Foraminifers and algae from the Khuff Formation (late Middle Permian-Early Triassic) of central Saudi Arabia

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ABSTRACT

Algae and smaller foraminifers of the eponymous Khuff Formation (Saudi Arabia) principally comprise *Permocalculus*, biseriamminids, hemigordiids and lagenids. Due to the end-Capitanian crisis (Late/Middle Permian boundary) and the regional palaeoecology, fusulinids are rare and only represented by *Nankinella* sp. and *Eostaffella?* sp. Palaeofusulinids are completely lacking. New age data shows that these foraminifers correspond to the complete Lopingian (Late Permian) as indicated by several species of *Paradagmarita*. The position of the Triassic/Permian Boundary is approximately characterised, but requires more accurate studies. Forty-three taxa were identified, mostly in open nomenclature. One new species is described: *Glomospirella? linae* n. sp. The foraminiferal assemblage is correlated with several associations in Iran, Turkey, Transcaucasia and south China.

INTRODUCTION

Permian to Triassic sedimentary rocks of the Khuff Formation are exposed in central Saudi Arabia along a North-South belt, some 1,200 km long (Figure 1). The Khuff Formation rests everywhere upon a major unconformity (the Pre-Khuff Unconformity - PKU) over Lower Palaeozoic or Proterozoic shield rocks (Powers, 1968; Powers et al., 1966). The Khuff Formation is conformably overlain by the clayey and evaporitic Lower Triassic (‘Scythian’) Sudair Shale Formation. Le Nindre et al. (1990a, b) published the first synthesis of field work and extensive systematic geological mapping, conducted in the 1980s by the Saudi Deputy Ministry of Mineral Resources (DMMR) and the French Geological Survey (BRGM), including lithostratigraphy, biostratigraphy and palaeoenvironmental reconstructions. More recent compilations from central Saudi Arabia, were interpreted in terms of sequence stratigraphy by Alsharhan and Nairn (1995), Al-Aswad (1997) and Sharland et al. (2001). Sharland et al. (2001) considered the Khuff Formation as part of a tectonic megasequence dominated by thick platform and ramp carbonate, with subordinate evaporitic and clastic deposits.

A complete revision, including new field acquisitions and compilation of local studies for oil exploration (Senalp and Al-Duaiji, 1995, 2001), was prepared by Vaslet et al. (2005). It includes a reassessment of the biostratigraphy based on foraminifers and algae (Vachard et al., 2002, 2003), ostracods (Crasquin-Soleau et al., 2004, 2006) and palaeofloras (Broutin et al., 2002; Berthelin et al., 2006). Vaslet et al. (2005) divided the central Saudi Arabian outcrops of the Khuff Formation (some 200 m thick) into five members, from oldest to youngest: Ash Shiqqah, Huqayl, Duhaysan, Midhnab and Khartam members (Figure 2). The aim of this paper is to build a precise biostratigraphy and systematically describe the foraminifers of the Khuff Formation in Saudi Arabia. Types and figured specimens are housed in the BRGM (Orléans, France) collection.

LITHOSTRATIGRAPHY, BIOSTRATIGRAPHY AND SEQUENCE STRATIGRAPHY OF THE KHUFF FORMATION

The Ash Shiqqah Member (nearly equivalent to the obsolete Unayzah member of the Khuff Formation of Delfour et al., 1982) consists of terrigenous sediments with secondary clayey dolomite and local evaporite in the upper part of the unit. The palaeoenvironments range from transitional to continental and supratidal. The Unayzah Flora (Hill and El-Khayal, 1983; El-Khayal and Wagner, 1985; Broutin et al., 1995), formerly described in the lower part of the Khuff Formation, is now attributed to the underlying Unayzah Formation (Vaslet et al., 2005). Rare benthic smaller foraminifers occur locally in the upper part of the Ash Shiqqah Member, indicating a possible Middle Permian age (Midian) for this lowest unit of the Khuff Formation (Vachard et al., 2002; Vaslet et al., 2005).
The Huqayl Member is subdivided into two sequential units containing calcarenite, gypsiferous claystone, dolomite, and solution breccias related to subsurface evaporites. This marine transgressive unit is tentatively assigned a Late Permian Wuchiapingian (Dzhulfian) age according to its benthic foraminiferal content (Vachard et al., 2002; Vaslet et al., 2005). The Duhaysan Member is the first true Khuff Formation outcrop, central Saudi Arabia.
calcareous subtidal to littoral unit of the Khuff Formation (Le Nindre et al., 1990b), and interpreted as the transgressive unit of the above Midhnab Member (Vaslet et al., 2005). The Duhaysan Member has yielded benthic foraminifers, nautiloid embryos, and abundant bactritids. A Late Permian Wuchiapingian to Changhsingian age is tentatively assigned to the Duhaysan Member (Vaslet et al., 2005). The Midhnab Member displays a succession ranging from marine fossiliferous limestones at the base, toward gysiferous and dolomitic rocks deposited in restricted palaeoenvironments, in the upper part. The lower part of the Midhnab Member is dated by benthic foraminifers as Late Permian Changhsingian (Dorashamian) by Vachard et al. (2002). Locally, in northern central Saudi Arabia, the topmost part of the Midhnab Member presents continental facies including lacustrine limestone, sandstone channels and claystone in meandering river systems and swamps. These facies contain drifted wood and plant remains (Hill and El-Khayal, 1983; Vaslet et al., 1985b; Le Nindre et al., 1990b; Vaslet et al., 2005). Recent descriptions of the Midhnab Flora indicate a Late Permian mixed flora including Cathaysian, Euramerian and Gondwanan plant remains (Broutin et al., 1995, 2002; Berthelin, 2002; Berthelin et al., 2006).

The Khartam Member, the uppermost mainly carbonate unit of the Khuff Formation is subdivided into two marine units characterised by littoral to tidal and intertidal palaeoenvironments. The Lower Khartam Member consists in claystone, dolomite and sands, deposited in supratidal to tidal palaeoenvironments. The Upper Khartam Member is an oolitic, peloidal and bioclastic limestone locally dolomitised, deposited in littoral to tidal and intertidal palaeoenvironments. The Lower Khartam Member yielded rare benthic foraminifers possibly dated as late Late Permian (late Changhsingian) by Vachard et al. (2002), while the Upper Khartam Member, consisting principally of reworked dasycladacean algae thalli Aciculella? sp., is characterised by the appearance of Spiroorbis phlyctaena Brönniman and Zaninetti, a serpulid that is particularly abundant in the Early Triassic rocks in Neo-Tethyan areas.

According to Vaslet et al. (2005), the Khuff Formation consists of four main Depositional Sequences (DS PKh, DS PKm, DS PKk and DS TrS, see Figure 2). The last Depositional Sequence starts with the Khuff Formation and continues in the overlying Sudair Shale Formation. The DS PKh (named after Permian-Khuff-Huqayl) includes the Ash Shiqqah and the Huqayl members. Its basal Sequence Boundary (SB) corresponds to the Pre-Khuff Unconformity (PKU) and it contains the first Late Permian flooding event over central Saudi Arabian outcrop areas (MFI PKh). This flooding interval is located in the basal part of the Huqayl Member and is followed by the regressive evaporitic palaeoenvironments of the Huqayl Member (Le Nindre et al., 1990b; Vaslet et al., 2005).

The DS PKm (named after Permian-Khuff-Midhnab) starts with the deposition of subtidal to littoral Duhaysan Member above an erosive surface at the top of DS PKh, and ends with the regressive supratidal to continental deposits of the upper part of the Midhnab Member. A maximum flooding interval (MFI PKm) is clearly located in the outcrops at the base of the Midhnab Member, with abundant marine fauna including cephalopods and brachiopods (Angiolini et al., 2006; Chirat et al., 2006; Vaslet et al., 2005).

The DS PKk corresponds to the Lower Khartam Member (Permian-Khuff-Khartam), and represents the terminal Late Permian Depositional Sequence in the outcrops of central Saudi Arabia. The basal SB is marked by a return to marine subtidal conditions after the continental break at the end of DS PKm. It contains a maximum flooding interval (MFI PKk) and manifested by marine fauna, including abundant Permian ostracods (Crasquin-Soleau et al., 2005, 2006), bactritids and locally cephalopods (Chirat et al., 2006).

The DS TrS (named after the Sudair Shale Formation) starts with the littoral, tidal to intertidal deposits of the Early Triassic Upper Khartam Member of the Khuff Formation, and ends with the closed-basin, clayey to evaporitic rocks of the Lower Triassic Sudair Shale Formation (Le Nindre et al., 1990b; Vaslet et al., 2005).
Foraminifers and algae from the Khuff Formation, central Saudi Arabia

Figure 2: North-South regional correlation of the five members of the Khuff Formation outcrop sections from the Buraydah to the Wadi Al Mulayh quadrangles, central Saudi Arabia (modified after Vaslet et al., 2005). The members of the Khuff Formation are divided into units that are shown to the right of the sections. The sequence stratigraphy of the Khuff Formation is interpreted in terms of four depositional sequences (DS), three maximum flooding intervals (MFI) and four sequence boundaries (SB).
PREVIOUS STUDIES

Foraminifers were first recorded in the Khuff Formation of Saudi Arabia by Powers et al. (1966), and also reported by Powers (1968), who recognised a Late Permian fauna, while formally defining the unit. In the 1980s, the Saudi Arabian and French geological surveys more precisely positioned the biostratigraphy deduced from Late Permian foraminifer assemblages into the framework of the geological mapping programme of central Saudi Arabia. Foraminifers collected from these field campaigns, were identified by D. Vachard (1982-1983, quoted in Le Nindre et al., 1990b), M. Lys (in Le Nindre et al., 1990b), and A. Roux and C. Gigot (in Delfour et al., 1982). These results were reported and summarised in the explanatory notes of the Saudi Arabian geoscience maps (Delfour et al., 1982; Vaslet et al., 1983, 1985a, 1985b, 1987; Kellogg et al., 1985; Manivit et al., 1985a, 1985b, 1986; Robelin et al., 1994), and the biostratigraphic data and conclusions compiled by Le Nindre et al. (1990a, b). The present micropalaeontological study only investigates the collections made from samples taken in the field by BRGM geologists. More recent references to foraminifers of the Khuff Formation in Saudi Arabia were made by Okla (1992) while describing algae, and by Al-Aswad (1997) who placed the biostratigraphical data into stratigraphic cycles. The poorly diversified but numerous algae were studied by Rezak (1959), Roux (1991) and Okla (1992).

The Khuff Formation of Saudi Arabia was principally attributed to the Colaniella parva biozone (despite the absence of the eponymous zonal fossil), i.e. late Dzhulfian-Dorashamian (Manivit et al., 1986; Broutin et al., 1995). Guides among palaeofusulinids (e.g. Palaeofusulina, Codonofusiella) were never mentioned. The presence of “Colaniella parva? (Colani)” was primarily indicated by Powers et al. (1966) and Powers (1968), but no advanced species of Colaniella was found during our study. The
Foraminifers and algae from the Khuff Formation, central Saudi Arabia

presence of Dzhulfian-aged rocks (in a strict sense), and the location of the Triassic/Permian Boundary within the Iranian equivalent of the Khuff Formation were established by Rosen (1979) in the Iranian part of the Gulf and Fars, and more recently by Virgone et al. (2002) in the Zagros and southern Pars. Another foraminiferal guide-fossil of the latest Permian (= Dorashamian = Changhsingian) (Figure 3), Paradagmarita, was first mentioned by Manivit et al. (1985b, 1986), but apparently neglected.

Alsharhan and Nairn (1995) assigned the Khuff Formation to the “Middle to Late Permian”, but they did not mention any foraminifers. Al-Aswad (1997) listed microfossils including the algae Mizzia and Permocalculus, several species of Globivalvulina and some genera of lagenids. This author assigned the Huqayl and Duhaysan members to a Kazanian age (Figure 4), and the Midhnab and Khartam members to the Tatarian (see Figure 3, for correlation of these names of stages).

Sharland et al. (2001) assigned to the Khuff Formation an age from Ufimian/Kazanian to Early Triassic, and emphasized the following Maximum Flooding Surfaces (MFS): P20 (252.5 Ma) within the Khuff D, P30 (250 Ma) within the Khuff C, P40 (249 Ma) within the Khuff B, and Tr 10 (248 Ma) in the lower part of the Khuff A. Vaslet et al. (2005) redefined maximum flooding intervals from central Saudi Arabian outcrops, reassigning the MFS Tr10 of Sharland et al. (2001) to a Late Permian (late Changhsingian = late Dorashamian) age and discussed new possible correlation with regional MFS as described by Virgone et al. (2002) in the Zagros and southern Pars in Iran.

**ASSEMBLAGES OF MICROFOSSILS**

**Ash Shiqqah Member**

Although relatively diversified, the microfacies are generally devoid of microfossils. These microfacies of the Ash Shiqqah Member are tidalitic micrites locally sandy and peloidal with extracasts of stromatolites and calcrites; dolomicrites, eolian ferruginous sandstones, and calcareous or siliceous sandstones. The rare microfossils are Permocalculus sp., Globivalvulina sp. and hemigordiids.

**Huqayl Member**

The assemblage is characterised by the algae Permocalculus digitatus Elliott, 1955 (Plates 1.1, 1.3 and 1.4), P. solidus (Pia, 1937) (Plate 1.5), P. plumosus Elliott, 1955 (Plate 1.6 and 1.7?) and Mizzia velebitana Schubert, 1909 (Plate 1.2); and the foraminifers Earlandia? spp. (Plates 2.1–2.4, 2.13), Nankinella spp.
Vachard et al.

(Plates 2.15 and 2.20), Globivalvulina cf. graeca Reichel, 1946, Cornuspira sp. (Plates 2.9 and 2.10), Hemigordiellina regularis (Lipina, 1949) (Plates 2.6 and 2.8), Pseudodiniella cf. labensis Pronina-Nestell in Pronina-Nestell and Nestell, 2001 (Plates 5.1 and 5.2), Hemigordius schlumbergeri (Howchin, 1895) (Plate 2.11), Neodiscus aff. qinglongensis Wang, 1976, Agathammina sp., Nodosinelloides aff. concinna (Potievskaia, 1962) (Plate 6.13), N. shikhanica (Lipina, 1949), Polarisella elabugae (Cherdynsetev, 1914) (Plate 6.10), P.? hoae (Trifonova, 1967), Geinitzina sp., Pachyphloia spp. and Ichtysfrondina? sp. (Plate 6.30).

