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Lithofacies and microbiofacies (foraminifers and radiolarians) of the Permian Sequence in the Shalamzar area, Central Alborz, North Iran

Seyed Hamid VAZIRI[1], Akira YAO[2] and Kiyoko KUWAHARA[2]

[1]Department of Geology, Faculty of Science, Islamic Azad University, North Tehran Branch, P. O. Box 19585-851, Tehran, Iran. E-mail: s.h.vaziri@kavosh.net

[2]Department of Geosciences, Graduate School of Science, Osaka City University, Sugimoto 3-3-138, Sumiyoshi-ku, Osaka 558-8585, Japan. E-mail: yao@sci.osaka-cu.ac.jp, kuwahara@sci.osaka-cu.ac.jp

Abstract

The Permian sequence in the Shalamzar area occurs along the Gord Calleh Mountain in Central Alborz (NW Tehran), North Iran and attains a thickness of up to 622 meters. This sequence is composed mainly of clastic rocks in the lower part and fossiliferous carbonate rocks in the upper part. The clastic facies were deposited in continental (meandering rivers) and transitional (deltaic and littoral) environments, and the carbonate facies were deposited in a shallow marine environment of the continental margin in the Paleo-Tethys.

This sequence consists of three formations: the Dorud (Asselian-Sakmarian), the Ruteh (Artinskian-Murgabian) and the Nesen (Early Djulfian) formations, and overlies non-conformably on the volcanic rocks (Devonian?) of the basement. This sequence is disconformably overlain by the Elikah Formation (Scythian-Ladinian). The rich foraminifer fauna indicates an Asselian to Early Djulfian age of the succession. Five biozones by foraminifers are established in the Permian System of this region. These biozones include the *Pseudofusulina-Schwagerina* Assemblage Zone (Asselian-Sakmarian), *Schubertella-Mesosubertella* Assemblage Zone (Artinskian), *Dunbarula-Neoschwagerina* and *Neoendothyra-Globivalvulina* Assemblage zones (Murgabian), and *Codonofusiella-Reichelina* Assemblage Zone (Early Djulfian).

Ten species of the Permian radiolarians include the *Latentifistula*? sp. A, *Latentifistula*? sp. B, Latentifistularia A, Latentifistularia B, *Orbiculiforma*? sp. A, *Orbiculiforma*? sp. B, Spherical Radiolaria A, Spherical Radiolaria B, Spherical Radiolaria C and Ellipsoidal Radiolaria A were detected from the Ruteh Formation for the first time in the present study. Index foraminifer's age of the Ruteh Formation assigns the age of detected radiolarians to Artinskian and Murgabian. The detected radiolarians are correlative with those of China, Thailand, Japan, Malaysia, Turkey, Far East of Russia, Kazakhstan, North America, Philippines and Italy. According to time unit, all recorded radiolarians can be correlated with the Permian radiolarian zones in South China, Southwest Japan and Oregon, USA and also are correlated with the *Schubertella-Mesoschubertella* Assemblage Zone (Artinskian), *Dunbarula-Neoschwagerina* and *Neoendothyra-Globivalvulina* Assemblage zones (Murgabian).

Key-words : Permian, Foraminifera, Radiolaria, Shalamzar, Central Alborz, North Iran

1. Introduction

Lower to Upper Permian rocks are widely distributed throughout North Iran (Alborz Range). They consist mainly of clastic rocks in the lower part and fossiliferous carbonate rocks in the upper part. The clastic rocks were deposited in continental (meandering rivers) and transitional (deltaic and littoral) environments (Mokhtarpour, 1997a), and carbonate rocks were deposited in a shallow marine environment of the continental margin in the Paleo-Tethys. These have been named as the Dorud and the Ruteh formations by Assereto (1963), and the Nesen Formation by Glaus (1964).

The first research on the Abyek-Hiv area has been carried out by Sieber (1970). Annells *et al.* (1977) prepared geological map of Shakran on a 1:100.000 scale in Central Alborz that Shalamzar area is situated in south part of this map. Vaziri (1993) studied biostratigraphy and lithostratigraphy of the Permian rocks in the study area and prepared a revised geological map of the Abyek-Hiv area on a 1:50.000 scale. Sedimentary petrology and depositional environments of the Lower Permian (Dorud Formation) clastic rocks in the Alborz Range (including study section) were studied by Mokhtarpour (1997a).

In the present paper, lithofacies and microbiofacies (foraminifers) have been studied by the first author (S. H. Vaziri) at the Department of Geology, Islamic Azad University, North Tehran Branch (Iran) with a reviewing at Osaka City University and radiolarian biostratigraphical study have been done by first author with contributions from the second and third authors at the Department of Geosciences, Osaka City University.

For the foraminiferal biostratigraphical study, one hundred and twenty limestone samples were collected from the Dorud, Ruteh and the Nesen formations and for study of radiolarians, twenty-seven samples were collected from chert nodules and beds of the Ruteh and the Nesen formations in the study section. No previous studies have been done on the Permian radiolarians in the Alborz Range. Therefore, the present study is the first record of Permian radiolarians from the Alborz Range, North Iran.

2. Geological setting

The clastic sediments of the Dorud Formation characterize the Lower Permian rocks of the Alborz Range. The type section of the Dorud Formation is located in Central Alborz near the village of Dorud (North Tehran), where it has a thickness of 180 meters (Assereto, 1963). It overlies unconformably the Jeirud Formation (Upper Devonian) and consists of red sandstones, shales, conglomerate, fossiliferous limestones and quartzite. The Dorud Formation is subdivided into two groups, including clastic and carbonates facies. The clastic rocks of the Dorud Formation were deposited in continental (meandering rivers) and transitional (deltaic and littoral) environments (Mokhtarpour, 1997a).

The Dorud Formation is equivalent to the Vazhnan Formation (Baghbani, 1990b, 1996) in the Abadeh (Central Iran) and Jolfa (northwestern Iran) regions, the Howz-Dora Formation (Partoazar, 1995) in the Shotori Range, Tabas area (eastern Iran) and the Faraghan Formation (Szabo and Kheradpir, 1978; Ghavidel-Syooki, 1984, 1988) in the Zagros Range, southwestern Iran (Fig. 1).

The Ruteh Formation conformably overlies the Dorud Formation. The type section of the Ruteh Formation is located in Central Alborz near the village of Ruteh (North Tehran), where it has a thickness of 230 meters and consists of dark-grey medium-bedded to massive fossiliferous limestones (Assereto, 1963). The Ruteh Formation was deposited in barrier, lagoon-tidal flat and open marine environments (Lasemi and Mokhtarpour, 1993; Mokhtarpour, 1997b). This formation is equivalent to the Surmaq Formation (Taraz, 1969, 1974; Iranian-Japanese Research Group, 1981; Partoazar, 1995; Baghbani, 1996; Kobayashi and Ishii, 2003) in the Abadeh (Central Iran) and the Jolfa (northwestern Iran) regions, middle part of the Jamal Formation (Stocklin *et al.*, 1965; Partoazar, 1995) in the Shotori Range, Tabas area (eastern Iran) and the lower part of the Dalan Formation (Szabo and Kheradpir, 1978; Baghbani, 1990a) in the Zagros Range, southwestern Iran (Fig. 1).

The type section of the Nesen Formation is located in northeast Nesen village (Central Alborz) and has a thickness of 144 meters (Glaus, 1964). This formation consists of black shales (abundant brachiopods and coral-bearing) and dark-grey cherty fossiliferous limestones. The Nesen Formation was deposited in barrier, lagoon and open marine environments (Mokhtarpour, 1997b). The lower as well as the upper boundary of the Nesen Formation is disconformable. The Elikah Formation (Lower to Middle Triassic) disconformably overlies the Ruteh Formation.

The Nesen Formation in the Alborz Range is equivalent to the Jolfa Formation (Partoazar, 1995) in the Jolfa Region (northwestern Iran), upper part of the Jamal Formation (Stocklin *et al.*, 1965; Partoazar, 1995; Aghanabati, 2004) in the Shotori Range, the Tabas area (eastern Iran), middle part of the Dalan Formation (Szabo and Kheradpir, 1978; Baghbani, 1990a) in the Zagros Range (southwestern Iran), and the Abadeh Formation

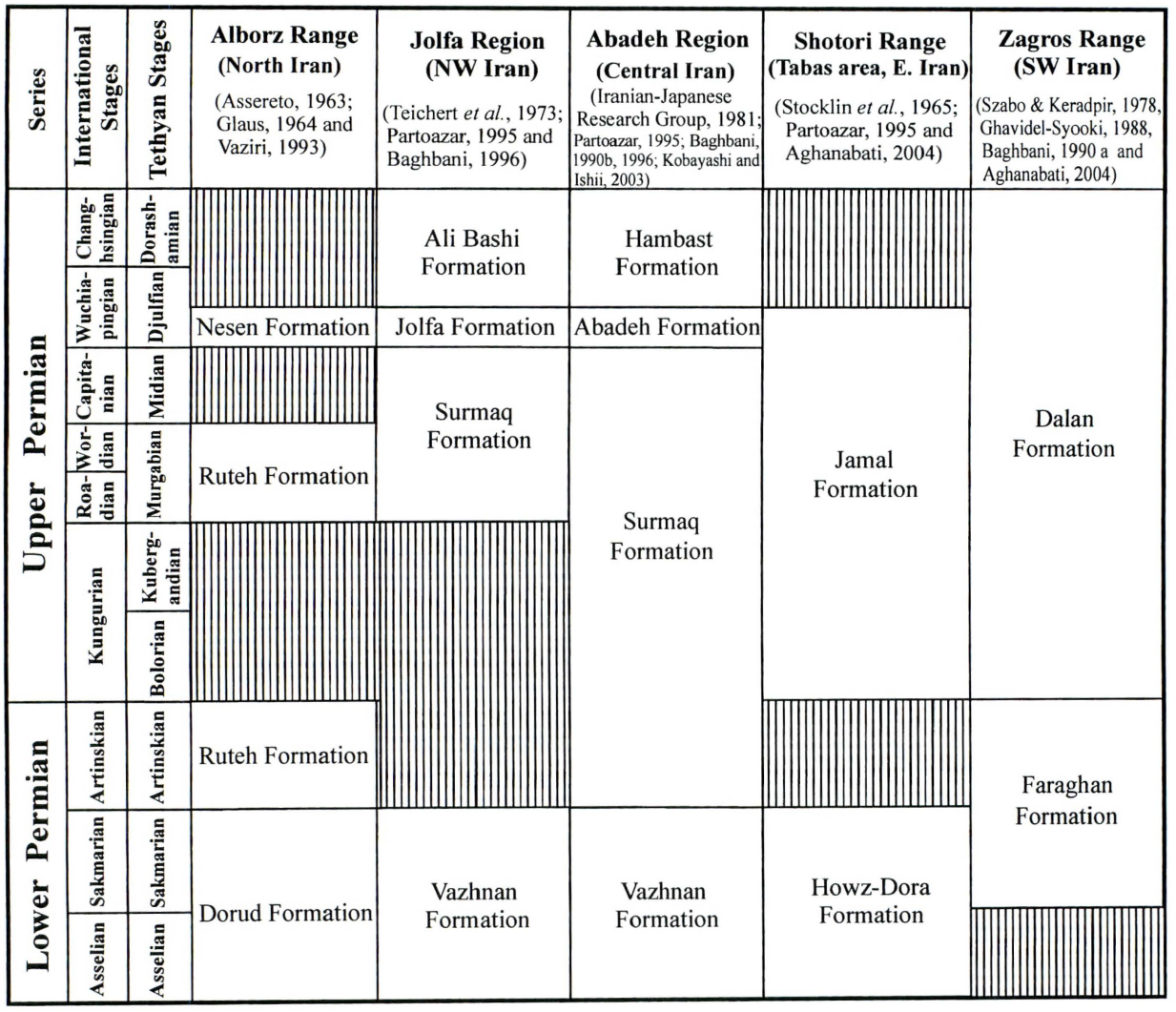


Fig. 1 Stratigraphic correlation chart of the Permian rocks-units of Iran.

(Taraz, 1969, 1974; Partoazar, 1995, 2002) in the Abadeh Region, Central Iran (Fig. 1).

