55, fig. 1-4.

1967 - *Stachyodes costulata* Lecompte – Yavorsky V.I., p. 34, pl. 16, fig. 1-4,; pl.17, fig. 7; pl.18, fig. 1-3.

1968 - Stachyodes costulata Lecompte – Flügel E. & Flügel-Kahler E., p. 167, 565. (With synonym list from 1952 to 1968).

1970 - *Stachyodes costulata* Lecompte – Stearn C.W. & Mehrotra P.N., p. 18, pl. 4, fig. 3-4.

1970 - *Syringostroma ? costulatum* (Lecompte) – Fishbuch M.R., p. 1079, pl. 148, fig. 5-6.

1971 - *Stachyodes (Stachyodes) costulata* Lecompte – Zukalova V., p. 101, pl. 34, fig. 5-6.

1972 - Stachyodes costulata Lecompte – Lacroix D., p. 208.

non 1973 - *Stachyodes costulata* Lecompte – Mistiaen B., p; 74, pl. 3, fig. 5-7 (= *Stachyodes* e. g. *verticillata*)

? 1974 - *Stachyodes costulata* Lecompte – Khromych V.G., p. 62, pl. 16, fig. 1, pl. 17, fig. 2.

1975 - *Stachyodes costulata* Lecompte – Stearn C.W., p. 1663.

1975 - Stachyodes costulata Lecompte – Cornet P., p. 158, 164, 166, 175, 185, tabl. 3, ann. 1a, 4a, 5a, 6a, 7.

1976 - *Stachyodes costulata* Lecompte – Khromych V.G., p. 68, pl. 10, fig. 1, pl. 2,

non 1976 - *Stachyodes* sp. aff. *costulata* Lecompte – Mistiaen B., p. 188, pl. 14, fig. 4-9 (= *Stachyodes australe*)

1979 - *Stachyodes costulata* Lecompte – Yang J. & Dong D., p. 81, pl. 46, fig. 9-10.

1981 - *Stachyodes costulata* Lecompte – Dong. D., p. 109, pl. 5, fig. 5-6.

? 1982 - *Stachyodes costulata* Lecompte – Stock C.W. p. 676, pl. 4, fig. 7-9.

non 1984 - *Stachyodes costulata* Lecompte – Cockbain A.E., p. 28, pl. 19 A-D, 20 A. (= *Stachyodes verticillata* ?).

v. 1985 - *Stachyodes costulata* Lecompte – Mistiaen B., p. 198, fig. 123, pl. 18, fig. 7-8, pl. 19, fig.7-8.

1990 - Stachyodes (Stachyodes) costulata Lecompte – May A., p. 103.

Material : Two samples from Bidu River section : I-BR3.b.1; I-BR3.b.2. Eleven specimens. Two thin sections.

Description

Some very recrystallized circular sections of dendroid coenostea included in a dolomitised (ankerite) limestone.

1) *External features* not observed.

2) *Internal features*

- **In transverse sections**, specimens present two more or less differentiated successive zones. In central zone, elements are not discernible and structure appears very dense. In external zone, laminae can be marked by concentric microlaminae, about 3 or 4 per 1 mm; radial elements (pillars), up to 300 µm thick, are very close together (also 3 or 4 per 1 mm). Some rare galleries, 60 to 150 µm wide, are observable. Axial canal, when present, reaches 400 to 450 µm.

- No longitudinal section was obtained.

3) *Microstructure* is completely hidden by recrystallization.

Discussion

By the general aspect of sections, the specimens belongs undoubtely to the genus *Stachyodes* Bargatzky, 1881.

The specimens are very badly preserved and largely recrystallized, but, in their dimensions and coenosteal densities, they correspond *to S. costulata* Lecompte, 1952.

Distribution

The holotype of *Stachyodes costulata* comes from the Upper Frasnian of the Dinant Basin (Belgium).

The species is also noted in the Frasnian of the South and North borders of the Namur Basin (Belgium); the Givetian and the Lower Frasnian of the Holy Cross Mountains (Poland); the Frasnian of the Moravian Karst (Czech Republic); the Frasnian of Omolon and the Upper Devonian of Ulachan Mountains, Siberia, (Russia); the Middle and Upper Devonian of Alberta and the Olgivie Fm., Givetian of Yukon (Canada); the Dewal and Ghoujerak Fm., Givetian and Frasnian of Central Mountains (Afghanistan); the Kweilin Fm., Upper Devonian of Guangxi (South China) and the Dingzonglong Fm., Givetian of Tibet.