Duhaysan Member

The organic content is composed of algae Permocalculus digitatus (Plate 1.4), P. tenellus (Pia, 1937), P. cf. plumosus (Plate 1.7); of calcispheres Radiospira cf. baslica Reitlinger, 1957 (Plates 2.5 and 2.7); and foraminifers Earlandia? sp., Globivalvulina graeca (Plate 3.1), Septoglobivalvulina? decrouezae (Köylüoglu and Altiner, 1989) (Plates 3.5 and 3.6), Glomospirella? sp. (Plate 4.2), Hemigordius baoqingsensis Wang in Zhao et al., 1981 (Plates 5.4–5.6, 5.11), Neodiscus aff. qinglongensis Wang, 1976 (Plates 5.8–5.10), Pseudodiniella cf. labensis, Agathammina sp., Graecodiscus cf. kotlyarae Pronina-Nestell in Pronina-Nestell and Nestell, 2001 (Plate 2.19), Rectostipulina sp. (Plate 6.8), Nodosinelloides shikhanica (Plate 6.16), Polarisella elabugae, Geinitzina sp., Pachyphloia sp., “Lingulina” cf. semivelata Cherdynsetev, 1914 (Plate 6.33), Robuloides lens Reichel, 1946 (Plate 6.9) and Colaniella cf. minuta Okimura, 1988 (Plates 6.6 and 6.7).

Midhnab Member

This third assemblage is constituted by the algae Permocalculus digitatus (Plate 1.1 and 1.3) and P. plumosus (Plate 1.6) and the foraminifers Earlandia? sp., Eosifella? sp. (Plate 2.14), Nankinella spp., Globivalvulina aff. graeca (Plate 3.13), Dagmaritata shahrezaensis Mohtat-Aghai and Vachard, 2003 (Plate 3.9), Paradagmarita n. sp. (Plate 3.8), Neodiscus aff. qinglongensis (Plates 5.3–5.7), Cornuspira sp., Glomospirella? sp. (Plate 4.1), G.? linae n. sp. (Plates 4.3–4.15, 4.17), Palaeonubecularia n. sp. (Plate 2.18), Hemigordius schlumbergeri, Neohemigordius ex gr. zaninetti (Altiner, 1978) (Plate 2.12), Multidiscus spp., Agathammina spp. (Plate 2.21), Nodosinelloides shikhanica, Polarisella elabugae (Plates 6.3–6.5, 6.20–6.22, 6.32), P. cf. elabugae (Plates 6.23–6.24, 6.31), Protonodosaria cf. proceriformis Gerke, 1959 (Plates 6.18 and 6.35), Geinitzina sp. (Plate 6.14), Pachyphloia spp. (Plate 6.34) and Cryptoseptida? sp. (Plate 6.29) and Colaniella? sp. The gastropod Bellerophon sp. (Plate 7.3) is relatively frequent.

Khartam Member

The Khartam Member contains, at its base and in its lower part, a diversified assemblage composed of Permocalculus sp. (remains), Nankinella? sp., Globivalvulina cf. graeca, G. vonderschmitti Reichel, 1946 (Plate 3.2), Dagmaritata shahrezaensis (Plates 3.10 and 3.15?), Paradagmarita flabelliformis Zaninetti, Altiner and Çatal, 1981 (Plates 3.3 and 3.7), P. monodi Lys in Lys and Marcoux, 1978 (Plate 3.11), P. “sp. 1” (Plates 3.4, 3.12 and 3.14), Glomospirella? linae n. sp. (Plate 4.16), Multidiscus spp. (Plate 2.16 and 2.17), Nodosinelloides cf. concinna (Plate 6.1), N. n. sp.? (Plate 6.17), Polarisella elabugae (Plate 6.2), P.? hoae (Plates 6.11 and 6.19), Protonodosaria cf. proceriformis (Plate 6.15) and Pachyphloia spp. (Plates 6.25–6.28).

The upper part of the Khartam Member contains only Polarisella? hoae (Plate 6.12), below horizons with relatively abundant Spirorbis phlyctaena Brönnimann and Zaninetti, 1972 (Plates 7.4–7.7).

BIOSTRATIGRAPHY

The Ash Shiqqah Member can be dated as late Midian (Figure 5) for two reasons: (1) the continuity with the early Dzhulfian Huqayl Member; (2) the lateral correlation with beds containing schwagerinoid fusulinids (e.g. Vaslet et al., 2005), for example Monodioxodina spp.

The stratigraphical range of Monodioxodina is discussed by Ueno (2003), Ehiro and Misaki (2004) and Pronina-Nestell (personal communication, 2005), but our observations in Afghanistan, Thailand and Timor (Vachard, unpublished) confirm the dating assigned by Kotlyar et al. (1989), i.e. late Midian, correlated with the Lepidolina zone, just before the disappearance of giant keriothecal fusulinids (Sheng, 1992; Jin et al., 1994).
The Huqayl Member is dated as early Dzhulfian by (1) the continuity with the late Dzhulfian Duhaysan Member; and (2) the absence of schwagerinoids, despite the relative diversity of the microfauna. The local marker seems to be *Pseudomidiella cf. labensis*, which appears at the base of the Huqayl Member, and is still present in the Duhaysan Member.

The Duhaysan Member is dated as late Dzhulfian by (1) the superposition to the Huqayl Member; and (2) the presence of very primitive *Colaniella*, considered as late Dzhulfian (e.g. Vachard et al., 2002). The earlier presence of *Colaniella* in the late Midian-early Dzhulfian (Chediya and Davydov, 1982; Jenny-Deshusses and Baud, 1989) was invalidated by the new dating of the beds by means of associated dunbarulid fusulinids *Shindella* (Kotlyar et al., 1999b, and Pronina-Nestell, personal communication, 2003). Contrary to age determination of Kotlyar et al. (1984) or Vachard et al. (2003), these beds are not late Dzhulfian but late Dorashamian in age.

The presence of *Graecodiscus* confirms an interval from Midian to Dorashamian (Vachard et al., 1993a; Pronina-Nestell and Nestell, 2001). *Septoglobivalvulina? decrouezae* is also Murgabian to Dorashamian in age, and only mentioned in the Wuchiapingian of Iran by Mohtat-Aghai and Vachard (in press).

The Midhnab Member is dated Changhsingian (= Dorashamian) by (1) the superposition to the Huqayl Member; (2) the presence of *Paradagmarita*; (3) the presence of *Glomospirella? linae* n. sp. Gaillot (work in progress) considers a late Dzhulfian-Dorashamian distribution for *P. monodi* and several unpublished species, whereas he considers *P. flabelliformis* and *P. "sp. 1"* as Dorashamian fossils. Consequently, the Midhnab Member is controversially dated, i.e., late Dzhulfian or Dorashamian. It is assigned here to Changhsingian in age due to the specific diversification of *Paradagmarita* and the presence of *P. flabelliformis* and *P. "sp. 1"*. This unit probably belongs to the late Changhsingian.

The Lower Khartam Member is typically Changhsingian in age due to the specific diversification of *Paradagmarita* and the presence of *P. flabelliformis* and *P. "sp. 1"*. This unit probably belongs to the late Changhsingian.
Plate 1: Algae from the Khuff Formation of Saudi Arabia.
1.1, 1.3–1.4: *Permocalculus digitatus* Elliott, 1955. 1.1 Longitudinal section and abundant remains. Sample VD 80-87 (4). Midhnab Member (lower part). Early? Dorashamian. Al Huwwah Section (Figure 2). x 38. 1.3: Longitudinal section, cellular files at the stage *Tauridium* Güvenç, 1966. Sample JMA 83-130. Photo 109. Midhnab Member (basal part). Early? Dorashamian. Unayzah Jal Khartam
Changhsingian since the Midhnab Member can be early Changhsingian, due to: (1) to the appearance of *Glomospirella? linae*; and (2) to the latest Permian character of the Lower Khartam Member.

The earliest fossiliferous Triassic levels in the Tethyan region with *Rectocornuspira kahlori* Brönnimann, Zaninetti and Bozorgnia, 1972 and *Cyclogyra? mahajeri* Brönnimann, Zaninetti and Bozorgnia, 1972, are identified in many areas, e.g. central Alborz (Iran), Abadeh region (Iran), northern Italy, Taurus (Turkey). They are related to stromatolitic or thrombolitic microbialites (Brönnimann et al., 1972; Altiner et al., 1979; Marcoux and Baud, 1986; Heydari et al., 2000, 2003; Crasquin-Soleau et al., 2002; Ünal et al., 2003), generally associated with a particular cement of calcite crystals (Heydari and Hassanzadeh, 2003). Until today, they have not been identified in Saudi Arabia.

The Triassic/Permian Boundary could be positioned between the Lower and Upper Khartam members (Figure 5). The basal part of the Upper Khartam Member only yields in the studied samples, a *Polarisella? hoae* (formerly *Dentalina hoi*) in a microfacies that is probably Triassic, according to the criteria of Ünal et al. (2003). The Upper Khartam Member contains the Early Triassic annelid *Spirorbis phlyctaena* (Manivit et al., 1985a, b, 1986; Vaslet et al., 1985b; Broutin et al., 1995). The biostratigraphical subdivisions are summarised in Figure 5.

**SYSTEMATIC PALAEONTOLOGY: ALGAE**

*Genus: Permocalculus Elliott, 1955*

*Type species: Gymnocodium gracile Pia, 1937*

*Permocalculus* spp. (Plates 1.1, 1.3–1.7)

**Remarks:** Contrary to Rezak (1959), Roux (1991) or Okla (1992), only *Permocalculus* was observed in our material. The genera *Gymnocodium* and *Succodium* are apparently lacking. The populations are relatively homogenous, and the different morphotypes indicated here, for example *P. digitatus* and *P. solidus*, could correspond to stages of growth of *P. gracilis* (Pia, 1937) as indicated by Roux (1991). Consequently our material should be reduced to *P. ex gr. gracilis*, moreover true *P. gracilis* is absent in Saudi Arabia. The alga attributed to this species by Delfour et al. (1982, fig. 15) is probably *P. solidus*.

Apparently, several genera or subgenera can correspond to morphotypes or stages of preservation of *Permocalculus: Dzhulfanella* Korde, 1965, *Succodium* Konishi, 1955, *Siamporidium* Endo, 1969, *Tauridium* Güvenç, 1966, *Pyrulites* Mu, 1981, *Nanjinophycus* Mu and Riding, 1983. The *Gymnocodium* of Delfour et al. (1982) and Okla (1992) are probably *P. digitatus*, and the *Succodium* of Okla (1992) seems to correspond to fertile (i.e. with conceptacles) specimens of *P. solidus*. *Gymnocodium* inhabits more marine environments than *Permocalculus* (Vachard et al., 2003).

**Occurrence:** The period of appearance (FAD) of *Permocalculus* is poorly known, probably early Middle Permian (Kubergandian =? Roadian) with the “*Dzhulfanella*” identified by Vachard (1980) and Vachard and Montenat (1981); up to the Latest Permian (see here their presence in the Lower Khartam Member).
Plate 2: Microgranular and porcelaneous foraminifera; calcispheres.

2.1–2.4, 2.13: *Earlandia?* spp. 2.1. Longitudinal section. Sample DV 79-122. Photo 134. Huqayl Member. Early Dzhulfian. Jabal Duhaysan (Figure 2). x 140. 2.2: Longitudinal section. Sample VD 82-189. Photo 37. Huqayl Member (middle part). Early Dzhulfian. Midhnab Section (Figure 2). x 95.
Genus: *Mizzia* Schubert, 1909  
Type species: *Mizzia velebitana* Schubert, 1909

*Mizzia velebitana* Schubert, 1909 (Plate 1.2)

1909 *Mizzia velebitana* n. gen. n. sp. - Schubert, pl. 16, figs. 8–12.
1959 *Mizzia velebitana* Schubert - Rezak, pl. 72, figs. 1–3, 5–6, 8–10, 12, 13, 15–19.
1992 *Mizzia velebitana* Schubert - Okla, pl. 45, figs. 7–10.
2000 *Mizzia velebitana* Schubert - Granier and Grgasovic, p. 102–107 (no illustration) (with synonymy).

Remarks: Very rare specimens are found, especially in the Huqayl Member. According to Okla (1992), the *Mizzia* are more abundant in the Duhaysan Member. Our material does not confirm this fact. “*Mizzia* bramkampi” Rezak, 1959 was not observed in our samples. It is more probably *Gyroporella* or *Eogoniolina*. Consequently, the name “*Mizzia* Schubert 1909, emend. Rezak, 1959” (Granier and Grgasovic, 2000) is considered here as superfluous and therefore only *Mizzia* Schubert was adopted.

Plate 2 (continued): 2.3: Longitudinal section. Sample VD 82-190. Photo 40. Huqayl Member (middle part). Early Dzhulfian. Midhnab Section. x 140. 2.4: Longitudinal section. Sample VD 82-188. Photo 128. Huqayl Member (middle part). Early Dzhulfian. Midhnab Section. x 140. 2.13: Transverse section. Sample VD 82-190. Photo 41. Huqayl Member (middle part). Early Dzhulfian. Midhnab Section. x 140.
2.5, 2.7: *Radiosphaera* cf. *basilica* Reitlinger, 1957. 2.5: Numerous sections in a microfacies. Sample DV 79-77. Photo 137. Duhaysan Member. Late Dzhulfian. Jabal Duhaysan Section. x 140. 2.7: Isolated specimen showing the irregular wall and the spherical central cavity. Sample DV 79-77. Photo 138. Duhaysan Member. Late Dzhulfian. Jabal Duhaysan Section. x 140.
2.6, 2.8: *Hemigordiellina regularis* (Lipina, 1949). 2.6: Axial section. Sample VD 80-40 (9). Huqayl Member (upper part). Early Dzhulfian. Al Quway’iyah Section (Figure 2). x 140. 2.8: Axial section. Sample VD 80-40 (2). Huqayl Member (upper part). Early Dzhulfian. Al Quway’iyah Section. x 140.
2.9, 2.10: *Cornuspira* spp. 2.9: Axial section. Sample VD 82-187. Photo 21. Huqayl Member (middle part). Early Dzhulfian. Midhnab Section. x 140. 2.10: Transverse section. Sample VD 82-189. Photo 35. Huqayl Member. Early Dzhulfian. Midhnab Section. x 140.
2.11: *Hemigordius schlumbergeri* (Howchin, 1895). Axial section. Sample VD 82-188. Photo 29. Huqayl Member. Early Dzhulfian. Midhnab Section. x 140.
2.12: *Neoehemigordius* ex gr. *zanimettiae* (Altiner, 1978). Axial section. Sample JMA 83-130. Photo 105. Midhnab Member (basal part). Early? Dorashamian. Unayzah Jal Khartam Section (Figure 2). x 140.
2.14: *Eostaffella* sp. Axial section. Sample DV 79-52 (8). Midhnab Member (lower part). Early? Dorashamian. Khuff (Wadi Maghib) Section (Figure 2). x 95.
2.15, 2.20: *Nankinella* spp.
2.15: Abraded transverse section. Sample VD 82-189. Photo 38. Huqayl Member (middle part). Early Dzhulfian. Midhnab Section. x 60.
2.20: Recrystallised transverse section. Sample VD 82-189. Photo 34. Huqayl Member (middle part). Early Dzhulfian. Midhnab Section. x 95.
2.16, 2.17: *Multidiscus* spp.
2.16: Axial section. Sample JMA 81-156. Photo 146. Khartam Member (basal part). Late? Dorashamian. Al Quwway’iyah Section. x 140.
2.17: Axial section. Sample JMA 83-131. Photo 112. Midhnab Member (lower part). Early? Dorashamian. Unayzah Jal Khartam Section. x 140.
2.18: *Palaeonubecularia* n. sp. Longitudinal section. Sample VD 80-62. Photo 83. Midhnab Member (basal part). Early? Dorashamian. Wadi Ar Rayn Section (Figure 2). x 95.
2.19: *Graecodiscus* cf. *kotlyarae* Pronina-Nestell in Pronina-Nestell and Nestell, 2001. Axial section. Sample JMA 83-88. Photo 71. Duhaysan Member (middle part). Late Dzhulfian. Buraydah At Tarafiyah Section (Figure 2). x 95.
2.21: *Agathammina* sp. Axial section. Sample VD 80-84 (9). Midhnab Member (middle part). Early? Dorashamian. Al Huwwah Section. x 140.
Dimensions: Outer diameter = 0.630–0.930 mm, inner diameter = 0.430–0.670 mm, wall thickness = 0.100–0.130 mm, pore diameter = 0.040–0.120 mm.