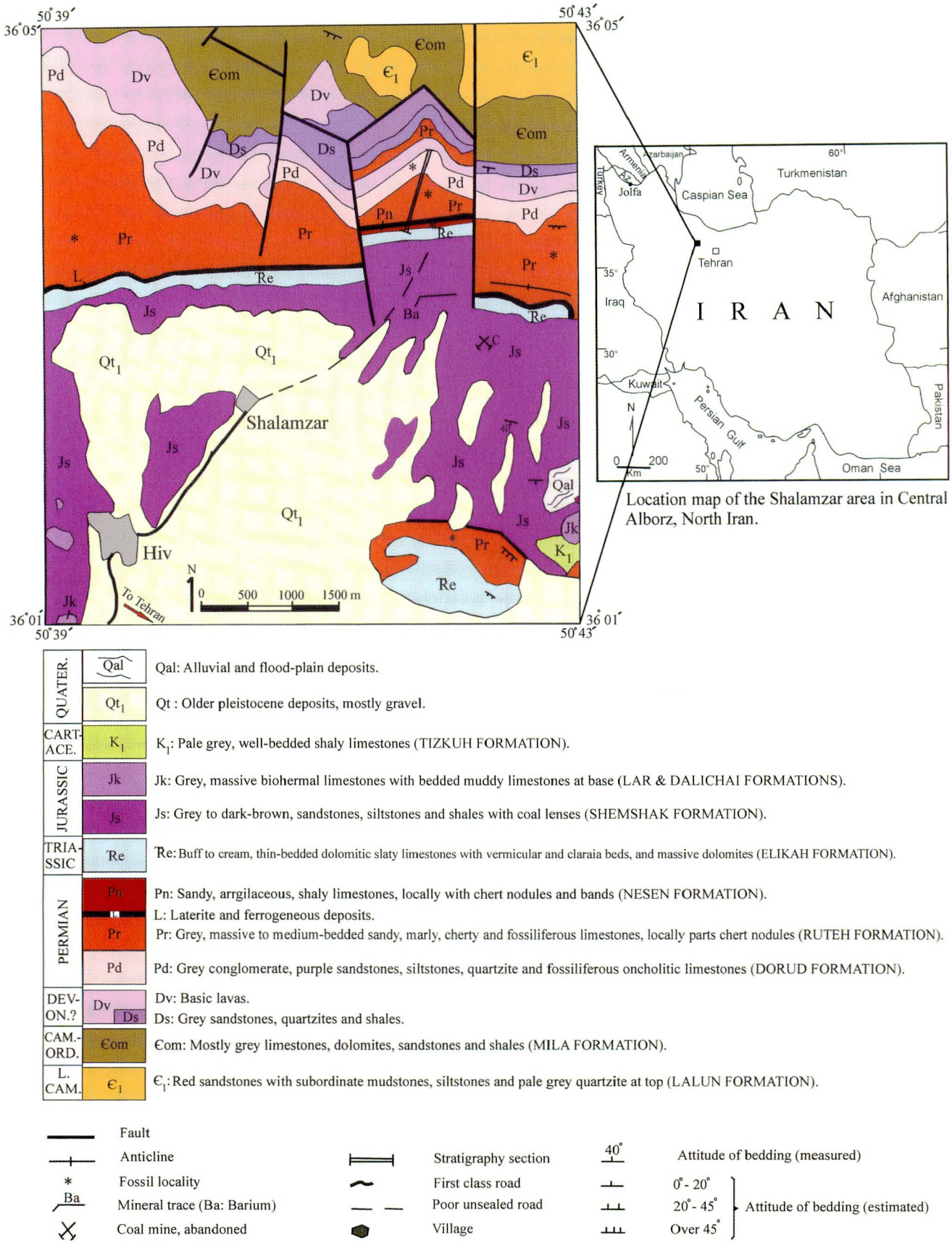
The rich foraminifer fauna from the Permian rocks along Alborz Range indicates an Early to Late Permian (Asselian to Early Djulfian) age. These rocks contain abundant fusulinids, corals, brachiopods, bellerophons and rare radiolarians.

In the Alborz Range, the Dorashamian Stage and at least the upper part of Djulfian are missing. The sedimentation gaps of Upper Djulfian and Dorashamian deposits in the Alborz Range are related to activity of Late Hercynian orogenic phase. This is to say that the *Araxoceras tectum* subzone and the *Vedioceras* subzone as well as the *Physonites, Shevyrevites-Iranites* and *Paratirolites* zones are missing in the Alborz Range (Golshani *et al.*, 1986). But Early Djulfian Stage is well represented by the *Codonofusiella-Reichelina* Assemblage Zone. Therefore, a larger sedimentary gap exists between the Permian-Triassic strata in the Alborz Range than either Jolfa Region (northwestern Iran) or Abadeh Region (Central Iran). This is widely traced laterally, which indicates a cessation in the continuous sedimentation (Golshani *et al.*, 1986).

3. Lithostratigraphic description of the section

Well-defined outcrops of the Lower to Upper Permian rocks occur along the Gord Calleh Mountain (Kuh-e-Gord Calleh), northeast Shalamzar village (Abyek-Hiv area) in Central Alborz, northern Iran with the following coordinates: N 36°. 04′, E 50°. 11′(Figs. 2 & 5a). These rocks in northeast Shalamzar attain a thickness of up to 622 meters. Permian rocks overlie non-conformably the black volcanic rocks (Devonian?) and on the top are covered disconformably by the Elikah Formation (Fig. 3).

The Permian rocks of the Shalamzar area consist of three formations: the Dorud, the Ruteh and the Nesen formations with Asselian to Early Djulfian age. They can



Location map of the Shalamzar area in Central Alborz, North Iran.

Fig. 2 Geological map of the Shalamzar area in Central Alborz, North Iran (modified from Annells *et al.*, 1977).

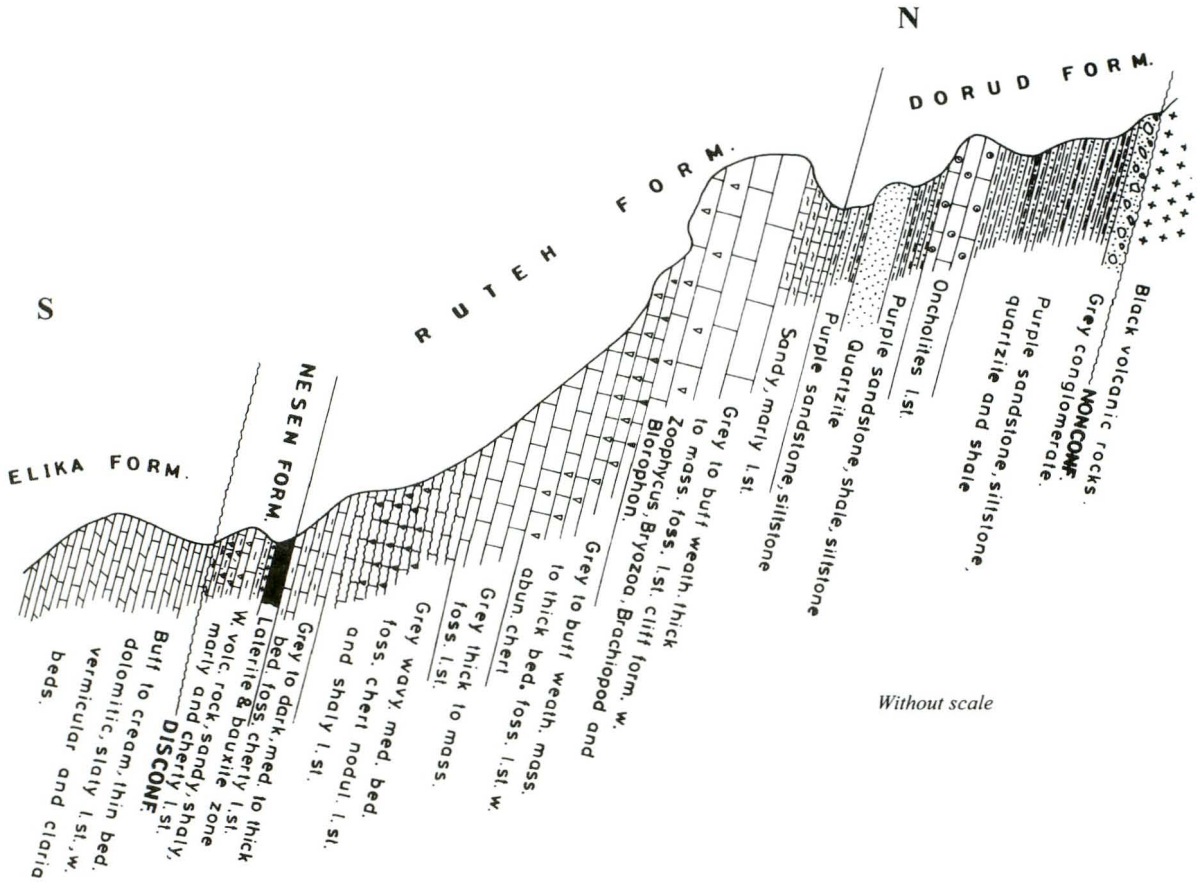


Fig. 3 Stratigraphic profile of the Permian sequence and Permo-Triassic boundary in northeast of Shalamzar, Central Alborz, North Iran

be subdivided into 12 members based on their facies characteristics (Fig. 4).

3.1 The Dorud Formation

This formation with a thickness of 269 m consists of grey congelomerate, red to purple sandstone, silty shale, quartzite and oncolitic limestones with Early Permian (Asselian-Sakmarian) age, which is covered conformably by the Ruteh Formation. This formation in the study section can be subdivided into four members as follows (Fig. 4):

Member 1 (6 m):

Grey conglomerate (composed of limestone, sandstone, quartz and volcanic fragments). Volcanic fragments belong to the volcanic rocks of the basement (Fig. 5b).

Member 2 (198 m):

Alternating purple to reddish, thin-bedded sandstones, siltstones and shales with intercalations of light grey, thin-bedded quartzite. The bedding shows N 290° W strike, dipping at 45° SW.

Member 3 (8 m):

Grey to buff, oncolitic limestones with fusulinids, brachiopods and corals. The bedding shows N 290° W strike and dip at 45° SW. This member can be compared with the third subunit of the Dorud Formation in type section (Asserto, 1963) in northeast Tehran. This member includes the *Girvanella permica* Pia (Pl. 3, figs. 1, 2) as a cyanobacteria (Riding, 1991; Flugel, 2004) and the following foraminifers that indicate a Asselian to Sakmarian age (thin sections no. H.V-3 ~ 10): *Earlandia* sp., *Eolasiodiscus* cf. *donbassicus* Reitlinger, *Eostaffella* sp., *Geinitzina postcarbonica* Spandel, *Globivalvulina* cf. *scaphoidea* Reitlinger, *Globivalvulina* sp., *Globivalvulina mosquensis* Reitlinger, *Mesoschubertella* sp., *Monogenerina* sp., *Nankinella* sp., *Pseudofusulina* sp., *Pseudofusulina* aff. *P. tchernyshevi* (Schellwien), *Pseudofusulina* cf. *krotovi candata* Rauser, *Pseudofusulina* cf. *diserta* Saerovich, *Pseudostaffella* sp., *Pseudoschwagerina* sp.,

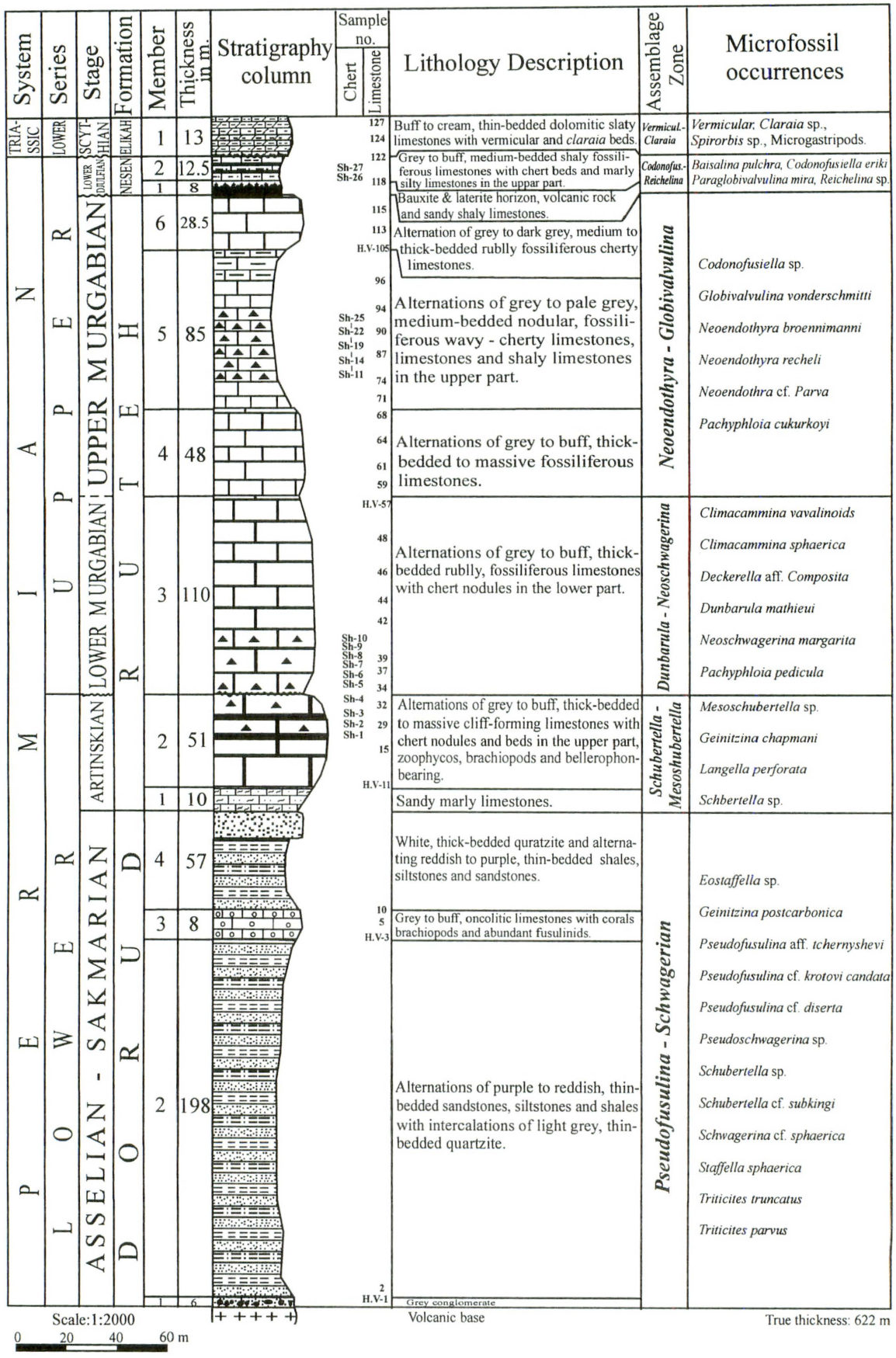


Fig. 4 Lithological characteristics and biozones of the Permian sequence and Permo-Triassic boundary in northeast of Shalamzar, Central Alborz, North Iran.