Stachyodes australe (Wray, 1967)
(Pl. VI, fig. 9-10)

v * 1967 – *Keega australe* n. sp. – Wray J.L., p. 18, pl. 3 fig. 1-6, fig-texte 6.

p.p. 1967 – *Syringostroma confertum* Stearn – Stearn C.W., p. 800, pl. 4b.

1969 – *Keega*. – Wray J.L., p. 1368, fig. 15-16.

1970 – *Keega* sp. cf. *Keega australe* Wray - Wray J.L. & Playford P.E. p. 548, pl. 2, fig. 5.

1972 – *Keega* sp. – Machielse S.W., p. 224-226, pl. 16, fig. 1-3, pl. 17, fig. 1-3.

1974a – Stachyodes australe (Wary) – Riding R., p. 572, pl.85, fig.5.

1975 – *Keega*. - Cornet P., p. 153.

1975b – Stachyodes jonelrayi n. sp. – Stearn C.W., p. 1664, pl. 4, fig. 3-6.

v. 1976 – *Stachyodes* sp. aff. *costulata* Lecompte – Mistiaen B., p. 188, pl. 14, fig. 4-9.

v. 1976 – *Stachyodes* sp. aff. *costulata* Lecompte – Mistiaen B. *in* Brice D. *et al.*, p. 145, tabl. 5.

1977 – *Keega*. – Wray J.L., p. 72.

v. *1977 – Syringostroma ? confertum* Stearn – Mistiaen B. *in* Brice D. *et al.*, p. 142, tabl.

1980 – *Keega*. – Mistiaen B., p. 107.

1981 – *Stachyodes*. – Mountjoy E.W. & Riding R., p. 308, fig. 9.

1984 – *Keega*. – Tsien H.H., p. 26.6, fig. 14.

1984 – *Stachyodes australe* (Wray). – Cockbain A.E., p. 28, pl. 18.

1985 – *Keega*. – Mistiaen *in* Bordet *et al.*, p. 16.

1985 – *Stachyodes australe* (Wray, 1967) – Mistiaen B., p. 202, fig-text. 125126, pl. 19, fig. 1-6.

1987 – *Stachyodes (Keega) jonelrayi* Stearn 1975. – May. A., p. 72, fig. 6.

1988 – *Stachyodes (Keega) jonelrayi* Stearn 1975. – May. A., p. 182, fig. 3-4.

1991 – *Stachyodes (Keega) australe* (Wray, 1967) – May A., p. 144, fig. 3.

Material : Two samples from Bidu River : I-BR3a.71.16 (GFCL 1907), I-BR3a.71.17 (GFCL 1908). Two thin section.

Description

1) *External features* not observed.

2) *Internal features*

- **Vertical section.** Small lamellar specimens, 4 to 11 mm thick, with a very dense tissue where skeletal elements are difficult to recognize. Vertical elements (pillars) are placed side by side, and about 5 to 7 per 2 mm; horizontal elements are distinguish by presence of microlaminae (between 8 to 9 per 2 mm). Crescent growth base, 2 to 2.5 mm thick, and with small astrorhizal canals (150 to 180 µm wide).

- **In longitudinal section**, the tissue appears very dense with some astrorhizal canals 120 to 300 µm wide.

3) *Microstructure* is completely hidden by recrystallization.

Discussion

By the general aspect of sections, the specimens belongs undoubtely to the genus *Stachyodes* Bargtzky, 1881.

The specimens are very characteristic of *S. australe* (Wray, 1967), with the presence of a typical crescent growth zone at the bottom.

Distribution

The holotype of *Stachyodes australe* comes from the Frasnian of the Caning Basin (Western Australia).