Occurrence: The species and the genus are classically believed to be limited to the Permian, from Asselian to Dorashamian.

SYSTEMATIC PALAEONTOLOGY: “CALCISPHERES”

Genus: *Radiosphaera* Reitlinger, 1957
Type species *Radiosphaera basilica* Reitlinger, 1957

*Radiosphaera* cf. *basilica* Reitlinger, 1957 (Plates 2.5 and 2.7)

cf. 1957 *Radiosphaera basilica* n. sp. Reitlinger, p. 775, fig. 1b.

Remarks: A unique level contains incertae sedis which look like Devonian *Radiosphaera*. This genus disappears in the Early Carboniferous (Mississippian). Its unquestionable presence in the Late Permian would correspond to a Lazarus effect. The morphological similarity is great with *R. basilica*, but the dimensions are smaller (inner diameter of *R. basilica* = 0.140–0.170 mm). By their size and their irregular external walls, these specimens differ from the Permian “calcispheres” of Cirilli et al. (1998).

Dimensions: Outer diameter = 0.090–0.150 mm, inner diameter = 0.045–0.080 mm, wall thickness = 0.020–0.060 mm.

Occurrence: Devonian-Mississippian, cosmopolitan. Discovered in the Duhaysan Member (late Dzhulfian) of Saudi Arabia.

SYSTEMATIC PALAEONTOLOGY: FORAMINIFERS

Genus: *Earlandia* Plummer, 1930
Type species: *Earlandia perparva* Plummer, 1930

*Earlandia*? spp. (Plates 2.1–2.4 and 2.13)

Remarks: Despite the relatively large size, the proloculus is never visible, but the morphological similarities (e.g. size and type of wall) are great with the primitive foraminifer *Earlandia*. Some other authors (e.g. Cirilli et al., 1998), assign the taxon to *Aeolisaccus* Elliott. The correct status of *Aeolisaccus* is not well established, it may be cyanobacteria (Chuvashov et al., 1987) or incertae sedis (Elliott, 1958). Many *Aeolisaccus* of the literature seem to be assigned to *Earlandia*, but proloculi are always lacking. Therefore, we use the name *Earlandia*?. A species of median size of *Earlandia*? in Saudi Arabia is comparable with the Viséan *Earlandia minor* Rauzer-Chernousova, 1948a (Plate 2, figs. 1, 2: Length = 0.500–0.770 mm, Diameter = 0.115–0.130 mm, wall thickness = 0.020 mm). Another one is comparable with “*Aeolisaccus*” *amplimuralis* Pantic, 1972 (Plate 2, figs. 3, 13: Diameter = 0.140–0.160 mm, wall thickness = 0.040–0.050 mm), and the last group, with “*Aeolisaccus*” *tintinniformis* Misik, 1971 (Plate 2, fig. 4: Diameter = 0.060 mm, wall thickness = 0.007 mm).

Occurrence: *Earlandia* is Mississippian-Pennsylvanian. “*Aeolisaccus*” is Middle Pennsylvanian-Permian-Jurassic (e.g. Vachard and Montenat, 1981).

Genus: *Eostaffella* Rauzer-Chernousova, 1948b
Type species: *Eostaffella parastruvei* Rauzer-Chernousova, 1948b

*Eostaffella*? sp. (Plate 2.14)

Remarks: Only one specimen similar to *Eostaffella* or *Mediocris* was found. These two genera disappear respectively in the Early Permian (= Cisuralian) and the Early Carboniferous (= Mississippian). According to Gaillot (unpublished data) several Eostaffellidae are also present in the Lopingian of Iran.
Foraminifers and algae from the Khuff Formation, central Saudi Arabia

Dimensions: Diameter = 0.360 mm, Width = 0.180 mm, W/D = 0.50, proloculus diameter = 0.030 mm, number of whorls = 4.

Occurrence: Midhnab Member (early? Changhsingian) from Saudi Arabia.

Genus: *Nankinella* Lee, 1933
Type species: *Nankinella orbicularis* Lee, 1933

*Nankinella* spp. (Plate 2.15 and 2.20)

? 1983 *Nankinella minor* Sheng - Vaslet et al., p. 18 (no illustration, not seen).
2005 *Nankinella minor* Sheng - Vaslet et al., p. 117 (no illustration).
2005 *Nankinella* sp. - Vaslet et al., p. 115 (fig. 34), 117.

Remarks: The material is poor and somewhat badly preserved. Furthermore, the specimens possibly suffered dwarfism and/or immaturity due to unfavourable environments. They are often abraded (corresponding to the early diagenetic types called *Hayasakina*). Therefore, the taxon is retained in open nomenclature. The last specimen of *Nankinella* (not illustrated here) from the Lower Khartam Member (sample VD 80-45) from the Al Quway‘iyah Section (Figure 2) are more elongate (Diameter up to 1.500 mm and Width/Diameter = 0.40) and are tentatively assigned to *Nankinella*, because of apparently more curved septa.

Dimensions: Diameter = 0.720–0.950 mm, Width = 0.440 mm, W/D = 0.60, number of whorls = 5–6.

Occurrence: Middle Pennsylvanian to Latest Permian, cosmopolitan.

Genus: *Globivalvulina* Schubert, 1921
Type species: *Valvulina bulloides* Brady, 1876

*Globivalvulina graeca* Reichel, 1946 (Plate 3.1 and 3.13?)

1946 *Globivalvulina graeca* n. sp. Reichel, p. 550–553, fig. in text 36, 38, pl. 19, figs. 15–17.
p. 1970 *Globivalvulina graeca* Reichel - Canuti et al., fig. 14, 3, 4, 6 (non fig. 14. 1 = *Septoglobivalvulina gracilis*).
1978 *Globivalvulina graeca* [sic] Reichel - Lin, p. 27, pl. 5, fig. 2.
1979 *Globivalvulina graeca* Reichel - Nguyen, p. 96, pl. 9, figs. 6–9 (with synonymy).
1981 *Globivalvulina graeca* Reichel - Altiner , p. 277–278, pl. 36, figs. 14–17 (with synonymy).
1983 *Globivalvulina graeca* Reichel - Jenny-Deshusses, p. 112, pl. 6, fig. 1 (with synonymy).
1984 *Globivalvulina graeca* [sic] Reichel - Altiner, pl. 1, figs. 13, 14.
1985 *Globivalvulina graeca* Reichel - Trifonova, pl. 1, fig. 6.
v. 1985 *Globivalvulina graeca* Reichel - Vaslet et al., p. 16 (no illustration).
1986 *Globivalvulina graeca* Reichel - Marcoux and Baud, fig. 2 (no illustration).
1987 *Globivalvulina graeca* Reichel - Noé, p. 107, 108, pl. 30, fig. 4.
? 1987 *Globivalvulina aff. G. graeca* Reichel - Panzanelli-Fratoni et al., pl. 6, fig. 7.
1989 *Globivalvulina graeca* Reichel - Kotlyar et al., pl. 4, fig. 8.
1989 *Globivalvulina graeca* Reichel - Köylüoglu and Altiner, pl. 7, figs. 8?, 9, 10.
1990 *Globivalvulina graeca* Reichel - Lin et al., p. 163, pl. 11, figs. 17–21 (with synonymy).
1991 *Globivalvulina graeca* Reichel - Vachard and Ferrière, pl. 1, fig. 9.
1994 *Globivalvulina graeca* Reichel - Fontaine et al., pl. 5, figs. 1, 2.
? 1995 *Globivalvulina cf. graeca* Reichel - Berczki-Makk et al., pl. 8, fig. 4.
1996 *Globivalvulina graeca* Reichel - Leven and Okay, pl. 8, fig. 16.
1999a *Globivalvulina graeca* Reichel - Kotlyar et al., p. 304, 307, 309, 311 (no illustration).
2005 *Globivalvulina graeca* Reichel - Vaslet et al., p. 117 (no illustration).

Remarks: Species of median size, characterised by the small number of whorls (1 to 1.5), the weakly depressed apertural face, and a possible increasing of height in the two last chambers. A population
Plate 3: Biseriamminids of the Khuff Formation of Saudi Arabia.

3.1: *Globivalvulina graeca* Reichel, 1946. Transverse section. Sample DV 79-40 (9). Duhaysan Member. Late Dzhulfian. Khuff (Wadi Maghib) Section (Figure 2). x 140.

3.2: *Globivalvulina vonderschmitti* Reichel, 1946. Axial section. Sample JMA 81-156. Photo 154. Khartam Member (basal part). Late? Dorashamian. Al Quway’iyah Section (Figure 2). x 75.
of the Midhnab Member (Khuff, Wadi Maghib Section, Figure 2) (Plate 3, fig. 13) is larger (Diameter up to 0.630 mm) with less chambers, and the last chamber is more quadratic. It is attributed to G. aff. graeca.

**Dimensions:** Diameter = 0.320–0.470 mm, proloculus = 0.050–0.060 mm, height of last chamber = 0.160–0.200 mm, wall thickness = 0.010–0.020 mm.

**Occurrence:** Middle-Late Permian, Tethyan including New Zealand (Vachard and Ferrière, 1991). Discovered in the Dzhulfian and perhaps the Dorashamian (with G. aff. graeca) of Saudi Arabia.

*Globivalvulina vonderschmitti* Reichel, 1946 (Plate 3.2)

1946 *Globivalvulina vonderschmitti* n. sp. Reichel, p. 556, fig. 37a-e.
1979 *Globivalvulina vonderschmitti* Reichel - Nguyen, p. 95, 96, pl. 9, figs. 1–5 (with synonymy).
1980 *Globivalvulina vonderschmitti* Reichel - Vachard, pl. 29, fig. 17.
1981 *Globivalvulina vonderschmitti* Reichel - Altiner, p. 286–287, pl. 36, figs. 10, 11, 12?, 13 (with synonymy).
? 1983 *Globivalvulina vonderschmitti* Reichel - Jenny-Deshusses, pl. 6, figs. 4, 5, pl. 22, fig. 1 (probably *Septoglobivalvulina* or *Paraglobivalvulinoides*).
1984 *Globivalvulina vonderschmitti* Reichel - Kotlyar et al., pl. 1, fig. 1.
1984 *Globivalvulina vonderschmitti* Reichel - Altiner, pl. 1, fig. 12.
1985 *Globivalvulina vonderschmitti* Reichel - Trifonova, pl. 1, figs. 9, 10.
v. 1985 *Globivalvulina cf. vonderschmitti* Reichel - Vaslet et al., p. 16 (no illustration).
1986 *Globivalvulina vonderschmitti* Reichel - Marcoux and Baud, figs. 2–4 (no illustration).
1985 *Globivalvulina* sp. of *G. vonderschmitti* group - Okimura et al., pl. 1, fig. 10.
1987 *Globivalvulina vonderschmitti* Reichel - Noé, p. 107, 108, pl. 30, fig. 5.
? 1987 *Globivalvulina aff. G. vonderschmitti* Reichel - Panzanelli-Fratoni et al., pl. 6, figs. 5, 6.
non 1987 *Globivalvulina* ex gr. *G. vonderschmitti* Reichel - Panzanelli-Fratoni et al., pl. 6, figs. 9–12 (probably *Charliella*).

Plate 3 (continued): 3.3, 3.4: *Paradagmarita flabelliformis* Zaninetti, Altiner and Çatal, 1981. 3.3: Transverse section. Sample JMA 81-156. Photo 140. Khartam Member (basal part). Late? Dorashamian. Al Quway’iyah Section. x 140. 3.4: Subtransverse section. Sample JMA 81-156. Photo 147. Khartam Member (basal part). Late? Dorashamian. Al Quway’iyah Section. x 140.
3.5, 3.6: *Septoglobivalvulina? decrouezae* (Köylüoğlu and Altiner, 1989). 3.5. Subtransverse section. Sample JD 82-198. Photo 91. Duhaysan Member. Late Dzhulfian. Midhnab Section (Figure 2). x 140. 3.6. Transverse section. Sample JD 82-198. Photo 89. Duhaysan Member. Late Dzhulfian. Midhnab Section. x 140.
3.7, 3.12, 3.14: *Paradagmarita* “sp. 1” Gaillot (work in progress). 3.7: Abraded subtransverse section. Sample JMA 81-156. Photo 144. Khartam Member (basal part). Late? Dorashamian. Al Quway’iyah Section. x 95. 3.12: Subaxial section. Sample JMA 81-156. Photo 141. Khartam Member (basal part). Late? Dorashamian. Al Quway’iyah Section. x 140. 3.14: Abraded subtransverse section. Sample JMA 81-156. Photo 148. Khartam Member (basal part). Late? Dorashamian. Al Quway’iyah Section. x 140.
3.8: *Paradagmarita* n. sp. Transverse section. Sample JMA 83-131. Photo 114. Midhnab Member. Late? Dorashamian. Unayzah Jal Khartam Section (Figure 2). x 95.
3.9, 3.10, 3.15: *Dagmarita? shahrezaensis* Mohtat-Aghai and Vachard, 2003. 3.9: Axial section. Sample DV 79-52 (7). Midhnab Member (lower part). Early? Dorashamian. Khuff (Wadi Maghib) Section. x 75. 3.10: Subaxial section. Sample JMA 81-156. Photo 156. Khartam Member (basal part). Late? Dorashamian. Al Quway’iyah Section. x 95. 3.15: Lateral section. Sample JMA 81-156. Photo 142. Khartam Member (basal part). Late? Dorashamian. Al Quway’iyah Section. x 95.
3.11: *Paradagmarita monodi* Lys in Lys and Marcoux, 1978. Axial section. Sample JMA 81-156. Photo 151. Khartam Member (basal part). Late? Dorashamian. Al Quway’iyah Section. x 140.
3.13: *Globivalvulina aff. graeca* Reichel, 1946. Subtransverse section. Sample DV 79-52 (2). Midhnab Member (lower part). Late Dzhulfian. Khuff (Wadi Maghib) Section. x 95.
1988 *Globivalvulina vonderschmitti* Reichel - Okimura, fig. 3, 5.
1989 *Globivalvulina vonderschmitti* Reichel - Köylüoğlu and Altiner, pl. 7, figs. 5–7.
1989 *Globivalvulina vonderschmitti* Reichel - Kotlyar et al., pl. 2, fig. 27.
1990 *Globivalvulina vonderschmitti* Reichel - Lin et al. p. 164, pl. 11, fig. 39, pl. 12, figs. 1–4.
1991 *Globivalvulina cf. vonderschmitti* Reichel - Vachard and Ferrière, pl. 1, fig. 9.
1993b *Globivalvulina vonderschmitti* Reichel - Vachard et al., p. 97 (no illustration).
1994 *Globivalvulina vonderschmitti* Reichel - Fontaine et al., pl. 21, figs. 4–6.
1995 *Globivalvulina vonderschmitti* Reichel - Berzczi-Makk et al., pl. 8, figs. 1, 3.
1999a *Globivalvulina vonderschmitti* Reichel - Kotlyar et al., p. 309, 312 (no illustration).
non v. 2002 *Globivalvulina vonderschmitti* Reichel - Vachard et al., pl. 1, fig. 16 (probably *Charliella*).
2003 *Globivalvulina vonderschmitti* Reichel - Ünal et al. pl. 1, fig. 13.
2004 *Globivalvulina vonderschmitti* Reichel - Kobayashi, fig. 6, 51.
2005 *Globivalvulina vonderschmitti* Reichel - Vaslet et al., p. 117 (no illustration; not seen).