Fig. 5 **(a)** Permian sequence in the Gord Calleh section, Central Alborz. **(b)** Basal conglomerate of the Dorud Formation (member 1) **(c)** The contact between the Dorud and Ruteh formations, and cliff-forming limestones of the Ruteh Formation (member 2). **(d)** Ichnofossil of the *Zoophycos* in limestone of the Ruteh Formation (member 2). **(e, f)** Chert bed in alternating limestones of the Ruteh Formation (member 2). **(g)** Chert nodules in limestone of the Ruteh Formation (member 3). **(h)** Alternating wavy-cherty limestones of the Ruteh Formation (member 5).

Pseudoschwagerina cf. *beedi uralensis* Rauser, *Schubertella* sp., *Schubertella* cf. *subkingi* Dunbar et Skinner, *Schwagerina* sp., *Schwagerina* cf. *sphaerica* Sherb, *Staffella* sp., *Staffella sphaerica* (Abich), *Tetrataxia* sp., *Tetrataxia* cf. *planulata* Morozova, *Triticites parvus* Chen. *Triticites truncatus* Chen, *Tuberitina* sp. (Pl. 3, figs. 3-9).

Member 4 (57 m):

Consists of white, thick-bedded quartzite (14 m, Fig. 5c) and alternating reddish to purple, thin-bedded shales, siltstones and sandstones. Sandstones have sedimentary structures such as lamination and cross lamination. The bedding shows N 315° W strike and dip at 30° SW.

3.2 The Ruteh Formation

This formation with thickness of 332.5 meters conformably overlies the Dorud Formation (Fig. 5c), and consists of fossiliferous limestones. This formation in the study section can be subdivided into six members as follows (Fig. 4):

Member 1 (10 m):

Consists of grey sandy marly limestones. The bedding is the same as that of the fourth member of the Dorud Formation.

Member 2 (51 m):

Alternating grey to buff, thick-bedded to massive cliff-forming limestones with chert nodules and beds in the upper part (Figs. 5e, f). The bedding shows N 320° W strike and 40° SW dip. This member is considered Artinskian on the basis of microfossils, which indicates the *Parafusulina* Zone (*Schubertella* sp.-*Mesoschubertella* sp.), macrofossils such as *Fenestrllina* sp., *Septopora, Orthotetina, Orthotechia*, Bellerophontid and brachiopods, ichnofossil of the *Zoophycos* (Fig. 5d), and cyanobacteria of the *Tubiphytes obscurus* Maslov. *Tubiphytes* is commonly interpreted as a calcified cyanobacterium (Riding, 1991; Pratt, 1995). Senowbari-Daryan and Flugel (1993) asserted that a combination of non-preserved soft organism (central tube) and a cyanobacterial envelope is the original interpretation of Maslov (1956) regarding *Tubiphytes*. Riding (1993) emphasized that the correct name of *Tubiphytes obscurus* is *Shamovella obscura*. The traditional name is consequently used in the article.

This member also includes the following microfossils (thin sections no. H.V-11 ~ 33):

Foraminifera: *Climacammina* sp., *Climacammina sphaerica* Potieskaya, *Deckerella* sp., *Endothyra* sp., *Geinitzina* sp., *Geinitzina postcarbonica* Spandel, *Geinitzina uralica* Suleimnov, *Geinitzina chapmani* Schubert Var. Longa Sulemanov, *Globivalvulina* sp., *Hemigordius* sp., *Kahlerina* sp., *Kahlerina pachytheca* Koch. Devide et Ramors, *Langella* sp., *Langella* cf. *ocarina* S.de Civr & Dess., *Langella perforata* Lange, *Lasiodiscus* sp., *Mesoschubertella* sp., *Pachyphloia* sp., *Pachyphloia pedicula* Lange, *Palaeosiroplectammina sobhaniansis* Partoazar & Vaziri, *Palaeobigenerina* sp., *Pseudolangella fragils* Decivr. & Dess., *Pseudostaffella* sp., *Schubertella* sp., *Tuberitina* sp., *Tuberitina collosa* Reitlinger (Pl. 3, figs. 11-15); **Algae:** *Gymnocodium* sp., *Gymnocodium bellerphontis* (Rotheletz), *Permocalculus* sp., *Pseudovermiporella* sp., *Vermiporella* sp., *Vermiporella nipponica* Endo (Pl. 3, fig. 10).

Member 3 (110 m):

Alternating grey to buff, thick-bedded rubbly, fossiliferous limestones with chert nodules in the lower part (Fig. 5g). The bedding shows N 270° W strike and 40° SW dip.

This member includes the following microfossils that indicate an Early Murgabian age (thin sections no. H.V-34~ 57): **Foraminifera:** *Climacammina* sp., *Climacammina vavalinoids* Lange, *Climacammina sphaerica* Potieskaya, *Climacammina major* Morozova, *Codonofusiella* sp., *Codonofusiella erki* Rauser, *Cribrogenerina sumatrana* (Volz), *Deckerella* sp., *Deckerella* aff. *composita* Reitlinger, *Dunbarula mathieui* Ciry, *Endothyra* sp., *Geinitzina* sp., *Geinitzina postcarbonica* Spandel, *Geinitzina uralica* Suleimnov, *Geinitzina chapmani* Schubert Var. Longa Sulemanov, *Globivalvalina* sp., *Globivalvalina mosquensis* Reitlinger, *Globivalvulina scaphoidea* Reitlinger, *Glomospira* sp., *Hemigordius* sp., *Kahlerina* sp., *Langella* sp., *Langella conica* De Civer. & Dess., *Cryptosetida* (*Langella*) *bozorgniansis* Partoazar & Vaziri, *Langella* cf. *cukurkoyi* De Civer. & Dess., *Neoschwagerina margarita* Deprat, *Nankinella* sp., *Pachyphloia* sp., *Pachyphloia pedicula* Lange, *Pachyphloia* cff. *schwageri* Lange, *Palaeotextularia* sp., *Staffella* sp., *Tuberitina* sp.(Pl. 4, figs. 1-5); **Algae:** *Gymnocodium* sp., *Permocalculus* sp., *Pseudovermiporella* sp., *Vermiporella* sp., *Vermiporella nipponica* Endo; **Cyanobacteria:** *Tubiphytes* sp., *Tubiphytes obscurus* Maslov.

The member 3 overlies the member 2 paraconformably and there are no Bolorian-Kubergandian deposits.

Member 4 (48 m):

Alternating grey to buff, thick-bedded to massive fossiliferous limestones with N 270° W strike and 40° SW dip. This member includes the following microfossils (thin sections no. H.V-58 ~ 69): **Foraminifera:** *Climacammina* sp., *Codonofusiella* sp., *Codonofusiella erki* Rauser,

Dunbarula mathieui Ciry, *Earlandia* sp., *Frondinodosaria* sp., *Geinitzina* sp., *Geinitzina chapmani* Schubert Var. Longa Sulemanov, *Globivalvalina* sp., *Globivalvalina vonderschmitti* Reichel, *Hemigordius* sp., *Langella* sp., *Cryptosetida* (*Langella*) *bozorgniansis* Partoazar & Vaziri, *Langella* cf. *acanthi* (Lange), *Langella* cf. *cukurkoyi* De Civer. & Dess., *Neoendothyra* sp., *Neoendothyra reicheli* Reitlinger, *Neoendothyra broennimanni* Bozorgnia, *Pachyphloia* sp., *Pseudolangella* sp., *Schubertella* sp., *Staffella* sp., *Tetrataxia* sp., *Tuberitina* sp. (Pl. 4, figs. 6, 7, 9-12, 14); **Algae:** *Gymnocodium* sp., *Permocalculus* sp., *Pseudovermiporella* sp., *Vermiporella* sp.; **Cyanobacteria:** *Tubiphytes obscurus* Maslov.

Member 5 (85 m):

Alternating grey to pale grey, medium-bedded fossiliferous wavy-cherty limestones, limestones and shaly limestones in the upper part (Fig. 5h). The bedding shows N 275° W strike and 42° SW dip. This member includes the following microfossils (thin sections no. H.V-70 ~ 104): **Foraminifera:** *Aghathammina* sp., *Climacammina* sp., *Climacammina sphaerica* Potieskaya, *Climacammina vavalinoids* Lange, *Cryptosetida* (*Langella*) *bozorgniansis* Partoazar & Vaziri, *Deckerella* sp., *Deckerella* aff. *composita* Reitlinger, *Dunbarula mathieui* Ciry, *Geinitzina* sp., *Geinitzina chapmani* Schubert Var. Longa Sulemanov, *Globivalvalina* sp., *Globivalvalina vonderschmitti* Reichel, *Hemigordius* sp., *Langella* sp., *Langella* cf. *cukurkoyi* De Civer. & Dess., *Lasiodiscus* sp., *Neoendothyra* sp., *Neoendothyra reicheli* Reitlinger, *Neoendothyra broennimanni* Bozorgnia, *Neoendothyra* cf. parva (Lange), *Pachyphloia* sp., *Pachyphloia cukurkoyi* De Civer. & Dess., *Pachyphloia pedicula* Lange, *Palaeobigenerina* sp., *Palaeotextularia* sp., *Staffella* sp., *Tetrataxia* cf. *planulata* Morozova, *Tuberitina* sp.(Pl. 4, fig. 13); **Algae:** *Gymnocodium* sp., *Permocalculus* sp., *Pseudovermiporella* sp., *Vermiporella* sp., *Vermiporella nipponica* Endo (Pl. 4. fig. 15 & Pl. 5, fig. 1); **Cyanobacteria:** *Tubiphytes obscurus* Maslov.

Member 6 (28.5 m):

Alternating grey to dark-grey, medium to thick-bedded rublly fossiliferous cherty limestones. The bedding shows N 295° W strike and 40° SW dip.

This member includes the following microfossils (thin sections no. H.V-105 ~ 115): **Foraminifera:** *Climacammina* sp., *Climacammina sphaerica* Potieskaya, *Climacammina vavalinoids* Lange, *Cryptosetida* (*Langella*) *bozorgniansis* Partoazar & Vaziri, *Deckerella* sp., *Dunbarula mathieui* Ciry, *Geinitzina* sp., *Geinitzina* cf. *uralica* Suleimnov, *Geinitzina reperta* Bikova, *Globivalvalina* sp., *Globivalvalina vonderschmitti* Reichel, *Hemigordius* sp., *Kahlerina pachytheca* Koch, *Langella* sp., *Neoendothyra* sp., *Neoendothyra broennimanni* Bozorgnia, *Neoendothyra reicheli* Reitlinger, *Neoendothyra* cf. *parva* (Lange), *Pachyphloia* sp., *Pachyphloia cukurkoyi* De Civer. & Dess., *Pachyphloia pedicula* Lange, *Staffella* sp., *Tetrataxia* sp., *Tuberitina* sp. (Pl. 4, fig. 8); **Algae:** *Gymnocodium* sp., *Permocalculus* sp., *Pseudovermiporella* sp., *Vermiporella* sp.; **Cyanobacteria:** *Tubiphytes* sp., *Tubiphytes obscurus* Maslov.

The followings are microfossils present in the members 4, 5 and 6 of the Ruteh Formation that include the *Neoendothyra* assemblage indicating a Late Murgabian age for these members.

3.3 The Nesen Formation

The Nesen Formation in the study section consists of dark grey, medium-bedded shaly cherty limestones, bauxite-laterite horizon and volcanic rock that can be subdivided into two members with a thickness of 20.5 meters. The Nesen Formation overlies the Ruteh Formation disconformably and there are no Midian deposits. These beds show N 320° W strike and 20° SW dip.

Member 1 (8 m):

Consists of bauxite-laterite horizon with thickness of 6 meters (Fig. 6d), volcanic rock and grey, thin-bedded sandy shaly limestones. This volcanic rock is similar to the volcanic rocks present at the base of the Nesen Formation in the Elikah valley (Glaus, 1964).