The species is also reported from many countries. In the Leduc and Grosmont Formations, Frasnian of Alberta (Canada); in the Noces Mb. (Beaulieu Fm.) and the Fiennes, du Bois and Parisienne Mb. (Ferques Fm.), Middle Frasnian, Boulonnais, and in the "Calcaire noir d'Avesnes" Middle Frasnian of Avesnois (North of France); in the Frasnian of Dinant Basin (Belgium); the Frasnian of Poland; in the Badragha, Sin Ghar, Olsenak, Cawak, Dewal and Koh-e Giru Fm., Frasnian of Central Mountains (Afghanistan).

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LEGENDS OF PLATES

PLATE III

Fig. 1 to 4. — *Actinostroma filitextum* Lecompte, 1951

1: Vertical section with succession of thin and thick pillars. Specimen GFCL 3893. Thin section I-AB.BR1.6a. (x 4.5).

Coupe verticale montrant la succession de zones à piliers épais et minces. Spécimen CFCL 3893. Lame mince I-AB.BR1.6a. (x 4,5).

2: Id° (x 10).

3: Id° (x 15).

4: Tangential section with locally "hexactinelloid" network. Same specimen. Thin section I-AB.BR1.6b. (x 10).

Coupe tangentielle avec localement la maille "hexactinelloïde". Même spécimen. Lame mince I-AB.BR1.6b. (x 10).

Fig 5 to 8. — *Actinostroma* ? sp.

5: Vertical section. Specimen GFCL 3895. Thin section I-AB.BR1.7a. (x 4.5).

Coupe verticale. Spécimen GFCL 3895. Lame mince I-AB.BR1.7a. (x 4,5).

6: Id° (x 10).

7: Tangential section. Same specimen. Thin section I-AB.BR1.7b. (x 10).

Coupe tangentielle. Même spécimen. Lame mince I-AB.BR1.7b. (x 10).

8: Tangential section. Specimen GFCL 3894. Thin section I-AB.BR1.2b. (x 37.5).

Coupe tangentielle. Spécimen GFCL 3894. Lame mince I-AB.BR1.2b. (x 37,5).

Fig. 9 to12. — *Stictostroma saginatum* (Lecompte, 1951)

9: Vertical section. Specimen GFCL 3896. Thin section I-AB.BR1s2f. (x 15).

Coupe verticale. Spécimen GFCL 3896. Lame mince I-AB.BR1s2f. (x 15).

10: Id° (x 10).

11: Id° (x 37.5).

12: Tangential section. Same specimen. Thin section I-AB.BR1s2c. (x 10).

Coupe tangentielle. Même spécimen. Lame mince I-AB.BR1s2c. (x 10).

PLATE IV

Fig. 1 and 2. — *Stictostroma saginatum* (Lecompte, 1951)

1: Tangential section. Specimen GFCL 3896. Thin section I-AB.BR1s2c. (x 15).

Coupe tangentielle. Spécimen GFCL 3896. Lame mince I-AB.BR1s2c. (x 15).

2: Punctuated aspect of the section. Id°. (x 37.5).

Aspect punctué de la section. Id°. (x 37,5).

Fig. 3 to 6. — *Stictostroma brylkini* (Yavorsky, 1955)

3: Vertical section with some astrorhizae where skeletal elements are very thick. Specimen GFCL 3897. Thin section I-AB.BR1.4a. (x 4.5).

Coupe verticale, plusieurs azstrorhizes à éléments squelettiques très épaissis. Spécimen GFCL 3897. Lame mince I-AB.BR1.4a. (x 4,5).

4: Vertical section in an astrorhiza. *Id°* (x 10).

Section verticale dans une astrorhize. Id° (x 10).

5: Tangential section, general view. Same specimen. Thin section I-AB.BR 1.4b. (x 4.5).

Coupe tangentielle, aspect général. Même spécimen. Lame mince I-AB.BR 1.4b. (x 4,5).

6: Tangential section of an astrorhizae with large canals. Specimen GFCL 3898. Thin section I-AB.BR1.5b. (x 15).

Section tangentielle dans une astrorhize à larges canaux. Spécimen GFCL 3898. Lame mince I-AB.BR1.5b. (x 15).

Fig. 7 to 9. — *Clathrocoilona* cf. *inconstans* Stearn, 1962

7: Vertical section. Specimen GFCL 3900. Thin section I-AB.BR1.13a. (x 4.5).

Coupe verticale. Spécimen GFCL 3900. Lame mince I-AB.BR1.13a. (x 4,5).