**Remarks:** Only one specimen found; characterised by its large dimensions, its circular apertural face and its high and wide chambers.

**Dimensions:** Diameter = 0.790 mm, height of last chamber = 0.280 mm, wall thickness = 0.033 mm.

**Occurrence:** Murgabian?-Midian-Dorashamian of the Palaeo-Tethys. Discovered in the Lower Khartam Member (late? Dorashamian) from Saudi Arabia.

**Genus: Septoglobivalvulina** Lin, 1978

**Type species:** *Septoglobivalvulina guangxiensis* Lin, 1978

**Remarks:** *Septoglobivalvulina* differs from microgranular-walled *Globivalvulina* by the subspherical test and the inflated chambers, and differs from *Paraglobivalvulina* by the type of microstructure of the wall, and a less spherical test. The species *G. decrouezae*, which differs from typical *Globivalvulina*, is tentatively assigned here to *Septoglobivalvulina*. Some specimens of *G. globosa* Wang in Zhao et al. (1981) might be synonyms of *G. decrouezae*, with a priority of the first name.

**Septoglobivalvulina? decrouezae** (Köylüoğlu and Altiner, 1989) (Plates 3.5 and 3.6)

p. 1970 *Globivalvulina graeca* Reichel - Canuti et al., fig. 14.1 (non fig. 14. 3, 4, 6 correctly interpreted).
1970 *Globivalvulina* sp. - Canuti et al., fig. 14. 2, 5.
1981 *Globivalvulina globosa* n. sp. Wang in Zhao et al., p. 48 (in Chinese), p. 75-76 (in English), pl. 2, figs. 8-9.
1985 *Paraglobivalvulina mira* Reitlinger - Vaslet et al., p. 16 (no illustration).
1989 *Globivalvulina* sp. Kotlyar et al., pl. 3, fig. 21.
1991 *Globivalvulina decrouezae* n. sp. Köylüoğlu and Altiner, p. 479-481, text-fig. 8 A-H, J-K, pl. 7, fig. 14.
1990 *Globivalvulina globosa* Wang - Lin et al., p. 162, pl. 11, figs. 26-29.
1991 *Paraglobivalvulina?* sp. - Vachard and Ferrière, p. 2, fig. 2.
1993 *Globivalvulina or Paraglobivalvulina?* - Fontaine et al., fig. 5E.
1993 *Paraglobivalvulina mira* Reitlinger - Fontaine et al., fig. 6F.
1994 *Paraglobivalvulinoides?* - Fontaine et al., pl. 47, fig. 7.
1998 *Globivalvulina decrouezae* Köylüoğlu and Altiner - Altiner and Özkan-Altiner, pl. 3, fig. 23.
2004 *Globivalvulina globosa* Wang - Zhang and Hong, p. 70, pl. 1, figs. 24-26.
2005 *Septoglobivalvulina decrouezae* (Köylüoğlu and Altiner) - Mohtat-Aghai and Vachard, pl. 2, fig. 17.

**Remarks:** Small, subspherical, biseriate test, coiled in a trochoid spire incompletely involute. Interseptal chamberlets are small. Wall very thin, microgranular. Only two specimens, both illustrated here.

**Dimensions:** Larger diameter = 0.340–0.360 mm, smaller diameter = 0.230–0.275 mm, wall thickness = 0.007–0.015 mm.
**Foraminifers and algae from the Khuff Formation, central Saudi Arabia**

**Occurrence:** Murgabian-Dorashamian of southern Turkey (e.g. Köylüoglu and Altiner, 1989; Ünal et al., 2003; Canuti et al., 1970), Thailand and Malaysia (Fontaine et al., 1993, 1994). Late Midian of Transcaucasia (Kotlyar et al., 1989). Midian of New Zealand (Vachard and Ferrière, 1991), Dorashamian of Greece (Altiner and Özkan-Altiner, 1998). Changhsingian of South China (Lin et al. 1990). Wuchiapingian of Iran (Mohtat-Aghai and Vachard, 2005). Discovered in the Duhaysan Member (late Dzhulfian) from Saudi Arabia.

**Genus: Dagmarita Reitlinger, 1965**

*Dagmarita? shahrezaensis* Mohtat-Aghai and Vachard, 2003 (Plates 3.9, 3.10, 3.15?)

**Remarks:** This *Dagmarita* is devoid of a horn-like expansion. This character is of generic rather than of specific significance. Therefore, the taxon is denominated here *D.? shahrezaensis*.

**Dimensions:** Height = 0.620–0.800 mm, Width = 0.230–0.450 mm, whorls = 4–5 pairs.

**Occurrence:** Dzhulfian-Dorashamian of Iran, Himalaya, Transcaucasia, South China and Malaysia. Discovered in the Midhnab and Lower Khartam members (Dorashamian) of Saudi Arabia.

**Genus: Paradagmarita Lys in Lys and Marcoux, 1978**

*Paradagmarita flabelliformis* Zaninetti, Altiner and Çatal, 1981 (Plates 3.3 and 3.7)

**Remarks:** Test biseriate, secondarily coiled in an involute spire. Juvenarium with a small distortion. Adult chambers enlarged in the equatorial plane giving the characteristic flabelliform shape.

**Dimensions:** Height = 0.535 mm, Width = 0.195 mm.

**Occurrence:** Latest Dzhulfian-Dorashamian of Turkey. Discovered in the Lower Khartam Member (late? Dorashamian) of Saudi Arabia.

**Paradagmarita n. sp.** (Plate 3.8)

? 1978 *Paradagmarita* sp. 2 - Lys in Lys and Marcoux, p. 1420, pl. 1, figs. 1–5.
? 1988a No legend - Pronina, pl. 2, fig. 14.
? 1989 *Paradagmarita* sp. - Pronina, pl. 1, fig. 14.
\v 2005 *Paradagmarita* sp. - Vaslet et al. p. 77, 115 (fig. 34), 117, 118 (fig. 35), 127 (no illustration).
**Remark:** This new species differs from *P. flabelliformis* by the wider and more trochoid uncoiled part, and the shorter initial coiled part.

**Dimensions:** Height = 0.700 mm, Width = 0.560 mm, proloculus diameter = 0.030 mm, height of last chamber = 0.100 mm, 7 chambers in the arcuate part, 10? in the rectilinear biseriate part.

**Occurrence:** Only one section in the Midhnab Member (early? Dorashamian) from Saudi Arabia.

*Paradagmarita monodi* **Lys in Lys and Marcoux, 1978** *(Plate 3.11)*

1978 *Paradagmarita monodi* n. sp. Lys in Lys and Marcoux, p. 1419, 1420, pl. 1, fig. 2.
1981 *Paradagmarita monodi* Lys in Lys and Marcoux - Zaninetti, Altiner and Çatal, p. 6, 7, pl. 2, fig. 6, pl. 3, figs. 9–23.
1981 *Paradagmarita monodi* Lys in Lys and Marcoux - Altiner, p. 295, 296, pl. 38, figs. 1–15.
1984 *Paradagmarita monodi* Lys in Lys and Marcoux - Altiner, pl. 1, figs. 1, 2.
non 1985 *Paradagmarita monodi* Lys in Lys and Marcoux - Okimura et al., pl. 1, fig. 16 (probably a teratogenic *Globivalvulina*).
1986 *Paradagmarita monodi* Lys in Lys and Marcoux - Marcoux and Baud, figs. 2–4 (no illustration).
1986 *Paradagmarita monodi* Lys in Lys and Marcoux - Manivit et al., p. 14 (no illustration; not seen; mentioned in the Duhaysan Member).
1988 *Paradagmarita monodi* Lys in Lys and Marcoux - Loeblich and Tappan, pl. 230, fig. 6.
1989 *Paradagmarita monodi* Lys in Lys and Marcoux - Köylüoğlu and Altiner, pl. 6, figs. 1–8.
1996 *Paradagmarita monodi* Lys in Lys and Marcoux - Rauzer-Chernousova et al., p. 72, pl.18, fig. 14.
2003 *Paradagmarita monodi* Lys in Lys and Marcoux - Ünal et al., pl.1, figs. 1, 2.
 v. 2005 *Paradagmarita monodi* Lys in Lys and Marcoux - Vaslet et al., p. 117 (no illustration; not seen; mentioned in the Duhaysan Member).

**Remarks:** Wall simple, microgranular. Small specimen, which is considered here as a juvenile of *P. monodi*.

**Dimensions:** Height = 0.330 mm, Width = 0.185 mm, number of whorls = 3 pairs.

**Occurrence:** Taurus (Turkey), Zagros (Iran), Dzhulfian-Dorashamian. The specimen of Oman, not illustrated (Montenat et al., 1977), is probably misinterpreted because its association with late Midian *Shanita* is theoretically impossible (Gaillot and Vachard, unpublished data).

*Paradagmarita* “sp. 1” **(Plates 3.4, 3.12, 3.14)**

**Remarks:** *P. sp. 1* differs from *P. flabelliformis* by the thicker septa often microsparitised. The specimens are here peripherically abraded.

**Dimensions:** Maximal length of a fragment = 0.500 mm, septa thickness = 0.040–0.055 mm.

**Occurrence:** Dorashamian of Iran (Gaillot, unpublished data). Discovered in the Lower Khartam Member (late? Dorashamian) of Saudi Arabia.

**Genus:** *Cornuspira* Schultze, 1854

**Type species:** *Orbis foliaceus* Philippi, 1844 (see Loeblich and Tappan, 1988)

**Remarks:** Contrary to Pronina (1999), *Cornuspira*, a porcelaneous foraminifer, is not a synonym of *Pseudoammodiscus*, with a microgranular test. They belong to two different orders, respectively Milliolid and Fusulinida of the subclass Foraminifera.

*Cornuspira* sp. **(Plates 2.9 and 2.10)**

**Remarks:** Test small, biumbilicate, with relatively numerous and narrow whorls.
Foraminifers and algae from the Khuff Formation, central Saudi Arabia

Dimensions: Diameter = 0.160–0.190 mm, Width = 0.060 mm, w/D = 0.38, proloculus diameter = 0.075 mm, whorls = 4.5–5.

Occurrence: Early Pennsylvanian (Bashkirian) to Recent.

Genus: *Hemigordiellina* Marie in Deleau and Marie, 1961 emend. Vachard and Beckary, 1991 (= *Glomospira* Rzehak, 1885 of the authors)
Type species: *Glomospira diversa* Cushman and Waters, 1930

*Hemigordiellina regularis* (Lipina, 1949) (Plate 2.6 and 2.8)

1949 *Glomospira regularis* n. sp. Lipina, p. 205, pl. 2, fig. 6.
1978 *Glomospira regularis* Lipina - Lin, p. 11, pl. 1, fig. 8.
1990 *Glomospira regularis* Lipina - Lin et al., p. 119, pl. 1, figs. 36–38 (with synonymy).
? 2001b *Pseudoagathammina regularis* (Lipina) - Vachard and Krainer, pl. 4, figs. 16, 17, 19-21.
? 2004 *Glomospira regularis* Lipina - Zhang and Hong, p. 67, pl. 1, figs. 1–3 (more probably *Neodiscus*) (with synonymy).
v. 2005 “*Glomospira*” - Vaslet et al., p. 115, fig. 34 (no illustration).

Remarks: Porcelaneous test, streptospirally but relatively regularly coiled.

Dimensions: Diameter = 0.240–0.265 mm, proloculus = 0.050 mm, height of the last whorl of the tube = 0.050 mm, wall thickness = 0.007 mm.

Occurrence: From Early Permian (Lipina, 1949) to Late Triassic (Salaj et al., 1983).

Genus: *?Glomospirella* Plummer, 1945
Type species: *Glomospira umbilicata* Cushman and Waters, 1927

*Glomospirella?* spp. (Plates 4.1 and 4.2)

Remarks: Some undetermined specimens having the coiling of *Glomospirella* are present, but *Glomospirella* is theoretically agglutinated and not porcelaneous. The misinterpreted *Pseudovidalina* spp. and *Raphconilia?* sp. of Kobayashi (2002: figs. 9.1–7) might belong to *Glomospirella?*. Moreover, true *Pseudovidalina* and *Raphconilia*, which are synonyms (Pinard and Mamet, 1998; Vachard and Krainer, 2001a), differ from this genus.

Occurrence: Duhaysan and Midhnab members of Saudi Arabia (Dzhulfian-Dorashamian).

*Glomospirella? linae* Vachard and Gaillot n. sp. (Plates 4.3–4.17)

1978 *Glomospirella spirillinoides* Lipina - Lin, p. 12, pl. 1, figs. 11–12.
1981 *Glomospirella spirillinoides* (Grozdilova and Glebovskaya) - Zhao et al., pl. 1, figs. 8, 9.
v. 2005 “*Glomospirella spirillinoides*” (Grozdilova and Glebovskaya) - Vaslet et al., p. 77, 115 (fig. 34), 117, 118 (fig. 35), 127 (no illustration).

Etymology: Dedicated to Mrs. Jiaxing Lin, eminent specialist of the Chinese Permian microfauna.

Type level: Lower part of the Midhnab Member, early? Dorashamian from Saudi Arabia.

Type locality: Al Huwwah Section, Saudi Arabia (Figure 2).

Holotype: Plate 4, fig. 6 (Sample VD 80-84. Photo 11).

Diagnosis: The species is characterised by its relative large size, compared to the small irregular stage. The cross section of the tube is hemi-circular to bean-shaped. The wall is relatively thick.
Plate 4: *Glomospirella?* of Khuff Formation.

4.1, 4.2: *Glomospirella?* spp. 4.1. Axial section. Sample JMA 83-130. Photo 101. Midhnab Member (basal part). Early? Dorashamian. Unayzah Jal Khartam Section (Figure 2). x 140. 4.2: Subaxial section. Sample DV 79-42 (1). Duhaysan Member. Late Dzhulfian. Khuff (Wadi Maghib) Section (Figure 2). x 140.