Member 2 (12.5 m):

Grey to buff, medium-bedded shaly fossiliferous limestones with bedded cherts (Fig. 6e) and marly silty limestones at the top. This member includes the following microfossils (thin sections no. H.V-116 ~ 122): **Foraminifera:** *Aghathammina* sp., *Aghathammina pusilla* Geinitz, *Baisalina pulchra* Reitlinger, Climacammina sp., *Codonofusiella* sp., *Codonofusiella eriki* Rauser, *Cryptosetida* (*Langella*) *bozorgniansis* Partoazar & Vaziri, *Dagmarita* sp., *Deckerella* sp., *Dunbarula mathieui* Ciry, *Earlandia* sp., *Geinitzina* sp., *Geinitzina reperta* Bikova, *Geinitzina postcarbonica* Spendel, *Globivalvalina* sp., *Globivalvulina vonderschmitti* Reichel, *Hemigordius* sp., *Monogenerina* sp., *Nankinella* sp., *Neoendothyra reicheli* Reitlinger, *Pachyphloia* sp., *Pachyphloia* cf. *iranica* Bozorgnia, *Palaeotextularia* sp., *Paraglobivalvulina* sp., *Paraglobivalvulina mira* Reitlinger, *Reichelina* sp., *Staffella* sp. (Pl. 5, figs. 3-14); **Algae:** *Gymnocodium bellerphontis* (Rotheletz), *Permocalculus* sp., *Vermiporella*

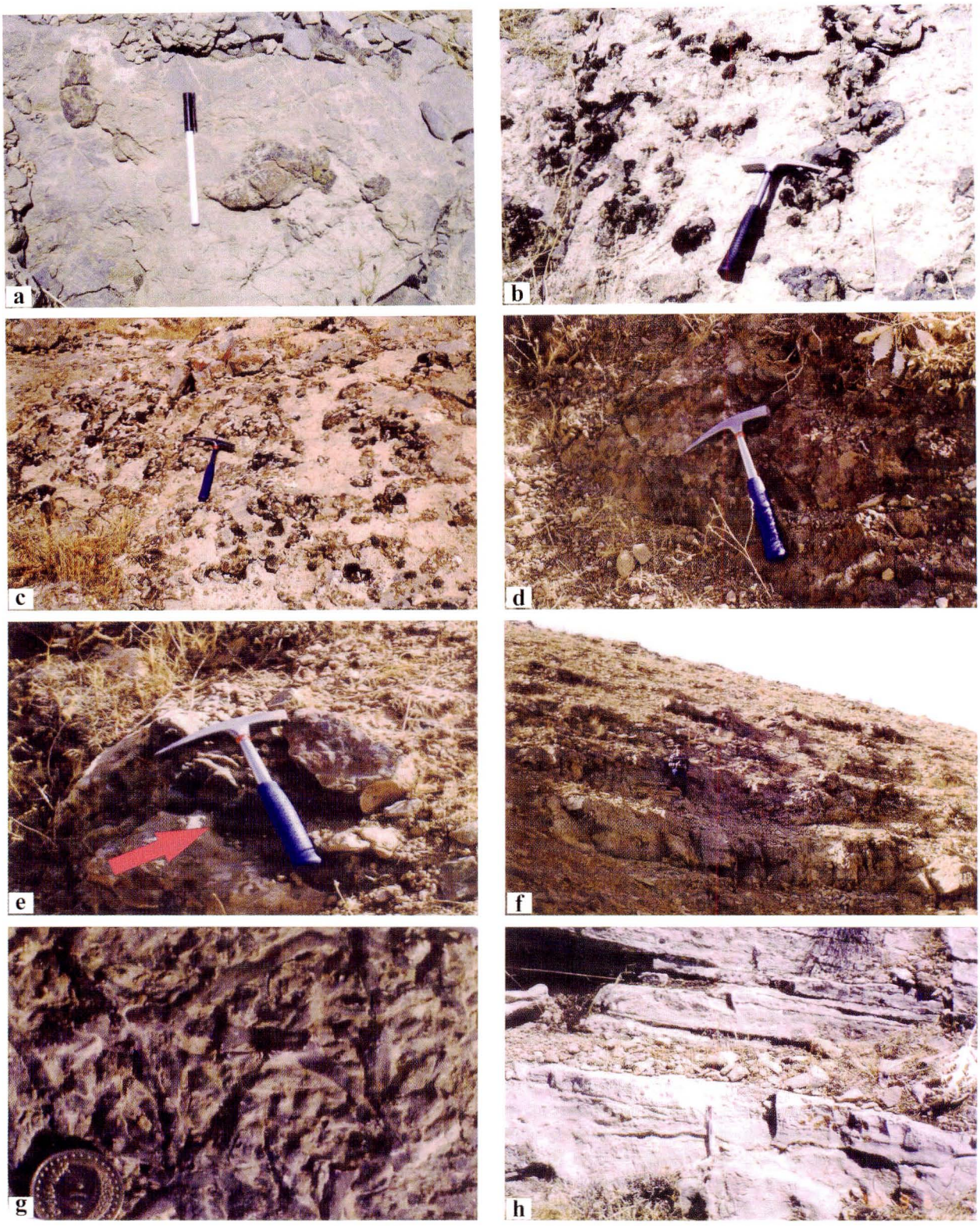


Fig. 6 **(a-c)** Chert nodules in limestones of the Ruteh Formation (member 5). **(d)** Bauxite-laterite horizon of the Nesen Formation (member 1). **(e)** Chert bed in alternating limestones of the Nesen Formation (member 2). **(f)** Alternating dolomitic slaty limestones with vermicular and *Claraia* beds of the Elikah Formation (member 1). **(g)** "Calcareous vermicular" in member 1 of the Elikah Formation. **(h)** Buff to cream dolomites of the Elikah Formation (member 2).

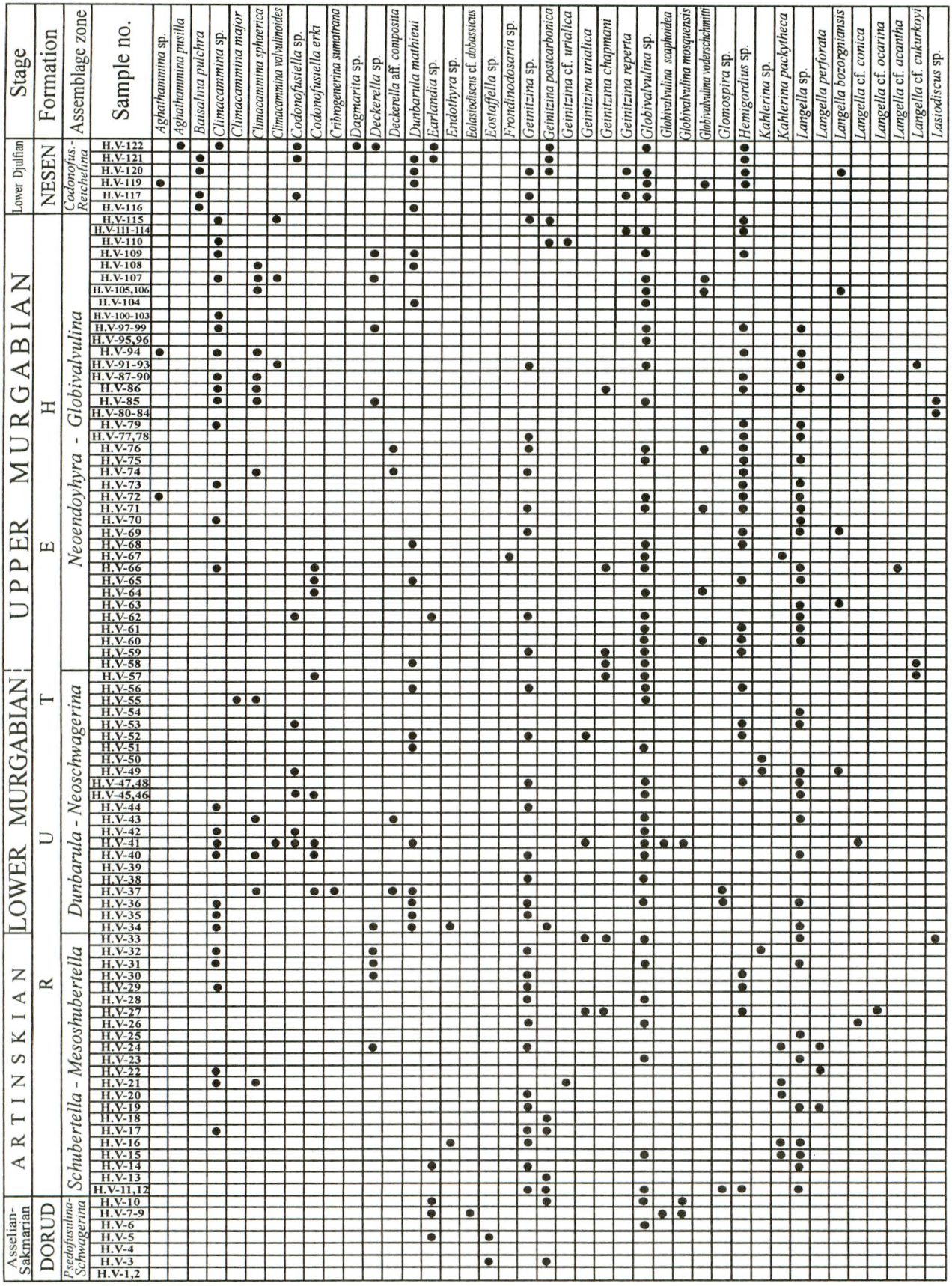


Fig. 7 List of the foraminifera species at the Gord Calleh section in Shalamzar area, Central Alborz, North Iran

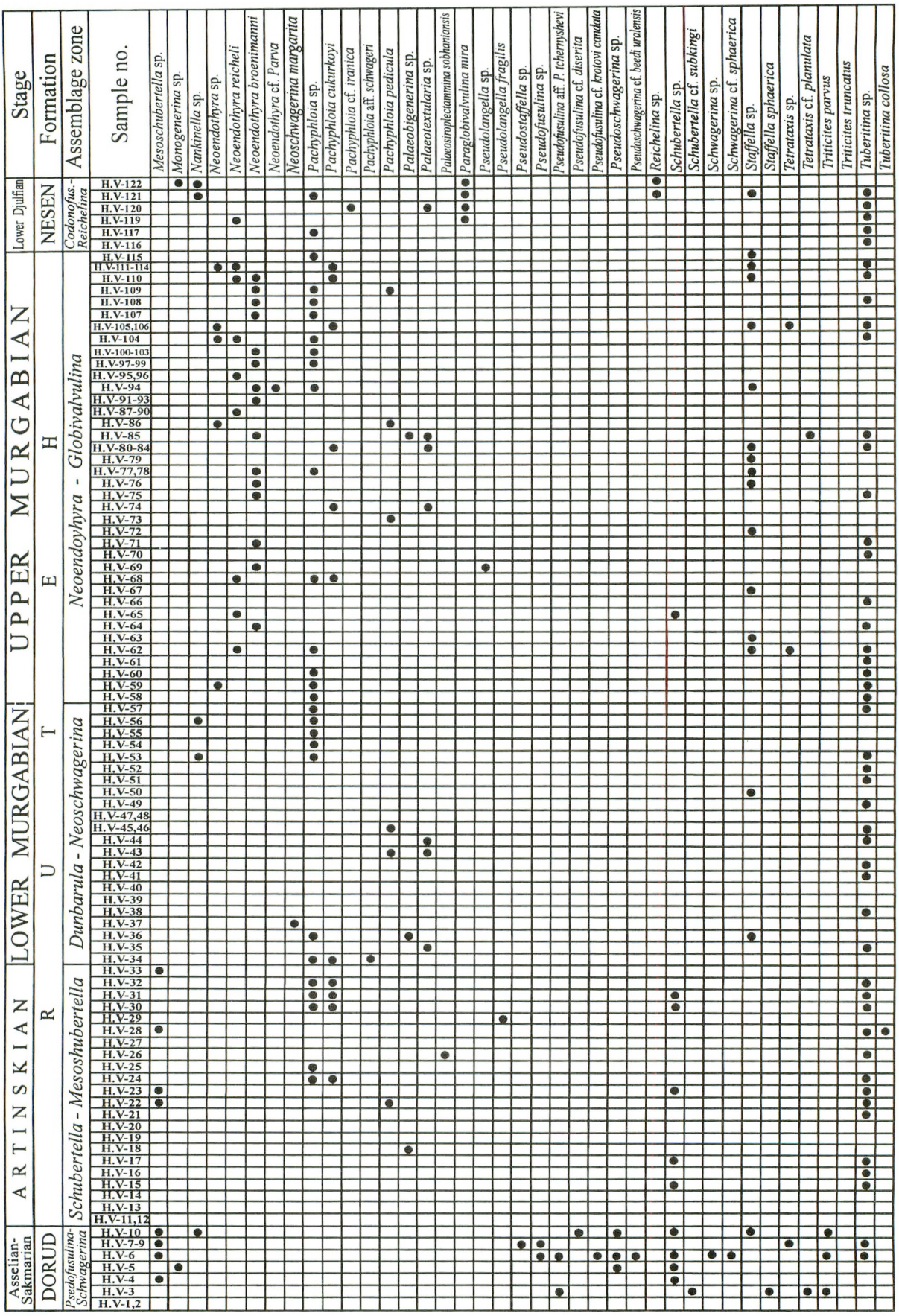


Fig. 8 List of the foraminifera species at the Gord Calleh section in Shalamzar area, Central Alborz, North Iran

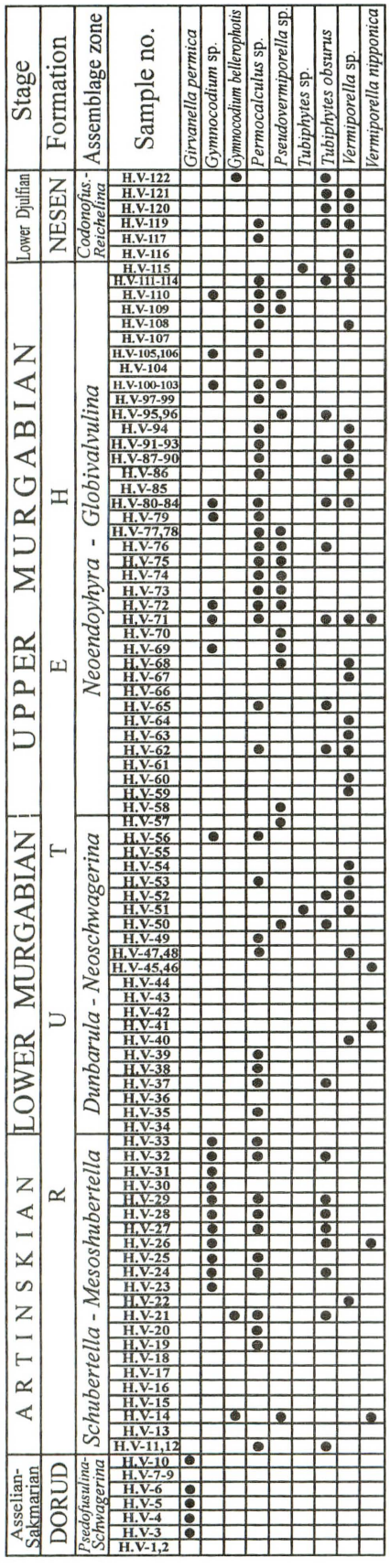


Fig. 9 List of the algae and cyanobacteria species at the Gord Calleh section in Shalamzar area, Central Alborz, North Iran.

sp.; **Cyanobacteria:** *Tubiphytes obscurus* Maslov. (Pl. 5, fig. 2).