8: Vertical section. Specimen GFCL 3899. Thin section I-AB.BR1.1a. (x 10).

Coupe verticale. Spécimen GFCL 3899. Lame mince I-AB.BR1.1a. (x 10).

9: Tangential section. Same specimen. Thin section I-AB.BR1.1c. (x4.5).

Coupe tangentielle. Même spécimen. Lame mince I-AB.BR1.1c. (x 4,5).

Fig. 10. — *Dendrostroma* sp.

Longitudinal section. Specimen GFCL 3902. Thin section I-BR2.71.2. (x 15).

Coupe longitudinale. Spécimen GFCL 3902. Lame mince I-BR2.71.2. (x 15).

Fig. 11. — *Clathrocoilona* sp.

Vertical section. Specimen GFCL 3901. Thin section I-BR2.71.2. (x 10).

Coupe verticale. Spécimen GFCL 3901. Lame mince I-BR2.71.2. (x 10).

PLATE V

Fig. 1 to 3. — *Hermatoporella* cf. *pertabulata* (Zukalova, 1971)

1: Vertical section. Specimen GFCL 3903. Thin section I-AB.BR1.19. (x 4.5).

Coupe verticale. Spécimen GFCL 3903. Lame mince I-AB.BR1.19. (x 4,5).

2: Id°. (x 10).

3: Tangential section. Same specimen. Same thin section. (x 10).

Coupe tangentielle. Même spécimen. Même lame mince. (x 10).

Fig. 4 to 6. — *Habrostroma dubia* (Lecompte, 1952)

4: Vertical section. Specimen GFCL 1904. Thin section I-AB.BR1.12a. (x 10).

Coupe verticale. Spécimen GFCL 1904. Lame mince I-AB.BR1.12a. (x 10).

5: Vertical section. Specimen GFCL 1905. Thin section I-AB.BR1.22. (x 37.5).

Coupe verticale. Spécimen GFCL 1905. Lame mince I-AB.BR1.22. (x 37,5).

6: Tangential section. Same specimen. Same thin section. (x 10).

Coupe tangentielle. Même spécimen. Même lame mince.

Fig. 7 and 8. — *Habrostroma* sp.

7: Vertical section. Specimen GFCL 1906. Thin section I-AB.BR1.3a. (x 10).

Coupe verticale. Spécimen GFCL 1906. Lame mince I-AB.BR1.3a. (x 10).

8: Tangential section. Same specimen. Thin section I-AB.BR1.3b. (x 10).

Coupe tangentielle. Même spécimen. Lame mince I-AB.BR1.3b. (x 10).

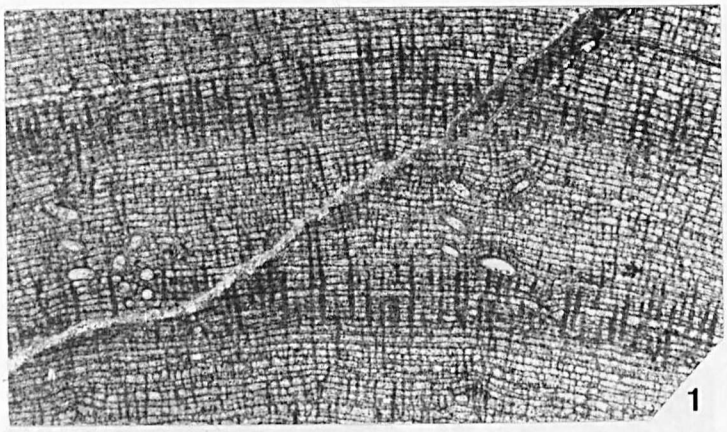
Fig. 9 and 10. — *Stachyodes australe* (Wray, 1967)

9: Vertical section. Specimen GFCL 1908. Thin section I-BR3a.71.17a. (x 15).

Coupe verticale. Spécimen GFCL 1908. Lame mince I-BR3a.71.17a. (x 15).

10: Tangential section. Specimen GFCL 1907. Thin section I-BR3a.71.16b. (x 10).