4.3–4.17: *Glomospirella? linae* n. sp. 4.3: Numerous sections in a microfacies, associated with *Permocalculus* sp. Sample VD 80-84 (1). Midhnab Member (middle part). Early? Dorashamian. Al
Description: Test discoidal, generally deeply biumbilicate. The initial irregularly coiled initial part is reduced to 1–2 oscillating whorls; the diameter of the initial part does not exceed 1/5 of the test diameter. The adult second part is constituted by 4–5 aligned to planispiral whorls. The width and height of deuterolocus increases slowly. The transverse section of this deuterolocus is hemicircular to bean-shaped. Proloculus is spherical and relatively large, but megalo- and microspheric specimens exist. Wall porcelaneous relatively thick. Some well-preserved specimens have their primary porcelaneous (amber-coloured), becoming black (Plates 4.11, 4.14 and 4.15).

Dimensions: Diameter = (0.350–0.435) 0.520–1.180 mm, Width = (0.100–0.110) 0.120–0.220 mm, W/D = 0.16–0.21 (0.22–0.26), number of whorls = (4–4.5) 5.5–7, proloculus diameter = 0.020–0.050 mm, height of last whorl = (0.040) 0.060–0.100 mm, wall thickness = (0.005) 0.010–0.030 (0.050) mm.

Material: Abundant (approximately 200 specimens) in the thin section VD 80-84 from Al Huwwah Section (Figure 2, and Plates 4.3–4.10); also found in several other localities (Plates 4.11–4.17).

Comparisons: Differs from all other Glomospirella (in a broad sense) described in the literature by the weak initial deviation and the numerous aligned whorls; differs from Brunsia spirillinoides (Grozdilova and Glebovskaya) by the wall porcelaneous and not microgranular (i.e., by the membership to the order Miliolida and not to the order Fusulinida). Differs from Glomospirella? spp. mentioned above, by its dimensions, and the number of whorls compared to the size.

Occurrence: Dorashamian (Midhnab and Lower Khartam members) of Saudi Arabia. Changhsinghian of South China.

Genus: Palaeonubecularia Reitlinger, 1950
Type species: Palaeonubecularia fluxa Reitlinger, 1950

Palaeonubecularia n. sp. (Plate 2.18)

Remark: A sessile species with a long, irregularly coiled deuterolocus. The dimensions of the deuterolocus increase gradually in height and width during the growth. The most closely packed first whorls form a juvenarium. The porcelaneous wall is often recrystallised in anhydrite.
Plate 5: Porcelaneous (i.e., order Miliolida) of the Khuff Formation of Saudi Arabia.

5.1, 5.2: *Pseudomidiella cf. labensis* Pronina-Nestell *in* Pronina-Nestell and Nestell, 2001. 5.1: Axial section. Sample VD 82-180. Photo 17. Huqayl Member (basal part). Early Dzhulfian. Midhnab Section (Figure 2). x 140. 5.2: Transverse section showing the pseudosepta. Sample DV 79-122. Photo 135. Huqayl Member (upper part). Jabal Duhaysan Section (Figure 2). x 140.
Palaeonubecularia n. sp. differs from P. rustica Reitlinger, by the coiled juvenarium, different size parameters and the Late Permian age. This species builds some small foraminiferal boundstones in Iran (Gaillot, unpublished data).

**Dimensions**: Maximal length of the test = 0.675 mm, maximal length of juvenarium = 0.265 mm, maximal height of the deuteroloculus = 0.150 mm, maximal thickness of whorl = 0.085 mm.

**Occurrence**: Latest Midian-Dzhulfian of Iran (Gaillot, work in progress). Discovered in the Midhnab Member (early? Dorashamian) of Saudi Arabia.

**Genus: Hemigordius Schubert, 1909**

**Type species**: Cornuspira schlumbergeri Howchin, 1895

*Hemigordius schlumbergeri* (Howchin, 1895) (Plate 2.11)

1895 *Cornuspira Schlumbergi* (sic) n. sp. Howchin, p. 195, 196, pl. 10, figs. 1–3.
1990 *Hemigordius schlumbergeri* (sic) (Howchin) - Lin et al., p. 212, pl. 24, fig. 22.
1996 *Hemigordius schlumbergeri* (Howchin) - Pronina, pl. 3, figs. 5, 6.
1998 *Hemigordius schlumbergeri* (Howchin) - Pinard and Mamet, p. 32–33, pl. 9, fig. 1, 2?, 3, 4?, 5, 7, 9–11, 14 (with synonymy).
2000 *Hemigordius schlumbergeri* (Howchin) – Groves, pl. 3, figs. 21-28.
2001a *Hemigordius schlumbergeri* (Howchin) – Vachard and Krainer, pl. 4, fig. 8.
2001b *Hemigordius schlumbergeri* (Howchin) - Vachard and Krainer, pl. 9, figs. 8, 18, 19, 25.
2003 *Hemigordius schlumbergeri* (Howchin) - Altiner et al., fig. 4 in text.
2003 *Hemigordius schlumbergeri* (Howchin) - Shang et al., p. 380, pl. 2, figs. 2–5.

**Remarks**: Test discoidal, sides almost parallel, 1–2 streptospiral initial whorls followed by 3–4 aligned whorls, last whorl often semi-evaolute.

**Dimensions**: Diameter = 0.330 mm, Width = 0.095 mm, W/D = 0.29, proloculus = 0.030 mm.

**Occurrence**: From Late Pennsylvanian (Pinard and Mamet, 1998) to Middle Permian of Russia (Pronina, 1996), and South China (Lin et al., 1990). Rare in late Changhsingian of South China (Shang et al., 2003).

*Hemigordius baoqingensis* Wang in Zhao et al., 1981 (Plates 5.4–5.6 and 5.11)

1981 *Hemigordius baoqingensis* n. sp. Wang in Zhao et al., p. 47, 73–74, pl. 1, figs. 17, 18.
1987 *Hemigordius cf. baoqingensis* Wang - Noé, p. 108, pl. 31, fig. 1.

v. 2005 *Hemigordius baoqingensis* Wang - Vaslet et al., p. 77, 115 (fig. 3), 116, 118 (fig. 35), 127 (no illustration).

Plate 5 (continued): 5.3, 5.7–5.10: *Neodiscus aff. qinglongensis* Wang, 1976. 5.3: Transverse section; coloured by alizarine red S. Sample VD 80-62. Photo 75. Midhnab Member (basal part). Early? Dorashamian. Wadi Ar Rayn Section. (Figure 2). x 95. 5.7: Axial section. Sample VD 80-62. Photo 80. Midhnab Member (basal part). Early? Dorashamian. Wadi Ar Rayn Section. x 140. 5.8: Oblique section. Sample VD 80-43 (3). Duhaysan Member. Late Dzhulfian. Wadi Ar Rayn Section. x 140. 5.9: Subaxial section. Sample VD 80-43 (4). Duhaysan Member. Late Dzhulfian. Wadi Ar Rayn Section. x 140. 5.10: Subaxial section. Sample VD 80-43 (10). Duhaysan Member. Late Dzhulfian. Wadi Ar Rayn Section. x 140.

5.4, 5.6, 5.11: *Hemigordius baoqingensis* Wang in Zhao et al., 1981. 5.4: Axial section. Sample DV 79-40 (1). Duhaysan Member (lower part). Late Dzhulfian. Khuff (Wadi Maghib) Section (Figure 2). x 95. 5.5: Axial section. Sample DV 79-40 (3). Duhaysan Member (lower part). Late Dzhulfian. Khuff (Wadi Maghib) Section. x 95. 5.6: Axial section. Sample DV 79-40 (7). Duhaysan Member (lower part). Late Dzhulfian. Khuff (Wadi Maghib) Section. x 140. 5.11: Axial section. Sample DV 79-40 (4). Duhaysan Member (lower part). Late Dzhulfian. Khuff (Wadi Maghib) Section. x 95.
Remarks: Test of medium size, slightly asymmetrical and flattened on one side. Deuteroloculus with oscillating coiling. Wall recrystallised in white microsparite.

Dimensions: Diameter = 0.500–0.550 mm, Width = 0.170–0.220 mm, proloculus diameter = 0.040 mm, number of whorls = 4–5.

Occurrence: Late Changhsingian of south China (Zhao et al., 1981). Late Changhsingian of southern Alps (Noé, 1987). Discovered in the Duhaysan Member (late Dzhulfian) of Saudi Arabia.

Genus: **Neodiscus** Miklukho-Maclay, 1953
Type species: **Neodiscus milliloides** Miklukho-Maclay, 1953

Remarks: *Neodiscus* is similar to *Hemigordius*, i.e., constituted by a tube, without septa or pseudosepta, enrolled streptospirally at the juvenile stage, oscillating, aligned or sigmoid at the adult stage and involute or semi-evolute. *Hemigordius* is compressed and discoidal, whereas *Neodiscus* is inflated.

*Neodiscus aff. qinglongensis* Wang, 1976 (Plates 5.3, 5.7–5.10)

aff. 1976 *Neodiscus qinglongensis* n. sp. Wang, p. 191–192, pl. 1, figs. 11a–d.
? v. 1978 *Hemigordius* sp. 1. Zaninetti et al., pl. 85, figs. 26–31.
aff. 1990 *Hemigordius qinglongensis* (Wang) - Lin et al., p. 214, pl. 25, figs. 14, 15.
? p. 1998 *Hemigordius* sp. - Cirilli et al., pl. 2, figs. 17, 18 (not figs. 15, 19 = true *Hemigordius*).
? 2003 *Hemigordius*? sp. - Ünal et al., pl. 1, fig. 46.
aff. 2004 *Hemigordius qinglongensis* (Wang) - Zhang and Hong, p. 71, pl. 2, figs. 1–5 (with synonymy).
v. 2005 *Neodiscus aff. qinglongensis* Wang - Vaslet et al., p. 77, 127 (no illustration).

Remarks: Test thickly lenticular, involute, of median size. Spherical proloculus passing into tubular undivided deuteroloculus coiled in two planes. Pseudo-septa absent or very faint. 3–4 initial whorls (glomus) are streptospirally coiled; the following 1–2 whorls are slightly oscillating to aligned. Aperture terminal simple. Wall porcelaneous relatively thick, usually recrystallised in white microsparite.

Dimensions: Diameter = 0.340–0.800 mm, Width = 0.200–0.480 mm, W/D = 0.60–0.65, proloculus = 0.050–0.060 mm (for specimens of 0.460–0.800 mm).

Comparison: Differs from *N. qinglongensis* by its less oscillating final whorls. In Saudi Arabia, several populations exist: the Huqayl Member specimens are smaller than the Midhnab Member specimens (Plate 5.3 and 5.7).

Occurrence: Wuchiapingian-Changhsingian type of South China. Questionable in the Dorashamian of Turkey, Iran and Italy (see list of synonymy). Discovered from the Huqayl to the Midhnab members (Dzhulfian-early? Dorashamian).

Genus: **Pseudomidiella** Pronina-Nestell in Pronina-Nestell and Nestell, 2001
Type species: **Pseudomidiella labensis** Pronina-Nestell in Pronina-Nestell and Nestell, 2001

Remarks: With the exception of the type material and the population from New Zealand described by Vachard and Ferrière (1991), almost all the *Baisalina* of the literature are assignable to *Pseudomidiella*. Consequently its range is Midian (see in particular the “*Baisalina*” of Gargouri and Vachard, 1988) to Dorashamian in the Palaeo-Tethys and the Neo-Tethys.

*Pseudomidiella cf. labensis* Pronina-Nestell in Pronina-Nestell and Nestell, 2001 (Plates 5.1 and 5.2)

v. 1985 *Baisalina* - Vaslet et al., p. 16 (no illustration).
cf. 2001 *Pseudomidiella labensis* n. sp. Pronina-Nestell in Pronina-Nestell and Nestell, p. 213, 214, pl. 1, figs. 18-21 (with synonymy).
v. 2005 *Pseudomidiella cf. labensis* Pronina-Nestell in Pronina-Nestell and Nestell - Vaslet et al., p. 77, 116, 118 (fig. 35), 127 (no illustration).

**Remarks:** Test of median size, ovoid in longitudinal section and round in transverse section. The coiling is sigmoidal, with 1–1.5 aligned last whorl. Proloculus spherical small; deuteroloculus with rare pseudo-septa. Wall porcelaneous, black. Aperture terminal simple.

Our specimens differ from typical specimens by the type of coiling and the shorter septa.

**Dimensions:** Diameter = 0.430–0.570 mm, Width = 0.280–0.300 mm, W/D = 0.60–0.70, whorls = 5–6, proloculus = 0.030–0.045 mm.

**Occurrence:** The typical specimens have been found in the Himalaya, northern Italy and NW Caucasus. Discovered in the Huqayl Member, and rare in the Duhaysan Member (Dzhulfian) of Saudi Arabia.

**Genus:** *Neohemigordius* Wang and Sun, 1973  
**Type species:** *Neohemigordius maopingensis* Wang and Sun, 1973

*Neohemigordius ex gr. zaninettiae* (Altiner, 1978) (Plate 2.12)

Compare with:
1978 *Hemigordius zaninettiae* n. sp. Altiner, p. 28, pl. 1, figs. 7–14.
1981 *Hemigordius changxingensis* n. sp. Wang in Zhao et al., p. 47, 73, pl. 1, fig. 16.
1988b *Hemigordius (Midiiella) zaninettiae* Altiner - Pronina, fig. 2. 19, 20.
? 1989 *Hemigordius (Midiiella) zaninettiae* Altiner - Kotlyar et al. tabl. 1 p. 32 (no illustration).
1989 *Hemigordius zaninettiae* Altiner - Köylüoglu and Altiner, pl. 11, figs. 3–5.
1990 *Hemigordius changxingensis* Wang - Lin et al., p. 212, pl. 24, fig. 36.
1991 *Neohemigordius cf. zaninettiae* (Altiner) - Vachard and Ferrière, p. 219, pl. 4, figs. 4, 5 (with synonymy).
? 1995 *Hemigordius zaninettiae* Altiner - Berczki-Makk et al., p. 209–210, pl. 19, figs. 1a, 2a, 3, pl. 20, fig. 1a, 2, 4a, 5, pl. 22 fig. 6a (with synonymy) (perhaps *Multidiscus*).
1996 *Hemigordius zaninettiae* Altiner - Leven and Okay, pl. 9, figs. 22, 23.
1998 *Hemigordius zaninettiae* Altiner - Altiner and Özkân-Altiner, pl. 4, fig. 17.
1999a *Midiiella zaninettiae* (Altiner) - Kotlyar et al., p. 309 (no illustration).
2001 *Midiiella zaninettiae* (Altiner) - Pronina-Nestell in Pronina-Nestell and Nestell, pl. 1, fig. 17.
2003 *Hemigordius zaninettiae* Altiner - Altiner et al., p. 207, fig. 6 in text.
2003 *Hemigordius zaninettiae* Altiner - Ünal et al., pl. 1, fig. 47.