The above-mentioned microfossil assemblages, especially the *Baisalina pulchra*, *Codonofusiella eriki*, *Paraglobivalvulina mira* and *Reichelina* sp. indicate an Early Djulfian age for the formation.

The Nesen Formation overlies disconformably, via a lateritic-bauxitic horizon (6 m), the Ruteh Formation and is covered disconformably by the Elikah Formation (Scythian-Ladinian). In the Alborz Range, the Permian-Triassic boundary is marked by somewhat larger sedimentary gap, resulting in the non-deposition of Upper Djulfian-Dorashamian sediments. This gap is represented by the development of a few meters of lateritic-bauxitic layers (Golshani *et al.*, 1986).

List of the foraminifera species in the study section are shown in Figs. 7, 8 and list of the algae and cyanobacteria species are shown in Fig. 9.

3.4 The Elikah Formation

The Elikah Formation in the study section consists of platy, buff to cream, thin-bedded dolomitic slaty limestones with vermicular and besides bivalves (*Claraia*), serpulids (*Spiorbis*) and thick-bedded to massive dolomites with Early to Middle Triassic (Scythian-Ladinian) age (Figs. 6f-h & Pl. 5, fig. 15). The Elikah Formation was deposited on a vast platform along the shelves of Paleo-Tethys and Neo-Tethys (Seyed-Emami, 2003). The rather poor fossil content can deduce the age of the Elikah Formation, mainly concentrated in the lower part. The main fossil taxa are foraminifers, pelecypods, ammonoids and conodonts, indicating an Early and Middle Triassic age for the formation (Allenbach, 1966; Stepanov *et al.*, 1969; Nakazawa *et al.*, 1981; Hirsch and Sussli, 1973; Kozur *et al.*, 1975; Sweet, 1979; Vaziri, 2004). In few localities such as Aruh area (west of Firuzkuh) and Veresk area (northeastern Firuzkuh) along Central Alborz and Shahrud area in eastern Alborz, where the pre-Shemshak erosional phase (Early Cimmerian tectonic event) has not been deep enough, a light grey limestone up to 100 meters (Aruh Limestone Member) builds up of the top of the Elikah Formation (Zaninetti *et al.*, 1972; Stampfli *et al.*, 1976; Nabavi, 1987; Jahani, 2000; Vaziri and Majidifard, 2001; Seyed-Emami, 2003; Vaziri, 2004) and age of the Elikah Formation spans up to Late Triassic (Carnian). In the Shahrud area in eastern Alborz, this limestone contains serpulids (*Spiorbis*) and foraminifers of the *Ammobaculites* sp., *Involutina* sp., *Ophthalmidium* sp., *Reophax* sp., *Sigmolina* sp. and *Trochammina* sp. that indicate a Carnian age (Vaziri and Majidifard, 2001).

Except in the Jolfa area in northwestern Alborz, where

the Permo-Triassic boundary is rather continuous (Stepanov *et al.*, 1969; Golshani *et al.*, 1986), elsewhere along the Alborz Range, the Elikah Formation overlies with a distinct disconformity Upper Permian or even older strata (Seyed-Emami, 1971, 2003) and may have thickness up to 1000 meters.

4. Foraminiferal biozones of Permian system in the study section

Five biozones by foraminifers have been established in the study section as the following (Fig. 4):

4.1 *Pseudofusulina - Schwagerina* Assemblage Zone

This biozone includes four members of the Dorud Formation with thickness of 269 meters. It indicates an Asselian-Sakmarian age and includes foraminifers of the *Eostaffella* sp., *Geinitzina postcarbonica* Spandel, *Pseudofusulina* aff. *tchernyshevi* (Schellwien), *Pseudofusulina* cf. *krotovi candata* Rauser, *Pseudofusulina* cf. *diserta* Saerovich, *Pseudoschwagerina* sp., *Schubertella* sp., *Schubertella* cf. *subkingi* Dunbar et Skinner, *Schwagerina* cf. *sphaerica* Sherb, *Staffella sphaerica* (Abich), *Triticites truncatus* Chen and *Triticites parvus* Chen (Figs. 7, 8).

4.2 *Schubertella - Mesoschubertella* Assemblage Zone

This biozone includes members 1 and 2 of the Ruteh Formation with thickness of 61 meters. It indicates an Artinskian age and includes foraminifers of the *Mesoschubertella* sp., *Geinitzina chapmani* Schubert Var. Longa Sulemanov, *Langella perforata* Lange and *Schubertella* sp. (Figs. 7, 8).

4.3 *Dunbarula - Neoschwagerina* Assemblage Zone

This biozone includes member 3 of the Ruteh Formation with thickness of 110 meters. It indicates an Early Murgabian age and includes foraminifers of the *Climacammina vavalinoids* Lange, *Climacammina sphaerica* Potieskaya, *Deckerella* aff. *composita* Reitlinger, *Dunbarula mathieui* Ciry, *Neoschwagerina margarita* Deprat and *Pachyphloia pedicula* Lange (Figs. 7, 8).

4.4 *Neoendothyra - Globivalvulina* Assemblage Zone

This biozone includes members 4, 5 and 6 of the Ruteh Formation with thickness of 134.5 meters. It indicates a Late Murgabian age and includes foraminifers of the *Codonofusiella* sp., *Globivalvalina vonderschmitti* Reichel, *Neoendothyra broennimanni* Bozorgnia, *Neoendothyra reicheli* Reitlinger, *Neoendothyra* cf. *parva* (Lange) and *Pachyphloia cukurkoyi* De Civer. & Dess. (Figs. 7, 8).

4.5 *Codonofusiella - Reichelina* Assemblage Zone

This biozone includes members 1 and 2 of the Nesen Formation with thickness of 20.5 meters. It indicates an Early Djulfian age and includes foraminifers of the *Baisalina pulchra* Reitlinger, *Codonofusiella eriki* Rauser, *Paraglobivalvulina mira* Reitlinger and *Reichelina* sp. (Figs. 7, 8).

5. Materials and Methods

The Ruteh and the Nesen formations in the study section consist mainly of limestones with chert nodules and beds. For study of radiolarian faunas, twenty-five samples (numbered from Sh-1 to Sh-25) from nodular and bedded cherts of the Ruteh Formation were collected and two samples (numbered Sh-26 and Sh-27) from bedded cherts of the Nesen Formation. All chert samples were used for the extraction of radiolarian fossils. These were about 200 g to 300 g per sample.

The chert samples were immersed in a 5 % hydrofluoric acid (HF) solution for 24 hours. After removing the HF solution, the residues were collected using 35 and 200 mesh sieves. In some samples, the same treatment was conducted several times in order to obtain sufficient radiolarian fossils. The residues, in which radiolarian fossils were concentrated by panning, were mounted on a glass slide, a medium (Entellan new) added, and covered with a cover glass.

Radiolarian specimens on slides were observed under a transmitted light microscope. In case of necessity, a scanning electron microscope (JSM-5500) was used to observe and to take photographs of radiolarian specimens.

6. Results

From Twenty-five chert samples that were collected from the members 2, 3 and 5 of the Ruteh Formation, ten samples yielded radiolarian faunas. A total of ten species of the Permian (Artinskian and Murgabian) radiolarians were recorded that include six species and four unidentified species are systematically described in the present paper.

Occurrences of radiolarian species characteristic are described below. Photomicrographs of characteristic radiolarian species are shown in Plates 1 and 2. Their horizons are shown in the columnar section (Fig. 10).

(a) Samples Sh-1 to Sh-4 of the member 2 include foraminifers, ostracods, sponge spicules, bryozoans (Pl. 2, fig. 12) and radiolarians of the *Latentifistula*? sp. A,

Orbiculiforma? sp. B and Spherical Radiolaria B. (Pl. 2, figs. 1, 4).

(b) Samples Sh-5 to Sh-10 of the member 3 include foraminifers, sponge spicules, bryozoans (Pl. 2, fig. 13) and radiolarian of the *Latentifistula*? sp. B (Pl. 2, fig. 9).

(c) Samples Sh-11 to Sh-25 of the member 5 include foraminifers, ostracods, sponge spicules, bryozoans (Pl. 2, figs. 14, 15) and radiolarians of the *Latentifistula*? sp. A, *Latentifistula*? sp. B, Latentifistularia A, Latentifistularia B, *Orbiculiforma*? sp. A, Spherical Radiolaria A, Spherical Radiolaria B, Spherical Radiolaria C and Ellipsoidal Radiolaria A (Pl. 1, figs. 1-15 & Pl. 2, figs. 2, 3, 5, 6-8, 10, 11).

(d) In two samples Sh-26 and Sh-27 from bedded cherts of the Nesen Formation no radiolarians were found. These samples only include foraminifers and abundant

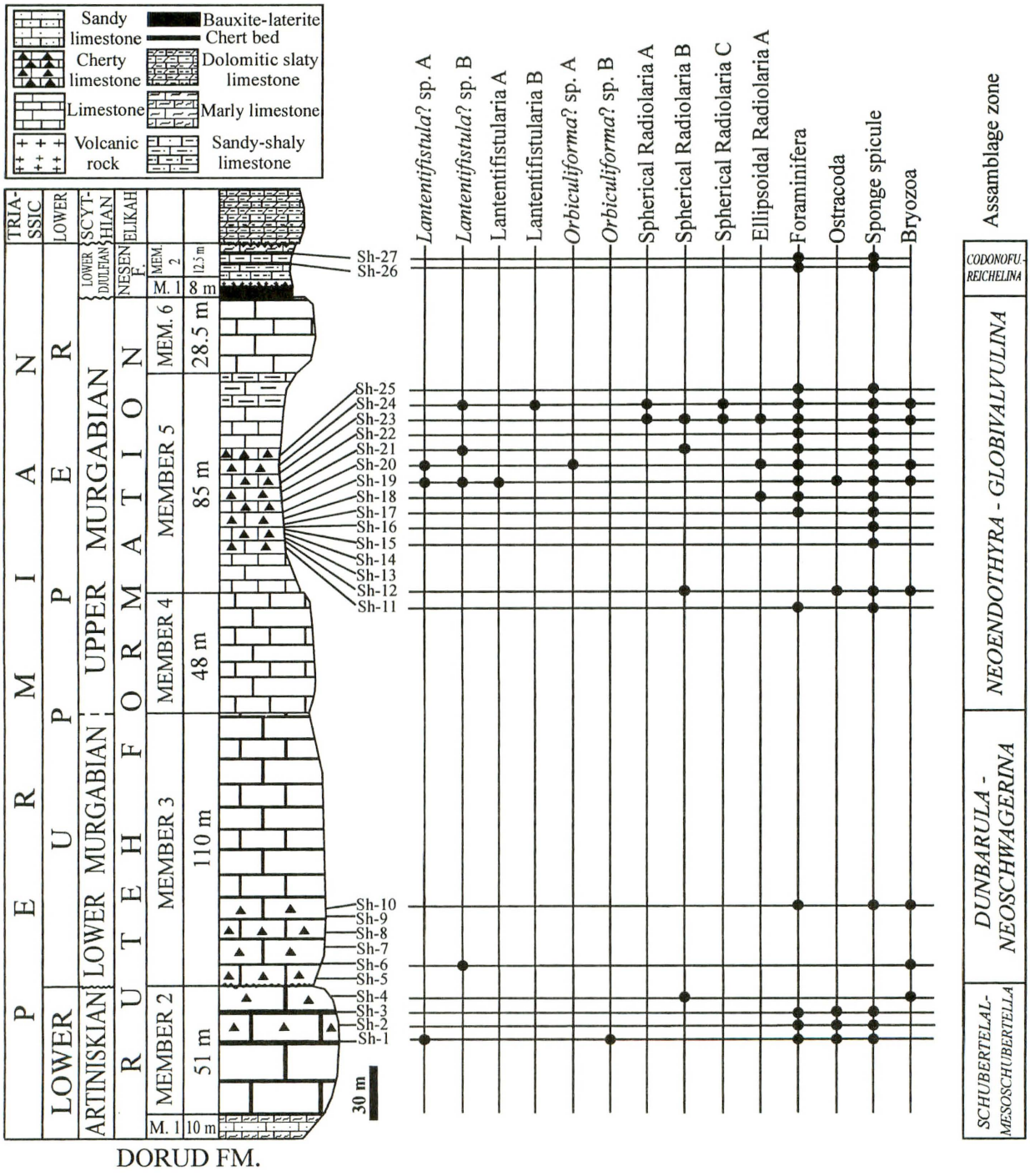


Fig. 10 Columnar section showing the horizons of radiolarian occurrence at the Gord Calleh section in northeast of Shalamzar, Central Alborz, North Iran.

sponge spicules.