Coupe tangentielle. Spécimen GFCL 1907. Lame mince I-BR3a.71.16b. (x 10).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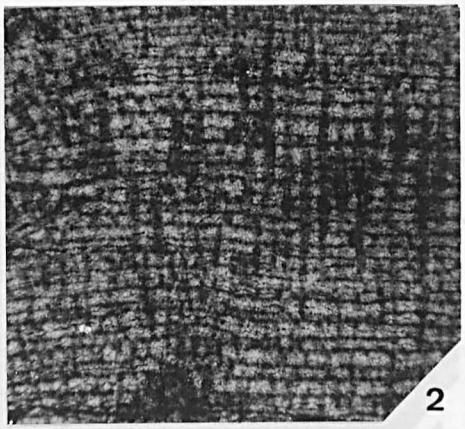
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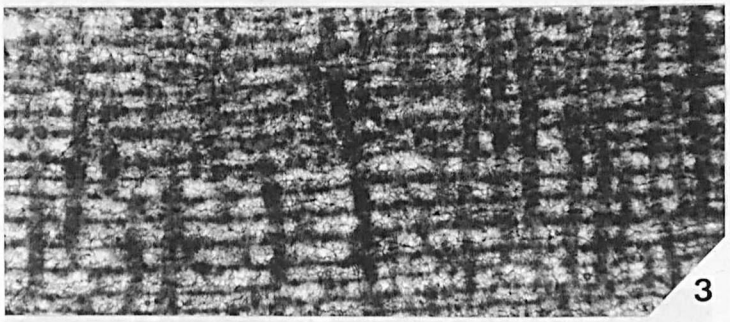
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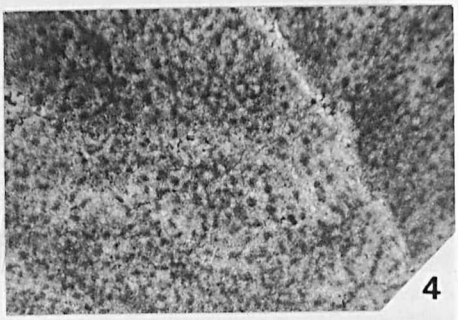
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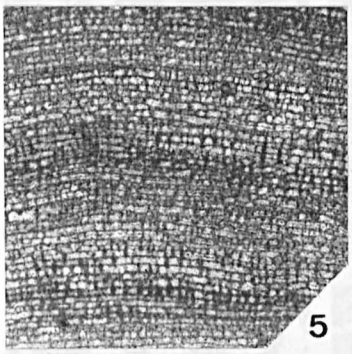
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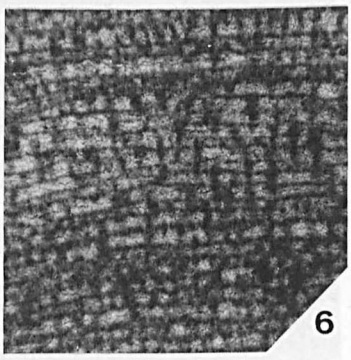
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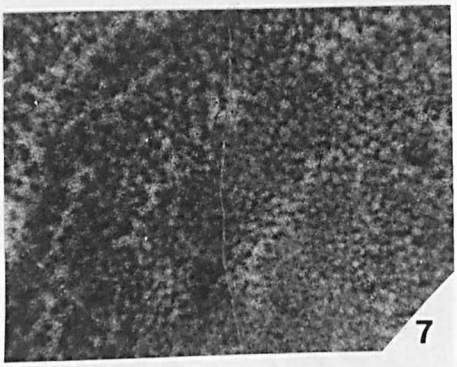