**Remarks:** This is a small species of the group *zaninettiae*, apparently very similar to “*Hemigordius* changxingensis”. It is lenticular, characterised by its regularly oscillating coiling. Because of the inflated test and the streptospirally coiling followed by a planispiral coiling, this species is attributed here to *Neohemigordius*, equivalent to *Midiiella* (see Vachard and Ferrière, 1991).

**Dimensions:** Diameter = 0.285 mm, Width = 0.115 mm, W/D = 0.40, number of whorls = 7.

**Occurrence:** Midian of New Zealand. Dorashamian of Turkey and Greece (see list of synonymy). Late Changhsingian of South China and NW Caucasus. Discovered in the Midhnab Member (early? Dorashamian) of Saudi Arabia.

**Genus:** *Multidiscus* Miklukho-Maclay, 1953  
**Type species:** *Nummulostegina padangensis* Lange, 1925

*Multidiscus spp.* (Plates 2.16 and 2.17)

**Remarks:** Several species are probably present, but each one represented by one or two specimens.
**Dimensions:** Specimen fig. 16: Diameter = 0.360 mm, Width = 0.145 mm, W/D = 0.40, number of whorls = 5? Specimen fig. 17: Diameter = 0.385 mm, Width = 0.180 mm, W/D = 0.47, number of whorls = 4.5.

**Occurrence:** Midian-Dorashamian of Tethys. Discovered in the Midhnab and Lower Khartam members (Dorashamian) of Saudi Arabia.

**Genus:** *Agathammina* Neumayr, 1887  
**Type species:** *Serpula pusilla* Geinitz *in* Geinitz and Gutbier, 1848

*Agathammina* spp. (Plate 2.21)

**Remarks:** The quinqueloculine regular coiling of the tubular undivided deuteroloculus is a characteristic feature. The material is too poor (four sections) to discriminate a species. The coiling seems to be similar to *A. pusilla* (Geinitz), but the wall is especially thin.

**Dimensions:** Diameter = 0.650 mm, Width = 0.170 mm, number of whorls = 6–7.

**Occurrence:** The FAD is poorly known; the genus is relatively common from Midian to Dorashamian. The LAD seems to be Rhaetian in the Austrian Alps (Salaj et al., 1983) but this reference is discussed (Pronina-Nestell, personal communication, 2005). Discovered in the Dzhulfian and Dorashamian (Huqayl and Midhnab members) from Saudi Arabia.

**Genus:** *Graecodiscus* Vachard *in* Vachard, Clift and Decrouez, 1993a  
**Type species:** *Graecodiscus teresae* Vachard *in* Vachard, Clift and Decrouez, 1993a

*Graecodiscus* cf. *kotlyarae* Pronina-Nestell *in* Pronina-Nestell and Nestell, 2001 (Plate 2.19)

?1995 *Agathammina multa* Pronina - Berczi-Makk et al., pl. 13, fig. 8.  
*cf.* 2001 *Graecodiscus kotlyarae* n. sp. Pronina-Nestell *in* Pronina-Nestell and Nestell, p. 214, pl. 1, fig. 23.  
v. 2005 *Graecodiscus* cf. *kotlyarae* Pronina-Nestell *in* Pronina-Nestell and Nestell - Vaslet et al., p. 77, 115 (fig. 34), 116, 117, 118 (fig. 35), 127 (no illustration).

**Remarks:** Test relatively large, inflated and prominent in the central part, discoidal in the extremities. Proloculus large. 4 initial agathamminoid whorls are followed by 2–3 aligned whorls. The last half whorl is semi-involute. This taxon differs from typical *G. kotlyarae* by the type of coiling.

**Dimensions:** Diameter = 0.460–0.850 mm, Width = 0.200–0.240 to 0.370 mm, number of whorls = 4–6.5, proloculus = 0.065–0.085 mm, height of last whorl = 0.100–0.115 mm, wall thickness = 0.007–0.020 mm.

**Occurrence:** Late Changhsingian of Caucasus. Discovered in the Duhaysan Member (late Dzhulfian) of Saudi Arabia.

**Genus:** *Rectostipulina* Jenny-Deshusses, 1985  
**Type species:** *Rectostipulina quadrata* Jenny-Deshusses, 1985

*Rectostipulina* sp. (Plate 6.8)

**Remarks:** Only one transverse section measuring: outer diameter = 0.075 mm, inner diameter = 0.035 mm.

**Occurrence:** *Rectostipulina* is Midian-Dorashamian in age in Palaeo-Tethys and Neo-Tethys. Pronina (1995) considers its FAD as Dzhulfian. Discovered in the Duhaysan Member (late Dzhulfian) of Saudi Arabia.
Genus: *Nodosinelloides* Mamet and Pinard, 1992

Type species: *Nodosinelloides potievskayae* Mamet and Pinard, 1996

(for *Nodosaria gracilis* Potievskaya, 1962 preoccupied)

*Nodosinelloides shikhanica* (Lipina, 1949) (Plate 6.16)

1949 *Nodosaria shikhanica* n. sp. Lipina, p. 217, 218, pl. 4, figs. 7, 8, pl. 6, figs. 3, 9.
1990 *Nodosaria shikhanica* Lipina - Lin et al., p. 226, 227, pl. 28, fig. 13 (with synonymy).
1998 ?*Nodosinelloides netschajewi* (Cherdynzev) (sic) - Pinard and Mamet, p. 20, pl. 5, figs. 1, 2 (with synonymy of *N. shikhanica*).

Remarks: Acute test with hemispherical chambers increasing in height, but not in width. Smooth surfaces of the wall and the septa. *N. shikhanica* is often considered synonymous with *N. netschajewi* (Cherdynzev, 1914), but this species is poorly defined, and needs revision. We use the name *N. shikhanica* well defined by Lipina (1949).

Dimensions: Height = 0.400 mm, Width = 0.070 mm, number of chambers = 8.

Occurrence: Mainly, latest Pennsylvanian-earliest Permian, but ranges to the Dorashamian of South China (Lin et al., 1990). Discovered in the Dzhulfian-Dorashamian of Saudi Arabia (Huqayl Duhaysan, Midhnab and Lower Khartam members).

*Nodosinelloides* cf. *concinna* (Potievskaya, 1962) (Plate 6.1)

cf. 1962 *Nodosaria concinna* n. sp. Potievskaya, p. 70, 71, pl. 5, figs. 16, 17.
cf. 1990 *Nodosaria concinna* Potievskaya - Lin et al., p. 222, pl. 27, fig. 18.
cf. 2004 *Nodosaria concinna* Potievskaya - Zhang and Hong, p. 21, pl. 2, fig. 20 (with synonymy).
v. 2005 *Nodosaria dzhulfensis* Reitlinger - Vaslet et al., p. 77, 115 (fig. 34), 118 (fig. 35) (no illustration).

Remarks: Test rectilinear, gently tapering. Arched chambers increasing slowly in height and width. Smooth surfaces of the wall and the septa. Although this species was described in the Early Permian, the section of Saudi Arabia seems to be relatively similar to *N. concinna*. It was confused with *N. dzhulfensis* Reitlinger by Vachard in Vaslet et al. (2005).

Dimensions: Height = 0.280 mm, Width = 0.100 mm, number of chambers = 6, outer proloculus diameter = 0.050 mm.

Occurrence: Early Permian of Ukraine (Donbass). Changhsingian of South China (Lin et al., 1990; Zhang and Hong, 2004). Discovered in the Lower Khartam Member (late? Dorashamian) of Saudi Arabia.

*Nodosinelloides aff. concinna* (Potievskaya, 1962) (Plate 6.13)

Remarks: Similar in size to *N. cf. concinna*, this unique specimen differs by more inflated chambers and more depressed sutures.

Dimensions: Height = 0.250 mm, Width = 0.090 mm, number of chambers = 5?

Occurrence: Discovered in the Huqayl Member (early Dzhulfian) of Saudi Arabia.

*Nodosinelloides* n. sp.? (Plate 6.17)

Remarks: Very small species very acute with constrictions and consequently deep sutures between each chamber.

Dimensions: Height = 0.160 mm, Width = 0.040 mm, number of chambers = 6 or 7.

Occurrence: Discovered in the Lower Khartam Member (late? Dorashamian) of Saudi Arabia.
Plate 6: Lagenids from Khuff Formation of Saudi Arabia.

6.1: *Nodosinelloides* cf. *concina* (Potievskaya, 1962). Axial section. Sample VD 80-93. Photo 5. Khartam Member (basal part). Late? Dorashamian. Al Huwwah Section (Figure 2). x 140.

6.2, 6.4, 6.5, 6.10, 6.20–6.22, 6.32: *Polarisella elabugae* (Cherdyncev, 1914). All are subaxial sections. 6.2: VD 80-93. Photo 4. Khartam Member (basal part). Late? Dorashamian. Al Huwwah Section. x 140.
Plate 6 (continued): 6.4: Sample JMA 81-170. Photo 171. Midhnab Member (basal part). Early? Dorashamian. Al Quway’iyah Section (Figure 2). x 140. 6.5: Sample JMA 81-170. Photo 167. Midhnab Member (basal part). Early? Dorashamian. Al Quway’iyah Section. x 140. 6.10: Sample JMA 81-170. Photo 165. Midhnab Member (basal part). Early? Dorashamian. Al Quway’iyah Section. x 140. 6.11: Sample JMA 81-170. Photo 164. Midhnab Member (basal part). Early? Dorashamian. Al Quway’iyah Section. x 140.

6.3, 6.11, 6.12, 6.19: Polarisella? hoae (Trifonova, 1967). Three subaxial sections. 6.3: Sample JMA 81-170. Photo 169. Midhnab Member (basal part). Early? Dorashamian. Al Quway’iyah Section. x 140. 6.11: Sample JMA 81-170. Photo 167. Midhnab Member (basal part). Early? Dorashamian. Al Quway’iyah Section. x 140. 6.12: Sample JMA 81-170. Photo 165. Midhnab Member (basal part). Early? Dorashamian. Al Quway’iyah Section. x 140.

6.6, 6.7: Colaniella cf. minuta Okimura, 1988. Two subaxial sections. 6.6: Sample JMA 83-88. Photo 55. Duhaysan Member (middle part). Late Dzhulfian. Buraydah At Tarafiyah Section (Figure 2). x 140. 6.7: Sample JMA 83-88. Photo 68. Duhaysan Member (middle part). Late Dzhulfian. Buraydah At Tarafiyah Section. x 140.

6.8: Rectostipulina sp. Sample JMA 83-88. Photo 74. Duhaysan Member (middle part). Late Dzhulfian. Buraydah At Tarafiyah Section. x 140.

6.9: Robuloides lens Reichel, 1946. Sample JMA 83-88. Photo 57. Duhaysan Member (middle part). Late Dzhulfian. Buraydah At Tarafiyah Section. x 140.

6.13: Nodosinelloides aff. concinna (Potievskaya, 1962). Subaxial section. Sample JMA 81-170. Photo 162. Midhnab Member (basal part). Early? Dorashamian. Al Quway’iyah Section. x 140.

6.14: Geinitzina sp. Axial section. Sample JMA 81-170. Photo 115. Midhnab Member (basal part). Early? Dorashamian. Al Quway’iyah Section. x 140.

6.15?, 6.16, 6.35: Protonodosaria cf. proceraeformis Gerke, 1959. 6.15? Transverse section. Sample JMA 80-93. Photo 9. Khartam Member (basal part). Late? Dorashamian. Al Huwwah Section. x 48. 6.16: Oblique section. Sample JMA 80-93. Photo 9. Midhnab Member (lower part). Early? Dorashamian. Al Huwwah Section. x 95. 6.35: Axial section. Sample JMA 81-170. Photo 172. Midhnab Member (basal part). Early? Dorashamian. Al Quway’iyah Section. x 75.

6.17: Nodosinelloides n. sp.? Axial section. Sample JMA 80-93. Photo 7. Khartam Member (basal part). Late? Dorashamian. Al Huwwah Section. x 140.

6.23, 6.24, 6.31: Polarisella cf. elabugae (Cherdnytshev, 1914). Three subaxial sections. 6.23: Sample JMA 81-170. Photo 58. Midhnab Member (basal part). Early? Dorashamian. Al Quway’iyah Section. x 140. 6.24: Sample JMA 81-170. Photo 160. Midhnab Member (basal part). Early? Dorashamian. Al Quway’iyah Section. x 140. 6.31: Sample JMA 81-170. Photo 172. Midhnab Member (basal part). Early? Dorashamian. Al Quway’iyah Section. x 140.

6.25–6.28, 6.34: Pachyphloia spp. 6.25: Oblique section. Sample JMA 80-93. Photo 9. Khartam Member (basal part). Late? Dorashamian. Al Huwwah Section. x 140. 6.26: Subtransverse section. Sample JMA 80-93. Photo 6. Khartam Member (basal part). Late? Dorashamian. Al Huwwah Section. x 140. 6.27: Lateral section. Sample JMA 80-93. Photo 1. Khartam Member (basal part). Late? Dorashamian. Al Huwwah Section. x 140. 6.28: Subaxial section. Sample JMA 80-93. Photo 2. Khartam Member (basal part). Late? Dorashamian. Al Huwwah Section. x 140. 6.34: Subtransverse section. Sample JMA 80-93. Photo 1. Khartam Member (basal part). Late? Dorashamian. Al Huwwah Section. x 140. 6.31: Sample JMA 81-170. Photo 172. Midhnab Member (basal part). Early? Dorashamian. Al Quway’iyah Section. x 140.

6.29: Cryptoseptida? sp. Transverse section. Sample JMA 81-170. Photo 10. Early? Dorashamian. Al Quway’iyah Section. x 140.

6.30: Ichtyofrondina? sp. Axial section. Sample JMA 82-67. Photo 116. Huqayl Member (basal part). Early Dzhulfian. Sajir Section (Figure 2). x 140.

6.33: “Lingulina” cf. semivelata Cherdnytshev, 1914. Axial section. Sample JMA 79-42 (3). Duhaysan Member. Late Dzhulfian. Khuff (Wadi Maghib) Section. x 75.
Genus *Polarisella* Mamet and Pinard, 1992

Type species *Polarisella blindensis* Mamet and Pinard, 1992

*Polarisella elabugae* (Cherdyntsev, 1914) (Plates 6.2–6.5, 6.10, 6.20–6.22, 6.32)

1914 *Nodosaria elabugae* n. sp. Cherdyntsev, p. 34, pl. 2, fig. 2.

1953 *Nodosaria* ex gr. *elabugae* Tscherdznzew (sic) - Rauzer-Chernousova, p. 77, fig. 32 in text.

1965 *Nodosaria armeniensis* Efimova - Reitlinger, pl. 2, figs. 6, 7.

? 1970 *Frondicularia* sp. - Canuti et al., fig. 12. 10 (cf. our Pl. 6, fig. 21).

p. 1970 *Frondicularia* cf. *woodwardi* Howchin - Canuti et al., fig. 12. 11 (non fig. 12. 12 = *N. hoae*).

? 1974 *Nodosaria ordinata* Trifonova - Efimova, pl. 5, fig. 4.

? 1974 *Nodosaria aff. ordinata* Trifonova - Efimova, pl. 5, fig. 3.