According to time unit, the detected Permian (Artinskian and Murgabian) radiolarians in the Shalamzar area (Ruteh Formation) can be correlated with the Permian radiolarian zones in South China, Southwest Japan and Oregon, USA as follow:

1. Early Permian (Artinskian) radiolarians include the *Latentifistula*? sp. A, *Orbiculiforma*? sp. B and Spherical Radiolaria B in the member 2 of the Ruteh Formation can be correlated with the *Albaillella xiaodongensis* and *Albaillella sinuate* zones in southeast Guangxi, South China (Wang *et al.*, 1998), *Albaillella sinuate* Zone in Southwest Japan (Ishiga 1990) and the *Albaillella sinuate* Zone in Oregon, USA (Blome and Reed, 1992), which are shown in Fig. 11. These radiolarian faunas also are correlated with the *Schubertella-Mesoschubertella* Assemblage Zone and the age is assigned to Artinskian.

2. Late Permian (Murgabian) radiolarians include the *Latentifistula*? sp. A, *Latentifistula*? sp. B, Latentifistularia A, Latentifistularia B, Orbiculiforma? sp. A, Spherical Radiolaria A, Spherical Radiolaria B, Spherical Radiolaria C and Ellipsoidal Radiolaria A in the members 3 and 5 of the Ruteh Formation can be correlated with the *Pseudoalbaillella globosa, Follicucullus monacanthus* and *Follicucullus scholasticus - Follicucullus ventricosus* zones in southeast Guangxi, South China (Wang *et al.*, 1998), *Pseudoalbaillella globosa, Follicucullus monacanthus* and *Follicucullus scholasticus* zones in Dachongling section, South China (Sun *et al.*, 2002), *Pseudoalbaillella globosa, Follicucullus monacanthus* and *Follicucullus scholasticus - Follicucullus ventricosus* zones in Southwest Japan (Ishiga 1990; Kuwahara *et al.*, 1998) and the *Pseudoalbaillella globosa, Follicucullus monacanthus* and *Follicucullus scholasticus* zones in Oregon, USA (modified from Blome and Reed, 1992), which are shown in Fig. 11. The detected Late Permian radiolarians also are correlated with the *Dunbarula-Neoschwagerina* and *Neoendothyra- Globivalvalina* Assemblage zones, and the age is assigned to Murgabian.

On the basis of the above-mentioned correlation and

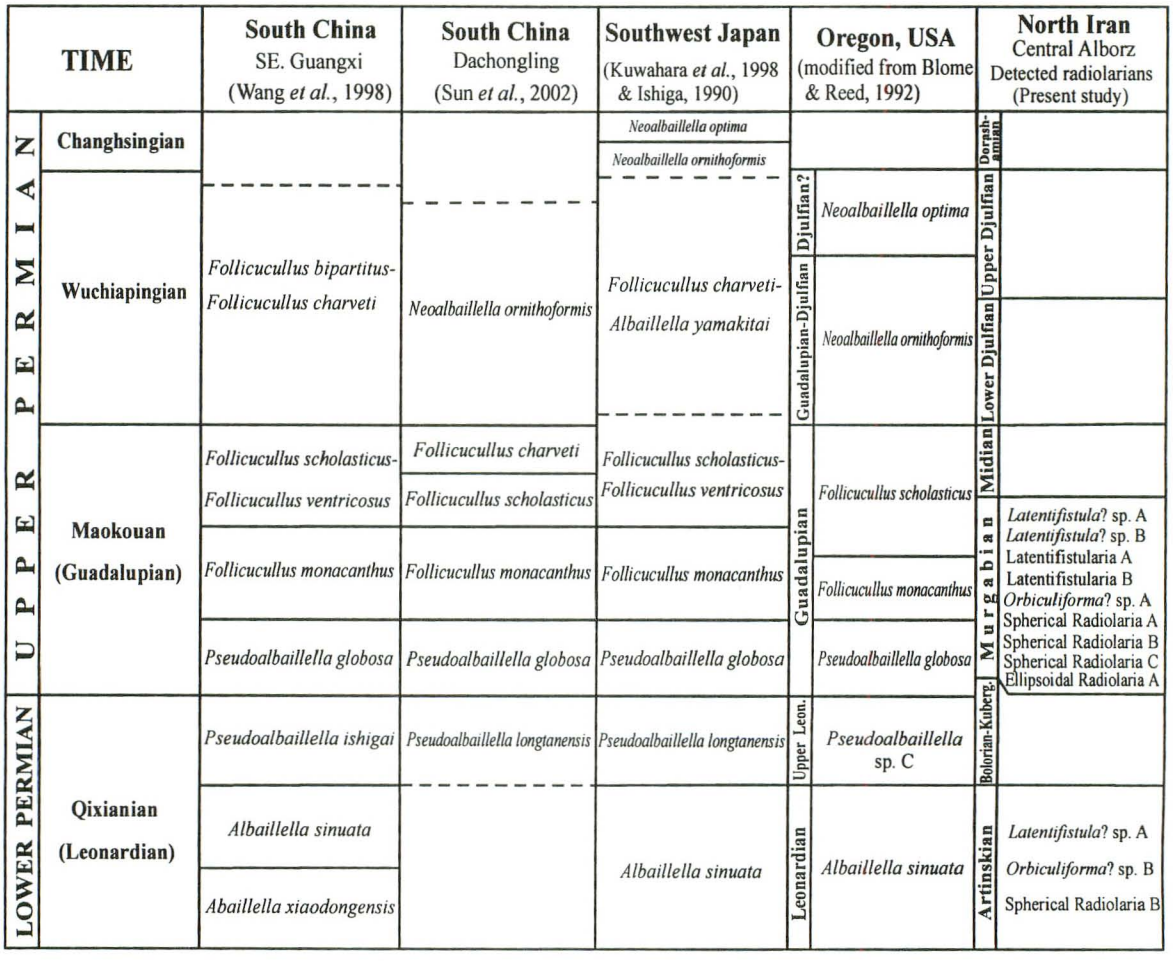


Fig. 11 Time correlation of detected Permian radiolarians in the Shalamzar area, Central Alborz, North Iran with the Permian radiolarian zones in South China, Southwest Japan and Oregon, USA.

index foraminifer's age of the Ruteh Formation, the age of detected radiolarian faunas is assigned to Artinskian and Murgabian.

7. Conclusions

The Permian sequence in the Shalamzar area consists mainly of clastic rocks in the lower part (Dorud Formation) and fossiliferous carbonate rocks in the upper part (Ruteh and Nesen formations), and is bounded between two unconformities. The sedimentation gaps in lower and upper boundaries are related to the Hercynian orogenic phase. The rich foraminifer fauna indicate an Early to Late Permian (Asselian to Early Djulfian) age of the succession.

In the Present study, five biozones by foraminifers are established in the Permian System of the study section that include the *Pseudofusulina-Schwagerina* Assemblage Zone (Asselian-Sakmarian), *Schubertella-Mesosubertella* Assemblage Zone (Artinskian), *Dunbarula-Neoschwagerina* and *Neoendothyra-Globivalvalina* Assemblage zones (Murgabian), and *Codonofusiella-Reichelina* Assemblage Zone (Early Djulfian).

The Dorud Formation in the study section consists of conglomerate, sandstone, siltstone, shale, quartzite and few fossiliferous limestones that do not have chert. The clastic rocks of the Dorud Formation were deposited in continental (meandering river) and transitional (deltaic and littoral) environments (Mokhtarpour, 1997a). This formation is correlated with the *Pseudofusulina-Schwagerina* Assemblage Zone and the age is assigned to Asselian to Sakmarian.

The Ruteh and the Nesen formations in the study section consist mainly of fossiliferous limestones with chert nodules and beds that were deposited in barrier, lagoon, tidal flat and open marine environments (Mokhtarpour, 1997b). The Ruteh Formation is correlated with the *Schubertella-Mesoschubertella*, *Dunbarula-Neoschwagerina* and *Neoendothyra-Globivalvalina* Assemblage zones, and the age is assigned to Artinskian-Murgabian. The Nesen Formation is correlated with the *Codonofusiella-Reichelina* Assemblage Zone and the age is assigned to Early Djulfian.

There are remarkable chert nodules and beds in the Ruteh and Nesen formations of northern Iran in order to study radiolarians. The present study examined chert samples from the Ruteh and Nesen formations for radiolarian study and ten species of radiolarian faunas were detected. Detected Permian (Artinskian and Murgabian) radiolarians include the *Latentifistula*? sp. A, *Latentifistula*? sp. B, Latentifistularia A, Latentifistularia B, *Orbiculiforma*? sp. A, *Orbiculiforma*? sp. B, Spherical Radiolaria A, Spherical Radiolaria B, Spherical Radiolaria C and Ellipsoidal Radiolaria A were recorded from the Ruteh Formation in northeast Shalamzar, Central Alborz for the first time. The detected radiolarians are correlative with those of south and southwestern China, eastern Thailand, central and southwest Japan, Malaysia, Turkey (NW Anatolia), Far East of Russia (Primoryie), Kazakhstan (southern Urals), North America, Philippines and Italy (western Sicily). According to time unit, all recorded radiolarians can be correlated with the Permian radiolarian zones in South China, Southwest Japan and Oregon, USA and these also are correlated with the *Schubertella-Mesoschubertella* Assemblage Zone (Artinskian), *Dunbarula-Neoschwagerina* and *Neoendothyra-Globivalvalina* Assemblage zones (Murgabian). On the basis of the above-mentioned correlation and index foraminifer's age of the Ruteh Formation, the age of detected radiolarian faunas is assigned to Artinskian and Murgabian.

The occurrence of *Orbiculiforma*? sp. A, *Orbiculiforma*? sp. B, Spherical Radiolaria A, Spherical Radiolaria B, Spherical Radiolaria C and Ellipsoidal Radiolaria A were reported also from Jolfa Region in northwestern Iran by Vaziri and Yao (2005) for the first time.

The present study shows that Permian rocks of northern Iran contain radiolarian faunas, but they are not numerous and their diversity is scarce. It is dependent on the depth of the sedimentary site and type of facies. Also this study shows that distribution and diversity species of radiolarian faunas in the upper part of the Ruteh Formation (member 5) is more than the lower part of this formation (Fig. 10) and the relative ratio of radiolarians to sponge spicules of sample changes through the study section. In each sample that ratio of sponge spicules increases together with the amount of lithic fragments, radiolarians decrease or disappear. For example: chert samples of the Nesen Formation (samples Sh-26 and Sh-27) contain abundant sponge spicules but they have not radiolarians. This may be related to global environmental changes.

8. Systematic Paleontology of the Radiolarians

All specimens described in this paper are deposited in Earth History laboratory, Department of Geosciences, Graduate School of Science, Osaka City University, Japan.

Spherical Radiolaria A

(Pl.1, figs. 1-4)

Description: Shell is spherical to subspherical in shape with fine pores. Pores are subcircular to subelliptical. Most species have some big pores.

Measurements (in μm): Diameter of shells is "between 210 to 225". Average of diameter is 217.5.
Age: Late Permian (Murgabian).
Locality: Ruteh Formation, Gord Calleh section (samples Sh-23, Sh-24), Shalamzar area, Central Alborz, North Iran. This species is also reported from the Jolfa Formation (Early Djulfian) in the Jolfa Region, Northwestern Iran by Vaziri and Yao (2005).
Occurrence: Worldwide.

Spherical Radiolaria B

(Pl.1, figs. 5-11)

Description: Shell is spherical to subspherical in shape with fine pores. Pores are subcircular to subelliptical. Most species have some big pores.
Measurements (in μm): Diameter of shells is "between 155 to 220". Mainly "between 190 to 220". Average of diameter is 198.
Age: Early to Late Permian (Artinskian-Murgabian).
Locality: Ruteh Formation, Gord Calleh section (samples Sh-4, Sh-12, Sh-21, Sh-23), Shalamzar area, Central Alborz, North Iran. This species is also reported from the Jolfa Formation (Early Djulfian) in the Jolfa Region, Northwestern Iran by Vaziri and Yao (2005).
Occurrence: Worldwide.

Spherical Radiolaria C

(Pl. 1, figs. 12, 13)

Description: Shell is spherical to subspherical in shape with fine pores. Pores are subcircular to angular. Some species have few big pores.
Measurements (in μm): Diameter of shells is 82.
Age: Late Permian (Murgabian).
Locality: Ruteh Formation, Gord Calleh section (samples Sh-23, Sh-24), Shalamzar area, Central Alborz, North Iran. This species is also reported from the Jolfa Formation (Early Djulfian) in the Jolfa Region, Northwestern Iran by Vaziri and Yao (2005).
Occurrence: Worldwide.

Ellipsoidal Radiolaria A

(Pl. 1, fig. 15)

Description: Shell is ellipsoidal in shape with clear pores. Pores are angular.
Measurements (in μm): Length of shells is 245. Diameter of shells is 170.
Age: Late Permian (Murgabian).
Locality: Ruteh Formation, Gord Calleh section (samples Sh-18, Sh-20, Sh-23), Shalamzar area, Central Alborz, North Iran. This species is also reported from the Jolfa Formation (Early Djulfian) in the Jolfa Region, Northwestern Iran by Vaziri and Yao (2005).
Occurrence: Worldwide.

Suborder SPUMELLARIA Ehrenberg, 1875
Family OBICULIFORMIDAE Pessagno 1973
Genus ORBICULIFORMA Pessagno, 1973
***Orbiculiforma*? sp. A**

(Pl. 1, fig. 14)

Description: Shell is circular and flat in outline. Pores are circular or angular.
Measurements (in μm): Diameter of shells is 450.
Age: Late Permian (Murgabian).
Locality: Ruteh Formation, Gord Calleh section (sample Sh-20), Shalamzar area, Central Alborz, North Iran. This species is also reported from the Jolfa Formation (Early Djulfian) in the Jolfa Region, Northwestern Iran by Vaziri and Yao (2005).
Occurrence: North and Northwestern Iran, South China, Southwest Japan.