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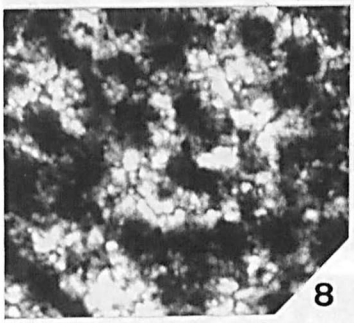
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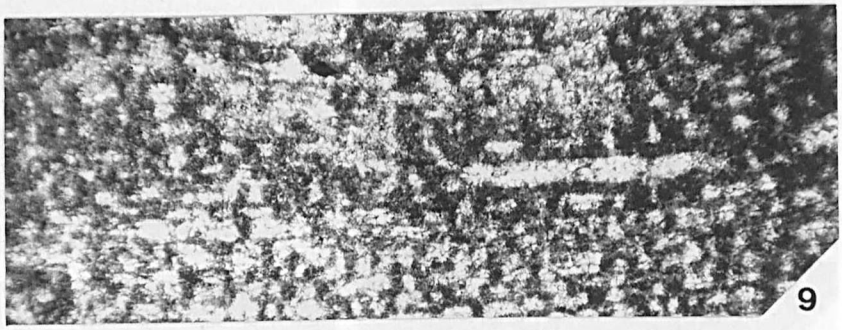
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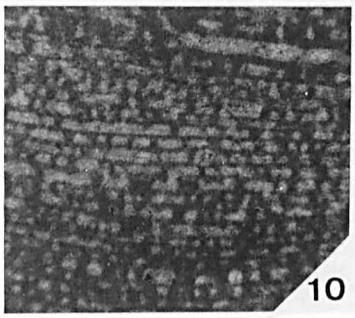
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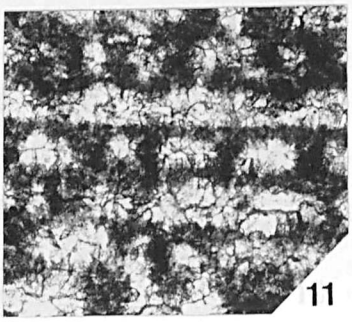
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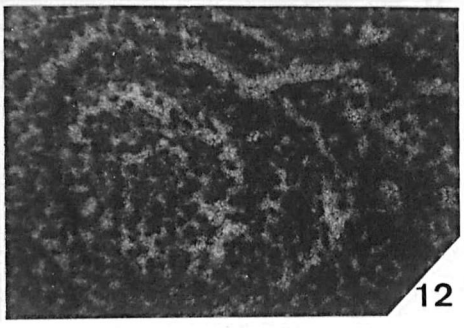
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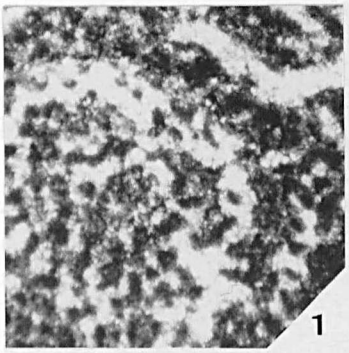
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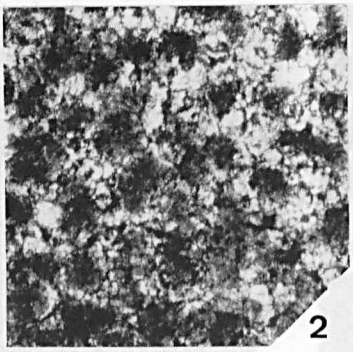