1978 *Nodosaria armeniensis* Efimova - Lys and Marcoux, pl. 1, fig. 15.

1981 *Nodosaria armeniensis* Efimova - Altiner, pl. 42, figs. 1, 2.

? 1982 *Nodosaria djulfensis* (sic) Reitlinger - Delfour et al., fig. 16.

? 1983 *Nodosaria dzulfensis* Reitlinger - Vaslet et al., p. 18 (no illustration).

1983 *Nodosaria armeniensis* Efimova - Jenny-Deshusses, pl. 19, fig. 1.

? 1983 *Nodosaria ordinata* Trifonova - Salaj et al., p. 118–119, pl. 80, figs. 9, 14, pl. 144, fig. 10.

? 1984 *Frondicularia woodwardi* Howchin - Salaj et al., pl. 82, figs. 2–7, 9–13.

1984 *Nodosaria armeniensis* Efimova - Kotlyar et al., pl. 6, fig. 13.

1985 *Nodosaria armeniensis* (sic) Efimova - Trifonova, pl. 3, fig. 7.

1986 *Nodosaria armeniensis* Efimova - Marcoux and Baud, figs. 2, 4 (no illustration).

? 1989 *Nodosaria armeniensis* Efimova - Kotlyar et al., table 1, p. 33 (no illustration).

1992 *Polarisella elabugae* (Cherdyntsev) - Mamet and Pinard, p. 377 (no illustration).

1996 *Nodosaria elabugae* Tcherdzncev (sic) - Pronina, p. 251, pl. 3, fig. 14.

? 1996 *Cryptoseptida?* sp. - Kobayashi, fig. 5. 24–25.

1998 *Nodosaria elabugae* Tcherdzncev (sic) - Pronina, p. 167 (no illustration).

Remarks: Test acute, gently tapering, with bridge-shaped septa, occasionally with rugosities protruding in the following chamber (Plate 6, fig. 22). Last chamber often hemispherical (Plate 6, figs. 3, 22).

The species seems to be relatively similar to several Permian and Triassic taxa: *N. armeniensis*, *N. ordinata* and *F. woodwardi* auctorum.

Dimensions: Height = 0.115–0.350 mm, Width = 0.050–0.090 mm, number of chambers = 4–8.

Occurrence: Permian of former USSR. Dzhulfian of Turkey and Transcaucasia. Possible presence in the Triassic. Discovered in the Dzhulfian-Dorashamian of Saudi Arabia (Huqayl, Duhaysan, Midhnab and Lower Khartam members).

*Polarisella cf. elabugae* (Cherdyntsev, 1914) (Plates 6.23, 6.24, 6.31)

Remarks: Similar to *P. elabugae*, but with much larger size. This morphotype is limited to the Midhnab Member in Saudi Arabia. This species is probably new (as confirmed by G. Pronina-Nestell, personal communication, 2005) but our material is too poor to allow a specific description.

Dimensions: Height = 0.385–0.450 mm, Width = 0.080–0.110 mm, number of chambers = 7–8?

Occurrence: Discovered in the Midhnab Member (early? Dorashamian) of Saudi Arabia.

*Polarisella? hoae* (Trifonova, 1967) orth. mut. (Plates 6.11, 6.12, 6.19)

1967 *Dentalina hoi* n. sp. Trifonova, p. 7, pl. 2, figs. 3–9.

1974 *Dentalina hoi* Trifonova - Efimova, p. 71 (no illustration).

1975 *Dentalina hoi* Trifonova - Styk, p. 518–519, pl. 36, fig. 14 (with synonymy).
Foraminifers and algae from the Khuff Formation, central Saudi Arabia

p. 1970 *Froudicularia* cf. *woodwardi* Howchin - Canuti et al., fig. 12, 12 (non fig. 12. 11 = *N. elabugae*).
1982 *Nodosaria armeniensis* Efimova - Delfour et al., fig. 16.
1982 *Nodosaria armeniensis* Efimova - Vaslet et al., p. 18 (no illustration, not seen).
1983 *Dentalina* *hoi* Trifonova - Salaj et al., p. 121, pl. 81, fig. 1, pl. 83, fig. 5b, pl. 144, fig. 6, figs. 3–9 (with synonymy).

v. 2005 "*Dentalina* *hoi*" - Vaslet et al., p. 77, 115 (fig. 34), 116, 117, 118 (fig. 35), 127 (no illustration).

**Remarks:** Test sometimes arcuate (Plate 6.11). Chambers subquadratic to pear-shaped. Wall relatively thick and chamber reduced to a conical or trapezoidal space. The characters of *Dentalina* are very subjective in this species, hence it is questionably attributed here to *Polarisella* because of the thick wall and the shape of the chambers. The rare specimens of Saudi Arabia are incomplete or immature.

**Dimensions:** Height = 0.265–0.315 mm, Width = 0.030–0.070 mm, number of chambers = 5–6.

**Occurrence:** Late Permian of Hazro (Turkey). Triassic of central Europe (e.g. Salaj et al., 1983). Discovered from the Huqayl Member to the Upper Khartam Member (Dzhulfian-Early Triassic) of Saudi Arabia.

**Genus:** *Protonodosaria* Gerke, 1959

**Type species:** *Protonodosaria proceraeformis* Gerke, 1959

*Protonodosaria* cf. *proceraeformis* Gerke, 1959 orth. mut. (Plates 6.15?, 6.18, 6.35)

cf. 1959 *Protonodosaria proceraeformis* n. sp. Gerke, p. 8–13, pl. 11, figs. 1–5, pl. 2, figs. 1–6, pl. 3, figs. 1–4.

cf. 1961 *Protonodosaria proceraeformis* Gerke - Gerke, p. 163, pl. 20, figs. 12, 13, pl. 21, figs. 8–10.

cf. 1979 *Protonodosaria proceraeformis* Gerke - Nguyen, p. 92, pl. 6, figs. 13–17.

cf. 1988 *Protonodosaria proceraeformis* Gerke - Loeblich and Tappan, pl. 434, figs. 28, 29.

cf. 1994 *Protonodosaria proceraeformis* Gerke - Fontaine et al., p. 8–13, pl. 11, figs. 1–5, pl. 2, figs. 1–6, pl. 3, figs. 1–4.

cf. 1999 *Protonodosaria proceraeformis* Gerke - Pronina, p. 183, 184 (no illustration).

**Remarks:** Medium-sized taxon (one of the largest lagenids in Saudi Arabia), with chambers increasing moderately in height and width. Wall relatively thick. Many characters are common with *P. proceraeformis*, but the apertures were not observed.

**Dimensions:** Height = 0.840 mm, Width = 0.270 mm, number of chambers = 6.

**Occurrence:** Permian of Russia. Midian of Cambodia and Malaysia. Dorashamian of Saudi Arabia (Midhnab and Lower Khartam members).

**Genus:** *Geinitzina* Spandel, 1901

**Type species:** *Geinitzina postcarbonica* Spandel, 1901

(see Sellier de Civrieux and Dessauvagie, 1965)

*Geinitzina* spp. (Plate 6.14)

**Remarks:** According to the taxonomic criteria of the literature, several "species" could be present, but the group *Geinitzina postcarbonica*, illustrated here, is the most frequent. A possible *Geinitzina "reperta"* Bykova is mentioned by Delfour et al. (1982, fig. 16). In fact, the taxon *reperta* belongs to the Devonian genus *Eogeinitzina*, and the Permian specimens attributed to *Geinitzina "reperta"* must be renamed.

**Dimensions:** Height = 0.200 mm, Width = 0.150 mm, number of chambers = 7.
Occurrence: Latest Pennsylvanian (Groves, 2002) - Permian, cosmopolitan, up to Dorashamian (Lin et al., 1990). Discovered in the Dzhulfian-Dorashamian of Saudi Arabia (Huqayl, Duhaysan and Midhnab members).

Genus: *Pachyphloia* Lange, 1925  
Type species: *Pachyphloia ovata* Lange, 1925  
(see Loeblich and Tappan, 1988 and not Sellier de Civrieux and Dessauvagie, 1965)

*Pachyphloia* spp. (Plate 6.26–6.28 and 6.34)

Remarks: Several species differing principally by the size and the general morphology (compare Plate 6.26 specimen with height = 0.320 mm, and Plate 6.34 specimen with height = 1.120 mm).

Occurrence: The FAD of *Pachyphloia* is discussed as probably middle Permian according to Pinard and Mamet (1998), late Early Permian, Chihsian (Lin et al., 1990), Artinskian (Groves, 2000), or may be early Early Permian (Sakmarian) (Vachard and Krainer, 2001b). The last downhole appearance (LAD) is Dorashamian (e.g. Lin et al., 1990; Pronina-Nestell and Nestell, 2001; Wang and Ueno, 2003; Shang et al., 2003).

Genus: ?*Cryptoseptida* Sellier de Civrieux and Dessauvagie, 1965  
Type species: *Cryptoseptida anatoliensis* Sellier de Civrieux and Dessauvagie, 1965

Remarks: *Cryptoseptida* is a poorly known genus. It is interpreted here as a morphological variation of *Pachyphloia* with deeply arched chambers. Hence, a small gap is visible between the successive whorls (compare Plate 6, fig. 29 and Plate 6, fig. 26).

*Cryptoseptida*? sp. (Plate 6.29)

p. 1970 *Robuloides* sp. - Canuti et al., fig. 12. 3 (not figs. 6, 8 = *Pachyphloia*).  
v. 1985 *Cryptoseptida* sp. - Vaslet et al., p. 16 (no illustration).

Remarks: Due to the absence of illustrated axial section of *Cryptoseptida anatoliensis*, specific identification is impossible.

Dimensions: Height = 0.430 mm, Width = 0.150 mm, number of chambers = 6?

Occurrence: Late Permian of Turkey. Dzhulfian of Transcaucasia (Kotlyar et al., 1989). *Cryptoseptida*? sp. is mentioned by Wang and Ueno (2003) in the Changohsingian of South China, and *Cryptoseptida* sp. in the Changohsingian of Japan by Kobayashi (2002). This form of Kobayashi (2002, fig. 9. 40–41) corresponds to our definition of *Cryptoseptida*. Another *Cryptoseptida*? sp. is cited in the Midian of Japan, but its illustration (Kobayashi, 2001, pl. 2, fig. 14) corresponds more probably to the genus *Pseudolangella*. The Triassic (Anisian) *Cryptoseptida*? sp. of Kobayashi (1996) is more similar to *Nodosinelloides elabugae*. *Cryptoseptida* is synonymised with *Pachyphloides* by Berczi-Makk (1996), and might range in this case to Jurassic, but we do not agree with this synonymy. Discovered in the Midhnab Member (early? Dorashamian) of Saudi Arabia.

Genus: *Robuloides* Reichel, 1946  
Type species: *Robuloides lens* Reichel, 1946

*Robuloides lens* Reichel, 1946 (Plate 6.9)

1946 *Robuloides lens* n. sp. Reichel, p. 536, fig. 21–26 in text, pl. 19, figs. 6, 7.  
1981 *Robuloides lens* Reichel - Vachard and Montenat, pl. 15, fig. 6.  
1981 *Robuloides lens* Reichel - Altiner, pl. 42, figs. 8–14.
Foraminifers and algae from the Khuff Formation, central Saudi Arabia

non 1983 Robuloides aff. lens Reichel - Salaj et al., p. 125, pl. 81, fig. 4.
1984 Robuloides aff. lens Reichel - Kotlyar et al., pl. 6, fig. 18.
1985 Robuloides lens Reichel - Pasini, pl. 61, fig. 12.
1985 Colaniella sp. - Trifonova, pl. 4, fig. 7.
v. 1985 Robuloides lens Reichel - Vaslet et al., p. 16 (no illustration).
1988 Robuloides lens Reichel - Loeblich and Tappan, pl. 437, figs. 6, 7.
1989 Robuloides lens Reichel - Köylioglu and Altiner, pl. 10, figs. 16, 17.
1990 Robuloides lens Reichel - Lin et al., p. 193, pl. 19, figs. 19–21 (with synonymy).
1991 Robuloides lens Reichel - Baud et al., fig. 3 in text p. 193 (no illustration).
1991 Robuloides lens Reichel - Grant et al., tabl. 2 (no illustration).
1993b Robuloides lens Reichel - Vachard et al., p. 97 (no illustration).
1995 Robuloides lens Reichel - Berczi-Makk et al., pl. 9, fig. 5.
1996 Robuloides lens Reichel - Leven and Okay, pl. 9, figs. 29, 30.
1998 Robuloides lens Reichel - Altiner and Özcân-Altiner, pl. 4, fig. 14.
1999 Robuloides lens Reichel - Kobayashi, fig. 1. 12.
2001 Robuloides cf. lens Reichel - Kobayashi, pl. 2, fig. 12.
2003 Robuloides lens Reichel - Ünal et al., pl. 1, fig. 45.
2003 Robuloides lens Reichel - Wang and Ueno, table 1 (no illustration).
? 2005 Robuloides lens Reichel - Vaslet et al., p. 120 (no illustration; not seen).

Remarks: Small species, with lozenge-shaped outline, subcarinate, with partly diagenetically recrystallised wall in the chamber (3 specimens in the same sample).

Dimensions: Diameter = 0.160 mm, Width = 0.090 mm, W/D = 0.56, number of whorls = 2.5 or 3.

Occurrence: Late Permian of Tethys. Discovered in the Duhaysan Member (late Dzhulfian) of Saudi Arabia.

Genus: ?Ichtyofrondina Vachard in Vachard and Ferrière, 1991
Type species: Ichtyolaria latilimbata Sellier de Civrieux and Dessauvagie, 1965

Ichtyofrondina? sp. (Plate 6.30)

Remarks: Large enveloping chevron-shaped chambers. The unique section is deformed and also looks like Partisania or Nodosinvolutaria. An Ichtyofrondina latilimbata (de Civrieux and Dessauvagie, 1965), under the name Ichtyolaria, was illustrated by Delfour et al. (1982, fig. 16).

Dimensions: Height = 0.420 mm, Width = 0.250 mm, number of chambers = 7?

Occurrence: Middle-Late Permian of Tethys. Discovered in the Huqayl Member (early Dzhulfian) of Saudi Arabia.

Genus: Lingulina d’Orbigny, 1826
Type species: Lingulina carinata d’Orbigny, 1826

“Lingulina” cf. semivelata Cherdyntsev, 1914 (Plate 6.33)

cf. 1914 Lingulina semivelata n. sp. Cherdyntsev, p. 17, pl. 1, fig. 1.
cf. 1996 Lingulina semivelata Cherdyntsev - Pronina, p. 251, pl. 3, fig. 21.
cf. 1998 Lingulina semivelata Tserdynecev (sic) - Pronina, p. 168 (no illustration).

Remarks: Subtriangular or horseshoe-shaped chambers. Septa and wall of the same thickness.

Dimensions: Height = 0.770 mm, Width = 0.130 mm, number of chambers = 7, proloculus = 0.070 mm.