***Orbiculiforma*? sp. B**

(Pl. 2, fig. 1)

Description: Shell is circular and flat in outline with a cavity in center. Shape and depth of the central shell are depression and central cavity flanked by prominent rim. Pores are circular or angular.
Measurements (in μm): Diameter of shells is 450.
Age: Early Permian (Artinskian).
Locality: Ruteh Formation, Gord Calleh section (Sh-1), Shalamzar area, Central Alborz, North Iran. This species is also reported from the Jolfa Formation (Early Djulfian) in the Jolfa Region, Northwestern Iran by Vaziri and Yao (2005).
Occurrence: North and Northwestern Iran, South China, Southwest Japan.

Superfamily LATENTIFISTULIDEA Nazarov and Ormiston, 1983
Family LATENTIFISTULIDAE Nazarov and Ormiston, 1983
Genus LATENTIFISTULA Nazarov and Ormiston, 1983
***Latentifistula*? sp. A**

(Pl. 2, figs. 2-6)

Description: This species is characterized by having three characteristic arms, each with strong longitudinal beams connected with transverse bars, coarse sponge meshwork at distal part and a small spine at tip. We know latentifistularia with an initial spicule, with one apical and two to three basal spines, and perforate to partly perforate microsphere. Here, species are broken and one arm can be seen. Shell is

knobby and cylindrical in shape with long furrow and small pores. Pores irregularly arranged.

Measurements (in μm): Length of arms is "between 450 to 520" and average of length is 453. Diameter of arms is "between 70 to 160" and average of diameter is 95. Some species have rounded bulge in up with 138 average diameters.

Age: Early to Late Permian (Artinskian-Murgabian).

Locality: Ruteh Formation, Gord Calleh section (samples 1, Sh-19, Sh-20), Shalamzar area, Central Alborz, North Iran.

Occurrence: North Iran, South China, Central and Southwest Japan, Eastern Thailand, Far East Russia (Primoryie), Kazakhstan (southern Urals), Malaysia, Turkey (NW Anatolia), North America, Italy (western Sicily).

Latentifistula? sp. B

(Pl. 2, figs. 8-10)

Description: Here, species are broken. The first species (fig. 4) has two arms. The second species (fig. 5) has one arm and only the third species (fig. 6) shows three arms. Shells are knobby in shape with fine and coarse-grained pores. Pores irregularly arranged.

Measurements (in μm): Length of arm in second species is 550. Length of arms in first species is 140 and 460, and in third species they are 200, 270 and 300.

Age: Late Permian (Murgabian).

Locality: Ruteh Formation, Gord Calleh section (samples Sh-6, Sh-19, Sh-21, Sh-24), Shalamzar area, Central Alborz, North Iran.

Occurrence: North Iran, South China, Central and Southwest Japan, Eastern Thailand, Far East Russia (Primoryie), Kazakhstan (southern Urals), Malaysia, Turkey (NW Anatolia), North America, Italy (western Sicily).

Latentifistularia A

(Pl. 2, fig. 7)

Description: Latentifistularia has three arms. Here, species is broken and only one arm can be seen. Shell is knobby in shape and has rounded bulge in up. Shell is perforate and pores are angular.

Measurements (in μm): Length of shell is 540 and width of shell is 100. Width of rounded bulge in up is 240. This rounded bulge has a big hole in center.

Age: Late Permian (Murgabian).

Locality: Ruteh Formation, Gord Calleh section (sample Sh-19), Shalamzar area, Central Alborz, North Iran.

Occurrence: North Iran, South and Southwestern China, Southwest Japan, Malaysia, Thailand, Turkey (NW Anatolia), North America, Philippines.

Latentifistularia B

(Pl. 2, fig. 11)

Description: Species is fusiform with big spine. Shell is perforate and pores are angular.

Measurements (in μm): Length of species is 160 and its diameter is 75. Length of spine is 85.

Age: Late Permian (Murgabian).

Locality: Ruteh Formation, Gord Calleh section (sample Sh-24), Shalamzar area, Central Alborz, North Iran.

Occurrence: North Iran, South and Southwestern China, Southwest Japan, Malaysia, Thailand, Turkey (NW Anatolia), North America, Philippines.

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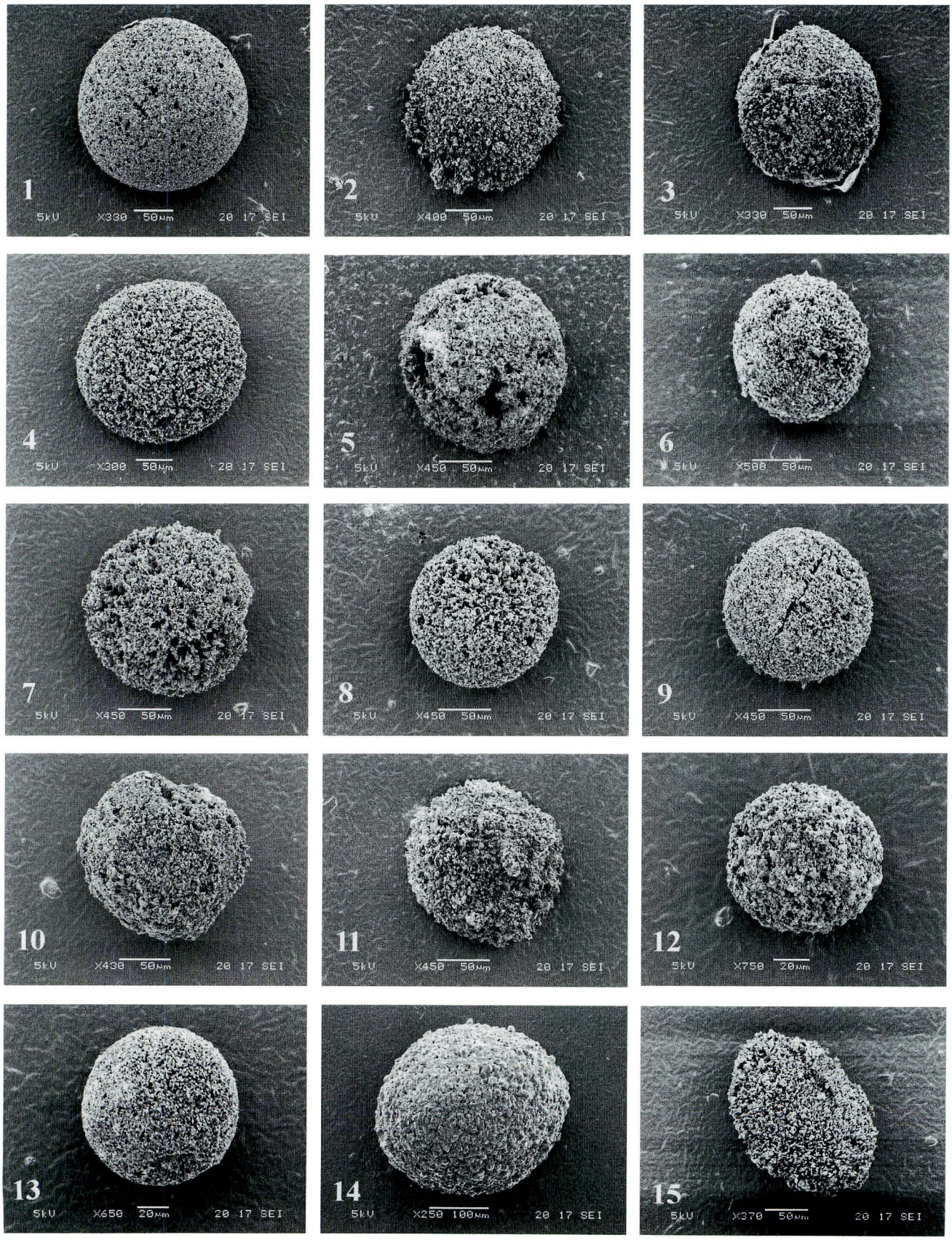
Scanning photomicrographs of Early and Late Permian (Artinskian and Murgabian) radiolarians from the Ruteh Formation, Gord Calleh section, Central Alborz, North Iran

Plate 1 (Murgabian)

Figs. 1, 2: Spherical Radiolaria A, sample no. Sh-23.
Figs. 3, 4: Spherical Radiolaria A, sample no. Sh-24.
Fig. 5: Spherical Radiolaria B, sample no. Sh-12.
Fig. 6: Spherical Radiolaria B, sample no. Sh-21.
Figs. 7-11: Spherical Radiolaria B, sample no. Sh-23
Figs. 12, 13: Spherical Radiolaria C, sample no. Sh-23.
Fig. 14: *Orbiculiforma*? sp. A, sample no. Sh-20.
Fig. 15: Ellipsoidal Radiolaria A, sample no. Sh-20.

Plate 1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2
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4
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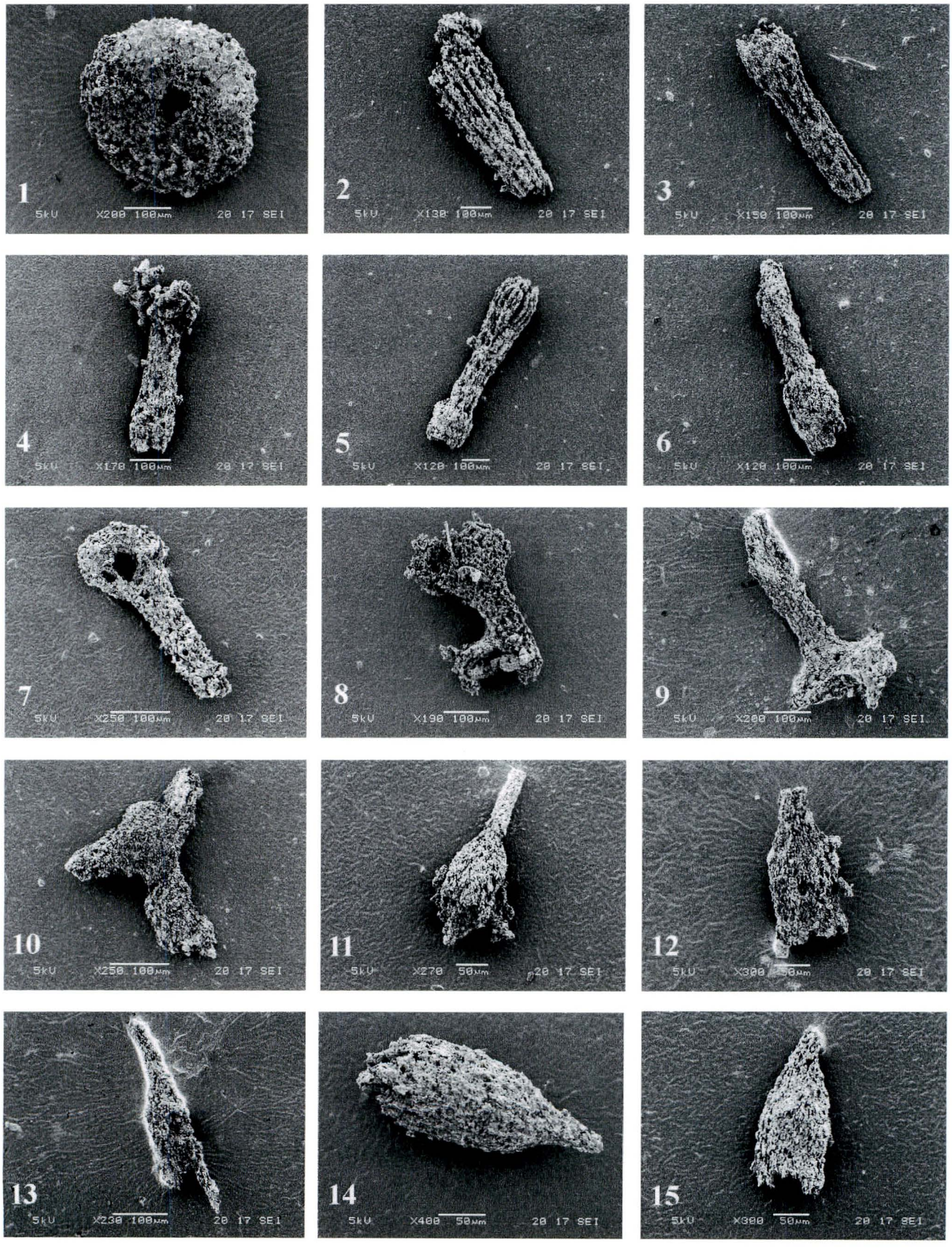
5
5kV X450 50µm 20 17 SEI
6
5kV X500 50µm 20 17 SEI
7
5kV X450 50µm 20 17 SEI
8
5kV X450 50µm 20 17 SEI
9
5kV X450 50µm 20 17 SEI
10
5kV X430 50µm 20 17 SEI
11
5kV X450 50µm 20 17 SEI
12
5kV X750 20µm 20 17 SEI
13
5kV X650 20µm 20 17 SEI
14
5kV X250 100µm 20 17 SEI
15
5kV X370 50µm 20 17 SEI

Plate 2 * Samples Sh-1, Sh-4: Artinskian
Others: Murgabian

Fig. 1: *Orbiculiforma*? sp. B, sample no. Sh-1.
Figs. 2, 5: *Latentifistula*? sp. A, sample no. Sh-19.
Figs. 3, 6: *Latentifistula*? sp. A, sample no. Sh-20.
Fig. 4: *Latentifistula*? sp. A, sample no. Sh-1.
Fig. 7: *Latentifistularia* A, sample no. Sh-19.
Fig. 8: *Latentifistula*? sp. B, sample no. Sh-19.
Fig. 9: *Latentifistula*? sp. B, sample no. Sh-6.
Fig. 10: *Latentifistula*? sp. B, sample no. Sh-21.
Fig. 11: *Latentifistularia* B, sample no. Sh-24.
Fig. 12: Bryozoa, sample no. Sh-4.
Fig. 13: Bryozoa, sample no. Sh-6.
Fig. 14: Bryozoa, sample no. Sh-19.
Fig. 15: Bryozoa, sample no. Sh-24.