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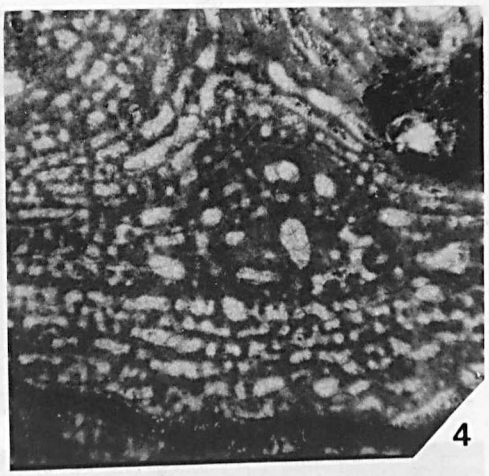
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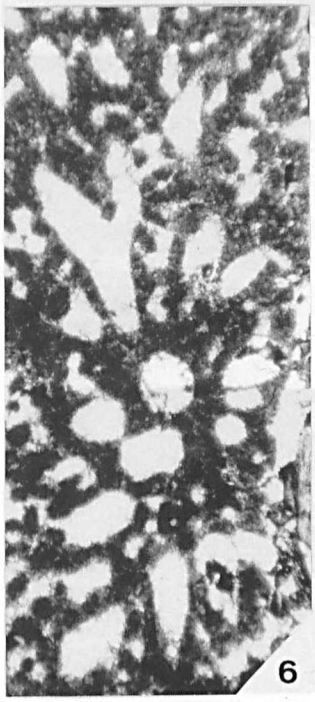
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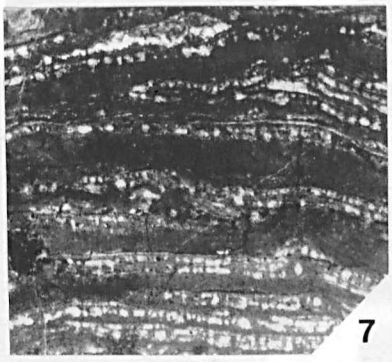
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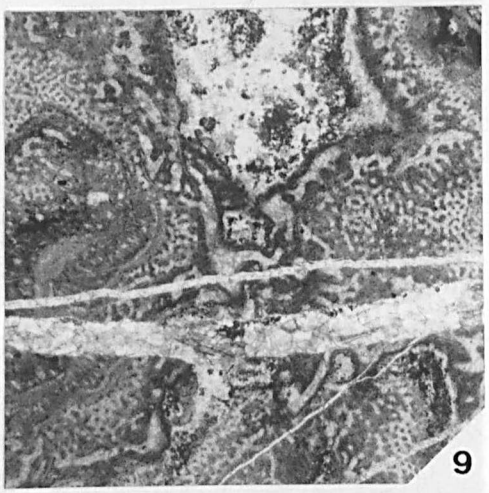
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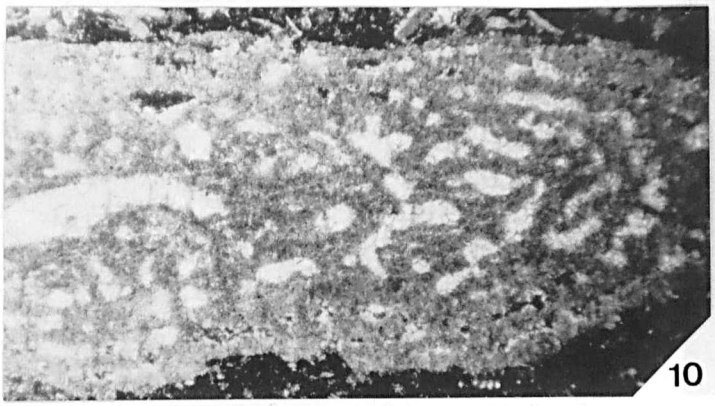
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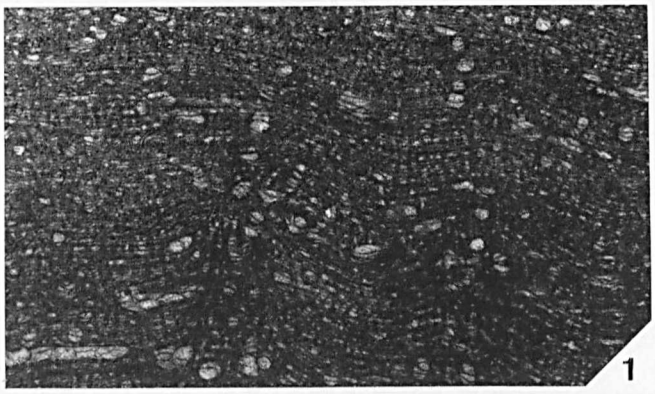
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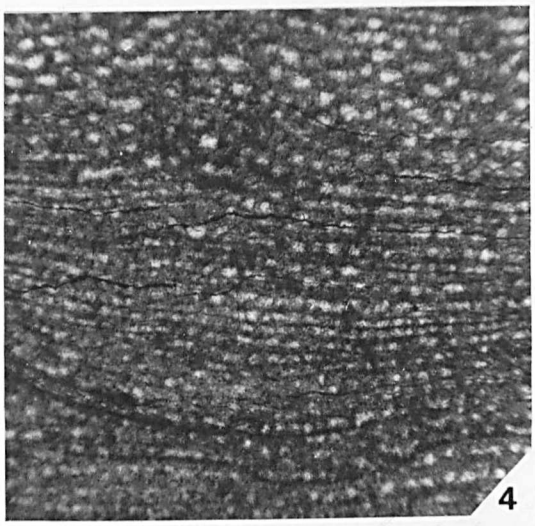