Occurrence: Middle Permian of Russia and Zechstein of Baltic region (Pronina-Nestell, personal communication, 2005). Discovered in the Duhaysan Member (late Dzhulfian) of Saudi Arabia.
Plate 7: Metazoan remains of Khuff Formation of Saudi Arabia.
7.1, 7.2: Ramose bryozoan. 7.1: Longitudinal, oblique and transverse sections. Sample VD 82-22. Photo 175. Duhaysan Member. Late Dzhulfian. Safra as Sark Al Faydah Section (Figure 2). x 24. 7.2: Transverse section. JMA 83-130. Photo 111. Midhnab Member (basal part). Early Dzhulfian. Unayzah Jal Khartam Section (Figure 2). x 38.
Genus: Colaniella Likharev, 1939  
Type species: Pyramis parva Colani, 1924

**Occurrence:** Late Midian-Dorashamian (Jenny-Deshusses and Baud, 1999). Late Dzhulfian-Dorashamian (Vachard et al., 2002). Only mentioned in the Dorashamian of South China (Lin et al., 1990).

*Colaniella cf. minuta Okimura, 1988* (Plates 6.6 and 6.7)

cf. 1988 *Colaniella minuta* n. sp. Okimura, p. 719, 721, figs. 6. 1–6. 4.
cf. 1990 *Colaniella minuta* Okimura - Nakazawa, fig. 1. 10 (no illustration).
v. 2005 *Colaniella* sp. - Vaslet et al., p. 77, 115 (fig. 34), 116, 117, 118 (fig. 35), 127 (no illustration).

**Remarks:** Two very small and very primitive specimens presenting some similarities with *Colaniella minuta*. The genus *Colaniella* is absent in Zagros, Taurus, Arabia or represented by primitive forms, for instance *C. bozkiri* Çatal and Dager, 1974 in Turkey. The advanced *Colaniella* of other Neo-Tethyan areas: Alborz, Transcaucasia, Oman Mountains, Himalaya, Salt Range, central Afghanistan, are unknown in the Taurus-Zagros-Arabia Province.

**Dimensions:** Height = 0.115–0.130 mm, Width = 0.070–0.085 mm, number of chambers = 4.

**Occurrence:** Late Permian of Salt Range (horizons 3 and 4 of the Zaluch I section). Discovered in the Duhaysan Member (late Dzhulfian) of Saudi Arabia.

**Metazoan Fragments**

Metazoan fragments are rare except in the maximum flooding deposits or the middle ramps where they are represented by crinoids and bryozoa (Plates 7.1 and 7.2). In the biologically restricted environments (e.g. intertidal, inner ramp), appear the classical biumbilicate gastropods *Bellerophon* sp. (Plate 7.3). The annelid *Spirorbis phylactena* is the main marker of the Early Triassic (Plates 7.4–7.7).

**PALAEOECOLOGY AND PALAEOBIOGEOGRAPHY**

The majority of the outcropping Khuff Formation beds include sabkha deposits. More marine deposits are wackestones with bryozoa, or wackestones with lagenids. Due to the evaporitic conditions that prevailed in the inner ramp, the bioherms with calcisponges and corals, the fusulinids, and the biodiversity of the small foraminifers decreased. Consequently the list of fossils in Saudi Arabia is poorer than the list of Greece (Vachard et al., 2003), northwest Caucasus (Pronina-Nestell and Nestell, 2001), or South China (Zhao et al., 1981; Lin et al., 1990; Wang and Ueno, 2003; Zhang and Hong, 2004).

Due to the palaeoecological constraints, there is a good correlation between Saudi Arabia, southern Turkey (Altiner, 1981; Ünal et al., 2003) and southern Iran (Baghban, 1993; Partoazar, 1995; Gaillot, work in progress). The Khuff Formation is relatively uniform in age, but diachronisms may exist. For example, in the Oman Mountains, a hiatus in the Late Permian occurs between the *Shanita* levels.
and the base of the Triassic. Moreover, the presence of: (1) *Palaeofusulina* sp. and *Colaniella* ex gr. *parva* (Colani) in the Musandam Peninsula (Qamar Jbel; Pillevuit, 1993, p. 47); (2) of *Colaniella* (Glennie et al., 1974, figs. 4.4.2-4.4.3), probably *C. parva* in the Oman Mountains; and (3) of *Robustopachyphloia* sp. in Batain Plain (Hauser et al., 2000) confirm the presence of marine Lopingian in Oman.

Turkey, the Zagros Mountains, Saudi Arabia, and parts of Oman form a biogeographic province (Figure 6) dominated by *Paradagmarita* (Sengör et al., 1988; Altiner et al., 2000; Gaillot and Vachard, work in progress). The stratigraphy of several parts of Oman (for example Al Jabal al Akhdar) are different. The presence of *Paradagmarita* is questionable, and a hiatus seems to exist between the latest Midian *Shanita* zone and the Triassic transgression (Vachard et al., 2002). Nevertheless, in many works the Akhdar Group is dated Guadalupian to Lopingian (e.g. Weidlich and Bernecker, 2003). *Paradagmarita* is rare but present in the other provinces of the world (Altiner et al., 2000; Gaillot, work in progress).

The sea of Taurus-Zagros-Saudi Arabia is considered to have been confined due to some barriers located between the Abadeh region and Zagros in Iran (Vachard et al., 2002). The open sea, rich in
We do not agree with the complete list of Salaj; moreover it remarkably indicates that the survivors of the *Pseudoglandulina* *Rectoglandulina*, *Dentalina*, *Robuloides*, *Lingulina*, *Frondicularia*, *Protonodosaria*, *Ichtyolaria*, *Klubovella*, *Endothyranopsis*, *Glyphostomella*, *Agathammina*, *Calcitornella*, *Arenovidalina*, *Nodosaria*, *Neoendothyra*, *Endothyranella*, *Paraendothyra*, *Rectoseptaglomospiranella*, *Haplophragmella*, *Haplophragmina*, *Earlandinita*, *Nodosinella*, *Pachyphloia*, *Geinitzina*, *Multiseptida*, *Palaeonubecularia*, *Tetrataxis*, *Endothyra*, *Tolypammina*, *Reophax*, *Lituotuba*, *Ammobaculites*, *Spiroplectammina*, *Textularia*, *Caligella*, *Earlandia*, *Mountains were directly connected with the Neo-Tethys Ocean and contain* 

*Palaeofusulinida* and *Palaeofusulina* *Pseudomidiella* cf. *labensis* and *Graecodiscus* cf. *kotlyarvae* are relatively similar to species of the northwest Caucasus. Compared with this area, *Lasiodiscus*, an advanced Permian lagenid, true *Dagmarita*, *Paraglobivalvulina*, *Abadehellia*, *Neoendothyra*, *Urushtenella*, *Paraglobivalvulinoides* are lacking. *Colaniella* is very poorly represented. *Palaeofusulinidae* are also lacking although they are relatively dispersed in Palaeo-Tethys and Neo-Tethys (Gaillot and Vachard, work in progress).

The relationships between the Cimmerian continent (e.g. Sengör, 1979, Kobayashi, 1999; Ueno, 2003 = Extragondwan Domain of Vachard, 1980), the Peri-Gondwanan border in Iran and Turkey, and South China can be easily explained by a model of Pangea B (Morel and Irving, 1981; Erwin, 1992; Besse et al., 1998; Crasquin-Soleau et al., 2001, 2004, 2006).

Regarding the problem of the Triassic/Permian Boundary, several taxa have been cited as displaying a stratigraphic range that transgresses this event and include *Cornuspira, Agathammina, Hemigordiellina* (= *Glomospira* of the authors), *Glomospirella*, *Nodosinelloides* and *Cryptoseptida*?. They are at the origin of all the lineages of *Miliolina* and *Lagenina/Rotaliina* of the Mesozoic-Cenozoic. *Earlandia* is here the only survivor of the Fusulinidae. These taxa are more numerous according to Salaj et al. (1983) and include *Rhizammina, Hyperammina*, *Ammodiscus*, "*Glomospira*", *Glomospirella*, *Turritlelleta*, *Tolypammina*, *Reophax*, *Lituotuba*, *Ammobaculites*, *Spirolectamina*, *Textularia*, *Caligella*, *Earlandina*, *Nodosinella*, *Pachyphloia*, *Geinitzina*, *Multiseptida*, *Palaeonubecularia*, *Tetrataxis*, *Endothyra*, *Neoendothyra*, *Endothyranella*, *Paraendothyra*, *Rectoseptaglomospiranella*, *Haplopflagmella*, *Haplopflagrina*, *Klbouvella*, *Endothyranopsis*, *Glyphostomella*, *Agathammina*, *Calcitornella*, *Arenovidalina*, *Nodosaria*, *Rectoglandulina*, *Dentatula*, *Rabuloides*, *Lingulina*, *Frdnpecificularia*, *Protonodosaria*, *Ichtyolalia*, *Pseudoglandulina* and *Permodiscus*.

We do not agree with the complete list of Salaj; moreover it remarkably indicates that the survivors of the Permian are more numerous in the Triassic, an observation that contradicts the published compilations for these species (e.g. Erwin, 1992; Rampino and Adler, 1998; Benton and Twitchett, 2003).

Due to the abundance and biodiversity of *Paradagmarita*, Taurus, Zagros, Oman and Saudi Arabia constitute a bioprovince limited by the Neo-Tethys, the Palaeo-Tethys, the seaway to Madagascar and Karoo and the African and Arabian continent (Figure 6). Connections existed with Afghanistan and other sectors of the Cimmerian blocks (according to the geographical distribution of *Paradagmarita*; Gaillot and Vachard, work in progress). In Afghanistan, a species of the group *P. monodi* is a nomen nudum: *P. dubreilli* (Vachard, 1980), and is known as far as Japan (Iwai-Kanyo area; Chichibu Terrane), with *Paradagmarita* sp. (Kobayashi, 1997, pl. 4, fig. 19: 2004, fig. 6.47–6.50). *Paradagmarita* is also known in the Alborz and Djulfa area (northern Iran) (Okimura et al., 1985; Partoazar, 1995). This palaeogeographical existence at least since the latest Midian, with the *Shanita* province (e.g. Sengör et al., 1988; Ueno, 2003).

The base of the Khuff Formation appears to be diachronous, because it is dated as early Wordian in the Haushi-Huqf area (southeastern Oman) (Angiolini et al., 1998, 2004). This part of the Khuff seems to be coeval with the Saq Formation of the Oman Mountains, because the Khuff Formation is not Lopingian in Al Jabal al Akhdar but limited to the Midian (Vachard et al., 2002). In fact the conodont assemblage of the Haushi-Huqf is similar to that of the Amb Formation of the Salt Range (Angiolini et al., 1998), attributed to the early Midian by Vachard et al. (2002). In this case, the diachronism of the base of the Khuff Formation might to be limited to the Midian.
Conversely, the Wordian age attributed to the major Neo-Tethys transgression (Angiolini et al., 2003) is probably underestimated; this transgression (Figure 6) is more probably Capitanian (Midian) in age. According to the fusulinoid assemblages, the Wordian-Murgabian ages deduced for the ancient classifications of Leven used in the Perigondwan (e.g. Lys, 1988) are in fact Capitanian (Midian), due to the re-establishment of the importance of *Neoschwagerina schuberti* Kochansky-Devidé, *N. craticulifera* (Schwager), *N. margaritae* Deprat, compared with the FAD of *Yabeina, Lepidolina, Dunbarula, Sumatrixina, Codonofusiella* and *Reichelina* (e.g. Leven, 2003).

The recently proposed Deev Jahi model of Heydari and Hassanzadeh (2003), indicating that gas hydrates are the main cause of biological crisis on Earth, is particularly interesting to verify in the Province Neo-Tethys-Taurides-Saudi Arabia-Oman, since the mass extinction started in the ocean (Neo-Tethys) and spread landwards to Saudi Arabia.

### CONCLUSIONS

The Khuff Formation in the outcrops of central Saudi Arabia is composed of five members, which are assigned to the late Guadalupian Epoch (late Middle Permian, late Capitanian or late Midian Stage), Lopingian Epoch (Late Permian, Wuchiapingian-Changhsingian or Dzhulfian-Dorashamian stages) and Early Triassic ages. Palaeobiogeographically, the regions of the Taurides, Zagros, Oman and Saudi Arabia constitute a bioprovince limited by the Neo-Tethys, the Palaeo-Tethys, the Seaway to Madagascar and Karoo and the Afro-Arabian landmass. Communication existed with Afghanistan and other sectors of the Cimmerian blocks (according to the geographical repartition of *Paradagmarita*), and as far as Japan.

Algæ are represented only by *Permocalculus* and *Mizzia*. Smaller foraminifers are numerous, but the fusulinoids are restricted to the primitive genera *Eostaffella*? and *Nankinella*. Foraminiferal biomarkers are generally lacking, for example *Pseudodunbarula, Paradunbarula, Palaeofusulina* or advanced *Colaniella*. The local markers are similar to those of Taurides and Zagros: *Paradagmarita* and *Septoglobivalvulina*?

A Lazarus effect is observed with the genus *Radiospaera*, known respectively in the Late Devonian-Early Carboniferous and in the Late Permian. *Earlandia*? is diversified. It is confined in hypersaline to normal environments, and can be confused with *Aeolisaccus*.

The biseriamminids / globivalvulinids are relatively diversified, especially the genus *Paradagmarita*, with four taxa. The cornuspirids and hemigordiids are also abundant. The hemigordiopsids *Hemigordiopsis, Lysites* and *Kamurana* are absent. A new species *Glomospirella*? *linae* can be locally common, and can characterise secondarily the local Dorashamian. The lagenids are principally represented by species of genera *Nodosinelloides* and *Polarisella*, mainly with *P. elabugae* and *P.? hoae*. Taphonomically, the general abrasion of the tests of *Nankinella* and *Paradagmarita* “sp. 1” is noticeable.

### NOTE ON ABBREVIATIONS

(1) *aff.* (Latin affinis) means "with only some relations with".
(2) *cf.* (Latin confer) means "almost similar to".
(3) *ex gr.* (Latin ex gregae, literally: out of the flock) means "only related with a group of species not to a peculiar species" or in the case of forams in thin sections "with a type of section common to several species").
(4) *p.* for Latin pars or partim; to mean in part when only a part of the figure correspond to our understanding of the taxon.
(5) *sp.* means "indeterminate species". Consequently, we can denominate a species in the decreasing order of certainty: *Hemigordiellina regularis, Hemigordiellina cf. regularis, Hemigordiellina aff. regularis, Hemigordiellina ex gr. regularis* or finally, *Hemigordiellina sp.*
(6) *spp.* (Latin abbreviation, with the double letter at the end which is the mark of plural), means "several indeterminate species".
(7) *v.* for Latin video or vidimus; to mean that the present authors have seen the material in question.
(8) *non v.* is non video/vidimus; the material was not seen by us.
(9) *?* to mean questionable identification.
(10) FAD means ‘First Appearance Datum’ and LAD means ‘Last Appearance Downhole’.
(11) Parentheses (at the author name and date of creation) correspond to a nomenclatural change at the generic level; i.e., *Glomospira regularis* Lipina, 1949 becomes *Hemigordiellina regularis* (Lipina, 1949).
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