Plate 2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5
5kV X120 100µm 20 17 SEI
6
5kV X120 100µm 20 17 SEI
7
5kV X250 100µm 20 17 SEI
8
5kV X190 100µm 20 17 SEI
9
5kV X200 100µm 20 17 SEI
10
5kV X250 100µm 20 17 SEI
11
5kV X270 50µm 20 17 SEI
12
5kV X300 50µm 20 17 SEI
13
5kV X230 100µm 20 17 SEI
14
5kV X400 50µm 20 17 SEI
15
5kV X300 50µm 20 17 SEI

Plate 3

Dorud Formation, Gord Calleh section, Early Permian (Asselian- Sakmarian),
Shalamzar area, Central Alborz, North Iran

Figs. 1, 2: *Girvanella permica* Pia, X20, thin section no. H.V-6.
Fig. 3: *Schwagerina* sp., X20, thin section no. H.V-6.
Fig. 4: *Pseudoschwagerina* sp., X20, thin section no. H.V-6.
Fig. 5: *Pseudoschwagerina* sp. and Schubertella sp., X29, thin section no. H.V-6.
Fig. 6: *Pseudofusulina* sp., X20, thin section no. H.V-6.
Fig. 7: *Pseudofusulina* aff. p. tchernyshevi (Schellwien), X20, thin section no. H.V-6.
Fig. 8: *Pseudofusulina* cf. diserta Sherbovich, X12.6, thin section no. H.V-10.
Fig. 9: *Tuberitina* sp., X100, thin section no. H.V-8.

Ruteh Formation, Gord Calleh section, Early Permian (Artinskian),
Shalamzar area, Central Alborz, North Iran

Fig. 10: *Permocalculus* sp., X20, thin section no. H.V-11.
Fig. 11: *Hemigordius* sp., X40, thin section no. H.V-27.
Fig. 12: *Palaeospiroplectammina sobhaniansis* Partoazar and Vaziri, X100, thin section no. H.V-26.
Fig. 13: *Palaeobigenerina* sp., X40, sample no. H.V-18.
Fig. 14: *Climacammina sphaerica* Potieskaya, X40, thin section no. H.V-21.
Fig. 15: *Kahlerina packytheca* Koch. Devide et Ramors, X100, thin section no. H.V-21.

Plate 3

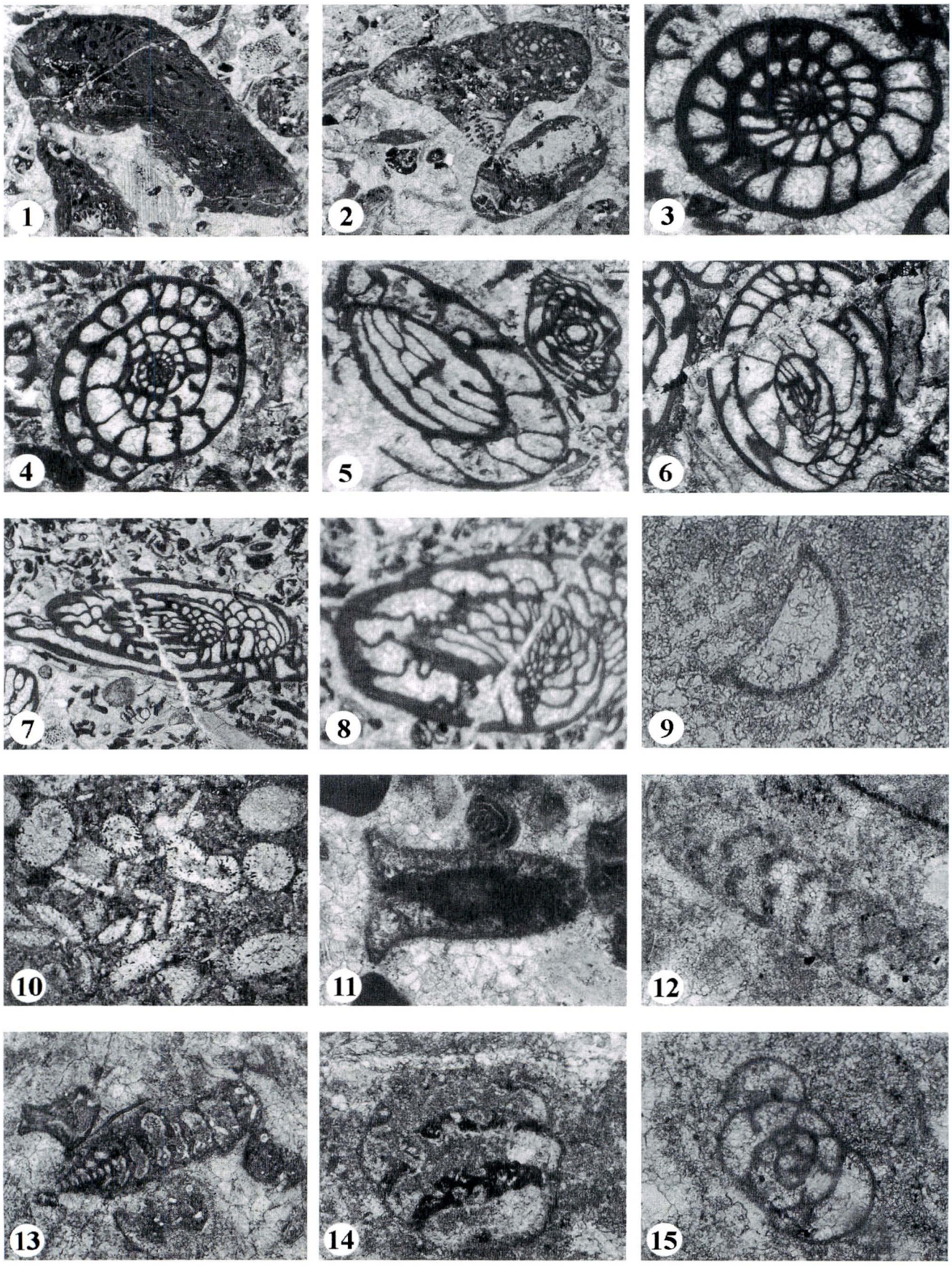

Plate 4

Ruteh Formation, Gord Calleh section, Late Permian (Murgabian),
Shalamzar area, Central Alborz, North Iran

Fig. 1: *Neoschwagerina margarita Deprat*, X20, thin section no. H.V-37.
Fig. 2: *Cryptosetida* (*Langella*) *bozorgniansis* Partoazar and Vaziri, X40, thin section no. H.V-49.
Fig. 3: *Langella perforata* (Lange), X100, thin section no. H.V-34.
Fig. 4: *Deckerella composita* Reitlinger, X40, thin section no. H.V-37.
Fig. 5: *Climacammina sphaerica* Potieskaya, X20, thin section no. H.V-37.
Fig. 6: *Climacammina valvulinoides* Lange, X20, thin section no. H.V-66.
Fig. 7: *Langella* cf. *acanthi* (Lange), X20, thin section no. H.V-60.
Fig. 8: *Pachyphloia cukurkoyi* De Civer. & Dess., X100, thin section no. H.V-105.
Fig. 9: *Geinitzina chapmani* Schubert Var. Longa Sulemanov, X40, thin section no. H.V-66.
Fig. 10: *Schubertella* sp., X40, thin section no. H.V-65.
Fig. 11: *Globivalvulina* sp., X100, thin section no. H.V-64.
Fig. 12: *Globivalvulina* cf. *vonderschmitti* Reichel, X100, thin section no. H.V-60.
Fig. 13: *Neoendothyra reicheli* Reitlinger, X63, thin section no. H.V-95.
Fig. 14: *Neoendothyra broennimanni* Bozorgnia, X100, thin section no. H.V-64.
Fig. 15: *Pseudovermiporella* sp., X12.6, thin section no. H.V-96.

Plate 4

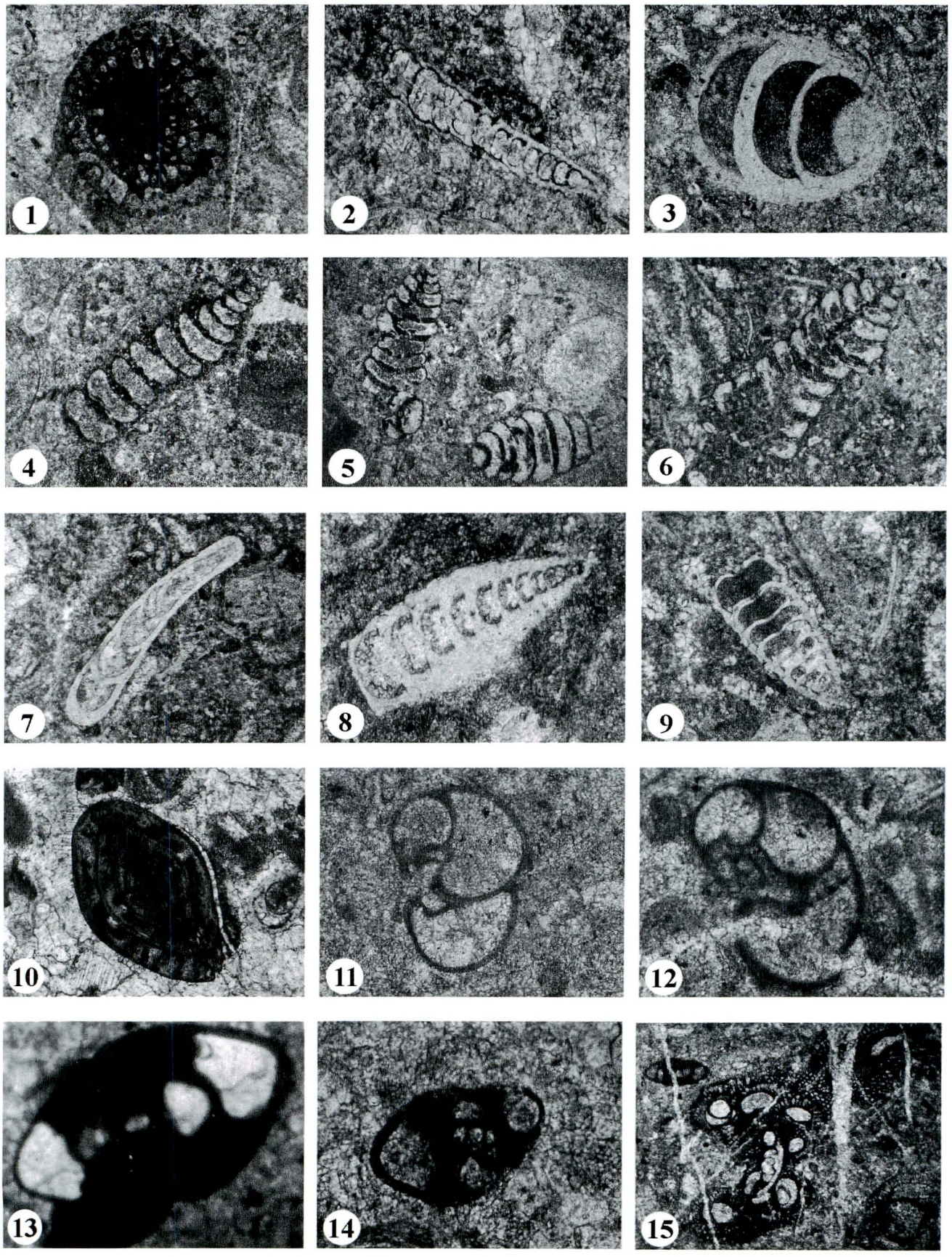

Plate 5

Ruteh Formation, Gord Calleh section, Late Permian (Murgabian),
Shalamzar area, Central Alborz, North Iran

Fig. 1: *Vermiporella nipponica* Endo, X40, thin section no. H.V-71.

Nesen Formation, Gord Calleh section, Late Permian (Early Djulfian),
Shalamzar area, Central Alborz, North Iran

Fig. 2: *Tubiphytes obscurus* Maslov, X40, thin section no. H.V-121.
Fig. 3: *Geinitzina postcarbonica* Spendel, X100, thin section no. H.V-120.
Fig. 4: *Globivalvulina vonderschmitti* Reichel, X40, thin section no. H.V-122.
Fig. 5: *Paraglobivalvulina* sp., X40, thin section no. H.V-120.
Fig. 6: *Paraglobivalvulina mira* Reitlinger, X40, thin section no. H.V-120.
Fig. 7: *Hemigordius* sp., X40, thin section no. H.V-121.
Fig. 8: *Codonofusiella* sp., X100, thin section no. H.V-121.
Fig. 9: *Dunbarula mathieui* Ciry, X100, thin section no. H.V-120.
Fig. 10: *Staffella* sp., X40, thin section no. H.V-121.
Fig. 11: *Reichelina* sp. and Dagmarita sp., X40, thin section no. H.V-122.
Fig. 12: *Reichelina* sp., X100, thin section no. H.V-121.
Figs. 13, 14: *Baisalina pulchra* Reitlinger, X100, thin section no. H.V-122.

Elikah Formation, Gord Calleh section, Early Triassic (Scythian),
Shalamzar area, Central Alborz, North Iran

Fig. 15: *Spirorbis* sp., X40, thin section no. H.V-127.

Plate 5