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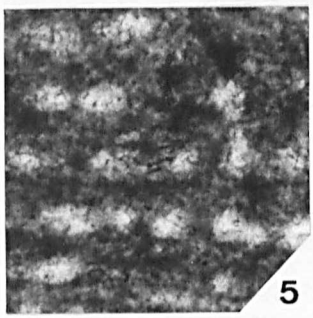
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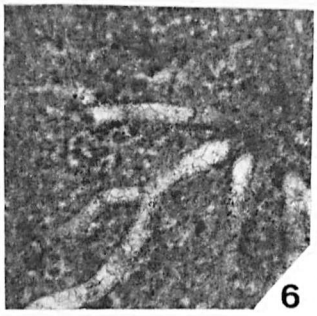
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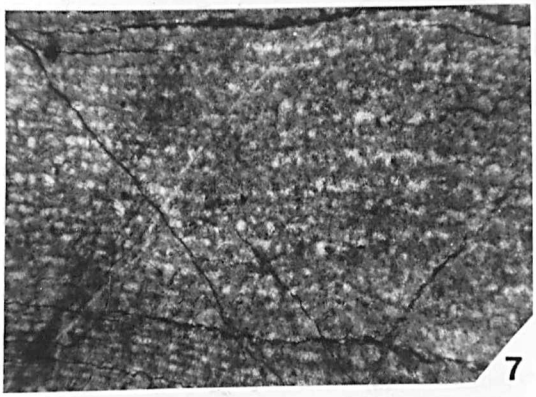
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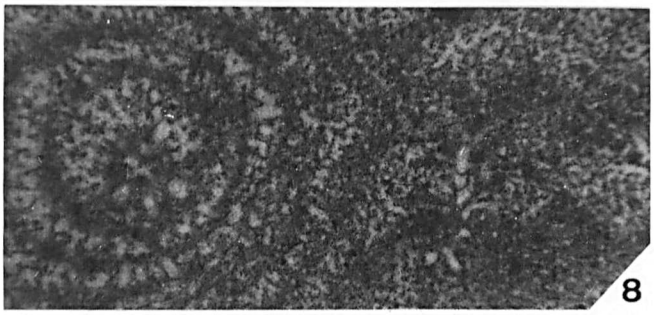
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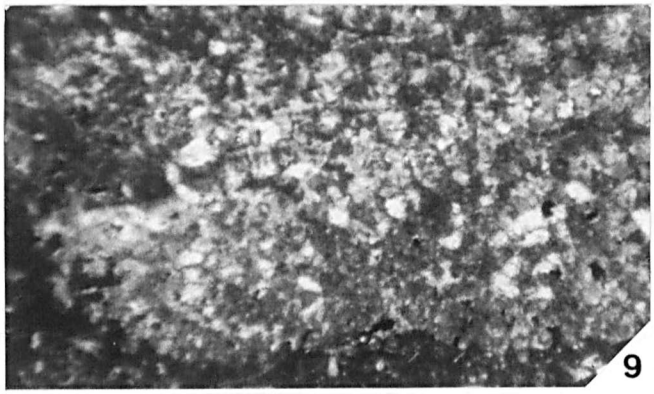
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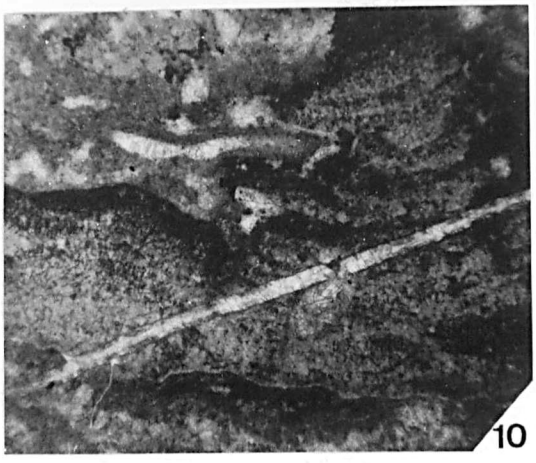
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